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ASSESSMENT OF RISK FACTORS THAT AFFECTING AGRICULTURE PRODUCTIONS AND IDENTIFYING ADAPTATION OPTIONS FOR INCREASED PRODUCTIONS AND IMPROVED LIVELIHOODS OF THE FARMING COMMUNITY IN THE VULNERABLE AREA OF DROUGHTS IN BANGLADESH

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Abstract: Bangladesh is one of the most vulnerable countries in the world to climate change. The major environmental vulnerabilities viz. droughts, floods, flash floods, cyclone, salinity, tidal surges, water-logging, extreme temperature, low light intensity, fogginess, incidences of pests and diseases etc are affecting the agricultural production systems. Adaptation is important to limit the negative impacts of climate change. Majority of the people in vulnerable areas are involved in crop cultivation, homestead gardening and fishing but they remain frequently unemployed due to climate risks and other natural disasters resulting food insecurity. Present study was undertaken during 2012-13 under ARCAB to analyze the climate impacts on crop production systems and to suggest appropriate coping strategies and adaptation options for increased agricultural productions and better livelihood of the vulnerable people of Naogaon Sadar. Survey, FGDs, HHs and Stakeholders' Consultations were conducted under the project following a multi-disciplinary and participatory approach for assessing climatic risk factors, soil-related constraints and socio-economic problems affecting agriculture productions. The main reasons of changing crops/cropping patterns and lower productivity in drought prone areas were identified as: growing demands for food crops, erratic rains/moisture stress, problems in tillage operations due to cracking clays, poor soil fertility due to deficiencies of N, P, K, Ca, Mg, B and Mo with low SOM, low CEC etc. The study has evaluated the major risk factors viz. climate risks, soil-related constraints and socio-economic problems that affecting agriculture productions at different farm household levels and identified possible production opportunities of agriculture innovations including other ways/means of farm income for increasing their overall agriculture productions and household income. This study highlights and integrates multi-dimensional, multi-level and dynamic understandings of poverty, of poor people's livelihoods and of changing roles of agricultural systems with introduction of improved agriculture innovations in drier areas of Naogaon Sadar.

Keywords*:* Agriculture innovations, Adaptive Capacity, Climate risks, Production Risk Factors, Community based adaptation.

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INTRODUCTION

The vulnerability of individuals and communities comprising of different farm households under Ullashpur Block and nearby city areas of Naogaon Sadar to climate variability and change is an outcome of the interaction between an external threat or hazards and the internal characteristics of a livelihood system. For residents of low-income and informal settlements in urban areas, these internal

characteristics which may include limited income, few assets and poor provision of basic services are particularly important in shaping the consequences of climate-related hazards. On the other hand, landless and marginal farmers have limited sources of income due to inadequate agricultural land, low capital and poor knowledge constraining agriculture productions in drought prone areas of Naogaon. Similarly, effectively responding to climate change requires not only addressing the direct outcomes of particular events, but also more generally building the resilience of marginalized and vulnerable groups (DAE, Naogaon, 2010). Climate is a pervasive factor in social and economic development for all countries in the world including Bangladesh. Adaptation or especially Adaptation Agriculture is a vital part of a response to the challenges of climate change. People are adapted to the distinct climate of the place where they live. Adaptation is important to limit the negative impacts of climate change. This is most obvious in productive sectors such as agriculture, where the choice of crops and the mode of cultivation have been finely tailored over decades, even centuries, to the prevailing climate. But the same is true for other economic sectors that are obviously weather-dependent, such as livestock, fisheries, forestry, water resources and recreation (ADPC/FAO, 2006). Adaptation will be crucial in reducing vulnerability to climate change and is the only way to cope with the impacts that are inevitable over the next few decades. In regions that may benefit from small amounts of warming, adaptation will help to reap the rewards. It provides an impetus to adjust economic activity in vulnerable sectors and to support sustainable development, especially in developing countries like Bangladesh. But it is not an easy option and it can only reduce, not remove, the impacts. There will be some residual cost –either the impacts themselves or the cost of adapting. Without early and strong mitigation, the costs of adaptation rise sharply. Adaptation can operate at two broad levels:

a. Building adaptive capacity: Creating the information and conditions (regulatory, institutional, managerial) that are needed to support adaptation. Measures to build adaptive capacity range from understanding the potential impacts of climate change and the options for adaptation (i.e. undertaking impact studies and identifying vulnerabilities), to piloting specific actions and accumulating the resources necessary to implement actions.
b. Delivering adaptation actions: Taking steps that will help to reduce vulnerability to climate risks or to exploit opportunities. Examples include: planting different crops and altering the timing of crop planting; and investing in physical infrastructure to protect against specific climate risks, such as flood defenses or new reservoirs (ADPC/FAO, 2006).

Adaptation perspectives

Some adaptation will occur autonomously, as individuals respond to changes in the physical, market or other circumstances in which they find themselves. Other aspects will require greater foresight and planning, *e.g.* major infrastructure decisions. Adaptation is different from mitigation because it will in most cases provide local benefits and these benefits will typically be realized without long lag times. As such, many actions will be taken 'naturally' by private actors such as individuals, households and businesses in response to actual or expected climate change, without the active intervention of policy. This is known as autonomous adaptation. In contrast, policy-driven adaptation can be defined as the result of a deliberate policy decision. Autonomous adaptation is undertaken in the main by the private sector (and in unmanaged natural ecosystems), while policy-driven adaptation is associated with public agencies - either in that they set policies to encourage and inform adaptation or they take direct action themselves, such as public investment. There are likely to be exceptions to this broad-brush rule, but it is useful in identifying the role of policy. The extent to which society can rely on autonomous adaptation to reduce the costs of climate change essentially defines the need for further policy. Costs may be lower in some cases if action is planned and coordinated, such as a single water-harvesting reservoir for a whole river catchment rather than only relying on individual household water harvesting (ADPC/FAO, 2006; Miah, 2010).

Barriers and limits to adaptation

In many cases, market forces are unlikely to lead to efficient adaptation. Broadly, there are three reasons for this:

a. Uncertainty and imperfect information;
b. Missing and misaligned markets, including public goods;
c. Financial constraints, particularly those faced by the poor.

