AGRICULTURAL ECONOMICS

Working Paper

A Diagnostic Study on Bangladesh Agriculture

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A DIAGNOSTIC STUDY ON BANGLADESH AGRICULTURE

RED, BRAC

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Acronyms and Abbreviations

ARIMA	Autoregressive Integrated Moving Average
B	Boron
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agriculture Research Council
BBS	Bangladesh Bureau of Statistics
BIDS	Bangladesh Institute of Development Studies
BIHS	Bangladesh Integrated Household Survey
BER	Bangladesh Economic Review
BR	Bangladesh Rice
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
CBC	Cross-breed Cow
CWU	Consumptive Water Use
DAE	Department of Agricultural Extension
DAP	Diammonium Phosphate
DFID	Department for International Development
DLS	Department of Livestock Services
DoF	Department of Fisheries
DRC	Domestic Resource Cost
DTWs	Deep Tube-wells
FAO	Food and Agriculture Organization of the United Nations
FCD	Flood control and drainage
FMTW	Force Mode Tube-wells
FPMU	Food Planning and Monitoring Unit
FTF	Feed the Future
FY	Financial Year
GAP	Good agricultural practices
GCA	Gross cropped Area
GDP	Gross Domestic Product
GIA	Gross Irrigated Area
GIS	Geographic Information System
GNP	Gross National Product
GoB	Government of Bangladesh
HYV	High Yielding Variety
HTW	Hand Tube Well
IRRI	International Rice Research Institute
Kg	Kilogram
LLP	Low Lift Pump
LPL	Low Poverty Line
LC	Local Cow
MDG	Millennium Development Goal
MFI	Micro-finance Institutions
Mha	Million Hectares

MLE	Maximum Likelihood Estimation
MMt	Million Metric Tonnes
MOA	Ministry of Agriculture
MOCHTA	Ministry of Chittagong Hill Tracts Affairs
MOF	Ministry of Food
MoF	Ministry of Finance
MoP	Muriate of Potash
MT	Metric Ton
MV	Modern Variety
NAEP	New Agricultural Extension Policy
NAP	National Agriculture Policy
NARS	National Agricultural Research System
NGO	Non-Government Organization
NMTPF	National Medium Term Priority Framework
N-P-K	Nitrogen-Phosphorous-Potash
OCI	Overall Composite Index
S	Sulphar
SFYP	Sixth Five Year Plan
SME	Small and Medium Enterprise
SRDI	Soil Resource Development Institute
SRR	Seed Replacement Rate
SSP	Single Super Phosphate
STW	Shallow Tube-wells
T	Transplanted
TFP	Total factor productivity
TE	Technical Efficiency
Zn	Zinc
WP	Water productivity

Executive Summary

Agriculture plays a dominant role in the growth and stability of the economy of Bangladesh and more than three quarters of the total population in rural areas derive their livelihood from the agricultural sector.

The overall objective of this study/report is to formulate development options for interventions to promote inclusive growth by promoting faster economic growth – transformational by moving from the present situation to one of high productivity and commercialisation. The specific objectives were to: (1) Assess the current productivity status of Bangladesh agriculture and its contribution to growth and poverty reduction. (2) Assess the structure of agriculture, its competitiveness, commercialization and value chain development. (3) Assess vulnerability in Bangladesh agriculture due to climate change and investment needs for adaptation and mitigation to agriculture. (4) To identify challenges of Bangladesh agriculture. (5) Suggest interventions for supporting sustainable agricultural development to promote poverty reduction, employment generation and enhance food security in Bangladesh.

The study method includes: (1) Data collection: this used a BRAC Survey data base of randomly selected households in 62 villages of 62 districts, so far surveyed four times (1988, 2000, 2008 and 2014). (2) Collection of secondary information from BBS, DAE, MOA, MOF, etc. and various on-line resources, etc. (3) Estimates based on different econometric models. (4) Analysis and synthesis of information and preparation of report.

The shifting rate of agricultural land to non-agricultural use is about 1% per year. Availability of agricultural land in Bangladesh is gradually declining. About 60 percent of farmers are functionally landless and depend on sharecropping of land owned by the others. Average farm sizes are very small to support a family adequately. The fertility status of Bangladesh soils is extremely variable. Most of the soils are depleted and in urgent need of replenishment with manure and fertilizer if productivity has to be enhanced. It is estimated that more than 100 kg nutrients per ha year are mining out from the soil system. The fertilizer policy of Bangladesh evolved from a heavily subsidized public centralized distribution system to a market oriented one over time, in order to popularize and enhance fertilizer use in the country. There was sharply increasing trend in the use of fertilizer during 1981-2008. As a result of a policy shift towards privatization of irrigation equipment, STWs under private ownership played a significant role for irrigation development during 1980s. The agricultural growth in the country has been largely due to expansion of minor irrigation. There is a sharp increasing trend in the growth of irrigation in Bangladesh during 1982 to 2012. The seed policy of Bangladesh has evolved over time. In the post green revolution period (1960-80s) there was heavy subsidization of seed and public sector role played in the seed market through BADC. During the 1990s to 2000s, the seed market has been liberalized and the market opened for participation. The objective of the agricultural credit policy of the Bangladesh Bank is to ensure easy access to agricultural and rural credit facilities from the scheduled banks of the country. There is an increasing trend in disbursement of agricultural credit during 2005-12, but the demand is much more than that met by institutional sources.

The production of main staple, rice, has a long term growth trend of 2.8 percent per annum over the period from 1981/82 to 2011/12.TFP of milk production of both Cross-breed Cows (CBC) and

Local Cows (LC) has been estimated and found that there is an increasing trend in the TFP of milk production for both CBC and LC. During the period 2003-04 to 2013-14 total fisheries production in Bangladesh has shown a sharp increase from about 20 lakh MT to 35 lakh MT. During this period, a structural change has been taken in the composition of the country's total fisheries production from its three sources – inland capture, inland culture and marine.

Changes in aggregate GDP have been analysed in terms of main components: changes in growth within sectors, and intra-sectoral resource shifts or reallocation effect (structural transformation). It was revealed by the results of the decomposition that agriculture played an important positive role in driving the overall GDP growth of Bangladesh. The contribution of agriculture in overall growth was 2% during the period 1999-2014 while the leading role in overall growth was played by industry (2.6%). The contribution of the service sector to overall growth was at a smaller rate (0.95%). The reallocation effect was also at a smaller rate (1.2%).

Land is the main source of livelihood in rural Bangladesh. It was found that the proportion of both medium and large farmers have both rapidly gone down since 1988. Households owning up to three bighas of land (up to 0.4 ha) constitute about 70 per cent of all households but control only 20 per cent of the total land. As opposed to this, only four per cent of households (with 15 bigha or 2 ha and above land) controls about one-third of the land The average size of owned land stood at 0.61 ha in 1988 and significantly declined over time to peak at 0.48 ha in 2007 - a decline of 21 per cent over the last two decades and further decreased to 0.39 ha in 2014. It was observed that, as with farm size, the proportion of the marginal farmers (owning up to 0.40 ha) has risen from about 21 per cent in 1988 to 24 per cent in 2008 and further increased to 28 per cent in 2014. At the same time, the amount of land under their command almost tripled. The group we identify as functionally landless with tiny farm holdings – comprising 33-35 per cent of all farmers – have also been commanding more land over time. By and large, marginal and small farm households now cultivate more than four-fifths of the total land in rural areas. We observed that the dominance of the share-cropping system in the tenancy market has dwindled over time, and the contributions of other tenancy arrangements have been growing.

Despite modern technology, roughly 40 percent of the cultivated land continues to be single cropped. Quite expectedly, it is the large and medium farms who have more single cropped land than small farms. The database shows that in 62 districts the yield rate in terms of paddy has substantially risen over time. The yield from boro is estimated to be about 6 tons/ha – about twice the yield of 2000, and the yield of MV aman has increased from 3.3 to 3.8 tons/ha over same period of time. The case of the aus yield is similar. The yield of maize increased from barely 1 ton/ha to about 8 tons/ha, which could be contributing to the increased area under maize, and the reduction of the areas of wheat and other crops.

During the last two decades and a half, important changes occurred in the realm of rice production and profitability. First, the cost of producing rice is several times higher than potato but the rate of profit is more than double for potato. Second, the yield of wheat, jute and potato has increased over time but the yield of rice has almost doubled from 2.16 t/ha in 1988 to 3.7 t/ha in 2000 and about 4.6 t/ha in 2014. TVs have gone down from 46 percent of total cultivated land in 1988 to 24 percent in 2000 and further to only 14 percent in 2014. Third, the yield of MVs has increased partly due to adoption of higher yielding varieties and partly (possibly more importantly also) due to better crop management.

The labour use per hectare has reduced from 164 days in 1988 to 132 days in 2000 and 99 days in 2014. The use of hired labour, however, remained at 50 percent of the total labour; the use of hired labour by small holders and tenants has grown over time. Apparently the fall in labour demand was fuelled by the spread of mechanization in land preparation and threshing. 90 percent of the farmers in Bangladesh now use machines compared to 60 percent in 2000, and almost none in 1988. During this period, the cost of machine rental has increased five times – indicating the pressure from the demand side.

Bangladesh has a comparative advantage of production for pulse, potato, onion, maize, vegetables, chili and garlic, for both the owner operators and share croppers. So, there is good scope for crop diversification. Sugarcane, however, has a comparative advantage for import substitution only for the owner operators. While looking at the export possibility, it was observed that Bangladesh has a comparative advantage in export of oil seeds, potato, onion, maize, vegetables and chili for the owner operators and it has a comparative advantage for potato, onion, maize, vegetables and chili for the share croppers. The analysis of comparative advantage carried out suggests that the menu of crops that Bangladesh can produce efficiently either for import substitution or for export is quite large.

Current climate change issues are considerably affecting food security of the millions of people of Bangladesh as the country is one of the countries most vulnerable to climate risks. In Bangladesh, damage caused by natural disasters is one of the main sources of crisis for poor households. Every year, natural calamities such as floods, cyclones, erosion, and droughts cause extensive damage to crops, homes, household and community assets, which can lead to illness or death and a decrease in livelihood opportunities for the poor. Disasters hamper physical access to food and food stocks, destroy crops, disrupt markets and affect household food security.

Climate change will diminish rainfall in the dry season and will increase winter and pre-monsoon temperatures significantly, causing more frequent and more severe droughts in Bangladesh. Some part of the Northern region and some part of the hill region will experience moderate drought during the Rabi and Pre-Kharif season (November to February) by 2030.

The major challenges related to agriculture and food security in Bangladesh are: (1) The curse of poverty, food insecurity and malnutrition. (2) Degradation of natural recourses, (3) Low agricultural productivity and limited modernization and/or diversification, (4) Weak research extension linkage and technology delivery, (5) High post harvest losses, (6) Problems of market linkages and value chains, (7) Scarcity of availability of agricultural labour, (8) Farm mechanization, (10) Food quality and safety problem, (11) Inadequate institutional credit, (12) Inadequate availability of quality seeds to the farmers, (12) Increased environmental shocks and livelihood risk. The development options or interventions suggested are: (1) Technology development and dissemination, (2) Improved water resource management and irrigation, (3) Crop diversification, (4) Sustainable supply and use of improved quality of inputs, (5) Farm mechanization, (6) Improving market linkages and development of value chains, (7) Livelihood improvement and food security, (8) Interventions for climate change adaptation and (10) Improved land management.

Chapter 1

Introduction

Chapter Summary: *The overall objective of this study/report is to formulate development options for interventions to promote inclusive growth by promoting faster economic growth – transformational by moving from the present situation to one of high productivity and commercialisation. The specific objectives were to: (1) Assess the current productivity status of Bangladesh agriculture and its contribution to growth and poverty reduction. (2) Assess the structure of agriculture, its competitiveness, commercialization and value chain development. (3) Assess vulnerability in Bangladesh agriculture due to climate change and investment needs for adaptation and mitigation to agriculture. (4) To identify challenges of Bangladesh agriculture. (5) Suggest interventions for supporting sustainable agricultural development to promote poverty reduction, employment generation and enhance food security in Bangladesh.*

The study method includes: (1) Data collection: this used a BRAC Survey data base of randomly selected households in 62 villages of 62 districts, so far surveyed four times (1988, 2000, 2008 and 2014). (2) Collection of secondary information from BBS, DAE, MOA, MOF, etc. and various on-line resources, etc. (3) Estimates based on different econometric models. (4) Analysis and synthesis of information and preparation of report.

1.1 Background

Bangladesh has an area of about 50,000 square miles of which about 22.3 million acres (69 percent of total land area) are cultivated land. Agriculture plays a dominant role in the growth and stability of the economy of Bangladesh. More than three quarters of the total population in rural areas derive their livelihood from the agricultural sector. About 48 percent of the labour force is still employed in Agriculture.

During the recent decade, the overall Gross Domestic Product (GDP) of Bangladesh has shown a considerably increasing trend. But the growth in agricultural GDP slightly declined, with an average growth of about 3.4% during 1997 to 2014. Agriculture being an important engine of growth of the economy, there is no other alternative but to develop the agriculture sector for the alleviation of poverty by attaining accelerated economic growth. Since achievement of food security, and generation of employment opportunities of the huge population of the country are directly linked to the development of agriculture, there have been continued efforts by the Government for the overall development of this sector.

There is continuous transformation of Bangladesh's economy as measured by changes in the sectoral shares of Gross Domestic Product (GDP). This structural change clearly indicates a rapid movement away from an agriculture-dominated economy. Agriculture's share of GDP declined from 62 percent in 1975 to 19 percent in 2013, but agriculture's share of total employment has not declined as much. The declining share of agriculture in GDP should not be construed to reflect a diminishing role of agriculture in the overall growth of the economy or in poverty reduction. Notably, the service sector has expanded at a rapid pace at this stage of economic transformation.

Much of the growth in the services sector relates to the marketing and processing of agricultural products resulting from rapid commercialization and diversification in agriculture.

The agriculture sector is dynamic, changing with demand of the people, availability of technology and change of management practices. Thus, it requires regular adjustment with different planning and development programmes. The country has much potential, yet it faces many challenges including vulnerability to climate change. For planning and sustainable development purposes, a diagnostic study of Bangladesh Agriculture is required in order to foster growth of this important sector harmonizing with the management of natural resources and addressing the challenges.

1.2 Objectives of the study

The overall objective of this study is to formulate development options for interventions to promote inclusive growth by promoting faster economic growth – transformational by moving from the present situation to one of high productivity and commercialization.

The specific objectives of the diagnostic study are to:

- Assess the current productivity status of Bangladesh agriculture and its contribution to growth and poverty reduction.
- Assess the structure of agriculture, its competitiveness, commercialisation and value chain development.
- Assess the vulnerability in Bangladesh agriculture due to climate change and investment needs for adaptation and mitigation in agriculture.
- Identify challenges in Bangladesh agriculture and suggest interventions for supporting sustainable agricultural development to promote poverty reduction, employment generation and enhance food security in Bangladesh.

1.3 Method

The method used includes:

- MH/BRAC Survey data base of randomly selected households in 62 villages of 62 districts, which have so far been surveyed in four rounds (1988, 2000, 2008 and 2014). This helped the generation of longitudinal panel data at household level to serve as the most credible and confident source of statistics. The 2014 data base - generated by BRAC funding - could be construed as the most recent representation of the national situation on any rural indicator.
- Review of relevant policy and planning documents - Sixth Five Year Plan, Agriculture Policy, Livestock and Fisheries Policy, Food Policy, Input Policy, Irrigation and Land Use Policy, etc.
- Collection of secondary information from BBS, DAE, MOA, MOF, etc. and various on-line resources, etc.
- Analysis and synthesis: different econometric models have been used for estimation and a description of underlying models and estimation techniques have been stated in the Annex related to a respective chapter.
- Report preparation.

Chapter 2

Natural Resources, Agricultural Productivity and Drivers

Chapter Summary:

Land use pattern: *The shifting rate of agricultural land to non-agricultural use is about 1% per year. Availability of agricultural land in Bangladesh is gradually declining. About 60 percent of farmers are functionally landless and depend on sharecropping land owned by others. Average farm sizes are very small to support a family adequately. Apart from sharecroppers, approximately 20 percent of farmers are regarded as marginal. Agricultural and particularly crop cultivation takes place in millions of tiny-to-small farms, operating no more than 2.5 acres of land. Such smallholders account for 88 percent of farms and 60 percent of all operated land. Large farmers, with operational holdings 7.5 acres or above, accounted for 1.2 percent of farms and 10 percent of area*

Soil fertility status: *The fertility status of Bangladesh soils is extremely variable. Most of the soils are depleted and in urgent need of replenishment with manure and fertilizer if productivity has to be enhanced. It is estimated that more than 100 kg nutrients per ha year are being mined out from the soil system. Balanced fertilization is the key to successful crop production and maintenance of good soil health.*

Growth in fertilizer use: *The fertilizer policy of Bangladesh evolved from a heavily subsidized public centralized distribution system to a market oriented one over time, in order to popularize and enhance fertilizer use in the country. There was a sharply increasing trend in the use of fertilizer during 1981-2008. During 1963 to 1979, total fertilizer use increased dramatically with a growth rate of 16.5% per annum. Thereafter, the growth rate of urea declined. During 2004-12 the growth rate of TSP and MoP sharply increased due to having government subsidy on these two fertilizers. Still there exists a gap between the actual and recommended dose for crops.*

Growth of irrigation: *As a result of a policy shift towards privatization of irrigation equipment, STWs under private ownership played a significant role for irrigation development during 1980s. The agricultural growth in the country has been largely due to expansion of minor irrigation. There is a sharp increasing trend in the growth of irrigation in Bangladesh during 1982 to 2012. In 2012, the national irrigation coverage was 6.5 million hectares which is 77.6% of the total cultivable land, where groundwater covered 65.4% and surface water covered 34.6% of the total irrigated area. A projection has been made on irrigation Consumptive Water Use (CWU) demand to 2020 and 2030: (under the scenario of area expansion and surplus rice production. the irrigation CWU demand for rice will be 27% and 48% higher from the 2010 level, respectively. It will be difficult to exploit groundwater resources sustainably to meet projected water demand. So, it is necessary to use water saving technology, enhance water use efficiency and water productivity.*

Growth in supply of HYV seed: *The seed policy of Bangladesh has evolved over time. In the post green revolution period (1960-80s) there was heavy subsidization of seed and the public sector played a role in the seed market through BADC. During the 1990s to 2000s, the seed market has* *been liberalized and the market opened for participation. This period also saw the rise of private enterprises in seed production, import, and distribution.*

Growth in agricultural credit: *Agricultural credit, as an input, plays an important role in driving the agriculture of Bangladesh towards a sustainable level. The objective of the agricultural credit policy of the Bangladesh Bank is to ensure easy access to agricultural and rural credit facilities from the scheduled banks of the country. There is an increasing trend in disbursement of agricultural credit during 2005-12.*

Productivity growth in agriculture

Varietal improvement and improvement of production practices developed by the National Agricultural Research System (NARS) institutes are disseminated to the farmers through the extension department and NGOs. Crop agriculture is dominated by rice cultivation, and crop diversification is still limited. The production of the main staple, rice, has a long term growth trend of 2.8 percent per annum over the period from 1981/82 to 2011/12.

TFP of milk production of both Cross-breed Cows (CBC) and Local Cows (LC) has been estimated and found that there is an increasing trend in the TFP of milk production for both CBC and LC.

During the period 2003-04 to 2013-14 total fisheries production in Bangladesh has shown a sharp increase from about 20 lakh MT to 35 lakh MT. During this period, a structural change has been taken in the composition of the country's total fisheries production from its three sources – inland capture, inland culture and marine.

Obstacles to be addressed by Government:

Improved pricing policy, along with investments in awareness-raising for balanced fertilizer application and popularization of more efficient fertilizer application techniques, can help preserve soil quality, raise output, lower costs of production, and save the government budget huge amounts of money.

Given the declining groundwater tables and water quality issues in Bangladesh, it will be extremely difficult to exploit groundwater resources sustainably without an increase in Water Productivity and it will be difficult to meet even reduced demand. A few districts have already passed the sustainable thresholds of groundwater use.

Agricultural growth is dependent on a very wide-scale switch to HYV seed, but seed quality in general remains a major problem. Various related investments are needed to enhance provision of quality seeds in adequate quantities. Further private-public partnerships for seed, marketing, and extension need to be explored.

Besides a few government projects with a credit component, public sector credit agencies are characterized by numerous impediments to access by farmers and especially women. As total demand for credit far outweighs its supply, private moneylenders dominate the credit market. Poor farmers have little choice. This requires major reform.

In meeting the demand for higher food production, thrust should be given to frontier research including genetic engineering, reduction of cultivation costs, strengthening of the technology-transfer linkage, and improvement of postharvest technology.

Agricultural land in Bangladesh is shrinking fast. The option left for increasing productivity is through minimizing the yield gap. This could produce 37.6 million tons of rice production by the year 2021 from the existing rice area.

To support the poor fisherman's livelihood from water bodies, a licensing system should be introduced for the genuine fishermen. Other problems confronting the development of open water fishery are overfishing, lack of proper implementation of fisheries regulations, lack of awareness development and non participation of the community, conflict of water uses, environmental pollution and habitat degradation.

Currently the shrimp sector is facing a number of problems which need to be addressed. These include: land use conflicts among the various user groups and agencies and resistance to large scale forced leasing; social opposition to the environmental effects of large scale bagda monoculture; lack of proper pond engineering design and management; diseases; quality control and post harvest technology; inadequate infrastructure and financial facilities; lack of technical knowledge and skill; lack of resources information and non compliance.

Natural resources

Natural resource refers to resources such as land, water, forest, fishery and the climate in which these belong. Many of them are essential for our survival while others are used for satisfying our needs. Natural resources may be further classified on the basis of origin, and may be divided into: *abiotic* – these are the resources that comprise of non-living things. Examples include land, water, climate etc., and *biotic* – these are the resources that are obtained from the biosphere, such as forests, livestock and fisheries. Natural resource management focuses on how management of the resources affects the quality of life for both present and future generations. Natural resource management is congruent with the concept of sustainable development, a scientific principle that forms a basis for sustainable land management and environmental governance to use, conserve and preserve natural resources for human development. As agriculture is the dominant sector of the economy, land enjoys the highest importance as a resource.

2.1.1 Land resources

Total land area of Bangladesh is about 14.8 million hectares, of which net cropped land is 7.8 million ha. (59%), 17 percent is forest area, and 25 percent is not available for cultivation (Table 2.1). Bangladesh has about 160 million people and the best available forecast indicates that the total population could be as much as 250 million in 2050, indicating more people to share the area for survival. Agriculture plays a major role in the livelihoods of rural households, in securing national food self-sufficiency and in the country's overall economic development. The dominant influence on agricultural activity in Bangladesh is its location at the basin of several major rivers.

Besides explaining the high fertility of land, it gives a unique dynamic system: alluvial land is gained and lost through river bank accretion and erosion. As a result, total cultivable area varies over the years.

Land availability and land use pattern: Agricultural land is an important natural resource. Over the last 30-40 years, the availability of agricultural land has been declining at the rate of 1% per year (UNDP 2003), and at least one quarter of the country's agricultural land has been lost over the last 30-40 years. The Bangladesh Bureau of Statistics (BBS), shows that between 1971-72 and 2010-11, the net cropped area decreased by 4.9% (i.e. from 20,371 to 19,368 thousand acres) which represents an annual average decline of about 0.5%. It was found that cropped land has declined about 2.64% during 1982 to 2005, and according to the agricultural census 2008, this decline was about 2% per annum during 2001-08. On average, Bangladesh is losing good quality agricultural land by approximately 79,000 ha annually due to urbanization, building of new infrastructure such as roads, and implementation of other development projects. Fig. 2.1 presents trends in land use pattern in Bangladesh during 1971-2011.

In a densely populated country such as Bangladesh, which is already experiencing high pressure on its natural resource base, a decline in the availability of agricultural land could have devastating consequences on the country’s ability to achieve and maintain self-sufficiency targets sustainably, as well as to guarantee food security and availability. Per capita availability of land for agricultural production is currently about 0.06 hectares.

Table 2.1: Current Land use in Bangladesh

Land Use type	**’000 ha**	**%**
Total land area	14,846	100
Net cropped land	7,841	53
Forest	2,578	17
Not Available for Cultivation	3,740	25
Cultivable Waste	219	1
Fallow Land	467	3

Sources: BBS (2011)

Land and soil Erosion: Water erosion accounts for about 40 percent of land degradation, due to washing away of topsoil and depositing sand on the croplands from upstream. River bank erosion and siltation of channels are chronic concerns for Bangladesh. About 1,200 kilometers of riverbank are eroding and more than 5,000 kilometers of river bank face erosion-related problems in the country. The major rivers such as the Jamuna, Ganges and Padma have eroded several thousand hectares of floodplain, making thousands of people landless and homeless every year. During the last three decades the Jamuna, Ganges and Padma rivers have eroded about 180,000 ha. (BWDB 2009). This amount excludes the annual erosion along the other major rivers and also in the Meghna estuary where the amount of erosion is very high. From the 1970s to early the 1990s, the extent of mean annual erosion was about 3,300 hectares along both banks of the Jamuna River only. The Flood Action Plan, Bangladesh predicts a net erosion loss in the Brahmaputra-Jamuna basin of 34,120 hectares of "mainland" acreage for the period 1992-2011, an area similar to what had eroded in the 12 years previous to that time (MPO 1987). Similar rates of net loss in land due to erosion are expected in the other three main rivers. The river bank erosion is expected to increase further with the rise of water flow in the rivers due to global temperature rise and increased ice melting in the Himalayas. Given the geo-morphological development of the rivers and the prevailing socio-economic context of Bangladesh, it would not be feasible to protect the river banks fully from erosion. Non-structural measures, such as prediction of erosion when and where applicable and educating people how to mitigate could be alternatives to minimize the suffering of the people.

Land Accretion**:** The average sediment load that passes through Bangladesh to the sea is huge, about 1–3 billion tons a year (BWDB 2009). A part of this is deposited on the flood plains, gradually changing their topography and accreting new land (called char lands) within and adjacent to the estuary of the major rivers. These lands are frequently subject to erosion. Active floodplains, i.e. char lands and adjoining bank lines, account for about six percent of the total land area of the country and support four percent of the total population. However, land use and land tenure in these areas is transitory due the nature and productivity of the land. Char lands often have lower economic productivity due to a high sand content in the soil base. Similarly, lower agricultural productivity in the char lands relative to similar areas outside the active floodplain reflects not only soil conditions, but is also due to uncertainties of erosion, and frequent flood damage. This indicates that the annual rate of accretion is about 4,656 ha, the rate of erosion is about 7,978 ha and net loss of agricultural land due to erosion is about 3,300 ha. (ISPAN 1993). Riverbank protection measures and dredging the riverbed may increase the water flow capacity in the summer and development of plantation in the char lands may stabilise newly accreted lands, although it provides no protection against bank erosion.

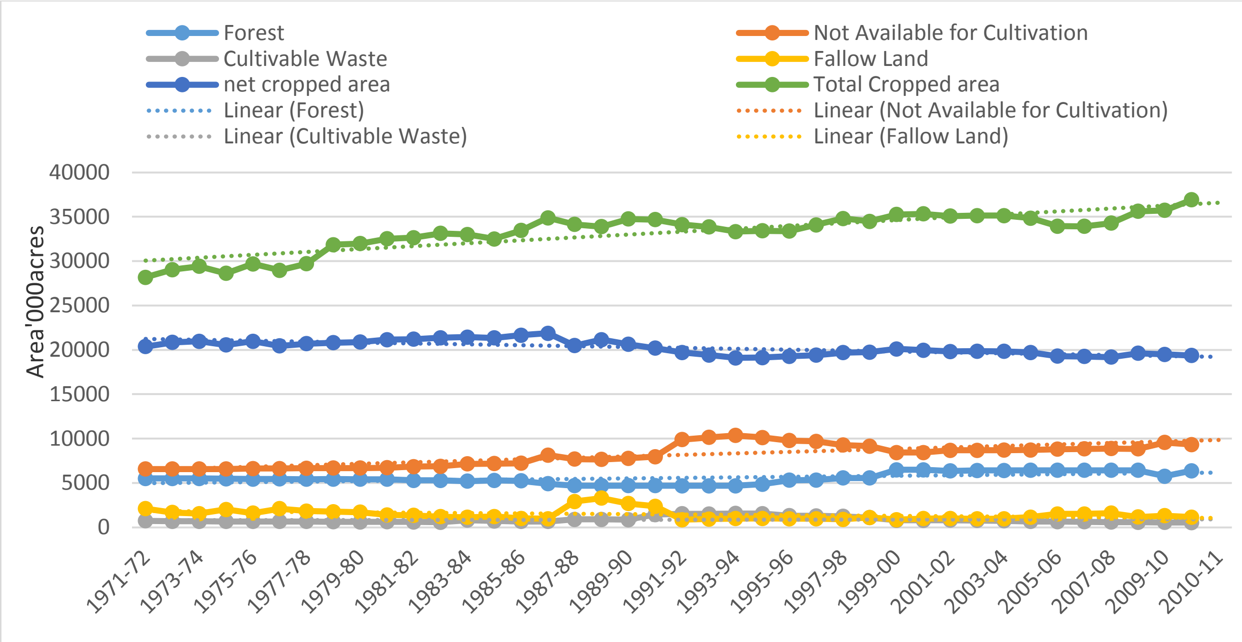
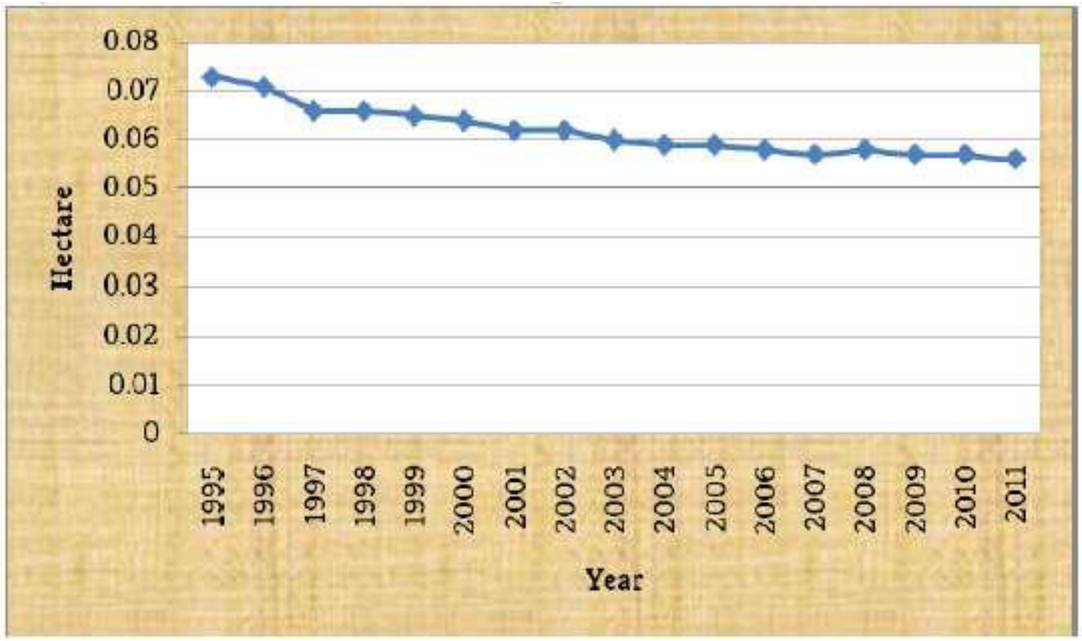


Figure 2.1: Trend of land use pattern of Bangladesh (1971-2011)

Figure 2.2: Trend of Loss in the Availability of Net Cultivable Land

Source: Ministry of Agriculture, 2013

Figure 2.3: Trend of Loss in Per Capita Cultivable Land



Source: Authors' calculation based on Ministry of Agriculture, 2013 and
World Bank 2013

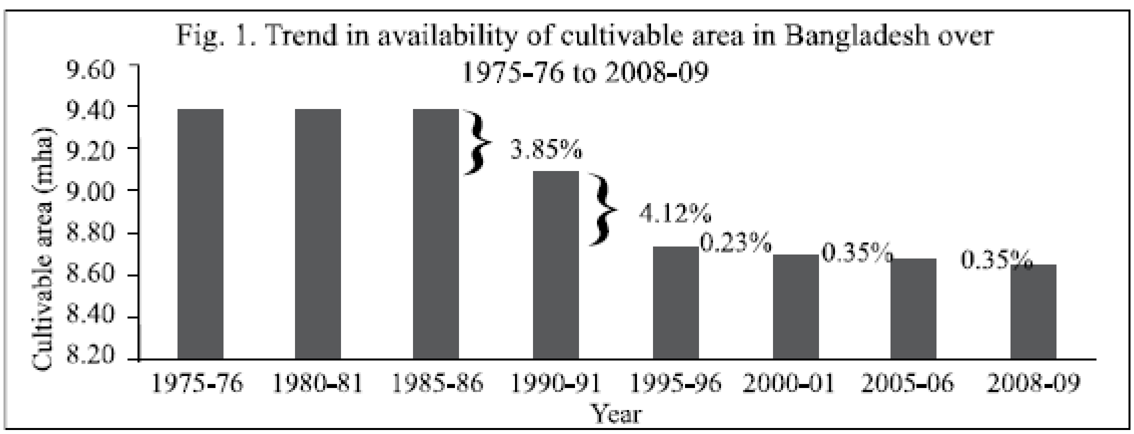


Fig 2.3 Trend of availability of cultivable land area in Bangladesh

The land use pattern of a country reflects its socio-economic conditions. While land use changes are sources of concern in the perspective of the socio-economic changes of a country, the pattern of change in Bangladesh is to meet the dynamic demand of the society that creates pressure on the natural environment.

The agriculture of Bangladesh is however constrained by a number of challenges every year. Major challenges include: loss of arable land, climate changes, inadequate management practices (Fertilizer, Water, and Pests & Diseases), inadequate investment and an inefficient marketing system. Another major challenge affecting agriculture is the increase in the growth of population.

The population growth rate, at present, stands at 1.26% (BER, 2008-2009). Population is increasing at 2 million per year and the total population would be around 233 million by 2050 if the current growth rate continues. Such a growth rate in a country of 143,000 sq. km. is viewed as a great challenge not only to different economic development activities but also as a crisis for accommodation, environment and meeting other basic needs (food, education, and health). Despite the fact that agricultural growth has been higher than the rate of population growth (MoA 2004), concerns have been raised whether the land mass of Bangladesh is actually capable of supporting its ever expanding population. It is highly imperative that the twin problem of arable land loss and population growth are addressed simultaneously to ensure increased and sustained production and thereby food security. Against this backdrop, it is pertinent to investigate the driving forces of arable land loss, low productivity and possible ways and means of coping with the situation. Besides this, crop agriculture in Bangladesh has become regularly vulnerable to the hazards of climate change - flood, drought, and salinity in particular.

Land ownership and Sharecropping**:** Agriculture and particularly crop cultivation takes place in millions of tiny-to-small farms, operating no more than 2.5 acres of land. Such smallholders account for 88 percent of farms and 60 percent of all operated land. Large farmers, with operational holdings of 7.5 acres or above, accounted for 1.2 percent of farms and 10 percent of area. With access to land so limited, there is fierce competition for land. There is an active market for share-cropping in and out as well as renting land in and out. In general, however, most farmers operate what they own, or rent from others to supplement their own land. It is estimated that 10 percent of farmers in Bangladesh own 50 percent of the land (BBS, 2009). About 60 percent of farmers are functionally landless and depend on sharecropping of land owned by others.

Average farm sizes are very small to support a family adequately. Apart from sharecroppers, approximately 20 percent of farmers are regarded as marginal and are regarded as viable. The country's resource base, notably agricultural land, is stretched to the limit. Several past attempts at redistributive land reforms ended in failure. Other attempts, such as distribution of *khas* (government owned) land, apparently had only limited success, since most such lands are under the control of influential local people (predictable in a country with huge population and limited land area). Nevertheless, any investment in agriculture must help the smallholders, or all efforts to raise production will be in vain.

While population is still growing at a rate of 1.6%, a slower pace than in the previous decades, however, there is fierce competition for land. Non-farm employment is creating opportunities but not fast enough to ease pressure on the land. Sharecropping has good effects in terms of cultivation and agricultural production; however, it has an adverse effect on soil productivity. Most sharecroppers do not use the proper doses of fertiliser, appropriate crop rotation, or organic manure, due to a seasonal or annual contract arrangement and want to get as much benefit as possible from the land within the contract period. As a result, soil fertility has been declining with an adverse impact on soil productivity.

2.2 Drivers of agricultural productivity

2.2.1 Soil fertility status

Thirty agro ecological zones and 88 sub zones of Bangladesh have been identified by adding successive layers of information on the physical environment, which are relevant for land use, and assessing agricultural potential (BARC/GIS Data System 2000). These layers are:

- Physiographic (land forms and parent materials)
- Soils and their characteristics
- Depth and duration of seasonal flooding
- Length of the rained kharif and rabi growing periods
- Length of the pre-kharif period of unreliable rainfall
- Length of the cool winter period and frequency of occurrence of extremely low winter temperature.
- Frequency of occurrence of extremely high (> 40˚C) summer temperature.

Agro ecological zones and sub zones are very broad units. Fertility status and agricultural productivity of these regions varies considerably. Individual farmers have fragmented the land into small pieces causing wide variation in the management of each piece of land. This leads to the large variation in the fertility levels even between adjacent plots.

Although Bangladesh is a small country, it has a wide variety of soils. The fertility status of Bangladesh soils is extremely variable. Most of the soils are depleted and in urgent need of replenishment with manure and fertiliser if productivity is to be enhanced It is estimated that more than 100 kg nutrients per ha year are leaching out of the soil system.

Although Bangladesh is a small country, it has a wide variety and complexity of soils at short distances due to the diverse nature of physiographic conditions, parent materials, land, and hydrology and drainage conditions. Due to intensive cropping to grow more food, continuous changes are taking place in the soil fertility status due to organic matter depletion, nutrient deficiencies, drainage impedance/water logging followed by degradation of soil physical and chemical properties as well as soil salinity/acidity. The fertility status of Bangladesh soils is extremely variable. Most of the soils are depleted and are in urgent need of replenishment with organic matter and fertilizers in order to enhance crop productivity.

Nitrogen deficiency in soils: All the agricultural soils are critically deficient in soil nitrogen content and deficiency of micro nutrients are also limiting crop production. But the extent of deficiency varies geographically depending on the extent of land use and the nature of parent materials. The main reasons for such deficiency are:

- Intense decomposition of organic matter
- Rapid removal of mineralized products under high leaching conditions and crop removal.

Nitrogen, being the most important nutrient element in soils, plays the most vital role in crop production in Bangladesh. Responses of modern rice to applied nitrogen have been studied extensively throughout the country by a series of fertility trials. The average yield increase due to fertilizer N varies from 30% to 75%. In some cases, without application of nitrogen fertilizer modern rice showed almost complete failure, whilst application of 100 kg N/ha along with other nutrients resulted in a very successful crop yielding 6-7 t/ha.

Phosphorus deficiency in soils: Phosphorus is the second most important nutrient element limiting successful crop production. It becomes unavailable or fixed in the soils through a variety of ways. In acidic terrace and brown hill soils, phosphorus is largely fixed by iron and aluminum oxides at low pH, while in calcareous soils, fixation occurs by calcium-magnesium carbonates. The net result of fixation is a decrease in the immediate availability of native and applied phosphorus.

Potassium deficiency in soils: Potassium is the third major plant nutrient recently identified as deficient in most Bangladesh soils. The previous idea about the sufficiency of potassium in Bangladesh soils might be true for local crop varieties with low yield potentials. 1 ton wheat/ha or 2 ton rice/ha can be obtained from soils where K would be a continuous limiting factor without K fertilisers. Crop intensification with high yielding and hybrid varieties has shown widespread deficiency of potassium in Bangladesh soils. It has been recorded that a 5 ton/ha rice crop will remove more than 110 kg K which is to be made available to plants in less than 3 months' time and many of our old and highly weathered soils may not have the potential to supply K at this rate.

Sulphur deficiency in soils: Sulphur has been recognized as the fourth major nutrient limiting crop production as early as 1980. In the past very little attention was paid to this nutrient until 1977 when sulphur deficiency in wetland rice was first detected at the Bangladesh Rice Research Institute (BRRI) farm and on nearby farmers' fields. Since then sulphur deficiency in Bangladesh soils is becoming widespread and acute. It has been reported that a variable amount of available S in soil ranging from as low as 2μg g^{-1} soil to as high as 75 mg g^{-1} is available. The use of high analysis fertilizers such as urea, triple super phosphate, muriate of potash and diammonium phosphate, cultivation of modern varieties, increasing cropping intensities and limited application of organic manure have all contributed to the intensification of the S deficiency problem in Bangladesh soils. The problem is more severe in wetland rice than in upland crops as anaerobic conditions, under which rice is grown, reduces sulphate and makes it unavailable to plants.

Soil degradation and necessity of balanced fertilization**:** Soil degradation is common in Bangladesh, whether man made (for example, through unbalanced use of fertilizers) or due to natural factors (salinity ingress in coastal areas, or landslides on hilly terrain). Estimates by the Bangladesh Agricultural Research Council (BARC) indicate that problem soils may be a major constraint to agricultural growth. Organic matter depletion is observed in 7.5 million ha of land. Declining soil fertility, soil erosion, and salinisation, affect respectively 5.6–8.7 million ha, 5.3 million ha and 3.05 million ha of land.

Saline intrusion from sea water in coastal areas, compounded by tidal surges, adversely affects life, property, ecology and agricultural production in those areas. The problem is intensified by the effect of global climate change and more areas being degraded by salinity**.** Karim (2009), mentioning the Soil Research Development Institute **(**SRDI) data showed that over 1,030,000 ha of lands were saline in 2000, which is about 20% more than the saline area in 1973 (833,000 ha). This indicates that the saline area has been increasing in the country over the three decades and will continue in the coming years with sea level rise due to climate change. During the monsoon, about 12% of the total area is under high salinity levels which increases to 29% during the dry season. The increased salinity level would limit the cultivation of many crops in coastal areas.

It is estimated that some 2 million metric tons of nutrients are removed from Bangladesh soils annually. Unless compensated through balanced application of nutrients every year, the fertility of land is expected to decline and so will its productivity. One estimate puts the cost of land degradation as 3 percent of crop output or 1 percent of crop GDP every year (BIDS 2004).

Balanced fertilization is the key to enhancing crop productivity and maintenance of good soil health. It is important to see how close nutrient addition and removal by crops match with each other. According to a study by Karim, 2010, the farmers of Bangladesh use 215 kg nutrients (N: 149 kg, P^2O^5: 37 kg, K^2O: 22 kg and S + Zn + B + others: 7kg per ha/year from chemical fertilizers, against the estimated removal of around 300 - 400 kg/ha. From organic and natural sources about 50-70 kg nutrients are added to the soil system every year. One nutrient balance study made by DAE-SFFP (2002) from a typical Boro - Fallow - T. Aman cropping pattern (10 ton grain yield) is shown Table 2.2. It is quite evident from the study that severe leaching of N and K are going on in the country's soil system. That is why the productivity of the soils is low and decline in crop yields has been recorded in many areas. Apart from the natural factors, a major reason is unbalanced use of fertiliser—a reflection of the historical legacy of the low relative price of urea compared to non-urea fertilizers. Pricing policy, along with investments in awareness-raising for balanced fertilizer application and popularization of more efficient fertilizer application techniques, can help preserve soil quality, raise output, lower costs of production, and save the government budget huge amounts of money.

Table 2.2: Nutrient depletion due to rice cultivation

Nutrition dynamics	N(kg/ha)	P(kg/ha)	K(kg/ha)
Nutrient uptake cropping pattern	180	27	180
Leaching losses from: Soil Fertilizer	 12 17	 - -	 6 -
Erosion	12	2	12
Gaseous losses	24	-	-
N fertilizer	68		
Total output	**313**	**29**	**198**
Fertilizer	170	25	75
Organic manure (5t/ha)	20	12	24
Incorporated crop residue	25	3	25
Non-symbiotic fixation	10	-	-
Atmospheric fixation	8	1	2
Sedimentation/weathering	-	2	10
Irrigation water	2	6	21
Total input	**235**	**49**	**157**
Balance	**-78**	**20**	**-41**

Figure 2.4: Organic Matter Status of Bangladesh Soil

Fertiliser recommendation for single crops and cropping patterns are usually made by following the guidelines clearly stated in “The National Fertiliser Recommendation Guide” which is revised and published from time to time by the Bangladesh Agricultural Research Council in consultation with NARS scientists engaged in soil fertility and fertiliser management research activities. The Upazila Soil Use Guide published and updated by SRDI from time to time is also a useful guide for site-specific fertilizer recommendation. Research on site-specific N management using a leaf colour chart in Bangladesh is in progress at the Bangladesh Rice Research Institute.

2.2.2 Fertiliser use in Bangladesh agriculture

Increase in food production and attaining self-sufficiency in Bangladesh requires sustainable growth of the agricultural sector in order to provide food for her increasing population. Fertiliser is considered to be one of the main inputs for increasing crop yields and farm profit. But balanced fertilisation is the key to efficient fertiliser use for sustainable high yields. Bangladesh has virtually no possibility of increasing its cultivable land area. Therefore, food production of this country can be increased through increasing irrigation facilities together with expansion of HYVs and balanced use of fertiliser. Besides, well-timed supply and availability of fertiliser should receive top priority to sustain/increase crop production in Bangladesh.

The use of chemical fertiliser started in the country in 1951 with the import of 2,698 tons of ammonium sulphate, phosphates in 1957 and muriate of potash in 1960. Then, in 1965, the Government launched a 'Grow More Food' campaign and provided fertilisers and low lift pumps (LLP) at a highly subsidised rate with pesticides free of cost to popularise these inputs among the farmers and meet the country's food shortage. Thus, fertiliser consumption began to increase rapidly with the introduction of HYV rice (i.e. IR5 and IR8) and LLP use.

There has been a progressive shift in fertiliser policies in Bangladesh towards privatisation, deregulation, and a reduction of subsidies, which began in the mid-1980s and continued until the mid 1990s. This was partially reversed following the severe fertiliser crisis in 1995. During the global food price crisis in 2007-08 public sector roles were further strengthened towards market intervention and providing subsidy of fertilisers for achieving self-sufficiency and food security. Table 2.3 presents a brief description of the evolution of the fertilizer policy in Bangladesh until the first decade of the 21st century.

Table 2.3 Summary of Transformation Process of Fertilizer Policy/Regulation

Period	Policy, role of public and private sector
Post Green Revolution period (1960-1980s): Heavy subsidization and public sector role	
1960s–1970s	In response to inadequate supply and progress in the use of fertilizer, the public sector was given complete control over fertilizer procurement and distribution, with the responsibility of procuring fertilizer from both domestic and external sources and distributing it right to the level of the small administrative unit (*thana*) vested solely with the BADC. Under this “old marketing system” (OMS), the distribution of fertilizer was through Thana Sale Centers (TSCs) at subsidized prices. BADC-registered dealers were also allowed to lift fertilizer from TSCs and sell to farmers at regulated prices, for which a commission was paid to them.
1970s–1980s	The OMS was found to have a number of deficiencies, especially with regard to appointment of dealers, erratic supply, inadequate storage, and skewed incentives for dealers and farmers. Beginning in 1978, efforts were made to improve the system under a series of measures referred to as the “new marketing system” (NMS). Although the overall procurement operations remained a public sector monopoly, significant changes were introduced in the distribution chain, with the aim of improving efficiency and bringing in competitiveness and private participation. BADC withdrew from retail sales and instead concentrated only on maintaining wholesale centers at various strategic points in the country. Restrictions on fertilizer movement across the country and the cumbersome registration process for retailers were eased. Starting in 1983, fertilizer price at the retail level was also decontrolled.
1990s	Although the NMS had enjoyed major success in many aspects, various constraints remained and meeting farmer demand during peak season continued to be a problem. Thus, policy started to shift toward an open market system. By 1989, direct lifting of fertilizer from domestic production centers as well as ports was allowed in response to a urea crisis that occurred despite there being large stocks present. In 1992, the government excluded fertilizers from the list of restricted imports, paving the way for the private sector to import fertilizer. By December 1992, the subsidy on fertilizers was completely withdrawn and import and distribution of fertilizer were privatized.
Liberalization –reducing public sector roles (1990s-2000s)	

Period	Policy, role of public and private sector
1990s–2000s	Fertilizer crises at various points in time (initially in 1995, followed by more recent setbacks in 2005, 2007, and 2008) resulted in partial restoration of government control over the fertilizer market. In recent years, following the promulgation of a new dealership policy in 2008 and 2009 in the wake of a fertilizer supply crisis and price spikes, the fertilizer distribution system was revamped and some amount of subsidy was also introduced (though the stated aim of the subsidy was more toward balancing the use of various fertilizers to maintain soil health). The fertilizer distribution network is once again composed of appointed/licensed dealers who are limited to selling in a particular designated area, with the objective of ensuring effective fertilizer distribution across the country. BADC is withdrawn from retail and whole sale markets at Primary Distribution Points (PDP). Licensing process for dealer was simplified and they can buy fertilizers from factory or import. They can sell non- urea fertilizers in their own price.
Post Global Food Price Crisis (Post 2008 to current)	
Post 2008 to current	The prices of non-urea fertilizers were slashed to almost half per kilogram to help farmers during the *Boro* season. In order to mitigate crisis the government decided to bring the market under its direct control. The control measures were reintroduced on the marketing and distribution of urea in 2010 which again was withdrawn in 2011 and non-urea fertilizer prices are now available at a heavily subsidized price.

Total requirement of fertilizers like Urea, TSP, SSP, MP, Gypsum and mixed fertilizer for crop production in 20011-12 were 28.0, 5.0, 1.25, 1.5 and 3.0 lakh metric tonnes per year respectively. Among them 60 percent of Urea and 100 percent of mixed fertilizer were produced in the country. Fig 2.5 shows that annual consumption of chemical fertilizer is increasing at a constant rate. During 1963-1964 to 1970-1979, total fertilizer use increased rapidly at 16.5% per annum. Thereafter, the growth rate of urea declined. During 2004-12 the growth rate of TSP and MP sharply increased due to government subsidy on these fertilizers (Table 2.4).

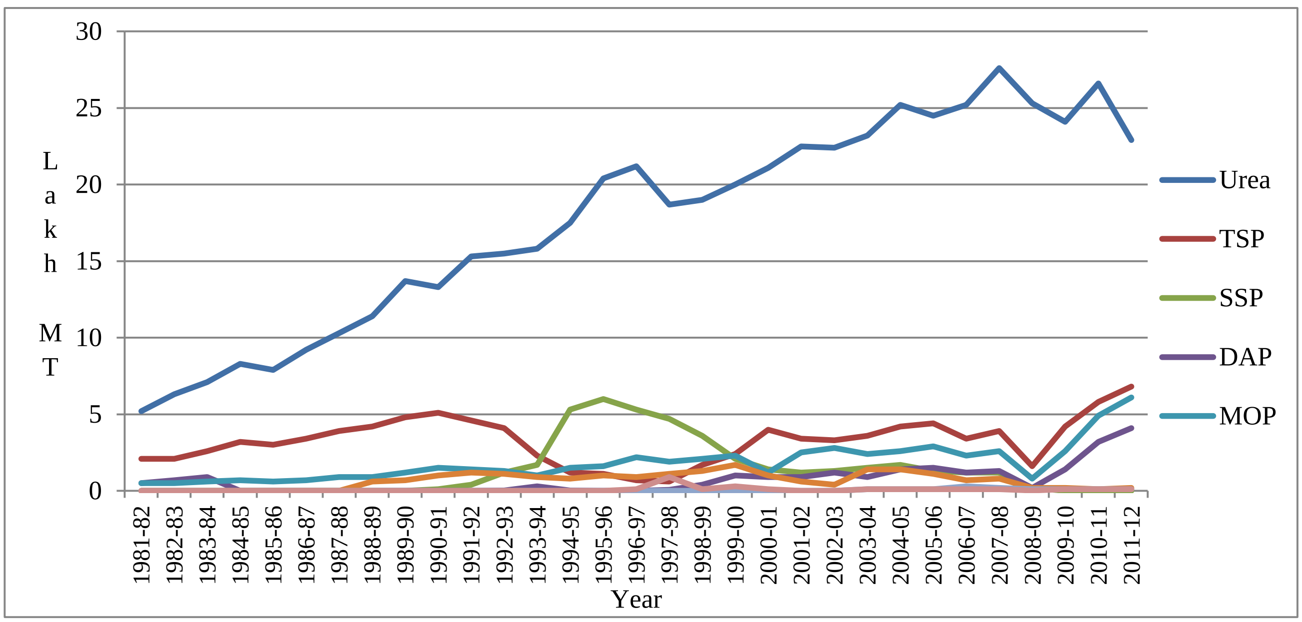


Figure 2.5 Fertilizer use by different types in Bangladesh: 1981-82 to 2011-12

Table 2.4 Growth rates of fertilizer consumption over time (1984-85 to 2011-12)

(Percentage)

Year	Total Consumption	Urea	TSP	MoP
1984/85-2011/12	4.17	4.24	1.80	7.12
1984/85-1989/90	8.05	8.31	5.46	8.97
1990/91-1994/95	3.65	5.57	-7.69	0.59
1995/96-1999/00	1.22	0.92	2.35	1.099
2000/01-2004/05	4.37	3.28	2.84	1.95
2005/06-2011/12	1.35	0.70	3.44	7.54

Source: Bangladesh Economic Review

As part of government policy to promote balanced use of different fertilizers by reducing use of urea and increasing use of non-urea fertilizers, the Government drastically reduced prices of non-urea fertilizers (TSP, MP and DAP) while the price of urea was raised from 2008-09. The price of urea reached Tk 16/kg in 2013-14, from Tk 6/kg in 2008-09. For non-urea fertilizers prices in 2013-14 were at least one-fifth of the price in 2009-10. Compared to 2009-10, subsidy on urea and non-urea in 2012-13 was raised by nearly 2.44 and 3.38 times respectively. The process of rebalancing subsidy among different fertilizers started from 2007-08. The share of the subsidy to urea was reduced from 89% in 2007-08 to 40% in 2012-13 (FPMU 2014). In line with the Government policy, urea use decreased while TSP and MoP use increased, though use in 2012-13 was marginally lower than that in 2011-12 (Table 2.5).

Table 2.5: Use of fertilizer and subsidies

SFYP output proxy indicators	2009-10	2010-11	2011-12	2012-13
Use of urea (000 MT)	2409	2652	2296	2247
Use of TSP (000 MT)	420	564	678	654
Use of MoP (000 MT)	263	482	613	571
Subsidies (billion taka)				
Urea	19.79 (-53.7%)	25.71 (29.9%)	23.28 (-9.5%)	48.24 (107.2%)
Non Urea	20.99 (162.0%)	29.71 (41.5%)	46.24 (55.6%)	71.00 (53.5%)
Total	40.78 (-19.6%)	55.42 (35.9%)	69.52 (25.4%)	119.0 (71.2%)

Source: FPMU 2013, 2014 and 2015 & BER (2014)
Note: Figures in parentheses indicate change from previous fiscal year

2.2.3. Growth of irrigation in Bangladesh

Bangladesh is a lower riparian country in the flood plains of three great rivers—the Ganges, the Brahmaputra, and the Meghna and their tributaries and distributaries. Fifty-three rivers drain 1.72 million square kilometers in Bangladesh, Bhutan, China, India, and Nepal. Only 8 percent of the catchment area is in Bangladesh. The country has about 25,000 kilometers of waterway stretching across 4.3 million hectares (MoL 2001), or almost 40 percent of the country's net cultivated area. This also includes wetlands and permanent water bodies that have a major impact on agricultural production and bio-diversity conservation in the country.

Rice (paddy) is the largest irrigation user with about 86% of the total irrigated area. In Bangladesh, irrigation is accomplished by: i) Major irrigation schemes using canal/gravity irrigation by surface water, ii) Minor irrigation schemes using groundwater from Deep Tube-wells (DTWs), Shallow Tube-wells (STWs), Force Mode Tube-wells (FMTWs) and also surface water using Low-Lift Pumps (LLPs). Irrigation is considered as a necessary precondition to enhancing agricultural production in Bangladesh.

In this country the earliest approach to irrigation facilities was through constructing large scale multipurpose irrigation, flood control and drainage (FCD) projects during 1960 – 1970. Expansion of minor irrigation through groundwater using DTWs and STWs was the vital component of the GoB's strategy to facilitate irrigation for agricultural development. Irrigation policy in Bangladesh has been evolved in 2-3 stages. The process of evolution of the policy of irrigation is presented in Table 2.6. As a result of a policy shift towards privatisation of irrigation equipment, STWs under private ownership played a significant role for irrigation development during the 1980s and a sharp increase in use of this equipment has been recorded. During the Third Five Year Plan (1985-90), continued emphasis on irrigation facilities tremendously increased groundwater irrigation through the use of DTWs, STWs and manually operated HTWs

Table 2.6 Evolution of irrigation policy in Bangladesh

Year	Policy, role of public and private sector
Post Green Revolution period (1960-1980s): Heavy subsidization and public sector role	
1961	BADC initially owned, operated, and maintained LLP sets and provided water to farmers on a flat charge on the basis of land area, and then began to rent LLPs to farmers on an annual basis, along with a 75 percent subsidy on fuel.
1962–66	The Bangladesh Water Development Board (BWDB) installed and operates 380 DTWs with a large capacity and with 100 percent subsidy for farmers. Managing large farmer groups was a problem, and experimenting with smaller capacity DTWs was started, found successful, and replicated across the country by the Bangladesh Rural Development Board (BRDB).
1972–75	BADC started to import and rent STWs to farmers' organizations and then shifted to selling STWs to individual farmers with the help of soft loans through banks, and until the late 1970s procurement, installation, distribution, and management of the irrigation system was entirely under the onus of parastatals, such as the BADC, BWDB, and BRDB.
1979	With increasing subsidy burden and growing inefficiencies in the parastatals as well as farmer groups managing the tubewell, policy shifted toward increasing private-sector participation. The private sector was allowed to import and distribute STWs, and credit facilities from commercial banks and the specialized Bangladesh Krishi Bank (BKB) were extended to enable farmers to purchase irrigation equipment. The private sector also started to make inroads in the repair and maintenance of equipment.
1980–83	Import duty on STW sets was reduced to 15 percent, and the BADC stopped renting LLPs and instead started to sell new and used LLPs to farmers' cooperatives. Privatization measures continued but subsidies for spare parts and repairs were still in place, hindering the spread of the local repair and maintenance market. Despite this, some private-sector manufacturing of pumps started.
1983–87	Bangladesh experienced a severe drought in 1983, with groundwater levels dropping especially in the northern districts. In response, there was a rollback of the liberalization process, which included banning the sale of STWs in 22 northern Upazillas a stay on the imports of small diesel engines and controls and standardization of permitted engine brands; the formulation of the Groundwater Management Ordinance, laying down spacing requirements for tubewells; and the reduction in agricultural credit outlay. As a result growth of minor irrigation equipment usage slowed and remained stagnant over 1985–1987.

1988–89	Following a change of leadership at the agricultural ministry, the reform process was put back in motion. The ban on small engine imports was removed, import duties were eliminated, and standardization requirements were withdrawn. As a result, the private sector started to import cheap STWs from China and South Korea on a large scale, and STWs of various brands and sizes started to proliferate in the countryside.
Liberalization – reducing public sector roles (1990s-2000s)	
1990s	BADC started clearing out its stock of irrigation equipment and more or less withdrew completely from the STW market. The market for engines, pumps, and spare parts started to grow rapidly, and private-sector participation in repair and maintenance works spread all over the country. Liberalization of trade, import of agricultural machinery and minor irrigation devices made duty free. Also credit support was given for purchase of these machineries.
Post Global Food Price Crisis (Post 2008 to current)	
2008 to current	Government giving direct subsidy on diesel used for irrigation in order to reduce irrigation cost and introduced Bank card for distribution of subsidy

Agricultural growth in the country has been largely due to the expansion of minor irrigation through the use of DTWs, STWs and LLPs with private sector investment. The trend of irrigation growth in Bangladesh from 1982 to 2011 has been presented in Figure 2.6. The agricultural growth in the country has been largely due to the expansion of minor irrigation through the use of Deep Tubewells (DTWs), Shallow Tubewells (STWs) and Low Lift Pumps (LLPs) (Figure 4). During 2006, there were 29,170 DTWs, 12,02,720 STWs and 1,07,290 LLPs fielded and the total irrigated area was estimated at 4.883 M ha which was 56.51% of the net cultivable area of the country, where irrigation coverage by groundwater and surface water were 80.6% and 19.4%, respectively. In 2012, the national irrigation coverage was 6.5 million hectares which is 77.6% of the total cultivable land, where groundwater covered 65.4% and surface water covered 34.6% of the total irrigated area (MoF, 2012).

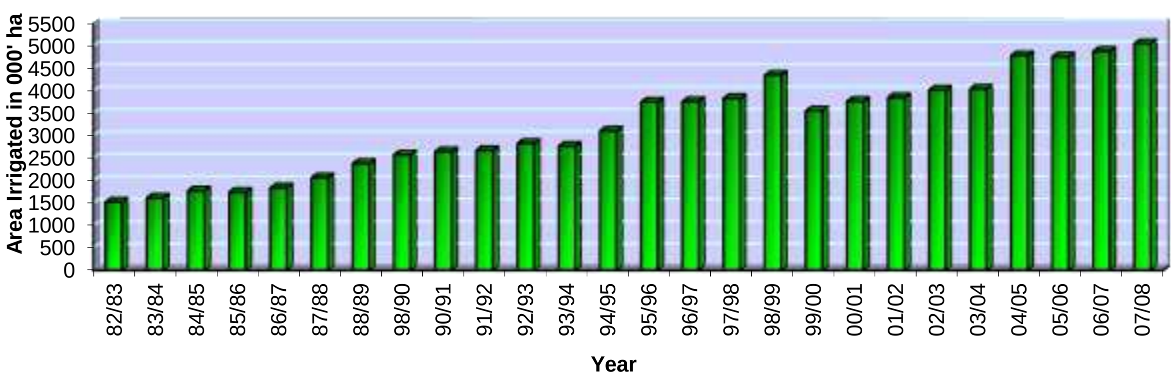


Figure 2.6 Trend in irrigation growth in Bangladesh

2.2.4 Demand for irrigation water

Rice occupies nearly 80% of the gross cropped area (GCA) and gross irrigated area (GIA), and accounted for 93% and 77% of the total increases in Gross Cropped Area (GCA) and GIA, respectively, between 1990 and 2010. Therefore, this analysis only projects the supply of rice and water demand, based on a study of International Water Management Institute (Upali *et al*, 2014). Among the rice crops:

- *Aus* rice area decreased rapidly and is only 9% of the GCA now;
- *Aman* rice area accounts for the largest portion of GCA (40% in 2010); and
- *Boro* rice expanded rapidly, mainly at the expense of *Aus* rice.

The ARIMA time series models (Box and Jenkins 1976) were used to project water demand to 2020 and 2030. The ARIMA (p, d, q) model has p and q autoregressive and moving average terms of the stationary time series of order d. (For details see Upali *et al*, 2014). The framework used for estimating future crop and water demand is presented in Fig. 2.7.

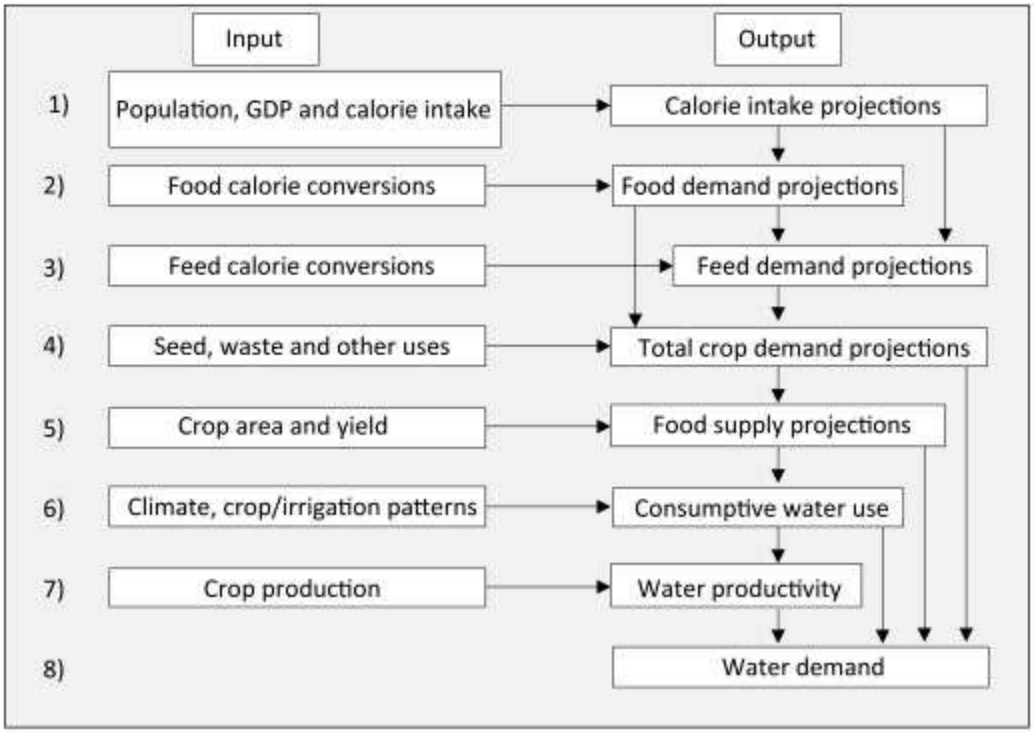


Figure 2.7 Framework used for estimating future crops and water demand

ARIMA models predict the following:

● A further decline in the *Aus* rice area (to 0.7 Mha by 2020 and 0.2 Mha by 2030).

● No significant changes in the *Aman* rice area. It is likely to stabilize between 5.7 and 6.1 Mha.

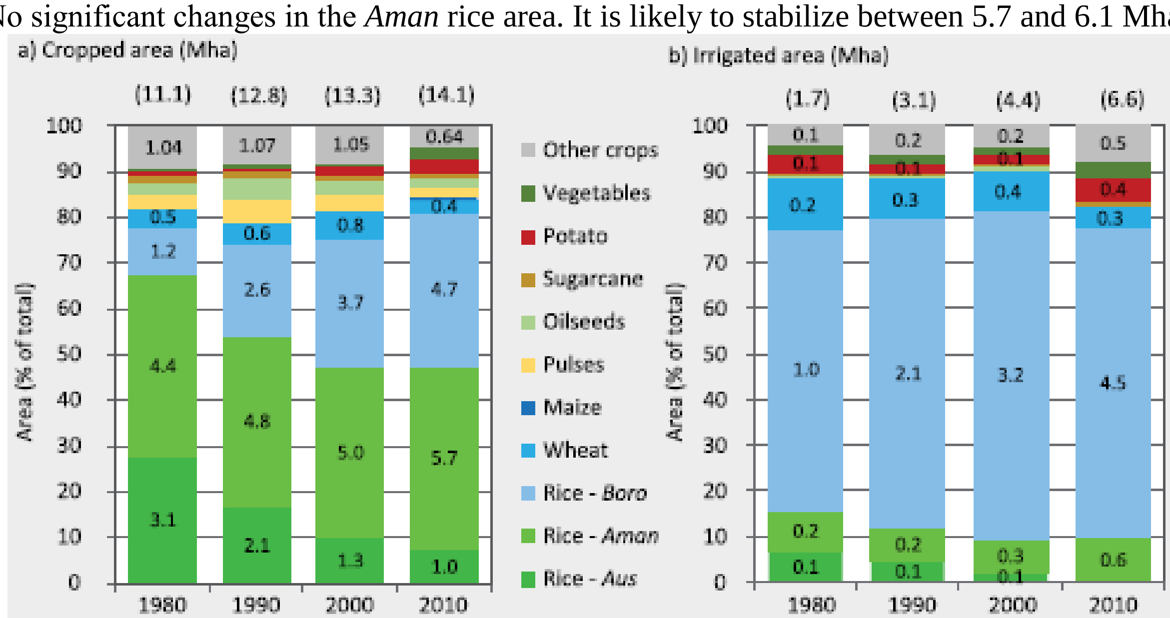


Figure 2.8 a. Cropped area (million ha) and b. Irrigated area (million ha)

There will be a further increase in the *Boro* rice area (to 5.7 Mha by 2020 and another 1 Mha by 2030). The predicted increase in the *Boro* rice area will be significantly more than the decline in the *Aus* rice area (Figure 3.5 a). According to the ARIMA forecasts, the total rice area will increase to 12.5 Mha by 2030; an additional 1.1 Mha from the present level and the *Boro* rice area (6.7 Mha) will contribute to almost all of this expansion.

