Report on

Option Menu for Livelihood Adaptation to Climate Change and Extension Tool Development

Climate Change Impact Assessment and Livelihood Adaptation Options in Drought Prone Areas

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1. INTRODUCTION

Droughts are very frequent in Bangladesh due to its geo-physical position and varying rainfall pattern. They are considered devastating and causing substantial damage and loss to agriculture and allied sectors. Droughts are associated with either late arrival or early withdrawal of monsoon rains and some times complete failure of monsoon. Drought impacts are spread over a larger geographical area than are damages that result from other natural hazards. Like floods, Bangladesh is also vulnerable to recurrent droughts. After 1971 Bangladesh has experienced droughts of major magnitude in 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994, and 1995. Although droughts are not always continuous in any area, they do occur sometimes in the low rainfall zones of the country. As listed above, Bangladesh experienced consecutive droughts in 1978-1979, 1981- 1982, and 1994-1995. The droughts of 1994-95 in the northwestern districts of Bangladesh led to a shortfall of rice production of 3.5 million tons.

As experience in the 1978-79 drought showed, drought can be as dramatic in its results as a major flood or cyclone. The total amount of foodgrain production lost in the 1978-79 drought was probably 50-100 percent more than was lost in the great 1974 flood. Foodgrain off-take through the ration and relief systems averaged 227,000 tons per month in June-November 1979 compared with 169,000 tons per month in June-November 1974. Rice, jute and other crops suffered severely. Jute suffered additionally because of the lack of water for retting. Livestock suffered from lack of fodder, and many farmers had to sell their cattle at distress prices for this reason and because of their need for cash with which to buy food at high scarcity prices. The human distress resulting from reduced crops, reduced employment and incomes, and increased food prices was widespread and considerable.

Drought adversely affects rice crop in three different seasons, which accounts for more than 80% of the total cultivated area in the country. Droughts in March-April prevent land preparation and ploughing activities from being conducted on time, delaying planting of crops during monsoon season. Inadequate rains in July - August delay transplantation of Aman in highland areas, while droughts in September and October reduce yields of both broadcast and transplanted Aman and delay sowing of pulses and potatoes. Boro, wheat and other crops grown in the dry season (summer) are also periodically affected by drought.

Increased climate variability is additional threats in drought-prone environments, and also one of the major factors of crop production risk. It forces farmers and other dependent rural livelihoods to depend on low input and low risk technologies. Non-adoption of new technologies to derive maximum gains during favourable seasons delays recovery after disasters. The investment made for poverty reduction efforts could not lead to sustainable development especially in high risk areas. Increasing climate risks undermine development efforts in drought prone areas and aggravate rural poverty.

Future climate change would aggravate these problems even further in drought-prone environments. The impacts of climate change on agricultural production are global concerns, however, they are particularly distinct for Bangladesh as agriculture is the largest sector of economy, accounting for about 35% of the GDP and about 63% of

the labor force. Agriculture in Bangladesh is already under pressure both from increasing demands for food, and from problems of agricultural land and water resources depletion, through overuse and contamination. The current climate variability and projected future global climate change makes the issue particularly urgent.

Adapting to climate change is one of the approaches targeted to reduce the impacts due to low frequency long-term changes in climate variables. Adaptation is a process by which strategies to moderate, and cope with the consequences of climate change, including climate variability are enhanced, developed, and implemented. Obviously, many countries are already adapting to current climatic events at different spatial scales – National, Provincial/State, district and local levels, and over different time frames – short term, mid-term, and long-term. Many structural/physical and institutional adaptation mechanisms have been implemented in the past through conventional top-down approach. However, they lack community participation and livelihood focus. Developing adaptation strategy also requires a vision that balances the need to reduce climate change impacts with any constraints in national policy making processes.