Bangladesh has made a remarkable progress in the last three decades towards achieving self-sufficiency in food grains due to substantial intensification of cropping, introduction of high yielding crop varieties, expansion of irrigated areas and increased use of chemical fertilizers. Among the factors, contribution of fertilizers leading to increased production is about 50% (Miah, et al. 2005). But recently, declining or stagnation of major crop yields have been recorded due to cumulative effects of many soil-related constraints and climatic risks viz. depletion of soil organic matter, imbalanced use of fertilizers, nutrient mining, degradation of soil physical, chemical and biological properties, temperature rise, erratic rainfall, droughts, floods, flash flood/soil erosion, increased salinity, tidal surges, water-logging, cyclone, scanty use of bio and organic fertilizers and poor management practices. Bangladesh is presently facing a serious challenge in agricultural production to feed the growing population in the context of shrinking agricultural land and climate change impacts. The population has been projected to grow to 191 million in 2030 from the current 148 million. The major challenges for increased growth and production for agriculture sector are:

- Arresting conversion of good agricultural land into non- agricultural purposes;
- Reversing trend of nutrient mining and depletion of soil organic matter (SOM) due to mono-culture in intensive crop agriculture;
- Utilization of remarkable areas of agricultural land (30-50% of NCA of concerned vulnerable districts) that remains fallow or seasonal fallow in drought prone, flood prone, hills and coastal/tidal surge areas due to environmental risk factors;
- Introduction of location specific production packages and sustainable/adaptation agricultural technologies/options using risk tolerant crop varieties to facilitate the growth of agriculture sector;
- Reduction of yield gap and large scale adoption of proven agro-technologies at farm level;
- Ensuring accessibility/availability of standard fertilizers, organic manures and composts and problems of using balanced fertilizers (based on IPNS) at farm level;
- Soaring price of agricultural inputs viz. seeds, fertilizers, irrigation, pesticides, agricultural machinery etc.
- Ensuring efficient on-farm water management for maximizing water productivity;
- Making adequate quality seeds and seed materials at farmers' level;
- Unavailability of short duration and suitable salt-tolerant and submergence tolerant crop varieties in coastal region;
- Developing drought-tolerant and short duration varieties for drought prone areas and char lands and submergence tolerant varieties for water-logged floodplain soils;
- Improving marketing facilities, entrepreneurship development and Farmers' Group in agro-processing using value added crops;

Climatic risks/hazards such as floods, flash floods, water-logging, soil erosion/landslides, droughts, salinity, cyclones, tidal surges and increase of soil salinity have been occurring since long past in Bangladesh. Impacts of these climatic hazards caused loss to crops, lives, infrastructures and livelihoods. The vulnerabilities due to climate change are likely to aggravate more in the future. These vulnerabilities hinder the agriculture production systems, economic and social development through two processes:

- Firstly, damaging the crops, livestock, fisheries and agro-forestry, natural resources and infrastructure;
- Secondly, pulling back the on-going development, business and trade at local, regional and even global levels.

To cope up with these dreadful evils farmers through their location specific indigenous knowledge have, with error and trials, developed some means/innovative practices over the years. The scientists with their institutional knowledge have also developed/improved some technologies/innovative practices for adaptation to these natural hazards. In the recent years, climate has become more furious to affect loss to crops, lives and infrastructures in mass scale. The Government of Bangladesh (GoB) is strongly committed to the World Food Summit (WFS) target of reducing the number of undernourished people by half by 2015 and the MDG1 target of eradicating hunger and poverty by halving the proportion of people in the world who are undernourished and living on less than $1 a day (POA:2008-2015; ADPC/FAO, 2006). Under this context, strengthened efforts to raise productivity and efficiency in food grain production to support agricultural commercialization and diversification, in due consideration of environmental impacts will be paramount. Actions are needed on many fronts, including location-specific technology development, identifying sustainable adaptation options for vulnerable areas, input (good seeds, standard fertilizers, irrigation, pesticides, machinery) supply and access expansion and critically rural financing which stands currently far below rural producers' seeds. Over the last 20 years or so, understanding of poverty and of the ways in which people escape from poverty or fall into or locked in poverty has advanced in many ways and in particular has become more holistic. Thus multiple dimensions of poverty and their interaction are now widely recognized e.g. in the Millennium Development Goals, Human Development Index and the UNDP Human Development Reports) to include, people's lack of ability to make choices, lack of access to services, social degradation and isolation and vulnerability- as well as inadequate incomes, consumption and wealth (Rodrik, D, 2004).

In this research paper, agricultural production systems in vulnerable areas, contribution of assets and production potentials in production systems and related activities have been assessed for people's livelihood changes. Livelihoods involve the use of assets in different activities to produce outputs, both to meet people's consumption requirements and aspirations and to invest assets and activities for the future production systems. Under this study, agricultural production risks and potentials and related households' livelihood systems (with different asset portfolios, activities, vulnerabilities and aspirations) of vulnerable project sites of drought prone areas of Naogaon Sadar under Barind Tract (AEZ 26) have been assessed (DAE/Naogaon, 2010).

EXPERIMENTAL

Project Sites of Drought Prone Areas: Naogaon Sadar Upazila, Naogaon district (AEZ 26)-(Ullashpur Agriculture Block of Hapania Union). Project Sites/Proposed Working Sites have been selected from defined Agricultural Blocks having different categories of farm family viz. landless, marginal, small, medium and large farmers) of vulnerable areas for each site involving concerned local SAAOs/Sr. Scientific Assistants of DAE/OFRD-BARI.

The main approach of conducting this study is multidisciplinary and participatory in nature. Major activities and methodology includes the followings:

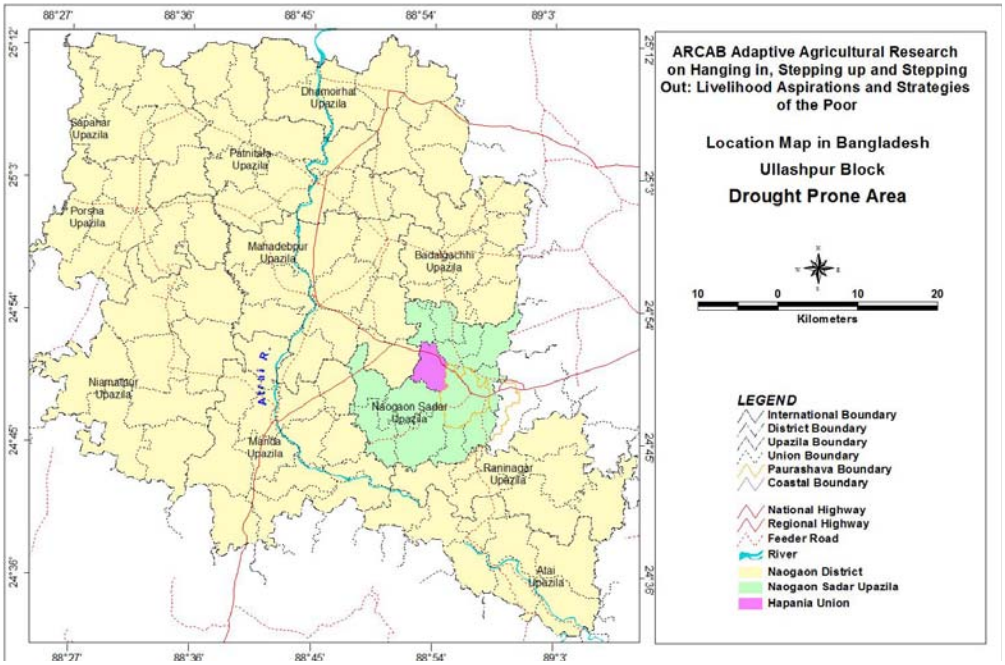
i) Review and analysis of related literature, reports etc

ii) Conduct survey/field visits, FGDs, HHs using standard checklist and Stakeholders' Consultations for pro- poor impact assessment and listing/evaluating target households (HHs) based on assets (viz. land, animals, skills, social contacts etc) and identifying/assessing risk factors (viz. climatic risks, soil-related constraints and socio-economic problems) affecting crop production systems and livelihoods of vulnerable farming community.

iii) Analyzing/evaluating the risk factors affecting agricultural production systems and livelihood changes of the farming community of each project site and classifying target HHs into 3 (three) categories: Hanging in, Stepping up and Stepping out.

iv) Identifying sustainable innovative farming systems and adaptation options for increased agricultural productions and improved livelihoods.

v) Prepare Strategic Production Plan for above 3 groups for developing rural agriculture based livelihoods to new, more specialized and productive activities emphasizing on cross-sectoral dynamics and on livelihood diversity and diversification encourages a multi-disciplinary views of poverty reduction in the project sites.