Realistically, the increase in *Boro* rice hectarage will not be possible due to increasing population, urbanization and land constraints. The Bangladesh Rice Research Institute (BRRI) projected that the total rice area will reduce to about 10.3 Mha by 2020 (BRRI 2013). The study carried out by the International Food Policy Research Institute (IFPRI) (Ganesh-Kumar et al. 2012) assumes that the *Boro* rice area can increase up to 6.5 Mha and the total rice area up to 12.6 Mha. While the extent of the projected expansion varies, all studies confirm that the main path to increasing rice production in the future is mainly through yield increases.

The ARIMA models predict:

- Yield of *Aus* rice to increase 2.0% annually between 2010 and 2020; 1.2% annually in the 2020s; and to reach 2.4 t/ha by 2030.
- Yield of *Aman* rice to increase 1.8% and 1.1% annually in the next two decades, respectively, and to reach 2.8 t/ha by 2030; and
- Yield of *Boro* rice to increase 1.2% and 1.0% annually in the next two decades, respectively, and to reach 4.8 t/ha by 2030. The projections of rice yield above assume that factors that contributed to growth in the past, such as advances in technology and high-yielding rice varieties, will continue to be developed and contribute to yield increases.

This analysis assesses future agricultural water demand under two scenarios of increases in WP: (i) area expansion and surplus rice production and (ii) self-sufficiency in rice production, improving water productivity with no area expansion. Rice production accounted for 93% of the total CWU and 90% of the total irrigation CWU.

The irrigation CWU of rice production, which was 11.8 Bm3 in 2000 (Table 3), has increased by 40% to 16.5 Bm3 in 2010 (Table 4); the latter is estimated using the irrigation CWU per hectare of 265 mm in 2000 (Table 3). This analysis estimates irrigation CWU demand to 2020 and 2030 under two different scenarios:

Scenario 1: Area expansion and surplus rice production: This scenario assumes that the area and yield of rice will increase as projected. This means that the irrigated area will increase only in *Boro* rice: from 4.5 Mha in 2010 to 5.7 Mha in 2020 and 6.7 Mha in 2030. The irrigation CWU demand for rice will be 20.9 Bm3 and 24.5 Bm3 in 2020 and 2030, which are 27% and 48% increases from the 2010 level, respectively.

Scenario 2: Self-sufficiency in rice production, improving water productivity with no area expansion: According to this scenario, rice production will have to be 37.2 MMt by 2020 and 40.3 MMt by 2030, respectively. These estimates are 5% more than the projected consumption demand; and the additional 5% replenishes stocks. The assumption of self-sufficiency requires 3 MMt less production than in the "Business as Usual" scenario. This scenario analyses irrigation CWU under different WP growth scenarios of 0%, 5% and 10%. These are potentially feasible, since increases in WP are possible in both *Boro* and *Aman* rice. If the saving in production that is made from self-sufficiency is from *Boro* rice then the following will be true.

● Even with no growth in WP, irrigation CWU demand will decrease by 2.6 Bm3 and 6.1 Bm3 by 2020 and 2030, respectively, from the estimates in scenario 1, due to lower production requirement;
● With 5% growth in WP, irrigation CWU demand will decrease by 2.7 Bm3 and 6.4 Bm by 2020 and 2030, respectively; and
● With 10% growth in WP, irrigation CWU demand will decrease by 2.9 Bm3 and 6.8 Bm 3 , respectively.

Importantly, the reduced irrigation CWU of rice in scenario 2 can meet most of the irrigation demand of other crops. The other three major irrigated crops are wheat, vegetables and potatoes: (a) the additional demand for these crops would be 0.7 MMt, 11.1 MMt and 4.0 MMt, respectively; (b) the water productivity of these crops is 1.29 kg/m3, 1.96 kg/m3 and 3.98 kg/m3, respectively; and (c) the additional CWU demand (crop demand/water productivity) of these crops is 0.5 Bm3, 1.5 Bm3 and 5.7 Bm3, respectively. Since irrigation contributes to 19%, 74% and 62% of the total CWU, the total additional irrigation CWU of these three crops is 4.9 Bm3, which is less than the reduction in CWU of rice in scenario 2. Indeed, demand management taking into consideration food demand and production, can substantially reduce the irrigation demand. However, there are still water supply constraints that need to be addressed.

Groundwater is the source for more than 75% of the irrigated area (BBS 2011). Thus, groundwater would have contributed to about 13 Bm3 of irrigation CWU in 2010. A large part of this CWU is from natural recharge, and the balance is from return flows of surface water irrigation. If the current share of groundwater irrigation was to continue, this would require at least 14-16 Bm3 by 2020 and 14-19 Bm3 by 2030. Besides this, domestic and industrial water demand will also increase. Therefore, a pertinent question is whether there are adequate renewable groundwater resources to meet the increasing demand.

Given the declining groundwater tables and water quality issues in Bangladesh, it will be extremely difficult to exploit groundwater resources sustainably under scenario 1. Without an increase in WP, it will be difficult to meet even the reduced demand under scenario 2. A few districts have already passed the sustainable thresholds of groundwater use in Khulna in the Khulna region, Bogra and Pabna in the Rajshahi region, Barisal, Chittagong, Kishoreganj, Kushtia and Rajshah where irrigation CWU exceeds the usable groundwater recharge.

Table 2.7 Irrigation CWU demand under different scenarios of WP growth

Time	Season	Area (Mha)		CWU (Bm^3)		Total Production (MMt)	Water Productivity (Kg/m^3)	Savings of irrigation CWU (Bm^3) by only meeting the rice demand[1]		
		Total	Irrigated	Total	Irrigation			WP growth scenarios[2]		
								0%	5%	10%
2010	Aus	1.1	0.0	4.8	0.0	1.9	0.40	-	-	-
	Aman	5.6	0.6	30.7	0.0	12.5	0.41	-	-	-
	Boro	4.7	4.5	27.5	16.5	18.3	0.67	-	-	-
	Total	11.4	5.1	63.0	16.5	32.8	0.52	-	-	-
2020	Aus	0.7	0.0	3.2	0.0	1.5	0.47	-	-	-
	Aman	5.7	0.0	30.8	0.0	14.1	0.46	-	-	-
	Boro	5.7	5.7	33.9	20.9	24.6	0.73	2.60	2.74	2.89
	Total	12.1	5.7	67.9	20.9	40.2	0.59	-	-	-
2030	Aus	0.2	0.0	1.1	0.0	0.6	0.53	-	-	-
	Aman	5.7	0.0	30.8	0.0	15.9	0.52	-	-	-
	Boro	6.7	6.7	39.9	24.5	32.1	0.81	6.08	6.40	6.76
	Total	12.6	6.7	71.7	24.5	48.6	0.69	-	-	-

Sources: The area and total production data for 2010 are from the Bangladesh Bureau of Statistics; Water productivity and CWU for 2010, and projections for 2020 and 2030 are authors' estimates.
Notes: 1 Rice demand in 2010, 2020 and 2030 are 30.2 MMt, 37.2 MMt and 40.3 MMt, respectively.
2 WP growth scenarios are only assumed for *Boro* rice.

Two important issues arise from scarcity of availability of irrigation water and rising costs. First, how can water-use efficiency be increased to reduce the cost of production of crops, particularly boro rice? A higher water-use efficiency would also reduce energy consumption and lower greenhouse gas emissions, for example, through the adoption of the alternative wetting and drying method. Development of new varies that consume less water can also help reduce boro water needs. Second, how far can surface water be substituted for groundwater, particularly in areas where surface water is more abundant, for example, in the Southwest?

2.2.5 Supply and demand for seeds

The National Seed System is mixed, with three intercepting circles representing the main components (Figure 2.9).This diagram provides a conceptual overview of the national system so that the relationship of the various sectors can be better understood. National Seed Systems vary greatly between countries. Some countries have quite strong national seed systems with well developed agricultural research, national seed services and private sector seed companies. Other countries have quite weak national seed systems with the community based seed system providing most of the seed used by farmers. In Bangladesh the National Agricultural Research (NARS) Institutes, Agricultural Universities, International Research Institutes and some private seed companies act as the source of modern varieties. The formal seed system (commercially oriented seed supply) involves both public and private sector seed enterprises, producing foundation and certified seeds. In the informal system the farmers produce, save and exchange seeds.

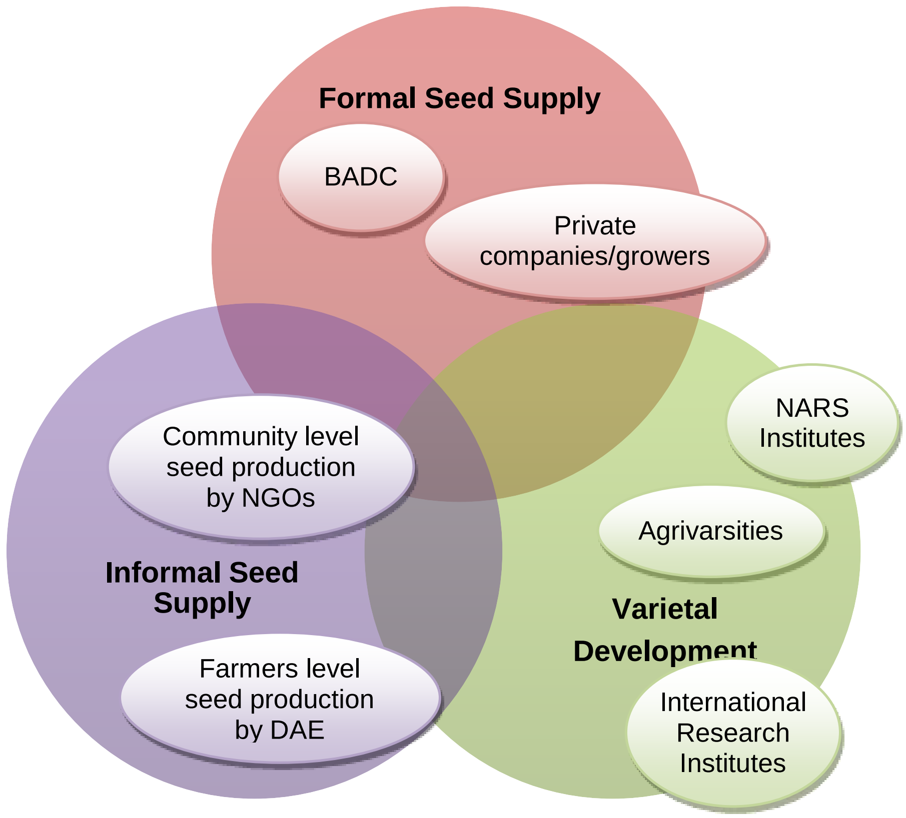


Figure 2.9 National seed system in Bangladesh

The first formal and organized seed system was introduced in Bangladesh with the establishment of the public sector organization providing agricultural input supply and service - the then East Pakistan Agricultural Development Corporation (EPADC) in 1961-62, later renamed as the Bangladesh Agricultural Development Corporation (BADC) after the independence of Bangladesh in 1971. The BADC started its journey with the production of a meagre quantity of 13.8 tons of quality seeds. During 2011-12 it has increased its capacity to the extent that it could supply a large quantity of 1,44,200 tons of quality seeds of HYVs/MVs/Hybrids of four notified crops (rice, wheat, jute, and seed potato), and eight non-notified crops (maize, barley, kaon, cheena, pulses, oilseeds, spices, and vegetable seeds) .

The evolution of seed policy of Bangladesh has been presented in Table 2.8. In the post green revolution period (1960-80s) there was heavy subsidization of seed and the public sector role played in the seed market through BADC. During the 1990s to 2000s the seed market has been liberalized with the New Seed Policy 1993, Seed Amendment Acts 1997 and 2005, and the Seed Rules 1998 and opened market for participation and rise of private enterprises in seed production, import, and distribution.

Table 2.8 Evolution in seed policy in Bangladesh

Period	Policy, role of public and private sector
Post Green Revolution period (1960-1980s): Heavy subsidization and public sector role	
1960s–1980s	The public sector organization, BADC was given complete control over seed procurement and distribution, with the responsibility of procuring and multiplication of seeds in its own farms and seed processing plants from both domestic and external sources and distributing it right to the level of the small administrative unit (*thana*) vested solely with the BADC. Under this “old marketing system” (OMS), the distribution of seeds was through Thana Sale Centers (TSCs) at subsidized prices. There was restriction on import of seeds by private sector. The seed sector in Bangladesh has been dominated by the public sector, and the Bangladesh Agricultural Development Corporation (BADC), an autonomous corporate body under the Ministry of Agriculture (MOA) that is a major agricultural input supplier. The legal framework underpinning the seed sector comes from the Seed Ordinance 1977.
Liberalization –reducing public sector roles (1990s-2000s)	
1990s–2000s	The legal framework underpinning the seed sector comes the New Seed Policy 1993, Seed Amendment Acts 1997 and 2005, and the Seed Rules 1998. The legal, regulatory, and institutional mechanisms governing the sector have been drawn together in the National Seed Policy (NSP) of 1993. The NSP marked the beginning of liberalization in the seed sector and heralded the rise of private enterprises in seed production, import, and distribution. Quality seeds crises at various points resulted in deregulation of government control over the seed market. New Seed Policy 1993 was formulated and seed sector is more liberalized. Private sector allowed importing, developing and registering new seed varieties of all seeds and distributing to the farmers. All private dealers involved with seed import, registering new seed variety and packaging seeds in label containers, must be registered. Also all varieties of seed must be certified by Seed Certification Agency (SCA). The National Seed Policy (NSP) adopted in 1993 provided a comprehensive policy and strategy framework as well as directives to increase the production of improved seeds both in public and private sector.
Post Global Food Price Crisis (Post 2008 to current)	
2008- present period	Capacity of BADC has been strengthened, Priority was given on development and distribution of hybrid seeds both in public and private sector, development of climate resilient varieties, such as salt and drought tolerant crop varieties. Also policy and strategy framework were provided for use of bio-technology for seed production. Private sector allowed importing, developing and registering new seed varieties of all seeds and distributing to the farmers. Provided easy credit and access to facilities and equipments for the private sector.

In Bangladesh the national requirement for quality seeds of all crops is estimated to be 9,32,250 metric tons. Against this national requirement, the supply of quality seeds was 1,86,450 metric tons in 2005-2006 (Seed Wing, Ministry of Agriculture). The performance of the seed supply system through quality seed replacement rate (SRR) against national requirement up to 2011-12 was 25% of which about 80 percent seed is being fulfilled through the informal seed system of farmers’ own saved seeds.

During 2011-2012, the SRR of the quality rice seed of HYVs/MVs/Hybrids has increased to about 43 percent from 25% in 2005-2006,.The contribution of BADC alone is significant i.e. 39% against 10% in 2005-2006. This has made a significant contribution to the increase in the country's rice production to over 33.5 million tons in 2010-2011, and 33.9 million tons in 2011-12.

Ensuring supply of quality seeds and controlling marketing of adulterated seeds was emphasized in the 6th FYP. The supply of improved seeds from the Bangladesh Agricultural Development Corporation (BADC), DAE and private companies continued decreasing for the consecutive two fiscal years for all the crops except vegetables (Table 2.9).

Table 2.9: Improved seed supply (BADC, DAE and private companies) as a percentage of agricultural requirements

Crop	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**
Rice	44.5%	57.9%	58.8%	52.4%	33%
Wheat	67.0%	55.1%	71.5%	56.5%	55%
Maize	84.2%	100.0%	95.9%	74.4%	28%
Potato	3.3%	4.2%	11.8%	9.5%	6%
Pulses	2.8%	4.7%	11.8%	14.8%	8%
Vegetables	32.1%	32.7%	19.8%	20.3%	76%
Edible oilseeds*	4.4%	8.1%	11.5%	13.6%	5%

Note: * Includes sesame, rape & mustard, groundnut and soya bean
Source: FPMU 2013, 2014 and 2015

Agricultural growth is dependent on a very wide-scale switch to HYV seed, but seed quality in general remains a major problem. Various related investments are needed to enhance provision of quality seeds in adequate quantities. Some of the non-government organizations and the private sector have started to enter the seed sector with positive impacts on availability, although quality still remains a vexing issue in some cases. Further private-public partnerships for seed, marketing, and extension need to be explored.

2.2.6 Agricultural credit

Agricultural credit, as an input, plays an important role in driving the agriculture of Bangladesh towards a sustainable level. Food security, employment generation and poverty alleviation are closely linked with the development of the agriculture sector. To strengthen the agricultural and rural credit programme, Bangladesh Bank formulated its Agricultural and Rural Credit Policy and Programme for the FYs 2009-10, 2010-11, 2011-12 in an extended format. The objective of this policy is to ensure easy access to the agricultural and rural credit facilities by the farmers from the scheduled banks of the country. There was an increasing trend in disbursement of agricultural credit during 2005-12 (Table 2.10).

Table 2.10 Year-wise disbursement and recovery of agricultural credit(In crore Taka)

Fiscal year	Target	Disbursement	Recovery	Balance

2005-06	5982.21	5496.21	4164.35	15376.79
2006-07	6351.30	5292.51	4676.00	14582.56
2007-08	8308.55	8580.66	6003.70	17822.50
2008-09	9379.23	9284.46	8377.62	19598.15
2009-10	11512.30	11116.88	10112.75	22588
2010-11	12617.40	12184.32	112148.61	25492.13
2011-12	13800.00	13132..15	12359.00	25974.97

Source: Bangladesh Bank

While demand for credit is increasing with the advent of new technologies and high value crops, the supply side has remained less vibrant. The volume of institutional credit is conspicuously low and the proportion of the public sector in the total volume of institutional credit is even smaller. According to data of the Bangladesh Bank, around 25 percent total disbursement of rural credit is delivered by the public sector. The remaining 75% has been delivered by micro-finance institutions (MFI) including NGOs and the Grameen Bank. However, the demand for credit is much more than that met by non-institutional sources.

In a case study conducted under the preparation of the Master Plan for agricultural development of the Southern region it is roughly estimated that around 80 percent of the volume of credit comes from various non-institutional sources largely dominated by *mohajans* and *dadanders* (Figure 7.3). They charge interest on loan at exorbitant rates, generally 10 percent per month.

Loan conditionality of *dadanders* is quite stringent, as they lend money with the guarantee of repayment in the form of products whose price is fixed unilaterally by them in advance. Advance sale of labour in crop fields in exchange for loans (cash or rice) is also common.

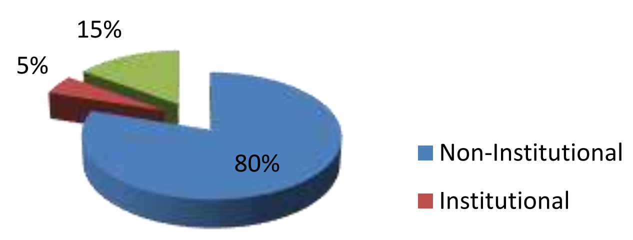


Figure 2.10 Supply of rural credit in the Southern region

Specialized banks, like the *Krishi Bank*, are a major source of agricultural credit. Two-thirds of the credit from public sector agencies is from specialised banks (Planning Commission, 2011). As of July 2010, there were 527 NGOs registered by the Microfinance Regulatory Authority (MRA). The *Grameen Bank*, however, operates as a quasi-NGO specialized bank outside the orbit of the MRA. They usually cover the landless and poor women who are categorized as "non-farm" households (defined as those who own less than 0.05 acre of land). The average amount of microcredit received per person from MFI sources has been Tk 7,144 (Planning Commission, 2011). The total amount of credit received per person would be higher as people borrow from multiple sources.

Despite a fast growing microfinance sector and its better recovery performance, there has hardly been any attempt by public sector institutions, particularly specialized banks, to reform their mode of operation and make them user-friendly. Besides a few government projects with a credit component, public sector credit agencies are characterized by the following phenomena.

- Access to credit is impeded by procedural complexities, such as, provision of collateral, filling up forms and delay in approval.
- Farmers often find it difficult to understand procedures.
- Hidden and real costs of credit are high in terms of travel, time and obscure payments that discourage farmers to go to the banks for credit.
- Poor farmers do not receive satisfactory clientele service from banks.
- Women are excluded from the banking service as they can hardly offer any collateral (land).

As total demand for credit far outweighs its supply, private moneylenders dominate the credit market. Poor farmers have little choice.

During the Sixth Five Year plan period, agricultural credit disbursement steadily increased.

During the last two fiscal years, disbursement was more than target whereas in other years it was almost close to the targets (Table 2.11). Recovery of agricultural credit increased by 16% to 143.62 billion taka in 2012/13 from 123.6 billion taka in 2011/12 (Bangladesh Bank 2013).

Table 2.11 Agricultural credit disbursement during 2009-14

	2009-10	2010-11	2011-12	2012-13	2013-14
Credit disbursed (billion taka)	111.17	212.84	131.32	146.67	160.37
% of target	97%	97%	95%	104%	110%

2.3. Technology generation

2.3.1 Technology generation

The government of Bangladesh has given priority to the agricultural sector to boost agricultural production. Increasing the speed and sustaining agricultural growth are priorities for increasing food production and reducing poverty. The future challenge of increasing food production could be met through the introduction of modern biotechnology and an increase in investment in agricultural technology generation and transfer. Table 3.1 presents information on technology generation and innovations in Bangladesh agriculture during 2004-14 and Table 2.12 presents information on the number of cultivars registered for notified crops, 2000–14.

Varietal improvement and improvement of production practices are a high priority of NARS research for rice, wheat, sugarcane, oil seeds, pulses, vegetables, fruits, fisheries and livestock. Also improvement of water resource for agricultural use, post-harvest management and farm mechanization are high priorities for NARS research. NARS Bangladesh has 12 ARIs, which are coordinated by BARC under MoA. The ARIs are mainly involved in doing agricultural research on crops, fisheries, livestock, and forestry. Technologies developed by the NARS institutes are disseminated to the farmers through the extension department and NGOs. In meeting the demand for higher food production, thrust should be given to frontier research including genetic engineering, reduction of cultivation costs, strengthening of the technology-transfer linkage, and improvement of postharvest technology.

Table 2.12 Technology generation and innovations in Bangladesh agriculture during 2004-14

Product type	**Examples of innovations**
Inputs	
Seed	Rice cultivars, hybrid rice, hybrid maize, Cultivars for potatoes, vegetables, spices and other crops
Fertilizer	Biofertilizer from coconut dust, earthworm compost, and green manure
Pesticide	Pheromones, parasitoids, and phostoxin
Machinery	Corn shellers, rippers, threshers, straw-bundle cutting machines, and seeders
Large-scale production	
Crop-based	Cultivars for gladiolas, strawberries, longum, grapes, guava, jujube, and durian
Processing	
Crop-based	Rubber rollers, color sorters, and graders for rice processing; and solvent extraction for oil seeds and rice bran

The Sixth FYP prioritized the importance of research and extension for agricultural intensification, diversification and resilience to climate change. Since 2009-10, the Government of Bangladesh (GoB) agencies developed 23 new rice varieties (Table 2.10). Of these, some important ones are: saline tolerant rice variety BRRI Dhan 61, the world's first zinc-enriched rice variety BRRI Dhan 62, submergence tolerant BINA Dhan-11 and 12, water logging resistant BINA Dhan-14, BINA Dhan-13, three new stress tolerant rice varieties (BRRI Dhan 55, 56 and 57) and one short duration (BRRI Dhan 58) rice variety. The released varieties are expected to address adverse climatic conditions, particularly in the south and northern regions of the country. For non-rice crops, five new varieties were developed for vegetables, while no new varieties were released for maize and potato in 2013-14 (Table 2.13).

Table 2.13: Technological innovations in varietal development and irrigation coverage

SFYP output proxy indicators	2009-10	2010-11	2011-12	2012-13	2013-14
No. of improved new rice varieties developed by GoB agencies	5	2	5	3	8
No. of new non-rice varieties developed					
Wheat	2	0	2	1	2
Maize	0	0	0	1	0
Potato	2	2	11	13	Na
Pulses	1	5	0	4	2
Vegetables	3	11	7	5	5
Edible oilseeds*	1	7	0	4	4
Fruits	10	4	3	4	2
% of cropped area under irrigation	45.3%	45.8%	46.8%	47.4%	Na
Surface water irrigation area as % of total irrigation area	22.0%	21.3%	21.3%	20.9%	21%
No. of farmers trained on sustainable agriculture practices by DAE (lakh)	13.34	12.78	12.77	12.83	Na

Source: FPMU 2013, 2014 and 2015

The Sixth FYP emphasized the importance of increasing the irrigated area, particularly for the southern region. Special importance was attached to reducing dependency on ground water by expanding the area under surface water irrigation. The share of cropped area under irrigation increased since 2009-10, though the growth rate in 2012-13 was lower than that of 2011-12. The share of surface water irrigation in total irrigated area decreased marginally in 2010-11 and remained at around 21% during the past four years, indicating that despite policy commitment it has not been possible to reduce dependency on ground water irrigation.

Table 2.14 Number of cultivars registered for notified crops, 2000–14

Species, type of seed	Cultivars submitted by private companies or NGOs	Cultivars submitted by public agencies	Total
Rice			
Hybrid	76	5	81
Variety	0	13	13
Wheat	0	6	6
Maize	44	8	52
Jute	0	3	3
Potatoes	0	11	11
Sugarcane	0	8	8

For all non-notified crops, such as maize and vegetables, private companies have introduced hundreds of cultivars, but there is no centralized record of what has been introduced. For example, the Seed Certification Agency registered 52 maize cultivars during 2000–08, of which private organizations submitted 44.

2.4 Productivity assessment of agriculture

Crop agriculture is dominated by rice cultivation, and crop diversification is still limited. Over 2003/04, 2004/05, and 2005/06, the rice area accounted for 75–76 percent of total cropped area. In later years this may have shot up above 80 percent, to as much as 84 percent by 2008/09. In terms of value added, however, the shares are somewhat less. The changes in shares in value added for rice and other selected crops are presented in Table 2.15.

Table 2.15 Shares of crops in value added in crop agriculture (%)

Crops	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Paddy	68.2	67.8	63.4	64.1	62.8	62.6
Wheat	2.6	2.1	1.6	1.2	1.1	1.2
Beverages	2.7	2.8	2.8	2.9	2.8	2.4
Jute	2.8	2.7	2.4	2.7	2.7	2.5
Pulses	2.2	2.1	1.9	1.7	1.6	1.5
Oilseeds	1.7	1.7	1.8	1.8	1.9	1.8
Sugarcane	2.4	2.2	2.1	1.7	1.8	1.7
Potato	3.8	4.3	5.3	4.6	5.5	7.7
Other veg.	5.10	5.3	6.1	6.1	5.9	5.3
Fruits	3.7	3.9	5.5	5.9	6.2	5.4

Source: BBS 2009.

Table 2.15 indicates that the shares in value added for paddy has somewhat fallen and those of the so called minor crops, potato, other vegetables and fruits have increased. Several other crops have lost share, including sugarcane and pulses, while others have remained static. Such figures lead to two kinds of implications. First, despite efforts over the years, crop diversification has not progressed well. As Deb (2008) observes, the index of diversification has moved only slightly, from 0.54 in the 1980s to 0.6 in recent times. The diversification indices (constructed on value share basis) for the years 2002/03 to 2007/08 have generally remained within the range 0.52 to 0.57. Even after much effort, the diversification that has occurred is of little significance.

2.4.1 Productivity assessment of rice

Rice is the staple food of about 156 million people in Bangladesh. About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. Rice plays a vital role in the livelihood of the people of Bangladesh.

Rice is grown all over Bangladesh. Figure 2.11 presents the top 11 rice producing districts in terms of highest contribution to the country’s total rice production. In this regard Comilla stood first followed by Patuakhali and Bhola.

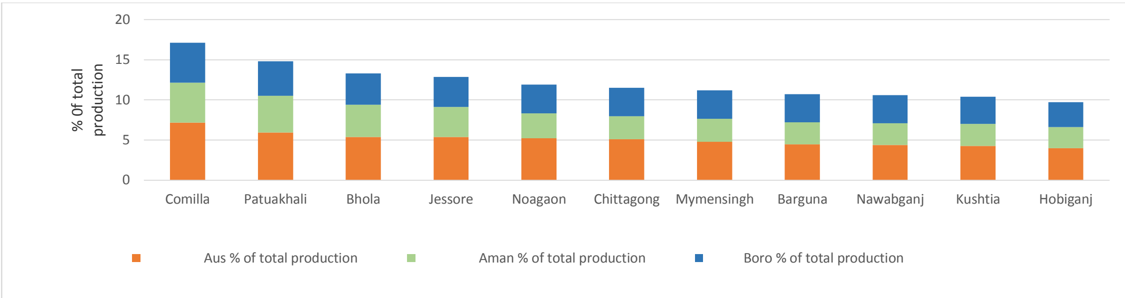
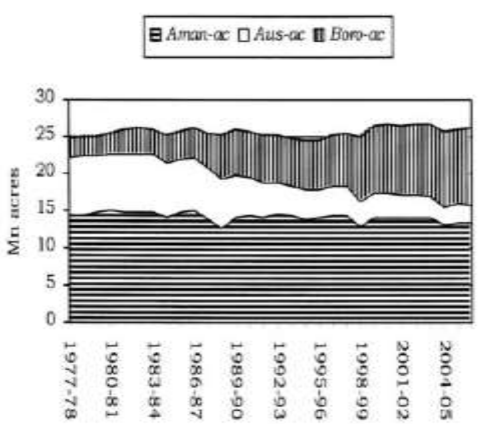


Figure 2.11: Top eleven rice producing districts of Bangladesh

Rice is grown in three seasons. *Aman*, grown during July/August to December/January, is part rain-fed (during early part of growth) and part dry season crop (during flowering and harvest time). This is followed by *boro*, grown at present under irrigated conditions during the largely dry period from February/March to April/May. *Aus* is grown in rainfed conditions; it falls in between the *boro* and *aman* season but may overlap with both. This means that the longer-duration varieties of rice do not allow for more than two rice crops per season on the same land, although other crops may be grown, depending on duration of the crop and other agronomic factors.

The growth in rice output over the last quarter of a century has been characterized by increasing reliance on irrigated *boro* cultivation, using fertilizer-intensive high-yielding varieties (HYVs). *Boro* rice now accounts for the bulk of rice grown in the country (Figure 2.12-2.13). The area expansion under *boro* has come increasingly at the expense of *aus*, and, more recently, of *aman* as well, although *aman* acreage has generally remained static. Within *aman*, too, there has been a switch to HYVs. Yet the output growth in *aman* has been rather modest, reflecting not only loss of area but also slower rate of yield increase compared to *boro* (see Table 2). A possible contributing factor is damage caused by weather-related hazards, such as floods, drought, and cyclonic storms along the coast.



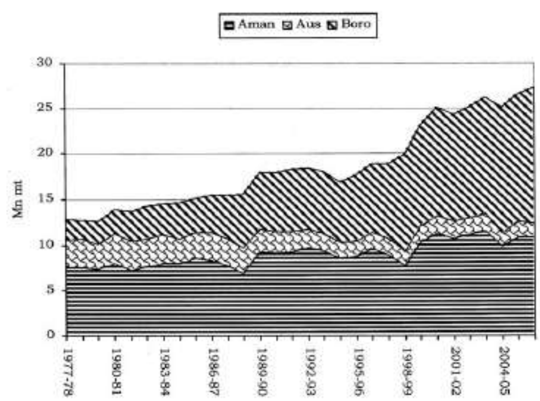


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Figure 2.12. Rice acreage by season **Figure 2.13 Rice output by season**

Table 2.16 Component of change in rice output (1992-2007)

Season	Output change	Area change	Yield change
Aman	1.65	-0.42	2.07
Boro	6.60	4.04	2.56
Aus	-1.08	-4.30	3.22
All	**3.67**	**0.52**	**3.14**

Source: Assaduzzaman 2009

Currently, Boro rice accounts for about 60 percent of total food grain production. Scope for its further expansion, however, appears to be limited except for specific pockets. Thus, the focus for *Boro* rice has to be on increasing the efficiency of inputs - both water and fertilizers. Moreover, the cost of production of *boro* high-yield variety (HYV) rice is rather high because of intensively used, costly inputs such as irrigation and fertilizer. Further increase in rice output over the long run is therefore likely to come from *aman*. In the near future, however, such an increase is not likely because of the uncertainties that surround the *aman* harvest in any given year.

Aman output is highly volatile due to its susceptibility to natural hazards. Figure 2.14 shows that both *aman* and *boro* outputs are volatile. But whereas *aman* has just two major peaks above the zero line (representing no change), it shows several troughs signifying fall in output. The nature of volatility of *boro* output is just the opposite, with changes mostly on the positive side. In fact, the positive *boro* output change often counterbalances the negative output changes in *aman*, as indicated by the line for total production.

One way of achieving higher output is to focus on regions where crop agriculture has comparatively lagged behind, particularly in Southwest Bangladesh (SWB). It has been observed that all districts showing low yields of rice are in the southwestern region, particularly along the coast. There are three types of problems in raising crops in the coastal districts of SWB: salinity, particularly during the dry period; water-logging and drainage congestion in many areas; and the storm surges during cyclones which make agriculture riskier.

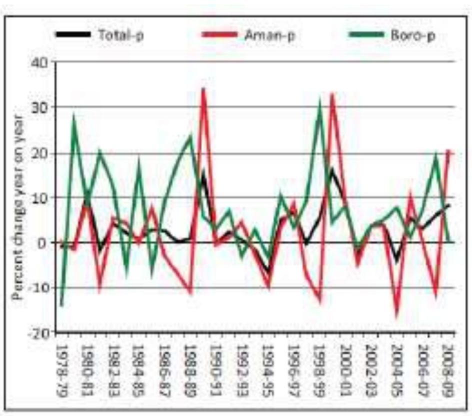


Figure 2.14 Year to year fluctuation in rice output

The production of main staple rice has shown a long term growth trend of 2.8 percent per annum over the period from 1981/82 to 2011/12 (Fig 2.15). During 1997 to 2013, total rice acreage changed little, T. Aman acreage remained almost unchanged, while irrigated Boro acreage substantially increased with the reduction of rain-fed Aus which showed about 6.3 percent annual growth during the same period.

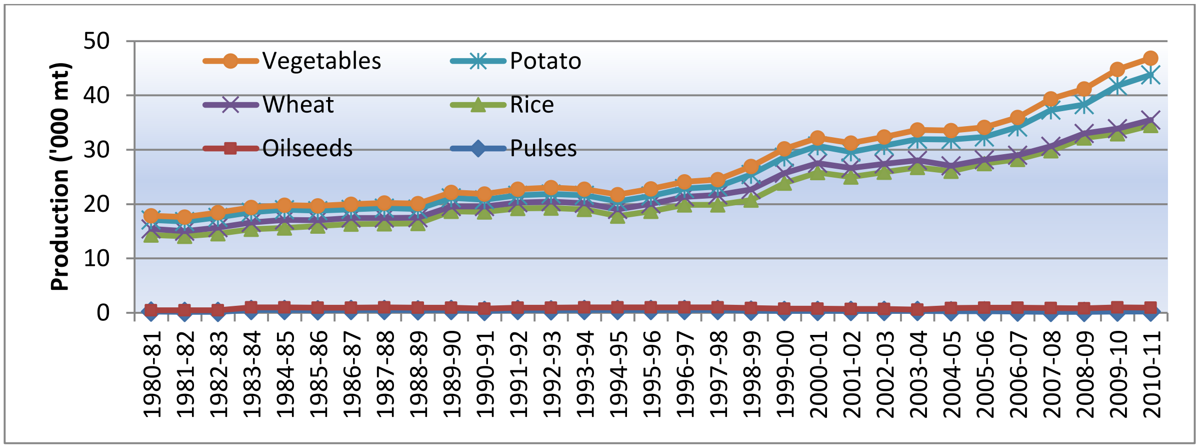


Fig. 2.15 Trend in production of rice and non-rice crops during 1980-2011

Figure 2.16 illustrates the trends of rice production over the past decades. Over the last 30 years, Bangladesh has experienced a "green" revolution in rice production, with a tripling of production from approximately 10 million metric tons in the mid-1970s to almost 34 million tons in 2013/14. It was largely based on the cultivation of high-yielding varieties (HYVs) under irrigation with use of chemical fertilizers This ‘Green Revolution’ has enabled Bangladesh to increase food availability to meet the demands of a rapidly growing population. Fig 2.17 presents trends in rice production in Bangladesh by season. It is found that during 1970-2010 growth in Aus rice production was almost stagnant while both Boro and Aman Rice production had increasing trends.

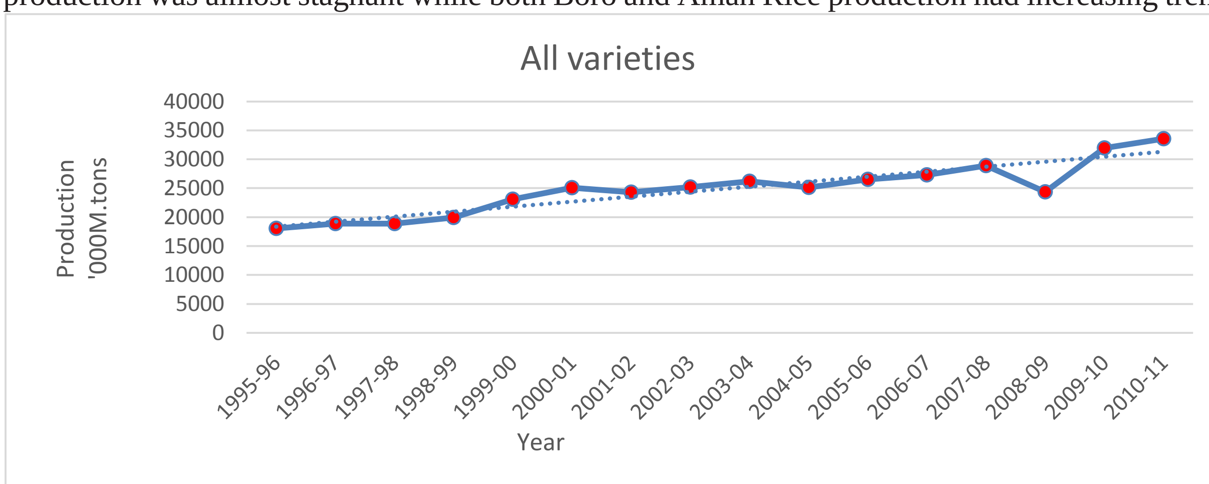


Figure 2.16: Trends of rice production during 1995-2011 period

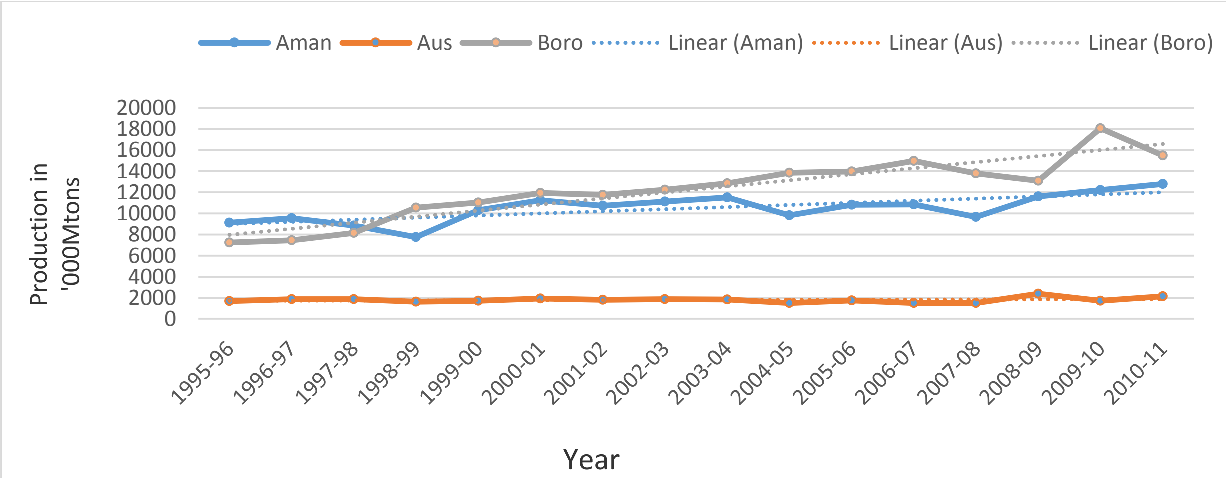


Figure 2.17: Trends of rice production by season during 1995-2011 period

2.4.2 The potential of rice varieties in Bangladesh

Since 1973, BRRI in partnership with IRRI has been engaged in adaptive research for evaluating elite lines under the IRRI managed International Network for Genetic Evaluation of Rice (INGER) and released varieties that suited Bangladesh agro-ecological conditions under the brand name BR and later Brridhan. Many of the elite lines that came to Bangladesh were suited for the boro and aus seasons. The most popular of them are BR1, BR3, BR14, BR14, and more recently BRRI Dhan 28 and BRRI Dhan 29.

We have analyzed yield gaps by growing seasons: Aus, Aman and Boro. We have used one data set of BRRI based on a field survey during 2006-7 and another data set based on a survey in 2010-11. We have used also BBS and DAE data sets. Yield gaps between the potential yield in BRRI Research Station farm and actual farmers' yields for different modern rice varieties by season are presented in Table 2.17 and also in Figures 2.18.1 to 2.18.4. Less yield gap was observed for modern Boro rice. Comparing results of different data sets it was found that BRRI survey results indicated less yield gaps compared to BBS and DAE results. According to the BRRI results of 2006-7, the yield gap ranged 18-26%. This means that the farmers' actual yield is 18-26%. lower than the potentially attainable yield. The BRRI results of 2010-11 showed that yield gaps ranged 22 to 32% with an average of 20%. But if we compare yield gaps estimated using farmer's actual yield from BBS survey and BRRI's technically attainable yields than the yield gap is much higher (30-62%). Results of Karim (2009) based on DAE and BBS data also indicated that higher yield gaps exist.

Some causes of yield gaps are decreasing soil productivity, inefficient water and fertilizer use, inadequate supply of quality seeds, imbalanced use of fertilizer, low labour productivity, and higher input price. These factors are restricting realization of full yield potential of HYVs, resulting in lower yield of cereals in the farmers' field compared with much higher yield obtained in the research station. The major concern is how to reduce this yield gap by improving soil, water and labour productivity, optimizing fertilizer use and reducing input price. Declining land resources and competing demand for limited land is a major concern for future agriculture. New technological breakthroughs, appropriate development interventions and a robust land use policy will be needed to address the problems.

Table 2.17 Maximum possible rice output considering new modern rice varieties in Bangladesh (2010-12)

Season	No. of Rice Varieties	On-station Potential Farm Yield (t/ha)	BRRI on-farm Yield (t/ha)	Yield Gap (t/ha)
T. Aman	22 BRRI rice varieties	5.03	3.45	1.58
Boro	16 BRRI rice varieties	5.59	4.35	1.24
Aus	Average 15 BRRI rice varieties	5.1	3.51	1.59
Average of all variety		5.22	3.74	1.48

Data source: Household survey of BRRI in 9 regions of Bangladesh, Annual report of BRRI 2010-11 and 2011-12.

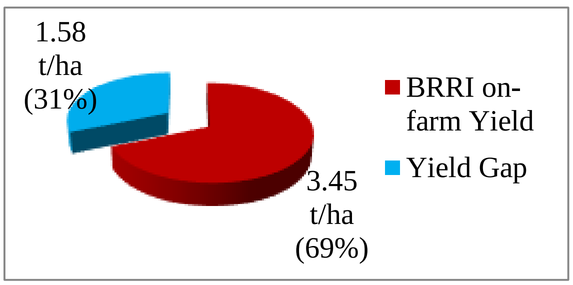


Figure 2.18.1 Yield Gap of Modern T. Aman Rice 2010-11

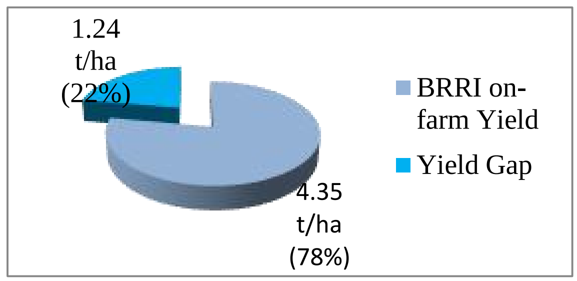
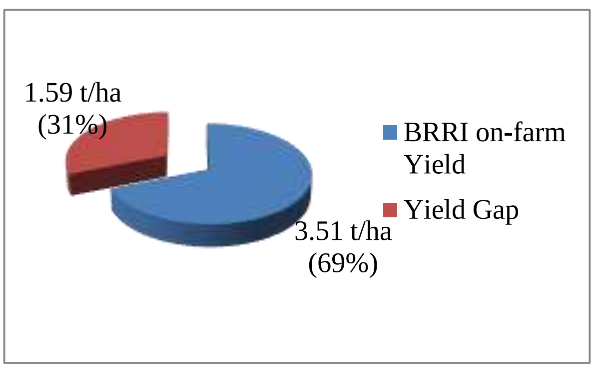


Figure 2.18.2 Yield Gap of modern Boro Rice in 2010-11



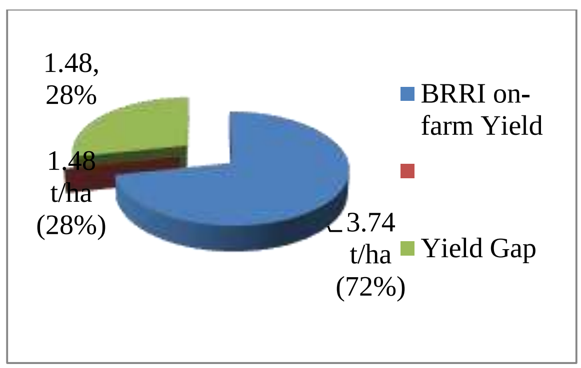


Figure 2.18.3 Yield Gap of Modern Aus Rice in 2010-11
Figure 2.18.4 Yield Gap of all Modern Rice Varieties in 2010-11

Agricultural land in Bangladesh is shrinking fast. The option left for increasing productivity is through minimizing the yield gap. Table 2.15 provides the projected production of rice with the assumption of a reduction of the yield gap by 30% and 60% by 2021. There could be 37.6 million tons of rice production by the year 2021 from the existing rice area (Table 2.18).

Table 2.18 Projection of rice production in 2021 with 60%, 30% yield gap minimisation (YGM)

Rice by season	Projection of milled rice production in 2020-2021 (000 mt)	
Aus Rice	**30% YGM**	**60% YGM**
Local	408	408
HYV	1275	1450
Aman Rice		
Broadcast	287	287
Local	1660	1660
HYV	9485	11251
Boro Rice		
Local	226	226
HYV	19631	21783
Total	**32972**	**37064**

For enhancing rice productivity in the country, the following interventions could be considered:

- Bridging the yield gap
- Scaling up of good farmers' management practices (GFMP) under favourable Agro-Ecological Zones (AEZ)
- Greater thrust of agricultural intensification in the Southern and Sylhet regions.
- Replacement of local varieties by modern varieties in T. Aman season where possible.
- Limited increase in modern variety Boro area.
- Replacement of the present varieties by superior inbred, hybrid and super high yielding varieties.
- Increment of irrigation areas in both Boro and T. Aman season.
- Application of superior management technologies.
- The use of quality seeds.
- Mechanization of rice cultivation particularly minimization of post-harvest losses.

2.4.3 Impact of market reform policies on rice productivity

The government of Bangladesh has undertaken different direct and indirect policy interventions for the development of the agricultural sector. After independence (1971) agricultural policies were mainly state oriented but until the 1980s the policies did not work at all and a very low growth of technological change has been observed (Selim, 2007). To overcome the stagnant situation the government shifted all its policies gradually from state oriented to market oriented. A summary of these polices in pre-reform (1977-1989) and post-reform (1990-2004) periods is presented in Table 2.19-20.

Although market reform policies started in the 1980s, they gained momentum in the 1990s. Therefore, in this study we have considered 1977-89 as the pre-reform period and 1999- 2004 as the post reform period. The aim of the policy reforms was to increase production growth by reducing subsidies, reorganizing the public food distribution system and realigning market incentives. All of the policy tools were synchronized with the freeing up of the domestic markets, allowing importation of inputs and outputs via private channels. The government reduced the control of agricultural input and output markets and lowered tariffs and non-tariff barriers, gradually eliminated subsidies on fertiliser and minor irrigation equipment, minimised government involvement in input distribution, and allowed private sector involvement in distribution of agricultural inputs. However, various polices have been taken up gradually (after 1990s to till date) with the aim of ensuring food grain availability and long-term food security.

Table 2.19 : Summarization of market reform policies in Bangladesh during 1977-2004

Period	Policy	Purpose	Observed outcome
Pre-reform (1977-1989)	• Huge input subsidy • Market quantity rationing • Differentiated tariffs rates • Inputs distributions through government channel • Credit ceiling • Price control • Output price support	• Self sufficiency in food production • Protecting domestic farmers from competition • High production growth • Reducing production cost of the farmers	• Low output growth • Slow rate of technology adoption
Post-reform(1990-2004)	• Deregulation of input subsidy • Reducing government control in agricultural inputs and output markets • Lowering tariffs and non-tariffs barriers (NBTs) • Foodgrain importation by private sector • Gradual elimination of the public foodgrain distribution system • Price stabilization through open tender procurement policy • Permitting the private sector in procuring fertilizers and irrigation equipment	• High production growth • Increase productivity and efficiency of farms • Occasionally ensuring food security • Agricultural inputs availability to farmers	• Boro rice production increased • Less than projected growth in production of hybrids rice

Table 2.20 Gradual reform in the Bangladesh input markets

Actions	**Time**	**Remark**
Fertilizer market		
BADC withdraws from retail and wholesale markets, private traders introduced	1978-83	First done in Chittagong division, then other places.
Licensing requirement abolished. Restriction on movement withdrawn	1982-83	Private trade responds vigorously.
Deregulation of prices	1982-84	Real competition starts

Actions	Time	Remark
Private trade allowed to purchase directly from factory gates and port points	1987	Vigorous response from traders
Free import from world market	1992	Good response but fear of oligopoly persists
Fertilizer crisis and reversal of some reform	1995	Subsidy returns but on a smaller scale
Government does not privatize production of urea	—	Scope of inefficiency persists
Irrigation policies		
BADC sells all low-lift pumps	1980-82	Good response from farmers
BADC sells all tubewells	1983-85	Good response from farmers
Restriction on import of engines and standardization requirement removed	1988	Drastic fall in cost and vigorous growth starts
No reform of BWDB policies	—	Wastage continues
Power tiller, pesticides and seeds		
Restriction on import and standardization requirement removed	1989	Vigorous response
Restriction on brand names in import removed	1989	Modest response
Except rice and wheat seeds, all seed import liberalized	1990	New private seed farms and nurseries are mushrooming
Rice and wheat seed import liberalized	1997	

Source: Ahmed (2001), Guisselquist (1992) and also personal contact.

By constructing an index of Total Factor Productivity (TFP), it is possible to assess the performance of the food grain productivity of the Bangladesh agricultural system over time under pre-reform and post-reform policy as stated in Table 2.17.

The main focus of our analysis is to find out the trend of rice productivity and efficiency at farm level during two policy regimes. For this purpose we have estimated total factor productivity (TFP) and technical efficiency (TE) changes covering the data from the pre and post-reform periods. The methodology of estimation of TFP and technical efficiency has been presented in Annex 2.1.

There are a few studies available on total factor productivity (TFP) growth in Bangladesh, Some of these are Islam (2003), Pray and Ahmed (1991), Dey and Evenson (1991) and Coelli *et al.*, (2003). These studies used time series data for estimation of TFP. However, Alam, *et al* (2011) used farm level panel data for estimation of TFP of rice farmers in Bangladesh. In the present study we have used a time series data to estimate TFP of rice during the pre-reform period (1977-1990) and also used a farm level panel data of 64 districts of BRAC for the post-reform period 2004 and 2014. The result is discussed below.

2.4.4 Impact of market reform policies on TFP of rice

Total factor productivity (TFP) indices were estimated using a large sample of farmers in 64 districts of Bangladesh for the three season modern rice, to measure their productivity over the two policy regimes by using the procedure of TT index described in the Annex. The result is presented in Table 2.21 and Fig 2.22. It was found that TFP of modern variety Aus, Aman and Boro sharply increased during the pre-reform period (1977-89). During the post reform period (1999-2004), the TFP of modern Aus, Aman and Boro declined but remained positive.

It was found that the TFP of modern Aus and Aman rice increased by 2.3% and 19.6%, respectively while the TFP modern boro declined by 16.8% but remained positive and the TFP of total rice increased by 1.9% during 2004-2014 (Table 2.20). The result is found to be consistent with the findings of Alam *et al* (2011) that during the post-policy reform period the TFP of modern rice declined but was positive. Alam *et al* (2011) used a panel data set of BIDS, IRRI and IFPRI of the period 1987, 2000 and 2004 from 64 districts of Bangladesh and estimated TFP of modern rice from farm specific information. It was found from our analysis of input-output information from a large sample of farmers in 64 districts of Bangladesh that during 2004-2014, rice output per unit of labour increased while it declined for fertilizer (Table 2.23). During this period per ha labour use declined (Fig 2.20) while the fertiliser cost increased considerably and insecticide cost decreased (Fig. 2.21 and 2.22).

Table 2.21 Impact of market reform policies on rice productivity (TFP) in Bangladesh

Policy regime	Year	TFP MV Aus	TFP MV Aman	TFP MV Boro	All MV rice
Baseline	1973	100	100	100	96
Pre-reform period	1979	155	180	172	169
	1984	160	200	183	181
	1989	110	140	202	151
Post- reform period	1992	115	126	172	138
	2004	111	100	108	106
	2014	113	119	90	108

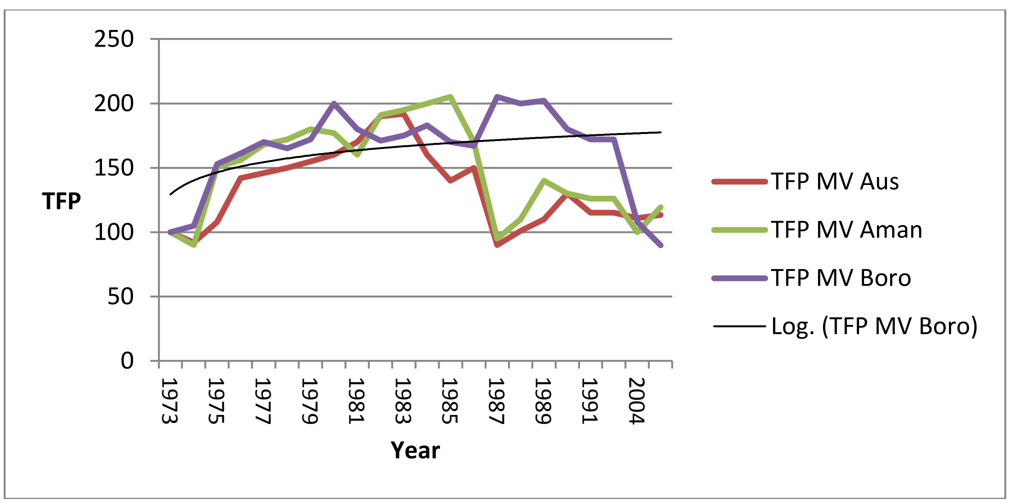


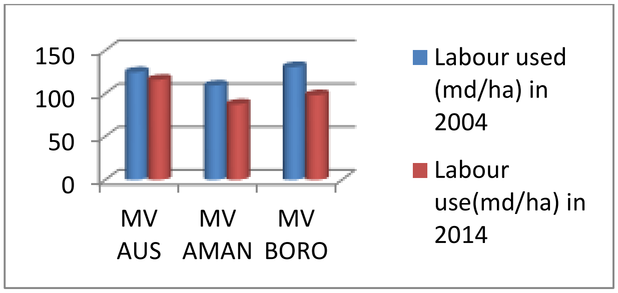
Figure 2.19 TFP of modern variety Aus, Aman and Boro rice during 1973 to 2014

Table 2.22 Changes in TFP of modern rice production of sample farmers of 64 Districts of Bangladesh by season (2004-14)

Year	Mean TFP			
	Aus	Aman	Boro	All rice
2014	113	119	90	108
2004	111	100	108	106
Change (%)	2.3	19.6	-16.8	1.9

Table 2.23 Productivity of labour and fertiliser for modern rice production (2004-2008)

Inputs	Rice Output (Kg)					
	MV Aus		MVAman		MV Boro	
	2014	2004	2014	2004	2014	2004
Per unit labour use (man days)	130.22	23.45	128.89	36.06	169.55	45.33
Per Tk invested in fertilizer	.74	2.09	.95	2.98	.89	1.82



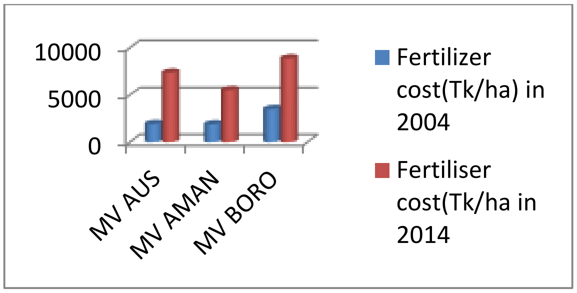


Fig. 2.20 Labour use in MV rice (2004-2014)

Fig 2.21 Fertilizer cost of MV rice cultivation (2004-14)

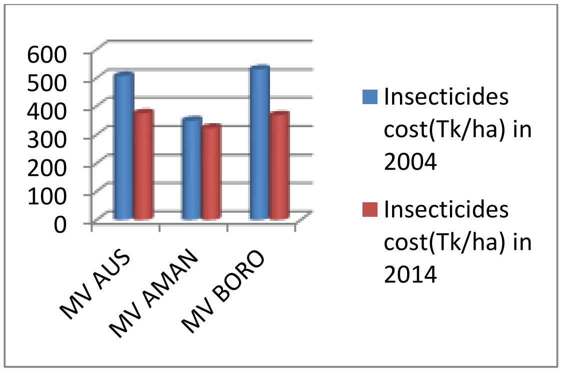


Figure 2.22 Insecticide cost of MV rice (2004-14)

2.4.4 Technical efficiency of Boro rice production in Bangladesh

The methodology of estimation of frontier production function and technical efficiency has been presented in the Annex.

Table 2.24 presents the maximum likelihood parameter estimates (MLE) of stochastic frontier production function of modern boro rice of sample farmers of 64 districts of Bangladesh in 2014. The results of stochastic frontier production function show that fertiliser, irrigation, insecticides and human labour costs are significant. The coefficient of fertilizer cost is 0.163 meaning that if the other things remain constant, return from boro rice will be increased by 0.163% for 1% increase in the use of fertilizer. Similarly, irrigation and insecticide costs also contributed to the return from boro rice positively. For the inefficiency model, farmers' education level and age are significant and negative. The negative sign of the coefficient of education level and age indicate that they reduced the inefficiency in boro rice cultivation. Table 2.25 presents the maximum likelihood parameter estimates (MLE) of stochastic frontier production function of modern boro rice of sample farmers of 64 districts of Bangladesh in 2004.

Table 2.24 Maximum likelihood estimates of parameters of stochastic frontier production function and inefficiency model of boro rice cultivation in 64 districts of Bangladesh in 2014

Stochastic production function variables	Coefficients	Inefficiency variables	Coefficients
Constant	0.995 (0.201)*	Constant	0.279(0.107)*
Ln fertilizer cost	0.163(0.0218)**	Cultivated land	0.105(0.302)
Ln irrigation cost	0.067(0.009)**	Education of farmer	-0.121(0.034)*
Ln insecticides cost	0.004(0.001)**	Age of farmer	-0.254(0.0761)*
Ln human labour cost	-0.035(0.008)*	Log- likelihood function	65.337**
Variance (σ^2)	0.184(0.485)	LR Test statistics (λ)	25.68**
$\Upsilon = (\sigma^2_u/\sigma^2_v)$	0.988 (0.003)		

Note: * and ** shows statistical significance at 1% and 5% level, respectively. Figures in parentheses are standard error of the estimates

Table 2.25 presents the maximum likelihood parameter estimates (MLE) of stochastic frontier production function of modern boro rice farmers of 64 districts of Bangladesh in 2004.

Stochastic production function variables	Coefficients	Inefficiency variables	Coefficients
Constant	9.74 (0.214)**	Constant	0.523(0.160)*
Ln fertilizer cost	0.074(0.022)*	Cultivated land	-0.04(0.001)*
Ln irrigation cost	0.004(0.003)	Education of farmer	-0.001(0.001)
Ln human labour cost	0.102(0.02)*	Age of farmer	-0.048(0.004)*
Variance (σ^2)	0.073(0.006)*	Log- likelihood function	20.0*
$\Upsilon = (\sigma^2_u/\sigma^2_v)$	0.837 (0.066)*	LR Test statistics (λ)	32.30**

Note: * and ** shows statistical significance at 1% and 5% level, respectively. Figures in parentheses are standard error of the estimates

2.4.5 Farm specific technical efficiency

The distribution of farm specific technical efficiency in boro rice cultivation in 2014 is presented in Figure 2.23. In the case of boro rice cultivation, starting from 20% technical efficiency, the proportion of farmers rises with the increasing level of efficiency. The highest proportion of farmers (63.4%) has the efficiency level of 71-90% followed by 22.4% who have an efficiency level of 91-100%.

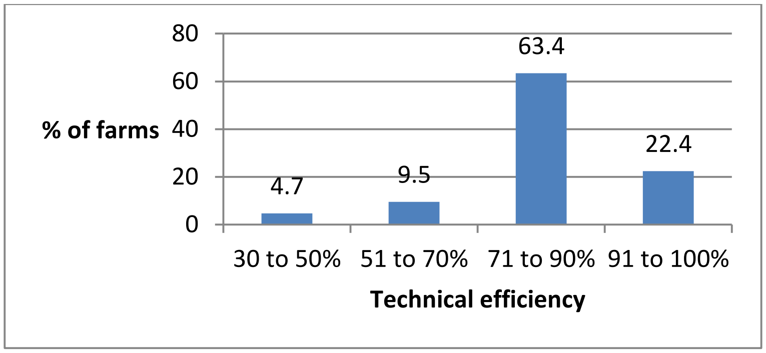


Figure 2.23 Distribution of farm specific technical efficiency of boro rice production in 64 districts of Bangladesh in 2014

Mean technical efficiency of the sample boro rice farmers of 64 districts in 2004 and 2014 are presented in Figure 2.24. The mean efficiency of the boro rice growers was 68% in 2004 and it increased to 80% in 2014. It shows that there is a considerable improvement of the mean technical efficiency of the sample farmers over the last decade. The main driver of reducing inefficiency in rice production was the human capital of the farmer, i.e, education and experience of the farmer.

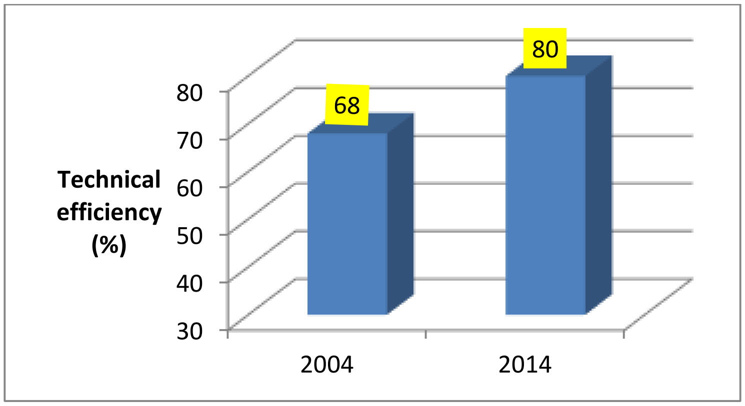


Figure 2.24 Specific mean technical efficiency of sample farmers of 64 districts in 2004 and 2014

2.5 Productivity of non-rice crops

The non-crop agricultural sectors performed better than the crop sector during the SFYP period. In 2013-14, the growth rate for fisheries, forestry, livestock and crop subsectors were 6.19%, 5.05%, 2.83% and 1.91% respectively. Between 2007-08 and 2012-13 period, the area under wheat, maize, oilseeds, spices, potato and vegetables increased, though the area under sugarcane and fruits decreased. It was found that production of all the crops except pulses and banana increased during the SFYP period (Table 2.26). A sharp increasing trend in production was observed for brinjal and edible oilseeds. With the exception of bananas and jackfruit, all the crops maintained an almost steady increasing trend in production since 2009-10.

Table 2.26: Annual change in major non-rice crop production and change in yields
(3 year moving average)

Crops	2009-10		2010-11		2011-12		2012-13		2013-14	
	Change (%)		Change (%)		Change (%)		Change (%)		Change (%)	
	Production	Yield	Production	Yield	Production	Yield	Production	Yield	Production	Yield
Wheat	6.1	9.6	7.9	6.3	2.4	5.1	26.1	7.7	3.8	6.3
Maize	21.6	-0.7	14.8	0.9	27.5	5.0	14.4	4.3	4.1	4.4
Potato	50.5	9.3	5.0	5.5	-1.5	1.8	4.8	2.0	4.0	3.3
Pulses	12.5	3.7	3.9	0.5	4.7	3.6	10.7	0.6	-40.7	9.8
Brinjal	1.1	0.8	-0.4	1.0	3.9	2.2	4.8	3.7	20.7	10.4
Oilseeds*	11.9	2.3	5.2	1.4	2.7	4.0	5.4	0.7	16.1	3.5
Mango	1.7	0.0	5.5	8.9	6.3	4.5	1.3	6.3	3.7	-2.9
Banana	-2.1	-3.9	-2.1	-2.7	-6.8	-3.7	3.8	1.9	-0.5	4.2
Jackfruit	3.1	2.3	-4.4	-2.1	-3.6	-1.6	3.0	1.1	5.0	7.9

Note: * Includes sesame, rape & mustard, groundnut and soya bean
Source: FPMU 2013, 2014 and 2015

2.6 Productivity assessment of livestock

During the last three decades a structural transformation has taken place in Bangladesh agriculture. The country has achieved self-sufficiency in food grain production due to an appreciable growth rate in the sector but the share of agriculture in GDP has declined relative to other sectors. Within the agriculture sector, the share of the livestock sub-sector has increased relative to crop, fisheries and forestry. The livestock share of agricultural income increased from 7.6% in 1973–74 to 12.9% in 1998–99 and is projected to increase to 19.9% in 2020. During 1973/74–1989/90, livestock output grew at 5.2% per annum compared to 1.7% for crop output and 2.6% for agricultural output in general (Hossain and Bose 2000, Jabbar, et al, 2005). During 2001/02–2011/12, agricultural output grew at 4.2% while livestock output grew at 4.0% against the crop output growth of 4.1% (at 1995-96 constant prices). Milk production in the country increased from 1.29 million tonnes in 1987–88 to 3.5 million tonnes in 2011-12. However, current national production is inadequate to meet demand. During the same period production of meat and eggs also sharply increased (Fig. #).

