National Food Policy Capacity Strengthening Programme

Research Grant Initiative

Food Security for the Poor: Exploring Policy Options Under Alternative Price Regimes

Final Report

Principal Investigator: Dr. Rushad Faridi

Co-Investigator: Dr. Syed Naimul Wadood

Institution: Economic Research Group (ERG)

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Table of Contents

List of Tables

List of Figures

List of Acronyms

ADB - Asian Development Bank

AHM - Agricultural Household Models

BADC - Bangladesh Agricultural Development Corporation

BARC - Bangladesh Agricultural Research Council

BIDS - Bangladesh Institute of Development Studies

CPI - Consumer Price Index

EP - Essential Priorities

FFE - Food For Education

FFW - Food For Works

FPMU - Food Policy Monitoring Unit

FSSAP - Female Secondary School Assistance Program

GATT - General Agreement on Trade & Tariff

GDP - Gross Domestic Product

GO - Government Organization

GOB - Government of Bangladesh

GR - Gratuitous Relief

IFS - International Financial Statistics

MOA - Ministry of Agriculture

MOFDM - Ministry of Food and Disaster Management

NAEP - New Agricultural Extension Policy

NARS - National Agricultural Research System

NFP - National Food Policy

NGO - Non-Government Organization

OMS - Open Market Sales

OP - Other Priorities

PESP - Primary Education Stipend Program

PFDS - Public Food Distribution System

PKSF - Palli Karma Sahayak Foundation

RMP - Rural Maintenance Program

TCB - Trading Corporation of Bangladesh

TR - Test Relief

VGD - Vulnerable Group Feeding

VGF - Vulnerable Group Feeding

WHO - World Health Organisation

EXECUTIVE SUMMARY

- Rice price is experiencing an upward trend at home and abroad. Existing high import parity price has diminished the scope for the private sector to play the same stabilizing role this time around. In view of these changed circumstances, major objective of this study is to compare the impact of several government policy options on the food security of different income groups.

- Two interconnected models (namely the "market model" and the "household food security model") have been developed where government policy instruments are present as the exogenous variables in the system. The idea is that a "market model" will solve for the equilibrium price in the food grain market (as this equilibrium price is determined, among a number of other factors, government interferences in this food grain market). The next point is that the equilibrium price in the food grain market will enter a "household food security model" where the determinants of household food security will be estimated, along with the equilibrium prices in the food grain market, given that the government intervenes directly through transfers and indirectly through the food grain market as well as the agricultural input market.

- As expected, household characteristics are found to be strongly correlated with food security situation. Especially household infrastructure, land size and household head's employment characteristics are found to be strong indicators of food security situation. In order to devise policy action to help the subset of population which is food insecure, these results might have important implications.

- The market model exhibits that equilibrium rice price in the market is decided in the market through the interactions of demand for rice, supply of rice and rice import. The model shows that rice production amount has a clear negative impact on the price of rice, controlling for all other variables. At the same time, expectation of a future high price of rice has a tendency to increase the current price of rice in the market. Therefore a high price of rice has a tendency to continue by itself, unless large supply of rice reduces the upward tendency of rice increase to some extent. The market model also finds that government policy instruments also have influences on rice prices, but, rather in a smaller scale.

- The results show explicitly the impact of rice price increases on the household food security situation. Our results show that one percent increase in the price of coarse rice leads to around thirty three percent reduction in the likelihood of a household being food secure. This coefficient gives a quantifiable measure of the impact of rice price on the overall food security situation of the households.

- Among the employment categories, the effect of increases in price of rice is bearing heavily on the self-employed rather than wage or salary-employed. This is surprising given the fact that in terms of food security self-employed category has much lower percentage of households suffering than other categories. But our results are showing that these households (after controlling for other factors) have less coping ability than other households in case they face an external shock in terms of increases in price of rice.

- About the safety net results, the results are not very explicit. The amount received as safety net does not seem to have statistically significant impact on the food security situation. This is a cause of concern since it does not help to establish a causal relationship between the safety net programs and food security situation. It requires further investigation in the food security situation to have a clearer idea on the implication of safety net programs on the food security situation. But regression results clearly shows that after controlling for all the household characteristics, safety net recipients are around twenty percent more likely to be food secure compared to non-recipients.

1. INTRODUCTION

Since the trade liberalization in the early 1990s, private sector in Bangladesh has played an important role in stabilizing prices, particularly that of rice. During the devastating flood of 1998, the stabilizing role played by the private imports (Del Ninno et el., 2003) is a prime example of this. It was mainly possible because import parity price of rice was not exorbitantly high due to availability of enough surpluses in the world rice market at that time. Current situation in the world market is quite different. Rice price is experiencing an upward trend at home and abroad. Existing high import parity price has diminished the scope for the private sector to play the same stabilizing role this time around.

In these changed circumstances, we have to consider whether modification or expansion of government intervention is desirable or not. GOB mainly intervenes in the food market through the Public Food Distribution System (PFDS). Since trade liberalization, government role has considerably been diminished. The contribution of PFDS ranged between 3-5% of the total food grain availability for the last five/six years which is lower than historical average (FPMU, 2007). Of the total PFDS, for the last few years, the portion targeted to the poor has been more than 80% of the total off-take; whereas in 2003-04 and 2004-05 the percent fell to 55.2% and 63.1% respectively which coincided with the suspension of Food For Education (FFE) program. Under this regime of rising prices of rice, the objective of this study is to analyze the impact of different policy options like increased or decreased government role, maintaining the status quo or modification in the current distribution channels.

2. OBJECTIVE OF THE STUDY

One of the major objectives of this study is to compare the impact of several policy options on the food security of different income groups. In doing so, we addressed some important questions such as: when rice price changes, is there a quantifiable measure which would tell us how this price change affects different income groups, specially vulnerable and hard core poor? Would expansion or modification of government intervention positively affect food security of the targeted groups? Would a more open trade regime enhance food security?

In the process of answering these questions, we expect to find a measure which would allow us to estimate the impact of price level changes on the food security of household of different income groups. We would also try to develop an estimation framework that would enable us to assess the impact of government intervention on the food market outcome through both demand and supply functions and it will enable us to decide whether more or less government intervention is necessary.

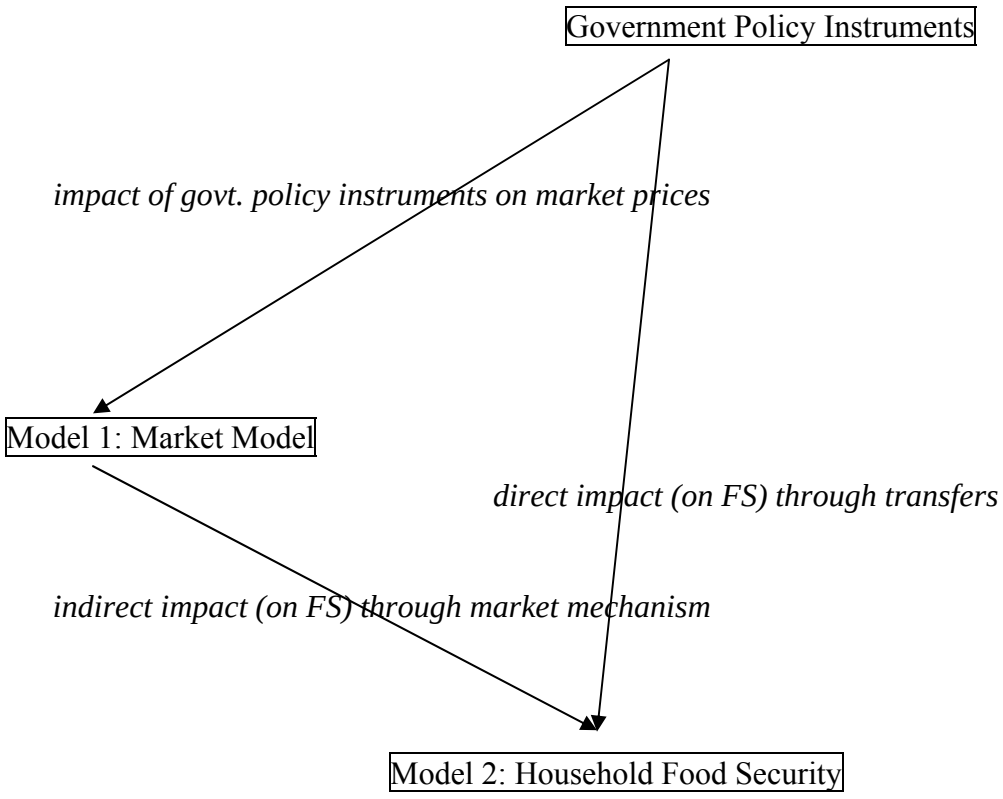
The theoretical model proposes that for analyzing the issue at hand, we need to develop ideas of two separate models interconnected with each other-- one is the "household food security model" and the other one is the "market model".

The basic idea is that the government policies can affect "household food security" through a number of different channels. One channel is the "direct transfers" from the government to the household, which is expected to have a direct effect on the

latter's food security (i.e., VGD, FFW, TR, GR). A second channel through which the government can influence the household food security is through the food grain market (i.e., OMS, procurement policy, import duty/trade policy). A third channel through which the government can influence the household food security is through the agricultural input market (i.e., price subsidies in the urea, seed, irrigation and power tiller).

This study requires to develop two models (namely the "market model" and the "household food security model") where government policy instruments would be present as the exogenous variables in the system. The idea is that a "market model" will solve for the equilibrium price in the food grain market (as this equilibrium price is determined, among a number of other factors, government interferences in this food grain market). The next point is that the equilibrium price in the food grain market will enter a "household food security model" where the determinants of household food security will be estimated, along with the equilibrium prices in the food grain market, given that the government intervenes directly through transfers and indirectly through the food grain market as well as the agricultural input market. By jointly analyzing the two models, we would address the issue of household food security as influenced by the government policy instruments.

Figure 2.1: Diagrammatic Framework of the Model



3. REVIEW OF LITERATURE

In this literature review section, we would cover two relevant and interrelated aspects of the research issue, such as, firstly, household food security, secondly, policy instruments for attaining this household food security.

3.1 Household Food Security

In the current literature, numerous studies are done which evaluated the cost-benefits of different public distribution schemes. One such study (Ahmed et al, 2004), looked into the operational performances of the food aid distribution in Bangladesh. This study identified problems in the whole food distribution system, determined the level of losses, leakages, and other lapses at various stages, and recommended solutions. In a related study (Jha and Srinivasan, 2004), evaluated the domestic and international trade and marketing policies in India and analyzes the effects of deregulating domestic markets and liberalizing external trade on the food grain sector. del Ninno et al (2003) looked into the components of public and private response that averted a major crisis during the 1998 flood in Bangladesh. Another study found evidence that in Bangladesh, the government played a minor role in stabilizing price throughout the 1990s and early 2000s (Dorosh and Shahabuddin, 2002).

Several works have been done in the context of some countries other than Bangladesh. Poulton et al (2006) paper discusses the desirability and options for the stabilization of staple food prices principally in Eastern and Southern Africa. One of the major problems they found is that there was uncertainty among private agents created by inconsistent actions by the public sector. Cumming et al (2006), in the context of the Asian countries, concludes that, in the face of increased strength of private institutions, governments in Asia should revamp their different intervention schemes in ensuring food security. The contribution of our study is that, in one particular framework, we want to capture the role of private, public and international trade in ensuring food security. In that context our study would resemble Jha and Srinivasan (2004) but would go beyond to show the direct and indirect impact of different policy options on the food security level of different income groups.

3.1.1 Definition and Measures of Food Security

A. Definition of Food Security

"Access by all people at all times to enough food for active and healthy life" (World Bank, 1986).

B. Measures of Food Security

(i) Household food energy deficiency

This can be measured by a dummy variable (0, 1) showing whether a household falls below a certain energy intake requirement. There is some debate about what is the correct

energy requirement. Energy requirement depends on age, sex, body weight, activity and lots of other factors. In practice, WHO (1985) recommendation is followed which is based normatively specified minimum energy consumption levels given a minimum acceptable body weight for healthy people at each age and sex group. The requirements for each household member are summed up to derive energy requirement for the household as a whole.

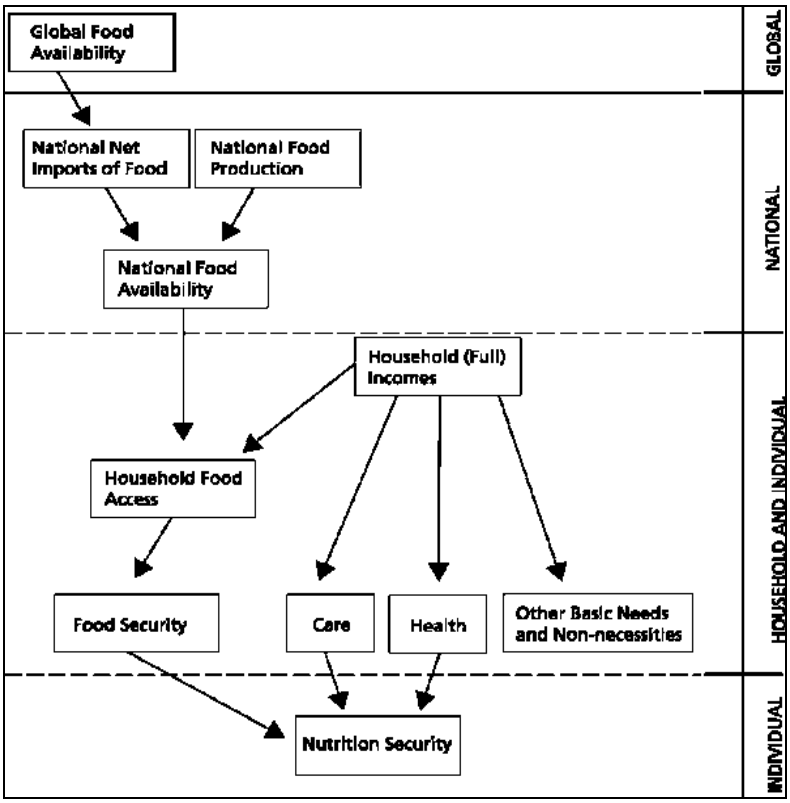
(ii) **Dietary diversity, a measure of diet quality**

Even if a household fulfills the food energy requirement, it does not guarantee whether it could manage the required nutrient to maintain a healthy life. Dietary diversity is considered to be a good measure of dietary quality. It is usually considered that a household should have more than ten different food items over the course of a week to maintain healthy diet diversity.

(iii) Percent of household expenditure on food item

The above two does not capture one important component of food security, that is, vulnerability to food deprivation in the future. One indicator of the vulnerability might be percentage of household expenditure on food. If that percentage is high, which is typically true for poorer households, the household is likely to suffer some food deprivation whenever it is facing some degree of income shock.

Figure 3.1: Diagrammatic Framework of the Household Food Security Issue



3.2 Policy Instruments and Food Security

3.2.1 Policy Framework

The recent government policy document that deals with the issue of "food security" is the "National Food Policy 2006" (NFP 2006) by the Ministry of Food and Disaster Management (MOFDM). This NFP 2006 provides a brief overview of the current GOB policy framework in this regard.

3.2.2 Stated Goals and Objectives

The Article 15(a) of the Constitution of Bangladesh places a fundamental responsibility on the State to secure its citizens to the provision of the basic necessities of food. As per Government of Bangladesh (GOB)'s Allocation of Business, it is the duty of the MOFDM to establish a dependable food security system for the nation. GOB claims that it is firmly committed to achieve "food security" for all, defined at the 1996 World Food Summit as: *access by all people at all times to the food needed for an active and healthy life*. Bangladesh is a signatory of GATT Uruguay Round Agreement of 1994, which among other issues, asks for agricultural trade liberalizations. In 2000, a task force document entitled "A Comprehensive Food Security Policy for Bangladesh" was released by GOB following recommendations of the Bangladesh Development Forum. The recent NFP 2006 is based on the 2000 task force document, the currently ongoing Poverty Reduction Strategy Paper (2005-2008), the broader definition of "food security" in the World Food Summit agreements as well as international-level obligations to achieve the Millennium Development Goals (2000), that of reducing the number of poor people by half by 2015.

The objectives outlined in the NFP 2006 are as follows.

Objective 1: to ensure adequate and stable supply of safe and nutritious food,

Objective 2: to enhance purchasing power of the people for increased food accessibility, and

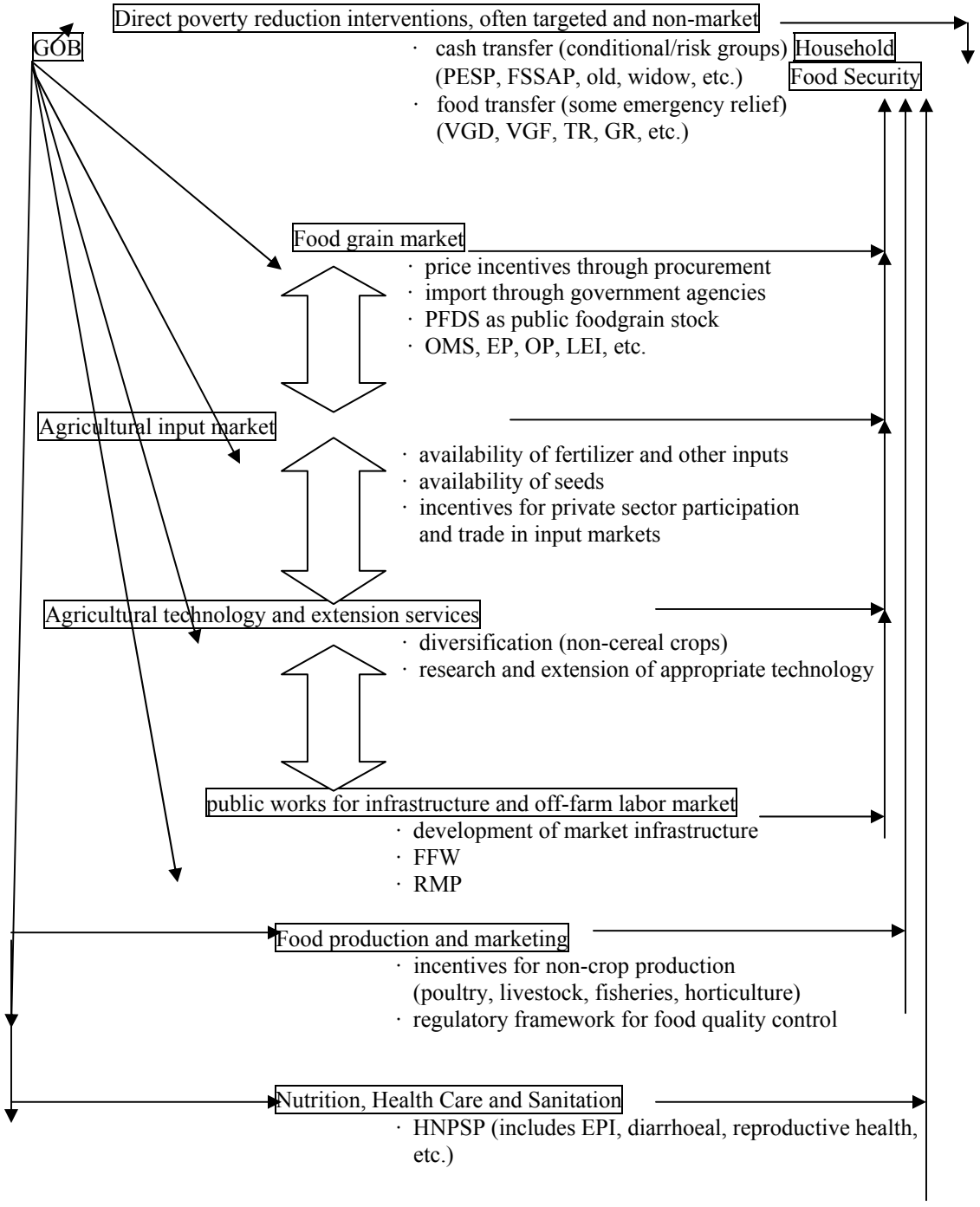
Objective 3: to ensure adequate nutrition for all (especially women and children).

The supply of food consists of domestic food production, public and private stock and international trade. On the other hand, household's access to food depends on household income, assets, remittances, gifts, borrowings, transfers and food aid. Adequate health care and sanitation facilities are needed for ensuring proper nutrition for all, particularly vulnerable household members such as women and children. A traditional exclusive emphasis on the supply of food is now being replaced by a more balanced emphasis that also incorporates household demand for (physical, social as well as economic access to) food and utilization of food. NFP 2006 acknowledges that while supply of food may be considered as a necessary condition for ensuring household food security, the sufficient conditions are ensuring access to food as well as food safety measures, nutrition, health care and sanitation facilities.

3.2.3 Policy Instruments

Figure 3.3.1 presents a diagrammatic view of the set of policy instruments pursued by the GOB that affects household food security, through a number of channels.

Figure 3.2: Diagrammatic Framework of GOB Interventions on Household Food Security



The first channel is through direct poverty alleviation and disaster management initiatives (often targeted). This includes conditional cash transfers such as the Primary Education Stipend Program (PESP, replacing formerly FFE), the Female Secondary School Assistance Program (FSSAP), the Old Age Allowance, Allowance for Widows and Abandoned Women, Welfare Fund for Freedom Fighters and the Dependents, Funds for Acid Burn Victims, etc. This direct transfer channel also includes food transfers such as the Vulnerable Group Development (VGD), the Vulnerable Group Feeding (VGF) as well as other programs such as the Test Relief (TR), Gratuitous Relief (GR), etc. (World Bank 2006).

The second set of channels operate through government interventions in the regular functioning of the market. Within this set, a sub-set operates through interventions in the foodgrain market, such as, public procurement, import from government agencies such as the Trading Corporation of Bangladesh (TCB), maintenance of a public foodgrain stock for emergency requirements and regular supply of food based transfers, consumer price support programs like the Open Market Sales (OMS), Essential Priorities (EP), Other Priorities (OP), Large Employment Industries (LEI), etc. The GOB also intervenes in the agricultural input market, through arrangements for timely availability of fertilizer, seeds and other agricultural equipments in crop and fisheries production. The GOB gives incentives to the private sector agents in the agricultural input market to encourage their participation, with some restrictions.

A third sub-set of government intervention in market is through agricultural research and development and extension services (this impact expected to be long-term). A fourth sub-set of government intervention in the market has some overlap with direct transfer payments-- the key difference is that these operate through off-farm labor markets associated with development of rural infrastructure. This includes the in-kind transfer-based Food-for-Work (FFW) program managed by the Local Government Engineering Department, the Ministry of Water Resources and the Ministry of Food and Disaster Management and the cash transfer-based Rural Maintenance Program (RMP) which is a public works program for the working age population.

The recent broader definition of "household food security" encompasses a large number of government interventions since these can have impacts on the (household) food security situation. A household tries to maintain food security for itself through participation in the labor market, agricultural enterprises, non-agricultural enterprises, assets, gifts, remittances, borrowings, government transfers, etc. Therefore, broadly speaking, any additional dollar spent from the public fund has the potential to have an impact (either short-term or long-term) on the food security status of the household. In particular, interventions from two ministries of the GOB would be directly relevant in the household food security issue, namely, the Ministry of Food and Disaster Management (MOFDM) and the Ministry of Agriculture (MOA). The MOFDM is primarily responsible for ensuring food security, while MOA programs are relevant since agriculture still contributes 21.11% of real GDP (1995-96 constant prices) as recently as in 2006-07 and more importantly involves 51.69% of the labor force in 2002-03 (Bangladesh Economic Review 2007, in Bangla).

3.2.4 Major Changes in the Agricultural Sector Policies in Recent Years

The major policy changes over the last decade and a half have been the following (see MOA website).

A. Encouraging competition in the Minor Irrigation Sector

GOB pursued a policy of gradual liberalization of trade in minor irrigation sector and gradually encouraged the private sector for supply of minor irrigation equipments. The withdrawal of restrictions on imports of irrigation equipment and pumping installations in the last 1980s has opened up ways for fast expansion of irrigated area (World Bank and ADB 2003). As a consequence, as of in 2003, less than 10 percent of irrigated land is serviced from public irrigation facilities (op. cit.). In the early 1990s the Bangladesh Agricultural Development Corporation (BADC) was removed from the procurement and distribution of minor irrigation equipment-- removal of this government organization monopoly has encouraged the private firms to participate more enthusiastically in this market.

B. Encouraging Private Sector Participation in the Fertilizer Market

Privatization of trade in fertilizer was introduced with an objective of eventually transferring the fertilizer management and distribution services exclusively by the private sector. The fertilizer market began to be liberalized in the early 1980s, and all categories of fertilizer imports and marketing were placed in the private sector by the early 1990s (except the case of urea-- production and farm-gate pricing of urea has been still government controlled). The GOB has issued the revised Fertilizer Control Ordinance in 1995 in consultation with private sector and IFDC for quality control and regulation of fertilizer prices.

C. Encouraging Private Sector Participation in Agricultural Machinery Import

A policy of liberalization of trade and foreign exchange was pursued for enhanced participation of private sector in agricultural machinery of agriculture business. The GOB claims to be continually reviewing conditions affecting competitive trade and taking action to remove barriers. The duties on power tillers and engines were eliminated in 1989, resulting in an expansion of their use. On the other hand, reductions in duties on equipment and raw materials for food processing helped the nonagricultural rural sector.

D. Encouraging Private Sector Participation in the Seed Industry

A policy of liberalization of production, processing, distribution and import of seeds to the private sector was followed. This encouraged private sector seed dealers in the seed industry. Liberalization of seed policy started in the mid-1980s as private sector was

allowed to import seed for the first time in 1984-85. In 1992 the seed policy was further liberalized with the procurement of imports (including seeds of notified crops) and domestic seed varieties (including direct purchases from research institutes). The Seed Act was revised in 1997 and it allowed for imports of vegetable seeds without testing--the Act also reduced the previously two year-long testing period timeframe for imported seeds of notified crops. The private sector is now allowed to import any improved germ-plasm for research and development and to develop its own facilities for producing foundation seeds. They are also allowed to import and sale seeds except five notified crops (rice, wheat, sugarcane, potato and jute). In the case of import of seeds of the notified crops, private sector importers are still required to fulfill certain formalities.

3.2.5 Evolution in the Food Supply and Management System

A. Gradual downsizing of the Public Food Distribution System (PFDS)

Major changes occurred in food supply and management system; these include introduction of Open Market Sale (OMS), procurement of food grains from the farmers at market prices, abolition of rural rationing system and allowing import of food grains by the private sector. Government distributes food-grains mainly rice and wheat through its monetized and targeted channels under Public Food Distribution System (PFDS). The government has eliminated the Statutory Rationing and Rural Rationing Channels in early 1990s-- and instead tried to rely more on targeted food distribution. This has reduced the requirement for a large PFDS system. This accompanied reduction in the size of the PFDS and trade liberalization of the early 1990s has diminished the government's involvement in the food grain market in Bangladesh, at the same time trade liberalization has opened up a new channel to stabilize prices of food grain through private sector imports (Dorosh and Shahabuddin, 2002).

B. Measures to Strengthen Agricultural Research and Extension Services

In order to provide the newer concept of "need felt" extension services to the farmers, "Agricultural Support Service System" was introduced in accordance with the provisions of "New Agricultural Extension Policy" (NAEP). On the other hand, agricultural research system has been overhauled following the provision of the "National Agricultural Research System" (NARS) through bringing ten primary research institutes under it with the Bangladesh Agricultural Research Council (BARC) at the apex.

