ASSESSMENT OF POTATO FARMERS' PERCEPTIONS ON ABIOTIC STRESSES AND IMPLICATIONS FOR POTATO IMPROVEMENT RESEARCH IN BANGLADESH: A BASELINE SURVEY

Team Members

M. A. Monayem Miah, S. Hossain, M. Hossain, M. S. Kadian, Tanvir. M. B. Hossain, M. S. Rahman, M. M. Hassan, N. Sharma, Z. Ibragimov, S. Araya, B. C. Kundu

AGRICULTURAL ECONOMICS DIVISION
BANGLADESH AGRICULTURAL RESEARCH INSTITUTE
JOYDEBPUR, GAZIPUR 1701

OCTOBER, 2011

ACKNOWLEDGEMENT

This study is an outcome of collaborative work of CIP and BARI. In the first place, the authors express their deepest indebtedness to the Almighty Allah, for blessing them in the successful completion of this report. The authors obtained help from many individuals during conducting and completing this research work and wish to acknowledge them with gratitude and appreciation.

Authors are grateful to Dr. Hamim Reza, Senior Scientific Officer, TCRC Sub-station, Bogra and Dr. Mahbub Alam Patwary, Senior Scientific Officer, Agricultural Research Sub-Station, Pahartoli, Chittagong for their co-operation, help in selecting study sites and constant support during field survey. The authors wish to record their gratitude to Dr. Md. Rafiqul Islam Mandal, Director General, Bangladesh Agricultural Research Institute (BARI) and Dr. Md. Badirul Islam, Director (TCRC), BARI, Gazipur for their encouragement, cooperation and suggestions in conducting this study. Authors are also thankful to Dr. Md. Azimuddin, PSO, ASICT, BARI for providing updated map of Bangladesh showing potato growing areas using GIS. Authors are especially thankful to the Gesellschaft fuer Technische Zusammenarbeit (GTZ) for financially supporting this study

Authors

Executive Summary

Introduction: Potato is an important food crop in Bangladesh. It ranks 11th in the world in terms of potato production in 2008 (Hossain and Miah, 2010). The area and production of potatoes are increasing day by day due to its higher demand and profitability. It has a significant contribution to the socio-economic condition of the people of Bangladesh.

Most farmers in Bangladesh are vulnerable to climate change since the production of potato is highly sensitive to various abiotic stresses including temperature and soil salinity. In 2005, Bangladesh, India and Pakistan faced temperatures 5–6°C above the regional average. Potato production is adversely affected by high temperature during tuber initiation and tuber bulking stages. The *Barind* and coastal areas of Bangladesh are facing temperature and salinity problem respectively. Therefore, it is important to develop potato varieties which can cope with the impending rise in temperature and salinity in the near future. The researchers and policy makers are lacking of abiotic stresses impact information for preparing appropriate policies for the development of heat, drought and saline tolerant potato varieties for the country. Therefore, the present study was undertaken to answer the following questions.

Research Questions: An effort has been made in this study to answer the following research questions.

1. What actions, according to farmers, can further increase potato yield and income on their farms?
2. What is farmers' perception on desirable and undesirable characters of existing potato varieties grown by them?
3. Why farmers abandoned some potato varieties in the past?
4. To what extent potato growers consider abiotic stresses a limiting factor?
5. How to identify baseline indicators and standpoints for future impact assessment of potato research and development in Bangladesh?

Objectives of the study: The specific objectives of the study were: (i) To assess farmers' perception on abiotic stresses on potato cultivation in Bangladesh; and (ii) To generate some baseline indicators for future impact assessment of potato research and development in Bangladesh.

Methodology: The study was conducted in two purposively selected potato growing districts namely Bogra (drought) and Chittagong (heat and saline). Again, four *Upazilas* namely Shibgonj, Dupchachia, Kahalu and Adamdighi from Bogra district and two *Upazilas* namely Satkania and Chandanaish from Chittagong district were also purposively selected consulting with extension personnel and potato scientists. Finally, a total of 240 potato farmers taking 40 farmers from each *Upazila* were randomly chosen irrespective of farm category for interview. A pre-tested interview schedule was used to collect farm level data from potato farmers during October, 2010. Relevant information of the studied *Upazilas* was obtained from local DAE offices. Secondary data were gathered from BBS, journal, articles, research reports and various websites. The collected data were analyzed based on various categories of potato farmers. Descriptive statistics were used to fulfill the objectives of the study.

Farmers' Perception on Variety Development

Responses on yield enhancing attribute: The highest proportion of farmers (68.8%) in drought areas (Bogra district) believes that the current potato yield can be further increased through introducing new high yielding potato varieties followed by drought resistant varieties (64.2%), training on potato cultivation (59.6%), availability of adequate fund (57.9%), proper late blight control (57.5%), and adequate quantity and timely availability of fertilizers (51.3%). In heat and saline areas, 75% farmers believed that the current potato yield can be further

increased through introducing new high yielding potato varieties followed by heat tolerant variety (70.0%), proper late blight control (61.3%), salinity tolerant variety (57.5%) and adequate fund (57.5%). Marginal farmers in both areas put higher stress on having adequate availability of fund and new high yielding varieties.

Good and bad varietal characters: In Bogra, the good characters of cultivated HYV potatoes were reported to be high yield (92.2%), early maturity (44.8%) and good demand/price (44.3%). Whereas, good test (77.3%), good storability (66.0%) and good colour (42.0%) were reported for local variety. Again, the bad qualities of cultivated HYV potatoes were poor storability (78.1%), bad taste (77.6%) and low price (35.4%). For local variety, the bad qualities were low yield (84%), bad tuber size (60.7%) and late maturity (49.3%).

In Chittagong, the good characters of HYV potatoes were high yield (90.5%) and early maturity (66.7%). Good test (87.5%), high demand/price (78.8%) and good storability (75%) were reported for local variety. Again, the bad qualities of HYV potatoes were poor storability (71.4%) and bad taste (52.4%). For local variety, the bad qualities were late maturity (70.0%) and low yield (58.8%).

Response on abiotic stresses: Respondent farmers faced some abiotic stresses during potato production. Drought and heat were two important limiting factors towards achieving the higher levels of potato yield in both the study areas. However, a positive relationship was found between farm category and two limiting factors. The relative importance of salinity was low. According to farmers' perceptions, Dohazari variety for Chittagong district and Lalpakri for Bogra district have higher levels of tolerance against abiotic stresses compared to other local and HYV potatoes.

Reasons for abandoning varieties: Lower yield, susceptible to diseases, late maturity and low demand were reported to be the reasons of abandoning some potato varieties by some farmers in the past. Bogra farmers abandoned Granola, Diamant, and Pakri varieties, whereas Chittagong farmers abandoned Diamant variety. However, the abandoned varieties are still popular and widely cultivated in the other areas.

Preference of potato varieties: The farmers of all categories in both the study areas showed very high level of preference toward the variety having early maturing and drought tolerant. The other important attributes farmers wanted in new potato varieties were heat tolerance and salinity tolerance.

Baseline Indicators Related to Potato Farmers

Family size and dependency ratio: The average family size per household was 5.01 in drought areas (Bogra) and 8.04 in Chittagong. The dependency ratio found in Chittagong (4.24) was much higher compared to Bogra (3.28). The earning member of respondent family increases with the increase in farm category.

Educational qualification: The percent of educated farmers found in Bogra (87.6%) was higher than that of Chittagong areas (82.6%). Of the educated respondents, the highest 41.3% and 40.0% farmers of Bogra and Chittagong had secondary and primary level of education respectively.

Occupational status: In Bogra, about 98% potato farmers' primary occupation was agriculture, whereas it was 100% for Chittagong. On the other hand, service and business were the highest secondary occupation for Bogra and Chittagong farmers respectively.

Land holding: The average farm size of the respondent farmers of Bogra was 1.07 ha in which 77.2% was from own cultivated land. Again the average farm size of Chittagong farmers was 0.95 ha in which 39.3% was from own cultivated land. The average lands under potato cultivation were 0.66 and 0.46 ha for Bogra and Chittagong districts, respectively.

Land use pattern: The highest amount of land was devoted to *T. Aman* (36.9%) and *Boro* rice (36.1%) cultivation in drought areas, whereas *Aus* rice was occupied the highest proportion of cultivated land (25.5%) in heat and saline areas. A positive relationship was observed between the percent share of land devoted to rice cultivation and farm category in both the areas.

Inventory of livestock and poultry: A respondent household in both the study areas owned more than three cattle. The numbers of goat, chicken and pigeon owned by the farmers of Bogra were much higher than the farmers of Chittagong areas. Almost a positive relationship was found between the number of livestock owned and farm category in both the study areas.

Inventory of agricultural equipment: The higher number of large and medium category farmers in both the study areas owned costly agricultural equipment like power tiller and irrigation device. To some extent, a positive relationship was found between the number of farm equipment owned and farm category.

House condition: Most respondent farmers (73.8%) in drought areas lived in those houses of which walls were constructed by mud, and roofs were made of CI sheet, whereas this percentage (42.5%) was much lower for heat and saline areas (Chittagong).

Sanitation system: Majority of the potato growers (50-68%) in both the study areas used sanitary toilets and only a few farmers used flush toilet.

Household expenditure: The average monthly expenditure of a Bogra farmer was estimated at Tk. 6,292/US$ which was much lower than the farmer of Chittagong (Tk. 14,811). The highest percentage of expenditure was for purchasing food items in both the study areas.

Modern amenities: About 84% farmers in Bogra and 79% in Chittagong owned a mobile phone. The percentage of television owner was much higher in Bogra (70%) than in Chittagong (44%). However, the use of modern amenities increases with the increase in farm size.

Social participation: About 35% respondent farmers in Bogra and 15% farmers in Chittagong were a member of the society. The highest involvement was reported by large farmers followed by small and medium farmers.

Baseline Indicators on Potato Production and Marketing

Varietal adoption: The highly adopted varieties were Granula (51.7%), Cardinal (17.9%) and Lalpakri (39.6%) in Bogra district, whereas Dohazari (33.3%) was found in Chittagong areas.

Potato yield: In Bogra, the average yields during 2009-10 ranged from 21.5 to 22.6 t/ha for HYV potato and 15.0 to 16.8 t/hafor local variety compared to just 13.1 t/ha at national level. In the same year, the average yield was estimated at 22.1 t/ha for HYV potato and 16.3 t/ha for local variety in Chittagong district.

Variety wise seed rate: In 2009-10, the average seed rates for HYV potato were 1.83 t/ha for Granula, 1.66 t/ha for Diamant and 1.54 t/ha for Cardinal. For local variety, it was 0.95 t/ha for Ruma, 0.87 t/ha for Pakri and 1.05 t/ha for Dohazari.

Size of seed potato: In Bogra, most of the farmers (62.5-75.6%) used medium sized (20-60g) and cut seeds for HYV potatoes, whereas the highest percentage of farmers ranged from 63.2 to 92.9% used small sized (<20g) whole tubers for local variety during 2009-10. In the same year, 75.0% and 63.8% Chittagong farmers used medium and small sized seed potatoes for HYV and local potato respectively. Some Chittagong farmers replaced Dohazari variety after 19.6 years, whereas Bogra farmers replaced Ruma variety after 1.0 year. For other varieties this period ranged from 3.5 to 7.4 years.

Retention of own seed: The percentages of own retained seed were 7.4% for HYV and 8.0% for local variety in Bogra district. Again, the percentages of own retained seed were 5% for HYV and 15% for local variety in Chittagong district. 85% Bogra farmers sorted out larger tubers from potato heap for storing as seed, while it was 98.8% for Chittagong farmers. Among

the other techniques, 63.8% farmers in Bogra and 67.5% farmers in Chittagong retained own seed through selecting the best looking plants respectively.

Sources of seed potatoes: About 60-69% Bogra farmers used HYV potato seeds from own source, whereas these proportions ranged from 80.0-88.1% for local varieties. Again, 57.1% and 91.3% Chittagong farmers used HYV and local potato seeds from own source respectively. The other important sources of seed potatoes were traders, neighbouring farmers and BADC.

Problems of seed collection: Higher price and scarcity of quality seed were the major problems reported by the respondent farmers for seed collection in both the study areas.

Post-harvest losses: It comprises harvesting loss and storage loss. In both the study areas, the highest proportion of harvesting losses was due to potato remained under soil (61-65%) followed by potato cutting/cracking (24-30%), insect damage (1-9%), and curing loss after heaps (3-4%). Again, total storage loss was reported to be 125 kg/ton for Bogra and 186 kg/ton for Chittagong areas.

Disposal pattern: The respondent farmers of drought areas sold 91% of HYV and 84% of local variety potatoes, whereas the share was 93% and 78% for heat and saline areas, respectively. They consumed local potato higher than HYV potato in both the areas. About 73.0% and 88.1% Bogra and Chittagong farmers sold potatoes to *Beparis* respectively. The other important buyers of their produce were retailers and *Faria*. In most cases, farmers themselves took decision for selling potatoes.

Other Baseline Indicators

Status of mechanization: Out of seven operations, mechanization index was higher for field preparation through two wheel tractor followed by irrigation and spraying in both the study areas. Farmers still follow the primitive method for grading potato in the study areas.

Access to technical information: In Bogra, the important source of information regarding new inputs was input dealers/sellers (69.4%) followed by government extension worker (66.3%) and neighbouring farmers (55.0%). In Chittagong, the important source of information on new inputs was also input dealers/sellers (60.3%) followed by government extension worker (55.1%) and neighbouring farmers (48.7%). Radio/TV was the main information source for weather forecast and government polices in both the areas.

Soil health awareness: Respondent potato farmers in both areas were not aware of the soil health of their crop land. Only 12.5% farmers in Bogra and 6.3% farmers in Chittagong tested the soil of their crop land.

Status and quality of irrigation water: Ground water was the major source of irrigation for Bogra farmer, whereas this major source was surface water for Chittagong farmers. About 89% respondent farmers in Bogra irrigated their crops through purchased water from DTW, while this percentage was 85% for Chittagong farmers. They had no complaint against the quality of irrigation water. The important irrigation problems were regular power supply of electricity, ground water scarcity and non-availability of irrigation water in both the areas.

Cropping patterns: *T.aman-Potato-Boro* was the dominant cropping pattern in Bogra, whereas it was *Aus-Potato-Fallow* in Chittagong district.

Policy Implication: Potato production is highly sensitive to various abiotic stresses including temperature and soil salinity. Development of heat, drought and saline tolerant varieties enhance potato production and extend its cultivation to non-traditional potato areas. Therefore, breeders should assign higher importance to develop abiotic stress tolerant potato varieties for combating future climate threats. They should also give emphasis to develop early maturing varieties having better storability at home condition and late blight resistance.

Higher proportion of marginal and small farmers considered drought and heat to be potential threat for their potato crops. So, the state authority should encourage cooperative tube wells through establishing self help groups of the farmers providing them financial assistance.

The farmers of all categories believe that their current potato yield can be further increased through imparting training and making input (i.e. seed, fertilizer, pesticides) timely available and inexpensive. Therefore, government should provide training to the interested farmers on a regular basis and take appropriate steps to make these inputs available and economic to the farmers.

TABLE OF CONTENTS

Particulars **Page No.**

Particulars **Page No.**

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

Aman rice	=	A type of rice cultivated during Monsoon season
Aus rice	=	A type of rice cultivated during Kharif II season (April-June)
BARI	=	Bangladesh Agricultural Research Institute
BADC	=	Bangladesh Agricultural Development Corporation
BBS	=	Bangladesh Bureau of Statistics
Bepari	=	Relatively big and non-licensed traders in the market premises.
Boro rice	=	A type of rice cultivated during Spring season (January to mid-April)
CI	=	Corrugated Iron (locally called tin)
CIP	=	International Potato Center
DAE	=	Department of Agricultural Extension
Dolil	=	Land/property ownership document
DTW	=	Deep Tube Well
Faria	=	Non-licensed small traders who usually operate in the primary market
GIS		Geographical Information System
ha	=	Hectare
HYV	=	High Yielding Variety
HTW	=	Hand Tube Well
ICM	=	Integrated Crop Management
IPCC	=	Intergovernmental Panel on Climate Change
IPM	=	Integrated Pest Management
kg	=	Kilogram
LLP	=	Low Lift Pump
Macha	=	Bamboo made platform
NGO	=	Non-government Organization
Pacca house	=	House with concrete roof and brick wall
PT	=	Power Tiller (two-wheel tractor)
Rabi season	=	Winter cropping season
SAAO	=	Sub-Assistant Agricultural Officer
STW	=	Shallow Tube Well
SRDI	=	Soil Resources Development Institute
Tk.	=	Taka (Bangladeshi currency)
Upazila	=	A small administrative unit of Bangladesh

Conversion Factors:

1 US dollar = Taka 80.00 (as on 30 September, 2011)
1 ha = 10,000 sqm
1 ton = 1000 kg

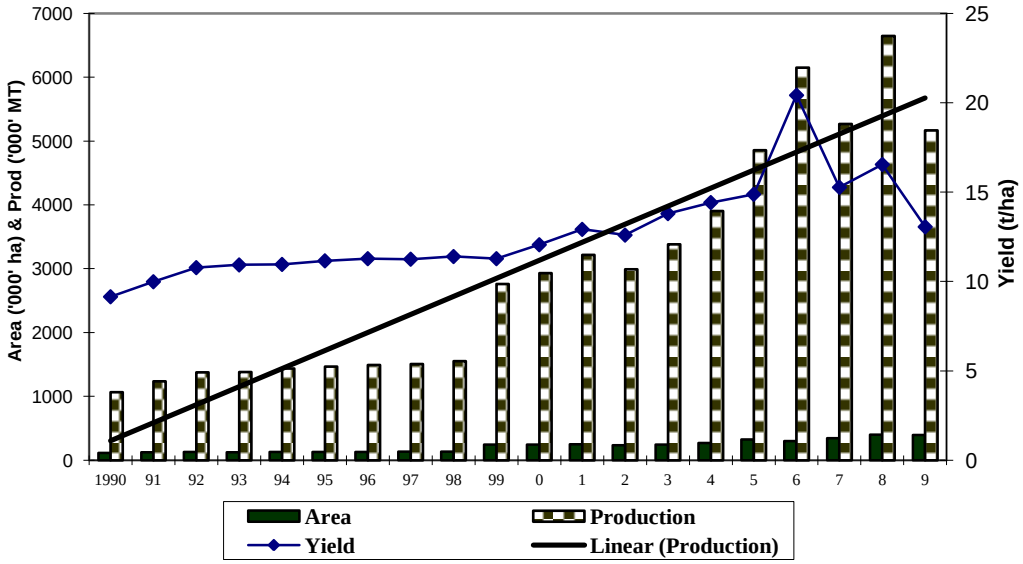
1. INTRODUCTION

1.1 Background

Potato (*Solanum tuberosum* L.) is one of the most important food crops grown in more than 100 countries in the world. Over one billion people consume potato worldwide and it is the staple diet of half a billion people in developing countries. Because of the dry matter, edible energy and edible protein content, potato is considered nutritionally a superior vegetable as well as a versatile food item not only in our country but also throughout the world (CPRI, 1992).

Potato has emerged as a major food as well as vegetable crop in Bangladesh and is being cultivated throughout the country. Bangladesh ranks 11th in the world in terms of potato production in 2008 (Hossain and Miah, 2010). In 2008-2009, about 5166.7 thousands metric tons of potatoes have been produced from 395.6 thousands hectares (2.9% of total cultivated area) of land in Bangladesh (BBS, 2009). The area and production of potatoes are increasing day by day due to its higher demand and profitability. The annual growth rates of area, production and yield of potato were estimated at 7.14%, 9.90% and 2.76% during 1989-1990 to 2008-2009 respectively (Fig-1).

Fig-1. Area, production and yield of potato, 1990-09



Potato has multi-purpose uses (*Singara*, *Samucha, Chop*, chips etc.) and provides nutrients and plenty of carbohydrates. Since potato is consumed as a popular vegetable, it helps stabilize the vegetables market round the year through its adequate supply (Moazzem and Fujita, 2004). It is one of the productive crops that can play significant role in ensuring food security in Bangladesh since it can help to widen the food supply base and thereby help to minimize the risk of serious food shortages in the tropics and sub-tropics. Recently, the government has been trying to diversify food habits and encouraged potato consumption to reduce pressure on cereals especially on rice. So, potato is becoming an important food for ensuring food security in Bangladesh.

Climate change is now widely recognized as a phenomenon which is threatening for current way of life on the earth. During 2005, Bangladesh, India and Pakistan faced temperatures 5–6°C above the regional average (UNDP, 2008). The average warming in annual temperature in the Himalaya and its vicinity between 1977 and 1994 was 0.06ºC per year (Shrestha *et al*., 1999). Climate related changes are observed in precipitation patterns, temperature, high intensity floods, cyclones, landslides, erosion and increased sedimentation in Bangladesh.

Climate change raises serious concerns for developing countries like Bangladesh, with its tremendous social, environmental and economic impacts. IPCC fourth assessment report mentions climate change could decrease agricultural productivity in South Asia up to 30% by mid-21st century (IPCC, 2007).

Most farmers in Bangladesh produce potato at a subsistence level. They are also vulnerable to climate change since the production of potato is highly sensitive to various abiotic stresses including temperature and soil salinity. It is adversely affected by high temperature during tuber initiation (Basu and Minhas, 1991) and tuber bulking (Minhas and Devendra, 2005) stages. In India, potato production is estimated to fall during 2020 and 2050, respectively, by 19.65% and 44.90% in Karnataka; 18.23% and 31.77% in Gujarat; 13.02% and 24.59% in Maharashtra; and 9.65% and 16.62% in Madhya Pradesh (Singh *et al*., 2008). Many parts of Bangladesh especially in *Barind* areas (drought prawn) are also facing temperature problem. Nonetheless, the saline areas of the country are also vulnerable to crop production including potato. So there is an urgent need to develop varieties which can cope with the impending rise in temperature and salinity. Developing heat, drought and saline tolerant potato varieties will not only enhance production but may also extend its cultivation to non-traditional potato areas.

No empirical socio-economic study regarding this line has been found in Bangladesh. The researchers and policy makers are lacking of abiotic stresses impact information for preparing appropriate policies for the development of heat, drought and saline tolerant potato varieties for the country. Therefore, the present study was undertaken to answer the following questions.

1.2 Research Questions

Bangladesh Agricultural Research Institute has developed a good number of improved potato varieties for farm level use. But most farmers are found to be reluctant to adopt these varieties that need to be identified. It is also important to assess the nature and magnitudes of farmers' awareness about the harmful impacts of future abiotic stresses in potato cultivation. Finally, some baseline indicators are essential to be used in near future for measuring the socio-economic impacts of investment on varietal research and development in Bangladesh. However, an effort has been made in this study to answer the following research questions.

7. What actions, according to farmers, can further increase potato yield and income on their farms?
8. What is farmers' perception on desirable and undesirable characters of existing potato varieties grown by them?
9. Why farmers abandoned some potato varieties in the past?
10. To what extent potato growers consider abiotic stresses a limiting factor?
11. How to identify and fix baseline indicators and standpoints for future impact assessment of potato research and development in Bangladesh?