These changes have been prompted by a rapid growth in demand for livestock products due to income and population growth and urbanization. This is part of a phenomenon observed throughout the developing world. From the beginning of the 1970s to the mid-1990s, the market value of the increase in meat and milk consumption in the developing countries was approximately US$ 155 billion (in 1990 dollars), more than twice the market value of increased cereal consumption under the Green Revolution. The demand growth for livestock products in the developing world is expected to continue well into the new millennium, creating the opportunity for a veritable Livestock Revolution if the increased demand can be met from increased domestic production. Producers may gain through increased income and employment and consumers through access to cheaper livestock products. Evidence from field studies in developing countries show that rural poor and landless households typically derive a larger share of their cash income from livestock than do well-off farmers (Delgado et al. 1999).

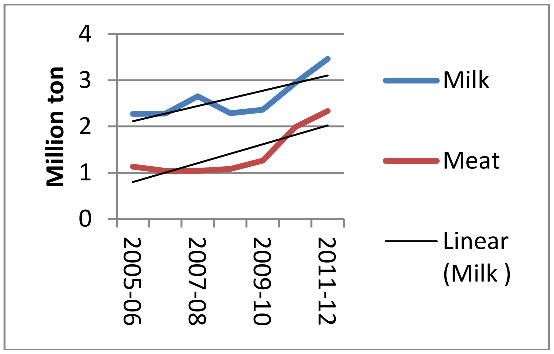


Figure 2.25 Trend in production of milk and meat

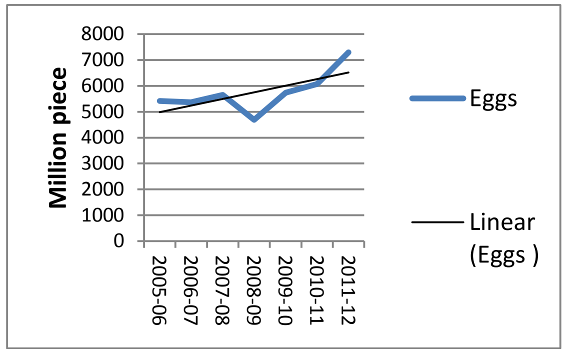


Figure 2.26 Trend in production of egg

Dairy and poultry are the most important livestock enterprises produced by smallholder crop–livestock farmers in Bangladesh. Milk production still remains predominantly in the hands of small-scale mixed farms and landless households with 1–2 local cows, who produce 70–80% of the milk in the country. Dairy development efforts through cross-breeding, milk collection and processing for urban markets are limited to a number of milk sheds covering a tiny part of the country and to medium to large farms. On the other hand, poultry is the most widely-held livestock species among smallholder farmers, especially poor and landless households. In many cases, poultry serve as the first of a 'livestock asset ladder' in that a family may start with a few chickens and gradually acquire a goat, then a cow through accumulated income and savings (Todd 1998). Until recently such traditional rural smallholder producers raising scavenging poultry using non-descript indigenous breeds were the only source of poultry and eggs in both rural and urban markets.

In 1962–63, the Directorate of Livestock Services established 91 small poultry units in 91 *thanas* with the objective of supplying improved types of birds to rural farmers. During the1990s the Department of Livestock Services (DLS) and BRAC developed a smallholder poultry model through trial and error targeting poor and landless, especially women, to use poultry as a vehicle for poverty alleviation. During 1992–2002, through three large projects funded by the Danish International Development Agency (DANIDA), International Fund for Agricultural Development (IFAD), Asian Development Bank (ADB) and the Government of Bangladesh, the model has been extended to about 875 thousand poor and landless households in 195 *thanas* (Islam and Jabbar 2003). However, these efforts alone could not cope with rapidly rising urban demand for poultry meat and eggs. In response to this market opportunity, beginning from the early 1990s, a commercial poultry (broiler and layer) sector has emerged using intensive production techniques (exotic and crossbred birds, concentrate feeds and drugs) and with technical and policy support (subsidized credit, local production and import of DOCs, drugs etc).

Income elasticity of demand for milk was estimated to be 1.62 compared to 1.19 for meat and eggs in 1995–96, and these are projected to be 0.65 and 0.63, respectively, in 2020. Milk production in the country needs to grow by 4.2–5.6% and meat and egg production by 4.7–5.9% per annum to meet increased demand (Hossain and Bose 2000). Achievement of such a high growth rate in the livestock sector has the potential to create employment and income generation for a large number of smallholder producers and others involved in dairy and poultry production, processing and marketing, and get them out of poverty. Dairy and poultry generate more regular cash income and their production, processing and marketing generate more employment/unit value added compared to crops (Asaduzzaman 2000; Omore et al. 2002).

Table 2.27 presents productivity of the livestock subsector during the sixth Five Year Plan. The contribution of the livestock sub-sector to GDP at constant prices was 2.58 percent in FY 2010-11.The estimated contribution to GDP during FY 2011-12 from this sub-sector was 2.50 percent. Though the share of the livestock sub- sector in GDP is small, it makes an immense contribution towards meeting the daily animal protein requirements. A number of initiatives have been taken for livestock development. The most important ones include: production and distribution of vaccine for poultry and livestock, supply of ducklings and chicks at a cheaper price, artificial insemination extension programme for improved breeds, transfer of improved farming technology, prevention and control of anthrax, foot and mouth diseases and avian influenza.

Table 2.27: Productivity of livestock subsector during Sixth Five Year Plan, 2009-14

SFYP output proxy indicators	2009-10	2010-11	2011-12	2012-13	2013-14
GDP from livestock sector as % of agricultural GDP (excluding forest, at constant price 2005-06)	12.4%	14.1%	12.2%	12.3%	14.08%
Total production of Egg (millions)	5,742.4	6078.5	7,304	7,617	10168
Milk (millions MT)	2.37	2.97	3.47	5.07	6.9
Meat (million MT)	1.26	1.99	2.33	3.62	4.52
Annual change in artificial insemination	15.25%	7.67%	10.11%	7.40%	na
Annual change in number of poultry deaths due to avian flu	274%	231%	-75.4%	-95.1%	na

Source: FPMU 2013, 2014 and 2015 & BER (2014)

According to the estimate of the Department of Livestock Services, the population of livestock and poultry rose to 52,836,000 thousand and 288,566,000 respectively in 2011-12. Table 2.28 shows the growth of the livestock and poultry population of the country during 2005-12. Table 2.29 shows increasing trends in production of milk, meat and eggs

Table 2.28 Growth of Livestock and Poultry in Bangladesh.
(Number in lakh)

Livestock/ Poultry	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Cattle	228.0	228.7	229.0	229.76	230.51	231.21	231.95
Growth Rate (%)	-	0.31	0.13	0.33	0.33	0.30	0.32
Buffalo	11.6	12.1	12.6	13.04	13.49	13.94	14.43
Growth Rate (%)	-	4.13	3.97	3.37	3.34	3.23	3.40
Goat	199.4	207.5	215.6	224.01	232.75	241.49	251.16
Growth Rate (%)	-	3.90	3.76	3.75	3.76	3.62	3.85
Sheep	25.7	26.8	27.8	28.77	29.77	30.02	30.82
Growth Rate (%)	-	4.10	3.60	3.37	3.36	0.83	2.60
Total livestock	**464.7**	**475.1**	**485.0**	**495.58**	**506.52**	**516.66**	**528.36**
Growth Rate (%)	**-**	**2.19**	**2.04**	**2.13**	**2.16**	**1.96**	**2.21**
Chicken	1948.2	2068.9	2124.7	2213.94	2280.35	2346.86	2428.66
Growth Rate (%)	-	5.83	2.63	4.03	2.91	2.83	3.37
Duck	381.7	390.8	398.4	412.34	426.77	441.20	457.00
Growth Rate (%)	-	2.33	1.91	3.38	3.38	3.27	3.46
Total Poultry	**2329.9**	**2459.7**	**2523.1**	**2626.28**	**2707.12**	**2788.06**	**2885.66**
Growth Rate (%)	**-**	**5.28**	**2.51**	**3.93**	**2.99**	**2.90**	**3.38**

Table 2.29 Trend in production of milk, meat and eggs

Product	**Unit**	**Production**						
		2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Milk	Lakh tonnes	22.7	22.8	26.50	22.86	23.65	29.47	34.63
Meat	Lakh tonnes	11.3	10.4	10.40	10.84	12.64	19.86	23.32
Eggs	Lakh	54220	53690	56532	46920	57424	60785	73038.9

2.6.1 Productivity assessment of dairy

Table 2.30 presents daily milk yield of Cross Breed Cows (CBC) and local cow (LC). Average daily milk yield of CBCs is 8 liter and average yield of local cow is 4.9 liter. Table 2.31 presents profitability of milk production of CBC farms and LC farms. Net profit of CBC farms is almost double of LC farms.

Table 2.30 Productivity of dairy farms in Bangladesh

	Daily milk yield(Liter/cow)			
	Small	Medium	Large	All farm

Cross Breed Cow (CBC)				
All CBCs	8.2	8.3	7.6	8.0
Frisian cross	8.7	8.7	7.9	8.5
Jersey cross	9.4	7.5	8.1	8.6
Sahiwal cross	7.1	8.3	8.1	7.8
Red Sindhi cross	5.1	6.7	5.8	5.8
Local cow farms	4.9	4.1	5.5	4.9

Source: Jabbar and Islam (2005)

Table 2.31 Costs and returns (Tk/litre) of milk production by farm type and size.

Farm type and size	Small	Medium	Large	All farms
CBC farms				
Total variable cost	8.31	7.97	7.74	8.16
Total fixed cost	2.66	1.78	1.67	2.31
Total cost	10.97	9.75	9.41	10.47
Gross return	16.15	16.23	16.48	16.24
Gross margin	7.84	8.26	8.74	8.08
Net profit	5.18	6.48	7.07	5.77
LBC farms				
Total variable cost	8.70	10.02	5.83	8.76
Total fixed cost	5.32	2.81	2.75	4.85
Total cost	14.02	12.83	8.58	13.61
Gross return	15.92	16.34	16.50	16.11
Gross margin	7.22	6.32	10.67	7.35
Net profit	1.90	3.51	7.92	2.50

Source: Jabbar and Islam (2005)

Total factor productivity (TFP) of milk production of both CBC and LC has been estimated and presented in Table 2.320. It was observed that there is an increasing trend in TFP of milk production for CBC and LC.

Table 2.32 Total factor productivity of milk production (per cow/day)

	Local cow			Cross breed Cow		
	1991	2002	2008	1991	2002	2008
Total output (Tk/cow)	14.64	16.11	52.27	13.81	16.24	224.76
Total inputs(Tk/cow)	14.12	13.61	32.85	10.41	10.47	71.23
TFP	1.04	1.18	1.59	1.33	1.55	3.16

Source: author's estimation

2.6.2 Technical efficiency in dairy farming

Jabbar and Islam (2005) found that the price of dry roughage, the price of veterinary treatment, the value of the herd and access to credit have a significant effect on the profitability of dairy farming. The price of dry roughage and the cost of veterinary treatment significantly reduced profit of the CBC farms. On the other hand, fixed factors like the value of the total herd and access to credit (as proxy for financial capital) significantly increased profit of this type of dairy farm, indicating that larger scale operation helps to enhance profit. In the case of LBC farms, the parameters of the wage rate, the price of green roughage, the annual fixed labour and value of the total herd were found to be significantly affecting profitability. The positive effects of fixed factors like total herd value and annual fixed labour indicate that there was an economy of scale. The coefficient of credit access was not statistically significant. One possible reason was that few LBC farms obtained credit and the volume of credit rather than access per se might have been more important, but the effect of volume could not be adequately captured by the credit dummy variable.

The mean economic efficiency of LBC farms is higher than that for CBC farms but the range, standard deviation and variance of farm-specific efficiency are almost similar for the two groups (Table 2.33). Average efficiency of small and medium farms did not differ significantly in case of either CBC or LBC farms but in both cases, efficiency of large farms was significantly higher than the small and medium farms.

In the case of CBC and LBC farms, the coefficients of age of the head of household are positive and significant. The results imply that older farmers may be less efficient as they may not use up-to-date management methods. A higher proportion of crossbred cows in the dairy herd significantly reduced inefficiency implying the importance of better quality animals for improving productivity and profit. A larger number of extension visits to the provider organization by the farmers themselves significantly reduced inefficiency. Ownership or regular access to pasture land significantly reduced inefficiency as it allowed more flexibility in the use of good quality feed. Larger dairy herd size significantly reduced inefficiency of LBC farms by reducing cost/unit of feeds and other inputs.

Table 2.33: Descriptive statistics for farm specific economic efficiencies of dairy farms

Farm specific efficiency	Farm specific economic efficiency	
	CBC farm	LBC farms
Minimum	11	16
Maximum	100	98
Mean	44	55
Variance	24	30
Standard deviation	5	6

2.7 Productivity assessment of fisheries

The country's fisheries resources can be divided into two major categories such as inland fisheries and marine fisheries. Inland fisheries are further classified into two groups, i.e. inland culture and inland capture. Inland fisheries occupy an area of 47.04 lakh ha with an area of 1,18,813 sq.km along with 200 nautical miles of EEZ which form the baseline. The culture fisheries include ponds, ox-bow lakes and coastal shrimp farms. The flood-plains and the beels, which cover an area of 29.25 lakh ha, offer tremendous scope and potential for augmenting fish production by adopting appropriate aquaculture enhancement techniques.

During the period 2003-4 to 2013-14 total fisheries production in Bangladesh sharply increased from about 20 lakh MT to 35 lakh MT (Fig. 2.27). The major contribution to such a large increase taking place in the composition of the country's total fisheries production came from changes in three sources – inland fisheries (capture), inland fisheries (culture) and marine fisheries. In 2003-04, shares of inland capture, culture and marine fisheries were 38%, 39% and 24%, respectively. During 2003-14, the share of inland culture fisheries to the country's total fish production sharply increased to 56%, while the share of inland capture fisheries declined to 22% and marines fisheries also declined to 12%. Also, flood plain fisheries production and case and pen culture also had an increasing trend and contributed positively towards increasing the country's total fisheries production.

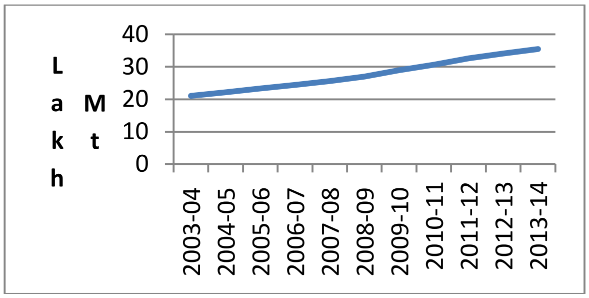
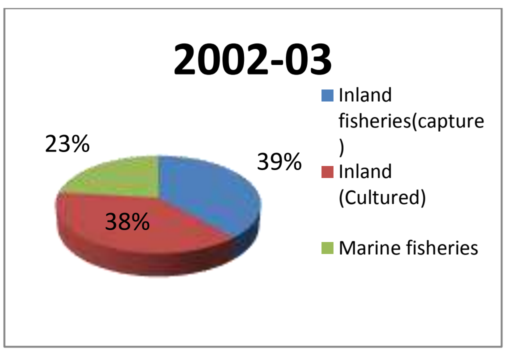


Fig. 2.27 Increasing trend in fisheries production of Bangladesh,
Source: Bangladesh Economic Review, 2015, 2010



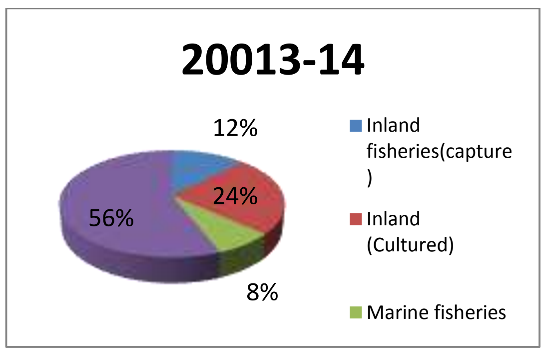


Fig. 2.28 Share of different sources of fish production to country's total production (2002-14)

2.7.1 Productivity of inland open water fisheries

Bangladesh is rich in terms of inland water resources, including 24,000 km of rivers, streams and canals with an estimated area of 480,000 ha, some 114,161 ha of natural depressions or beels, 68,800 ha of reservoir and some 5.5 million ha of floodplains. Rivers and canals roughly cover 5.8% of the total area of the country. Annual flooding during the rainy season inundates up to 60% of the total land surface. Permanent flooded areas represent 6.75% of Bangladesh's landmass. After China and India, Bangladesh is the third largest country in the world in inland fisheries. But at present the average yield for inland fishery is low and declining by about 2.7 per cent a year. Inland waters comprise numerous rivers, canals, haors, beels, lakes and a vast area of flood plains amounting to about 4.4 million ha (88.45% of total) and produce about 1.6 million MT which was about 41.36% of total fish production.

Beel fishery has taken a new dimension in certain areas, particularly in the greater Mymensingh region, wherein about 45-50% beels have been brought under intensive pangas cultivation giving a production from 10 MT/ha/year to 40MT/ha/year. Similarly, floodplain fisheries have also become a profitable business following the Daudkandi model of community based aquaculture in the floodplain area. However, some initiatives such as community based management of resources, fingerling stocking in open waters, expansion of cage and pen culture in the open water, Jatka- the juveniles of hilsa - protection and sanctuary development in the open water areas have been taken up, although these are not sufficient. One of the major problems faced by the open water fisheries is the leasing system of the Jalmohal which is based on revenue collection only but the production enhancement and biological management has not been considered. As a result, the poor fisherman's/person's livelihood will not be sustained. Another problem is the open access to the flowing water has restricted the access of the poor fishermen and encouraged the richer. To support the poor fisherman's livelihood from such water bodies, a licensing system should be introduced for the genuine fishermen. Other problems confronting the development of open water fishery are overfishing, lack of proper implementation of fisheries regulations, lack of awareness development and non participation of the community, conflict of water uses, environmental pollution and habitat degradation.

2.7.2 Productivity of Hilsa fishery

Hilsa is our national fish and has the highest contribution to the country's fish production as a single fish species. During the year 1989-90, hilsa contributed 34.14% of the total capture fisheries whereas during 2014, it contributed around 27.35%. Hilsha productivity in Bangladesh is declining over time. The main causes of declining hilsha productivity are destruction of spawning grounds, higher salinity in the spawning grounds and Jatka killing in the coastal districts. To ensure its steady growth in production, the government has adopted a coordinated program to protect Jatka from 2003-04.

2.7.3 Marine fisheries productivity

Bangladesh has a coast line of about 714 km and an Exclusive Economic Zone (EEZ) of 164,000 Km^2, of which 44% is continental shelf. It offers great potential for marine fisheries production. In spite of this high potential, this sub sector contributes only about 21% of the total fish production among which artisanal fisheries contributes 93% and industrial fisheries only 6% of the total marine fish production. Due to lack of development efforts in this sub-sector, the production remained almost static during the last ten years (1998-2008) although some resources declined. The sub-sector is divided into artisanal and industrial fisheries based on the subsistence and commercial scale of the operation. Though the Bay of Bengal has about 442 species, only about 20 species are harvested commercially. The trend of marine fishing over the last 15-16 years has been declining.

Data indicated that, as inland sources were being gradually depleted, pressure has been mounting on the remaining marine and estuarine sources. Therefore, marine and estuarine sources are being over exploited, which might lead to diminishing fish resources in these regions in the near future. Indiscriminate and over fishing have already been reported to leading fish resources in the coastal seas to near-exhaustion (Nazimuddin, 2008). Illegal fishing by other countries is also depleting the country's valuable deep sea resources affecting the fishermen as well. Marine fisheries provide a livelihood to about 0.51 million fisher folk. Improvement in landing and industrialization of the sub-sector will improve the livelihood of this population.

2.7.4 Productivity of pond culture

Currently, fish culture in ponds has been practised in a total area of about 3.7 lakh ha which is 7.9 % of total inland water. Pond aquaculture is producing about 19.6 lakh MT fish contributing 56% of total inland production in 2013-14. The average productivity of pond fish is 3,430 kg/ha (DOF, 2013). Pond aquaculture is contributing about 866,049 MT representing 41.92% of total inland production (2839 Kg/ha), which is far lower compared with other neighbouring countries. The trend of pond production over the last two decades has been increasing. Most of the pond production involves poly-culture. Under monoculture of certain species (catfish, tilapia, perch), average production reached up to 3,500-4,000 kg/ha/year. Under the improved poly-culture system, production was found to be doubled. Intensively managed ponds, using improved fingerling, commercial feed and good pond management practices produced up to 10,000 kg/ha/year (NMTPF 2010).There are instances that private farmers in Narshingdi, Trishal and Mymensingh areas have improved poly-culture systems of carp, pangas and GIFT etc. There are records of producing over 40 tons per hectare of pangas under intensive farming with improved supplemental feeds in the Trishal area. In the greater Mymensingh region, most of the aman and boro lands are being converted into ponds for pangas culture. As a result, the total pond area has been increasing. This trend of fish cultivation has already been expanded throughout several districts in the country. The future development of aquaculture depends on the status of existing resources and the potential for bringing more resources under management using aquaculture principles.

2.7.5 Fish culture in the floodplain and paddy field

An opportunity for increased production in the flood-prone ecosystem is the integration of fish culture with rice farming. The flood-prone areas are seasonally flooded during the monsoon and remain submerged for 4 to 6 months. The vast water bodies can provide natural habitats for various aquatic resources including wild fish and shrimps. The yearly silt deposition and organic matter decomposition favour the natural growth of flora and fauna. The abundance of natural organisms favours fish culture for 4 to 5 months in these flood-prone areas. Community-based management approaches have been successfully used to culture fish in the floodplain.

Paddy fields and seasonal floodplains are potential and promising resources for aquaculture. It has been estimated that paddy fields cover an area of about 80 lakh ha of which 28.34 lakh ha are floodplains which remain under water for 4-5 months. Previously, Government has taken the initiative to increase fish production from these flood plains through stocking fish fingerlings. Through the 2nd ADP and 3rd Fisheries project, farmers were motivated to stock in suitable floodplains. Some NGOs have been leading community based floodplain aquaculture in Daudkandi of Comilla District. The Department of Fisheries (DoF) along with partner NGOs has taken initiatives to maximize fish production from rice fields and to extend the coverage area. The fish production obtained from the floodplain aquaculture projects in and around the Daudkandi area ranges from 2.5 to 3.0 ton/ha. It is very encouraging for the landowners and farmers to have the additional income from their land within a 4-6 months period, when land is usually left fallow. The farmers on average get a gross return of Tk. 176,385/ha and a net return of Tk 61,077 /ha. Flood plain fish culture is now intensively practiced in the Teesta Basin regions of Rangpur, Kurigram, and Nilphamari districts. If 10% of paddy fields come into this culture system where paddy fields go under water, then about 85 lakh MT more fish will grow annually producing 300 kg fish per ha (DOF 2013).

2.7.6 Productivity of cage and pen culture

Cage aquaculture has been identified as a means of livelihood for landless people. The Northwest Fisheries Extension Project (NFEP) in Parbatipur, Dinajpur and Patuakhali-Barguna Aquaculture Extension Project (PBAEP) demonstrated cage aquaculture on a pilot basis. The production achieved through cage culture was encouraging and satisfactory. Cage culture of monosex tilapia is being practised in Chandpur, Laxmipur Faridpur, Barishal, Mymensingh, Dhaka, Munsigonj, Gopalganj, Narshindi, Chapainawabgonj and other regions of Bangladesh. In 2013 about 6750 MT fish was produced from 6000 cages.

Pen culture: Pen culture is also one of the potential means of producing fish from vast water bodies or water channels (DOF 2013). In recent years, pens are made with different materials like bamboo, net, iron mesh, wooden pillars etc. The area of pen also varies in size from half to few ha. The fish species reared in the pen are carp, tilapia, pangas etc. Feeds are also applied in the pen culture system but not regularly. Both single and multi owners are found in pen management. The culture period also varies from June to December depending on the availability of water. Pen culture is also becoming popular in and around Dhaka and Narayanganj and expanding every year.

2.7.7 Productivity and potential of Shrimp culture in the coastal region

In 1994 the government declared the coastal region as open for brackish water shrimp farming through a government order. From then, brackish water shrimp farming has been expanded rapidly. The area under brackish water shrimp farming started growing almost exponentially. The highest increase was in the SW region i.e. Bagerhat, Khulna and Satkhira because of the abundant source of shrimp post larvae (fry) in the Sundarbans mangrove forest and surrounding rivers and estuaries. Among the coastal districts, the highest increase in shrimp farming occurred in Bagerhat, Khulna, Satkhira and Cox’s Bazar. Again, within these districts the highest numbers of shrimp farms were raised in Shyamnagar, Paikgacha, Rampal and Chakaria Upazilas. By 2012 over 209,456 ha of land were brought under bagda culture and still it is increasing. The culture system of bagda varies from traditional extensive to improved extensive. In 2012-13 bagda production in Bangladesh was 57,785 MT.

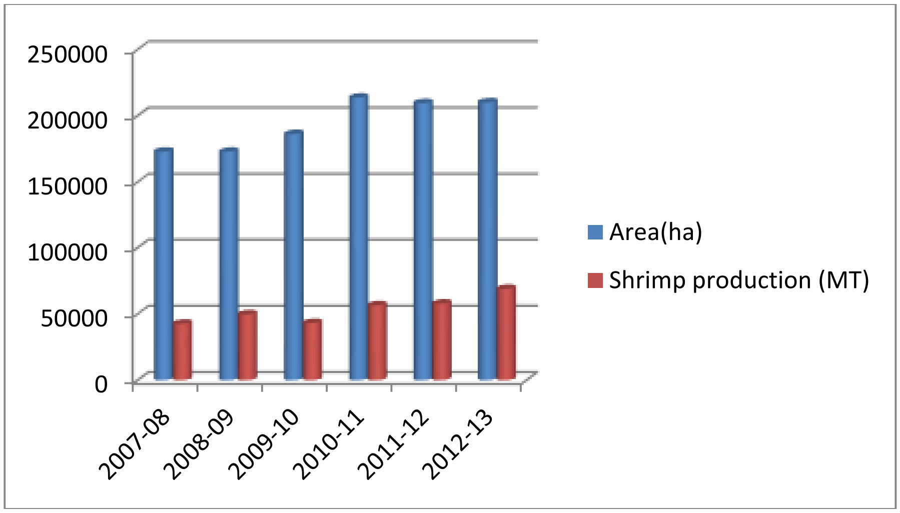


Fig 2.29 Trend in brackish water shrimp area and production in the coastal region of Bnagladesh
Source: Fisheries Statistical Year Book of Bangladesh, 2013,2014

Different types of farming systems evolved from earlier `no stocking' subsistence shrimp farming to extensive, improved extensive and semi-intensive culture system. The farming system in Bangladesh is mostly traditional extensive type with a low level of productivity per hectare. Overall shrimp production has increased steadily over the last 20 years (Figure 3), but is still much lower than that of the neighbouring countries such as Thailand with 800 kg/ha (Samsak et al. 2006) and India with 600 kg/ha (Vasu, 2006). Among shrimp producing countries, Bangladesh ranks fourth with respect to area under shrimp farming and sixth in volume of production.

2.7.8 Productivity and potential of prawn (golda) culture

Traditionally the giant freshwater prawn, called golda in Bangla, were being trapped and reared with other fishes in the tidal ponds and low lands. Generally, the species was harvested from the river/canals, flood plains and beel areas which have connectivity with rivers. At present, golda is being cultured in 'ghers' in an organised way along with other aquaculture, agriculture and horticulture crops. Different culture systems such as monoculture, polyculture along with other fishes, and aquaculture in paddy fields along with paddy are being practised. The unit production of golda under the different systems ranged from 375 kg/ ha to 750 kg / ha. The highest production was observed in monoculture (750 kg / ha). Currently, golda are being farmed in gher, pond and paddy fields covering an area of about 0.63 lakh ha. About additional 0.60 lakh MT fish are produced along with the golda.

There is an increasing trend in golda production during 2007-08 to 2012-13 (Fig #). Around 70 to 80% of shrimp produced are exported each year.

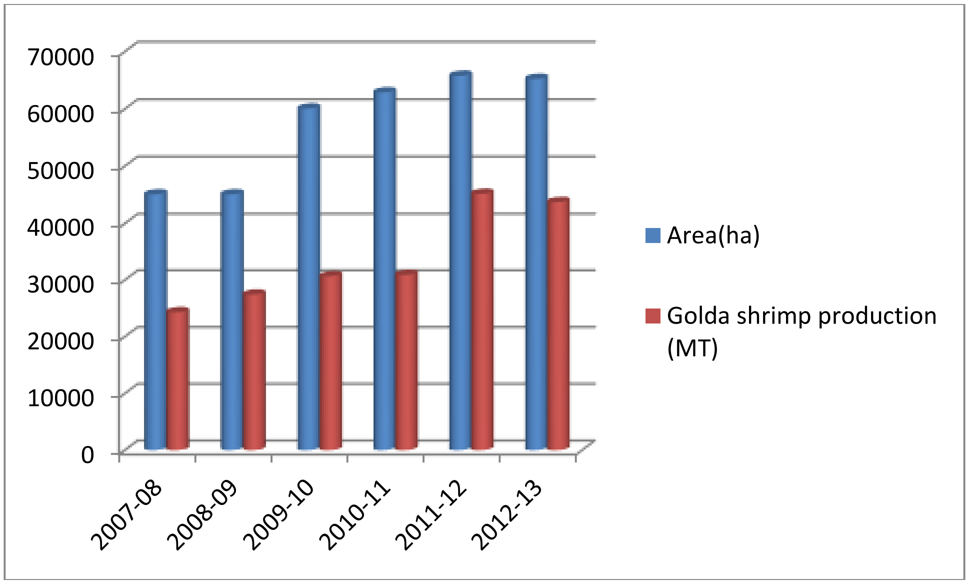


Fig 2.30 Trend in Golds shrimp area and production

Currently the shrimp sector is facing a number of problems. These are: land use conflicts among the various user groups and agencies; social opposition to the environmental effects of large scale bagda monoculture; lack of proper pond engineering design and management; diseases; quality control and post harvest technology; inadequate infrastructure and financial facilities; lack of technical knowledge and skill; lack of resources information and non compliance.

Annex 2.1 Methodology of estimation of Total Factor Productivity (TFP)

TFP is a ratio of index of aggregate output to aggregate inputs (Caplbo and Antle, 1988; Lingard and Rayner, 1975; Bamett *et al*., 1995). Generally, the. ratio of TFP between a couple of years, denoted by r and s is defined by:

$$\frac{TFPr}{TFPs} = \frac{\frac{Qr}{Qs}}{\frac{Xr}{Xs}} \qquad (1)$$

$$\text{or } \ lnTFPr - lnTFPs = \ln\left(\frac{Qr}{Qs}\right) - \ln\left(\frac{Xr}{Xs}\right) \qquad (2)$$

Laspeyres, Paasche and Tornqvist-Theil (TT) indexes are the three commonly used arithmetic indexes for measuring TFP (Nadiri, 1970; Squires, 1988; Islam, 1998). The most widely used logarithmic index is TT index. The TT index number has appealing theoretical properties, including consistency with an assumed underlying homogeneous translog production technology (Christenson, 1975). Although Christensen warns that the TT and Laspeyres indexes may diverge when the period of analysis is very long, or when 'large' changes occur in either prices or quantities, several studies have found the difference to be small (Boyle, 1988; Ball, 1985; Sidhu and Byerlee, 1992). Most previous studies used aggregate data to analyze agricultural performance at the state, national or multinational level (Boyle, 1988; Ball, 1985; Jorgenson et al., 1987; Antle, 1987). A few studies (Sidhu and Byerlee, 1992; Cooke and Sundquist, 1989) have used survey data to analyse the performance of 'average' or representative producers by using TT index. In this study, we used a TT index formula. The TT index was computed as (Ball, 1985):

$$\ln\left(\frac{TFPr}{TFPs}\right) = 0.5(Rir + Ris)\ln\left(\frac{Yir}{Yis}\right) - 0.5(Sjr + Sjs)\ln\left(\frac{Xir}{Xis}\right) \quad (3)$$

Where Y_{ir}/Y_{is}; X_{ir}/X_{is} are output and input indexes, respectively; R_i are output revenue shares and S_j are input cost shares.

There are a few studies on total factor productivity (TFP) growth in Bangladesh, These are the work of (Islam, 2003) Pray and Ahmed (1991), Dey and Evenson (1991) and Coelli *et al.,* (2003). These studies used time series data for estimation of TFP. However, Alam, et al (2011) used farm level panel data for estimation of TFP of rice farmers in Bangladesh.

Chapter 3

Contribution of Agriculture to GDP Growth and Poverty Reduction

Chapter Summary: Contribution of agriculture to GDP growth and poverty reduction

Changes in aggregate GDP have been analysed in terms of main components: changes in growth within sectors, and intra-sectoral resource shifts or reallocation effect (structural transformation). It was revealed by the results of the decomposition that agriculture played an important positive role in driving the overall GDP growth of Bangladesh. The contribution of agriculture in overall growth was 2% during the period 1999-2014 while the leading role in overall growth was played by industry (2.6%). The contribution of the service sector to overall growth was at a smaller rate (0.95%). The reallocation effect was also at a smaller rate (1.2%).

A multiple regression analysis has been carried out to quantify the contribution of growth of GDP per worker from agriculture and non-agriculture to poverty reduction. The regression coefficients for agricultural GDP/worker and non-agricultural GDP/worker are statistically significantly negative. There is an inverse relationship between the poverty rate and the productivity growth of GDP/worker from agriculture and non-agriculture. The estimated coefficient on agricultural GDP/worker is significantly higher than that for non-agriculture GDP. The coefficient of agriculture GDP per worker is -0.39 and is highly significant at the 1% level. It implies that, other things remaining the same, a 1 percent increase of income of agriculture GDP per worker would reduce poverty by 0.39 percent. The coefficient of non-agriculture GDP per worker is -0.11 and significant at the 5% level. It implies that, other things remaining the same, a 1 percent increase of income of non-agriculture GDP per worker would reduce poverty by 0.11 percent.

Obstacles to be addressed by Government:

Since GDP growth per worker in the agriculture sector produces a rate of poverty reduction three times greater than similar growth in the non-agricultural sector, continued government policy and support to agricultural productivity growth is an essential part of an effective poverty reduction strategy.

3.1 Role of agriculture in driving economic growth

Agriculture plays a dominant role in the growth and stability of the economy of Bangladesh. More than three quarters of the total population in rural areas derive their livelihood from this sector. About 48 percent of the labour force is still employed in agriculture.

During the recent decade, overall gross domestic product (GDP) of Bangladesh has shown a considerable upward trend. But the growth in agricultural GDP slightly declined with an average growth rate of about 3.4% p.a., during 1997 to 2013. Agriculture being an important engine of growth of the economy, government has invested in this sector to develop it for the alleviation of poverty and achievement of food security, by attaining accelerated economic growth. Since the achievement of food security, and the generation of employment opportunities for the huge population of the country are both directly linked to the development of agriculture, there have been continued efforts by the Government for the overall development of this sector.

Table 3.1 presents the contribution of Bangladesh agriculture to GDP during 1980-2014. There is continuous transformation of Bangladesh's economy as indicated by changes in the sectoral shares of GDP. This structural change clearly indicates a rapid movement away from an agriculture-dominated economy. Agriculture's share of GDP declined from 62 percent in 1975 to 16.3 percent in 2014. Notably, the industry and service sectors have expanded at a good pace at this stage of economic transformation. During 1971 to 2014, value addition of the service sector to GDP increased considerably from 34.2% to 56.1% and value addition of the industrial sector to GDP almost doubled from 13.2% to 27.2% (Table 3.2). Much of the growth in the service sector is related to the marketing and processing of agricultural products resulting from rapid commercialisation and diversification in agriculture. Although the relative share of agriculture's GDP to total GDP declined much with the expansion of industry and the service sector, the relative shares of crops, livestock and fisheries changed little (Table 3.3). The agriculture of Bangladesh is dominated by crops which now account for half of total agricultural GDP.

Table 3.1Trend of structural transformation of broad sectoral shares in GDP and growth rate at constant prices.

Share (in percent)										
Sector	**1980-81**	**1985-86**	**1990-91**	**1995-96**	**2000-01**	**2005-06**	**2010-11**	**2011-12**	**2012-13**	**2013-14**
Agriculture	33.07	31.15	29.23	25.68	25.03	19.01	18.01	17.38	16.78	16.33
Industry	17.31	19.13	21.04	24.87	26.20	25.40	27.38	28.08	29.00	29.61
Service	49.62	49.73	49.73	49.45	48.77	55.59	54.61	54.54	54.22	54.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Average growth rate (in percent)										
Agriculture	3.31	3.31	2.23	3.10	3.14	5.50	4.46	3.01	2.46	3.35
Industry	5.13	6.72	4.57	6.98	7.45	9.80	9.02	9.44	9.64	8.39
Service	3.55	4.10	3.28	3.96	5.53	6.60	6.22	6.58	5.51	5.83

Source: Bangladesh Economic Review 2014.

However, agriculture's share of total employment has not declined as much. The declining share of agriculture in GDP should not be construed to reflect a diminishing role of agriculture in the overall growth of the economy or in poverty reduction.

Table 3.2. Value addition from agriculture, industry and service sectors during 1971-2014.

Year		Value added (% of GDP)				
	Agriculture				Industry	Service
	Crops	Livestock	Fisheries	Total		
1971-80	38.3	4.2	10.0	52.4	13.3	34.2
1981-90	26.0	4.2	3.6	33.8	20.7	45.5
1991-00	18.6	2.3	4.9	25.8	23.3	50.8
2001-10	13.4	2.2	4.1	19.7	25	55.3
2011-14	11.4	1.8	3.5	16.7	27.2	56.1

Table 3.3 Relative share of crops, livestock and fisheries to agricultural GDP during 1971-2014.

Year	Crops	Livestock	Fisheries	Total
1971-80	73	8	19	100
1981-90	77	8	15	100
1991-00	72	9	19	100
2001-10	68	11	21	100
2011-14	68	11	21	100

Bangladesh agriculture is considered central to growth for two reasons. It has a big share of GDP and it stimulates "structural transformation" - the process whereby resources move from low productivity sectors to higher productivity sectors. There are two possibilities for structural transformation. It can be driven by productivity improvements within the agricultural sector and it can be driven by productivity improvement outside the agriculture sector.

3.2 Decomposition of the growth process

Bosworth and Collins (2008) studied growth in China and India from 1978 to 2004. Using primarily data from national accounts, they set up a growth account for each country that decomposes aggregate growth into contributions from sectoral growth and the gains associated with the movement of workers between sectors. We have also used the same methodology to decompose aggregate growth into contributions from sectoral growth and the gains associated with the movement of workers between sectors.

We have decomposed changes in aggregate GDP into main components: changes in growth within sectors and intra-sectoral resource shifts or reallocation effect ("structural transformation"). The result of decomposition is presented in Table 3.4. The methodology of decomposition of overall growth into sectoral contribution is presented in Annex 3.1

Table 3.4 Decomposition of overall growth in output per worker in Bangladesh, India and China

(Percentage contribution to growth)Country, period	Total	Decomposition of within sector effect			Decomposition of intra-sector effect
		Agriculture	Industry	Service	Reallocation
Bangladesh 1999–2014	6.4 (100)	2.0 (31.7%)	2.6 (41.3)	0.95 (15.1)	0.80 (11.9%)
India 1993-2004	4.6 (100)	0.5 (10.9%)	0.9 (19.6%)	2.0 (43.5%)	1.2 (26.1%)
China 1978-93	6.4 (100)	1.2 (18.8%)	2.4 (37.5%)	1.1 (17.2%)	1.7 (26.6%)

Source: Author' estimation, for India and China**:** Bosworth and Collins (2008)

The decomposition result showed that agriculture played an important positive role in driving the overall GDP growth of Bangladesh. The contribution of agriculture in overall growth was 2% during the period 1999-2014 while the leading role in overall growth was played by industry (2.6%) (Table 3.4). Bangladesh agriculture grew at a good pace of 3.7% per year from 1999 to 2014, but industry contributed the most to growth, expanding at a spectacular rate of 9% per year. The contribution of the service sector to overall growth was at a smaller rate. The reallocation effect was also at a smaller rate.

According to the study by Bosworth and Collins (2008), both in China and India, agriculture played a positive role but not a leading role in driving overall growth (Table 3.4). China's agricultural sector grew at a very rapid pace, 4.6 percent per year from 1978 to 2004. But it was industry that contributed most to growth, expanding at a spectacular rate of 10 percent per year. Its service sector also grew as rapidly as industry - even slightly faster on average - but because of its smaller share in output, contributed less to aggregate growth. India's agricultural sector also had a strong but less spectacular 2.5 percent growth rate over the same period. In India, the main growth driver was services, which accounted for as much as 50 percent of growth. Industry growth was surprisingly weak, but still faster than agricultural growth. In both China and India, the reallocation effect was an important source of growth.

3.3 Sectoral share in employment

Bangladesh has a total population of 157 million people out of which the labour force covers 78 million workers. A steady labour force growth of 2.2% was observed during the last decade. Agriculture continues to remain the main sector to absorb the vast majority of the labour force. The share of the economy as well as the share of employment in the agricultural sector has been decreasing. During 1981-90, the share of employment in the agriculture sector was 60% of the labour force, in 2000, agricultural sector employment accounted for almost half of the employment, 51% of the labour force, while in 2010 it declined to 48% of the labour force. Within the non-agricultural sector, the service sector accounted for the largest share of employment (35%) in 2014 followed by industry (17%) which signifies the rise of non-farm activities during this period. The share of the industry sector in total employment was 13% in 1999-2000, which rose to 17% in 2014. After agriculture, the service sector is the second largest employer of the labour force of Bangladesh but its contribution to total employment is much lower than its contribution to the country's GDP (Table 3.5). During the early 2000s, when liberalisation of some service sectors occurred, like telecommunication and financial intermediaries, the employment shares of the service sector grew substantially, reaching 37% by 2005-06 but again declined to 35% in 2010 (BBS, 2010).

Table 3.5 Sectoral share of employment during 1971-2010

	Employment (% of labour force)			
	Agriculture	Industry	Service	Total
1971-80				
1981-90	60			
1991-00	64			
1999-00	51	13	36	100
2002-3	52	14	34	100
2005-6	48	15	37	100
2010	48	17	35	100
2011-14				

3.4 Labour force participation rate

The labour force participation rate (LFPR) has progressively increased and stood at 59.3% in 2010 against 48.8% in 1990-91.The rural-urban variation in the labour force growth is also significant between 2006 and 2010, the rural labour force grew by 3.48 percent against 3.10 percent increase in urban labour force (BBS, 2010). It is notable that there is a decreasing trend in male LFPR from 87.4% in 2002-03 to 82.5% in 2010 while the female LFPR shows a sharp and steady increasing trend from 14.1 percent in 1990-91 to 26.1% in 2002-03 to 36% in 2010. LFPR is higher in rural (60%) than in urban areas (57.3%). Women's participation was significantly lower (36%) than that of men's (82.5%) in 2010 (Table 3.6).

Table 3.6 Labour participation rate in Bangladesh during 1990-2010

Year	Bangladesh			Urban			Rural		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
1990-91	79.6	14.1	48.8	76.2	12.7	48.3	80.0	14.4	49.0
1995-96	87.0	15.8	52.0	82.0	20.0	51.7	88.6	14.5	52.1
1999-00	84.0	23.9	54.9	83.7	26.5	55.8	84.0	23.1	54.6
2002-03	87.4	26.1	57.3	85.1	27.4	56.8	88.1	25.6	57.5
2005-06	86.8	29.2	58.5	83.2	27.4	55.7	88.0	29.8	59.4
2010	82.5	36.0	59.3	80.2	34.5	57.3	83.3	36.4	60.0

3.5 Unemployment rate

The number of people out of work in Bangladesh slightly increased to 2.5 million in 2010 from 2.1 million in 2005-06 and 1.7 million in 1999-2000 (BBS, 2010). Bangladesh's total unemployment rate was 4.5% in 2010, which does not reflect a very large job deficit. The low rate is a reflection of the definition used. In Bangladesh, where there exists a vast informal sector, the labour force can be engaged in some work - even for few hours and at low wages or even in their own family business. Thus, the unemployment rate, which is estimated according to the ILO definition does not give a real picture of the labour market.

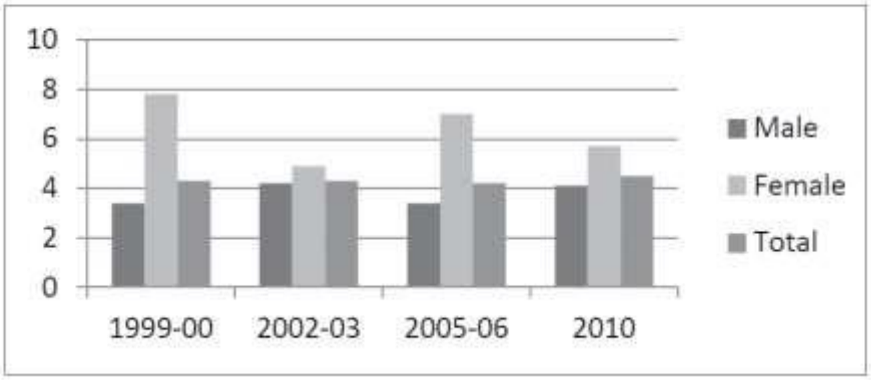


Figure 3.1 Unemployment rate in Bangladesh during 1999-2010,
Source: Bangladesh Labour Force Survey, 2010

3.6 Contribution of agriculture to poverty reduction

3.6.1 Historical trend in poverty reduction

The emerging pattern of growth in poverty reduction in Bangladesh is encouraging. Bangladesh experienced substantial poverty reduction during the last 15 years (1999-2014). During this period, the average annual rate of poverty reduction was 1.4% (Figure 3,2).

It was found that GDP growth had a higher impact on poverty in Bangladesh than that of all South Asian countries in the region, although Vietnam, China, and Thailand had a higher GDP growth rates than Bangladesh and had even further reductions in poverty (World Bank, 2008)

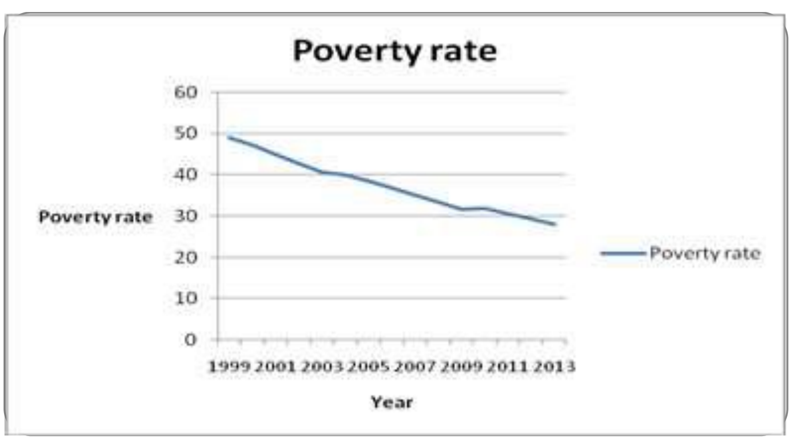


Figure 3.2 Trend in reduction of poverty rate of Bangladesh during 199-2014

3.6.2 Historical trend in GDP per worker

Figure 3.3 and 3.4 present the trend of GDP per worker in agriculture and non-agriculture during 1995-2014. During this period GDP per worker both in agriculture and non-agriculture increased substantially and contributed to poverty reduction in Bangladesh.

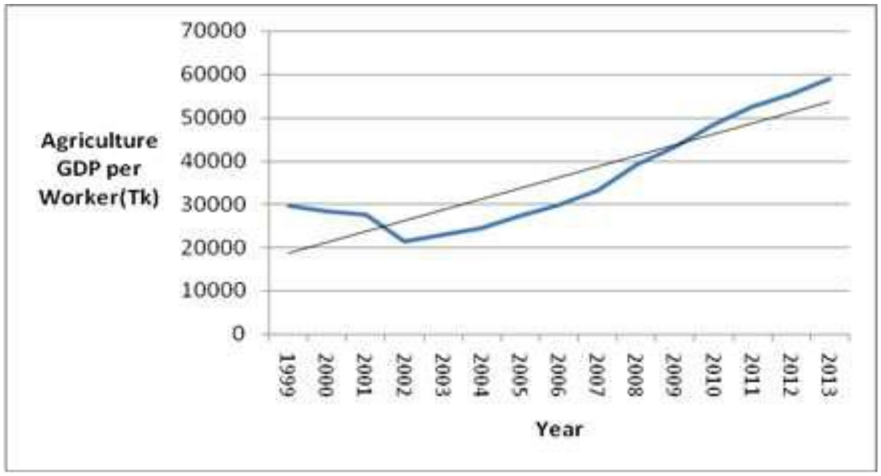


Figure 3.3 Trend in agriculture GDP per worker during 1999-2014

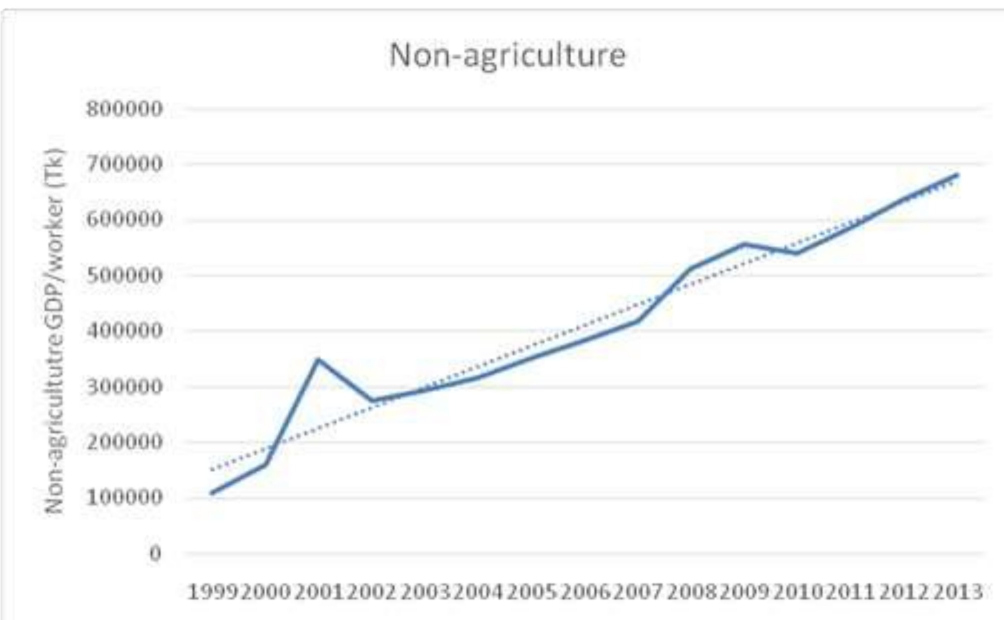


Figure 3.4 Trend in non-agriculture GDP per worker during 1999-2014

3.7 Contribution of agriculture to poverty reduction

We have plotted the complete dataset of time-series observations for the two variables GDP per worker in agriculture and non-agriculture, and poverty rates in Figures 3.5 and 3.6. Each dot in these Figures pairs a year observation for the poverty rate and, respectively: agricultural GDP per worker in Figure 3.5; non-agricultural GDP per worker in Figure 3.6. These plots reveal the expected negative relationships between poverty rates and GDP per worker from agriculture and non-agriculture (the two income categories). This result found was consistent and confirms the findings of a study of Cervantes-Godoy and Dewbre (2010) conducted in 25 countries of Asia and Africa. But, among the two sectors, which has been the most important source of reduction in observed poverty rates? Answering such a question requires, first, quantitative estimates of the statistical relationship between each of the two variables and the poverty rate. We estimated the relationships using a multiple regression analysis which is discussed below.

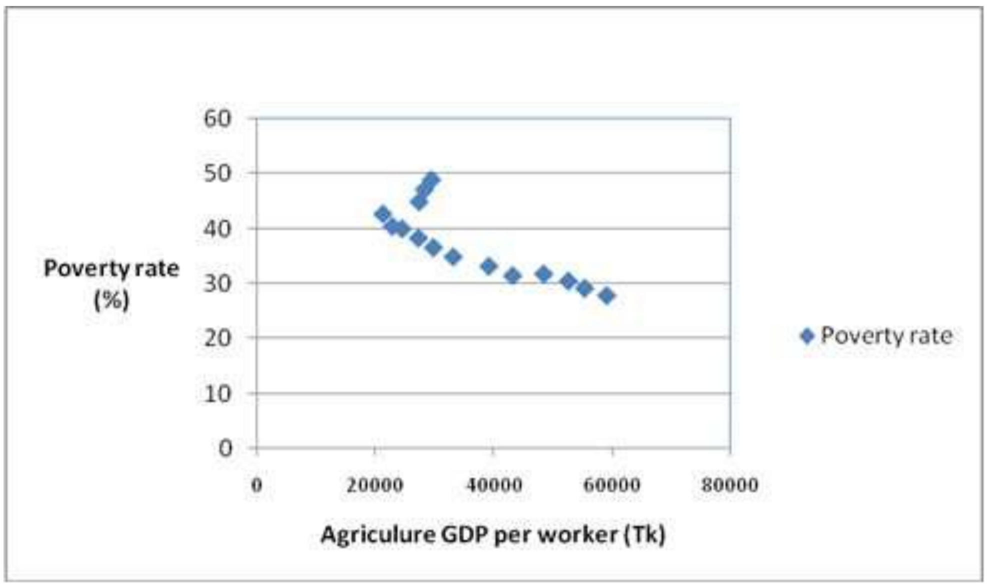


Figure 3.5 Relationship of agriculture GDP per worker and poverty rate

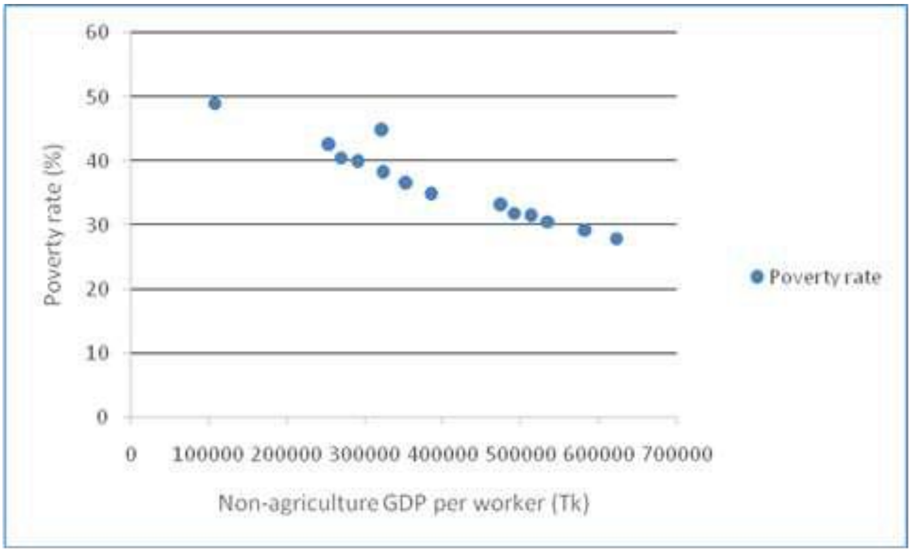


Figure 3.6 Relationship of non-agriculture GDP per worker and poverty rate

Regression results

We have carried out a multiple regression analysis in order to quantify the contribution of growth of GDP per worker from agriculture and non-agriculture to poverty reduction. The regression model and estimation methodology are presented in Annex 3.2. The estimated coefficients and related statistics are presented Table 3.7.

The regression model explains a high percentage of variation in the dependent variable of poverty rate of Bangladesh (R^2=0.78). The regression coefficients for agricultural GDP/worker and non-agricultural GDP/worker are statistically significantly negative as suggested by theory and also confirmed by the data plotted in Figures 3.5 and 3.6. There is an inverse relationship between the poverty rate and productivity growth of GDP/worker from agriculture and non-agriculture. The estimated coefficient for agricultural GDP/worker is significantly higher than that for non-agriculture GDP. The coefficient of agriculture GDP per worker is -0.39 and is highly significant at the 1% level. It implies that, other things remaining the same, a 1 percent increase of income of agriculture GDP per worker would reduce poverty by 0.39 percent. The coefficient of non-agriculture GDP per worker is -0.11 and is significant at the 5% level. It implies that other things remaining the same, a 1 percent increase of income of non-agriculture GDP per worker would reduce poverty by 0.11 percent.

Table 3.7 Estimated coefficients and related statistics of regression analysis of poverty rate and GDP per worker form agriculture and non-agriculture

Variables	Coefficients	t-value	R^2	F-value
Constant	2.62	2.90**	0.78	19.79*
Agriculture GDP per worker	-0.39	-4.92**		
Non-agriculture GDP per worker	-0.11	-2.26*		

** Significant at 1% level and * significant at 5% level

Annex 3.1 Decomposition of the growth process

Bosworth and Collins (2008) looked at growth in China and India from 1978 to 2004. Using primarily data from national accounts, they set up a growth account for each country that decomposes aggregate growth into contributions from sectoral growth and the gains associated with the movement of workers between sectors. We have also used the same methodology to decompose aggregate growth into contributions from sectoral growth and the gains associated with the movement of workers between sectors.

We have decomposed changes in aggregate GDP into main components: changes in growth within sectors and inter-sectoral resource shifts ("structural transformation"). We have used following regression model for decomposition:

$$\Delta \ln Y_t = s_1 \Delta \ln y_1 + s_2 \Delta \ln y_2 + s_3 \Delta \ln y_3 + s_4 \ln y_4 + u_i$$

where 1, 2, 3 corresponds to economic sectors agriculture, industry and services respectively.

$\Delta \ln Y_t$=Change in total GDP per worker
$\Delta \ln y_1$ = Change in agriculture sector GDP
$\Delta \ln y_2$= Change in industry sector GDP
$\Delta \ln y_3$= Change in service sector GDP
$s_1\Delta \ln y_1 + s_2\Delta \ln y_2 + s_3\Delta \ln y_3$ = Within sector effect
$s_4 \ln y_4 + u_i$= Resource shift effect

Annex Table 3.1. Regression results of decomposition of aggregate growth into contributions from sectoral growth

Parameter	Coefficients	t-value
Constant	-0.57	2.920
Change in agriculture GDP	2.02	1.213
Change in industrial GDP	2.64	4.171
Change in service GDP	0.948	2.097
Change in remittance	0.797	3.651
R^2	0.96	
F-value	56.16	

Annex 3.2 Estimation of stochastic frontier production function and inefficiency model and technical efficiency

Farrel's (1957) seminal article on efficiency measurement led to the development of several approaches to efficiency and productivity analysis. Among these, the stochastic frontier production *(*Aigner et al., 1977; Meeusen and van den Broeck 1977) and Data Envelopment Analysis (DEA) (Chames et al, 1978) are the two principal methods [see Caelli (1995) and Coelli et al, (1998) for detailed information on efficiency measurement using the stochastic production frontier and DEA, including their strength, weakness, and estimation procedures].

As noted by Coelli et al, (1998), the stochastic frontier is considered more appropriate than DEA in agricultural applications, especially in developing countries, where the data are likely to be heavily influenced by measurement errors and the effects of weather conditions, diseases, etc.

Thus, following Aigner et al. (1977) and Meeusen and Van Den Broeck (1977), the stochastic frontier production function with two error terms can be modeled as:

$Y_i = f(X_i, \beta) \exp(V_i - U_i)$ .... (1)

Where Y_i is the production of the i-th farmer(i= 1,2.3, ….., n), X_i is a (1xk) vector of functions of input quantities applied by the i-th farmer. β is a (k x 1) vector of unknown parameters to be estimated, V_i S are random variables assumed to be independently and identically distributed N (0, σ^2) and independent of U_is and the V_is; and the U_iS are non-negative random variables, associated with technical inefficiency in production assumed to be independently and identically distributed (iid) and truncations (at zero) of the normal distribution with mean, ZjO and variance tlu, (/N(ZiO, 02u,) *I);* Zj is a (I x m) vector of firm-specific variables associated with technical inefficiency, and 0 is a (mx1) vector of unknown parameters to be estimated (Shann. and Leung, 1998).

Following Battese and Coelli (I995), the technical inefficiency effects, Vi in equation (1) can be expressed as:

$U_i = Z_i\delta + W_i$ .. .. ………………………………………... .. (2)

Where, W_is are random variables, defined by the truncation of the normal distribution with zero mean and variance σ^2_v such that the point of truncation is $-Z_i\delta$, i.e. $W_i \geq .- 2Z_i\delta$. Besides the farm-specific variables, the Z_i variables in equation are (2) may also include input variables in the stochastic production frontier (I), provided that the inefficiency effects are stochastic. If Z-variables also include interactions between farm-specific and input variables, then a Huang and Liu (I994) non-neutral stochastic frontier is obtained.

The technical efficiency of the ith sample farm, denoted by TE; is given by:

TE; = $\exp(-U_i) = Yi/f(X_i, \beta) \exp(V_i) = Yi/ Yi$ .... ………… ... ... (3)

Where $Y_i = f(X_i, \beta) \exp(V_i)$ is the farm-specific stochastic frontier. If Y_i IS equal to Y_i; then $TE_i = 1$, reflects 100% efficiency. The difference between Y_i and Y_i is embedded in U_i (Dey et al., 1999). If $U_i = 0$, implying that production lies on the stochastic frontier, the farm obtains its maximum attainable output given its level of input. If $U_i < 0$; production lies below the frontier and indication of inefficiency.

The maximum likelihood estimate (MLE) of the parameters of the model defined by equations (I) and (2) and the generation of farm-specific TE defined by (3) are estimated using the FRONTIER 4.1 package (Coelli, 1994). The efficiencies are estimated using a predictor that is based on the conditional expectation of exp (-U) (Coelli, 1994). In the process, the variance parameters σ^2_u and σ^2_v are expressed in terms of the parameterisation:

$\sigma^2 = \sigma^2_u + \sigma^2_v$ …………………………(4) and

$\gamma = (\sigma^2_u / \sigma^2_v)$ ……………………………………………………………..(5)

The value of γ ranges from 0 to 1 with values close to 1 indicating that the random component of the inefficiency effects makes a significant contribution to the analysis of the production system (Coelli and Battese. 1996).

The use of generalized likelihood ratio test is another way of testing if inefficiency effects are absent from the model. This is used in testing the significance of the model as in the F-test in the Ordinary Least Squares (OLS) estimation. It can also be used in testing the function from of the model (e.g. Cobb-Douglas versus translog) and is more of fewer equivalents to the Chow test (Green, 1990; Johnston, 1984) in OLS estimation. The generalized likelihood ratio test statistic is defined by:

λ-= -2 log [L (Ho)/L (H_1)]. .. .. (6)

Where L (Ho) is the value of the log-likelihood function of a restricted model as specified by a null hypothesis Ho; and L(H_1) is the value of the log-likelihood function of an alternative hypothesis H_1. The test statistic has a χ^2 or mixed χ^2 distribution with degrees of freedom (df) equal to the difference between the number of parameters involved in H_0 and H_1.

Chapter 4

Agrarian Structure and Assets

Chapter Summary: Agrarian structure and assets

Land is the main source of livelihood in rural Bangladesh. It was found that the proportion of both medium and large farmers have both rapidly gone down since 1988. Households owning up to three bighas of land (up to 0.4 ha) constitute about 70 per cent of all households but control only 20 per cent of the total land. As opposed to this, only four per cent of households (with 15 bigha or 2 ha and above land) controls about one-third of the land The average size of owned land stood at 0.61 ha in 1988 and significantly declined over time to peak at 0.48 ha in 2007 - a decline of 21 per cent over the last two decades and further decreased to 0.39 ha in 2014. It was observed that, as with farm size, the proportion of the marginal farmers (owning up to 0.40 ha) has risen from about 21 per cent in 1988 to 24 per cent in 2008 and further increased to 28 per cent in 2014. At the same time, the amount of land under their command almost tripled. The group we identify as functionally landless with tiny farm holdings – comprising 33-35 per cent of all farmers – have also been commanding more land over time. By and large, marginal and small farm households now cultivate more than four-fifths of the total land in rural areas. We observed that the dominance of the share-cropping system in the tenancy market has dwindled over time, and the contributions of other tenancy arrangements have been growing.

We observed that even the very poor farmers (owning land up to 0.2 ha) substantially increased their participation in irrigation facilities over time. In fact, in 1988, small and marginal farmers were far behind their counterparts – large and medium farmers – in terms of irrigation coverage. That difference gradually dwindled over time. In other words, small and marginal farmers were once laggards in adopting this modern technology but, over time, they have caught up, and even overtaken the large farmers.

The share of land under pond/water bodies has increased substantially over time, signifying growing pond aquaculture at household level. On the other hand, land for gardens and orchards has also increased substantially, indicating the growing importance of horticultural crops.

In addition to land, livestock is another asset in rural Bangladesh which is not only a major source of livelihood but also an asset in coping with crisis. These days, the proportion of poor households rearing livestock, goats and poultry has increased. Rural households have now, on average, 2.7 large livestock, 2.4 goats/sheep and 2.7 poultry birds. Rearing of goats is another kind of asset accumulation. In times of crisis, poor households can sell the goats to maintain their livelihood and therefore, over time, the incidence of rearing of goats has increased.

Rural households also have physical capital stock to generate current income including power tillers, shallow tube wells, threshing machines, rickshaw vans, and so on. Eight in every one hundred households in rural areas have their own irrigation equipment - mostly shallow tube wells and power pumps. This compares with about 6 out of 100 households owning such assets in 2000, and 3 out of 100 in 1988.

Obstacles to be addressed by Government:

Provisions for facilities with regard to marketing, storage and information especially for perishable products should be increased. There is also a need for training programmes, especially for women, as homestead-based horticulture and aquaculture activities are gaining importance. More credit arrangements should be made available for homestead-based agriculture.

Income disparities should be more effectively addressed by selected interventions by the state through agricultural subsidies, special assistance for secondary and tertiary education, and special credit arrangements. It is essential to reverse the declining trend, especially for public investment in irrigation and water resource management. It is also essential to increase public investment in rural roads and rural electrification. Success in these areas will stimulate private investment and contribute to a revival of growth momentum in agriculture.

4.1 Land-people nexus: natural capital

Land is the main source of livelihood in rural Bangladesh. In a country of too many people chasing extremely scarce land, it is the most precious resource that every person wants to own, and does not want to sell, even when moving to non-farm occupations. With a view to understanding the land-people nexus and grasping its gravity, we begin with a discussion on land assets, mainly based on data obtained from the reports of Agricultural Censuses.