C. GO-NGO Cooperation, Particularly in Providing Social Services and Microcredit

A significant direction of change over the last one and a half decade has been a gradual strengthening of partnership between GO and NGO organizations, in the field of rural development, microcredit, providing health care facilities, etc. Particularly the microcredit initiatives, where the GO or NGO organizations specifically target households with low collateral capability and generally target is the poor women, have

been a huge success story acclaimed by the national and international observers alike. In 2000, the microcredit program delivered by the GO and NGOs covered over 10 million individuals. A large volume of public and donor resources are now flowing for micro-credit initiatives, while the *Palli Karma Sahayak Foundation* (PKSF) has been established as the apex organization to provide credit through various partner organizations.

3.2.6 Effectiveness of Policies in Securing Food Security

A. Transfers as in Social Safety Net Programs

World Bank (2006) study mentions that only a few studies till date have investigated the impacts of social safety net programs on the extent of poverty and vulnerability and as an extension "food security"-- and the overall assessment is somewhat mixed.

Some studies have found that most households benefiting from cash transfer programs (such as VGD program) were seen to have improved their income levels and the quality and quantity of their food-intake (del Ninno and Dorosh (2001) and Matin and Hulme (2003)). Khanum (2000) reports improvement in living conditions of the RMP beneficiaries such that home ownerships increased, new investments in housing materials were made and new productive assets were purchased (comparison between pre-RMP and post-RMP)-- these have potential short-run and long-run impacts on food security. Begum and Majumder (2001) report that some beneficiaries from the old age allowance and the widow allowance program have invested their allowance money for buying goat, cow, poultry, etc.-- potential sources of long-run household income generation and attainment of food security.

Dorosh and Shahabuddin (2002) on the other hand is of the opinion that programs designed to alleviate poverty and household food insecurity such as the FFW and the VGD programs, are limited by the extent of resources available, including food aid. World Bank (2006) study summarizes a common view held by a number of studies such that, while the social safety net programs are valuable in smoothing consumption they do not have much impact on structural changes in poverty.

B. Investment in Rural Infrastructure

Khondker, Bakht and Koolwal (2006) have examined the impacts of rural road projects in Bangladesh, based on a household-level panel data conducted by the Bangladesh Institute of Development Studies (BIDS) in 2004 examining the impacts of Rural Roads and Markets Improvement and Maintenance Project-I and II (RRMIMP-I and II). They have found that public investments in rural road constructions tend to reduce incidence of poverty through higher agricultural production, higher wages, lower input and transportation costs, and higher output prices and these projects may tend to increase girls' and boys' schooling. Though these public investments are found to be "pro-poor" in terms of impacts-- the issue of changes in household food security was not examined.
On the other hand, World Bank (2006) mentions anecdotal evidences for arguing that weak local governments are unable to undertake well planned community infrastructure

projects that can produce quality outputs. In addition, once the infrastructure assets have been installed, a common scenario is that insufficient resources are available for proper maintenance of these assets.

C. Conditional Cash Transfers

Conditional cash transfer programs (for example, the FSSAP and the FFE, now redesigned as PESP) are considered to be having a satisfactory impact on human capital accumulation and reduction of gender disparity and drop-out rates among the school-going boys and girls (BIDS 2003). But impact of these programs on household food security (at least in the immediate short-run) is not clear-cut.

D. Interventions in the Food-grain Market

Dorosh and Shahabuddin (2002) explore policy options for the government with regards to rice price stabilization and food security. Their argument is that while "food security" has been correctly viewed as the policy objective of the government, often other objectives such as "rice price stabilization" or a more operational objective of "smooth operation of the PFDS" have been followed through decisions and interventions. Yet since the trade liberalization in the early 1990s, the private sector import has been successful in stabilizing rice prices in a more cost-effective way, as it was visible in the months following the 1998 floods. While the PFDS is still important for mostly targeted interventions for food security, "rice price stabilization" needs to be considered as a separate objective that can as well be served by private sector imports, as long as these imports provide a price ceiling at import parity levels.

Del Ninno, Dorosh and Smith (2003) is one paper that directly relates public policy in food grain market with household food insecurity issue. Investigating post-1998 flood market data and household survey results, they conclude that a large-scale private sector imports of rice from India immediately after the flood helped stabilize rice prices and thereby prevented further deterioration of household's purchasing power and calorie consumption. They found short-term government response of the PFDS-based GR and VGF programs to be useful for household food security, but these were inadequate relative to household needs (survey households mostly depended on increased borrowings for consumption smoothing after the flood and the government transfers were only one-sixth to one-eighth the size of household borrowing; household reliance on increased borrowing was costly in terms of its food security in the longer term). On a positive note, the authors found government long-term policy directions, such as investments in expansion of winter-season rice (*boro*) crop rather than the monsoon-season rice (*aman*) crop, investments in infrastructure and liberalization of private sector import of wheat and rice, to be helpful in building a food grain market that could quickly respond to immediate production shortfalls.

E. Impacts of Agricultural Sector Reforms

Ahmed (1996) compares Bangladesh agricultural sector reforms (time frame of 1977-84 compared with 1985-92) with those of her South Asian neighbors, and finds that the extent of reforms have been much bigger in scope in Bangladesh and Sri Lanka as compared to those in India and Pakistan. By developing counterfactual results from a multi-equilibrium model framework, the author mentions that reform measures in the fertilizer and irrigation markets in Bangladesh contributed to approximately 20% to 32% of the increase in rice production over the reference period-- this increase can be attributed to the effect of reform on fertilizer consumption and private-sector irrigation development.

4. METHODOLOGY

We begin with an overview of the current rice market in Bangladesh. In terms of different stakeholders, we explore what are the contribution of two major institutions, government and private sector in influencing rice price. We also review the historical changes in different institutional structures and compare how the food security of different income groups is affected by these varied institutions. In current institutional structure, GOB has the following major policy instruments: (a) provide food aid directly to the poor (b) stabilize food price through market mechanism and (c) import food grain directly or facilitate private importers by removing trade barriers. The objective of this policy is to mitigate the shocks in prices of food grains important for the food security of the poor. When price level increases, consumer choice basket goes through an adjustment mechanism which might be a threat to the food security. Government aim is to intervene into the market or directly in the household so that poor consumers can maintain the original level of food security. We would like to assess which of the above mentioned policy instruments perform better.

Then we develop a dynamic open market model of rice price determination. The data required for estimation is available principally from Bangladesh Bank, Food Policy Monitoring Unit of Government of Bangladesh, Department of Agriculture and Marketing, and the Household Income and Expenditure Surveys of different years published by Bangladesh Bureau of Statistics. This model will help us to analyze different demand or supply factors that might affect the rice price. At the same time we would develop a reduced form model of calorie-intake determination where the importance of rice price as a determinant would be tested. Combining these two models, we would investigate how current government intervention practices and different institutional practices affect food security of various income groups, either directly or indirectly through changes in price level. These models would be primarily used to produce simulation data by comparing different counterfactual situations involving major policy instruments which are mentioned above.

The theoretical model requires that we develop two separate but interconnected models, such as the "*market model*" and the "*household food security model*".

The broad idea behind the "*market model*" is that it will solve for the equilibrium price of rice at the national level, controlling for a number of factors including government policy intervention variables (such as government procurement, etc). The main objective is to be able to construct a model in such a way that it would accurately predict the changes in the equilibrium market prices of food grain that would occur due to some government policy intervention changes. The next step would be to use the estimations obtained in this market model on to the "*household food security model*" and estimate the impact of government policy changes on to the household food security status. A simple presentation of this line of thinking can be described by the following "chain" expression:

[Δ household food security / Δ public procurement] =
[Δ household food security/ Δ equilibrium market price]×
[Δ equilibrium market price/Δ public procurement] ……. ……..(1)

The first part of the right hand side of equation (1) would be estimated by the "household food security model" at the *microeconomic level*, whereas the second part of the right hand side of equation (1) would be estimated by the "market model" at the *macroeconomic* level. An extended version of equation (1) would be required in the case of a government policy intervention variable having both "direct" impact on household food security and "indirect" impact on household food security through the market. A note on equation (1) is that, this chain expression needs to be estimated within the context of a model framework, since these partial effects expression can be influenced by a large number of exogenous as well as endogenous variables.

We expect this exercise would allow us to better understand the policy implications on household food security and eventually make recommendations regarding modification and/or rescaling of current government interventions under alternative price regimes.

5. MARKET MODEL

5.1 Discussion of Data

Data for the market model has been collected from a number of sources, namely Food Planning and Monitoring Unit (FPMU), Ministry of Food and Disaster Management, Government of People's Republic of Bangladesh, Bangladesh Bureau of Statistics (BBS.) and the Bangladesh Bank. The relevant data consisted of information of supply, demand, procurement, government distribution, import of rice and wheat during the recent years.

5.1.1 Selection of Series

Prices of rice (particularly the coarse type) and wheat are considered as the food commodity prices that are important with regards to food security.

5.1.2 Data Source

Price of rice and wheat, CPI (general and non food) are collected from FPMU. Annual Per capita GDP and GNI up to 2004 are retrieved from International Financial Statistics (IFS) and the part after that is collected from Bangladesh Bank web site. The annual data was then disaggregated into monthly series using the monthly growth rate that is consistent with the yearly growth rate.

5.1.3 Derivation of Trend

Hodrick-Prescott filter is used to decompose the data into trend and cycle. According to this filter, time series y_t is the sum of a trend component g_t and a cyclical component c_t : $y_t = g_t + c_t$ for t = 1, 2, ……,T.

Measure of the smoothness of the $\{g_t\}$ path is the sum of the squares of its second difference. The c_t's are deviations from g_t and over long periods, their average is near zero. So growth components can be determined from minimization of the following.

$$\underset{\{g_t\}_{t=-1}^{T}}{Min}\left\{\sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T}\left[\left(g_t - g_{t-1}\right) - \left(g_{t-1} - g_{t-2}\right)\right]^2\right\}$$

The parameter λ is a positive number which penalizes variability in the growth component series. The larger the value of λ, the smoother is the solution series. For a sufficiently, large λ, at the optimum all the $g_{t+1} - g_t$ must be arbitrarily near some constant β and therefore the g_t arbitrarily near $g_0 + \beta t$. This implies that the limit of solution to the optimum problem as λ approaches infinity is the least square fit of a linear time trend model. If the cyclical components and second differences of the growth components were identically and independently distributed, normal variables with means

zero and variances $\sigma_1^2 and \sigma_2^2$ (which they are not), the conditional expectation of the g_t, given the observations, would be solution to the minimization problem when $\sqrt{\lambda} = \frac{\sigma_1}{\sigma_2}$. Prior views indicate that a 5 percent cyclical component is moderately large, as is a one twenty-fourth of 1 percent change in the growth rate in a month. This leads to $\sqrt{\lambda} = \frac{5}{1/24} = 120$ or $\lambda = 14400$ as a value for the smoothing operator.

5.1.4 Defining Lean Period and Other Variables

Considering April, May, June and October as months of either the starting points of new harvests or close of preceding seasons, a simple regression where a dummy variable is the only explanatory variable and nominal price of rice is the dependable variable, reveals that nominal price has a tendency to increase during these months through the relationship is not a significant one (see Annex Table 1).

Here CPI and Non-food price indices are used with Jul, 1980 = 100. GDP per capita is measured in Taka; wholesale price of coarse rice is considered and measured in Taka per metric ton. Wheat price is also measured in Taka per metric ton.

5.1.5 Looking at the Long Term Trend

We observe that the real price of rice has been on the decline with respect to consumer price index, non-food price index and the gross domestic product per capita as well as gross national income per capita between 1980 and 2007 (Figure 5.1, 5.2, 5.3 and 5.4). A closer scrutiny actually reveals that the long-term decline of real price of rice has been reversed during the last five or six years. Again, wheat has traditionally been considered cheaper relative to rice, but in recent years, it has overtaken rice.

Figure 5.1: Nominal and Real Prices of Rice and Wheat (1980-2007)

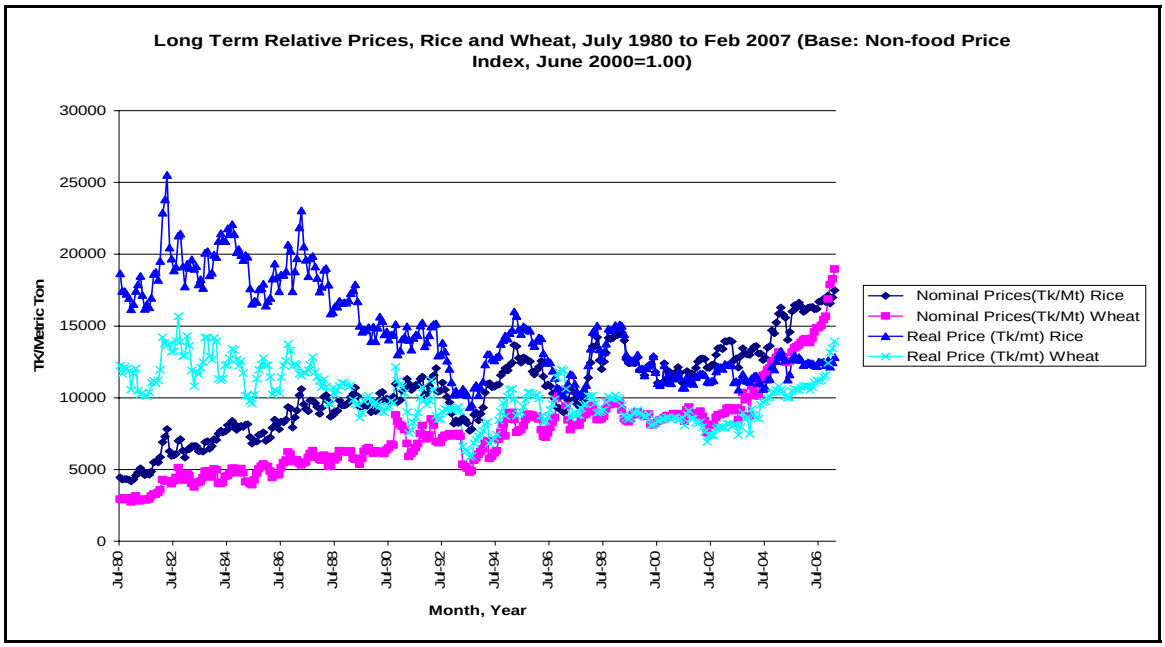


Figure 5.2: Changes in the Real Price of Rice (Relative to CPI) (1980-2007)

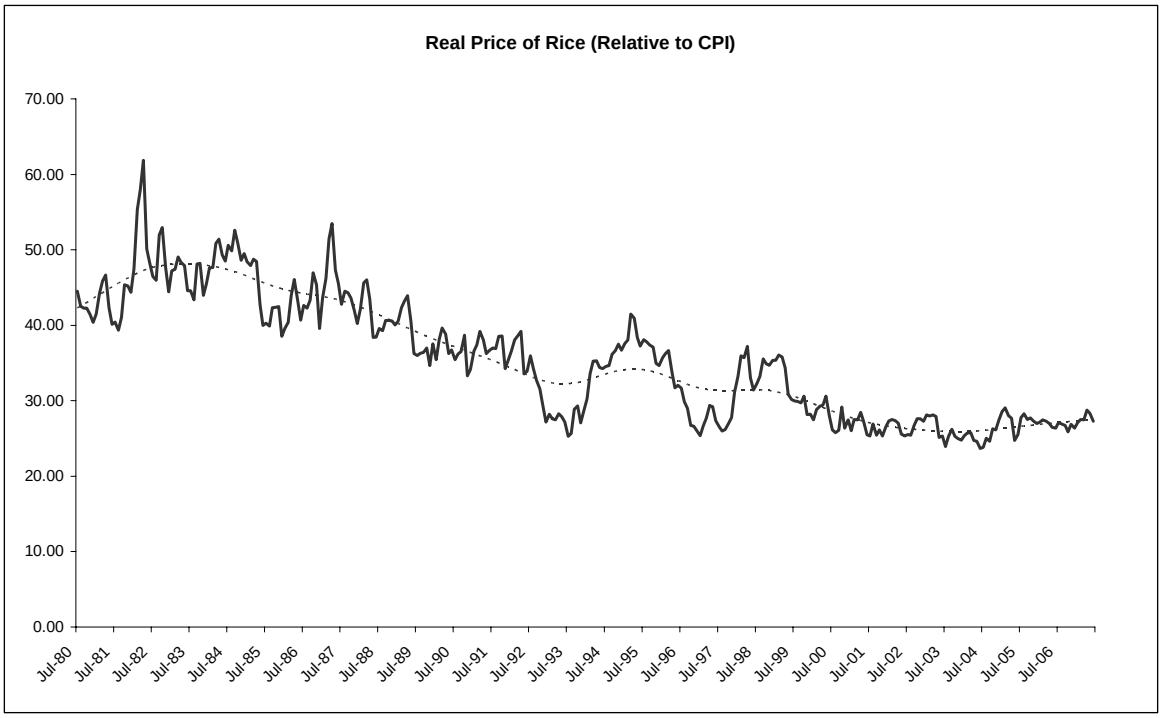


Figure 5.3: Changes in the Real Price of Rice (Relative to GDP per capita)

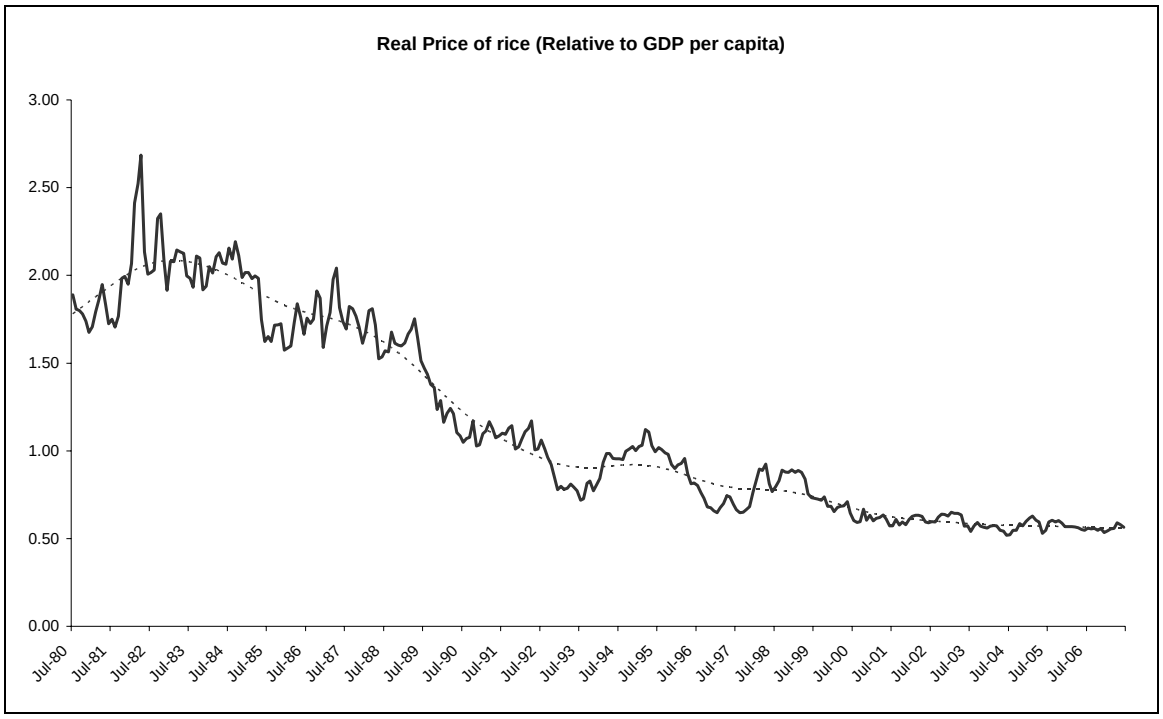


Figure 5.4: Changes in the Real Price of Rice (Relative to GNI per capita)

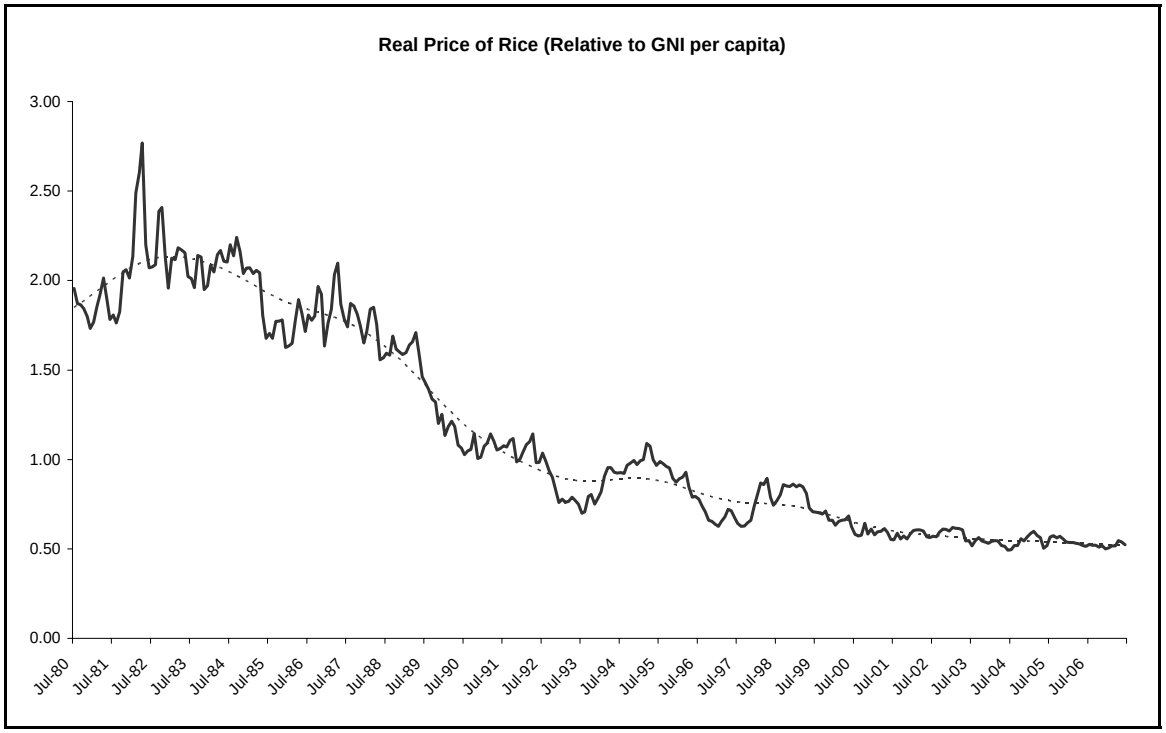


Figure 5.5: Rice Production Amount by Season, 1978-79 to 2006-07

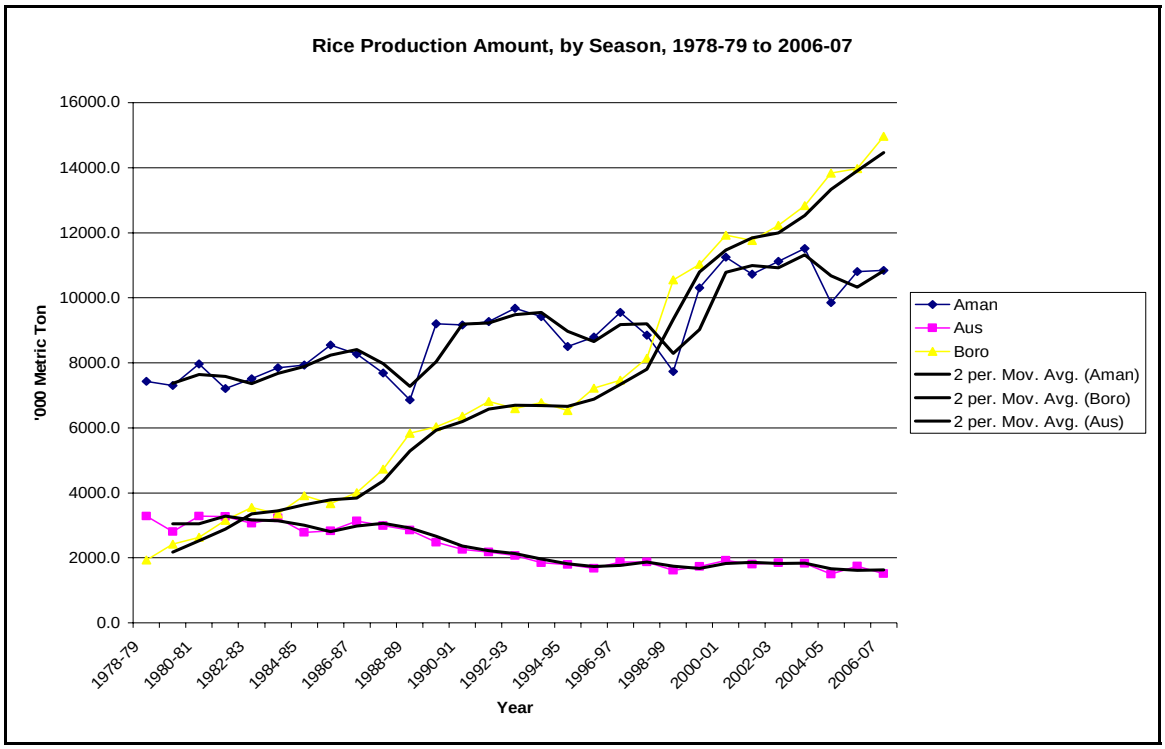
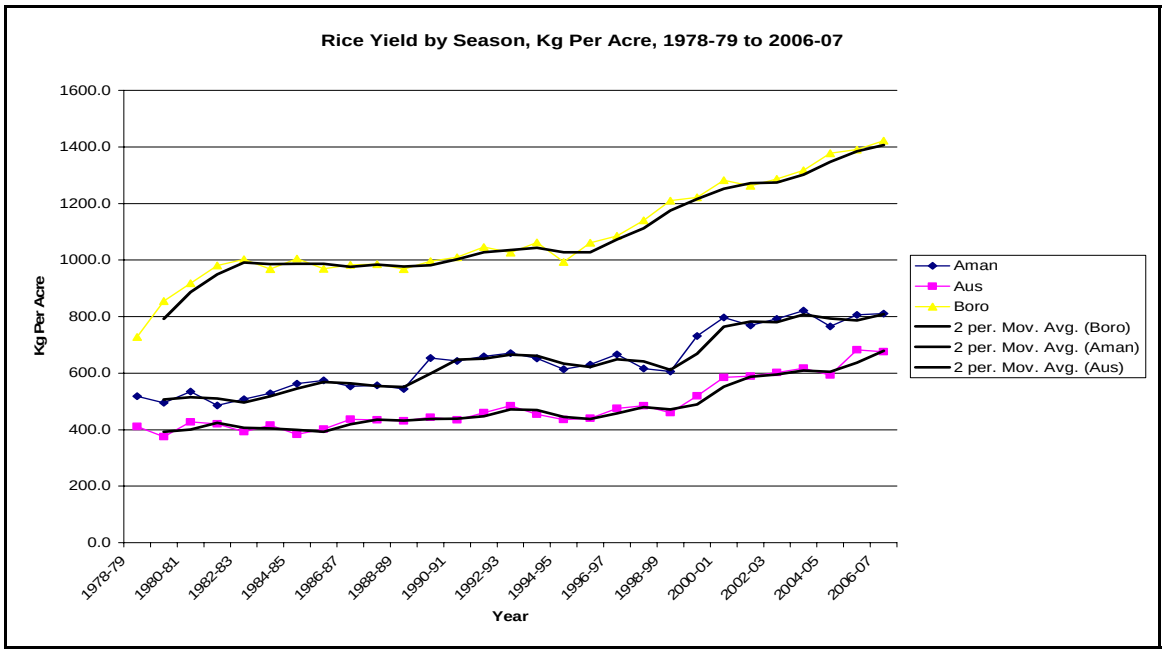


Figure 5.6: Rice Yield Amount, by Season, 1978-79 to 2006-07



5.1.6 Other Features of Data

(a) Production, Area, Yield Rate and Relative Share of Crops of Food grain

Figure 5.1, 5.2, 5.3 and 5.4 (see Annex) indicate that, during the period of 1978-79 to 2006-07, the relative importance of the *boro* crop within the rice crops have increased, while the relative importance of the *aman* and the *aus* crops have been on the decline. Another encouraging feature of these production data is that the yield rate of *boro* rice also has been much higher than those of other categories of rice, which has significantly contributed to overall increases in food grain production. The domestic production of wheat has been limited in scope.