In order to increase the resilience at all levels, from National to community and to reduce damage and losses from natural disasters, the Government of Bangladesh has approved the Comprehensive Disaster Management Program (CDMP) in 2003 as a key strategy to advance whole-of-government and agency risk reduction efforts in the country. The CDMP is among other thrusts also addressing the risks associated with climate variability and change, including livelihood adaptation to climate change.

CDMP is a strategic institutional and programming approach that is designed to optimize the reduction of long-term risk and to strengthen the operational capacities for responding to emergencies and disaster situations including actions to improve recovery from these events. However, efforts were also taken up to combat long-term climate change impacts by designing and promoting livelihood adaptation strategies in the agricultural and allied sectors which may help to reduce vulnerability to climate change, particularly amongst women and poor communities who have the lowest capacity to adapt.

Within the broader framework of climate change adaptation, the report provides comprehensive processes followed to develop viable adaptation options for drought prone areas of Bangladesh. The complete steps including assessment of current vulnerability, coping strategies and future climate-related risks and adaptation strategy will be presented as part of the final report.

2. METHODOLOGY FOR ESTABLISHING ADAPTATION OPTION MENU

The drought-prone pilot locations were identified in two districts (Chapai Nawobgonj and Naogaon) in north western Bangladesh. The criteria considered for selecting the pilot study locations are: (i) primarily drought prone[1] area (moderate to severe) (ii) subsistence small scale agriculture as a major livelihood activity.

Two upazillas (Gomestapur and Natchole in Chapai Nowobganj; Porsha and Sapahar in Naogaon) in each of the identified district were selected. Three villages have been identified in each of the four selected upazillas. Care was taken to select three villages from each upazilla with one being irrigated and remaining two being completely rainfed. The irrigation for these villages is made possible through deep tube wells installed by Barind Multi-purpose Development Authority (BMDA). The adaptation option menu for drought risk management considering future climate change impacts has been prepared for the pilot locations.

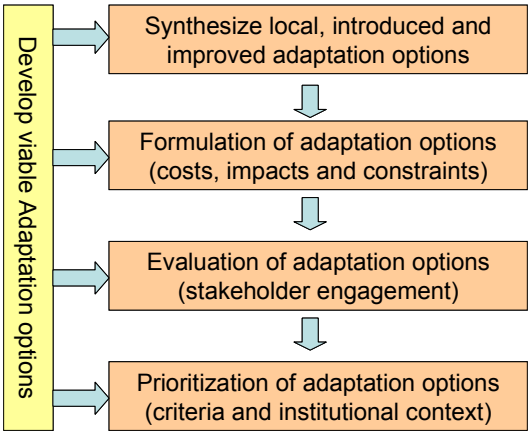

Fig.1. Sequential tasks in developing viable adaptation options for drought-prone areas

An adaptation option menu development refers to identification, synthesis, evaluation and prioritization of viable adaptation options for managing drought risks by employing criteria, prioritization tools and stakeholder engagement. The purpose of this component is to synthesize all the adaptation practices that can direct adaptation action. This process generally includes four major generic tasks, as presented in Figure 1. These are: (i) synthesis of local, introduced and improved adaptation options (ii) identification and formulating adaptation options based on the constraints and opportunities (iii) selecting and prioritizing adaptation options and (iv) formulating an adaptation option menu. The above steps matches well within the overall adaptation policy framework proposed for the country as a whole. The detailed activities and processes followed are presented in Fig.2.

[1]The term 'drought prone' is often used loosely and ambiguously. In Bangladesh it is sometimes used to refer to the driest parts of the country – the 'dry zone' – where the mean annual rainfall and short length of rainy season impose restrictions on agricultural production (Brammer, 1999)

The outputs of the viable adaptation options is developing a menu of adaptation option itself, including recommendations for the development planning process and potential integration into the institutional agenda. The adaptation option menu is an input and catalyst for demonstrating viable adaptation options to improve the adaptive capacity of the rural livelihoods to climate change.