The population density in Bangladesh is one of the highest in the world (about 920 persons per km^2). Eminent economist (late) Dr. Mahbub-ul-Huq of Pakistan used an example to explain the level of population density, and its implications that we reproduce for our readers: if all the people of the world could be accommodated in the United States of America, the population density of that country (America) would not be as high as it is now in Bangladesh (Haq 1997). Against this, the arable land per capita in this country, at 0.061, ha is pitifully low by any stretch of the imagination. Over the last three decades or so, population growth rate has appreciably declined from 3.0 to 1.4 per cent per year; but two million more people are added every year to the existing titanic total of 157 million. Two other important issues further compound the food and mouth mismatch: (a) the per capita GDP is extremely low at less than US$ PPP 2,000 per year (2005). This stands substantially lower when compared with even some Asian countries: US$ 3,486 (India), US$ 6,572 (China) and US$ 8,843 (Malaysia). Over and above this, (b) 60 per cent of the income is spent on food, and rice alone claims 30 per cent of the household budget (World Bank 2007; Hossain et al. 2002).

Over the years Bangladesh had been faced with increasing incidence of landlessness and shrinking of arable land. Historically, excessive population pressure on the limited land resource base has exacerbated the situation. According to the Agricultural Census of 1996, the number of rural households enumerated was 17.8 million. Out of that, 10 per cent did not own any land at all; about a third did not own any cultivable land, and roughly 60 per cent owned less than 0.2 ha. This group is called the "functionally landless" group, as the meagre amount of land cannot be a significant source of income for them. It was further reported that the number of the large landowners was also very small. According to the same census, only 0.1 per cent of the total households reported to own more than 10 hectares, and 2.1 per cent held more than 3.0 ha (BBS 1998). Even this tiny portion of the households that are considered "large landowners" by Bangladesh standards, controlled nearly two-fifths of the land resources. The earliest land occupancy survey of Bangladesh carried out in 1978 is a pointer to this pattern: only about one-tenth of the households controlled 48 per cent of the land at that time (Jannuzi and Peach 1980). Over time, with division of landholdings at inheritance, the proportion of land owners has declined but, at the same time, the proportion of small and marginal land owners has increased. Despite the rapid migration of the dispossessed to the cities seeking better economic opportunities, the proportion of landless households is on the rise.

In addition to population pressure, the attack on the limited agricultural resource base has also come from acquisition of land for government development projects, demand for housing and industrial and commercial establishments, and erosion of river banks. The 1996 Agricultural Census reported that the land area operated by rural households declined from 9.2 million ha in 1983-84 to 8.2 million ha in 1996. Out of the transfer of 1 million ha, 82,000 ha were on account of increased urban areas, homestead land and development of infrastructure. That means, Bangladesh had been surrendering, on average, 225 ha of agricultural land every day.[1] Thus, demographic pressures on the one hand and demand from non-agricultural sources on the other, continue to constrict availability of cultivable land. *Ipso facto,* the average size of farm holding declined from 1.70 ha in 1960 to 0.91 ha in 1983-84 and, further to 0.68 ha in 1996 (Bayes and Hossain 2007; Hossain 2001). It may be mentioned here that the 2005 national level sample survey, conducted by the Bangladesh Bureau of Statistics, estimated the average size of holding at 0.60 ha.

At the backdrop of the above mentioned information on land availability at the national level, let us analyze the findings of the changes in agrarian structure over the last two decades, as revealed by the repeated household surveys. We shall be particularly looking at the changes in land ownership and distribution, farm size and tenancy relations, as well as improvement in the productivity of land through expansion of irrigation infrastructure. The purpose is to evaluate the relationship between land and livelihoods in the rural context.

The rationale for evoking an interest in agrarian structure rests on the hypothesis proposed by a number of influential rural studies in the 1970s that the agrarian structure in Bangladesh itself imposes limits on the development potential of the country. These studies argued that dominance of small and marginal farms, fragmented and scattered holdings, and the prevalence of sharecropping tenancy arrangements would constrain the development forces in Bangladesh agriculture (Van Schendel 1981; Januzzi and Peach 1980; Boyce 1987). It was further argued that

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[1] One hectare (ha) equals 2.47 acres or about 7.5 standard bighas of 33 decimals. If we assume that a household with six members needs 0.40 ha of land to meet the need of staple food, the food security of 1.0 to 1.5 million people is being removed every year by losing this amount of land every day.

the green revolution would bypass the small and tenant farmers thereby contributing to further worsening the distribution of rural incomes. The large farmers with access to finance and credit would adopt modern technologies, and their profits would be used to buy out small farms and evict tenants. We realized that it is, perhaps, the time to put the hypothesis on an empirical plane by making use of the substantial pool of data at our disposal.

4.2 Land ownership and tenancy arrangements

4.2.1 Household's owned land

The civil society organizations and the government are deeply concerned with growing landlessness and land concentration because of its implications on the growing trend in income inequality in rural areas. That is why any discussion on rural livelihoods warrants an elaborate explanation of the emerging patterns of land ownership. To enlighten the discussion, we have segmented surveyed households into seven groups. We can consider two issues in this context: (a) the ratio of owners under different classes or groups, and (b) the proportions of the total land under their command.

We observe that the proportion of households with only homestead land – called absolute or pure landless households – has decreased rom 35 per cent in 1988 to about 29 per cent in 2007. This information allows us to argue that landlessness in Bangladesh has decreased over time (Table 4.1). But the share of functionally landless households (owning up to 0.20 ha or under 1.5 bigha) increased substantially during the same period of time. The reduction of absolute landless households might surprise the readers, but several factors might have contributed to this trend. First is the higher incidence of migration by the destitute households to urban areas. Second, the activities of the NGOs in rural areas providing access to credit might have borne fruit for them. And finally, it might have so happened that some of the pure landless households that improved their economic conditions with micro-credit may have gone for owning a piece of land for construction of houses. However, the proportion of small land owning groups stayed almost at the same level, although land under their command increased marginally.

It also appears that the proportion of both medium and large farmers has rapidly gone down since 1988. In this context we can also give attention to the existing disparity in the land ownership pattern. For example, as per the information of the last survey, households owning up to three bighas of land (up to 0.4 ha) constitute about 70 per cent of all households but control only 20 per cent of the total land. As opposed to this, only four per cent of households (with 15 bigha or 2 ha and above land) control about one-third of the land (Table 4.1).

That land is becoming scarce day by day is indicated by the sharp decline in the average size of land ownership per rural household. The average size of owned land stood at 0.61 ha in 1988 and significantly declined over time to reach 0.48 ha in 2007 - a decline by 21 per cent over the last two decades - and further declined to 0.39 ha in 2014 (Table 4.1). The rapid rural-urban migration has not been able to arrest the decline in land endowment of an average household in rural areas. The reduction in the size of owned land could be attributed mainly to the increase in population and fragmentation of households.

The above mentioned distributional aspect drives us to comment on a policy question: is drastic land reform an answer to the prevailing perverse ownership of land? A closer look at the distributional pattern of land suggests that, due to the dwindling dominance of medium and large farms and the widespread presence of landless and near-landless households, it is pauperisation - not differentiation - which has developed over time in rural Bangladesh. Under this state of things, we have serious doubts as to whether the objectives of putting a land ceiling on the large land owning groups, and then distributing the surplus to the landless households would work well. In other words, we have to see whether that could provide access to some land to the millions of landless and marginal landowning households to help them make a viable land holding. Imposing a ceiling of landownership at 3.0 ha (this is the ceiling imposed by the land reform in Japan and South Korea by the occupation forces after the Second World War), the reform will affect only the top 3-4 per cent of the households who would have very little surplus land to share with 10 million landless and near-landless households in the country. The bottom one-third of the households in the landownership scale would have to seek their livelihoods in the agricultural labour market or in rural non-farm occupations in any case, irrespective of the land reform. And, for that reason alone, the issue of redistributive land reform is likely to remain a big question mark in the discourse on redistribution of land. Some studies however indicate a considerable amount of land in the hands of the government agencies that acquired land in the name of development projects, but did not utilize all the land for the project. Also the government acquired the land left over by non-Muslims who migrated to India in the aftermath of the Partition in 1947 and during the War of Liberation in 1971, and there is also newly accreted land, especially in the South-east delta. Such land could be distributed to 10 per cent or so absolute landless households so that they have at least a piece to construct a house, to have some cover over their head.

4.2.2 Distribution of cultivated land

One of the dimensions of land distribution is concerned with cultivated land. A household may not own any land but could retain the capacity to live by cultivating land owned by other households. And that is possible through the tenancy market. Since time immemorial and whenever necessary for food security, small and marginal farmers of Bangladesh had been cultivating owned as well as rented-in land under a sharecropping arrangement. The economic history of Bangladesh is full of stories of the plight of the sharecroppers or the "*Barga Chashis*", and of the movements organized to improve their welfare.

It can be observed that, as per farm size, the proportion of the marginal farmers (owning up to 0.40 ha) has risen from about 21 per cent in 1988 to 24 per cent in 2008 and further increased to 28 per cent in 2014. At the same time, the amount of land under their command almost tripled (Table 4.2). It implies that, despite meagre amounts of owned land, farmers have been making a living by renting-in land from others. Again, the group we identify as functionally landless with tiny farm holdings – comprising 33-35 per cent of all farmers – has also been commanding more land over time. By and large, marginal and small farm households now cultivate more than four-fifths of the total land in rural areas. This trend should always be at the back of our mind while formulating agricultural policies. On the other side of the fence are large farms that have declined in proportion by 3 times - from 10 per cent to about 3 per cent over the last two decades. It appears that a large proportion of the medium and the large farmers have been giving up farming as a major source of livelihood. In support of this hypothesis, it can be shown that the share of land cultivated under their command decreased from about 36 per cent in 1988 to about 12 per cent in 2007 (Table 4.2).

What are the reasons behind the drastic decline in the proportion of medium and large farmers? This trend is in contrast to those observed in the early years of the green revolution in India, where it was argued that the profits from farming have been used for enlarging the size of farms. This was done through purchase of land from those who have unviable holdings or through eviction of tenants, as owner-farming had become more profitable. However, in our country the opposite syndrome holds true, and one reason for that is obviously the division of farm holdings among brothers at inheritance. The other factor could be that self-cultivation is becoming an expensive business these days with rapidly rising wage rates, especially for those who depend on hired labour. It might be due to the lack of capacity to supervise farm activities. Besides that, relatively more profitable non-agricultural activities might have increasingly attracted them. As they acquire some surplus with the adoption of improved technologies in farming, they invest them in non-farm activities in the villages or in rural towns with the expectation that they will be able to accumulate capital in the non-farm business over time. Since land is scarce, and no one wants to sell land unless under distress, it is difficult to enlarge farm holdings, and move fast on the virtuous circle of prosperity if remaining with farming.

The average size of cultivated land per household declined from 0.87 ha in 1988 to 0.56 ha in 2007 – a reduction by about 36 per cent over time (Table 4.2). The gradual squeeze of farms had reached such a height that, very soon we may face the crisis of the shortage of economically viable farms. It is because, as estimated, a household of six requires minimum 100 decimals (0.40 ha) of land to feed the family members. By and large, we observe the entry of small and marginal households and the exit of medium and large ones in the world of agricultural practices. To reiterate, what exists now in our agriculture is not differentiation, but pauperisation. Finally, the share of non-farm households has significantly risen from 34 per cent to 44 per cent over time. This also points to the declining emphasis on farm activities.

4.2.3 Incidence of renting out land

It has already been mentioned that even a landless household or family could depend on land for its livelihood. This is possible through renting in land from others through the tenancy market.[2]

During the comparison period, the share of households renting-out land more than doubled from about 13 per cent to 29 per cent, and the proportion of rented-out owned land also more than doubled. In 2004, four-fifths of the large farmers reported to have rented out land, partly or fully, which is more than twice the ratio of 1988. That indicates that only one fifth of the large farmers now engage in cultivation of owned land compared to three fourths in 1988 (Table 4.3). By and large, this trend confirms our earlier hypothesis that large farmers have been leaving land as direct tillers, while keeping intact their ownership of land. They get the parcels cultivated by small and marginal land owners or even by their erstwhile labourers. Field level information also reveals that even medium farmers turned their backs on farming. Only one-third of this group now cultivates owned land. Thus, it would not be an exaggeration to say that the large and the medium farms have been "missing" from rural areas. We have already discussed the reasons for their exit.

It is not only the large and the medium farmers who have been renting out land. Quite unexpectedly perhaps, a large proportion of the poor farmers (up to 1.0 ha) have also reported renting-out of

[2] Discussion on this in detail is available in Chapter 11.

their parcels of land. In 2004, 34 per cent of land in this group went to others compared to only 24 per cent in 1988. This trend needs an explanation. It may be that poor farmers found cultivation relatively less profitable, and have become more engaged in non-agricultural activities. Presumably, some small land owning families now residing in cities which are engaged in such occupations as petty trade, transport operations and construction labour have also been renting out their land rather than making outright sales.

4.2.4 Incidence of renting-in land

What is the story of the tenancy market from the demand side? For all farms under consideration, the share of tenant farmers has decreased from about 44 per cent in 1988 to 36 per cent in 2014. Likewise, the share of rented-in land as a proportion of cultivated holding has increased from 23 per cent in 1988 to about 50 per cent in 2014 (Table 4.4). As we mentioned earlier, it is the marginal and small landowners who generally rent in land to make their holdings more viable and to economize on farm holdings. However, although the proportion of tenant households had increased during 1988 to 2004, a marginal decline in that proportion was found in 2007. Perhaps the increase in profitability in the cultivation of paddy due to the increase in farm gate paddy prices during 2006-07, induced some landowners to get back land from tenants for self-cultivation. It also appears that almost all types of farms are renting in land, but two-thirds of the small and marginal farmers are reported in this kind of transaction. Again, the proportion of their holding under tenancy cultivation increased by 1.5 times compared to the benchmark level.

The farmers engaged in the tenancy market could be classified into four groups: (a) pure tenants - those who do not have owned land but all cultivated land comes from others; (b) joint tenant and owner farmer – who cultivate more than half of land owned by others; (c) joint owner-tenants - who cultivate more than half of owned land and (d) owner farmer – who cultivate only owned land. It is observed that the share of owner-farmers has declined over time, and the same trend applies for owner-tenants also. The share of the pure tenants almost doubled. The shares of pure tenant and tenant owners have risen from about 28 per cent in 1988 to about 41 per cent in 2007. At the same time, the proportion of cultivated land under their control also shot up during the same period of time (Table 4.6).

The increase in the proportion of pure tenant-farmers over time warrants some explanation. Earlier, it was rare to find pure tenants. The land owners preferred to rent out land only to those households who had a minimum farm establishment, i.e., a pair of draft animals with considerable experience in farming. It was presumed that these households will achieve higher productivity and, by renting land to them, the land owner will be able to maximize rent. The landless, on the other hand, will not be able to take good care of land as they will give priority to seeking wage employment in the labour market at times of busy farm operations in order to maximize earnings from the labour market. Over time however, the use of draft animals as a source of farm power has given way to mechanization of farm operations. Also, even the landless households now have access to micro-credit and hence could mobilize finance for the purchase of water and chemical fertilizers. So, the preference of marginal landowners over the landless as tenants has declined over time. In 2007, about half of the landless households have rented in land compared to less than one quarter in 1988.

In rural Bangladesh, about 40 per cent of the cultivated land is now operated by the tenants, compared to 23 per cent in 1988. The tenancy market now vibrantly operates to transfer land from the land-rich to the land-poor households. This can be construed as a remarkable development as far as the livelihood of the poor in rural areas is concerned. However, the effect of tenancy on productivity would depend on the incentive of the tenant-farmers to use inputs more intensively, and on their capacity to mobilize working capital to purchase inputs as and when needed. Also, the impact on livelihood of the land-poor households would depend on the terms and conditions in the tenancy market, availability of jobs, and the wage rates in labour markets. We shall discuss these issues in a later chapter (Chapter 11) in connection with the operation of the rural markets.

Finally, we observe that the dominance of the share-cropping system in the tenancy market has dwindled over time, and the contributions of other tenancy arrangements have been growing (Table 4.7). As we shall discuss in detail in subsequent chapters, such a shift indicates growing flexibility in the tenancy market.

4.3 Quality of Land

4.3.1 Expansion of irrigation facilities

Not all land is of the same quality. Land at higher elevation may suffer from infertility, and be exposed to droughts. Hence, these types of land may not be as productive as a parcel of land at a lower elevation which may benefit from the deposit of silt from flooding. But the low level land may be less intensively used as it might be kept fallow during the time of flooding. Apparently unproductive looking deserts could be turned into productive assets if water could be made available to grow crops there. Access to infrastructural facilities, such as irrigation, could make barren land productive by allowing the adoption of modern high yielding crops. In fact, it is the introduction of an irrigation system that brought about a revolutionary change in the strategy of land-based livelihoods in rural Bangladesh. For example, about 70 per cent of the households now use underground water for irrigation purposes. The share was only one-third in 1988. The land with access to groundwater irrigation infrastructure has increased three-fold over time - from about one-fifth in 1988 to about two-thirds in 2007 (Table 4.8). On the other hand, the trend of using surface water for irrigation had been rising too. Overall, considering all the methods of irrigation, four-fifths of rural households are reported to have accessed irrigation facilities in 2007, covering more than three-quarters of the cultivated land. This compares with 42 and 24 per cent, respectively, in 1988.

A question posed earlier in the literature on rural economy is whether the land-poor households would have access to irrigation, and whether they would benefit from the Green Revolution. The critics argued that the modern technology-led agricultural practices are expensive and cash-driven and, for that reason only the large and the medium farmers could afford to use such types of improved technologies. The argument was that the profit-hungry large and medium farmers would raise productivity of their land through irrigation, and would take back the rented-out land from the tenants in the hope of making more profits. In consequence, tenant farmers would go broke. On the other hand, small and marginal farmers would be marginalized in the absence of the finance needed for installing tube wells or power-pumps for irrigation. In the next section, we intend to address the perceptions of the critics on an empirical plane.

4.3.2 Irrigation and land ownership

The data obtained from the repeat household surveys fails to validate the positive relation between farm size and access to irrigation (Tables 4.9a and 4.9b). We observe that even very poor farmers (owning land up to 0.2ha) substantially increased their participation in irrigation facilities over time - from roughly one-third of the group in 1988 to over four-fifths in 2007. But the critics could possibly be right if we consider the conditions of the earlier periods or even of a few years back. In fact, in 1988, small and marginal farmers were far behind their counterparts – large and medium farmers – in terms of irrigation coverage. That difference gradually dwindled over time (Table 4.9a). In other words, small and marginal farmers were once laggards in adopting this modern technology but over time, they have caught up, and even overtaken the large farmers. Presumably, at the early stage of the introduction of a new technology, the large farmer shows a desire for risky adoption by because of asset endowments and the inherent risk elements in the new technology deter the smaller ones. However, over time, the laggards tend to 'learn by watching', and slowly become interested to the technology. This is just what happened in rural Bangladesh over the last two decades. Once there is a level playing field, implying that access to all technologies becomes certain for all, these tiny farmers prove that they can be more efficient and productive than others – an observation made long ago by Nobel Laureates Theodore Schultz (poor but efficient farmers) and Amartya Sen (smaller farms are more productive).

4.3.3 Farm size and irrigation

The above-mentioned 'good news' about irrigation has been cast so far in the light of land ownership groups. But we do not find any deviation from the conclusions, even when the observations are compared with farm size groups. For example, in terms of cultivated land, four-fifths of the poor farmers in rural Bangladesh now use irrigation water; in 1988, only 36 per cent of this group used to do so (Table 4.9b). More importantly, the laggards of the past – the marginal farmers – have become the leaders of the present by leaving behind the earlier champions – the large and the medium farmers. This again reminds us of Schultz's famous observation: small farmers are efficient. Access to given technology only makes them more efficient.

4.3.4 Changes in land utilization patterns

A household would have different types of land in its portfolio – homestead, orchards, ponds etc. - that are used for growing seasonal and permanent crops. We shall now take up the issue of changes in the portfolio of different types of land. First, it could be observed that the average size of homestead land has declined by about 44 per cent between 1988 and 2007. This might have happened for two reasons: division of households, and the growth of homestead-based agricultural crops. Second, total cultivable land has shrunk at a rate of 1.13 per cent per annum over the entire period (Table 4.10). This observation supports our earlier remarks, that Bangladesh loses cultivable land by 1 per cent per year. The reasons behind the loss are, for example, demand from non-agricultural uses, and building of infrastructure, growing urbanization etc. And also the share of land under pond/water bodies has increased substantially over time, signifying growing pond aquaculture at household level. On the other hand, land for gardens and orchards has also increased substantially, indicating the growing importance of horticultural crops. In fact, the proportions of households owning ponds and gardens have increased roughly four-fold over time (Table 4.10). It thus appears that, in the face of rising person-land ratio and declining cultivable land, rural households are engaged in optimizing the use of limited non-agricultural land for earning a living.

In this context, we can possibly put forward a few policy suggestions. Since the use of land in rural Bangladesh has been increasing for producing perishable crops, provisions for facilities with regard to marketing, storage and information should be increased. Besides, the Department of Agricultural Extension (DAE) or NGOs should come up with training programmes, especially for women, as homestead-based horticulture and aquaculture activities are gaining importance. And finally, credit arrangements should be made available for homestead-based agriculture.

4.4 Livestock assets

Besides land, livestock is another asset in rural Bangladesh which is not only a major source of livelihoods but also helps coping with crisis. There was a time when the size of the cattle-sheds and the number of livestock used to indicate the level of solvency of rural households. That is, it was assumed that the owners of more livestock assets are the solvent households or families in the villages, and a lack of it implied poverty. But available evidence now provides us with a different picture. These days, the proportion of poor households rearing livestock, goats and poultry has increased in tandem with the rich.

Rural households have now, on average, 2.7 large livestock, 2.4 goat/sheep and 2.7 poultry birds (Table 4.11). Seemingly, the earlier enthusiasm on the part of the rural rich for rearing animals has dissipated to some extent. It could have happened due to the growing costs of rearing animals caused by the scarcity of fodder, and an increase in the prices of livestock feed. Large and medium farmers have resorted to agricultural mechanization, and they are rearing dairy animals mostly for meeting the consumption needs of household members. On the other hand, a larger proportion of small and marginal farm households have been rearing cattle, in one or two units, based on the feed available within the homestead. The ownership of cattle is financed with loans obtained from micro-credit organizations (NGOs). It is reported that nearly 40 per cent of the micro-credit is used for livestock and poultry raising (Bayes and Hossain 2007).

Rearing of goats is another kind of asset accumulation. In times of crisis, poor households can sell the goats to maintain livelihoods. Over time, the incidence of rearing of goats has increased. For example, 23 per cent of rural households reported an increase in the ownership of goats during the comparable periods. Finally, if we consider the total value of livestock, we observe that rural households have increased their assets from US$ 247 in 2000 to US$ 427 in 2008, and poor households have increased such assets from $176 to $341 over the same period of time. In the distant past, these poor households fell behind in the accumulation of such assets, but now they have moved ahead in this respect. Income from livestock and poultry, for example, increased from $51 to $76 for all households and, particularly for the poor, it rose from $34 to $59 between 2000 and 2008 (Table 4.11). That means that poor households can benefit from accessing credit even at a rate of 30-40 per cent per annum.

4.5 Accumulation of physical capital

Leaving aside land and livestock, rural people also depend on some non-land fixed assets. The assets constitute an important component of their capital stock to generate current income, and include power tillers, shallow tube wells, threshing machines, rickshaw vans, and so on. As we shall see later, non-land fixed assets emerge as one of the significant determinants of household income in rural areas.

Noticeably, eight in every 100 households in rural areas have their own irrigation equipment - mostly shallow tube wells and power pumps. This compares with about 6 out of 100 households owning such assets in 2000, and 3 out of 100 in 1988. Assuming that the total number of agricultural farms in Bangladesh is 14.5 million, roughly 1.2 million households are now owners of this equipment. Of special note, the price of irrigation equipment has fallen to US $161 in 2008 from US$ 179 in 2000 and $729 in 1988. We argue that the import liberalization policy of the late 1980s and the early 1990s played a pivotal role in the expansion of ownership of irrigation machines over time. Households owning bullock-carts is on the wane, possibly pushed out by the advent of the modern transport mode, and the development of paved roads that has made operations of rickshaw vans easy and profitable. The average value of physical capital owned by sample households rose from US$ 500 to US$635 between 2000 and 2008 – growing by more than 6 per cent per annum.

4.6 Access to institutions, financial and social capital

Like land, livestock or non-land fixed assets, access to institutions could also be counted as an asset. For example, access to financial institutions can address the problem of the shortage of working or fixed capital; access to political organizations can reduce transaction costs or promote interests through political links etc. We call them social capital as they help producing the output.

Let us now pick up the issue of access to association of the rural households with political organizations. We observe that 2-3 households out of each 100 households are associated with political parties. But when disaggregated, roughly one-third of the richer segments of households are found to have access to any political party. This compares with 6-7 per cent for the poor households (Table 4.13). If access to political parties is assumed to contribute to capital accumulation, needless to mention the rural rich are far ahead of the rural poor. It thus appears that disparity of this kind also contributes to disparity in other branches of the livelihood strategy.

It can also be observed that about 40 per cent of rural households had access to NGOs in 2008 as compared to about 24 per cent in 2000. But the average again hides the disaggregated dynamics. Very poor households especially, (owning land up to 0.40 ha) could significantly increase their participation during that comparable period. That means, roughly four-fifths of poor households have taken shelter under the umbrella of the NGOs that provide access to credit and other services. This might have played a role for the accumulation of other assets like rickshaw vans, livestock or pumps for this group. Thus, access to financial institutions influences livelihoods by enabling the accumulation of other assets (Table 4.13).

This also points to another development of the coverage of NGO services and their targeting. About one-half of the relatively large and medium land owning groups (owning 1 ha and above) gained access to NGOs in 2008 as compared to one-fifth in 2000. This observation is quite surprising as the NGO bell was not supposed to ring for the rich. That means, although on paper the functionally landless households are the targets of the NGOs, in practice a sizeable portion of the better-off households appear to benefit from NGO activities, especially from their credit programmes.

But it should also be borne in mind that mere membership of NGOs might not help in the creation of assets, unless the access helps households with credit for pursuing economic activities. In this case particularly, we notice another significant development in recent times. The share of households borrowing from institutional sources of credit increased more than three times over the last two decades. The most dramatic improvement was observed in the case of the functionally landless households: 44 per cent of them have borrowed from institutional sources recently compared to only about five per cent in 1988. This means that, even without any collateral, a respectable proportion of rural households have access to an institutional source of credit (mainly NGOs). This kind of access, perhaps, enabled them to have access to other assets also. A quite opposite syndrome could be observed in the case of non-institutional sources of credit. Only one-tenth of rural households now borrow from non-institutional sources compared to about one-third in earlier periods. This means that access to highly usurious forms of credit has been replaced by a relatively cheap source of credit. That had positive impacts on all groups, especially on the poor. For example, only one-quarter of the marginal landowning groups borrowed from non-institutional sources in 2008 compared to one-thirds in 1988. The diminishing role of the non-institutional sources of credit, and the rise of institutional sources, should be construed as positive developments in rural areas. The landless households mostly benefited from this development through availing credit and creating assets for livelihoods.

4.7 Changes in Endowment of Assets

In the light of the discussions above, the question that can be raised is: have rural people been able to accumulate assets over time? And if so, what types of assets, and to whom the assets matter? We shall now submit some of the interesting and insightful observations below. In other words, the changes in four types of capital will be examined in the following paragraphs.

For all households, we observe that the endowment of owned land has declined, obviously due to sub-division and fragmentation of holdings at inheritance, among large and medium land owners. But the endowment of other components of natural capital – such as irrigated land, land under tenancy, and cultivated land for small farmers - increased over time. This implies that, despite a downward trend in land endowment, rural households were up on account of other assets. On the other hand, increase in average schooling years, reduction in household size, and increase in non-agricultural workers increased the overall human capital base of rural households. We also observe that physical capital accumulation has increased substantially over time, and access to micro-credit provided by NGOs has helped households with accumulation of financial capital. For example, in 1988, a functionally landless household had US$ 161 worth of agricultural and non-agricultural assets; by 2008 it stood at US$ 372 – indicating that even the poorest households were able to accumulate assets over time (Table 4.15). Having said all of this, we can now turn to the changes in endowment status of the most disadvantaged group – the functionally landless households. The following points are highlighted:

- The functionally landless households have marginally accumulated natural assets through accessing land in the tenancy market;
- These households gained tremendously on account of accumulation of human capital - the average years of schooling has increased to 3.1 years in 2008 from 1.7 years in 1988;
- Functionally landless households again increased their physical capital by about 53 per cent over time. In the case of agricultural capital accumulation it was 106 per cent, and about 29 per cent for non-agricultural capital;
- The functionally landless households also more than doubled the loans from the institutional sources, mostly from NGOs;

- By and large, functionally landless households accumulated assets over time to earn their livelihoods.

The ownership of land is an important determinant of human capital formation. The large and medium landowning households have also increased the average schooling years from 6.5 years to 7.5 years over the last two decades. This already high educational status might have pushed them faster towards accumulation of other assets. Possibly, the disparity in the access to education is at the root of the income disparities in rural areas. If we consider the case of physical capital, the disparity issue becomes more glaring. For example, in 1988, the physical capital of the functionally landless households was $ 161 as against US$ 763 for large and medium households. The gap has grown further by 2008 (Table 4.14).

4.8 Conclusions: hands on, not off

It is by now very clear that more owned land, and relatively more access to physical and financial capital by the rich, went to widen income disparity in rural areas over time. In this undesirable state of affairs, the state and the NGOs have the responsibility of increasing the access of the poor to various capital-augmenting facilities. And for that to happen, the poor segment should not be left to the ‘invisible hands’ nor to the mercy of the market. Visible but selected interventions by the state through agricultural subsidies, special assistance for secondary and tertiary education, special credit arrangements etc. could minimize the disparity, if not remove it once and for all (Box 4.1).

Box 4.1: From off to on

An important implication of the new agricultural policy is that it involves a substantial increase in public investment. This is an area where past trends need to be reversed. Public investment in agriculture began to decline in the 1980s, but initially the decline was offset by the fact that private investment in agriculture was increasing. Since the mid-1990s, private investment in agriculture has stagnated while public investment has continued to decline. It is essential to reverse these trends, especially for public investment in irrigation and water resource management. It is also essential to increase public investment in rural roads and rural electrification. Success in these areas will stimulate private investment and contribute to a revival of growth momentum in agriculture.
Montek S.Ahluwalia (2005) in *Annual Report 2004-2005, IFPRI.*

Table 4.1: Changes in the pattern of distribution of land ownership

Owned land (ha)	Share of Households (per cent)				Share of own land (per cent)			
	1988	2000	2008	2014	1988	2000	2008	2014
Homestead only	35.1	34.5	28.7	33.7	1.6	1.6	7.8	1.7
Up to 0.20	12.3	15.8	30.2	24.0	2.4	3.2	4.7	6.0
0.21-0.40	11.6	15.1	11.7	14.4	5.5	8.3	7.5	10.8
0.41-1.0	21.7	19.2	17.0	17.8	22.7	23.2	23.0	29.5
1.0-2.0	11.2	10.2	8.2	6.3	25.8	26.8	24.9	22.3
2.0-3.0	5.3	2.4	2.4	2.5	20.8	10.9	12.7	15.5
3.01 and above	2.9	2.8	1.8	1.2	21.2	25.9	19.4	14.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Size of own land (ha)	-	-	-	-	0.61	0.53	0.48	0.387

Table 4.2: Changes in the pattern of distribution of land holding

Size of cultivated holding (ha)	Per cent of Farms				Share (per cent) of land operated			
	1988	2000	2008	2014	1988	2000	2008	2014
Up to 0.2	20.7	22.2	24.0	27.9	2.6	4.0	5.1	6.4
0.2 to 0.40	14.9	24.5	28.2	26.3	4.9	10.9	14.7	14.6
0.41-1.0	35.0	34.3	33.9	33.6	26.6	32.7	37.7	40.4
1.0-2.0	18.8	15.1	11.3	10.4	30.0	31.8	28.4	26.8
2.0-3.0	7.4	2.1	1.7	1.0	19.8	7.3	7.0	4.6
3.01 and above	3.3	1.8	0.9	0.9	16.0	13.2	4.5	7.3
Average size of holding	-	-	-	-	0.87	0.654	0.56	0.519
Non-farm households	34.0	42.1	43.7	42.5	-	-	-	-

Table 4.3: Own land and incidence of renting-out

Size of land owned (ha)	Per cent of households renting out land			Share (per cent) of owned land rented-out		
	1988	2000	2014	1988	2000	2014
Up to 0.2	3.8	7.2	8.1	6.1	12.8	13.5
0.2-0.40	11.1	35.3	45.0	7.3	21.1	25.7
0.41-1.0	17.9	46.1	57.6	9.9	26.8	32.6
1.0-2.0	21.6	61.3	78.9	11.1	31.3	38.4
2.0-3.0	29.2	75.6	80.6	13.2	38.2	44.1
Over 3.0 ha	44.4	78.8	94.3	17.2	34.0	54.3
All households	12.7	28.1	29.6	12.1	29.9	36.5

Table 4.4: Cultivated land and Incidence of renting-in

Land owned (ha)	Per cent of households renting -in land			Share (per cent) of rented -in land		
	1988	2000	2014	1988	2000	2014
Up to 0.20 ha	34.2	31.9	39.5	31.1	91.0	91.3
0.21-0.40	41.8	42.8	38.2	27.1	53.4	58.9
0.41-1.0	50.0	31.1	32.5	31.1	28.6	37.1
1.0-2.0	50.0	23.0	18.3	28.4	12.1	14.1
2.0-3.0	35.0	8.9	9.7	13.1	13.9	5.7
3.01 and above	25.9	13.5	0.0	11.8	3.4	0.0
All households	43.6	31.4	35.5	23.4	32.9	49.5

Table 4.5: Cultivated land and land arrangements

Land tenure group	Per cent of farms				Total cultivated land (per cent)			
	1988	2000	2008	2014	1988	2000	2008	2014
Pure tenant	13.6	20.5	25.8	29.0	6.7	12.4	19.4	20.8
Tenant-owner	14.4	19.0	14.7	20.6	15.3	20.0	19.0	29.3
Owner-tenant	15.7	14.8	7.8	11.9	19.8	21.0	10.3	13.9
Pure owner	56.3	45.7	51.7	38.5	58.2	46.7	51.4	35.9
All farms	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4.6: Changing land tenure arrangements (% of cultivated land)

Type of tenancy	1988	2000	2008	2014
Share cropping	72.0	63.8	59.5	42.2
Fixed-rent	22.0	22.7	37.3	38.4
Mortgage	6.0	15.5	10.2	19.5
Total	100.0	100.0	100.0	100.0

Table 4.7: Expansion of irrigation by types of irrigation

Year of survey	*Ground water irrigation*		*Surface water irrigation*		*All types of irrigation*	
	% of households with access	% of land irrigated	% of households with access	% of land irrigated	% of households with access	% of land irrigated
1988	32.6	19.0	10.9	6.1	42.2	24.0
2000	57.2	48.9	17.1	14.8	72.2	63.6
2008	69.8	63.3	14.9	14.9	82.7	77.9
2014	70.3	63.6	20.0	18.6	87.0	82.2

Table 4.8a: Irrigation by land ownership

Size of own land (ha)	Per cent of households with access to irrigation			Share (per cent) of cultivated land under irrigation		
	1988	2000	2014	1988	2000	2014
Up to 0.2ha	40.5	74.0	87.1	27.6	62.2	83.5
0.21-0.4ha	40.5	81.5	84.4	25.2	66.3	79.4
0.41-1.0ha	46.5	78.0	87.0	23.5	61.8	76.7
1.0-2.0ha	49.6	75.3	89.1	21.8	58.4	85.8
2.0-3.0ha	53.3	88.2	89.3	25.3	64.4	84.7
Over 3.0ha	42.4	84.2	91.4	21.1	64.4	89.6
All	44.7	77.4	87.0	23.6	62.3	82.2

Table 4.8b: Access to irrigation by farm size group

Size of cultivated holding (ha)	Per cent of households with access to irrigation			Share (per cent) of cultivated land under irrigation		
	1988	2000	2014	1988	2000	2014
Up to 0.2ha	35.5	73.8	88.8	35.2	73.8	88.3
0.21-0.4ha	47.5	83.4	84.9	30.3	75.2	83.1
0.41-1.0ha	45.5	75.7	86.2	24.6	62.6	80.9
1.0-2.0ha	48.1	78.0	89.4	22.5	60.9	83.8
2.0-3.0ha	51.7	69.6	100.0	22.7	54.8	100.0
Over 3.0ha	48.1	72.1	90.0	20.7	54.8	78.3
All	44.7	77.4	87.0	23.6	62.3	82.2

Table 4.9: Changing endowments of different types of land

Types of land	Per cent of households Owning land			per cent of total land under this type			Average size of land (acre)		
	1988	2000	2014	1988	2000	2014	1988	2000	2014
Homestead	89.2	91.4	93.6	10.4	9.7	9.6	0.18	0.06	0.04
Garden/orchard	12.7	28.8	32.6	2.9	7.9	10.9	0.35	0.15	0.12
Pond/water body	11.4	22.8	33.7	1.5	2.7	4.0	0.20	0.06	0.04
Cultivable land	62.2	59.6	52.6	84.4	79.7	75.4	2.04	0.71	0.54

Table 4.10a: Information on livestock assets: Percent households owned

Land ownership	Cow/Buffalo			Goat/sheep			Poultry birds		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Up to 0.20	36.18	42.44	38.94	14.98	29.06	19.62	75.95	70.85	64.72
0.20-0.40	52.80	56.62	51.09	12.94	26.10	20.19	85.31	80.88	77.86
0.40-1.00	57.14	61.08	59.17	18.96	31.44	22.09	89.01	80.93	78.90
1.00-2.00	76.44	69.01	60.56	24.08	27.49	23.89	92.67	78.95	82.78
Above 2.0 ha	83.84	68.18	60.75	33.33	32.95	22.43	93.94	87.50	79.44
Total	49.31	51.34	46.49	17.32	29.15	20.52	82.52	75.57	70.84

Table 4.10b: Information on livestock assets: average number owned

Land ownership	Cow/Buffalo			Goat/sheep			Poultry birds		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Up to 0.20	0.78	0.96	0.80	0.33	0.65	0.45	5.51	4.01	5.63
0.20-0.40	1.32	1.38	1.17	0.29	0.66	0.49	8.16	5.93	8.70
0.40-1.00	1.59	1.75	1.62	0.57	0.77	0.57	8.50	6.11	9.16
1.00-2.00	2.53	2.39	1.68	0.69	0.71	0.71	10.65	8.92	10.56
Above 2.0 ha	3.92	3.60	2.34	0.98	1.08	0.55	14.05	10.27	11.14
Total	1.36	1.40	1.12	0.44	0.70	0.50	7.46	5.37	7.22

Table 4.10c: Information on livestock assets: Value in US$

Land ownership	Cow/Buffalo			Goat/sheep			Poultry birds		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Up to 0.20	64	146	182	4	11	12	8	8	13
0.20-0.40	114	239	280	4	11	14	10	10	19
0.40-1.00	162	286	385	7	14	18	11	11	20
1.00-2.00	223	366	391	10	12	25	14	14	22
Above 2.0 ha	356	523	551	13	22	13	19	18	24
Total	122	221	259	6	12	14	10	10	16

Table 4.10d: Information on livestock assets: Income in US $

Land ownership	Cow/Buffalo			Goat/sheep			Poultry birds		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Up to 0.20	8	52	110	0.0	3	7	5	7	20
0.20-0.40	26	97	141	0.0	6	8	7	9	27
0.40-1.00	31	95	229	0.2	5	11	7	12	29
1.00-2.00	35	125	177	0.5	5	9	10	13	33
Above 2.0 ha	48	180	250	0.0	8	12	15	15	41
Total	20	78	145	0.1	4	8	7	9	24

Table 4.11: Ownership of other non-land fixed assets

Fixed assets	Per cent of household reporting ownership			Av. present value of the asset (US$)		
	2000	2008	2014	2000	2008	2014
Irrigation equipment	6.10	10.85	13.11	179	161	146
Power tiller	0.78	1.79	2.35	424	461	950
Threshing machine	1.80	4.13	4.08	23	43	93
Spray Machine	3.67	5.47	10.89	7	9	10
Bullock cart	1.10	1.04	0.53	45	58	59
Rickshaw/Vans	4.20	6.52	4.15	58	60	69
Motor Cycle	0.90	3.13	6.96	1133	694	985
Bicycle	17.00	30.10	34.68	22	30	36
Car/Micro bus	-	0.15	0.39	-	5376	17075
Computer	-	-	2.64	-	-	333
Cell phone	-	-	85.63	-	-	43
Television	-	-	33.70	-	-	100
Refrigerator	-	-	15.88	-	-	289
Other agri. equipment	42.35	51.00	61.17	4	4	6
Other non-agri. equipment	17.80	83.38	41.46	94	4	11

Table 4.12: Access to organizations by land ownership group

Land owned (ha)	Access to NGOs	
	2000	2014
Only homestead	32.4	47.9
Up to 0.2	29.1	45.0
0.21-0.40	27.9	32.8
0.41-1.0	20.8	26.0
1.0-2.0	17.8	20.6
2.01 to 3.0	8.9	19.4
3.01 and above	7.7	17.1
All	26.2	38.3

Table 4.13: Access to credit by land ownership, 1988 to 2014

Size of cultivated holding (ha)	Per cent of households borrowing from institutional sources				Per cent of households borrowing from non-institutional sources			
	1988	2000	2008	2014	1988	2000	2008	2014
Only homestead	16.7	31.0	41.8	46.4	31.0	15.0	7.11	12.1
Up to 0.2	4.8	27.7	44.3	44.4	33.6	13.2	9.2	15.2
0.21-0.40	10.4	23.0	32.8	33.8	27.1	12.4	8.5	14.4
0.41-1.0	30.5	23.3	31.1	28.8	30.6	6.4	9.1	14.6
1.0-2.0	13.1	23.0	29.7	23.3	19.4	9.4	10.9	10.0
2.01 to 3.0	6.8	20.0	34.7	27.8	21.5	11.1	8.2	8.3
3.01 and above	18.8	25.0	22.2	22.9	16.7	15.4	11.1	8.6
All	11.9	26.5	38.2	38.8	28.6	12.0	8.9	13.4

Table 4.14: Changes in endowment of assets by land ownership

Items	Functionally landless households			Medium and large land owner			All households		
	1988	2000	2014	1988	2000	2014	1988	2000	2014
Natural capital(ha):									
Own land	0.05	0.05	0.05	2.13	2.19	1.99	0.61	0.53	0.39
Irrigated land	0.03	0.08	0.13	0.39	0.72	0.69	0.14	0.24	0.25
Cultivated land	0.12	0.13	0.16	1.71	1.16	0.79	0.58	0.38	0.30
Rented land	0.11	0.12	0.15	2.11	0.11	0.07	0.14	0.12	0.15
Human Capital(US $):									
Household size	6.06	4.93	4.10	7.90	6.44	4.95	6.89	5.25	4.33
Agri worker	0.86	0.79	0.71	1.68	1.37	1.08	1.14	0.97	0.81
Non-agri-worker	0.63	0.84	0.72	0.65	0.68	0.61	0.51	0.77	0.67
Total worker	1.49	1.63	1.44	2.33	2.05	1.69	1.65	1.74	1.49
Average education	1.73	2.56	3.91	6.5	7.61	7.82	3.09	4.28	5.01
Physical capital (US $):									
Agricultural capital	51	79	225	374	392	612	155	161	339
Other capital	52	127	538	389	1084	2787	172	338	955
Total capital	103	206	763	763	1476	3399	327	500	1294
Financial capital(US $):									
Institutional loan	7	37	197	31	190	899	16	64	275
Non-institutional loan	27	20	91	81	67	89	42	29	98

Total loan	34	57	288	112	257	988	58	93	373

Chapter 5

Land Utilisation, Cropping Patterns and Cropping Intensity

Chapter Summary: Land utilisation, cropping patterns and cropping intensity

It was found from analysis of panel data of 62 villages in Bangladesh that only one-fifth of the land is now being used in the aus season (Kharif-I) compared to more than half of the land used in 1988. Likewise, two-thirds of the land is being used in the aman season (Kharif-II) as against four-fifths in 1988. It appears that both seasons witnessed a substantial wane in land use by households during the comparable periods 1988 to 2014. This could be due to the resurgence of interest following the introduction of new high yielding varieties as well as a campaign by government and NGOs. However, land under cultivation in the boro season went up from about half to 90 per cent during the period under review. Specifically, cultivated land under paddy in this season went up from one-fifth to one-half. There has been another development over time. Maize crops now account for 7 per cent of cultivated land in the boro season – a crop that was unknown to farmers even in 2000. Secondly, out of the land owned by rural households, the homestead size has decreased over time while land under garden and pond increased, indicating growing land use for vegetables, horticulture crops and fish. Thirdly, only one-third of the cultivated land had access to irrigation in 1988; it rose to more than four-fifths by 2014 through then introduction of Shallow Tube Wells (STWs).

The most important observation to draw policy level attention is the fact that, despite modern technology, roughly 40 percent of the cultivated land continues to be single cropped. Quite expectedly, it is the large and medium farms who have more single cropped land than small farms. The database shows that in 62 districts the yield rate in terms of paddy has substantially risen over time. The yield from boro is estimated to be about 6 tons/ha – about twice the yield of 2000, and the yield of MV aman has increased from 3.3 to 3.8 tons/ha over same period of time. The case of the aus yield is similar. The yield of maize increased from barely 1 ton/ha to about 8 tons/ha, which could be contributing to the increased area under maize, and the reduction of the areas of wheat and other crops.

5.1 Introductory Remarks

For centuries, land has been considered the most important source of livelihood for the people. As human civilization advanced, use of this vital input also altered to suit society’s needs. But, for most of human civilization, the amount of land was always too small to satisfy wants. Furthermore, rapid growth of population, soil erosion, and competing claims from different sectors – all went to worsen the situation. Possibly, these events led Malthus to forecast a doomsday for mankind in terms of hunger, malnutrition and natural disasters. However, the forecast has failed in the wake of technological breakthroughs that boosted food production, and the advent of population control measures that slowed burgeoning population growth. We can argue that Malthus possibly could not apprehend these changes and the extent to which technology has penetrated agriculture for the sake of food security, bringing about major changes in land use patterns.

Most importantly for us, Bangladesh did not allow the Malthusian prediction to materialise. Many other countries had also developed the means to overcome food and population problems and have thus come out of the vicious circle of the crisis during the last 30 years or so. The reason may be that the widespread adoption of agricultural technology, and the concomitant changes in land utilization patterns paved the way for properly addressing food shortage problem.

However, we should not overlook some of the adverse impacts of technology. Factors such as consecutive growth of single crops on the same piece of land, keeping land wet year-round through irrigation, excessive use of chemical fertilizers etc., lead to deficiency of micro-nutrients and so contribute to a decline in the fertility levels of the soil. Second, too much extraction of underground water leads to a decline in the availability of drinking water and, even cause arsenic problems. Third, increased toxic materials from excessive use of pests and insecticides on food crops, fruits and vegetables and water, could harm human health. And finally, the effects of the pervasive use of chemical fertilizers and constructions of dams for flood control could seriously constrain fish culture and production.

However, we shall analyze mostly the positive impacts of the modern technology by focusing on three issues in the subsequent paragraphs: (a) the distribution of cultivated land under different seasons, ecological and tenancy conditions, soil type etc.; (b) cropping patterns, cropping intensity, and the production of crops, and (c) agricultural development and bio-diversity. From an empirical angle it appears that Bangladesh witnessed widespread changes in land utilisation patterns, and the changes obviously affected the lives and livelihoods of the poor segment in rural areas. But allegations also loom large that the trend of developments has impacted upon rural biodiversity. Therefore, we hypothesise that: (a) distribution and utilization of land were led by subsistence needs, availability of technology and profit maximisation, and (b) the developmental activities of the past decade(s) had no adverse impacts on crop bio-diversity.

5.2 Distribution of cultivated land

5.2.1 Seasonal factors

The distribution of cultivated land in different seasons appears to show that the aus season – spanning from March to August – almost lost its historic importance. This is reflected by a drastic deceleration in the share of land in that season. There was a time when the proportion of land cultivated in the aus season was almost on a par with the boro or rabi season (November-May). In subsequent periods, the pendulum swung rapidly, and only about one-fifth of the land was cultivated for aus in the most recent period as against four-fifths in the boro season (Table 6.1). But we also observe a resurgence of the aus season between 2004 and 2008 with a rise in hectarage under cultivation. Possibly this has been prompted by the food crisis during that period. However, we reckon that farmers have revisited their land use because of two important factors: (a) access to timely water in the boro season and (b) higher profitability of the crop grown with that water. That is why land under irrigation increased at a rapid pace in the boro season. This particular season also appears to have claimed some land from deep-water aman - a crop historically grown in the aman season. In consequence, the proportion of land used in this season dropped significantly - from four-fifths in the base year to two-thirds in recent periods (Table 5.1).

The trend in seasonal utilization of land clearly signals that farmers have increasingly leaned on mechanically irrigated crops – pervasive in the boro season – by gradually withdrawing from nature-dependent crops. Finally, we observe that the amount of cultivated land has been declining roughly by one per cent per annum which is quite in line with the observation from other studies. But the “missing land” also points to some policy directions, specifically reminding us of the need for new technology and more allocations to agricultural research. Thus, the time has come for us to think about the introduction of a second generation of the “green revolution”.

5.2.2 Distribution of owned land

Another interesting development to record is the changing use of owned land by rural households. The share of owned land for homestead has gone down from roughly 12 per cent to about 8 per cent during the in comparison period. Driven by economic hardships, rural residents possibly went for the production of homestead-based horticulture and vegetable crops by downsizing the area under homesteads. On the other hand, areas under ponds and gardens significantly increased to allow the production of fish, flowers, and vegetables (Table 5.2). Thus, in the face of shrinking cultivated land, rural households have somehow managed to compensate for the loss of output.

5.2.3 Distribution of irrigated land

To reinforce the observations made in the earlier paragraphs, we can now direct our attention to the utilization of irrigation-based land. Since irrigation is mostly related to modern varieties, the close link between water and crops is quite clear. By this we intend to imply that by diverting land use towards the boro season, the farmers, in fact, moved towards growing more HYV crops at the expense of the traditional ones. To drive home the point, we can take the help of a few statistics. Two decades ago, only 36 per cent of the cultivated land could be brought under irrigation. The rapid growth of irrigation since then continued unabated and covered 82 per cent of the cultivated land in 2007 (Table 4.3). This shows that Bangladesh was able to achieve substantial progress in terms of increasing irrigated land. And since irrigation is needed mostly for HYV paddy, it can also be argued that Bangladesh performed remarkably well in the production of this crop. The widespread cultivation of HYV paddy over time helped Bangladesh reduce its food deficit and, at the same time, save foreign exchange spent on the imports of food grains.

But this is only a part of the whole success story. Bangladesh witnessed another spell of success in the management and the distribution of irrigation equipment. The strategy and the modes of irrigation have undergone radical change over time. For example, shallow tube-wells (STWs) were used to irrigate about half of the total land in the base year, and the share shot up to three-quarters in the most recent periods. This indicates pervasive use of this equipment in rural areas. The use of Low Lift Pumps (LLP) also expanded over time (Table 6.3). The reason for the rise of STWs and, to some extent, of Low-Lift Pumps (LLPs) could be attributed mainly to a liberalised import regime enunciated by the government to promote irrigated agriculture. As various research documents show, in the early 1980s and 1990s, the government removed or reduced import duties on irrigation equipment and accessories to encourage greater participation of the private sector in the provision of irrigation facilities. Such a policy change was brought about with a view to encouraging farmers to grow more HYVs so that increased food production could help food security for the nation. This also contributed to the widespread use of the machines, especially in transport. It needs to be mentioned here that 'shallow machines' have three important advantages: (a) small investments are required in procuring the equipment; (b) farmers have their own control over irrigation ownership, and (c) the equipment can very easily be moved across plots or to other places. However, the second most important mode of irrigation in the past was by indigenous methods, that are now almost on the verge of extinction. This is partly due to the construction of infrastructure for flood control and partly due to a reduction in water flow in canals. Also, along with shallow machines, we also observe a significant increase in the use of low-lift pumps over time (Table 5.3).

5.2.4 Tenancy arrangements and land distribution

The pattern of land use can also be understood from another angle e.g. by looking at the changes under different tenancy arrangements. We have already dwelt on this in Chapter 4 and, in a country where drastic land reform is not likely to come in the near future for various reasons, the only way to affect the lives and the livelihoods of the small and the marginal farmers is a reform in the tenancy market. We observe that, in the base year, about 77 per cent of the total land was operated by owners themselves and 23 per cent went to other arrangements. At that time, three quarters of the total rented land was under a share-cropping system, 5 per cent under fixed-rent system and 1 per cent under a mortgage system (Tables 5.4 to 5.6).

But over time, a revolutionary change has swept through the management of cultivated land. For example, in the most recent periods, cultivation of land under own supervision stood at 60 per cent, the rest being placed under different arrangements. That means, over time, land under own cultivation went down and that of rental land went up. Interestingly, out of the total rented land, the proportion of share-cropping arrangements significantly dropped from three quarters in 1988 to about 60 per cent in 2008 (Table 6.4). On the other hand, the proportion of the fixed-rent system reached 25 per cent, and land under mortgage also increased over time. Since economists always blame share-cropping as an exploitative and inefficient system, such changes in the management of land should be seen as a relief for poor farmers. It is by now clear that most of the tenants in rural Bangladesh are very poor households, and a rise in the share of rented land or a flexible management system invariably should benefit them.

While the proportion of purely owner operated land decreased over time, that of non-farm households increased from 34 per cent in 1988 to about 44 per cent in 2007. At the same time, the share of pure tenants has gone up significantly over time (Table 5.6). The trend reinforces our earlier argument that, in rural Bangladesh, the tenancy market has developed with the gradual exit of land owning rural households.

To summarize, we observe that in comparable periods: (a) land under own cultivation drastically declined; (b) land under tenancy has increased rapidly; (c) exploitative and less productive share-cropping system is gradually losing ground to the fixed-rent or mortgage system, and (d) the share of owner-farmers decreased and that of tenants increased over time (Tables 6.5 and 6.6)). In other words, a traditional anti-incentive system is going to be replaced by a more modern land management system.

5.2.5 Distribution by land-level

The management of cultivated land in Bangladesh can also be examined by a glance at the land levels. We observe that, with the increase in irrigation facilities over time, the share of high land in cultivation began to increase. On the other hand, medium land that was once the most productive under cultivation, has been losing its lead. The same has happened with very low land that gradually lost importance (Table 5.7). It means that irrigation facilities had helped increase the productivity of high land. Besides this, in a flood prone country like Bangladesh and especially where early floods tend to inundate land, the shift of cultivation from low to high land points to the pragmatic utilization of land conditioned by topographical constraints.

5.2.6 Distribution by soil type

Changes could also be noticed in the case of using land of different soil types. As can be gleaned from the data set, in the base year, about one-third of the cultivated land was loamy soil followed by a quarter which was clay soils. By 2004, sandy loam soil took the lead accounting for roughly 35 per cent of all cultivated land, compared to 22 per cent in the base year (Table 5.8). The reallocation of the cultivated land indicates that farmers in rural Bangladesh are engaged in producing different crops on different types of land; for this effect, obviously, market demand has a role to play.

5.3 Land and crops

5.3.1 All land

In the realm of land management in rural Bangladesh, one important question often raised is how farmers use the meagre amount of land that they have, and what factors determine their decisions about which crops to grow and on which land. That is to say, we need to know whether there had been any change in cropping patterns over time. But before coming to that analysis, it would be pertinent to explain why such analysis assumes importance. First, land is the scarcest of all assets. The existing high man-land ratio demands that limited land resources be used optimally or, the highest profit maximizing use of land be ensured. In a society where population is increasing at the same time as the falling amount of land, optimal utilization of land holds the key to making lives and livelihoods more welfare-oriented. Admittedly, expansion of infrastructural facilities, and change in expenditure in conjunction with changes incomes, induce farmers to eke out the maximum benefit from the meagre amount of land. Second, land is the most important asset that affects the livelihood system of rural households. Therefore, an idea about farmers' decisions and their changes relating to land utilization would shed some light on the rural way of life and on livelihoods.

In this context, we observe that traditional aman paddy occupied more than half of the total cultivated land in the base year. This was followed by aus paddy claiming about one-third (Table 6.9). In other words, four-fifths of the total cultivated area at that time was captured by traditional varieties of paddy (henceforth, TVs). This indicates that the decisions of farmers in the past were dominated by these crops. On the other hand, farmers used to allocate less than one-fifth of land each to HYV boro and HYV aman (henceforth, MVs). It may be mentioned here that TVs generally have lower yield, and farmers have to cultivate more land to feed the growing family. Just the opposite happens with MVs that provide more output per unit of land. So, faced with limited land

and subsistence pressure, a rational farmer would always look for MVs at the cost of TVs. Were our farmers irrational in the past when they grew more TVs? The answer to this question is possibly no. It now appears that the widespread use of TVs by farmers in the past was a matter of force, and not of choice, and needless to say , it was the acute shortage of water – the leading input for MVs – that forced farmers to go for low yielding TVs.

The pendulum swung soon and sharply when cultivated land under MV boro and aman increased significantly over time. By and large, MVs now claim four-fifths of the cultivated land to steal the dominance earlier held by TVs. The most dramatic development, however, could be evidenced in the most recent periods: over 90 per cent of the cultivated land is operated under MVs (boro and amon). More prominently, cultivation of TVs in the aus season almost disappeared over time (Table 6.9). By and large, the time span 1988 to 2007 could be counted as the "golden" period for MVs in this country. And as said before, the economics of these paddy crops is very simple and straight forward: more production with less land. In other words, it is as if the amount of land used by the farmers tends to go up. Researchers reckon that the introduction of MVs and its adoption by the rational farmers contributed significantly in ensuring our food security over time.

But we must also point out the clouds on the horizon. For example, it is suggested that cultivation of various non-rice crops – once occupying a respectable share of the cultivated land - has been swept away by the 'tidal surge' of the MVs. That means, possibly led by the profit motive, farmers are now growing more MVs at the cost of other minor crops. In other words, crop diversification has been replaced by a mono-cropping system. In this context, special mention may be made of dal (lentil) occupying one-tenth of the cultivated land in the past but now claiming only half of that in the base period. Likewise, marginally though, jute cultivation has also surrendered to paddy cultivation (Table 5.9).

We share the views of the critics on two points. First, and to reiterate, mono-cropping system adversely affects soil fertility and conversely, multi-cropping helps maintain the fertility balance. Second, for a balanced diet in our everyday lives, we need both rice and dal. At the same time as the growth of paddy output reduced the price of rice, a reduction in the output of dal also raised its price. That means the lack of crop diversification has contributed to the lack of consumption diversification, especially for poor households.

However, there have been some improvements on this front also. In recent years, farmers have become increasingly interested in the production of non-rice crops, as reflected by a greater emphasis placed on the production of oilseeds, vegetables, spices and other crops. The other good news is that farmers have been taking up new, previously unseen crops. Specific mention may be made of the maize crop occupying roughly 7 per cent of land in the 2007 crop season. This crop emerged on the heels of increasing market demand for poultry feed. Second, in the aus season, farmers have taken up fish culture (Table 6.10). Special mention may be made of prawn cultivation that claimed some of the cultivated land. Third, among the old crops, non-rice crops like potato, pulses, and spices and chilly have been demanding more land than before. That means farmers have been responding to market signals over time.

From the policy point of view, however, the most disturbing trend could be the decline in cropping intensity over time: from 168 in the base year to 153 in recent years (Table 5.9). But much of the decline could be attributed to a drop in paddy cropping intensity. This means that farmers are not using the land for paddy as enthusiastically as they did before. If that is so, one could naturally cast serious doubt on the siren song of "self-sufficiency" in food grain production. But we reason that a fall in the cropping intensity over time is due to three factors: first, the fall in the profitability of paddy production over the years has constrained cultivation to a certain extent; second, the drastic reduction in the cultivation of deep-water aman has lowered cropping intensity; third, the expansion in rural non-farm activities, with better returns for households, might have lured farmers to other sources away from farming, and finally there could have been minor shifts in land allocation towards non-rice crops which are yet to impart visible impacts on intensity.

Therefore, to raise cropping intensity, we should attach importance to growing substitute crops of deep-water aman or encourage farmers to grow more non-paddy crops. Of course, the latter option requires that farmers have due access to seed and technology for these crops to be grown.

5.3.2 Land utilization: owned land

The discussion in the earlier paragraphs is related to the utilization pattern of all land. To sharpen the analysis a bit more, we shall present discussions separately for owners and share-croppers. As far as paddy is concerned, we observe no significant change over time in the pattern of utilizing owned land. In the past, farmers used their owned land predominantly for TVs and with relatively less emphasis on MVs. Again, among non-rice crops, 'dal' (lentil) occupied 13 per cent of the land owned by farmers, that gradually waned in subsequent years. In other words, farmers have been using more of the owned land largely for paddy – perhaps propelled by the necessity for food security. Of course, only oilseeds and other minor crops depicted marginal improvement over time. By and large, the overall cropping intensity came down from 171 in 1988 to 162 in recent periods (Table 5.11).

5.3.3 Utilization of rented land

Utilization of land by share-croppers warrants special attention mainly for two important reasons. As has been said before, cultivation under tenancy arrangements has substantially increased while the share of farming owned land has decreased. However, the aggregate picture of land utilization, as portrayed above, hides the differential treatments given to owned and rented land. The second reason is that most of the tenants come mostly from functionally landless and marginal households. Hence, by looking at the pattern of utilization of land by these groups, we can have a glimpse of how poor households in rural areas shape lives and livelihoods through land transactions in the tenancy market (Table 5.12). It appears that tenants devote more of their land to paddy cultivation. Obviously, this has to be so, as the issue of food security critical in all the economic pursuits they are engaged in. The poor group engages more than four-fifths of the rented land in the production of MVs (aman and boro) against only 37 per cent in the base year. The pattern then tells us that, in the adoption of modern technology, tenants are not lagging behind others; rather running fast to take a lead.

Another point becomes evident if we confine our analysis to 2000 and 2004 (Table 5.12). It can be observed that, barring potatoes, tenants have been allocating more land to all other types of vegetables. But the growing decline of their hectarages under potato production obviously warrants an explanation. Generally it is the lack of cash for keeping potatoes in cold storage that discourages poor farmers to go for potatoes. But besides that, we can also mention two other reasons: first, the eyes of the tenants are on food security and hence on the production of paddy. Second, our sample tenants appear to enjoy relatively more freedom in the allocation of the rented in land and the choice of crops to be grown on this land. This might have empowered them to grow crops at the dictate of the market, and not of the master (owner) who rented out land.

5.4 Cropping Patterns and Cropping Intensity

5.4.1 All land

Cropping patterns are influenced by a host of factors. Decisions about choice of land and crops usually hinge on the size of the cultivated land, but other important factors include subsistence pressure, infrastructural facilities, information base and marketing opportunities. We observe that the dominant cropping pattern in 1988 was somewhat as follows: production of paddy followed by keeping the land fallow (rice + fallow). This pattern claimed about one-third of the total cultivated land in that year. And depicting an upward movement, land under this pattern peaked at about 39 per cent in recent years (Table 5.13). Another pattern to notice is paddy followed by paddy (rice + rice). In comparable periods, the proportion of land under this pattern, on average, hovered around one third of cultivated land. But there has been a significant decrease in the case of land under triple crops and, possibly, for this reason the cropping intensity index has declined over time. Overall, it could be observed that the share of fallow land (after paddy or other crops) has increased from 39 per cent in the base year to 47 per cent in recent years. This is also an interesting development because: (a) farmers have learnt that land also needs some rest and (b) economic solvency has reduced the urgency to pursue the earlier pattern. In any case, our discussions on cropping patterns clearly show that 70 per cent of the cultivated land in rural Bangladesh is used only for paddy production and only 18 per cent goes to non-paddy crops. It signifies that crop diversification till now could not emerge as an attractive option for farmers engaged in the pursuit of food security.

5.4.2 Farm size and cropping patterns

Let us now look at the issue from the angle of farm size. First, in comparable periods of 1988 and 2004, the main cropping pattern for small farmers was paddy followed by paddy (rice + rice). That means, after harvesting one paddy crop, farmers used to prepare for growing another paddy crop. But by 2004, a marginal departure from the traditional pattern could be observed when, instead of going for another paddy crop, farmers began to keep the land fallow (Table 6.14). Of course, this pattern had been a favourite for medium and large farmers for a long time. It appears that small farmers, for the sake of food security, have been tilting towards paddy followed by the fallow option rather than paddy followed by the paddy option. Second, triple-cropped land seems to be almost on the verge of non-existence. In the past, there was a trend to grow another non-paddy crop after two consecutive paddy crops. The departure is definitely a sign of improvement as land is not being cultivated as intensively as before with adverse impacts on soil fertility. Third, we now observe that whatever feeble attempts at crop diversification have been made so far, it was mostly by the small and the medium farmers. And finally, an inverse relationship between farm size and cropping intensity can be observed. For small farmers, the intensity declined from 174 in 1988 to 163 in 2004; for large farmers, the index moved down from 169 to 159, respectively (Table 5.14).

5.4.3 Cropping pattern- by irrigation status

An examination of the cropping pattern and cropping intensity by irrigation status would provide another dimension of the issue under discussion (Table 5.15). In areas where the main sources of irrigation are rainfall and surface water, the cropping pattern is paddy cultivation followed by fallow. For example, in recent years such pattern has claimed 57 per cent of the cultivated land as against 36 per cent in 1988. But this pattern does not seem to suit areas where underground water is mostly used for irrigation purposes. The difference between the two areas is mainly caused by the timely availability of water for irrigation. Secondly, two consecutive paddy crops is the main pattern for the users of underground water, although over time the trend has diminished somewhat. For example, 60 per cent of the land embraced this pattern in the base year as against 46 per cent in recent times. In sharp contrast to this, it claims 15-20 per cent of land in areas where rainfall or surface water is used. And as noted before, the difference is mainly due to the availability of water. Understandably, underground water makes irrigation regular, but irrigation becomes erratic where surface water and rainfall dominate. Thirdly, possibly for the reasons mentioned just before, a favourite pattern for the users of rainfall and surface water is paddy followed by a non-paddy crop. Fourthly, triple-cropped land has always been low and over time it has reduced further. And finally, cropping intensity had always been highest in irrigated land, although it has been declining over time. The tendency to grow only one paddy crop in irrigated land has been declining but increasing in other modes (Table 5.15).

5.4.4 Land topography and cropping patterns

In the very low-lying areas, the cropping pattern is paddy cultivation followed by keeping the land fallow, although the pattern is changing over time. The reason behind such a pattern could be the early arrival of floods. In medium and high land, the main pattern is consecutive two paddy crops i.e. paddy followed by paddy. On the other hand, in all topographic conditions, the general pattern is to keep land fallow after growing one non-paddy crop (Table 4.16). Crop diversification, to whatever degree it takes place, is evident in high and medium land, as early flooding is unfriendly to vegetables, fruits and cash crops. That is why crop diversification is the lowest in low land, and relatively high in medium and high land.