For achieving high % farm income (wealthy, thick markets, low risks) from low % farm income (poor, thin markets, high risks), some production strategies viz. increased cereal/stapples production, trading cash crops, trading horticultural crops, high value/modern horticultural crops, trading livestock, modern livestock, fisheries etc will be identified/considered as Agricultural Productivity Potentials. Emphasis (during preparation of Production Plan of Adaptation Agriculture) on cross-sectoral dynamics and on livelihood diversity and diversification encourages multi-disciplinary views of poverty reduction. Main Strategies are:

-Under conditions of higher natural resource potential, crop farming may be more important to poor people's livelihoods.

-Importance of Market Access: Increased production will have little value without markets to dispose of it.

-In more favored areas with better natural resource potential (including science based adaptation options) and market access, agriculture is important for hanging in and in the short to medium term, provides opportunities for some people to step up or to accumulate resources for stepping out.

vi) Make a list of possible adaptation options of stepping up for each vulnerable site through FGDs and stakeholders' consultations.

vii) Arrange Stakeholders' Consultations at each site/upazila level for identifying/ finalizing strategic options of stepping up and stepping out through increased agriculture productions.

viii) Prepare draft Final Research Report of Initial Phase for publication.

RESULTS AND DISCUSSION

Study showed that Ullashpur Agricultural Block is comprised of 9 mouzas (viz, Shaluka, Chandikhetra, Lakhaijani, Bhabanigathi, Masharpur, Kumuria, Ullashpur Kashibari and Dashpaika under Hapania Union) having different categories of farm family (viz. landless, marginal, small, medium and large farmers) of drought prone area under Barind Tract (AEZ-26). Some important descriptions of different farm households are shown in Table 1. Study team visited project sites and conducted focus group discussions (FGDs) and household survey (HHs) in each project site. Observations/results of FGDs and HHs of project site are described below (Table 1).

Table 1: Important descriptions of Ullashpur Block/Hapania Union, Naogaon Sadar

Categories of Farm Households(HHs)	#HHs	Total Agril. Land (ha)	Average Monthly income(Tk.)	Average Monthly expenditure (Tk.)	Education level	Main Profession	Secondary Profession
Landless Farm HHs (0.00-0.20 ha) Members: 3-7	653	13.8 (3%)	7,000/-	7,500/-	Primary level-40% Secondary level-30%	Crop farming	Labour
Marginal Farm HHs (0.21-0.60 ha) Members: 3-7	424	55.2(12%)	8,650/-	8,850/-	-do-	Crop farming	Labour Small business
Small Farm HHs (0.61-1.00 ha) Members: 4-6	435	174.8 (38%)	11,050/-	10,100/-	Primary level-40% Secondary level-30% Graduate level-20%	Crop farming	Fish farming Livestock rearing
Medium Farm HHs (1.01-3.00 ha) Members: 5-8	113	165.6 (36%)	16,600/-	12,000/-	Primary level-30% Secondary level-40% Graduate level-20%	Crop farming Horticulture	Fish farming Livestock rearing Business
Large Farm HHs (3.01 ha- above) Members: 4-7	14	50.6 (11%)	35,700/-	27,000/-	Primary level-10% Secondary level-40% Graduate level-50%	Crop farming Horticulture	Fish farming Livestock rearing Business
Total	1,639	460(100%)					

Climate Risks on Agricultural Production Systems

a. Climatic risks: Drought, erratic rainfall, moisture stress, higher evapo-transpiration, untimely and excessive rainfall, lowering of ground water level in drier months, cold wave, fogginess, BPH, increased vulnerability etc
b. Soil-related constraints: Swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity etc. Degradation of natural resources due to integrated effects of these soil-related constraints has been identified as severe constraint to agricultural development in this drier area.
c. Socio-economic problems: Land crisis, capital problems, low market access, illiteracy, labour problem, poor housing, poor health and nutrition.

Impact of climatic vulnerabilities/risks on agriculture: Impact of these climatic risks/variabilities is affecting the performance of T. Aman rice, wheat and maize at tillering and grain filling stages.

Performance of mustard, wheat, potato, mung bean and winter vegetables are being affected due to increased fogginess with increased incidence of pests. Wheat yield is also being decreased due to occasional short cold period with decreasing trend of coldness at the flowering stage. Performances of irrigated Boro and T. Aus rice are also being hampered due to lowering of ground water table and soil cracking during drought period that affect the standing crops at tillering and grain filling stages. Due to the prevailing climatic situation incidence of pests and diseases is also increasing. There is yield loss of crop due to these climatic vulnerabilities/variabilities and pest attack. Study showed that the changes of the crops and cropping patterns in drought prone Ullashpur Block areas during the last 25-30 years. Back in 25-30 years, the dominant crops and cropping patterns were Fallow-Fallow-T. Aman rice (Local), Chickpea + mustard- Sesame- T. Aman rice (local), Fallow- Jute- T. man rice (local), Fallow- B. Aus (local) – T. Aman rice (local), Lentil+linseed- Fallow- T. Aman rice (local), Grasspea+Linseed- Fallow- T. Aman rice (local), Boro (local) Fallow- T. Aman rice (local). The yield level was low. With the introduction of high yielding crop varieties, increased irrigation facilities, availability of chemical fertilizers and improved management practices, many improved cropping patterns are now being practiced by farmers. Prevailing major cropping patterns are Chickpea+barley-Fallow- T. Aman rice (MV), Chickpea + Mustard- Fallow- T.Aman rice (MV), Lentil+Mustard- Fallow- T.Aman rice (MV), Chickpea + lentil- Fallow- T.Aman rice (MV), Mustard+lentil- Fallow- T. Aman rice (MV), Wheat- T. Aus- T. Aman rice (MV), Potato- T. Aus- T. Aman rice (MV), Wheat- Mungbean – T. Aman rice (MV), Potato- Maize- T.Aman rice (MV), Boro (MV)-Fallow- T. Aman rice (MV), Tomato-Maize-T.Aman (MV), Tomato-T. Aus (MV)-T.Aman rice (LIV), etc. But in most cases, the crop growth and yields of T. Aman rice, Rabi crops like mustard, chickpea, potato, wheat and vegetables are moderate due to temperature variation (shorter cold period), high temperature/droughtiness, swelling/cracking of clays, hot wind in summer and fogginess(in winter) with increased incidence of pests and diseases (Figures 1-2). The main reason of changing crops/cropping patterns are given below:

- Changed/growing demands for food crops.
- Climate change, moisture stress and rainfall variability.
- Difficulties in land preparation due to swelling/cracking clays.
- Poor soil structure and poor soil fertility with dominance of cracking clays.
- Low SOM and deficiencies of N, P, K, S, Ca, Mg, B and Mo having lower CEC.
- Increased irrigation facilities in the drought prone areas.
- Expansion of agricultural technology and agricultural education.
- Increased demand of high value crops for getting cash money.
- Availability of improved seeds and fertilizers at farmers' level.