(b) Rice Production and Area-- the Local variety versus HYV variety

Figure 5.5 (see Annex) indicates that, during the period of 1987-88 to 2005-06, the local varieties in the rice production have been gradually giving way to the HYV varieties.

(c) Irrigation Share of Food grain Production Area

Figure 5.6 (see Annex) indicates that, during the period of 1992-93 to 2006-07, the share of irrigated land out of total land under different crop seasons have shown a consistent pattern. The pattern that is observed is that, within the *boro* category, the share of irrigation is very high. The share of irrigation is also steadily increasing within the *aman* category. The other two categories, wheat and aus, did not have much share of irrigated land.

(d) Food grain Surpluses

One significant achievement of the food grain production in Bangladesh is that, it has achieved self-sufficiency in terms of production of food grain as compared to the requirement of food grain around 1999-2000, as shown in Figure 5.7(see Annex). Here the total production of food grain data is compared with the national requirement data (as defined by 453 grams of food grain per person per day) for corresponding years within the timeframe of 1978-79 to 2006-07. Because of increases in per-capita production of rice, mainly to be attributed to dependence on HYV varieties as well as intensely irrigation-based *boro* production, the national food grain requirement has been surpassed by the end of the last decade.

(e) Cost of Production

Figure 5.8 (see Annex) exhibits cost of production increases in the production of HYV boro crop during 1997-98 to 2004-05. There has been a steady increase in the cost of production components over time. One can also notice that the rate of increases in nominal prices of different cost components differed as well, While the cost of urea has been steady, other cost components, particularly irrigation costs have registered significant increases over time. Figure 5.9 examines the increases in chemical fertilizer component more closely, during the period of 1999-91 to 2004-05. The cost of urea

fertilizer has been quite steady, while all other fertilizers have registered increases over this time period. We notice that his tendency of increases in prices of cost components may have, to a large extent, contributed to increases in prices of rice over time.

(f) Rainfall Shock

Figures 5.10 and 5.11 (see Annex) exhibit one more issue of the supply side of rice production—the issue of rainfall shock. The figures exhibit the national level data from 1985-86 to 2004-05. We notice that rainfall is distributed very unevenly over the year, necessitating irrigation for crops. Rainfall is lowest during the months of January and December, while it is typically the highest during the months of June and July. If we examine the "rainfall shock" term, defined as the deviation of actual rainfall from average rainfall, we notice that, even over nearly a twenty-year range of data, a slightly higher rainfall uncertainty occurs during the rainy season, whereas this rainfall shock term is marginal for the dry season. Therefore the rainy season crops have a more prominent rainfall uncertainty aspect, compared to the cases of the dry season crops.

(g) Natural Disasters

A recurrent issue in Bangladesh agriculture is natural disasters, particularly floods and cyclones. Figures 5.12 (see Annex) exhibit national-level data from 1980 till 2004 the percentage of total cropped land area that has been affected by floods in each of these years (data is missing for a number of years). On an average 20% of the total cropped land area gets affected by flood every year; whilst this percentage share varies widely from year to year, from a high above 80% in 1988 to nearly 0% in 1994. Here we notice significant uncertainty in the rice production arena regarding prospective extent of flood damage in any particular year. Figure 5.13 exhibits estimates of loss of crops from flood and cyclone damages. Overall, the percentage loss of crops from floods and cyclones has not been found to be high enough-- *aus* and *aman* crops have been more susceptible to flood damages, whereas *boro* crop has been found to be less susceptible to natural disasters, mostly cyclones.

(h) Rice Prices

Figures 5.14, 5.15, 5.16 and 5.17 (see Annex) exhibit rice price data. Figure 5.14 (see Annex) compares wholesale coarse rice price and wheat price, only recently wheat price have surpassed coarse rice price in the wholesale market-- this has challenged the old assessment that wheat has most often been found to be cheaper compared to rice. Figure 5.15 exhibits that coarse rice price in the market do not have much average month-wise variation, and at the same time, this does not get much affected by the average amounts of rice procurement, rice distribution, rice import and rice price in India (converted in to Taka per kg) per month. The range of data is in between 1999-00 to 2006-07. Figure 5.16 exhibits movement of Bangladesh coarse rice price vis-à-vis the price of rice in

India and Thailand; this shows that the recent increases of rice prices in the domestic market have been accompanied by similar increases in the international market as well. Figure 5.17 examines price differences of rice in the domestic market. There has been differences in average wholesale coarse rice prices (by month) in different regional markets; these differences has been persistent even in geographically proximate regions (such as Patia and Chittagong market, similarly in Patuakhali and Bhola markets). This data shows that, in terms of geographical regions, rice prices have been found to be different whilst one would have expected these differences would be minimum in proximate regions. Therefore consumers face different market prices in different regions and this pattern persisted even when we took into account average monthly prices over a six year timeframe. Rice prices in the national market therefore closely follow patterns in the international market, at the same time differences persist in regional market prices as well.

(i) Rice and Wheat Procurement and Distribution

Figure 5.18 (see Annex) examines private import, public procurement and public distribution of food grain during 1991-92 to 2006-07, as percent of net food grain production figures. This shows that while private import has gained in terms of net food production, both public procurement and public distribution has been diminished over time.

Rice and wheat procurement and distribution varies by month, as Figure 5.19 indicates. Particularly rice procurement varies widely by month, on the other hand, rice distribution is more evenly distributed over months. The data is in between July 1998 to January 2008.

Figures 5.20, 5.21 and 5.22 (see Annex) examine data for public procurement. These figures show that public procurement has often failed to achieve its' stated targets, since the procurement prices more often have lagged behind increases in the market prices of rice.

Figures 5.23 and 5.24 (see Annex) examine data for public food grain distribution (PFDS) during 1990-91 to 2006-07. Rice has overtaken wheat in terms of share of PFDS in recent years. On the other hand, "non-sales" component of PFDS (i.e., FFW, TR, VGD, VGF, GR) still dominates over the "sales" component (i.e., EP, OP, LE, OMS, FM, PC). But in recent years, the proportion of the "sales" component has been increased as compared to the "non-sales" component.

(j) Public Import

Public import of rice has become a minor component in the rice market since the role of import of rice has been taken over by the private sector. Figure 5.25 (see Annex) examines this aspect of the food grain market; data examined is in between July 1998 to June 2005.

(k) Food Aid

Figure 5.26 (see Annex) examines per capita food aid data from 1972-93 to 2006-07 in comparison with per capita food import data during the same period. Per capita food aid has been replaced by per capita food import in recent years, particularly after 1991-92. This implies that foreign assistance in the food grain market has become minimal in recent years.

(l) Revenue Expenditure

Direct revenue expenditure share of Ministry of Agriculture has been limited in recent years, as it is exhibited in Figure 5.27 (see Annex) . One needs to examine further to be able to analyze if there has been sufficient public expenditure allocation in the overall agriculture sector during the recent years.

5.1.7 Construction of Variables

Variables in the data set have different lengths of periods over which the data is readily available in time series formats. This poses a problem for estimating an accurate market model. As for illustration, population data is available well before 1971, whereas the currently available data series for national-level rice production and area under rice cultivation is from July 1978 to June 2007. Most of the data series are complete from July 1999 up till June 2007. For avoiding problems associated with missing values in regression data series, the timeframe of data has been selected as between July 1999 to June 2007 (a monthly data set of 96 months). Taking every month as an independent observation, we therefore have 96 time series observations in this fashion for estimating regression on rice prices in the national level.

We based our model on monthly observations-- this provides us with a reasonably large number of time series observations within a small period of time. The original version of the data set has some information available only on a yearly basis, such as the gross domestic product, and some data is available only on a seasonal basis, such as rice production amounts of Aus, Aman and Boro. We decided that a monthly data series would be providing us with more number of observations and therefore would be more helpful. For this reason, a number of variables have been converted to monthly data. For example, harvests of Boro (available in May) and Aus (available in July) have been combined together and spread over equally in seven months from May to November, and harvests of Aman (available in December) have been spread over five months from December to April; this completes a full year of rice production data. This artificial distribution of yearly production of rice actually closely resembles the percentage shares of Boro, Aus and Aman production within the total domestic production of rice in recent years. Again this monthly breakdown of yearly production actually enhances data observation points manifold, thereby facilitating analysis of monthly rice prices. Another variable, yearly gross domestic product (GDP) has been simply divided equally into

twelve months to have monthly GDP data; a corresponding data for remittance inflow is available in recent years on a monthly basis. A data for rice requirement figure is obtained as 453.6 grams of food grain per person per day and a weight of 0.88 (for rice consumption requirement, a rest 0.12 for wheat) has been applied as per documents in the FPMU data set. Another variable "income" has been obtained as sum of monthly GDP and monthly remittance inflow (we include remittance in with the GDP data since remittance earnings as compared to GDP has increased in recent years). International rice prices from India and Thailand have been quoted in US dollars. The variable for dollar exchange rate is quoted in a Taka per dollar basis.

Econometric Model

The basic objective of this model is the equilibrium price determination in the food grain market (i.e., rice and wheat), whereas this determination, among other things, is influenced by the government intervention in this market.

Demand

$$Q_R^d = \alpha_0 - \alpha_1 P_R + \alpha_2 P_W + \alpha_3 Y$$

$$Q_W^d = \beta_0 + \beta_1 P_R - \beta_2 P_W + \beta_3 Y$$

$$Y = PCGDP + T$$

$$T = (P_R - r_R) d_R + (P_W - r_W) d_W$$

Here, Q_i^d is quantity demanded for good i, P_i is the market price of good i, and Y is income which is the sum of per capita GDP (PCGDP) and consumption subsidy, T. This subsidy is measured through the fourth equation where r_i is the ration price of good i and d_i is the amount of good i sold at ration price.

Supply

$$Q_R^s = -\gamma_0 + \gamma_1 \left[E_t (P_{t+1})\right]_R$$

$$Q_W^s = -\delta_0 + \delta_1 \left[E_t (P_{t+1})\right]_W$$

Here, Q_i^s is quantity supplied of good i and $\left[E_t (P_{t+1})\right]_i$ is the expected price of good i in $(t+1)^{th}$ period where the expectation is formed one period ahead. The expected price can be approximated by 1-year-ahead forecasts obtained from the following ARIMA model fitted to the price series (this approach is known as "quasi-rational expectations" and was used by Marc Nerlove).

$$z_t = \omega + \rho z_{t-1} + \phi_1 u_t + \phi_2 u_{t-1}$$

Here, z_t is the first difference of price in period t that is $(P_t - P_{t-1})$. So both autoregressive and moving average parts are of order 1.

Market equilibrium

$$Q_R^d + Q_R^G = Q_R^s + d_R + M_R$$

$$Q_W^d + Q_W^G = Q_W^s + d_W + M_w$$

Here, Q_i^G is the quantity of good i purchased by the government and M_i is the amount of good i imported.

5.1.8 Model Specification

The basic idea behind the econometric model is that the rice market will be solved in the model through three different components, such as the supply function, the demand function and the import function. As simply stated, the framework can be written as,

[quantity demanded] − [quantity supplied] = [quantity imported] ..……(1)

If we incorporate the functioning of the government in this market, and noting that imports are distributed into private and public, and public food distribution system includes this public component of imports, the equilibrium condition can be rewritten as,

[quantity demanded] + [public procurement] = [quantity supplied] + [private import] + [public food-grain distribution system (includes public import)] ……...(2)

Now, we propose that, the market equilibrium price of rice will be solved in the market through the functioning of the three components,

First, we assume that, the supply function operates in this format,

$[\text{quantity supplied of rice}]_t =$

$[\text{price of rice}]_t + [\text{area under rice cultivation}]_t + [\text{price of fertilizer}]_{t-4}$

$+ [\text{rainfall shock}]_{t-1} + [\text{rainfall shock}]_{t-2} + [\text{rainfall shock}]_{t-3} + [\text{rainfall shock}]_{t-4}$

…….. …… ……...……(3)

The variables in the rice production components are chosen based on the analysis of the market data, and carefully chosen so that obvious multicollinearity issues do not arise. We assume that one determinant of amount of current rice supplied is farmers' prior assessment of the current rice price; hence current price of rice enters into the supply function. We expect a positive sign for this variable, since farmers' assessment of higher rice prices in the market is expected to induce them to bring more output to the market, holding all other things equal, as per a basic supply framework. Another determinant of current rice supplied is area under rice cultivation; as higher area under rice cultivation would increase supply in the market, we also expect a positive sign for this variable in the regression estimation. The current rice supplied is also expected to be affected by weather uncertainty, therefore previous realizations of rainfall shocks (as defined as actual minus the normal amount of rainfall for a particular month) are also in the model-- particularly relevant months are found to be a one month lag, a two-month lag, a three-month lag and a four-month lag of rainfall shock. The precise expected coefficient of rainfall shock terms is not easily identifiable, since rainfall shocks may increase or it may even decrease rice supply, depending on the exact timing of this rainfall which in excess of a normal one, and specific water requirements at that particular time. Another determinant of rice supply is fertilizer prices faced by farmer during cultivation time of the current crop (taken to be the four-month lag price of fertilizer). We expect a negative sign for the fertilizer price variable, since this is a cost of production variable in rice supply.

Second, we assume that the private import function operates in this format,
$[\text{quantity of rice imported (private import)}]_t =$

$[\text{US dollar exchange rate}]_t + [\text{Thailand rice export price, in US dollar}]_t$

$+ [\text{price of rice}]_t + [\text{income}]_t$

…….…….. …….. …….(4)

Since the public import is channeled into the market through the public food grain distribution system, and the variable "public distribution" is in the third model of equilibrium price determination, here we only consider the private import component. We assume that private rice import decision would be influenced by the ongoing dollar exchange rate, rice prices in Thailand, importers' prior assessment of current rice prices in the domestic market and the overall purchasing power of the country ("income" is calculated as monthly GDP and monthly remittance inflow). The importers' profitability of importing rice would depend on their prior assessment of the current market prices. Therefore we expect a positive sign for rice price in the import function. A high dollar exchange rate would increase cost of import; therefore we expect a negative sign for the US dollar exchange rate. Similarly we expect a negative sign for the Thailand rice export price variable, since this is also a cost component in the import function. The series of Thailand rice export price has been taken as indicative of movements of international prices of rice.

Third, the equilibrium rice price is solved in the market where the inverse demand function interacts with the rice production estimates (from equation (3)) and the rice import estimates (from equation (4)), taking into account functioning of the government in this market through steps like public procurement and public distribution,
$[\text{price of rice}]_t =$

$[\text{quantity supplied of rice}]_t + [\text{quantity of rice private imported}]_t$

$+ [\text{non-food price index}]_t + [\text{population}]_t + [\text{dummy for April}]_t$

$+ [\text{dummy for November}]_t + [\text{income}]_t + [\text{price of wheat}]_t$

$+ [\text{rice procurement amount}]_t + [\text{rice distribution amount}]_t$

$+ [\text{time trend}]_t$

……(5)

We expect negative signs for both rice supply and rice import, since these are the supply side components in the rice market. We expect a positive sign for non-food price index variable, since a higher non-food price may induce suppliers to ask for a higher price of rice as well. Since Novembers and Aprils are the end of the seasons as regards to our modeling (November is end of *Boro-Aus* combination, and April is end of Aman), we expect prices to be higher during two months, therefore we expect positive signs for both these seasonal dummies. We expect positive signs for population and income variables, since these are demand side components. We also expect positive sign for price of wheat,

since wheat is a substitute for rice. We may expect negative signs for both rice procurement and rice distribution, since one major aim of both of the operations are rice price stabilization. Rice distribution (i.g., OMS) is often offered at rates lower than the current market prices, therefore a higher amount offered for rice distribution would tend to lower the market price, holding all other things equal. Rice procurement is often carried by offering a slightly higher price compared to the market rate, in order to encourage farmers to submit their produce to procurement authority. This rice is then channeled through the rice distribution system, which ultimately tends to reduce rice market prices. Because of close interlinks of both of the operations, and their main stated objective is to stabilize prices, we can expect that, at high price situations in the rice market, a successful operation of rice procurement combined with rice distribution would be able to reduce price pressures in the market and stabilize prices at some lower levels. Therefore a higher rice procurement amount as well as rice distribution amount would be expected to lead to a lower price in the rice market, holding all other things equal.

Here, t implies month, time trend is numbers for months 1 through to 96 (July 1999 to June 2007), "income" is sum of GDP and remittance monthly inflow, "distribution" is release from government stock for OMS, FFW, TR, etc., at a particular month. Rice production amount is calculated as harvests of Boro and Aus over months from May to November and harvests of Aman from December to April. Since April and November are the last months of this distribution pattern, respectively, therefore, two dummies have been constructed to find out if there is an upward pressure on rice prices on these particular two months. We assume that current equilibrium rice price in the market would be influenced by the economic agents' (principally suppliers and importers) prior expectations of movements of rice prices; therefore rice price enters into the supply function and the import function.

The estimation is required to be in a "two-stage least squares" (2SLS) estimation form, since a simple ordinary least squares would be inappropriate in a supply-demand-import framework because of endogeneity problems. Simply stating, output supply is determined, among others, by price of output and at the same time, price is also being determined, along with others, by output supply. An ordinary least squares estimation (OLS) would be providing biased estimates in this case. So we need to proceed with a two-stage least squares (2SLS) regression. The idea would be that, in the first stage, two models would be solved simultaneously, such as the "rice supply" and the "rice import", and in the second stage, a third model would be solved, which is a solution for "equilibrium price of rice" solving for inverse demand function for rice, supply and import functions.

The 2SLS estimation result would not solve for specific time series problems, such as the issue of "stationarity". Stationarity is one major issue with time-series data like this one, where the real cause of concern is that, the variables themselves can be found to be nonstationary, and may have a tendency to grow simultaneously over time, thereby may show some significant regression relationships, while actually this relationship may be simply "spurious". One way to deal with this issue is to take regression over the data set with one-period lag (e.g, variable value at time t minus variable value at time t−1). While the regression on the "level" data may have problems with stationarity, in most of the cases, this new regression results with the "differenced" data may not have these problems, that means the variables would become stationary in the "differenced" data.

We propose that we model our regression on the "level" data first, and again we report the regression results from the data set with the "differenced" data. The regression with the "level" data provides us with an estimate of to what extent our model can fit the actual outcome in the market. The second set of regressions with the "differenced" data would provide with us the estimates not suspect of being "spurious". In case our regression results from the "level" data and the "differenced" data exhibit same signs, we can therefore rely on our results from the regression with the "level" data (since here our objective is to be able to fit the "rice price" (nominal, Taka per kg of rice) actual observations with our model-predicted values as closely as possible.

In order to ensure that the regression data series have achieved the "stationarity", we need to check each of the variables in the data set, with some particular tests, most common test is the augmented Dickey-Fuller test (ADF test). From the test statistic of augmented Dickey-Fuller test for each of the variables in the new "differenced" data set, we can assess whether the set of variables have achieved "stationarity", thereby solving the potential problem of "spurious regression".

We therefore propose that we run the regression with the following specification. Then we run the same regression with the "differenced" data (value of a variable at time t minus value of the same variable at time t−1). We would report both of the regression estimates to compare the outcomes, and we report model fit tables to assess to what extent our model has been successful in fitting the actual outcome in the reference time period.

At the first stage, domestic rice supply:

$$[\text{quantity supplied of rice}]_t =$$

$$\text{constant} + \beta_1 [\text{price of rice}]_t + \beta_2 [\text{area under rice cultivation}]_t$$

$$+ \beta_3 [\text{price of fertilizer}]_{t-4} + \beta_4 [\text{rainfall shock}]_{t-1} + \beta_5 [\text{rainfall shock}]_{t-2}$$

$$+ \beta_6 [\text{rainfall shock}]_{t-3} + \beta_7 [\text{rainfall shock}]_{t-4} + \text{error} \quad \ldots\ldots(6)$$

And, private rice import:

$$[\text{quantity of rice imported}]_t =$$

$$\text{constant} + \beta_8 [\text{US dollar exchange rate}]_t + \beta_9 [\text{Thailand rice export price, in US dollar}]_t$$

$$+ \beta_{10} [\text{price of rice}]_t + \beta_{11} [\text{income}]_t + \text{error} \quad \ldots\ldots(7)$$

And, at the second stage, equilibrium rice price:

$$[\text{rice price}]_t = \text{constant} +$$

$$\beta_{12} [\text{quantity supplied of rice}]_t + \beta_{13} [\text{quantity of rice imported}]_t$$

$$+ \beta_{14} [\text{non-food price index}]_t + \beta_{15} [\text{population}]_t$$

$$+ \beta_{16} [\text{dummy for April}]_t + \beta_{17} [\text{dummy for November}]_t$$

$+ \beta_{18}$ [income]$_t$ + β_{19} [wheat price]$_t$ + β_{20} [rice procurement amount]$_t$

$+ \beta_{21}$ [rice distribution amount]$_t$ + β_{22} [time trend]$_t$ + error

……..…(8)

6. HOUSEHOLD FOOD SECURITY MODEL

6.1 Econometric Model

The household food security can be modeled in the framework of consumer demand and production analysis following the Agricultural Household Models (AHMs) by Singh, Squire, & Strauss et el., (1986). In AHM models an agricultural household is both a consumer and a producer. Given the assumption of "separability" of consumption variables and production variables, the AHM model household can separate production decisions from the consumption preferences-- first it solves the production decisions (independent of consumption preferences) and then it solves the consumption decisions (based on optimal production decisions).

The household utility function is specified as

$U= U(F_i , F_m, l; D_h)$ …….. ……. ……(1)

-- here U is a utility function that is assumed to be well behaved (twice differentiable, increasing in its arguments and strictly quasi-concave); F_i is a vector of home-produced goods consumed by the household; F_m is a vector of market-purchased goods consumed by the household; and l is leisure. Here D_h is the demographic characteristics of the household.

The household, as both producer and consumer, is assumed to maximize its utility from the consumption of the goods subject to farm production, income and time constraint such as

$G(Q_i, L, A^0, K^0)= 0$ ……..(2)

$P_i (Q_i - F_i) - P_mF_m - w(L - L_f) + N= 0$ …… ..(3)

$T= L_f + l$ ……..(4)

-- here G(.) is an implicit production function that is assumed to be well-behaved (twice differentiable, increasing in outputs, decreasing in inputs and strictly convex); Q_i is a vector of quantities of goods produced on-farm; L is total labor input to the farm; A^0 is the household's fixed quantity of land; K^0 is the fixed stock of capital; P_i is the price of good i; P_m is the price of market-purchased good; $(Q_i - F_i)$ is the marketed surplus of good i; w is the wage rate; L_f is the household labor supply for on-farm use; N is non-farm income that adjusts to ensure that equation (3) is zero; T is the total time available to the household to allocate between work and leisure.

Given the assumption of "separability", the production side can be solved first. The first-order conditions for input demand (L*) and output supply (Q*) in terms of all prices, wage rate, fixed land and capital as,

$L^*= L^*(P_i, w, A^0, K^0)$ ……..(5)

and

$Q^*= Q^*(P_i, w, A^0, K^0)$ …….(6)

Rearranging equations (3) and (4) and putting L* and Q* into the rearranged equation,

$Y^*= P_iQ_i^* + wT - wL^* + N$ ……(7)

and

$Y^*= wT+ \pi^*(P_i, w, A^0, K^0) + N$ ……(8)

-- here Y* is "full" income under the assumption of maximized profit π^*.

Now, the first-order conditions for consumption demand can be solved for in terms of prices, wage rate and income as--

$F_k = F_k (P_i, P_m, w, Y^*)$ ……(9)

-- (here k=i,m). Incorporating the household characteristics (D_i), the demand for food can be rewritten as,

$F_k = F_k[P_i, P_m, w, Y^* (w, A^0, K^0, N), D_h]$ ……(10)

After determining the demand for both home-produced and market-purchased goods, we can use "Food-Calorie Conversion Table" to calculate the amount of calories (C_i) available in the respective food items. Now, one can define "household food security" as $C_i^* = C_i - \gamma_i$ (C_i is the calorie availability and γ_i is the specific calorie requirement for that particular ith household), and $C_i^* \geq 0$ indicates that the household is "food secure" while $C_i^* < 0$ indicates that the household is "food insecure". Assuming a linear function, one can write the food security equation as,

$C_i^* = \sum_{j=1}^{n=k} \beta_j X_{ij} + \varepsilon_i$ ……..(11)

The household observed to be food secure ($Z_i = 1$) is assumed to have $C_i^* \geq 0$; while the household observed to be food insecure ($Z_i = 0$) is assumed to have $C_i^* < 0$. Here the dependent variable Z_i is a discrete variable, the model is a qualitative response model where φ_i is the probability of food security, such as,

$\varphi_i = \text{Prob}(Z_i = 1) = \text{Prob}(\sum \beta_j X_{ij} + \varepsilon_i > 0)$ ……(12)

One can consider a logistic regression model of food security as

$\text{Ln}(\varphi_i / [1 - \varphi_i]) = \beta_0 + \sum_{j=1}^{n=k} \beta_j X_{ij} + \varepsilon_i$ ……..(13)

-- here φ_i is the conditional probability of food security and β_j's are parameters to be estimated. X_{ij}'s the independent variables.

Given this standard framework (following Feleke et al (2005)) of AHM in the case of "household food security model" and with the background of "market model" first solving for the equilibrium prices in the food grain market-- the main objective of the theoretical section of the study would be to estimate impacts of market price and government interventions on the household food security issue.

6.2 Discussion of Data

Source of most of the data used in the following analysis is Household Income-Expenditure Survey (HIES) for the years 2000 and 2005.

7. RESULTS

7.1 Results from the Market Model

The 2SLS regression model provides a close examination of the variables in the model. Set A shows the level estimation of the regression whereas Set B shows the first-difference estimation. The objective of regression as per Set A is to closely examine the determinants of rice prices and to be able to fit the actual observations of rice prices with the model-predicted values of the rice prices (nominal, in Taka per Kg of rice format). On the other hand, the objective of regression as per Set B is to solve problems of nonstationarity in the time series structure of the regression data (see Section 5.1.8 for further explanation of this).

With regards to "Set A" in the first stage, for rice production estimation as dependent variable, the corresponding independent variables are *riceprice*, *arearice*, *lagfertpri4* and *rainfallshlags* within a 2SLS framework. We notice that, *riceprice* and *arearice* have expected positive signs, but the coefficient for *arearice* is small in magnitude and both of them are found to be not statistically significant. The same applies to the coefficient of *lagfertpri4*-- the *four-month lag of fertilizer price*. The lagged rainfall shock terms do contribute to some extent in determining the current amount of rice output, controlling for all the other variables; and estimated signs are negative, therefore this implies that a higher amount of rainfall as compared to "normal" amounts of rainfall, during different stages of production would negatively affect rice amount available in the current month. The three months' and four months' lags of rainfall shocks have been found to have statistically significant negative coefficients.