5.4.5 Ecology and cropping patterns

The cultivated land can be categorized into two main segments: (a) favourable zones and (b) unfavourable zones. In favourable zones, water availability is somewhat certain; there is no salinity and no fear of drought or excessive floods. In unfavourable zones, the main determinant of cropping patterns is mostly nature. We observe that, cropping intensity has declined in all regions – the highest in unfavourable zones and the lowest in favourable zones (Table 5.17). Interestingly, in drought-prone areas, cropping intensity has risen by about 20 per cent as compared to a decline in the favourable zones. This unexpected observation could be due to the fact that irrigation facilities have expanded in these regions to help the growth of MVs (aman and boro), and to bring more land under these crops, which is undoubtedly good news. But the bad news is that, as elsewhere, farmers in drought-prone areas have increasingly tilted towards growing only paddy, and the increasing trend of crop diversification is almost a matter of the past.

5.5 Yield of crops

The level of the yield of crops is an important consideration for farmers as well as for policy makers. It appears that, among all crops, the yield levels of MVs (aman and boro) have depicted a sharp upward trend. For example, in the base year, the yield of boro paddy was 4.43 tons per ha. After a steep rise in 2000, the yield level appreciably reached 6.4 tons per ha in 2007. For aman, the yield levels stood at 3.3 and 3.6 tons, respectively (Table 4.18). But at the same time, one also needs to be cautious in interpreting the average yield, lest it conceal regional differences. Interestingly, the yield level of TVs in the aus season has increased while that of MVs has fallen over time. Besides paddy, the increasing trend of yield also applies to all other non-paddy crops - sharply in the case of potato and sugarcane. In a regime of limited and also declining land space, increase in yield levels and, hence of land productivity, is encouraging.

5.6 Modern paddy and crop diversity

It is an on-going debate in Bangladesh that the advent of modern technology in paddy cultivation has adversely affected crop diversity. In other words, the widespread use of the cultivation of modern paddy has seriously damaged crop diversity and productivity of crops in rural areas. As the critics contend, a large number of varieties that farmers used to use in the past, in fact, maintained an ecological balance. But over time, that ecological balance has been significantly eroding with the advent of modern paddy. Keeping this debate in mind, we can draw upon empirical information to grasp the gravity of the situation.

From the list of varieties of paddy grown in different seasons we observe that, ten varieties occupy 58 per cent of the land in the aus season. Of course, more varieties could be there but our survey has failed to capture them. However, out of these 10 varieties, BR-2, BR-1, Parijat and IR-50 were grown on more than 50 per cent of the land (Table 6.19). These are modern varieties and all other varieties were traditional. Again, out of the 15 varieties used, only four varieties have a yield rate exceeding 3 tons/ha, and the yield rate of other varieties was below 2 tons/ha.

According to our research findings, a total of 15 varieties claim about three-quarters of the land in the aman season. That means only 15 varieties claim the lion's share of the land in the aman season. Among them, BR-11, Swarna, Pajam and Digha are noteworthy. It may be mentioned here that, some of the varieties grown in the aman season, such as Swarna, have originated from India. However, there may be more varieties grown in the aman season, but our survey could not identify them. In this season also, only a few varieties produce output exceeding 3 tons/ha. These are, for example, BR-11, Pajam, BR-32, BR-30 etc.

In the boro season, only 11 varieties dominate the scene capturing about three-quarters of the land under cultivation. We presume that there are more varieties grown by farmers in the boro season that lie outside our survey. However, only 6 varieties such as BR-28, BR-29, BR-14, BR-8, BR-1 and Ratna are reported to be the most popular in survey areas. In the boro season, the average yield of these varieties exceeds 5 tons/ha, and the yield rates of the remaining varieties appear to be higher than the highest yield rates for varieties used in the other two seasons. This explains the reasons for an increasing switch-over of farmers from traditional to modern varieties, particularly in the boro season.

Therefore our survey data do not seem to support the allegation that farmers have been growing only one variety since their access to modern paddy. Undoubtedly, of course, we notice a tremendous tendency among them to cultivate modern paddy, but it is clear that they are not using the same variety in the same village. In sample villages, we observe farmers tend to grow 10 to 15 varieties of paddy. The rationale behind using different varieties is mostly topographic. Some lands are very high, some very low and some are medium types of land. Even if the farmers do not target the maintenance of crop diversity, they are in fact forced towards that by the very nature of the parcels that they cultivate. Meantime, the economic logic also appears no less important and convincing. What farmers do, in fact, is to spread the risks by growing a number of varieties with different levels of elevation. The loss of crops in one plot is then compensated by the gain in crops in other plots. Another factor that provides incentive to the maintenance of crop-diversity is the taste of consumers. By growing different varieties of paddy, the farmers tend to respond to different tastes of paddy demanded by the consumers in the market. In any case, the apprehension that crop diversity in rural Bangladesh had been lost due to modern paddy is not supported by our collected information.

Table 5.1: Land utilization pattern, 1988, 2000 and 2014

Seasons	1988		2000		2014	
	Land (ha)	%	Land (ha)	%	Land (ha)	%
Aus (Kharif -1) (March-August)	361.9	50.9	107.8	15.0	156.1	18.0
Amon (Kharif –II) (July-December)	579.5	81.5	478.6	66.8	537.2	66.5
Boro (November-May)	382.3	53.8	543.8	75.9	705.9	86.4
Cultivated land	710.6	10.00	716.8	100.0	807.2	100.0
Cropping intensity (%)		186.2		157.7		173.4

Table 5.2: Distribution of owned land, 1988, 2000 and 2014

Items	1988		2000		2014	
	Number	Share (%)	Number	Share (%)	Number	Share (%)
Households	1238	100.0	1888	100.0	2846	100.0
Land area (ha):						
Total owned	661.3	100.0	1002.5	100.0	1102.2	100.0
Homestead area (ha)	78.4	11.9	96.7	9.6	831.5	75.4
Garden area (ha)	21.8	3.3	62.6	6.2	98.2	8.9
Own cultivated	544.3	82.3	799.9	79.8	831.5	75.4
Pond area	11.2	1.7	27.0	2.7	44.6	4.0
Fallow area	-	-	14.0	1.4	35.9	3.3
Other area	6.7	0.9	2.4	0.2	5.2	0.5

Table 5.3: Cultivated land by irrigation status, 1988, 2000 and 2014

Irrigation status	1988		2000		2014	
	Land (ha)	%	Land (ha)	%	Land (ha)	%
No irrigation	459.5	64.7	250.2	34.9	117.8	14.6
Irrigated land:	251.1	36.3	466.6	65.1	689.4	85.4
Shallow tube well (STW)	116.6	16.3	344.7	48.1	468.1	58.0
Deep tube well (DTW)	31.2	4.4	15.6	2.2	55.0	6.8
Low lift pump (LLP)	31.6	4.4	85.1	11.9	142.2	17.6
WDB Canal	11.3	1.6	0.9	0.1	10.8	1.3
Indigenous method	61.5	8.6	20.4	2.8	13.3	1.6
Total	710.6	100.0	716.8	100.0	807.2	100.0

Table 5.4: Cultivated land under tenancy, 1988, 2000 and 2014

Items	1988		2000		2014	
	Land (ha)	(%)	Land (ha)	(%)	Land (ha)	(%)
Own cultivation	544.3	76.6	481.8	67.2	423.8	52.5
Rented land:	166.3	23.4	235.0	32.8	383.3	47.5
Share-cropping	120.8	17.0	149.9	20.9	161.7	20.0
Fixed-rent	35.5	5.3	48.7	6.8	147.0	18.2
Mortgage	7.8	1.1	36.4	5.1	74.6	9.2
Total	710.6	100.0	716.8	100.0	807.1	100.0

Table 5.5: Changing tenancy arrangements 1988, 2000 and 2014

Type of tenancy	1988	2000	2014
Share cropping	72.0	63.8	42.2
Fixed-rent	22.0	20.7	38.4
Mortgage	6.0	15.5	19.5
Total	100.0	100.0	100.0

Table 5.6: Cultivated land by tenancy groups, 1988, 2000 and 2014

Land tenure group	Per cent of farms			Average size of holding (ha)		
	1988	2000	2014	1988	2004	2007
Non-Farm	34.0	42.1	43.1	--	--	--
Pure tenant	9.3	11.9	17.7	0.43	0.44	0.37
Tenant-owner	9.2	11.0	10.5	0.94	0.64	0.71
Owner-tenant	10.3	8.5	6.7	1.10	0.97	0.59
Pure owner	37.2	26.4	21.9	0.89	0.67	0.47
All farms	100.0	100.0	100.0	0.86	0.66	0.50

Table 5.7: Distribution of cultivated land by land level 1988, 2000 and 2014

Land level	1988		2000		2014	
	Land (ha)	%	Land (ha)	%	Land (ha)	%
High land	202.45	28.7	245.80	34.3	243.7	30.2
Medium high land	236.75	33.1	198.57	27.7	322.1	39.9
Low land	111.48	16.5	111.13	15.5	117.1	14.5
Very low land	151.71	21.6	161.31	22.5	124.2	15.4
Total	706.38	100.0	716.81	100.0	807.1	100.0

Table 5.8: Distribution of land by soil type

Soil type	1988			
	Land area (ha)	%	Land area (ha)	%
Loamy soil	218.89	30.5		
Sandy loam	156.84	21.7		
Clayey	164.97	23.0		
Clay-loam	148.72	20.7		
Sandy	28.40	4.1		
Total	716.80	100.0		

Table 5.9: Pattern of land utilization (all land) 1988, 2000 and 2014

Crops	1988		2000		2014	
	Area (ha)	% of cultivated land	Area (ha)	% of cultivated land	Area (ha)	% of cultivat ed land
TV Aus	212.97	30.2	32.54	4.5	9.7	1.2
MV Aus	54.17	7.7	26.75	3.7	27.5	3.4
TV aman	384.81	54.6	212.54	29.7	155.3	19.2
MV Aman	136.96	19.4	264.3	36.9	364.6	45.2
TV Boro	16.02	2.3	17.93	2.5	11.0	1.4
MV Boro	116.38	16.5	333.01	46.5	399.7	49.5
Gross rice cropped area	**921.31**	**130.70***	**887.10**	**123.80***	**967.8**	**119.9**
Wheat	43.17	6.1	46.67	6.5	54.1	6.7
Maize	--	--	--	--	58.6	7.3
Jute	46.28	6.6	37.89	5.3	54.2	6.7
Pulses	79.72	11.3	43.08	6.0	56.1	6.9
Oilseeds	26.09	3.7	23.38	3.3	82.1	10.2
Potato	15.81	2.2	20.69	2.9	33.3	4.1
Other vegetables	9.17	1.3	14.50	2.0	34.4	4.3
Spices	15.92	2.3	21.33	3.0	24.0	3.0
Sugercane	15.31	2.2	9.81	1.4	12.7	1.6
Others	12.97	1.8	20.38	2.8	23.4	2.9
Gross non-rice cropped acreage	**264.44**	**37.50***	**237.73**	**33.2***	**432.9**	**53.7**
Total gross cropped land	**1185.75**	**168.20***	**1124.83**	**157.0***	**1400.7**	**119.9**
Total cultivated land	**705.38**		**716.81**		**807.2**	

* Indicates cropping intensity=Gross cropped area/net cropped areaX1000.

** For example, Tobacco, Banana, Kaon etc.

Table 5.10: Land use by season and cropping pattern 1988, 2000 and 2014

Crops	1988			2000			2014		
	Aus	Amon	Boro	Aus	Amon	Boro	Aus	Amon	Boro
Wheat	--	--	6.48						
Maize	--	--	--						
Jute	7.36		--						
Fish	--		--						
Prawn	--	--	--						
Sugarcane	0.94	0.25	1.03						
Oilseeds	0.34		3.96						
Pulses	0.06	0.18	13.16						
Potato	--	--	2.56						
Onion	--	--	0.71						
Spices	--	--	0.37						
Chili	--	0.08	1.24						
Vegetables	0.1	0.30	1.83						
Tobacco	--	--	1.15						
Other area	0.84	0.18	0.71						
MV rice	7.72	19.31	16.39						
TV rice	29.97	54.25	2.25						
Rice area	37.69	73.56	18.64						
Others Crop area	9.63	0.98	33.19						
Cult land (ha)	47.32	74.54	51.84						
Cropping Intensity (%)	710.6	710.6	710.6						

Table 5.11: Pattern of land utilization (owned land) 1988, 2000 and 2014

Crops	1988		2000		2014	
	Area (ha)	% of cultivated land	Area (ha)	% of cultivated land	Area (ha)	% of cultivate d land
TV Aus	163.15	30.2	20.00	4.2	4.44	1.05
MV Aus	43.25	8.0	21.33	4.4	12.05	2.84
TV aman	295.17	54.6	147.85	30.7	88.29	20.83
MV Aman	104.37	19.3	178.50	37.1	191.71	45.23
TV Boro	13.86	2.6	8.83	1.8	5.24	1.24
MV Boro	87.8	16.3	218.20	45.3	208.54	49.20
Gross rice cropped area	**707.60**	**131.0***	**594.71**	**123.5***	**510.27**	**120.38**
Wheat	34.38	6.4	38.86	7.7	28.70	6.77
Maize	--	--	--	--	36.13	8.52
Jute	38.65	7.2	29.54	6.1	29.15	6.88
Pulses	68.26	12.6	34.26	7.1	31.78	7.50
Oilseeds	21.73	4.0	16.70	3.50	52.86	12.47
Potato	13.66	2.5	17.05	3.50	13.29	3.14
Other vegetables	11.97	2.2	13.02	2.7	19.84	4.68
Spices	7.15	1.3	10.23	2.1	14.44	3.41
Sugercane	12.57	2.3	5.86	1.20	9.30	2.19
Others**	9.04	1.7	22.66	4.7	14.87	3.51
Gross non-rice cropped area	**217.41**	**40.2**	**188.18**	**38.6**	**250.36**	**59.07**
Total gross cropped land	**925.01**	**171.2***	**782.89**	**162.2**	**760.65**	**179.45**
Total cultivated land	**540.40**		**481.83**		**423.88**	

Table 5.12: Utilization of rented-in land

Crops	1988		2000		2014	
	Area (ha)	% of cultivated land	Area (ha)	% of cultivated land	Area (ha)	% of cultivated land
TV Aus	49.82	30.2	12.54	5.3	5.29	1.38
MV Aus	10.92	6.6	5.53	2.4	15.48	4.04
TV aman	89.65	54.3	64.68	27.5	66.99	17.48
MV Aman	32.59	19.8	85.80	36.5	172.84	45.09
TV Boro	2.16	1.3	9.10	3.9	5.71	1.49
MV Boro	28.58	17.3	114.81	48.9	191.20	49.88
Gross rice cropped area	213.72	129.5*	292.46	124.5	457.50	119.36
Wheat	8.80	5.4	10.81	4.6	25.42	6.63
Maize	--	--	--	--	22.47	5.86
Jute	7.64	4.6	8.35	3.6	25.08	6.54
Pulses	11.47	7.0	8.82	3.8	24.27	6.33
Oilseeds	4.36	2.6	6.67	2.8	29.28	7.64
Potato	1.01	0.6	4.27	1.8	20.06	5.23
Other vegetables	3.84	2.3	7.67	3.3	14.58	3.80
Spices	5.86	3.6	4.28	1.8	9.55	2.49
Sugercane	2.74	1.7	3.95	1.7	3.39	0.88
Others**	2.04	1.2	2.14	1.0	8.56	2.23
Gross non-rice cropped area	47.76	29.0	56.96	24.4	182.66	47.63
Total gross cropped land	261.48	158.5*	349.42	148.9*	640.17	166.99*
Cultivated land	164.99		234.98		167.01	

*Indicates cropping intensity=Gross cropped area/ Net cropped area X 1000.
** For example, Tobacco, Banana, Kaon etc.

Table 5.13: Changes in cropping pattern and cropping intensity (all land)

Cropping pattern	1988	2000	2014
Rice+ fallow	33.4	36.2	30.9
NR + fallow	5.6	6.8	5.2
Rice-Rice	32.2	33.6	30.5
Rice-NR	15.0	16.9	18.1
NR-NR	3.0	3.1	5.5
Rice-rice-rice	0.2	0.6	0.5
NR-rice-rice	9.6	1.1	1.2
NR-rice-NR	0.9	1.6	5.8
NR-NR-NR	-	0.1	2.2
Cropping intensity	171.5	160.4	173.6
Rice only	65.8	70.4	62.0
NR only	8.6	10.0	12.9
Rice-based	25.6	19.6	25.1

Note: NR=Non-rice crop

Table 5.14: Cropping pattern and cropping intensity by farm size

Cropping pattern	Small farm			Medium farm			Large farm		
	1988	2000	2014	1988	2000	2014	1988	2000	2014
Rice+fallow	30.4	29.8	28.2	36.6	36.9	36.7	36.3	49.6	33.9
NR+fallow	6.5	7.7	5.3	6.1	5.3	3.5	3.4	6.9	8.8
Rice+Rice	33.0	37.2	30.9	27.9	34.0	29.3	35.0	24.7	31.6
Rice+NR	16.2	16.5	18.4	13.9	17.3	17.4	13.6	17.2	18.7
NR+NR	2.5	4.3	6.6	3.7	2.9	3.7	3.3	0.9	3.2
Rice+Rice+Rice	0.2	1.3	0.7	0.3	0.0	0.0	0.1	0.1	0.6
NR+Rice+Rice	10.2	1.1	1.1	10.7	1.3	1.3	7.5	0.6	0.9
NR+Rice+NR	0.9	1.8	6.2	0.9	2.3	6.6	0.8	0.0	0.6
NR+NR+NR	0.0	0.2	2.5	0.0	0.0	1.4	0.0	0.0	1.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cropping intensity	174.2	166.7	177.1	169.4	161.4	169.2	168.7	144.2	161.2
Rice only			59.8			66.0			66.0
Non-rice only			14.5			8.7			13.8
Rice-based			25.7			25.3			20.2

Note: NR=Non-rice crop

Table 5.15: Cropping pattern by irrigation status

Cropping pattern	Rain-fed			Surface water			Ground water		
	1988	2000	2014	1988	2000	2014	1988	2000	2014
Rice-fallow	34.1	44.9	23.3	38.4	54.4	47.7	26.7	24.9	41.9
NR-Fallow	7.4	9.9	6.1	2.8	5.5	3.5	1.2	5.0	3.3
Rice-rice	25.5	16.2	37.5	28.7	23.6	24.9	59.7	48.4	9.2
Rice-NR	17.0	21.5	15.7	15.2	10.3	17.3	7.6	15.8	28.7
NR-NR	3.5	5.1	5.4	2.6	4.3	3.5	1.8	1.5	8.3
Rice-rice-rice	.01	0.0	0.8	0.0	0.5	0.0	0.0	1.1	0.1
NR-rice-rice-rice	11.6	2.2	0.6	10.8	0.8	0.7	0.8	0.3	3.9
NR-rice-NR	0.8	0.2	7.7	1.2	0.4	1.7	1.5	2.9	3.2
NR-NR-NR	0.0	0.1	2.8	0.1	0.0	0.8	0.7	0.1	1.3
Cropping Intensity	171.0	147.9	182.5	170.5	141.4	152.0	175.1	174.5	163.2
Rice only	59.7	61.1	61.6	67.1	78.5	72.6	86.4	74.4	51.2
NR only	10.9	15.1	14.4	5.5	9.8	7.7	3.0	6.6	13.0
Rice-based	29.4	23.8	24.0	27.4	11.7	19.7	10.6	19.0	35.8

Table 5.16: Cropping pattern by topography of land

Cropping pattern	High land		Medium land		Low land		Very low land	
	2000	2004	2000	2004	2000	2004	2000	2014
Rice-fallow	21.8	16.2	23.8	21.0	39.8	43.8	72.1	73.5
NR-Fallow	7.7	9.9	7.1	2.8	6.6	3.9	5.0	3.0
Rice-rice	42.4	30.7	41.9	42.3	33.0	20.5	9.7	9.3
Rice-NR	19.6	20.8	20.2	22.9	13.0	13.2	11.3	5.3
NR-NR	4.4	7.2	1.9	3.5	4.6	7.2	1.9	6.1
Rice-rice-rice	0.4	0.2	1.5	1.1	0.2	0.2	-	0.0
NR-rice-rice	0.8	0.9	1.4	1.8	2.4	1.2	-	0.0
NR-rice-NR	2.8	8.2	2.2	3.9	0.3	9.3	-	2.8
NR-NR-NR	0.2	5.9	0.1	0.7	-	0.7	-	0.0
Cropping Intensity	174.9	189.1	174.5	183.7	156.3	163.6	122.9	126.4
Rice only	64.6	47.0	67.2	64.4	73.0	64.5	81.8	82.8
NR only	12.3	23.1	9.1	7.0	11.2	11.8	6.9	9.1
Rice-based	23.1	29.9	23.7	28.6	15.8	23.7	11.3	8.1

Table 5.17: Percentage of cultivated land by ecological region, 1988, 2000,2014 [% of cultivated area]

Crops	Coastal			DW-flood prone			Drought-prone			Favorable		
	1988	2000	2014	1988	2000	2014	1988	2000	2014	1988	2000	2014
All paddy	153.3	123.6	119.7	119.7	102.3	111.3	119.9	126.0	111.5	150.0	156.0	148.8
Aus	56.4	19.0	10.2	32.8	7.4	2.0	31.8	4.0	1.8	43.0	9.0	7.5
TV	45.6	9.3	4.7	30.6	7.2	0.3	25.1	0.8	0.4	29.5	1.8	0.2
MV	10.8	9.6	5.5	2.3	0.2	1.7	6.7	3.2	1.4	13.6	7.3	7.4
Aman	92.9	68.6	78.9	62.2	45.7	44.0	72.6	78.9	73.1	84.3	87.6	70.2
TV	84.3	62.2	35.5	59.4	37.9	16.5	41.7	17.9	16.0	51.6	14.3	11.2
MV	8.6	6.5	43.4	2.9	7.8	27.5	30.9	61.0	57.1	32.7	73.2	59.0
Boro	4.0	35.9	30.6	24.6	49.2	65.3	15.4	43.1	36.6	22.7	59.5	71.1
TV	2.1	6.2	-	3.2	3.5	-	3.3	0.4	-	0.7	1.5	-
MV	1.9	29.7	30.6	21.4	45.7	65.3	12.2	42.7	36.6	22.0	57.9	71.1
Wheat	0.0	0.0	0.1	5.2	5.2	6.3	9.0	17.6	11.5	7.6	2.2	6.8
Jute	0.1	0.0	1.0	6.7	6.5	8.5	6.4	9.3	5.4	9.9	2.1	12.1
Sugarcane	0.0	0.0	0.2	4.3	3.0	1.4	1.6	0.6	3.6	1.4	0.2	0.1
Pulses	21.4	8.3	16.8	16.9	11.0	5.0	11.0	4.3	4.7	2.5	0.3	3.0
Oilseeds	5.9	20.5	12.2	6.6	2.6	6.5	1.5	2.5	4.1	1.9	0.2	3.8
Potato	1.6	0.0	0.4	3.3	2.3	0.1	1.1	5.7	7.8	2.5	4.9	4.6
Vegetables	2.5	0.7	2.3	0.9	1.1	1.2	2.1	3.8	3.9	0.6	2.5	5.4
Spices	4.5	0.3	1.1	2.6	5.3	3.8	1.5	2.5	0.7	1.1	0.9	0.3
Other crops	0.7	0.1	6.7	0.7	3.3	3.9	1.9	0.5	26.0	4.1	10.3	3.9
Cropping intensity (%)	190.1	153.5	160.5	167.1	142.6	148.0	155.9	172.9	179.2	181.6	179.5	188.8
Percentage point change in cropping intensity	-36.6			-24.5			17.0			-2.1		

Table 5.18: Changes in the yield of major crops

Crops	1988	2000	2004	2007	2014
TV aus	1.67	1.37	1.75	1.77	2.22
MV aus	3.05	2.93	2.95	2.79	3.46
TV amon	1.92	2.01	2.37	1.85	2.66
MV amon	3.29	3.33	3.59	2.81	3.80
MV boro (TV included)	2.63	3.22	3.23	2.98	5.89
Wheat	4.43	6.14	6.22	6.38	2.91
Jute	1.62	2.19	1.85	2.23	2.53
Sugar cane	1.54	1.99	1.94	1.90	25.37
Potato	26.10	36.60	36.91	50.60	19.21
Pulses	10.56	21.86	22.69	19.36	0.94
Oilseeds	0.79	0.81	0.80	1.35	0.97
Maize	0.85	0.84	0.63	1.22	7.74

Table 5.19: Popular rice varieties and yield rates by season, 2000

Aus rice variety			**Amon rice variety**			**Boro rice variety**		
Variety	Per cent of area	Yield rate (t/ha)	Variety	Per cent of area	Yield rate (t/ha)	Variety	Per cent of area	Yield rate (t/ha)
BR2	10.2	3.2	BR11	24.6	3.8	Brridhan28	11.4	6.5
Change	6.8	1.8	Swarna	13.1	2.9	BR8	10.5	6.2
BR1	6.1	3.5	Pajam	8.4	3.1	Brridhan29	9.6	6.8
Boilian	6.0	0.9	Digha	6.6	1.9	BR14	9.6	6.2
Parijat	6.7	3.4	Joyna	4.2	1.7	BR1	6.9	6.1
Laksmi lata	4.5	1.3	Mota	2.7	2.0	Ratna	6.5	6.3
Muralee	4.3	2.1	Aloi	1.7	2.6	BR3	4.4	3.5
Manik muri	3.9	1.3	Zatua	1.7	2.5	BR26	4.4	6.6
Haitta	3.6	1.4	Sada bawla	1.5	1.5	Bhajan	3.9	4.8
IR-50	3.1	3.2	BR30	1.5	3.4	BR16	3.3	3.5
			Kachra	1.5	2.4	BR11	2.9	4.0
			Tibajal	1.3	1.9			
			BR32	1.3	4.1			
			Chikon	1.1	1.8			
			Rayenda	1.1	1.9			
Total	58.2	-		72.3	-		73.4	-

[a] Farmer's said name of varieties.
[b] Yield rate (t/ha) measure was considered in terms of paddy.

Table 5.20: Popular rice varieties and yield rate by season, 2014

Aus rice variety			Aman rice variety			Boro rice variety		
Variety	% of area	Yield rate (t/ha)	Variety	area	Yield rate (t/ha)	Variety	% of area	Yield rate (t/ha)
BR-28	14.4	2.8	Swarna	28.4	4.0	BR-28	31.8	5.3
BR-2/Mala								
IRRI	13.1	2.4	Paizam	10.1	3.3	BR-29	28.4	6.3
IR-50	9.5	3.6	BR-11/Mukta	5.8	4.1	Hira	8.6	7.1
Kalihaty	8.1	1.2	BR-49	3.4	3.4	Zira Shail	5.1	5.5
ACI-2	8.0	5.4	BR-32	3.3	3.7	Agro-14	3.2	7.3
Moynatiya	7.4	2.8	BR-22/Kiron	2.5	3.5	Hira-5	3.1	6.5
IRRI-20	5.9	2.2	Suman	2.4	3.6	BR-16/Shahi Balam	2.9	5.9
Sarna	4.3	4.2	Duth Monor	2.4	2.8	Kutrapary	1.7	7.5
Porijat	3.2	6.0	Digha	2.3	1.9	Bhajan	1.4	6.3
ACI-1	3.1	5.8	Mota	2.1	2.8	Super Hybrid	1.3	6.8
Molla	2.5	2.0	Hori	2.1	4.2			
Bawra	2.2	1.5	Shornpari	1.9	3.5			
BR-1/Chandina/Chaina	2.1	3.5	Azal Digha	1.8	2.2			
Vaturee	1.6	1.9	BR-23/Disharee	1.7	3.6			
		2.9	BR-34	1.7	2.2			
			Bina-7	1.6	4.3			
Total	85.5			73.7			87.6	

Chapter 6

Costs and Returns from Crops

Chapter Summary: Costs and returns

Costs and returns are important considerations in day to day business, including agriculture. This is because farmers all over the world are assumed to be rational – to maximize profits and minimize costs. It can be observed that the cost of producing 40 kg of paddy in 2014 was Tk.502 against the price of Tk.700/40 kg thus giving a rate of profit of 39 percent. The family income from farming one hectare of land in 2014 was Tk.45,820 in paddy compared to Tk. 31,668 in wheat, Tk 37,406 in jute and Tk 1,92,582 in potato. However, the tenant farmers do not seem to make any surplus in rice cultivation as they have to surrender almost one-third of the harvest to their land owners.

During the last two decades and a half, important changes occurred in the realm of rice production and profitability. First, the cost of producing rice is several times higher than potato but the rate of profit is more than double for potato. Second, the yield of wheat, jute and potato has increased over time but the yield of rice has almost doubled from 2.16 t/ha in 1988 to 3.7 t/ha in 2000 and about 4.6 t/ha in 2014. TVs have gone down from 46 percent of total cultivated land in 1988 to 24 percent in 2000 and further to only 14 percent in 2014. Third, the yield of MVs has increased partly due to adoption of higher yielding varieties and partly (possibly more importantly also) due to better crop management.

The labour use per hectare has reduced from 164 days in 1988 to 132 days in 2000 and 99 days in 2014. The use of hired labour, however, remained at 50 percent of the total labour; the use of hired labour by small holders and tenants has grown over time. Apparently the fall in labour demand was fuelled by the spread of mechanization in land preparation and threshing. Machines cost less than labour in both of the activities. As the labour market got tight and the wage rate hiked, machines became a friend of the farmers– 90 percent of the farmers in Bangladesh now use machines compared to 60 percent in 2000, and almost none in 1988. During this period, the cost of machine rental has increased five times – indicating the pressure from the demand side.

Obstacles to be addressed by Government:
Excessive fertilizer use is still a constraint so it is important to train farmers continuously about when and how much fertilizer to apply. At the same time, farmers need to be educated in the beneficial impacts of organic fertilizers so that they can contribute towards "green agriculture" in the hope of harnessing wider acceptance in the international market.

Tenants and share-croppers are capable of obtained yields as high or higher than land owners, so should be given comparable support, especially in terms of credit.

6.1 Introduction

The importance of an analysis of profitability of farm production is as important for scholarly discourse as it is for policy making purposes. In both cases, however, input and output prices are at the centre of attention. In addition to this, for various reasons we need to have some idea about the relative contributions of inputs used in crop production to focus our attention on changing profitability of the farms. By segregating the respective contributions, we can arrive at average and marginal productivity of the inputs. Secondly, it needs to be noted that profitability of farmers heavily hinges on two factors: the judicious use of inputs and with that, input and output prices.

We intend to start the discussion with an idea about the impact of changing profitability of farmers as induced by factor and product prices. But before that, we can present field-level information on the status of farm income and expenditure, following which we shall use the famous Cobb-Douglas Production Function in the determination of factor shares. And finally, we shall invoke the old debate of farm size and productivity in the context of recent rural Bangladesh.

6.2 Use of inputs

6.2.1 Labour

The first observation to note is the use of labour in the most recent period. Labour is a vital input in production, and its use is related to economic uplift of households. The variation in the demand and the supply of labour is thus closely connected with the profitability of farms. It could be observed that labour use was 110 days per hectare for traditional paddy (henceforth, TVs) and 120 days per hectare for modern paddy (henceforth, MVs). Quite obviously, the demand for labour has increased as a result of the expansion of labour-intensive MVs, but the edge over TVs seems to have narrowed down over time. However, there has been a drastic reduction in the labour-days used in comparable periods for all crops. For example, total labour use in crop production was 159 days per hectare in 1988 as against 115 days in 2007 (Table 6.1). Use of family labour has gone down significantly while the use of hired labour, after a dip in 2004, marginally increased in 2007. Seemingly, it shows that mechanization might have adversely affected the use of human labour in crop production. But we shall discuss other causes later on.

Crop-wise distribution of labour absorption shows that the most labour intensive crops are potatoes, jute, MVs and sugarcane. Labour use in these crops also declined over time. But noticeably, use of family and hired labourers is still widespread in these crops. These crops are, in fact, the main sources of wage labour in rural Bangladesh. By and large, labour use has drastically declined particularly in the production of TVs, pulses and oilseeds.

In this context the relevant question is: why did the labour use decline over time? Many factors might have caused it but we can cite a few. First, and especially in the case of paddy, some labour could have been released with increased production coming through technological advances. Second, the use of labour saving devices, especially mechanized tillage and threshing, might have squeezed the demand for labour to some extent. Third, the farmers have almost abandoned some of the labour-intensive crops such as pulses, oilseeds and TV paddy. Finally, the widespread use of labour in the past might have significantly included disguised unemployment. That could have gone down with employment opportunities opening up in the non-farm sector. The developments in this respect over the last two decades possibly pulled out that 'disguised' labour from agriculture. Therefore, it is not surprising to learn that labour use has declined in the recent period.

Now the second relevant question is: has the downward trend in labour use adversely affected total employment? Possibly the answer to this question is not as easy as it seems. During the last one or two decades, there has been a significant increase in the proportion of land under irrigation as well as in the amount of labour employed. In contrast to this, labour use in the past was higher in some specific areas. Thus, the decline in per hectare use of labour was compensated for by the increase in MV areas. The rise in the wage rate between 1988 and 2008 (details later in this section) also bears out the argument that the demand for labour is still higher than its supply in rural areas.

6.2.2 Use of Chemical fertilizer

Since the dawn of modern agricultural practices in our country, excessive use of chemical fertilizer has been at the heart of a debate. It has long been alleged that the widespread use of such inputs brings adverse impacts on the environment, human health and fish production. To put the premise in the right context, let us draw on some empirical evidence (Table 6.1). It appears that the intensity of chemical fertilizer use more than doubled over time, from 87 kg per hectare in 1988 to 209 kg in 2004, and to 213 kg in 2007. Admittedly, farmers had been applying more than the recommended doses and that might have led to the alleged adverse side-effects. But a closer look at the data set reveals that, between 2004 and 2007, the increase in intensity was marginal. In fact, the yearly rate of increase was 9 per cent during 1988 and 2004 and only less than 1 per cent between 2004 and 2007. That means that the enthusiasm with which farmers began to use chemical fertilizers in earlier days tends to have cooled down in the later part of the decade. May be it is due to the (a) growing awareness among farmers about the adverse side-effects; (b) advice from NGOs and extension officials about the optimal doses, and (c) a rise in fertilizer prices. However, crop-wise, the intensity has increased for traditional paddy, sugarcane and jute but shown fluctuations in the case of other crops (Table 6.2).

We also observe that an increasing proportion of farmers have been using chemical fertilizers in TVs. For example, the ratio rose from about one-half of the total farmers in 1988 to about four-fifths in 2004. In the most recent past, all of them reported to have used chemical fertilizers. Not only that, the intensity of use in these crops has also seen a steep rise over the same period from 43 kg per hectare to 211 kg. This outcome is surprising because of the conventional wisdom that only MVs have the dominant share of chemical fertilizers, and are playing an important part in pollution. The sign is also ominous given that many farmers may be continuing the use of fertilizers out of ignorance, and without knowing the actual costs and returns.

Let us now look at the trend for MVs – the main target of the critics. All of the growers reported to have used chemical fertilizers, and there seems to be almost no change in the proportions over time. The observation is not surprising given the fact that MVs cannot be grown without chemical fertilizer. On the other hand, the intensity of use is important and we notice that the intensity has also increased over time, from 177 kg per hectare in 1988 to 268 kg in 2004. In 2007, sample farmers reported to have used 213 kg/ha. It can be noticed that the rate of increase in fertilizer use fell drastically between 2004 and 2007. Even then, there should not be any doubt that fertilizers are being used in more than the recommended doses.

In this respect, the policy suggestion would be to train farmers continuously about when and how much fertilizer to apply. At the same time, farmers need to be educated in the beneficial impacts of organic fertilizers so that they can contribute towards “green agriculture” in the hope of harnessing wider acceptance in the international market.

6.3 Cash and unit costs

At this stage, we shall furnish information on the degree and the dimensions of costs of production. “Cash cost” includes seed, fertilizer (chemical and manure), irrigation, pesticides and hired labour. On the other hand, the “total cost” includes the imputed values of family-owned human labour and draft animals. It needs to be mentioned here that small farmers and sharecroppers generally have surplus labour with little or no alternative opportunity to use them (opportunity cost is zero). That is, this surplus labour can be utilized on own farms with low opportunity costs. It is not then surprising that, in taking production decisions, these farmers value cash costs more than the total costs. The total cost is more relevant for large land owners with higher opportunity costs of family labour. Cash cost per unit of land also indicates the requirement of working capital, where small farmers are relatively in a more disadvantageous situation. This is because they the lack a surplus after meeting family consumption. Access to financial institutions is also very limited for them.

It is observed that cash cost per unit of land, especially for TVs, has increased over time. The hike in cost is not unusual since farmers these days widely use chemical fertilizer even for growing TVs (a point also made before). However, the cash cost of MVs has declined from $286/ha to $262/ha in comparable periods. Quite expectedly perhaps, the falling cash costs have encouraged farmers to go for MVs at a faster pace. Cash cost for all non-paddy crops (excepting pulses) has gone up. On this aspect, special mention may be made of cash costs of the potato crop which almost doubled over the periods under consideration (Table 6.3). But between 2000 and 2004, the situation appears to be a bit different. During this period the cash costs of all paddy crops have increased, while all non-paddy crops (except for potatoes) faced a decline. It could be due to relatively low use of modern inputs in these crops. By and large, between 2000 and 2004, the overall increase to the cash costs of paddy was caused by the increased price of diesel and hired labour.

If costs are shown against unit of output, rather than against unit of land, a different picture seems to emerge. For example, the unit cost of production has decreased in the comparable two periods for all crops. But the rate of this reduction was relatively more during the 1988 to 2000 period (Table 6.3). For example, in comparable periods, the cash cost per unit of output of MVs has almost halved. And finally, information about the difference between buying and selling prices – which is called ‘margin’ (per cent of price over costs) - tends to show that the margin has significantly increased for all crops. But apparently, MV paddy had the highest margin in the base year (other than dal and potatoes) and that significantly went down in recent years. For example, the farmers had a margin of 134-207 per cent from crops like potato, dal and jute in 2004. This is against 33-53 per cent from paddy. May be the fall in margin in this case is due to a rise in the prices of diesel and fertilizer.

Obviously the question that comes to mind is, despite high margins from other crops, why do the farmers become more interested in growing paddy? In reply, suffice it to say here that in addition to the objective of food security, farmers in rural Bangladesh also aim at ensuring the optimum use of the scarcest factor of production (e.g. land). They do not run only after margin or profits. To drive home this point, we can cite an example. In 2004, by investing $265 in a hectare of land on MVs, a farmer used to get $405. But by investing $32 on other crops (such as dal) on the same amount of land, the said farmer used to get $66/ha. On the other hand, had capital been the scarcest input then, possibly, the second objective would have been realised. Perhaps based on this impression, farmers are tilting more towards jute and potatoes at the cost of pulses and traditional paddy.

6.4 Changes in Output and Input Prices

6.4.1 Output prices

It could be observed that the Consumer Price Index (CPI) has increased by 5.3 per cent per annum between 1988 and 2004. The price of TVs rose by 2.9 per cent per year, while that of MVs by 2.6 per cent. Thus, increase in paddy price was less than half of the CPI increase during that period. It is true that low prices of rice helped the poor to have access to food, notwithstanding its adverse impact on incentive to the growers (Table 15.4). Again, the price of potatoes rose relatively fast (about 11 per cent) followed by pulses, wheat and jute (averaging about 5 per cent). Price increase of pulses and potatoes at a higher rate, possibly, reflects the substantial shortage in domestic availability. But with hindsight, it also means that high prices deprived the poor of these protein-rich products. However, the 'exorbitant' rise in the price of paddy, at roughly 23 per cent/year between 2004 and 2007, suggests a price incentive for the producers. However, that hike in prices put the poor in peril as their real income went down drastically. By and large, the double-digit rise in prices of all commodities during 2004-2007 can be attributed to volatile domestic and international market swings.

We could not discuss the changes in prices of other crops due to a lack of data, but Hossain and Rahman (2003) have shed some light on that. An analysis of the movement of retail prices between 1984-85 (base year) and 1995-96 tends to show that the terms of trade between agricultural and industrial products depicted no discernible swing. But among agricultural commodities, prices of fish soared very high (9.5 per cent/year). Take one specific example. Rice worth of Tk. 100 in 1984 was sold at Tk. 175 in 1996 while, during the same time, fish worth of Tk. 100 fetched Tk. 296. That means, the farmers had bought the same amount of fish in exchange for twice the amount of rice that they exchanged in 1984. The exchange rate between paddy and essential items like saris, cloth, kerosene oil and sugar also drastically dropped. It is only in the case of lentils that the farmers have been receiving better bargains; but the reward from the price rise did not bring much benefit as its production did not increase that much.

It therefore appears that, to help farmers with increased income in future, the supply of paddy and vegetables needs to rise at a lower rate than demand. On the other hand, the supply of lentils, oilseeds, fish, meat, egg and milk should proceed at a faster rate than demand. And finally, in the interest of farmers, proper emphasis should be laid on the development of fishery and livestock sub-sectors, and crop diversification should be facilitated.

6.4.2 Input prices

During the 16 years between 1988 and 2004, the price of Urea has increased at 1.8 per cent per annum, while that of TSP increased by 9.7 per cent. On the other hand, irrigation cost increased by 1.8 per cent per annum - from Tk. 4,524/ha to Tk. 5,863 /ha (Table 15.4). Thus, the prices of urea fertilizers and irrigation increased at a rate below that of the CPI during the first decade. Standing close to the rate at which prices of paddy increased, the slow upward movement of urea and irrigation prices should have kept farmers on an even keel. Unfortunately that did not seem to have happened for two reasons: first, the increase in the wage rate was substantial (at 7.3 per cent/year) and much above the rate of the movement of the CPI. For example, the wage rate was Tk. 29.5/day in 1988 and shot up to Tk. 63.2 in 2004 - a rate of rise by 6.2 per cent per annum (Table 15.4). But between 2004 and 2007, farmers should have faced relatively good economic conditions. During this period, the CPI increased roughly at 7 per cent per annum, as against the rate of increase in paddy prices at about 20 per cent. The pinch, however, came from increased wage rates at about 25 per cent and irrigation costs at about 17 per cent per annum. The rise in the wage rate reflects serious labour shortages in villages, and has put pressure on the profitability of crop cultivation, especially of paddy. Second, the frustration of farmers was also triggered by a substantial rise in TSP and irrigation costs – rising at an average of 15 per cent in most recent years. However, as we shall see shortly, the fall in profitability was, to some extent, compensated for by the increased yield of output per unit of land. This has positively impacted upon the aggregate income of the households.

6.5 Costs and returns in cultivation

6.5.1 Paddy cultivation

Let us clarify a few things first. Household income hereafter would imply the gross value of output that a household produces *minus* paid-out cost. On the other hand, the operating surplus would imply the total value of the produce *minus* total costs. Defined so, let us look at costs and returns that sample farmers faced over time. First, we observe that production per unit of land or the yield level increased in the comparable periods for both types of paddy. However, the yield rate of TVs was half the yield of MVs which, perhaps, explains the reasons for increased allocation of areas under MVs by farmers. Second, paid-out costs increased substantially for TVs (by 40 per cent), but declined for MVs (by 6 per cent) during the same period of time (Table 6.5a). The increase in costs for TVs has been mainly due to increased costs for material inputs, human labour and capital services. On the other hand, relatively less use of human labour in MVs caused a large reduction in costs which, in turn, led to a reduction in paid-out costs. Third, animal power for both crops constituted an important component of paid-out cost in the base year but by 2004, we witness the dominance of mechanization. Fourth, the prices of both the crops declined by about 22-25 per cent in the comparable periods, and that has contributed in lowering family income. But the relatively high yield and increased acreage under MVs possibly boosted family income. The rise in yield helped increase the gross value of the output, and hence, of the operating surplus for farmers.

Farmers faced problems mostly during 2004 and 2007 with cost-escalation followed by moderate increase in output prices. Between 1988 and 2004, we observe a rise in family income and the operating surplus increased by a respectable margin. But family income fell and the surplus almost stagnated between 2004 and 2007 (Table 15.6). This has mostly been due to a fall in the gross value of output that witnessed a respectable rise during the first decade.

6.5.2 Cultivation of non- rice crops

Let us start with potatoes. Among non-paddy crops, potatoes are the most profitable. It appears that the paid-out costs for potatoes increased almost three-fold between 1988 and 2007 (Table 6.6). The important reason behind this could be the substantial increase in material costs followed by the costs of capital services. And for this reason, the total cost of potatoes almost doubled. What is noticeable, however, is that the yield of potatoes more than doubled over the same period of time. With a sudden jump in yield rate and a reasonable rise in output price, the gross value of potatoes increased by more than three times. And finally, despite a rise in costs, increased yield per acre pulled down the unit cost of production. This is the reason why the return over cost rose to 132 per cent in 2007 from about 52 per cent in 1988 (Table 6.7).

Furthermore, family income from wheat production has gone down over the years and, along with that, also declined the return over costs. It is, thus, not surprising that wheat acreage has shrunk in recent years. Jute is another profitable crop with its yield almost doubling over the years. Returns from pulses, however, have not been to the level of the competing crops like paddy, which could be one of the important reasons for its declining hectarage over the years.

6.5.3 Cost and returns: tenants

So far our discussions on costs and returns were mainly related to owner cultivators. However, if we consider tenants, we might get some interesting insights, since they shed a part of their output as rent to the owners. The rent is for example, 33 per cent for TV paddy, 30 per cent for MVs and 50 per cent for other crops. For small farms and tenants, the cash cost of cultivation appears more important than total costs for reasons already mentioned before.

However we observed that, despite a transfer of income through land rent, the family income of tenants from paddy cultivation marginally increased over time. Seemingly, the incremental family income came mainly from TV or local aman (Table 6.7). We also observed that, with the exception of wheat, the family income of tenants also increased from jute, potatoes and pulses. Of course, the scope of increasing tenants' family income depends somewhat on the whims of the owner. For example, the owner might desire that paddy should be grown on his parcels of land, although cultivation of pulses could bring more operating surplus for the tenant than from paddy. By and large, the negative operating surplus clearly confirms that growing TVs is never sufficient for tenants. On the other hand, the operating surplus (gross value of output minus total costs) turned from negative to positive for all paddy crops. This might be due to a substantial increase in operating surplus from growing MVs. Noticeably, the operating surplus from modern boro declined significantly during the comparable periods. And as we have argued before, the rise in input costs over the years might have caused this. However, among non-rice crops (except for wheat), the operating surplus of other crops increased between the comparable periods (Table 6.7).

The moot question is: why tenants should cultivate paddy while faced with falling operating surplus and family income? There are many reasons behind this, but we shall cite a few. One, the tenants' first priority is food security. Hence, they try to maximize paddy output by utilizing family labour. Since the opportunity cost of family labour is almost zero, growing crops means more employment for household members. Two, the tenants also take into account the return per day of the labour that they use in cultivation. That means, in valuation of efforts, tenants try to reach as close to the existing wage rate as possible. In that sense, the wage rate in the cultivation of boro and MV amon are close to the prevailing wage rate. Especially the returns from the productions of pulses and potato are much higher than alternative crops. And finally, taking all crops into consideration, it certainly appears worthwhile for tenants to pursue the production of crops.

6.6 Mechanization and costs

One of the debates in the analysis of rural economic dynamics is the introduction of mechanized cultivation and its impacts upon the rural livelihood system. In the base year, all farmers used animal power for growing crops. By 2000, the proportion of farmers using animal power had declined significantly. None of the farmers used mechanical devices in the base year but a large proportion of them switched over to mechanized practices in 2004. For example, 80 per cent of the paddy growers used mechanized devices such as tractors, tillers etc. in 2004 (TVs: 72 per cent, MVs: 81 per cent). Again, the pervasive presence of such practices is evident in the case of potatoes and jute and, with the exception of pulses, over four-fifths of farmers used mechanized cultivation practices in 2004 (Table 6.8).

The important point to note is that the introduction of mechanical devices made a considerable impact on the costs of production of crops. For all paddy, the cost of production has come down from US $93/ha in 1988 to US $47/ha in 2004. That means, over time, the cost of cultivation almost halved due to the use of mechanical power. The same trend applies for other crops also. It is obvious to think that, in rural Bangladesh, changes in the relative prices of men and machines tilted the balance in favour of the machines. This trend is particularly true in areas where labour shortages are acute. But seemingly this change was spearheaded by two other factors: first, a liberalized import regime that allowed the imports of agricultural equipment at reduced or no duty. And second, the innovative initiatives of the rural people that showed the paths to use 'shallow machines' for various agricultural activities.

6.7 Contribution of factors and productive force

6.7.1 Theoretical tool for measurement

To measure the contributions and the productivity of the factors of production, we have used the following Cob-Douglas Production function:

$$Y = A\, L^{\alpha}\ K^{\beta}\ M^{\lambda}\ l^{\sigma}$$

Where,

Y = Gross value of output (Taka);
L = Labour input (costs of labor use);
K = Capital services (costs of irrigation, machine rental and draft power);
M = Material inputs (costs of seed, fertilizer and pesticides);
I = Land under own control (ha), and

A, α, β, λ and σ are constants determined by the technology.

(a) If α, β, λ and σ = 1, the production function is assumed to show constant returns to scale. This means, inputs and outputs vary by the same proportion;
(b) If α, β, λ and σ >1, the production function exhibits increasing returns to scale. For example, if input increases by 1 per cent, output increases by more than 1 per cent, and
(c) if α, β, λ and σ <1, the production function shows decreasing returns to scale implying that, a 1 per cent increase input results in lower than 1 per cent increase in output.

6.7.2 Empirical results: contribution of factors

We have considered two years: 1988 and 2004. But hopefully, the results would also apply for the most recent periods also. The results of the regression equation show the contributions of different factors (Table 6.9). It can be observed that, for inputs used in paddy production in 1988 and 2004, the model turned out to be a good fit. This is reflected by the value of the Adjusted R^2 at roughly 0.69 in both years. That is, more than two-thirds of the variations in output are explained by the explanatory variables used in the model. The "F' value also stands high to indicate to the overall power of the model. The parenthesized values of 't' indicate that the coefficients are highly significant.

Let us first consider the case of paddy. In the base year, the largest contribution to increased production came from land. That means, land was responsible for 61 per cent of the total output. This is not surprising given the fact that paddy cultivation invariably means the use of land. In that year, the second important factor was material inputs – such as seeds, fertilizer and irrigation - accounting for about a quarter of the output generated. This is also plausible since modern varieties of paddy need these inputs most. However, the contribution of labour to output was 13 per cent and of capital services 20 per cent. It indicates that roughly one-third of the output came from the joint contribution of material inputs and capital services. Note that the total contributions from all inputs come to 1.20 or 120 per cent. This tells us that, in the base year, the production function was depicting increasing returns to scale - the ratio at which inputs increased was lower than the ratio at which output increased (Table 6.9).

But we observe a deviation in 2004 somewhat. For example, the contribution of land substantially declined, to peak at 47 per cent against 61 per cent in the base year. This means that the share of land in total output has reduced by 14 percentage points in the comparable periods. On the other hand, the contribution of labour increased 53 per cent and that of material inputs decreased by 40 per cent, capital services by 8 per cent. Summing all the contributions of different factors, we observe that output increased by 1.0 or 100 per cent. In other words, the output increase was at the same rate as the input increase – implying constant returns to scale of the production function in 2004. It is quite in tune with available empirical observations where it has been noted that, the long-run trend of the production function tilts towards constant returns to scale, although there could be increasing returns to scale in the short-run. It can also be noticed that the value of the constant term assumed a 55 per cent increase in 2004 over 1988 (Table 15.9). Since the constant term embraces the managerial and other factors, we can presume that paddy production in Bangladesh approached a more efficient path in 2004 than in 1988 through better management at the farm level.

Let us now examine the contributions of factors in the production of all crops. The values of the adjusted R^2 (0.58 and 0.64) and 'F' statistics (714 and 1671) for 1988 and 2004, respectively, point to the robustness of the model in explaining the contributions of factors and their changes over time. Again, the parenthesized 't' values indicate that the coefficients are highly significant.

Contributions of factors in the production of all other crops in the base year were as follows: land 67 per cent, labour and capital 50 per cent and material inputs 10 per cent. The contribution of material input was less as these crops use less fertilizers, pesticides and seed. However, the sum of the contributions amount to 1.24 or 124 per cent. It implies that the production function depicted increasing returns to scale (Table 6.9). Noticeably, the contribution of land almost halved in 2004. But, unlike paddy, the contribution of labour has declined. Interestingly, as opposed to the case of paddy, the contribution of material inputs increased for all crops. This could be due to the fact that, of late, farmers have been using more fertilizers in traditional paddy as well as in other crops. By and large, the production function indicates constant returns to scale, pointing to efficiency in resource use in all crops through better management. Finally, in the 1980s, farmers were more dependent on increased use of inputs; recently the shift had been towards knowledge and management.

6.7.3 Average and marginal productivity (paddy and all crops)

Besides labour, the average productivity of other factors of production showed a decline over time. This was also the case with marginal productivity (MP). The higher value of MP for labour shows the possibility of maximizing labour use by withdrawing labour from paddy production to equate with average productivity (Table 6.9a).

In 2004, average productivity of all crops surpassed paddy. This could be due to the fact that only paddy production witnessed major technological breakthrough in 1988 but by 2004, other crops also experienced the some kind of technological improvements. However, the marginal productivity of labour and material inputs increased over time. This implies that, there is scope to withdraw labour from all crops to equate average and marginal productivity and thus optimize the use of these inputs.

6.8 Farm Size and Productivity

6.8.1 Introduction

Our aim in this section is to invoke the debate of farm size and productivity in the light of available information. Meanwhile, some research has already reached the conclusion that there exists an inverse relationship between farm size and productivity (Hossain 1977; Taslim 1989). We can now draw upon the data set for recent years to accept or reject the hypothesis. And to this effect, we shall take the help of the results of the surveys conducted in 1988 and 2004. The hypothesis that we are going to test is: small farms are more efficient than large farms.

6.8.2 Dawn of the debate

Interest in the relationship between farm size and productivity (output per unit of land) is not new. It dates back to the early days of development economics (Bauer 1946; Sen 1962). Since that time, an avalanche of empirical research on this hovered around a negative relationship between these two variables. The majority of the research presumes that small farmers are ahead of large farmers in terms of yield of crops. In other words, small farmers produce more than large farmers on a particular plot of land. Later, especially in the context of land reform and rural development, the idea emerged with important ramifications (Heltberg 1996). It is being argued that the negative relationship between farm size and productivity is a genuine argument in support of drastic land reform. That means, if the size of farms could be equalized then, simultaneously, efficiency and equity will increase, and the attained success would impart dynamism in rural economy (Eckstein 1978; Lipton 1993). And in support of this contention, examples of land reform are drawn from the experience of Japan, South Korea and Taiwan. It had been argued that land reform-led economic transformation of those countries contributed to creating agricultural surplus, consumer markets, and political stability which are preconditions of sustainable development.

In the context of Bangladesh, the maiden attempt was made by Hossain (1977) with the research on farm size and productivity. According to the researcher, the low opportunity costs of family labour enable small farmers to use them intensively. For this reason, they receive more output (yield) than the farms of other sizes. Taslim (1989) argues that, due to the high costs of monitoring and supervising the labour force, large farmers are likely to use labour less intensively. However, Toufique (2005) has drawn the opposite conclusion. According to him, because of low transaction costs of time in high potential areas (such as Madhupur), large farmers become efficient. On the other hand, small farmers remain more efficient in low potential areas (such as Chandina). Therefore, the relationship between farm size and productivity may not be negative everywhere.

6.8.3 Recent empirical enquiry

Our field level information on crop-specific yield levels shows that the negative relationship between farm size and productivity is not consistent in all cases. Maybe technical and environmental considerations in crop-specific analysis failed to lend support to the hypothesis. Let us elaborate the observation citing a few examples. In the base year and in the case of the yield of TV aman, small farmers had a marginal edge over large farmers. But the inverse relation was not consistent as farms between large and small displayed more yield per acre. By 2004, the yield per unit of land was largest for the functionally landless farms followed by other farm size groups (Tables 6.11 and 6.12). The negative relationship quite visibly emerged in this particular case. Again, a positive relationship could be noticed for MVs in 1988 but a negative relation was found in 2004. However, in 2004, the negative relationship was not consistent and clear. For example, small farms had 6 per cent higher yield than large farms (4.18/ton vs. 3.94 ton/ha), and the difference with other groups was even more. Again, the difference was very distinct in the base year when small farms had 2.68 ton/ha compared to 2.08 ton/ha of large farms– a difference of about 29 per cent.

It appears that our data-based observations confirm the conclusions reached by Hossain (1977) and Taslim (1989). The arguments of both are acceptable, although the respective conclusions were drawn from different angles. It is true that small farms tend to have low opportunity costs of family labour, and hence can be used intensively. On the other hand, the cost of monitoring and supervision of labour is relatively high for large farms, which avoid proper utilization of labour. We also reckon that the desperation of small farms for food security from tiny parcels always makes them vigilant over crop management, which helps raise productivity. The famous observation of Nobel Prize winning economist Theodore Schultz might also be true for Bangladesh: small farmers are rational and efficient. Therefore, it is not unlikely that these rational and efficient farmers put every effort in their lives to get the maximum production from the given land. A small crop failure could be disastrous for them.

The debate on farm size and productivity also centres on the tenure status of farms. Following Adam Smith and Alfred Marshall, many researchers presume that the yield level of the tenants is likely to be lower than owner cultivators. The main reason in this case is the incentive problem. Since tenants have to shed one-half of incremental output, they lose interest in producing additional output. Besides, a farmer is not likely to be as careful with others' land as he is with his own land.

When production of all types of paddy is considered together, the yield levels of share-croppers are found to be higher than owner operators. Share-croppers have topped the list in the case of boro and MV aman in 2004 (Table 6.12). Seemingly, our findings reject the contentions of Marshall and Adam Smith. That is, we observe no shortage of productivity on the part of the tenants, even after surrendering half of the output. It may be that owners are sharing the inputs with tenants these days, and for this reason the efficiency of the tenants is not affected. The hypotheses of Cheung might have worked in this case. The other reason could be that (and it is really so) the share croppers are not lagging behind the owner operators in the adoption of MVs. And finally, low opportunity costs of labour and high costs of supervision and monitoring might have upset the conventional calculus.

The same results also follow for non-paddy crops. Especially for wheat, we notice a discernible positive relationship between farm size and productivity. That is, large farms tend to have more production per unit of land. This could be due to the fact that the crops are mostly grown in Dinajpur district where the average size of land is relatively very large. Added to this is another factor: wheat is considered to be a relatively risky crop (e.g. depends on the duration of winter) that could become expensive for small and tenant farmers. But for potatoes and pulses, we observe an inverse relationship between farm size and productivity. Again, for tenant farmers, the output level of potatoes is higher than that of owner-farmers.