Figure 1: Drought in Barind area

Figure 2: Drought affecting T.Aman in drought area

Long- term Impacts of Climate Risks Affecting Crop Productions*:* During the study, time series data/information on land use systems, conversion of agricultural land, climatic parameters viz. erratic rainfall, changes in temperature, humidity, sunshine, day length, fogginess etc. land/soil data on different crops and crop performance and yield etc were collected and studied for assessing the yield trend of major crops.

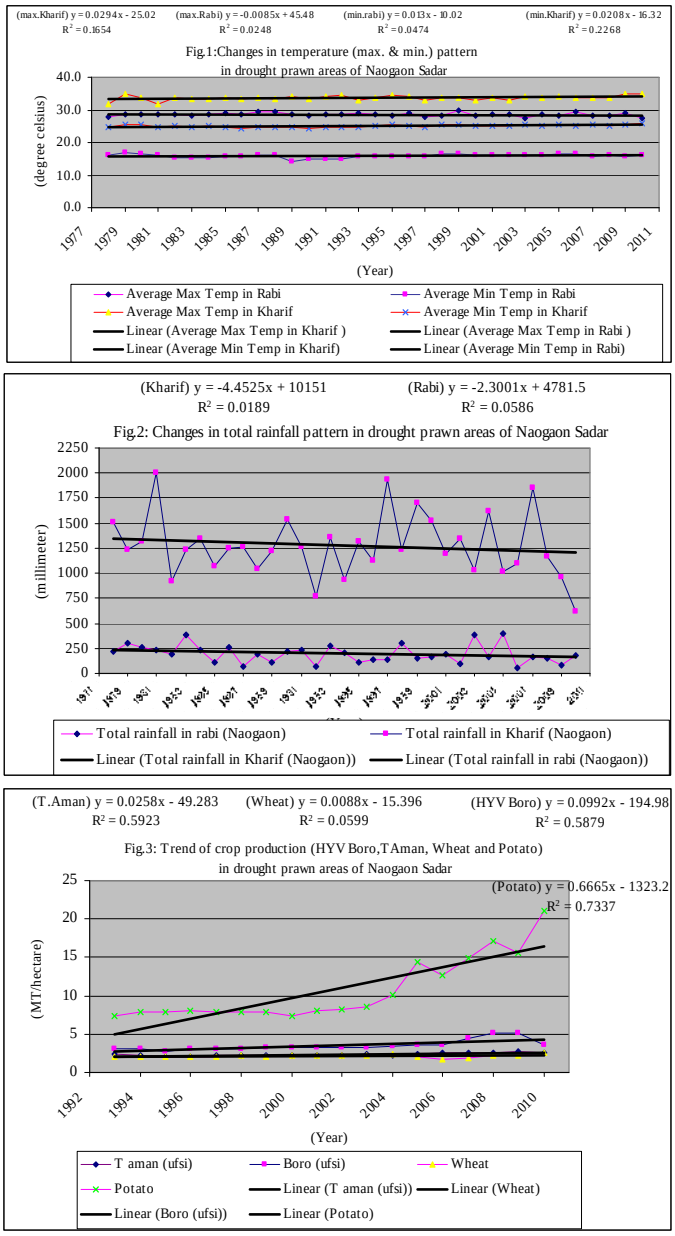
Temperature: There is an increasing trend of average max. and min. temperatures in rabi season that affecting rabi crops in drier areas of Barind/Naogaon. Temperature rise both in rabi and kharif seasons indicates a sign of global warming

Rainfall: Total rainfall patterns both in rabi and kharif seasons are decreasing that affecting the cultivation of rabi crops and rain-fed crops in kharif season in drier areas of Barind/Naogaon.

A summary of risk factors (viz. climatic risks, soil-related constraints and socio-economic problems) and production opportunities in agriculture productions in livelihood changes among different farm households (HHs) based on FGDs and HHs are given below (Table 2):

-Poverty Situations within Ullashpur Block, Naogaon Sadar have been assessed based on HHs land category, socio-economic livelihood and ARCAB Poverty Concept (Table 3).

-Income sources of different farm households (HHs) viz. landless, marginal, small, medium and large HHs in drought prone area of Ullashpur Block, Naogaon Sadar have been shown in Figures 6-10.



Figures 3-5: Changes in temp., total rainfall and trend of crop production at Naogaon Sadar

Landless, Marginal and Small Farm Households (HHs):

Main Climatic risks identified/assessed: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level in drier months, cold wave, fogginess, BPH, increased vulnerability etc

Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients (B and Mo), acidity etc

Socio-economic problems: land crisis, capital problems, low market access, illiteracy, labour problem, poor housing, poor health and nutrition.

Production Opportunities/Potentials:

a. High management
b. Use of balanced fertilizers
c. Use of organic manures and green manure
d. Innovative in nature (viz. mulching, priming, dry farming)
e. Drip irrigation, pond water harvesting

Small, Medium and Large Farm Households (HHs):

Major Climatic risks identified: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level, cold wave, fogginess, increased vulnerability etc

Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients (B and Mo), acidity etc

Socio-economic problems: no land crisis, no capital problems, higher production, high market access, educated, less labour problem.

Production Opportunities/Potentials:

a. Use of assets/capital in modern farming for higher outputs
b. Balanced use of fertilizers based on IPNS
c. Prefer integrated farming (crop, fisheries, livestock and poultry)
d. Entrepreneurships, business and market access
e. Prefers improved agriculture innovations
f. Facilities of drip irrigation, pond water harvest

Long-term Crop Productivity in Drought Prone Areas of Barind/Naogaon (Figure 5): The average yields of HYV Boro and HYV Potatoes showed an increasing trend because of high management at irrigated conditions, whereas the average yields of HYV wheat and HYV T.Aman showed a stagnancy trend because of short winter for wheat and droughtiness for T.Aman crop. In wheat cultivation, sterility of wheat causing serious yield reduction is being observed due to short winter period and temperature rise during flowering stage. There is a great prospect of introducing /promoting some potential innovative farming practices viz. zero tillage (maize), priming (chickpea), mulching (potato), relay cropping of sweet gourd in potato fields, homestead gardening, dry land farming, pond water harvesting etc for increased agriculture productions in drought prone areas of Naogaon, Bangladesh.