The determinants of private rice import have been modeled as including dollar exchange rate as against Taka (*usd*), indicator of movements of international prices of rice as in.*thairice*, private importers' prior assessment of rice prices in the market in the form of *riceprice*, and *income* as defined as monthly GDP plus monthly remittance earnings. As expected, dollar exchange rate negatively affects monthly private import of rice, controlling for all other variables, and it has been found to statistically negatively significant. The same applies to movements of international prices of rice, as in dollar-expressed Thailand rice prices, and it has also been found to statistically negatively significant. As expected, private importers' prior assessment of rice prices in the market also plays some role in determining the amount of private import of rice into the country. The coefficients for *riceprice* and *income* have expected signs, but *income* has been found to be statistically significant. Therefore, a high dollar exchange rate against Taka has a tendency to discourage rice import, and at the same time, a high international price of rice tends to discourage private imports, whilst a high current price of rice, in this model implying the private importers' prior assessments of the market price, and a high level of national income, both have tendencies to encourage private import of rice.

With regards to "Set A" in the second stage, the equilibrium rice price in the market has been found to be influenced by the production amount of rice, but the sign is negative but not statistically significant. Therefore rice price is influenced by the domestic production amount of rice, *riceprod*, but the magnitude of coefficient is small. The same discussion applies for private import amount of rice, *privaterimp*, we do expect

a negative coefficient, and here is a negative coefficient estimate but the magnitude of this coefficient is small. The non-food price index, *nfpi*, is also in the regression, but not with expected signs. The coefficient of *wheatprice* has been found to be expectedly positive and statistically significant, and the coefficient amount is 0.37, this implies that a 1 Taka per Kg of wheat higher price of wheat is to lead to a higher price of rice by the amount of Taka 0.37 per Kg of rice, controlling for all other effects. Rice procurement (*riceproc*) has a slight impact on the equilibrium price of rice. And similarly rice distribution (*ricedist*) has a slight impact of the equilibrium price determination of rice. The first-order autocorrelation test has been done and the value of the rho-hat is statistically significant. This implies, regression in this form, did show signs of first-order autocorrelation. Similar result is obtained from the augmented Dickey-Fuller test of the same. So the most common time-series problem of serial autocorrelation remains in the regression, therefore we needed to move on to the differenced-level regression in "Set B" in order to solve this issue.

Figures 7.1, 7.2 and 7.3 fit the model predicted values of rice production, private rice import and rice price data. We note that rice price model predicted values closely match with the actual values. The model predicted values also closely match with the monthly production data that has been constructed, but the model predicted values do not match that much with the actual observations in the private rice import data. For our purpose, it was needed that at least the rice price model should be able to match closely with the actual outcomes of rice prices in the rice market. Figure 7.3 indicates that the model fits the actual outcomes in the monthly rice price data closely. Therefore this specification provides a close approximation to the actual outcome of the equilibrium price of rice in the national market during the corresponding data period.

With regards to "Set B", in order to reach stationarity of the data set and therefore reliability of the regression estimates, we have differenced the data set one period (value at period t minus value at period t–1) and run the regression again exactly with the same specifications. Because of one-period differencing, number of observations now is 95. Taking the first-differences have actually solved potential issues with non-stationarity, as we notice from the augmented Dickey-Fuller test results of all the variables in the data set in the first-difference form (since the test statistic in each of the cases are more negative than the critical value, we can reject the null hypothesis that "variable at t minus variable at t−1" is non-stationary in each of the cases of variables, as the Mackinnon approximate p-value is 0 in all the cases). We notice that most variables still retain the same signs as compared to those in the level estimation. Now some variables have become statistically significant in the differenced form. For example, in the rice production estimation in the first stage, *arearice* is now expectedly statistically significant at 5% level. It turns out that *arearice* has been found to be one key variable in the determination of rice production available in the market. On the other hand, in the private rice import estimation, *riceprice* has become statistically significant and with an expected positive sign for the coefficient. The corresponding Mackinnon approximate values of the augmented Dickey-Fuller tests report that the non-stationarity problem of the original model specification has been solved. Figure 7.4 fits the model predicted values of rice in the difference form as against the actual values observed and shows that the fit is satisfactory.

Table 7.1: 2SLS Regression Estimation Result from the Market Model (Set A)

Model	Variable	Coefficient	Stand. Error	P-value
First Stage				
dependent variable: *riceprod*	*constant*	1801.89***	*120.57*	0.00
	riceprice	13.86	*28.42*	0.63
	arearice	0.01	*0.02*	0.63
	lagfertpri4	–0.13	*43.1*	0.99
	rainsklag1	–0.24	*0.17*	0.14
	rainsklag2	–0.26	*0.17*	0.11
	rainsklag3	–0.39**	*0.17*	0.02
	rainsklag4	–0.38**	*0.17*	0.02
dependent variable: *privaterimp*	*constant*	206.79*	*116.18*	0.08
	usd	–12.62**	5.42	0.02
	thairice	–0.77*	0.41	0.06
	riceprice	3.68	*9.89*	0.71
	income	0.03***	*0.01*	0.00

Table 7.2: 2SLS Regression Estimation Result from the Market Model (Set A) (Continued)

Second Stage				
dependent variable: *riceprice*	*constant*	–65.1	*84.17*	0.44
	riceprod	–0.00	*0.00*	0.77
	privaterimp	–0.00	*0.01*	0.63
	nfpi	–0.00	*0.00*	0.83
	pop	4.81	*6.01*	0.42
	aprildum	0.78**	*0.37*	0.03
	novdum	–0.26	*0.46*	0.57
	income	0.00**	*0.00*	0.03
	wheatprice	0.37***	*0.11*	0.00
	riceproc	0.00	*0.00*	0.83
	ricedist	0.00	*0.00*	0.44
	timedum	–0.11	*0.12*	0.35
For "rice supply" model: N=96, Root MSE= 129.95, "R-Sq"= 0.29, F-Stat= 5.53, P=0.00 For "private rice import" model: N=96, Root MSE= 56.44, "R-Sq"= 0.15, F-Stat= 3.18, P=0.01 For "rice price" model: N=96, Root MSE= 0.86, "R-Sq"= 0.93, F-Stat= 97.85, P=0.00 Test for first-order serial autocorrelation: ρ hat coefficient= 0.78 *(s.e.= 0.06)*, p-value= 0.00 (significant at 1%) Dickey-Fuller Test for Unit Roots: (Variable, Test Statistic, MacKinnon approximate p-value): (*error in supply regression*, –2.172, 0.22); (*error in import regression*, –2.36, 0.15); (*error in price regression*, 0.256, 0.98); (*riceprice*, 0.78, 0.99); (*arearice*, –1.13, 0.71); (*lagfertpri4*, 0.29, 0.98); *(rainsklag1*, –10.62, 0.00); *(rainsklag2*, –10.67, 0.00); *(rainsklag3*, –10.75, 0.00); *(rainsklag4*, –10.63, 0.00); (*usd*, –0.58, 0.88); (*riceprod*, -3.60, 0.00); (*thairice*, –0.14, 0.95); *(income,*–0.06, 0.95); (*privaterimp*, –3.20, 0.02); (*nfpi*, –4.54, 0.00); (*pop*, 0.89, 0.99); *(aprildum,*–10.58, 0.00); (*novdum*, –10.58, 0.00); (*wheatprice*, 1.19, 0.99); *(riceproc,* –5.26, 0.00); (*ricedist*, –8.10, 0.00)				

Note: *** signifies 1%, ** signifies 5% and * signifies 10% level significance.
Source: Authors' Calculations

Figure 7.1: Market Model Fits-- Rice Production

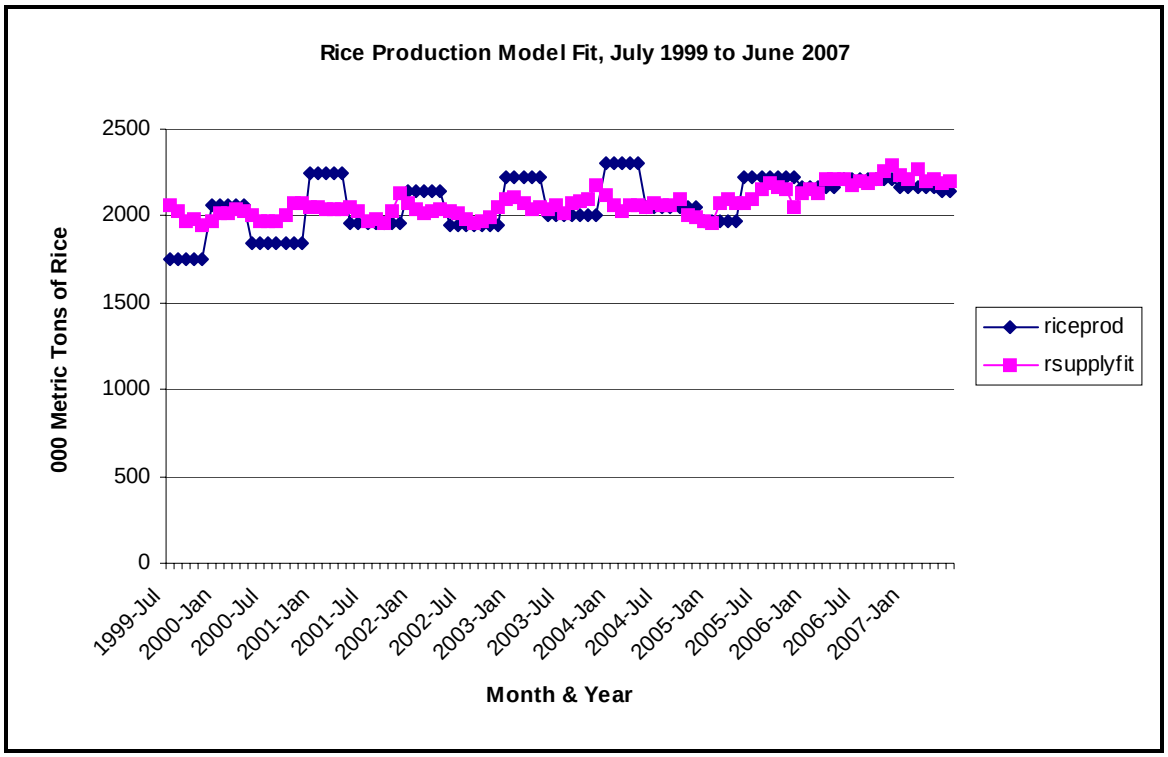


Figure 7.2: Market Model Fits-- Rice Import

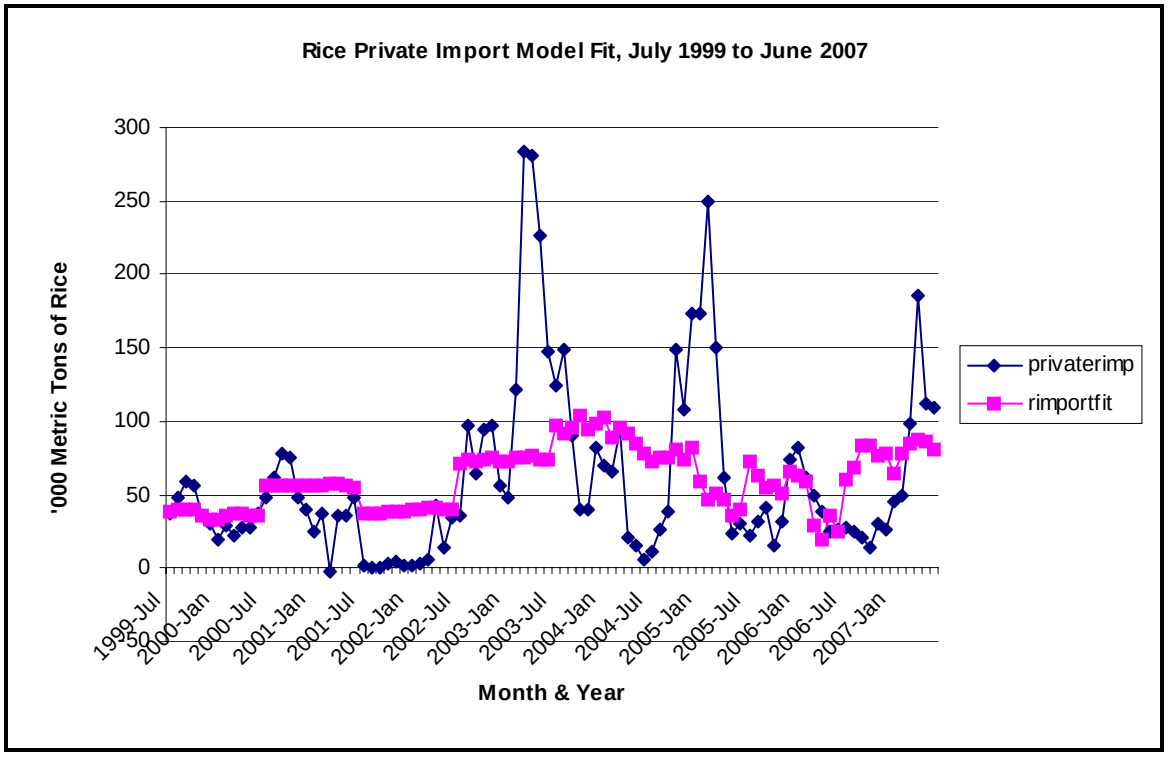


Figure 7.3: Market Model Fits-- Rice Price

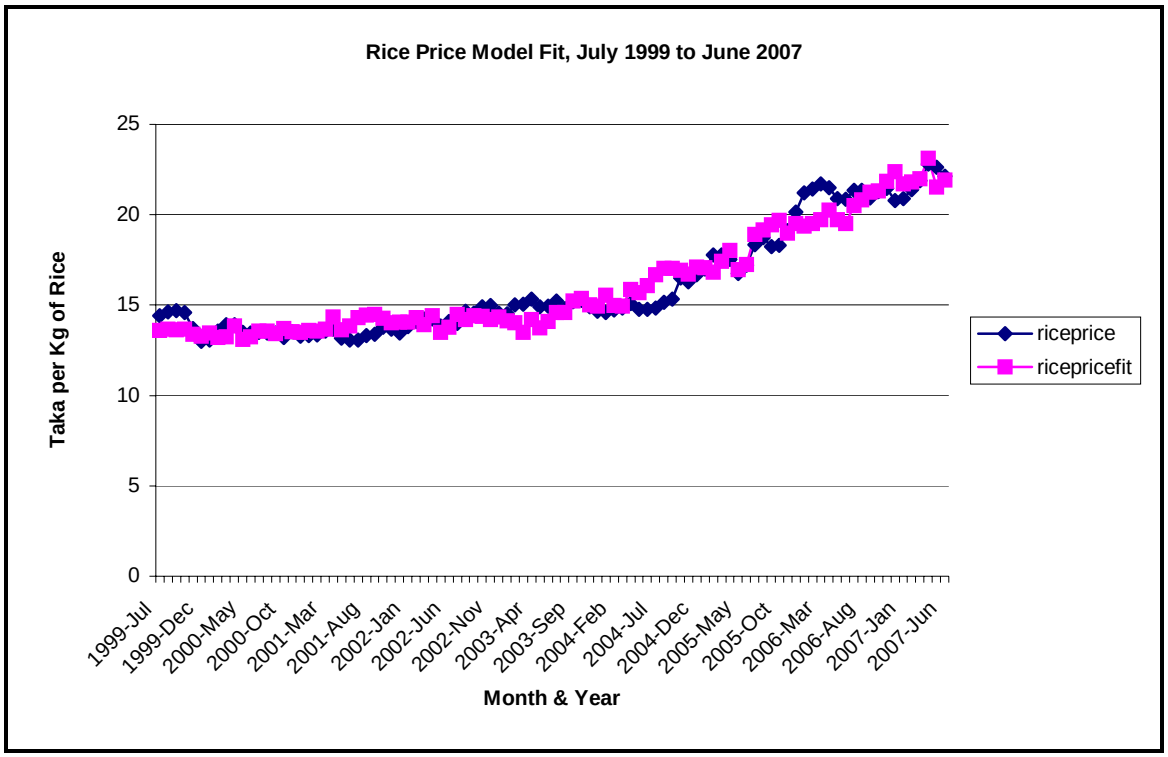


Table 7.3: 2SLS Regression Estimation Result from the Market Model (Set B)

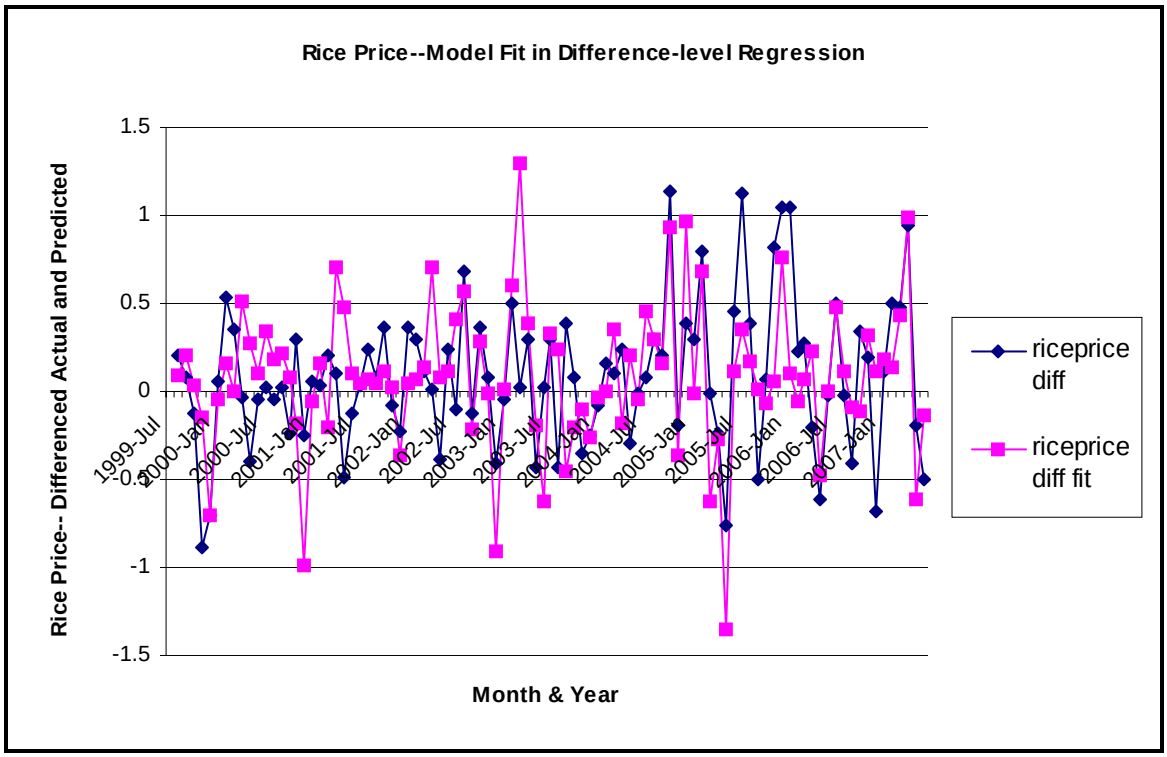
Model	Variable	Coefficient	Stand. Error	P-value
First Stage				
dependent variable: *riceprod*	*constant*	4.17	*10.28*	0.69
	riceprice	–17.94	*49.27*	0.72
	arearice	0.03**	*0.01*	0.04
	lagfertpri4	–6.85	*46.22*	0.88
	rainsklag1	0.05	*0.10*	0.61
	rainsklag2	0.09	*0.12*	0.49
	rainsklag3	0.02	*0.12*	0.90
	rainsklag4	0.05	*0.10*	0.65
dependent variable: *privaterimp*	*constant*	–1.67	*4.04*	0.68
	usd	–4.48	6.34	0.48
	thairice	–0.44	0.53	0.41
	riceprice	56.99***	*19.42*	0.00
	income	–0.01	*0.01*	0.52

Table 7.4: 2SLS Regression Estimation Result from the Market Model (Set B) (Continued)

Second Stage				
dependent variable: *riceprice*	*constant*	dropped		
	riceprod	–0.00	*0.00*	0.41
	privaterimp	0.01	*0.01*	0.15
	nfpi	–0.00	*0.00*	0.84
	pop	2.13	*4.99*	0.67
	aprildum	0.32	*0.24*	0.18
	novdum	–0.08	*0.26*	0.77
	income	0.00	*0.00*	0.12
	wheatprice	–0.08	*0.11*	0.47
	riceproc	–0.00	*0.00*	0.66
	ricedist	–0.00	*0.00*	0.92
	timedum	0.04	*0.09*	0.66
For "rice supply" model: N=95, Root MSE=92.50, "R-Sq"= 0.09, F-Stat= 0.95, P=0.47 For "private rice import" model: N=95, Root MSE= 36.41, "R-Sq"= 0.13, F-Stat= 2.21, P=0.07 For "rice price" model: N=95, Root MSE= 0.43, "R-Sq"= 0.00, F-Stat= 2.21, P=0.01 Test for first-order serial autocorrelation: ρ hat coefficient= 0.09 *(s.e.= 0.10)*, p-value= 0.41 (not significant at 10%) Dickey-Fuller Test for Unit Roots: (Variable, Test Statistic, MacKinnon approximate p-value): (*error in supply regression*, –9.627, 0.00); (*error in import regression*, –9.338, 0.00); (*error in price regression*, –8.78, 0.00); (*riceprice*, 0.78, 0.99); (*arearice*, –1.13, 0.71); (*lagfertpri4*, 0.29, 0.98); *(rainsklag1*, –10.62, 0.00); *(rainsklag2*, –10.67, 0.00); *(rainsklag3*, –10.75, 0.00); *(rainsklag4*, –10.63, 0.00); (*usd*, –0.58, 0.88); (*riceprod*, -3.60, 0.00); (*thairice*, –0.14, 0.95); *(income,*–0.06, 0.95); (*privaterimp*, –3.20, 0.02); (*nfpi*, –4.54, 0.00); (*pop*, 0.89, 0.99); *(aprildum,*–10.58, 0.00); (*novdum*, –10.58, 0.00); (*wheatprice*, 1.19, 0.99); *(riceproc,* –5.26, 0.00); (*ricedist*, –8.10, 0.00)				

Note: *** signifies 1%, ** signifies 5% and * signifies 10% level significance.
Source: Authors' Calculations

Figure 7.4: Market Model Fits--Difference Regression--Rice Price



7.2 Results from the Household Food Security Model

7.2.1 Food Security and Household characteristics

There are evidences that, other than consumption levels, different household characteristics can also show improvement in the standard of living. Since food security and standard of living is expected to be highly correlated, it would not be surprising to find these characteristics to be related with food security issues. Hence, it would be reasonable to expect that households with better characteristics are also demonstrating lesser level of food insecurity. Table 7.5 describes the relationship between these different household characteristics and food security and the dynamic change in this relationship for the period between 2000 and 2005.

Quality of housing and food security level are closely related in Bangladesh, established by earlier works (Narayan et el., 2007). Specifically households which are living in houses built with straw roofs (hemp/hay/bamboo) are the poorest segment of the population. Similarly, as shown in Table 7.5, households living in houses with a straw roof, both in 2000 and 2005, food insecurity is the most prevalent among this segment (except the category "other" which might be squatter, free shelter etc). Another

observation is in all categories, we observe that food insecurity level has decreased in general from 2000 to 2005[1].

Table 7.5: Amenities, Infrastructure and Food Insecurity

	% Food Insecure		
Construction material (wall)	**2000**	**2005**	**p-value***
Brick/Cement	39.4%	36.4%	0.002
CI sheet/Wood	43.8%	37.8%	0.000
Mud Brick	41.8%	42.1%	0.000
Hemp/Hay/Bamboo	53.1%	45.8%	0.155
Other	52.5%	42.0%	0.000
Present Occupancy Status			
Owner	45.7%	40.2%	0.000
Renter	51.6%	44.9%	0.065
Squatter	55.3%	44.0%	0.625
Provided free by relatives/employe	51.8%	46.1%	0.298
Other	76.8%	46.3%	0.693
Any electricity connection?			
NO	48.5%	42.9%	0.000
YES	42.1%	37.9%	0.000

Source: HIES 2000, 2005 (Author's Calculation)

** Two sided p-value where null hypothesis is no difference between 2000 and 2005 percentages*

If we categorize households by the level of ownership, occupancy status also plays an important part in determining the household well fare situation. Owners of the houses are better-off in both 2000 and 2005 compared to other categories and we find similar trends as we have seen in the quality of housing that in 2005 food security situation is better than in 2000. In the same manner, electricity connection is also an indicator showing higher instances of food-insecurity among the households which have no electricity connection.

Education is clearly linked with food security issues with the assumption that household heads with more human capital are prone to suffer less from food insecurity. This presumption is aptly reflected in Table 7.6 where there is a general trend of decrease in food insecurity as the education level of household is increasing, specifically in the year of 2000. But in 2005, this secular trend is somewhat broken which needs to be further investigated.

[1] See Table 7.12 and related discussion

Being an agricultural country, possession of land shows the general level of wealth for households. Typically, landless population falls into the category of extreme poor and we find the same phenomenon in Table 7.7 which implies a negative correlation between amount of land owned and food insecurity index.

Table 7.6: Household Head's Level of Education and Food Insecurity

	% Food Insecure		
Highest Grade by Household Head	**2000**	**2005**	**p-value***
Primary or less (1-5 years)	47.8%	42.0%	0.0013
Secondary or less (6-10 years)	44.7%	37.1%	0.0002
Higher secondary or less(11-12 years)	40.0%	38.8%	0.078
Graduate or less (13-16 years)	34.3%	44.4%	0.0216

Source: HIES 2000, 2005 (Author's Calculation)

** Two sided p-value where null hypothesis is no difference between 2000 and 2005 percentages*

Table 7.7: Land Size and Food Insecurity

	% Food Insecure		
Land Size	**2000**	**2005**	**p-value***
Landless<0.05 acre	50.4%	48.4%	0.000
Functionally Landless 0.05-0.5 acre	44.1%	43.7%	0.002
Marginal 0.5-1.5 acres	40.5%	34.3%	0.142
Small 1.5-2.5	36.3%	32.4%	0.336
Medium/Large: 2.5 acres or more	28.5%	26.9%	0.092

Source: HIES 2000, 2005 (Author's Calculation)

** Two sided p-value where null hypothesis is no difference between 2000 and 2005 percentages*

It would be of interest to know which income group is the most affected by the increase in food prices and thus suffer from food insecurity. Usually, the argument is that regular wage earners are the most affected, since their income is fixed and thus with higher food prices, their real income goes down. On the other hand, self-employed are able to vary their work or effort level and thus can compensate at least partly for this high level of food prices. Table 7.8 provides credence to this observation, showing evidence from year 2000 and 2005 respectively, where all the wage earning categories are suffering from lower degree of food security. Households where the household head is daily wage earner in both agricultural and non-agricultural sector are the worse in terms of food security. Salary wage earners are just slightly better than the daily wage earners. On the other hand, self-employed both in agricultural and non-agricultural are faring well compared to any other categories. Therefore, empirical evidence is quite consistent with the general theory that fixed wage earners suffer more from food insecurity.