Table: 6.1 Cost and Returns, 1988-2014

Items	Traditional varieties			Modern varieties			All rice		
	1988	2004	2014	1988	2004	2014	1988	2004	2014
Material inputs	35.21	36.64	68.49	91.50	73.03	166.26	58.52	67.06	152.78
Seeds	16.44	14.05	33.44	16.57	16.35	40.66	16.08	16.13	39.66
Fertilizer	14.36	18.33	28.44	56.11	46.39	96.55	31.65	40.96	87.15
Manure	2.93	1.72	1.72	8.41	6.34	10.90	6.20	4.74	9.63
Pesticides	1.48	2.54	4.90	11.41	6.95	18.16	6.59	6.23	16.33
Capital Services	41.97	42.95	98.44	126.35	96.46	238.99	76.29	87.88	221.18
Irrigation	0.32	14.89	7.33	77.43	63.79	130.81	32.26	56.80	113.78
Machine rental	0.11	26.91	91.11	0.43	29.95	104.28	0.24	29.26	102.46
Animal power	41.54	2.15	11.41	48.49	2.72	3.90	42.79	2.62	4.94
Human Labor	128.16	134.40	289.95	199.17	160.02	356.83	158.36	156.54	347.16
Family	73.45	73.43	152.35	91.86	61.59	142.61	81.73	63.28	143.51
Hired	54.71	60.97	137.60	107.31	98.43	214.21	76.61	92.26	203.65
Paid-out cost	98.85	139.11	296.76	286.12	267.92	594.20	176.74	244.10	553.18
Interest charges	6.92	8.35	17.81	17.17	16.08	35.65	10.60	14.65	33.19
Total cost	206.34	214.00	314.56	434.19	329.51	797.73	302.77	324.93	754.31
Crop yield (t/ha)	1.48	2.16	2.64	3.79	4.40	5.01	2.24	4.00	4.69
Price (US $/ton)	163.84	126.63	245.62	159.06	119.84	220.89	161.62	120.72	224.22
By-product (US $/ha)	29.27	30.63	81.54	33.29	33.00	91.32	30.94	32.56	89.97
Gross value (US $/ha)	271.10	304.66	730.06	636.60	560.42	1198.66	394.43	516.16	1140.62
Family income	172.25	166.55	433.30	350.48	292.50	604.46	217.69	272.06	587.44
Operating surplus	66.76	90.67	243.96	202.41	230.91	400.93	91.65	191.23	386.31
Cost (US$/ton)	139.42	99.07	119.14	114.56	74.89	159.13	135.17	81.23	160.98
Rate of surplus	17.52	27.81	106.17	38.84	60.02	38.81	19.57	48.61	39.29

Table: 6.2 Cost and Returns, 1988-2014

Items	Wheat			Jute			Potato		
	1988	2004	2014	1988	2004	2014	1988	2004	2014
Material inputs	**73.00**	**81.46**	189.21	**37.27**	**22.54**	90.84	**218.82**	**634.96**	968.68
Seeds	27.91	31.24	62.27	11.27	8.02	19.90	64.55	379.16	493.12
Fertilizer	36.22	46.33	112.58	12.28	12.06	65.48	140.71	204.91	356.75
Manure	6.77	3.76	8.95	9.02	1.95	2.22	7.35	9.19	32.76
Pesticides	2.10	1.13	5.40	4.7	0.51	3.24	6.21	41.7	86.06
Capital Services	**37.39**	**56.00**	195.59	**41.81**	**31.57**	145.21	**82.23**	**102.25**	225.81
Irrigation	24.20	22.28	84.46	-	4.73	77.62	29.36	47.27	74.24
Machine rental	-	27.81	105.59	0.18	22.48	62.35	18.33	53.37	147.72
Animal power	**13.12**	**1.91**	5.54	**41.63**	**4.36**	5.24	**34.54**	**1.61**	3.85
Human Labor	**117.33**	**137.96**	126.31	**142.78**	**152.41**	492.98	**190.28**	**168.29**	323.32
Family	67.70	56.80	68.44	8.096	53.44	179.35	89.86	28.29	81.12
Hired	49.63	82.16	57.87	61.82	98.97	313.62	100.42	140	242.20
Paid-out cost	156.87	218.62	412.59	106.76	151.04	549.67	360.11	876.61	1436.68
Interest charges	9.35	13.12	24.76	6.41	9.18	32.98	21.61	52.6	86.20
Total cost	**237.00**	**287.54**	535.86	**191.17**	**216.7**	762.01	**512.94**	**958.1**	1604.01
Crop yield (t/ha)	1.738	1.858	2.92	1.652	2.64	2.17	11.33	22.7	22.25
Price (US $/ton)	156.39	163.31	272.24	181.97	152.27	451.33	68.6	98.84	127.51
By-product (US $/ha)	21.04	26.78	24.98	67.2	77.58	218.81	-	-	-
Gross value (US $/ha)	**291.1**	**329.21**	819.40	**367.81**	**479.57**	1196.12	**777.24**	**2243.67**	2469.23
Family income	136.22	110.58	406.82	261.06	328.53	646.44	417.28	1376.06	1032.55
Operating surplus	54.1	41.67	283.54	178.64	263.87	434.11	264.3	1286.57	865.22
Cost (US$/ton)	126.51	142.64	183.64	94.57	68.48	351.90	46.27	42.21	72.09
Rate of surplus	22.8	14.5	48.25	92.4	122.3	28.25	51.50	134.2	76.88

Table 6.3 Changes in labour use in crops (Days/ha), 1988 and 2014

Crops	Total labour used					% of hired labour used				
	1988	2000	2004	2008	2014	1988	2000	2004	2008	2014
Rice	164	132	118	105	99	47.0	53.8	60.6	61.0	58.6
Rice traditional	144	119	99	67	78	42.4	48.7	54.5	49.3	47.4
Rice modern	207	136	123	110	103	53.6	55.1	61.8	61.8	60.2
Wheat	138	70	99	59	41	42.0	30.0	59.6	44.1	46.3
Jute	208	160	163	140	163	43.3	54.4	65.0	66.4	63.8
Pulses	81	42	38	40	40	23.5	19.0	13.2	32.5	37.5
Oilseeds	118	46	55	54	48	46.6	23.9	58.2	40.7	39.6
Potato	231	193	166	229	134	52.8	65.8	76.5	81.7	74.6

Table 6.4 Use of hire labour by farm size, major rice varieties

Farm size	Total labour used						% of hired labour used					
	Boro rice		TV aman		MV aman		Boro rice		TV aman		MV aman	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Up to 0.20 h	157	129	134	95	145	114	38.2	43.8	32.8	31.7	37.4	41.7
0.20-0.40	161	116	135	74	140	106	43.5	52.9	37.5	44.3	41.6	50.5
0.40-1.0	152	119	118	87	146	99	54.6	53.1	39.2	38.0	47.6	59.6
1.0-2.0	152	93	141	93	126	92	68.4	73.6	65.4	47.2	55.7	67.2
2.0 ha and over	134	92	109	92	105	75	71.3	82.5	54.8	79.8	63.9	78.1
Total	155	117	129	86	140	104	50.6	52.6	43.5	40.6	45.3	52.4

Table 6.5 Use of hire labour by land tenure group, major rice varieties

Land tenure group	Total labour used						% of hired labour used					
	Boro rice		TV aman		MV aman		Boro rice		TV aman		MV aman	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Pure-tenants	150	110	106	104	119	100	36.3	45.6	28.5	30.3	36.8	43.1
Tenant-owner	166	112	135	71	148	104	40.0	55.5	32.4	39.7	41.2	51.2
Owner-tenant	170	139	148	124	136	108	64.2	43.8	52.5	27.6	45.6	51.0
Owner farmer	147	120	127	73	137	107	57.4	60.0	49.0	56.4	54.0	59.7
Total	155	117	129	86	136	104	50.6	52.6	43.5	40.6	46.7	52.4

Table 6.5 Percentage of farmers using farmyard manure

Crop	% of farmer using			Cost taka/ha			Cost US $/ha		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Aus TV	13.9	16.7	5.3	152	352	36	3.01	5.17	0.46
Aus MV	11.3	26.8	20.5	73	560	512	1.45	8.21	6.57
Aman TV	8.6	8.5	4.8	60	195	141	1.19	2.86	1.80
Aman MV	13.6	22.4	14.9	130	370	491	2.57	5.42	6.30
Boro	27.6	54.6	31.7	269	989	1176	5.31	14.50	15.08
Wheat	24.5	21.9	19.7	402	493	698	7.95	7.23	8.95
Jute	8.2	21.6	5.0	104	314	173	2.06	4.60	2.22
Potato	18.0	50.0	63.5	362	859	2555	7.15	12.60	32.76

Table 6.6 Percentage of farmers using pesticides

Crop	% of farmer using			Cost taka/ha			Cost US $/ha		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Aus TV	13.9	33.3	52.6	49	395	469	0.97	5.79	6.01
Aus MV	53.2	46.4	73.1	231	471	1410	4.56	6.91	18.07
Aman TV	16.5	15.8	34.9	73	137	376	1.44	2.01	4.82
Aman MV	61.2	49.7	78.4	383	397	1219	7.56	5.82	15.63
Boro	80.5	81.5	89.4	684	813	1583	13.51	11.92	20.29
Wheat	12.2	9.4	34.2	33	60	422	0.65	0.88	5.41
Jute	12.3	37.3	19.0	80	472	253	1.58	6.92	3.24
Potato	94.0	95.8	95.2	2514	5182	6713	49.66	75.98	86.06

Table 6. 7 Machine use in crop cultivation

Crops	% farm use			Cost of machine tk/ha			Cost US $/ha		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Rice	60.1	88.5	94.1	1107	3163	7992	21.87	46.38	102.46
Wheat	59.2	96.9	97.4	1253	4169	8236	24.75	61.13	105.59
Jute	69.9	94.1	95.0	1233	2365	4863	24.36	34.68	62.35
Pulses	33.3	42.0	44.2	474	1235	2306	9.36	18.11	29.56
Oilseeds	71.4	95.2	94.1	1096	2204	4960	21.65	32.32	63.59
Potato	72.0	95.8	96.8	3595	4520	11522	71.02	66.28	147.72

Table 6.8 Irrigation use in crop cultivation

Crops	% farm use			Cost of irrigation tk/ha			Cost US $/ha		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Rice	45.1	49.8	60.4	2642	4694	8875	52.19	68.83	113.78
Boro rice	94.9	96.4	98.6	5759	9859	17406	113.77	144.56	223.15
Wheat	77.6	84.4	89.7	1715	3597	6588	33.88	52.74	84.46
Jute	21.9	47.1	80.2	322	1024	6054	6.36	15.01	77.62
Pulses	2.0	2.9	10.6	4	26	530	0.08	0.38	6.79
Oilseeds	2.4	7.1	20.7	8	31	769	0.16	0.45	9.86
Potato	84.0	95.8	96.8	2025	4257	5791	40.00	62.42	74.24

Table 6.9 Fertilizer use in crop cultivation

Crops	% farm use			Rate tk/ha			Cost US $/ha		
	2000	2008	2014	2000	2008	2014	2000	2008	2014
Rice	94.5	97.8	97.4	2285	2901	6798	45.14	42.54	87.15
Wheat	100	100	100	2920	4749	8781	57.68	69.63	112.58
Jute	93.2	88.2	95.9	1072	2148	5108	21.18	31.50	65.49
Pulses	37.3	43.5	38.5	124	425	1327	2.45	6.23	17.01
Oilseeds	40.5	38.1	71.1	659	1233	4890	13.02	18.08	62.69
Potato	98	100	98.4	11624	15533	27826	229.63	227.76	356.74

Table 6.10 Percent yield loss in rice cultivation

Rice variety	% farm reported			% loss of total production		
	2000	2008	2014	2000	2008	2014
TV aus	25.0	11.1	8.47	9.3	3.8	16.5
MV aus	30.6	39.3	14.1	7.2	24.3	4.3
TV aman	19.8	75.7	4.1	8.0	50.3	1.9
Mv aman	16.6	55.4	5.8	6.1	24.9	7.1
Boro	14.2	14.1	10.1	4.6	7.9	7.2
TV	21.1	69.7	5.6	8.0	47.6	2.6
MV	15.7	33.0	8.3	5.1	13.9	7.1
Rice	16.9	37.5	7.9	5.5	16.2	6.7

Table 6.11Change in use of urea by farm size in rice cultivation

Farm size	TV rice						MV rice					
	% farm using			Amount used (kg/ha)			% farm using			Amount used (kg/ha)		
	2000	2008	2014	2000	2008	2014	2000	2008	2014	2000	2008	2014
Up to 0.20 h	80.3	94.1	84.3	110	109	92	99.2	100.0	99.2	215	211	202
0.20-0.40	80.8	82.6	81.1	111	105	88	99.7	99.7	99.4	219	207	197
0.40-1.0	81.4	83.9	80.9	83	78	72	98.8	100.0	99.8	198	204	191
1.0-2.0	78.8	85.0	80.0	89	89	74	98.8	100.0	100.0	204	190	180
Over 2.0 h	52.6	-	100.0	43	-	154	100.0	97.1	100.0	194	172	183
Total	78.6	85.9	81.8	92	94	82	99.1	99.8	99.6	208	204	194

Table 6.12 Change in use of TSP by farm size in rice cultivation

Farm size	TV rice						MV rice					
	% farm using			Amount used (kg/ha)			% farm using			Amount used (kg/ha)		
	2000	2008	2014	2000	2008	2014	2000	2008	2014	2000	2008	2014
Up to 0.20 h	29.5	26.5	31.4	24	20	22	74.1	80.5	79.4	90	79	89
0.20-0.40	41.0	34.8	28.4	46	31	22	81.7	80.7	83.5	105	76	103
0.40-1.0	41.6	21.4	33.9	34	13	21	80.5	83.8	82.5	94	79	92
1.0-2.0	39.4	35.0	30.0	36	17	26	86.2	77.9	75.1	92	71	82
Over 2.0 h	36.8	-	50.0	22	-	42	88.9	79.4	83.3	97	68	94
Total	38.1	28.2	31.8	34	20	22	80.5	81.4	81.3	96	77	94

Table 6. 13 Change in use of MOP by farm size in rice cultivation

Farm size	TV				MV			
	% farm using		Amount used (kg/ha)		% farm using		Amount used (kg/ha)	
	2008	2014	2008	2014	2008	2014	2008	2014
Up to 0.20 h	17.6	21.6	13	12	66.1	80.6	39	55
0.20-0.40	23.9	28.4	11	17	68.8	80.8	38	55
0.40-1.0	16.1	30.4	7	14	71.8	80.6	40	56
1.0-2.0	30.0	30.0	13	22	72.7	80.5	41	54
Over 2.0 h	-	100.0	-	59	82.4	80.0	42	54
Total	20.5	29.7	10	17	70.0	80.7	39	55

Table 6.14: Cost and Returns of rice, 2014

Items	Boro rice			Aman rice		
	Own cultivation	Share cropped	Fixed rent	Own cultivation	Share cropped	Fixed rent
Material inputs	15649	15699	14905	10248	9284	10509
Seeds	3478	3561	3407	2739	2704	2907
Fertilizer	9223	9198	9197	5748	4887	5975
Manure	1403	1145	807	492	565	432
Pesticides	1545	1796	1494	1269	1128	1195
Capital Services	26337	26182	24876	10395	10016	10759
Irrigation	18042	17215	16474	2285	1499	1966
Machine rental	8011	8612	8140	7832	8074	8594
Animal power	284	355	263	279	442	199
Human labor	30318	27462	28335	27117	25043	26577
Family	11249	13409	11076	9418	12674	11645
Hired	19069	14053	17260	17699	12370	14932
Paid-out cost	58669	87362	85410	40643	58280	60524
Interest charges	3520	5242	5125	2439	3497	3631
Rent paid	-	33920	30800	-	23311	20898
Total cost	75824	106470	102194	50061	70953	72169
Crop yield (t/ha)	6.07	6.17	5.69	3.94	4.07	4.00
Price (US $/ton)	17104	16657	17146	17570	17372	17450
By-product (US $/ha)	7148	5840	7448	7777	6919	7135
Gross value (US $/ha)	109946	108627	105063	77004	77559	76946
Family income	51276	21265	19653	36361	19280	16422
Operating surplus	34122	2157	2869	26943	6606	4776
Cost (US $/ton)	12484	17254	17950	12706	17449	18040
Rate of surplus	37.01	-3.46	-4.48	38.29	-0.44	-3.27
Returns to family labor	1227	448	494	1024	423	391
Wage rate	269	282	278	265	278	277
Labor return and wage rate ratio	4.6	1.6	1.8	3.9	1.5	1.4

Table 60.15 Farm size productivity: Rice, 2014

Farm size	Yield kg/h	% yield diff	T-value	Significance
Up to 0.20 h	5163	-3.0	0.42	0.677
0.20-0.40	5144	-3.4	0.35	0.730
0.40-1.0	4995	-6.2	1.03	0.304
1.0-2.0	5209	-2.1	0.28	0.779
2.0 ha and over	5323	0.0	-	-

Table 6.16 Farm size productivity: All crops, 2014

Farm size	Yield tk/h	% yield diff	T-value	Significance
Up to 0.20 h	95475	-5.1	0.41	0.679
0.20-0.40	93213	-7.4	0.76	0.446
0.40-1.0	88709	-11.9	1.17	0.241
1.0-2.0	89980	-10.6	1.14	0.253
2.0 ha and over	100646	0.0	-	-

Table 6.17. Productivity by type of tenancy: All crops, 2014

Type of tenancy	Yield tk/h	% yield diff	T-value	Significance
Own cultivation	90584	0.0	-	-
Share cropping	90578	0.0	0.00	0.999
Fixed rent	98968	9.3	-1.88	0.060
Mortgaze	93957	3.7	-0.77	0.440

Table 6.18 Productivity by type of tenancy: Rice, 2014

Type of tenancy	Yield kg/h	% yield diff	T-value	Significance
Own cultivation	5061	0.0	-	-
Share cropping	5227	3.3	-1.12	0.261
Fixed rent	4997	-1.3	0.37	0.710
Mortgaze	5264	4.0	-1.24	0.215

Table 6.19 Farm size productivity: Rice, 2008

Farm size	Yield kg/h	% yield diff	T-value	Significance
Up to 0.20 h	4709	2.9	-0.36	0.722
0.20-0.40	4497	-1.7	0.22	0.824
0.40-1.0	4353	-4.8	0.63	0.527
1.0-2.0	4418	-3.4	0.40	0.688
2.0 ha and over	4574	0.0	-	-

Table 6.20 Farm size productivity: All crops, 2008

Farm size	Yield tk/h	% yield diff	T-value	Significance
Up to 0.20 h	51032	3.2	-0.20	0.841
0.20-0.40	49637	0.0	0.97	0.824
0.40-1.0	49804	0.7	-0.08	0.940
1.0-2.0	50335	1.8	-0.16	0.871
2.0 ha and over	49455	0.0	-	-

Table 6.21 Farm size productivity: Rice, 2000

Farm size	Yield kg/h	% yield diff	T-value	Significance
Up to 0.20 h	4279	14.4	-2.38	0.018
0.20-0.40	4375	17.0	-2.61	0.009
0.40-1.0	4289	14.7	-2.40	0.017
1.0-2.0	4300	15.0	-2.18	0.030
2.0 ha and over	3739	0.0	-	-

Table 6.22 Farm size productivity: All crops, 2000

Farm size	Yield tk/h	% yield diff	T-value	Significance
Up to 0.20 h	24100	13.2	-1.36	0.174
0.20-0.40	26953	26.6	-1.83	0.068
0.40-1.0	23969	12.6	-1.40	0.161
1.0-2.0	24453	14.9	-1.43	0.153
2.0 ha and over	21288	0.0	-	-

Table 6. 23 : Estimates of production function of rice, 1988 to 2014

Factors of production	Rice			
	1988	2000	2008	2014
Land	0.610 (13.49)	0.477 (14.68)	0.472 (14.91)	0.467 (22.50)
Labor	0.126 (2.56)	0.183 (4.13)	0.193 (4.48)	0.147 (7.12)
Material inputs	0.258 (11.07)	0.213 (9.16)	0.220 (9.68)	0.217 (13.07)
Capital services	0.206 (7.78)	0.176 (9.99)	0.167 (9.75)	0.167 (12.64)
Constant term	2.537 (16.65)	6.610 (34.85)	6.584 (35.79)	7.032 (53.00)
Adjusted-R^2	0.70	0.696	0.709	0.783

Table 6. 24 : Estimates of production function of all crops, 1988 to 2014

Factors of production	All crops			
	1988	2000	2008	2014
Land	0.671 (13.52)	0.598 (21.14)	0.492 (18.56)	0.388 (22.07)
Labor	0.231 (4.57)	0.077 (5.54)	0.207 (5.96)	0.284 (17.85)
Material inputs	0.100 (4.05)	0.260 (15.25)	0.268 (15.55)	0.284 (23.10)
Capital services	0.235 (7.97)	0.036 (5.59)	0.093 (8.38)	0.092 (10.80)
Constant term	2.531 (16.04)	3.963 (39.34)	6.800 (47.72)	6.584 (64.70)
Adjusted-R^2	0.58	0.538	0.678	0.733

Chapter: 7

Comparative Advantages of Crop Production in Bangladesh

Chapter summary: comparative advantages of crop production in Bangladesh

When economic profitability and domestic resource costs (DRCs) of production of rice and non-rice crops of 62 districts in 2014 were compared with that of the period up to 2004, it was observed that profitability and efficiency of domestic resource use considerably increased. In 2014 all three Modern Variety (MV) rice varieties have comparative advantage at import and export parity prices for both owner operators and share croppers.

Bangladesh has a comparative advantage of production for pulse, potato, onion, maize, vegetables, chili and garlic, for both the owner operators and share croppers. So, there is good scope for crop diversification. Sugarcane, however, has a comparative advantage for import substitution only for the owner operators. While looking at the export possibility, it was observed that Bangladesh has a comparative advantage in export of oil seeds, potato, onion, maize, vegetables and chili for the owner operators and it has a comparative advantage for potato, onion, maize, vegetables and chili for the share croppers. The analysis of comparative advantage carried out suggests that the menu of crops that Bangladesh can produce efficiently either for import substitution or for export is quite large.

This chapter focuses on the comparative advantages of crop production in Bangladesh agriculture. Social or economic profitability deviates from private profitability because of distortions in factor and in product markets, externalities and government policy interventions that tend to distort relative prices. The analysis of comparative advantage, it may be emphasized, can help in deriving meaningful policy conclusions on how to reorient farming systems towards more efficient crop activities. Secondly, while farmers would decide what to grow based on their own perceptions of potential and constraints, public policies concerning irrigation, water control, technology and prices can influence a farmer's choice of crop-growing decisions. Assessment of the comparative advantage of producing rice and other crops is, therefore, necessary to examine the issue of food grain self-sufficiency and crop diversification in the country under the medium and long-term perspectives.

In the context of potential benefits of globalization and international trade, Bangladesh could gain more benefits from the potential trading opportunities for both import substitution and export promotion. Eventually, however, whether or not Bangladesh can take advantage of the liberalized trading opportunities would depend upon its comparative advantage, without subsidies or with limited subsidies that are permitted for all trading partners by the rules governing the open market trading environment. Therefore, an assessment of comparative advantage of crop production either for import substitution or for export can be helpful in this respect. Further, Bangladesh will need a more diversified cropping pattern, including an increase in the contribution of non-rice crops to attain higher agricultural growth rates in the future.

Obstacles to be addressed by Government

Bangladesh has comparative advantage in rice production for import substitution as well as for exports. Bangladesh could export surplus rice and the farmer could earn higher returns through access to international markets. Policy support would be needed to disseminate improved rice technology. Wheat and maize production could also be expanded for substitution of imports by using more improved technology as the country's wheat and maize demand is met largely from imports every year.

Up to date and timely information regarding inputs, input prices, availability of improved varieties, output market prices, and agricultural and macroeconomic policies should be ensured to improve further the competitiveness and comparative advantage of farmers. To exploit the export opportunities, Bangladesh will need to enhance its supply-side capacity, improve value chains and pursue a broad based diversified agricultural production and export strategy.

Several studies have looked into the profitability and efficiency of domestic production of different crops in the past. Some of these are the World Bank's Food Policy Review (1993), the World Bank Sector Report (1995), the IFPRI-BIDS study on agricultural diversification (Mahmud et al, 1994), IFPRI/CIMMYT Research Report (Chowdhury, Moms and Meisner, 1994) and more recently, the FAO Ministry of Agriculture Report on assessment of comparative advantage in Bangladesh agriculture (Shahabuddin, 1999), and FMRSP-Ministry of Food Working Paper on comparative advantage in Bangladesh agriculture (Shahabuddin and Dorosh, 2001).

7.1 Methodology and data

The comparative advantage of producing different crops in Bangladesh agriculture has been analyzed using basically two measures: (a) Net Economic Profitability- the profitability using economic, rather than financial costs and prices, and (b) Domestic Resource Cost (DRC) Ratio- cost of non-tradable domestic resources used in production divided by the value of tradable products. To calculate these efficiency indicators requires data related to (a) production coefficients (b) financial prices of crops and production inputs (c) economic (shadow) prices of crops and production inputs, and (d) the shadow (equilibrium) price of foreign exchange. The analysis has been carried out using a panel survey data of BRAC collected from the farmers of 64 districts for the 2004 and 2014 periods. The farm specific information on production coefficients of crops, farm level input and output prices have been used to analyze comparative advantages of rice and non-rice crops.

7.2 Comparative advantage in crop production

7.2.1 Comparative advantage of crops

Economic returns and DRCs of modern varieties of Aus, Aman and Boro rice and non-rice crops have been estimated for owner farmers and sharecroppers at the import and export parity price for the production year 2004 (Table 7.1). The economic profitability analysis demonstrates that Bangladesh had a comparative advantage in domestic production of rice for import substitution, with the exception that the sharecropper did not have comparative advantage for MV Aus production at import parity price. However, at the export parity price the picture becomes different.

Moving to an export price regime implies a considerable decline in economic profitability for all rice crops and Bangladesh only had comparative advantage of producing only Boro rice for the owner operator in 2004. Moreover, when compared with economic profitability of some non-rice crops, it appeared that the country had more profitable options other than production for rice export in 2004. Shabuddin *et al* (2001) also found similar results. The estimated domestic resource cost (DRC) ratio for rice is generally consistent with the results of the economic profitability analysis discussed above.

Table 7.1 Economic profitability, and DRC of modern variety rice and non-rice crops in Bangladesh in 2004

Crops	Net Economic return(Tk/ha)				DRC			
	Import parity		Export parity		Import parity		Export parity	
	Owner	Share-cropper	Owner	Share-cropper	Owner	Share-cropper	Owner	Share-cropper
Rice:								
MV Aus	8081	3700	5512	3637	0.76	1.05	1.12	1.57
MV Aman	9523	17413	6496	6496	0.76	0.82	1.11	1.23
MV Boro	21489	12014	14659	9675	0.60	0.73	0.87	1.10
Non-rice:								
Wheat	11459	2187	6940	6159	0.60	0.76	1.15	1.45
Jute	-	-	24814	3944	-	-	0.37	0.68
Sugarcane	9910	-2152	3705	3288	1.12	1.43	2.99	2.16
Oil seeds	13513	2541	5052	2526	0.46	0.62	1.43	1.66
Pulses	11843	4325	4428	2214	0.36	0.39	1.04	1.10
Potato	138465	31675	91879	45939	0.29	0.54	0.44	0.82
Onion	93116	13117	61787	30894	0.430	0.39	0.59	1.08
Vegetable	84107	30941	55809	27905	0.18	0.71	0.25	0.40

The estimated domestic resource costs (DRC) of wheat at import parity price are observed to be lower than unity under irrigation conditions thereby demonstrating its efficiency of domestic production for import substitution. However, as compared to MV rice, the ratios are observed to be similar for owner farmer implying that resources can be used efficiently both in the cultivation of wheat and MV rice under irrigated conditions. However, for the share cropper, DRC of Boro at import parity price is lower than wheat, implying that resources could be used more efficiently than wheat. For the non-rice crops: oil seeds, pulses, potato, onion and vegetables, Bangladesh had the comparative advantage of production for import substitution both for the owner farmers and share croppers. While at the export parity price, potato, onion and vegetable production of the owner operators had comparative advantage. For the sharecropper, only potatoes and vegetables had comparative advantage. Bangladesh had no comparative advantage for sugarcane production at import and export parity price.

7.2.2 Changes in comparative advantage of crops over last decade

When economic profitability and DRCs of production of rice and non-rice crops in 64 districts in 2014 were compared with that of the period to 2004 it was observed that profitability and efficiency of domestic resource use considerably increased as evidenced by higher net economic returns and lower DRCs for both the owner operator and share cropper (Table 7.2).

In 2014 all three MV rice varieties have comparative advantage at import and export parity prices for both owner operators and share croppers. Bangladesh has comparative advantage of production of pulses, potatoes, onions, maize, vegetables, chili and garlic for both the owner operators and share croppers. So, there is good scope for crop diversification. However, sugarcane has comparative advantage for import substitution only for the owner operators. While looking at the export possibility it was observed that Bangladesh has comparative advantage of export of oil seeds, potatoes, onions, maize, vegetables and chili for the owner operators and it has comparative advantage for potatoes, onions, maize, vegetables and chili for the share croppers.

Table 7.2 Financial and economic profitability, and DRC of modern variety rice Crops in Bangladesh in 2014

Crops	Net economic return(Tk/ha)				DRC			
	Import parity		Export parity		Import parity		Export parity	
	Owner	Share-cropper	Owner	Share-cropper	Owner	Share-cropper	Owner	Share-cropper
Rice:								
MV Aus	72025	47537	43882	28962	0.47	0.28	0.69	0.41
MV Aman	72729	48001	44861	29608	0.25	0.26	0.36	0.38
MV Boro	10106	66704	59393	39199	0.30	0.35	0.45	0.51
Non-rice:								
Wheat	66464	43866	31058	16399	0.29	0.35	0.93	1.13
Jute			103797				0.37	0.50
Sugarcane	71252	47026	43847	27404	0.49	0.67	1.18	1.14
Oil seeds	17345	11448	25383	8376	0.78	1.18	0.85	1.62
Pulses	52463	34625	24029	12014	0.58	0.78	1.04	1.10
Potato	63544	41939	195310	145245	0.10	0.30	0.25	0.40
Onion	21539	14215	1223833	807727	0.50	0.60	0.87	0.72
Maize	13963	92160	52201	68905	0.28	0.38	0.66	0.74
Vegetable	85468	56409	148006	83384	0.10	0.22	0.44	0.75
Chili	17143	11314	85717	148388	0.42	0.60	0.84	0.79
Garlic	17009	11225	850454	92016	0.59	0.85	1.12	1.25

Policy implications

The analysis of comparative advantage carried out suggests that the menu of crops that Bangladesh can produce efficiently either for import substitution or for export is quite large. In fact, the profitability estimates and estimated domestic cost ratio indicate Bangladesh has a comparative advantage in the production of most agricultural crops.

Bangladesh has comparative advantage in rice production for import substitution as well as for exports. Bangladesh could export surplus rice and the farmer could earn higher returns through access to international markets. Policy support would be needed to disseminate improved rice technology. Wheat and maize production could also be expanded for substitution of imports by using more improved technology as the country's wheat and maize demand is met largely from imports every year. Up to date and timely information regarding inputs, input prices, availability of improved varieties, output market prices, and agricultural and macroeconomic policies should be ensured to improve further the competitiveness and comparative advantage of farmers. To exploit the export opportunities, Bangladesh will need to enhance its supply-side capacity, improve value chains and pursue a broad based diversified agricultural production and export strategy.

Chapter 8

Commercialization of Agriculture

Chapter summary: Commercialization of agriculture

It was found that seasonality in food grain production and prices in Bangladesh have changed in the last decades and the change is more discernible since 2000. The quantities of rice and other crops marketed have increased over the years. The majority of the rural people want to ensure food security through growing staple crops on their meagre amount of land. Thus, the land use pattern is dominated by growing food crops only. Food insecurity always remains instrumental in the allocation of resources.

The trends in marketing of paddy show that it has increased over time despite farm size becoming smaller. For example, in the 1980s, a quarter of the total output produced by the households found its way to markets; in recent years the share rose to roughly 40 percent. The main reason could be an increase in land productivity due to the adoption of modern varieties.

We observe that farmers have considerable stock holding capacity that is hardly taken into account by policy makers and researchers. We also notice that all classes of farmers keep stocks to tide them over bad days and the proportion of output held in stock varies directly with farm size: big farms have large stocks and smaller farms have smaller stocks.

The importance of high-value commodities is increasing, the share of these products was 40 percent and 49 percent of the food consumption basket in rural and urban areas, respectively. Given high income elasticities, this share is expected to further increase in the future. It is estimated that Bangladesh would demand an extra $8 billion of these high-value products by 2020. At present a number of fresh and processed agro-commodities are exported from Bangladesh. It is projected that Bangladesh could earn more than $1,800 million in a period of about 18 years from export of fresh and processed foods.

It was revealed from value chain analysis that producers are suffering from low productivity and low quality of inputs. Productivity of vegetables is low compared to China and India. Farmers often lack knowledge of good agricultural practices (GAP), post-harvest management and suffer from the lack of an improved transport system. The growers, as well as market intermediaries suffer from high post-harvest loss of perishable produce because of poor handling, transportation, lack of cool chain and storage facilities. Production and marketing of high-value products successfully require a range of interventions and investments.

Bangladesh agriculture has been transformed from low input use traditional subsistence farming to an intensive commercial system. Also the market environment has changed. This chapter highlights some issues on the commercialization of Bangladesh agriculture.

Obstacles to be addressed by Government:

Export capacity concerned actors needs enhancement: for example strengthening the Hortex Foundation, Food Quality Certification capacity of concerned agencies, enhancing the capacity of compliance of SPS and traceability of produces, improving the capacity of farmers and exporters, etc. It is expected that during a 10 year period (2014-24) 50% improved capacity could be achieved and during a later 10 years (2024-34) Bangladesh would be fully capable of operating in the international food markets.

There is an urgent need to strengthen the Chittagong Port Laboratory, where no facilities exist for analysis of agro-products. The laboratory has three qualified Chemists only, but they have to carry out analysis inspection for certification of a lot of diversified items both for export and import in the country.

Government initiatives and support are required to develop marketplaces, market outlets and farmers' groups. Credit facilities are required to promote private initiatives for small and medium-scale agri-businesses in processing and packaging. Formation of farmers' groups with enhanced access to credit is needed to encourage their participation in the marketing of agricultural produce.

The issue of food safety, quality and standards is a growing concern for Bangladesh for a number of reasons, most importantly for achieving better nutrition and health standards. Post-harvest management and quality assurance is one of the most significant supply chain activities. The policy, institutional and infrastructure barriers to agribusiness, agro-processing and the supply chain needs to be removed in order to provide a "big push" to agriculture and rural development.

Extension workers need additional training in farm management, agricultural marketing, value chain analysis and the newly emerging, high-value crops and products; also about various micro-finance options and agribusiness management.

Successful production and marketing of high-value products require a range of interventions and investments including a change in policy towards an enabling environment conducive to private trade; infrastructure development; improved access to credit; research and development; capacity building and taking advantage of international trade.

8.1 Historical profile of main crops produced for domestic market and exports

8.1.1 Seasonality of production

We observed that seasonality in food grain production and prices in Bangladesh has changed in recent decades and the change is more discernible since the 2000s (Fig 8.1). The share of dry season rice has increased from 10 percent of the country's rice production in 1966–67 to 61 percent in 2008 due to increased use of shallow tubewells and the expansion of cultivation of high-yielding boro rice, (Hossain 2009). This change in production patterns has led to a change in price seasonality in Bangladesh.

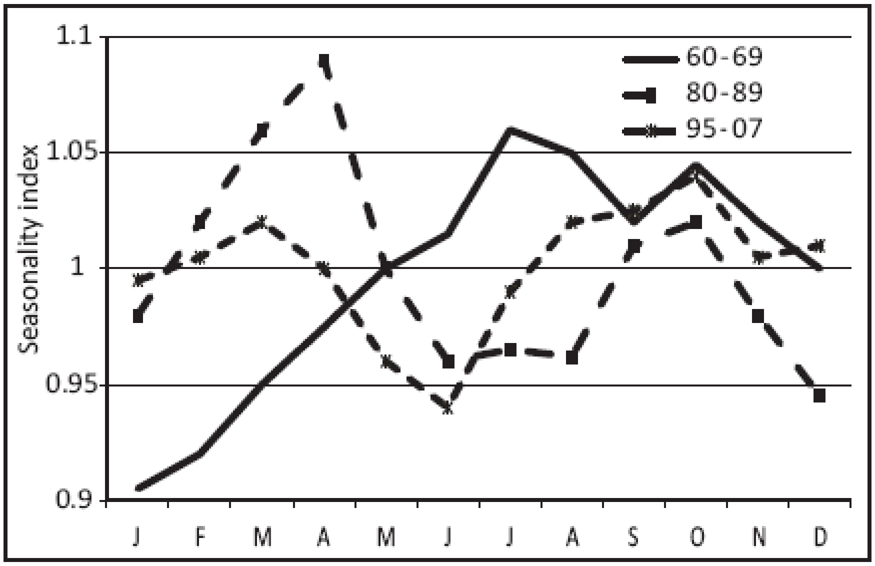


Figure 8.1 . Changes in rice price seasonality (prices over 12-month moving average)

Source: Murshid et al. 2009; Chowdhury and Haggblade 2000: 73-100.

8.1.2 Production of main and other crops

The quantities of rice and other crops marketed have been increased over the years. The majority of the rural people want to ensure food security through growing staple crops on their meagre amount of land. Thus, the land use pattern is dominated by growing food crops only. Food insecurity always remains instrumental in the allocation of resources. As most of the farms are of a subsistence nature, staple crops are grown largely for home consumption, and roughly one-third of the output is being marketed (Table 8.1). Farmers also grow cash crops to meet cash needs where 75-80 per cent of these crops are marketed. Marketing of paddy has increased over time despite farm size becoming smaller. For example, a quarter of the total output produced by households found its way to markets in the base year. By 2007 the share rose to one-third (Table 6.2). A number of factors could be responsible for this market orientation on the part of the rural households, but we shall cite a few: (a) an increase in land productivity resulting from new technology helped households reap a better harvest from the same amount of land; (b) improvements in communications - including telecommunications, and media - has widened the base of market information, and (c) a reduction in household size has reduced home consumption to leave some outputs for the market. The proportion of marketing of other crops has historically been high, and has become higher over time. This is not unusual given that most of these are perishable products and traded for cash income. Farmers usually meet their non-rice demands by selling these commodities. The potato crop is a particular case where substantial expansion of marketing has taken place because of the fact that cold storage facilities expanded, modern varieties were introduced, and cultivation of potatoes spread from a few regions to the whole country. Due to population increase as well as urbanization, it is expected that domestic marketing of rice and other staples will increase even further in the future.

However, a cursory look at marketing of the paddy/rice crop by socio-economic groups provides some interesting insights into the changing marketing environment. We observed that 36 percent of the paddy output has been marketed in 2007 as compared to 26 per cent in 1988. As a strategic and staple commodity, the marketed output of paddy is always likely to be lower. Nevertheless it is increasing over time. This also applies to the international market. Reportedly, only 6 per cent of the total rice produced in the world finds its way to the international market. We observe that households owning up to 0.40 ha of land ('poor' in the land ownership scale) have increased their contributions to total paddy production from 16 per cent in 1988 to 28 per cent in 2007 (Table 6.3). This could be due to the increase in their number, and a greater access to land through the tenancy market. However, the degree of market orientation for this group tends to hover around 40-44 per cent with very little change over time. The important point to note is that, despite deficits in terms of production and consumption, small farmers also sell in the market, although they buy back at a later stage.

In Bangladesh, marketing of paddy is mostly done by medium and large landowning households. Nearly one half of the total marketed paddy comes from 13 per cent of rural households (with owned land at 1.0 ha and above). As opposed to this, about 30 per cent of the marketed output comes from about 76 per cent of the rural households (with owned land up to 0.40 ha) (Table 6.4). From the angle of economic status, we observe that solvent households comprise 15 per cent of rural households and they supply 41 per cent of the marketed paddy; 'self-sufficient' or 'break-even' households are 42 per cent and they supply 47 per cent. Over time, however, the share of marketed output from both the groups increased. Finally, the 'poor' segment of rural households constitutes about 45 per cent, but they supply only 13 per cent of the total marketed output (Table 8.4). The policy implication of this precarious position is that we need to keep the price of paddy at a remunerative level to appease the actors in the market. However, the impact of that on the poor households should not take a back-seat.

8.1.3 Farm level food stock

Based on household level information, we observe the following behavioural dynamics as far as storage is concerned. Taking 2007 as our point of focus we observed that, farmers have considerable stock holding capacity that is hardly taken into account by policy makers and researchers. We also notice that all classes of farmers keep stocks to tide them over bad days (Table 8.5). Field survey shows that output held in stock was 12 per cent of the output produced before the aman harvest (lean season), and about 22 per cent of the output of one month after the boro harvest (peak season). Quite expectedly perhaps, the level of stock is related to farm size. For example, large and medium groups keep 22-30 per cent of total harvest as stock against 18-19 per cent by the poor groups (Table 8.5). By and large, it is not always true that farmers sell total output immediately after harvest, and how much stock they would keep depends on the expectation about future prices.

8.1.4 Harvest sales

We observe that sales within one month of the harvest increased from 49 per cent to 63 per cent over time. Interestingly, poor farmers (up to 0.40 ha) have reduced distress sales over time, although in absolute terms, they still sell roughly two-thirds of output immediately after the harvest. This can be compared with about 50 per cent of the large and the medium farmers (Table 8.6). By and large, the medium and large farms sell a smaller proportion of their crops at harvest than small and marginal farms, because the former group has higher economic capacity for holding stocks. Or, it may be that solvent farmers can wait in order to benefit from market swings. Second, the proportion of output sold at harvest – for all classes of farmers - has increased over time. This is particularly true for recent years because the price margin for sales later in the season has declined. However, at periods of rising prices, larger farmers would hold more in stocks in the expectation of getting better prices.

The important question is: have farmers faced economic losses due to the early sales? It appears that, as a result of growing market integration, information dissemination and storage costs, harvest sales are less harmful these days than they possibly were before. We note the following reasons in support of this hypothesis (Table 8.7):

- The seasonal fluctuations in rice prices has come down from 10 to 13 per cent in 1988 to 5 to 8 per cent in recent years;
- Holding of stocks has a cost because of (a) high rate of interest, (b) reduction in the weight of the grain, and (c) storage loss, and as such there should not be any incentive to hold onto production except for keeping stocks for home consumption.

8.1.5 Farm-gate prices

In examining agricultural prices, we have decomposed the whole period (1988-2007) into two sub-periods, particularly keeping in mind the rise in food grain prices in 2007. We notice that the price of paddy almost doubled between 2004 and 2007 while it increased at a much slower rate between 1988 and 2004 (Table 8.8). Obviously, the poor benefited most from the low prices in earlier periods as they appear to spend a large part of their incomes on rice. The other crop for which the price remained relatively depressed is oilseeds due to the competition from low-cost imported oil. The price of potatoes increased at a somewhat robust rate over the entire comparable periods, but escalated during 2004 and 2007. However, soaring prices of paddy at about 31 per cent/year during 2004-2007 translated into higher prices of rice for the poorer groups. Finally, we notice that the price of paddy has increased on a par with other agricultural prices in post-2004 periods but, still the relative price of paddy remains low compared to other commodities. The implications of this in terms of balanced nutrition are well-understood.

8.1. 6 Marketable surplus

The following observations on marketable surplus of rice are derived from field level output:

- Rice production, by all types of rural households, averages 1.52 tons which is only 10 per cent higher than household needs. Marketable surplus generated for urban households is small;
- Households who own land up to 0.4 ha – comprising 70 percent of rural households - do not generate any marketable surplus. They are rice-deficit households, and an increase in rice price is likely to affect them adversely;

- Most of the marketed surplus is generated by households who own more than one acre of land. Large and medium households (owning land more than 1 ha) produce roughly 70 percent more than their needs, while poor households produce 60-70 percent less than their consumption requirements (Table 8.9). Thus, large and medium households are the beneficiaries of high rice prices.

Table 8.1: Production and marketing of crops, 2000 to 2014

Crops	Year 2000			Year 2014		
	% of farm growing	Production per farm (ton)	Sale per farm (ton)	% of farm growing	Production per farm (ton)	Sale per farm (ton)
Paddy	92.9	3.19	1.09	97.6	2.92	1.46
Wheat	15.4	0.62	0.42	13.8	0.76	0.52
Pulses	11.8	0.29	0.17	13.6	0.25	0.17
Oilseeds	6.2	0.35	0.28	16.1	0.32	0.26
Potato	11.6	3.98	3.64	10.9	3.83	3.08
Onion	4.3	1.61	1.52	4.4	2.99	2.68
Jute	17.8	0.38	0.33	15.9	0.47	0.40
Sugarcane	3.2	9.18	8.26	1.2	17.53	16.98
Maize	-	-	-	10.4	2.98	2.49

Table 8.2: Changes in marketing of crops (% of output), 1988 to 2014

Crops	1988	2000	2014
Paddy	26	34	50
Wheat	48	68	68
Pulses	54	59	67
Oilseeds	66	80	82
Potato	45	92	80
Onion	78	95	89
Jute	81	86	85
Sugarcane	95	90	97
Maize	-	-	84

Table 8.3: Marketing of paddy by socio-economic groups 1988-2014

Socioeconomic group	1988		2000		2014	
	% share of rice production	% rice marketed	% share of rice production	% of rice marketed	% share of rice production	% of rice marketed
Land ownership (Ha.):						
Only HS	5	3	10	23	10	38
Up to 0.2	3	17	7	19	18	41
0.2-0.4 0	8	20	12	28	16	41
0.4-1.0	25	24	24	35	27	46
1.0-2.0	23	28	23	50	14	63
Above 2 ha	35	27	24	65	15	73
Total	100	26	100	42	100	50
Land holding (Ha):						
Up to 0.4	11	11	18	17	34	29
0.4 to 1.0	28	24	32	26	35	50
1.0 to 2.0	27	27	33	56	23	69
Above 2.0	35	32	17	72	8	78
Total	100	26	100	42	100	50

Table 8.4: Stockholding capacity, 2008-2014

Farm size	2008			2014		
	Storage capacity (ton)	% stored		Storage capacity (ton)	% stored	
		slack season	peak season		slack season	peak season
Up to 0.4	1.69	12	18	1.59	5	10
0.40-1.0	3.29	10	19	3.06	8	10
1.0-2.0	6.71	10	22	6.88	19	10
Above 2.0	13.94	10	30	9.04	8	10
Total	2.48	12	22	2.60	10	10

Table 8.5: Incidence of sales within one month of harvest (% of total sales)

Farm size (ha)	1988	2000	2004	2008
Up to 0.4	76	56	65	65
0.4 to 1.0	55	53	59	57
1.0 to 2.0	52	39	58	66
Over 2.0	42	22	53	40
Total	49	39	58	63

Table 8.6: Harvest sales and price- penalty

Year	Price for Sales within one month after harvest (Tk. / maund)		Price for total sales(Tk. / maund)		% difference	
	TV	MV	TV	MV	TV	MV
1988	186	176	204	199	9.6	13.0
2000	256	226	271	242	6.8	7.0
2004	280	265	298	282	6.4	6.4
2008	537	461	572	500	6.5	8.4

Table 8.7: Prices of agricultural commodities Tk/ton, 1988 to 2014

Crops	Price (tk/ton)			Increase (Percent/Year)		
	1988	2000	2014	1988-2000	2000-2014	1988-2014
Paddy, traditional	5100	6396	22633	0.019	0.090	0.057
Paddy, improved	4975	5640	18033	0.010	0.083	0.050
Paddy, hybrid	-	-	16622	-	-	-
Wheat	4850	7794	21452	0.040	0.072	0.057
Pulses	7500	15301	48364	0.059	0.082	0.072
Oilseeds	10025	12732	44381	0.020	0.089	0.057
Potato	2150	3526	9534	0.041	0.071	0.057
Jute	5675	8617	34666	0.035	0.099	0.070

Table 8.8: Surplus over consumption of rice, 2000-2014

Land ownership (ha)	2000				2014			
	Production (kg)	Consumption (kg)	Deficit/Surplus (%)		Production (kg)	ConSumption (kg)	Deficit/Surplus (%)	
			Reported	Standard			Reported	Standard
Only HS	350	877	-151	-102	440	610	-39	-32
Up to 0.2	520	913	-76	-42	752	639	15	19
0.2-0.4	981	949	3	25	1039	681	34	38
0.4-1.0	1522	1045	31	50	1436	726	49	53
1.0-2.0	2746	1269	54	69	2051	724	65	67
Above 2.0	5411	1829	66	80	3781	908	76	78
Total	1204	1015	16	37	1011	667	34	38

Table 8.9: Change in household size and rice consumption by own land

Land ownership (ha)	Household size		% change	Rice consumption (kg/day/hh)		% change
	2000	2014		2000	2014	
Only HS	4.9	4.0	-17.5	2.40	1.67	-30.4
Up to 0.2	5.1	4.2	-17.0	2.50	1.75	-30.0
0.2-0.4	5.1	4.5	-11.9	2.60	1.87	-28.2
0.4-1.0	5.2	4.6	-11.4	2.86	1.99	-30.5
1.0-2.0	5.9	4.6	-21.7	3.48	1.98	-43.0
Above 2.0	7.5	5.7	-23.9	5.01	2.49	-50.4
Total	5.3	4.3	-17.1	2.78	1.83	-34.3

8.1.7 Public food grain procurement

Another important observation is that the share of procurement of the public sector in food grain markets has declined over time, since private food grain imports were legalized in 1993 and are now being imported by private channels (Figure 8.1). While the share of the public sector in total imports before that date was 100 percent, this declined to 25 per cent at the beginning of the 2000s and to 9 per cent in 2007/08. Similarly, government procurement from local rice and wheat production declined from 4 and 5 percent (respectively) at the end of the 1980s to 2 percent and 0 percent in 2007/08 (Chowdhury 2010).

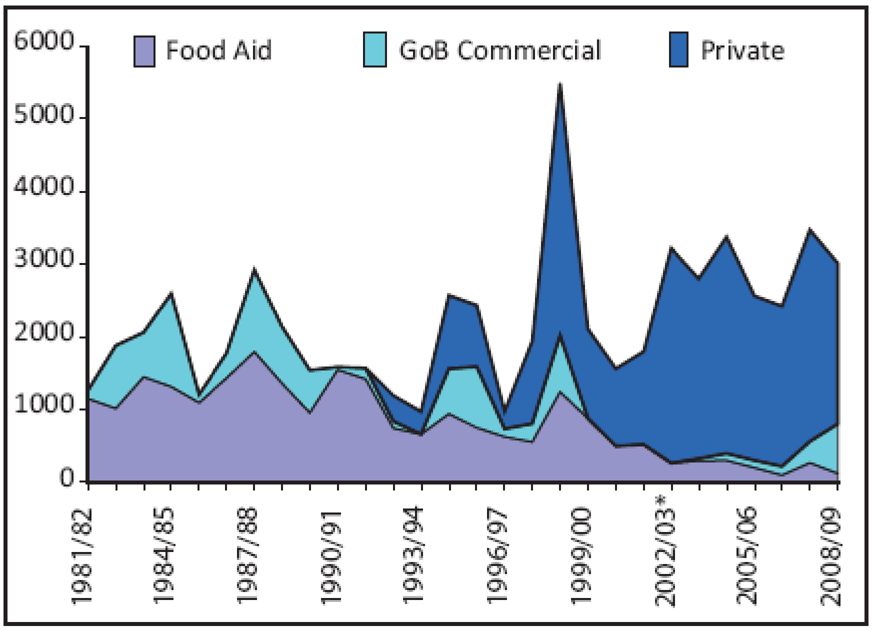


Figure 8.1 Imports of foodgrains by Bangladesh, 1981/82 to 2008/09
Source: Directorate of Food

8.1.8 Demand for high value crops

The importance of high-value and perishable commodities (such as fruit and vegetables, fish, meat, and dairy products) in the food consumption basket is increasing (World Bank 2008). Based on national household surveys in 2004/05, the share of these products was 40 percent and 49 percent of the food consumption basket in rural and urban areas, respectively (HIES, 2005). Given high income elasticities, this share is expected to further increase in the future. Using demand projections based on reasonable growth rates in incomes and population, it is estimated that Bangladesh would demand an extra $8 billion of these high-value products by 2020 (World Bank 2008).

In addition to increased demand for high value products, there is a shift towards the consumption of better quality food products. Based on a recent survey of rice wholesalers in Dhaka, it is estimated that the lower-quality coarse rice makes up 28 percent of their total rice sales (compared to medium and fine rice, accounting for 43 percent and 29 percent respectively). Ten years ago, the share of coarse rice in the total wholesaler turnover was 45 percent (Minten and Murshid, 2010). The increasing demand for high quality rice is also seen in the rise of the share of automatic mills in the milling sector and of the share of packaged rice in rice purchases by consumers.

The changing demand in domestic and international markets for high-value product markets creates challenges as well as opportunities for existing food supply chains. The growing demand for high-value products might provide extra opportunities, especially for rural areas. First, it generates greater employment. The export of shrimp and fish directly employs more than 600,000 persons, and it is estimated that 70 percent of the jobs related to agro-processing in Bangladesh are generated in rural areas. Second, high-value product markets lead to higher income for farmers. For example, when assigning net profits of the export value chain of shrimp to the deferent stakeholders, it is shown that the biggest share of the extra earnings directly benefits farmers. (Deb and Bairagi 2009).

8.1.9 Agro-processing

The importance of modern retail and the processing industry has been growing and is expected to further increase in the future. While the share of processed products is currently still small, agro-processing is estimated to have grown at 8 per cent per year between 1985 and 2005. Rice mills are the most important in this sector, generating 40 percent of employment. Processing of high-value products is still limited, however. Modern food retail is currently also very small, making up less than 1 percent of urban food retail markets, but it is growing rapidly, as in a number of other Asian countries.

8.1.10 Market integration

Food grain markets seem to have become well integrated over time and space (Murshid *et al.* 2010), possibly driven by the large investments in road infrastructure by the Bangladeshi government (and by donors) as well as by the larger availability of mobile phones (Chowdhury and Torero 2005). This result implies that information on food grain markets circulates well, so that food grains flow from surplus to deficit areas when needs arise. There also seems to be little collusion between traders to fix prices, except for short periods (Murshid et al.2009; Goodland 2001). The increasing importance of the private sector in agricultural trade, low barriers to entry in trade, and a competitive environment seem thus to have contributed significantly towards improved food security for the country.

On the other hand, price instability is an important challenge for the government in the liberalized food and agricultural markets of Bangladesh (Chowdhury et al. 2009; Goletti 2000: 189–212; Dorosh et al. 2004). Goletti (2000) shows that overall price stabilization in Bangladesh is an especially political question as the economic benefits and impacts on poverty alleviation are limited while the costs of achieving stability might be sizable. Although the government intervenes in product markets in order to stabilize prices, its impact has been constrained given that procurement prices and Open Market Sales (OMS) prices do not function as floor and ceiling prices, as the quantities bought and sold at this price are limited (Dorosh et al. 2004). For example, OMS over total market supply never reached more than 2 percent in the four years prior to 2010 (FPMU 2009). Instead of price stabilization, the government policy has been to provide targeted subsidies to the poor through the Public Food Distribution System (PFDS). The functioning of this system and recommendations on its improvement are discussed elsewhere.

8.2 Export potentials of agricultural commodities

Bangladesh produces a large number of diversified High Value Agricultural Crops (HVACs) in different agro ecological regions. Marginal and small farmers are the key players in production, value chain and marketing of the agro products.

Besides the above commodities some of the private sector agencies are currently exporting a good quantity of jute leaves, barley, sesame, cashew nuts, baby pineapples, baby corn, French beans, black pepper some indigenous fruits and vegetables. Barley is the most saline tolerant crop and it has the potential of production for export from about one million hectares of coastal saline land. The Halal meat market exists in some countries, which Bangladesh can explore.

Table 8.10: Agro-commodities from Bangladesh in the Export Market

Fruits	Vegetables		Others
Lemons	Teasel gourd	Green chili	Betel leaf
Jackfruits	Yard long bean	Coriander leaves	Betel nut
Mango	Bottle gourd	Garlic	Flowers
Pineapple	Okra, egg plant	Ginger	
Papaya	Taro stolon	Turmeric	
Guava	Leafy vegetables		
Banana	Radish, beans		
Melon,	Cabbage		
Litchi	Cauliflower		
Jujubi	Bitter gourd		
Hog plum	Potato, tomato		

Source: Islam, 2014

8.2.1 Projection of export of agro-commodities

Karim and Islam (2014) estimated that Bangladesh could earn more than $1,800 million in a period of about 18 years from the export of fresh and processed foods (Fig 8.1 and Table 8.2). The export potential of fruit and vegetables is about 160 thousand metric tons (Fig 8.2) and potatoes would be around 200 thousand metric tons (Fig 8.3). The potential of exporting fresh and frozen horticultural crops and processed food would exceed 600 thousand metric tons. Bangladesh exported shrimp and fish of around $ 530 million in 2012-13 (Bangladesh Economic Review, 2014).

The export potential of Bangladeshi agro-commodities is constrained by low productivity, poor hygiene and non-compliance of with sanitary and phytosanitary standards and HACCP practices. Exports will increase substantially by overcoming some hindrances, described below.

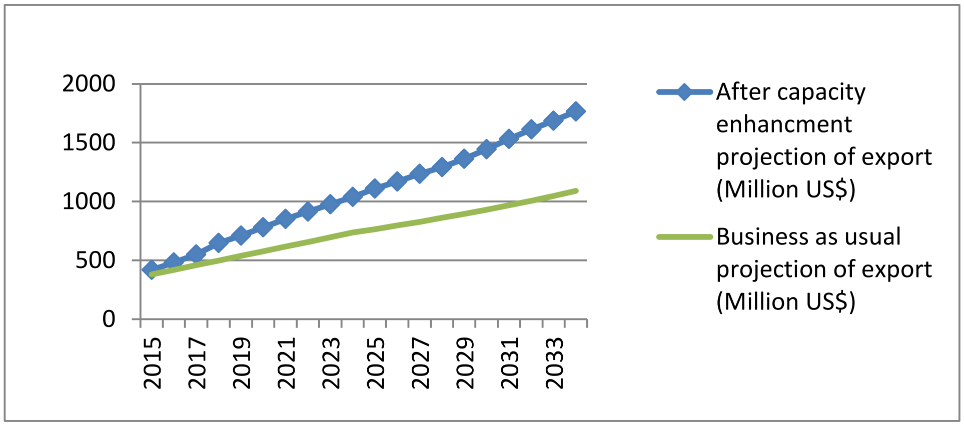


Figure 8.1: Projection of export of fresh, frozen horticultural crops and processed food (Million US$) under business as usual and enhanced capacity, Source: Karim and Islam (2014)

Table 8.11 Projection of export of fresh, frozen horticultural crops and processed food (Million US$) under business as usual and enhanced capacity scenarios

Year	Business as usual projection of export (Million US$)	After capacity enhanceme nt projection of export (Million US$)	Incremental benefits due to capacity enhancemen t (Million US$)	Year	Business as usual projection of export (Million US$)	After capacity enhancemen t projection of export (Million US$)	Incremental benefits due to capacity enhancement (Million US$)
2015	380	418	38	2026	796	1171	374
2016	420	482	63	2027	828	1234	406
2017	459	551	92	2028	861	1292	431
2018	499	648	150	2029	896	1361	466
2019	538	711	172	2030	932	1444	512
2020	578	780	202	2031	969	1531	562
2021	617	852	235	2032	1008	1612	605
2022	657	913	256	2033	1048	1687	639
2023	697	975	279	2034	1090	1765	676
2024	736	1038	302	Total	14773	21576	6803
2025	766	1110	345	GDP% (2013)	21.7	14.9	6.9

Source: Karim and Islam (2014)

During 2015-2034 total export under business as usual scenario is US $ 14,773 million and under improved scenario is US $21,556 million and additional benefit due to improvement is US $ 6,803 million.

Box: Projection method of export of fresh, frozen horticultural crops and processed food
A time series data of exports of horticultural crops and food was used for the period 2008-13. The database of the Hortex Foundation and Export Promotion Bureau was used. Statistical Forecasting software is used for generation of projections for 20 years using simple linear regression techniques. Two alternative scenarios have been assumed: (1) Business as usual scenario and (2) Capacity enhancement of concerned actors: For example strengthening the Hortex Foundation, Food Quality Certification capacity of concerned agencies, enhancing the capacity of compliance of SPS and traceability of produces, improving the capacity of farmers and exporters, etc. It is assumed that during a 10 year period (2014-24) 50% capacity has been improved and during a later 10 years (2024-34) Bangladesh is fully capable of operating in the international food markets.

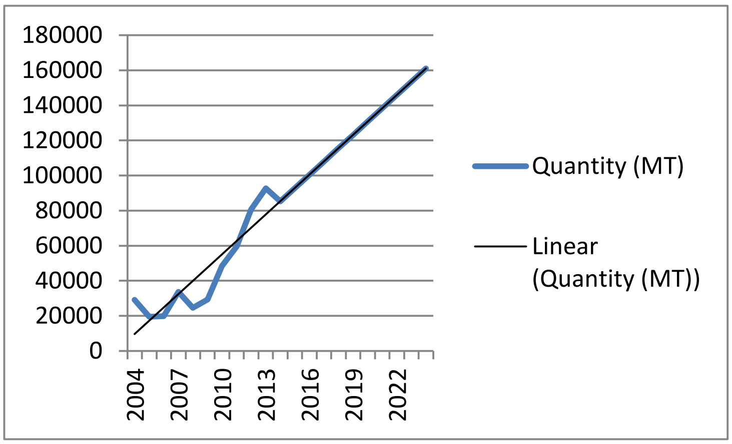


Figure 6.2 Projection of export of fresh fruits and vegetables (MT),
Source: Karim and Islam (2014)

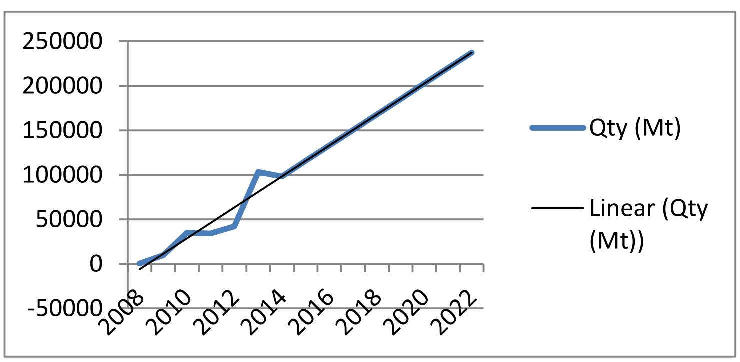


Figure 6.3 Projection of potato export quantity (Mt),
Source: Karim and Islam (2014)

8.3 Main hindrances to exports

Non-compliance with Sanitary and Phyto-Sanitary Standards (SPS)

In recent years, sanitary and phyto-sanitary (SPS) measures have become an increasingly prominent issue for global trade in agricultural products. These concerns are typically greatest for

Bangladesh which tends to have weak SPS management capacities that can thwart efforts towards export-led horticultural diversification and rural development. The arbitrary imposition of SPS measures especially for horticultural and fisheries products is a ploy that developed countries have been able to use in the guise of environmental concerns to further protect their agriculture by restricting imports from developing countries.

The European Union (EU) requirement, for example, on the levels of Maximum Residue Level (MRL) allowed on horticultural exports is a major challenge. Implementation of the zero analytical level means that farmers have to reduce the levels of pesticides used or use those pesticides which have very low residual levels. Other SPS measures imposed include Pest Risk Analysis and Environmental Protection Requirement by the export market. Small-scale farmers in particular find it difficult to meet these standards. There is therefore a need for the government and all concerned to provide technical support on the benefits of SPS adhering to the regulations and local markets.

In general, the level of awareness of the role that SPS management capacity plays is limited among small holder horticultural farmers and hence there is a need for concerted information, campaigns and training at all levels of stakeholders. For high value horticultural products, international regulations and standards related to food safety and quality will determine trade opportunities, but must also safeguard the health of the populations. Therefore, corresponding national regulations should be developed and enforced for commodities both for local and/or regional consumption as well as for the exports that constitute about 1% of the total horticultural production in Bangladesh.

Poor HACCP System

Bangladesh is a member of Codex Alimentarius Commission (CAC). It deals with standards for food safety including food standards for commodities; codes of hygienic or technological practice, and pesticide residue in foods for export of HVACs, Codex standard of HACCP must be followed. BSTI is trying for some items but still problems remain mostly with frozen shrimps, fish and vegetables, which restrict expansion of the export market.

Non-traceability of Production and Packaging Processes of HVACs

Hortex, in its initial period in collaboration with BRAC, did a wonderful job of exporting French beans in the mainstream market maintaining traceability, SPS and standard packaging. Unfortunately, the export of French beans discontinued, although the potential for export still exists. For traceability, supervised contract farming is a pre-requisite. In the NATP- 2, contract farming should be organized in production, processing and marketing, organizing groups of marginal and small farmers in the CIG and non-CIG areas and the Hortex Foundation should build the capacity of organizing the contract farming system.

Lack of Farmers' Access into Supermarkets

It is also important to realize that the process of super-marketization (evolution of the supermarket system) has initiated a series of restructuring waves across the world's food retail industry leading towards a tighter "knitting together" or integration of the national and regional food markets. This has also caused numerous spillovers to occur with and across surrounding sectors and marketing channels.

Supermarkets offer a massive market opportunity for those producers who are willing and able to organize themselves to respond to international market demand through meeting the requirements of the specified standards. However, recent research shows that for farmers to respond effectively to these new market opportunities, they must make substantial on and off farm investments in technology and adjustment of the production system, quality assurance, processing, and food safety standards consistent with the global market. Such conditions often limit market access options for small and limited resource farmers.

It is clear that the changes in the agri-food systems caused by the combination of increasing globalization, market liberalization and supermarkets, present significant challenges for small-scale producers in developing and transition countries. Unless development programs actively and continually facilitate farmers' access to newly emerging global marketing channels, farmers will be forever excluded and they will remain in continued poverty. The Hortex Foundation should bear this great challenge in mind and prepare itself continuously to undertake a rigorous program of capacity building including market access training of all stakeholders operating in export. The nation should also build required infrastructure for testing HACCP and SPS.

Limitations of SPS Services in Bangladesh

In Bangladesh there is no organized contract farming for HVACs for which no traceability system is yet established. This is a serious weakness of our commodities. The country's position of SPS and HACCP is poor. From consultations and visits of the Plant Quarantine Wing of DAE and the Testing Laboratory located in the Port Custom House at Chittagong, we observed that they have almost no facilities for the required SPS and HACCP services for HVACs. The Plant Quarantine Wing is newly created with all the officers and staff seconded from DAE. Many of them do not have the required background for plant quarantine service; moreover they are subject to transfer at any moment. The Government is trying to make it an Independent Directorate. However, it should be fully independent with facilities and well trained staff positions.

To cope with the international requirement many countries have established independent accredited laboratories for performing the SPS services following the WTO's and FAO's Codex and HACCP standards. The system of analysis of residuals of pesticides and chemicals must be established following environmental protection regulations and health safeguard standards.

In the Port Laboratory, no facilities exist for analysis of agro-products. About two years ago they have received three expensive pieces of equipment, i) UV-VS Spectrophotometer, ii) Gas Chromatograph and iii) High Performance Liquid Chromatograph. This equipment is still unpacked and the concerned chemists informed that they could not install them because of some missing parts, which is really disappointing. The laboratory has three qualified Chemists only, but they have to carry out analysis inspection for certification of a lot of diversified items both for export and import in the country.

8.4 Marketing problems in relation to commercialization of agriculture

Bangladesh agriculture is changing towards commercialization with the production of high value products. But there are a number of problems facing the small and marginal farmers:

- Limited market access due to small volume of production,
- High post-harvest loss,

- Inadequate storage and transpiration facilities,
- Lack of cool chain,
- Food quality and safety problems,
- Inadequate credit facilities,
- Lack of processing facilities,
- Low output prices, etc.
- Poor road, link road and market infrastructure.

Lack of organized markets for selling farm produce is an important problem for Bangladesh. The salient features of agricultural product markets are poor infrastructure, with lack of storage and processing facilities, poor roads and communication system, unfair practices of middlemen, etc. Marginal and small farmers are often facing the problem of marketing their product and are not getting a fair price due to the existence of trade syndicates. Government initiatives and support will be required to develop marketplaces, market outlets and farmers' groups. Credit facilities would be required to promote private initiatives for small and medium-scale agri-businesses in processing and packaging. Formation of farmers' groups with enhanced access to credit will be needed to encourage their direct participation in the marketing of agricultural produce. A fair price for agricultural crops and products needs to be ensured.

The issue of food safety, quality and standards is a growing concern for Bangladesh for a number of reasons, most importantly for achieving better nutrition and health standards. Post-harvest management and quality assurance is one of the most significant supply chain activities to minimize post-harvest crop losses and ensure a quality product to maximize customer demand and price as well as to achieve a competitive advantage over other suppliers. There is post -harvest loss of around 12% (Table 8.12) in rice and 30% in vegetables and fruit. There is also substantial scope to increase agricultural production by reducing post-harvest losses, by increasing the shelf life of perishable commodities and by adding value through agro-processing of agricultural commodities into finished or semi-finished products, packaging in appropriate containers, proper storage and exports. The food processing industry in Bangladesh is growing. The policy, institutional and infrastructure barriers to agribusiness, agro-processing and the supply chain needs to be removed in order to provide a "big push" to agriculture and rural development. The production and processing of these products is also labour intensive and, therefore, is likely to have a significant favourable impact for generating additional employment in rural areas.

Table 8.12. Post harvest losses of major corps in Bangladesh

Food crops	Production (million tons)	Loss (%)	Total losses (million tons)	Loss (Tk/kg)	Total loss (Million Tk.)
Rice	29.75	12	3.57	8.00	28,560
Wheat	0.77	13	0.10	8.00	8,000
Maize	0.78	13	0.05	5.00	475
Pulses	0.56	15	0.08	25.00	2,075
Oil seeds	0.55	15	0.082	20.00	1,640
Spices	1.46	15	0.22	10.00	2,200
Vegetables	8.75	30	2.62	4.00	10,492
Fruits	7.88	25	1.97	9.00	17,721
Potato	5.37	20	1.07	8.00	8,592
Sweet potato	0.72	20	0.15	3.00	435
Sugarcane	3.51	20	0.70	2.00	1,404
Total	60.1		10.1	-	81,594

Source: BARI

In Bangladesh, small farms account for 96 percent of operational holdings with a share of 69 per cent of cultivated area. Most poor farmers are not linked to markets for a variety of reasons: remoteness, low production, low farm-gate prices, and lack of information, to name a few. Most of these smallholders practise either subsistence farming or operate largely in local markets due to lack of connectivity to more lucrative markets at regional, national or global levels. As a result, incentives remain weak, investments remain low, and so does the level of technology adoption and productivity, resulting into a low level equilibrium poverty trap. Identifying and linking poor primary producers to productive opportunities in the agriculture and fish sub-sectors can significantly increase incomes as they access high-value markets and sell value added produce. Specifically, commercial production of vegetables, pulse and oils, fish, poultry and rice all represent expanding, profitable sub-sectors within which smallholder producers can engage and generate the productivity and increased income necessary to elevate themselves out of poverty.

There is a strong demand for investment in the sector for development of market and value chains, speeding up dissemination of technology and enhancing institutional capabilities. This would deliver essential services to the small farmers, traders and various supply chain actors for developing demand led value chains and enhancing market linkages of the small and marginal farmers. Successful marketing requires learning new skills, new techniques and new ways of obtaining information.

Hortex implemented an innovative, market-driven value chain development approach through the Supply Chain Development Component (SCDC) of the National Agriculture Technology Project (NATP). This approach is linking consistently with the agricultural innovation systems, especially within the rapidly changing globalized economy of Bangladesh. In short, with the stable economic growth of the country, there are changes in consumption patterns that are creating emerging markets for new high-value products of crops, livestock and fisheries. Under this emerging value chain development approach, it is the growing market for high-value products that controls specific innovations that can be successfully taken up by different farm households within local communities to improve their farm household income. In the process, each farm household must consider its own resources (e.g., land, labor, access to water) and access to different markets (e.g., transportation infrastructure; distance to different local, regional, and even global markets). Then, it must determine which enterprises would be most feasible and whether appropriate technologies are easily available for them to successfully produce and market these different crops, livestock, fisheries, or other products (Fakhrul, 2014).

Also important is the number of other farm households within each local community who share common interests (CIGs) and who are willing to work together, especially in creating producer organizations (POS) in the post-harvest handling and marketing of these products to urban or export markets. The increasing demand for different high value food products (e.g., fruit, vegetables, fish, animal products, etc.) creates new market opportunities for products that can be produced by small-scale farm households who have the necessary labour resources to produce and market these high-value, labour-intensive crops and other products. This transformation requires a longer time, because most extension personnel are trained in technical fields associated with the major food crops as well as animal production. Most extension workers have little or no training in farm management, agricultural marketing, value chain analysis and the newly emerging, high-value crops and products; nor about various micro-finance options and agribusiness management. In this regard, Hortex Foundation developed some important supply chain models for high value crops. During 2008-14, SCDC has developed an approach/business model and piloted value chain development activities in 20 upazilas through a collaborative approach between Hortex and line extension agencies- Department of Agricultural Extension (DAE), Department of Livestock Services (DLS) and Department of Fisheries (DOF) (Fig . 8.4).

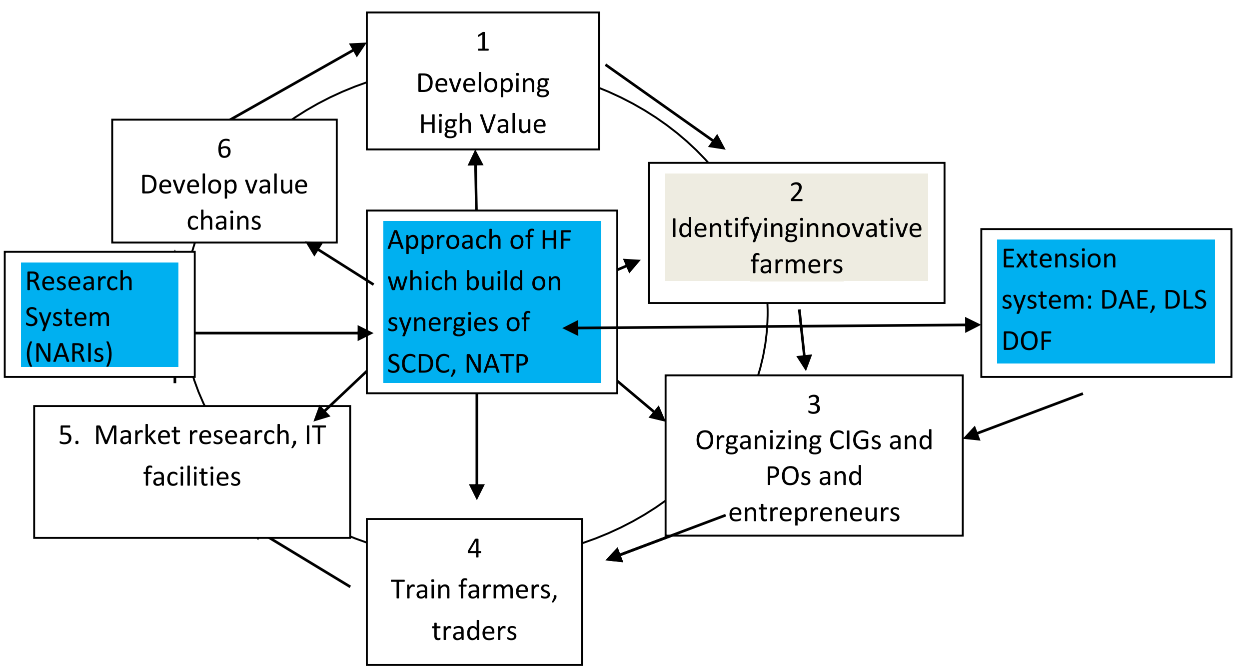


Figure 8.4. Innovative approach of Hortex Foundation for developing value chains of high value products

Hortex has piloted and established a network of 25 Commodity Collection and Marketing Centres (CCMCs) and so shortened 2 segments (*faria* and collector) of the value chain. The SCDC of Hortex has developed 62 high potential value chains in 20 upazilas in 13 districts across the country and provided support for post-harvest management, improvement of market linkages and enterprise development activities. Twenty four technologies were demonstrated and training of CIG farmers was organized through CCMCs in project sites for development of market linkage of the farmers. It is necessary to scale up value chain development activities of NATP for improving market linkages, minimizing post-harvest loss, entrepreneurship development and value chain development.