Table 2: Summary of FGDs/HHs Findings of Ullashpur Block, Naogaon Sadar under ARCAB (Agriculture) in assessing climate risk factors and production opportunities that affecting agriculture productions and livelihoods

Categories of Farmers/ HHs	# Family Members	Name of Mouza	Homestead (area in decimal)	Agril land (in decimal)	HH Monthly Income (Tk.)	HH Monthly Expenditure (Tk.)	Major risks(viz. climatic risks, soil-related constraints and socio-economic problems) facing by HHs in farming	Opportunities/ Productivity Potentials availed by HHs in farming	Remarks/ Livelihood changes
Landless Farmers	3-7	Ullashpur Kumuria Dash Paika Monsurpur Shaluka	5-30	0-49.40	5,800/- to 8,000/-	6,000/- to 9,000/-	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level in drier months, cold wave, fogginess, BPH, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity etc Socio-economic problems: land crisis, capital problems, low market access, illiteracy, labour problem, poor housing, poor health and nutrition.	-High management -Use of balanced fertilizers -Use of manures and green manure -Innovative in nature -Drip irrigation	-High risks -Lower production compared to needs of HHs -Less access to markets -Less asset/ capital
Marginal Farmers	3-7	Ullashpur Kumuria Dash Paika Monsurpur Shaluka	5-30	51.8-148.2	6,000/- to 11,500/-	6,000/- to 12,000/-	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level in drier months, cold wave, fogginess, BPH, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity etc Socio-economic problems: land crisis, capital problems, low market access, illiteracy, labour problem, poor housing, poor health and nutrition.	-High management -Use of balanced fertilizers -Use of manures and green manure -Innovative in nature -Drip irrigation	-High risks -Lower production compared to needs of HHs -Less access to markets -Less asset/capital
Small Farmers	4-6	Ullashpur Kumaria Mosiharpur Bhabanigati	20-30	150.67-247.0	8,500/- to 14,000/-	8,700/- to 12,500/-	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level, cold wave, fogginess, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity, land	-Use of manures and green manure -Innovative in nature -Zero tillage(potato, garlic, onion) cultivation -Mulching for moisture	-High risks -Lower production compared to needs of HHs -Less access to markets -Less asset/capital

							degradation etc Socio-economic problems: low market access, low commodity price, unavailability of quality seeds and fertilizers, lower input use, labour crisis, poor housing, poor health and nutrition.	conservation	
Medium Farmers	5-8	-Ullashpur - Bhabanigati -Shaluka	20-35	249.47-741.0	10,500/- to 24,000/-	9,500/- to 16,000/-	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level, cold wave, fogginess, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity Socio-economic problems: no land crisis, no capital problems, higher production, high market access, educated, less labour problem.	-Use of assets/capital in modern farming for higher output -Balanced use of fertilizers -Prefer integrated farming(crop, livestock and poultry) -Facilities of drip irrigation, pond water harvesting	-Lower risks -Higher agril productions -Higher market access -Have opportunities of assets/ capital in production systems/ improved innovations.
Large Farmers	4-7	Ullashpur Bhabanigati Shaluka	20-40	743.47-above	20,500/- to 50,000/-	18,000/- to 36,000/-	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level, cold wave, fogginess, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity Socio-economic problems: available land, enough asset/capital for production systems, higher market access.	-Use of assets/capital in modern farming for higher output -Balanced use of fertilizers -Prefer integrated farming(crop, livestock and poultry) -Facilities of drip irrigation, pond water harvesting	-Lower risks -Higher agril productions -Have opportunities of assets/ capital in production systems. -Higher market access to city market/ super market

Table 3: Assessment of Poverty Situations within Ullashpur Block, Naogaon Sadar based on HHs land category, socio-economic livelihood and ARCAB Poverty Concept

Farm HHs based on land category*	Farm HHs based on CBN/Socio-economic Livelihoods**	Poverty Situations of Farm HHs based on ARCAB/Dev. in Practice Concept***	Major Risks(climatic risks, soil-related constraints and socio-economic problems) facing by HHs in farming	Opportunities/ Production Potentials
Landless HHs Marginal HHs	Ultra Poor Poor	Hanging in	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering of ground water level, cold wave, fogginess, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity etc Socio-economic problems: land crisis, capital problems, low market access, illiteracy, labour problem, poor housing, poor health and nutrition.	-High risks -Lower agril productions compared to HHs needs -Less access to markets -Low farm income -Less asset/capital
Small HHs	Lower Middle Class	Stepping up	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level, cold wave, fogginess, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity, land degradation etc Socio-economic problems: low market access, low commodity price, unavailability of quality seeds and fertilizers, lower input use, labour crisis, poor housing, poor health and nutrition.	-Lower risks -Higher farm income -Less asset/capital compared to needs -Knowledge/Skill of Integrated Farming/ improved innovations -Higher market access
Medium HHs	Middle Class	Stepping up	-Climatic risks: above -Soil-related constraints: above -Socio-economic problems: skilled labour crisis during planting and harvesting, storage problems, lower market price, problems in skilled manpower in integrated farming (crop, fisheries and livestock etc)	-Lower risks -Higher farm income -Have opportunities of asset/capital in production systems/improved innovations -Higher market access
Large HHs	Upper Middle Class or Rich	Stepping out	Climatic risks: drought, erratic rainfall, moisture stress, untimely and excessive rainfall, lowering ground water level, cold wave, fogginess, increased vulnerability etc Soil-related constraints: swelling and cracking clays, soil wetness, tillage problems, low fertility, low SOM, deficiencies of Ca, Mg and micro-nutrients, acidity etc Socio-economic problems: problems for balanced feeds, higher market access.	-Lower risks -Higher farm income -Have opportunities of asset/capital in production systems/improved innovations -Higher market access to city market/ super market -Wider scope of development.

*Farmers' Category based on agricultural land

Farmers' Category	Agricultural land (in hectare)	Remarks
1.Landless Farm Households (HHs)	0.00- 0.20 hectare	Mainly agricultural land for producing crops and homestead spaces available for horticultural crops
2.Marginal Farm Households (HHs)	0.21- 0.60 hectare	-do-
3.Small Farm Households (HHs)	0.61- 1.00 hectare	-do-
4.Medium Farm Households (HHs)	1.01- 3.00 hectare	-do-
5.Large Farm Households (HHs)	3.01 hectare- above	-do-

Source: DAE, 2002

**Farmers' Category based on CBN/Socio-economic Livelihoods

Farmers' Category/Poverty Situations	Criteria	Remarks(mentioned in sources)
1.Ultra Poor Farm Households (HHs)	Cost of basic needs (CBN)	BBS Source using CBN
2.Poor Farm Households (HHs)	-do-	-do-
3.Lower Middle Class Households (HHs)	-do-	-do-
4.Middle Class Households (HHs)	-do-	-do-
5.Upper Middle Class or Rich Households (HHs)	-do-	-do-

Source: Bangladesh Bureau of Statistics (BBS) using the Cost of Basic Needs (CBN) method as the standard method for estimating the incidences of poverty, 1995-96. The quantities in the basket (eleven food items) are scaled according to the nutritional requirement of 2,122 kcal per person per day. For estimating the poverty incidence with HIES data, several points viz. up-to-date data on food items etc should be considered.

