Baseline study on sustainable management of soil health towards improving food and nutritional security and livelihood upliftment of farming community in Northern Bangladesh

Socio-economic Component

Draft Report

Submitted By

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ABBREVIATION

AEZ	:	Agro Ecological Zone
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Burau of Statistics
DAE	:	Department of Agriculture Extension
DAP	:	Di Amonium Phosphate
FRG	:	Fertilizer Recommendation Guide
FRS	:	Fertilizer Recommendation System
GDP	:	Gross Domestic Production
GoB	:	Government of Bangladesh
ha	:	Hectare
HH	:	Household
HSC	:	Higher Scondary Certificate
HYV	:	High Yielding Variety
MoP	:	Muriate of Potash
NGO	:	Non-Governmental Organization
NPK	:	Nitrogen, Phospate and Potash
SAAO	:	Sub-Assistant Agriculture Officer
SRDI	:	Soil Resource Development Institute
SSC	:	Secondary School Certificate
Tk.	:	Bangladeshi Currency
TSP	:	Triple Supper Phosphate

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EXECUTIVE SUMMARY

Bangladesh has made remarkable progress in its agriculture sector despite decreasing arable land, population growth, and adverse climatic effects. The agriculture sector contributes 13.31% of GDP (Gross Domestic Product), provides employment for around 40% of the total labor force and feeds about 164.6 million of its population. To attain this self-sufficiency, the government has designed and implemented various agricultural policies, production and distribution of high yielding variety seeds and other inputs including direct fertilizer subsidies for sustainable soil health management thereby increase food production and livelihood improvements. The government of Bangladesh also encourage development partners to collaborate with national research and development institutes to implement and disseminate advanced farm technologies to the farming community. In this line, ICARDA, BARI, BAU and IFDC have jointly implementing a research and development project supported by OCPE foundation. The overall aim of this project is to expand BARI, ICARDA and IFDC development technologies to the farming community to enhance yields and farmers' income resulting in food and nutritional security by next couple of years. In connection to the overall objective of the project, socio-economic component aims at documenting existing farm practices along-with soil health management across farm category and study districts.

To attain the objectives, survey methods was adopted to gather required information from sample respondents in study sties. Six study sites were selected considering the representativeness of northern Bangladesh particularly three different climatic zones (High Barind, Medium High Barind and Low Barind Tract regions). Selected districts are Bogura, Chapai-Nawabganj, Natore, Nilphamari, Dinajpur, and Kurigram. A total 609 sample farmers were surveyed consisting 99-102 samples in each sampling unit- a sampling unit consists of 5-6 adjacent villages. Both descriptive and econometric analysis were adopted to analyze the data. However, descriptive analysis is performed in this report while econometric analysis will be carried out by PhD fellow.

Documenting sociodemographic and household economics, it is revealed that the average age of the farmers was 45.7 and a good percentage of the farmers belonged to the young age cohort (31-45). It is observed that 24.3% farmers do not have any formal education. Of the educated respondents, 32.5% farmers have secondary level education followed by primary (28.2%), HSC (7.2%) degree level education (7.7%). The majority of the respondent farmers belonged to the Muslim community (88%) and the rest 12% belong to the Hindu community. On an average about 86% percent of the respondents reported farming as their main occupation that varies from 76% to 93%. The average experience of farmers in crop farming was estimated at about 25 years. The average family size of the respondent farmers is 4.91 person/family-this is a bit higher than the national average of 4.06 person/family. Average farm size of all respondent farmers was 0.89 ha (219.2 decimal). As expected, large category farmers had the largest farm size estimated 3.97 ha (980.5 decimal) followed by medium category farmers (405.1 decimal), small farmers (134.8 decimal) and marginal farmers (39.4 decimal). There was a large variation in farm income earned by different category of farmers. As obvious, highest annual income was earned Tk. 647 thousand by large farmers while it was only Tk. 61 thousand for marginal farmers. About 48% of income was generated through farm sources and remaining 52% coming from non-farm sources by all category of farmers. Among various expenditure items, about 62% of money spent for household activities (food consumption reported 40%) and remaining (38%) spent as farm expenses.

In respect to cropping pattern and soil nutrient management, baseline report identified a total of 103 cropping patterns of which the highest number was found in Natore district (53) followed by Dinajpur

(41), Nilphamari (39), Bogura (30), Kurigram (29) and Chapai Nawabganj district (15). Boro-Fallow-T.Aman is the most dominant pattern and the second most dominant is Boro-Fallow-Fallow but varies across districts. Farmers of Natore district have followed more diversified cropping pattern while Chapai Nawabganj district observed lower level of crop diversification. Looking at farm category, small farm category reported highest 96 patterns followed by small farm (71), marginal (18) and large farm (15).

About 9% of the farmers had received training related to crop production and about 6% farmers had received nutrient management related training. The marginal farmers received less training both in soil nutrient management (none) and crop production. The farmers who received training reported that provided training was adequate. About 10% farmers received various supports including seed, fertilizer, demo plot again the marginal farmers received lower percent of input supports. Only 8.4% of the sample farmers reported that they had tested their soil of which majority 21% consisted of large farmers and none of the marginal farmers tested their farm soil. The main reasons for not testing soil were-they had not heard about soil test (36%) and 30% thought that their crops grow well without soil test. DAE is the most important sources for training, input supports, provide soil testing facilities.

Fertilizer application decision depends on several factors including types of crop grown in the field (21.9%), followed by the quality of soil (18%), availability of manure (9.6%), land topography (elevation-9.5%), crop season (8%), based on fertilizer dealer suggestion (6.4%), follow neighbor farmers (5.5%), and follow the advice receive from extension personnel (5.4%). About 42% of the sample farmers reported that fertilizer did not work as per their expectation, the reasons of not working fertilizer as reported by farmers are, low quality (41%) followed by imbalanced application (28.5%), reasons was unknown (11.7%), the soil quality deteriorated (11.3%), and climate variation (7.8%). About 50% sample farmers reported that they could identify nutrient deficiency by looking at the color of the plant leaf followed by overall growth of the plant (38.8%), soil health (4.4%), expected yield gap (3.9%) and compare with other farmer's field (1%). Once they identified, they applied fertilizer and pesticide by own experience (49.1%), consulted with fertilizer dealer (24.3%), SAAO (15.6%), and peer farmers (6.6%), and a small percent wait to see the results (4.4%).

Encouragingly, none of the farmers claimed about the availability of fertilizer in the market. However, 57% farmers reported that they could not buy fertilizer as per their requirements-farmers of Kurigram district faced more challenges than that of other districts. To overcome the situation, most of the farmers (90%) borrow money or buy on credit from fertilizer dealers. A few percent of the farmers bought low cost of fertilizer as a coping strategy- this mostly related to micronutrient fertilizer. About 54% of the total respondents were familiar with fertilizer subsidy provided by the government.

Based on analysis of secondary data, it is evident that a significant changes occurred in temperature and rainfall over the period of 1982–2016. Slope of line graph clearly indicate the declining trend of annual rainfall in all study districts. The annual average minimum temperature has increased by 0.02^0C in Chapai Nawabganj district while it was increased steadily in Bogrua and Natore districts (High medium Barind Tract). In contrast, an additional year the annual average minimum temperature has increased by 0.03^0C in the low Barind Tract region. The groundwater table depletion rate is higher for medium high Barind regions than that of low Barind tract. However, in High Barind region, the worst situation of groundwater crisis had faced between the period of 2005 to 2015, afterward the water table became stable though it is below the suction limit of hand tube well during dry seasons.

Farmers are familiar with climatic events- on average 88% sample respondents mentioned that over the last 20 years the temperature has increased, the response ranges from 88.4% to 92.3% across districts. Regarding rainfall, about 36% famers reported that the rainfall pattern has changed followed by decreased rainfall (31%), sudden rainfall with thunderstorms (25.8%), and rainfall remained same

(4.4%). About 3/4th of the farmers perceived that drought occurrence has increased over period of time.

The various mechanisms adopted by the farmers to cope with the effects of adverse climatic events particularly drought these includes- crop rotation/diversification; follow conservation agriculture practice, grow high value crops, deploy more family labor and seasonal migration etc. On average, about 63 % farmers reported that they followed crop rotation at various levels. Irrespective of farm category, about 76% farmers followed conservation agriculture practice but the extent of practice various including hardly, sometimes, often and regular. About 48% of marginal famers never thought of growing high value crops as a consequences of adverse climatic effect while it was only 7% for large farm category. Overall, 77% farmers grew high value crops as strategy to reduction of adverse climatic effects. Most of the farmers irrespective farm category reported that they had not sale advanced their produces to minimize the effects of climatic events. Actually, due to adverse climatic effect, farmers could harvest minimum yield which they don't like to sale considering their food security issue. Results shows that on an average, 59% farmers deploy their additional family members as one the coping strategy under climate change. About 20% of the farmers seasonally migrated to recover their losses due to adverse climatic events.

Livelihood status is measured based on five capitals, most of the sample respondents were young in age, and about 61% of the family members are economically active and few of them (9%) received skill development training which can be considered as a strength under human capital category. In general, farmers reported that they could afford and had access to medical facilities. In respect to physical capital, besides land ownership a good percentage of sample farmers had livestock and poultry birds. Encouraging all sample households had poultry birds, and about 77% households had cattle and 53% had goat. About 69% of large farmers had possession of power tiller while it was only about 4% for marginal and small farm category of HHs. Among different farm equipment, small and marginal farmers had the greater ownership of STWs then that of other farm equipment. Encouraging almost all household had mobile phone even more than one phone per household. The value of furniture and other asset was reported higher amount for large farmers then that of other farm categories. Among various life sustaining facilities, about 99% household had safe drinking water access then followed by access to electricity (91%), and sanitary latrine (66%). In fact, access to sanitary latrine found to be relatively lower status then that of other life sustaining facilities.

Regarding household savings on an average large farmers could save relatively higher amount of money estimated at Tk 104.6 thousand and followed by medium farmers (Tk. 54.1 thousand), small farmers (39.5 thousand) and marginal farmer (Tk. 8,500 household) in the last year of field survey (2018-19). About 25% households had borrowing experience in the last 12 months that varies from 24 to 43%. Relatively greater portion of the sample households borrowed money from national NGOs that estimated 55% for all average and ranges from 39 to 55 percent. Ranging 44 to 61% survey household borrowed money for crop production. Although male dominate in borrowing money ranges from 45 to 68% but it various across farm category. About 55% of female under marginal farm category of household borrowed money while it was 30% in case of medium farm households.

The medium farm households were involved in all types of social organizations but domination over NGO membership. In fact, involvement in NGO as group member is common in rural Bangladesh which estimated at 38 to 72 % across farm category. Relatively marginal farmers had more involvement in NGO as members than that of other farm categories. However, none of the marginal farmers got access to DAE and project membership which is really concern for reaching the bottom of the farming community. Surprisingly, female had higher access to social institutions for marginal farm category

household as because of their extensive participation in NGO programs. However, in all other category, the male members had greater level of participation in social organizations.

Finally, this baseline report documents the existing situation of the farming community in respect to soil health management, adaptation strategy under adverse climatic events and livelihood status. Considering limited access to training and knowledge on soil health management, project might think of providing extensive training as well as leaflet regarding importance of soil health for better yield. Demonstration of balance fertilizer application at farmers' field could motivate farmers towards largely adoption. In selecting farmers for project interventions, a certain percent of marginal and small farmers should be included as project participants considering they have been ignored by existing framework. Although farmers are following crop diversification at different levels but they should be given well advanced information about adverse climatic events and market price so that they can motivate to grow high value crops instead of rice-rice cropping pattern. In summary, project support could be channeled into five areas: awareness creation, technology development, strengthening extension services, assurance of input quality and supply, and financial support.

Chapter I

INTRODUCTION

1.1 Background

Bangladesh has made remarkable progress in its agriculture sector despite decreasing arable land, population growth, and adverse climatic effects (MoF, 2019). The agriculture sector contributes 13.31% of GDP (Gross Domestic Product), provides employment for around 40% of the total labor force and feeds about 164.6 million of its population (LFS,2018; BBS, 2018). In fact, the country has one of the lowest land-person ratios in the world, estimated at 0.088 ha per person (BBS, 2018). The number of agricultural farm households is estimated at 1.66 million which accounts for 46.61% of total households (BBS, 2019). There is huge pressure on land to produce more crops to ensure self-sufficiency in food. To attain this self-sufficiency, the government has designed and implemented various agricultural policies for expansion of irrigation facilities, production and distribution of high yielding variety seeds and other inputs (Rahman, 2003; Rahman et.al. 2011). In fact, the government supports agricultural intensification, encourages farmers to use high yielding varieties along with improved production technologies, and provides direct fertilizer subsidies. Accordingly, government prepared several policy documents including Seventh Five Year Plan, National Agriculture Policy, Agricultural Research Priority: Vision-2030 and Beyond, and Sustainable Development Goals (SDGs) assign high priority to land and soil health, soil salinity and research on nutrients and fertility issues for sustainable soil health improvement, cropping intensification and sustainable water management.

Nevertheless, availability of irrigation has been the most significant contributor to being able to grow crops year round and increase crop productivity in the northern Bangladesh (Day et. al. 2017) where over 97% of the total area uses groundwater irrigation (Mojid at.al. 2019). The northern region had the highest percentage (85%) of net cultivable area irrigated during 2012–13 followed by the northcentral region (73%) and south-east and southwest regions (45%). The northwest region is one of the major crop production areas and supplies about 35% of the irrigated *Boro* rice and about 60% of the wheat of the whole country (Mainuddin et.al., 2019). This reflected as the cropping intensity has increased by 245% in the Northern region higher than the notational average (194%). The total crop production was 41 million tons in 2002 whereas it was 76 million tons in 2018. All these efforts create additional demand for fertilizers use in Bangladesh. The use of fertilizer was 225 kg/ha in 2000 whereas it was 322 kg/ha in 2018. The increasing cropping intensity, the decreasing arable land and the crop diversification raise questions about sustainable management of soil health thereby improve livelihoods of the farming community.

1.2 Trend of Major Field Crops in Bangladesh and Study District

The agricultural land use is highly dynamic in Bangladesh. Single, double, triple, and quadruple (at present) crops are grown in the same field. Among different crops, rice has the wide

adaptation ability under different agro ecological niches of Bangladesh. It can be cultivated throughout the year with an adjustment of not experience of extreme temperature during the reproductive phase (Nasim et.al., 2017). Although rice has greater adaptation ability, farmers grow both cereal and non-cereal crops in their field.

Following Table 1.1 shows the average acreage of major crops in Bangladesh and northern Bangladesh. It is clearly visible that rice is dominating particular Aman rice which is occupied 41 to 50 percent of cultivated land during 1980 to 2017 (Table 1.1). There is a reverse scenario observed between *Aus* and *Boro* rice, where *Boro* rice occupying *Aus* rice area because of development of irrigation facilities and HYVs. In the year 2006-10 (average) the Boro rice occupied maximum 36 per of land while it was only 7.89 per cent for Aus rice. For other crops, potato, maize, lentil mustard and jute are increasing over the period in general but there is fluctuation found in some years. However, sugarcane and wheat are found to be declined over the period.

Table 1. 1 contribution in terms of acreage by major crops in Bangladesh

Crops/Year	1980-84	1985-90	1991-95	1999-00	2001-05	2006-10	2011-15	2016-17
Aus	25.13	22.72	15.04	12.25	9.63	7.89	8.04	7.30
Aman	50.13	47.98	47.49	46.11	44.64	43.49	41.55	41.60
Boro	11.15	16.98	21.52	25.58	30.91	35.94	35.70	34.43
Wheat	4.62	4.85	5.08	6.44	5.46	3.28	3.00	2.93
Potato	0.36	0.39	0.43	0.59	0.86	1.23	0.93	1.47
Maize	0.02	0.03	0.02	0.02	0.26	1.21	1.83	2.70
Pulses	0.61	0.84	1.73	1.62	1.25	0.79	0.81	1.15
Mustard	1.57	1.43	2.66	2.77	2.29	1.72	2.14	2.44
Sugarcane	1.31	0.84	1.53	1.43	1.30	1.09	0.81	0.71
Jute	5.11	3.95	4.49	3.20	3.41	3.37	5.19	5.27

Trend of major crops acreage in six study districts since the year1980 to 2015 is shown in Figure 1.1. It is evident from Figure 1.1 that rice is dominating particular Aman rice followed by Boro and Aus rice. There is variation across study district, for example, acreage of boro rice has increased in Dinajpur, Kurigram and Nilphamari districts while it was steady or a bit declining trend observed in Chapai Nawabganj, Natore and Bogura district. On the other hand, acreage of pulses has been increased in Natore and Chapai Nawabganj districts while it was found decreasing trend in other four study districts. Encouragingly, acreage of maize and potato have been increased in all study districts over the period of time. Similarly, allocation of land for vegetable cultivation had also been increased over period of time in all study districts. Jute and sugarcane acreage also declined with little variation across study districts.

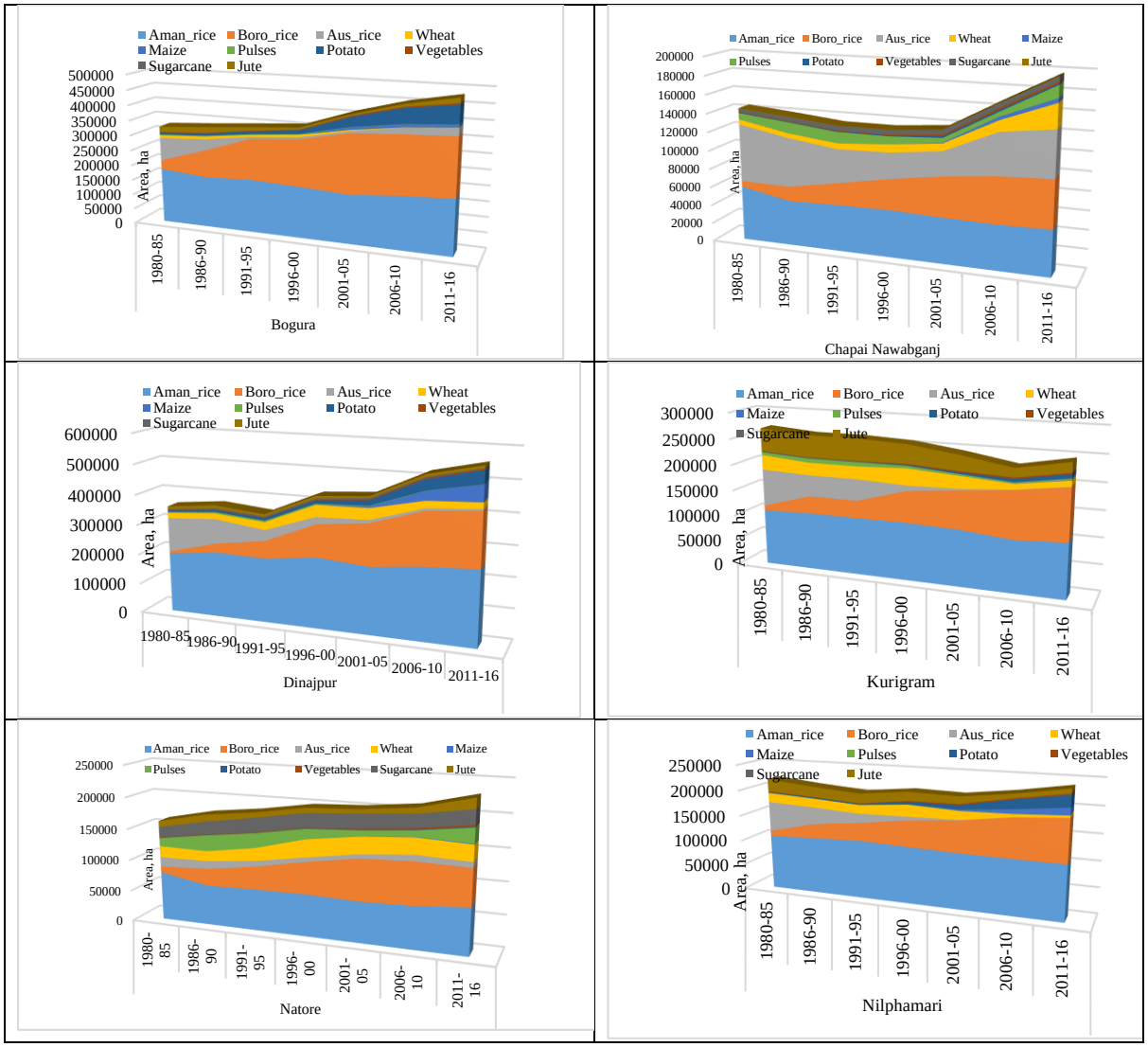


Figure 1. 1 Trend of major crops acreage (hectare) in six study districts

As mentioned earlier, some field crop areas are expanding while others are declining due to comparative advantage of particular crops in respect to resource utilization. Following Figure 1.2 presents the crop calendar to understand the competiveness of different crops in northern Bangladesh. In Bangladesh, a crop calendar year represents three major growing seasons namely summer seasons (locally named *Kharif-1* from mid-March to mid-July and *Kharif-2* from mid-July to mid-November) and winter season (locally named *Rabi* from mid-November to mid-March) (Figure 1.2). The summer seasons are mostly rainfed and the winter season is mostly irrigated in Bangladesh. The major portion of the cereal food supply comes from winter crops. Rice is the staple food in Bangladesh. Therefore, farmer usually produces rice in both seasons along with other crops and vegetables.

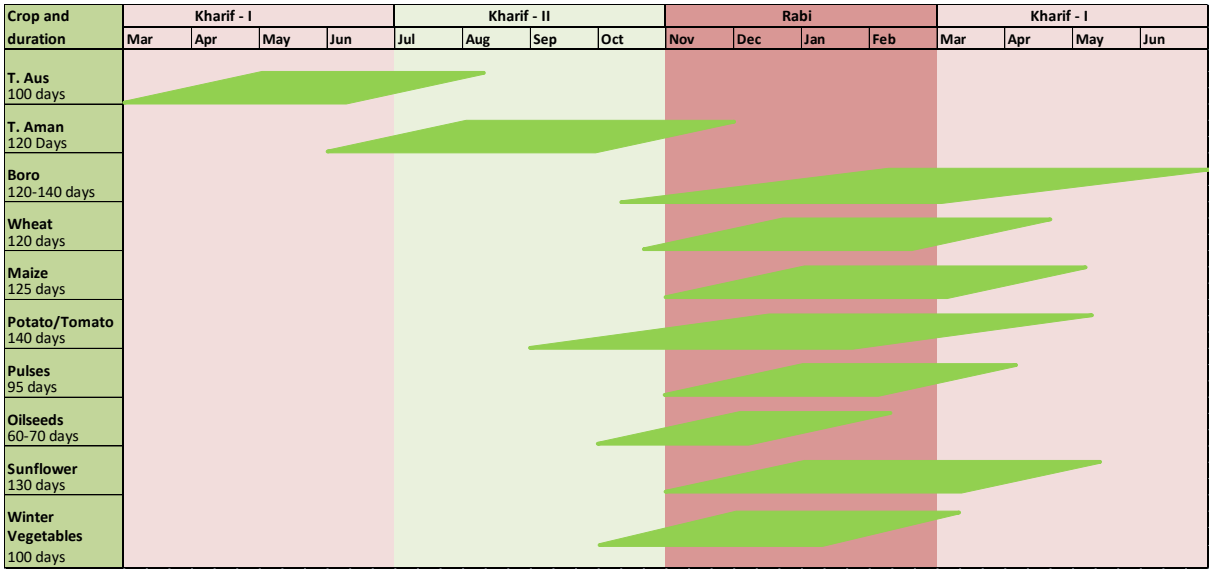


Figure 1. 2 Cropping season and the standard crop calendars major crops

Source: Mainuddin et al. (2019)

1.3 Trend of Fertilizer Use in Bangladesh

The expansion of modern agricultural farming practices like the use of high-yielding variety (HYV) seed together with intensified cultivation is needed to ensure food for all. A consequence of these changes is an increasing demand for fertilizers. The increased cropping intensity has been supported by the increased use of fertilizers from 225.15 kg/ha in 1999-00 to 321.51kg/ha in 2017-18 (BER, 2018). In 2017-18, the total quantity of fertilizer used in the country was 49.43 lakh MT (excluding other fertilizers) which was 64% higher that the quantity used in 1995-96. The use of urea fertilizer alone was the highest. However, the overall use of fertilizers is showing an increasing trend during 1995/96-2017/18 (Table 1.2). It further reveals that the uses of different types of chemical fertilizers have been increased to a great extent.

Table 1. 2 Trend of using chemical fertilizers ('000' MT) in Bangladesh

Fertilizer	Using year					
	1995-96	*2000-01*	*2005-06*	*2010-11*	*2015-16*	*2017-18*
Urea	2046	2121	2451	2652	2291	2427
TSP	111	400	436	564	730	707
MoP	156	140	291	442	727	789
DAP	0	90	145	305	658	690
SSP	597	139	130	0	0	0
Zinc	1	3	8	7	53	80
Gypsum	104	102	105	105	229	250
Total	3015	2995	3566	4075	4688	4943
% increase over 1995-96	--	-0.7	18.3	35.2	55.5	63.9

Source: *Miah et.al., 2019*

1.4 Justification of the Study

Farming systems is a dynamic system that are constantly evolved. Both endogenous factors (household goals, labor, technologies and resources) and exogenous factors (market development, demand shift, government policies, the dissemination of new technologies and the availability of market and policy information) drive the evolution of individual farms, farming community and overall farming system. Depending on the natural resource base and management systems, intensification can either sustain and improve productivity over time, or degrade the natural resource base and therefore lower production potential over time. Government policy support and project based interventions might encourage farmers to grow certain crops then others. Accordingly, some farms may successfully intensify and even specialize to produce for the market, whereas others may regress to low-input/low-output systems.

In Bangladesh, the government emphasis on production of cereals crops, thus crop production of the country has increased by about 3 times compared to that in 1970's. Increased crop production through crop intensification has been supported by increased use of fertilizers. High intensity of cropping, decreasing arable lands and diversified cropping raises questions about sustainable soil health management. The challenge for the future is to develop nutrient management packages that will ensure sustainable crop production maintaining current nutrient levels, avoid nutrient deficiencies and imbalance use of fertilizers. Deficiency of micronutrients like Zn, B, Mn and Mo has been reported in many parts of the county, particularly in Northwestern region. Organic matter content in soils in Bangladesh is very low; the majority being below the critical level and it is depleting rapidly due to higher decomposition rates causes by tropical climate coupled with inadequate use of organic manure in the soil. The situation is same in the selected study sites namely Nilphamari, Dinajpur, Bogura Natore and Chapi Nawbganj. To respond this, there is a need of baseline data and information regarding farmers' existing knowledge, perception and practice of soil health management and decision factor under socio, economic and environmental context. This baseline information might help to develop relevant interventions for sustainable soil health management to improve the life and livelihoods of the farming community in study hubs and thereby upscale to other regions of Bangladesh.

Despite remarkable progress made in food production particularly the cereals, food insecurity and undernutrition still remain problems in rural Bangladesh. It is reported that roughly half of Bangladeshis are unable to access sufficient food to meet their dietary needs (USAID, 2017). Hence, agricultural intervention is a crucial for improving food and nutritional security. The interventions could be enriching soil health and changing cropping patterns. By improving the quality, quantity, and diversity of agriculture production will enhance nutritional status of women and children in the targeted households. In fact, food-based solutions that expand agricultural production of nutritious foods have possible benefits that do not exist for specific supplementation and fortification efforts. For example, such solutions can support both the livelihoods and nutritional status of smallholders, while having the potential to more sustainably address persistent rates of malnutrition (Pinsrup, 2013). Food-based solutions have the potential to confront nutritional needs directly and within

the contexts of the primary source of macro and micro-nutrients (Burchi, et al., 2011). These approaches are oriented to improve food security and provide households with a variety of foods that can meet multiple dietary and micronutrient requirements (Blasblag, *et al.*, 2011). Proposed project supported by OCPE and implemented by ICARDA, BARI and BAU will provide need based interventions to enhance yields and farmers' income resulting in food and nutritional security next couple of years.

In connection to the overall objective of the project, socio-economic component aims at documenting existing farm practices along-with soil health management across farm category and study districts. Based on this details baseline results, other components of project will demonstrate different interventions including fertilizer and crops. Finally, it is expected to assess the impact of these interventions on livelihood and nutritional status of the targeted households at the end of this project in line with the baseline report.

1.5 Study Objectives

Overall objective of this research is to document the existing farm practices along-with soil health management across farm category and study districts. Specific objectives of this research are-

1. To document sociodemographic characteristics and household economics across study sites and farm category;
2. To identify the existing farm practices and knowledge and perception about soil health management in the study areas;
3. To explore the knowledge and perception about climatic events and thereby adaptation strategies;
4. To examine the livelihood potential by farm category and study districts;
5. To identity the determinants of crop diversification and its impact on livelihood improvement and food security in the study areas;

Among five objectives, the fifth objective will be attained by PhD fellow- who is working under socio-economic component.

1.6 Organization of the Report

The study comprises of 7 chapters. Chapter 1 mainly focuses on background information, crop production and fertilizer use trend, justification and objectives of the study while chapter 2 reviews relevant literature in respect to agricultural intensification, soil nutrient management, climate change and adaptation strategies, agriculture and livelihood improvement. Chapter 3 provides details methodology of the study including analytical technique. Chapter 4 presents the basic sociodemographic and household economics of sample farmers across district and farm category. Chapter 5 describe the cropping pattern and the current status of soil nutrient management across district and farm category. Trend of climatic events and farmers' perception on the events and thereby strategy to overcome the adverse effects. Chapter 7 describes the livelihood assets possess by different category of farmers. At the end of this report, presents highlight the key findings and suggests possible project interventions.

Chapter II

REVIEW OF LITERATURE

2.1 Introduction

This chapter reviews the literature and research that has been carried out in Bangladesh and around the world relating to farm practices, knowledge and perception about farming, climate change and livelihoods to have better direction to conduct the research. The purpose of the review is to convey to the reader what knowledge and idea has been established on a topic and what is their strength and weakness (Taylor and Procter, 2005). In fact, literature review helps in identifying the research gap in order to justify the present study.

2.2 Agricultural Intensification

Intensification of agriculture by use of high-yielding crop varieties, better animal breeds and animal husbandry, aquaculture, fertilization, irrigation, and pesticides has contributed substantially to the tremendous increases in food production over the past 50 years. Bangladesh has a cropping intensity of ~200% having grown from 154% in 1980 (BBS, 2018). Cropping intensification now underpins food security in Bangladesh. It has enabled food energy intake to increase from 2000 to 2450 kcal per person per day from 1980 to 2013 (World Development Indicators, 2016). It has been supported by a 30 % increase in supply of fertilizers from 160 kg/ha in 2003 to 209 kg/ha in 2013 (World Development Indicators, 2016). In aggregate terms, agricultural intensification is undeniably increasing food production and ensuring food demand is met. In broad terms it is also helping alleviate poverty. Some of the key drivers of agricultural intensification are:

- Higher use of agricultural inputs
- Development of surface and ground water resources for irrigation
- Diversification from low to high value crops
- Availability of appropriate machinery to overcome labor shortages
- Improvements to rural infrastructure such as roads, electrification, storage facilities
- The IT revolution - providing new avenues of information and service delivery.

Promotion of irrigation practices for intensification and drought mitigation in the northern Bangladesh is a technically feasible route for agricultural intensification. It has enhanced for agricultural growth in general and livelihood improvement of the millions of farmers. Environmental or agro-ecological conditions, and related risks or relative advantages are the main determinants of cropping pattern along with several socioeconomic factors (Mandal and Bezbaruah, 2013).

In fact, for increasing cropping intensity, the crop diversification program (CDP) was launched in the country during the early 1990's. A systematic arrangement of growing a variety of crops in rotation with rice was undertaken, based on farmers' own choice and performances with respect to soil and climatic conditions, thereby ensuring a variety of diverse dietary standards and nutritional status of the rural households (Hoque, 2006). To enhance farmers' income

through the production of high-value crops and to help maintain a better soil structure for long-term sustainability. The government is also implementing programmes to promote crop intensification and diversification involving high-value crops, fruits and vegetables, potatoes, oilseeds, pulses and spices through appropriate packages of seed-fertilizer-irrigation technologies as well as credit support.

In this line, Metzel and Ateng (1993) focused the problems associated with diversified crops by using household level primary data. They used Simpson index and Rice share index to find out the extent of crop diversification. They found low profitability, high input cost, risk in selling nonrice crops and vulnerability to weather variation and pests stand against in the way of crop diversification. In addition they concluded that proximity to towns increased crop diversity while credit decreased it.

Mahmud et al (1994) identified the agricultural growth and crop diversification in Bangladesh. They identified some problems and offered suggestion to enhance crop diversification in Bangladesh. They found that high price risk, price variability associated to nonrice HVCs and present irrigation system are prominent hindrances on the way of crop diversification. They also believed that real prospects for crop diversification, however, would still depend on how far technological innovations could make non-cerea1 crops competitive under conditions of modern irrigation.

Malik and Singh (2002) studied the extent of crop diversification by employing entropy index of crop diversification. They concluded that availability of market, increased demand of crops, export facilities and proximity to town area facilitate crop diversity whereas absence of proper market, price variability and irrigation facility are the notable hindrances for crop diversification.

Similarly, Ashfaq *et al.,* (2008) examined the factors affecting crop diversification. They used a multiple regression model in which the values of Entropy index of crop diversification were taken as dependent variable and different factors affecting diversification were taken as independent variables. They found that size of land holding, age of respondent, education level of respondent, farming experience of respondent, off farm income of respondent, distance of farm from main road, distance of farm from main market and farm machinery are the main factor of crop diversification. While Haque and Bhattacharya (2010) used Simpson's index of crop diversification by using 2010-11 data in India and found that the value of Simpson index is the highest in Orissa (0.25) followed by Bihar (0.18), West Bengal (0.16), Uttar Pradesh (0.15), and Jharkhand (0.08).

Signorelli *et al.,* (2017) described both productivity and on-farm production diversity positively affect household dietary diversity, with the effect of the latter getting stronger the longer the travel time to the nearest daily market. They found that women's education and responsibility within the household play have significant positive effect on household dietary diversity, suggesting the importance of incorporating gender dimensions into interventions that aim to promote nutrition security. This study contributes to the growing empirical evidence on the agriculture-nutrition nexus using data from West Africa, a region with relatively fewer relevant empirical studies.

Feliciano (2018) reviewed extensive articles on crop diversification and tried to linked with Sustainable Development Goal 1(SDG1) "No poverty" by also considering other dimensions of poverty, namely gender equality, food security and nutrition, and vulnerability to climate change. It demonstrates that the contribution of crop diversification to food security and nutrition, gender equality, and reduction of poor farmers' vulnerability to climate change has not been properly researched. Several factors across the studies analysed were found to influence the implementation of crop diversification, but these were hardly connected to poverty reduction. New research and policy impact evaluation methods that follow a sustainability approach perspective to poverty need to be undertaken in order to assess the contribution of crop diversification to SDG1

Tisdell et. al., (2019) verified the statement that declining agricultural diversity threatens agricultural sustainability using a three-pillar concept embodying ecological, social and economic dimensions. They provided a comprehensive general assessment of the sustainability of agricultural systems. It pays particular attention to consequences for agricultural diversity and sustainability of the increasing dependence of agriculture on the market system and new agricultural technologies. The diversity and sustainability of Bangladeshi agriculture by applying a novel index of the diversity of cropping land use, an output decomposition method, and statistical techniques. Crop diversity in Bangladesh is very low and dominated by the cultivation of rice, which now depends very heavily on a limited number of high yielding varieties (HYVs). Higher rice yields in Bangladesh and seasonal changes in rice cultivation have resulted in land sparing, which make room for greater crop diversity. They recommend that Bangladesh consider increasing the diversity of its crops as a food security measure and as a hedge against a decline in its agricultural sustainability.