Table 7.8: Employment Type and Food Security

	% Food Insecure		
Employ. type	**2000**	**2005**	**p-value***
Daily wage(Agri)	52.9%	48.2%	0.0683
Self-Employed(Agri)	36.4%	29.8%	0.0012
Daily wage(non-agri)	52.7%	46.9%	0.0129
Self-employed(non-agri)	37.8%	39.3%	0.5295
Wage employment(non-agri)	50.9%	45.2%	0.0162

Source: HIES 2000, 2005 (Author's Calculation)

** Two sided p-value where null hypothesis is no difference between and 2005 percentages*

7.2.2 Determinants of Food Security

(a) Comparison of Logit and IV estimates

Logistic regression results in Table 7.9 are used to estimate the determinants of food security at the household level. Logistic regression is used to find the log-odds ratio of food security with the dependent variable is dummy for the food security indicator. In the OLS regression, sex of household head has not been found to be a statistically significant factor even at 10% level of significance, whereas the IV estimates show it is statistically significant at slightly above 5% level. IV estimates is showing that a female headed household is about 7% less likely to be food secure than male-headed households. This is expected given the fact that female headed households are found to be more vulnerable with lesser household assets in general. Most of the female heads are widowed or abandoned by the husband in rural Bangladesh who has vulnerability in all aspects of livelihood characteristics.

Table 7.9: Determinants of Food Security

	(1)OLS	Mar. Effect	(2)IV estimates	Mar. Effect
Sex of Household head	-0.210	-0.052	-0.280+	-0.069+
	(0.145)	(0.145)	(0.054)	(0.054)
Age in Years	0.024+	0.006+	0.019	0.005
	(0.094)	(0.094)	(0.172)	(0.172)
Age Squared	-0.000	-0.000	-0.000	-0.000
	(0.598)	(0.598)	(0.702)	(0.702)
Education of household head	0.026**	0.006**	0.032**	0.008**
	(0.001)	(0.001)	(0.000)	(0.000)
House with brick wall (d)	0.120	0.030	0.222*	0.055*
	(0.228)	(0.229)	(0.035)	(0.036)

House with wooden wall (d)	0.059	0.015	0.094	0.023
	(0.397)	(0.397)	(0.184)	(0.184)
House with mud wall (d)	0.188*	0.047*	0.264**	0.066**
	(0.021)	(0.021)	(0.002)	(0.002)
Total Land (decimal)	0.187**	0.047**	0.204**	0.051**
	(0.000)	(0.000)	(0.000)	(0.000)
Household with electricity (d)	0.176**	0.044**	0.219**	0.055**
	(0.007)	(0.007)	(0.001)	(0.001)
log of Price of Rice	-1.366**	-0.339**	-1.392**	-0.346**
	(0.000)	(0.000)	(0.000)	(0.000)
Males (1-15 years old)	-0.287**	-0.071**	-0.282**	-0.070**
	(0.000)	(0.000)	(0.000)	(0.000)
Males (16-49 years old)	-0.390**	-0.097**	-0.350**	-0.087**
	(0.000)	(0.000)	(0.000)	(0.000)
Males (Above 50 years)	-0.506**	-0.126**	-0.484**	-0.120**
	(0.000)	(0.000)	(0.000)	(0.000)
Females (1-15 years old)	-0.277**	-0.069**	-0.279**	-0.069**
	(0.000)	(0.000)	(0.000)	(0.000)
Females (16-49 years old)	-0.098+	-0.024+	-0.104*	-0.026*
	(0.055)	(0.055)	(0.042)	(0.042)
Females (Above 50 years)	0.090	0.022	0.065	0.016
	(0.196)	(0.196)	(0.356)	(0.356)
Self-employed:agri (d)	0.414**	0.103**	0.446**	0.111**
	(0.000)	(0.000)	(0.000)	(0.000)
Daily wage:non-agri (d)	-0.167+	-0.041+	-0.133	-0.033
	(0.061)	(0.059)	(0.135)	(0.133)
Self-employed:non-agri (d)	0.034	0.009	0.051	0.013
	(0.704)	(0.705)	(0.572)	(0.572)
Salary Wage Employment (d)	-0.408**	-0.099**	-0.381**	-0.093**
	(0.000)	(0.000)	(0.000)	(0.000)
Recieved Safety Net? (d)	-0.216*	-0.053*		
	(0.012)	(0.011)		
Recieved Safety Net? (IV)			0.785*	0.195*
			(0.018)	(0.018)
Observations	5935	5935	5935	5935
Pseudo R^2	0.068	0.068	0.068	0.068

Marginal effects; *p*-values in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$
Source: HIES (2005),Author's Calculation

Age of the household head does not seem to have practically and statistically significant impact on food security. Education of household is highly significant statistically though the impact seems to be quite marginal in both OLS and IV estimates. This might not be surprising in the sense that with high unemployment rate and widespread underemployment, the returns to education in the market is not that high. As a result education does not help much to alleviate the food security situation.

The infrastructure quality of households might be an important indicator of living standards of households as we have already discussed above (Table 7.5). The regression model includes dummy variables indicating the materials of household wall with the base

category where the household wall is made of hey/straw, the category, which represents the poorest segment of the household. IV estimates show that, after taking care of all other factors that might affect the household food security, houses made with brick wall are 5.5% percent more likely to be food secure than houses made of hey/straw while the OLS coefficient is statistically significant. The houses made with mud are respectively 4.7% and 6.6% more likely to be food secure than hey/straw houses as shown by the OLS and IV estimates respectively. Here, we have to emphasize the difference between descriptive analysis we presented earlier in tables and regression analysis in this section. The advantage of regression analysis is that it captures the ceteris paribus effect which the tabular description fails to capture.

Among the other factors, not surprisingly, total land owned by the household plays a strong impact on food security situation with a high statistical significance. IV estimates show that one decimal increase in land leads to around 5.1 more likelihood for a household to be food secure. Availability of electricity connection is another strong indicator of household welfare in terms of food security. Households with electric connection are around 6 percent more likely to be food secure than those does not have any electricity connection.

For the purpose of this study, the most important variable in this regression analysis would be the variable representing the price of coarse rice. Since it is measured in logarithm, the co-efficient can be termed as the elasticity of food security vulnerability with respect to price of rice. Our results show that a ten percent increase in the price of coarse rice leads to around thirty three percent reduction in the likelihood of being food secure. This measure underscores the importance of rice price in determining the food security of a typical household in Bangladesh. This coefficient also provides a quantifiable measure of the impact of rice price on the overall food security situation of the households.

The rest of the variables control for age-sex ratio in the family to reflect the demographic structure of households which might have important implication for food security. In general, all the coefficients are negative implying that the greater the number of household members in the household the lower the food security situation. Even then investigating individual categories might give important insights. Among the males, it shows that presence of male more than 50 years old has the largest negative impact on the food security situation. This is expected given the fact that male are the principal income earner for a household and as the age increases it greatly reduced the income potential for the households and thus implies negative impact on the household food security situation. Similarly, the presence of female member, in the same age range, does not have any statistically significant impact on the household food security situation.

In the same manner, household head's occupation also might have strong bearings on the food security situation which is captured by the relevant dummy variables. The base category is household head's occupation in agricultural labor which is supposed to be the most distressed economically. But in the regression framework, after controlling for other household characteristics, we find that the households, with their head engaged in salaried wage employment, are around 9.3% more likely to be food insecure than households with their head in agricultural labor.

The last variable indicating whether the household received safety net programs or not requires some elaboration. The reason two types of estimates has been reported

here stems from the fact that the dummy variable indicating the status of safety net receipts is an endogenous variable. The reason it is endogenous is that the same unobserved factors that correlates with the dummy is also likely to affect the food security indicator, the dependent variable in this case. Not surprisingly, simple OLS gives us a counterintuitive result showing that the households which receives the safety net programs are worse-off compared to the households which did not receive.

There are quite a few issues to deal with here. First OLS simply compare the participants and non-participants and if the observed characteristics of the households controlled by the regression framework does not adequately capture the factors that makes the participants and the non-participants comparable then we get biased estimates of the impact of the intended program. One way to deal with this endogeneity problem is to resorting to instrumental variable (IV) approach. We find a variable for the endogenous dummy variable in such a way that it is correlated with another variable but uncorrelated with the error term.

(b) Region as IV for Safety Net Programs

One suitable candidate for such IV is the region where the households are currently living. The data has been collected from the whole of Bangladesh which is divided in 23 regions. These regions are probable candidate for IV of safety net programs for the following reason. It certainly fulfills the criterion of being correlated with the original dummy variable indicating the status of safety net programs receipt. The regions where a household lives is an reliable indicator regarding whether the household would receive the safety net programs or not as the decision to allocate such programs have strong regional component in those. Poverty or food security situation has strong regional division in Bangladesh ((Narayan et el., 2007).

Crucially, these regional dummies are supposed to be uncorrelated with any unobserved factors that are likely to affect the food security indicator. This is because the location of households are supposed to be random in nature. Combining these two conditions, we get a reliable indicator for IV for the safety net programs recipient status.

In the first stage, we regress the safety net program dummy on the regional dummies and other observed factors and collect the predicted values to be included the original equation. The results are dramatically different between OLS and IV estimates. The IV has positive coefficient compared to the negative coefficient produced by the OLS. The IV estimates suggest that safety net recipients are 19.5% more likely to be food secure compared to their non-recipients after controlling for other observed characteristics. This is of huge practical significance for the policy makers in the sense that effectiveness of these programs are heavily reflected here. This coefficient is also statistically significant at five percent level of significance.

Logistic regression results in Table 7.10 disaggregate the food security situation across the different employment categories of household head. This type of analysis is required to understand the determinants of food security situation in different occupational groups. The categories differentiating the agriculture and non-agricultural sector has been merged into one single category for each of the broader divisions. As in the overall population, the land continues to be both of statistical and practical influence in the overall regression framework and surprisingly the effect is consistent across the

three major groups of professions, which is around six percent. The increased effect of price of rice on the self-employed seems to be higher than the other three groups.

Table 7.10: Determinants of Food Security by Employment Categories

	(1)Daily Wage	M.E.	(2)Self-emp.	M.E.	(3)Salary Wage	M.E.
Sex of Household head	-0.805**	-0.194**	-0.059	-0.015	-0.029	-0.007
	(0.000)	(0.000)	(0.825)	(0.825)	(0.932)	(0.932)
Age in Years	0.009	0.002	0.038+	0.009+	0.032	0.008
	(0.723)	(0.723)	(0.064)	(0.064)	(0.418)	(0.418)
Age Squared	0.000	0.000	-0.000	-0.000	-0.000	-0.000
	(0.800)	(0.800)	(0.317)	(0.317)	(0.938)	(0.938)
Education of household head	0.007	0.002	0.046**	0.011**	0.003	0.001
	(0.675)	(0.675)	(0.000)	(0.000)	(0.861)	(0.861)
House with brick wall (d)	-0.088	-0.021	0.191	0.047	0.253	0.060
	(0.670)	(0.667)	(0.208)	(0.204)	(0.280)	(0.285)
House with wooden wall (d)	0.045	0.011	0.180+	0.045+	-0.109	-0.025
	(0.682)	(0.683)	(0.086)	(0.085)	(0.596)	(0.595)
House with mud wall (d)	0.255*	0.062*	0.302*	0.074*	0.072	0.017
	(0.036)	(0.038)	(0.020)	(0.018)	(0.803)	(0.805)
Household with electricity (d)	-0.008	-0.002	0.281**	0.070**	0.204	0.047
	(0.943)	(0.943)	(0.003)	(0.003)	(0.250)	(0.245)
Total Land (decimal)	0.287**	0.069**	0.232**	0.058**	0.278**	0.065**
	(0.002)	(0.002)	(0.000)	(0.000)	(0.002)	(0.002)
log of Price of Rice	-1.664**	-0.400**	-2.420**	-0.602**	0.761	0.178
	(0.009)	(0.009)	(0.000)	(0.000)	(0.381)	(0.382)
Males (1-15 years old)	-0.376**	-0.090**	-0.193**	-0.048**	-0.398**	-0.093**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Males (16-49 years old)	-0.478**	-0.115**	-0.307**	-0.076**	-0.388**	-0.091**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Males (Above 50 years)	-0.666**	-0.160**	-0.394**	-0.098**	-0.877**	-0.205**
	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)	(0.000)
Females (1-15 years old)	-0.367**	-0.088**	-0.230**	-0.057**	-0.276**	-0.065**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Females (16-49 years old)	-0.092	-0.022	-0.143*	-0.036*	-0.140	-0.033
	(0.358)	(0.358)	(0.038)	(0.038)	(0.279)	(0.279)
Females (Above 50 years)	0.080	0.019	0.064	0.016	-0.035	-0.008
	(0.511)	(0.511)	(0.525)	(0.525)	(0.849)	(0.849)
Recieved Safety Net?	0.203	0.049				
	(0.548)	(0.548)				
Recieved Safety Net?			1.165+	0.290+		
			(0.058)	(0.058)		
Recieved Safety Net?					0.770	0.180
					(0.394)	(0.394)
Observations	2297	2297	2713	2713	885	885
Pseudo R^2	0.061	0.061	0.060	0.060	0.061	0.061

Marginal effects; *p*-values in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$
Source: HIES (2005),Author's Calculation

Logistic regression results in Table 7.11 further details the food security situation of the households which received the assistance from the safety net programs. Among these recipients, the amount received in kilogram does not have a significant impact on the food security situation which is surprising and needs further investigation. One probable cause is that there is some uniformity in the amount received which results in very less variation. Any explanatory variable with few variation usually leads to biased estimates and essentially that might be the case here. Amount of land owned by the households are again significantly affecting the household food security situation. The effect of land ownership is more prominent compared to the overall group and three different employment categories. Holding all other variables constant, surprisingly price of rice no longer has any statistically significant impact on the food security situation of household. This might be due to the mitigating factor of receiving safety net programs that offsets the impact of rice price on the food security situation.

Table 7.11: Food Security and Safety Net Programs

	Coefficients	M.E.
Sex of Household head	0.002	0.000
	(0.996)	(0.996)
Age in Years	0.026	0.006
	(0.491)	(0.491)
Age Squared	-0.000	-0.000
	(0.925)	(0.925)
Food Grain Received(Kg)	-0.001	-0.000
	(0.605)	(0.605)
Education of household head	0.088**	0.021**
	(0.002)	(0.002)
House with brick wall (d)	-0.125	-0.030
	(0.819)	(0.816)
House with wooden wall (d)	0.028	0.007
	(0.885)	(0.885)
House with mud wall (d)	0.171	0.041
	(0.489)	(0.494)
Household with electricity (d)	0.092	0.022
	(0.663)	(0.664)
Total Land (decimal)	0.360*	0.086*
	(0.014)	(0.014)
log of Price of Rice	-0.828	-0.198
	(0.474)	(0.474)
Males (1-15 years old)	-0.399**	-0.095**
	(0.000)	(0.000)
Males (16-49 years old)	-0.464**	-0.111**
	(0.004)	(0.004)
Males (Above 50 years)	-0.818**	-0.195**
	(0.005)	(0.005)
Females (1-15 years old)	-0.392**	-0.094**
	(0.000)	(0.000)
Females (16-49 years old)	-0.231	-0.055
	(0.164)	(0.164)
Females (Above 50 years)	0.115	0.027
	(0.570)	(0.570)
Self-employed:agri (d)	0.020	0.005
	(0.941)	(0.942)
Daily wage:non-agri (d)	-0.304	-0.071
	(0.172)	(0.162)
Self-employed:non-agri (d)	-0.070	-0.017
	(0.769)	(0.768)
Salary Wage Employment (d)	-0.356	-0.082
	(0.274)	(0.252)
Observations	744	744
Pseudo R^2	0.103	0.103

Marginal effects; *p*-values in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$
Source: HIES (2005),Author's Calculation

Table 7.12 records the results from the pooled regression combining information in 2000 and 2005 HIES information. This analysis is required to capture the temporal dimension of the food security. These results will also try to explain the tabular results that we have

discussed earlier where we have found that food security situation in general worsened if we compare the situation between 2000 and 2005. Our analysis includes mainly two types of estimation. First column shows the ordinary pooled regression framework. These results are mainly used to investigate the impact of time dimension on the food security situation. Holding all other variables constant, we find that dummy for year variable is both statistically and practically insignificant. This means that after taking care of all the possible effect, there is no meaningful change on the food security situation in 2005 than in 2000. Since our food security measure is evaluated at household calorie availability level, this result is not surprising. HIES (2005) also reports very marginal change in the calorie availability between 2000 and 2005, average per capital per day calorie intake decreased to 2238.5 in 2005 from 2240.3 in 2000. Estimates (2) is used to check whether there is any structural difference in the two time periods. This is essentially performing a Chow test which is done by incorporating interaction terms involving all the explanatory variables and time dummy. The results provide evidence that there is some structural difference in the food security determinants between these two time periods.

Table 7.12: Temporal Dimension of Food Security

	(1)Pooled Estimates	Mar. Effect	(2)With Interaction terms
Sex of Household head	-0.015	-0.004	-0.281
	(0.874)	(0.874)	(0.118)
Age in Years	0.018+	0.004+	0.013
	(0.082)	(0.082)	(0.432)
Age Squared	-0.000	-0.000	-0.000
	(0.339)	(0.339)	(0.579)
Education of household head	0.015*	0.004*	0.004
	(0.019)	(0.019)	(0.703)
House with brick wall (d)	0.337**	0.080**	0.624**
	(0.000)	(0.000)	(0.000)
House with wooden wall (d)	0.268**	0.065**	0.261**
	(0.000)	(0.000)	(0.005)
House with mud wall (d)	0.291**	0.070**	0.389**
	(0.000)	(0.000)	(0.000)
Household with electricity (d)	0.206**	0.050**	0.224**
	(0.000)	(0.000)	(0.000)
Total Land (decimal)	0.192**	0.047**	0.166**
	(0.000)	(0.000)	(0.000)
Log of Rice Price	-0.302	-0.074	0.848*
	(0.243)	(0.243)	(0.014)
Males (1-15 years old)	-0.210**	-0.051**	-0.213**
	(0.000)	(0.000)	(0.000)
Males (16-49 years old)	-0.211**	-0.052**	-0.276**
	(0.000)	(0.000)	(0.000)
Males (Above 50 years)	-0.272**	-0.066**	-0.227*
	(0.000)	(0.000)	(0.050)
Females (1-15 years old)	-0.209**	-0.051**	-0.185**
	(0.000)	(0.000)	(0.000)
Females (16-49 years old)	-0.048	-0.012	-0.079

	(0.229)	(0.229)	(0.210)
Females (Above 50 years)	0.095+	0.023+	0.018
	(0.084)	(0.084)	(0.832)
Year Dummy (d)	0.058	0.014	6.047**
	(0.565)	(0.565)	(0.000)
sex* Year Dummy			0.385+
			(0.068)
age* Year Dummy			0.005
			(0.825)
age_sq* Year Dummy			0.000
			(0.947)
highest_grade* Year Dummy			0.021+
			(0.099)
wallmat1* Year Dummy			-0.343
			(0.506)
wallmat2* Year Dummy			0.085
			(0.864)
wallmat3* Year Dummy			-0.117
			(0.814)
wallmat4* Year Dummy			0.053
			(0.913)
tot_op_land* Year Dummy			0.072+
			(0.082)
lrprice* Year Dummy			-2.596**
			(0.000)
mal1_15* Year Dummy			0.006
			(0.897)
mal16_49* Year Dummy			0.118+
			(0.064)
mal50up* Year Dummy			-0.064
			(0.665)
fem1_15* Year Dummy			-0.035
			(0.443)
fem16_49* Year Dummy			0.043
			(0.599)
fem50up* Year Dummy			0.124
			(0.269)
Observations	8722	8722	8722
Pseudo R^2	0.039	0.039	0.043

Marginal effects; *p*-values in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$
Source: HIES (2000, 2005),Author's Calculation
Results of Chow Test
chi2(15) = 51.79
Prob > chi2 = 0.0000

8. KEY FINDINGS

- Rice prices are determined in the market through the interactions of three segments of the market-- the demand for rice, the supply of rice and the rice import. The key variables the influences rice price in the market are mostly supply side, such as area of rice production, and the amount of rice production itself. One more variable that is found to be quite significant in its' contribution to determination of rice prices is the agents' expectations of future prices of rice (taking an one-month ahead price of rice as proxy for this variable).

- Government policy instrument variables also have impact on rice prices, but not that strong impact is found. One possible that the government policy instruments (e.g., public procurement) is through formation of expectations—a satisfactory public procurement will provide a signal to the agents that government has procured a large amount of food grain and thereby a sharp price increase in that case would be unlikely in the near future. This will in turn dampen the pressure on rice prices to increase arising out of expectations of high future prices of rice.

- The market model also implies that the supply side variables play an important role in determination of rice prices. Therefore, emphasis on increases in rice production amount needs to be one major priority area. A high rice production would ensure a stable rice price in the market and dampen any expectations of high rice price increases in the market in the near future, which contributes to increases of rice prices in the current market as well. Therefore, besides with government policy instruments that are already utilized (public procurement and distribution), the government would need to give high priority to productivity increases in rice production (necessitating long-term investment in agricultural research, irrigation, etc.).

- As expected, household characteristics are found to be strongly correlated with food security situation. Specially household infrastructures, land size and household head's employment characteristics are a strong indicator of food security situation. In order to devise policy action to help the subset of population which is food insecure.

- The results show explicitly the impact of rice price increase on the household food security situation. Our results show one percent increase in the price of coarse rice leads to around thirty four percent reduction in the likelihood of being food secure. This coefficient gives a quantifiable measure of the impact of rice price on the overall food security situation of the households.

- Among the employment categories, the effect of increase in price of rice bearing heavily on the self-employed rather than wage or salary-employed. This is surprising given the fact that in terms of food security self-employed category has much lower percentage of household suffering than other categories. But our

results are showing that these household (after controlling for other factors) has less coping ability than other households when they face an external shock in terms of increase in price.

- About the safety net results, the results are not very explicit. The amount received as safety net does not seem to have statistically significant impact on the food security situation. This is a cause of concern since it does not help to establish a causal relationship between the safety net programs and food security situation. It requires further investigation in the food security situation to have a clearer idea on the implication of safety net programs on the food security situation. But regression results clearly shows that after controlling for all the household characteristics, safety net recipients are around twenty percent more likely to be food secure compared to non-recipients.

9. CONCLUDING REMARKS

- Major objective of this study was to demonstrate how the market price of rice (the main staple of Bangladesh) affects the household food security situation. We wished to have a quantifiable measure for clear policy direction and clear understanding on why and how the price of rice increases and how that affects the food security situation. It was expected to help to identify the factors that affect the price of rice and eventually the food security situation of the households. In light of the recent situation of price hike, results of the study have important implications.

- This study was able to identify the factors that affect the price of rice through a dynamic market model. This market model explains how the price of rice changes with different determinants of market mechanism. It essentially brings about demand and supply factors along with government intervention instruments to show the impact of each determinant on the market price. For policy makers, these results might be of substantial importance since it would show how different policy instruments would affect the market price of rice and eventually the food security situation.

- From the market model, this study made transition to household food security model with the common factor linking the both models is price of rice. Food security model is displaying how the price of rice affecting the food security situation of the households after controlling for other relevant factors.

- Price of rice is found to be a both statistically and economically significant factor affecting the household food security. This study gives an exact quantifiable measure of the effect of rice price increase on the food security situation.

- This study also further investigates the food security situation of different households and try to identify the difference in effect for these different categories of households so that policy formulations can be adapted to capture this varied characteristics.

- There are quite a few limitations of the study that need to be acknowledged. This project started with an ambitious plan but due to data limitations, some elements of broader framework could not be incorporated fully into the model.

- We could not check all the model specification issues that need to be addressed. The underlying assumptions of regression models need to be thoroughly checked before the results will have more robust interpretation. Specific issues are highly technical in nature and beyond the scope of this study at its current state.

- Both the market model and food security model could not deal with all the policy variables that were envisaged at the beginning. For example, in the market model external factors, such as, import tariff and other world market factors could not be meaningfully incorporated because of an mismatch of relevant data. In the food security model (and also in the market model) all the government policy options, such as, OMS could not be incorporated due to data incompatibility.

- While we were able to incorporate some safety net measures, which are direct government policy instruments to fight food insecurity, those results could not be meaningfully interpreted for policy interpretation. These issues can be further investigated in the future research works.

- Keeping these several limitations in mind, the major contribution of this study is that it provided a framework to understand the complicated interconnection between market and household food security. This framework is not quite perfect yet, but provides a basis for further research on understanding this complex relationship between government policy instruments and food security in partial equilibrium models.