*** Livelihood Aspirations and Strategies of the Poor

Farmers' Category/ Poverty Situations	Criteria/Determinants	Remarks
1.*Hanging in* Farm HHs	Assets are held and activities are engaged in to maintain livelihood levels, often in the face of adverse socio-economic circumstances.	-HHs struggle to maintain precarious and vulnerable livelihoods. -crop-based activities -local economy is stagnant
2.*Stepping up* Farm HHs	Current activities are engaged in, with investments in assets to expand these activities, in order to increase production and income to improve livelihoods (an example might be the accumulation of productive diary livestock).	-Higher natural resource -Higher production based on crop based and livestock based farming -Market opportunities.
3.*Stepping out* Farm HHs	Existing activities are engaged in to accumulate assets which in time can then provide a base or 'launch pad' for moving into different activities that have initial investment requirements leading to higher and /or more stable returns.	-More favoured areas with better natural resource potential and market access. -High non-farm income -Longer term successful agricultural development.

Figures 6-10: Income sources of different farm households (HHs) viz. landless, marginal, small, medium and large HHs in drought prone area of Ullashpur Block, Naogaon Sadar

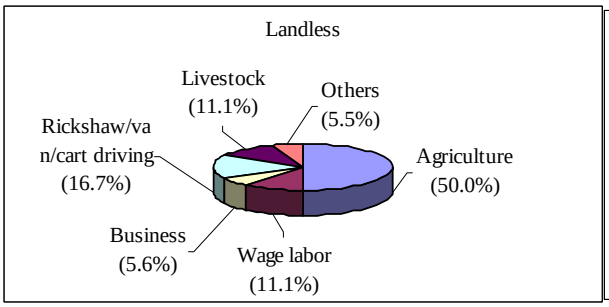


Figure 6: Landless Farm HHs

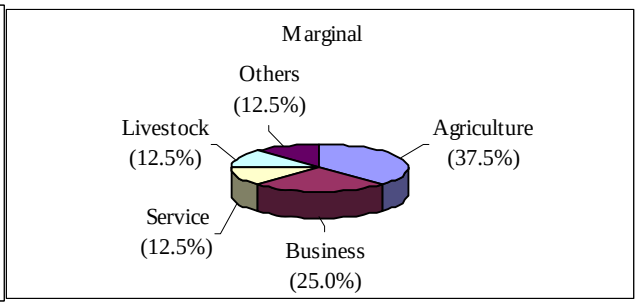


Figure 7: Marginal Farm HHs

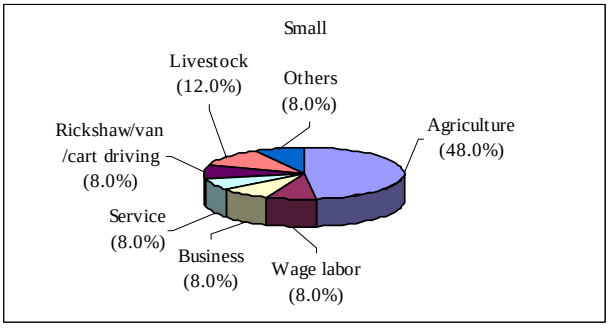


Figure 8: Small Farm HHs

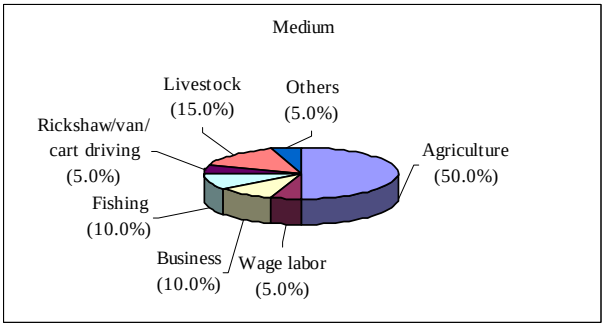


Figure 9: Medium Farm HHs

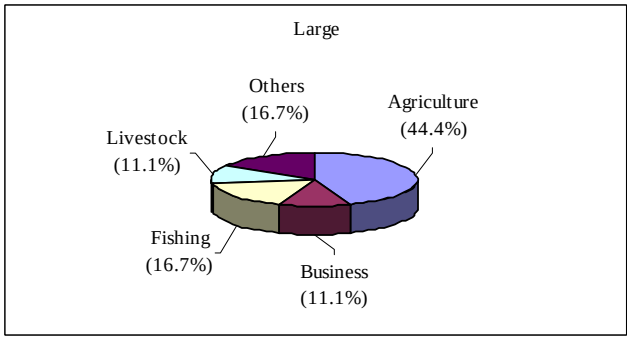


Figure 10: Large Farm HHs

Findings/Comments on Farm HHs Income based on household survey: Farm HHs income sources and concerned livelihood options/changes of landless HHs are mainly dependent on agriculture productions, rickshaw/van driving and some livestock rearing, agriculture with some small business and livestock for marginal farm HHs, mainly agriculture productions and livestock rearing for small farm HHs whereas modern agriculture/integrated farming viz. crop, livestock and fisheries, with business entrepreneurship and wider market access are identified as potential sources of household incomes and livelihood options among medium and large farm HHs . Crop loss or yield reductions (30-80%) of major crops due to climatic risk factors have been shown in Table 4.

Table 4: Climatic risk factors affecting crops/cropping patterns in drought prone areas of Ullashpur Block, Naogaon Sadar

Vulnerable Areas	Climatic risks/ variability and consequences on environment	Crops affected	Stages of crops	Yield reduction (%)
Drought	-High temperature -Very low temp -Short cold period	Rainfed Crops Wheat, Potato, Mustard, M.bean	Grain filling stage and pod formation	30-70%
	-Droughtiness, Low rainfall -Soil compaction/ cracking -Hot/stormy wind	T. Aman, Maize	Tillering and grains filling stage seedling establishment	40-80%
	-Fogginess -Shorter cold period -Boron deficiency -Erratic and low rainfall	Potato, Mustard, Mung bean, Chickpea, Vegetables, T.Aman	Tuberization, Pod formation Seedlings establishment tillering and grain filling	50-60% 30-50%
	-Scarcity of irrigation water -Lowering ground water level -Soil cracking	Irrigated Boro, T. Aus	Tillering and grain filling	30-40%
	-Salinity intrusion -Scarcity of fresh water -Increased salinity in coastal char lands	Irrigated Boro (MV) T. Aus	Tillering and grain filling stage	30-50%

Incidences of Pests and Diseases on Crops/Cropping Patterns in Project Sites: Survey and discussions with concerned field level scientists, extension officers and farmers ventilated that the incidences of insects/pests and diseases on field crops have been increased due to impact of climate change. A summary of incidence of pests and diseases is described in Table -5.