In summary, one of the major objectives of the 7FYP (2016-20) is to ensure that the country's agricultural sector is profitable, sustainable and competitive through the promotion of agricultural diversification. Attaining crop diversification is crucial for increasing productivity, for ensuring human nutritional security, maintaining soil health and increasing cropping intensity, employment and the income of farmers. The National Agricultural Policy (2013) aims at promoting diversification by increasing space and production of other crops, e.g. potato, pulses, oilseeds, vegetables, fruits and spices, under the Crop Diversification Program.

2.3 Farmers Knowledge and Perception on Soil Nutrient Management

This section reviews the extant literature on farmer's knowledge and perception about soil nutrient management. Cropping intensification underpins food security in Bangladesh. From 1980 to 2013, crop production increased by a factor of 2.6, allowing per capita food energy intake to increase from 2000 to 2450 kcal/day. The intensification of cropping has been supported by increased use of fertilizer's. However, the high intensity of cropping, the decreasing arable land area (@ 0.49% per year) and diversity of crops grown by farmers raises questions about the profitability and sustainability of current nutrient management.

Nevertheless, the trend in fertilizers' subsidy has been constantly increasing from 35 (US$ 503 million) in 2007-08 to 119 billion Taka (US$ 1 billion) in 2012- 13.12 However, in 2013-14

subsidy to fertilizers has decreased by 28 percent, accounting 86 billion Taka (US$ 1 billion).13 In 2014- 15, the government subsidy on fertilizers accounts for about 2.2 percent of total public expenditure. Part of this budget finances increasing imports of urea, to boost domestic production, which has decreased severely during the last years (FAO, 2016).

Organic matter in soil is crucial for soil fertility, crop productivity, and overall crop profitability. Farmers are gradually realizing that there is a problem with soil fertility related to organic matter depletion due to less use of crop residues and manure. Hossain (2001) reported that organic matter increases yield, reduces the production cost, improves crop growth and the economy, increases water-holding capacity and improves the soil structure. Farmers recognize soil with higher organic matter content by darker brownish to black in colour. They used green manure crops, compost, quick compost, cow dung, and azolla to increase soil organic matter. However, cow dung and crop residues have other uses such as cooking fuel and fodder for livestock. In terms of organic matter, Roy and Farid (2011) found that farmers are often not aware of the benefits of organic matter and that although it is available it tends to be used for fuel. Rahmam et al. (2011) reported that farmers described fertilizer as costly and scarce input. Crop residues/manures were reported to be used in a limited way as farmers were often reluctant to use them as fertilizer and instead used them for cooking, house building, and cattle feed. The use of inorganic fertilizer in the savannas of Nigeria falls below the recommendation, this paper looks at the factors influencing farmers' decision to adopt or not adopt inorganic fertilizer (Chianu and Tsujii, 2004). It revealed that 49% of the respondent farmers have adopted inorganic fertilizer. The range of application was reported to be from 5.6 kg/ha to 64.4 kg/ha. Farmers cited high costs, lack of credit facilities, removal of fertilizer subsidies, and government withdrawal from fertilizer distribution as the main reasons for non-adoption.

Farmers in general can't imagine crop production without the use of fertilizers (organic or inorganic). They at least apply fertilizers may be at balanced or imbalanced rates for crop production. In China, 550 farmers were interviewed about their fertilizer application behaviors, decision making processes, attitudes towards adopting better fertilizer application technologies, and environmental consciousness (Yang and Fang, 2015). The study found different factors influencing the adoption of better fertilizer application technologies. The factors were demographic shift whereby younger HH members were leaving and older family members were remaining on the farms and were less able and/or willing to adopt new technologies; habitual practices modified by their individual judgment of the crop, weather and soil conditions. In this case the cost of inputs/outputs were seldom taken into account. Reduction in the use of traditional practices that involved applying organic fertilizers. Farmers are instead applying more chemical fertilizers to respond to soil fertility decline. If the crops don't grow as well as expected they often blame the poor quality of the chemical fertilizers and translate that into the need for more fertilizers. Lack of extension training on fertilizer and perception that fertilizer dealers were a major source of knowledge on fertilizers as opposed to extension staff.

Bizimana et al. (2002) looked at the factors influencing technology adoption by the coffee farmers of Rwanda. The study found that there was a strong association between soil testing and fertilizer use- implying that a farmer who tests soils on his farm is also likely to use

fertilizer. The study recommended some strategies to reduce the gap between nutrient management guidelines and farmers practice vary depending on the factors identified as impacting fertilizer use (e.g., improved credit facilities for credit constrained farmers, improved distribution systems for those hampered by supply issues, improved extension systems for farmers lacking training/knowledge/information and so on).

Freeman and Omiti (2003) studied the fertilizer adoption behavior of the smallholder farmers in Kenya. They found that fertilizer adoption behavior was positively associated with the level of education of HH head, experience in fertilizer use, growing a cash crop (diversification into cash crops seen as a way to intensify fertilizer use), availability of fertilizer in rural retail outlets, availability in small packages, and land pressure (farm HH facing land pressure are more likely to adopt improved soil fertility management as a means to satisfy their subsistence needs). Again, the intensity of fertilizer use behavior was negatively associated with family labour and family size. HH with smaller family size are more likely to adopt and apply greater amounts of fertilizer which utilizes less labour per hectare compared to alternative practices such as the use of manure/compost. This might reflect rural HH's preference for labour saving technologies particularly when there are alternative income earning opportunities from off-farm sectors.

The study conducted by Hedlund et al. (2004) looked at the farmers' perceptions of soil fertility in Vietnam. Farmers' perceptions were more directly connected to the ability of the whole system to promote good yields than the scientific concept of soil fertility as the soil's ability to deliver sufficient nutrients and water to the plant. Farmers identified problems with soil fertility relating to three areas: acidity, market, and flooding. The most important problem was the market- unstable price of agricultural products leading to under investment in fertilizer.

Asfaw and Admassie (2004) investigated the spill-over effect of intra-HH education on the adoption process and decisions relating to fertilizer use in Ethiopia. This study looked at the education of other HH members and found that the decision making process was a decentralized one in which educated adult members actively participated.

Chirwa (2005) studied the adoption of fertilizer and hybrid seed technologies for maize cultivation in Malawi. He found that fertilizer adoption was positively associated with higher levels of education, larger plot sizes, and higher non-farm incomes, but negatively associated with female headed HH and distance from input markets. However, Peterman et al., (2010) in their review found that Chirwa's finding differs from other studies in relation to the gender of the HH head.

In Ethiopia, Fufa and Hassan (2006) looked at fertilizer use and considered some influencing factors such as age of head of HH, family size, literacy, land holding size, wealth status, weather, and price of fertilizer. It was revealed that older farmers used less fertilizer. If farmers expect the rainfall to be bad they are unwilling to use fertilizer and vice versa. Farmers' perception of the price of fertilizer was also influenced its use. In Ethiopia input costs are high-one factor being the cost to transport it. If the farmers perceived the cost to be high fertilizer use reduced.

Islam et al. (2008) examined the gaps in management between recommended and actual practices for Boro rice cultivation for a range of practices including doses of urea, TSP, MoP and gypsum through analyzing 250 farmers interviewed in Kurigram District. They identified some farmers' characteristics that showed significant negative relationship with the management gap. The characteristics were farming experience, knowledge, attitude towards modern *Boro* rice cultivation, use of information source, and decision making ability.

Islam et al. (2009) established that there was an application gap for urea, TSP, and MoP (extent of gap varied) fertilizers. Seven characteristics looked at in relation to application gap: age, education, farm size, annual income, credit received, extension contact, and knowledge of using fertilizer. They identified two characteristics as having a significant relationship with fertilizer application gap- extension contact and knowledge of using fertilizer minimized the gap. According to farmers, the main reasons for the application gap were scarcity of fertilizers, high price, lack of credit facilities, lack of adequate supply in time, and government appointed dealers charging higher prices.

Mapila et al. (2012) identified the determinants of fertilizer use by smallholder maize farmers in Malawi, Mozambique and Zambia. The study found that the use of fertilizer was influenced by different HH and farm characteristics, social and human capital, and farmers' perceptions of the effect of fertilizer on soil fertility. They also found that male headed HH were more likely to use fertilizer than female headed in Zambia, but this was not the case for Malawi and Mozambique. In Mozambique, land holding and access to inorganic fertilizers influenced fertilizer use. However, in Malawi and Zambia these were not significant. In Malawi, the fertilizer subsidy and what farmers expect the price to be also influences use as some farmers saved to pay the subsidized rate, but when it wasn't enough didn't have the resources to purchase additional fertilizer. Availability of food and crop performance in one season influence decisions to use fertilizer in the next season. HH with greater food reserves were more likely to use fertilizer than those with lower reserves. The study also revealed that HH participated in agricultural training/study tour more likely to use fertilizer in Malawi, but not in the other countries. This was attributed to Malawi having a more intensive extension system. Membership of a farmer group positively influenced use only in Mozambique. Membership by the household head increased the odds even more. In Zambia some farmers (30%) perceived it as bad for the soil and therefore were less likely to use it.

DIME and GAFSP, (2013) conducted baseline survey in eight districts of Bangladesh revealed that 94% of households applied some fertilizers. Urea fertilizer was most commonly applied (80%) followed by TSP (68%), MoP (64%), animal manure (41%), Gypsum (30%), DAP (17%), Zinc (16%), Compost (8%), and NPK or mixed fertilizer (7%). In total, a household (HH) spent approximately Tk. 6556 ($82) on fertilizers/inputs over the year. Most of that money was spent on chemical fertilizers such as urea, DAP, TSP and potash

Islam *et al.*, (2013) reported that farmers used on an average 1.06 ton of manures per hectare in BARI developed improved mungbean cultivation. The study also reported that 47.3% farmers used on an average 21kg urea, 37.3% farmers used 12kg MoP, and 55.3% used 26kg

TSP in cultivating improved variety of mungbean. The usages of these fertilizers were much below the recommended dose of urea (40-50kg/ha), MoP (30-35kg/ha), and TSP (80-85kg/ha).

Miah *et al.*, (2014) conducted a survey with 217 mustard and 540 sesame farmers to find out the adoption status of recommended fertilizer application at farm level. They found that only 6.9% mustard and 16.5% sesame farmers applied cow dung manure following the recommendation (8-10 t/ha), whereas 44.7% mustard and 83.5% sesame farmers did not used any cow dung at all. In mustard cultivation, 3.2, 91.8 and 5.0% farmers applied urea fertilizer at recommended (250-300kg/ha), below recommended, and above recommended level respectively. Similarly 16.1, 53.9, 5.7% farmers used urea fertilizer in sesame cultivation at recommended (100-150kg/ha), below recommended, and above recommended level respectively. TSP fertilizer was found to use by 1.8% farmer at recommended dose (170-180kg/ha), 50.2% at below recommended, and 19.4% at above recommended level in mustard cultivation. In sesame cultivation, 4.8% farmers applied TSP at recommended (130-150kg/ha), 49.6% at below recommended, and 3.7% at above recommended level. In the case of MoP fertilizer, 11.5% mustard and 6.9% sesame farmers applied it following recommended dose (85-100kg/ha for mustard & 40-50kg/ha for sesame) and rest of the respondent farmers either used lower dose or upper dose. The share MoP non-users were ranged from 20-55%. Majumder *et al.*, (2016) identified different factors that influence the use of fertilizer. The factors were age, farming experience, level of education, diversification of income generating activities, access to credit, and access to particular types of education.

Nasrin and Bauer (2016) surveyed 299 HHs from Dinajpur, Mymensingh and Tangail district. The study revealed that farm experience and manure application did not significantly impact on the intensity of fertilizer use. Off-farm income (with higher off farm incomes farmers can afford fertilizers in the required amount), labour availability, and fertilizer-paddy price ratio (particularly for marginal farmers) had impacted on fertilizer use. Besides, output price played a role in addition to fertilizer prices in enhancing fertilizer usage. Fertilizer usage for marginal and small farms mostly depends on their financial conditions, access to various credit institutions, and services received from extension agents.

Miah *et al.*, (2017) conducted a study with the financial assistance of ACIAR from a conservation agriculture project coordinated by Murdoch University, Australia. In this project input costs of producing different crops including maize following agriculture conservation technologies were estimated for identifying conservation benefits. However, the study revealed that on an average 6.43 ton manure, 297 kg urea, 196.7 kg TSP, 200.2 kg MoP, 41.7 kg Gypsum, 5.5 kg DAP, 5.0 kg Boron, and 4.4 kg zinc sulphate were applied in producing maize per hectare. Except MoP, all these applied rates were lower than the recommendations [(e.g. urea 375-600 kg, TSP 180-350 kg, MoP 150-250 kg, Gypsum 130-220 kg, Zinc 6-12 kg, Boron 5-10 kg per ha depending on seasons. Winter season (Rabi) maize needs more fertilizer compared to summer maize (Kharif-1).

Siddique *et al.* (2018) found that farmers' rate of nitrogen application as Urea and DAP was much higher than BRRI recommendation. Similarly, the application of phosphate fertilizer including TSP and DAP was considerably higher than BRRI recommendation in all seasons.

On the other side, the application of MoP fertilizer was quite lower than the scientific recommendation.

A recent study (Matin *et al.*, 2018) covering 1050 samples was conducted in seven wheat growing districts of Bangladesh revealed that about 12-31% of the respondent wheat farmers applied inorganic fertilizers especially NPK following the scientific recommendation. A good percentage of farmers also used different inorganic fertilizers at above and below recommendation levels. However, all sample wheat farmers used manure bellow the recommendation.

In summary, farmers are unable to apply nutrients/fertilizers based on scientific recommendations. A range of studies have explored the gap of fertilizer application between farmers' practice and scientific recommendations and established that this exists at farm level, but the extent of it varies (by farmer/type of fertilizer). Miah et. al., (2019) identified 10 important barriers related to recommended fertilizer application by the farmers these are- (1) Lack of relevant knowledge and skills, (2) Lack of sufficient working capital, (3) High price of fertilizers, (4) Lack of training on soil nutrient management, (5) Complexity to apply recommended fertilizer doses, (6) Lack of extension advisory services, (7) Non-availability of soil testing facilities, (8) Giving less importance to recommendation and pre-determined attitudes about fertilizer practice, (9) Giving less importance to low profit crops, and (10) Lack of connectivity with progressive farmers.

2.4 Climate Change and Adaptation Strategies

Bangladesh is one of the most vulnerable countries in the world to climate change. In the last 30 years, the country has experienced nearly 200 climate-related disasters including drought, extreme temperature, floods, and storms. These events have killed hundreds of thousands of people, destroyed homes and livelihoods, and cost approximately $16 billion in damages. Hence, understanding farmer's perception on climate changes and modes of adjustments made in farming practices will offer some insights into necessary interventions to ensure a successful adaptation practice. Numerous literatures examined the differences between farmers' perception of their exposure to climate variability and change, some of them are discussed below. The reviews began with world scenario and focuses the Bangladesh context.

Udmale *et al.* (2014) investigated the farmers' perception of drought impacts, local adaptation and administrative mitigation measures in India and found that about 92.8% farmers' perceived drought as a natural phenomenon, while 7.2% perceived it as a mismanagement of water resources. It was found that about 85.6% of farmers have experienced drought in the past years. Moreover, only 33.2% farmers believed that they were able to deal with drought, while majority indicating they were unable to mitigate drought impacts. Gandure *et al.* (2013) studies shows that all groups regardless of age and gender agreed that Gladstone is experiencing long-term changes in climate. The study also revealed the rainfall variability in terms of annual and seasonal variations with rainfall likely to be irregular from one year or season to the next. A number of studies in South Africa (Reid and Vogel, 2006; Quinn *et al.*, 2011) have found that the rural communities live with numerous livelihood risks including climate risks. Similarly in Gladstone, the livelihood vulnerability encompasses economic, environmental, social, political

and policy dimensions. Tambo and Abdoulaye (2013) showed that a large share of the farmers' interviewed (92 %) perceived long-term changes in temperature and 39% believed that God is responsible for the changing climate. Kelkar *et al.* (2008) pointed out that, almost all the households felt that rainfall has declined in quantity and they could no longer rely on the timely onset of the monsoon. The study by Howe and Leiserowitz (2013) in U.S showed that, beliefs of global warming had significant effects on subjective experiences with normal temperatures, particularly among those people who believed that global warming is not happening. Desalegn *et al.* (2006) showed that on average drought prevails in Ethiopia once every two years and causes damage to both crops and livestock. Consequently, under such drought conditions, the farmers have adopted various coping strategies such as, the sale of labor and sale of livestock and their products. Nguyen *et al.* (2016) mentioned that in Italy farmers perceived that temperature had increased over time and rainfall there had decreased in the last few decades. Likewise, the majority of the farmers agreed that groundwater had decreased over time.

Bangladesh was one of the first countries to develop a climate change strategy and action plan. Bangladesh Climate Change Strategy and Action Plan (BCCSAP) has identified six thematic areas and corresponding programs related to key sectors, including: agriculture and food security; human wellbeing; water resources; disaster risk management; and infrastructure (MoEF, 2009). In this line Habiba *et al.* (2013) examined qualitative data from field visits in 12 upazillas of two drought-prone districts (Rajshahi and Chapai Nawabganj) and their results recommended the composition of livelihood adaptations in long-term planning, successive growth in research and development activity on new crops, improved access to credit, the improvement of information networks, and the advancement of an enabling institutional environment. Study revealed that farmer's perceived a changed climate in recent years. They not only identified that drought is the most prevalent disaster because of rainfall and temperature variation, but also groundwater depletion, lack of canal and river dragging, increased population, deforestation, etc. accelerate drought in Northwestern Bangladesh. Ahmed and Chowdhury (2006) reported that drought-prone areas of Bangladesh have adopted a holistic approach to livelihood adaptation practices on rural communities without a specific focus on rice farming, and have relied on qualitative analysis examined by most studies. While FAO (2008) pursued some major adaptation strategies accomplished by farmers, including the enhancement of mango plantations, excavation of ponds and deep tube-well facilitated irrigation, the plantation of short-duration and drought tolerant crop varieties, and homestead gardening. Sarker *et al.* (2013) used data involving 550 rice farm households from two upazillas in the Rajshahi district (Tanore and Godagari) to analyze farm-level adaptation using a multinomial logit model. The study recognized factors that determined choice of adaptation strategies.

Similarly, Thomas *et al.* (2013) examined the likely impacts of climate change on agriculture in Bangladesh, using climate data from four general circulation models (GCMs). They evaluated crop yields at 1,789 different points in Bangladesh, using a grid composed of roughly 10 kilometer (km) squares, for 8 different crops in 2000 and 2050. They also explored potential gains in changing fertilizer levels and in using irrigation to compensate for rainfall changes. This analysis indicates that when practiced together, using cultivars better suited for climate change and adjusting planting dates can lessen the impacts of climate change on yields,

especially for rice, and in some cases actually result in higher yields. They used a household survey to collect information on the incidence of climatic shocks in the last five years and adaptation options. Bangladesh farmers already perceived the impacts of climate change-climate change-related shocks, floods, waterlogging, and river erosion caused the largest loss to rice production. Farmers lost around 12 percent of their harvest, on average, to some kind of shock, with about half of that attributable to flooding-related issues. The second leading cause of rice crop loss was pests, responsible for around 3 percent of production. Taken together, the results indicate that adaptation efforts in Bangladesh should include adjusting planting dates, using improved cultivars better suited for climate change, improving fertilizer application, exploring increased maize production, and bolstering flood and pest protection for farmers.

Alauddin and Sarker (2014) conducted a study in ground water depleted areas of Bangladesh and mentioned that majority (95.9%) of the farmers belief are in favour of the increased severity and frequency of droughts. Most farm households (92.0% and 93.3%) respectively perceived a decline in the availability of both groundwater and surface water during the summer season. In addition, farmers believed that temperatures have increased with a decrease in rainfall over the past two decades.

Ali (2014) investigated the local perceptions of climate change impacts and adaptation in ural Bangladesh. The findings showed that most of the respondents had a clear nderstanding of hat was directly affecting their lives and livelihoods in terms of climate trends and the wider environment over the long term. Men and women widely expressed concerns about drought, lack of rainfall, and lowered groundwater levels. Furthermore, men tended to talk much more about problems with arable agriculture whereas women were much more concerned with problems with accessing drinking and washing water, family health problems, food security, livestock health, and lack of social power.

Huq et.al., (2015) identified and analyzed climate change impacts, their cascading consequences and the livelihood implications of these impacts on smallholder agricultural communities of coastal Bangladesh. Three orders of impacts of climate change on smallholder farmers are identified and described. The first order impacts involve increasing erosion of the capacity of local communities to mitigate vulnerability to climate change impacts. This situation led to the second order impacts, which significantly transformed the agricultural landscape and production patterns. The cumulative effects of the first and second order impacts sparked the third order impacts in the form of worsening community livelihood assets and conditions.

Delaporte and Maurel (2016) estimated the impact of climatic shocks on the household agricultural income and subsequently, on farmers' adaptation strategies. Results showed that a one percentage point climate induced decline in agricultural income pushes households to adapt by almost 3 percentage points. Certain strategies are too costly and cannot be afforded in bad times. Households are not passive victims of climatic shocks- they opt for risk coping mechanisms such as changing the amount of land under production, changing the pattern of crop consumption, changing the field location, seeking off farm employment and/or migrating to this place from another. They found positive association between the most demanding options and agricultural income diminishes with wealth, size of the household, and to a lesser

extent education. Access to electricity is a powerful way of reducing the discriminatory effect of agricultural income, as agricultural income correlate with adaptive capacity but to a much lower extent. Poor households have a more limited access to strategies for coping with climate hazards.

Rakib and Anwar (2016) identified the perception of farmers about changes in climate in Bangladesh. The determinants of farmers' perception on climate variability in different specifications of household characteristics. The sample was adult farmers with at least 20 years of farming experience in the area. The results indicated that more than 80% of farmers believe that temperature in the district had become warmer and over 90% were of the opinion that rainfall timing had changed, resulting in increased frequency of drought.

Stojanove et al (2016) documented the local expert's perception in respect to- (i) the role of environmental factors in migration-related decision-making; and (ii) migration as a climate change adaptation strategy? The experts' perceptions matched the nuances and subtleties present in migration and livelihoods literature which are not always prominent in studies adopting a climate change perspective. The local experts showed environmental factors playing different roles in different circumstances for migration-related decision-making, meaning that, at times, migration is used as a climate change adaptation strategy, but not exclusively so. These local perceptions exemplify an historical, cultural, and political depth which is sometimes lacking from international approaches that permit contemporary climate change perspectives to dominate.

Alam *et al.* (2017) explored the local knowledge of adaptation in response to the perceived impacts of climate change and climatic hazards using a survey of 380 resource-poor riverbank erosion-prone households in Bangladesh. The results indicated that the respondents' perceptions of changes in the climate and of extreme climatic events are similar to the observed climate data. Households have recognized the impacts on their livelihood and resources, resulting in an increased sense of vulnerability. To build resilience, households have undertaken a range of farming and non-farming adaptation strategies, which vary significantly among the farming groups. The important adaptation strategies include adopting new crop varieties, changing planting time, homestead gardening, planting trees and migration. Improved access to finance and to information about appropriate strategies appears to be crucial to support adaptation processes locally and thus to enhance the resilience of vulnerable households.

Alamgir et al. (2018) study examined in detail adaptation practices in six key social and economic sectors – agriculture, fisheries, livestock, housing and habitats, energy, and water. Numerous adaptation practices adopted in different sectors are discussed, including the introduction of drought-tolerant and flood-tolerant crop varieties, the livestock-leasing adhi system, raising the level of the house plinth, maize and pumpkin cultivation in sandy soil, and rainwater harvesting. This study has identified various coping mechanisms and adaptation practices of varied communities- these are traditional, indigenous knowledge as well as adopt new technologies to adapt to the adverse effects of erratic climatic behavior. The current adaptation practices are not adequate for building resilience of the communities and the impacted sectors in the Lower *Teesta* basin. They need further support from the government to

protect them from floods and riverbank erosion. The government, NGOs, and civil society can work together and help design appropriate and innovative adaptation measures, strategies, and practices to combat climate change impacts and reduce vulnerability.

Aryal (2020) examined major climate risks, farmers' adaptation strategies, and the factors affecting the choice of those strategies using data collected from 630 households in southwestern coastal Bangladesh. Farmers identified cyclones, excessive rain and flooding, and salinity as direct climate risks. Increased crop diseases/pests and livestock diseases were perceived as indirect risks resulting from climatic variability. Farmers used multiple adaptation strategies against those risks such as modifications in farm management, use of savings and borrowing funds from family and neighbors, and periodically reducing household food consumption. The results show that male-headed households are more likely to change farming practices and reduce consumption compared with female-headed households that conversely tended to take assistance from NGOs as an adaptation strategy. Ownership of land and livestock, as well as farmers' prior exposure to climate change and educational training, also had a significant effect on the choice of adaptation strategy.

Kabir and Islam (2020) investigated farmers' perception to climate change and their agricultural adaptation in the coastal area of Bangladesh. Two hundred household survey were conducted in Satkhira and Barguna district. Study revealed that farmers were well aware of climate change and they observed an increased temperature, rainfall, number of cyclones, flood intensity etc. over the years in the study area. Farmers' thought that weed and pest infestation, disease outbreak and pesticide use have been increased due to the change in temperature and rainfall. Water logging, cyclone, river erosion and salinity were identified as the major environmental problems in the study area. However, the study identified 28 adaptation strategies that have been adopted by the farmer s to reduce the impact of climate change. Crop diversification, introduction of new crops that can resist climatic stress, crop rotation, mix cropping, change in planting and harvesting date, shortening growing season, homestead gardening, application of organic fertilizers and pesticide, increased use of irrigation, different soil conservation techniques and income diversification were found as the most common adaptation measures. The results of the regression analysis showed that socioeconomic characteristics of the farmers (age, education, farming status and experience, farm income etc.) and their perception to climate change influenced the farmers in choosing different adaptation strategies. The adaptation measures were economically profitable as well as agriculturally sustainable though lack of experience and knowledge, agricultural extension services, availability of inputs and lack of credit facilities were identified as the major challenges in the area.

2.5 Livelihood, Food and Nutritional Security

Livelihood consists of the capabilities, the assets (natural, physical, human, financial and social capital) and activities required for fulfilling the basic needs (Chambers and Conway, 1992). A livelihood is sustainable when it has the ability to cope with and recover from stresses and shocks for now and retains and enhances its capabilities and assets for the next generation in the short and long-run (Chambers and Conway, 1992). The economic progress of a country

brings changes in rural household livelihood patterns. Outmigration of households, de-population of the countryside as well as changes in energy consumption level and land uses occur for such economic progress of a country (Chengchao et al. 2010). According to Ellis (1991), assets are things that a household has and that it uses to develop a strategy for making a living. Assets can be a stock of wealth in a household; the capital assets of the poor commonly identified as being financial, human, natural, physical, and social (Moser, 2006). Only capital assets itself cannot affirm the strategy of living; effective activities i.e. livelihood strategies and access to the capital assets restricts rural households to change their livelihood patterns. Reviews and on livelihood and food security are presented from both global and Bangladesh perspectives.

Berti et al., (2003) reported that most agriculture interventions increased food production, but did not necessarily improve nutrition or health within participating households. Nutrition was improved in 11 of 13 home gardening interventions, and in 11 of 17 other types of intervention. Of the 19 interventions that had a positive effect on nutrition, 14 of them invested in four or five types of capital in addition to the agriculture intervention. Of the nine interventions that had a negative or no effect on nutrition, only one invested in four or five types of capital**.** Agriculture interventions had mixed results in terms of improving nutritional status in participating households. Study found difficult to distinguish between the effects of the type of intervention, having a nutrition objective and the types of capital investment, because of the fact that all of the home gardening interventions had an explicit nutrition objective as well as investing broadly in various types of capital, especially nutrition education (human capital).

Rajbhandari (2011) explored bio-intensive farming system promotes practice of scientific crop rotation, integrated plant nutrient management, integrated pest management that ultimately increase the crop biodiversity and yield efficiency along with conservation/revitalization the crop land. This system also improves food security and livelihoods situation of the small farm households. Bio-intensive farming system is recommended to promote for widespread adoption in other areas or districts of the country. Efforts to promote widespread adoption of BIFS for improving livelihoods and sustainability would require an understanding of how variability among individual, household, farm, and national-level characteristics affect farmers' response to incentives and disincentives.

Sunderland (2011) described agriculture and biodiversity have often been regarded as separate concerns. Although biodiversity underpins much of modern agriculture, the development of contemporary production systems has resulted in extensive land conversion and concomitant biodiversity loss. In order to feed an ever growing population, innovative and acceptable ways of integrating biodiversity conservation and food production need to be identified. The nutritional and livelihood benefits of diverse production systems are one way of achieving food security. Such systems are also more resilient to climate induced events or other shocks. Forests represent an important repository of food and other resources that can play a key role in contributing towards food security, especially if integrated into complex systems that are managed for multiple benefits.

Burchi, et al., (2011) refers the interrelationships of food, health, and environment, and their role in addressing chronic micronutrient deficiencies, also known as ―hidden hunger, affecting over two billion people worldwide. While the complexity and underlying determinants of under nutrition have been well-understood for decades, the scaling of food and nutrition system approaches that combine sustainable agriculture aimed at improved diet diversity and livelihoods have been limited in their development and implementation. However, an integrated system approach to reduce hidden hunger could potentially serve as a sustainable opportunity.

Masset, et al., (2012) the interventions had a positive effect on the production of the agricultural goods promoted, but not on households' total income. The interventions were successful in promoting the consumption of food rich in protein and micronutrients, but the effect on the overall diet of poor people remains unclear. No evidence was found of an effect on the absorption of iron, but some evidence exists of a positive effect on absorption of vitamin A. Very little evidence was found of a positive effect on the prevalence of stunting, wasting, and underweight among children aged under 5.

Girard et al., (2012) examined and summarized the effects of agricultural interventions to increase household food production on the nutrition and health outcomes of women and young children and provide recommendations for future research and programming. Overall the evidence base for the potential of agricultural strategies to improve the nutrition and health of women and young children is largely grounded in a limited number of highly heterogeneous, quasi-experimental studies, most of which have significant methodological limitations. While household food production strategies hold promise for improving the nutrition of women and children, the evidence base would be strengthened by additional research that is methodologically robust and adequately powered for biological and dietary indicators of nutrition. Sustainability impact assessment to improve food security of smallholders in Tanzania.

Beuchelt & Badstue (2013) addressed issues of gender and human development opportunities and tradeoffs related to promoting improved technologies for agricultural development in Mexico. They examined these aspects for conservation agriculture (CA) as part of a cropping system with nutrition- and climate-smart potential. Findings point up situations where the promotion of CA for smallholders in developing countries may have undesired effects from gender and human development perspectives, specifically relating to drudgery, nutrition and food security, residue use, assets, mechanization and extension. The direction and magnitude of potential trade-offs depend on the local context and the specific intervention.

Birhane, et al., (2014) mention food insecurity in Ethiopia is not only a rural problem. Urban a growing concern due to the toxic combination of high rates of urban poverty, high dependency of urban households on food supplied by the market, and fluctuating food prices. Household food insecurity was particularly high among low income households and those headed by uneducated, daily wagers and government employed household heads. Therefore, policy makers should work on stabilization of the food market and creating opportunities that could improve the livelihood and purchasing power of urban households.

Kassie, et al., (2014) explored the link between the gender of a household head and food security in rural Kenya. The results show that the food security gap between male-headed households (MHHs) and female-headed households (FHHs) is explained by their differences in observable and unobservable characteristics. FHHs' food security status would have been higher than it is now if the returns (coefficients) on their observed characteristics had been the same as the returns on the MHHs' characteristics. Even if that had been the case, however, results indicate that FHHs would still have been less food-secure than the MHHs due to unobservable characteristics.

Pellegrini & Tasciotti, (2014) conducted household surveys to estimate the effects of crop diversification on nutrition (dietary diversity) and on income (crops sold) of rural households from eight developing and transition economies. They found that the vast majority of households grow crops despite the modest contribution of agriculture to income. Most agricultural land is devoted to staple food production; high-value commodities such as fruits and vegetables are also produced, but in limited quantities. Both descriptive statistics and regression results show a positive correlation between the number of crops cultivated, household income from crops and the two indicators we use for dietary diversity, also after controlling for household characteristics.

Harris-Fry *et al.*, (2015) refers household food insecurity remains a key public health problem in Bangladesh, with households suffering food shortages for an average of one quarter of the year. Simple survey and analytical methods are able to identify numerous interlinked factors associated with household food security, but wealth and literacy were the only two determinants associated with both improved food security and dietary diversity. We cannot conclude whether improvements in all determinants are necessarily needed to improve household food security, but new and existing policies that relate to these determinants should be designed and monitored with the knowledge that they could substantially influence the food security and nutritional status of the population.

Yosef et al., (2015) addressed the persistence of undernutrition in Bangladesh, multiple evidence-based, nutrition specific interventions have been in place for a couple of decades. Agriculture impacts human nutrition in many ways, both positive and negative. As a source of food, agriculture provides vital macro and micronutrients, as well as dietary diversity, to smallholder households. As a source of income for approximately half of the people of Bangladesh that depend on it for their livelihoods, of which two-thirds are women, agriculture allows those same producers to purchase foods that supplement their home production. Although much work has been done on the theoretical links between agriculture and nutrition, there is limited understanding of how existing evidence from observational and experimental research studies that documents the impacts of agriculture programs on nutrition outcomes aligns with these links, particularly in developing countries such as Bangladesh.

Fiorella, et al., (2016) mention agricultural interventions represent a promising set of strategies to improve maternal and child nutrition. The diversity of these food-based strategies, though a strength in tailoring them to local contexts, provides for challenges in generalizing evaluations and impacts. The typologies they propose and apply to existing

evaluations of agricultural interventions provide a nuanced view of the impacts of such interventions on household livelihoods and food consumption behavior. Importantly these typologies have implications for the intervention intensity, potential for displacement effects, and pathways of impact. Though the evidence base for agricultural interventions to improve nutrition is quickly expanding, generalizing the effects of specific interventions requires a broader set of strategies that still provides for nuance in appreciating the extent to which such interventions and the complex contexts in which they operate differ.

Schindler et al., (2016) explored the sustainability impacts of planned agricultural development interventions, so called upgrading strategies, to enhance food security and to identify what advantages and risks are assessed from the farmer's point of view in regards to social life, the economy and the environment. The positive impacts identified were mainly attributed to increased agricultural production and its related positive impacts such as increased income and improved access to necessary means to diversify the diet. They discussed the strong interdependence of socio-economic and environmental criteria to improve food security for small-scale farmers and analyzed several trade-offs in regards to upgrading strategies choices and food security criteria.