1.3 Objectives

The specific objectives of the study were:

1. To assess farmers' perception on abiotic stresses on potato cultivation in Bangladesh.
2. To generate some baseline indicators for future impact assessment of potato research and development in Bangladesh.

2. THE STUDY AREAS

The study was conducted in two districts of Bangladesh, namely Bogra and Chittagong (see Fig-2). Details of these districts are described in the following sections.

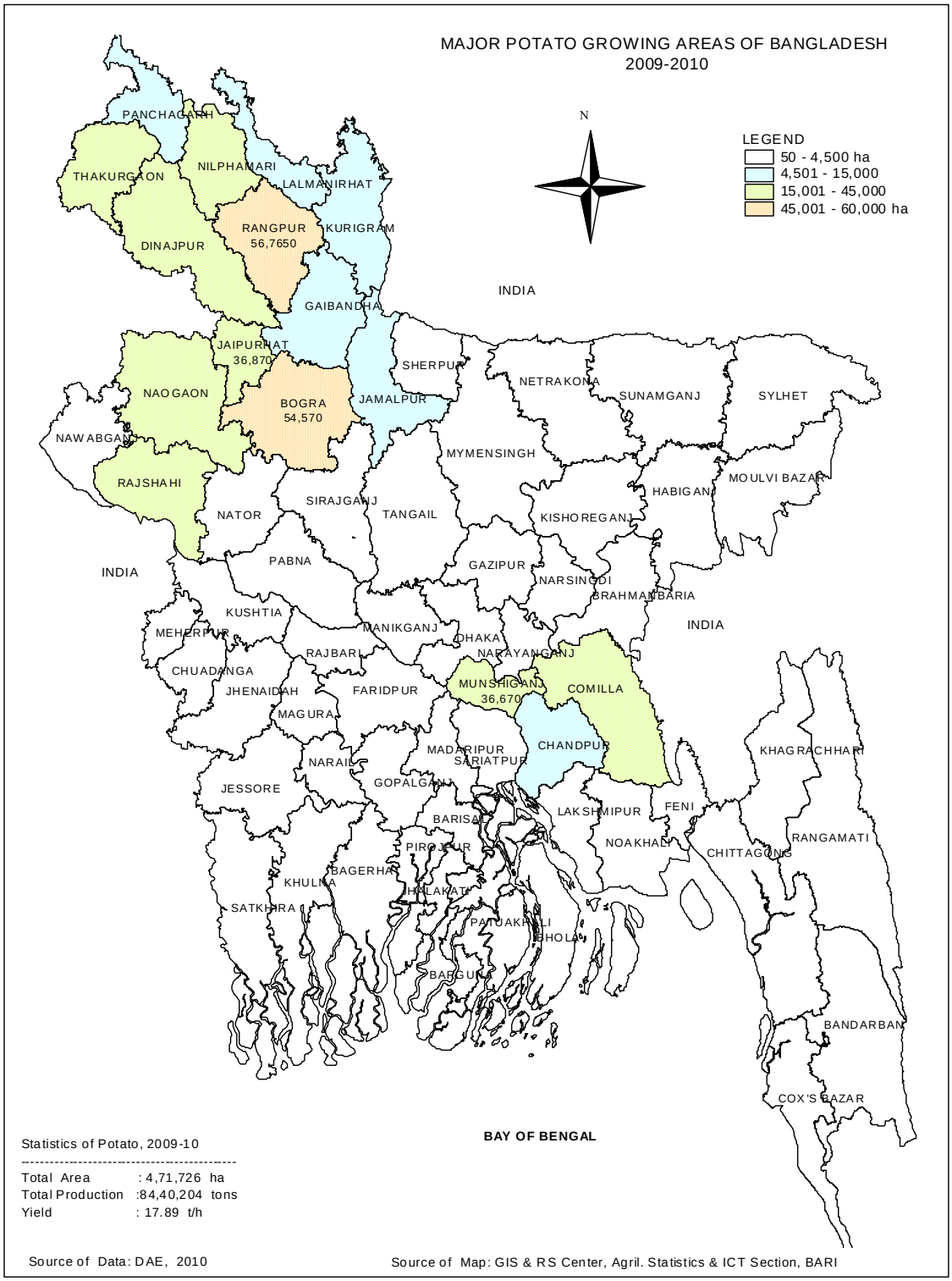


Figure 2. Map of Bangladesh showing potato growing areas

2.1 Bogra District (Drought area)

2.1.1 Location and area: Bogra is one of the oldest and historic districts of Bangladesh. The district lies in 24.78^0 North latitudes and 89.35^0 East longitudes. The district is bordered on the north by Gaibandha district, on the south by Natore and Sirajgong district, on the east by Jamalpur district and on the west by Naogaon district. Bogra is the gateway to the north Bengal. It holds an area of 2898 sq. km. It ranks 3rd among the eight districts of Rajshahi division in term of land area. Among the 12 *Upazilas*, Shibgonj holds an area of 315.33 sq. km (121.7 sq miles) which is 10.88% of the total area of the district. Kahalu having an area of 238.38 sq. km. Adamdighi and Dupchachia hold an area of 169.1 and 162.45 sq km respectively.

2.1.2 Soil type and topography: The soil of most parts of the district is called eastern alluvial tract. Eastern alluvial tract is fertilized by the silt of flood waters. Western part of the district is slightly higher than eastern parts and is generally above flood level. Except Dupchachia most of the lands of the study areas are medium high land. In Dupchachia most parts of the land (10,610 ha) is high followed by low land (Table 1).

Table 1. Information relating to agriculture of the studied *Upazilas* of Bogra district

Particulars	Shibgonj	Dupchachia	Kahalu	Adamdighi
1. Land topography (ha)	**23863 (100)**	**13950 (100)**	**20540 (100)**	**13756 (100)**
High land (flood free)	6920 (29)	10610 (76)	--	31 (0)
Medium land (0'-3' water)	12000 (50)	3300 (24)	20540 (100)	10645 (77)
Medium-low land (3'-6' water)	4943 (21)	40 (0)	--	3080 (23)
2. Total cultivable land (ha)	**26135**	**16035**	**20690**	**16978**
a. Permanent fallow	65	2085	150	--
b. Net cultivable land (ha)	26070 (100)	13950 (100)	20540 (100)	16978 (100)
Single cropped area	600 (2)	150 (1)	--	4500 (27)
Double cropped area	8370 (32)	4000 (29)	5764 (28)	4650 (27)
Triple cropped area	17100 (66)	9800 (70)	14776 (72)	7828 (46)
3. Cropping intensity (%)	265	269	273	267
4. Agro-ecological zones (AEZ)	3, 4, 25, 27	25 & 3	25 & 3	25 & 3
5. Farmers' category	**43560 (100)**	**28500 (100)**	**41082 (100)**	**38690 (100)**
Large farmer (>7.5 acre)	824 (2)	868 (3)	652 (2)	548 (1)
Medium farmer (2.5-7.49 acre)	6537 (15)	4687 (16)	3896 (9)	3550 (9)
Small farmer (2.5-2.49 acre)	8027 (18)	8250 (29)	5756 (14)	4708 (12)
Marginal farmer (0.5-1.49 acre)	3808 (9)	8195 (29)	19906 (48)	12998 (34)
Landless farmer (<0.49 acre)	24364 (56)	6500 (23)	10872 (26)	9761 (25)
Tenant farmers	--	--	--	7125(18)
6. No. of irrigation equipment	**8865**	**1387**	**1257**	**1487**
Deep tube well	282	242	570	220
Shallow tube well	8583	1145	687	1267

Figures in the parentheses indicate percentage of total
Source: Upazila DAE offices, 2010

2.1.3 Cultivable land and cropping pattern: Among the study areas net cultivable land is found higher for Shibgonj (26,070 ha) followed by Kahalu (20,540 ha). Most of the lands of the study areas are triple cropped. The cropping intensities of the studied *Upazilas* are more than 260% which is much higher than the national average of 182% (Table 1). The major cropping patterns found in the study areas are Fallow - T. Aman - Boro and Fallow - T. Aman - Potato.

2.1.4 Major crops: T.Aman, *Boro*, potato, mustard, and different vegetables are the major crops grown in the study areas. In Shibgonj *Upazila* the highest land is occupied by boro

cultivation (22,700 ha) followed by T. Aman and potato. In other three *Upazilas*, the highest lands are under the cultivation of T. Aman rice followed by *Boro* rice and potato**.** The area and production of different crops are presented in Table 2.

Table 2. Area and production of major crops grown in the studied *Upazilas* of Bogra district

Crops	Shibgonj		Dupchachia		Kahalu		Adamdighi	
	Area (ha)	Production (mt)	Area (ha)	Production (mt)	Area (ha)	Production (mt)	Area (ha)	Production (mt)
1. T.Aus rice	900	2700	205	461	50	86	1500	4125
2. T.Aman rice	22400	89600	13,500	43300	19250	45238	12800	45568
3. Boro rice	22700	113500	13,450	56213	19110	80166	12750	49470
4. Potato	18000	270000	7400	84600	9250	184723	5000	71250
5. S. potato	100	2200	5	55	--	--	--	--
6. Wheat	85	212.5	10	31	25	71	10	23
7. Maize	700	5250	1.5	9	2	11	--	--
8. Mustard	650	650	2100	2460	2720	3346	1750	1925
9. Pulses	120	144	15	20	--	--	--	--
10. Chili	300	4650	30	45	25	--	60	90
11. Onion	150	1575	15	90	20	--	75	638
12. Vegetables	2500	51250	165	3300	400	9732	510	6120
13. Garlic	70	595	--	--	--	--	--	--
14. Turmeric	300	5550	--	--	--	--	--	--
15. Ginger	80	1240	--	--	--	--	--	--
16. Banana	800	-	--	--	--	--	--	--

Source: Upazila DAE offices, 2010

2.1.5 Climate: The climate of the district is temperate and pleasant. The maximum and minimum average temperature was 40.5^0C and 7^0C respectively (BBS, 2009). Most of the areas of Bogra district are under Barind Tract (one of the agricultural ecological zones of Bangladesh). These areas are also experienced frequent drought in many years. The rainfall is generally heavy during the month of May. The annual rainfall of the district during 2008-09 was recorded as 1434 mm. The level of humidity is around 60% in February and around 86% in July.

2.1.6 River system: The major rivers of the district are Jamun, Donai, Karotoya, Bengali, and Nagar. The total length of all the rivers in the district is about 127 km. These rivers are of little importance for communication.

2.1.7 Households and population: The total number of households in Bogra district are about 6,88,000 (BBS, 2009). Among the study areas the highest number of households is estimated for Shibgonj (43,560) followed by Kahalu (41,082), Adamdighi (38,690) and Dupchachia (28,500). According to the BBS 2009, total population of the district was about 3013 thousand with a density of 1024 per sq.km which is higher than the national average of 933 per sq.km. Among the selected *Upazilas*, the density of population is higher in Adamdighi (1009 per sq.km) compared to other three *Upazials*. The ratio of male and female in the district was 106:100.

2.2 Chittagong District (Heat and Saline area)

2.2.1 Location and area: Chittagong district is located in south eastern region of Bangladesh. It is the second most developed district of Bangladesh. It is situated in 22.34^0 north latitudes and 91.84^0 east longitudes. It holds an area of 5283 sq. km. It is about 3.58% of total area of the country. In respect of size, it ranks 2^{nd} among the district of the country. Among 26 *Upazilas* of the district, Satkania situated in 22.21^0 north and 92.0412^0 east longitudes with an area of 281 sq.km which is 5.32% of total area of the district. On the other hand, Chandanaish holds an area of 202 sq. km which is 3.82% of the total area of the district.

2.2.2 Soil type and topography: The soil of the district is mainly formed by grey piedmont and brown hill soils. Most of the land is high land (4045 ha) in Satkania, whereas it is medium high in Chandanaish *Upazila*. Details are shown in Table 3.

2.2.3 Cultivable land and cropping pattern: Total cultivable land is higher in Satkania (13,655 ha) compared to Chandanaish (10,306 ha). Most of the cultivable lands of the study areas are double cropped. The cropping intensity of Satkania (187%) is lower than Chandanaish (206%) *Upazila*. The major cropping patterns of the study areas are T. Aus-Fallow-Potato; and Fallow-T.Aman-Boro (Table 3).

Table 3. Information relating to agriculture of the studied *Upazilas* of Chittagong district

Particulars	Satkania	Chandanaish
1. Land topography (ha)	**4620 (100)**	**10306 (100)**
High land (flood free)	4045 (88)	1065 (10)
Medium land (0'-3' water)	--	6061 (59)
Medium-low land (3'-6' water)	575 (12)	2993 (29)
Very low land	--	187 (2)
2. Total cultivable land (ha)	13655	10306
a. Permanent fallow	-	-
b. Net cultivable land (ha)	**13655 (100)**	**10306 (100)**
Single cropped area	2649 (19)	1217 (12)
Double cropped area	10061 (74)	6892 (67)
Triple cropped area	945 (7)	2197 (21)
3. Cropping intensity (%)	187	206
4. Agro-ecological zones (AEZ)	--	23, 29 & 22
5. Farmers' category	**53147 (100)**	**46695 (100)**
Large farmer (>7.5 acre)	1225 (2)	481 (1)
Medium farmer (2.5-7.49 acre)	2426 (5)	2235 (5)
Small farmer (2.5-2.49 acre)	6244 (12)	6605 (14)
Marginal farmer (0.5-1.49 acre)	29520 (56)	13563 (29)
Landless farmer (<0.49 acre)	13732 (26)	7449 (16)
Tenant farmers	--	16362 (35)
6. No. of irrigation equipment		
Deep tube well	22	1
Shallow tube well	276	64
Low lift pump	364	127
Functional irrigation engine	--	266

Figures in the parentheses indicate percentage of total
Source: Upazila DAE offices, 2010

2.2.4 Major crops: T. Aman, boro, T.Aus, pulses, and potato are the major crops grown in the study areas. In both areas, the highest amount of lands is found to be cultivated to T. Aman rice followed by Boro, T. Aus and potato. Details can be seen in Table 4.

2.2.5 Climate: The maximum and minimum average temperature of the district is 38^0C and 11^0C respectively as recorded by the metrological department. Annual total rainfall is 3461 mm in 2008-2009. Humidity level is around 65% in February and 85% in July. These *Upazilas* are mainly heat and saline prone areas.

Table 4. Area and production of major crops grown in the studied *Upazilas* of Chittagong district

Crops	Satkania		Chandanaish	
	Area (ha)	Production (mt)	Area (ha)	Production (mt)
1. T. Aus rice	1460	4022	2650	6975
2. T. Aman rice	12710	37228	8350	22526
3. Boro rice	5190	17122	3046	11034
4. Potato	1150	14846	540	9720
5. S. potato	--	--	330	3630
6. Mustard	55	53	50	50
7. Pulses	1122	1130	430	465
8. Chili	236	267	300	450
9. Onion	8	34	5	30
10. Vegetables	1484	26694	131	7860

Source: Upazila DAE offices, 2010

2.2.6 River system: The Karnaphuli and Sangu are the main two rivers flow over the district. Karnaphuli river plays an important role in the national economy. The total length of the rivers of the district is about 87 km.

2.2.7 Households and population: According to the BBS (2009), the total number of households of Chittagong district was about 12,40,000. The total number of households in Satkania and Chandanaish *Upazila* is more than 50 and 46 thousands respectively. Population of the district is about 6,61,21,000. The density of population was estimated as 1239 per sq.km as compared to 933 per sq. km for the country. The population density is much higher in Satkania *Upazila* (1067 per sq.km) compared to Chandanaish *Upazila* (856 per sq.km). The male and female ratio is 111:100 for the district.

3. METHODOLOGY

The study was conducted in two purposively selected potato growing districts namely Bogra and Chittagong as discussed in previous sections. Bogra district represents the drought prawn areas, whereas Chittagong district represent the heat and saline areas of Bangladesh. Again, four *Upazilas* from Bogra district and two *Upazilas* from Chittagong district were also purposively selected consulting with both local extension personnel and potato scientists. Finally, a total of 240 potato farmers taking 40 farmers from each *Upazila* were randomly chosen irrespective of farm category (e.g. marginal, small, medium, and large) for interview.

A pre-tested interview schedule was used to collect primary data and information from potato farmers during October, 2010. Relevant information of the studied *Upazilas* were obtained from local DAE offices. Secondary data were gathered from BBS, journal articles, research reports and various websites. A team of experienced scientists and trained enumerators collected primary data and information using personal interview technique. The collected data were edited and analyzed based on various categories of potato farmers i.e. marginal (cultivated area *0.50-1.49 acre)*, small *(cultivated area 2.5-2.49 acre)*, medium (cultivated area *2.5-7.49 acre*) and large (cultivated area *>7.5 acre)*. In most cases, simple statistical procedures and methods were used to fulfill the objectives of the study. Indices were also calculated for some important attributes for easy understanding.

4. FARMERS' PERCEPTION ON VARIETY DEVLOPMENT IN DROUGHT PRONE AREAS

4.1 Responses on Yield Enhancing Attributes

An attempt was made to analyze farmers' opinions on whether potato yield on their farms can increase and results have been presented in Table 5. A total of nineteen factors relating to crop management and enabling environment, which can contribute towards increasing the yield of potato along with factors respective importance in farmers' mind were also collected and analyzed.

The farmers in the drought prone areas believe that it is possible to increase the yield of potato. The highest proportion of farmers (68.8%) believes that the current potato yield can be further increased through introducing new high yielding potato varieties. Other closely perceived factors by the farmers were drought resistant potato varieties (64.2%) followed by training on potato cultivation (59.6%), availability of adequate fund (57.9%), proper late blight control (57.5%), and adequate quantity and timely availability of fertilizers (51.3%). Importance index of these factors, ranging from 1 (low) to 5 (high) was the highest for high yielding new potato varieties (3.1) followed by drought resistant potato varieties (2.5), availability of adequate fund (2.3), adequate quantity and timely availability of fertilizers (2.2), and proper late blight control (2.1).

The analysis also reveals that marginal farmers put higher stress on having adequate availability of fund and new high yielding varieties. Both medium and large category farmers put the highest emphasis on having drought tolerant potato varieties and proper late blight control (Table 5).

4.2 Good and Bad Varietal Characters

Potato farmers in the drought areas cultivated different types of HYV and local potatoes. They were asked to name three most important good and bad characters of their cultivated potato varieties. In the case of HYV potato, the highest desirable varietal character was high yield (92.2%) followed by early maturity (44.8%), good demand/price (44.3%) and desirable tuber size (33.9%). On the other hand, good test (77.3%), good storability (66%), higher price (59.3%), and good colour (42.0%) were important desirable characters of the local variety (Table 6).

Respondent farmers also mentioned undesirable qualities of their cultivated varieties. The highest proportion of farmers (78.1%) opined that poor storability was the worst character of HYV potato which was followed by bad taste (77.6%), low price (35.4%) and susceptible to late blight (27.6%). For local variety, the undesirable characters were reported to be low yield (84%), bad tuber size (60.7%), late maturity (49.3%), and susceptible to late blight (32%).

Table 5. Bogra farmers' perceptions on factors increasing the yield of potato (multiple responses)

Factors of increasing yield	Farmers' Category								All category	
	Marginal farmer		Small farmer		Medium farmer		Large farmer			
	% responded	Impor-tance	% responded	Impor-tance	% responded	Impor-tance	% responded	Impor-tance	% responded	Impor-tance
Yield can further increase	100.0	--	100.0	--	100.0	--	100.0	--	100.0	--
1. Timely and sufficient irrigation water	56.3	1.9	44.1	1.5	42.3	1.5	40.0	1.3	42.9	1.5
2. Soil reclamation (for alkaline/saline/too acidic)	12.5	0.4	16.9	0.7	20.5	0.8	0.0	0.0	17.1	0.7
3. High yielding potato varieties	87.5	3.8	69.9	3.0	69.2	2.9	70.0	2.4	68.8	3.1
4. Drought resistant/ tolerant potato varieties	43.8	1.8	62.5	2.4	78.2	2.9	80.0	3.0	64.2	2.5
5. Heat tolerant potato varieties	56.3	1.9	50.0	1.7	39.7	1.3	60.0	1.5	45.4	1.6
6. Salinity tolerance	31.3	0.8	19.1	0.3	16.7	0.4	20.0	0.3	19.2	0.4
7. Higher doses of fertilizers	12.5	0.3	24.3	1.0	19.2	0.8	10.0	0.1	20.8	0.9
8. Proper weed control	12.5	0.4	11.8	0.4	11.5	0.4	10.0	0.4	11.7	0.4
9. Right insect/ pest control	18.8	0.7	31.6	1.0	30.8	1.1	20.0	0.8	29.6	1.0
10. Right late blight disease management	62.5	2.4	57.4	2.1	61.5	2.2	70.0	2.9	57.5	2.1
11. Right control of other diseases	25.0	0.9	28.7	1.0	29.5	1.0	10.0	0.4	27.9	1.0
12.Right quality and timely availability of pesticides	50.0	1.8	37.5	1.3	44.9	1.6	60.0	1.7	39.6	1.5
13. Right quality and timely availability of fertilisers	68.8	3.1	50.0	2.0	55.1	2.3	40.0	1.4	51.3	2.2
14. Right quality and timely availability of seed	37.5	1.8	47.8	1.8	55.1	2.4	60.0	2.5	47.9	2.0
15. Availability of adequate funds	87.5	3.9	61.0	2.3	52.6	1.9	40.0	1.6	57.9	2.3
16. Low prices of inputs	37.5	1.6	38.2	1.4	29.5	1.2	10.0	0.4	34.2	1.3
17. Improvement in agricultural extension services	31.3	1.3	31.6	1.1	37.2	1.3	40.0	1.4	32.1	1.2
18. Keep potato in the field for long time	12.5	0.6	2.9	0.1	7.7	0.2	10.0	0.2	5.0	0.1
19. Training on potato cultivation	68.8	2.3	63.2	1.9	59.0	1.9	30.0	1.0	59.6	1.9

* Farmers' perceived importance index (range 1 to 5): 1= very low, 2= Low, 3= Medium, 4= High, 5= Very high

Table 6. Percent responses on desirable and undesirable qualities of different varieties

Type of quality	High Yielding Variety (HYV)				Local Variety (LV)			
	Gran-ula	Card-inal	Dia-mant	All HYV	Ruma	Lal pakri	Fata pakri	All LV
No. of respondent	***n* = *126***	***n*** = 51	***n*** = 15	***n*** = 192	***n*** = 22	***n*** = 91	***n*** = 37	***n*** = 150
A. Good qualities								
High yielding	98.4	82.4	73.3	92.2	68.2	4.4	13.5	16.0
Good skin colour	13.5	37.3	26.7	20.8	63.6	38.5	37.8	42.0
Heat tolerant	3.2	--	--	2.1	--	1.1	2.7	1.3
Resistant to late blight	19.8	5.9	20.0	16.1	9.1	3.3	--	3.3
Early maturing	51.6	29.4	40.0	44.8	45.5	4.4	8.1	11.3
Good tuber size	39.7	23.5	20.0	33.9	31.8	2.2	8.1	8.0
Drought tolerant	2.4	--	--	1.6	9.1	11.0	16.2	12.0
Good storability	4.0	7.8	6.7	5.2	50.0	69.2	67.6	66.0
Good demand/high price	38.1	54.9	60.0	44.3	13.6	67.0	67.6	59.3
Good in taste	3.2	54.9	53.3	20.8	4.5	94.5	78.4	77.3
Others	5.6	--	--	3.6	--	2.2	--	1.3
B. Bad qualities								
Low yielding	3.2	13.7	6.7	6.3	27.3	94.5	91.9	84.0
Bad skin colour	18.3	17.6	6.7	17.2	9.1	1.1	--	2.0
Susceptible tolerant	--	2.0	--	0.5	--	--	--	--
Susceptible to late blight	24.6	35.3	26.7	27.6	36.4	29.7	35.1	32.0
Late maturing	--	15.7	20.0	5.7	--	58.2	56.8	49.3
Bad tuber size	2.4	5.9	6.7	3.6	22.7	61.5	81.1	60.7
Susceptible to drought	12.7	19.6	26.7	15.6	--	1.1	--	0.7
Bad storability	81.0	72.5	73.3	78.1	68.2	3.3	2.7	12.7
Low demand/low price	42.9	23.5	13.3	35.4	13.6	--	2.7	2.7
Taste is not good	92.9	51.0	40.0	77.6	50.0	1.1	2.7	8.7
Others	10.3	13.7	6.7	10.9	9.1	2.2	5.4	4.0

4.3 Reasons for Abandoning Varieties

Due to some negative perceptions some respondent farmers in Bogra district abandoned five potato varieties of which three HYV and two local varieties. Low yield and susceptible to diseases were reported to be common reasons for abandoning these varieties as shown in Table 7. Late maturity was another important reason for which some farmers in all study areas abandoned Diamant, Cardinal and Pakri varieties. It is important to state that the potato varieties those were abandoned by some responding farmers are still popular and widely cultivated varieties in the study areas.