Table -5: Incidences of pests and diseases of crops due to climatic vulnerability in drought prone areas of Ullashpur Block of Naogaon Sadar

Vulnerability	Crops	Pests/ diseases	Causes	Trend of incidences
Drought	T. Aman rice	Sheath blight	-Susceptible variety	Increasing
	Wheat	Rust	-Fluctuating temperature, rainfall and humidity	Not consistent
	Chickpea, Mungbean	Pod borer, root rot	-Due to increased tem	Increasing
	Mustard, Linseed	Aphids, alternaria blight	-Due to temp. variation and low pH	Increasing
	Guava, Mango	Fruit borer, anthracnose	-Due to temp. variation and low pH	Increasing

Identification of Sustainable Innovative Practices/Adaptation Options: To cope up with these dreadful evils of climate risks, farmers through their location specific indigenous knowledge have, with error and trials, developed some means/innovative practices over the years. The scientists with their institutional knowledge have also developed/improved some technologies/innovative practices for adaptation to these natural hazards. In the recent years, climate has become more furious to affect loss to crops, lives and infrastructures in mass scale.

Adaptation Practices: Adaptation to climate change takes through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological and human systems. In involves changes in social and environmental processes, perception of climate risks, practices and functions to reduce potential damages or to realize new opportunities.

Suggestions

i. Sustainable: Sustainable development13 will ensure that we are best placed both to minimize the threats posed by the impacts of climate change and to capitalize on potential opportunities presented by it.
ii. Proportionate and integrated: Assessing climate risks should become 'business as usual' and part of normal risk management. Action must relate to the level of risks and the desired outcomes and will need to be taken at the most appropriate level and timescale.
iii. Collaborative and open: Adapting to climate change is a challenge for the whole of our economy and society and will require action from a range of individuals and organizations, within and across sectors working together.
iv. Effective: Actions should be context specific, implementable and enforceable. They should incorporate flexibility to adjust to a range of future climate scenarios, as well as socio-economic, technical and other changes.
v. Efficient: Actions should weigh costs, benefits and risks involved. Measures should be timed appropriately.
vi. Equitable: The distributional consequences of different options should be considered to inform decision makers of the effects of the activity on the natural environment and different social groups, especially vulnerable ones, to ensure that individuals or groups do not bear a disproportionate share of those costs or residual risks.

Identification/Delineation of Innovative Practices in drought prone areas: During survey/FGD and HHs conducted at Ullashpur Block, team members have identified and documented some sustainable innovative farming practices with delineation of the vulnerable areas (Table 6) from different innovative farming practices. Because

- People are to live with these climatic vulnerabilities. Efforts should be made to retain the people in their own ecological systems to adapt to these climate vulnerabilities following innovative farming practices.
- In the drought prone areas, soils are kept fallow during winter and Kharif-I season after harvest of T.Aman due to moisture stress and heavy clays/cracking clays. Zero tillage (maize), mulching (potato), pond water harvest, priming (chickpea) and relay cropping are identified as promising innovative/adaptation options.

Table 6: Estimated Areas of Innovative Practices/Adaptation Options under Vulnerable Areas of Drought under Ullashpur Project Location

Locations of vulnerable areas	Total vulnerable areas(ha) deleneated	Identified/selected suitable practices for extrapolation through conduction of demos	Suitable crops and season
Drought Prone Area Naogaon Sadar,	460.00 ha	i) Zero tillage ii) Mulching iii) Priming technique	i) Maize in rabi season ii) Potato in rabi season iii) Chickpea and lentil in rabi season

Locations of vulnerable areas	Total vulnerable areas(ha) deleneated	Identified/selected suitable practices for extrapolation through conduction of demos	Suitable crops and season
Naogaon -Ullashpur Block		iv) Relay cropping v)Pond water/rain water harvesting technique vi) dry land farming	iv) Relay cropping of sweet gourd in the fields of potato, tomato in Kharif-I season. v) Vegetable cultivation vi) Dry land cultivation of sesame

Improvement of Innovative Farming Practices with Science Based Knowledge: Traditional/innovative farming practices have been improved/upgraded through incorporation of science based knowledge and production strategies. Examples are: selection of suitable HYV crop varieties (viz. drought tolerant/salt tolerant varieties, submergence varieties, short duration varieties, right time of sowing/planting, planting techniques, minimum/zero tillage, priming of seeds, mulching for soil conservation, rain water/pond water harvesting technique, dry farming, relay cropping, balanced use of fertilizers (combined use of chemical fertilizers and organic manures/cowdung/composts) based on soil testing and IPNS concept, use of organic pesticides, post harvest technology, storage facilities, profitability, training needs of farmers, road network and marketing facilities, employment opportunities, involvement of women in homestead gardening and integrated farming, farmers' association, entrepreneurship development for value added products etc. Summarized results of some adaptive trials conducted in vulnerable areas of droughts/Barind Tract (2008-20013) are shown below (Table 7):

Table 7: Results of adaptive trials conducted in drought prone areas of Naogaon Sadar during 2008-2013.

Adaptive Trial on Innovative Practices	Crop/Variety	Average Yield (t/ha)		% Yield Increase due to improved innovations
		Innovative Practice	Improved Innovative Practice	
Zero tillage (maize) with mulching	BARI hybrid Bhutta-5	6.50	8.30	27.69
Priming (chickpea) technique	Chickpea (BARI Chhola-5)	0.80	1.20	50.00
Mulching (potato) technique	Potato (var. Cardinal)	16.50	21.30	29.09
Relay cropping of sweet gourd in potato fields	Sweet gourd (var. Misti Kumra-1)	6.50	8.00	23.08
Cultivating winter vegetables (tomato) using pond water	Tomato (var. BARI Tomato-3)	20.00	26.50	32.50
Dry land farming (sesame)	Sesame (BARI Til-3)	0.80	1.10	37.50

During field visits and conduction of FGDs and HHs, Block Farmers were found happy to get the highest crop yields in their plots of improved practices e.g. suitable HYV varieties, right time of sowing/planting, mulching, combined use of chemical fertilizers and organic manures based on IPNS etc. of innovative practices (viz, zero tillage, priming, mulching, dry land farming, relay cropping, pond water harvest etc) Major benefits of innovations were found during FGDs and HHs (Figure 9), agriculture innovations viz. use of organic fertilizers, mulching and dry land farming practices are being practiced by landless, marginal and small farm HHs whereas combined use of chemical fertilizers and organic manures based on IPNS, mulching, green manuring, zero tillage, priming and relay cropping practices are being followed by small, medium and large farm HHs for increased agriculture productions and improved

livelihoods. However, block farmers prefer agriculture innovations in order of priority like: balanced fertilizers>mulching>organic fertilizers>priming>green manuring>zero tillage>dry land farming>relay cropping>pond water harvest etc irrespective of farm households (HHs) for their increased agriculture productions in the drought prone areas of Naogaon Sadar (Figure 11). High lights/benefits of improved innovative practices are given below:

- Higher crop yields and quality produces were obtained with increased cropping
- Timely sowing/planting and land preparation cost is reduced
- Less loss of added fertilizers and efficient utilization of nutrients obtained
- Overall fertilizer/nutrient efficiency is increased due to combined use of chemical fertilizers and organic manures based on IPNS concept.
- Soil moisture is conserved and less irrigation is required
- Residual soil moisture and fertilizers use are efficiently utilized with low emissions of GHGs under improved innovative practices.
- Climate risks are reduced.