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ANNEX1

Considering April, May, June and October as pre-harvesting season					
Regression Statistics					
R Square	0.0018599				
Adjusted R Square	-0.0012399				
Observations	324				
	df	SS	MS	F	Significance F
Regression	1	5774335	5774335	0.60001	0.4391413
Residual	322	3.1E+09	9623677		
Total	323	3.1E+09			
	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	10527.546	211.078	49.8751	2E-153	10112.279
X Variable 1	283.19444	365.598	0.77461	0.43914	-436.0691

Figure 5.Production of Food grain by Season, 1978-79 to 2006-07

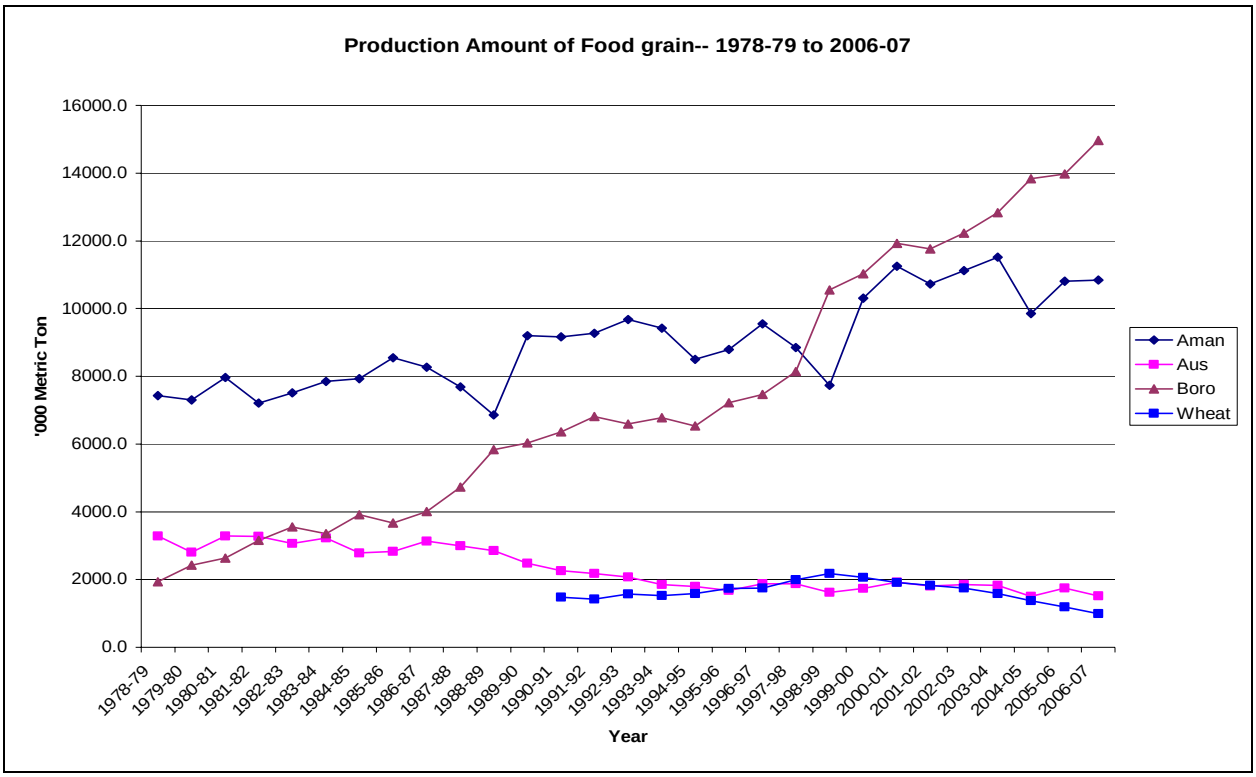


Figure 5.2 Food Grain Production Area, by Season, 1978-79 to 2006-07

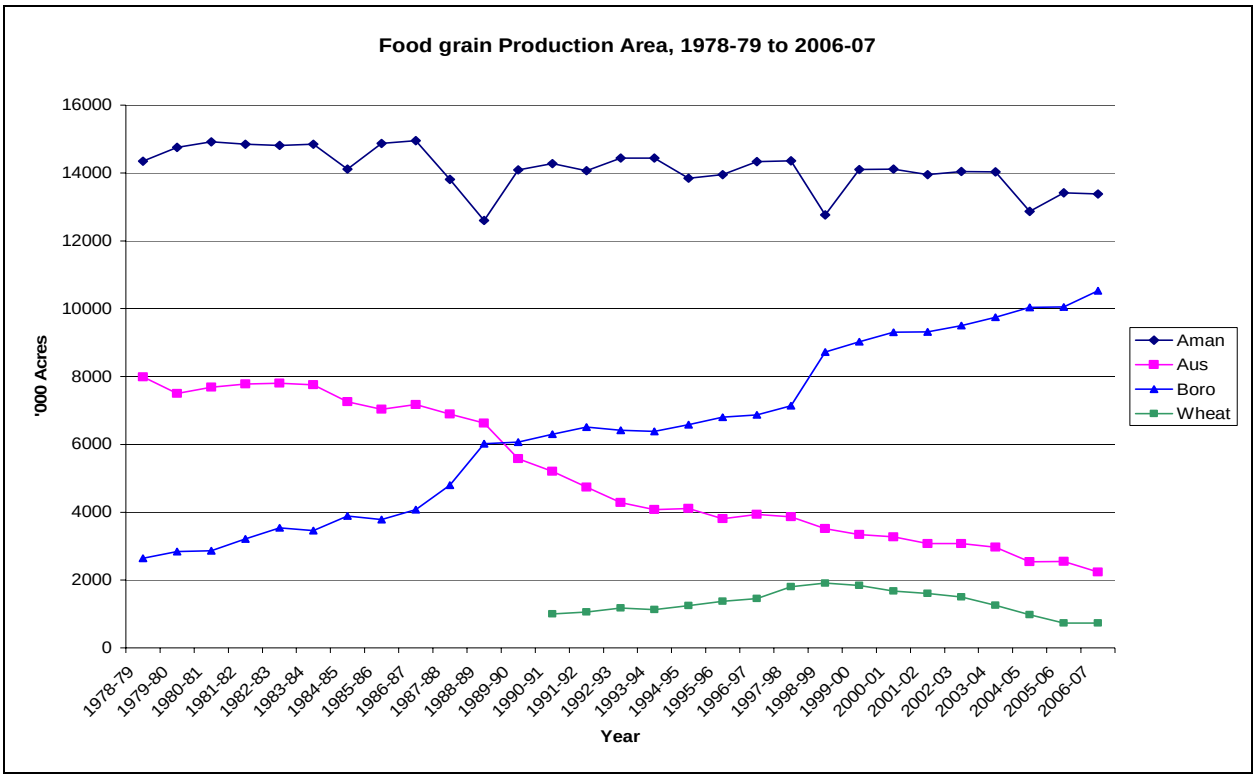


Figure 5.3 Yield Rate of Food grain, by Season, 1978-79 to 2006-07

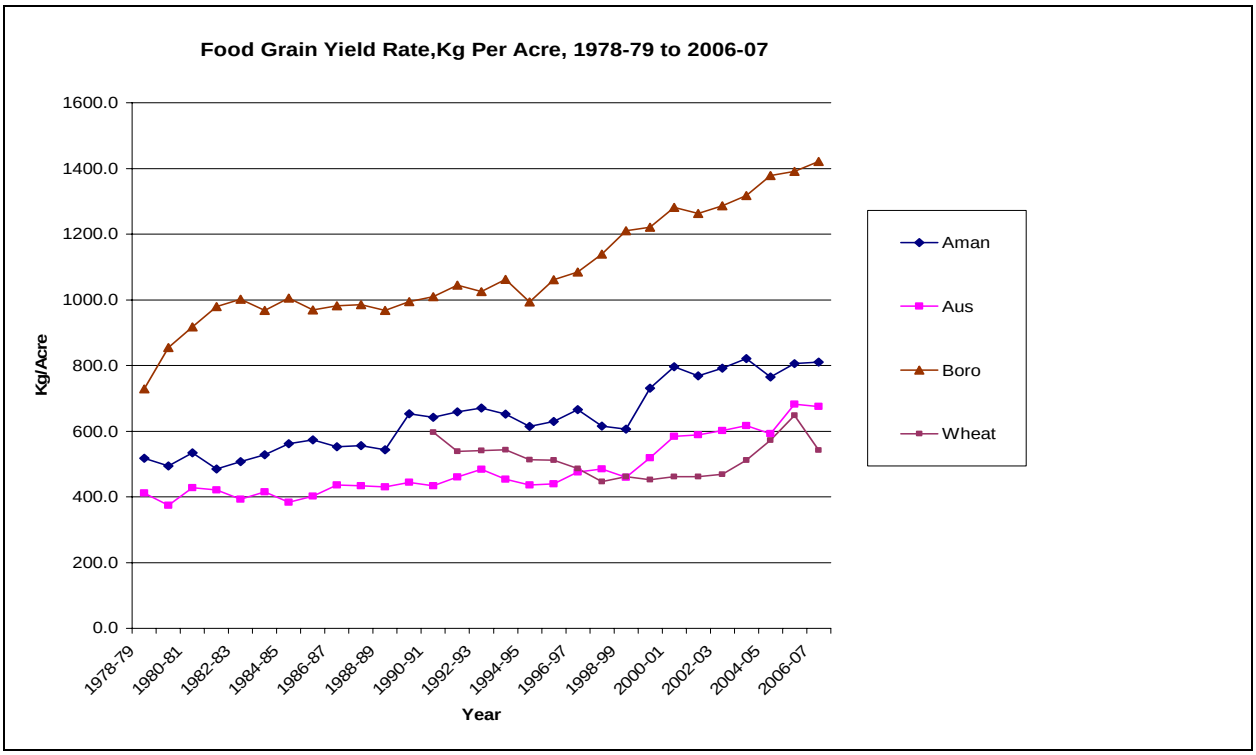


Figure 5.4 Relative Shares of Crops in Total Rice Production, 1978-79 to 2006-07

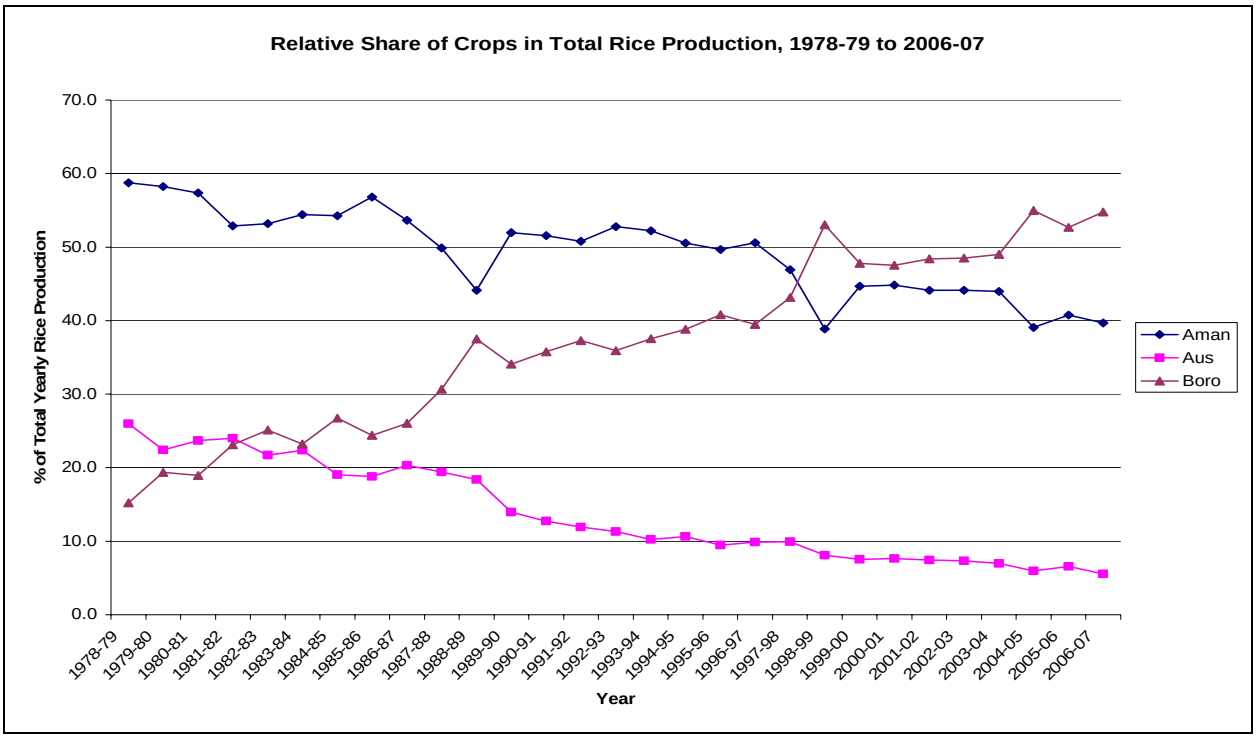

Relative Share of Crops in Total Rice Production, 1978-79 to 2006-07
% of Total Yearly Rice Production
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1978-79
1979-80
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
Year
Aman
Aus
Boro

Figure 5.5 Rice Production and Area-- Local versus HYV, 1987-88 to 2005-06

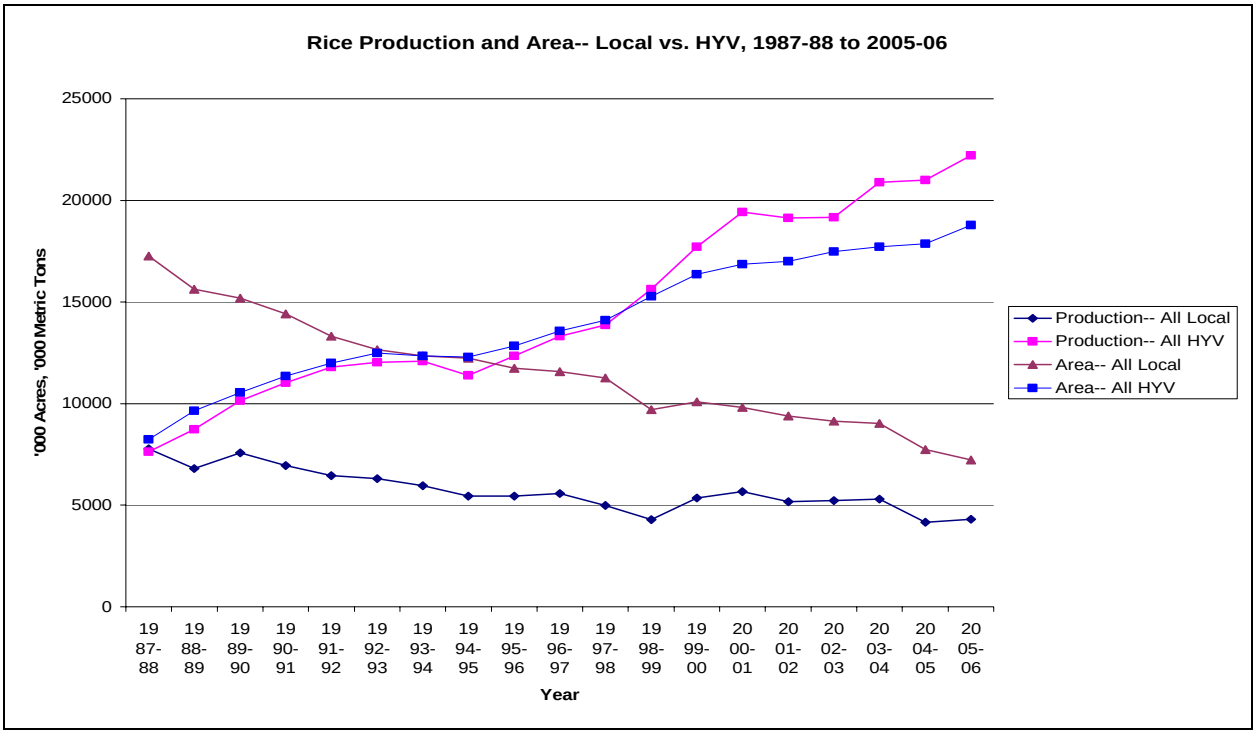


Figure 5.6 Irrigation Share of Food Grain Production Area, 1992-93 to 2006-07

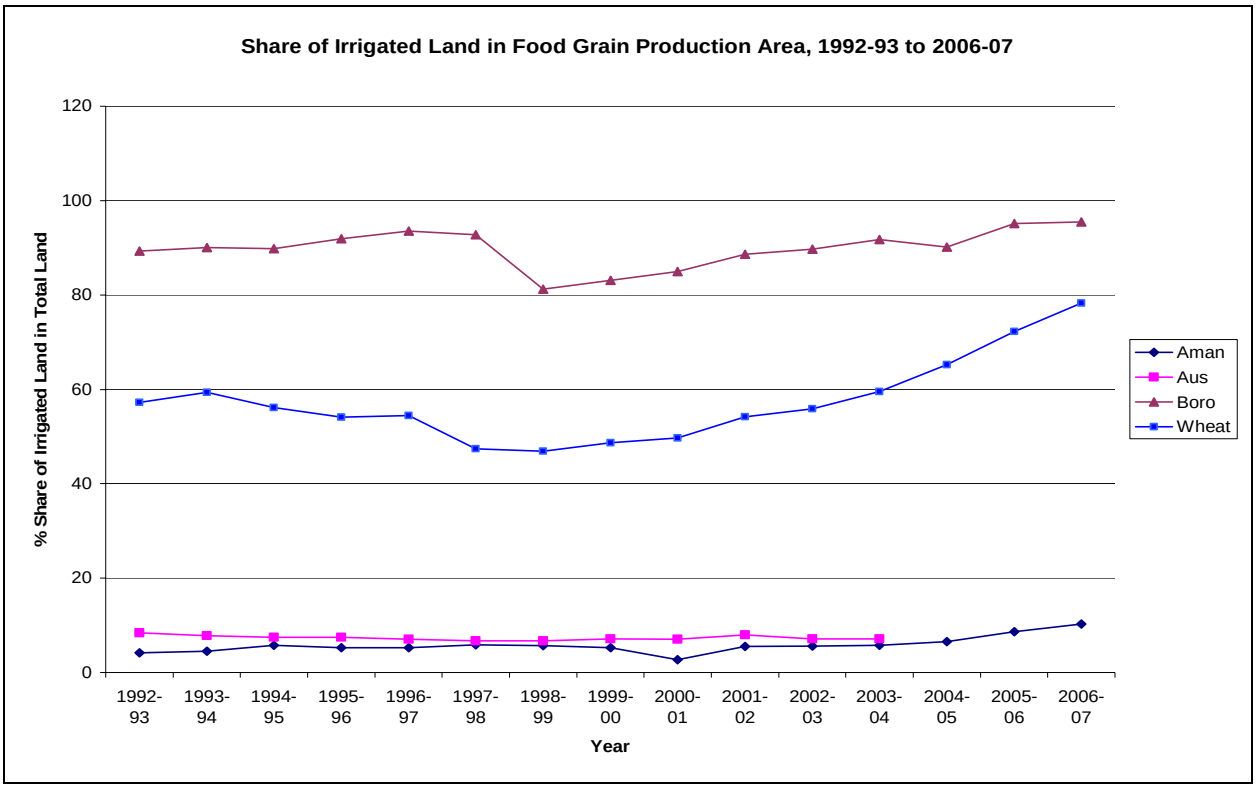

Share of Irrigated Land in Food Grain Production Area, 1992-93 to 2006-07
% Share of Irrigated Land in Total Land
120
100
80
60
40
20
0
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
Year
Aman
Aus
Boro
Wheat

Figure 5.7 Rice, Wheat and Total Food Grain Surplus, 1978-79 to 2006-07

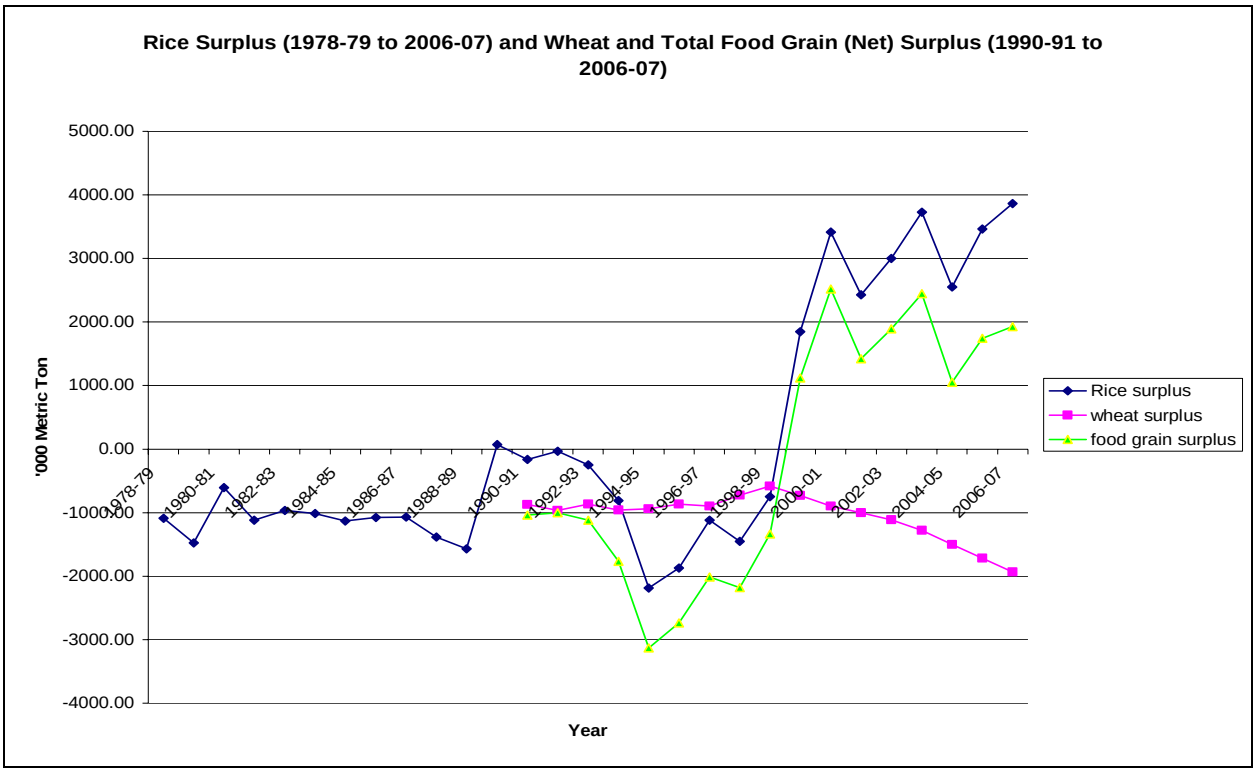


Figure 5.8 Cost of Production Increases in HYV Boro, 1997-98 to 2004-05

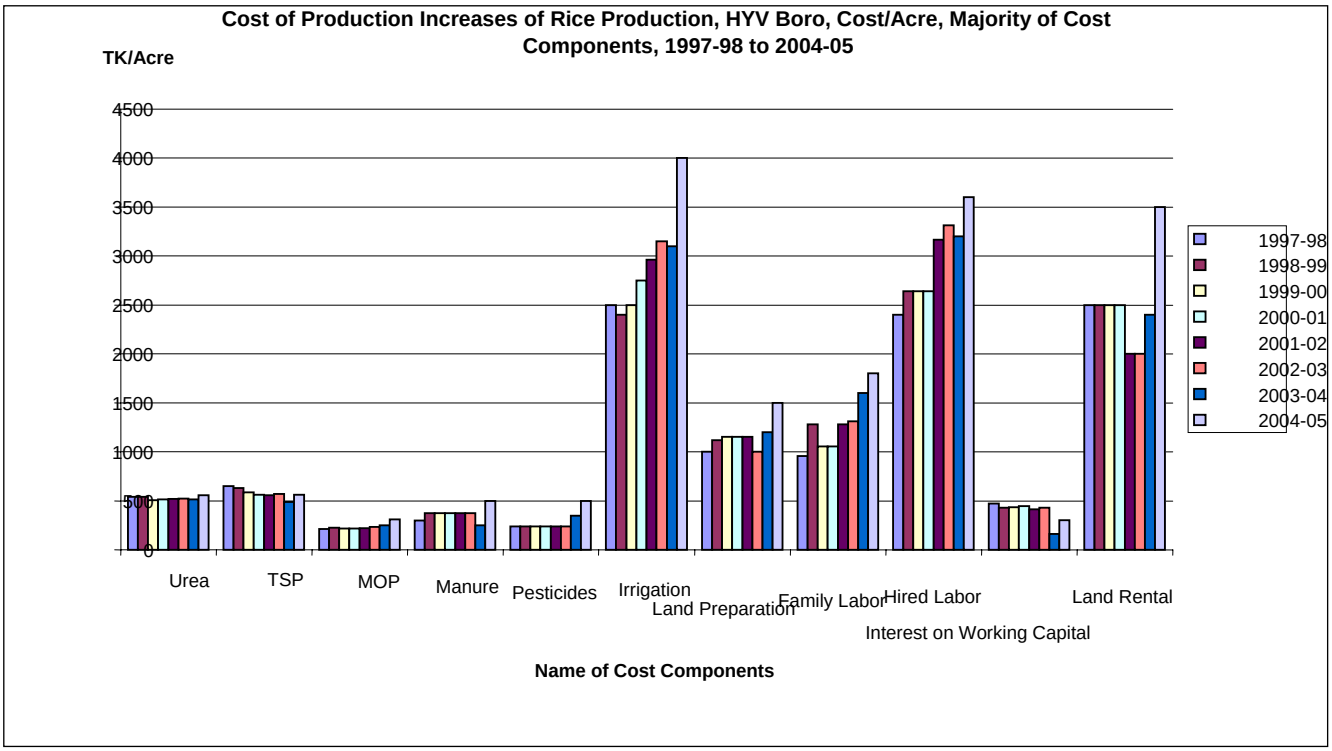

Cost of Production Increases of Rice Production, HYV Boro, Cost/Acre, Majority of Cost Components, 1997-98 to 2004-05
TK/Acre
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Urea
TSP
MOP
Manure
Pesticides
Irrigation
Land Preparation
Family Labor
Hired Labor
Interest on Working Capital
Land Rental
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
Name of Cost Components

Figure 5.9 Fertilizer Prices, 1990-91 to 2004-05

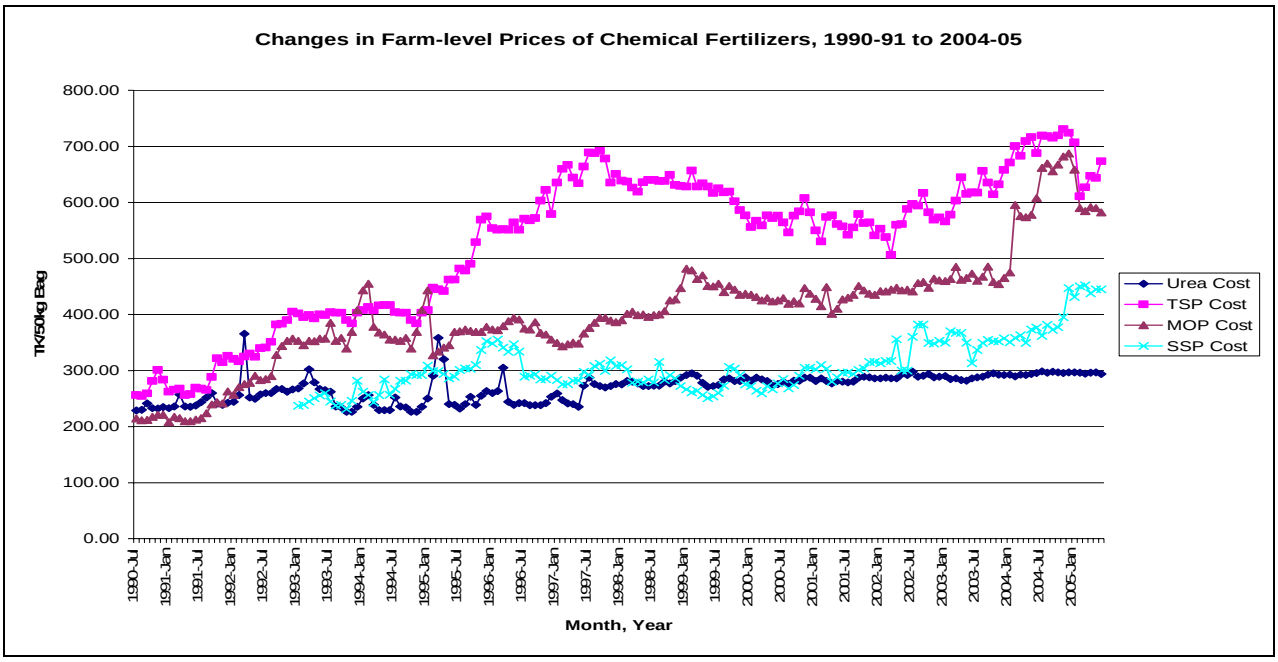


Figure 5.10 Actual, Normal Rainfall & Rainfall Shock, by Month, 1985-86 to 2004-05

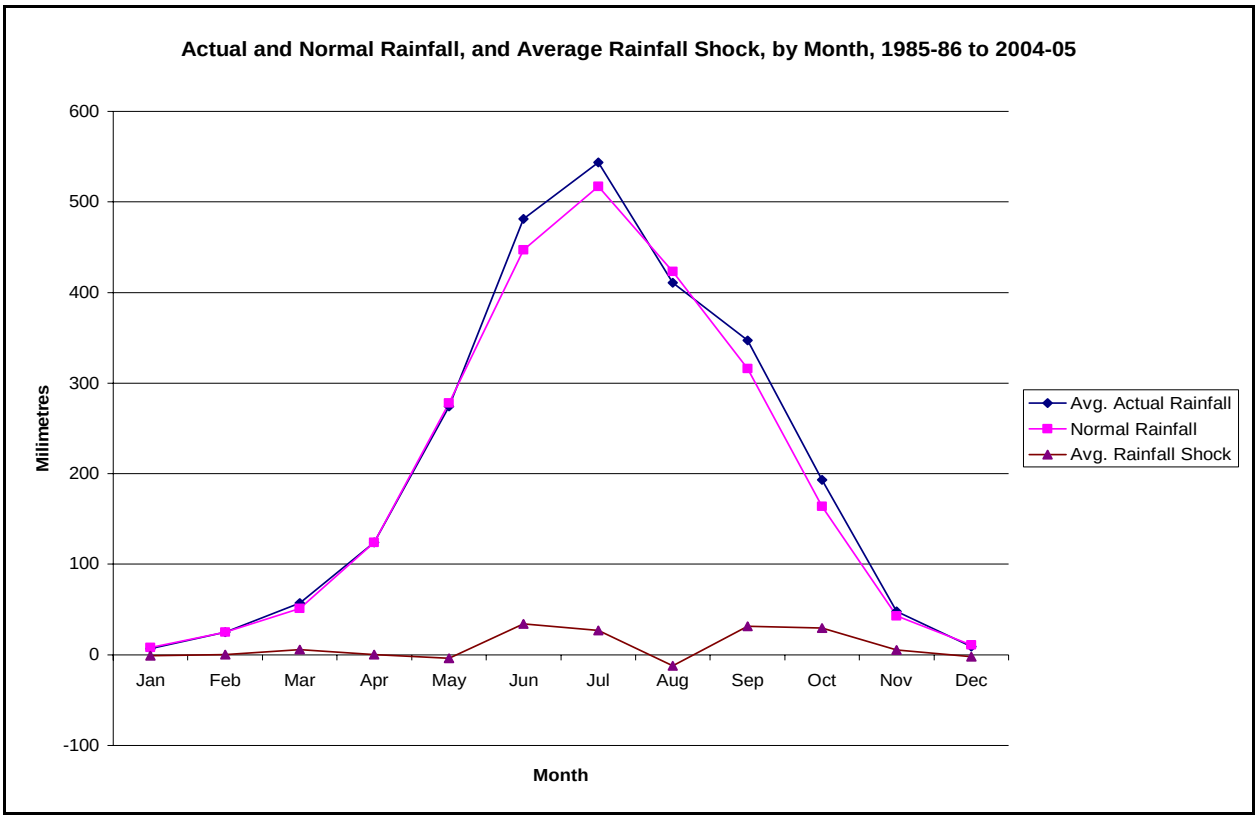

Actual and Normal Rainfall, and Average Rainfall Shock, by Month, 1985-86 to 2004-05
600
500
400
300
200
100
0
-100
Milimetres
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Avg. Actual Rainfall
Normal Rainfall
Avg. Rainfall Shock