2.1 Assessment and synthesis of adaptation practices

The general approaches were used to assess the impact of past and current climate hazards[2] in agriculture sector and local adaptation practices. The local adaptation practices followed by the community to minimize the impact of natural hazards like drought were documented through employing participatory rural appraisal methods. The most convenient method followed for documentation was focus group discussions[3] in selected 12 villages. The time line analysis[4] was followed where ever necessary to understand the past impacts of climate variability and adaptation practices. The seasonality diagramming[5] was used to identify the crops and other enterprises, which are exposed to climate related hazards and possible adaptation practices at a specified time in a year.

Adaptation practices introduced by national development, research and extension organizations to manage drought were also documented from the respective organizations. Short seminars were organized in local research organizations to introduce about the project activities and also to exchange views about the recent adaptation practices for drought risk management.

2.2 Formulation of adaptation options

A subjective assessment has been used to formulate adaptation options for future evaluations. The most important aspects considered for formulation of adaptation options are cost of implementation, possible future impact and constraints in accessing and implementing the adaptation practices at local levels.

2.3 Evaluation of adaptation options

The identified local adaptation practices along with adaptation practices documented from other similar areas in this region were validated with National level Technical Implementation Working Group (NTIWG) and Upazilla level Technical Implementation Working Group (UTIWG) members and other relevant national institutions. The NTIW'G and UTIW'G were formed as part of the project involving representatives from various relevant organizations at various levels to facilitate and involve in the implementation process. The guidance and collaboration was given to

[2] Climate hazard is a potentially damaging physical event or phenomenon (hydrometeorological) that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

[3] Focus group discussion is a powerful tool to explore a focused issue through well facilitated discussions. The topic would be introduced to the participants and participants will be asked to discuss the issue.

[4] time line analysis provides a historical perspective of the major events that have occurred in the village and their impact upon the lives of the community.

[5] Seasonality diagramming shows seasonal concerns of farmers including crop cycles and seasonal weather issues.

the national research and extension institutions (eg.DAE) to develop technically viable agricultural practice menus depending on the local conditions like climatic and non-climatic risks.

The institutional aspect of the approach is maintaining a collaboration and involvement of various international, national and local institutions through constant input to Sub-Component Manager (SCM) attached with Department of Agricultural Extension (DAE). Strong linkages with co-operating partners like Department of Environment (DoE) and United Nations Development Program (UNDP) were maintained throughout the process.