Table 7. Reasons for varietals abandonment in Bogra (multiple responses)

(Figures in %)

Reasons	Granula *(n = 111)*	Diamant *(n = 36)*	Cardinal *(n = 41)*	Ruma *(n = 2)*	Pakri *(n = 151)*
Low yield	0.9	8.3		50.0	23.8
Susceptible to diseases	2.7	2.8	7.3	50.0	6.6
Low demand/price	1.8	--	--	--	--
Late maturing	--	5.6	12.2	--	22.5
Low demand/price	--	--	2.4	--	--
Bad storability	--	--	2.4	--	--

Note: (i) Due to less number of responses in respect to various farm categories, the category wise analysis was not carried out.

(ii) Bogra farmers abandoned potato varieties 2.22 years ago.

4.4 Preference of Potato Varieties

Respondent farmers were asked to give preference on the four available future potato varieties against abiotic stresses. The likely future varieties will be heat tolerant, drought tolerant, saline tolerant and early bulking in nature. Respondent's preferences were analyzed and presented in Table 8. It was observed that the farmers of all categories showed very high level of preference (4.62) toward the variety having early maturing character. Among the three characters of abiotic stresses, respondent farmers expressed the highest level of preference (3.74) for drought tolerant variety followed by heat tolerant (2.72) and saline tolerant variety (1.41) in the near future.

Table 8. Level of preference of potato varieties in Bogra against abiotic stresses in the near future

Potato variety	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
Heat tolerant	3.22	2.74	2.56	3.13	2.72
Drought tolerant	4.22	3.80	3.56	3.63	3.74
Saline tolerant	1.56	1.53	1.17	1.38	1.41
Early maturing	4.22	4.66	4.65	4.38	4.62

Note: Level of preference: Very low =1; Low = 2; Medium = 3; High = 4; Very high =5

4.5 Response on Abiotic Stresses

Heat, drought and salinity are very important abiotic stress factors for crop production. With exposure to higher temperature, potato plants show increase vegetative growth with out converting carbohydrates into tubers (Minhas and Devendra, 2005). Drought is responsible in general disturbance in plant health. Plant becomes weak and more susceptible to other biotic and abiotic stresses.

Bogra district represents the drought area of Bangladesh. Respondent farmers faced to some extent these abiotic stresses during potato production. Therefore, potato farmers were asked to express their opinions on these three abiotic stresses. The respondent farmers in all categories believed that drought and heat were important two limiting factors towards achieving the higher levels of yield (Table 9). A lower proportion (1.05) of respondents pointed out salinity as abiotic stress to the potato crop.

Table 9. Relative importance of abiotic stresses in Bogra district

Abiotic stress	Farmers' category				All category *(n = 160)*
	Marginal *(n = 9)*	Small *(n = 91)*	Medium *(n = 52)*	Large *(n = 8)*	
Draught	4.33	3.84	3.65	3.63	3.79
Heat	3.00	3.10	2.90	3.25	3.04
Salinity	1.00	1.00	1.00	1.50	1.05

Note: Level of priorities: 1= very low, 2= Low, 3= Medium, 4= High, and 5= Very high

Respondent farmers were also interviewed to give their perceptions on the abiotic tolerance capacity of their cultivated potato varieties. In this respect, they pointed out Lalpakri which have higher levels of tolerance against abiotic stresses compared to other local and HYV potatoes (Table 10). Cardinal and Diamant varieties were reported to be more or less similar level of tolerance (1.8) against abiotic stresses.

Table 10. Level of abiotic stress tolerances of different potato varieties in Bogra district

Variety	Farmers' category				All category *(n = 160)*
	Marginal *(n = 9)*	Small *(n = 91)*	Medium *(n = 52)*	Large *(n = 8)*	
Granula	2.0 (3)	2.0 (22)	2.0 (17)	2.5 (4)	2.1 (46)
Cardinal	--	1.9 (8)	1.7 (11)	2.0 (1)	1.8 (20)
Diamant	--	1.8 (4)	2.0 (3)	1.0 (1)	1.8 (8)
Pakri	1.0 (3)	1.5 (32)	1.3 (29)	1.5 (4)	1.4 (68)

Note: Figures in the parentheses are number of respondents

Level of abiotic stresses tolerance (1= Very high, 2= High, 3= Medium, 4= Low, 5= Very low)

5. FARMERS' PERCEPTION ON VARIETY DEVLOPMENT IN HEAT AND SALINE AREAS

5.1 Responses on Yield Enhancing Attributes

All the respondent farmers of heat and saline areas believe that current potato yield can further be increased through many ways. Seventy five percent farmers believe that the current potato yield can be further increased through introducing high yielding new potato varieties. Other perceived factors by the farmers were heat tolerant potato varieties (75%), proper late blight control (61.25%), salinity tolerant potato varieties (57.5%), the availability of adequate fund (57.5%), timely and sufficient irrigation (53.75%), and low price of inputs (53.75%). Importance index of these factors, ranging from 1 (low) to 5 (high) was the highest for high yielding new potato varieties (3.13) followed by heat tolerant potato varieties (2.61), availability of adequate fund (2.23), proper late blight control (2.19), and drought tolerant variety (2.01). The analysis also reveals that marginal farmers put higher stress on having adequate availability of fund and high yielding new varieties (Table 11).

5.2 Good and Bad Varietal Characters

The potato farmers of the study areas cultivated two potato varieties namely diamante (HYV) and dohazari (local). They mentioned three most important good and bad characters of their cultivated potato varieties. In the case of diamante variety, the highest desirable varietal character was high yield (90.5%) followed by early maturity (66.7%), good demand/price (47.6%) and desirable tuber size (38.1%). On the other hand, good test (87.5%), higher price (78.8%), and good storability (75%) were important desirable characters of the local variety (Table 6).

They also mentioned some undesirable qualities of their cultivated varieties. The highest proportion of farmers (71.4%) opined that poor storability was the worst character of HYV potato which was followed by bad taste (52.4%), low price (42.9%) and susceptible to late blight (28.6%). The undesirable characters of the local variety were late maturity (70%), low yield (58.8%), bad tuber size (53.8%), and susceptible to late blight (43.8%).

Table 11. Chittagong farmers' perceptions on factors increasing the yield of potato (multiple responses)

Factors of increasing yield	Farmers' Category								All category	
	Marginal farmer		Small farmer		Medium farmer		Large farmer			
	% responded	Impor-tance	% responded	Impor-tance	% responded	Impor-tance	% responded	Impor-tance	% responded	Impor-tance
Yield can further increase	100	--	100	--	100	--	100	--	100	--
1. Timely and sufficient irrigation water	57.14	1.71	51.11	1.51	57.69	1.88	50	2	53.75	1.66
2. Soil reclamation (for alkaline/saline/too acidic)	14.29	0.29	17.78	0.76	15.38	0.62	--	--	16.25	0.65
3. High yielding potato varieties	85.71	3.86	73.33	3.20	73.08	2.73	100	4	75.00	3.13
4. Drought resistant/ tolerant potato varieties	57.14	2.14	51.11	1.87	61.54	2.23	50.00	2.00	55.00	2.01
5. Heat tolerant potato varieties	71.43	2.57	71.11	2.71	69.23	2.46	50.00	2.50	70.00	2.61
6. Salinity tolerance	71.43	1.86	57.78	1.02	50.00	1.23	100.00	1.50	57.50	1.18
7. Higher doses of fertilizers	--	--	24.44	0.93	15.38	0.73	--	--	18.75	0.76
8. Proper weed control	14.29	0.43	4.44	0.13	15.38	0.46	50.00	2.00	10.00	0.31
9. Right insect/ pest control	14.29	0.43	13.33	0.42	38.46	1.35	50.00	2.00	22.50	0.76
10. Right late blight disease management	71.43	2.71	60.00	2.13	57.69	1.96	100.00	4.50	61.25	2.19
11. Right control of other diseases	42.86	1.57	42.22	1.38	42.31	1.42	50.00	2.00	42.50	1.43
12.Right quality and timely availability of pesticides	57.14	2.00	37.78	1.42	53.85	1.77	50.00	2.00	45.00	1.60
13. Right quality and timely availability of fertilisers	57.14	2.57	44.44	1.76	53.85	2.23	50.00	2.00	48.75	1.99
14. Right quality and timely availability of seed	28.57	1.43	37.78	1.82	53.85	2.23	50.00	2.00	42.50	1.93
15. Availability of adequate funds	71.43	3.00	57.78	2.20	53.85	2.04	50.00	2.50	57.50	2.23
16. Low prices of inputs	57.14	2.29	55.56	2.04	50.00	1.85	50.00	2.00	53.75	2.00
17. Improvement in agricultural extension services	28.57	1.29	13.33	0.40	23.08	0.77	--	--	17.50	0.59
18. Keep potato in the field for long time	14.29	0.57	--	--	7.69	0.19	--	--	3.75	0.11
19. Training on potato cultivation	42.86	1.57	35.56	1.31	42.31	1.46	--	--	37.50	1.35

* Farmers' perceived importance index (range 1 to 5): 1= very low, 2= Low, 3= Medium, 4= High, 5= Very high

Table 12. Percent responses on desirable and undesirable qualities of different varieties

Type of quality	Potato variety	
	Diamant (HYV)	Dohazari (LV)
No. of respondent	*n = 21*	*n = 80*
A. Good qualities		
High yielding	90.5	27.5
Good skin colour	28.6	8.8
Early maturing	66.7	3.8
Good tuber size	38.1	2.5
Drought tolerant	--	12.5
Good storability	9.5	75.0
Good demand/high price	47.6	78.8
Good in taste	19.0	87.5
B. Bad qualities		
Low yielding	--	58.8
Bad skin colour	14.3	6.3
Susceptible tolerant	--	1.3
Susceptible to late blight	28.6	43.8
Late maturing	--	70.0
Bad tuber size	14.3	53.8
Susceptible to drought	4.8	2.5
Bad storability	71.4	--
Low demand/low price	42.9	2.5
Taste is not good	52.4	--
Others	9.5	2.5

5.3 Reasons for Abandoning Varieties

Due to some negative perceptions some respondent farmers abandoned only one variety in Chittagong district. Susceptible to diseases and low demand/price were reported to be common reasons for abandoning the diamant variety in Chittagong. Low yield was another important reason for which some farmers in the study area abandoned diamant variety

Table 13. Reasons for varietals abandonment in Chittagong district (multiple responses)

(Figures in %)

Reasons	Diamant *(n = 8)*
Low yield	25.0
Susceptible to diseases	62.5
Late maturing	12.5
Low demand/price	62.5
Less water resistant	12.5

Note: (i) Due to less number of responses in respect to various farm categories, the category wise analysis was not carried out.

(ii) Chittagong farmers abandoned potato varieties 2.09 years ago.

5.4 Preference of Potato Varieties

Respondents of Chittagong were asked to give preference on the four available future potato varieties against abiotic stresses. It was observed that the farmers of all categories showed very high level of preference (4.14) toward the variety having early maturing character followed by the variety having drought (3.28) and heat (3.11) tolerant character (Table 14).

Table 14. Level of preference of potato varieties in Chittagong against abiotic stresses in the near future

Potato variety	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Heat tolerant	3.57	3.16	2.85	4.00	3.11
Drought tolerant	3.00	3.29	3.31	3.50	3.28
Saline tolerant	1.57	1.62	1.65	3.00	1.66
Early maturing	4.43	4.18	4.04	3.50	4.14

Note: Level of preference: Very low =1; Low = 2; Medium = 3; High = 4; Very high =5

5.5 Response on Abiotic Stresses

Chittagong district represents the heat and saline areas of Bangladesh. Respondent farmers were asked to express their opinions on the abiotic stresses they faced during potato cultivation. The higher proportion of marginal and small farmers regarded drought as a potential threat to their potato crop. The respondents in all categories opined that drought (3.23) and heat (2.96) were most important factors that's affects the yield of potato (Table 15).

Table 15. Relative importance of abiotic stresses in Chittagong district

Abiotic stress	Farmers' category				All category *(n = 80)*
	Marginal *(n = 7)*	Small *(n = 45)*	Medium *(n = 26)*	Large *(n = 2)*	
Draught	3.14	3.22	3.23	3.50	3.23
Heat	3.43	2.93	2.77	4.50	2.96
Salinity	2.67	2.50	2.67	2.00	2.55

Note: Level of priorities: 1= very low, 2= Low, 3= Medium, 4= High, and 5= Very high

According to the potato farmers of Chittagong, Dohazari (1.3) was the highly abiotic stress tolerant variety followed by Lolita and Diamant (Table 16).

Table 16. Level of abiotic stress tolerances of different potato varieties in Chittagong district

Variety	Farmers' category				All category *(n = 80)*
	Marginal *(n = 7)*	Small *(n = 45)*	Medium *(n = 26)*	Large *(n = 2)*	
Diamant	--	2.0 (2)	1.8 (5)	1.0 (1)	1.8 (8)
Dohazari	--	1.0 (2)	1.2 (5)	--	1.3 (8)
Lolita	--	2.0 (2)	1.5 (2)	--	1.7 (3)

Note: Figures in the parentheses are number of respondents

Level of abiotic stresses tolerance (1= Very high, 2= High, 3= Medium, 4= Low, 5= Very low)

6. BASELINE INDICATORS RELATED TO POTATO FARMERS

Socio-economic characteristics of the farmers are important in influencing farm decision making and production planning. Therefore, some salient socio-economic characteristics like education, occupation, household assets, household income, household expenditure, livelihood standard, and social participation will be used as indicators for future impact assessment. All these indicators have been discussed in the following sections.

6.1 Drought Area (Bogra District)

6.1.1 Age, Family size and Dependency Ratio

Age is an important factor that influences farmers' production decision, efficiency and adoption of improved technologies. Irrespective of farmers' category, most household respondents (64.4%) belong to the age group of 30-49 years followed by 50-64 years (16.3%) and 20-29 years (13.1%) age group. Similar observations were found among farm categories. The average age of the respondents was about 44 years (Table 17).

Family size included the number of adult male, adult female and children of the respondent households. The average family size of the farmer's household was 5.01 no./hh. The earning member per household was 1.76 no./hh. Male earning member was higher (1.61 no./hh) than the female member number (0.14 no./hh). Considering the earning member and total member of the family the dependency ratio was found to be 3.28 in the study areas. This ratio was higher for large farmers and lower for marginal farmer (Table 17).

Table 17. Age family size, dependency ratio and age category of the farmers in Bogra

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
1. Age category (%)					
20-29 years	11.1	16.5	7.7	12.5	13.1
30-49 years	44.4	60.4	71.2	87.5	64.4
50-64 years	11.1	18.7	15.4	-	16.3
Above 64 years	33.4	4.4	5.7	-	6.2
Average age (year)	47.56	40.25	42.08	36.38	41.06
2. Family size (No/hh)	3.78	4.46	5.97	6.50	5.01
Adult male	1.56	1.65	2.37	2.50	1.92
Adult female	1.22	1.56	2.02	2.50	1.74
Children	1.00	1.25	1.58	1.50	1.36
3. Earning member (No/hh)	1.44	1.51	2.12	2.51	1.76
Male earning member	1.33	1.37	2.00	2.13	1.61
Female earning member	0.11	0.14	0.12	0.38	0.14
4. Dependency ratio	2.72	3.29	3.31	3.58	3.28

6.1.2 Level of Education

Table 18 indicates that 87.5% of the respondents were educated and the rest 12.5% had no education. Of the educated respondents, highest 41.3% had secondary level of education and 28.1% farmer had primary level of education. There were no illiterate, primary and degree educated farmer in the large farmer's group. On the contrary, there were no marginal farmers in the higher secondary and degree level of education. The proportion of higher secondary educated persons increases with the increase in farm category.

Table 18. Literacy level of the potato farmer in Bogra district

(Figures in %)

Literacy level	Farmers' category				All category
	Marginal	Small	Medium	Large	
Illiterate	22.2	17.6	3.8	-	12.5
Primary	33.3	36.3	17.3	-	28.1
Secondary	44.5	31.9	53.8	62.5	41.3
Higher secondary	-	8.8	21.2	37.5	13.8
Degree & above	-	5.5	3.8	-	4.4

6.1.3 Occupational Status

A good number of potato farmers have both primary and secondary occupation. In the study areas, 97.5% potato farmer's primary occupation was agriculture and about 17.5 and 26.3% farmer's secondary occupation were business and service respectively. One hundred percent marginal, medium and large category farmers took agriculture as primary occupation. (Table 19).

Table 19. Occupational status of the sample potato farmers in Bogra district

(Figures in %)

Occupation type	Farmers' category				All category
	Marginal	Small	Medium	Large	
1. Primary occupation					
Agriculture	100	95.6	100	100	97.5
Service	-	3.4	-	-	1.9
Business	-	1.1	-	-	0.6
2. Secondary occupation					
Agriculture	44.4	4.4	-	-	2.5
Service	11.1	20.9	36.5	-	26.3
Business	-	22.0	9.6	25.0	17.5

6.1.4 Status of Land Holding

Table 14 indicates farm size and tenure status of the respondent households. The average farm size of all farmers was 1.07 ha, in which about 77.16% was from own cultivated land. The average farm size of the marginal, small, medium and large category farmers were 0.193 ha, 0.657 ha, 1.555 ha and 3.592 ha respectively. Area for rented out and mortgage out were insignificant in farm size compared to land use through rented in and mortgage in for cultivation. However, the lands under own cultivation and rented in increase with the increase in farm category.

It was observed that about 61.56% of the lands were used for potato cultivation during *Rabi* season. A negative relationship was found between farm size and the percent share of land devoted to potato cultivation. On the other words, the amount of potato area increase with the increases of farm category (Table 20).

Table 20. Land holding status of the sample potato farmers in Bogra

Holding type	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
1. Farm size (ha)	0.19388	0.65736	1.55565	3.59261	1.0700
a. Own cultivated	0.17859	0.45163	1.18137	3.49545	0.82563 (77.16)
b. Rented in	0.01305	0.06279	0.09211	0.25304	0.07903 (7.39)
c. Rented out	0.01305	0.00440	0.01129	0.13057	0.01344 (1.26)
d. Mortgaged in	0.03329	0.16399	0.30927	0.07591	0.19945 (18.64)
e. Mortgaged out	0.01799	0.01664	0.01581	0.10121	0.02067 (1.93)
2. Total potato area (ha)	0.15969	0.46996	0.90272	1.78138	0.6587 (61.56)

Note: Farm size = (a+b+d-c-e)
Figures in parentheses indicate the percentage of total cultivated land

6.1.5 Land Use Pattern

Potato farmers in the study areas grow different types of crops throughout the year. Among different crops, the highest area was devoted to rice and potato cultivation. Irrespective of farmers' category, the highest amount of land was devoted to *T. Aman* (36.93%) followed by *Boro* (36.07%) and potato (23.68%) during 2009-2010. A positive relationship was observed between the percent share of land devoted to rice (T.Aman and Boro) cultivation and farm category (Table 21).

Table 21. Average cultivated areas under different crops in Bogra during 2009-10

(Figures in ha)

Cultivated crops	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
Aus rice	--	--	0.0637	--	0.0207 (0.44)
T. Aman rice	0.3949	1.0821	2.5276	5.4039	1.7293 (36.93)
Boro rice	0.3730	1.0723	2.5053	4.8742	1.6888 (36.07)
Potato	0.3020	0.7897	1.5168	2.9932	1.1087 (23.68)
Pulses	--	0.0024	0.0011	0.0119	0.0023 (0.05)
Spices[1]	0.0038	0.0003	0.0190	0.0085	0.0009 (0.02)
Vegetables[2]	0.0008	0.0008	0.0755	0.0468	0.0322 (0.69)
Other crops	0.0110	0.0772	0.1439	0.1539	0.0990 (2.11)
Total cultivated area	1.0855	3.0248	6.8529	13.4924	4.6819 (100)

[1]Onion, garlic & chili [2]Brinjal, cabbage, cauliflower, radish, country bean, bitter gourd, okra and tomato
Figures in the parentheses indicate percentage of total cultivated area

6.1.6 Inventory of Livestock and Poultry

Potato farmers in the study areas rear different types of livestock and poultry bird for earning additional income for their families. On an average, a household owned 1.59 nos. of cow, 1.08 nos. of goat, 81.59 nos. of chicken and 3.97 nos. of pigeon. The average number of poultry is found to be higher for large farmers as because two large farmers each owned a commercial poultry farm. In general the average number of goat, pigeon and poultry was higher for medium farmers compared to other farm categories. Almost a positive relationship was found between the number of livestock owned and farm category in the study areas (Table 22).

Table 22. Average number of livestock and poultry owned by the farmers of Bogra

Livestock & poultry	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
Cow	0.33	1.08	2.08	5.75	1.59
Bull/Ox	0.33	0.49	0.52	3.25	0.63
Buffalo	--	0.03	0.06	0.38	0.06
Calves	0.22	0.70	1.25	2.51	0.95
Goat	0.78	0.76	1.69	1.13	1.08
Poultry	52.78	14.77	136.27	518.63	81.59
Pigeon	--	2.48	5.85	13.13	3.97

6.1.7 Inventory of Agricultural Equipment

The adoption of farm mechanization can be observed through the information of having farm equipments by the farmers. It was observed that the higher number of large and medium category farmers owned costly agricultural equipment like power tiller and irrigation device compared to small and marginal farmers. Table 23 shows that all categories of farmers had the highest number of spade (4.91) and the lowest number of thresher (0.04). To some extent, a positive relationship was found in the number of farm equipment owned and farm category.