8.5 Value chain of selected agricultural commodities

Value chain development is an important activity in order to advance towards commercialization of farm produce. In the supply chain or a marketing channel of distribution, it is simply the ways in which the producers make their products available for sale. Improvement of post-harvest activities is important so that the products are made available for sale as efficiently as possible before the quality deteriorates. Hence, marketing activities are very important to the producers in the supply chain. Value chains of some high value commodities are described below:

Value chain of vegetable (pointed gourd): Value chain is a chain of activities. The product passes through all activities of the chain in order and at each activity the product gains some value. The chain of activities gives the product more added value. A value chain analysis is done to identify the actors involved in the supply chain of that commodity, to improve access of inputs, markets and services by mobilizing the poor farmers and policy environment towards facilitation of the chain. The value chain generally starts with the raw material supply at the farm level and ends with consumers who make the choice to buy, or not to buy, the finished product. Pointed gourd has several links between the farm and the consumer such as procurement, transportation, processing, commodity storage, conversion packaging, distribution, retailing, and consumption.

Figure 8.5 presents the value chain of pointed gourd production at Parbatipur, Dinajpur. Mostly local varieties of pointed gourd are grown by the farmers, who use inorganic chemicals (insecticides-Furadan, Suntaf and fungicide like Noyin powder) in pest control. The frequency of application exceeds more than 30 times including insecticide and fungicide application which increases the cost of production and the produce is not safe for consumption. It is revealed that there are opportunities for significant increases in growers' returns that would result from judicial management of inputs like use of appropriate quantities of fertilizer, safe methods of producing vegetables (e.g. pheromone trap etc), by setting demonstration trials on good Post Harvest Management (PHM) practices.

Regarding PHM, farmers sorted out only damaged and infected fruits, but no appropriate grading is done for marketing of pointed gourd crop. The cost of trellis making is also high; the farmers explained that they used low cost materials like jute sticks, but after passing through the rainy season the trellis broke down. They also tried pointed gourd cultivation on the ground by distributing rice straw without making a trellis. The termites are the major problem in this case, and also the colour of the fruit on the ground side becomes white. Due to the unimpressive look of the fruit, both market demand and unit price of the produce decreased. Moreover, the taste of pointed gourd also changed, as reported by farmers. Therefore, they are making a trellis that makes the initial investment high.

Value chain of broiler and layer: Figure 6.6 and Figure 6.7 present value chains of broiler meat and eggs, respectively. It reveals that profit margins are quite low for small and medium producers of commercial broilers and eggs; these producers also bear a greater share of risk than all other stakeholders. Major costs for small and medium producers of broilers are the costs of DOCs and feed. The lack of processing facilities to balance the periods of higher production and demand, poor planning of production and insufficient knowledge of the demand structure all contribute to huge fluctuations in prices of broiler meat**.** For the time being, the market for processed and frozen meat is very limited, however, as the majority of customers definitely prefer to buy a live chicken.

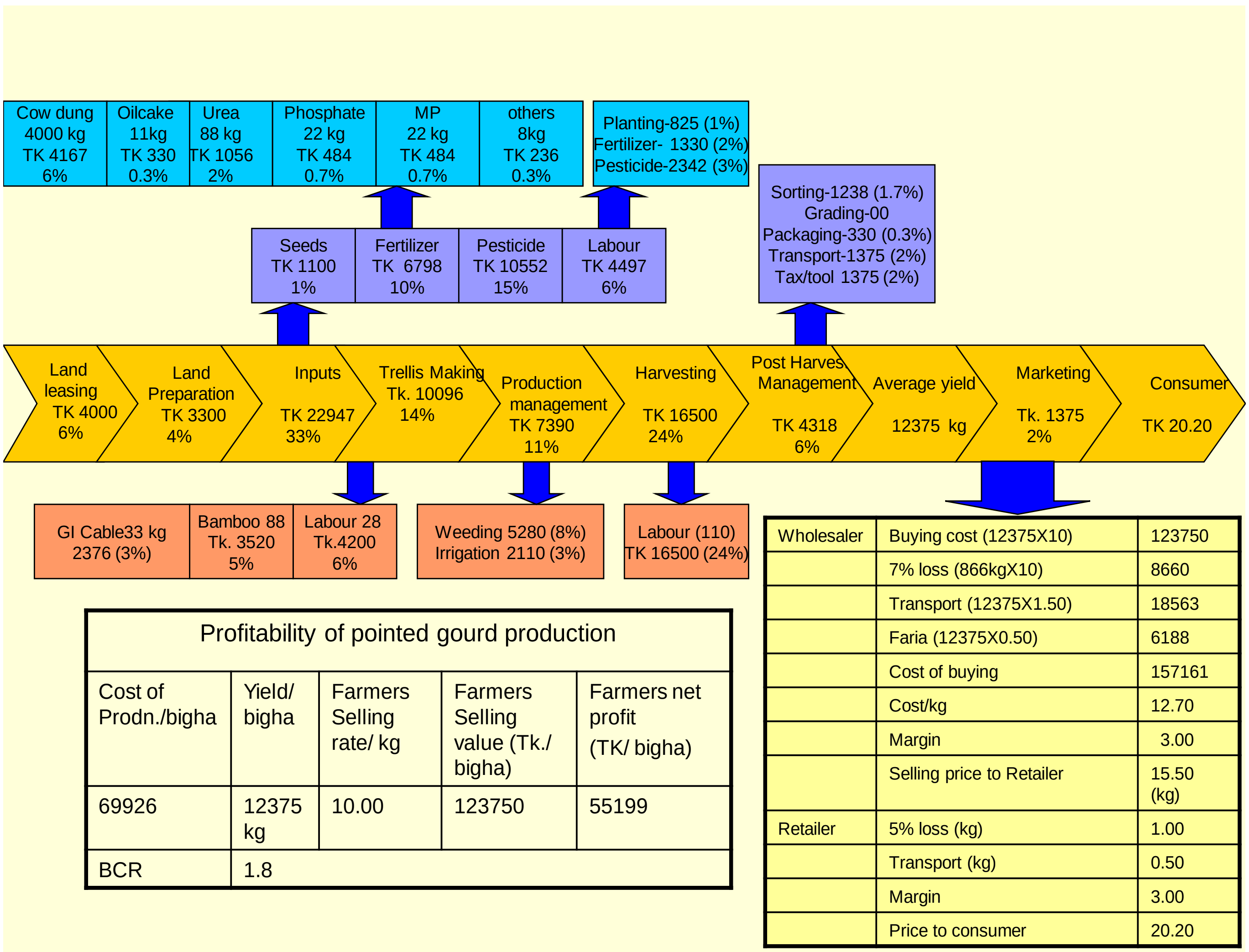


Figure 8.5 Value chain of pointed gourd production at Parbatipur, Dinajpur, Source: Hortex Foundation, 2014

Poor technical knowledge of intensive poultry production is a major constraint that must be addressed to improve efficiency in the industry, particularly in the SMEs**.** The value chain analysis revealed that technical knowledge of poultry production and management including production technology and methods, nutrition, water quality, and bio-security was deficient on farms of all sizes leading to inefficiencies and higher costs. The absence of quality control for all inputs, including DOCs, feed, and medicine is a major impediment**.** The impediments faced by the market actors are inadequate transport and storage facilities (lack of cool chain), poor market infrastructure and unhygienic slaughter houses.

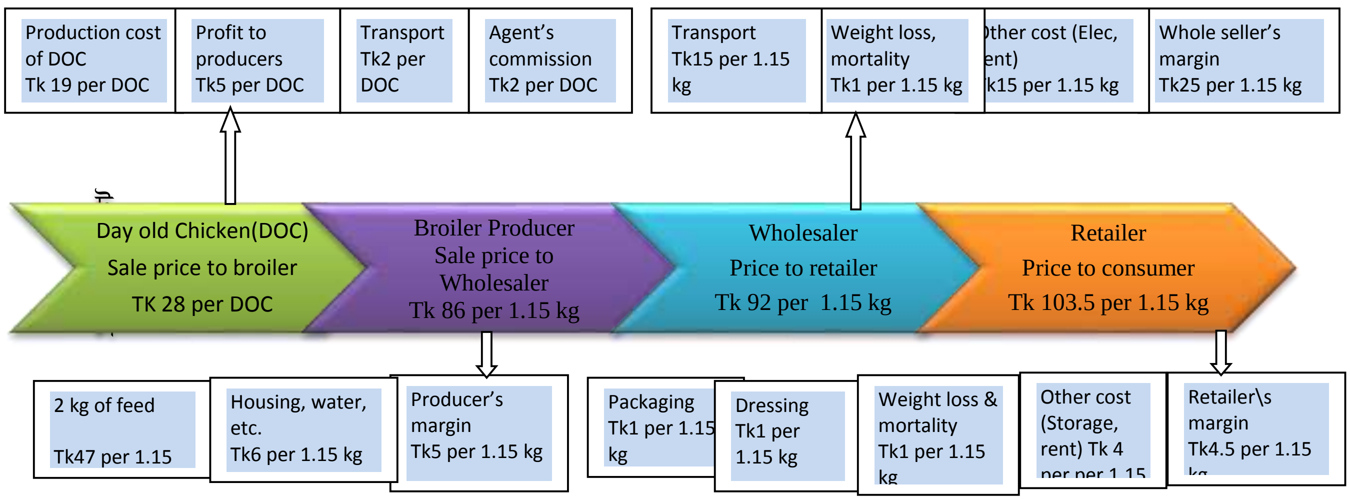


Figure 8.6:Value chains for commercial broilers from small and medium producers
Source: Azad, 2014

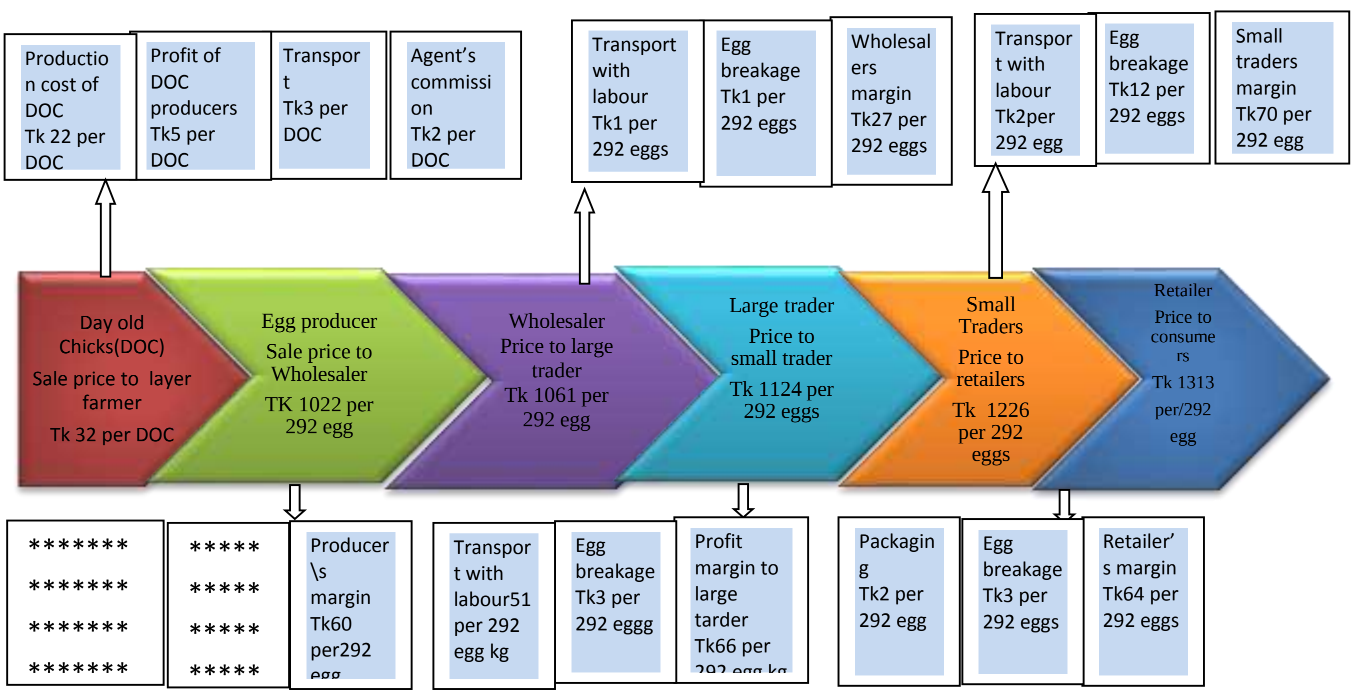


Figure 8.7: Value chains for commercial layers from small and medium producers
Source: Azad, 2014

Fig 8.8. Highlights of various food safety issues prevailing in each link in the value chain
Source: BARI-Cornell University, 2011

It revealed from the review of the value chain studies that producers are suffering from low productivity, low quality of inputs (mainly seeds and fertilizers). Productivity of vegetables is low compared to China and India (Islam, 2014, 2006, Hoq, *et al*, 2012, Minten, 2010, Abdullah and Hossain, 2013). Farmers often lack knowledge, good agricultural practices (GAP) and appropriate post-harvest management (Cleaning, sorting, grading, packaging, storage, transportation, etc.) and suffer from lack of an improved transport system. The growers, as well as market intermediaries, suffer from high post-harvest loss of perishable produce because of poor post-harvest handling and transportation and lack of cool chain and storage facilities. Growers are not getting the full benefits of high food prices due to limited access to market information and undeveloped infrastructure. Improving the transport system and minimizing the number of intermediaries in the supply chain can increase the profit margin of farmers. There are insufficient well equipped wholesale markets. Inferior communication and transport conditions and inadequate financial and information services also contribute to poor distribution of perishable food.

8.6 Policy implications

Successful production and marketing of high-value products require a range of interventions and investments including a change in policy towards an enabling environment conducive to private trade; infrastructure development; improved access to credit; research and development; capacity building and taking advantage of international trade. These issues are discussed below:

There is enormous need for implementing strategies for sustainable yield increase using technologies that can transform high value agriculture in Bangladesh. The development of productive high-value products will require significant and sustained investment in several areas: the development and distribution of better seeds of high yielding varieties; improved breeds/broods for livestock and fisheries; improved disease and health management practices; processing of high-value products; and post-harvest management. These investments must be a priority for improved functioning of high-value product chains. Support is needed for improvement of public and private seed sector, hatcheries, and nurseries for enhancing distribution of HYV seeds, fingerlings and day old chicks. There is serious concern on the quality deterioration and adulteration of agricultural inputs, (specifically, fertilizers, feeds). Strategic action is needed to improve quality of agricultural inputs and its distribution system.

Huge post- harvest losses in fruits and vegetables and inadequate cold storage facilities are a big constraint in Bangladesh for transformation of high value agriculture. Due to lack of many post-harvest arrangements, farmers resort to illicit preservation techniques by applying hazardous chemicals, compromising on food safety.

The current horticultural crops in Bangladesh are prone to heavy doses of contamination with toxic chemicals, food borne bacteria and pathogens due to exposure of the crops to indiscriminate spraying of chemicals. Food contamination exposure also occurs due to lack of processing capacity and lack of access to technologies to store harvested produce.

As high-value product value chains are more demanding in food safety and quality standards. Greater attention is required for certification and quality enforcement (for both inputs and outputs) and for adherence to quickly changing standards. This requirement includes the strengthening, reforming and enforcement of institutions such as the Department of Agricultural Marketing (DAM), the Hortex Foundation and specific quality certification systems. It is necessary to promote Good Agricultural Practices (GAP) and good Post Harvest Management (PHM) practices and traceability of products. These can help to build much required trust between different actors in the value chains. They can also be used towards effective information sharing on market challenges and opportunities for particular sectors. Such institutional structures might have high payoff for improved organization of the value chain.

Investments are needed in laboratory and testing infrastructure to make them compatible with international standards. This will require modern equipment, skilled manpower, and enforcement of Hazard Analysis and Critical Control Points (HACCP) operations to control all types of food contamination. The Bangladesh Standards and Testing Institution (BSTI) currently lacks the capacity and equipment to carry out some of the more demanding tests. Proof of adherence to these tests will be increasingly important in export markets as well as for more demanding local markets.

Capacity building is required for various market participants. Extension systems at the farm level are especially important given the often quickly changing requirements of food quality and safety regulations and the availability of new technologies in high-value agricultural markets; such systems should use private-public partnerships and include marketing extension programs.

Establishment of agro-export and processing zones along with better vertical linkages between the farmers and buyers (such as contract farming and vertical integration) can help to overcome some of the risks inherent in the marketing of high value products.

A better regulatory framework and management structure of local markets are needed. Local markets are currently governed by a multitude of institutions and the fees charged to traders and farmers are often not clear and transparent. Moreover, the fees collected in markets often go towards other purposes than market development and service provision for farmers and traders serving merely to increase transaction costs for participants in the value chains leading to lower prices for producers and higher costs for consumers.

Appropriate marketing infrastructure is also essential for sustained growth of high value agriculture. Efficient transportation and product handling is a crucial requirement for trade of agricultural products. This requires investments and improved maintenance of roads and port infrastructure as well as improvements in railway container handling and enhanced air cargo capacity.

Assembly and wholesale market infrastructure is inadequate and Bangladesh would benefit from upgrading these markets. Most of the assembly, wholesale and retail markets tend to be highly congested and lack much-needed basic facilities such as potable water, toilets, sewage systems, loading spaces, and storage facilities. Poor market infrastructure contributes to important losses in high-value food market chains, estimated to be between 10% and 11% (World Bank 2008).

Lastly, access to timely credit might benefit actors in agricultural value chains in several ways. Easy access to credit is essential to increase operational efficiency of actors to promote value chain development. For example, access to finance is mentioned by agro-processing firms as an important constraint in doing business in Bangladesh (World Bank 2008). There will thus be benefits from stimulating access to credit for these businesses as well as for agricultural traders.

Chapter 9

Climate Change and Vulnerability

Chapter summary: Climate change and vulnerability

Current climate change issues are considerably affecting food security of the millions of people of Bangladesh as the country is one of the countries most vulnerable to climate risks. In Bangladesh, damage caused by natural disasters is one of the main sources of crisis for poor households. Every year, natural calamities such as floods, cyclones, erosion, and droughts cause extensive damage to crops, homes, household and community assets, which can lead to illness or death and a decrease in livelihood opportunities for the poor. Disasters hamper physical access to food and food stocks, destroy crops, disrupt markets and affect household food security.

Floods affect about 80% of land in Bangladesh. In a normal year, 20-25% of the country is inundated by river spills and drainage congestions. The locations most threatened by natural disasters are char lands, coastal zones, flood plains and the drought zone

An increase in temperature due to climate change will bring a transformation in the management of both surface water and groundwater resources in Bangladesh. The pressure on water resources intensifies leading to several after-effects which are: water scarcity, reduction in agricultural production, poverty, lack of potable water, sanitation and hygiene problems.

Water salinity level in the country has increased at most points at an alarmingly high rate over the last 30 years. The increased salinity level would limit the cultivation of many crops in coastal areas.

Climate change will diminish rainfall in the dry season and will increase winter and pre-monsoon temperatures significantly, causing more frequent and more severe droughts in Bangladesh. Some part of the Northern region and some part of the hill region will experience moderate drought during the Rabi and Pre-Kharif season (November to February) by 2030.

The Overall Composite Index (OCI), which is an assessment of development of districts, has been used for assessing the coping capacity of the districts and their vulnerability. The OCI captures various dimensions of socioeconomic and infrastructural development including development constraints, poverty, deprivation and women's empowerment. A total of 23 indicators, which are aspects of demographic, socio-economic and development performance at the district level, were aggregated to derive the OCI. Probability of flooding of the district, damage, risk and OCI were used to estimate the vulnerability scale of 62 districts. In this exercise, vulnerability is expressed in the scale of very low (0) to very high (9). As the scale increases from 0 to 9, intensity of vulnerability also increases. It was revealed that the most vulnerable districts are Maulavibazar, *Sunamgonj and Hobigonj with a vulnerability scale of 9 and Dhaka, Gazipur, Chittagong, Madaripur and Gopalgonj are the least vulnerable districts.*

The government has allocated more than $10 billion in investments for the period 2007 to 2015 to make Bangladesh less vulnerable to natural disasters. Investment needs for adaptation and mitigation to climate change in Bangladesh have been estimated for the period 2011-2030. A total of USD 69.67 billion is estimated as adaptation cost for major investment components in the agriculture sector for the period 2011-30. The majority of the investment proportion is planned to be invested for the infrastructure development (30%) followed by market development (17%), irrigation and water management (15%), and others.

Obstacles to be addressed by Government:

A total of USD 69.67 billion is estimated as adaptation cost for major investment components in the agriculture sector for the period 2011-30 The majority of the investment proportion is planned to be invested for the infrastructure development (30%) followed by market development (17%), irrigation and water management (15%), and others.

Since this is a very large amount and will require substantial financial support from Development Partners the 'credibility obstacle' needs to overcome by high quality, independent, multi-disciplinary research into the potential practical efficiency and effectiveness (i.e. Value for Money) of the proposed investments. In particular, past absence of maintenance and suitable operation of water management infrastructure needs to be properly addressed.

Current climate change issues are considerably affecting food security for the millions of people of Bangladesh, as the country is one of the most vulnerable countries to climate risks. The country is situated at the confluence of three great rivers - the Ganges, the Brahmaputra and the Meghna. Over 90% of the area of these three river basins lies outside the boundaries of the country. The country is intersected by more than 200 rivers. Floods, tropical cyclones, storm surges and droughts are likely to become more frequent and severe in the coming years.

Bangladesh is currently ranked as the most climate-vulnerable country in the world. The following changes have been observed in climate trends, variability and extreme events (IPCC, 2007):

- In Bangladesh, average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985 to 1998.
- The annual mean rainfall exhibits increasing trends in Bangladesh. Decadal rain anomalies are above long term averages since 1960s.
- Serious and recurring floods have taken place during 2002, 2003, and 2004. Cyclones originating from the Bay of Bengal have been noted to decrease in number since 1970 but the intensity has increased.
- Frequency of monsoon depressions and cyclone formation in the Bay of Bengal has increased.
- Water shortages have been attributed to rapid urbanization and industrialization, population growth and inefficient water use, which are aggravated by the changing climate and its adverse impacts on demand, supply and water quality.
- Salt water from the Bay of Bengal is reported to have penetrated 100 km or more inland

along tributary channels during the dry season.

- There has been drying up of wetlands due to decrease of up stream flow and intensification of irrigation, resulting in severe degradation of ecosystems during the dry season.

9.1 Recurrent natural disasters and climatic threats

In Bangladesh, damage caused by natural disasters is one of the main sources of crisis for poor households. Every year, natural calamities such as floods, cyclones, erosion, and droughts cause extensive damage to crops, homes, household and community assets, which can lead to illness or death and a decrease in livelihood opportunities of the poor. Disasters hamper physical access to food and food stocks, destroy crops, and disrupt markets. Natural disasters directly affect household food security because of loss of employment opportunities, an increase in health expenditure and an increase in necessary food expenditure.

Covariate shocks are those shocks that affect many households at once, and are likely to overwhelm social coping strategies based upon support within families and communities. These include the severe floods of 2004 and 2007 and Cyclone Sidr in 2007. At the community or national level, natural disasters pose a threat to all households, especially poor households with few assets or savings. Different types of **c**ovariate shocks in relation to climatic threats in Bangladesh are discussed below.

9.1.1 Floods

Most of Bangladesh lies in the delta of three of the largest rivers in the world – the Brahmaputra, the Ganges and the Meghna. These rivers have a combined peak discharge in the flood season of 180,000 m^3/s. (the second highest in the world, after the Amazon) and according to BWDB carry about two billion tons of sediment each year. The topography of the country is mostly low and flat. Two-thirds of the country is less than 5 meters above sea level and is susceptible to river and rainwater flooding and, in low lying coastal areas, to tidal flooding during storms.

In an 'average' year, approximately one quarter of the country is inundated. The people living in these areas have adapted by building their houses on raised mounds and adjusting their farming systems. In the past, people here grew low-yielding deep water rice in the Medium Lowland and Lowland during the monsoon season. Now they mostly cultivate high-yielding rice crops, often using irrigation. Once in every 4 to 5 years, however, there is a severe flood that may cover over 60% of the country and cause loss of life and substantial damage to infrastructure, housing, agriculture and livelihoods. During severe floods, it is the poorest and the most vulnerable ones who suffer most because their houses are often in more exposed locations.

Floods in Bangladesh are a normal phenomenon and affect about 80% of land in Bangladesh. In a normal year, 20-25% of the country is inundated by river spills and drainage congestion. Four types of flooding occur in Bangladesh.

- Flash floods caused by overflowing of hilly rivers in eastern and northern Bangladesh (in April-May and in September-November).
- Rain floods caused by drainage congestion and heavy rains.
- Monsoon floods in the flood plains of major rivers (during June-September).
- Coastal floods due to storm surges.

Extreme flood frequency has increased in recent years. In the last 35 years, Bangladesh has experienced seven severe floods (Table. 9.1). In 2007, two successive and damaging floods inundated the country in the same season. During high floods, river bank erosion is common. It can result in the loss of thousands of hectares of agricultural land and scores of villages, and displace many thousands of people from their homes. River bank erosion occurs every year, and in the dry season as well as in the flood season (CEGIS, 2008). Flash floods can also be a problem in the more hilly North-eastern and South-eastern regions of the country on the scale of the severe flooding in 2004 and 2007.

Table 9.1: Impacts of major floods in Bangladesh (last 35 years)

Event	**Impact**
1974 flood	Moderately severe, over 2,000 deaths, affected 58% of country, followed by famine with over 30,000 deaths [3]
1984 flood	Inundated over 50,000sq. km, estimated damage US$ 378 million
1987 flood	Inundated over 50,000sq. km, estimated damage US$ 1 billion, 2,055 deaths
1988 flood	Inundated 61% of the country estimated damage US$ 1.2 billion, more than 45 million homeless, between 2,000-6,500 deaths
1998 flood	Inundated nearly 100,000 sq. km., rendered 30 million people homeless, damaged 500,000 homes, heavy loss to infrastructure, estimated damage US$ 2.8 billion, 1,100 deaths
2004 flood	Inundation 38%, damage US$ 6.6 billion, affected nearly 3.8 million people. Estimated damage over $ 2 billion, 700 deaths
2007 flood	Inundated 32,000 sq. km, over 85,000 houses destroyed and almost 1 million damaged, approximately 1.2 million acres of crops destroyed or partially damaged, estimated damage over $ 1 billion, 649 deaths

Sources: GoB (2005) and GoB (2007)

The districts of Sylhet, Moulvi Bazaar, Hobiganj, Sunanganj, Netrokona, Kishoreganj and Brahmanbaria are subject to increasing threats of flash floods as well as river floods. The northern bordering region of the North and Northwest districts of Sherpur, Mymensingh, Netrokona, Nilphamari and Lalmonirhat are at high risk of increasing flash floods while the districts of Kurigram, Gaibandha, Bogra, Jamalpur, Tangail, Pabna and Sirajganj are at very high risk of flooding from the Jamuna. The remaining districts in the central region are at moderate to high risk of river floods.

Ganges-Bramaputra-Meghna (GBM) regional model and national hydrologic model are developed by the World Bank (2009) using IPCC General Circulation Model (GCMs). In order to capture agro-ecological variation, 11 sub-regions are used for hydrologic modelling purposes. The GCMs

[3] Estimates vary, however, up to 1.5 million.

predict both an increasing trend of monsoon rainfall and greater inflows into Bangladesh indicating worse flooding intensity. In general, models demonstrate that the flooded area increases in the future 10 per cent by 2050. Besides most GCMs show earlier onset of the monsoon and delay in the recession of flood waters.

In Bangladesh floods and cyclonic storm surges are major natural disasters that cause loss of lives and direct and indirect damage. In more recent years from 1970 to 1998, cyclonic storms and floods killed more than 460,000 and 41,000 people respectively and affected another nearly 45 million and 356 million people respectively (UNDP, 2001). When a major disaster struck, the whole economy suffered. Agriculture suffered more than non-agricultural sectors. Yet, as Islam (1997) has found, even in such a situation, floods cause much of the damage indirectly though the sectoral linkage effects. Devastating floods of 1987, 1988 and 1998 inundated more than 60% of the country. The 1998 flood alone caused 1,100 deaths, inundated nearly 100,000 km^2, rendered 30 million people homeless, damaged 500,000 homes and caused heavy losses to infrastructure. In 2004, floods inundated 38% of the country. Figure 9.1 shows the flood prone areas of Bangladesh, Figure 9.2 presents the frequency of extreme floods in the past (1954 to 2006) and Table 9.1 presents the broad adverse impacts of major floods during the last 35 years.

The locations most threatened by natural disasters are:

- Char Lands: Chars are unstable lands, unprotected by embankment, that form and erode in the major rivers and coastal zone of Bangladesh. It is estimated that around 5 million people live on char lands throughout the country. The population living on chars are constantly exposed to risk of flooding and erosion and are considered among those most vulnerable to natural disasters such as flooding and cyclones.
- Coastal Zones: The area is vulnerable to cyclones and tidal waves.
- Haor Areas: Haor areas are low-lying areas flooded about 6 months of the year which limits the cropping intensity.
- Flood Plains: As the name suggests these areas are prone to regular flooding. Flooding is a recurring phenomenon, people have developed successful coping strategies that limit the impact of floods on their livelihoods if they have the time and capital to prepare.
- The Drought Zone: this is concentrated in the westernmost parts of Nawabjanj, Rajshahi and Noagaon districts, just north of the Padma river. The weather in this part of the country tends to be extremely hot in the summer and experiences a relatively long dry season, both of which contribute to poor crop production. A combination of high temperatures, low annual rainfall and soil moisture deficiencies have a devastating impact on agricultural production and threaten both small-scale farmers and labourers. Limited and expensive irrigation options exacerbate this problem further.

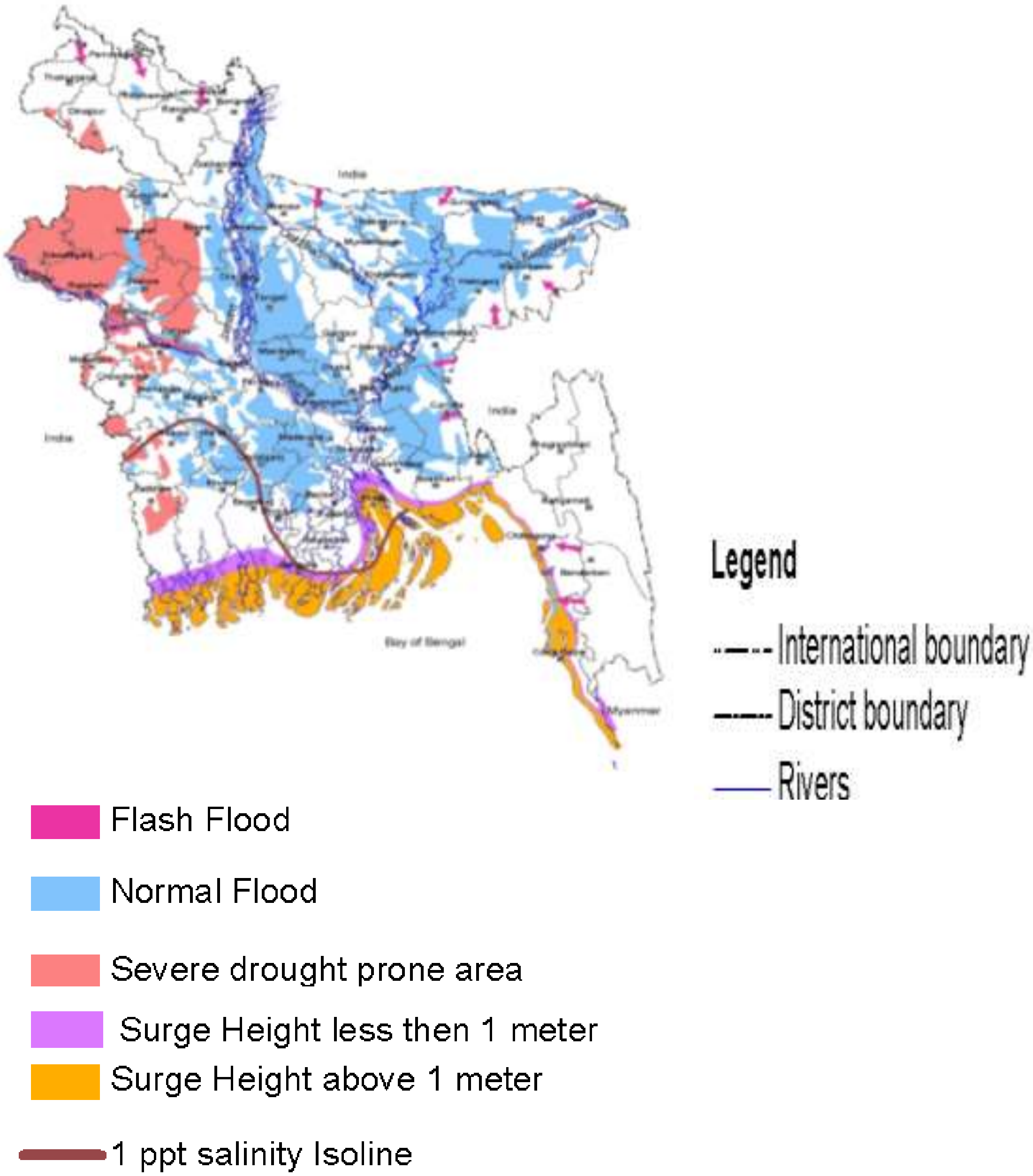


Fig. 9.1 Vulnerability to Natural Disasters
Source: CEGIS

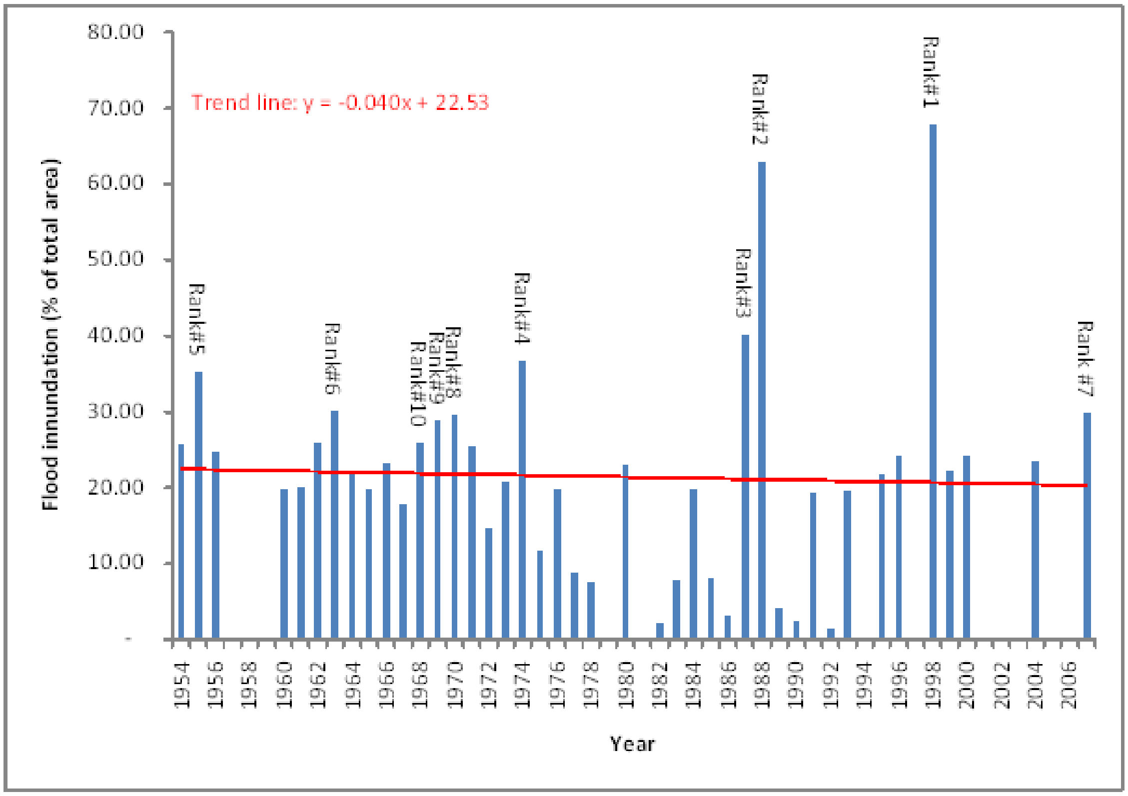


Fig. 9.2 Frequency of extreme floods.
Source: CEGIS

9.1.2 Tropical cyclones and storm surges

On average, a severe tropical cyclone hits Bangladesh once in every 3 years. These storms generally form in the months just before and after the monsoon and intensify as they move north over the warm waters of the Bay of Bengal. They aree accompanied by high winds of over 150 km/hour and can result in storm surges up to seven metres high. Cyclones affect the coastal districts of Bangladesh and cause tremendous damage to/loss of: housing, agricultural crops, draught animals, food stocks and sources of drinking water. Fishermen and those with poor housing conditions are most likely to suffer injury or death.

The storm surges related to the tropical cyclones in 1970 and 1991 are estimated to have killed 500,000 and 140,000 people, respectively. The storm surges are higher in Bangladesh than in neighbouring countries because the Bay of Bengal narrows towards the north, where Bangladesh is located. General cyclonic activity in the Bay of Bengal causes rougher seas that can make it difficult for fishermen and small craft to put to sea.

In recent years, cyclone preparedness has le improved. Bangladesh also suffers from tornadoes and strong storms, which mostly occur in the central and North-western area of the country during the pre- and post-monsoon period.

Cyclone Sidr in 2007

Cyclone Sidr in 2007 has affected, to various degrees, some 33 out of 64 districts (Table. 3.2) in the country. In total some 8.7 million people have been affected at a time when the country hardly had a chance to recover from devastating floods a few months earlier. The floods alone had affected some 10 million people and took large swathes of precious agricultural land out of production. An FAO Mission estimated that up to 70 per cent of the Boro season crops, mainly rice and grass pea, were damaged in the severely affected sub-districts and between 20 and 40 per cent in the moderately damaged sub-districts. In addition, crop damage in a further 5 districts in the South have also been estimated at about 10 percent of the normal production levels (Table 9.2).

Table 9.2 Districts and sub-districts ranked by damage severity by cyclone Sidre

District	Upazila	Status of damage
Khulna	Sarankhola	Severe
	Moralganj	
	Mongla	Moderate
	Kachua	
	Rampal	
	Sadar	
	Mathbaria	Severe
	Bhandaria (a part is O K)	
	Sadar	Moderate
	Kowkhali	
	Shaurpkathi	
Barguna	Patharghata	Severe
	Sadar	
	Amtoli	
	Bamna	
	Betagi	Moderate
Patuakhahli	Mirjaganj	Severe
	Galachipa	
	Kolapara	
	Sadar	Moderate
	Baufal	
	Doshmina	
Barisal	Bakerganj	Moderate
	Sadar	
	Gournadi	
	Muladi	
	Hijla	
Jhalokathi	Kathalia	Severe
	Sadar	Moderate
	Rajapur	
	Nalchiti	
Madaripur	Kalkini	Moderate
	Sadar	
	Rajoir	
Khulna	Dakope	Moderate
Bhola	Bhola Sadar	Moderate

Source: FAO Mission Report, 2007

Aila 2009

Around 9 million households (around 3.7 million people) were affected by Cyclone Aila in 2009. The cultivated land damaged in the area is around 96,617 ha (out of 542,006 ha cultivated); the loss in the production is of around 482,144 ton worth of BDT 6,776 million (around US$ 99 million) (Table 9.3 and Table 9.4).

Table 9.3 Losses in ha and equivalent estimated value in BDT

	Item	TotalLand (ha)	Total Loss (,000 BDT)
1	Aus Seed Bed	5493	30211
2	Transplanted Aus	53122	2390490
3	Summer Vegetables	18921	2270520
4	Banana	6952	2085600
	Total:	**84488**	**6776821**

Source: FAO mission estimate, 2009.

Table 9.4 Households affected by Cyclone Aila in 2009

Sub-sector	Most vulnerable affected households
Crop Production	143,312 HHs for Boro (20% of the affected farmers HHs) 71,656 HHs for Maize (10%) 143,312 HHs for Vegetable Gardening (20%)
Fisheries and aquaculture	25,000 fish-farmers (11% of the population) 2,500 fisherfolk (3.69% of the population)
Livestock production	119,000 HHs for livestock feeding
Total:	**504,780 Households**

Source: FAO Mission estimate 2009

9.1.3 Droughts

The drought situation in Bangladesh Agriculture could be classified into five drought classes as presented in Table 9.5 and Fig. 9.4. About 2.7 million ha in area is vulnerable to annual drought. About 18% of the Rabi crops and 9% of the Kharif crops are highly vulnerable to annual drought problems.

Table 9.5 Summary of drought severity areas in Bangladesh by crop season (in Million ha)

Drought class	Rabi	Pre-Kharif	Kharif
Very severe	0.446	0.403	0.344
Severe	1.71	1.15	0.74
Moderate	2.95	4.76	3.17
Slight	4.21	4.09	2.90
No Drought	3.17	2.09	0.68

Source: Karim, *et al.* 1990

Droughts are associated with the late arrival or the early recession of the monsoon rains and with intermittent dry spells coinciding with critical stages of the transplanted aman rice. Bangladesh experienced droughts in 1973, 1978, 1979, 1981, 1982, 1989, 1994, and 1995. The drought in 1973 was in part responsible for the famine in Northwest Bangladesh in 1974. The 1978-79 drought was one of the most severe resulting in widespread damage to crops (rice production was reduced by about 2 million tons) and directly affected about 42 percent of the cultivated land. Rice production losses due to drought in 1982 were about 50% more than losses due to floods that same year. Losses in 1997 were about 1 million tons and valued at around USS500 million (FAO, 1006).

Prolonged droughts are not common in Bangladesh. However, dry spells or "crop droughts" can cause enormous suffering for the poor, especially for those depending on rain fed, subsistence farming. Much of the western part of the country can be affected by drought, with the northwest being the most commonly affected.

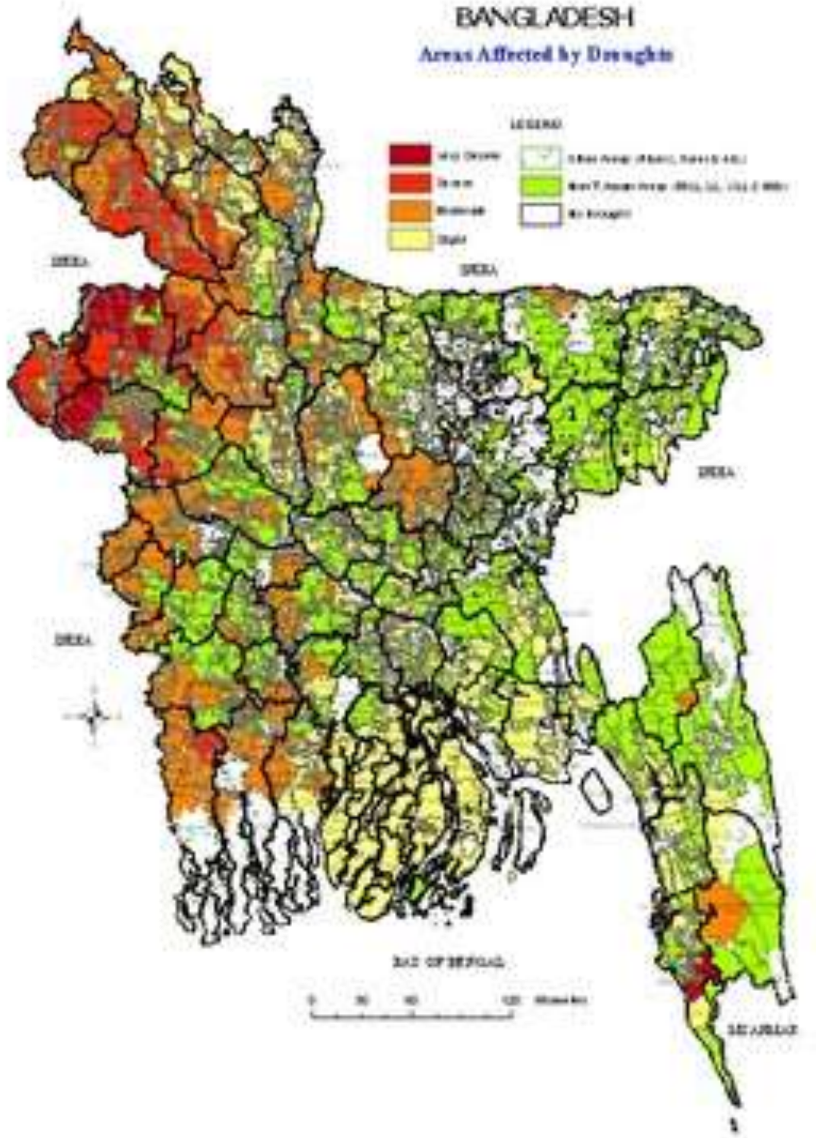


Fig 9.4 Drought affected areas of Bangladesh by regions and T Aman cropped areas

9.1.4 River erosion

Riverbank erosion is a severe threat to the livelihood of poor people living along the Jamuna, Brahmaputra, Padma, and Meghna rivers. People living on the chars are particularly vulnerable and are forced to move frequently due to river erosion (Fig 6.5).

Fig. 9.5 Areas affected by river bank erosion in Bangladesh, Source: WFP

9.1.5 Other natural shocks

Earthquakes: Bangladesh is divided into three earthquake seismic zones with the highest seismic activity in zone I, covering the northern districts from Kurigram to Moulvibazar. Experts have been forewarning a 6-7 magnitude earthquake to occur at any time which would cause unimaginable destruction and death in a country that is ill-prepared for such a disaster (Fig 7.6).

Arsenic Contamination: The latest data indicates that 59 out of 64 districts have wells with arsenic levels above the safe limit, exposing about 75 million people to this toxic substance on a daily basis (Fig. 7.7). The deteriorating health of arsenicosis patients puts a heavy burden on their families, contributing to economic hardship, social exclusion and food insecurity.

Diarrhoea: The incidence of diarrhoea is high throughout the year but the crisis period is from July-September and is exacerbated by receding flood waters. Fig 7.8 presents mapping of incidence of diarrhoea contamination in Bangladesh.

Fig 9.6 Earthquake zones in Bangladesh, Source: WFP

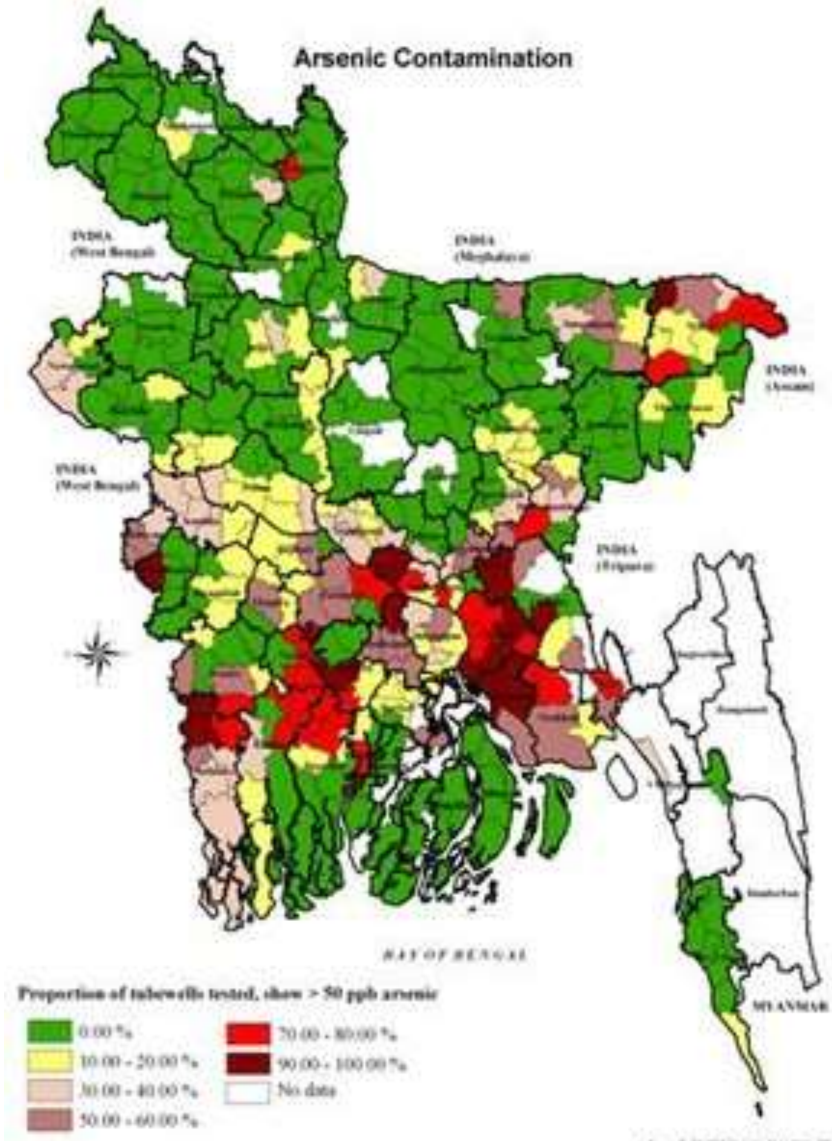


Figure 9.7 Arsenic contamination zones of Bangladesh

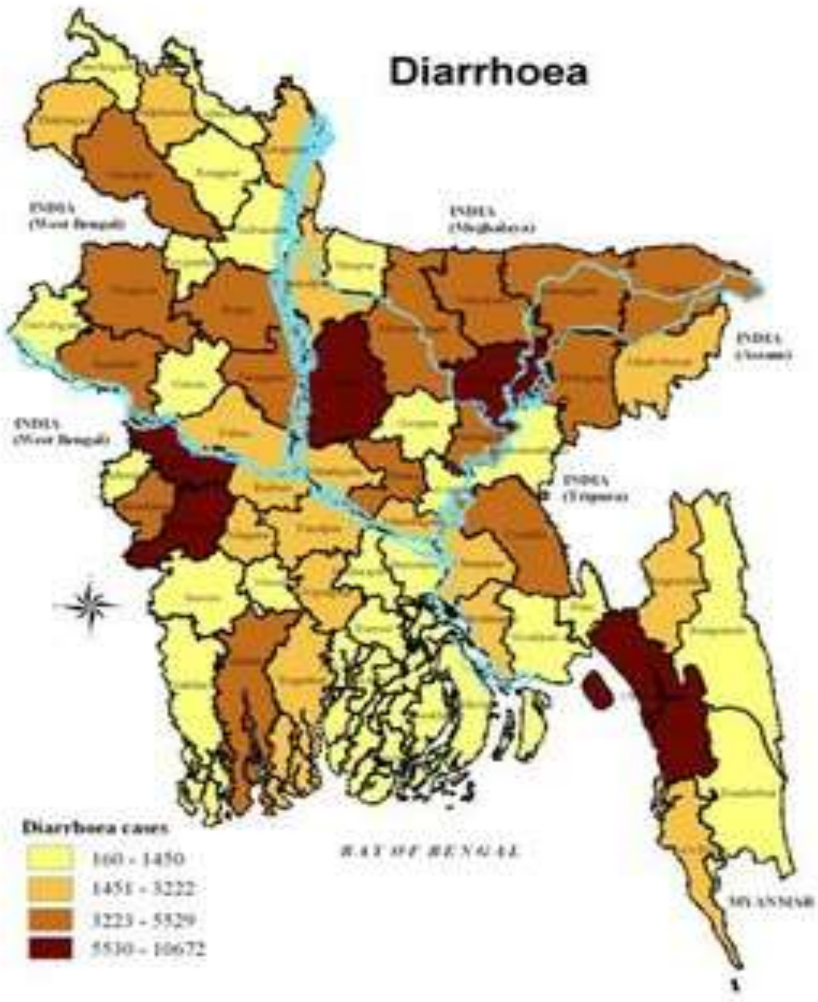


Fig 9.8 Incidence of diarrhoea occurrence by region

9.2 Effect of climate change on water availability

Water has become a critical and scarce resource during the dry season for irrigated agriculture, domestic and all other uses. Increase in temperature due to climate change will bring a transformation in the management of both surface water and groundwater resources. The pressure on water resources intensifies leading to several after-effects which are: water scarcity, reduction in agricultural production, poverty, lack of potable water, sanitation and hygiene problems, decline in groundwater level, water quality deterioration, conflict among users and environmental hazards etc.

About 96% of potable water and nearly 80% of irrigation water is supplied from groundwater.

Temporary overdraft or ‘mining’ conditions occur in many areas of the country due to extensive abstraction of groundwater for mitigating hydrologic droughts especially in the dry season. In recent years groundwater levels in many areas, particularly in the North-west region experienced depletion up to 10 m from the static water level for which reason most of the shallow tube wells (STWs) and Hand Tube wells (HTWs) almost ran dry. Moreover, about 50,000 ponds and ditches have almost dried up. Decline in water levels of these local water bodies are due to interaction of pumping groundwater from the adjacent shallow aquifers and evaporation losses.

Unfortunately, ground water in many places in Bangladesh is not safe and contains variable amounts of arsenic. In South-west Bangladesh, arsenic levels in rice range from 0.29 µg to 0.38 µg per gram of rice. A much higher concentration is found in leafy vegetables (UNICEF, 2009) and high levels in drinking water are more dangerous. The arsenic problem along with climate change will further complicate availability of water during the dry season.

9.3 Impact of sea level rise

Sea level rises lead to submergence of low lying coastal areas and cause saline water entry into coastal rivers and intrusion into groundwater aquifers, reducing freshwater availability, and contributing to drainage congestion inside coastal polders, adversely affecting agriculture. Increased river bank erosion and saline water intrusion in coastal areas are likely to displace many people who will be forced to migrate, often to slums in Dhaka and other big cities. If sea level rise is higher than currently expected, and coastal polders are not strengthened and/or new ones built, displacement and resettlement by 2050 could be substantial. Sea-level rise of one metre by the end of the current century is a real possibility.

9.3.1 Increase in soil and water salinity

The Bangladesh Water Development Board and SRDI are collecting and maintaining soil and water salinity data and the FAO has provided support to CEGIS for compiling, updating and interpretation of the salinity information. Annual maximum surface water salinity levels increased considerably in the South-west, by the year 2008 compared to reference salinity information of 1980s developed by the MPO (Fig.9.9). The maximum increase of 20 mS/cm is in Khulna followed by 14.4 mS/cm at Nalianala Forest Office in the Sundarban. In areas like Gopalgong, Tongipara and Narail the maximum salinity level also increased substantially. Increase in salinity levels is also related to large reductions of upstream flow related to a secular shift in the Ganges distributaries probably caused by tectonic plate movement and to reductions in dry season flow related to the operation of the Ganges barrage at Farakka in West Bengal.

SRDI produced soil salinity data using the reference information of 1973 (Fig.9.7[4]). A large area has become salt affected over 27 years and more than 170,000 ha has been affected in the 11 districts (Table 9.6). The situation has been further aggravated since 2000. This is a very severe threat which affects productivity and livelihoods in the area, by limiting the uptake of MVs of paddy, which are generally less salt tolerant than less productive LVs, and also limiting rabi season crops, although farming systems have adjusted to some extent by expanding shrimp production for

[4] It should be noted that a large part of the area in the map shown to be strongly or very strongly saline is in the Sundarban Mangrove Forest (which has evolved in saline conditions).

export, which requires saline conditions.

The World Bank (2009) using a coastal model determined that during the monsoon period (June-September) the Meghna estuary is fully saline, the maximum salinity variation during the monsoon season is 5 parts per thousands (ppt) and it intrudes more than 70 km landward in the western part of the Sundarbans, whereas comparatively higher fresh water flows through the lower Meghna in the Eastern delta are pushing the 5 ppt saline front towards the estuary mouth.

In contrast, during the dry season (December to March) salt water intrusion occurs through various inlets in the western part of the coastal zone and through the Meghna estuary. The 5 ppt isohaline intrudes more than 90 km landward at the western part of the coastal area in the Sundarbans. Moreover, with decreases in freshwater flow in the Lower Meghna, largely caused by lower flows in the Ganges/Padma, the saline front can move by as much as 30-40 km from the coast. Table 9.9 shows the total area affected by low, moderate and high salinity levels for a base condition in 2005 during both the monsoon and dry seasons. During the monsoon, about 12% of the total area is under high surface water salinity levels which increase to 29% during the dry season. With sea level rise, drainage gradients may reduce thereby decreasing the flow to the Bay of Bengal and allowing riverine salinity to move inland.

Finally, high salinity in groundwater is known to threaten drinking water wells in the coastal zone, particularly at shallow depths, and limit the possibility for groundwater irrigation for crop production. Deeper aquifers, at depths greater than 150 m, and often up to 300m, groundwater is typically fresh, thus much of the groundwater used for drinking water supply is drawn from these depths, but wells are very expensive because of the long pipes required.

9.4 Spatial vulnerability to climate change

The areas of Bangladesh vulnerable to hazards are very likely to increase in their frequency and severity, like droughts, floods, landslides, and cyclones. Some maps could be useful to study spatial vulnerabilities due to climate change and discussed below.

9.4.1 Climate change-induced droughts

It is evident from climate change literature that, climate change will diminish rainfall in the dry season and will increase winter and pre-monsoon temperatures significantly, causing more frequent and more severe droughts in Bangladesh. The likely most affected areas of Bangladesh can be identified based on (a) historical drought hazard maps (Figure 9.5) and (b) projections on climate change-induced drought areas (Table 9.4). Some part of the Northern region and some part of the hill region will experience moderate drought during the Rabi and Pre-Kharif season (November to February) by 2030.

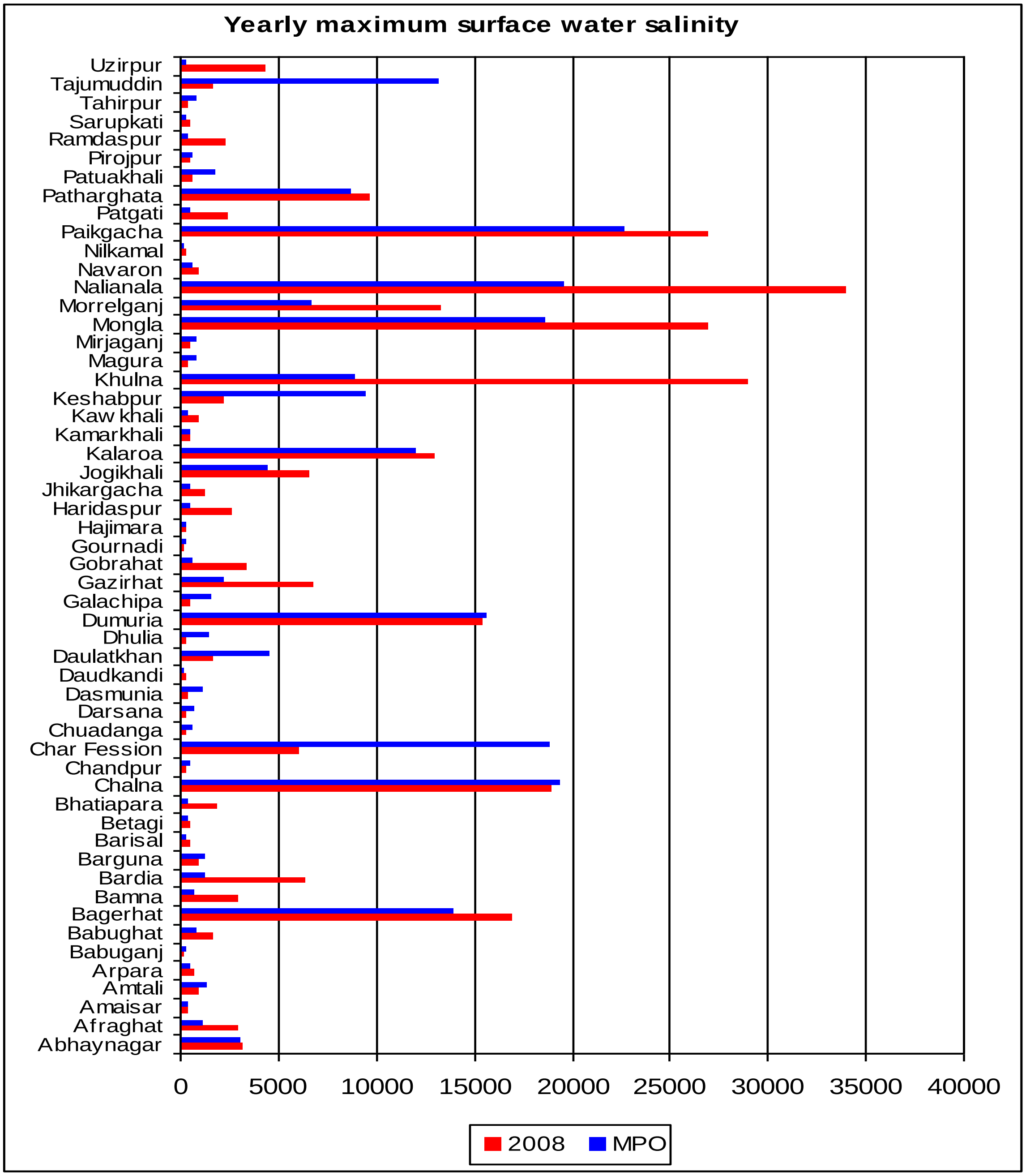


Fig. 9.9 Annual maximum surface water salinity µS/cm

Source: BWDB/CEGIS 2009

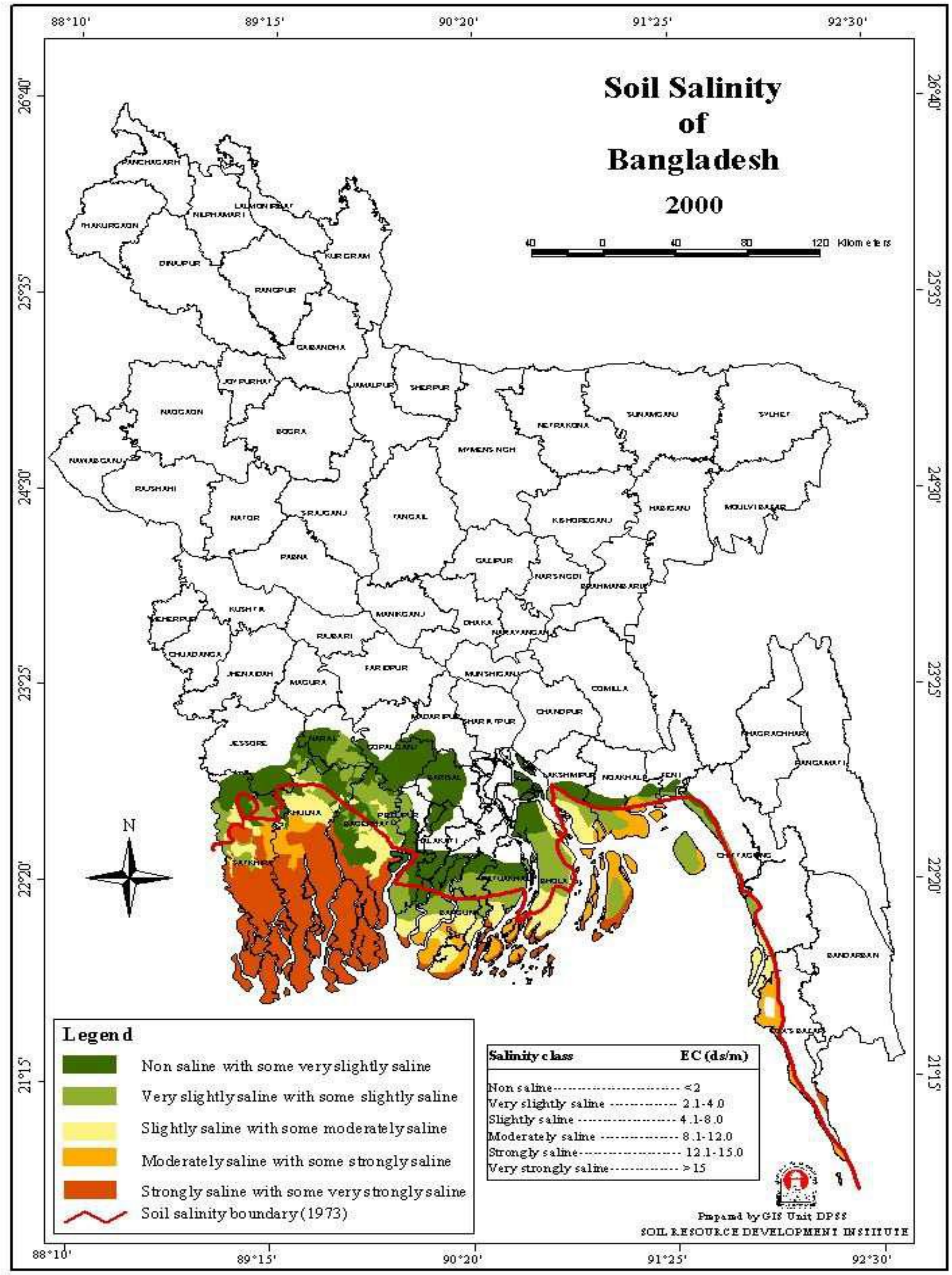


Fig. 9.10 Soil Salinity of Bangladesh
Source: SRDI, 2009.

Table 9.6: Extent of soil salinity during last three decades in coastal areas (1973-2000).

District	Salt affected area (000'hectares)		Salinity class								Salinity increase over 3 decades	
			S1 2.0-4.0 dS/m		S2 4.1-8.0 dS/m		S3* 8.1-16.0 dS/m		S4 >16.0 dS/m		Area (000 ha)	Per.
	1973	2000	1973	2000	1973	2000	1973	2000	1973	2000		
Khulna	374.37	408.68	48.70	90.52	255.22	110.12	49.75	160.68	20.70	48.36	34.31	9.2
Jessore	*0*	*26.91*	*0*	*17.88*	*0*	*7.36*	*0*	*1.67*	*0*	*0*	*26.91*	*100.0*
Jhalakati	*0*	*3.52*	*0*	*2.35*	*0*	*1.17*	*0*	*0*	*0*	*0*	3.52	100.0
Barisal	*0*	*10.82*	*0*	*8.12*	*0*	*2.70*	*0*	*0.55*	*0*	*0*	10.82	100.0
Barisal	60.63	134.62	27.92	56.17	32.71	43.62	0	30.11	0	5.27	73.99	122.0
Patuakhali	218.65	237.48	164.89	72.22	53.80	72.39	0	79.57	0	13.29	18.83	8.6
Gopalganj	*0*	*10.20*	*0*	*5.76*	*0*	*3.12*	*0*	*1.32*	*0*	*0*	10.20	100.0
Madaripur	*0*	*1.19*	*0*	*0.79*	*0*	*0.40*	*0*	*0*	*0*	*0*	1.19	100.0
Faridpur	*0*	*11.39*	*0*	*6.55*	*0*	*3.52*	*0*	*1.32*	*0*	*0*	*11.39*	*100.0*
Noakhali	77.9	78.43	18.8	24.20	53.40	27.32	5.70	19.16	0	7.75	0.53	0.70
Chittagong	100.40	106.46	25.60	15.21	31.30	33.16	24.30	45.62	19.20	10.50	6.06	6.03
G.Total	833.45	1003.96	287.37	282.75	426.43	297.49	79.75	336.58	39.90	87.14	170.51	20.4

Source: SRDI, 2009.