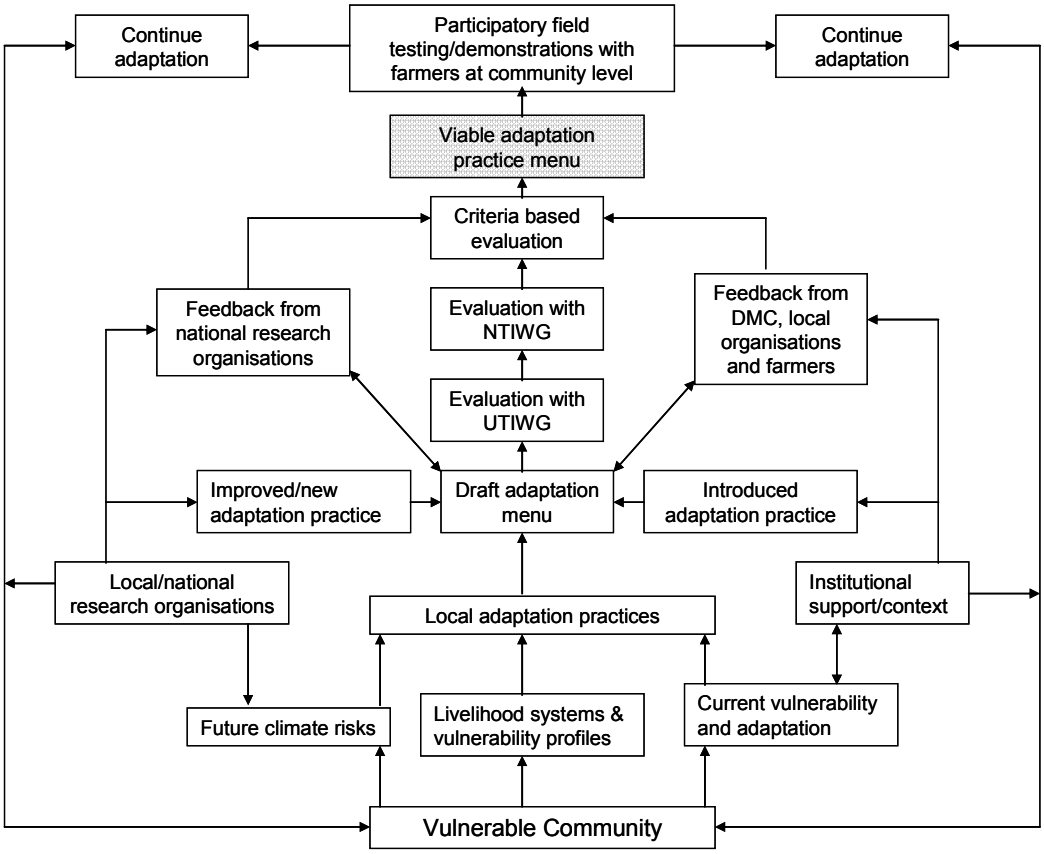

Fig 2. Overall framework describing activities and process of selection, evaluation and prioritization of adaptation practices for drought-prone areas in Bangladesh

2.4. Prioritization of viable adaptation options

Adaptation options were listed through a sequence of evaluation process at different levels starting from Upazilla level DMC members, Upazilla Technical Implementation Groups (U'TIWG) and National level Technical Implementation Working Groups (N'TIWG). Consultative meetings and brief feed back workshops were also organized with the local research institutions (BARI and BRRI) and developmental organizations.

The task of prioritization of viable adaptation options involves selecting adaptation practice which is able to satisfy the general criteria. The criteria need to be context

specific based on the type of problem and future expectations. Initially, environmental friendliness and cost effectiveness were the only two important criteria considered for documenting draft menu of adaptation practice. The objective of the second task is to derive priorities among the array of adaptation options and measures. This will generally be done using selected criteria and prioritization methods. The output of the task is to rank list of adaptation options.

This task involves selecting and applying prioritization methods. In view of the diversity of climate change adaptation options, there will probably be a need to use more than one method to review all choices. Here we used a four stage process to prioritize viable adaptation options:

- environment friendliness and qualitative cost benefit analysis
- evaluation of adaptation options for their technical suitability
- multi-criteria analysis
- expert judgment

The adaptation options were evaluated with the UTIWG and NTIWG for its technical suitability for drought prone areas. The outcome of the stakeholder evaluation was integrated into the multi-criteria analysis. The criteria identified and followed for multi-criteria analysis are as follows.

1. Drought mitigation (potential to reduce the impact of drought in-terms of resource and economics)
2. Suitability under future climate change (suitability for future climate change scenarios such as high temperature, frequent dry spells, high evaporation etc.,)
3. Environmental friendliness (less impact on the environment interms of deteriorating quality of resources and its secondary impacts)
4. Economic viability (cost effectiveness, low cost and more cost: benefit ratio)
5. Increased productivity (capacity to improve the overall productivity per unit area)
6. Sustainability (long-term effectiveness and capable of continuance after the project)
7. Social acceptability (preference of the community in all sections)
8. Gender integration (capacity to give more role for women due to the particular adaptation practice)
9. Household income (capable of increasing household income on continuos basis)
10. Employment opportunity (year round employment opportunity for the family members)
11. Relevant to vulnerable community (relevancy of the adaptation practice to vulnerable communities such as small farmers, wage labours and small businessman)
12. Applicability to multiple sectors (applicability of the adaptation practice to sectors such as agriculture, livestock, fisheries, forestry and water resource management)
13. Relevant to drought prone season (relevancy of the adaptation practice to drought-prone kharif II season)
14. Immediate need (matching the adaptation practice to local community's immediate need)