Table 23. Average number of agricultural equipment owned by the farmers of Bogra

Equipment type	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
Power tiller	--	0.11	0.21	0.75	0.17
Irrigation equipment	0.11	0.14	0.60	0.75	0.32
Sprayer	0.56	0.86	1.27	1.50	1.01
Thresher	--	0.02	0.08	--	0.04
Country plough	0.22	0.48	0.63	0.25	0.51
Ladder	0.89	1.15	1.50	0.88	1.24
Spade	2.22	3.87	6.65	8.38	4.91
Other small tools	1.89	1.78	3.77	1.00	2.39

6.1.8 Household Assets and Standard of Living

Household assets are one of the important indicators of economic wellbeing and status of the society. House condition, sanitation system, monthly expenditure, household assets, social participation, and some other household facilities are considered for measuring the standard of living of the potato growers. Higher the users of these facilities higher are their standard of living. The household assets and living standard of Bogra farmers have been presented in Table 24 and briefly discussed below.

House condition: House condition is not a good indicator of standard of living in the study areas as because some small, marginal and medium category farmers have houses with brick wall and concrete/tin-shaded roof, whereas large category farmers do not have those types of houses. Most of the potato growers (irrespective of farm category) lived in those houses of which walls were constructed by mud and roofs were made of CI sheet. A good percentage (23.1%) of potato farmers owned brick wall houses with tin-shaded (CI sheet) roof.

***Sanitation system*:** The respondent farmers were found to use three types of toilets: flash toilet, sanitary toilet and temporary toilet in the study areas. Table 24 shows that majority of the potato

growers (67.5%) and their family members used sanitary toilets and only a few farmers used flash toilet. The percentages of temporary toilet users were about 30%. However, the use of temporary toilet decreased with the increase of farm sizes. To some extent, the opposite scenario was found in the case of sanitary latrine.

Table 24. Inventory of household assets and the standard of living of Bogra farmers

(Figures in %)

Particulars	Farmers' category				All
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n =160*
1. Type of house owned					
Brick wall-concrete roof	--	1.1	3.8	--	1.9
Brick wall-tin shed	44.4	17.6	28.8	25.0	23.1
Mud/other wall-tin shed	55.6	79.1	67.3	75.0	73.8
Mud/other wall-straw shed	--	2.2	--	--	1.3
2. Sanitation system used					
Flash toilet	--	2.2	1.9	12.5	2.5
Sanitary toilet	55.6	61.5	80.8	62.5	67.5
Temporary toilet	44.4	36.3	17.3	25.0	30.0
3. Monthly expenditure (Tk)	5589	5555	7042	10588	6292
Food	4433	4104	5582	8213	4808
Children's education	689	1074	1000	1500	1050
Travel	467	377	460	875	434
4. Type of vehicle owned					
Car	--	--	1.9	--	0.6
Motor cycle	--	6.6	30.8	37.5	15.6
Bicycle	33.3	81.3	86.5	50.0	78.8
5. Modern amenities used					
Mobile phone	88.9	80.2	86.5	100.0	83.8
Television	22.2	64.8	88.5	62.5	70.0
6. Water source used					
Hand tube well	88.9	90.1	90.4	75.0	89.4
Water pump	11.1	5.5	17.3	25.0	10.6
7. Other household facilities					
Cooking gas	--	1.1	3.8	12.5	2.5
Electricity	55.6	83.5	90.4	75.0	83.8
8. Organizational membership	22.2	39.6	23.1	62.5	34.4
9. Migrate to outside villages	22.2	11.0	3.8	25.0	10.0

***Household expenditure*:** Three items such as food, children's education and travel were considered for measuring the household expenditure of potato farmers, although they spent their income on so many things. The average monthly expenditure for a potato farmer was estimated at Tk. 6292 ($87.39). It was also found that the highest percentage (76.41%) of expenditure was for purchasing food for the family. However, the monthly expenditure increased with the increase of farm sizes.

Vehicle used: Majority of the potato farmers (78.8%) used bicycle as their principal mode of transportation. Besides, a good number of other category farmers except marginal farmer owned motor cycle. It was observed that the number of vehicles owners increased with the increase of farm categories.

Modern amenities: Most of the potato growing farmers have both mobile phone and television. Table 24 shows that about 84% and 70% farmers owned a mobile phone and television

respectively. One hundred percent of large farmers used mobile phone followed by marginal and medium farmers.

***Water sources*:** Hand tube well was reported to be the main source of drinking water for potato farmers in the study areas. A small number of farmers in all categories also used deep water lifting through the electric pump. Electric pump owners have water connection with pump.

Other household facilities: Household facilities include the availability of cooking gas and electricity in the house. It was found that about 84% potato farmers enjoyed electric facility, whereas a very small percent (2.5%) of potato farmers had cooking gas facility in their houses. Most farmers in the study areas used fire wood for cooking purpose. The highest availability of electricity (90.4%) was found for medium farmers followed by small (83.5%) and large (75%) farmers (Table 18).

Social participation: Social participation is an indicator of respondent's likely exposure to new knowledge and improved decision making. There are a number of social organizations such as Farmers' Cooperative Society, Mosque Management Committee, Village Development Society, Integrated Pest Management School, various self-help group, etc. in the study areas. Membership of these social organizations was considered to measure social participation. Table 24 reveals that irrespective of farmers' category, about 34.4% of potato farmers were reported to be a member of these societies. The highest involvement was reported by large farmers followed by marginal farmers.

6.2 Heat and Saline Area (Chittagong District)

6.2.1 Age, Family size and Dependency Ratio

Highest 43.8% of the respondents belong to the age group of 50-64 years followed by 30-49 years (37.5%). Similar observations were found among farm categories. The average age of the respondents was more than 48 years (Table 25).

Table 25. Age, family size and dependency ratio of the farmers in Chittagong

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Age category (%)					
20-29 years	14.3	4.4	7.7	50.0	7.5
30-49 years	14.3	42.2	34.6	50.0	37.5
50-64 years	71.4	42.2	42.3	-	43.8
Above 64 years	-	11.2	15.4	-	11.2
Average age (year)	45.4	48.7	50.0	33.0	48.4
2. Family size (No/hh)	5.42	7.56	9.58	9.00	8.06
Adult male	2.14	2.80	3.50	3.50	2.99
Adult female	1.57	2.40	2.65	2.00	2.40
Children	1.71	2.36	3.42	3.50	2.68
3. Earning member (No/hh)	1.71	2.13	2.62	3.00	2.28
Male earning member	1.57	2.04	2.62	3.00	2.21
Female earning member	0.14	0.09	-	-	0.06
4. Dependency ratio	3.79	4.19	4.53	3.25	4.24

The average family size of the farmer's household was found to be 8.06 no./hh. The highest family members (9.58 no./hh) belonged to the medium farmers and the lowest with marginal

farmers (5.42 no./hh). The earning member per household was 2.28 no./hh. The earning member of respondent family increases with the increase in farm category. Lower number of female earning member indicates that there is unsatisfactory level of woman contribution in the family. The dependency ratio was found to be 4.24 in the study areas.

6.2.2 Level of Education

The sample farmers of Chittagong are classified into five categories based on their education level. Irrespective of farmers' category, 40% of the respondents had primary level of education and about 36% of the respondents had secondary level of education. Overall, 82.5% of the respondents were educated and the rest 17.5% had no education. There were no illiterate, higher secondary and degree educated farmer in the marginal and large farmer's group. The proportion of higher secondary educated persons increases with the increase in farm category.

Table 26. Literacy level of the potato farmer in Chittagong district

(Figures in %)

Literacy level	Farmers' category				All category
	Marginal	Small	Medium	Large	
Illiterate	-	24.4	11.5	-	17.5
Primary	71.4	37.8	38.5	-	40.0
Secondary	28.6	31.1	42.3	100	36.3
Higher secondary	-	6.7	7.7	-	6.3
Degree & above	-	-	-	-	-

6.2.3 Occupational Status

Primary occupation of a person generally reflects his commitment in that particular field and demonstrates his economic standing in the society. In the study areas, 100% potato farmer's primary occupation was agriculture and about 24% farmers's secondary occupation was business. The highest percentage of marginal farmer's secondary occupation was service, whereas it was business for small, medium and large category farmers (Table 27).

Table 27. Occupational status of the sample potato farmers in Chittagong district

(Figures in %)

Occupation type	Farmers' category				All category
	Marginal	Small	Medium	Large	
1. Primary occupation					
Agriculture	100	100	100	100	100
Service	-	-	-	-	-
Business	-	-	-	-	-
2. Secondary occupation					
Agriculture	-	2.2	-	-	1.3
Service	14.3	4.4	-	-	3.8
Business	-	22.2	26.9	100	23.8

6.2.4 Status of Land Holding

The average farm size was found to be 0.948 ha, in which about 39.30% was from own cultivated land. The average farm size of the marginal, small, medium and large category farmers were 0.175 ha, 0.669 ha, 1.471 ha and 3.107 ha respectively. The lands under own cultivation, rented in and mortgaged in, increase with the increase in farm category.

It was observed that average potato cultivation area 0.456 (48.17%) ha for all category of farmers during *Rabi* season. A positive relationship was found between farm size and the percent share of land devoted to potato cultivation (Table 28).

Table 28. Land holding status of the sample potato farmers in Chittagong

Holding type	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Farm size (ha)	0.17582	0.66946	1.47197	3.10729	0.9480
a. Own cultivated	0.14517	0.25533	0.51448	1.96356	0.3726 (39.30)
b. Rented in	0.00868	0.18156	0.48334	0.60729	0.2752 (29.02)
c. Rented out	-	0.00360	0.03114	0.00000	0.0122 (1.28)
d. Mortgaged in	0.03470	0.23617	0.50529	0.53644	0.3135 (33.06)
e. Mortgaged out	0.01272	-	-	-	0.0011 (0.12)
2. Total potato area (ha)	0.14691	0.36527	0.69293	0.52632	0.4566 (48.17)

Note: Farm size = (a+b+d-c-e)
Figures in parentheses indicate the percentage of total cultivated land

6.2.5 Land Use Pattern

Potato farmers in the study areas grow different types of crops throughout the year. The highest area was devoted to rice and potato cultivation. The highest amount of land was devoted to *Aus* rice (25.54%) followed by potato (22.96%), T. Aman (14.64%) and *Boro* rice (13.46%) during 2009-2010. A positive relationship was observed between the percent share of land devoted to rice cultivation and farm category (Table 29).

Table 29. Average cultivated areas under different crops in Chittagong during 2009-10

(Figures in ha)

Cultivated crops	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Aus rice	0.3071	0.7033	1.1172	2.7211	0.8536 (25.54)
T. Aman rice	0.1225	0.3070	0.8778	0.8163	0.4891 (14.64)
Boro rice	-	0.4110	0.6201	0.6803	0.4497 (13.46)
Potato	0.2468	0.6138	1.1643	0.8844	0.7674 (22.96)
Pulses	0.0778	0.2298	0.6829	-	0.3580 (10.71)
Spices[1]	-	0.0460	0.0937	-	0.0563 (1.68)
Vegetables[2]	0.0972	0.1101	0.3399	1.360	0.2124 (6.36)
Other crops	0.0292	0.1633	0.1146	0.9524	0.1554 (4.65)
Total cultivated area	0.8806	2.5843	5.0105	7.4145	3.3419 (100)

[1]Onion, garlic & chili [2]Brinjal, cabbage, cauliflower, radish, country bean, bitter gourd, okra and tomato
Figures in the parentheses indicate percentage of total cultivated area

6.2.6 Inventory of Livestock and Poultry

On an average, a household owned 3.10 nos. of cattle, 0.26 nos. of goat, 10.17 nos. of chicken and 0.51 nos. of pigeon. In general the average number of cattle and goat was higher for large farmers compared to other farm categories. Almost a positive relationship was found between the number of livestock owned and farm category in the study areas (Table 30).

Table 30. Average number of livestock and poultry owned by the farmers of Chittagong

Livestock & poultry	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Cow	1.14	1.18	1.65	2.50	1.36
Bull/Ox	0.43	0.53	0.96	2.00	0.70
Buffalo	-	0.04	0.08	-	0.05
Calves	1.00	0.87	1.08	2.50	0.99
Goat	-	0.22	0.27	2.00	0.26
Poultry	6.14	11.38	9.19	10.00	10.17
Pigeon	-	0.38	0.92	-	0.51

6.2.7 Inventory of Agricultural Equipment

It was observed that the higher number of large and medium category farmers owned costly agricultural equipment like power tiller and irrigation device compared to small and marginal farmers. Small farmers did not have any power tiller and thresher. Table 31 shows that on an average all categories of farmers had the highest number of spade (5.14) followed by other small agricultural tools (3.34) and ladder (1.06). Almost a positive relationship was found in the number of farm equipment owned and farm category.

Table 31. Average number of agricultural equipment owned by the farmers of Chittagong

Equipment type	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Power tiller	-	0.09	0.42	1.00	0.21
Irrigation equipment	-	0.27	0.77	1.50	0.44
Sprayer	0.14	0.76	0.62	1.00	0.66
Thresher	-	0.07	0.04	1.00	0.08
Country plough	0.71	0.58	0.50	-	0.55
Ladder	0.86	1.04	1.19	0.50	1.06
Spade	2.86	4.73	6.12	9.50	5.14
Other small tools	2.14	3.36	3.88	-	3.34

6.2.8 Household Assets and Standard of Living

The household assets and standard of living of the potato growers of Chittagong district have been presented in Table 32 and briefly discussed below.

House condition: House condition is not also a good indicator of standard of living in the study areas as because some small and medium category farmers have pucca building, whereas large category farmers do not have it. About 43% farmers (irrespective of farm category) lived in those houses of which walls were constructed by mud and roofs were made by CI sheet. More than 16% of potato farmers owned brick wall houses with tin-shaded (CI sheet) roof. The same percentage of farmers owned houses with mud wall and straw shad. The proportion of houses with mud wall and straw shad decreases with the increase in farm category.

***Sanitation system*:** The respondent farmers used both sanitary toilet and temporary toilet. Table 32 shows that the percentages of farmers using sanitary toilet and temporary toilet were same.

However, the use of temporary toilet decreased with the increase of farm sizes. To some extent, the opposite scenario was found in the case of sanitary latrine.

***Household expenditure*:** Respondent potato farmers spent their income on so many things. But, the cost of food, children's education and travel expenses were considered in this study. The average monthly expenditure was estimated at Tk. 14,811 ($205.71). It was also found that the highest percentage (66.9%) of expenditure was for purchasing food for the family.

Table 32. Inventory of household assets and the standard of living of Chittagong farmer

(Figures in %)

Particulars	Farmers' category				All
	Marginal	Small	Medium	Large	
No. of respondent	*N = 7*	*N = 45*	*N = 26*	*N = 2*	*N = 80*
1. Type of house owned					
Brick wall-concrete roof	--	4.4	15.4	--	7.5
Brick wall-tin shed	--	20.0	11.5	50	16.25
Mud/other wall-tin shed	42.9	37.8	50.0	50	42.5
Mud/other wall-straw shed	42.9	15.6	11.5	--	16.25
Other types	14.3	22.2	11.5	--	17.5
2. Sanitation system used					
Sanitary toilet	28.6	46.7	61.5	50	50
Temporary toilet	71.4	53.3	38.5	50	50
3. Monthly expenditure (Tk)	9966	16115	14814	2371	14811
Food	7439	11007	9309	1498	9905
Children's education	1907	3850	4164	660	3702
Travel	620	1258	1342	212	1203
4. Type of vehicle owned					
Motor cycle	--	2.2	3.8	--	2.5
Bicycle	57.1	40.0	46.2	100	45.0
5. Modern amenities used					
Mobile phone	71.4	77.8	80.8	100	78.8
Television	28.6	35.6	57.7	100	43.8
6. Water source used					
Hand tube well	85.7	80.0	73.1	100	78.8
Water pump	--	2.2	3.8	--	2.5
7. Other household facilities					
Electricity	57.1	84.4	96.2	100	86.3
8. Organizational membership	--	13.3	19.2	50	15.0
9. Migrate to outside villages	14.3	6.7	7.7	--	7.5

Vehicle used: The principal mode of transportation in the study area was found to be bicycle. Besides, a few proportion of the respondent small and medium farmers also used motor cycle.

Modern amenities: Most of the potato growing farmers have both mobile phone and television. Table 32 shows that more than 78% and 43% farmers owned a mobile phone and television respectively. One hundred percent of large farmers owned both mobile phone and television. However, the use of modern amenities increases with the increase in farm size.

***Water sources*:** Hand tube well was reported to be the main source of drinking water for potato farmers in the study areas. A small number of small and medium category farmers used deep water lifting through the electric pump.

Other household facilities: It was found that 86.3% potato farmers enjoyed electric facility in their houses. They have no cooking gas facility. They used firewood for cooking purpose. However, the electricity facility was increased with the increase in farm size in the study areas.

Social participation: Social participation is an indicator of respondent's likely exposure to new knowledge and improved decision making. Irrespective of farmers' category, only 15% of potato farmers were reported to be a member of the society. The highest involvement was reported by large farmers followed by medium and small farmers.

7. BASELINE INDICATORS ON POTATO PRODUCTION AND MARKETING

Baseline data and information on current potato cultivation are very much important in assessing the impact of future potato research and development in Bangladesh. Therefore, adoption status of potato varieties, trend of cultivation, variety wise yield, seed replacement rate, seed source, seed rate, seed size, retention of own seed, price of potato, and post-harvest losses are considered as indicators for future impact study. A brief discussion has been made on the aforesaid indicators in the following sections.

7.1 Drought Area (Bogra District)

7.1.1 Adoption of Potato Varieties

Both HYV and indigenous variety of potatoes are being cultivated in the study areas. In Bogra, the highly adopted varieties were Granula, Cardinal, Diamant, Ruma and Lalpakri. In the case of HYV, the highest percentage of farmers in all categories (77.5%) cultivated Granula variety followed by Cardinal and Diamant. On the other side, nearly 60% farmers used Lalpakri and 21.3% farmers used Fata pakri as indigenous potato varieties (Table 33). The average experience in potato farming was reported to be 13 years. Large farmers were more experienced compared to other farmers.

Table 33. Percent farmers planted potato varieties and their potato experience in Bogra

(Figures in %)

Variety cultivated	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents					
1. High yielding variety					
Granula	77.8	73.6	80.8	100	77.5
Diamant	-	6.6	7.7	12.5	6.9
Cardinal	11.1	25.3	32.7	25.0	26.9
Others[1]	-	3.3	2.6	10.0	2.1
2. Indigenous variety					
Ruma	-	12.1	21.2	25.0	15.0
Lal pakri	66.7	54.9	63.5	75.0	59.4
Fata pakri	-	26.4	17.3	12.5	21.3
Others[2]	-	8.2	30.7	-	15.0
3. Potato experience (year)	11.1	11.8	14.7	16.8	13.0

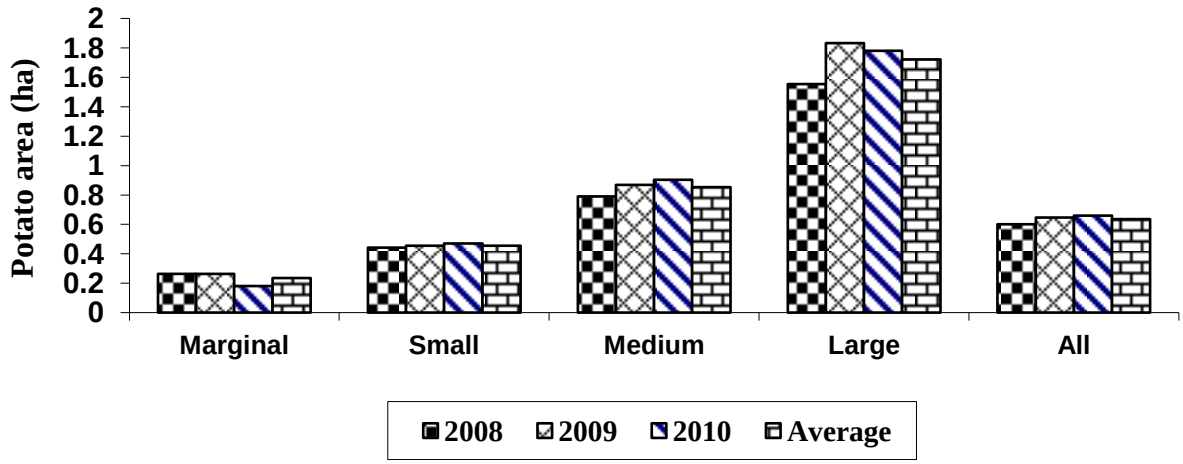
[1]Patronis, Alvira and Asterisk variety; [2]Tel pakri, Bot pakri and Lolit variety

7.1.2 Trend of Potato Cultivation

It was observed that there was an increasing trend of potato area from 0.601 ha in 2007-2008 to 0.647 ha in 2008-2009 and 0.660 ha in 2009-2010. The potato area was decreased for the

marginal farmer though the area of other category farmers increased within these three years period (Fig.3).

Figure 3. Trend of potato cultivation in the last three years



Nearly 37% respondent farmers increased their potato areas, whereas about 16% farmers decreased it in the last year (2010). They stated various causes for increasing and decreasing the potato areas. The highest percentage of respondent farmers (62.1%) increased potato areas because of its attractive profitability. As farmers can earn cash income through potato cultivation, so they stated this as the second most important reason for increasing potato area. The important causes of decreasing potato areas were increase in vegetable cultivation, shortage of land, lack of capital, and disease infestation (Table 34).

Table 34. Causes of increasing or decreasing potato cultivation in the last year

(Figures in %)

Causes of increase/decrease	Farmers' category				All category
	Marginal	Small	Medium	Large	
No of respondents					
Farmers increase potato area	-	35.87	43.13	37.50	36.30
Farmers decrease potato area	22.20	17.40	9.80	25.00	15.60
Causes of increasing	n=0	n=32	n=23	n=3	n=58
Highly profitable	--	62.5	60.9	66.7	62.1
Can earn cash income	--	15.6	17.4	33.3	17.2
Reduction of irrigation cost	--	3.1	4.3	--	3.4
Higher demand	--	9.4	17.4	--	12.1
Use of fallow land	--	9.4	--	--	5.2
Causes of decreasing	n=2	n=16	n=5	n=2	n=25
Disease infestation	0.0	37.5	--	--	24.0
Increase in vegetable cultivation	50.0	25.0	40.0	50.0	32.0
Shortage of land	50.0	6.3	40.0	50.0	20.0
Lack of capital	--	12.5	20.0	--	12.0
Higher cost of production	--	18.8	--	--	12.0

7.1.3 Variety Wise Potato Yield

The productivity of potato depends on many factors such as varietal character, use of appropriate amount of inputs, intercultural operations, disease and insect-pest management, and local weather variables. Change in any factors results in the change of potato yield. Area and variety wise potato yields are presented in Table 35.

The average yield of HYV potato was higher than that of local variety. In 2009-2010, the average per hectare yield was estimated at 21.49 for Granula, 21.22 for Diamant, and 22.57 for Cardinal. On the other hand, the average per hectare yield of local variety was 16.76 for Ruma, 15.01 for Lal pakri, and 15.21 for Fata pakri. It was observed that the average yields of HYV and local variety potatoes in 2008-2009 were much lower compared to the yields observed in 2009-2010 (Table 35). The main reason behind this lower yield was opined to be bad weather especially the occurrence of drought. However, the average national yield was 13.06 tons per hectare during 2008-2009 (BBS, 2009).