Figure 5.11 Rainfall—Normal and Shock (Actual minus Normal), Jan 1986 to Dec 2004

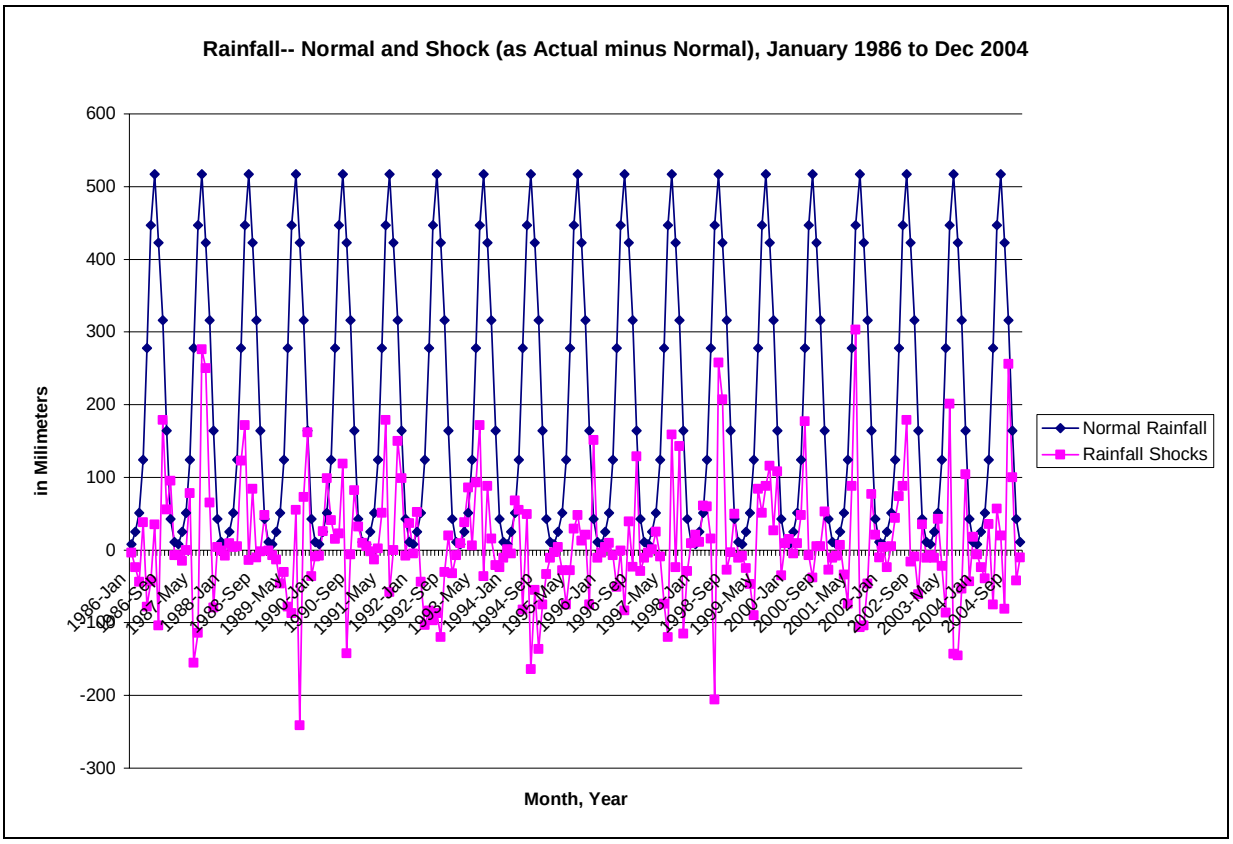


Figure 5.12 Total Land Area Percentage, Affected by Flood, 1980 to 2004

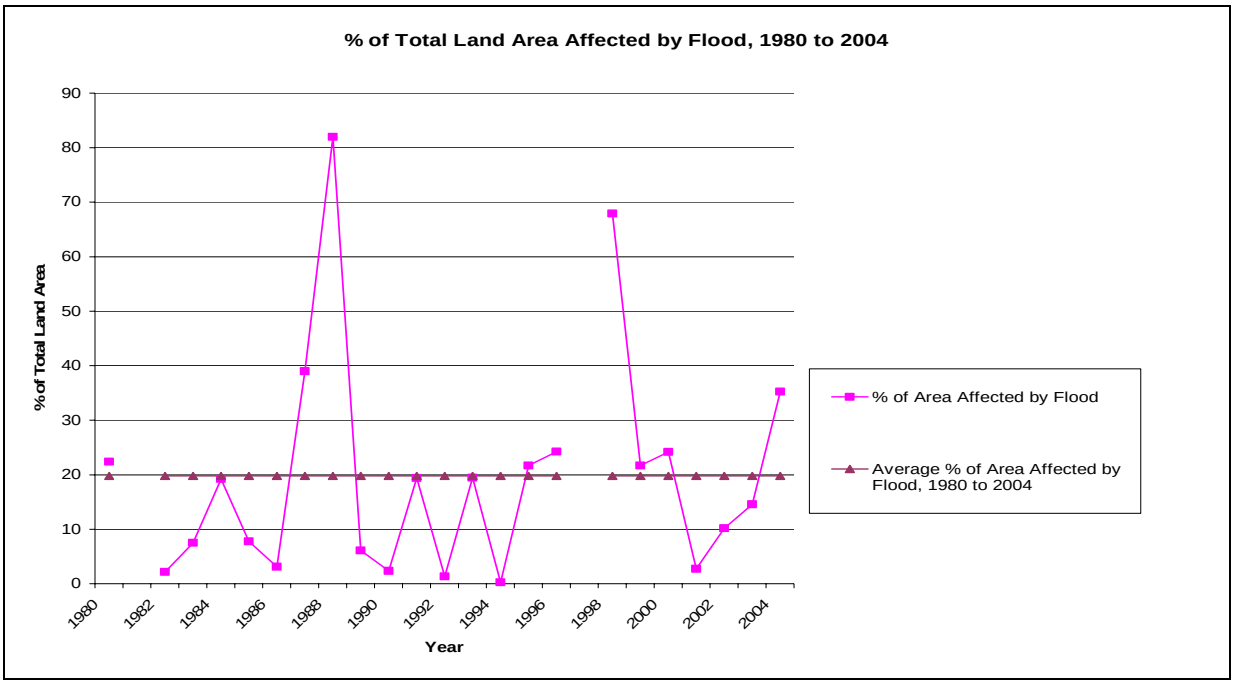

% of Total Land Area Affected by Flood, 1980 to 2004
% of Total Land Area
90
80
70
60
50
40
30
20
10
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
% of Area Affected by Flood
Average % of Area Affected by Flood, 1980 to 2004

Figure 5.13 Estimated Loss of Crop From Natural Disasters, 2000-01 to 2004-05

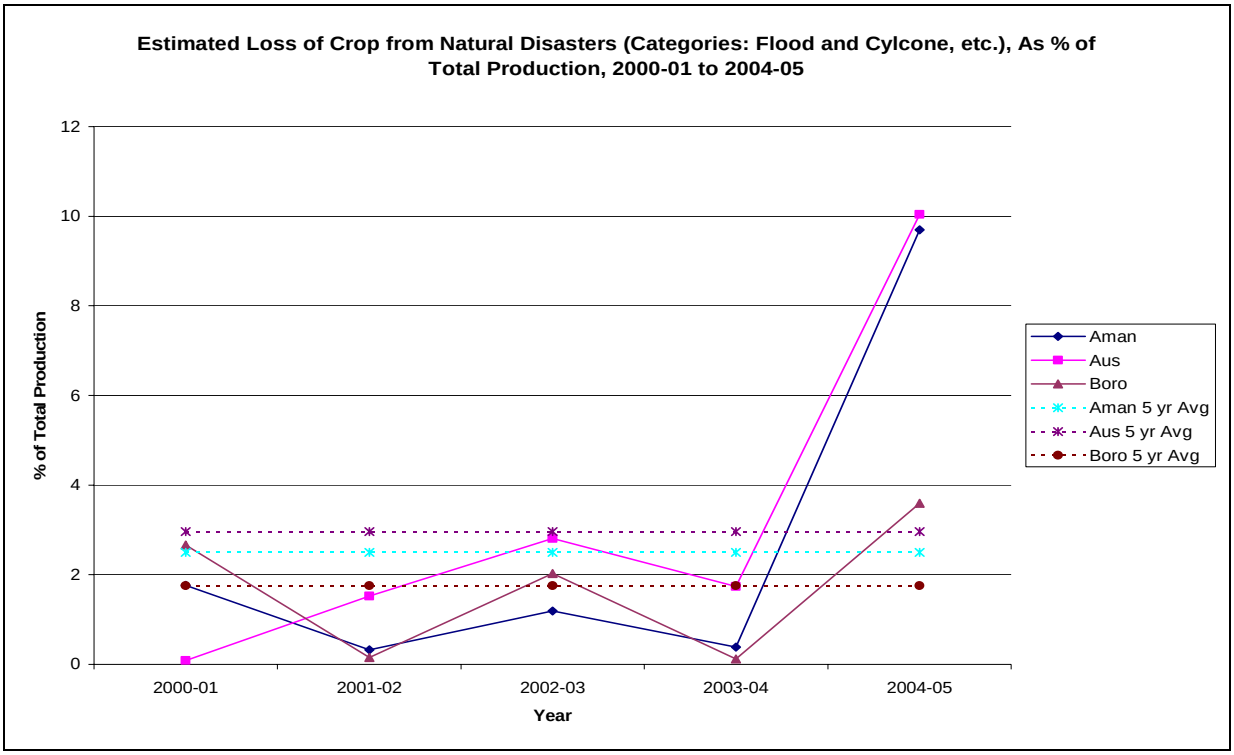


Figure 5.14 Wholesale Coarse Rice Price and Wheat Price, July 1999 to Dec 2007

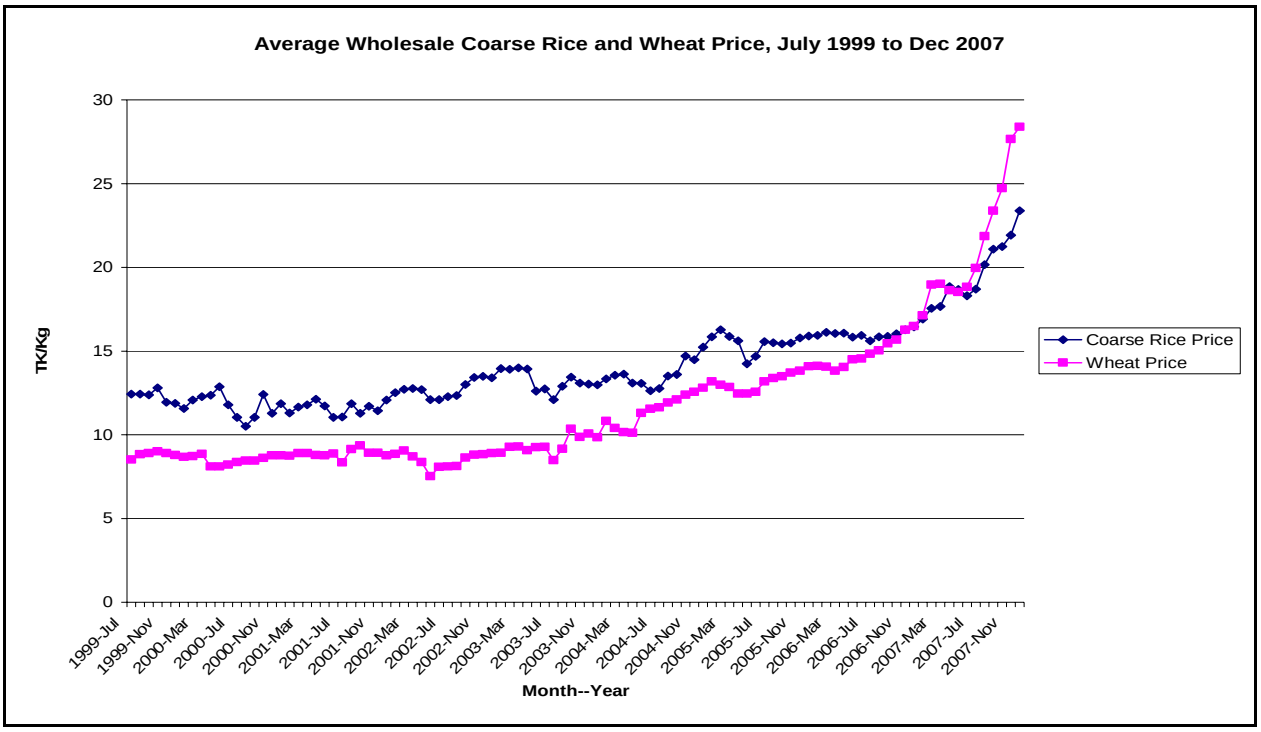


Figure 5.15 Coarse Rice Price and Amount of Rice Procurement, Distribution, Import and India Rice Price (in Taka) by Month, 1999-00 to 2006-07

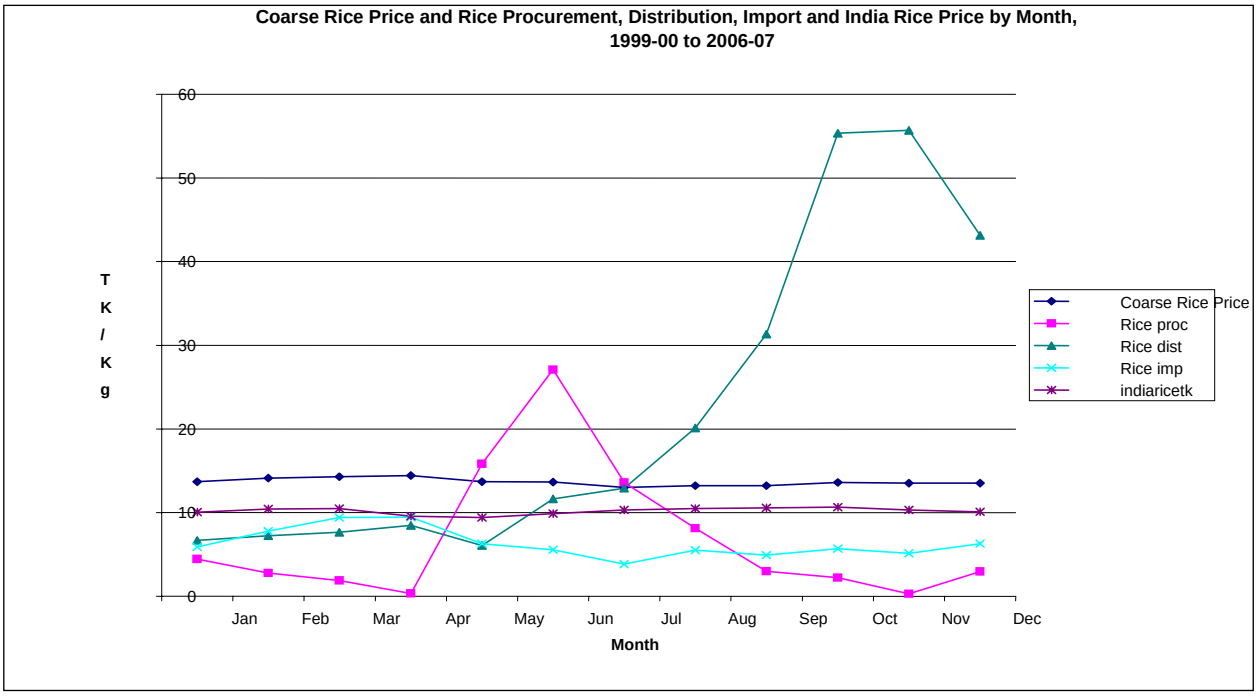


Figure 5.16 Bangladesh Coarse Rice, India and Thai Rice Prices, July 1999-Dec 2007

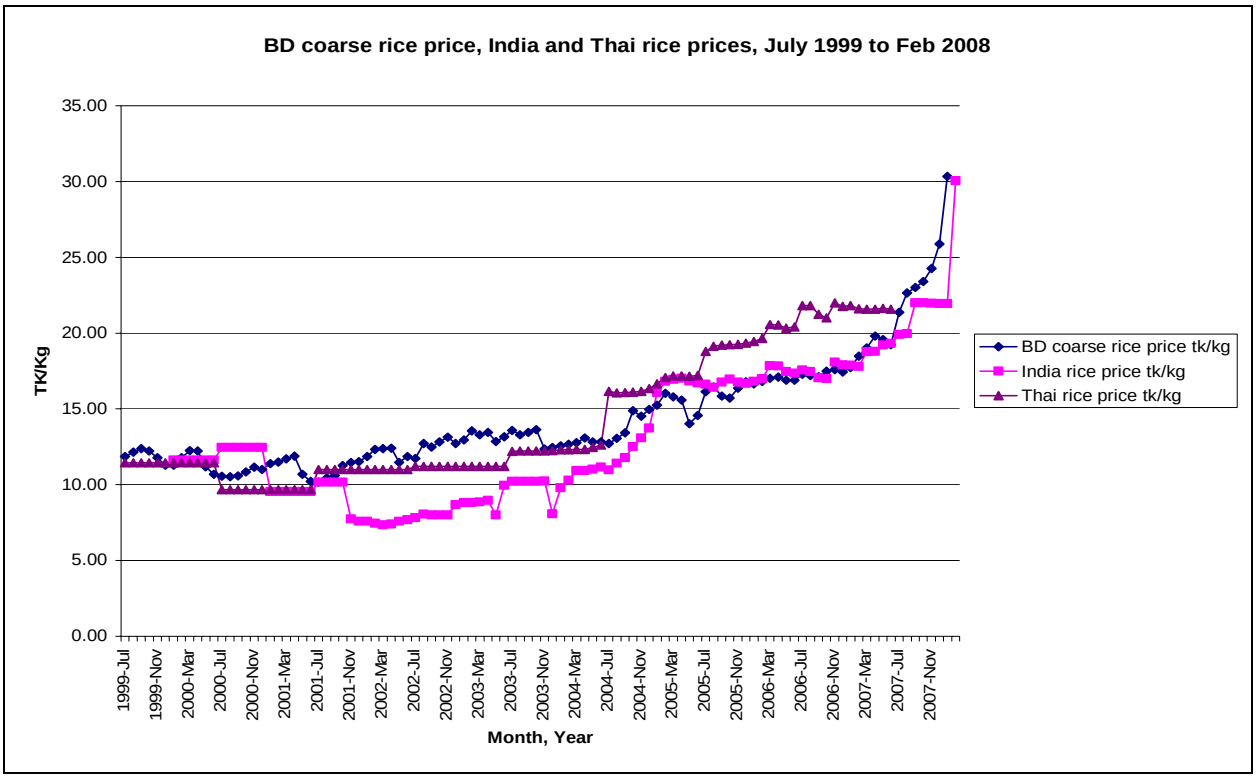


Figure 5.17 Average Whole sale Coarse Rice Prices at Selected Markets, By Month, July 1999 to June 2005

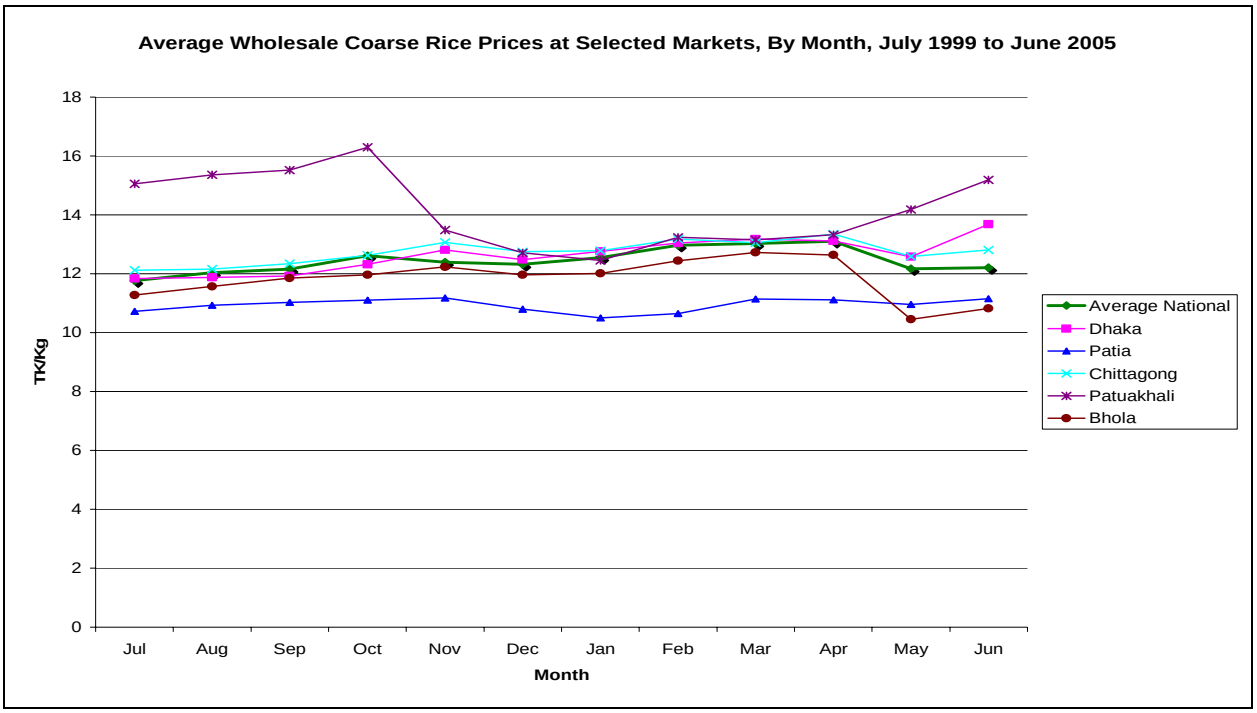


Figure 5.18 Private Import, Public Distribution and Public Procurement as Percent of Net Food Grain Production, 1991-92 to 2006-07

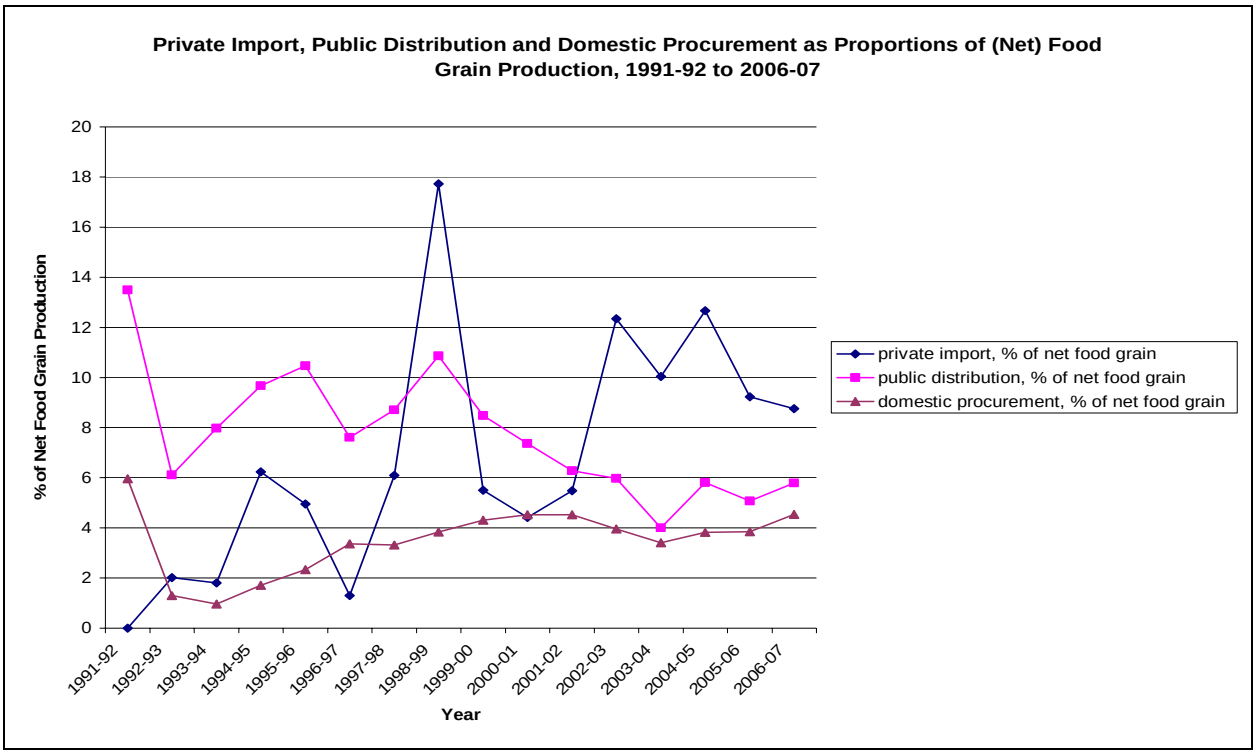

Private Import, Public Distribution and Domestic Procurement as Proportions of (Net) Food Grain Production, 1991-92 to 2006-07
% of Net Food Grain Production
0
2
4
6
8
10
12
14
16
18
20
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
Year
private import, % of net food grain
public distribution, % of net food grain
domestic procurement, % of net food grain