15. Institutional support (support from government policy and local institutions to take up a particular adaptation practice)
16. Expert's acceptance (feedback from the evaluation workshop organized at Upazilla and National level)

The potential adaptation measures identified were then used in discussions with key stakeholders from each sector to determine their relative feasibility based on the following criteria:

- Effectiveness of the measure to reduce key risks
- Feasibility considering the technical aspects as well as costs, social acceptance and manageability
- Current state of implementation and requirements of improvements (referring to how they are being practiced in the country with or without consideration of climate change)

2.5 Update of the adaptation options menu

The options menu will be updated regularly by (i) addition of new innovative adaptation practices when ever possible/available and (ii) making regular changes to the individual adaptation practices based on the field level experience during pilot demonstration processes. Methodologies for implementation will be updated based on the feedback from various institutions involved in the demonstration process and also from the local community.

2.6 Adaptation options: Dissemination, pilot testing and extension strategies

The impacts of climate hazards were translated into a menu of good practices and these practices need to be tested at pilot locations for their acceptance. The sequential steps followed are:

- understand the impact of anticipated climate change on agriculture sector in the pilot study locations through desktop analysis and local perceptions.
- develop technically viable agricultural practice menu in collaboration with the national research institutions.
- monitor pilot testing by farmers (demonstrations) in cooperation with agricultural extension staff
- translate adaptation options into farmer friendly extension tools
- raise awareness through demonstration of identified livelihood adaptation practices with farmers in the pilot sites

The extension tools include written and explanatory pamphlets, brochures and pictures of good practices. The printed materials will contain good practice menus with cost benefit analysis. The successfully tested options would be disseminated through radio. Details of extension and dissemination strategies are provided in chapter 4.

3. OPTION MENU FOR LIVELIHOOD ADAPTATION TO CLIMATE CHANGE

3.1 Assessment and synthesis of adaptation options

The livelihood adaptation options to climate change in drought prone areas were targeted based on the general typology of options and overall resource availability in the Barind tracts. Though the Barind tract is drought prone and the future climate change could aggravate the problems further, there are many positive aspects that can be considered for selection of viable adaptation options.

Table 1. Categories of adaptation options and their sources

Sl. No	Categories	Adaptation practice	Source
1.	Agronomic management	Seedbed method for T.Aman rice	Farmers and experts
2.		Manures and composting	Farmers
3.		Depth of transplanting for T.Aman	Farmers
4.		Weed control-reduce water seepage	Farmers
5.		Manual closing of soil cracks	Farmers
6.		Strengthening field bunds (Ail lifting)	Farmers
7.	Water harvesting	Re-excavation of traditional ponds	Farmers
8.		Re-excavation of khari canals	BMDA
9.		Canals	Farmers
10.		Water control structures	BMDA
11.		Mini-ponds	BMDA
12.		Supplemental irrigation	Farmers/ DAE
13.	Water resources exploitation	Shallow and deep tube wells	BMDA
14.	Water use efficiency	System of rice Intensification	Experts
15.		Direct sown rice (Drum Seeder)	Experts
16.		Drought resistant rice varieties	Multiple sources
17. a)	Crop intensification	Green Manure – T.Aman system	Farmers
b)		T. Aus – Chini Atap system	Farmers
c)		T. Aman – Mustard/Linseed system	BARI/ BRRI
d)		T. Aman – Chickpea	BARI/ BRRI
e)		T. Aman – Mung Bean	DAE
d)		Famine reserve crops	Experts
18.	Alternate enterprise	Mango cultivation	Farmers
19.		Homestead gardens	BARI
20.		Mulberry intercropping in rice	BRRI
21.		Fodder cultivation	DoL
22.		Fish cultivation in mini ponds	DoF
23.		Cottage industries	Community
24.		Manufacturing industries	Community
25.	Alternative energy source	Community based bio-gas and tree planting	Experts
26.	Post harvest practices	Seed storage for higher viability	Farmers

Based on the general typology of options, a list of adaptation practices were collected from various sources including community level participative discussions. The most of the adaptation practices are related to agriculture and allied sectors as majority of the population are depending on that particular sector. The sources for the adaptation practices include farmers, village community, community level leaders, key informants, local institutions, and research and development organizations. An initial list of adaptation practices and their sources are given in Table 1.