Table 35. Variety wise yield (ton/ha) of potato in Bogra district

Year	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula					
2008-2009	19.437 (7)	17.613 (59)	14.582 (37)	18.067 (8)	16.750 (111)
2009-2010	20.924 (6)	23.078 (68)	22.675 (41)	22.654 (8)	21.485 (123)
Diamant					
2008-2009	--	15.700 (7)	14.779 (9)	18.712 (2)	15.574 (18)
2009-2010	--	21.330 (7)	20.777 (8)	23.952 (1)	21.217 (16)
Cardinal					
2008-2009	8.347 (1)	16.759 (18)	13.485 (19)	14.733 (3)	14.888 (41)
2009-2010	20.441 (1)	22.406 (25)	22.679 (20)	23.886 (3)	22.568 (49)
B. Local variety					
Ruma					
2008-2009	--	13.628 (1)	17.964 (1)	--	15.796 (2)
2009-2010	--	16.444 (10)	17.109 (9)	--	16.759 (19)
Lal pakri					
2008-2009	13.499 (5)	12.456 (54)	10.962 (33)	10.834 (5)	11.918 (97)
2009-2010	15.598 (4)	14.908 (52)	15.046 (36)	15.305 (6)	15.011 (98)
Fata pakri					
2008-2009	9.539 (1)	12.460 (29)	11.149 (21)	13.555 (3)	11.957 (54)
2009-2010	17.034 (1)	15.614 (23)	13.866 (12)	17.711 (2)	15.210 (38)

Figures within parentheses are no. of respondent farmers

7.1.4 Variety Wise Seed Rate

Seed rate is an important factor that influences overall potato yield of a farm. This information can be compared in the future to study the change of cultural practices among respondent farmers. It was found that the seed rate applied by the farmers varied from variety to variety. In 2009-2010, the average seed rates for HYV potato were 1.833 ton/ha for Granula, 1.656 ton/ha for Diamant, and 1.538 ton/ha for Cardinal. In the case of local variety, it was 0.946 ton/ha for Ruma, 0.895 ton/ha for Lal pakri, and 0.831 ton/ha for Fata pakri. The seed rates applied in 2008-2009 for HYV and local potatoes except Pakri variety were slightly higher compared to the seed rates used in 2009-2010 (Table 36).

Table 36. Variety wise seed rate (ton /ha) used by Bogra farmers in the last two years

Year	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula					
2009-2010	1.869 (6)	1.918 (68)	1.688 (41)	1.822 (8)	1.833 (123)
2008-2009	2.080 (7)	1.807 (59)	1.894 (37)	2.000 (8)	1.867 (111)
Diamant					
2009-2010	--	1.574 (7)	1.701 (8)	1.871 (1)	1.656 (16)
2008-2009	--	1.524 (7)	1.848 (9)	1.747 (2)	1.711 (18)
Cardinal					
2009-2010	1.363 (1)	1.597 (52)	1.500 (36)	1.360 (6)	1.538 (49)
2008-2009	1.363 (1)	1.720 (54)	1.675 (33)	1.423 (5)	1.669 (41)
B. Local Variety					
Ruma					
2009-2010	--	0.839 (10)	1.097 (9)	0.659 (1)	0.946 (20)
2008-2009	--	1.274 (1)	1.617 (1)	--	1.446 (2)
Lal pakri					
2009-2010	0.943 (4)	0.911 (52)	0.862 (36)	0.920 (6)	0.895 (98)
2008-2009	0.807 (5)	0.843 (54)	0.830 (33)	0.793 (5)	0.834 (97)
Fata pakri					
2009-2010	0.795 (1)	0.815 (23)	0.882 (12)	0.732 (2)	0.831 (38)
2008-2009	0.783 (1)	0.798 (29)	0.852 (21)	0.690 (3)	0.813 (54)

Note: Figures in the parentheses indicate no. of respondent

7.1.5 Size of Seed Potato

In 2009-2010, the highest percentage of farmers ranging from 62.5 to 75.6% used medium sized (20-60g) HYV seed potatoes. The proportion of farmers used small sized (<20g) seed ranged from 63.2 to 92.9% for local variety cultivation. A small proportion of farmers used small sized seed for HYV potato and medium sized potato for local variety. No exceptional difference in using sizes of seed potatoes was found among farmers' categories (Table 37).

Table 37. Size of seed potato used by Bogra farmers in 2009-2010

(Figures in %)

Seed size	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula	*n = 6*	*n = 68*	*n = 41*	*n = 8*	*n = 123*
Small size (<20g)	16.7	1.5	2.4	--	2.4
Medium size (20-60g)	66.7	76.5	70.7	100.0	75.6
Large size (>60g)	16.7	22.1	26.8	--	22.0
Diamant	*n = 0*	*n = 7*	*n = 8*	*n = 1*	*n = 16*
Small size (<20g)	--	--	25.0	100.0	18.8
Medium size (20-60g)	--	85.7	50.0	--	62.5
Large size (>60g)	--	14.3	25.0	--	18.8
Cardinal	*n = 1*	*n = 25*	*n = 20*	*n = 3*	*n = 49*
Small size (<20g)	--	12.0	15.0	--	12.2
Medium size (20-60g)	100.0	76.0	60.0	66.7	69.4
Large size (>60g)	--	12.0	25.0	33.3	18.4
B. Local Variety					
Ruma	*n = 0*	*n = 9*	*n = 9*	*n = 1*	*n = 19*
Small size (<20g)	--	44.4	77.8	100.0	63.2
Medium size (20-60g)	--	55.6	22.2	--	36.8
Lal pakri	*n = 4*	*n = 52*	*n = 36*	*n = 6*	*n = 98*
Small size (<20g)	100.0	96.2	91.7	66.7	92.9
Medium size (20-60g)	--	3.8	8.3	33.3	7.1
Fata pakri	*n = 1*	*n = 23*	*n = 12*	*n = 2*	*n = 38*
Small size (<20g)	100.0	87.0	83.3	100.0	86.8
Medium size (20-60g)	--	13.0	16.7	--	13.2

In the year 2008-2009, the highest proportion of potato farmers also used medium sized seed for HYV potato varieties and small sized seed for local potato varieties. The proportion of farmers used medium size seed ranged from 71.2 to 83.3% for HYV potato cultivation and 50.0 to 90.7% for local potato cultivation (Table 38).

Table 38. Size of seed potato used by Bogra farmers in 2008-2009

(Figures in %)

Seed size	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula	*n = 7*	*n = 59*	*n = 37*	*n = 8*	*n = 111*
Small size (<20g)	14.3	--	2.7	--	1.8
Medium size (20-60g)	71.4	69.5	67.6	100.0	71.2
Large size (>60g)	14.3	30.5	29.7	--	27.0
Diamant	*n = 0*	*n = 7*	*n = 9*	*n = 2*	*n = 18*
Medium size (20-60g)	--	100.0	66.7	100.0	83.3
Large size (>60g)	--	--	33.3	--	16.7
Cardinal	*n = 1*	*n = 18*	*n = 19*	*n = 3*	*n = 41*
Small size (<20g)	--	--	15.8	--	7.3
Medium size (20-60g)	100.0	88.9	57.9	66.7	73.2
Large size (>60g)	--	11.1	26.3	33.3	19.5
B. Local Variety					
Ruma	*n = 0*	*n = 1*	*n = 1*	*n = 0*	*n = 2*
Small size (<20g)	--	--	100.0	--	50.0
Medium size (20-60g)	--	100.0	--	--	50.0
Lal pakri	*n = 5*	*n = 54*	*n = 33*	*n = 5*	*n = 97*
Small size (<20g)	80.0	92.6	90.9	80.0	90.7
Medium size (20-60g)	20.0	7.4	9.1	20.0	9.3
Fata pakri	*n = 1*	*n = 29*	*n = 21*	*n = 3*	*n = 54*
Small size (<20g)	100.0	79.3	81.0	100.0	81.5
Medium size (20-60g)	--	20.7	19.0	--	18.5

7.1.6 Use of Cut and Whole Seed

The potato farmers in the study areas use both cut and whole tubers as seed. Generally, they cut HYV seed potato into 3-4 pieces for planting as its size is larger compared to local variety seed. It was reported that the use of cut seed could reduce 50% of the total cost of seed (Rana et al. 2009). On the other hand, farmers use whole tubers as seeds in the case of local variety since their sizes are very small. Table 39 reveals that nearly 81.3 to 99% HYV potato farmers used cut potato as seed during 2009-2010, whereas these proportions ranged from 88.9 to 98.2% during 2008-2009. On the other hand, one hundred percent local variety potato growers used whole tubers as seed during 2009-2010 and these percentages were found little bit lower in 2008-2009. The detailed variety wise seed use can be seen in Table 39.

Table 39. Use of cut and whole seed potato by Bogra farmers during 2008-2010

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula	*n = 6*	*n = 68*	*n = 41*	*n = 8*	*n = 123*
2009-2010 Cut potato	100	100	100	100	100
	n = 6	*n* = 59	*n* = 37	*n* = 8	*n* = 110
2008-2009 Cut potato	100.0	98.3	97.3	100.0	98.2
Whole potato	--	1.7	2.7	--	1.8
Diamant	*n = 0*	*n = 7*	*n = 8*	*n = 1*	*n = 16*
2009-2010 Cut potato	0.0	100.0	62.5	100.0	81.3
Whole potato	--	--	37.5	--	18.8
	n = 0	*n* = 7	*n* = 9	*n* = 2	*n* = 18
2008-2009 Cut potato	--	85.7	88.9	100.0	88.9
Whole potato	--	14.3	11.1	--	11.1
Cardinal	*n = 1*	*n = 21*	*n = 15*	*n = 3*	*n = 40*
2009-2010 Cut potato	100.0	100.0	100.0	100.0	100.0
	n = 1	*n* = 18	*n* = 19	*n* = 3	*n* = 41
2008-2009 Cut potato	100.0	94.4	84.2	100.0	90.2
Whole potato	--	5.6	15.8	--	9.8
B. Local Variety					
Ruma	*n = 0*	*n = 10*	*n = 9*	*n = 1*	*n = 20*
2009-2010 Whole potato	--	100.0	100.0	100.0	100.0
	n = 0	*n* = 1	*n* = 1	*n* = 0	*n* = 2
2008-2009 Whole potato	--	100.0	100.0	--	100.0
Lal pakri	*n = 4*	*n = 52*	*n = 36*	*n = 6*	*n = 98*
2009-2010 Whole potato	100.0	100.0	100.0	100.0	100.0
	n = 5	*n* = 54	*n* = 33	*n* = 5	*n* = 97
2008-2009 Cut potato	--	7.4	6.1	20.0	7.2
Whole potato	100.0	92.6	93.9	80.0	92.8
Fata pakri	*n = 1*	*n = 23*	*n = 12*	*n = 2*	*n = 38*
2009-2010 Whole potato	100.0	100.0	100.0	100.0	100.0
	n = 1	*n = 29*	*n = 21*	*n = 3*	*n = 54*
2008-2009 Cut potato	--	6.9	9.5	--	7.4
Whole potato	100.0	93.1	90.5	100.0	92.6

7.1.7 Price of Seed Potato

In 2009-2010, the per ton average prices of HYV seed potatoes were calculated at Tk.20,202, Tk.21,431 and Tk.22,351 for Granula, Diamant, and Cardinal variety respectively. The prices of local variety seed potatoes were much higher compared to the seed potatoes of HYV variety. The prices of local variety seed potato were estimated at Tk.24,824 for Ruma, Tk.25,931 for Lal pakri, and Tk.28,116 for Fata pakri variety. In 2008-2009, the per ton average prices of HYV potatoes were found to be much lower compared to the prices received in 2009-2010. Except Ruma variety, the prices of other local varieties were also much lower than the prices paid in 2009-2010. The highest price was found for Cardinal and Fata pakri variety in 2009-2010, whereas it was for Diamant and Ruma variety in 2008-2009 (Table 40).

Table 40. Price (Tk/ton) of seed potato in drought areas during 2008-2010

Year	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula					
2009-2010	16863	20549	19957	21075	20202
2008-2009	21046	14872	15708	16972	15691
Diamant					
2009-2010	--	20300	21663	27500	21431
2008-2009	--	19161	17703	21150	18528
Cardinal					
2009-2010	20000	20281	24358	27000	22351
2008-2009	20000	17804	17074	17975	17532
B. Local Variety					
Ruma					
2009-2010	--	23200	26675	26250	24824
2008-2009	--	25000	29750	--	27375
Lal pakri					
2009-2010	24375	25713	25791	29675	25931
2008-2009	18000	17910	18173	17405	17977
Fata pakri					
2009-2010	24250	28127	27523	33488	28116
2008-2009	14250	17472	18286	21917	17964

7.1.8 Sale Price of Potato and Price Satisfaction

Irrespective of farmers' category, the average price received by the potato farmers of Bogra areas was Tk.12.43 per kg during 2008-2009 which was 30% higher than the price received in the next year (Table 41). The reason of higher price was opined to be low production across the country due to unsuitable weather. Table 41 further reveals that nearly 69% respondents satisfied with the price they received in 2009-2010. The level of price satisfaction was found higher among marginal farmers due to higher price of their produce. Although the large farmer received the lowest price, their price satisfaction level was ranked second. The highest proportion (40.4%) of medium farmers was dissatisfied with their potato price.

Farmers' dissatisfaction over price they were getting was due to higher production followed by over supply in the market and low demand. About 72.2% farmers reported that the cause of lower price was for higher production and about 13.2% opined to be over supply in the market. Potato farmers believe that export promotion of potato followed by the minimum support price of potato and higher processing can ensure better price to them. Like many other crops such as rice, wheat and tobacco no minimum support price scheme exits for potato in Bangladesh. Nevertheless, no demand is being showing for such a support price for potato from farmers' level at all.

Table 41. Sale price and level of price satisfaction of potato farmers in Bogra district

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
Respondent #	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
1. Sale price of potato (Tk/kg)					
In 2008-2009	11.33 (17)	12.59 (32)	12.5 (30)	11.38 (20)	12.43 (30)
In 2009-2010	9.39	8.61	8.79	9.06	8.73
2. Price satisfaction (%)					
Satisfied	88.9	71.4	59.6	75.0	68.8
Non-satisfied	11.1	28.6	40.4	25.0	31.3
3. Reasons for lower price (%)					
Over supply in the market	--	18.1	8.7	--	13.2
Higher production	85.7	67.5	78.3	75.0	72.2
Low demand	14.3	14.5	13.0	25.0	14.6
4. Steps for getting right price (%)					
Govt. purchase/minimum price	--	30.7	18.0	40.0	26.6
Export promotion	--	48.9	52.0	40.0	49.7
Ensure higher processing	--	14.8	20.0	20.0	16.8
Multiple use of potato	--	5.7	10.0	--	7.0

Bracketed figures represent percent higher than its next years' price.

7.1.9 Sources of Seed Potatoes

Potato farmers in the drought areas (Bogra district) have collected seed potatoes from different sources. In general, home supplied seed potato was reported to be the prime source of seed potatoes. It was observed in 2009-2010 that about 59.8-68.8% HYV potato seeds were supplied from their own source, whereas these proportions were ranged from 80-88.1% for local varieties. The other important sources of seed potatoes were market traders, neighbouring farmers, and BADC (Table 42).

Table 42. Percentage of farmers' responses on sources of seed potatoes in 2009-2010

Sources of seed potatoes	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula	*n = 6*	*n = 68*	*n = 40*	*n = 8*	*n = 122*
Home supplied	33.3	67.6	47.5	75.0	59.8
Neighbouring farmer	50.0	11.8	10.0	--	12.3
Seed traders in the market	16.7	13.2	35.0	25.0	21.3
Commercial seed company	--	1.5	--	--	0.8
BADC	--	5.9	7.5	--	5.7
Diamant	*n = 0*	*n =7*	*n = 8*	*n = 1*	*n = 16*
Home supplied	--	57.1	75.0	100.0	68.8
Neighbouring farmer	--	28.6	12.5	--	18.8
Commercial seed company	--	14.3	--	--	6.3
BADC	--	--	12.5	--	6.3
Cardinal	*n = 1*	*n = 25*	*n = 20*	*n = 8*	*n =54*
Home supplied	100.0	72.0	75.0	12.5	64.8
Neighbouring farmer	--	4.0	5.0	--	3.7
Seed traders in the market	--	12.0	10.0	12.5	11.1
Commercial seed company	--	4.0	5.0	--	3.7
BADC	--	8.0	5.0	75.0	16.7
B. Local Variety					
Ruma	*n = 0*	*n = 10*	*n = 9*	*n = 1*	*n = 20*
Home supplied	--	80.0	77.8	100.0	80.0
Neighbouring farmer	--	20.0	--	--	10.0
Seed traders in the market	--	--	22.2	--	10.0
Pakri*	*n = 5*	*n = 74*	*n = 48*	*n = 8*	*n = 135*
Home supplied	60.0	91.9	87.5	75.0	88.1
Neighbouring farmer	20.0	2.7	2.1	12.5	3.7
Seed traders in the market	20.0	5.4	10.4	12.5	8.1

*Lalpakri and Fatapakri

In 2008-2009, the proportions of home supplied HYV seed potatoes ranged from 50.5 to 65.9% and for local varieties these percentages were ranged from 86 to 100%. The other important sources of seed potatoes were the same as stated above (Table 43). It was also observed that the proportion of home supplied seed increased to some extent in 2009-2010 compared to the 2008-2009.

Table 43. Percentage of farmers' responses on sources of seed potato in 2008-2009

Sources of seed potatoes	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Granula	n = 7	n = 57	n = 37	n = 8	n = 109
Home supplied	28.6	59.6	43.2	37.5	50.5
Neighbouring farmer	28.6	19.3	16.2	--	17.4
Seed traders in the market	42.9	15.8	32.4	62.5	26.6
BADC	--	5.3	8.1	--	5.5
Diamant	n = 0	n = 7	n = 9	n = 2	n = 18
Home supplied	--	71.4	66.7	--	61.1
Seed traders in the market	--	14.3	11.1	50.0	16.7
Commercial seed company	--	14.3	--	50.0	11.1
BADC	--	--	22.2	--	11.1
Cardinal	n = *1*	n = *18*	n = *19*	n = *3*	n = *41*
Home supplied	100.0	61.1	73.7	33.3	65.9
Neighbouring farmer	--	22.2	5.3	--	12.2
Seed traders in the market	--	5.6	21.1	33.3	14.6
Commercial seed company	--	--	--	33.3	2.4
BADC	--	11.1	--	--	4.9
B. Local Variety					
Ruma	n = *0*	n = *1*	n = *1*	n = *0*	n = *2*
Home supplied	--	100.0	100.0	--	100.0
Pakri*	n = 6	n = *82*	n = *54*	n = *8*	n = *150*
Home supplied	50.0	87.8	87.0	87.5	86.0
Neighbouring farmer	16.7	3.7	3.7	--	4.0
Seed traders in the market	33.3	7.3	9.3	12.5	9.3
BADC	--	1.2	--	--	0.7

* Lalpakri and Fatapakri

Respondent farmers were asked to tell about the best source of seed potatoes. According to their knowledge and opinion, the best source of seed potatoes was BADC (73.8%) followed by home supply (15.6%). BADC supply HYV seeds of various crops including potato are generally good quality seed. In that point of view BADC ranked first. Although the highest percentage of farmers knew BADC as the best source of seed, but most of them used own seed due to its scarcity and higher price (Table 44).

Table 44. Best sources of seed potatoes to the farmers in Bogra

(Figures in %)

Sources of seed	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents					
1. Home supplied	--	17.6	13.5	25.0	15.6
2. Neighbouring farmer	11.1	2.2	1.9	--	2.5
3. Market trader	22.2	2.2	1.9	--	3.1
5. Commercial seed company	--	4.4	1.9	37.5	5.0
6. Government or BADC	66.7	73.6	80.8	37.5	73.8

7.1.10 Sources of First and Last Time used Potato Variety

Potato growers in the draught areas usually do not collect potato seed from the same source year after year. There are various sources of seed potato which are used by the respondent farmers. The source of seed potato varies from variety to variety and significantly from HYV to local varieties. At the time of initial use, the highest proportion of respondent farmers (42.1-53.2%) collected both HYV and local seed potatoes from neighbouring farmers followed by market traders (31.5-27.0%), whereas at the time of last use they used their own seed potatoes (64.5-85.1%) for cultivation (Table 45).

Table 45. Sources of first and last time used potato variety in Bogra

Sources of seed potato	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Sources of first time use (%)	*n = 14*	*n = 100*	*n = 71*	*n = 12*	*n = 197*
Home supplied	14.3	4.0	1.4	8.3	4.1
Neighbouring farmer	35.7	46.0	40.8	25.0	42.1
Market trader	28.6	30.0	35.2	25.0	31.5
Commercial seed company	7.1	7.0	4.2	16.7	6.6
Government or BADC	14.3	13.0	18.3	25.0	15.7
Sources of last time use (%)					
Home supplied	21.4	64.0	74.6	58.3	64.5
Neighbouring farmer	21.4	13.0	7.0	8.3	11.2
Market trader	14.3	13.0	14.1	25.0	14.2
Commercial seed company	--	4.0	--	--	2.0
Government or BADC	42.9	6.0	4.2	8.3	8.1
B. Local variety					
Sources of first time use (%)	*n = 6*	*n = 79*	*n = 48*	*n = 8*	*n = 141*
Home supplied	16.7	16.5	22.9	25.0	19.1
Neighbouring farmer	50.0	57.0	47.9	50.0	53.2
Market trader	33.3	26.6	27.1	25.0	27.0
Government or BADC	--	--	2.1	--	0.7
Sources of last time use (%)					
Home supplied	33.3	86.1	93.8	62.5	85.1
Neighbouring farmer	50.0	6.3	2.1	12.5	7.1
Market trader	16.7	7.6	4.2	25.0	7.8

Potato farmers in the study areas do not continue with a specific variety for a long time. They usually change variety when new variety is available to them. The length of period for changing seed depends on variety. It was found in the draught areas that some potato farmers changed Lal pakri variety after 12.5 years. For other potato varieties these periods ranged from 3.5 to 9.4 years (Table 46).

Table 46. Duration (year) of changing potato seed by Bogra farmers

Variety	Farmers' category				All category
	Marginal	Small	Medium	Large	
Granula	2.0 (7)	3.6 (69)	3.4 (44)	4.5 (8)	3.5 (128)
Cardinal	9.5 (2)	4.9 (26)	5.8 (22)	12.7 (3)	5.9 (53)
Diamant	--	2.7 (9)	6.8 (6)	20.0 (1)	5.3 (16)
Lal pakri	7.6 (5)	10.8 (48)	15.3 (28)	18.8 (5)	12.5 (86)
Fata pakri	10.0 (1)	8.2 (22)	11.3 (14)	9.7 (3)	9.4 (40)
Ruma	--	3.3 (12)	5.7 (10)	5.0 (1)	4.4 (23)

7.1.11 Retention of Own Seed

Generally seed incurred about half of the variable cost of potato cultivation (Haque *et al*. 2011; Huq *et al*. 1995). Therefore, own seed provides a big financial relief to potato farmers. Table 47 reveals that 85% farmers sorted out larger tubers from potato heap for storing as seed. Among the other techniques, 63.8% farmers retained own seed through selecting the best looking plants and 30.6% farmers did it through separating seed plot. An insignificant number of potato farmers retained own seed potato by using proper seed plot technique.