Rajendran et. al. (2017) reported that the households that diversify their crop production tend to increase their dietary diversity from their existing dietary diversity score at a decreasing rate. Monthly food expenditure also tends to positively influence household dietary diversity, indicating that farm households that spend more on market-purchased food have consistent increases in their dietary diversity scores at the household level. Study concluded that improving economic access to variety of foods at the smallholder household level by diversifying diets through increased crop diversification should be encourage within maize-based farming systems of the study locale, through integration of micronutrient-rich foods such as vegetables.

Harris-Fry *et al.*, (2017) program benefits may be differentially distributed within households of different socioeconomic status, and targeting of nutrition programs might be improved by influencing determinants that are amenable to change, such as food security, women's employment, or nutrition knowledge. Longitudinal studies in different settings could unravel causal effects. Conclusions are not generalizable to the whole South Asian region, and research is needed in many countries.

Sibhatu and Qaim (2017) used representative data from rural Ethiopia covering every month of one full year to address this knowledge gap. On average, subsistence production accounts for 58% of rural households' calorie consumption, that is, 42% of the calories consumed are from purchased foods. Some seasonal variation occurs. During the lean season, purchased foods account for more than half of all calories consumed. But even during the main harvest and post-harvest season, purchased foods contribute more than one-third to total calorie consumption. Markets are even more important for dietary quality. During all seasons, purchased foods play a much larger role for dietary diversity than subsistence production. These findings suggest that strengthening rural markets needs to be a key element in strategies to improve food security and dietary quality in the African small-farm sector.

Sajith (2017) indicated that there has been a significant change in dietary composition; primary cereals have shifted from millets to rice and dairy products have been included in the diet in India. Cropping pattern has a weighted influence on HH nutritional status. Farmers have shifted from subsistence farming to high value commercial farming in the hope for a 'bumper crop', which is a solution to all their problems. Given India's focus on nutrition security it has become imperative to understand the impacts of agricultural transition on HH diets. This study provides empirical evidence to suggest nutrition is being compromised as a result of commercial farming

Waha, et al., (2018) examined the crop diversification impacted on food security in Africa. They found that households with greater farming diversity are more successful in meeting their consumption needs, but only up to a certain level of diversity per ha cropland and more often if food can be purchased from off-farm income or income from farm sales. More diverse farming systems can contribute to household food security; however, the relationship is influenced by other factors, for example, the market orientation of a household, livestock ownership, nonagricultural employment opportunities, and available land resources. On the continental scale, the greatest opportunities for diversification of food crops, cash crops, and livestock are located in areas with 500–1,000 mm annual rainfall and 17-22% rainfall variability. Forty-three percent of the African cropland lacks these opportunities at present which may hamper the ability of agricultural systems to respond to climate change.

Adjimoti and Kwadzo (2018) reported that crop diversification has a positive effect on household food security status. The diversity of crops grown through dietary diversity can improve household food security. In rural remote areas where household access to food depends largely on it production, crop diversification provides farmers with the different crops that they cannot access either because of the cost or because of the poor infrastructure constraints (physical access). Beyond, the results also show that some other factors are also affecting the household food security status such as access to extension services and storage facilities.

Mango, et al., (2018) reported that crop diversification is one viable option in smallholder farming that can ensure establishment of resilient agricultural systems that can contribute significantly to household food security. In terms of policy, the results imply that the current efforts by government of Malawi to intensify promotion of crop diversification should remain a priority policy direction due to the continued malnutrition and food insecurity threat. This is particularly so in this era of climate variability that poses an extra burden to farmers.

Marquis, et al., (2018) stunting remains an issue in rural Ghana, and most young children in rural Upper Manya Krobo District, Ghana, did not meet the recommendation for minimal dietary diversity. Integrated support for agricultural production of nutrient-dense foods and poultry, combined with nutrition and health training, improves diet and growth of young children in rural Ghana. Inter-sector collaborations to implement and sustain integrated agriculture–nutrition program

Cooper et.al (2019) used Feed the Future datasets from Ghana and Bangladesh to examine the impact of precipitation extremes on nutrition, measured by children's height-for-age and weight-for-height Z-scores, and food security, measured by the Household Hunger Scale. We

used a spatial error regression to control for the effects of spatial autocorrelation, and we found an association between precipitation shocks and household hunger in both Ghana and Bangladesh, as well as an association between higher rainfall and worse child nutrition in Ghana. In Bangladesh, household head education had significant effects on both WHZ and HAZ scores, with more educated household heads being associated with better nourished children. The month of the household survey also had a significant effect on both HAZ and WHZ scores, especially for months earlier in the calendar year. For covariates of HHS, education played a significant role, with more educated household heads having lower HHS scores, indicating less hunger, and less-educated household heads having higher HHS scores, indicating more hunger.

Roy et. al. (2019) reviewed confirmed that Bangladesh has made remarkable improvements in food availability, access, and utilization in the last few decades, but it is not the case regarding the food stability. The country experiences numerous challenges regarding food insecurity. Despite the increase in the income of people, the food quality is not good. Unequal land ownership and income distribution have made the food access below par. Food utilization has improved but balanced food intake is still far below the standard. A notable portion of people are still severely food insecure and malnourished. To ensure food security, government of Bangladesh has undertaken several programs but they were not sufficient to cope with this everlasting issue.

2.6 Research Gaps

Bangladesh government have been implementing programs to promote crop intensification and diversification involving high-value crops, fruits and vegetables, potatoes, oilseeds, pulses and spices through appropriate packages of seed-fertilizer-irrigation technologies as well as credit support for ensuring food and nutritional security. It is apparent from above reviews that much work has been done on the theoretical links between agriculture, food and nutrition but there is limited understanding of how existing evidence from observational and experimental research studies that documents the impacts of agriculture programs on food and nutrition outcomes aligns with these links, particularly in developing countries such as Bangladesh. More importantly, mostly of the previous study focusses on agriculture, livelihood and food and nutritional security in a separate way. Impact of cropping pattern towards livelihood improvement was not well addressed. More importantly, impact of cropping pattern that lead to improving nutritional status of smallholders, women and youth were not integrated in the past researches. Therefore, present study intended to fill-out the gaps through integrated assessment of agriculture interventions (cropping pattern and soil nutrition) towards livelihood improvement.

Chapter III

METHODOLOGY

3.1 Introduction

The reliability of a research depends on the proper methodology. So, methodology is very important for any research and has to be chosen carefully to fulfill the purpose of the study. Following section presents a clear idea about selection of the study areas, selection of samples and sample size, sources and the coverage of data used for the study and also deals with the analytical techniques for the study. The present research is based on both the primary and secondary data. Secondary data were collected from various secondary sources and primary data were collected from the respondents directly through personal interviews. Considering the nature of data and diverse analysis, following section provides overall methods as well as including analytical techniques.

3.2 Study Design

A simple study design is presented in following flow chart (Figure 2.2). First a concept note was prepared based on preliminary consultation with the team leader, which was refined later based on further consultation. A draft proposal was then prepared and finalized after couple of iterations among research team (BAU, BARI and ICARDA). Accordingly, survey instrument was prepared and pre-tested. Then data were collected from different sources. After collection of data, it was edited, coded, categorized, sub-categorized and analyzed in connection to the settled objectives. A draft report is prepared and planning to submit, after having overall feedback, the final baseline report will be submitted.

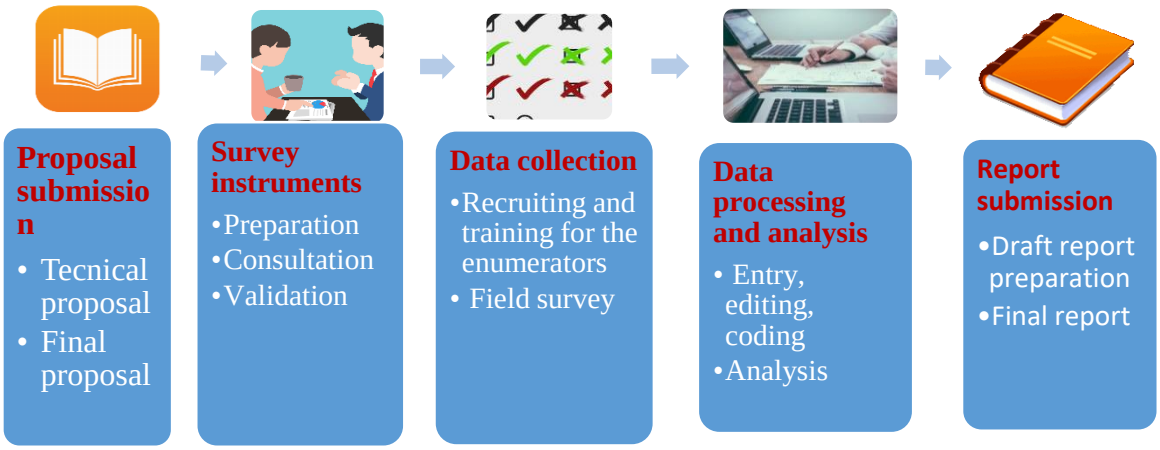


Figure 3. 1 Flow diagram of the study design

3.3 Selection of the Study Area

A total six sub-district of six district namely Nilphamari, Dinajpur, Natore, Kurigram, Bogura and Chapai Nababganj were selected purposely considering the representativeness of northern Bangladesh. Selected districts are the major rice along-with other agriculture crops producing areas. The major growing crops in these areas are rice, maize, wheat, potato, lentil crops, spicies etc. In fact, in these areas, new cropping patterns are emerged, changes in phenology of existing crops, market demand, national and family needs. Hence, documentation of existing crop farming add value for future interventions to change the direction. Figure 3.1 shows the study locations.

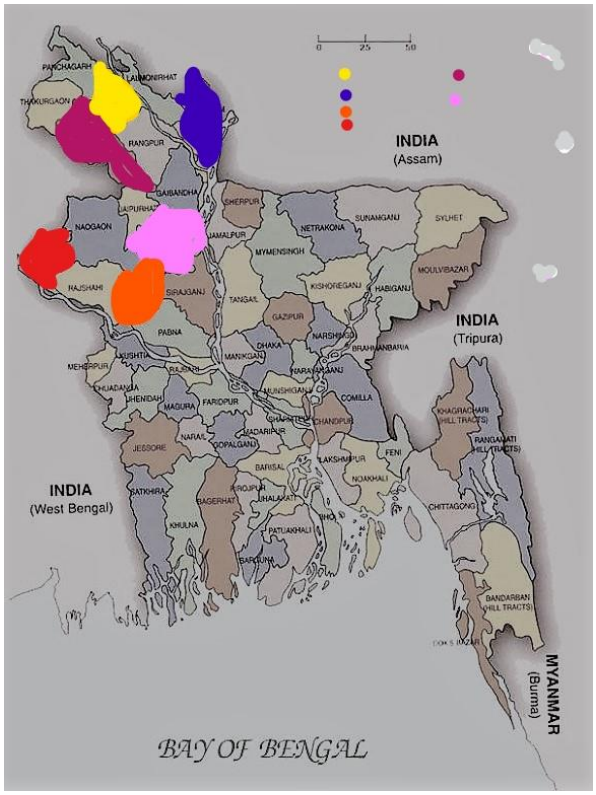


Figure 3. 2. The study locations

3.4 Determination of Sample Size and Sampling Procedure

This research is a survey type research, where baseline survey is being carried out in the first year of the project. In fact, baseline information is required for other components of this project for successful implementation of the project interventions, and to evaluate the project output at the end of the project. Therefore, the socio-economic team selected the above mentioned districts purposively for this study. Hence, six Upazilas from were selected form six purposely selected districts. One Upazila from each district was purposively selected for this study. Five to six clustered villages were selected with the help Agriculture Offices of the respective Upazila. The population of this study are those farm-households who engaged with crop farming. From each selected location/clustered, 100 farmers were selected randomly from the list provided by the DAE personnel in the respective sites. In addition, 2-3 more samples were

collected from each location to keep total sample size at least 600. A total 612 samples were collected across hubs in which 3 samples could not be used due to the poor quality of data observed during cleaning of data. Finally, 609 sample found feasible for baseline study which is presented below. Following Table 2.1 shows the sample distribution across district and farm category.

Table 3. 1Distribution of the samples across district and farm category

Farm category	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All
Marginal	2	4	3	12	3	3	27
Small	80	41	77	75	60	79	412
Medium	15	47	20	15	39	20	156
Large	2	10	2	0	0	0	14
All category	99	102	102	102	102	102	609

3.5 Methods of Data Collection

To collect required data, interview schedule was developed in accordance with the objectives set for the study. In connection to the objectives, a semi-structured questionnaire was prepared and then pre-tested in the field before final data collection. Necessary correction and adjustment were made based on responses received from the samples. For collecting survey data seven (7) data enumerators were recruited. In addition, one PhD student was also recruited who supervise the data collection activities. The enumerators were selected from post-graduate students of Bangladesh Agricultural University. A comprehensive two-day long training workshop on "Data Collection Procedure" was performed. General techniques and ethics of data collection were thoroughly described to the enumerators. Attempts were made to ensure a uniform pattern in administering the survey. The training plan would put more emphasis on skill training on the real situation rather than classroom training. The following training strategy was maintained:

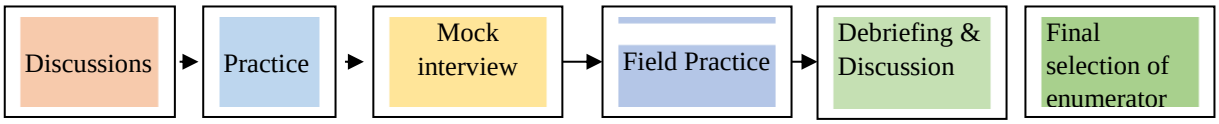


Figure 3. 3 Role playing by the enumerators

Data were collected by the enumerators from 612 farmers through face to face interview under direct supervision of the research team. It was supposed to collect 600 samples across regions but researcher collected additional twelve samples due to possibility of out-layer samples. The enumerator stayed in the field to have better access to the sample farmers. Most of cases research team visited with the enumerators and stay together for providing instant clarification. PhD fellow also visited in the study sites. Data were collected during October to December in 2019.

3.6 Data Processing and Analysis

As soon as the filled-out interview schedules returned from the field, these were sorted based on some identification criteria. The sorted and identified schedules were stored and handled carefully during data processing stage with direct supervision of the research team. Despite extensive supervision, it is obvious to have some errors in various forms such as inaccuracy, incompleteness, inconsistencies, local unit etc. Each schedule, therefore, was edited and coded before final entry into the computer. Enumerators were trained and supplied data entry format and asked to complete data entry. Every enumerator submitted their daily note books and summary write-up of their field observation. PhD fellow was also involved in data entry activities. Research team cleaned the data set. In case of any inconsistency, re-checked the filled out questionnaire and sometimes phoned to the farmers for clarification.

Both descriptive and inferential statistical techniques were adopted to analyze the data. Data were analyzed by using SPSS software. Descriptive statistics were used to generate statistical measures such as averages, percentages, ratio, frequency, etc. After generating descriptive tables, a consultation meeting was carried out with the enumerators to listen their different perspectives of various issues. The consultation meeting helped greatly in incorporating the diverse views and perception. More importantly, a selection criterion is planned to develop to assist other project components to go for interventions. Adaptive research is a prime component of the initiative, as new technologies developed by BARI and ICARDA will be brought into the farmers' field. A second round data will be collected after project interventions.

Besides descriptive analysis, it is also expected to carry out econometric analysis which will be administrated by the PhD students, during her tenure of project.

Figure 3. 4 Consultation meeting with Enumerators

3.6.1 Model specification

PhD student is planned to identify the factors that influence for crop diversification adopting probit model. The dependent variable of this model is the value of crop diversification index (CDI). In other words, the dependent variable is the share of non-cereal income to total agricultural income of the farmer. The value of dependent variable is 0 when the farmer is producing only cereal (rice and wheat) products otherwise the value is 1. The empirical probit model is as follows. The basic model is can be presented as:

$Y = \alpha + biXi$ .....

Y= Dependent variable

α= Intercept, βi= Co-efficient of ith variables, Xi= explanatory variables

The following equation will be used for identifying the determinants of crop diversification.

$$CDI = a + b1X1 + b2X2 + b3X3 + b4X4 + b5X5 + b6X6 + b7X7 + b8X8 \dots\dots\dots\dots\dots\dots\dots (i)$$

CDI = Farmer's crop diversity index (Only cereals = 0; Otherwise = 1)

α = Intercept

X1 = Farm experience

X2 = Land suitability dummy (if suitable 1, otherwise 0)

X3 = No. of training received

X4 = Extension linkage (score value; high score indicates higher linkage)

X5 = Education

X6 = Credit facility dummy (if available 1, otherwise 0)

X7 =Profit

X8=Access to market (km); Considered lowest distance from home, market & union council

βi = Coefficients of respective variables to be estimated (i = 1, 2,3 -------9)

Ui = Error term

However, the variables will be finalized after validation through statistical test. PhD fellow is planned to look into the effects of crop diversification on farmers' livelihood, and food security by adopting appropriate econometric model which is under developing stage. For livelihood measurement five capitals will be used. For measuring food security, she will estimate Food Consumption Score (FCS) first and then dietary diversity indices.

3.7 Ethical Consideration

The study is based on a set of field level primary data collected from the selected respondents by help of interview schedule designed for this study. The respondents were given assurance that all information will be kept confidential, be used exclusively for research purpose and the study will not affect their interest in any adverse way, rather it might produce some benefits to the society. The questions were asked in a very simple manner with necessary explanation. The research team did nothing contemporary to law and ethics of country as well as environment. We respect "The Bangladesh Environment Conservation Act, 1995" Whereas it is necessary and expedient to provide for conservation of the environment, improvement of the environmental standards, and control and mitigation of environmental pollution.

Chapter IV

SOCIODEMOGRAPHIC PROFILE AND HOUSEHOLD ECONOMICS

4.1 Introduction

This section describes the socioeconomic characteristics of sample farmers by farm category and district. It is very essential to know the socioeconomic features of sample farmers because it influences farmer's decision making ability to produce crops under different kinds of management. Variables such as family size and working person, educational status, occupational status, ownership pattern of land, annual household income and expenditure of sample farm household have been taken into consideration for the present study. The following sections of this chapter discuss sociodemographic and household economics of sample farmers.

4.2 Age Distribution

The age of the farmer can influence crop production and management decisions. The age structure of the sample farmers was classified into four age groups such as 15-30, 31-45, 46-60, and above 61 years (Table 4.1). A good percentage of the farmers belonged to the young age cohort (31-45) across district which is considered as productive age and they can take decision for any challenging task. The average age of the respondent farmers is 45.7 years. The average age was highest for large category of farmers (49.8 years) followed by marginal (47.1 years), medium category (46.1 years) and the lowest for small category (45.3 years). The age distribution of farmers according to farm category can be seen in *Appendix 4.1*.

Table 4. 1 Percent distribution of respondent farmers according to age group

Age cohort	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
15-30	7.4	17.7	16.0	21.4	16.9
31-45	40.7	35.4	30.8	7.1	33.8
46-60	37.0	33.3	41.7	42.9	35.8
61-75	14.8	13.6	11.5	28.6	13.5
Average age	**47.1**	**45.3**	**46.1**	**49.8**	**45.7**

4.3 Educational Status

There have been numerous studies conducted relating to education and agricultural productivity which have shown that there is a positive relationship between education and agricultural productivity (Okpachu et al., 2014; Asfaw and Admassie, 2004; Appleton and Balihuta, 1996). So, farmer's education is expected to play a role in increasing the enterprise output. The education level of the respondent farmers has been grouped into five categories: (1) illiterate, (2) primary, (3) secondary, (4) higher secondary and (5) degree and above. Information on the educational levels of the respondents is presented in Table 4.2. It is observed

that 24.3% farmers do not have any formal education. Of the educated respondents, 32.5% farmers have secondary level education followed by 28.2% primary level. The number of respondents with higher secondary and degree level education is small (7.2% and 7.7%). It is observed from Table 4.2 that none of the members of marginal category household have completed higher secondary and tertiary (degree & above) level of education. Comparing the marginal households to other category of households, it can be seen that they are neither the least educated or most educated among the respondents: fewer have higher secondary level education or degrees; a higher proportion have primary school education. District level educational status of the farmers can be seen in *Appendix 4.2*.

Table 4. 2 Percent distribution of farmers according to the level of education

Education level	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Illiterate	22.2	24.0	25.6	21.4	24.3
Primary (I-V)	40.7	30.1	21.8	21.4	28.2
Secondary (VI-X)	37.0	33.7	28.2	35.7	32.5
Higher secondary	-	4.9	14.1	14.3	7.2
Degree & above	-	7.3	10.3	7.1	7.7

4.4 Religious Status

There are four major religions in Bangladesh (Muslim, Hindu, Buddhism, and Christian). The majority of the respondent farmers belong to the Muslim community (88%) and the rest 12% belong to the Hindu community. The percent share of Hindu respondents was highest in the Dinajpur (32.4%) followed by Bogura (18.2%), Nilphamari (16.7%) district respectively. A limited number of respondent were found from the Hindu community in Natore (2.9%), Kurigram (1%) and Chapai Nawabganj (1%) respectively (Figure 4.1).

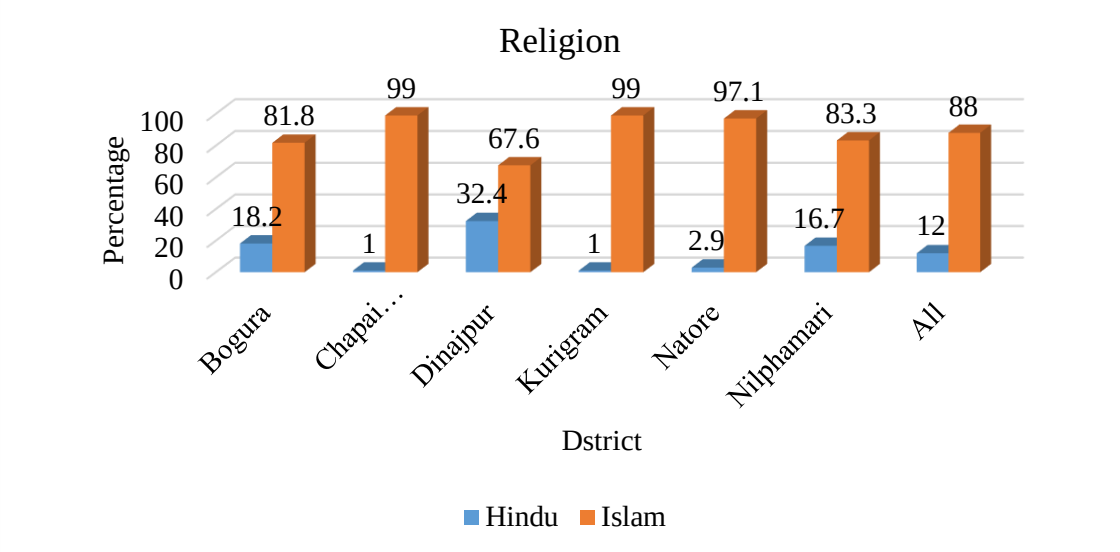


Figure 4. 1 Percent distribution of farmers according to religion

4.5 Marital Status

Most of the respondent farmers in the study areas are married. Figure 4.2 shows that on average 95% of the sample farmers are married and only 5% are unmarried. Relatively higher percent (97%) of Nilphamari respondents are married than that of other study districts- ranges from 94-95% (Figure 4.2).

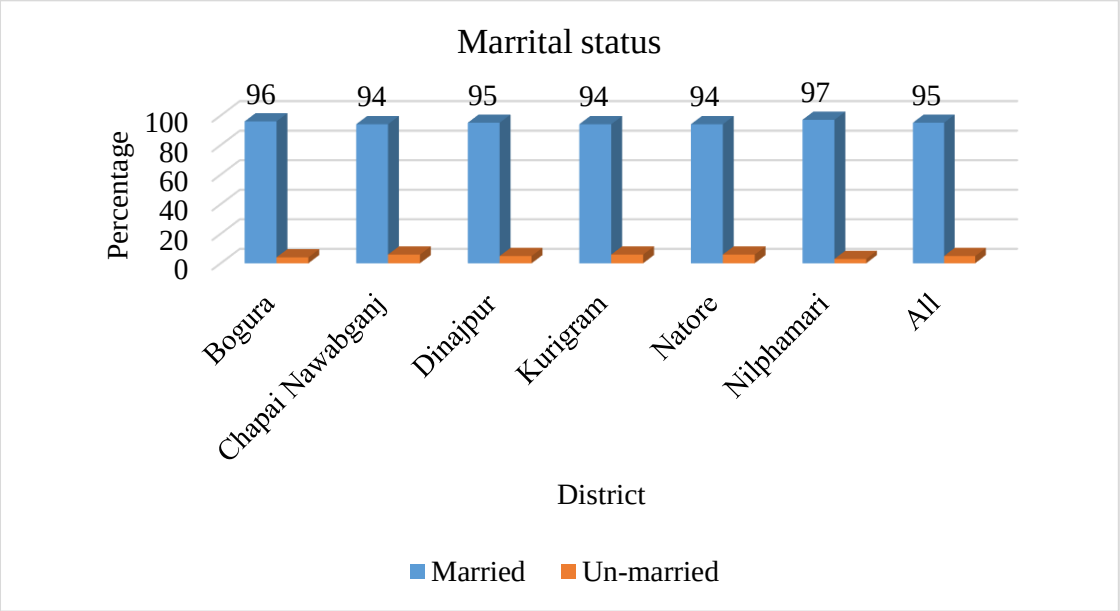


Figure 4. 2 Percent of married sample farmers in the study areas

4.6 Occupational Status

The work for which an individual is engaged throughout the year is known as their main occupation. As Bangladesh is an agro-based country, most of the people in the rural areas engage in agriculture as their main occupation. Respondent farmers were asked to report on their main occupation, accordingly in this study, respondent's occupations were grouped into four major activities: farming, wage laborer, business, services and other (mix category). Farm activities exclusively related to crop and livestock production.

Table 4.3 presents the occupation status of the respondents across district. On an average about 86% percent of the respondents reported farming as their main occupation that varies from 76% to 93%. The higher percent was observed in Chapai Nawabganj district (93.1%) followed by Bogura (89.9%), Nilphamari (89.2%), Kurigram (85.3%), Dinajpur (84.3%) and Natore (75.5%), respectively. A limited percent of the respondents also involved in business (5.6%), wage laborer (1.6%), service (1.3%) and other income generating activities (5.3%) as reported by sample respondents. Given that the survey was targeting farmers the percentage of respondents reporting non-farm activities as their main activity was very small in all categories and study areas.

Table 4. 3 Percent distribution of farmers according to occupation

Occupation	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	Total
Farming	89.9	93.1	84.3	85.3	75.5	89.2	86.2
Wage laborer	-	2.0	-	3.9	3.9	-	1.6
Business	9.1	2.0	4.9	4.9	8.8	3.9	5.6
Service	-		1.0	-	6.9	-	1.3
Others	1.0	2.9	9.8	5.9	4.9	6.9	5.3

4.7 Farming Experience

Farming experience is often reported as an important factor for ensuring farm productivity. Previous findings reported that farmers who have more experience in farm operations generally attain a higher level of technical efficiency and technical inefficiency of the production is significantly related to farming experience of the farmers (Rahman et al., 1999; Miah et al., 2014). It has also positive role in the adoption of modern technologies in crop production (Ainembabazi and Mugisha, 2014). The average experience of farmers in crop farming was estimated at about 25 years (see Table 4.4). Kurigram farmers are relatively more experienced (26.8 years) and Nilphamari farmers less experienced (22.4 years). Looking at different experience category, comparatively higher percent (32.7%) of farmers had farming experience of 10-20 years then followed by 21-30 experience group (20.4%), less than 10 years group (17.6%), 31-40 experience group (16.3%), 41-50 years (10.8%) and 51 and above age group (2.3%), respectively.

Table 4. 4 Percent distribution of farming experience across district

Experience category	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Less than 10 Year	12.1	14.7	19.6	12.7	17.6	28.2	17.6
10-20 Years	44.4	22.5	32.4	32.4	36.3	28.4	32.7
21-30 Years	21.2	21.6	18.6	21.6	20.6	18.3	20.4
31-40 Years	8.1	24.5	19.6	17.6	13.7	13.7	16.3
41-50 Years	14.1	11.8	5.9	15.7	8.8	8.8	10.8
51 and Above	-	4.9	3.9	-	2.9	2.0	2.3
Average experience	23.8	27.5	24.6	26.8	24.7	22.4	24.9

4.8 Family Size

The average family size of the respondent farmers is 4.91 person/family, this is a bit higher than the national average of 4.06 person/family (HIES, 2016). Among different study district, relatively higher family size reported in Chapai Nawabganj district (5.32 person/family) followed by Nilphamari (5.07 person/family), Kurigram (4.96 person/family) and Dinajpur

(4.87 person/family), Natore (4.75 person/family) and Bogura (4.44 person/family), respectively. The average male member (2.54 person/family) in the household is observed relatively higher than that of female members (2.38 person/family). The highest male member is found in Chapai Nawabganj (2.99 person/family) district and lowest is found in Bogura district (2.17 person/family).

Physically or economically active persons are important for a family. The average number of working male member in the household is 2.54 while it is 1.62 for female (Table 4.5). Relatively higher working male member is reported in Chapai Nawabganj (1.88 person/family) but it is minimum in Bogura district (1.43 person/family). On an average 1.42 members have attended school/university from each family, this number ranges from 1.25 to 1.64 person/family. However, number of infant reported less than one (one an average) in all study districts.

Table 4. 5 Average family size, working member, school going member of the sample family

District	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All Average
Family size	4.44	5.32	4.87	4.96	4.75	5.07	4.91
Male member	2.17	2.99	2.40	2.56	2.47	2.61	2.54
Female member	2.27	2.36	2.47	2.40	2.28	2.46	2.38
Working male	1.43	1.88	1.56	1.60	1.66	1.58	1.62
Working female	1.31	1.53	1.43	1.26	1.34	1.25	1.35
School going member	1.29	1.32	1.44	1.55	1.25	1.64	1.42
Infant (0-5 years)	0.39	0.58	0.43	0.54	0.50	0.61	0.51

4.9 Farm Size

Land is the most important asset for farmers because farm families depend mainly on land. Farm size is calculated based on the entire land area operated by the respondent family. It includes the area of cultivated land owned and the area rented in from others minus the area rented out. It also includes the homestead land (housing plot), fallow land, orchard and ponds. As shown in Table 4.6, the average farm size of all respondent farmers was 0.89 ha (219.2 decimal). As expected, large category farmers had the largest farm size estimated 3.97 ha (980.5 decimal) followed by medium category farmers (405.1 decimal), small farmers (134.8 decimal) and marginal farmers (39.4 decimal). It is obvious that large farmers should have more ownership of land which was estimated at 336.8 decimal of land but they also leased in more land (619.8 decimal) than other farm category. This results implies that absentee land lord is prevail in the study sites particularly in Chapai Nawabganj district where greater portion of large farmers reported (Table 4.6).

In different study areas, the relatively greater average farm size was 1.53 ha (377.1 decimal) reported in Chapai Nawbganj district followed by Natore (234.0 decimal), Bogura (194.4),

Dinajpur (193.0 decimal), Nilphamari (175.3 decimal) and Kurigram (140.8 decimal), respectively see (*Appendix 4.3*).

Table 4. 6 Average farm size of the sample farmers in the study area (in decimal)

Land allocation	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Total cultivated land	31.8	114.3	360.2	921.0	192.2
1. Own cultivated land	26.4	82.5	215.0	336.8	119.8
2. Rented/mortgaged in land	5.4	41.7	163.3	619.8	84.5
3. Rented/mortgaged out land	-	9.8	18.2	35.6	12.1
4. Homestead	6.1	11.9	15.4	16.2	12.6
5. Ponds	1.1	3.8	13.1	22.0	6.5
6. Orchard	0.4	4.8	16.4	21.3	7.9
Farm size (in decimal)	39.4	134.8	405.1	980.5	219.2

Total cultivated land= (1+ 2)- 3; Farm size (decimal): (1+2+4+5+6)-3

4.10 Household Income

The average annual incomes for sample farm households are shown in 4.7. Level of farm income depends mainly on farm size and farm enterprises produced. Table 4.7 also revealed that there was a large variation in farm income earned by different category of farmers. Since the marginal farmers land holding was smaller, the average farm income was only Tk. 61 thousand in which Tk. 35 thousand from crops only. On the hand, the average annual farm income for large farm category was estimated at Tk. 647 thousand in which crops alone contribute Tk. 438 thousand. The medium and small farmers income from farm activities were estimated at Tk. 306 and 153 thousand Tk. respectively- the contribution from crops sector was reported higher than other sub-sector like livestock and fisheries (Table 4.7). Within crop sector, on an average Tk. 67 thousand earned from *Rabi* season while it was 26 thousand from Kharif I and 40 thousand from Kharif II season. In fact, Rabi (dry season) contributed largely in the farm income across farm category. Among other earning sources, wages and salaries and business contribute significantly to increase household income.

Table 4. 7 Average annual household income of sample farmers by farm category in thousand Tk

Sources of Income	**Marginal farmers**	**Small farmers**	**Medium farmers**	**Large farmers**	**All average**
Farm income from Rabi season	18	52	101	225	67
Farm income from Kharif-I	6	22	39	49	26
Farm income from Kharif-II	10	28	65	164	40
Crops income	**35**	**102**	**205**	**438**	**133**
Income from livestock & poultry	21	30	42	70	34
Income from fisheries/ponds	3	15	32	76	21
Income from orchard (fruit sale)	3	6	26	64	14
Total farm income	**61**	**153**	**306**	**647**	**202**

Income from wages and salaries	74	75	93	110	79
Income from remittance	52	17	71	96	31
Income from business	41	83	111	74	88
Other income	47	21	30	26	24
Total income	**275**	**349**	**610**	**953**	**426**

While looking at the percent of contribution in household income by various sources. It is evident from Table 4.8 that on an average 48% income was generated through farm sources and reaming 52% coming from non-farm sources by all category of farmers. However, the large farmers had the highest contribution from farm income estimated at 68% while it was only 22% for marginal farm category. Within the farm income crops sector contributed largely estimated at 31% for all farm category. It is observed that marginal farmers depended on diverse sources of income- other than farm income a significant portion of income earned through wages and salaries (27%) followed by remittance (19%) and business (15%). Details households earnings across district and farm category is presented in *Appendix 4.4.*

Table 4. 8 Share of household incomes from various sources by farm category

Sources of Income	Marginal farmers	Small farmers	Medium farmers	Large farmers	Total
Farm income from Rabi season	7	15	17	24	16
Farm income from Kharif-I	2	6	6	5	6
Farm income from Kharif-II	4	8	11	17	9
Crops income	**13**	**29**	**34**	**46**	**31**
Income from livestock & poultry	7	9	7	7	8
Income from fisheries/ponds	1	4	5	8	5
Income from orchard (fruit sale)	1	2	4	7	3
Total farm income	**22**	**44**	**50**	**68**	**48**
Income from wages and salaries	27	22	15	11	19
Income from remittance	19	5	12	10	7
Income from business	15	24	18	8	21
Other income	17	6	5	3	6
Total	100	100	100	100	100

Following Table 4.9 presents the contribution of household income across study sites. Total household income was reported relatively higher for Natore district (Tk. 801 Thousand) while it was estimated minimum in Dinajpur district (Tk. 296 thousand). In the same line, the highest contribution of farm income was estimated for Chapai Nawabganj district (Tk. 298 thousand) followed by Bogura (Tk. 240 thousand), Natore (Tk. 238 thousand), Dinajpur (Tk. 175 thousand) and Kurigram (Tk. 150 thousand). In fact, Kurigram district had the lowest amount of arm income and thereby household income (Table 4.9).