3.2 Typology of adaptation options

3.2.1 Increased crop productivity and food security

Bangladesh is highly sensitive to climate change impacts on the *agriculture sector*. Considering the agriculture based subsistence economy, and almost two thirds of the population employed in that sector, adaptations to climate change impacts are vital in achieving sustainable development. The key risks from climate change to agriculture and allied sectors in North West Bangladesh are related to increased drought frequencies (kharif II) and inadequate availability of water for irrigation (rabi). Agriculture is closely linked to freshwater resources, and the success of adaptations in that sector. Moreover, the agriculture sector has the difficult task to meet the ever-increasing demand for food.

The vision for a sustainable agriculture sector firstly aims at increasing the productivity so that agriculture remains a key source of economic development, and employment. Crops would be diversified to become less vulnerable to changes in market conditions and climate. Due to successful adaptation, the production of major crops would not be threatened by climate change. Adaptation practices related to new cropping systems involving drought resistant crops will benefit the sector as a whole. The agronomic management practices suggested above in Table 1 would also capable of improving the productivity of crops under climate change conditions.

3.2.2 Improved irrigation efficiency

Success of climate change adaptation depends on availability of fresh water in drought prone areas. It should be emphasized that, most of the adaptations provide benefits even with the lower end of climate change scenarios, such as improved irrigation efficiency or strengthening the extension services to farmers. Irrigation efficiency and water productivity can be improved by practicing innovative cultivation methods like System of Rice Intensification (SRI), direct sown rice culture and modern drought resistant varieties. Physical adaptation measures to reduce drought impact on agriculture will mainly focus on improved irrigation efficiency (boro), crop diversification (kharif II and boro), rain water harvesting (kharif II), and use of surface and groundwater for supplemental irrigation (kharif I and kharif II).

Improved irrigation efficiency will become an important adaptation tool especially in Boro season as the water become limiting factor in the future. In that respect, System of Rice Intensification and Direct Sown rice will be highly beneficial. Climate change is expected to result in decreased fresh water availability (surface and ground water) and reduced soil moisture during the dry season (boro), while the crop water demand is expected to increase because of climate change induced increased evapo-

transpiration and the continuous introduction of high yielding varieties and intensive agriculture in Barind tracts. Present day irrigation practices for boro are rather water intensive.

Although the technical and financial feasibility of such adaptation is promising, it might require adequate training and extension (institutional support). Dissemination of these techniques and very weak financial capability of the farmers may prove to be the limiting factors in this case. Various forms of pricing of water are already in practice in the irrigation schemes (BMDA) of Barind areas. However, it requires re-visit in the near future as the water pricing is very low (Tk.90/hr).

Adaptation may also be possible by promoting optimal use of both surface and ground water. These adaptations should only be applied with great care. In terms of ground water usage, some areas are already under threat of over-abstraction. Availability of groundwater is therefore a very pertinent question where it is necessary to know the rate of groundwater re-charges and the limit where extraction may exceed recharge**.** Indiscriminate proliferation of Deep Tube Wells (DTW) has shown detrimental effects on afforestation programs in the Barind Track. Such measures could be investment intensive. Therefore, such adaptations have medium feasibility (Table 4) and at times it is not considered environmental friendly.