Table 47. Percent farmers used seed retention technique in Bogra

Seed retention technique	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
Using separate seed plot	--	27.5	40.4	37.5	30.6
Selecting best looking plant	55.6	64.8	63.5	62.5	63.8
Sorting out larger tubers	88.9	84.6	86.5	75.0	85.0
Using proper seed plot technique	--	-	3.8	12.5	1.9

7.1.12 Problems of Seed Collection

Respondent farmer reported various problems in collecting seed potatoes. The highest percentage of farmers (53.1%) mentioned higher seed price as a major problem which was followed by scarcity of quality seed in the local market (29.4%) and scarcity of BADC seed (16.9%). A small percentage of farmers also mentioned that the quality of BADC seed was very good and some traders used false label in the name of BADC on seed potato bags (Table 48).

Table 48. Overall problems of seed collection in Bogra

Type of problem	% of farmers
Scarcity of government or BADC seed	16.9
Scarcity of quality seed in local market	29.4
Higher price of seed	53.1
Using BADC seal on low quality potato bag	11.9
No assurance of germination	4.4
Others*	4.4

*Others: Transportation cost high, dealer take higher price, can't understand the type of variety

7.1.13 Post-harvest Losses

Potatoes are semi perishable commodity, which contain more than 70% of moisture. Therefore, a huge loss is occurred both in quantity and quality during the whole process of harvesting, curing, storage, handling, transportation, and marketing. The post-harvest losses of potato at different stages of operations at farm level in the study areas are shown in Table 49.

It was found in the drought areas that entire potatoes were harvested manually using country plough or spade. No mechanical harvester was used for harvesting potatoes. The harvesting loss of potato in Bangladesh is found to be 5.65% (Hossain and Miah, 2010), which is higher than the result presented by Meyhuay (2007) for Costa Rica (3%) due to manual harvesting with spade. The harvesting loss of potato is ranged from 1 to 6% in India (http://agmarknet/nic.in/). In all category farmers, the average harvesting loss in Bogra district was found to be 597.14 kg/ha.

Harvested potatoes are cured in the shade to adjust to the environment and heel injuries normally caused during harvesting, handling and transportation from field to the farmer's home. In the northern part of Bangladesh, potatoes are bagged from the field and the bags are kept in the

shade at home for several days for curing. Sometimes, potatoes are spread on the floor and kept in the shade for one to two weeks. After curing, potatoes are sorted and sometimes graded and bagged. Table 49 reveals that total harvesting loss comprised potato remained under soil (61%), spoilage due to cut/crack (24%), insect damage (9%), curing loss after heaps (4%), and sorting/grading loss. It was also found that harvesting loss was higher for large farmers and lower for marginal farmers.

Another important loss was for storage of potato at home or in the cold storage. In traditional method, farmers stored potatoes at home by stacking them on the earthen floor of dwelling houses or stacking them on bamboo or wooden made platforms (*Macha)* for better aeration. In this method bulk potatoes are generally stored for three to four months. They frequently checked their home stored potatoes to sort out rotten ones and diseased ones which otherwise would cause damage to the whole quantity of stored potatoes. Traditional storage causes large-scale damage due to rot by disease, insect damage and weight loss. The total storage loss in the study areas was estimated at 124.7 kg/ton of which 36% and 64% were due to storage at home and in cold storage respectively. The storage loss was found to be higher for marginal farmers and lower for small farmers (Table 49). This loss was found to be lower than the loss estimated by Hossain and Miah (2010). In their study, they estimated the total storage loss of potato as 140.3 kg per ton of which 81.5% incurred for home storage and 58.8% for cold storage. Meyhuay (2007), referred to in CIP (2009) reports that traditional home storage loss of potato in Peru for a period of one, two and three months were 4.0, 10.5 and 15.2%, respectively. Rhoades (1984) reported that post harvest loss of traditional storage of potato was as high as 29% for only two months storage in Sri Lanka.

Table 49. Post-harvest losses of potato at farm level in Bogra district

Stages of loss	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
A. Harvesting method used (%)					
With spade	100	100	100	100	100
B. Loss during harvesting (kg/ha)	**417.48** (100)	**593.37** (100)	**617.36** (100)	**711.05** (100)	**597.14** (100)
Remained under soil during harvesting	274.44 (66)	349.98 (59)	390.08 (63)	458.44 (64)	364.18 (61)
Spoilage due to cut/crack during harvesting	93.14 (22)	144.60 (24)	154.30 (25)	159.05 (22)	145.58 (24)
Rotten loss due to LB infec./insect infest.	16.63 (4)	67.5 (11)	37.42 (6)	32.75 (5)	53.14 (9)
Curing loss after heaps	33.27 (8)	18.92 (3)	24.04 (4)	46.78 (7)	22.78 (4)
Sorting loss/ grading loss	--	12.34 (2)	11.52 (2)	14.03 (2)	11.46 (2)
C. Loss due to storage (kg/ton)	**129.9** (100)	**123.6** (100)	**125.7** (100)	**126.6** (100)	**124.7** (100)
Storage loss at home condition	50.0 (38)	42.8 (35)	44.8 (36)	62.5 (49)	44.8 (36)
Storage loss in the cold storage	79.9 (62)	80.8 (65)	80.9 (64)	64.1 (51)	79.9 (64)
Spoilage	40.3 (31)	38.3 (31)	38.4 (31)	31.3 (25)	38.0 (30)
Weight loss	39.6 (31)	42.5 (34)	42.5 (33)	32.9 (26)	41.9 (34)

Figures in the parentheses are percentages of total

7.1.14 Disposal Pattern

The average production of HYV potatoes was 17.7 ton per farm, whereas it was 8.3 ton for local variety. The respondent farmers in Bogra areas sold 91% and 84% of the total potatoes of HYV and local variety respectively. The percentages of retained seed were estimated at 7.4% for HYV and 8% for local variety. Again, they retained higher amount of seed of Granula variety followed by Cardinal and Diamant. Respondent farmers generally consumed local potato higher than that of HYV potato. It was also observed that they consumed more of Cardinal variety than Granula and Diamant. Among local varieties, Lal pakri was found to be the highest consumption variety followed by Fata pakri. A small percentage of total potato was also gifted to relatives and used as animal feed (Table 50).

Table 50. Disposal pattern of HYV and local potato in Bogra district

(Figures in kg/farm)

Disposal pattern	Farmers' category				All category
	Marginal	Small	Medium	Large	
1. High Yielding Variety					
Total production	4527 (100)	15121 (100)	21664 (100)	26391 (100)	17696 (100)
Sold to others	3779 (83)	13809 (91)	19635 (91)	23661 (90)	16061 (91)
Retained for seed	487 (11)	990 (7)	1838 (8.1)	2020 (8)	1332 (7.4)
Home consumption	241 (5)	277 (1.8)	132 (.6)	559 (1.4)	247 (1.4)
Gifted to relatives	21 (1)	44 (0.2)	54 (.3)	73 (0.3)	49 (0.2)
Feed	--	1 (0)	4 (0)	78 (0.3)	7 (0)
2. Local Variety					
Total production	6000 (100)	9885 (100)	14659 (100)	13840 (100)	8335 (100)
Sold to others	5043 (84)	8573 (86)	12555 (86)	10359 (75)	7042 (84)
Retained for seed	545 (9)	681 (7)	1316 (9)	1421 (10)	649 (8)
Home consumption	350 (6)	574 (6)	743 (5)	1761 (13)	587 (7)
Gifted to relatives	63 (1)	53 (1)	43 (0)	230 (1.5)	51 (1)
Feed	--	3 (0)	2 (0)	69 (0.5)	6 (0)

Figures in the parentheses are percentage of total

Fig 4. Disposal pattern of HYV potato (%)

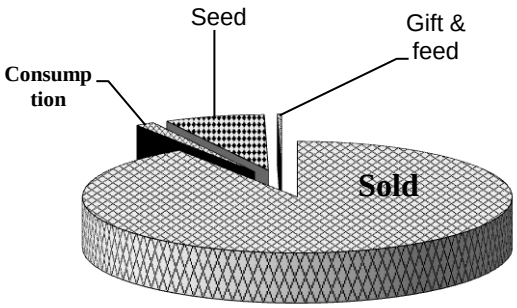
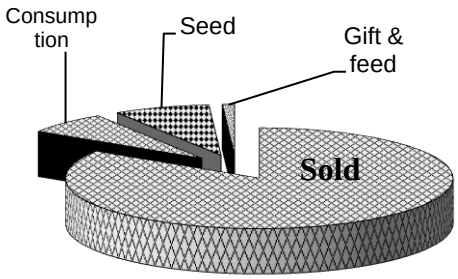


Fig 5. Disposal pattern of local potato (%)



7.1.15 Potato Sale and Sale Decision

Respondent farmers generally sell their potatoes mostly in the local market immediate after harvesting. Sometimes they sold it to *Beparis*[1] at their field. A very few farmers go to distant market for higher price. The study reveals that about 73% respondent farmers sold their potatoes to *Beparis* followed by retailers (6.8%) and *Faria* (5.9%). In most cases, farmers themselves took decision of selling potatoes. A good proportion of farmers (32.4%) took sale decision with their wives (Table 51).

[1]*Beparis* are relatively big and non-licensed traders. Some of them have fixed establishments in the market places with adequate keeping and short time storage facilities. *Beparis* purchase large amount of potatoes from farmers at farmyard and primary market. They had permanent labour for running their business.

Table 51. Percent responses on potato sale and sale decision in Bogra district

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
*Responses**	*n = 14*	*n = 184*	*n = 122*	*n = 20*	*n = 340*
1. Where to sell?					
Local market	71.4	61.4	58.2	35.0	59.1
Distant market	--	7.1	8.2	20.0	7.9
Potato field	28.6	31.5	33.6	45.0	32.9
2. Whom to sell?					
Faria[2]	--	7.6	1.6	20.0	5.9
Bepari	42.9	75.5	79.5	25.0	72.6
Arathdar	21.4	4.3	6.6	15.0	6.5
Retailer	7.1	8.2	4.9	5.0	6.8
Others	28.6	4.3	7.4	35.0	8.2
3. Who make sale decision?					
Self	50.0	57.6	54.1	50.0	55.6
Wife	--	1.1	6.6	15.0	3.8
Both husband & wife	28.6	33.7	32.8	20.0	32.4
Father	21.4	7.6	6.6	15.0	8.2

*Multiple responses due to sell more than one varieties

7.1.16 Payment Mode and Price Information

Table 52 reveals that one hundred percent respondent farmers sold potatoes in cash. Nearly 75% farmers reported that they received cash money from buyers immediately after selling. More than half of the respondents felt that the existing price information system is improved enough. The potato farmers who reported price information system traditional opined that the existing price information system can be improved through using mass media (43.1%), mobile phone (31.9%) and publishing price chart (13.8%).

[2] Non-licensed traders operate in the traditional potato marketing systems. They have no fixed business premises. They are generally landless or small farmers having no full-time work on the farm. *Farias* generally buy small amount of potatoes from farmer either at farm gate or in the primary markets and sell those to *Beparis* and retailers.

Table 52. Marketing information on potato in drought areas

Marketing information	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
1. Mode of payment (%)					
In cash	100	100	100	100	100
2. Nature of payment (%)					
On spot	77.8	82.4	65.4	50.0	75.0
Delayed	22.2	17.6	34.6	50.0	25.0
3. Price information system (%)					
Traditional	44.4	45.1	59.6	37.5	49.4
Improved	55.6	54.9	40.4	62.5	50.6
4. Steps for improvement (%)					
Through mobile	33.3	22.0	48.1	37.5	31.9
Use mass media	44.4	44.0	38.5	62.5	43.1
Publishing price chart	--	16.5	13.5	--	13.8

7.2 Heat and Saline Area (Chittagong District)

7.2.1 Adoption of Potato Varieties

Both HYV and indigenous variety of potatoes are being cultivated in the study areas. Diamant and Dohazari varieties were found in Chittagong areas. Twenty five percent of the farmers in all categories cultivated Diamant variety. On the other side, 100% farmers used Dohazari as indigenous potato varieties (Table 53). The average experience in potato farming was found to be 21.1 years. Medium farmers were more experienced compared to large and other farmers.

Table 53. Percent farmers planted potato varieties and their potato experience in Chittagong

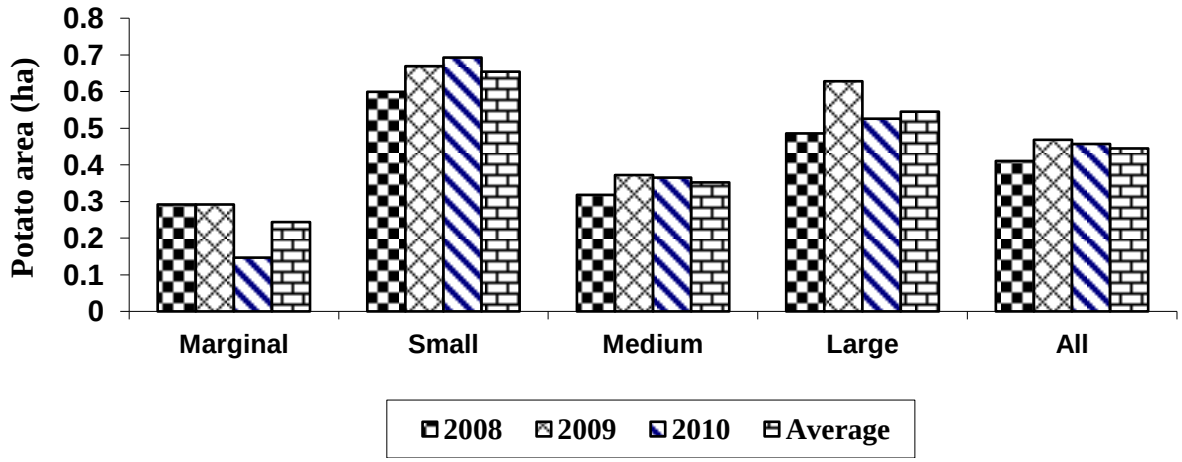
(Figures in %)

Variety cultivated	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents					
Diamant (HYV)	--	17.8	46.2	--	25.0
Dohazari (Local)	100	100	100	100	100
Potato experience (year)	15.0	20.5	24.2	14.0	21.1

7.2.2 Trend of Potato Cultivation

There was an increasing trend of potato area from 0.411 ha in 2007-2008 to 0.468 ha in 2008-2009 but it was gone down to 0.457 ha in 2009-2010. The potato area was decreased for the marginal farmer though the area of other category farmers increased to some extent within these three years period (Fig.6).

Figure 6. Trend of potato cultivation in the last three years



More than 41% of the respondent farmers increased their potato areas, whereas about 16% farmers decreased it in the last year (2010). They stated various causes for increasing and decreasing the potato areas. The highest 43.75% of respondent farmers increased potato areas because of higher profitability. The important reason for decreasing potato areas were shortage of land as stated by 61.5% of the farmers followed by lack of capital (Table 54).

Table 54. Causes of increasing or decreasing potato cultivation in the last year

(Figures in %)

Causes of increase/decrease	Farmers' category				All category
	Marginal	Small	Medium	Large	
No of respondents					
Farmers increase potato area	--	46.7	42.3	50	41.3
Farmers decrease potato area	14.3	15.6	15.4	50	16.3
Causes of increasing	*n=0*	*n=21*	*n=11*	*n=1*	*n=33*
Highly profitable	--	57.14	18.18	--	43.75
Can earn cash income	--	19.05	27.27	100	21.88
Causes of decreasing	*n=1*	*n=7*	*n=4*	*n=1*	*n=13*
Increase in vegetable cultivation	--	14.3	25.0	--	15.4
Shortage of land	--	71.4	50.0	100.0	61.5
Lack of capital	100	14.3	25.0	--	23.1

7.2.3 Variety Wise Potato Yield

In 2009-2010, the average per hectare yield was estimated at 22.06 for diamant variety and 16.27 for Dohazari variety. It was observed that the average yields of diamant and Dohazari variety potatoes in 2008-2009 were much lower compared to the yields observed in 2009-2010 (Table 55). The main reason behind this lower yield was opined to be bad weather especially the occurrence of drought. However, the average national yield was 13.06 tons per hectare during 2008-2009 (BBS, 2009).

Table 55. Variety wise yield (t/ha) of potato in Chittagong district

Year	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. Diamant (HYV)					
2008-2009	--	14.70 (8)	15.74 (9)	14.82 (1)	15.23 (18)
2009-2010	--	21.46 (5)	23.05 (3)	--	22.06 (8)
B. Dohazari (Local)					
2008-2009	13.46 (7)	12.31 (45)	12.37 (26)	11.72 (2)	12.42 (80)
2009-2010	14.82 (7)	16.69 (45)	16.07 (26)	14.41 (2)	16.27 (80)

Figures within parentheses are no. of respondent farmers

7.2.4 Variety Wise Seed Rate

Information regarding seed rate can be compared in the future to study the change of cultural practices among respondent farmers. The seed rate applied by the farmers varied from variety to variety in Chittagong areas. In 2009-2010, the average seed rate for Diamant (HYV) variety was 1.658 ton/ha, whereas this rate was 1.053 ton/ha for Dohazari variety. The seed rates applied in 2008-2009 for both HYV and local potatoes were slightly higher compared to the seed rates used in 2009-2010 (Table 56).

Table 56. Variety wise seed rate (ton /ha) used by Chittagong farmers in the last two years

Year	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. Diamant (HYV)					
2009-2010	--	1.689 (5)	1.606 (3)	--	1.658 (8)
2008-2009	--	1.723 (8)	1.708 (9)	1.482 (1)	1.702 (18)
B. Dohazari (Local)					
2009-2010	1.066 (7)	1.158 (45)	1.060 (26)	1.094 (2)	1.053 (80)
2008-2009	1.074 (7)	1.190 (45)	1.061 (26)	1.100 (2)	1.136 (80)

7.2.5 Size of Seed Potato

In 2009-2010, 75% of farmers used medium sized (20-60g) HYV seed potato, whereas 63.8% farmers used small sized (<20g) seed potatoes for local variety. A good proportion of farmers also used small sized seed for cultivating HYV potato and medium sized seed for cultivating local variety potato. The percentages of small size seed users increases with the increase in farm size. In the year 2008-2009, the highest proportion of potato farmers also used medium sized seed for HYV potato varieties and small sized seed for local potato varieties (Table 57).

Table 57. Size of seed potato used by Chittagong farmers in 2009-2010

(Figures in %)

Seed size	Farmers' category				All category
	Marginal	Small	Medium	Large	
	Year: 2009-2010				
A. Diamant (HYV)	*n = 0*	*n = 5*	*n = 3*	*n = 0*	*n = 8*
Small size (<20g)	--	40	--	--	25
Medium size (20-60g)	--	60	100	--	75
B. Dohazari (Local)	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Small size (<20g)	57.1	57.8	76.9	100.0	63.8
Medium size (20-60g)	42.9	42.2	23.1	--	36.3
	Year: 2008-2009				
A. Diamant (HYV)	*n = 0*	*n = 8*	*n = 9*	*n = 2*	*n = 19*
Medium size (20-60g)	--	62.5	66.7	100.0	68.4
Large size (>60g)	--	37.5	33.3	--	31.6
B. Dohazari (Local)	*n* = 7	*n* = 45	*n* = 26	*n* = 2	*n* = 80
Small size (<20g)	57.1	60.0	76.9	50.0	65.0
Medium size (20-60g)	42.9	40.0	23.1	50.0	35.0

7.2.6 Use of Cut and Whole Seed

The potato farmers in the Chittagong areas use both cut and whole tubers as seed. They cut HYV seed potato into 3-4 pieces for planting because this system reduces production cost. In the case of local variety, they use whole tubers as seeds since their sizes are very small. Table 58 reveals that one hundred percent respondent farmers used cut potato as seed in the case of HYV potato during 2009-2010, whereas this proportion was 88.9% during 2008-2009. Again, one hundred percent local potato growers used whole tubers as seed in 2009-2010 and 2008-2009. The detailed variety wise seed use can be seen in Table 58.

Table 58. Use of cut and whole seed potato by Chittagong farmers

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. Diamant (HYV)	*n = 0*	*n = 5*	*n = 3*	*n = 0*	*n = 8*
2009-2010 Cut potato	--	100	100	--	100
	n = 0	*n* = 8	*n* = 9	*n* = 1	*n* = 18
2008-2009 Cut potato	--	100	77.8	100	88.9
Whole potato	--	--	22.2	--	11.1
B. Dohazari (Local)	*n* = 7	*n* = 45	*n* = 26	*n* = 2	*n = 80*
2009-2010 Whole potato	100	100	100	100	100
2008-2009 Whole potato	100	100	100	100	100

7.2.7 Price of Seed Potato

The per ton average price of Diamant (HYV) seed potatoes was Tk.19,269 in 2009-2010. The price of Dohazari (local) variety seed potato was much higher than that of HYV seed potato. The price of local variety seed potato was 59% higher than the price of HYV seed in 2009-2010. In 2008-2009, the per ton average price of HYV potato was found to be lower (10%) compared to the prices received in 2009-2010. The price of Dohazari (local) variety was much higher (51%) than the price paid in 2008-2009 (Table 59).

Table 59. Price (Tk/ton) of seed potato in Chittagong areas during 2008-2010

Year	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. Diamant (HYV)					
2009-2010	--	18030	21333	--	19269
2008-2009	--	17918	15305	30000	17283
B. Dohazari (Local)					
2009-2010	48500	46611	45577	50000	46525
2008-2009	20714	23478	22149	26250	22873

7.2.8 Sale Price of Potato and Price Satisfaction

In 2008-2009, the average sale price received by potato farmers was Tk.19.4 per kg which was 15% higher than the price received in the next year. The reason of higher price was opined to be low production across the country due to unsuitable weather. Table 60 reveals that 56.3% farmers satisfied with the price they received in 2009-2010. A negative relationship was observed between farm size and price satisfaction. Farmers' dissatisfaction over price they were getting was due to higher production followed by low demand. About 73.3% farmers reported that the cause of lower price was for higher production and about 16% opined to be over low demand for potato.

Over 43% potato farmers believed that export promotion of potato followed by the minimum support price of potato and higher processing can ensure better price to them. No demand was demonstrated for such a support price for potato from farmers' level in Chittagong areas.