Table 4. 9 Average annual household income of sample farmers by district in (Thousand Tk.)

Sources of Income	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari
Farm income from Rabi season	88	80	63	41	70	62
Farm income from Kharif-I	34	22	27	11	32	31
Farm income from Kharif-II	36	83	36	15	33	34
Crops income	**158**	**185**	**126**	**68**	**135**	**127**
Income from livestock & poultry	48	34	28	28	35	30
Income from fisheries/ponds	15	41	13	48	35	10
Income from orchard (fruit sale)	19	38	8	6	32	4
Total farm income	**240**	**298**	**175**	**150**	**238**	**171**
Income from wages and salaries	108	107	39	76	128	58
Income from remittance	91	159	3	45	260	8
Income from business	108	105	58	101	146	51
Other income	47	32	21	31	29	15
Total income	**594**	**700**	**296**	**403**	**801**	**302**

4.11 Expenditure

Table 4.10 shows annual expenditure in different categories of farm households. Firstly, the expenditure was broadly divided into two categories- farm expenditure and household expenditure. On an average farm expenses were estimated at Tk. 100 thousand by all category of farm households. It is obvious that large farm household spent maximum amount of money for farm production which was estimated at Tk 344 thousand while it was only 37 thousand for small farm category. Although marginal farmers had lower expenses on farm production but their household expenses were estimated at Tk 150 thousand which they earned from other sources. Among household expenditure, expenses on purchasing food was reported maximum Tk 63 thousand for all category of farmers followed by education and repairing jointly (25 thousand), health (21 thousand), recreation (18 thousand) and cloths (9%). Expenses on clothing reported lower amount for all category of household. Details expenditure is presented in *Appendix 4.5* across district and farm categories.

Table 4. 10 Average annual expenses of different farm categories in thousand Tk

Particular	**Marginal farmers**	**Small farmers**	**Medium farmers**	**Large farmers**	**Total**
Crops	27	59	134	299	82
Livestock	11	15	23	45	18
Farm expenses	**37**	**74**	**157**	**344**	**100**

Food	55	60	70	96	63
Education	17	22	31	31	25
Health	17	18	26	48	21
Cloth	7	8	12	12	9
Recreation	10	15	23	39	18
Repairing	44	17	43	117	25
HHs expenses	**150**	**141**	**205**	**343**	**160**
Total	**187**	**214**	**362**	**687**	**260**

Looking at percent distribution of expenditure in Table 4.11, it is observed that on an average 62% of money spent for household activities and remaining (38%) spent as farm expenses. However, for the large farm category household spent 50% for farm production in which 44% incurred for crop production. A similar pattern observed in other category of farm households, medium farmers spent 43% of the total expenses for farm production following by small farmers (34%), and marginal farmers (20%), respectively. Conversely, marginal farmers spent more share of their expenses for household activities (80%) followed by small (66%), medium (57%) and large farmers (50%). The expenditure by study districts also presented in the *Appendix 4.6*.

Table 4. 11 Share of expenditure in various activities

Expenditure	**Marginal farmers**	**Small farmers**	**Medium farmers**	**Large farmers**	**All average**
Crops	14	27	37	44	32
Livestock	6	7	6	7	7
Farm expenses of total expenditure	**20**	**34**	**43**	**50**	**38**
Food expenses of HHs expenditure	37	43	34	28	40
Education expenses of HHs expenditure	11	16	15	9	15
Health expenses of HHs expenditure	12	13	13	14	13
Cloth expenses of HHs expenditure	5	6	6	4	6
Recreation expenses of HHs expenditure	7	11	11	11	11
Repairing expenses of HHs expenditure	29	12	21	34	16
HHs expenses of total expenditure	**80**	**66**	**57**	**50**	**62**
Total	**100**	**100**	**100**	**100**	**100**

Chapter V

CROPPING PATTERN AND SOIL NUTRIENT MANAGEMENT

5.1 Introduction

This chapter describes about the existing cropping pattern and soil nutrient management across district and farm category in the northern Bangladesh. In fact, cropping pattern is an important indicator of land use, environment and socio-economic aspects of farmers of a locality. It indicates the proportion of areas under different crops in a given time period (Nasim et.al. 2017). It provides combination of different crop activities in a specific location. On the other hand, soil nutrient management is the science and resource conservation practices directed to link soil, crop, weather, and hydrologic factors for achieving optimal nutrient use efficiency, potential crop yields, ensuring crop quality, and economic returns, while reducing off-site transport of nutrients (fertilizer) that may impact the environment (Delgado and Lemunyon, 2006). It involves the interaction effect of soil, climate and crop management conditions to rate, source, timing and place of nutrient application (Wikipedia, 2018). Hence, this chapter provide the documentation of the knowledge and perception related to soil nutrient management in the study sites.

5.2 Major Cropping Patterns

Usages of agricultural land in Bangladesh is highly dynamic and there is unique biodiversity of crops throughout the year (Nasim, et.al., 2017). The yearly sequence or distribution of crops in an area is expressed as cropping pattern (CP). The following graph shows the total number of cropping patterns that farmers in the study areas practiced. Most of the CPs are rice-based patterns. In the study areas, a total of 103 CPs were identified of which the highest number of CPs was found in Natore district (53) followed by Dinajpur (41), Nilphamari (39), Bogura (30), Kurigram (29) and Chapai Nawabganj district (15), respectively (Figure 5.1). This suggests that, farmers of Natore district have more diversified crop production while Chapai Nawabganj has lower diversification of crops.

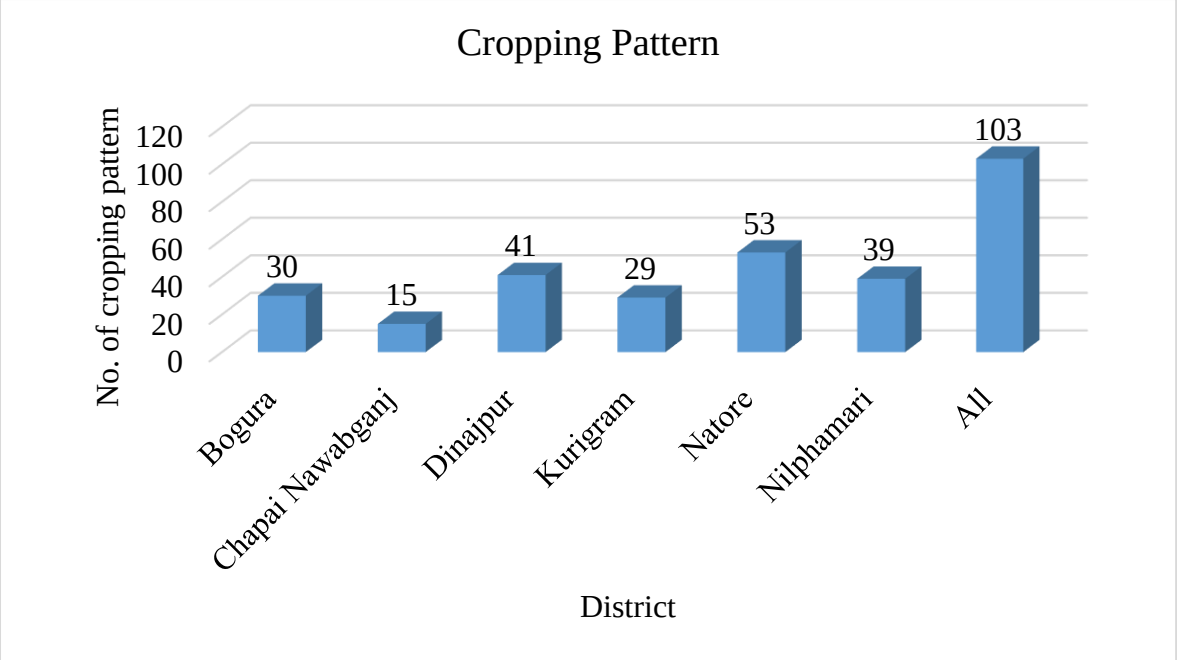


Figure 5. 1 Cropping patterns in the study areas

While looking at the different farm categories small and medium farm category farmers had more diversified cropping pattern that estimated highest for small farm category at 96 variation followed by small farm (71), marginal (18) and large farm (15), respectively (5.2). The large farm category of farmers followed limited cropping pattern compared to other farm category. It might be reason that most of the large farmers belonged to Chapai Nawabganj district where cropping pattern was reported lower level. In contrast, the number of farmers in small farm category is large and diverse across regions thus the estimated cropping pattern also found at higher level (Figure 5.2).

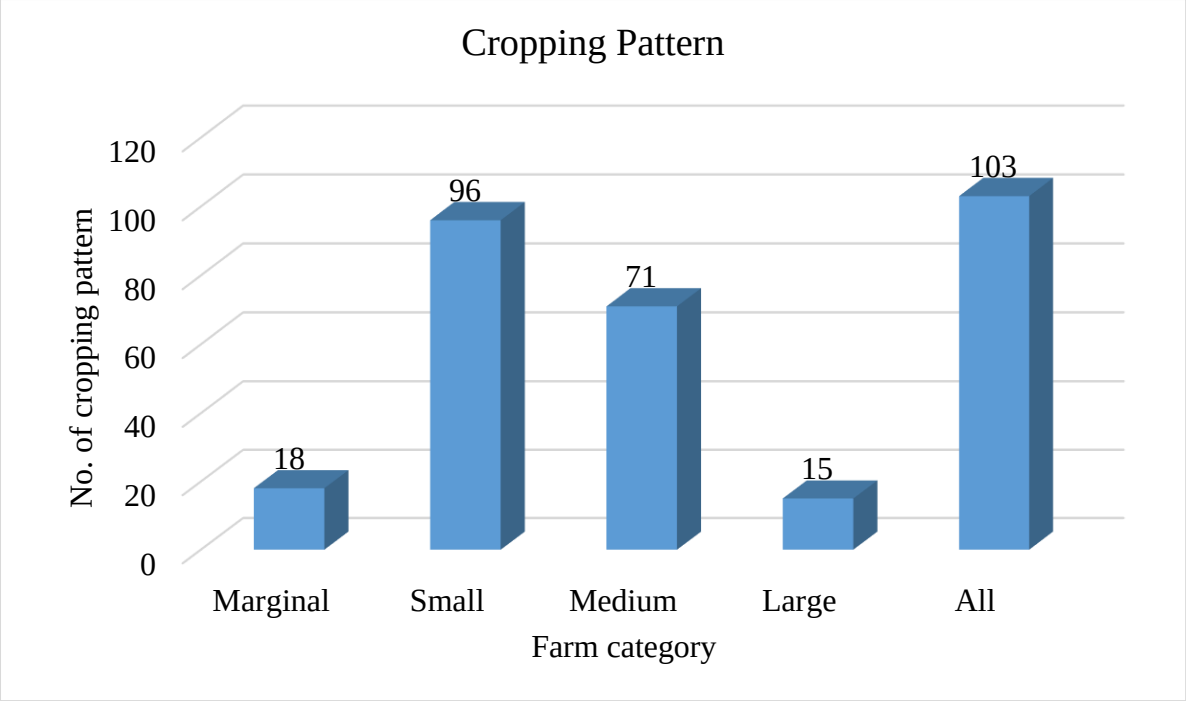


Figure 5. 2 Cropping patterns across farm category

5.3 Distribution of Cropping Pattern by District

Following Table 5.1 presents the top 15 different cropping pattern practiced by farmers across district. It is observed from Table 5.1, *Boro*-Fallow-*T.Aman* is the most dominant CP about 26.3% of the farmers in the study area followed this CP. The second most dominant CP is Boro-Fallow-Fallow irrespective district. District scenarios reveal that *Boro*-Fallow-*T.Aman* is the most dominant pattern in Kurigram (39.2%), Dinajpur (33.7%), Nilphaari (31.7%), and Bogura (27.6) district. On the other hand, Lentil-Fallow-Aman is the most dominant pattern observed in Chapai Nawabganj district, about 22% of the farmers follow this pattern. Wheat-Jute-Aman is the main cropping pattern for Natore district that are practiced by 9.8% farmers.

Table 5. 1 Percent of farmers practiced different cropping patterns by district

Pattern	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All
Boro-Fallow-Aman	27.6	19.0	33.7	39.2	6.9	31.7	26.3
Boro-Fallow-Fallow	10.1		9.5	12.7	2.3	11.1	7.6
Lentil-Fallow-Aman		21.6			1.3		3.8
Maize-Fallow-Aman		.3	15.7		0.3	1.3	3.0
Wheat-Fallow-Aman		12.1	1.0		2.0	0.3	2.6
Mustard-Fallow-Aman		13.1	0.3		1.0		2.4
Tobacco-Maize-Aman						11.8	2.0
Boro-Maize-Aman			2.3	0.3	0.3	8.2	1.9
Wheat-Jute-Aman			1.3		9.8		1.9
Potato-Boro-Aman	10.8		0.3				1.8
Fallow-Fallow-Aman	0.7	6.2		1.3	0.7		1.5
Pea-Fallow-Aman		8.5					1.4

Lentil-Sugarcane-Sugarcane					8.2		1.4
Potato-Banana-Banana	7.4				1.0		1.4
Potato-Vegetable-Vegetable	7.4					0.3	1.3

5.4 Distribution of Cropping Pattern by Farm Category

Following Table 5.2 shows the top 15 different cropping pattern practiced by different farm categories. *Boro*-Fallow-*T.Aman* is the most dominant CP about 26.3% of the farmers in the study area followed this pattern. The second most dominant CP is Boro-Fallow-Fallow irrespective district. Based on farm category it is revealed that *Boro*-Fallow-*T.Aman* is the most dominant pattern for marginal farm category (29.6%), small farm (28.0%) and medium (22.6%) farm category. On the other hand, Lentil-Fallow-Aman is the most dominant pattern observed for large farm category in which 23.8% farmers followed this pattern. Other important pattern that are practiced by different farm categories including Maize-Fallow-Aman, Wheat-Fallow-Aman, Mustard-Fallow-Aman, Tobacco-Maize-Aman and Boro-Maize-Aman etc.

Table 5. 2 Percentage of farmers practiced different cropping patterns by farm category

Cropping pattern	Marginal farmers	Small farmers	Medium farmers	Large farmers	All
Boro-Fallow-Aman	29.6	28.0	22.6	11.9	26.3
Boro-Fallow-Fallow	7.4	9.4	3.4	2.4	7.6
Lentil-Fallow-Aman	4.9	1.4	8.3	23.8	3.8
Maize-Fallow-Aman	-	3.6	1.7	2.4	3.0
Wheat-Fallow-Aman	-	1.2	5.8	11.9	2.6
Mustard-Fallow-Aman	1.2	1.0	5.8	9.5	2.4
Tobacco-Maize-Aman	2.5	2.3	1.1	-	2.0
Boro-Maize-Aman	1.2	2.2	1.3	-	1.9
Wheat-Jute-Aman		1.9	2.4	-	1.9
Potato-Boro-Aman	1.2	1.9	1.3	4.8	1.8
Fallow-Fallow-Aman	1.2	1.5	1.5	2.4	1.5
Pea-Fallow-Aman	1.2	.8	2.1	11.9	1.4
Lentil-Sugarcane-Sugarcane	-	.7	3.4		1.4
Potato-Banana-Banana	-	1.3	1.5	4.8	1.4
Potato-Vegetable-Vegetable	-	1.5	.6	2.4	1.3

5.5 Cropping Pattern based on Land Elevation

Crop production directly depends on the suitability of land and typology of land is highly correlated to the soil nutrient management. Land topography is an important issue to assess the nutritional status of the soil. Land elevation (slope) is also important factor to follow cropping pattern. All lands are not suitable for all crops due to water holding capacity as well as water logging condition. Therefore, land is categorized into three based on land elevation, these are high, medium and low land. Following Table 5.3 present the major cropping pattern in based on land evaluation in all study areas. It is evident that Boro-Fallow-Aman is the most dominated

cropping pattern for medium and low types of land. For high land there are huge crop diversification about 93 cropping pattern observed thus share of each pattern reported lower percent. Looking at different crop combination, Boro, Aman, Potato, maize, lentil, vegetable wheat and mustard are found greater combination with other crops (Table 5.3). District specific cropping pattern by land elevation is presented in *Appendix 5.1, 5.2, 5.3, 5.4 and 5.5.*

Table 5. 3 Percent of various cropping pattern practiced by the farmers by land elevation

Cropping Pattern	Land Elevation			All Average
	High	Low	Medium	
Boro-Fallow-Aman	13.6	31.9	33.5	26.3
Boro-Fallow-Fallow	1.3	6.1	15.4	7.6
Boro-Maize-Aman	0.3	0.5	4.8	1.9
Boro-Vegetable-Aman	0.3	0.2	2.8	1.1
Lentil-Fallow-Aman	4.1	3.1	4.3	3.8
Lentil-Fallow-Aman	4.1	3.1	4.3	3.8
Maize-Fallow-Aman	5.7	3.1	0.0	3.0
Potato-Vegetable-Vegetable	3.6	0.0	0.2	1.3
Tobacco-Maize-Aman	5.3	0.7	0.0	2.0
Wheat-Fallow-Aman	2.3	3.0	2.5	2.6
Mustard-Fallow-Aman	2.8	2.3	2.1	2.4
Wheat-Jute-Aman	2.8	1.0	1.8	1.9
Potato-Boro-Aman	2.3	2.6	0.5	1.8
Pea-Fallow-Aman	1.0	1.3	2.0	1.4
Lentil-Sugarcane-Sugarcane	2.1	1.3	0.7	1.4

5.6 Training on Soil Nutrient Management

Training is a common strategy for engaging farmers and increasing their knowledge, strengthening their skills and creating a forum for exchanging ideas. DAE and other research institutes provide different kinds of training to the farming community for increasing crop production. Following Figure 5.3 shows the percent of farmers received training on soil nutrient management in the last 12 months across district. It is observed that on an average of 6.2% farmers had received nutrient management related training of which the most training was received by the farmers of Dinajpur district (14.7%) followed by Bogura (11.1%), Natore (5.9%), Kurigram (3.9%) and jointly Nilphamari and Chapai Nawabganj (1.0%). Looking at training status based on farm category, the small and medium farmers had received training but marginal and large farmers did not receive the training on soil nutrient management. Perhaps due to a strong relationship with extension personnel or DAE/research institute has priority to extend the training to small and medium farmers. Regardless of farmer category or study area, the amount of training on nutrient management has been limited.

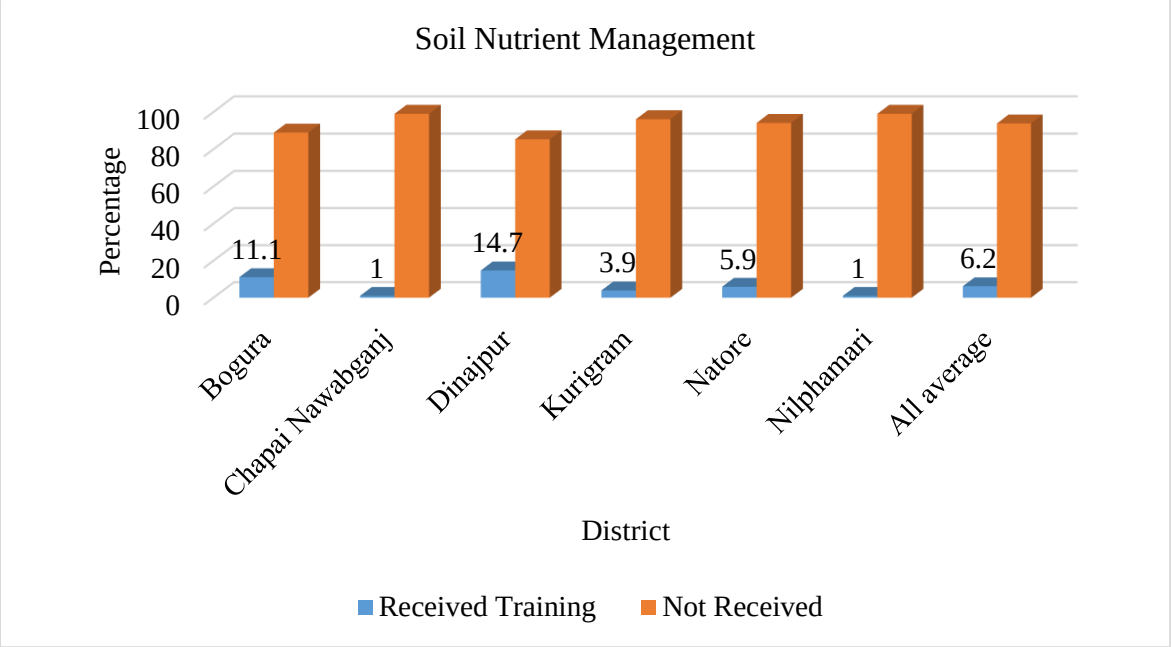


Figure 5. 3 Training status of the farming community related to soil nutrient management

Soil nutrient management related training is provided in all crop growing seasons i.e., Rabi, Kharif-I and Kharif II seasons. However, only Dinajpur district reported training in all three season while in Bogura farmers received training in Rabi and Kharif I season. Farmers of Nilphamari and Chapai Nawabganj districts received training in the Kharif II season while the farmers of Kurigam district received training in only Rabi season. In fact, relatively higher percent of training received in Rabi season, followed by Kharif II and Kharif I (Figure 5.4)

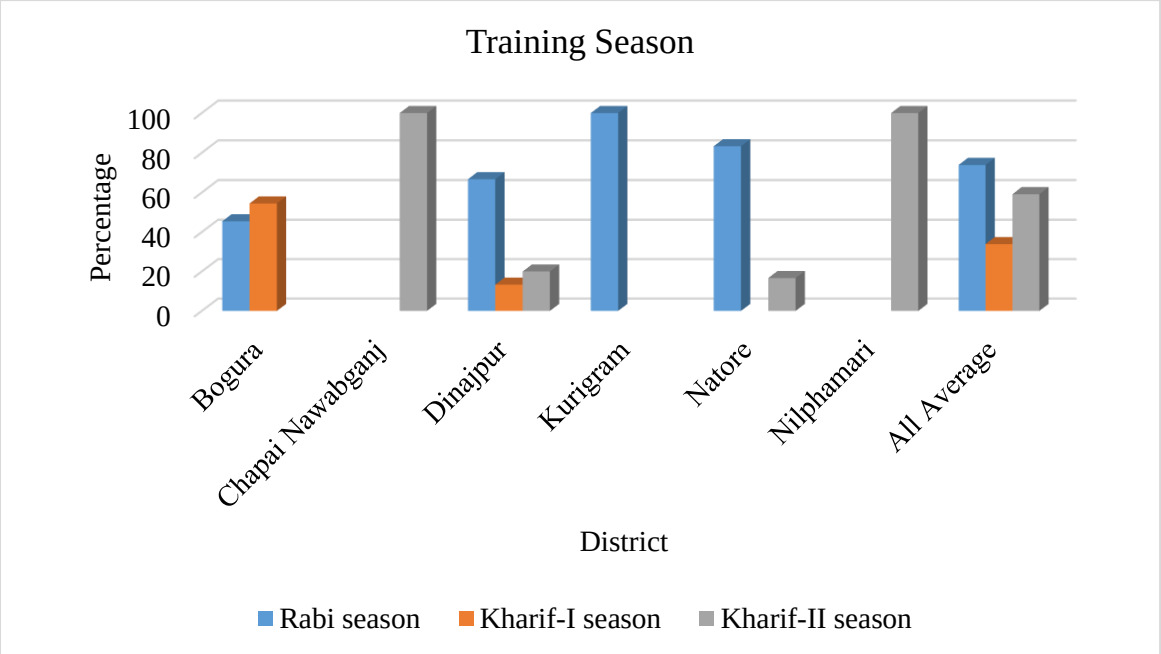


Figure 5. 4 Status of soil nutrient management training across seasons among the receivers

Following Table 5.4 provides the types of training received by the farmers in the study areas. Of the 38 farmers (6.2%) that reported receiving training, roughly one-third (28.9%) have received fertilizer application time and method training. A small percentage of farmers received training on soil quality enhancement (26.3%), overall better crop production (21.1%), pest and insect management (15.8%), and the demonstration of the importance of soil test (5.3). In the different study areas, only the farmers in Chapai Nawabganj and Nilphamari district had received training on fertilizer application and method and soil quality enhancement training, respectively. Other study sites, reported mix of various training including soil health management. Although farmers were asked to provide information related to soil health management but they gave diverse response but connect wisely with soil health management. During training session for better crop management, the trainee also provide suggestion to maintain the soil health.

Table 5. 4 Nature of training received by the respondents regarding soil nutrient management

Nature of training	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All Average
Fertilizer application and method	18.2	100.0	33.3	25.0	33.3	-	28.9
Soil quality enhancement	27.3	-	33.3	25.0	16.7	100.0	26.3
Better crop production including soil health	27.3	-	-	50.0	50.0	-	21.1
Pest and insect management (IPM)	18.2	-	26.7	-	-	-	15.8
Importance of soil test	9.1	-	6.7	-	-	-	5.3

5.7 Training on Crop Production

Training enhance the skills thereby increase the farm performance. Hence, appropriate and timely training could enhance the production capacity of the farmers. Following Table 5.5 shows the training status of different farm categories related to crop production. On an average 8.9% farmers had received training related to crop production in which only 1.2% farmers of marginal farm category got the opportunity to have training in the past 12 months. Table further delineates the types of training received by the sample farmers. Relatively higher percent of farmers received training on rice cultivation (28.4%), followed by vegetable production (18.5%), Pulses production (15.4%) wheat and maize cultivation (9.9%), IPM (8.6%) and other minor crop production related training listed in the Table 5.5. Importantly, the medium category farmers had received all sorts of training while marginal farmers had received only training on pulse production. This might be reason that the research institute extended support to the marginal farmers to grow pulses. In respect to study sites coverage of training, it is

observed that farmers of Bogura (18.2%), Dinajpur (13.4%) and Natore (11.8%) district had received relatively more training than other three study districts (*See appendix 5.3 for details*).

Table 5. 5 Types of crop production training received by the sample farmers

Types of training	Farm size (%)				All average
	Marginal farmers	Small farmers	Medium farmers	Large farmers	
Training recipient	**1.2**	**9.1**	**9.4**	**9.5**	**8.9**
Rice cultivation	-	34.5	15.9	-	28.4
Vegetable production		17.7	20.5	25.0	18.5
Pulses production	100.0	11.5	22.7	25.0	15.4
Wheat and Maize cultivation		7.1	18.2		9.9
IPM		8.0	6.8	50.0	8.6
Other crops		7.1	4.5		6.2
Banana cultivation		5.3	2.3		4.3
Fertilizer related		5.3	2.3		4.3
Seed management		2.7	0.0		1.9
Potato		0.9	2.3		1.2
Spices related			4.5		1.2

Following Table 5.6 depicts the sources of training that received by the sample respondents. It is evident that DAE is the most important sources of training for the farmers consisted 67.3% on an average across district. Looking at different farm category, the marginal farmers only received training from DAE while small farmers received training from all listed sources. The large farmers received training from DAE and Agriculture Research Institutes (ARIs)-reported equal percent (50%). The second important source of training was the Agriculture Research Institutes (ARIs) as reported by the sample respondents estimated at 22.2% irrespective farm category. Among study district, about 89% farmers of Dinajpur received training from DAE while it was only about 44% for Natore district. Few farmers also reported that they got training from research project (4.3%) but not all study district (*See Appendix 5.4*).

Table 5. 6 Sources of training received by the sample respondents across farm category

Sources of training	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
DAE	100.00	69.03	63.64	50.00	67.28
ARIs	-	17.70	31.82	50.00	22.22
Others	-	6.19	4.55		5.56
Project	-	6.19			4.32
NGO	-	0.88			0.62

The farmers who received training from different sources, their extent of satisfaction was measured based on their evaluation of the training activities. Farmers response in three levels- i) inadequate; ii) moderate; iii) satisfactory. The responses are portrayed in Figure 5.5. It is observed that on an average 50% of the sample farmers were moderately satisfied with the

training activities, only 6.8% reported that the training was inadequate. Interestingly, the marginal farmers who received the training were reported their cent percent satisfaction. In fact, access to training for marginal farmers are limited thus they show their happiness with whatever they received. Looking at district level responses, about 73% of the farmers of Kurigram district reported satisfaction with provided training while none of the respondents from Nilphamari district reported their satisfaction on given training but 90% were moderately satisfied (see Appendix 5.5)

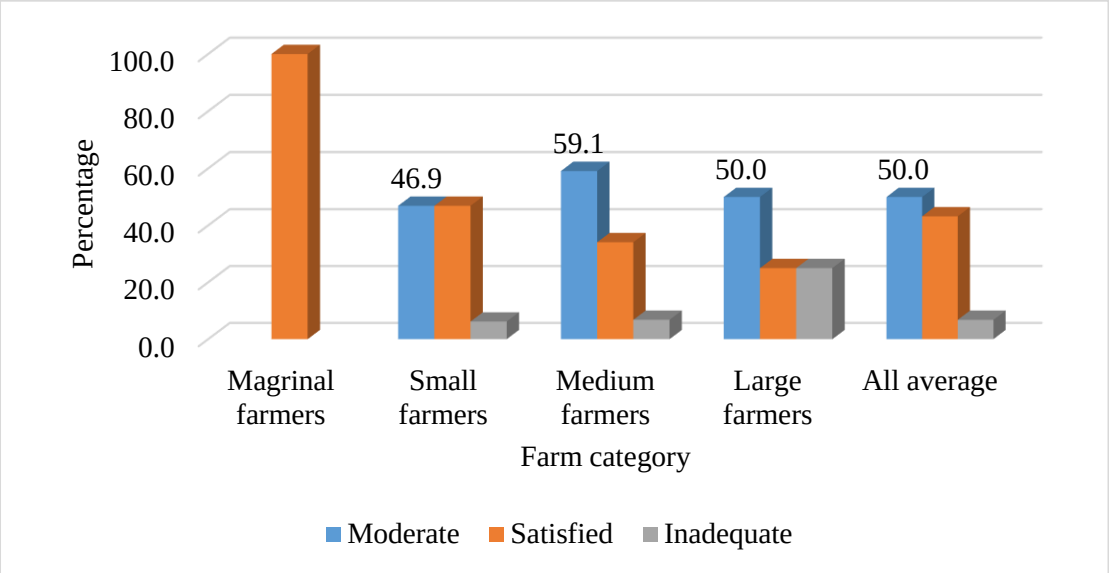
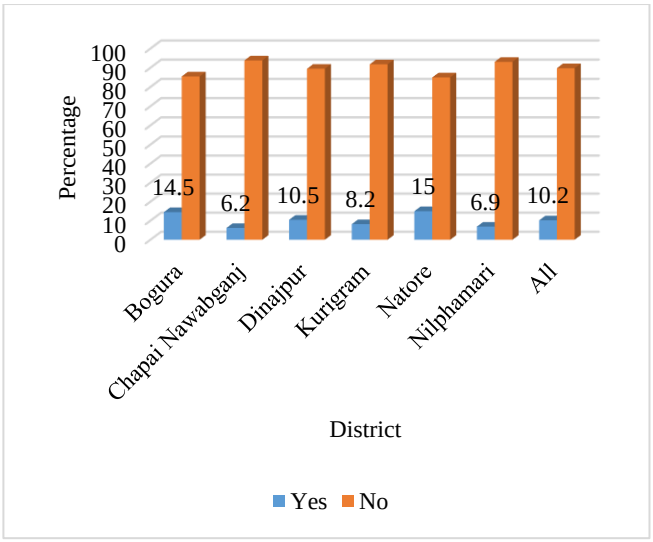


Figure 5. 5 Extent of farmers reported satisfaction level with training

5.7 Support Services

Following Figure 5.6 and 5.7 show the percent of farmers received support services across district and farm category. On an average about 10% farmers received various supports including seed, fertilizer, demo plot etc. Relatively, higher percent about 15% of the farmers form Natore district received input support while it was only 6.2% for Chapai Nawabganj district. On the other hand, large farmers got maximum (16.7%) input supports then followed by medium (11.5%0, Small (10%) and marginal farmers respectively. This results re-confirm that marginal farmers comparably ignored by the agriculture service providers in extending the benefits.



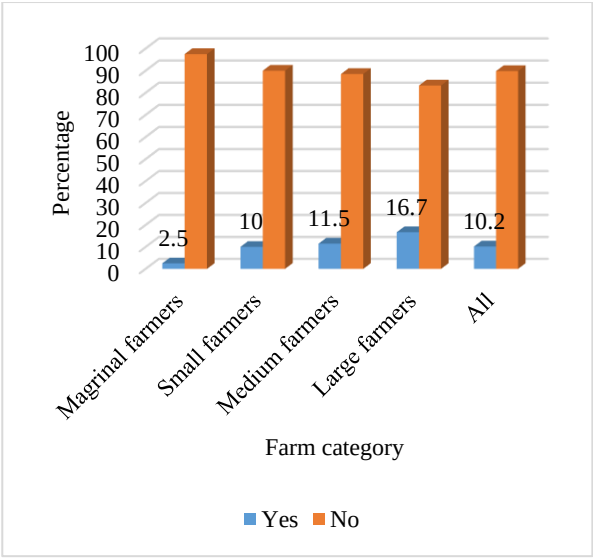


Figure 5. 6 Percent of farmers received various input support across district and farm category

Following Figure 5.8 portrays the types of support provided by the agriculture service providers. Among the recipient, about 37% had received seeds as support for crop production, both seed and fertilizer received by about 30% of the farmers. A good percentage of farmers also received fertilizer for growing their crops. Looking at the distribution across farm category, marginal farmers did not receive any demo which implies that they have been ignored by the service providers. In respect to district coverage, relatively higher number of farmers (58%) from Bogrua district received seed support for growing crops while it was only 14 % in Nilphamari district (*See appendix 5.6).*

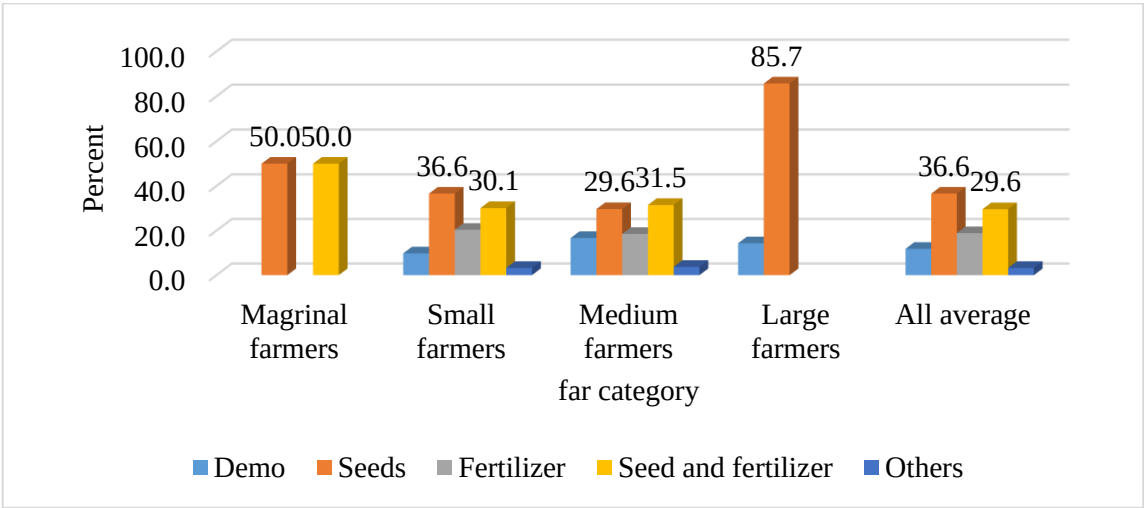


Figure 5. 7 Support provided by the agriculture service providers

It has been tried to delineate the training support by various crops in different study sites. Table 5.7 shows that on an average about 17% farmers received training related Aman rice production followed by wheat (14%), mustard (10.8%), Boro rice (10.2%), vegetable (9.1%), black gram (7%), lentil (6.5%) and other crops listed in the Table. It is evident that in Bogura about 23% farmers received support for growing vegetables as the study villages is considered as vegetable production hubs. Similarly, 40% farmers of Kurigram district received support for growing

mustard while about 29% farmers got support for growing wheat in Nilphamari district. Again in Chapai Nawabganj district, about 32% farmers got supports for lentil production. This results reflects the relative importance of a particular crops in a specific reasons that agriculture offices promoting through support services.