3.2.3 Rain water harvesting

Rainfall variability in the drought prone areas is significantly high. Different types of seasonal droughts (initial, mid and terminal) pose a major threat to rice production. Some time high intensity rainfall is being wasted due to non-availability of proper storage structures. Rain water harvesting and recycling is essential to manage seasonal droughts through supplemental irrigation. Thus the primary adaptation options need to be concentrated on rain water harvesting, recycling and conservation. The feasible adaptation options at community level are re-excavation of traditional ponds and khari canals, water control structures and mini-ponds.

3.2.4 Crop diversification and intensification

The adaptation practices need to target T. Aman rice crop, as it is most important and predominant system followed in the Barind areas under rainfed situations. In non-irrigated areas, cropping intensity is only 100% (one crop in a year) under rainfed. All the activities are revolving around the monsoon season and dependency on T. Aman rice is extremely high. The adaptation options need to be related to increasing cropping intensity by suitably adjusting practices and efficient use of limited resources. Careful adjustment of cropping systems involving pulses and oilseeds would be highly useful to use residual moisture after T.aman crop. The most suitable crops for exploitation of residual moisture after T.aman rice are mustard, chickpea and mung bean. These crops are already being grown in this region to a small extent. Efforts are needed to intensify further by careful analysis of rainfall pattern. Introduction of pulses and oil seeds in principally mono-cropped areas could increase the nutritional security of the people in future. Introduction of green manure in the system just before T.Aman is also another feasible adaptation to improve the soil water holding capacity and nutrient availability.

Emphasis on more drought resistant crops in drought prone areas should help to reduce vulnerability to climate change. For example, wheat requires significantly less irrigation water compared to Boro paddy. However, social acceptability of wheat is still very poor. Diversification towards high value crops is feasible in the medium to long term. Growing Mango in Barind areas is a kind of autonomous adaptation, showed promise on long-term basis. Growing crops or varieties that are relatively less water-intensive could also be considered in this context. Overall, crop diversity is a high priority adaptation measure in both irrigated and non-irrigated areas. However, it will be a slow process as traditionally dependency on rice is very high.

3.2.5 Alternative enterprises

There is lot of opportunities to promote alternative enterprises in the Barind tract. The alternative enterprises should able to withstand the shocks due to droughts. The alternative enterprises are meant to increase the overall household income and as a drought risk management strategy. Promotion of alternate enterprises helps to minimize the impacts of drought through stabilization of year-round income from one source even all other sources are failed due to drought. There is a scope for promoting economically viable livestock management, fishery, sericulture, homestead gardening etc., promotion of alternative enterprise will also helps to reduce the internal and temporary migration during the *monga* (seasonal famine) season.

3.2.6 Institutional focus on adaptation options

Measures to reduce drought vulnerability may consider development of drought tolerant crop varieties and training and extension, expanding access to credit etc. More efficient water use can also be stimulated through new cultivation techniques. A promising approach could be found through community based adaptations rather than regulation, i.e. the community should decide on how to share limited common resources (eg. water from traditional ponds).

Development of drought tolerant crop varieties could be stimulated with the National Agricultural Research System (NARS) such as Bangladesh Agricultural Research Institute (BARI) and Bangladesh Rice Research Institute (BRRI). Once the desired varieties are developed and tested in the fields, there should be a strong follow-up training and extension program to disseminate such developments. BARI and BRRI are showing keen interest to demonstrate the suitability of BRRI 32 and BRRI 39 varieties, as they are considered to be shorter duration capable of leaving some opportunity time for cultivation of rabi crops (mustard, chickpea and mung bean). Institutionally these adaptations are feasible, and much will depend on the success of dissemination of information about new and improved varieties. However, the sustainability of the new varieties depends on community preference and growing environment (soil type, climate, pest and diseases).

Various adaptations concerning changes in agricultural practices are required. These adaptations include: direct sown rice, reduction of turn around time after T. Aman harvest, dry seedbed method, ail lifting, growing vegetables in field bunds etc.,

Although such methods for managing drought are known among the research community, it appears that the farmers are little aware of the existence of such

adaptations. It is necessary to disseminate these ideas among the farmers through the existing network of the Department of Agriculture Extension (DAE).