Table 60. Sale price and level of price satisfaction of Chittagong farmers during 2008-2010

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
Respondent #	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Sale price of potato (Tk/kg)					
In 2008-2009	20.4 (26)	19.4 (21)	19.0 (24)	23.8 (21)	19.4 (15)
In 2009-2010	15.0	15.2	14.4	18.8	16.5
2. Price satisfaction (%)					
Satisfied	71.4	55.6	53.8	50.0	56.3
Non-satisfied	28.6	44.4	46.2	50.0	43.8
3. Reasons for lower price (%)					
Over supply in the market	40.0	8.7	6.7	--	11.1
Higher production	20.0	82.6	80.0	50.0	73.3
Low demand	40.0	8.7	13.3	50.0	15.6
4. Steps for getting right price (%)					
Export promotion	16.7	59.1	25.0	50.0	41.3
Govt. purchase/minimum price	33.3	22.7	25.0	50.0	26.1
Ensure higher processing	50.0	18.2	31.3	--	26.1
Multiple use of potato	--	--	18.8	--	6.5

Bracketed figures represent percent higher than its next years' price.

7.2.9 Sources of Seed Potatoes

Potato farmers in heat and saline areas (Chittagong district) have collected seed potatoes from different sources. Home supplied seed potato was also reported to be the prime source of seed potatoes. In 2009-2010, 57.1% HYV potato seeds were supplied from their own source, whereas this proportion was 91.3% for local variety. The other important sources of seed potatoes were market trader and neighbour (Table 61). In 2008-2009, home supplied seed was also the major

source of potatoes for both HYV and local varieties. The other important sources of seed potatoes were also the same as stated above (Table 61).

Table 61. Percentage of farmers' responses on sources of seed potatoes in 2009-2010

Sources of seed potatoes	Farmers' category				All category
	Marginal	Small	Medium	Large	
Year: 2009-2010					
A. Diamant (HYV)	*n = 0*	*n = 4*	*n = 3*	*n = 0*	*n = 7*
1.Home supplied	--	100	--	--	57.1
2.Neighbouring farmer	--	--	66.7	--	28.6
3.Seed traders in the market	--	--	33.3	--	14.3
B. Dohazari (Local)	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1.Home supplied	100.0	95.6	84.6	50.0	91.3
2.Neighbouring farmer	--	--	7.7	--	2.5
3.Seed traders in the market	--	4.4	3.8	50.0	5.0
45.Commercial seed company	--	--	3.8	--	1.3
Year: 2008-2009					
A. Diamant (HYV)	*n = 0*	*n = 8*	*n = 9*	*n = 1*	*n = 18*
1.Home supplied	--	12.5	55.6	--	33.3
3.Seed traders in the market	--	25.0	44.4	100.0	38.9
6.BADC	--	62.5	--	--	27.8
B. Dohazari (Local)	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1.Home supplied	100.0	91.1	96.2	100.0	93.8
2.Neighbouring farmer	--	4.4	--	--	2.5
3.Seed traders in the market	--	4.4	3.8	--	3.8

According to the opinion of the farmers, home supply seeds are the best source of seed potatoes (42.5%) followed by BADC supply seed (23.8%) and market trader (17.5%). Commercial seed companies have very little access to the seed potato market (Table 62).

Table 62. Best sources of seed potatoes to the farmers in Chittagong

(Figures in %)

Sources of seed	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents					
1. Home supplied	71.4	42.2	34.6	50.0	42.5
2. Neighbouring farmer	14.3	11.1	23.1	--	15.0
3. Market trader	14.3	20.0	15.4	--	17.5
4. Commercial seed company	--	2.2	--	--	1.3
5. Government or BADC	--	24.4	26.9	50.0	23.8

7.2.10 Sources of First and Last Time used Potato Variety

Potato growers usually do not collect potato seed from the same source year after year. There are various sources of seed potato which are used by the respondent farmers. The source of seed potato varies from variety to variety and significantly from HYV to local varieties. At the time of their initial use, about 48 and 60% collected HYV and local seed potatoes from market traders and neighbouring farmers respectively. At the time of last use, most of them used their own seed potatoes (56.5-85%) for cultivation. The other important sources of HYV seed potato for the first time use was BADC and for local variety it was own source and market traders (Table 63).

Table 63. Sources of first and last time used potato variety in Chittagong

Sources of seed potato	Farmers' category				All category
	Marginal	Small	Medium	Large	
A. High Yielding Variety					
Sources of first time use (%)	*n = 0*	*n = 9*	*n = 13*	*n = 1*	*n = 23*
Neighbouring farmer	--	11.1	30.8	--	21.7
Market trader	--	33.3	53.8	100.0	47.8
Government or BADC	--	55.6	15.4	--	30.4
Sources of last time use (%)					
Home supplied	--	77.8	46.2	--	56.5
Neighbouring farmer	--	--	15.4	--	8.7
Market trader	--	11.1	38.5	100.0	30.4
Government or BADC	--	11.1	--	--	4.3
B. Local variety					
Sources of first time use (%)	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Home supplied	--	6.7	15.4	100.0	11.3
Neighbouring farmer	57.1	68.9	50.0	--	60.0
Market trader	42.9	24.4	30.8	--	27.5
Commercial seed company	--	--	3.8	--	1.3
Sources of last time use (%)					
Home supplied	85.7	91.1	80.8	--	85.0
Neighbouring farmer	14.3	2.2	15.4	100.0	10.0
Market trader	--	6.7	3.8	--	5.0

Potato farmers in the heat and saline areas do not continue with a specific variety for a long time. The length of period for changing seed depends on variety. It was found that potato farmers changed Dohazari variety after 19.6 years, whereas this period was 8.9 year for Diamant variety (Table 64).

Table 64. Duration (year) of changing seed by Chittagong farmers

Variety	Farmers' category				All category
	Marginal	Small	Medium	Large	
Diamant	--	8.2 (9)	9.5 (13)	7.0 (1)	8.9 (23)
Dohazari	16.3 (7)	18.8 (45)	23.0 (26)	6.5 (2)	19.6 (80)

Figures in the parentheses are number of respondent farmers

7.2.11 Retention of Own Seed

Table 65 reveals that nearly 99% farmers sorted out larger tubers from potato heap for storing as seed. Among the other techniques, 67.5% farmers retained own seed through selecting the best looking plants. An insignificant number of potato farmers retained own seed potato by using proper seed plot technique.

Table 65. Percent farmers used seed retention technique in Chittagong

Seed retention technique	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n =80*
Using separate seed plot	--	11.1	3.8	50.0	8.8
Selecting best looking plant	57.1	68.9	69.2	50.0	67.5
Sorting out larger tubers	--	100	100	50.0	98.8
Using proper seed plot technique	14.3	-	-	-	1.3

7.2.12 Problems of Seed Collection

Respondent farmer reported various problems in collecting seed potatoes. The highest percentage of farmers mentioned higher seed price (20%) and scarcity of quality seed (17.5%) as a major problem of seed. The farmers of Chittagong did not face the problem of false BADC label based seed bag (Table 66).

Table 66. Overall problems of seed collection in Chittagong

Type of problem	% of farmers
Scarcity of government or BADC seed	5.0
Scarcity of quality seed in local market	17.5
Higher price of seed	20.0
No assurance of germination	5.0
Others*	2.5

*Others: Transportation cost high, dealer take higher price, can't understand the type of variety

7.2.13 Post-harvest Losses

It was found in the study areas that potatoes were harvested manually using country plough or spade. No mechanical harvester was used for harvesting potatoes. In all category farmers, the average harvesting loss was found to be 560.52 kg/ha. Table 67 reveals that total harvesting loss comprised potato remained under soil (65%), spoilage due to cut/crack (30%), insect damage (1%), curing loss after heaps (3%), and sorting/grading loss. It was also found that harvesting loss was higher for large farmers and lower for marginal farmers. Another important loss was for storage of potato at home or in the cold storage. The total storage loss was estimated at 185.5 kg/ton of which 59% and 41% were due to store at home and in cold storage respectively. The negative relationship was observed between the quantity of storage loss and farm category. This loss was found to be higher than the loss estimated by Hossain and Miah (2010). In their study, they estimated the total storage loss of potato as 140.3 kg per ton.

Table 67. Post-harvest losses of potato at farm level in Chittagong

Stages of loss	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
A. Harvesting method used (%)					
With spade	100	100	100	100	100
B. Loss during harvesting (kg/ha)	**507.9** (100)	**565.19** (100)	**553.31** (100)	**737.26** (100)	**560.52** (100)
Remained under soil during harvesting	344.30 (68)	367.09 (65)	359.27 (65)	426.64 (58)	364.04 (65)
Spoilage due to cut/crack during harvesting	163.60 (32)	176.98 (31)	144.23 (26)	198.35 (27)	165.60 (30)
Rotten loss due to LB infec./insect infest.	--	1.7 (0.3)	10.08 (2)	37.42 (5)	5.15 (1)
Curing loss after heaps	--	15.30 (3)	20.15 (4)	74.9 (10)	17.03 (3)
Sorting loss/ grading loss	--	4.16 (1)	19.58 (4)	--	8.70 (2)
C. Loss due to storage (kg/ton)	**207.1** (100)	**194** (100)	**167.5** (100)	**143.8** (100)	**185.5** (100)
Storage loss at home condition	125 (60)	117 (60)	97 (58)	62.5 (43)	110 (59)
Storage loss in the cold storage	82.1 (40)	77 (40)	70.5 (42)	81.3 (57)	75.5 (41)
Spoilage	*35.8 (17)*	*36.8 (19)*	*34.9 (21)*	*37.5 (26)*	*36.1 (19)*
Weight loss	*46.4 (23)*	*40.3 (21)*	*35.6 (21)*	*43.8 (31)*	*39.4 (21)*

Figures in the parentheses are percentages of total

7.2.14 Disposal Pattern

The respondent farmers of Chittagong areas cultivated two types of potatoes namely Diamant (HYV) and Dohazari (local). The average production of Diamant variety was 2.67 ton per farm, whereas it was 6.94 ton for local variety. They sold major proportion (78-93%) of their potatoes for cash. The percentages of retained seed were estimated at 5% for HYV and 15% for local variety. Respondent farmers in the study areas consumed local potato higher than that of HYV potato. A small percentage of total potato was also gifted to relatives (Table 68).

Table 68. Disposal pattern of HYV and local potato in Chittagong areas

(Figures in kg/farm)

Disposal pattern	Farmers' category				All category
	Marginal	Small	Medium	Large	
1. High Yielding Variety					
Total production	--	2360 (100)	2910 (100)	--	2674 (100)
Sold to others	--	2054 (87)	2817 (97)	--	2490 (93)
Retained for seed	--	244 (10)	33 (1)	--	123 (5)
Home consumption	--	49 (2)	51 (2)	--	50 (2)
Gifted to relatives	--	13 (1)	9 (0)	--	11 (0)
2. Local Variety					
Total production	4433 (100)	5344 (100)	10275 (100)	8260 (100)	6940 (100)
Sold to others	3289 (74)	4025 (75)	8318 (81)	7510 (92)	5443 (78)
Retained for seed	871 (20)	890 (17)	1372 (13)	370 (4)	1032 (15)
Home consumption	234 (5)	325 (6)	365 (4)	350 (4)	331 (5)
Gifted to relatives	39 (1)	104 (2)	220 (2)	30 (0)	134 (2)

Figures in the parentheses are percentages of total production

Fig 7. Disposal pattern of HYV potato (%)

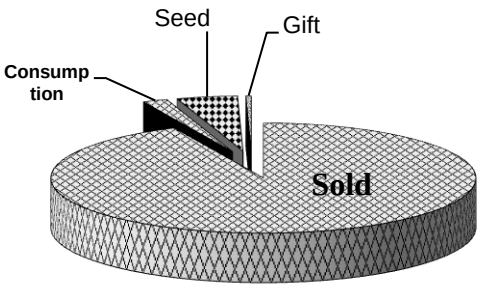
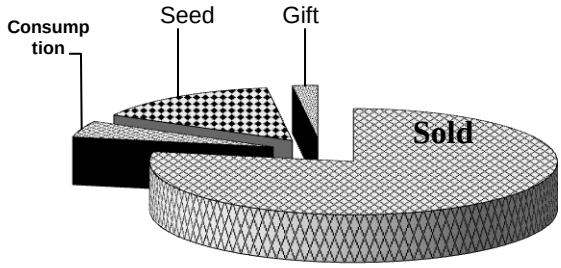


Fig 8. Disposal pattern of local potato (%)



7.2.15 Potato Sale and Sale Decision

More than 60% farmers of the study areas sold their potatoes in the local market and about 37% farmers sold potato at farm yard immediate after harvesting. A very few farmers go to distant market for higher price. The study reveals that about 88.1% respondent farmers sold their potatoes to *Beparis* followed by retailers (5%) and *Arathdars* (4%). In most cases, farmers themselves took decision of selling potatoes. A good proportion of farmers (37.6%) took sale decision with their wives (Table 69).

Table 69. Percent responses on potato sale and sale decision in Chittagong

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
*No. of responses**	*n = 7*	*n = 54*	*n = 38*	*n = 2*	*n = 101*
1. Where to sell?					
Local market	71.4	64.8	52.6	50.0	60.4
Distant market	--	1.9	2.6	50.0	3.0
Potato field	28.6	33.3	44.7	--	36.6
2. Whom to sell?					
Faria	14.3	3.7	--	--	3.0
Bepari	85.7	92.6	84.2	50.0	88.1
Arathdar	--	--	7.9	50.0	4.0
Retailer	--	3.7	7.9	--	5.0
3. Who make sale decision?					
Self	71.4	53.7	65.8	100	60.4
Wife	--	1.9	--	--	1.0
Both husband & wife	28.6	44.4	31.6	--	37.6
Father	--	--	2.6	--	1.0

*Multiple responses due to sell more than one varieties

7.2.16 Payment Mode and Price Information

Table 70 reveals that all the farmers sold potatoes in cash. Nearly 83% farmers reported that they received cash money from buyers immediately after selling. Only 17.5% farmers received money on delayed basis. More than half of the respondents felt that the existing price information system is not improved enough. The potato farmers who reported price information system traditional opined that the existing price information system can be improved through using mobile phone (18.75%), mass media (18.75%), and publishing price chart (16.25%).

Table 70. Potato marketing information in Chittagong areas

Marketing information	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Mode of payment (%)					
In cash	100	100	100	100	100
2. Nature of payment (%)					
On spot	71.4	77.8	96.2	50.0	82.5
Delayed	28.6	22.2	3.8	50.0	17.5
3. Price information system (%)					
Traditional	42.9	53.3	53.8	100	53.75
Improved	57.1	46.7	46.2	--	46.25
4. Steps for improvement (%)					
Through mobile	28.6	13.3	19.2	100	18.75
Use mass media	--	20.0	23.1	--	18.75
Publishing price chart	14.3	20.0	11.5	--	16.25

8. OTHER BASELINE INDICATORS

Some other information fully or partially important for potato cultivation was also considered in this study as baseline indicators for future impact study. The indicators are status of mechanization, access to technical information, training and extension activities, access to agricultural credit, soil health awareness, and status and quality of irrigation water. All these indicators are briefly discussed in the following sub-sequent sections.

8.1 Draught Area (Bogra District)

8.1.1 Status of Farm Mechanization

Mechanization is very much important in modern crop cultivation as it saves time and cost for the farmers. The level of mechanization in the study areas was not found too much satisfactory due to small holdings, availability of labour, and lack of funds. The level of mechanization was assessed in six important areas, viz., field preparation, planting, earthing up, grading, irrigation, and pesticides spraying (Table 71). Total or absolute mechanization was reported for field preparation through two wheel tractor locally called power tiller and irrigation. The higher level of partial mechanization was observed in spraying pesticides. Farmers still follow the primitive method in case of planting, earthing up and potato grading in the study areas.

Table 71. Percent responses on the level of mechanization in the study areas of Bogra

(Figures in %)

Mechanization type	Farmers' category				All
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n =160*
1. Field preparation					
Total mechanization	100	100	100	100	100
2. Planting					
No mechanization	100	100	100	100	100
3. Earthing up					
No mechanization	100	100	100	100	100
4. Grading					
No mechanization	100	100	100	100	100
5. Irrigation					
Total mechanization	100	100	100	100	100
6. Pesticides spraying					
Partial mechanization	100	100	100	100	100

8.1.2 Access to Technical Information

Technical information relating to crop cultivation includes information on new inputs, input prices, input availability, potato prices, weather forecast, and government policies. The potato farmers have access to these information in many ways. The important sources of information regarding new inputs were input dealers/sellers (69.38%) followed by government extension worker (66.25%) and neighbouring (55%) farmers. Input dealers, neighbour, and extension workers also played important role in conveying information relating to input price and its availability. The best source of information on local potato price to the farmers was reported to be neighbouring farmers (74.38%) followed by market middlemen (42.5%) and friends. Radio/TV was reported to be the prime information source for weather forecast and government polices to the farmers in the study areas (Table 72).

Table 72. Sources of technical information for potato cultivation in Bogra (multiple responses)

(Figures in %)

Information sources	Technical information				
	New inputs	Input prices/ availability	Local potato prices	Weather forecast	Govt. policies
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n =160*
1. Friend	6.88	6.88	19.38	1.25	0.63
2. Neighbouring farmers	55.00	40.63	74.38	10.00	13.13
3. Market middlemen	11.88	14.38	42.50	1.25	1.25
4. Govt. extension worker	66.25	25.63	3.13	12.50	33.75
5. Radio/TV	3.75	0.63	2.50	72.50	67.50
6. Newspaper	2.50	1.25	1.25	14.38	33.75
7. Agricultural fare	5.00	1.25	0.63	--	--
8. Field day	4.38	1.25	--	--	1.25
9. Training	3.75	0.63	--	--	0.63
10. Input seller/dealer	69.38	77.50	6.25	1.88	1.88
11. Private companies	1.88	1.25	0.63	--	0.63
12. Prediction	3.13	0.63	5.63	20.00	0.63

Majority of the potato farmers in all categories reported that important technical information properly reached to them. Only 35% farmers told that many important technical information did not reach to them, but they could not mention the exact information which was out of reach. Only a few percentages of potato farmers could mention the lacking areas of information such as government policies, weather forecast, new varieties, disease management, and fertilizer doses (Table 73).

Table 73. Perception on access to information and information lacking areas in Bogra

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n =160*
Access to information					
Not reached	55.6	35.2	26.9	62.5	35.0
Adequately reached	44.4	64.8	73.1	37.5	65.0
Information lacking areas	*n = 5*	*n = 32*	*n = 14*	*n = 5*	*n = 56*
Government policies	40.0	34.4	50.0	40.0	39.3
Weather forecast	--	12.5	7.1	--	8.9
New varieties/inputs	40.0	15.6	21.4	40.0	21.4
Disease management	20.0	28.1	14.3	--	21.4
Fertilizer doses	--	9.4	7.1	20.0	8.9

8.1.3 Training and Extension Activities

Table 74 reveals that 46.25% potato farmers got some kind of training in the field of agriculture. The fields of training were reported to be rice cultivation, potato cultivation, ICM and IPM. The highest percentage of small category farmers received agricultural training and the lowest for marginal farmers. Generally, government organizations and some NGOs impart training on technical know-how of agriculture for capacity building of the farmers. The name of the training imparting organization in the study areas was DAE.

Table 74. Agricultural training and extension activities during last one year in Bogra

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n =160*
Training information					
Farmers received training	11.11	49.45	48.08	37.50	46.25
Farmers not received training	88.89	50.55	51.92	62.50	53.75
Field/areas of training					
Rice cultivation	100.00	55.56	60.00	33.33	56.76
Potato cultivation	--	13.33	20.00	33.33	16.22
Integrated crop management (ICM)	--	31.11	16.00	33.33	25.68
Integrated pest management (IPM)	--	--	4.00	--	1.35
Imparting organization					
Department of agricultural extension (DAE)	100	51.11	64.00	66.67	56.76

8.1.4 Access to Agricultural Credit

Different nationalized banks, NGOs, and money lenders usually provide small credit facilities to farmers, petty traders and other landless groups in the study areas. The rate of interest was reported to be the highest for money lender and the lowest for nationalized bank. It was found

that only 19.38% respondent farmers received short-term small credit from nationalized bank amounting Tk. 13,871 with an interest rate of Tk. 8.00 per year for different crops cultivation and STW purchase. The percentages of recipient farmers were higher for medium farmers followed by large farmers in the study areas (Table 75).

Table 75. Information on agricultural credit received in the last two years in Bogra

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n =160*
1. Farmers received credit					
Yes	--	19.19	15.69	50.00	19.38
No	100	80.81	84.31	50.00	80.63
2. Amount of credit (Taka)	--	9211	22250	19250	13871
3. Duration of credit (month)	--	10	10	12	10
4. Interest rate (Tk/year)	--	8.00	8.00	8.00	8.00
5. Type of collaterals					
Land document (*Dolil*)	--	100	100	100	100
6. Sources of loan					
Nationalized Bank	--	78.95	100	75.00	83.87
Other source	--	21.05	--	25.00	16.13
7. Purpose of taking loan					
Boro rice cultivation	--	31.58	25.00	--	25.81
Potato cultivation	--	42.12	50.00	50.00	45.16
Other crops cultivation	--	21.05	25.00	50.00	25.81
STW purchase	--	5.25	--	--	3.22

8.1.5 Soil Health Awareness

The potato farmers in the study areas were found not so much aware of the soil health of their crop land. Traditionally, they use mostly chemical fertilizers and little amount of dung manure for crop production. They do not apply green manure at all to their farm land. Their lack of awareness toward soil health might be due to non-availability of soil test facility in the study areas. The interested farmers generally go to district town for testing their soil. The mobile soil test laboratory of SRDI sometimes provides soil test facility to the farmers at *Upazila* DAE office. The local research station of BARI sometimes tests farmers' soil for their own purpose.

Table 76. Information regarding soil test conducted by Bogra farmers

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
Farmers tested their soil (%)	11.1	9.9	13.7	37.5	12.5
Farmers used laboratory (%)					
SRDI	11.1	7.7	9.9	25.0	9.4
BARI	--	1.1	1.9	-	1.3
DAE	--	1.1	1.9	12.5	1.9
Tested soil years ago	3.0 (1)	2.40 (9)	2.60 (7)	7.00 (3)	3.2 (20)
Average cost of soil test (Tk)	-	22.22 (9)	38.57 (7)	16.67 (3)	26.0 (20)
Farmers observed structural change in the soil (%)	44.4	68.2	53.9	62.5	61.9
Farmers observed (%)					
1. Soil become good	11.1	27.5	21.2	25.0	24.4
2. Soil become worse	33.3	40.7	32.7	37.5	37.5

Note: Figures in the parentheses indicate the number of respondents

The study revealed that only 12.5% of the potato farmers tested the soil of their crop land more than three years ago. Out of them, 9.4% tested from SRDI, 1.3% from BARI and 1.9% from DAE. The average cost incurred for soil test was Tk. 26. About 62% farmers perceived that their soil texture or structure have been changed over 10 years. Among them 24.4% farmers observed good soil condition, but 37.5% farmers observed it worse condition (Table 76).

8.1.6 Status and Quality of Irrigation Water

The major sources of irrigation water in the study areas were DTW and STW. Table 77 reveals that more than 66% of the respondent farmers irrigated their crops through purchased water from DTW followed by STW. The farmers in all categories used furrow method of irrigation. More than 91% potato farmers uttered their satisfaction with the availability of irrigation water in the study areas. Most of them have no complain against irrigation water because of its good quality.