Table 5. 7 Percent of farmers received support for various crops across district

Crop Name	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Aman rice	16.3	15.8	21.9	16.0	13.0	19.0	16.7
Wheat	7.0	26.3	12.5	4.0	15.2	28.6	14.0
Mustard	4.7	5.3	9.4	40.0		19.0	10.8
Boro rice	16.3	10.5	15.6	8.0	6.5	-	10.2
Vegetable	23.3	-	6.3	12.0	2.2	4.8	9.1
Black gram	16.3	5.3	12.5	4.0	-	-	7.0
Lentil	-	31.6	-	-	13.0	-	6.5
Pea	-	-	-	4.0	19.6	4.8	5.9
Maize	7.0		9.4	-	4.3	9.5	5.4
Mung		5.3	-		13.0	-	3.8
Aus	4.7		3.1		4.3	-	2.2
Khesari					2.2	14.3	2.2
Muskalai				12.0	2.2	-	2.2
Banana	4.7						1.1
Jute			6.3				1.1
Sugarcane					4.3		1.1
Onion			3.1				0.5

Likewise soil nutrient management training source, following Figure 5.8 presents the sources of support for crop production. There are mainly three different sources where farmers receive support for their crop production. It is evident that DAE is the most important sources of support for the farmers consisted 64.5% on an average across farm category. Looking at different farm category, the marginal farmers only received training from DAE while small and marginal farmers received training from all listed sources. The large farmers received training from DAE (28.6%), Agriculture Research Institutes (ARIs)-reported equal percent (57.1%) and others (NGOs).

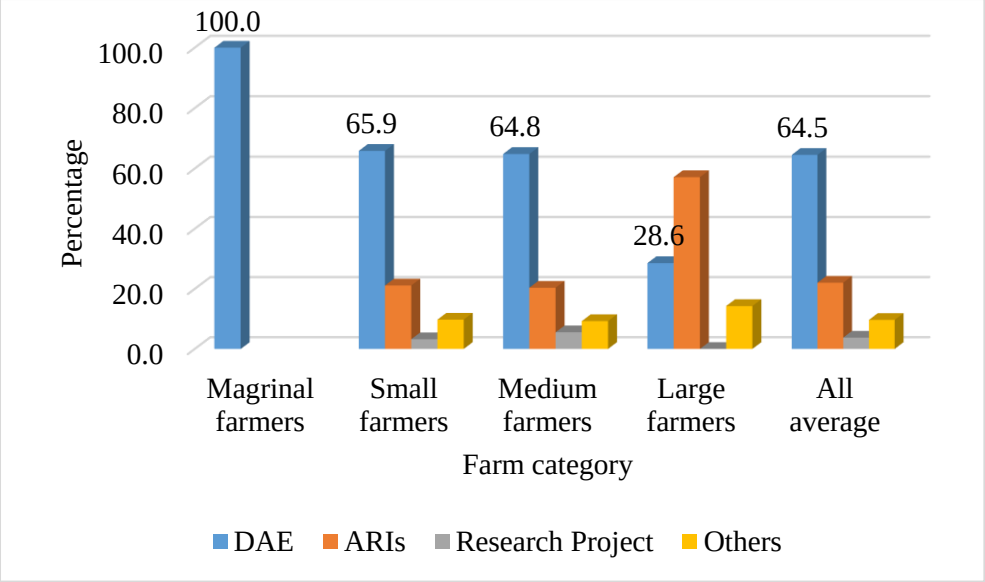


Figure 5. 8 Sources of agriculture input supports

It is important to document the level of satisfaction of the sample farmers after receiving inputs supports. Following Table 5.8 shows that relatively higher percentage of farmers (45.2%) were happy with the input supports while 15.6% reported that the inputs were insufficient to meet their requirement. About 39% farmers reported at moderate level of the inputs. Looking at farm category, 50% of the marginal farmers perceived that the given inputs were sufficient then followed by small farmers (48.8%), medium farmers (42.6%) and large farmers (14.3). In fact, the large farmers were not so happy with the input support as they require more inputs to grow the crops.

Table 5. 8 Level of satisfaction with input supports

	Marginal farmers	Small farmers	Medium farmers	Large farmers	All
Inadequate	1 (50.0)	17 (13.8)	10 (18.5)	1 (14.3)	29 (15.6)
Moderate	1 (50.0)	46 (37.4)	21 (38.9)	5 (71.4)	73 (39.2)
Sufficient		60 (48.8)	23 (42.6)	1 (14.3)	84 (45.2)

Parenthesis indicate the percent

5.8 Soil Testing Scenario at Farm Level

In Bangladesh, both soil testing facilities and motivation of farmers are lacking. Following Figure 5.9 and 5.10 show the percentage of farmers that tested the soil of their fields in the study areas across district and farm category. On an average 8.4% farmers in all farm categories reported that they had tested their soil. Among the farm category, about 21% of large farmers tested their soil while none of the marginal farmers tested their soil in last 12 months. Looking at district level status, relatively higher 16.2% farmers of Bogura district had tested their soil followed by Dinajpur (14.7%), joint Kurigram and Natore (6.9%) and Chapai Nawabganj and Nilphamari also jointly at 2.9%.

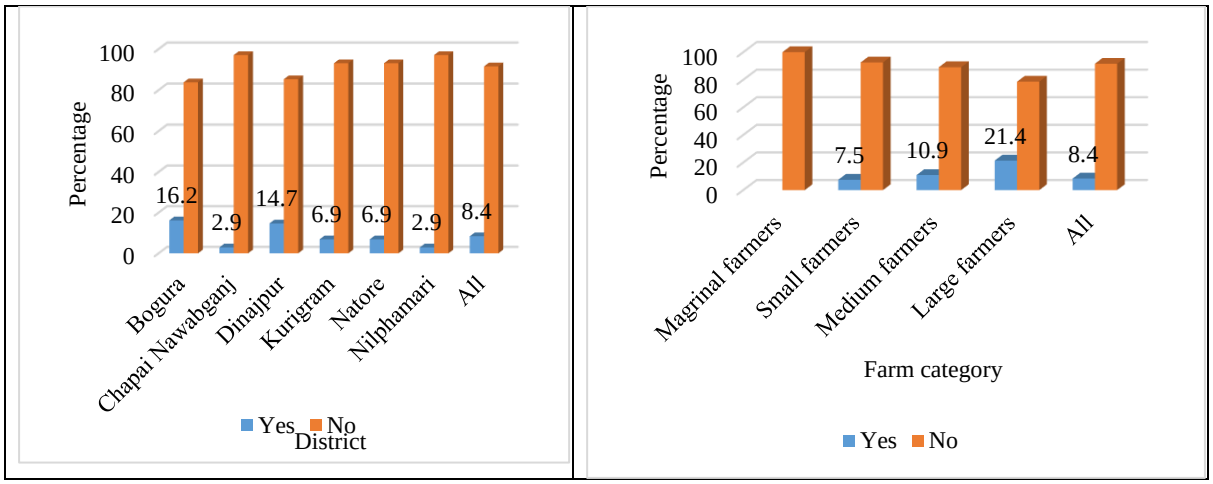


Figure 5. 9 Percent of farmers soil tested across district and farm category

The farmers who tested their soil were asked to inform about the sources of soil test. Following Table 5.9 presents the sources of soil test across farm category. As mentioned earlier, none of the marginal farmers tested their soil. Out of 51 farmers 30 (58.8%) tested soil with support from DAE officials followed by ARIs (19.6%) NGO (19.6%) jointly and private company (2%). Among farm category, the medium farmers tested soil in all sources while the large farmers tested their soil with the help of DAE official. While looking at district level situation, the relatively higher number (16) of farmers from Bogura district tested their soils followed by Dinajpur (15), Kurigram and Natore jointly (7) and Nilphamari and Chapai Nawabganj (see *Appendix 5.7*).

Table 5. 9 Percent of farmers tested soil from various sources by farm category

Source	Small farmers	Medium farmers	Large farmers	All average
ARIs	7 (22.6)	3 (17.6)		10 (19.6)
DAE	17 (54.8)	10 (58.8)	3 (100)	30 (58.8)
NGO	7 (22.6)	3 (17.6)		10 19.6%
Private company		1 (5.9)		1 (2.0)

About 92 % of the respondent farmers reported that they did not test their soil. The main reasons for not testing soil are presented in Table 5.10 by farm category. About 36% farmers reported that they had not heard about soil test and 30% thought that their crops grow well without soil test so the soil test cannot help much. In contrast, about 21% farmers reported that lack of motivation behind for not testing soils. A good portion of farmers (10%) claimed about the lack of soil testing facilities and few of the farmers reported that they did not test soil as because of leased in land. Investigating at farm category level, it is evident that a large portion (37%) of marginal farmers did not test their soil due to lack of their motivation while 38% small farmers

reported they were not familiar with soil testing facilities. The reasons might be that their application of fertilizer is based mostly on their long farming experience or that they have not seen the results of soil test based crop production. District level status shows that relatively higher percent of farmers from Chapai Nawabganj and Nilphamari districts did not test soil which is presented in *Appendix 5.7*.

Table 5. 10 Farmers responses (%) for not testing soil across farm category

	Marginal farmers	Small farmers	Medium farmers	Large farmers	All
Crops grow well	8 (29.6)	120 31.5%	39 28.1	1 9.1	168 30.1
Don't know about it	6 (22.2)	145 38.1	43 30.9	4 36.4	198 35.5
Lack of facilities	3 (11.1)	35 (9.2)	21 15.1	2 18.2	61 10.9
Lack of motivation	10 (37.0)	67 17.6	34 24.5	4 36.4	115 20.6
Leased in land		14 3.7	2 1.4		16 2.9

Parenthesis indicate the percent

5.9 Crop Residue Retention

Crop residue retention on the top of the soil with any number of tillage modifies various agronomic factors by increasing and stabilizing the soil moisture content, altering fertility and temperature in the topsoil layer, reducing soil erosion, nematode and sunlight incidence on the soil surface (Silva et al., 2003; Velini and Negrisoli, 2000; Vidal and Theisen, 1999). It also substantially reduces the amount of inorganic fertilizers use which brings both environmental and economic benefits to the farmers (Tiwari, 2007). It was found (see Table 5.11) that on an average 20% of the rice straw keep in the field, which ranges from 10-40 percent depending on rice season. Relatively large farmers (25% of crop height) kept more straw residue in the field than that of other category of farmers. Looking at district level, farmers of Bogura district kept more straw followed by Dinajpur, Natore, Nilphamari, Kurigram and Chapai Nawabganj district.

Table 5. 11 Percentage of farmers retained crop residues in the study areas

Farm category	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Marginal farmers	20.00	21.25	23.33	20.00	21.67	15.00	20.19
Small farmers	21.75	18.54	21.43	20.00	20.92	20.35	20.66
Medium farmers	25.00	18.83	22.65	20.00	22.05	20.75	21.08
Large farmers	20.00	24.00	25.00	-	-	-	23.57
Total	22.17	19.31	21.79	20.00	21.37	20.27	20.81

Farmers were asked about the uses of straw bringing to the home. On an average 83% farmers used the straw to feed the cattle, few of them used for fuel purposes and also let them parish for manure. Table 5.12 shows greater variation across district and farm category regarding uses of the straw. About 87% of the straw used for cattle feed by the small farmers while it was only 48% by the marginal farmers. In fact, uses for cattle feed depends on the availability of cattle in the household. Similarly, uses for fuel purpose depends of availability of alternative source of fuel too. The farmers who used rice straw for fuel, later on it used as manure. Looking at district level status, the farmers of Dinajpur (91.2%) used relatively more rice straw to feed cattle followed by Bogura (86.9%)), Nilphamari (86.3%), Natore (85.3%), Kurigram (78.4%) and Chapai Nawabganj (70.6%).

Table 5. 12 Percent use of rice straw across district and farm category

Particular	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Marginal farmers							
Cattle feed	50.0	50.0	0.0	66.7	0.0	66.7	48.1
Both	50.0	25.0	33.3	0.0	33.3	0.0	14.8
Manure	0.0	25.0	66.7	33.3	66.7	33.3	37.0
Small farmers							
Cattle feed	92.5	78.0	92.2	88.0	81.7	84.8	87.1
Fuel	1.3	2.4	1.3	0.0	1.7	1.3	1.2
Both	6.3	4.9	3.9	5.3	8.3	2.5	5.1
Manure	0.0	14.6	2.6	6.7	8.3	11.4	6.6
Medium farmers							
Cattle feed	73.3	70.2	100.0	86.7	79.5	95.0	81.4
Fuel	0.0	2.1	0.0	6.7	0.0	0.0	1.3
Both	20.0	17.0	0.0	6.7	7.7	0.0	9.6
Large farmers							
Cattle feed	0.0	50.0	100.0	0.0	0.0	0.0	50.0
Fuel	50.0	0.0	0.0	0.0	0.0	0.0	7.1
Both	50.0	40.0	0.0	0.0	0.0	0.0	35.7
Manure	0.0	10.0	0.0	0.0	0.0	0.0	7.1
All category							
Cattle feed	86.9	70.6	91.2	85.3	78.4	86.3	83.1
Fuel	2.0	2.0	1.0	1.0	1.0	1.0	1.3
Both	10.1	14.7	3.9	4.9	8.8	2.0	7.4
Manure	1.0	12.7	3.9	8.8	11.8	10.8	8.2

5.10 Fertilizer Application Decision

Following Table 5.13 presents various factors that influence farmers in deciding the amount of fertilizer to be applied in the field. It is apparent from Table 5.13 that several factors (at least 15 factors mentioned by the farmers) have been taken into consideration before applying fertilizer. Among the factors, types of crop grown in the field reported by relatively higher

percent of farmers (21.9%), followed by the quality of soil (18%), availability of manure (9.6%), land topography (elevation-9.5%), crop season (8%), based on fertilizer dealer suggestion (6.4%), follow neighbor farmers (5.5%), follow the advice receive from extension personnel (5.4%) and other factors listed in the Table 5.13. Encouragingly, it was not found much variation across farm category, accept large farmers gave more priority to the soil quality than that of types of crop grown in the field. In fact, it was observed that large farmers followed less cropping pattern this might cause their more preference on soil quality to apply fertilizer. Similar pattern also observed in respect to study districts regarding the application decision by farmers (*see details in Appendix 5.8*).

Table 5. 13 Percent of farmers' influence by various factors in fertilizer application

Factors	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Types of crop	24.1	21.9	21.6	19.4	21.9
Quality of soil	19.6	17.6	18.7	21.0	18.0
Availability of cow manure	9.8	9.9	9.1	6.5	9.6
Topography	7.1	9.8	8.8	11.3	9.5
Crop season	6.3	7.8	8.7	11.3	8.0
Recommendation made by dealer	7.1	6.1	6.8	6.5	6.4
Practice of neighbors	8.9	5.4	4.9	8.1	5.5
Advice given by extension/project staff	3.6	5.2	6.2	6.5	5.4
Cropping pattern	6.3	4.4	5.5	6.5	4.8
Availability of fertilizer	0.9	4.3	2.6	0.0	3.6
Cost of fertilizer	3.6	3.4	2.9	0.0	3.2
Sowing type	2.7	1.8	1.6	1.6	1.7
Market value of the crop	0.0	1.5	0.9	1.6	1.3
Soil testing advice	0.0	0.4	0.9	0.0	0.5
Fertilizer recommendation guide	0.0	0.4	0.9	0.0	0.5

5.11 Applicability of Fertilizer

On average, about 42% of the sample farmers reported that fertilizer did not work as per their expectation (Figure 5.11). The farmers of Chapai Nawabganj district indicated relatively higher percent (68.6%) that fertilizer did not work as per their expectation followed by Bogura (49.5%), Nilphamari (41.2%), Natore (35.3%), Kurigram (30.4%) and Dinajpur (27.5%). It does not implies that they only claimed about the quality of the fertilizer rather they had diverse opinion regarding not applicability of fertilizer as desired (see Table 5.14).

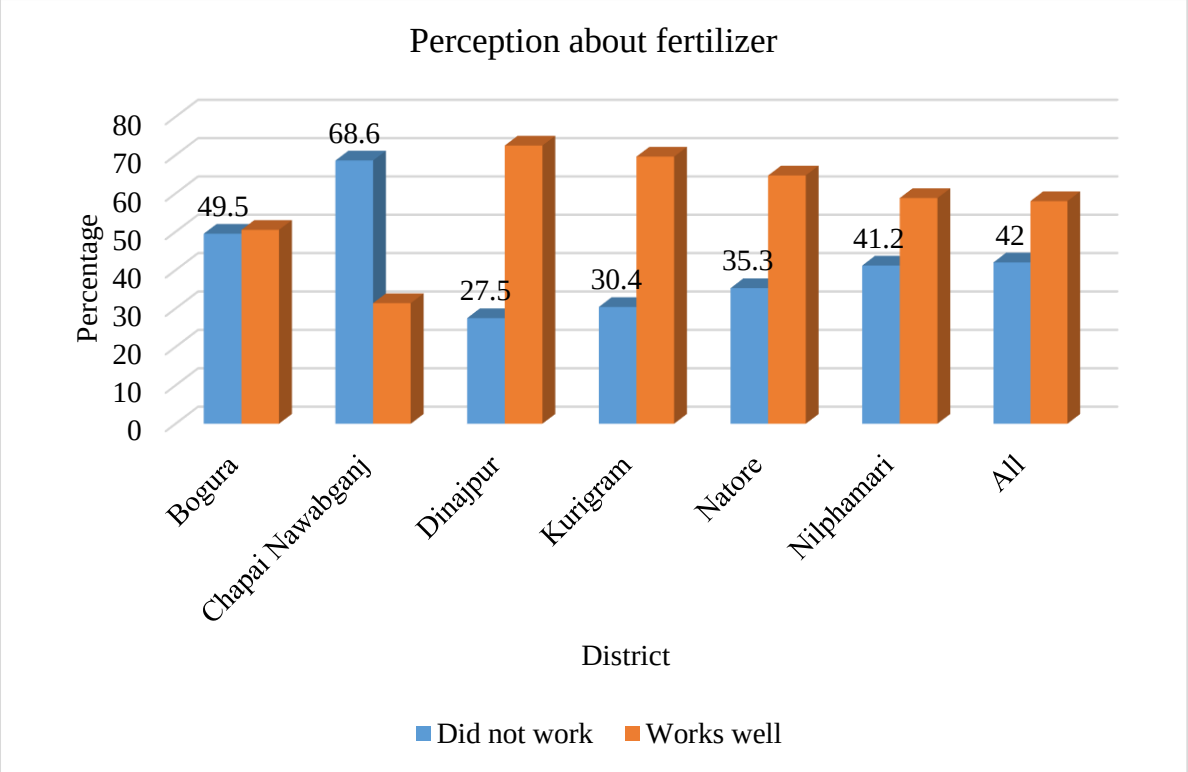


Figure 5. 10 Perception about fertilizer applicability as per expectation

Following Table 5.14 shows the reasons of not working fertilizer as desired. Among various reasons, about 41% sample farmers reported that the quality of fertilizer was not good followed by imbalanced application (28.5%), reasons was unknown (11.7%), the soil quality deteriorated (11.3%), and climate variation (7.8%). About 39% farmers of Dinajpur district reported that imbalanced application of fertilizer was the main reason for not working fertilizer as desired. Now the question is how they identify the deficiency symptom? Next Table 5.14 presents their responses.

Table 5. 14 Percent of farmers reported the reasons for not working fertilizer

Reasons	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All
Fertilizer quality is not good	36.7	51.4	32.1	25.8	50.0	35.7	40.6
Imbalance application	30.6	24.3	39.3	29.0	27.8	26.2	28.5
Don't know	8.2	8.6	10.7	22.6	13.9	11.9	11.7
Detoriate soil quality	4.1	8.6	17.9	12.9	8.3	21.4	11.3
Climate variation	20.4	7.1	-	9.7		4.8	7.8

Following Table 5.15 shows various symptom that helps farmers to identify the nutrient deficiency. The respondent farmers of the study areas identify nutrient deficiencies in following ways i) leaf color, overall growth of the plant, soil condition, yield/production, and compare with other farmers plants. On average, 50% sample farmers reported that they identified deficiency by looking at the color of the plant leaf followed by overall growth of the plant (38.8%), soil health (4.4%), expected yield gap (3.9%) and compare with other farmers field (1%). A little variation was observed across district status, for example the farmers of Bogura district gave more priority on the overall growth of the plant rather only the leaf color. It might be reasons that farmers of Bogura mostly grow vegetables in which overall plant growth is more important than leaf color only.

Table 5. 15 Farmers perception about fertilizer deficiency in the crop field

Identify symptom	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Leaf color	22.2	48.0	48.0	57.8	71.6	52.9	50.2
Overall growth of plant	65.7	41.2	38.2	27.5	18.6	42.2	38.8
Soil condition	0.0	9.8	1.0	8.8	4.9	2.0	4.4
Expected yield gaps	9.1	0.0	5.9	2.0	3.9	2.9	3.9
Compare with others	3.0	0.0	2.0	1.0	0.0	0.0	1.0
Don't understand	0.0	1.0	4.9	2.9	1.0	0.0	1.6

It is important to know what farmers usually do after identifying the nutrient deficiency. Following Table 5.16 portrays the various action taken by the farmers after identifying the nutrient deficiency symptom of their crops to reduce the losses. Once they identified, they applied fertilizer and pesticide by own experience (49.1%), consulted with fertilizer dealer (24.3%), consult with SAAO (15.6%), consult with peer farmers (6.6%), and a small percent wait to see the results (4.4%). Looking more closely at the districts however there were some differences. Fertilizer application was the main action of all farmers in response to identifying nutrient deficiency symptoms, but this was more common among farmers in Nilphamari disttict (54.9%). In contrast, the farmers of Chapai Nawabganj district relatively preferred to consult with dealer (46.1%) than that of other districts. On the other hand, farmers of Kurigram district reported their relative higher preference to consultation with SAAO (27.5%) then that of other study districts. Results bases on farm category is presented in the *Appendix 5.10.* Not much variation was observed in case of farm category in taken action. However, comparatively higher percentage of medium farmers consult with SAAO than that of other category of farmers.

Table 5. 16 Action taken after identifying the nutrient deficiency symptom for reduction of losses

Types of action	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All
Apply fertilizer and pesticide by own experience	52.5	46.1	48.0	47.1	46.1	54.9	49.1
Consult With dealer	21.2	46.1	20.6	11.8	16.7	29.4	24.3
Consult with SAAO/UAO	15.2	2.0	18.6	27.5	26.5	3.9	15.6
Consult with peer farmers	6.1	4.9	5.9	5.9	6.9	9.8	6.6
Wait to see the result	5.1	1.0	6.9	7.8	3.9	2.0	4.4

5.12 Availability of Fertilizer

In Bangladesh, all types of fertilizer are available in the market. Farmers can by the fertilizer nearby bazar where fertilizer dealers are available. Following Figure 5.12 re-confirm the statement that the fertilizer is available within short distance (Walking distance). On average, distance of fertilizer market was about 1.15 km. various from 0.79 km. to 1.86 km. across districts. Farmers of Chpai Nawab Ganj district purchased fertilizer relatively large distance (1.86 km.) followed by Nilphamari district (1.41), Bogura (1.02 km.) and other districts reported less than one km.

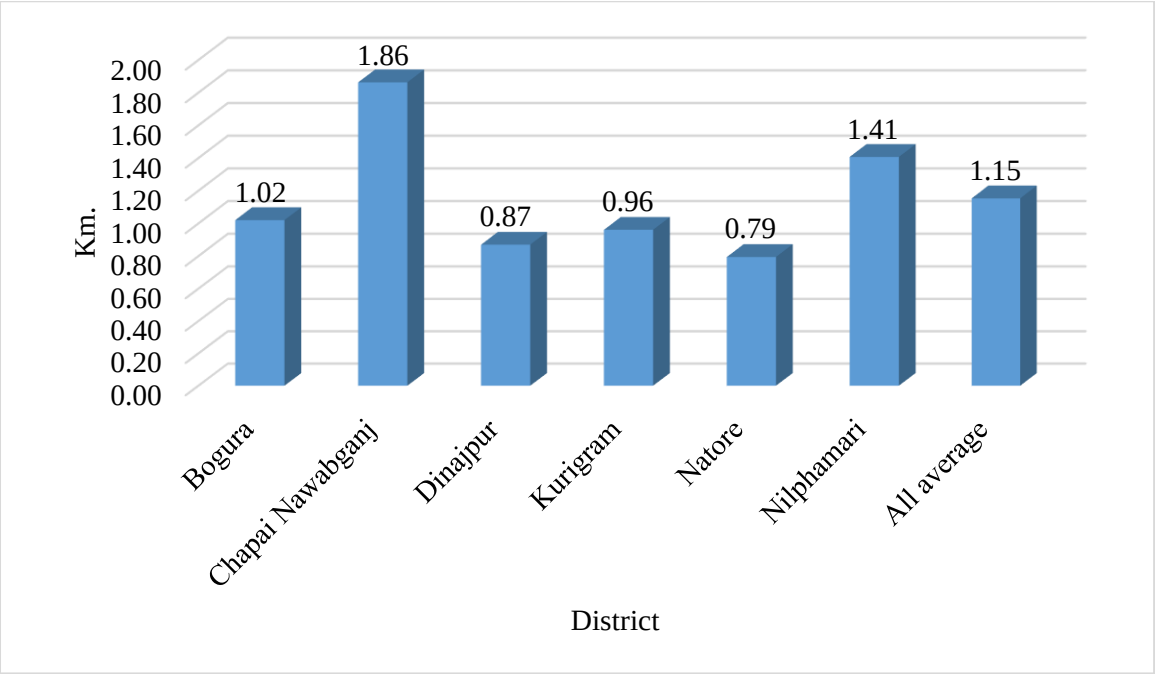


Figure 5. 11 Average distance of fertilizer dealers or fertilizer market

In respect to farmers' satisfaction with the availability of fertilizer, most of the farmers were happy with the availability of required fertilizer. Only about 12 farmers reported that they were

not satisfied with the availability of the fertilizer across district. In fact, they raised their concern as local market asked a bit more price of fertilizer than other markers- this situation made them unhappy rather the availability issue. Farmers of Borura district were reported relatively more satisfaction (93%) while in Nilphamari district about 79% farmers reported their happiness regarding the availability of fertilizer. Similarly, among different farm category, medium farmers (91%) reported relatively higher satisfaction followed by small farmers (88%), large farmers (79%) and marginal farmers (78%).

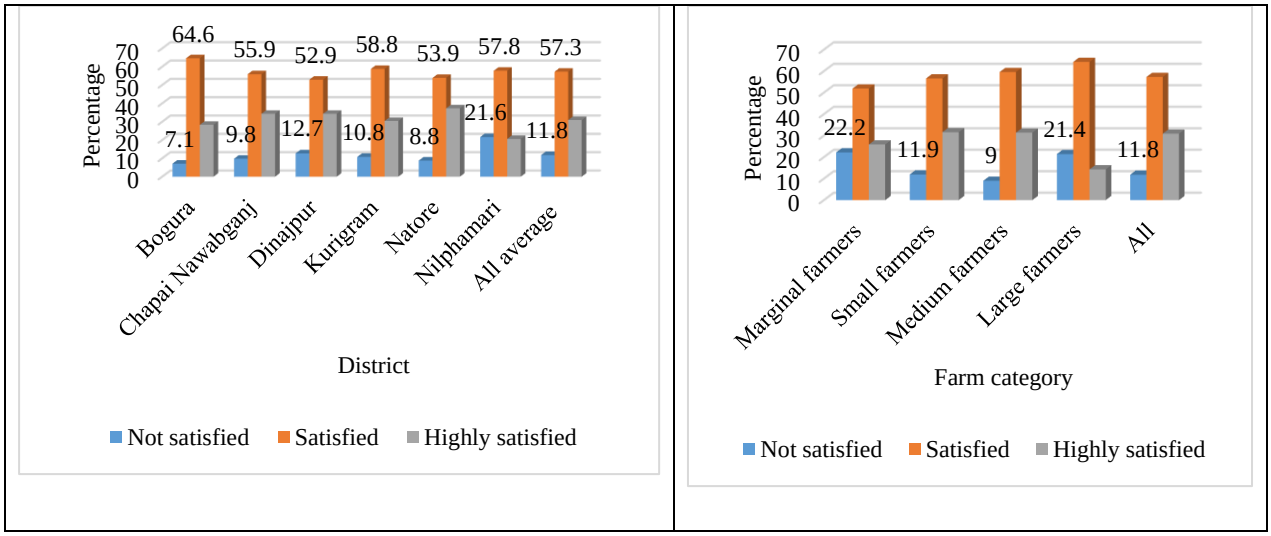


Figure 5. 12 Level of satisfaction on the availability of the fertilizer by district and farm category

5.13 Affordability of Fertilizer

Above discussion confirm that there was not much concern raised by the farmers related to the availability of fertilizer. Now the question is- can farmers afford to buy the fertilizer as an important input for crop production. On average, 57% farmers reported that they could not buy fertilizer as per their requirements. Investigating a district level shows that 90% of the farmers from Kurigram district reported that they could not buy fertilizer as per their requirements while it was about 60% for Bogura district. In fact, this is a usual phenomenon in Bangladesh that if you asked resource limitation, they usually reported over. Among farm category, the marginal farmers (81.5%) reported relatively higher percentage about their difficulties to purchase required fertilizer following small (72.6%), medium (64.7%) and large farmers (42.9). The trend seems rational as per resource constraint by different farm households.

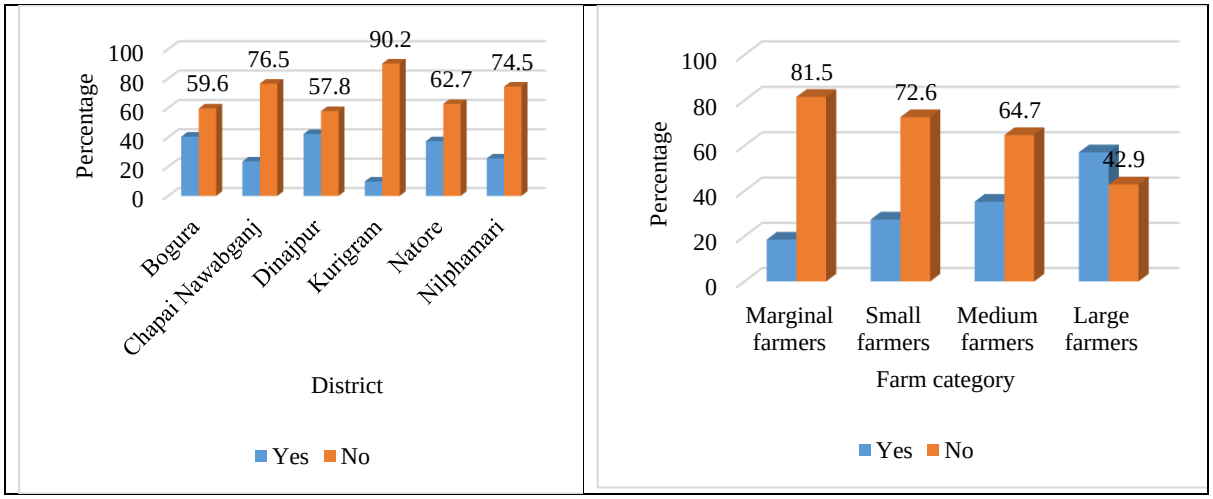


Figure 5. 13 Afford to buy required fertilizer by district and farm category

5.14 Familiar with Fertilizer Subsidy

It is found that 54% of the total respondents were familiar with fertilizer subsidy provided by the government (Table 5.17). Majority of the farmers (76%) in Kurigram district reported that they knew about government subsidy while it was only 30% for Chapai Nawabganj district. Among different types of fertilizer subsidy, farmers were familiar more with urea (28.7%) followed by TSP (25.1%), MoP (23%), DAP (8%) other fertilizer (4.1%) and Zinc (1.5%) respectively. However, almost in all cases farmers of Chapai Nawabganj were reported lower level of familiar with government subsidy. Farmers of Kurigram found to be more known about government subsidy which can be regarded that agriculture extension personnel were more communicative in the study location. In fact, the study area was selected with the help of local extension office that might be another reason for their relatively higher rate of familiarity with government support.

Table 5. 17 Percent of farmers familiar with government subsidy in various fertilizer across district

Subsidy	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Family with government subsidy	67.7	30.4	50.0	75.5	55.9	45.1	54.0
Urea	35.4	7.8	33.3	40.2	27.5	28.4	28.7
TSP	24.2	2.9	25.5	37.3	31.4	29.4	25.1
DAP	4.0	8.8	5.9	12.7	10.8	5.9	8.0
MoP	20.2	1.0	22.5	43.1	29.4	21.6	23.0
Zinc	4.0		1.0	1.0	1.0	2.0	1.5
Other	1.0		3.9	13.7	3.9	2.0	4.1

5.15 Strategy to Increase the Affordability

Farmers pay more attention to grow healthly crops thereby good harvest. Although farmers face difficulties to buy required amount of fertilizer by their own ability but they usually apply required amount of fertilizer by taking three different strategies- i) buy less amount; ii) borrow money from friends or purchase fertilizer in credit; iii) buy comparatively low cost fertilizer (in case micronutrient deficiency). Following Figure 5.14 displays the strategy across farm category. On average, 90% farmers borrow money or buy on credit across farm category. A few percent of the farmers buy low cost fertilizer as a coping strategy- this mostly micronutrient fertilizer. However, 100% of the large farmers borrow money or buy fertilizer in credit from the dealer while a limited percent (9%) of marginal farmers buy less fertilizer as coping strategy. Not much variation was observed across district adopted by the farmer (see *Appendix 5.11 for details*).