Figure 5.19 Rice and Wheat Procurement by Month, July 1998 to Jan 2008

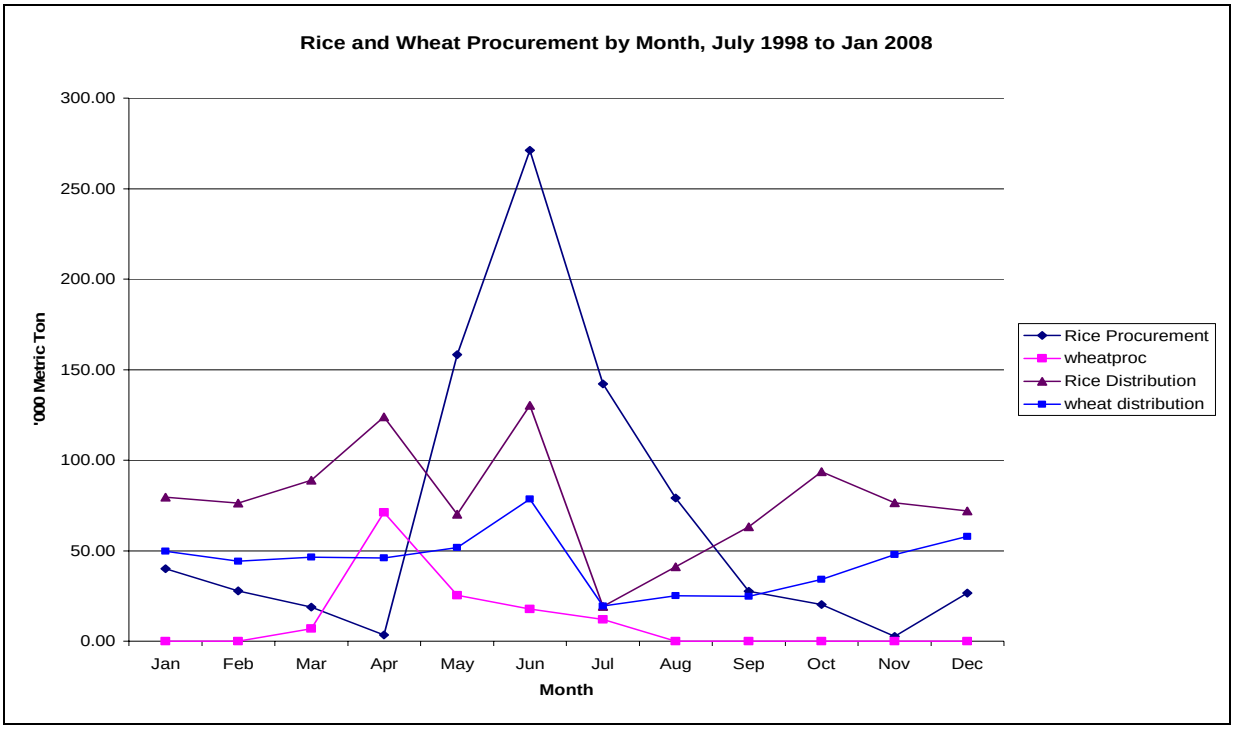


Figure 5.20 Rice Price in Market and Procurement Prices, July 1999 to June 2007

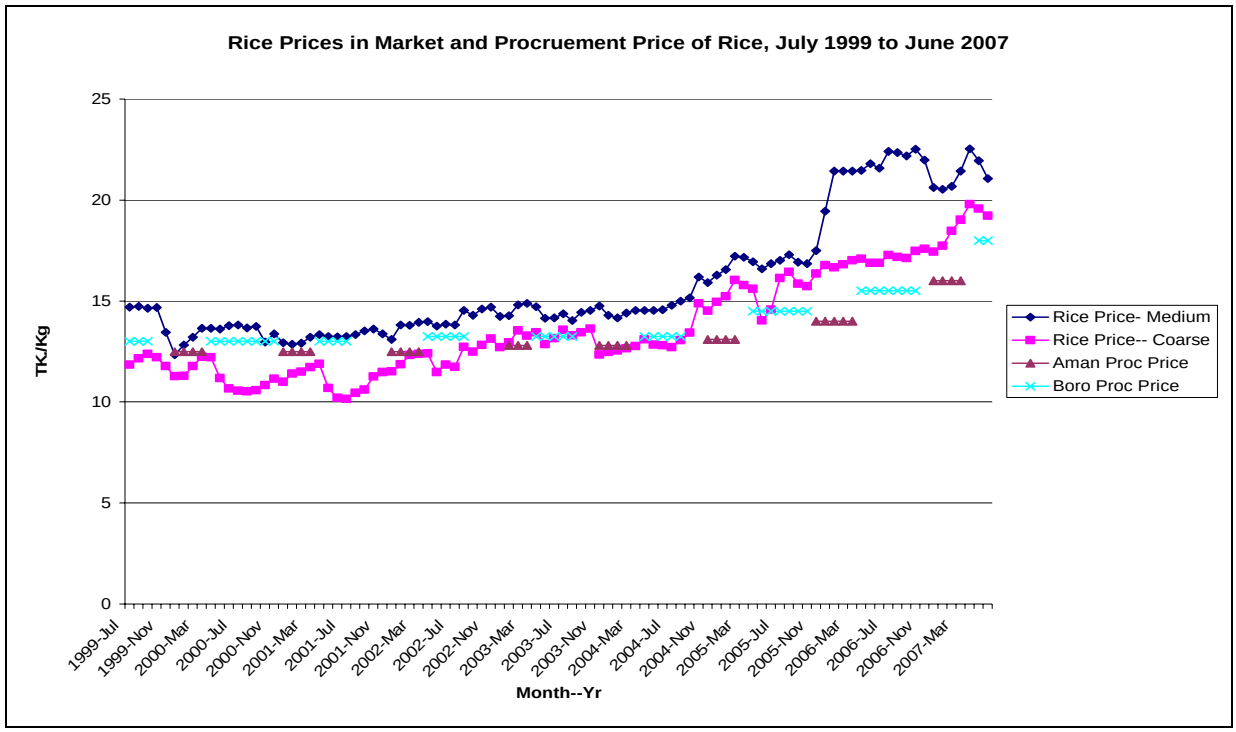

Rice Prices in Market and Procruement Price of Rice, July 1999 to June 2007
TK/Kg
25
20
15
10
5
0
1999-Jul
1999-Nov
2000-Mar
2000-Jul
2000-Nov
2001-Mar
2001-Jul
2001-Nov
2002-Mar
2002-Jul
2002-Nov
2003-Mar
2003-Jul
2003-Nov
2004-Mar
2004-Jul
2004-Nov
2005-Mar
2005-Jul
2005-Nov
2006-Mar
2006-Jul
2006-Nov
2007-Mar
Month--Yr
Rice Price- Medium
Rice Price-- Coarse
Aman Proc Price
Boro Proc Price

Figure 5.21 Aman, Boro and Wheat Procurement, Actual and Shortfall from Target, 1989 to 2007

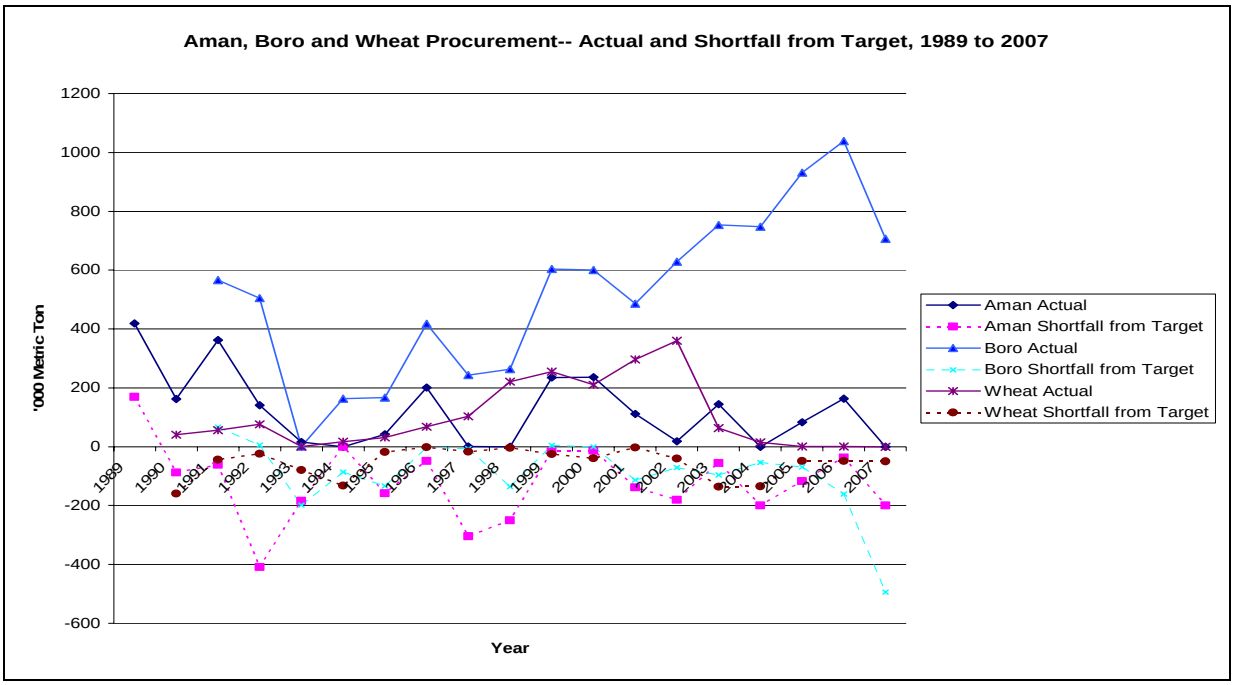


Figure 5.22 Procurement Price of Wheat and Market Price, July 1999 to June 2007

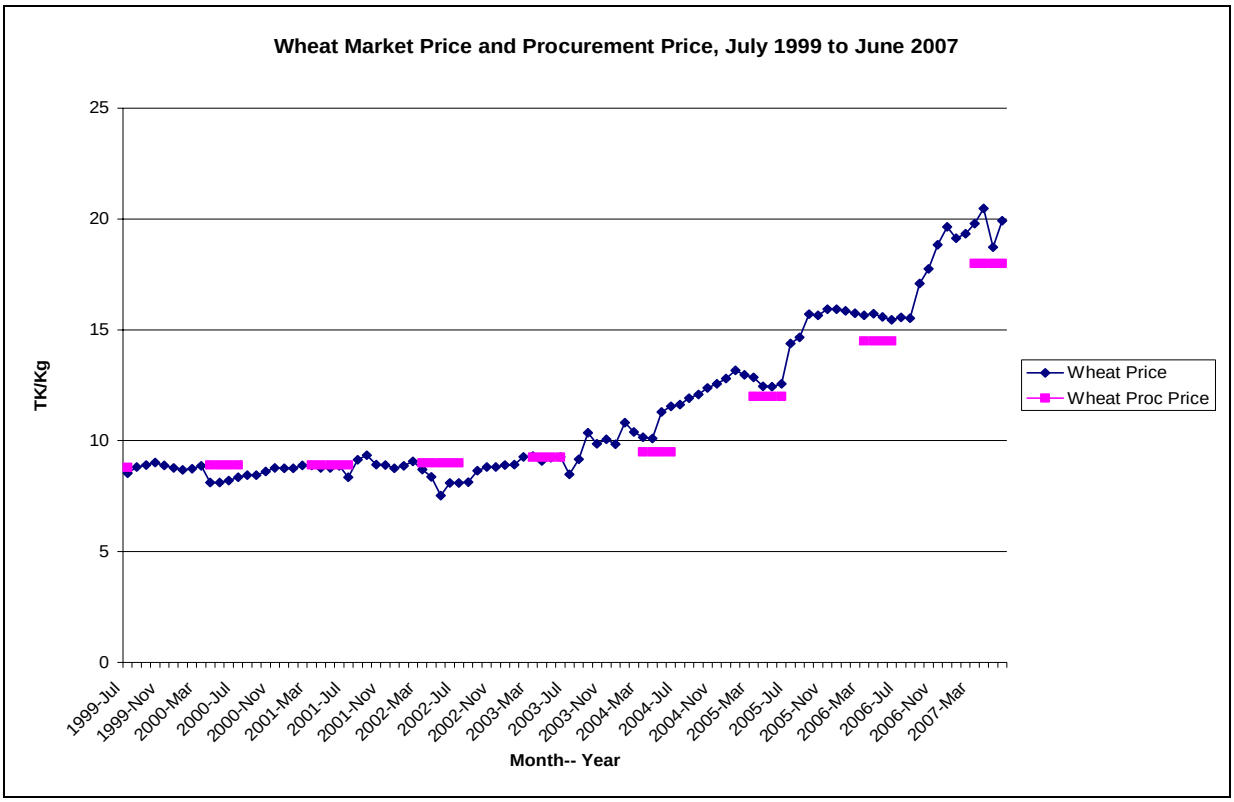

Wheat Market Price and Procurement Price, July 1999 to June 2007
TK/Kg
25
20
15
10
5
0
1999-Jul
1999-Nov
2000-Mar
2000-Jul
2000-Nov
2001-Mar
2001-Jul
2001-Nov
2002-Mar
2002-Jul
2002-Nov
2003-Mar
2003-Jul
2003-Nov
2004-Mar
2004-Jul
2004-Nov
2005-Mar
2005-Jul
2005-Nov
2006-Mar
2006-Jul
2006-Nov
2007-Mar
Month-- Year
Wheat Price
Wheat Proc Price

Figure 5.23 Public Food Grain Distribution, Total and By Item, 1990-91 to 2006-07

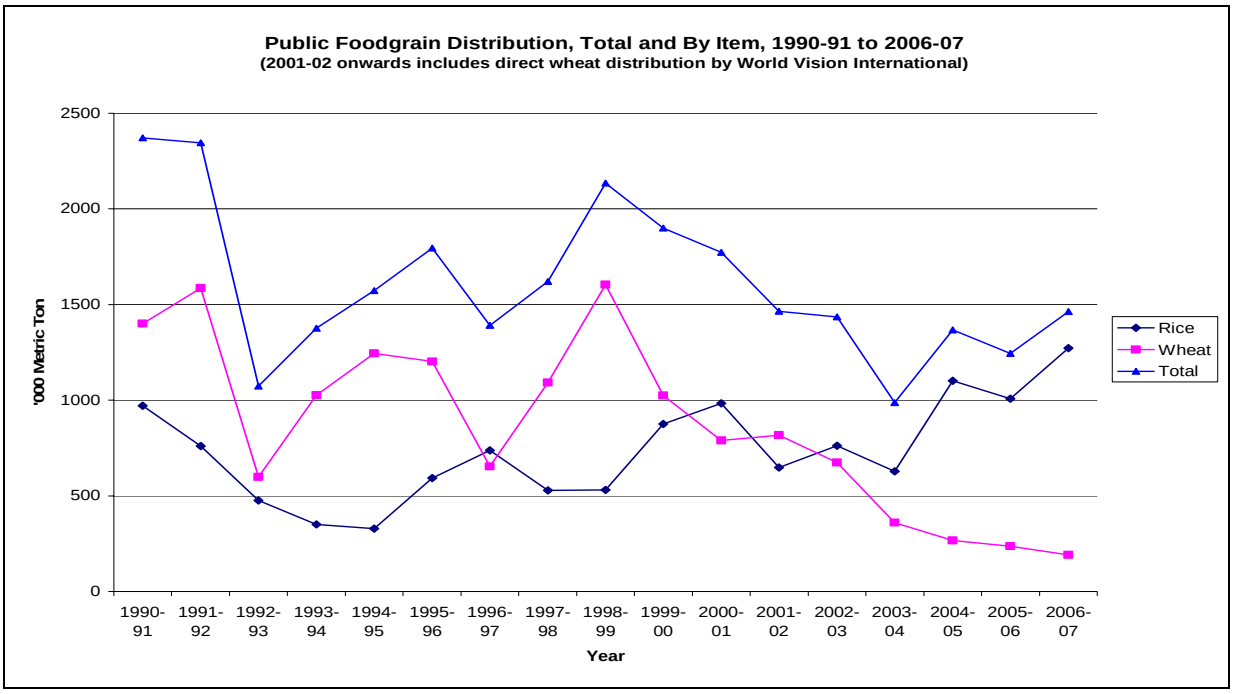


Figure 5.24 Public Food Grain Distribution, By Category, 1992-93 to 2006-07

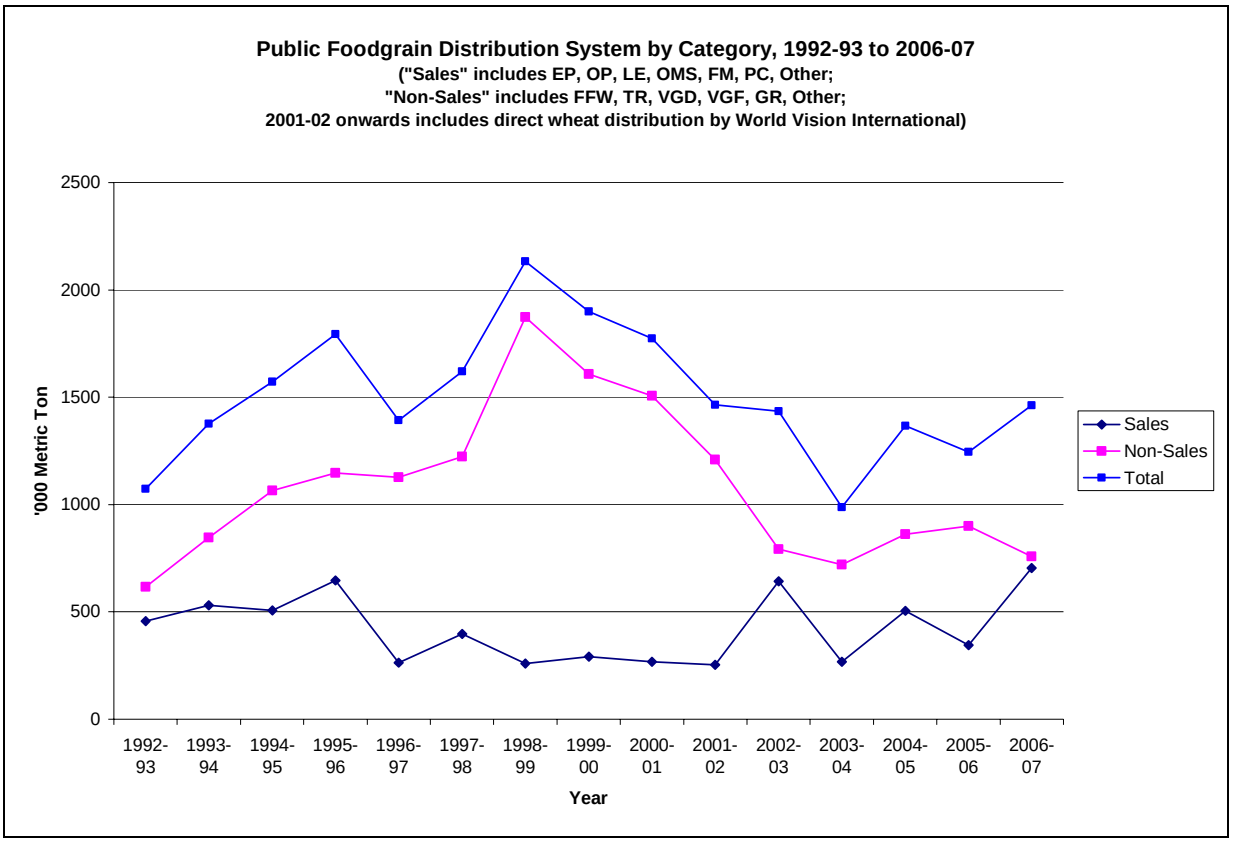

Public Foodgrain Distribution System by Category, 1992-93 to 2006-07
("Sales" includes EP, OP, LE, OMS, FM, PC, Other;
"Non-Sales" includes FFW, TR, VGD, VGF, GR, Other;
2001-02 onwards includes direct wheat distribution by World Vision International)
'000 Metric Ton
2500
2000
1500
1000
500
0
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
Year
Sales
Non-Sales
Total

Figure 5.25 Public Import of Rice, Month wise, July 1998 to June 2005

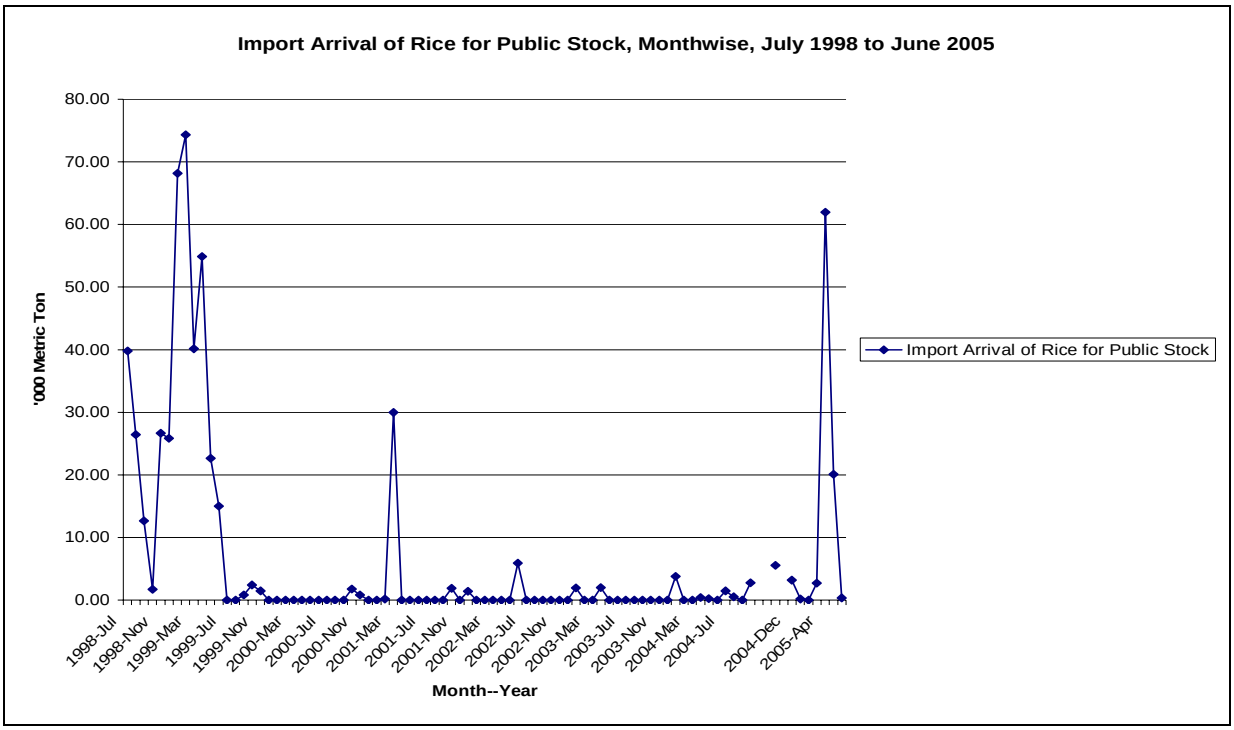
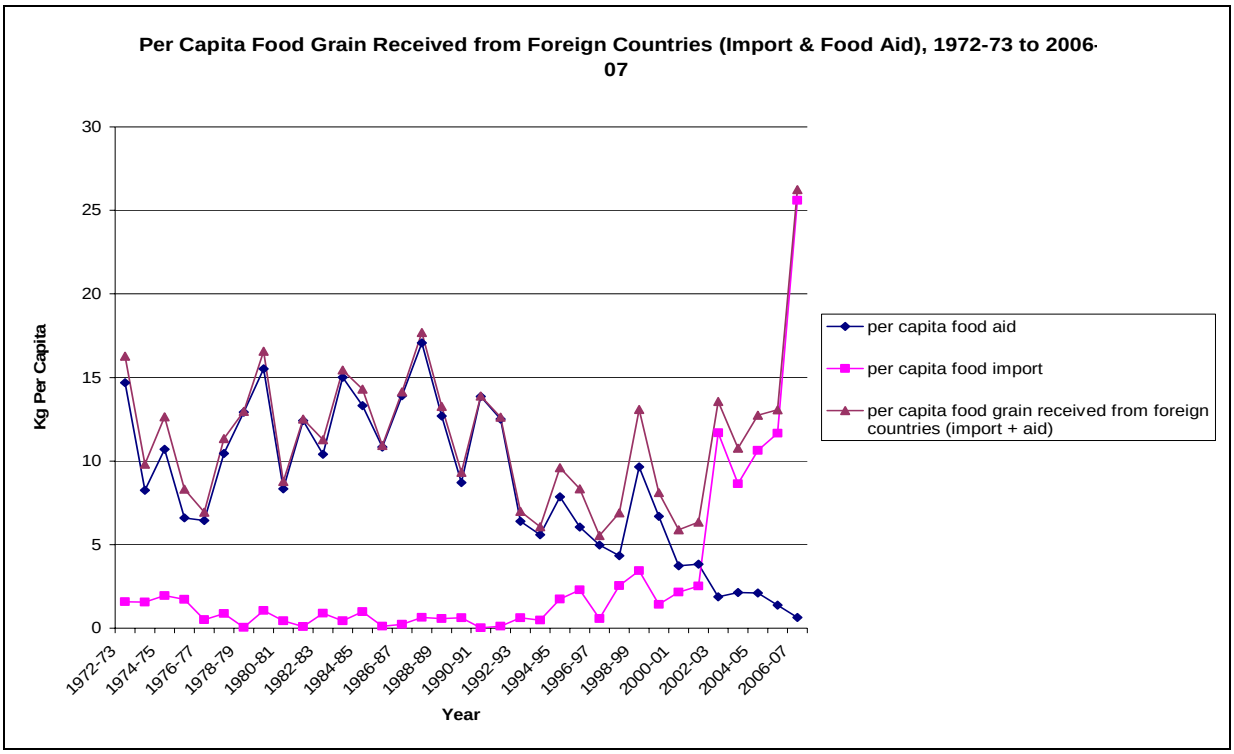


Figure 5.26 Per Capita Food Grain Aid versus Per Capita Food Grain Import, 1972-73 o 2006-07


Per Capita Food Grain Received from Foreign Countries (Import & Food Aid), 1972-73 to 2006-07
Kg Per Capita
30
25
20
15
10
5
0
1972-73
1974-75
1976-77
1978-79
1980-81
1982-83
1984-85
1986-87
1988-89
1990-91
1992-93
1994-95
1996-97
1998-99
2000-01
2002-03
2004-05
2006-07
Year
per capita food aid
per capita food import
per capita food grain received from foreign countries (import + aid)

ANNEX2

Food security calculation

Food energy consumption is measured at the household level as the total amount of energy in the food acquired by the household over the survey reference period for food data collection (the total time for which data are recorded). Calculation of this measure starts with the food data collected from HIES 2000 and 2005 where for each household, quantities acquired for different types of foods are listed.

The energy contents of the edible portion of all foods acquired are then summed and divided by the number of days in the reference period and the number of household members to arrive at the total energy acquired per household member. Note that although the data collected from households represent foods acquired, the mean of this measure across a randomly selected sample of households is felt to be a reasonably good estimate of mean food energy consumed by a population.

Actual energy requirements of individuals depend on their age, sex, body size, activity level, and individual physiology, for example, metabolism. When determining the energy needs of a group of individuals, given unknown actual requirements (because of individual variation), the Expert Consultation on Energy and Protein Requirements (FAO, WHO, and UNU 1985; see also UNU, WHO, and FAO 2004) recommends the use of average energy requirements for people of different sex and age groups, levels of activity, and, for adults, body size, which apply to all individuals globally.

In HIESs, data are collected on age and sex but none of the other characteristics. Use of the "light" activity level is recommended here as a normative standard applicable to all populations. A person who does not consume enough food to meet the energy requirement for basal metabolic function and light activity of the average-weight person in his or her age and sex group is considered food energy deficient. However, because we do not know each person's actual requirement (for basal metabolic function and light activity), and because in each age and sex group there is actually a range of requirements that may apply to individuals, there will be some classification error. Some people whose actual requirement is below the average might have an energy consumption level below the average requirement but still be meeting their own individual requirement. Similarly, some people whose actual requirement is above the average might have an energy consumption level above the requirement but below their own individual requirement. For estimating population prevalence, if these two groups are roughly the same size, the errors cancel each other out. Whether they are the same size is also a subject for future research.

After gathering data on calorie availability and requirement, food secure household is defined as the household which can meet requirement the requirement and food secure households are those which have availability below the requirement.