Selling and purchasing irrigation water was a common practice in the area and the average price of irrigation water was Tk.3171 per hectare. Irrespective of farmer's category, some DTW/STW owning farmers sold irrigation water to other farmers after satisfying their own needs. Besides, there were also some DTW/STW owners who purchased irrigation water from others for their distant crops. Table 77 further reveals that 88.8% farmers purchased water for irrigating crops and 21.9% farmer sold water to other farmers.

Table 77. Overall status and quality of irrigation water in Bogra

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents					
Farmers used irrigation					
1. Shallow tube well	52.22	29.63	33.65	60.13	33.73
2. Deep tube well	47.78	70.37	66.35	39.87	66.27
Farrow irrigation system	100	100	100	100	100
Availability of irrigation water	88.9	95.6	86.5	87.5	91.9
Good quality irrigation water	100	100	100	100	100
Farmers purchased water	88.9	93.4	82.7	75.0	88.8
Farmers sold water	11.1	11.0	38.5	50.0	21.9
Price of irrigation water (Tk/ha)	3046	3254	3090	2742	3171

Table 78. Investment on irrigation water by the sample potato farmer of Bogra

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 1*	*n = 11*	*n = 21*	*n = 4*	*n =37*
No. of farmers invested on:					
1. STW	1	8	16	4	29
2. DTW	-	4	8	-	12
Average area covered (ha)	5.8704	11.4854	4.5288	5.0809	6.6929
Average invested period (year)	8.0	12.5	10.0	10.5	10.8
Average initial investment (Tk)	8000	58545	61109	28750	55414
Average maintenance cost (Tk)	2000	12882	14509	14125	13646
Average operating cost (Tk)	9000	17932	15790	7660	15365

It was found that 29 respondent farmers invested on STW and 12 farmers on DTW. The average area covered by the irrigation investment was 6.69 ha. The average period of investment on

irrigation business was 10.8 years. The average initial investment was Tk. 55414, maintenance cost was Tk. 13646 and operating cost was Tk. 15365 (Table 78).

A good percentage of respondent potato farmers (53.1%) encountered various problems on overall irrigation system in the study areas. It was found that the irrigation problems were highly reported by the large farmers followed by medium, small and marginal farmers. It is meant that a positive relationship was found between the farm size and the extent of problems in the study areas. The reason behind this relationship was that the number of irrigation equipment was higher for large category farmers than small and marginal farmers. Table 79 reveals that the highest percentage of potato farmers (81.2%) reported load shading of electricity as a problem. The other problems were ground water scarcity, non-availability of irrigation water and higher price of oil and fuel.

Table 79. Problems associated with overall irrigation system in Bogra

Problems	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 9*	*n = 91*	*n = 52*	*n = 8*	*n = 160*
1. Farmers faced problem (%)	22.2	48.4	63.5	75.0	53.1
2. Responses on problems faced (%)	*n = 2*	*n = 44*	*n = 33*	*n = 6*	*n = 85*
Higher price of oil and fuel	50	2.3	6.1	--	4.7
Load shading of electricity	100	81.8	90.9	16.7	81.2
Ground water scarcity	--	15.9	15.2	33.3	16.5
Higher price of irrigation	100	2.3	3.0	50.0	8.2
Non-availability of irrigation water	--	9.1	3.0	66.7	10.6

8.1.7 Cropping Patterns

One hundred percent respondent farmers in Bogra district followed *T.Aman-Potato-Boro* cropping pattern (Table 80).

Table 80. Percent farmers' responses on potato based cropping pattern in Bogra

Cropping pattern	Farmers' category				All category
	Marginal	Small	Medium	Large	
	n = 9	*n = 91*	*n = 52*	*n = 8*	*n = 160*
T. Aman-Potato-Boro	100	100	100	100	100

8.2 Heat and Saline Area (Chittagong District)

8.2.1 Status of Farm Mechanization

The level of mechanization was assessed in six important areas, viz., field preparation, planting, earthing up, grading, irrigation, and pesticides spraying. Total or absolute mechanization was reported for field preparation through two wheel tractor locally called power tiller and irrigation. The higher level of partial mechanization was observed in spraying respectively. Farmers still follow the primitive method of planting, earthing up and potato grading in the study areas (Table 81).

Table 81. Percent responses on the level of mechanization in Chittagong

(Figures in %)

Mechanization type	Farmers' category				All
	Marginal	Small	Medium	Large	
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Field preparation					
Total mechanization	100	100	100	100	100
2. Planting					
No mechanization	100	100	100	100	100
3. Earthing up					
No mechanization	100	100	100	100	100
4. Grading					
No mechanization	100	100	100	100	100
5. Irrigation					
Total mechanization	100	100	100	100	100
6. Pesticides spraying					
Partial mechanization	100	100	100	100	100

8.2.2 Access to Technical Information

The important sources of information regarding new inputs were input dealers/sellers (60.26%) followed by government extension worker (55.13%) and neighbouring (48.72%) farmers. Input dealers, neighbour, and extension workers also played important role in conveying information relating to input price and its availability. The best source of information on local potato price to the farmers was reported to be neighbouring farmers followed by market middlemen and friends. Radio/TV was reported to be the prime information source for weather forecast and government polices to the farmers in the study areas (Table 82).

Table 82. Sources of technical information for potato cultivation in Chittagong (multiple responses)

(Figures in %)

Information sources	Technical information				
	New inputs	Input prices/ availability	Local potato prices	Weather forecast	Govt. policies
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Friend	14.10	1.28	24.36	--	--
2. Neighbouring farmers	48.72	23.08	75.64	1.28	2.56
3. Market middlemen	16.67	17.95	46.15	1.28	3.85
4. Govt. extension worker	55.13	19.23	3.85	3.85	16.67
5. Radio/TV	1.28	1.28	2.56	87.18	65.38
6. Newspaper	--	--	--	3.85	32.05
7. Agricultural fare	1.28	1.28	--	--	--
8. Input seller/dealer	60.26	92.31	2.56	--	--
9. Prediction	1.28	--	--	16.67	--

Most farmers (73.08%) in all categories opined that important technical information adequately reached to them. About 27% farmers reported about non-reach of technical information to them, but they could not mention the exact information which was out of reach. Only a few percentages of potato farmers could mention the lacking areas of information such as government policies, new varieties, disease management, fertilizer doses and weather forecast (Table 83).

Table 83. Perceptions on access to information and information lacking areas in Chittagong

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Access to information					
Not reached	28.57	24.44	30.77	50.00	26.92
Adequately reached	71.43	75.56	69.23	50.00	73.08
Information lacking areas					
Government policies	--	27.27	62.50		38.10
Weather forecast	--	18.18	--		9.52
New varieties/inputs	50.00	27.27	12.50	100	23.81
Disease management	50.00	18.18	25.00		23.81
Fertilizer doses	--	18.18	12.50		14.29

8.2.3 Training and Extension Activities

Most of the farmers did not get any training in the study areas. About 38% potato farmers got some kind of training in the field of agriculture. The highest percentage of large category farmers received agricultural training and the lowest for marginal farmers (Table 84). Generally, government organizations and some NGOs impart training on technical know-how of agriculture for capacity building of the farmers. The DAE was the imparting organization of their trainings.

Table 84. Agricultural training and extension activities during last one year in Chittagong

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Training information					
Farmers received training	28.57	40.00	30.77	100	37.50
Farmers not received training	71.43	60.00	69.23	--	62.50
Field/areas of training					
Rice cultivation	50.00	55.56	75.00	100	63.33
Potato cultivation	50.00	11.11	--	--	10.00
Integrated crop management (ICM)	--	5.56	12.50	--	6.67
Integrated pest management (IPM)	--	27.78	12.50	--	20.00
Imparting organization					
Department of agricultural extension (DAE)	100	100	100	100	100

8.2.4 Access to Agricultural Credit

It was found that a negligible number of small and medium farmers took short-term (for one year) loan from nationalized bank for different crops cultivation and purchasing STW. The average amount of loan was Tk. 13,333 and its interest rate was Tk. 8.00 per year. One hundred percent farmers took loan from bank giving *Dolil* as collateral (Table 85).

Table 85. Information on agricultural credit received in the last two years in Chittagong

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondent	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Farmers received credit					
Yes	--	2.22	7.69	--	3.85
No	100	97.78	92.31	100	96.15
2. Amount of credit (Taka)	--	10,000	15,000	--	13,333
3. Duration of credit (month)	--	12	9.5	--	10.33
4. Interest rate (Tk/year)	--	8.0	8.0	--	8.0
5. Type of collaterals					
Land document (*Dolil*)	--	100	100	--	100
6. Sources of loan					
Nationalized Bank	--	100	100	--	100
7. Purpose of taking loan					
Boro rice cultivation	--	100	--	--	--
Potato cultivation	--	--	100	--	--
STW purchase	--	--	--	--	100

8.2.5 Soil Health Awareness

The study revealed that only 6.3% of the potato farmers tested the soil of their crop land. Out of them, 1.3% tested from SRDI and 5% from DAE. The average cost incurred for soil test was Tk. 32. About 23% farmers perceived that their soil texture or structure have been changed over 10 years. Among them 17.5% farmers observed good soil condition and 26.1% farmers observed it worse condition (Table 86).

Table 86. Information regarding soil test conducted by Chittagong farmers

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
Farmers tested their soil (%)	-	2.2	15.4	-	6.3
Farmers used laboratory (%)					
SRDI	-	-	3.8	-	1.3
DAE	-	2.2	11.5	-	5.0
Tested soil years ago		7.0 (1)	3.0 (4)	-	3.8 (5)
Average cost of soil test (Tk)	-	-	40.0 (4)	-	32.0 (5)
Farmers observed structural change in the soil (%)	-	24.4	23.0	50.0	22.5
Farmers observed (%)					
• Soil become good	-	20.0	19.2	-	17.5
• Soil become worse	-	4.4	3.8	50.0	5.0

Note: Figures in the parentheses indicate the number of respondents

8.2.6 Status and Quality of Irrigation Water

The major sources of irrigation water in the study areas were DTW and STW. Farmers also used LLP for lifting irrigation water from ponds/*Khals*/cannels. Table 87 reveals that about 41% of the respondent farmers irrigated their crops through LLP followed by STW and DTW. All the farmers used furrow method of irrigation. 95% of the potato farmers uttered their satisfaction

with the availability of irrigation water in the study areas. Most of them have no complain against irrigation water because of its good quality.

The average price of irrigation water was Tk.3473 per hectare. Table 87 further reveals that 85% farmers purchased water for irrigating crops and 16.3% farmer sold water to other farmers.

It was found Table 88 that 12 farmers invested on STW, 1 farmer on DTW and 7 farmers on LLP. The average area covered by the irrigation investment was 1.58 ha. The average period of investment on irrigation business was 6.5 years.

Table 87. Overall status and quality of irrigation water in Chittagong

(Figures in %)

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents					
Farmers used irrigation					
1. Shallow tube well	14.28	35.11	45.77	20.00	36.38
2. Deep tube well	42.86	27.89	8.08	30.00	22.81
3. Pond/Khal/cannel	42.86	37.00	46.15	50.00	40.81
Farrow irrigation system	100	100	100	100	100
Availability of irrigation water	100	97.8	88.5	100	95.0
Good quality irrigation water	100	93.3	92.3	100	93.8
Farmers purchased water	100	88.9	80.8	100	85.0
Farmers sold water	100	13.3	19.2	100	16.3
Price of irrigation water (Tk/ha)	3144	3614	3321	-	3473

Table 88. Investment on irrigation water by Chittagong farmer

Particulars	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 0*	*n = 7*	*n = 10*	*n = 2*	*n =19*
No. of farmers invested on:					
1. STW	-	6	5	1	12
2. DTW	-	-	-	1	1
3. LLP	-	2	5	-	7
Average area covered (ha)	-	1.3996	1.4372	2.9959	1.5874
Average invested period (year)	-	5.1	7.9	4.0	6.5
Average initial investment (Tk)	-	10671	8230	83400	17042
Average maintenance cost (Tk)	-	883	2118	10850	2582
Average operating cost (Tk)	-	3643	4720	15750	5484

It is revealed from Table 89 that 36.3% of the farmers encountered various problems on overall irrigation system in the study areas. Large farmers were not facing any problem regarding irrigation system in the study area. Table 89 reveals that the highest 75.4% of the potato farmers reported load shading of electricity as a major problem. The other problems were non-availability of irrigation water, ground water scarcity and higher price of oil and fuel.

Table 89. Problems associated with overall irrigation system in Chittagong

Problems	Farmers' category				All category
	Marginal	Small	Medium	Large	
No. of respondents	*n = 7*	*n = 45*	*n = 26*	*n = 2*	*n = 80*
1. Farmers faced problem (%)	57.1	33.3	38.5	--	36.3
2. Responses on problems faced (%)	*n* =4	*n* =15	*n* =10	*n* =0	*n* =29
Higher price of oil and fuel	--	20.0	40.0	--	24.1
Load shading of electricity	75.0	53.3	60.0	--	58.6
Ground water scarcity	--	26.7	20.0	--	20.7
Higher price of irrigation	50.0	6.7	--	--	10.3
Non-availability of irrigation water	50.0	46.7	20.0	--	37.9

8.2.7 Cropping Patterns

The respondent farmers of Chittagong district mentioned four cropping patterns. The highest proportion of Chittagong farmers (83.8%) reported *Aus-Potato-Fallow* as their major cropping pattern followed by *T.Aman-Potato-Boro* cropping pattern (Table 90).

Table 90. Percent farmers' responses on potato based cropping pattern in Chittagong

Cropping pattern	Farmers' category				All category
	Marginal	Small	Medium	Large	
	n = 7	*n = 45*	*n = 26*	*n = 2*	*n = 80*
T. aman-Potato-Boro	--	6.7	11.6	--	7.5
T.aman-Potato-Fallow	14.3	--	3.8	--	2.5
Aus-Potato-Boro	--	8.9	3.8	--	6.2
Aus-Potato-Fallow	85.7	84.4	80.8	100	83.8

9. CONCLUSIONS AND POLICY IMPLICATIONS

9.1 Conclusions

1. Most respondent farmers in both areas believed that their current potato yields can further increase through introducing new high yielding potato varieties followed by drought resistant varieties, training on potato cultivation, availability of adequate fund, proper late blight control, and adequate quantity and timely availability of fertilizers.
2. Low yield, susceptible to diseases, late maturity and low demand were the reasons of abandoning five potato varieties by the farmers of draught areas (Bogra) in the past. In Chittagong, farmers only abandoned Diamant variety. However, the abandoning varieties are still popular and widely cultivated varieties in the study areas.
3. Drought and heat were two important limiting factors towards achieving the higher levels of potato yield in both the study areas. However, a positive relationship was found between farm category and two limiting factors.
4. Dohazari variety for heat and saline area (Chittagong district) and Lalpakri for drought area (Bogra district) have higher levels of tolerance against abiotic stresses compared to other local and HYV potatoes. Besides, early maturity followed by drought tolerance, heat tolerance and salinity tolerance were important attributes farmers in both areas wanted in new potato varieties.

5. Most of the baseline indicators related to farmers' socio-economic profiles were governed by farm size, in other wards, by family income. Educational qualification of household head, no. of earning member, proportion of land for rice cultivation, area under potato and vegetable cultivation, livestock inventory, costly farm equipment, house condition, monthly expenditure (for food, children education & travel), cooking gas connection and modern amenities (e.g. mobile phone, TV) were found to increase with the increase in farm size in both the study areas.
6. In both study areas, the highest proportion of cultivated land was devoted to rice cultivation followed by potato. The other important cultivated crops were vegetables, pulses and spices.
7. The highly adopted potato varieties were Granula, Cardinal and Lalpakri in Bogra district, whereas Diamant and Dohazari were found in Chittagong areas. In 2009-2010, the average potato yields found at Bogra district were ranged from 21.22 to 22.57 tons per hectare for HYV potato and 15.01 to 16.76 tons for local variety. In the same year, the average yields of Diamant and Dohazari variety were estimated at 22.06 and 16.27 t/ha for Chittagong areas.
8. In both areas, the highest proportion of harvesting losses was due to potato remained under soil followed by potato cutting/cracking and insect damage. Again, average storage loss were estimated at 125 kg and 186 kg per ton of which 64% and 41% were due to store in cold storage in Bogra and Chittagong respectively.
9. In 2009-10, the average seed rates were ranged from 1.54 to 1.83 tons/ha for HYV potatoes and 0.83 to 0.95 tons/ha for local variety in drought prone areas, whereas these seed rates were 1.66 and 1.05 t/ha for HYV and local potato in heat and saline areas respectively. Most potato farmers in both study areas used medium sized (20-60g) and cut seeds in the case of HYV potatoes, whereas it was small sized (<20g) whole tubers for local variety. Chittagong farmers replaced Dohazari variety after 19.6 years and Bogra farmers replaced Ruma variety after 1.0 year.
10. In Bogra, potato farmers sold 91% of HYV and 84% of local variety potatoes. The percentages of retained seed were 7.4% for HYV and 8% for local variety. In Chittagong, farmers sold 93% and 78% potatoes of HYV and local variety respectively. The percentages of retained seed were 5% for HYV and 15% for local variety. The potato farmers of both areas consumed local potato higher than HYV potato.
11. Majority of the farmers sorted out larger tubers from potato heap for retaining seed. The other seed retaining techniques were selection of best looking plants and separating seed plot.
12. Most farmers sold the major share (73-88%) of potatoes to *Beparis* in cash. In most cases (56-60%), farmers themselves took decision for selling potatoes. In both areas, price satisfaction was higher among marginal and small farmers due to receive higher price. The reasons of dissatisfaction were higher production followed by over supply in the market. Potato farmers believed that existing price information system can be improved through using mass media, publishing price chart and mobile phone.
13. Out of seven operations, mechanization indices were higher for field preparation through two wheel tractor, irrigation and spraying in both the study areas. Farmers still follow the primitive method for grading potato.
14. The important sources of technical information regarding new inputs and input availability or price were input sellers, extension worker and neighbouring farmers. Radio/TV was the main information source for weather forecast and government polices.
15. Respondent were not aware of the soil health of their crop land. About 13% potato farmers in Bogra and 6.3% farmers in Chittagong tested the soil of their crop land more than three years ago.

16. DTW was the major source of irrigation water in drought area (Bogra), whereas it was pond/cannel in heat and saline areas (Chittagong). Majority of the farmers (85-89%) irrigated their crops through purchased water from DTW and STW. They had no complained against the quality of irrigation water. The important irrigation problems were load shading of electricity, ground water scarcity and higher price of fuel.
17. *T.aman-Potato-Boro* was the dominant cropping pattern found in Bogra, whereas it was *Aus-Potato-Fallow* in Chittagong district.

9.2 Policy Implications

Development of abiotic stress tolerant varieties*:* Potato production is highly sensitive to various abiotic stresses including temperature and soil salinity. Development of heat, drought and saline tolerant varieties enhance potato production and extend its cultivation to non-traditional potato areas. Therefore, breeders should assign higher importance to develop abiotic stress tolerant potato varieties for combating future climate threats.

Development of early maturing varieties: *T.aman-Potato-Boro* is the dominant cropping pattern in Bogra district. Most farmers cultivate *Boro* rice after harvesting of potato. Therefore, most farmers show very high level of preference toward the variety having early maturing character. So breeders should give much emphasis to develop a number of early maturing potato varieties having late blight resistant character.

Development of new varieties having better storability: Most small and marginal farmers have poor access to cold storage facility due to small quantity of produces and financial inability. They have to sell their potatoes to middlemen immediately after harvesting with lower price. Therefore, development of new varieties having better storability at home condition will be highly beneficial to the poor potato farmers.

Availability of irrigation water*:* Higher proportion of marginal and small farmers considered drought and heat to be potential threat for their future potato crops. In drought areas, entire irrigation is through DTW and STW. They have to buy water from others since digging tube well needs higher cost. Besides, irrigation charge is very high and sometimes unavailable when required. Therefore, the government should encourage cooperative tube wells through establishing self help groups of the farmers providing them financial assistance.

Agricultural training: The respondent farmers of all categories believe that their current potato yield can be further increased through providing training on production technologies. Therefore, the DAE should arrange and provide training for the potato farmers on production technologies on a regular basis.

Availability of **seed and fertilizer**: Majority of the farmers also perceived that their potato yield can be further increased through making seed and fertilizers timely available and inexpensive. So, the government should take appropriate steps to make these inputs available and economic to the farmers.

References

BBS. 2009. Year book of Agricultural Statistics. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Basu P.S. and Minhas J.S. 1991. Heat tolerance and assimilate transport in different potato genotypes. *Journal of Experimental Botany*, 42: 861-866.

CIP. 2009. International Potato Centre. Lima, Peru. http://www.cipotato.org/potato. Accessed on 24 September, 2009.

CPRI, 1992. Tech Bulletin no-1, Central Potato Research Institute (CPRI), Shimla.

Haque, M.A.; Miah, M. A. M.; Hossain, S. and Rahman, M. M. 2011. Adoption and profitability of BARI released potato varieties at farm level in selected areas of Bangladesh. *Bangladesh Journal of Agricultural Research* (Accepted for publication).

Hossain, M.A. and Miah, M.A.M. 2010. Post-harvest losses and technical efficiency of potato storage systems in Bangladesh. Technical Report submitted to FAO Bangladesh. Available at: http://www.fao.org/inpho/content/conpend/text

Huq, A. S. M. A., M. S. Hussain and M. A. Rashid. 1995. Potato production in CDP demonstration area: yield gap analysis. Annual report 1995, Agricultural Ecinomics Division, BARI, Gazipur.

IPCC. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.), Cambridge University Press, Cambridge, UK.

Meyhuay, M. 2007. Potato: Post-harvest operations. Instituto de Desarrollo Agroindustrial (INDDA). http://www.fao.org/inpho/content/conpend/text/ch17_02.htm#TopOfPage

Minhas, J. S. and Devendra, K. 2005. Tuberization in heat tolerant hybrid HT/92-621 under controlled temperature conditions. *Potato Journal*, 32: 195-196.

Moazzem, K. G. and Fujita, K. 2004. Potato marketing system and its changes in Bangladesh: rom the perspective of village study in Comilla district. *The Developing Economics*. XLII-1 (March): 63-94.

Rana, R.K, Sharma, N., Kadian, M.S., Girish, B.H., Arya, S., Campilan, D., Pandey, S.K., Patel, N.H., Carli, C., Thiele, G., and Singh, B.P. 2009. Assessing potato farmers' perceptions on abiotic stresses and implication for crop improvement research: a diagnostic cum baseline survey in heat-prone Gujarat, India. Survey Report 2009. CPRI, Shimla-171001, HP, India.

Rhoades, R. E. 1984. Changing a post-harvest system: impact of diffused light potato storage in Sri Lanka. Social Science Department, Working paper 1984-1. International Potato Centre (CIP), Lima, Peru. (www.npcspud.com/history.htm).

Shrestha, A.B., Wake, C.P., Mayewski, P.A. and Dibb, J.E. 1999. Maximum temperature trends in the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period 1971-1994. *Journal of Climate*, 12: 2775-87.

Singh, J.P., SS Lal, P.M. Govindakrishnan, V.K. Dua and S.K. Pandey. 2008. Climate change and potato production in India. Poster presented in Global Potato Conference-2008, New Delhi, December 09-12, 2008.

UNDP. 2008. Impacts of climate change on human development. *Human Development Report*, 2007-2008.