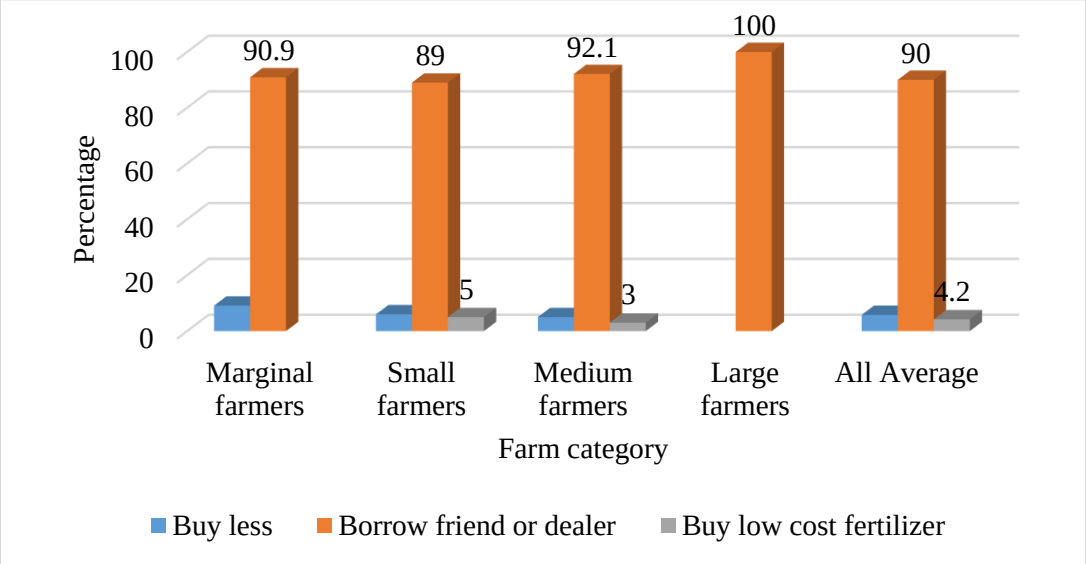


Figure 5. 14 Farmers strategy to increase

Chapter VI

CLIMATE CHANGE AND COPING STRATEGY

6.1 Introduction

This chapter provides the perception of climate change and coping strategy of the farming community of Northern Bangladesh using farm level survey data. Before investigating farmers' perceived belief, the study primarily focuses on the trends of climate change in the study areas based on historical data. In addition, to build the quantitative justification for climate change, the present simple provides trend analysis at first then the farmers' perespectives. Finally, this chapter provide details coping strategy related to farm practices.

6.2 Changes in Temperature and Rainfall

Significant changes in temperature and rainfall were evident for the period of 1982–2016. Results indicate that the climatic parameters (e.g. maximum and minimum temperature and rainfall) changes over the period of time. Following Figure 6.1 presents the overall trend of annual rainfall across district. In fact, the northern Bangladesh is known as Barind Tract regions which is further divided into three based on climatic variability i). High Barind Tract, ii) Medium High Barind Tract and iii) Low Barind Tract regions. Our study sites fall in three different regions, for example Chapai Nawabganj district fall under high Barind Tract region, Bogura falls into Medium high barind tract region while Dinajpur, Nilphamari and Kurigram fall under low Barind tract regions (Palash et.al., 2019). It is evident that annual rainfall decreased over time in all study location. Slope of the simple trend line clearly show the visibility. For more clarification Figure 6.2; 6.3 and 6.4 show the rainfall and temperature over the period with seasonal variation in three different Barind tract regions.

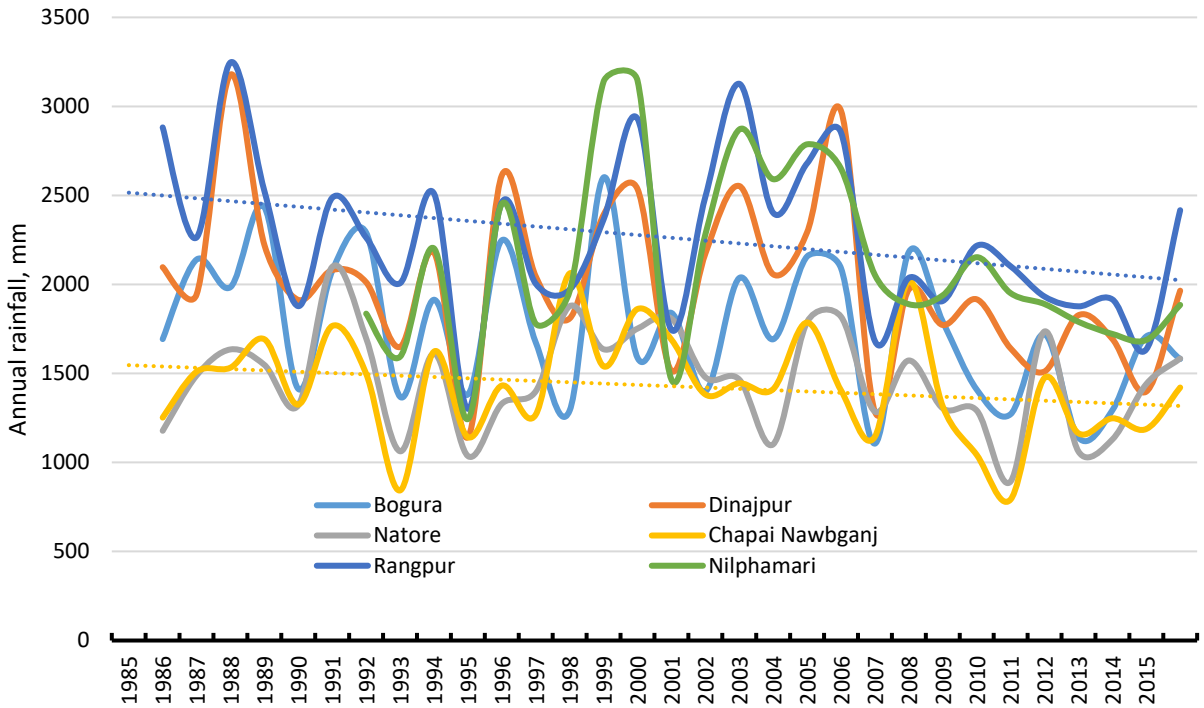
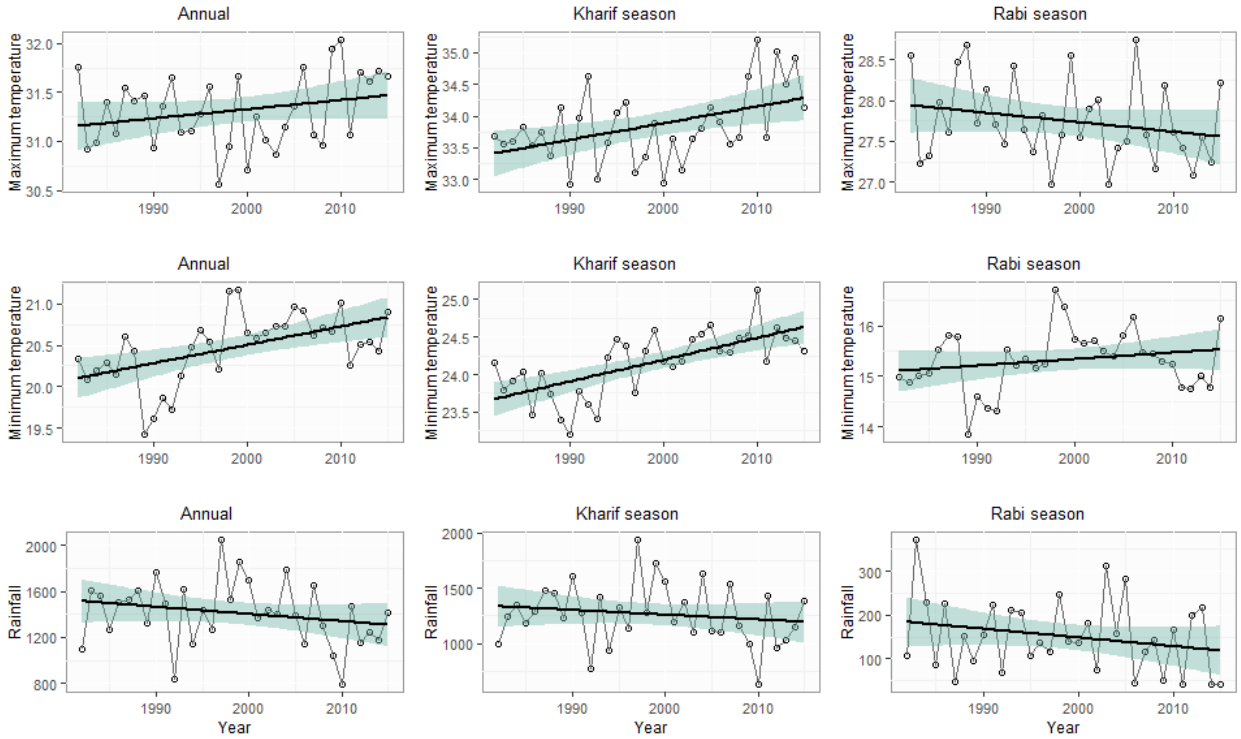


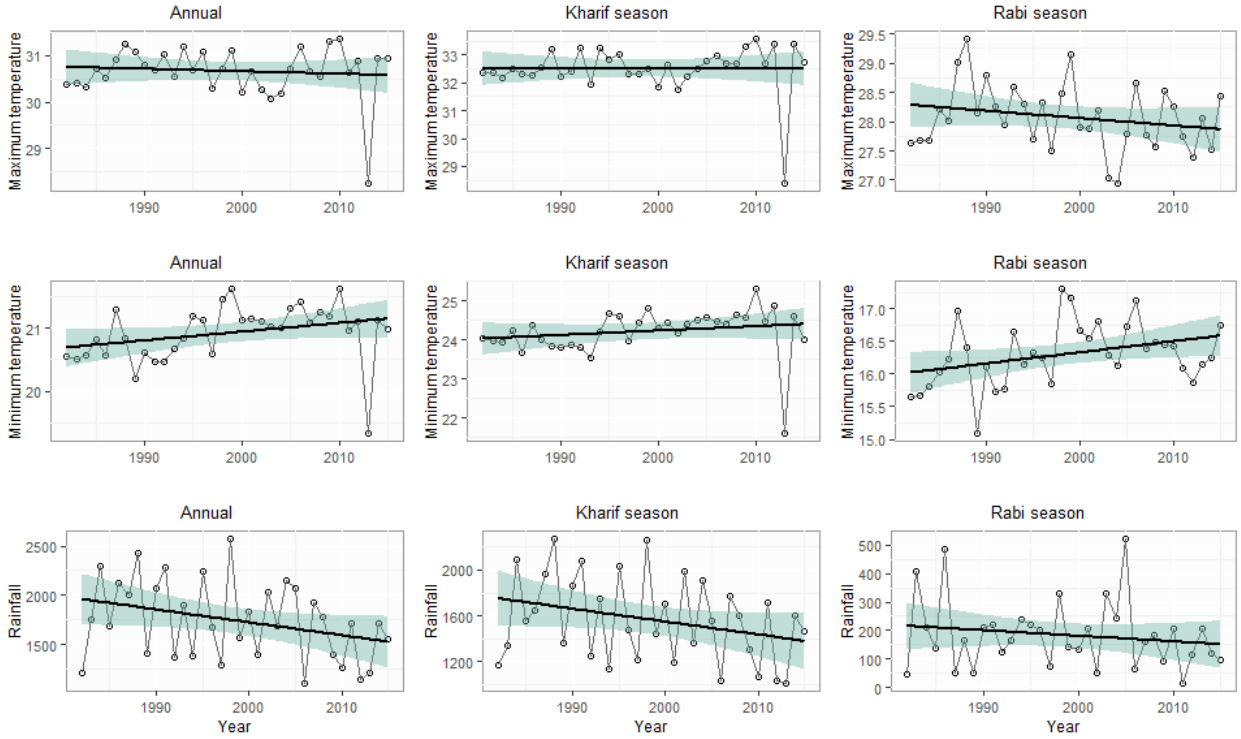
Figure 6. 1 Trend of annual rainfall across study district

Figure 6.2 shows the trends of annual and seasonal average maximum and minimum temperature, and rainfall in the high Barind Tract i.e. Chapai Nawabganj district. In that region, minimum temperature (mainly annual and *kharif* seasons) increased significantly. The annual average minimum temperature has increased by 0.02^0C (Figure 6.2). O the other hand, average trends of annual and seasonal temperature and rainfall of medium Barind tract (Bogura district) is shown in Figure 6.3. It can be seen that the minimum temperature of that region increased steadily in *Rabi* season as well as an annual and seasonal rainfall decreased over the period of time. It is also evident that of an additional year the annual average rainfall has decreased by 0.04 mm (Figure 6.3). It has been noticed that time has a larger impact on the higher to lower quantiles valued as 0.023 (50th) and 0.025 (75th) of annual average minimum temperature distributed significantly in Bogura district (Figure 6.3).



Source: Al-Amin et.al. 2020

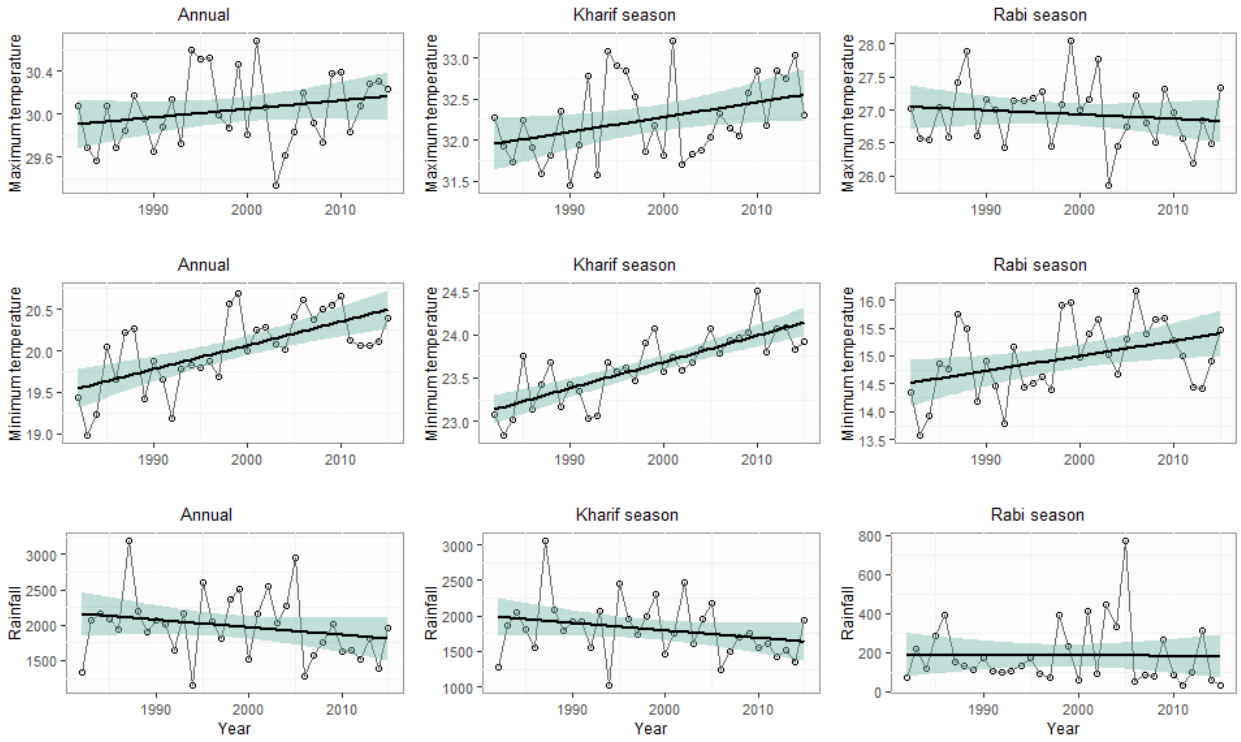
Figure 6. 2 Trends of annual and seasonal average maximum and minimum temperature, and rainfall in the High Barind Area (Chapai Nawabganj district).



Source: Al-Amin et.al. 2020

Figure 6. 3 Trends of annual and seasonal average maximum and minimum temperature, and rainfall in Bogura district

Figure 6.4 shows that the annual and seasonal minimum temperature of low barind tract reasons increased significantly. It is evident that of an additional year the annual average minimum temperature has increased by 0.03^0C and groundwater depth decreased by 0.06 m.



Source: Al-Amin et.al. 2020

Figure 6. 4 Trends of annual and seasonal average maximum and minimum temperature, and rainfall in low Barind areas (Dinajpur, Nilpahmari and Kurigam district)

7.3 Groundwater level in Northern Bangladesh

Changes rainfall and temperature have greater connection with groundwater level. In fact, the availability of irrigation has been the most significant contributor to being able to grow crops year round and increase crop productivity in the northern Bangladesh (Rahman and Parvin, 2009; Rahman et.al., 2020) where over 97% of the total area uses groundwater irrigation (Mojid et.al, 2019). Barind Multipurpose Development Authority has been operating 15,553 deep tube wells (DTWs) and 519 Low Lift Pumps (LLPs) in the northern Bangladesh (BMDA, 2019). Bangladesh Agriculture Development Corporation (BADC) and Rural Development Academy (RDA) have also installed a good number of DTWs. In addition, quite a large number of shallow tubewells (STWs) are being operated by individuals (Ahmed et.al. 2008; Uddin at.al. 2018) to assist in growing dry season crops. Hence, declining rainfall overtime and huge extraction of groundwater have contributed to decline the groundwater table. To see the picture of groundwater stress in the northern Bangladesh, monthly groundwater depletion level data from 1985-2016 was analyzed during water crisis period (October to March). A total of 132 active groundwater wells are considered for getting the actual picture of water level in the

specified water scarce areas among which 48 well was in high Barind areas (including Chapai Nawabganj district), 27 well from medium (including Bogrua district) and 57 well was from low barind (including Dinajpur, Nilphamari and Kurigram district) areas (Palash et.al., 2020).

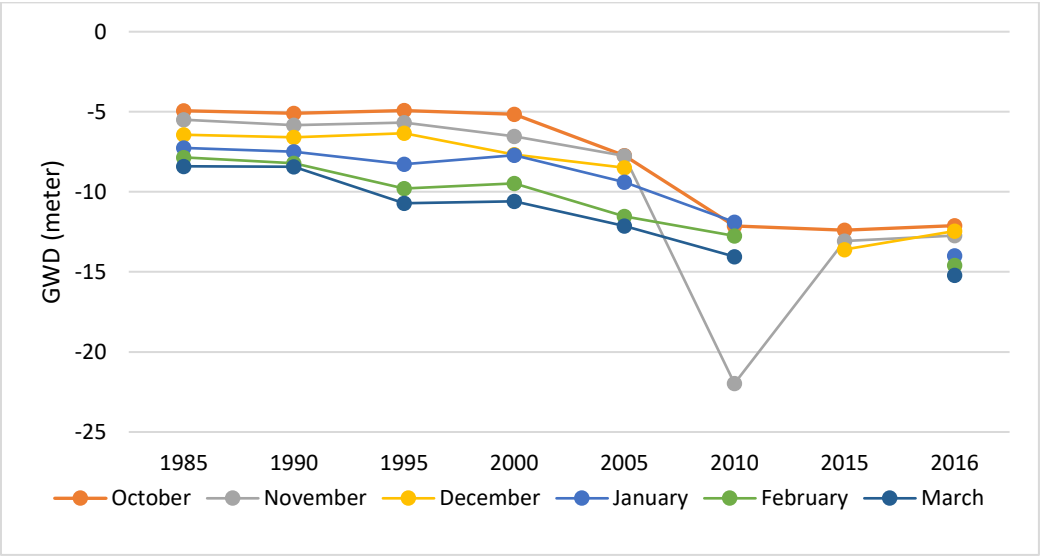


Figure 6. 5 Groundwater depth in the High Barind areas during water crisis months (Chapai Nawabganj)

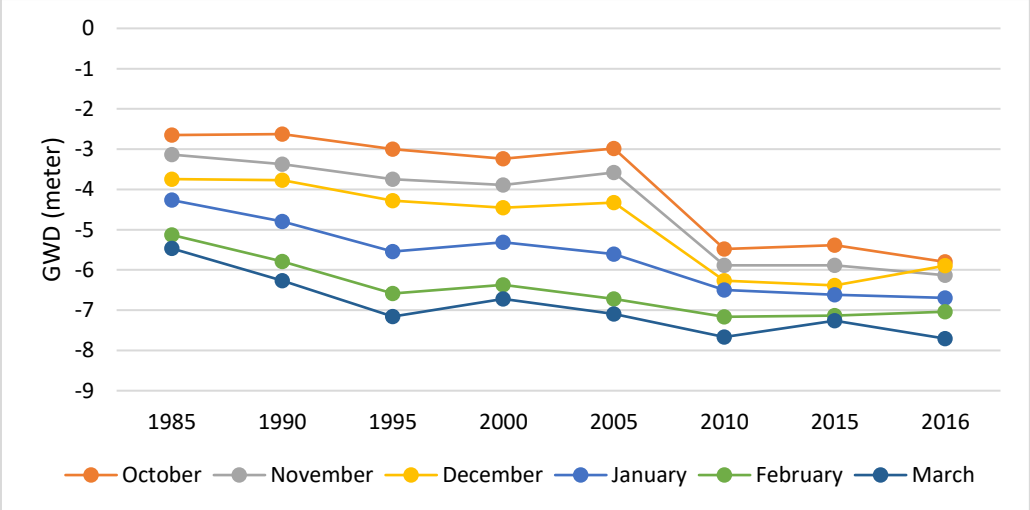


Figure 6. 6 Groundwater depth in the Medium High Barind areas during water crisis months (Bogura and Natore)

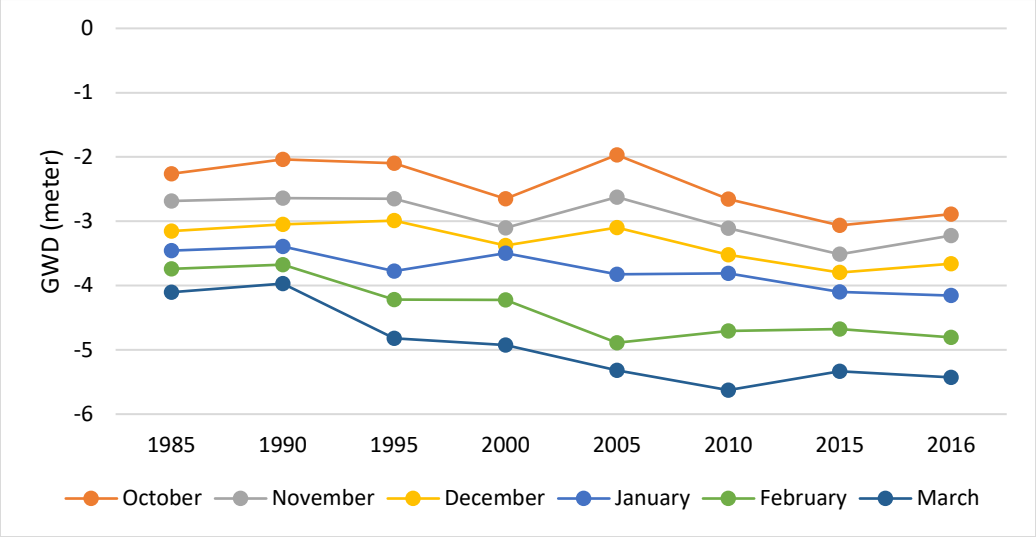


Figure 6. 7 Groundwater depth in the Low Barind areas during water crisis months (Dinajpur, Nilphamari and Kurigram)

Figure 6.5, 6.6 and 6.7 show the groundwater depletion rate in dry season of low, medium and high Barind regions from the year 1985 to 2016. Month-wise groundwater depletion rate is different for three regions, low scarcity regions suffered more in the month of March although all six months in the dry seasons groundwater table is decreasing over the year. Over the year, the groundwater table depletion rate is higher for medium water scarcity regions than that of low scarcity regions and the higher depletion was observed in the month of October and November. In case of high water scarcity areas, there was no groundwater depletion (from 1985 to 1990), but the situation had changed after 1995 where groundwater table started to go down in the month of January, February and March. The worst situation of water crisis had faced between the period of 2005 to 2015, afterward the water table became stable though it is below the suction limit of hand tube well during dry seasons.

6.4 Significant Climatic Events Particularly Drought

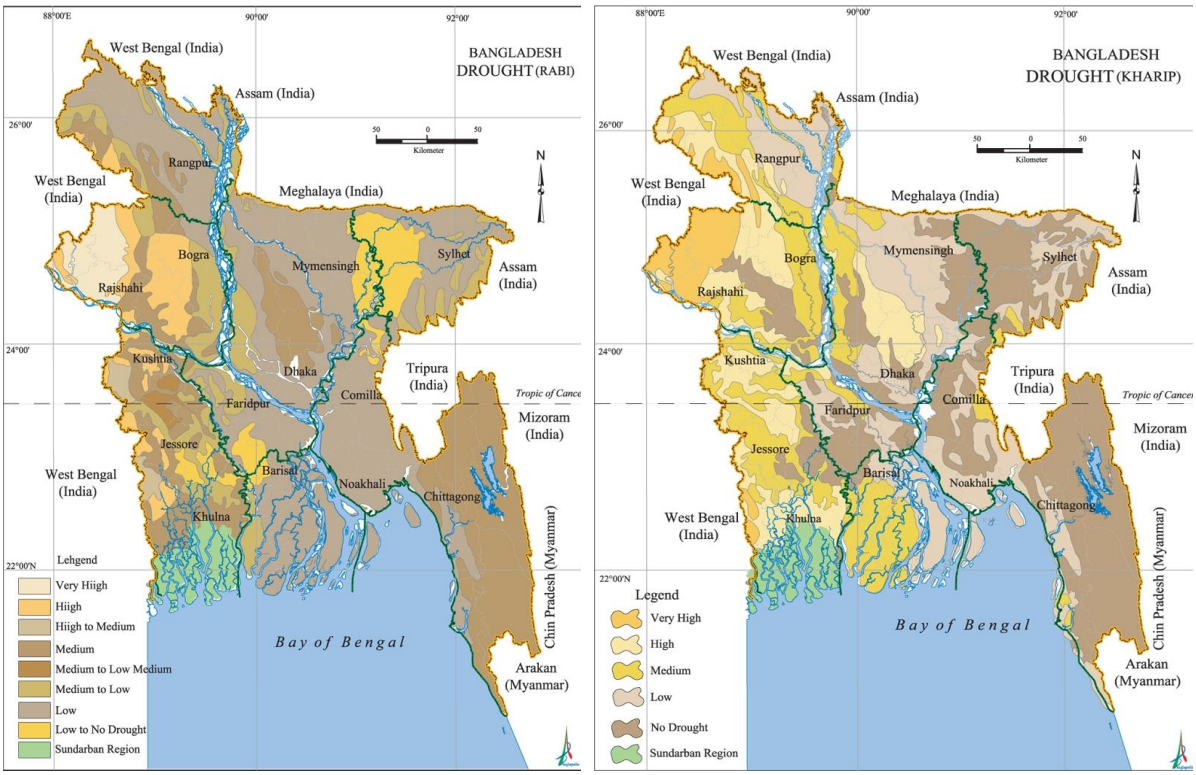
Table 6.1 summarizes the past significant climatic events particularly drought from secondary sources to have clear scenarios of the Northern Bangladesh. Bangladesh ranked sixth among the world's top 10 countries most affected by extreme weather events in the last 20 years, according to the global climate risk index by think-tank Germarwatch. Among various climatic events, Northern Bangladesh is mostly affected by drought. The study portrayed the climatic events since 1971 as due to the year of independence of the country. Table 6.1 shows the chronological history of climatic events particular droughts in Northern Bangladesh. The major historical drought events of Bangladesh were obtained from different sources and study reports. Most of the drought records were prepared based on the crop damage data due to extreme and severe drought events in different parts of the country. Post-independence, Bangladesh has experienced droughts in 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994 and

1995. However, the droughts of 1973, 1979 and 1994–1995 were the most severe in recent history, leading to a loss of 3.5 million tons of rice (in terms of agricultural production) in the northwestern region alone (Banglapedia, 2019). Moreover, during the 2006 drought in the north-western part of Bangladesh, the average crop production reduced by 25%–30% (Habiba et.al. 2013]. According to the Bangladesh Bureau of Statistics (BBS), between 2009 and 2014, natural disasters in the country accounted for damages (agricultural products and infrastructure) to the tune of 0.60 million USD; of these, 5.74% damage and casualties were attributed to droughts, which accounted for 126.33 million USD. In addition to crops, drought also affected orchards, forests, and the environment. Overall, 20 drought-years were recorded during the since independence of the country in 1971. Following Figure 6.8 presents the drought situation in Rabi and Kharif season in Bangladesh.

Table 6. 1 Chronological history of climatic events particular droughts in Northern Bangladesh

Year	Effects
1973	One of the severest in the present century and was responsible for the 1974 famine in northern Bangladesh.
1975	This drought affected 47% of the entire country and caused sufferings to about 53% of the total population.
1978-79	Severe drought causing widespread damage to crops. Reduced rice production by about 2 million tons and directly affected about 42% of the cultivated land and 44% of the population. It was one of the severest in recent times.
1981	Severe drought adversely affected crop production.
1982	Caused a total loss of rice production amounting to about 53,000 tons. In the same year flood damaged about 36,000 tons of rice.
1989	Most of the rivers in NW Bangladesh dried up and several districts, such as Naogaon, Nawabganj, Nilpahamari and Thakurgaon; dust syndrome occurred for a prolonged period due to drying up the topsoil.
1994-95	This drought was followed by that of 1995-96, caused immense damage to crops, especially in the case of rice and jute the main crops of NW Bangladesh. These are followed by bamboo-clumps, a major cash earning crop of many farmers in the region. In the recent times, this was most persistent drought in Bangladesh.
1999	Eastern regions
2003	Affected central area of Bangladesh
2004	Identified Southwestern regions
2006	Affected Northern Regions, the average crop production reduced by 25%–30%
2007	Affected Northern Regions
2009	Affected Northern Regions and whole county
2010	Affected Northern Regions and whole country
2011	Affected Northern Regions and whole country

2012	Affected Northern Regions and whole country
2013	Affected Northern Regions and whole country
2014	Whole country
2015	Affected south-western regions



Source: Banglapedia, 2019

Figure 6. 8 Map of drought in Rabi and Kharif season

6.5 Perception regarding temperature and rainfall

The enumerators asked farmers' perception about temperature and rainfall over the last 20 years and documented into the in the interview schedule. Figure 6.9 reveals that on average 88% sample respondent mentioned that over the last 20 years the temperature has increased, the response ranges from 88.4% to 92.3% across district. Relatively higher percentage of farmers in Chapai Nawabganj district reported that temperature has increased overtime. About 7% farmers across district reported that temperature remained same while a few percent of the farmers reported that temperature decreased overtime. This might happen as individual's perceived belief depends on his own understanding the climatic events.

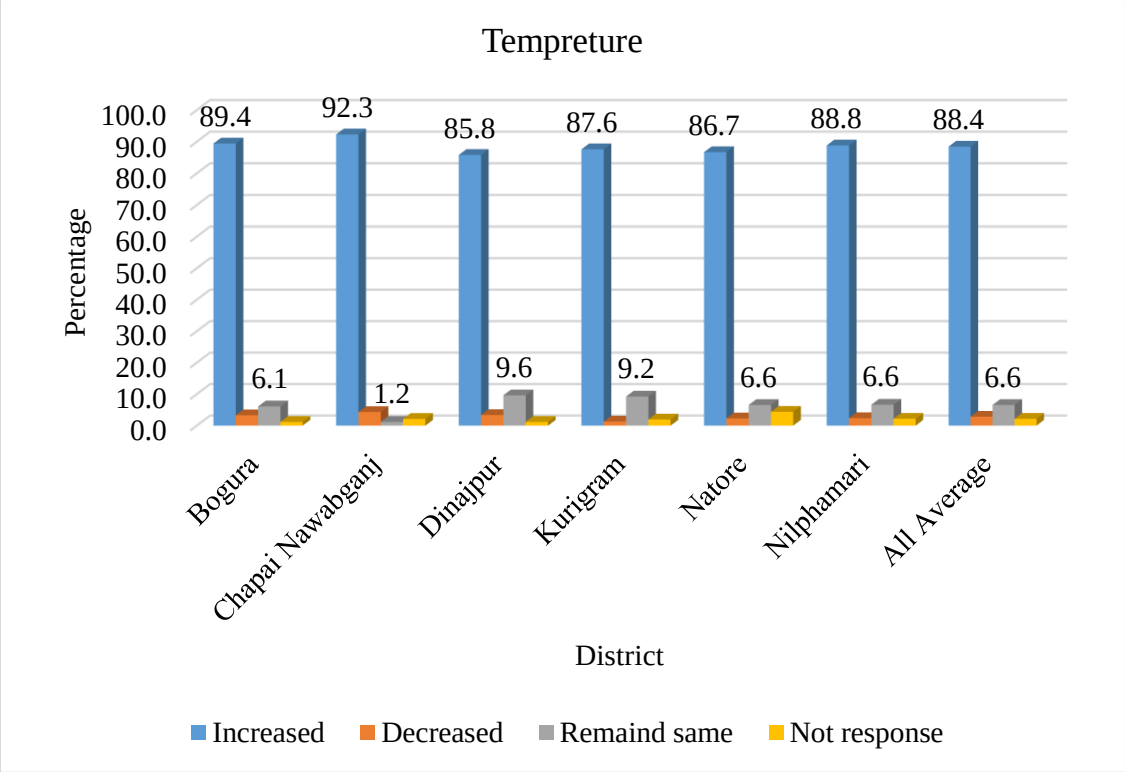


Figure 6. 9 Perception of temperature over the last 20 years

Following Table 6.2 shows the perception about rainfall in response to the question of changes of rainfall in the past 20 years. On average, only 2.6% mentioned that rainfall increased over the period which ranges from 1.4% to 4 % across district. On the other hand, about 36% famers reported that the rainfall pattern has changed followed by decreased rainfall (31%), sudden rainfall with thunderstorms (25.8%), and remained same (4.4%). Not significant variation was reported across districts. In fact, patterns of rainfall observed huge changes, incorporating changes in the timing of rains, sudden rainfall, rainfall with more thunderstorms as discussed by the farmers during interview.

Table 6. 2 Perception of rainfall over the last 20 years

Rainfall	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All Average
Increased	2.2	3.5	2.1	4.0	1.4	2.2	2.6
Decreased	24.1	35.3	31.6	14.1	38.8	42.2	31.0
Pattern change (time shift)	38.2	45.3	36.2	39.6	26.7	31.3	36.2
Sudden rainfall with thunderstorm	28.4	14.8	26.7	41.1	24.63	19.2	25.8
Remained same	7.1	1.1	3.4	1.2	8.4	5.2	4.4

6.6 Perception regarding drought experienced

Frequency of drought occurrence has close connection with groundwater availability for irrigation. Irrigation water unavailability acts as a bottleneck for agricultural productivity especially in this groundwater depleted areas. Sample farmers were asked to mention about their belief of drought occurrence over the period. About 3/4th of the farmers perceived that drought occurrence has increased over period of time. The response varies 68.6% to 79.6% across study district. On average, 17.5% farmers reported that drought occurrence remained same with greater variation across district.