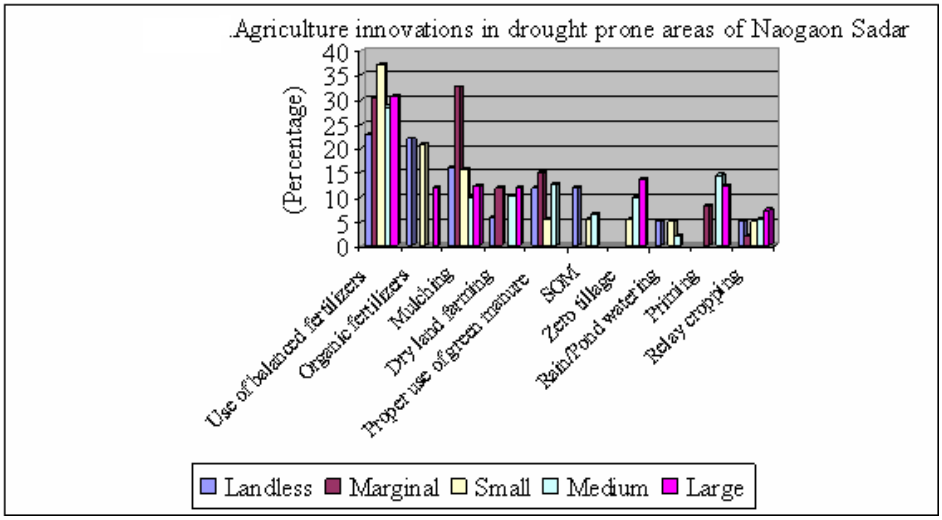


Figure 11: Agriculture innovations being followed by different farm households (HHs) for increasing agriculture productions and improved livelihoods in drought prone areas of Ullashpur Block, Naogaon Sadar

Livelihood Changes due to Climate Risks: Livelihoods involve the use of assets (viz. land, capital, machinery, higher inputs, quality seeds, market access etc) in different activities to produce outputs (viz. agricultural productions, livestock, fisheries etc), both to meet people's consumption requirements and aspirations and to invest assets and activities for the future. Study showed that high climate risks, lower agriculture productions compared to needs of farm HHs, less access to markets and less asset/ capital opportunity have been identified as barriers of poverty situations of landless, marginal and small households (Table 2 and 3 and Figures 4-8) in project area. On the other hand, lower risks of capital, higher agricultural productions with proper inputs, higher market access, opportunities of assets/ capital in production systems have been considered/identified as production opportunities with higher income among medium and large farmers at Ullashpur Block although Climatic risks are almost same. Let us now show a simple illustration of the application of the framework to consideration of the role and nature of livestock keeping in the livelihoods of poor people. An important question here concerns the contribution that livestock keeping makes to the livelihoods of poor people. In contributing to a 'hanging in' livestock keeping

commonly has four important functions providing for subsistence consumption (through home consumption of meat, milk, eggs or fibre), supporting complementary (commonly cropping) activities (providing draught power and/or manure), buffering against seasonality in income from other activities (for example, cropping activities or seasonal labour); and providing some assets for insurance against unpredictable demands for cash. Beyond these minimum minimal maintenance functions, livestock keeping may enable advancement through accumulation either of more productive animals (the 'stepping up' strategy) or of a set of assets that hold value as savings to be used to 'buy in' to other assets needed to gain entry to other livelihood activities (the 'stepping out' strategy). Whatever the market and natural resource potential of an area, very poor people are likely to consider 'hanging in' strategies to be important as they struggle to maintain precarious and vulnerable livelihoods. Different activities in these 'hanging in' strategies are likely to vary with the agro-ecological natural resources and market opportunities in the area and with their particular assets (such as land, capital, animals, skills and social constraints). Where natural resources or agro-ecological potential is low and local economy (and hence market) is stagnant, conditions will be very difficult, but livestock keeping may play a particular important role in 'hanging in' strategies because of greater/wider opportunities. Under conditions of higher natural resource potential, crop farming may be more important to poor people's livelihoods (working either on their own farms or on the farms of others).Greater security and more reliable (less risky) and faster accumulation may be more important goals, achieved through disease control, or more effective utilization of feed resources. With stagnant local markets, greater agricultural productivity may offer few livestock-based or crop-based opportunities for 'stepping up', unless there are communications and linkages to support 'exports' to more distant markets. A more dynamic local economy, on the other hand, with greater local market opportunities, should allow stepping up and stepping out to focus on both farm and non-farm local opportunities, rather than on migration or 'exports' to more distant markets. In more favoured areas, with better natural resource potential and market access, agriculture is important for hanging in and, in the short to medium term, provides opportunities for some people to step up or to accumulate resources for stepping out. Policy needs to support these different strategies, recognizing that in the longer-term successful agricultural development will lead most people to 'step out'.

This initial study has identified the major risk factors viz. climate risks, soil-related constraints and socio-economic problems that affecting agriculture productions at different farm households and also identified/shown the possible production opportunities of agriculture innovations including other ways of farm income (integrated farming and business) for increasing their overall agriculture productions and household income for attaining food security and improved livelihoods. This study simply highlights / integrates multi-dimensional, multi-level and dynamic understandings of poverty, of poor people's livelihoods and of changing roles of agricultural systems with introduction of improved agriculture innovations in drier areas of project site of Naogaon Sadar. A detailed study (5-year project) is needed for making location-specific production plan of improved agriculture innovations and their successful implementation at farm level following concept of Community Based Adaptation Agriculture for increased agriculture productions in attaining food security and improved livelihoods based on soil-crop-climate suitability.

CONCLUSION

This study is a primary step of assessing different climate risk factors that affecting agriculture productions and livelihoods of vulnerable farming community of drought prone areas of Naogaon, Bangladesh and tries to integrate the central themes of a multi-dimensional, multi-level and dynamic understanding of poverty and of the livelihoods of poor people. Both policy analysis and participatory work

with poor people could benefit from adoption of this framework and adaptation practices/options. This study can help participatory work with poor people by promoting innovative farming practices with greater attention to and considerations of longer-term aspirations, opportunities, constraints and activities in stepping out, in addition to the more short- to medium-term consideration of opportunities and constraints in 'hanging in' and 'stepping up' activities. Conclusions of this study are more study is needed for making location-specific production plan of Improved Adaptation Agricultural Practices based on soil-crop-climate suitability through proper assessment of soil-related constraints, climate risks and socio-economic problems presently affecting crop production systems and livelihood of the vulnerable people of the drier region and livelihood strategic options. There are many risk management non-farm activities but now they are becoming less common and climate change may push these practices further and may create unemployment. There will be a change in livelihood pattern of the farming community in the vulnerable areas of drought. The successful implementation at farm level concept of Community Based Adaptation Agriculture for increased agriculture productions in attaining food security and improved livelihoods of vulnerable farm households based on soil-crop-climate suitability through proper assessment of soil-related constraints, climate risks and socio-economic problems that presently affecting crop production systems and livelihood of the vulnerable people with a Pilot Project on Improved Innovative Practices as Block Farming may be initiated in the vulnerable areas of drought in Bangladesh for increased agriculture productions and better livelihood.

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CONFLICT OF INTEREST : Nothing