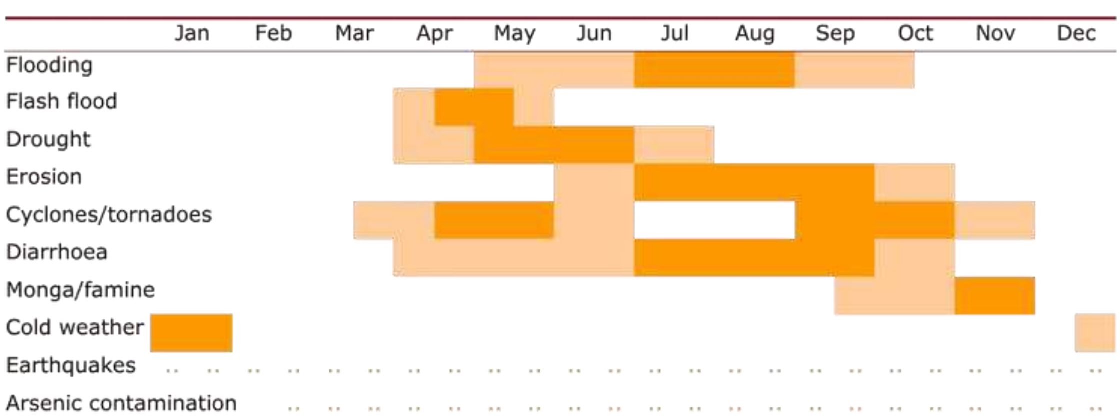
Table 9.7 Area affected by low, moderate and high surface water salinity levels (in 2005)

		Total area [km2]	Area Affected [km2]	Percentage of area affected [%]
Dry Season (Dec-Mar)	0-1 ppt	Low	25,625	54
	1-5 ppt	Moderate	7,808	17
	> 5 ppt	High	13,712	29
Monsoon Season (Jun-Sep)	0-1 ppt	Low	37,455	79
	1-5 ppt	Moderate	4,063	9
	> 5 ppt	High	5,707	12

9.4.2 Climate change-induced floods

The Climate Change Cell's (2006) fact sheet and the Ministry of Environment and Forest's (2005) and National Adaptation Programme of Action (NAPA) provide useful hazard maps based on current flood regimes and projected impact of water resources on arable land. Figure 9.4 shows the current flood regime. Alam, Nishat and Siddiqui (1999), assessed the vulnerability of water resources considering changes in flooding conditions due to a combination of increased discharge of river water during the monsoon period and sea level rise. The analysis reflected that much of the impact would be for F0 land, followed by F1 land, where embankment played an important role in restricting the extent of flood affected areas. A combination of development and climate change scenarios revealed that the Lower Ganges and the Surma floodplain would become more vulnerable compared to the rest of the study area. On the other hand, the North-central region would become flood free due to embanking of the major rivers.

Table 9.8. Calendar of various types of shocks in Bangladesh



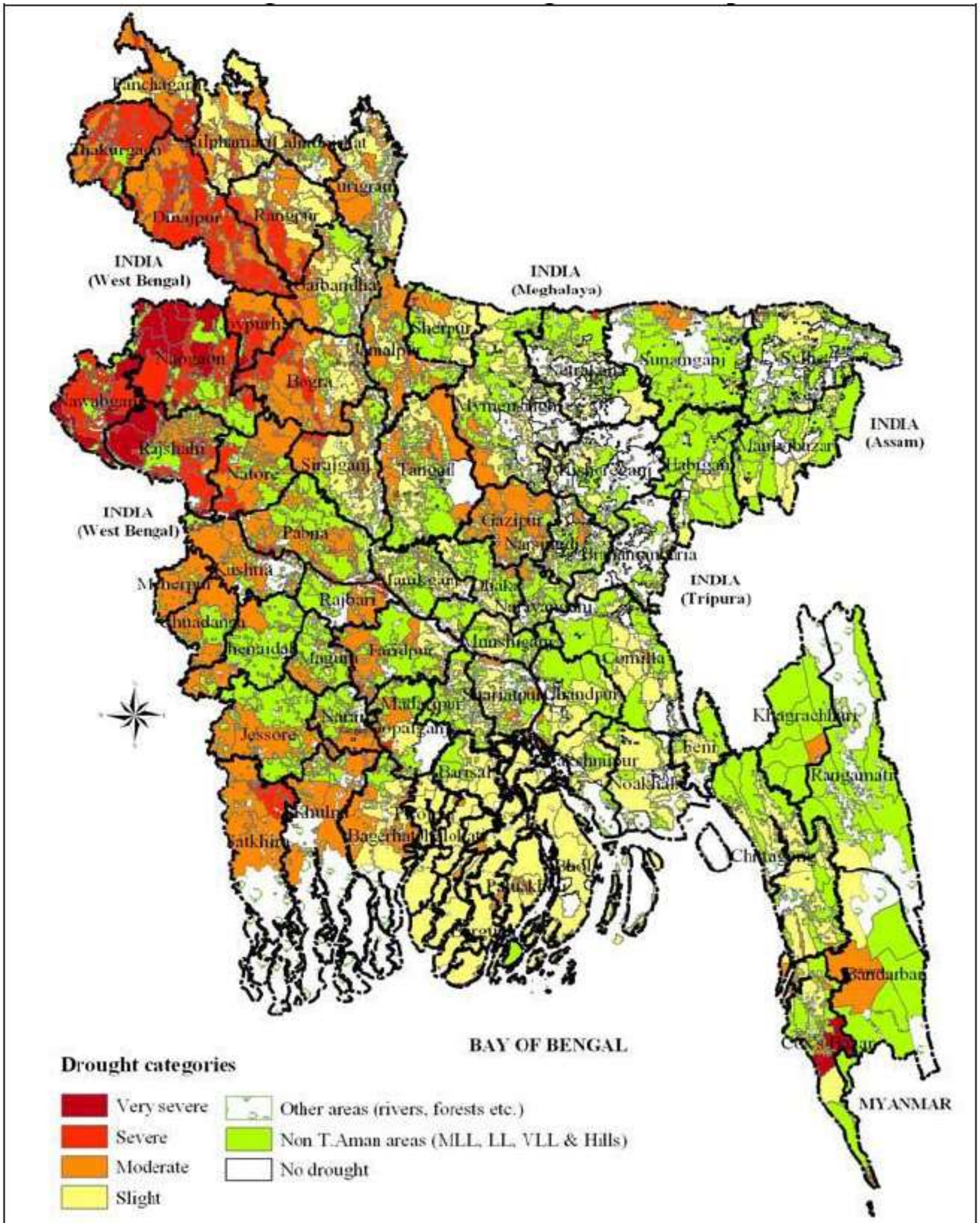


Figure 9.11: Historical drought hazard map, Source: Climate Change Cell (2006)

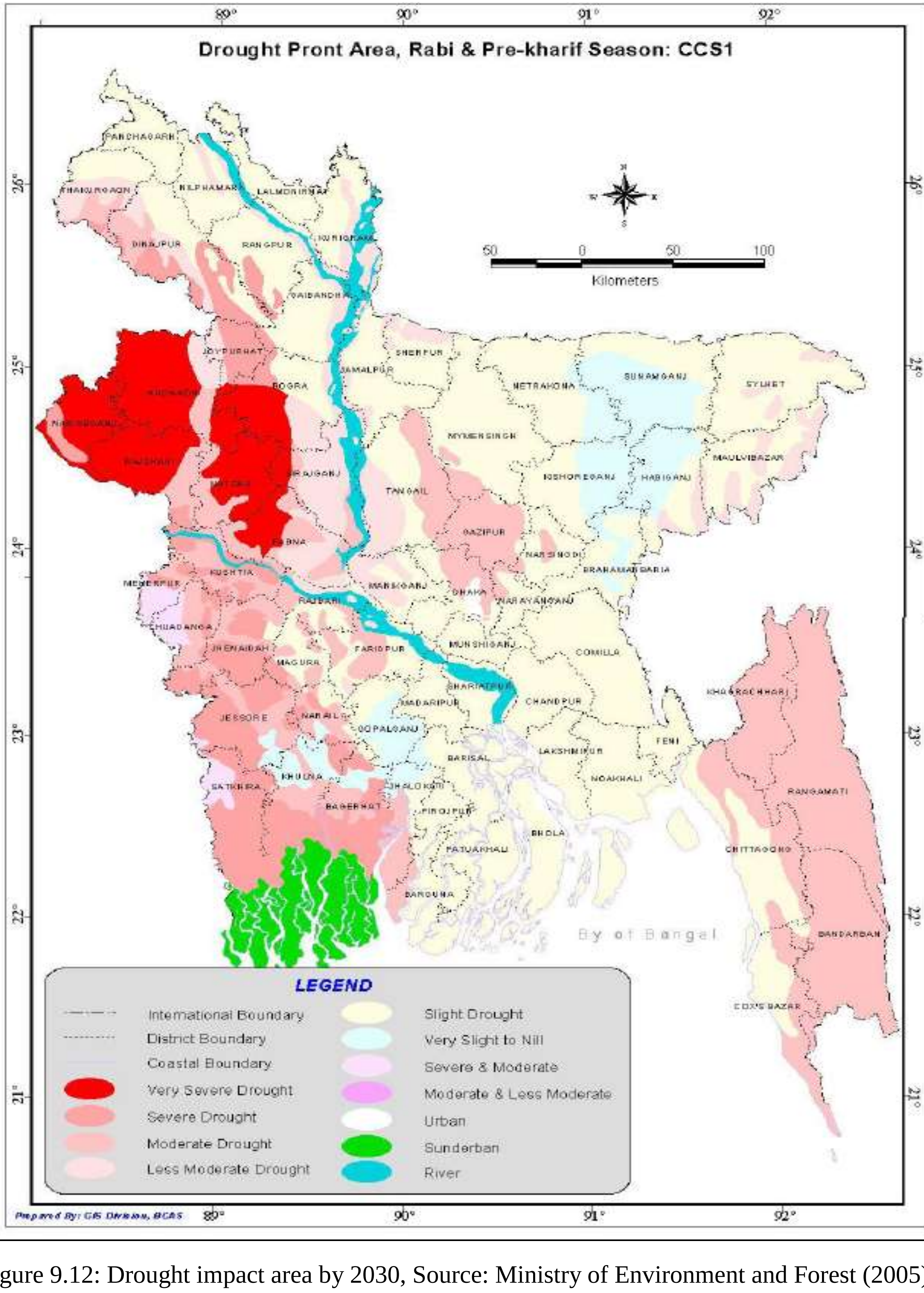


Figure 9.12: Drought impact area by 2030, Source: Ministry of Environment and Forest (2005),

9.4.3 Analysis of vulnerability of regions due to flood

Vulnerability refers to the full range of factors that place people at risk of becoming affected by disaster. Fakhrul (2009) estimated vulnerability of districts of Bangladesh due to flood. Vulnerability is the product of risk of disaster occurrence and the reciprocal of a population group's capacity to cope with a disaster risk. This is the same as saying, if a population group is facing a high disaster risk, and has limited capacity to cope with it, it is considered highly vulnerable. Conversely, a population group exposed to low disaster risk, and with high capacity to prepare for, or cope with it, can be considered to have low vulnerability.

The data used were sub-national data series of BBS such as the Zilla Series and Agricultural Survey Series 2005 and BSMRAU Household Survey 2008 for analyzing OCI. The Overall Composite Index (OCI), which is an assessment of development of districts, has been used for assessing coping capacity of the districts and vulnerability. The OCI captures various dimensions of socioeconomic and infrastructural development including development constraints, poverty, deprivation and women's empowerment. A total of 23 indicators, which are aspects of demographic, socio-economic and development performance at the district level, were aggregated to derive the OCI. Probability of flooding of the district, damage, risk and OCI was used to estimate the vulnerability scale of 64 districts (for methodology see Fakhrul, 2009 and Singh, 2009). Districts and regions falling in different vulnerability scales due to flood ares presented in Table 9.9. All the districts have been ranked according to vulnerability scale 0 to 9. In this exercise vulnerability is expressed in the scale of very low (0) to very high (9). As the scale increases from 0 to 9, intensity of vulnerability also increases. It revealed that most vulnerable districts are Maulavibazar, Sunamgonj and Habigonj with a vulnerability scale of 9 and Dhaka, Gazipur, Chittagong, Madaripur and Gopalgonj are least vulnerable districts.

Table 9.9 Vulnerability of districts and regions due to flood

District/Region		Probability of flood	Estimated Vulnerability scale
1	Chittagong	0.06	2
	Cox's Bazar	0.06	3
	Chittagong region	0.06	3
2	Comilla	0.33	3
	Chandpur	0.33	3
	Brahmanbaria	0.33	3
	Comilla region	0.33	3
3	Noakhali	0.17	3
	Lakshmipur	0.17	3
	Feni	0.17	3
	Noakhali region	0.17	3
4	Sylhet	0.61	9
	Maulavibazar	0.61	9
	Sunamgonj	0.61	9
	Hobigonj	0.61	6
	Sylhet Region	0.61	9

	Dhaka	0.56	2
	Gazipur	0.56	2
5	Manikgonj	0.56	3
	Munsigonj	0.56	3
	Narayangonj	0.56	3
	Narsingdi	0.56	3
	Dhaka Region	0.56	2
	Faridpur	0.33	2
	Rajbari	0.33	3
6	Madaripur	0.33	2
	Gopalgonj	0.33	2
	Shariatpur	0.33	3
	Faridpur region	0.33	3
	Jamalpur	0.50	3
7	Sherpur	0.50	2
	Jamalpur region	0.50	3
	Kishoregonj	0.22	3
8	Netrokona	0.22	3
	Kishoregonj region	0.22	3
	Mymenshing region	0.44	3
	Tangail	0.22	2
	Barisal	0.17	3
10	Jalakati	0.17	2
	Perojpur	0.17	2
	Bhola	0.17	3
11.	**Barisal region**	0.17	3
	Jessore	0.56	6
	Jhenaidah	0.56	6
	Magura	0.56	6
	Narail	0.56	6
	Jessore region	0.56	9
	Khulna	0.33	3
	Bagerhat	0.33	3
	Satkhira	0.33	2
	Khulna region	0.33	3
	Kustia	0.28	2
	Chuadanga	0.28	2
	Meherpur	0.28	2
	Kustia region	0.28	3
	Patuakhali	0.11	3
	Barguna	0.11	3
	Patuakhali region	0.11	3
	Bogra	0.39	3
	Joypurhat	0.39	3
	Bogra region	0.39	3
	Dinajpur	0.17	3
16	Thakurgaon	0.17	2
	Panchagar	0.17	3
	Dinajpur region	0.17	2

17	Pabna	0.28	3
	Sirajgonj	0.28	3
	Pabna Region	0.28	2
18	Rajshahi	0.78	2
	Noagaon	0.78	6
	Natore	0.78	4
	Nawabgonj	0.78	6
	Rajshahi region	0.78	4
19.	Rangpur	0.50	4
	Gaibanda	0.50	6
	Kurigram	0.50	4
	Nilphamari	0.50	4
	Lalmonirhat	0.50	4
	Rangpur region	0.50	4

Source: Fakhrul 2009

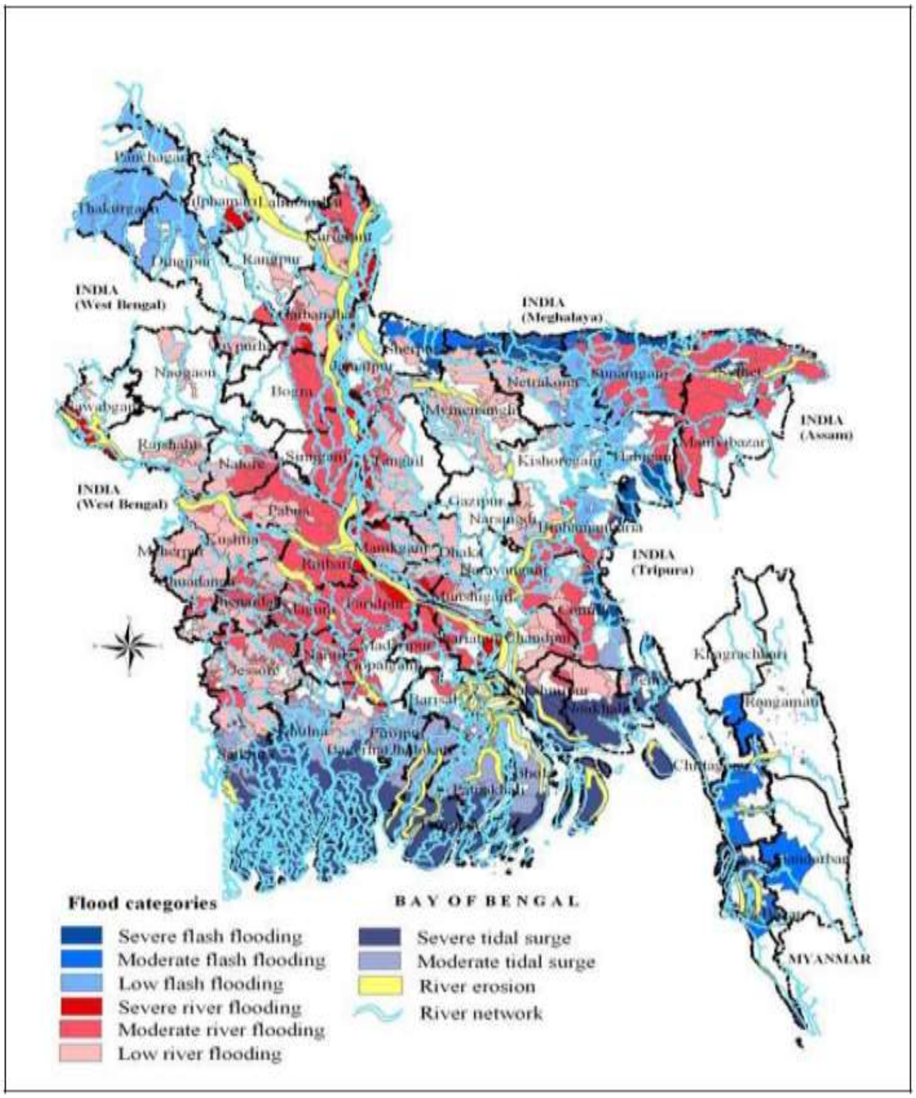


Figure 9.13: Historical Flood Hazard Map, Source: Climate Change Cell (2006).

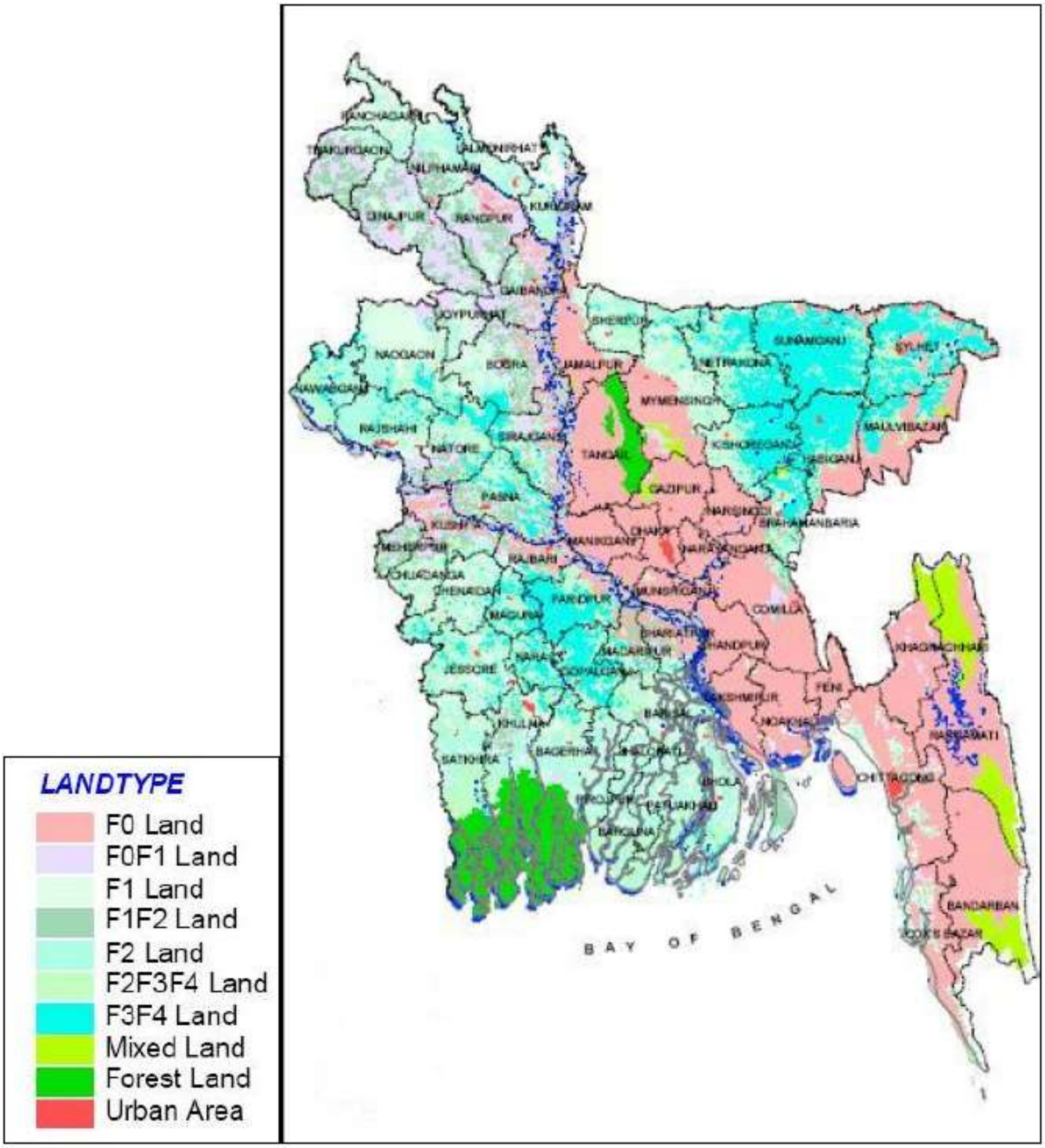


Fig 9.14 Projected Flood Hazard Map (2075), Source: Ministry of Environment and Forest (2005)

9.5 Impact of climate change on agriculture

The agriculture sector of Bangladesh is very vulnerable to climate change. The climate related elements, critical vulnerable regions, most impacted sectors are presented in Table 9.10 and intensity of impacts are given in Table 9.11.

Table 9.10. Causes of impacts, vulnerable regions and impacted sectors

Climate related elements	Critical vulnerable regions	Most impacted sectors
Temperature rise and drought	• North-west	• Agriculture (Crop, livestock and fisheries) • Water • Energy • Health
Sea level rise and salinity intrusion	• Coastal area • Island	• Agriculture (Crop, livestock and fisheries) • Water (water logging, drinking water and urban) • Human settlement • Energy • Health
Floods	• Central region • North east region • Charland	• Agriculture (Crop, livestock and fisheries) • Water (Urban, Industry) • Infrastructure • Human settlement • Health • Disaster • Energy
Cyclone and storm surge	Coastal and marine zone	• Marine fishing • Infrastructure • Human settlement • Life and property
Drainage congestion	Coastal area Urban South west	• Water (Navigation) • Agriculture (crops)

Source: NAPA

Table 9.11 Intensity of impacts on different sectors due to climate change

Physical vulnerability context								Sectoral vulnerability context
Extreme temperature	Sea level rise		Drought	Flood		Cyclone and storm surges	Erosion and accretion	
	Coastal inundation	Salinity intrusion		River flood	Flash flood			
+++	++	+++	+++	+	++	+++	-	Crop agriculture
++	+	+	++	++	+	+	-	Fisheries
++	++	+++	-	-	+	+++	-	Livestock
+	++		-	++	+	+	+++	Infrastructure
++	+++	++	-	++	+	+	-	Industries
++	+++	+++	-	++	-	+	-	Biodiversities
+++	+	+++	-	++	-	++	-	Health
-	-	-	-	-	-	+++	+++	Human settlement
++	+	-	-	+	-	+	-	Energy

Source NAPA

9.5.1 GOB initiatives to finance climate change adaptations

The Sixth Five Year Plan (2011-15) aimed to ensure a more equitable socio-economic environment and sustainable development through better protection from climate change and natural disasters. The government has allocated more than $10 billion in investments for the period 2007 to 2015 to make Bangladesh less vulnerable to natural disasters. Despite this effort, the direct annual cost of natural disasters over the last 10 years is estimated to be between 0.5 and 1 per cent of GDP. (The social safety net budget is 2.1 to 2.8 per cent of GDP.) The first phase of the Comprehensive Disaster Management Programme (CDMP), implemented by the Ministry of Food and Disaster Management (MoFDM), cost about $26 million.

Table 9.12 presents the Pilot Programme for Climate Resilience (PPCR) of the GoB in 2010. The government has taken several positive actions to implement BCCSAP-2009. It set up a ‘Climate Change Trust Fund (CCTF) and allocated about US$ 100 million in its budget for tackling climate change. A similar amount has been budgeted for 2010-11 as well. Early this year government has instituted a Board for managing the CCTF. The government has also established a Climate Change Unit under the MoEF to deal with all matters related to climate change and the implementation of BCCSAP-2009. So far the CCTF has approved a total of 66 projects (38 from the GoB and 28 from NGOs). Thirty four GoB projects are under implementation of which four are on food security, social protection and health, three for comprehensive disaster management, seven for infrastructure, six for research and knowledge development and six for mitigation and low carbon development. The country has invested heavily in adaptation measures such as flood management schemes, coastal embankments, cyclone and flood shelters, as well as raising roads and highways and research and development towards climate resilient farming. Over the last three decades Bangladesh has developed some ability to manage disasters, in particular, floods and cyclones, although there are considerable problems with the optimal operation and lack of maintenance of the flood control infrastructure.

Table 9.12 Allocation in PPCR for climate change adaptation in 2010

Program	Objectives	Implementing agency	DPs	Amount million US$
Promoting climate resilient agriculture and food security	1. Livelihood diversification through adaptive agriculture 2. Scaling up of climate resilient varieties including efficient irrigation system 3. Early warning system for farming communities	DAE, MOA and BMD	ADB, IFC and World Bank	13
Coastal embankment improvement and aforestation	1. Embankment stabilization	BWDB, FD,	World Bank	130
	2. Internal polder management	BFRI		
Coastal climate resilient water supply and infrastructure improvement	1. Improve safe drinking water supply and sanitation 2. Improve connectivity (small roads, bridges, culverts, etc.) within the coastal districts	LGED, Water Supply and Sewerage Authority, DPHE	ADB	250
Preparatory studies and technical assistance	1.Feasibility studies on individual climate resilient family housing in the coastal zone	MOFDM	IFC	0.7
	2. Capacity building for mainstreaming resilience to climate change and knowledge management, strengthening capacity of climate change department of MOEF			
Total				393.7

Source: Karim and Fakhrul , 2011

9.5.2 Investment needs for adaptation to (and mitigation of) climate change

Investment needs for adaptation to climate change in Bangladesh have been estimated for the period 2011-2030 (Karim and Fakhrul, 2011). The base line scenario of investment in the agriculture sector was assessed considering the investment database of the Ministry of Finance and Planning Commission collected from the Annual Development Programme (ADP) of the Government of Bangladesh (GoB) without any climate change adaptation costs for the period 2006- 2010. Annual investment requirement in the agriculture sector of Bangladesh was estimated considering baseline investment and assuming an annual growth rate of 8% (over the year 2012-2030) which is similar to GDP growth rate. The baseline scenario reflects a continuation of current policies and plans, i.e., a future until 2030 when no new measures are taken to address climate change (otherwise referred to as a "business as usual" scenario).

The adaptation scenario of investment in the agriculture sector was assessed considering ADP in 2010 with inclusion of costs of all adaptations to climate change. Considering this as adaptation costs, a projection has been made for the period 2012-2030 with an annual growth rate of 8%. The adaptation scenario until 2030 reflects new adaptation measures taken in the agriculture sector (an "adaptation scenario"). The investment costs of the baseline and adaptation scenarios are then compared to determine the changes in investments needed to mitigate or to adapt to the impacts on the agriculture sector in Bangladesh. Various adaptations to climate change for the agriculture sector were identified through review of various documents and consultations with concerned government agencies which are presented in Table 9.13.

Table 9.13 Mitigations and adaptations to climate change in agriculture of Bangladesh[5]

Broad programme areas	Adaptations
1. Awareness building	Specific extension and mass media programmes
2. Infrastructure development	Construction and repairing of roads and embankments
3. Disaster preparedness	Climate services, cyclone shelters, training and awareness
4. Disaster rehabilitation	Construction and management of food storage, silos, etc; distribution of inputs (seeds, fertilizers, saplings).
5. Research, Technology generation and knowledge management:	
Crops:	Varietal development: salt and draught tolerant varieties, management practices: short maturing varieties, fertilizer and soil management trials
Livestock:	Development of livestock species tolerant to climatic conditions, Animal health and diseases, Feeds and fodder production, Animal insurance, special breeding and
Fisheries:	Technology generation for increasing shrimp and fishery productivity, dredging of rivers, channels, community based management of water bodies and rehabilitation of fishers

[5] Mitigation measures are to be specified.

6. Agricultural extension services development	Technology disseminations: salt and draught tolerant varieties, improved farming practices for crops, livestock and fisheries, sustainable supply of inputs (seeds, fertilizers, breed, feed, fingerling, vaccines, etc.), irrigation and water management, soil fertility management (conservation and restoration of soil quality), plant protection and epidemiological surveillance.
7. Livestock development	Expanding veterinary health services, disease control, feeds and fodder production, special breeding and biogas production.
8. Fisheries development	Management of water reservoir, improved sanctuaries, disease control, improvement of fish landing sites and market infrastructure development, enhanced R & D and for climate resilient species development and management practices, protection of fish habitat from intrusion of slat water and establishment of improved hatchery
9. Food and nutrition security	Ensuring food availability, access, and utilization
10. Wet land conservation	Dredging, development of mangroves, sanctuary management and alternative income generation activities
11. Biodiversity management	
12. Reducing emission of green house gases from agriculture land	
13. Agro-processing	Promoting climate resilient agro-processing technique, value chain management specifically HRD and post harvest loss minimization
14. Market infrastructure development	Creation of facilities at all stages from farm to fork, development of long term storage facilities and quality control
15. Irrigation and water management	Improved water reservoir, channels, rivers and improved distribution system and on-farm water management technology, restructuring of land use based on availability and productivity
16. Agro-forestry	Improved nursery plantation an d management practices, development of climate resilient species, training on nursery and plantation
17. Coastal zone management	Polder management, development of improved drainage, land suitability zoning, and agricultural intensification, need for improved irrigation and water distribution system, climate resilient technology and improved management practices, establishment of special agricultural R & D centres, market development, promotion of off-farm activities, agro-tourism and human resettlement

Source: (Karim and Fakhrul, 2011)

A total of USD 69.67 billion is estimated as the adaptation cost for major investment components in the agriculture sector for the period 2011-30 (Table 9.14). The majority of the investment proportion is planned to be invested for the infrastructure development (30%) followed by market development (17%), irrigation and water management (15%), and others (14) (Fig. 9.15).

Table 9.14 Estimated Investment requirement for adaptations to (and mitigations of) climate change in Bangladesh agriculture (in million US$), 2011-2030

Year	Baseline scenario costs (A)	Adaptation costs to climate change (B)	Incremental adaptation costs (A-B)
2012	1375	3056	1681
2013	1485	3301	1816
2014	1604	3565	1961
2015	1733	3850	2118
2016	1871	4158	2287
2017	2021	4491	2470
2018	2183	4850	2667
2019	2357	5238	2881
2020	2546	5657	3111
2021	2749	6110	3360
2022	2969	6598	3629
2023	3207	7126	3919
2024	3463	7696	4233
2025	3740	8312	4572
2026	4040	8977	4937
2027	4363	9695	5332
2028	4712	10471	5759
2029	5089	11308	6220
2030	5496	12213	6717
Total	57002	126671	69669

Source: (Karim and Fakhrul, 2011)

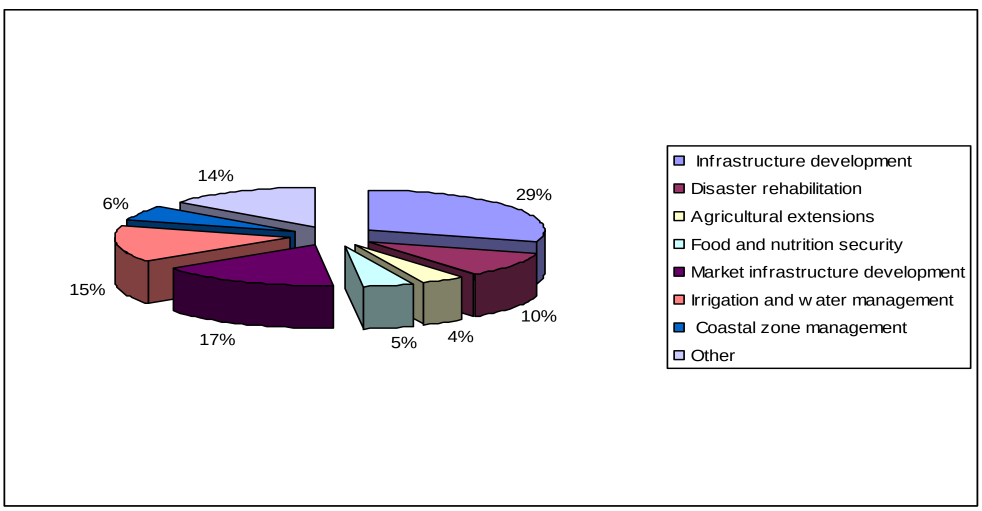


Figure 9.15. Proportions of incremental investment by type in Bangladesh Agriculture due to climate change mitigation and adaptation.
Source: (Karim and Fakhrul, 2011)

The comparison between the adaptation costs and baseline scenario without adaptation costs is illustrated in Fig. 9.16. There is a substantial difference between the baseline and the adaptation scenarios, implying that huge investment would be required for climate change adaptation. Bangladesh would require support from the Development Partners for climate change adaptations.

Therefore the credibility of the proposed investment needs to be assured by high quality, independent, multi-disciplinary research into the potential practical efficiency and effectiveness (i.e. Value for Money) of the proposed investments. In particular, past absence of maintenance and suitable operation of water management infrastructure needs to be properly addressed to ensure sustainability of projected benefits.

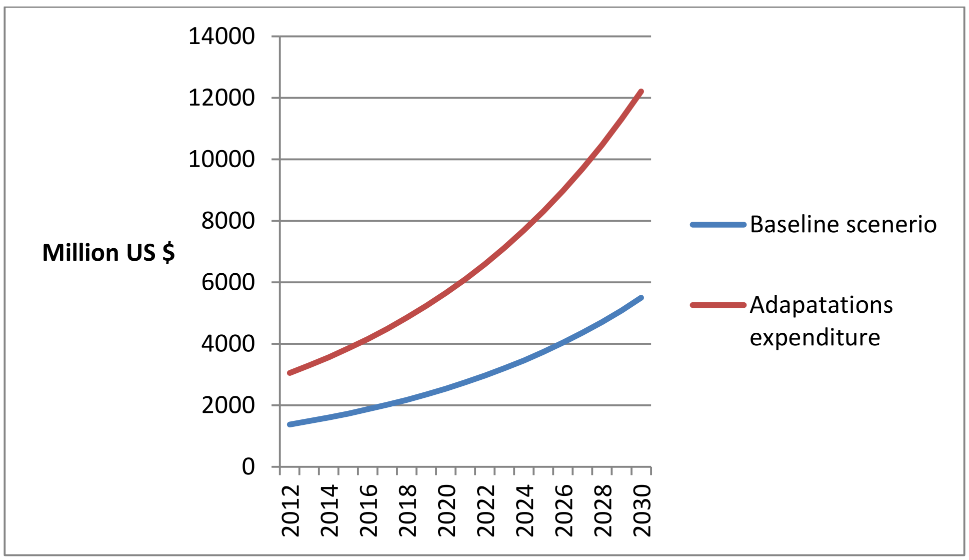


Figure 9.16 Mitigation and adaptation costs compared to baseline scenario.
Source: (Karim and Fakhrul, 2011)

Chapter 10

Future Trajectories

Chapter summary: Future trajectories

The major challenges related to agriculture and food security in Bangladesh are: (1) The curse of poverty, food insecurity and malnutrition. (2) Degradation of natural recourses, (3) Low agricultural productivity and limited modernization and/or diversification, (4) Weak research extension linkage and technology delivery, (5) High post harvest losses, (6) Problems of market linkages and value chains, (7) Scarcity of availability of agricultural labour, (8) Farm mechanization, (10) Food quality and safety problem, (11) Inadequate institutional credit, (12) Inadequate availability of quality seeds to the farmers, (12) Increased environmental shocks and livelihood risk.

Obstacles to be addressed by Government:

Development options or interventions: (1) Technology development and dissemination, (2) Improved water resource management and irrigation, (3) Crop diversification, (4) Sustainable supply and use of improved quality of inputs, (5) Farm mechanization, (6) Improving market linkages and development of value chains, (7) Livelihood improvement and food security, (8) Interventions for climate change adaptation and (10) Improved Land management

10.1. Challenges of agricultural development and food security

The major challenges related to agriculture and food security in Bangladesh are described below:

10.1.1 Poverty, food insecurity and malnutrition

Despite its transformation from a country of chronic food shortages to one of food self-sufficiency, Bangladesh still faces food security challenges. Around 40 per cent of people in rural Bangladesh live on less than $1.25 per day and 60 percent of that income is spent on food. In rural Bangladesh, 66 per cent of the labour force make their living in farming, and the vast majority of the farmers (81 percent) have farms less than 0.6 ha (Bangladesh Integrated Household Survey 2011-12)

Bangladesh has a population of approximately 165 million which is growing at a rate of 1.6% and the Bangladesh economy faces much pressure to feed increased numbers of people. Despite poverty reduction over the last two decades, absolute numbers are still high. About 50 million people, or 31.5% of the total population, are still poor, with one quarter caught in hard-core or extreme poverty. Regional and gender-based differences are also a great concern, as are time-bound vulnerabilities caused by fluctuations in weather throughout the year. Certain sections of people also tend to suffer more from poverty, malnutrition and food insecurity, including women, children, the elderly, the disabled and remote rural dwellers.

10.1.2 Degradation of natural recourses

The growing population places stress on limited natural resources. Cropped land is declining at the rate of about 1% per year. On average, Bangladesh is losing good quality agricultural land by approximately 80,000 ha annually due to urbanization, building of new infrastructure such as roads and implementation of other development projects. In addition, degradation is due to soil erosion, river erosion, soil fertility decline, depletion of soil organic matter, water logging, soil salinity, pan formation, acidification and deforestation.

Water erosion accounts for about 40 percent of land degradation due to washing away of topsoil and depositing sand on the croplands from upstream. Riverbank erosion and siltation are chronic concerns for Bangladesh. About 1,200 km of riverbank are eroding and more than 5,000 km of river banks face erosion-related problems in the country. The major rivers such as the Jamuna, Ganges and Padma consume several thousand hectares of floodplain making thousands of people landless and homeless every year. During the last three decades the Jamuna, Ganges and Padma rivers have consumed about 180,000 ha. (BWDB 2009). This amount excludes the annual erosion along the other major rivers and also in the Meghna estuary where the amount of erosion is very high. From the 1970s to early in the 1990s, the extent of mean annual erosion was about 3,300 hectares along both banks of the Jamuna River only. In the Flood Action Plan, Bangladesh predicts a net erosion loss in the Brahmaputra-Jamuna basin of 34,120 hectares of "mainland" acreage for the period 1992-2011, an area similar to that which had eroded in the 12 years previous to that time (MPO 1987). Similar rates of net loss in land due to erosion are expected in the other three main rivers. The river bank erosion is expected to increase further with the rise of water flow in the rivers due to global temperature rise and increased ice melting in the Himalayas. Given the geo-morphological development of the rivers and the prevailing socio-economic context of Bangladesh, it would not be feasible to protect against riverbank erosion. Non-structural measures, such as prediction of erosion when and where applicable and educating people how to mitigate, together with the planned development of recently accreted land, could be alternatives to minimize the suffering of the people.

In the last three decades, for instance, a 170,000 ha area of agriculture land has been affected by increased salinity. Soil fertility decline is occurring in Bangladesh due to unbalanced use of fertilizer, intensification of crop cultivation without appropriate techniques for sustainable natural resources management, and the advance of mono-culture rice without rotation. Cultivation practices in the Chittagong Hill Tracts (CHT) have led to top soil loss.

The major rivers passing through Bangladesh deposit sediment on the flood plains, gradually changing their topography and creating the phenomenon of *Charlands,* which tend to have lower agricultural productivity due to soil quality, and are subject to further erosion and frequent flood damage. The high levels of siltation affect irrigation and drainage systems; water logging can also be a severe problem. Over exploitation of groundwater has also led to arsenic contamination of tube wells and groundwater sources in 59 districts of the country where about 1.44 million tube wells have been affected and people are exposed to arsenic toxicity.[6]

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[6] FAO, UNICEF, WB & WHO, *Towards an Arsenic-Safe Environment in Bangladesh* (Dhaka, Bangladesh, March 2010), http://www.unicef.org/bangladesh/Towards_an_arsenic_safe_environ_report_22Mar2010.pdf.

Forest area amounts to about 11% of the total land area, but barely half of that is actual tree covered. High degradation of forested land is occurring in Bangladesh, largely due to population encroachment and crop/horticultural farming; illegal logging practices are also to blame (particularly in the CHT). In addition, the output of forests in Bangladesh is one of the lowest in the world. Productivity is low due to poor management practices, low initial survival, incompatible species composition, low soil efficiency, etc. Better management practices, even at community level, are necessary in this regard.

10.1.3 Low agricultural productivity and limited modernization and/or diversification

The agriculture sector in Bangladesh is characterized by a fragmentation of farm structure: 80% of farmers are marginal and small (0.02 to 1.0 ha of land). Decreasing farm sizes, inefficient use of limited water resources, degradation of soil quality and failure to adopt known modern technologies and practices are behind the phenomenon of low productivity. Indeed, there is a wide gap between farm yields and experimental stations. This is true across all sub-sectors. The yield gaps even in the favourable agri-ecological regions often exceed 40% of the farmer’s achievable yields with good practices.

10.1.4 Weak research extension linkage and technology delivery

While many improvements in management practices are theoretically possible, the National Mainstream Extension Approach of DAE, DLS and DOF does not have the capacity to cope with the emerging challenges in each sector on the scale needed. Equally, research scientists are only slowly adjusting the research agenda to meet the needs of farmers and producers. Despite a long history of Farmer Field Schools in the country there is a very limited amount of “action” or “adaptive” research being practised.

10.1.5 High post-harvest losses

There is large post-harvest loss, around 12% in paddy and 30% in vegetables and fruit (Table 10.1). There is also substantial scope to increase agricultural production by reducing post-harvest losses, by increasing the shelf life of perishable commodities and by adding value through agro-processing of agricultural commodities into finished or semi-finished products, packaging in appropriate containers, proper storage and exports. The food processing industry in Bangladesh is growing. The policy, institutional and infrastructure barriers to agribusiness, agro-processing and the supply chain need to be removed in order to provide a “big push” to agriculture and rural development. The production and processing of these products is also labour intensive and, therefore, likely to have a significant favorable impact for generating additional employment in the rural areas.

Table 10.1. Post harvest losses of major crops in Bangladesh

Sl. No.	Food crops	Production (million tons)	Loss (%)	Total losses (million tons)	Cost (Tk/kg)	Total loss (Million Tk.)
1.	Rice	29.75	12	3.57	8.00	28,560
2.	Wheat	0.77	13	0.10	8.00	8,000
3.	Maize	0.78	13	0.05	5.00	475
4.	Pulses	0.56	15	0.08	25.00	2,075
5.	Oil seeds	0.55	15	0.082	20.00	1,640
6.	Spices	1.46	15	0.22	10.00	2,200
7.	Vegetables	8.75	30	2.62	4.00	10,492
8.	Fruits	7.88	25	1.97	9.00	17,721
9.	Potato	5.37	20	1.07	8.00	8,592
10.	Sweet potato	0.72	20	0.15	3.00	435
11.	Sugarcane	3.51	20	0.70	2.00	1,404
	Total	60.1		10.1	-	81,594

Source: NMTPF, 2010.

10.1.6 Problems of market linkages and value chains

The lack of organized markets for selling farm produce is a significant problem for Bangladesh. The salient features of agricultural product markets are poor infrastructure, with lack of storage and processing facilities, poor roads and communication system, unfair practices of middlemen, etc. The marginal and small farmers are often facing the problem of marketing their products and are not getting a fair price due to the existence of trade syndicates. Additionally, in some localities such as coastal areas and the CHT, the limitations of infrastructure make access to markets difficult. The rate of post-harvest loss is quite high in such cases, estimated country-wide at around 12% in rice and 25% in vegetables and fruit.

Furthermore, agri-business and agro-processing activities are extremely restricted, which severely impedes the country's post-production potential. Value addition and supply chain investments including processing, packaging, storage and transportation at the local and national levels are a priority. In addition, efforts need to be made to ensure that products abide by certain quality attributes. Several issues including policy environment, such as product standardization, food safety, sanitary and phyto-sanitary measures need greater investment to increase the quality of produce and potentially the volume of exports.

In Bangladesh, small, medium, and even large farmers are vulnerable to the exercise and influence of market power by rural traders, wholesalers, retailers, and processors. These petty traders are poorly rewarded for their efforts and the risks they take in an environment of inadequate quality control and low gross returns as well as increasing product wastage. Formation of farmers' groups is one possible way to create better market linkages and ensure fairer competition in prices and curb exploitation of middlemen.

10.1.7 Scarcity of availability of agriculture labour

The share of the agricultural sector in informal economic activity in Bangladesh however, is very high (Sixth Five Year Plan, 2011). The contribution of labour in the agricultural sector is decreasing over the years (Figure 10.1). The participation rate of the labour force in the agricultural sector increased between 1999-2000 and 2002-2003 with a rate of 0.4 percent but since then it has decreased.

Household panel data collected from 62 villages showed that adult male participation in agriculture has sharply declined from 83% in 1988 to 56% in 2000, a decrease of 27%; this has however, increased to some extent to a level of 65% in 2008. Participation of women in agriculture on the other hand remained almost the same in 1988 and 2000 (59% and 58% respectively); but compared to 2000, in 2008 women's participation has increased by about 8%. Findings indicated that decrease in agricultural activities by adult males was due to less involvement in crop cultivation in recent years. About 79% of adult males were engaged in crop cultivation in 1988 which has dropped to only about 42% in the year 2000; however, there had been some increase in male participation in crop cultivation in 2008 (53%).

This transformation of agricultural labour is found to be due to productive and well paid jobs available mainly in the organized manufacturing and services sector. As a result, scarcity of agricultural labour during peak season is increasing. The government made a commitment to reduce the percentage of the labour force engaged in the agricultural sector to 30 percent by 2021. Based upon historical trends, the labour force engaged in agriculture has decreased to 47.3 percent in 2010 from 51.3 percent in 1999-2000. If this trend continues, the contribution of labour in agriculture might decrease to 39.55 percent by 2021, which is higher by about 10 per cent than the target of the government.

In Bangladesh, being a traditional Muslim society, women's participation in economic activities in general and in agriculture in particular has remained low. But recent Labour Force Surveys conducted by the Bangladesh Bureau of Statistics show rapidly increasing participation of women in economic activities. The progress is attributed to poverty, empowerment of women by NGOs, and migration of male family members from agriculture to non-farm occupations. With the absence of males, women's role is changing from unpaid family workers to farm managers.

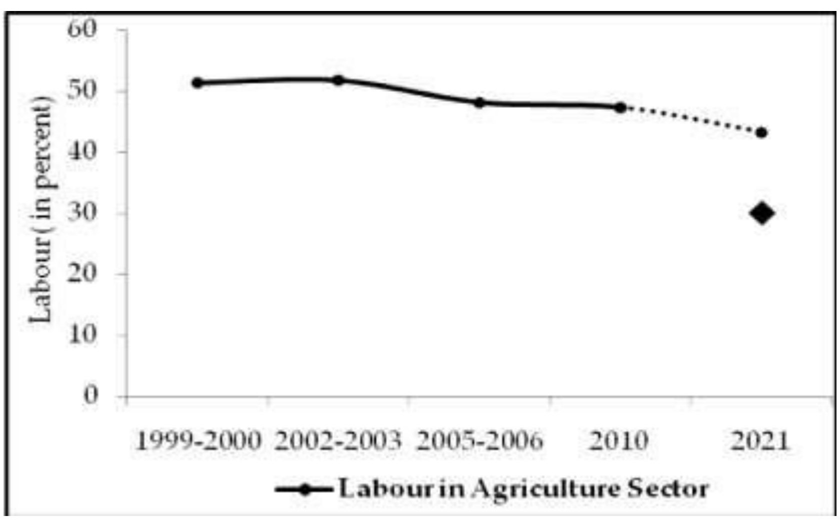

Figure 10.1: Labour employed in agriculture sector

Source: Labour Force Survey (1999-2000, 2002-2003, 2005-2006 and 2010), Bangladesh Bureau of Statistics (2002, 2004, 2008 and 2011a)

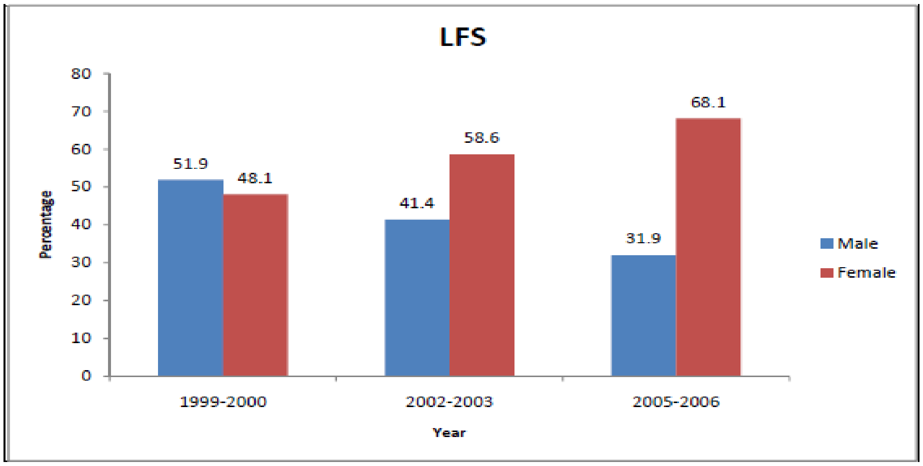

Figure 10.2 Percentage of adult male and female participation in Bangladesh agriculture over time
Source: Labor Force Survey (LFS) 1999-2000, 2002-2003 and 2005-2006.

7.8 Farm mechanization

Modernisation in the Bangladesh agricultural sector is going on with the increased use of power tillers, irrigation equipment, threshers, drum seeders, maize shellers, rice milling machines, improved storage, cool-chain and transportation, etc. Farm machinery, such as weeders, threshers, winnowers, centrifugal pumps etc. are developed and manufactured locally with locally available materials. Manually operated weeders and sprayers are used widely. A few hundred pedal and power operated winnowers are also being used in the country (Roy and Singh, 2008). It was found that farm mechanization promoted commercial farming and helped in reducing post-harvest losses. Post-harvest loss in agriculture amounts to over US$ 4,000 million a year. Proper grading, packing, pre-cooling, refrigerated storage and transportation can reduce these losses and maintain the quality. Mechanisation in the country is associated with some inherent drawbacks like fragmented land, poor buying capacity of farmers, lack of quality machines for farm operation, inadequate knowledge of the users about machines and insufficient awareness of building activities. For the modernization of the agricultural sector, support is needed in skill development of researchers, capacity building of manufacturers, formulation of agricultural mechanisation policies, support to the formation of farmers groups, review and rationalisation of current tariff rates and expansion of credit facilities for farm mechanisation.

10.1.9 Food quality and safety problems

Bangladesh faces significant problems with food contamination through poor handling practices, and deliberate adulteration for purposes of fraud (extension of shelf life, passing off cheaper ingredients as expensive ones, etc). Not only does this impact the health of the population, but it also affects the exportability of Bangladeshi agricultural produce. The challenge is how to create a satisfactory food control system backed by inspections and improved practices among food producers and handlers, as well as building awareness of consumers.

10.1.10 Inadequate institutional credit

While demand for credit is increasing with the advent of new technologies and high value crops, the supply side has remained less vibrant. The volume of institutional credit is conspicuously low and the proportion of the public sector in the total volume of institutional credit is even smaller. According to data from the Bangladesh Bank, around 25 percent total disbursement of rural credit is delivered by the public sector.

The remaining 75% has been delivered by micro-finance institutions (MFI) including NGOs and the *Grameen Bank*. However, the demand for credit is much more than that being met by non-institutional sources. In a case study conducted under the preparation of the Master Plan for agricultural development of the Southern region, it is roughly estimated that around 80 percent of the volume of credit comes from various non-institutional sources largely dominated by *mohajans* and *dadanders*. They charge interest on loans at exorbitant rates, generally 10 percent per month. Loan conditionality of *dadanders* is quite stringent, as they lend money with the guarantee of repayment in the form of products whose price is fixed unilaterally by them in advance. Advance sale of labour in crop fields in exchange for loans (cash or rice) is also common.

Specialized banks, like the *Krishi Bank*, are a major source of agricultural credit. Two-thirds of the credit from public sector agencies is from specialized banks (Planning Commission, 2011). As of July 2010, there were 527 NGOs registered by the Microfinance Regulatory Authority (MRA). The *Grameen Bank*, however, operates as a quasi-NGO specialized bank outside the orbit of the MRA. They usually cover the landless and poor women who are categorized as “non-farm” households (defined as those who own less than 0.02 ha of land). The average amount of microcredit from MFI sources has been Tk 7,144 (Planning Commission, 2011). The amount of credit received per person would be higher as people borrow from multiple sources.

Despite a fast growing microfinance sector and its better recovery performance, there has hardly been any attempt by public sector institutions, particularly specialized banks, to reform their mode of operation and make them user-friendly. Besides a few government projects with a credit component, public sector credit agencies are characterized by the following phenomena.

- Access to credit is impeded by procedural complexities, such as, provision of collateral, filling in forms and delay in approval.
- Farmers often find it difficult to understand procedures.
- Hidden and real costs of credit are high in terms of travel, time and obscure payments that discourage farmers to go to the banks for credit.
- Poor farmers do not receive satisfactory clientele service from banks.
- Women are excluded from the banking service as they can hardly offer any collateral (land).

As total demand for credit far outweighs its supply, private moneylenders dominate the credit market. Poor farmers have little choice.

10.1.11 Inadequate availability of quality seeds to the farmers

The first and foremost challenge in the seed sector of Bangladesh is how to make available a sufficient quantity of quality seeds to the farmers. The NSB has estimated national requirement of quality seeds to be 932,250 tons for the year 2011-12. The seed replacement rate of quality seed against national requirement was 12.61% in 2005-2006 which has increased to 20% (average of quality seed replacement rate of all agricultural crops) in 2011-2012 against target (22%). For improving total crop production, the seed replacement rate must be enhanced and the private sector has a major role to play in this endeavour.

10.1.12 Increased environmental shocks and livelihood risk

The prevailing high incidence of poverty and population density makes Bangladesh extremely vulnerable to climate change and natural disasters (flooding, tropical cyclones and storm surges). Indeed, in the Climate Change Vulnerability Index 2011, Bangladesh is rated 'extreme.' It is the sixth most cyclone-prone country in the world, and first rated flood prone country in terms of human exposure (annually, 30 to 50% of the country is flooded).

Climate change and variability have already been creating adverse impact on livelihoods, particularly for those who are living in the coastal areas and in the arid and semi-arid regions of the country. Poorer groups are even more vulnerable to climate-induced emergencies, in particular women and children. In addition to affecting lives and livelihoods directly, it also puts a strain on agricultural production and limits investments due to preoccupation with high risk. The most vulnerable regions in Bangladesh are 14 coastal districts in the south and 6 districts of the haor basins areas in the North-east.

10.2. Development Options

The following interventions have been suggested for the development of agriculture and achievement of food security in Bangladesh:

Technology development and dissemination

1) ***Enhance research and technology generation:*** To increase agricultural productivity and diversity in a sustainable manner requires research and technology development in support of increased productivity in varied ecosystems in the following areas: (i) for crops, varietals development (short maturing Aus and Aman rice, new HYVs, biotechnology) build on respective experiences of private and public sectors; management practices (fertilizer, cropping patterns, cultural practices for char land, hill and coastal areas); and water and soil conservation; (ii) promote frontier technology development through enhanced investment in R&D for increasing productivity. This will include activities to: (i) Develop new varieties, crops, improve food quality, nutrition, etc. (ii) Enhance agricultural productivity through diversification, sustainable management of natural resources (in flood plain and CHT) and inputs. (iii) Promote "agro-ecologically suitable" and "climate-smart" agriculture that are effective in feeding the population sustainably in the long term. (iv) Support transformation of agriculture by building innovative, action-oriented partnerships

with different countries. Promote innovation and best practice by bringing people together to share experience and expertise.

2) ***Improve research-extension-farmer linkages and extension services*:** Interventions should be based on existing programmes (such as the National Agricultural Technology Project) and aim to put in practice the agricultural extension policy. They are required in the areas of technology adoption, reducing yield gap, crop zoning and community-based learning (farmers skill training, soil health improvement, diversification of agriculture, cultivation of quick growing fruit and vegetables, cropping patterns, farm mechanization) and promotion of sustainable agriculture. In order for interventions to be successful, human and infrastructure capacities of DAE require strengthening.

Improved water resource management including irrigation

1)Augmentation of surface water for irrigation through development of water reservoirs, recharge of ground water, reduced use of ground water to avoid hazard of arsenic contamination: We have identified some key priority investment activities: (i) the development of small scale surface irrigation in the southern part of the country requiring new infrastructure and capacity building, possibly building on the projects implemented by the Ministry of Local Government; (iii) partially reduce reliance on deep tube well irrigation in the northern part of the country, reduce costs and mitigate the risk of arsenic contamination; (iv) rehabilitate dikes and embankments particularly affected by previous cyclones to protect vulnerable households and production base against sea intrusion in the extreme south, with effective community-based operation and maintenance of infrastructure (v) improved drainage, saline intrusion control and flood management.
2) Use water saving technology for improving efficiency of water and install facilities to reduce distribution losses: Activities include: (i) reduce water losses in existing schemes through improved water management (capacity building of water management organisations), development of water saving techniques or rehabilitation of existing schemes.
***3)Reduce impact of saline water intrusion in the South and enhance river water flow*:** The focused activities that emerged from the consultations are: rehabilitation of polders and their management; tidal river management; enhanced surface water irrigation; and improved brackish water resource management practices.

Crop diversification

Agricultural productivity enhancement through crop diversification, increased cropping intensity, appropriate farm mechanization, reduction of post-harvest losses, and modelling of climate events. Following public interventions will be needed:

Facilitate agricultural credit to farmers: Agricultural credit is an important factor for diversification of agriculture. Farmers with access to credit facilities are found to be more diversified than others.

Investment in transportation networks and improved market linkage: Access to markets is found to be less important at the farmers' level but it is important for increasing diversity in agriculture regionally. This means that districts with better communication and transport facilities are more diversified than other regions. Most of the non-cereal produce is perishable and so means of transportation and access to the market are important. It is necessary to promote export of agricultural commodities, particularly vegetables and fruit.

Training for farmers: Modern agriculture is much more challenging than before. There are elements of production, processing, storage and transportation and in all of them training is an important pre-condition for ensure higher profit to a farmer. To promote non-cereal diversification in agriculture, the DAE should organize itself to ensure farmers' level training programs.

Support research and extension for non-rice crops: To support research and extension for the promotion of pulses, oil crops, spices, roots and tubers, and vegetable crops.

Sustainable supply and use of improved quality inputs

1) ***Enhance availability of quality agricultural inputs*:** The proposed priority interventions are: expansion of both seed multiplication and processing farms and preservation facilities of BADC, NARS, DAE, and contract growers; capacity development of public laboratories and SCA for testing quality of inputs; strengthening participation of NGOs and private sector in seed distribution as the role of private sector in the provision of quality seeds and other inputs has increased over past years; capacity development of farmers for autonomous production of quality seeds; and establishment of mechanisms to ensure availability and reasonable prices of all quality and environmentally friendly agricultural inputs (i.e. seeds, planting materials, fertilizers, pesticides). Develop public private partnerships through capacity development. Public private partnerships are needed in order to strengthen capacity for the production of agricultural inputs, laboratories and the establishment of marketing networks in the country. It is necessary to establish an effective and strong monitoring system to protect against infected and low quality seeds from neighbouring countries.

2) ***Improve and increase sustainability of soil fertility management:*** Restoring soil fertility is an important issue for the Bangladesh government**.** The proposed interventions are to promote fertilizer use efficiency and balanced use of fertilizer. The main purpose is to strengthen environmentally sound fertility management practices. This will be done through facilitating application of fertilizers on the basis of soil tests, as well as strengthening of soil testing laboratories and promotion of improved soil health management practices. Additionally, awareness of the Upazilla Nirdeshika (land and soil use guide) for location specific prescription of fertilizers by the grass root level extension workers should be strengthened.

3) ***Facilitate access to credit and other financial services by smallholders and the rural poor***: There is a strong call for collateral-free bank loans/credit at low interest rates for crops, livestock and fishery production for smallholders and the rural poor. The need to create specialized financial institutions for these sectors was also iterated.

Farm mechanization

Agricultural production in the country is adversely affected owing to the insufficient use of farm power and inappropriate use of farm machinery thereby adversely impacting on environmental sustainability, labour productivity and/or labour scarcity. It is important to move towards sustainable agricultural practices, by increasing access to environmental friendly agricultural machinery that contributes to the enhancement of rural livelihoods, and reduces pressure on natural recourses that are the lifeblood for producing food. Some investment priorities are: (i) Increasing the availability of agricultural mechanization technology to the farmer. (ii) Develop and promote agricultural machinery that is resource and energy efficient and conserve natural resources. (iii) Applying appropriate machinery and equipment for agricultural production (iv) Promote research for development of cost-effective farm machinery for the farmers (v) Training and education for farmers in using suitable farm machinery.

Improving market linkages and development of value chains

1) ***Improvement of infrastructure:*** A number of **priority investments** have been identified that could form the programme, including (i) Construction and *adequate maintenance* of rural roads to facilitate marketing of products and access to services in particular in remote areas. (ii) Construction or rehabilitation of rural markets including the supply of potable water, drainage, and storage facilities. (iii) Improvement and rehabilitation of wholesale markets in major cities; (iv) Private storage facilities to reduce losses and increase value added.

2) ***Capacity building of value chain actors and market promotion:*** A number of **priority investments** have been identified that could form the programme, including (i) Capacity building for group marketing at community level in the form of marketing groups, service cooperatives whose capacities should be developed and training provided; (ii) Capacity development of farmers and market intermediaries through training in food quality and safety regulations and requirements, good agricultural practices so as to comply with market requirements; (iii) Improved post-harvest management, value chain analysis and facilitation (iv) Promote agro-processing. (v) Facilitate coordinated, market-based action, harnessing the productive capacity of agriculture to promote food security, and environmental sustainability.

3) ***Establishment of export processing zones:*** Harness opportunities to expand market linkages and agribusiness with establishment of export processing zones.

4) ***Improving Food Safety and Quality for Consumer Health and Nutrition:*** Food analytical laboratories at the central and regional level need to be established to facilitate support to food manufacturers, individuals and the enforcement of laws. There is no reliable surveillance data on food borne illnesses, impeding the understanding of the extent of disease burden and health and nutritional implications. An effective surveillance of food borne illnesses would therefore be necessary. These would include among others, strengthening capacity of the existing institutions, strengthening consumer protection and improving insufficient food safety activities.

Livelihood improvement and food security

1) **Development of programs of alternative income generation and food security**, reduce malnutrition of women, children and distressed population.

2) **Development of community based nutrition activities through livelihood approaches:** home gardening, poultry raising and other community level nutrition-based agricultural activities need to be included as a food based nutrition approach and also complemented by integrated horticultural development, fish ponds, behaviour change communication and other activities. This strategy will include linking agriculture and food based nutrition to other nutrition efforts, including health. The proposed programme would aim to restore a process to assist the rural communities, based on their local conditions and priorities, to undertake these activities through a livelihood approach aimed to build local capacities and provide technical and financial support in and where required.

3) **Livelihoods improvement of population of char land, haor, coastal region and CHT**: All of the *chars* regions are not easily accessible and people are beset with many problems and suffering. Despite appalling conditions, a large number of families, due to abject poverty and lack of alternatives, are often forced to relocate to such lands struggling with precarious weather and adverse living conditions. As the families are often hard to reach through mainstream anti-poverty programmes, it drastically reduces opportunities to promote social and economic development within these communities. In consequence, achievement of the millennium development goals (MDGs), accelerated economic growth and nationwide poverty reduction policies of the Government are hindered. Pioneering work by the government Char Livelihood Project and Char Development and Settlement Project may be mainstreamed and expanded.

Climate change adaptation

Bangladesh, due to its geo-physical position and socio-economic context, is highly prone to regular natural hazards and the impacts of climate change. Riverine *char* lands, coastal region and haor areas are considered as hotspots for climatic hazards. An integrated approach which combines traditional knowledge with innovative strategies needs to be adopted to address current vulnerability while building adaptive capacity to face emerging challenges. The process involves four inter-related strategies: promotion of climate-resilient livelihood strategies, disaster risk reduction strategies, capacity development for local civil society, and advocacy and social mobilization with particular focus on gender. Interventions should include: (i) Program to promote adaptive knowledge and technologies among communities/farmers. (ii) Enabling local communities to improve preparedness and participate in effective operation and maintenance of flood protection works, and modelling/researching the effectiveness of adaptations under extreme climatic events.

Improved Land management

1) **Promote planned urbanisation** and compact township planning to reduce substitution of agricultural land for non-agricultural purposes.

2) **Integrated char development and livelihood improvement:** The intervention activities include: (i) Prevent loss of life from natural disasters, (ii) Reduce loss of land, livestock and other assets due to flood and erosion, (iii) Promote sustainable agricultural development, (iv) Widen access to health and educational services, (v) Increase access to land rights for the landless, (vi) Improve access to development inputs and services.

3) **Improvement of land information, land administration and management**: Bangladesh has a very high population density. Scarce land and the rapid increase of population of the country are creating high pressure on the land-man ratio. The land ownership record system is old, paper based and incomplete in Bangladesh. Therefore, it is important to establish a compatible land administration and management system for establishing a systematic approach for planned land development. The Land Information System (LIS) should be an accountable and feasible systematic approach for developing an up-to-date land administration and management. The improved LIS shall be digitized and related to various quantitative and qualitative aspects of land resources. Holding different cartographic information, the improved LIS shall facilitate capturing, retrieval, and querying of information and provides tools to perform different analyses using digital information.

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Chapter 5

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Table 4.1: Land ownership by households

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