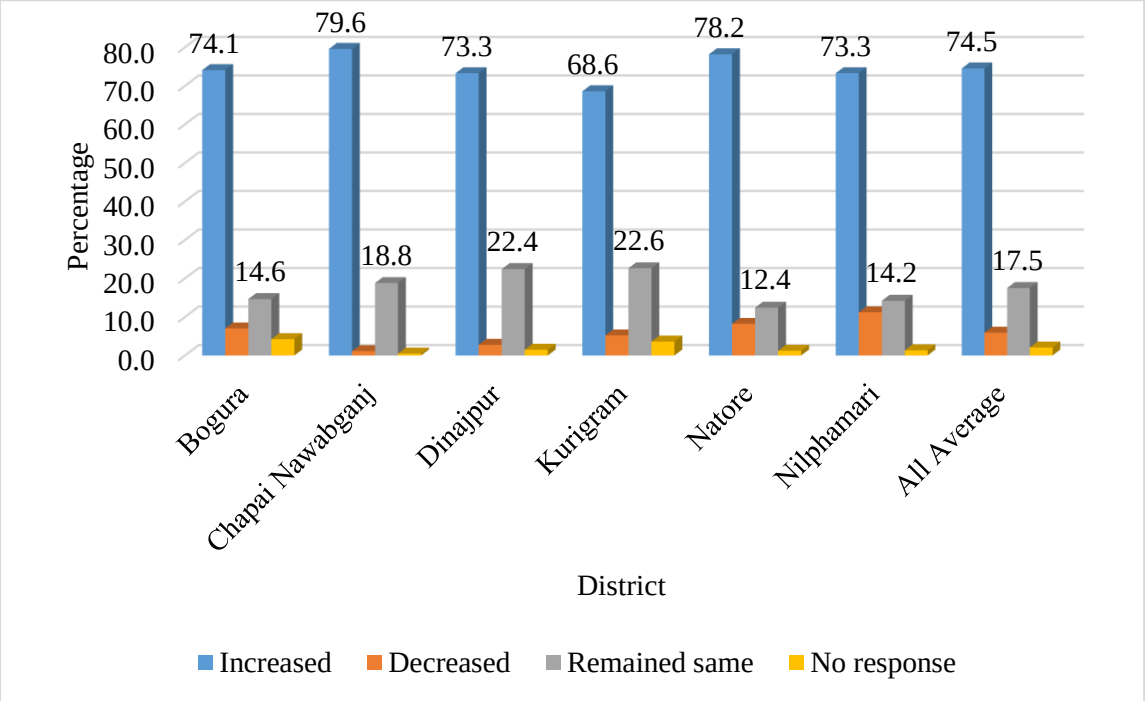


Figure 6. 10 Perception about drought experienced

6.7 Farmers Coping Strategy Under Adverse Climatic Effect

Farmers in the study areas have developed various survival mechanisms to cope with problems of climatic variability. The various mechanisms adopted by the farmers to cope with the effects of climatic event particularly drought these includes- crop rotation/diversification; follow conservation agriculture practice, grow high value crops, deploy more family labor and seasonal migration etc. Respondents who were exposed to drought risk used one or more strategies in different combinations to ensure their survival. Some of these strategies like selecting less water consuming varieties were incorporated into the nature of the farming system over a long period of time. Some others were employed only under certain risky situation that is just after the occurrence of drought.

6.7.1 Crop rotation and crop diversification

A crop rotation is the practice of growing a series of different types of crops in the same area over a sequence of seasons. Continuously growing the same crop will tend to exploit the same soil root zone which can lead to a decrease in available nutrients for plant growth and to a decrease in root development. This process helps to maintain soil nutrients, reduce soil erosion, prevents plant diseases and pests and maximize crop yield potential and profitability over time (Alam et al., 2019; Alam et al., 2016; Feizabady, 2013; Lauer, 2010).

Following Table 6.3 shows the crop rotation and crop diversification practiced by the farmers as a strategy to reduce the adverse effects of climatic events particularly drought or water shortage. On average about 37 % farmers reported that they did not follow crop rotation rather they followed the similar cropping pattern but large farmers mostly followed crop rotation (Table 6.3). Encouragingly, except marginal farmers, other farmers followed crop rotation at greater scale. On average, 10.5% farmers regularly practiced crop rotation in which large farmers dominating estimated at 35.7% followed by medium, small and marginal farmers. About 23% farmers sometimes practiced crop rotation irrespective farm category- again large farmer dominating. Lower percentage of marginal farmers followed crop, it might be reason that they have limited option to change the crops due to limited land- mostly grow staple food for survival. Details crop rotation practices across farm and district is shown in the *Appendix 6.1.*

Table 6. 3 Crop rotation practiced by different farm category due to adverse effect of climatic events

Crop rotation	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Never practice	70.4	42.2	20.5	-	36.9
Hardly	11.1	22.1	26.3	14.3	22.5
Sometimes	11.1	22.6	23.7	50.0	23.0
Often	3.7	5.8	11.5	-	7.1
Regular	3.7	7.3	17.9	35.7	10.5

6.7.2 Conservation agriculture practice

Conservation Agriculture (CA) is not an actual technology, rather it refers to a wide array of specific technologies that are based on applying one or more of the three main CA principles (IIRR and ACT, 2005). The CA principles are practicing suitable crop rotation, retention of crop residue on the field, and minimum tillage (Hobbs et al., 2008). Farmers in the study areas mostly practice one or two CA principles. Complete CA practice is very rare in the study areas. However, these practices vary by seasons and agro-ecological regions. Overall responses regarding CA practice under adverse climatic events is presented in Table 6.4 by farm category. Irrespective of farm category, 23.8% farmers never practice CA and remaining (76.2%) followed CA practice but the extent of practice various including hardly, sometimes, often and regular. Looking at different farm category, large farmer largely practiced CA technology (92.9%) followed by medium (84%), marginal (74.1%) and small (72.8%) farmers.

Table 6. 4 Crop rotation practiced by different farm category due to adverse effect of climatic events

CA practice	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Never practice	25.9	27.2	16.0	7.1	23.8
Hardly	40.7	24.8	24.4	7.1	25.0
Sometimes	14.8	31.8	32.1	64.3	31.9
Often	14.8	9.2	13.5	21.4	10.8
Regular	3.7	7.0	14.1		8.5

6.7.2 Grow high value crops and water saving crops

Following Table 6.5 presents the adaptation strategy in respect to adverse climatic events by cultivating high value and water savings crops. It is evident that about 57% large farmers sometimes grow high value crops while it was only about 11% practiced by small farmers. In contrast, relatively higher percentage of medium farmers (19.9%) regularly cultivate high value crops followed by small farmers (17.2%), marginal farmers (7.4%) and large farmers (7.1%). Unfortunately, about 48% of marginal famers never thought of growing high value crops as a consequences of climatic adverse effect while it was only 7% for large farm category.

Table 6. 5 Cultivate high value and water savings crops due to adverse effect of climatic events

High value and water saving crops	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Never	48.1	26.2	11.5	7.1	23.0
Hardly	11.1	22.3	27.6	7.1	22.8
Sometimes	14.8	23.3	23.7	21.4	23.0
Often	18.5	10.9	17.3	57.1	14.0
Regular	7.4	17.2	19.9	7.1	17.2
	100.0	100.0	100.0	100.0	100.0

6.7.2 Advanced sale of produces

Table 6.5 shows the status of advanced sale of produces due to adverse climatic events. Most of the farmers irrespective farm category reported that they did not sale produces in advanced to minimize the effects of climatic events. Actually, due to adverse climatic effect, farmers could harvest minimum yield which they don't like to sale considering their food security issue. However, a limited percent of the farmers reported that they sold their produces in advanced particularly the large who had no problems of food security. It is evident that only 11% of the marginal farmers sometime sold their produces in advanced (Table 6.6).

Table 6. 6 Advanced sale of the produces due to adverse climatic effects

Advanced sale produces	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Never	88.9	82.8	85.3	64.3	83.3
Hardly	-	5.1	5.1	7.1	4.9
Sometimes	11.1	10.0	9.0	14.3	9.9
Often	-	1.9	0.6	14.3	1.8
Regular	-	0.2	-	-	0.2

6.7.2 Deploy more family labor

As a coping mechanism/strategy farmers sometime deploy more family members to reduce the expenses of hire labor due to adverse climatic events. Results shows that on an average, 59% farmers deploy their additional family members as coping strategy. Relatively lower percent of marginal farmers deploy their additional family labor during adverse effects of climatic events. This might be reasons that they had less or no additional family members to be employed in the farm activities-in normal time/year most of their family members work in the field thus, they had limited additional member to be deployed in the farm. In contrast, large farmers usually depend on hire labor, in the crisis time (climatic events) they might have brought their family member to be worked in the farm thus, it shows relatively higher percent.

Table 6. 7 Deploy more family labor to mitigate adverse climatic events

Deploy more family labor	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Never	51.9	40.0	41.0	35.7	40.7
Hardly	7.4	8.7	10.3	14.3	9.2
Sometimes	14.8	25.5	25.6	21.4	25.0
Often	18.5	18.2	12.8	21.4	16.9
Regular	7.4	7.5	10.3	7.1	8.2

6.7.2 Seasonal migration

On average, 20% of the farmers seasonally migrated to recover their losses of adverse climatic events. It is evident from Table 6.8 that comparatively higher percent of marginal farmers said that they migrated seasonally to overcome the challenges that happened due to climatic events. However, the rate of regular and often migration found to be lower level and it was absent for larger farm category. Usually, large farmers did not require to migrate to support their family.

Table 6. 8 Seasonal migration happed due to adverse climatic effects

Seasonal migration	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Never	74.1	79.6	83.3	78.6	80.3
Hardly	7.4	4.6	3.2	14.3	4.6
Sometimes	11.1	8.7	4.5	7.1	7.7
Often	3.7	3.6	3.8	-	3.6
Regular	3.7	3.4	5.1	-	3.8

Chapter VII

LIVELIHOODS

7.1 Introduction

Livelihood consists of the capabilities, the assets (natural, physical, human, financial and social capital) and activities required for fulfilling the basic needs (Chambers and Conway, 1992). A livelihood is sustainable when it has the ability to cope with and recover from stresses and shocks for now and retains and enhances its capabilities and assets for the next generation in the short and long-run (Chambers and Conway, 1992). According to Ellis (1991), assets are things that a household has and that it uses to develop a strategy for making a living. Assets can be a stock of wealth in a household; the capital assets of the poor commonly identified as being financial, human, natural, physical, and social (Moser, 2006). Only capital assets itself cannot affirm the strategy of living; effective activities i.e. livelihood strategies and access to the capital assets restricts rural households to change their livelihood patterns. Farm households require land, farm equipment, livestock and other assets. This chapter deals with livelihood status of four different categories of farmers- i) marginal; ii) small, and iii) medium and iv) large farm holdings. In addition, it also tries to incorporate spatial differences across study districts. Livelihood status has measured based on human, physical, social, and financial assets/status of the respondents.

7.2 Human Capital

Human capital includes skills, knowledge, ability to labor and good health. Chapter 4 clearly describes the strength of human capital in respect to education, training, and occupation of the respondents. Hence, key features of human capital are highlighted in this section. Following Figure 7.1 and 7.2 show the economically active members in the household. On average, about 61% of the members are economically active irrespective of district and farm category. Among six study districts, relatively higher percent for family members reported as economically active followed by Natore (63.1%), Bogura (61.7%), Dinajpur (61.5%), Kurigrama nd Nilphamari are the same percent (55.7%). Looking at farm category, large farm household reported comparatively higher rate (70%) of economically active members while it was lower for marginal (58.2%) family. It creates dual challenges for marginal farm households- lower amount of landholding as well as minimum number of economically active members put challenges for sustainable livelihoods.

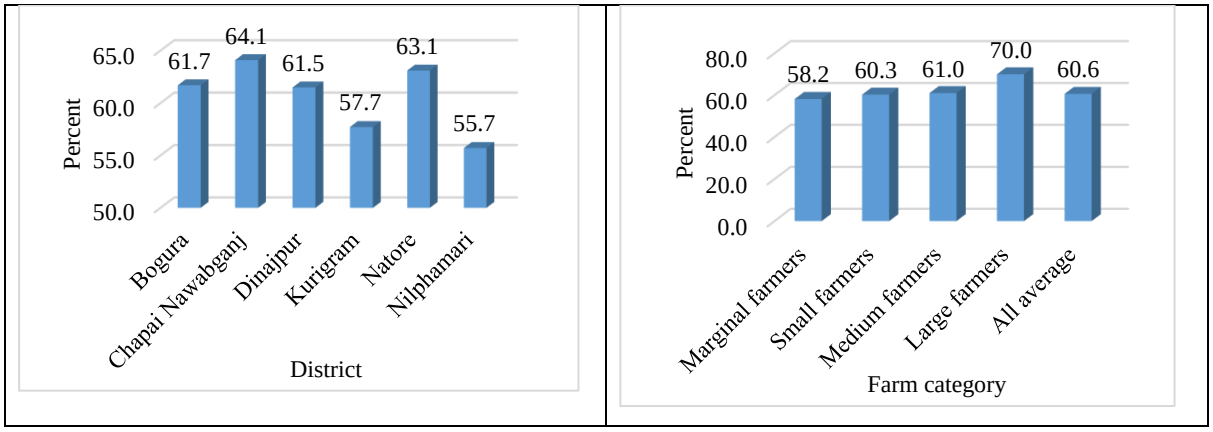


Figure 7. 1 Economically active member in the family across district and farm category

Following Figure 7.3 presents the access to training by the sample farmers across farm category. No doubt training enhances the capacity of human beings. It is evident from the Figure 7.3 only limited percent of the sample farmers had received training related to farming which estimated at about 9% for all farm category. Surprisingly, the marginal farmers (1.2%) got limited access to training than that of other farm category. This results re-confirms that existing extension advisory and training facilities somehow failed to reach the marginal and landless farmers.

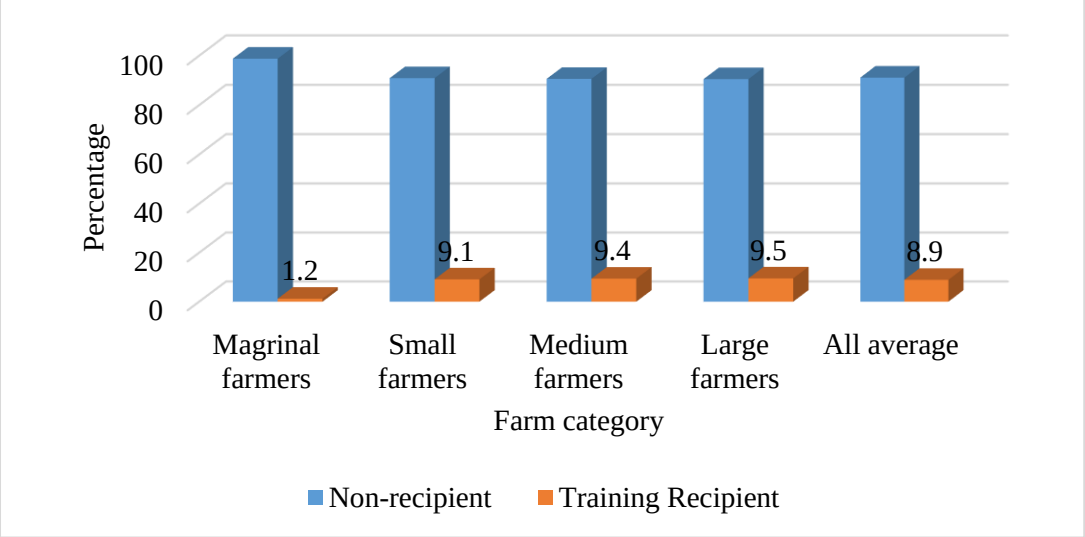


Figure 7. 2 Training status of the sample respondents

7.2.2 Access to medical and health facilities

Good heath is a blessing for better livelihood option. An active and health person can contribute largely towards sustainable livelihood. It is natural phenomena that people got sick and require treatment. Hence, access to health and medical facilities across farm category is presented in Figure 7.4 to see their present status. Rural people usually visit government hospital to have their medical facilities-it is cheap and affordable for the farming community. However, some of them could afford to visit private clinic which is a bit expensive. Figure 7.4 shows the status of medical treatment last 12 months of different category of households. It is apparent from the figure that relatively higher portion (37%) of marginal farmers visit to government hospital at the time of their sickness than that of other category of households. A greater percentage (57.1%) of large farm household visited both government and private

hospital to have their treatment which was 26.6% for medium farm, 21.8% for small farm and 11.1% for marginal farm category respectively. A good percentage of marginal household got treatment from medicine shop (18.5%) then other category of households.

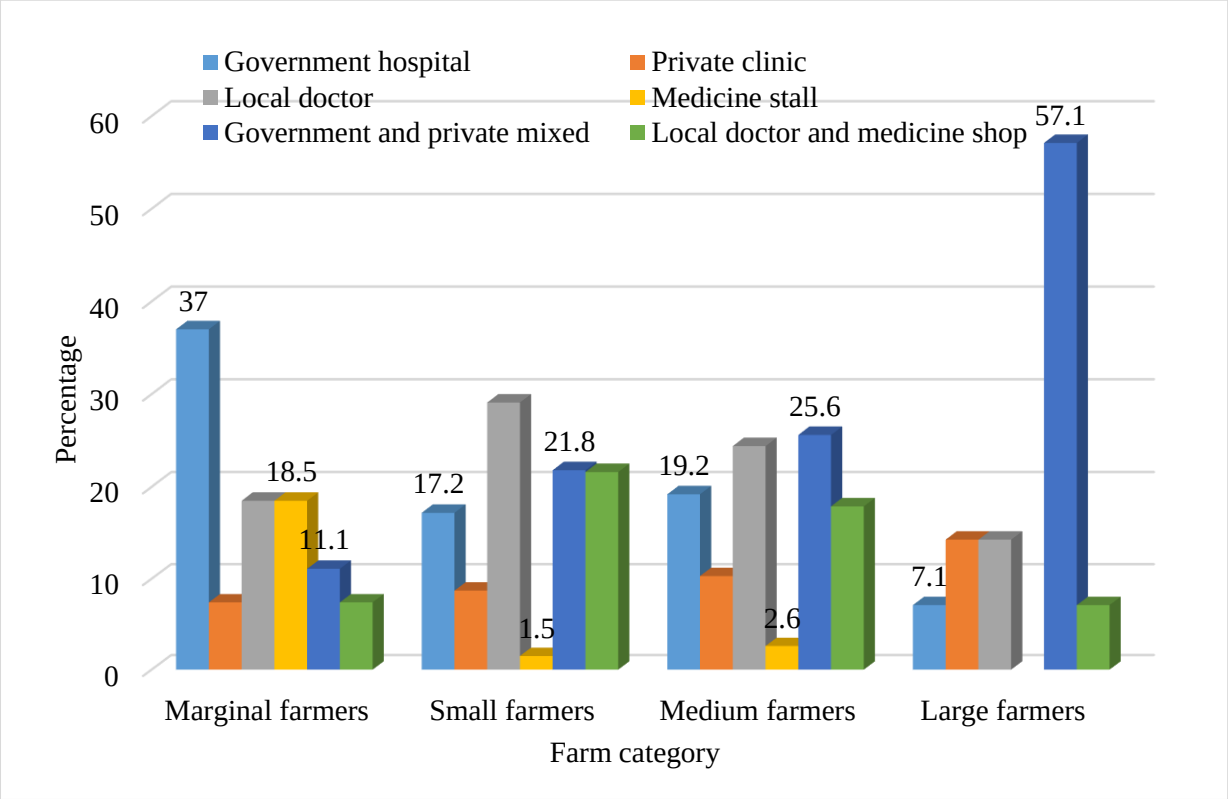


Figure 7. 3 Access to medical facilities across farm households

7.3 Physical Capital

This study considers physical capital that households have possession or control over resources rather than broader physical capital such as road, highways, school, college, bank etc.

7.3.1 Possession of livestock and poultry by the households

Generally, in the rural areas of Bangladesh, every farm family has more or less livestock/poultry as an emergency asset. Table 7.1 and 7.2 presents the percentage of the household possesses livestock and poultry, average number of livestock and asset value by farm category and across district respectively. It is apparent that large farm category had the higher percentage (85.7%) of cattle possession than follow by small (78.4%), medium and marginal farm (51.9%), respectively. Almost similar pattern was found in case of goat possession except small and medium farm households in which medium farmers stood second highest position. Encouragingly, cent percent household had the possession of poultry bird in all category of farm households. Average number of livestock and poultry birds were reported higher for large farm then followed by medium, small and marginal farmers in all three types of livestock and poultry birds.

Table 7. 1 Percentage of household possess livestock and poultry bird, average number and the value of assets in the sample households

	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Cattle					
With having cattle HHs (%)	51.9	78.4	76.3	85.7	76.8
Average number (No.)	2.5	2.7	3.5	6.7	3.0
Average asset value (Tk.)	100500	103122	132908	219167	113593
Goat					
With having goat HHs (%)	40.7	50.7	60.9	71.4	53.4
Average number (No.)	2.5	2.6	3.3	5.2	2.9
Average asset value (Tk.)	9000	10638	15679	26400	12541
Chicken					
With having chicken HHs (%)	100	100	100	100	100
Average number (No.)	8.7	9.1	11.6	9.9	9.7
Average asset value (Tk.)	1900	1983	2576	2340	2136

Likewise farm category, following Table 7.2 present the livestock and poultry status across study sites. It is depicted that Bogura district had higher percentage (87.0%) of cattle households while Chapain Nawabganj had the greater average cattle number (3.7), accordingly the district had higher amount of cattle assets. However, Dinajpur and Chapai Nawabganj districts had the similar percentage of household possessed goat but average number of goats found to higher for Kurigrm district. Each and every household had the possession of poultry birds in all study districts although the average number ranges from 6 to 12. This results reconfirm that the livestock and poultry birds are the important component for rural livelihoods. Most of the household rear livestock and poultry to meet their emergency family and farm requirement.

Table 7. 2 Percentage of household possess livestock and poultry bird, average number and the value of assets in the sample households

	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Cattle							
With having cattle HHs (%)	87.9	71.6	87.3	77.5	55.9	81.4	76.8
Average number (No.)	2.6	3.7	3.4	3.3	1.9	2.8	3.0
Average asset value (Tk.)	115816	142191	116865	113588	108052	86409	113592
Goat							
With having goat HHs (%)	41.4	63.7	63.7	38.2	59.8	52.9	53.4
Average number (No.)	2.5	3.3	2.8	3.9	2.7	2.3	2.9
Average asset value (Tk.)	5171	10068	6053	5362	8598	4855	6692

Chicken							
With having chicken HHs (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Average number (No.)	12.2	9.6	10.5	10.8	10.0	6.7	9.9
Average asset value (Tk.)	2433	1970	2389	2201	2276	1596	2136

7.3.2 Possession of farm equipment

The study investigated households' possession of agricultural equipment, power tiller, reaper, thresher, and Shallow Tube well. It is evident from the Table 7.3 that about 69% of large farm category households had possession of power tiller while it was only about 4% for marginal and small farm category of HHs. Average assets value also found to be higher for large category of household, it might be reason that some of them had tractor which is expensive.

Similarly, it was observed from the study that higher percentage of large farmers had the possession of all farm equipment (reaper and thresher) compared to other category of farmers (Table 7.3). However, in case of STW medium farm (49.7%) category got the higher percentage of ownership of STW then followed by small (44.9%), large (42.9%) and marginal farm category (40.7%), respectively. In fact, among different farm equipment, small and marginal farmers had the greater ownership of STWs then that of other farm equipment.

Table 7. 3 Percentage of household possess agricultural equipment, average number and value of the assets in the sample households

Agricultural equipment	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Tractor and power tiller					
With having goat HHs (%)	3.7	4.4	25.6	78.6	11.5
Average number (No.)	1.0	1.0	1.1	1.0	1.0
Average asset value (Tk.)	15000	64777	74325	119545	80057
Reaper					
With having reaper HHs (%)	11.1	18.9	51.9	78.6	28.4
Average number (No.)	1.0	1.0	1.1	1.1	1.0
Average asset value (Tk.)	1850	2291	2528	2671	2420
Thresher					
With having thresher HHs (%)	7.4	6.3	17.9	57.1	10.5
Average number (No.)	1.0	1.0	1.0	1.0	1.0
Average asset value (Tk.)	14500	11358	15661	17875	14372
Shallow Tube well					
With having STW HHs (%)	40.7	44.9	49.7	42.9	45.9
Average number (No.)	1.0	1.1	1.3	1.2	1.2
Average asset value (Tk.)	8545	12899	15773	16167	13599

7.3.3 Possession of other equipment

It appears from the Figure 7.4 that among different category of household's large farm category possesses higher number and amount of household amenities including value of mobile phone, furniture and other assets. Encouraging almost all household had mobile phone even more than one phone per household. However, the value of mobile phone varies across farm category-value was estimated higher for large (Tk. 10,657) category then followed by medium (Tk.9,789), small (Tk.6,125) and marginal (Tk.4,996) households. Similar trend also reported for furniture and other asset value, respectively.

Table 7. 4 Other assets possession among different category of households

Other household asset	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Average mobile at HHs	1.6	1.9	2.5	2.3	2.1
Value of mobile assets (Tk.)	4996	6125	9789	10657	7123
Furniture value (Tk.)	53229.6	67518.2	90342.9	122857.1	74003.6
Other assets value	13218.5	10060.0	21853.2	57142.9	14303.3

7.3.4 Possession of life sustaining assets

Availability of electricity in farmer's home is an important indicator to evaluate socioeconomic condition of the farmer. Irrespective of categories about 78-82% of selected farm households used to use electricity for their different activities (Table 7.5). Table 7.5 shows three different life sustaining assets that helps to improve the life and livelihoods of farming households. It is evident that all household of the large farm category had access to electricity, safe drinking water and sanitary latrine. Around 90% household of other three category of households had access to electricity and almost cent percent household had access to safe drinking water. In contrast, access to sanitary latrine was reported lower level for marginal household (44.4%) then small (61.4%) and medium (78.8%) farm household, respectively. Among different life sustaining asset, access to sanitary latrine found to be relatively lower status then that of other assets.

Table 7. 5 Availability of life sustaining facilities of sample households

Life sustaining facilities	Marginal farmers	Small farmers	Medium farmers	Large farmers	All Average
Access to electricity	92.6	89.6	93.6	100.0	91.0
Access to safe drinking water	96.3	98.5	99.4	100.0	98.7
Access to sanitary latrine	44.4	61.4	78.8	100.0	66.0

7.4 Financial Capital

Annual earning and expenses are presented in chapter 4 hence this section only presents the balance of farm and household income by farm category. It also presents the access to finance from different financial institutions. Following Figure 7.5 shows the balance of income and expenditure. The marginal farmer could save some money (Tk. 8,500/household) after bearing

the farm expenses but they were in deficit condition after meeting the household requirement. On the other hand, other three category of household could save some money from the farm income even after bearing the household expenses. The gross estimation shows that on an average large farmers could save relatively higher amount of money estimated at Tk 104.6 thousand and followed by medium farmers (Tk. 54.1 thousand), small farmers (39.5 thousand) in the last year of field survey i.e. in the year of 2019-2020.

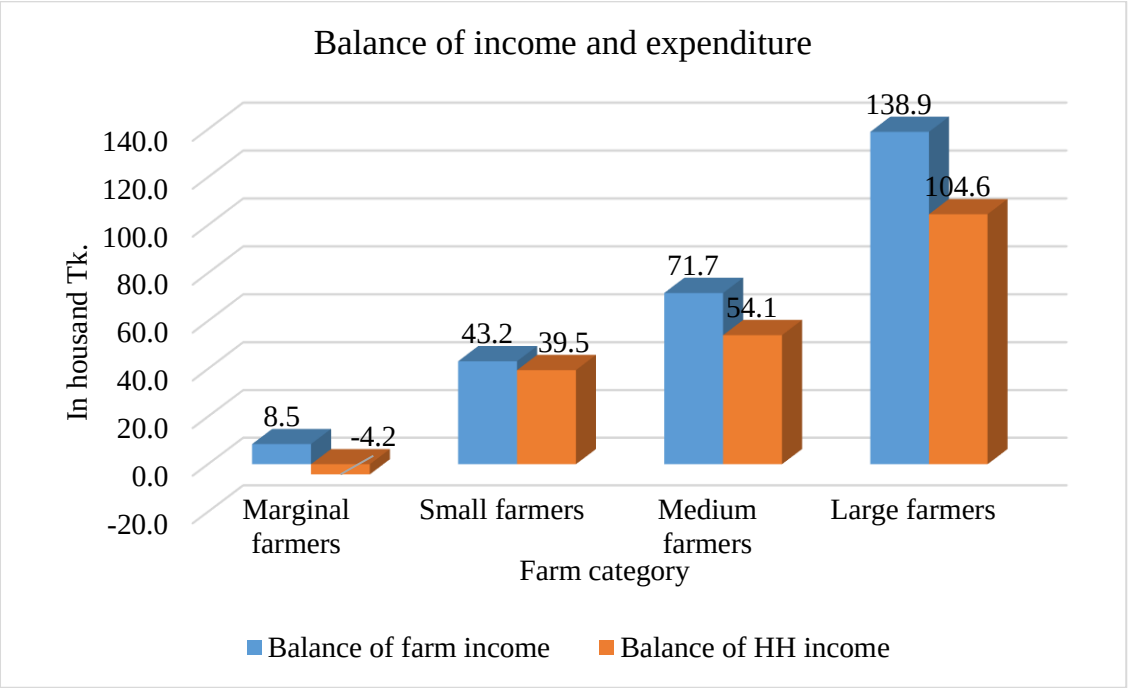


Figure 7. 4 Average balance of income and expenditure across farm category

7.4.1 Borrowing status of the households

Following Table 7.6 shows the percentage of farmers borrow money, average borrowing amount and the sources. About 25% households had borrowing experience in the last 12 months of the survey time that varies from 24 to 43 percent. The average borrowing amount also ranges from 50 thousand to 98 thousand Tk. The large farmer borrowed (Tk. 98,611) relatively higher amount of money than the other category of households. However, the marginal farmers also borrow larger amount on money than small and medium category of households (Table 7.5).

Regarding borrowing sources, relatively greater portion of the household across category borrow money from national NGOs that estimated 55% for all average and ranges from 39 to 55 percent. The marginal farmers were mostly dependent on national NGOs and agriculture and commercial bank, they had limited access or preference to local NGO and friends and relatives. In fact, none of them borrow money from money lender in the last 12 months of this investigation. Similarly, large farmer did not borrow from money lender but a good portion of them borrowed from local NGOs, agriculture and commercial banks and friends and relatives.

Table 7. 6 Percentage of farmers borrow money, the amount and sources of borrowing money by farm category

Financial access	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Percentage of farmers borrow money	24.7	24.1	25.6	42.9	25.0
Average borrowing Amount (Tk.)	65300	50034	64938	98611	56543
Borrowing sources					
Agriculture and commercial Bank	35.0	18.5	21.7	22.2	20.2
Friends and Relatives	5.0	15.1	12.5	11.1	13.8
Local NGO	5.0	7.7	10.8	27.8	9.2
Money Lender	-	2.0	1.7	-	1.8
National NGO	55.0	56.7	53.3	38.9	55.0

Following Table 7.7 presents the similar aspects across district. Among five study district, comparatively higher percentage (32.7%) of farmers in Dinajpur district borrow money in the last 12 months, followed by Chapi Nawabganj (30.4%), Kurigram (26.8%), Natore (22.5%), Bogura (21.2%) and Nilphamari (16%), respectively. In Nilphamari only 16% of the farmers borrow money and the average borrowing amount also lower compared to other regions. It is apparent that majority of the farmers (ranges from 49 to 67%) borrow from national NGOs than that of other sources of borrowing. It is encouraging to mention that few farmers borrow from money lender in all regions which is expensive than other sources of credit. Although national NGO charges more interest than the agriculture and commercial banks but farmers prefer to borrow from NGO due to less complexity and the services are extended to the door steps.

Table 7. 7 Percentage of farmers borrow money, the amount and sources of borrowing money by district

Financial access	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari
Percentage of farmers borrow money	21.2	30.4	32.7	26.8	22.5	16.0
Average borrowing Amount (Tk.)	59286	77097	42085	43110	74916	40122
Sources of borrowing						
Agriculture and commercial Bank	31.7	20.4	14.0	17.1	26.1	14.3
Friends and Relatives	7.9	8.6	20.0	17.1	11.6	16.3
Local NGO	7.9	16.1	10.0	4.9	11.6	-
Money Lender	3.2	1.1	-	3.7	1.4	2.0
National NGO	49.2	53.8	56.0	57.3	49.3	67.3

7.4.2 Purpose of borrowing money

This study unfolds the reasons of borrowing credit by farm category and across districts. Table 7.8 and 7.9 presents the purpose of borrowing money across farm category and district respectively. It is obvious that majority of the survey household borrow money for crop production that ranges from 44 to 61 percent. There is a greater variation among purposes of borrowing, for example marginal farmers reported second highest reason of borrowing was family/household expenses while small and medium farm category reported business were their second highest purpose of borrowing money.

Table 7. 8 Percent of sample farmers borrow money for various reasons across farm category

Purpose of borrowing	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Business	5.0	14.1	15.0	11.1	13.8
Purchase farm equipment	10.0	8.7	3.3	5.6	7.2
Child education and marriage	-	4.0	5.8	-	4.2
Farming	55.0	44.3	54.2	61.1	48.0
Family expenses	25.0	12.1	9.2	11.1	11.8
Leased in or purchase land	5.0	9.1	0.8	5.6	6.6
Purchasing means of transport	-	2.3	1.7	-	2.0
Treatment	-	5.4	10.0	5.6	6.4

Likewise farm category, the similar trend also observed in case of regional preference- farmers of Bogura district reported relatively lower percentage (31.7%) of borrowing money for crop production while it was higher level Chapai Nawabganj district (69.9%). It is observed that about 18% of the farmers in Nilphamari district borrow money for family expenses while it was only 3.2% for Chapai Nawabganj district. It is also observed that a certain portion of the farmers across district borrow money for farm equipment (ranges 2 to 10 %) which can be considered as steps forward towards farm mechanization.

Table 7. 9 Percent of sample farmers borrow money for various reasons across district

Purpose of borrowing	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari
Business	17.5	10.8	8.0	24.4	13.0	10.2
Purchase farm equipment	9.5	4.3	14.0	2.4	4.3	8.2
Child education and marriage	7.9	1.1	5.0	3.7	4.3	4.1
Farming	31.7	69.9	54.0	39.0	42.0	38.8
Family expenses	17.5	4.3	7.0	14.6	15.9	18.4
Leased in or purchase land	12.7	3.2	6.0	6.1	7.2	6.1
Purchasing means of transport	1.6	1.1	1.0	1.2	4.3	4.1
Treatment	1.6	5.4	5.0	8.5	8.7	10.2

7.4.3 Borrowing by gender

Following Figure 7.6 and 7.7 present the percentage distribution of male and female contribution in borrowing money from different sources by farm category and district, respectively. Although male dominate in borrowing money ranges from 45 to 68% but it various across farm category. For example, about 55% of female under marginal farm category of household borrowed while it was 30% in case of medium farm households. Similarly, male dominated in borrowing money across district with variation from 57 to 71 %. The highest male domination was observed in Natore district (71%) but it was lowest in Dinajpur district (57%). About 41% of the female found to be engaged in borrowing money from different sources as reported in Dinajpur district. In fact, in Bangladesh female has greater access to borrow credit from NGOs than that of male members. In contrast, male got more preference to borrow from agriculture and commercial banks as it requires collateral.

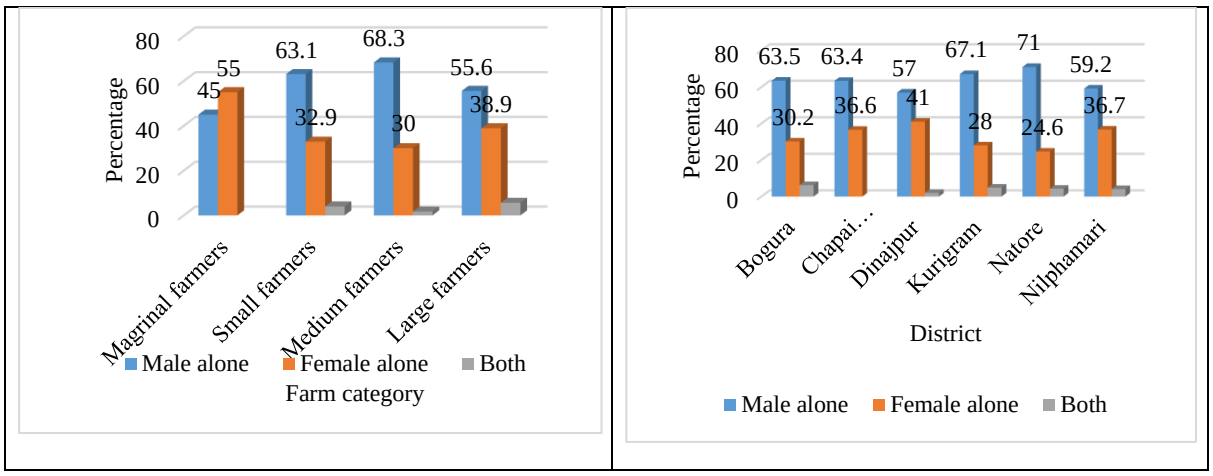


Figure 7. 5 Borrowing access by gender and farm category and by district

7.5 Social Capital

Social capital incorporates the formal organizations, the more informal network or connections, and the reciprocal and exchange relationships in which people engage. Hence, following table presents the engagement with social institutions by the sample households across farm category and district. Table 7.10 and 7.11 show the extent of participation in social organization and the types of organizations by farm category and district. It is observed that large farm category (50%) had the membership with social institution then followed by medium (30.8%), small (27.1%) and marginal farm (22.2%) category, respectively. The medium farm households were involved in all types of social organizations but domination over NGO membership. In fact, involvement in NGO as group member is common in rural Bangladesh which estimated at 38 to 72 % across farm category. Relatively marginal farmers were more involved in NGO membership than that of other categories. However, none of the marginal farmers got access to DAE and project membership which is really concern for reaching the bottom of the farming community.

Table 7. 10 Extent of participation in social organization and the types of organizations by farm category

Extent of participation	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Percentage of farmers engaged in social institutions	22.2	27.1	30.8	50.0	28.4
Type of organization					
Bazar committee	-	0.9	1.4	-	1.0
DAE and Project committee	-	6.0	2.8	4.8	4.8
Education institution	5.6	6.0	6.3	9.5	6.2
Local farmers club	5.6	9.6	4.2	4.8	7.7
Local government	0.0	0.3	1.4	4.8	0.8
NGO	72.2	57.3	50.7	38.1	55.2
Political committee	11.1	2.1	2.1	0.0	2.3
Religious institution	5.6	17.9	31.3	38.1	22.0

Similar to farm category, majority of the farmers had membership with NGOs across regions that ranges from 35 to 69%. Farmers of Dinajpur district had the higher level of engagement (68.5%) with NGOs while it was only 34.5% in Bogura district. The second highest engagement were reported for religious institutions which ranges from 14 to 33% percent. Farmers of Bogura district reported their engagement with all sort of social organizations but other districts had no involvement in 1-3 social organizations as reported in Table 7.9.

Table 7. 11 Extent of participation in social organization and the types of organizations by district

Extent of participation	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari
Percentage of farmers engaged in social institutions						
Type of organization						
Bazar committee	1.2	-	-	-	4.7	-
DAE and Project committee	13.1	2.0	3.3	4.0	2.3	5.3
Education institution	8.3	3.0	8.7	8.0	3.5	5.3
Local farmers club	10.7	7.1	4.3	9.0	7.0	8.8
Local government	1.2	1.0	-	1.0	1.2	-
NGO	34.5	60.6	68.5	58.0	45.3	64.9
Political committee	1.2	-	-	7.0	3.5	1.8
Religious institution	29.8	26.3	15.2	13.0	32.6	14.0

Following Figure 7.8 and 7.9 portray membership with social institutions by gender and farm category and by district. Surprisingly, female had higher access to social institutions for marginal farm category household as because of their extensive participation in NGO programs. However, in all other category, the male members had greater level of participation in social organizations. Male had relatively greater access to social organizations across district with variation from 45 to 79 %. The highest male domination was observed in Bogura district

(78.9%) but it was lowest in Dinajpur district (44.6%). About 53% of the female found to be engaged social organizations in Dinajpur district.

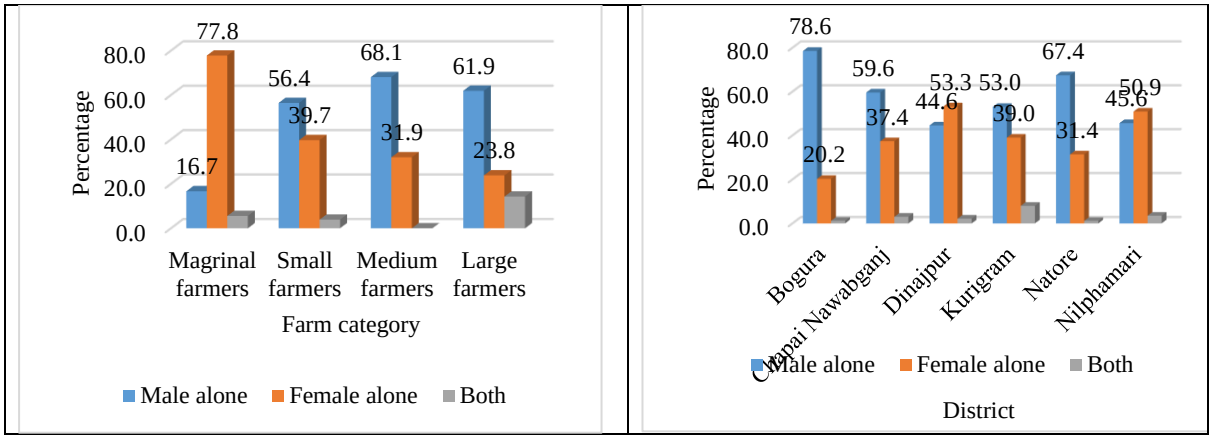


Figure 7. 6 Membership with social institution by gender and farm category and by district

Chapter VIII

BASELINE HIGHLIGHTS AND CONCLUSION

8.1 Highlights of Baseline Findings

The objective of the baseline survey it to document the existing farm practices along-with soil health management across farm category and study districts. Survey methods was adopted to gather required information from sample respondents and analyzed them based on settled objectives. Significant findings of the baseline study are presented below:

1. *Most of the sample farmers are young and economically active. By profession they are farmers and also involved in other income generating activities as supplementation of household income. Average farm size of all respondent farmers was 0.89 ha (219.2 decimal). Estimation shows the* ***positive balance of household income across farm category****-obviously large farm earned relatively higher amount then that of other farmers. Farming sources largely contributes to the annual income estimated 48%. Among various expenditure items, about 62% of money spent for household activities (food consumption reported 40%) and remaining (38%) spent as farm expenses.*
2. *Study has* ***identified a total of 103 cropping patterns*** *of which Boro-Fallow-T.Aman is the most dominant pattern Farmers of Natore district have followed more diversified cropping pattern while Chapai Nawabganj district observed lower level of crop diversification. On the other hand, small farm category reported highest 96 patterns followed by small farm (71), marginal (18) and large farm (15).*
3. *Only 9% of the farmers had received training related to crop production and* ***6% farmers had received nutrient management related training****, and only 8.4% sample farmers tested soil. DAE is the most important sources for training, input supports, provide soil testing facilities. The marginal farmers had limited access to this supports and trainings.*
4. *A good number of farmers able to* ***identify plant nutrient deficiency by observing the leaf color, plant growth and soil quality*** *etc. Fertilize application decision depends on several factors including types of crop grown in the field, quality of soil, availability of manure, land topography etc. A good percentage of sample farmers had experience of not working fertilizer as desired. In case of shortage of money, most of the farmers* borrow money or buy fertilizer on credit from fertilizer dealers.
5. *Farmers are familiar with the adverse climatic events, their perception about increasing temperature, decreasing rainfall and declining groundwater table and drought occurrence well matched with secondary data. Accordingly,* ***farmers have adopted various coping strategies*** *including crop rotation/diversification, follow conservation agriculture practice, grow high value crops, advance sale of produces, deploy more family labor and seasonal migration etc.*
6. *Findings reveal that sample farmers have* ***comparatively better livelihood assets*** *with variation across farm category. B*esides land ownership a good percentage of sample farmers had livestock and poultry birds, farm equipment, life sustaining amenities.

They also have some amount of yearly savings. *With variation across farm category,* ***both male and female has access to the membership of various*** **social organizations** but domination over NGO membership.

8.2 Research Recommendation

It is recommended that I summary, project support could be channeled into five areas: awareness creation, technology development, strengthening extension services, assurance of input quality and supply, and financial support. Some specific suggestions are-

- Considering limited access to training and knowledge on soil health management, project might think of providing extensive training as well as distribution of leaflet regarding importance of soil health for better yield;
- Demonstration of balance fertilizer application at farmers' field and observing field day could motivate farmers towards largely adoption;
- Although farmers are following crop diversification at different levels but they should be given well advanced information about adverse climatic events and market price so that they can motivate to grow high value crops instead of rice-rice cropping pattern.
- Finally, in selecting farmers for project interventions, a certain percent of marginal and small farmers should be included as project participants considering they have been ignored by existing framework.

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APPENDICES

Appendix 4.1: Percent distribution of respondent farmers according to age group across district

Age cohort	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
15-30	13	16	21	13	12	27	17
31-45	43	30	32	33	30	33	34
46-60	30	37	34	39	46	27	36
61-75	13	17	13	15	12	12	13
Average age	44.9	46.7	44.4	47.5	47.7	42.7	45.7

Appendix 4.2: Percent distribution of farmers according to the level of education by district

Education level	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	Total
Illiterate	14.1	30.4	22.5	33.3	26.5	18.6	24.3
Primary (I-V)	17.2	48.0	28.4	30.4	23.5	21.6	28.2
Secondary (VI-X)	47.5	14.7	34.3	27.5	29.4	42.2	32.5
Higher secondary	14.1	4.9	7.8	3.9	8.8	3.9	7.2
Degree & above	7.1	2.0	6.9	4.9	11.8	13.7	7.7

Appendix 4.3 Average farm size of the sample farmers in the study area (in decimal)

District	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	Total
Total cultivated land	162.3	358.2	168.3	122.1	189.3	151.9	192.2
1. Own cultivated land	133.0	64.0	111.9	100.4	152.4	157.5	119.8
2. Rented/mortgaged in land	42.6	297.2	68.0	33.5	47.0	17.5	84.5
3. Rented/mortgaged out land	13.3	3.0	11.7	11.8	10.0	23.0	12.1
4. Homestead	12.5	8.9	13.6	13.0	14.1	13.8	12.6
5. Ponds	7.5	6.0	6.1	2.7	12.2	4.5	6.5
6. Orchard	12.2	4.0	5.1	3.0	18.3	5.1	7.9
Farm size (in decimal)	194.4	377.1	193.0	140.8	234.0	175.3	219.2

Appendix 4.4 Average annual earnings of the farmers across district by farm category

Farm category by district	Annual earnings(Tk. '000)								
	Crops	Livestock	Fish	Wages	Orchard	Remittance	Business	Others	Total
Bogura									
Marginal farmers	41.0	21.0	0.0	0.0	0.0	0.0	0.0	120.0	122.0
Small farmers	134.3	46.5	14.5	117.4	9.8	86.7	110.9	40.8	285.0
Medium farmers	241.6	55.4	15.3	12.5	28.0	120.0	75.0	55.0	345.2
Large farmers	600.3	75.0	0.0	0.0	59.0	0.0	45.0	36.0	774.8
Chapai Nawabganj									
Marginal farmers	61.9	52.5	0.0	58.5	4.5	120.0	0.0	84.0	195.8
Small farmers	105.1	18.9	56.7	109.0	9.8	191.5	109.1	28.0	258.8
Medium farmers	213.5	38.3	36.0	106.0	19.1	156.6	108.2	6.0	370.4
Large farmers	429.3	67.7	40.0	123.3	69.4	120.0	84.0	15.7	686.5
Dinajpur									
Marginal farmers	30.4	12.0	2.5	20.0	0.0	0.0	72.0	65.3	152.5
Small farmers	104.6	26.7	5.0	37.5	3.8	0.0	56.8	16.5	214.7
Medium farmers	205.3	30.7	20.1	45.4	18.2	13.3	59.2	30.2	347.6
Large farmers	318.0	78.0	165.0	82.0	40.0	48.0	0.0	0.0	707.0
Kurigram									
Marginal farmers	24.4	15.1	6.5	92.0	5.3	45.0	55.3	44.3	155.0
Small farmers	61.0	23.8	50.8	75.3	5.1	0.0	91.0	28.1	182.2
Medium farmers	136.0	60.9	53.1	40.0	9.5	0.0	169.4	20.8	318.2
Natore									
Marginal farmers	31.2	15.5	0.0	142.5	0.0	0.0	0.0	0.0	141.7
Small farmers	101.2	32.2	20.4	119.2	15.7	0.0	139.0	29.0	280.0
Medium farmers	194.8	41.1	52.1	149.1	57.4	260.0	154.2	29.2	444.4
Total	134.9	35.1	35.2	128.1	32.4	260.0	146.2	29.1	338.8
Nilphamari									
Marginal farmers	47.0	13.2	0.0	49.0	0.0	48.0	12.0	1.7	170.8
Small farmers	103.4	28.6	9.7	54.0	4.0	6.2	52.1	12.0	229.6
Medium farmers	232.8	40.1	13.1	75.4	4.6	0.0	53.2	29.4	388.8
Total									
Marginal farmers	35.1	20.5	2.6	73.7	2.8	51.5	41.1	47.1	158.6
Small farmers	101.7	30.4	14.8	75.2	6.4	16.8	82.9	20.8	239.2
Medium farmers	205.5	42.1	31.9	92.9	26.2	71.4	110.5	30.0	380.9
Large farmers	437.9	70.2	75.7	109.5	63.7	96.0	74.3	25.9	702.0

Appendix 4.5 Average annual expenditure of the sample households across district by farm category

	Expenses (Tk. '000)

Farm category across district	Food	Farm	Education	Health	Cloth	Livestock	Recreation	Repairing	All average
Bogura									
Marginal farmers	64.5	13.0	12.0	13.5	8.5	16.5	9.5	3.0	139.0
Small farmers	70.8	80.0	29.4	19.8	10.0	25.5	16.7	40.0	249.3
Medium farmers	79.0	161.0	62.5	25.5	12.3	37.3	30.5	6.6	367.1
Large farmers	87.5	400.0	0.0	42.5	25.0	67.5	140.0	250.0	887.5
Chapai Nawabganj									
Marginal farmers	62.3	58.8	72.0	41.0	9.0	27.0	13.8	500.0	359.3
Small farmers	60.1	58.2	14.8	24.3	6.7	18.6	11.2	25.4	188.6
Medium farmers	64.6	148.3	17.7	25.9	8.3	27.1	16.3	59.2	308.9
Large farmers	98.7	288.5	34.1	57.3	8.5	45.7	20.5	13.5	544.5
Dinajpur									
Marginal farmers	55.0	17.7	15.3	18.7	7.2	5.0	9.7	30.0	155.2
Small farmers	57.4	59.0	20.3	19.7	8.0	11.8	11.3	12.6	194.4
Medium farmers	62.6	123.8	22.6	20.6	11.0	28.3	19.4	64.4	328.2
Large farmers	89.5	250.0	5.0	6.0	18.5	18.0	32.5	155.0	572.0
Kurigram									
Marginal farmers	47.7	24.0	14.3	14.3	7.0	3.3	8.8	13.2	123.5
Small farmers	54.2	40.2	18.0	11.2	6.6	7.7	15.3	17.4	160.8
Medium farmers	65.7	103.1	23.1	19.5	13.1	11.6	30.7	31.6	277.4
Natore									
Marginal farmers	52.7	20.0	5.8	8.2	6.0	40.0	12.7	10.0	123.4
Small farmers	58.8	53.6	28.6	18.5	8.0	19.7	24.4	21.1	211.3
Medium farmers	78.6	122.5	53.3	30.3	16.8	24.6	24.5	62.1	361.2
Total	66.2	78.9	38.4	22.7	11.3	21.6	24.1	34.0	266.0
Nilphamari									
Marginal farmers	70.7	19.0	2.0	8.0	5.3	5.0	9.0	2.3	121.3
Small farmers	57.8	57.9	21.5	17.7	8.3	10.0	13.2	8.1	188.5
Medium farmers	73.4	134.6	24.7	25.9	10.7	7.8	25.0	12.2	307.7
Total	61.2	71.8	21.4	19.1	8.7	9.4	15.4	8.7	209.9
All									
Marginal farmers	55.0	26.6	16.9	17.3	7.1	10.6	10.1	43.7	162.8
Small farmers	60.0	58.6	22.4	18.1	8.0	15.1	15.4	16.8	199.7
Medium farmers	70.4	133.8	31.3	25.7	11.9	23.1	22.6	43.4	326.8
Large farmers	95.8	298.9	30.8	47.9	12.3	44.8	39.3	117.4	597.5

Appendix 4.6 Average annual expenditure of the sample households across district

	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	Total
Crops	97	122	74	48	79	72	82
Livestock	28	26	15	8	22	9	18
Farm expenses	**125**	**148**	**89**	**55**	**101**	**81**	**100**
Food	72	66	59	55	66	61	63
Education	33	20	20	18	38	21	25
Health	21	29	20	13	23	19	21

Cloth	11	8	9	8	11	9	9
Recreation	21	15	13	17	24	15	18
Repearing	40	62	26	19	34	9	25
HHs expenses	**198**	**199**	**147**	**130**	**197**	**134**	**160**
Total_exp	278	286	227	174	266	210	240

Appendix 5.1 Percent of farmers practiced diverse cropping patterns in Bogura District by land elevation

Bogura	Land Elevation			All Average
	High	Medium	Low	
Boro-Fallow-Aman	1.0	39.4	42.4	27.6
Boro-Fallow-Fallow	-	27.3	3.0	15.2
Potato-Vegetable-Vegetable	21.2	1.0	-	11.1
Potato-Boro-Aman	14.1	3.0	15.2	10.8
Lentil-Banana-Banana	15.2	5.1	2.0	7.4
Potato-Vegetable-Fallow	5.1	-		5.1
Vegetable-Vegetable-Vegetable	5.1	-		5.1
Boro-Vegetable-Aman	2.0	9.1	1.0	4.0
Vegetable-Vegetable-Aman	4.0			4.0
Potato-Aus-Aman	2.0		4.0	3.0
Potato-Chilli-Aman	3.0			3.0
Vegetable-Fallow-Vegetable	5.1	1.0		3.0
Boro-Vegetable-Vegetable	1.0	6.1	1.0	2.7
Potato-Jute-Aman	4.0	1.0		2.5
Blackgram-Jute-Fallow	2.0			2.0

Appendix 5.2 Appendix 5.1 Percent of farmers practiced diverse cropping patterns in Chapai Nawabganj district by land elevation

Cropping Pattern	Land Elevation			All
	High	Medium	Low	
Lentil-Fallow-Aman	23.5	23.5	17.6	21.6
Boro-Fallow-Aman	23.5	17.6	15.7	19.0
Mustard-Fallow-Aman	15.7	11.8	11.8	13.1
Wheat-Fallow-Aman	7.8	13.7	14.7	12.1
Pea-Fallow-Aman	5.9	11.8	7.8	8.5
Fallow_Fallow_Aman	8.8	4.9	4.9	6.2
Garlic_Fallow_Aman	2.0			2.0
Vegetable_Fallow_Aman	1.0	1.0	3.9	2.0
Mustard_Boro_Aman	2.0		1.0	1.5
Khesari_Fallow_Aman			1.0	1.0
Khesari_Wheat_Aman			1.0	1.0
Lentil_Aus_Aman	1.0		1.0	1.0
Maize_Fallow_Aman	1.0			1.0
Vegetable-Vegetable-Aman		1.0		1.0

Appendix 5.3 Percent of farmers practiced diverse cropping patterns in Dinajpur district by land elevation

Dinajpur	Land Type			All Average
	High	Medium	Low	
Boro_Fallow_Aman	7.8	48.0	45.1	33.7
Boro_Fallow_Fallow		28.4		28.4
Maize_Fallow_Aman	30.4		16.7	23.5
Boro_Jute_Aman		7.8		7.8
Boro_Vegetable_Aman		3.9		3.9
Boro_Maize_Aman	2.0	4.9		3.4
Potato_Jute_Aman	2.9			2.9
Potato_Maize_Aman	4.9		1.0	2.9
Potato_Vegetable_Fallow	2.9			2.9
Mustard_Boro_Aman	2.0	1.0	3.9	2.3
Boro_Fallow_Vegetable		2.0		2.0
Boro_Vegetable_Fallow		2.0		2.0
Onion_jute_Fallow	2.0			2.0
Vegetable_Jute_Fallow	2.0			2.0
Vegetable_Maize_Aman	2.0			2.0
Wheat_Jute_Aman	2.9		1.0	2.0
Maize_Fallow_Blackgram	1.0		2.0	1.5
Wheat_Fallow_Aman	2.0		1.0	1.5
Blackgram_Jute_Fallow			1.0	1.0
Boro_Fallow_Maize	1.0		1.0	1.0

Appendix 5.4 Percent of farmers practiced diverse cropping patterns in Kurigram district by land elevation

Kurigram	Land Type			All
	High	Medium	Low	
Boro_Fallow_Aman	41.2	44.1	32.4	39.2
Boro_Fallow_Fallow	4.9	14.7	18.6	12.7
Fallow_Jute_Aman	6.9	1.0	2.9	3.6
Boro_Jute_Fallow	2.9	2.9		2.9
Khesari_Fallow_Fallow			2.9	2.9
Fallow_Jute_Fallow	2.9	3.9	1.0	2.6
Lentil_Fallow_Fallow	1.0	4.9	2.0	2.6
Blackgram_Jute_Fallow	2.0	2.		2.0
Boro_Fallow_Vegetable	2.0			2.0
Fallow_Aus_Aman		1.0%	2.0	1.5
Lentil_Jute_Fallow		1.0	2.0	1.5

Pea_Jute_Fallow	2.0	1.0		1.5
Fallow_Fallow_Aman	1.0	1.0	2.0	1.3
Wheat_Jute_Fallow	1.0	1.0	2.0	1.3
Blackgram_Jute_Aman	1.0			1.0
Boro_Fallow_Maize		1.0		1.0
Boro_Jute_Aman	1.0			1.0
Boro_Maize_Aman		1.0		1.0
Lentil_Jute_Aman	1.0			1.0
Mustard_Boro_Aman	1.0			1.0
Mustard_Jute_Fallow	1.0			1.0
Potato_Jute_Aman			1.0	1.0

Appendix 5.5 Percent of farmers practiced diverse cropping patterns in Nilphamari district by land elevation

Nilphamari	Land Type			All
	High	Medium	Low	
Boro_Fallow_Aman	2.9	44.1	48.5	31.9
Tobacco_Maize_Aman	31.4		4.0	17.
Boro_Maize_Aman		22.5	2.0	12.3
Boro_Fallow_Fallow	2.0	20.6	10.9	11.1
Tobacco_Fallow_Aman	7.8			7.8
Boro_Vegetable_Aman		3.9		3.9
Tobacco_Maize_Vegetable	3.9			3.9
Tobacco_Aus_Aman	3.9		3.0	3.4
Boro_vegetable_Vegetable		2.9		2.9
Tobacco_Fallow_Fallow	2.9			2.9
Maize_Fallow_Aman	2.0		2.0	2.0
Tobacco_Maize_Fallow	2.0		2.0	2.0
Boro_Fallow_Maize		2.0		2.0
Boro_Fallow_Vegetable		2.0		2.0
Potato_Vegetable_Fallow	2.0			2.0

Table 5.2 Appendix 5.5 Percent of farmers practiced diverse cropping patterns in Natore district by land elevation

Natore	Land Type			All
	High	Medium	Low	
Boro_Fallow_Aman	4.9	7.8	7.8	26.3
Boro_Fallow_Fallow	1.0	2.0	3.9	7.6
Lentil_Fallow_Aman	1.0	2.0	1.0	3.8
Maize_Fallow_Aman	1.0			3.0
Wheat_Fallow_Aman	2.9	1.0	2.0	2.6

Mustard_Fallow_Aman		1.0	2.0	2.4
Tobacco_Maize_Aman				2.0
Boro_Maize_Aman			1.0	1.9
Wheat_Jute_Aman	13.7	10.8	4.9	1.9
Potato_Boro_Aman				1.8
Sugarcane_Sugarcane_Sugarcane	14.7	4.9	7.8	1.5
Fallow_Fallow_Aman			2.0	1.5
Pea_Fallow_Aman				1.4
Lentil_Banana-Banana	1.0	2.0		1.4
Potato_Vegetable_Vegetable				1.3
Lentil_Jute_Aman	12.7	5.9	2.0	1.2
Garlic_Jute_Aman	8.8	7.8	3.9	1.1
Boro_Vegetable_Aman				1.1
Fallow_Jute_Aman	2.0	1.0	2.9	1.0
Khesari_Fallow_Aman	2.9	3.9	8.8	.9
Mustard_Boro_Aman			2.0	.8
Khesari_Jute_Aman	3.9	5.9	2.9	.7

Appendix 5.3 Types of crop production training received by the sample farmers across district

	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All Average
Training Recipient	**18.2**	**3.3**	**11.8**	**3.6**	**13.4**	**3.3**	**8.9**
Rice cultivation	37.0	20.0	30.6	18.2	24.4	10.0	28.4
Vegetable production	33.3	20.0	11.1	27.3	0.0	30.0	18.5
Pulses production	3.7	40.0		18.2	41.5		15.4
Wheat and Maize cultivation	1.9		16.7	18.2	14.6	10.0	9.9
IPM	1.9	10.0	16.7	9.1	2.4	40.0	8.6
Other crops	7.4		11.1	9.1	2.4		6.2
Banana cultivation	7.4		5.6		2.4		4.3
Fertilizer related	1.9	10.0	5.6		7.3		4.3
Seed management					4.9	10.0	1.9
Potato	1.9		2.8				1.2
Spices related	3.7		0.0				1.2

Appendix 5.4 Sources of training received by the sample respondents across farm category

Sources of Training	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
DAE	64.8	70.0	88.9	81.8	43.9	80.0	67.3
ARIs	18.5	30.0	5.6	9.1	48.8		22.2
Others	5.6		2.8		7.3	20.0	5.6
Project	9.3		2.8	9.1			4.3
NGO	1.9						0.6

Appendix 5.5 Extent of farmers reported satisfaction level with training

Satisfaction level	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Moderate	42.6	60.0	44.4	18.2	61.0	90.0	50.0
Satisfactory	50.0	20.0	47.2	72.7	39.0		43.2
Inadequate	7.4	20.0	8.3	9.1		10.0	6.8

Appendix 5.6 Support provided by the agriculture service providers

	Bogura	**Chapai Nawabganj**	**Dinajpur**	**Kurigram**	**Natore**	**Nilphamari**	**All**
Demo	18.6	15.8	15.6	8.0	4.3	9.5	11.8
Seeds	58.1	47.4	12.5	32.0	41.3	14.3	36.6
Fertilizer	20.9	21.1	15.6	24.0	17.4	14.3	18.8
Seed and fertilizer	2.3	15.8	50.0	36.0	32.6	52.4	29.6
Others			6.3		4.3	9.5	3.2

Appendix 5.7 Percent of farmers tested soil from various sources by district

Sources	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All
ARIs	4 (25)		3 20	2 28.6		1 33.3	10 19.6
DAE	12 (75)	2 (66.7)	5 33.3	5 71.4	5 71.4	1 33.3	30 58.8
NGO		1 33.3	7 46.7		1 14.3	1 33.3	10 19.6
Private company		0			1 14.3		1

Parenthesis indicates the percentage

Appendix 5.8 Farmers responses (%) for not testing soil across farm category

	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Crops grow well	39	14	36	30	31	18	168
	47.0%	14.1%	41.4%	31.6%	32.6%	18.2%	30.1%
Don't know about it	23	41	30	31	27	46	198
	27.7%	41.4%	34.5%	32.6%	28.4%	46.5%	35.5%
Lack of facilities	11	9	5	9	15	12	61
	13.3%	9.1%	5.7%	9.5%	15.8%	12.1%	10.9%
Lack of motivation	8	31	14	18	22	22	115
	9.6%	31.3%	16.1%	18.9%	23.2%	22.2%	20.6%
Leased in land	2	4	2	7	0	1	16
	2.4%	4.0%	2.3%	7.4%	0.0%	1.0%	2.9%

Parenthesis indicates the percentage

Appendix 5.9 Percent of farmers' influence by various factors in fertilizer application

Factors	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All average
Type of crop	20.0	21.7	19.8	24.6	24.6	21.4	21.9
Quality of soil	18.1	19.5	15.8	17.4	21.8	15.9	18.0
Availability of cow manure	6.8	11.2	10.4	14.0	4.2	11.1	9.6
Topography	16.5	8.3	9.4	7.2	5.0	9.4	9.5
Crop season	6.6	8.7	7.3	8.7	9.9	7.4	8.0
Recommendation made by dealer	4.1	11.0	5.8	4.3	8.7	4.6	6.4
Practice of neighbors	6.8	8.1	5.6	2.9	3.2	5.9	5.5
Advice given by extension/project staff	7.4	3.8	4.4	4.8	9.4	2.8	5.4
Cropping pattern	6.6	2.5	5.2	2.9	3.5	7.8	4.8
Availability of fertilizer	1.0	0.9	5.4	4.3	4.0	6.3	3.6
Cost of fertilizer	2.3	1.6	4.0	4.3	3.5	3.7	3.2
Sowing type	1.4	1.6	3.3	1.0	1.2	1.7	1.7
Market value of the crop	0.6	0.2	2.5	1.9	0.5	1.7	1.3
Soil testing advice	0.6	0.0	0.8	1.0	0.5	0.2	0.5
Fertilizer recommendation guide	1.0	1.1	0.2	0.5	0.0	0.0	0.5

Appendix 5.10 Action taken after identifying the nutrient deficiency symptom for reduction of losses

Types of action	Marginal farmers	Small farmers	Medium farmers	Large farmers	All average
Apply fertilizer and pesticide by own experience	33.3	48.8	52.6	50.0	49.1
Consult with dealer	33.3	23.3	25.0	28.6	24.3
Consult with SAAO/UAO	11.1	15.3	17.3	14.3	15.6
Consult with peer farmers	11.1	7.5	3.2	7.1	6.6
Wait to see the result	11.1	5.1	1.9	0.0	4.4

Appendix 5.11 Coping strategy in case shortage of money to buy fertilizer

Coping strategy	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All Average
Buy less	1.7	3.8	6.8	7.6	7.8	6.6	5.8
Borrow money or from dealer	98.3	96.2	91.5	84.8	84.4	86.8	90.0
Buy low cost fertilizer	-	-	1.7	7.6	7.8	6.6	4.2

Appendix 6.1 Crop rotation practices followed by different farm category across district

	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	All
Marginal Farmers							
Never	50.0	0.0	33.3	100.0	100.0	66.7	70.4
Hardly		50.0	33.3	0.0		0.0	11.1
Sometimes		50.0	33.3			0.0	11.1
Often						33.3	3.7
Regular	50.0					0.0	3.7
Small farmers							
Never	30.0	7.3	49.4	56.0	41.7	53.2	42.2
Hardly	20.0	19.5	18.2	25.3	21.7	26.6	22.1
Sometimes	35.0	29.3	16.9	16.0	26.7	15.2	22.6
Often	1.3	19.5	7.8	1.3	8.3	3.8	5.8
Regular	13.8	24.4	7.8	1.3	1.7	1.3	7.3
Medium farmers							
Never	20.0	4.3	20.0	46.7	23.1	35.0	20.5
Hardly	33.3	4.3	30.0	20.0	41.0	45.0	26.3
Sometimes	33.3	23.4	40.0	26.7	15.4	15.0	23.7
Often	6.7	19.1	5.0	6.7	12.8	5.0	11.5
Regular	6.7	48.9	5.0	0.0	7.7	0.0	17.9
Large farmers							
Never							0.0
Hardly	0.0	10.0	50.0				14.3
Sometimes	100.0	40.0	50.0				50.0

Often	0.0	0.0	0.0				0.0
Regular	0.0	50.0	0.0				35.7
All category							
Never	28.3	4.9	42.2	59.8	36.3	50.0	36.9
Hardly	21.2	12.7	21.6	21.6	28.4	29.4	22.5
Sometimes	35.4	28.4	22.5	15.7	21.6	14.7	23.0
Often	2.0	16.7	6.9	2.0	9.8	4.9	7.1
Regular	13.1	37.3	6.9	1.0	3.9	1.0	10.5

Appendix 7.1 Distribution of income of across study districts

Sources of Income	Bogura	Chapai Nawabganj	Dinajpur	Kurigram	Natore	Nilphamari	Total
Farm income from Rabi season	89698	77389	62751	40260	69218	63072	66953
Farm income from Kharif-I	35153	21520	27024	10915	32486	30836	26279
Farm income from Kharif-II	37737	85094	35532	14812	32734	33924	39983
Income from livestock & poultry	47915	33940	28088	28214	35124	30372	33873
Income from fisheries/ponds	14722	40556	13055	47960	35225	9880	21058
Income from wages and salaries	108304	107038	39119	76275	128119	57928	79470
Income from orchard (fruit sale)	18795	37875	7631	5963	32388	3944	14416
Income from remittance	91429	158714	3294	45000	260000	7769	31488
Income from business	107643	105143	57529	101125	146225	50658	88177
Other income	46650	31617	20694	30883	29100	14821	24279
Total Income	305222	348563	247557	197312	338287	259781	282677