3.2.7 Financial and market risk management

Success of adaptation practices depend on access to credit especially to vulnerable population (small farmers, wage labours etc.,). Access to credit requires institutional support, and is a high priority for the agriculture and allied sectors. As new type of practices and crops are targeted to be evolved, additional investment costs and institutional support is necessary. Another high priority institutional adaptation measure, as in other sectors, is guidelines to incorporate climate change in long term planning with sufficient credit facilities. Market is another important factor which decides the continuation of adaptation practice in drought prone areas. Though a stable market system is evolving to contribute to the needs of the people in response to autonomous adaptations like mango cultivation, it requires a solid institutional support. Establishment of cold storage facilities, processing industries and packaging are the additional requirement for the local people to stabilize the adaptation practices on a continuous basis.

3.2.8 Household level income generating livelihood activities

There were several household level income generation activities identified during the course of our investigation for viable adaptation practices. These activities have the potential to integrate the gender in implementing adaptation practices. Some of the household level income generation activities are:

- potteries
- bamboo work
- weaving
- wood work
- manual oil-grinder
- hand fans
- silk worm rearing

However, sustenance of these household level adaptation practices depends on availability of raw materials. As the proposed adaptation options consider promotion of afforestation, introduction of mulberry cultivation and annual crops such as mustard as an opportunity crop under residual moisture, these income generation activities can be sustained in future.

3.2.9 Processing/manufacturing industries

Already there are few processing and manufacturing industries are in operation in the region. There are potential opportunities to strengthen this by providing institutional support. The potential processing and manufacturing industries for the future considering the climate change impacts are related to processing of rice husks, rice brand oil, flour mills, mango pulp and oil mills. These industries could provide adequate employment opportunities to local population.

3.3. Evaluation of adaptation options

The adaptation practices documented from various sources were evaluated for their technical aspects and practical field level suitability for the Barind tracts. The project implementation strategy consists of formation of technical implementation working groups at National and Upazilla levels to assess, analyse and evaluate adaptation options. The National level Technical Implementation Working Group (NTIWG) and Upazilla level Technical Implementation Group (UTIWG) members were engaged in the evaluation sessions. Additional evaluation members include experts from Bangladesh Meteorological Department (BMD), Department of Environment (DoE), SPARSO, North South University of Bangladesh, Department of Relief, Department of Livestock, Department of Fisheries, CDMP and UNDP. The outcome of the sessions led to preparation of adaptation option menu and demonstration strategies. The summary table (Table 2) provides the list of adaptation options and expert's comments on each adaptation practice.

Table 2. Categories of adaptation options and their sources

Sl. No	Categories	Adaptation practice	Experts' comments
1.	Agronomic management	Seedbed method for T.Aman rice	The practice would be viable under climate change scenarios of the future as rainfall is expected to show higher variability
2.		Manures and composting	The compost can be applied in the pit surrounding mango plants. The expert group discussed about large scale availability of water hyacinth for such demonstrations. The other raw material can also be used.
3.		Depth of transplanting for T.Aman	The practice is suitable but very difficult to implement under field conditions
4.		Weed control-reduce water seepage	The practice is useful, but labour intensive
5.		Manual closing of soil cracks	The practice is useful and may be taken as information and need not be demonstrated
6.		Strengthening field bunds (Ail lifting)	The practice of ail lifting is highly useful in non-irrigated areas and is cost effective
7.	Water harvesting	Re-excavation of traditional ponds	Careful evaluation needs to be done in consultation with department of fisheries
8.		Re-excavation of khari canals	The khari canals are useful to enhance the yield of T.aman crop. DAE is interested in developing these structures. Information about number of such canals needs to be documented.
9.		Canals	Possibility of excavating new canals in non-irrigated areas may be assessed.
10.		Water control structures	Evaluation and feasibility need to be conducted.
11.		Mini-ponds	The optimal size for the small farmers in the region is 5m x 5m x 2m
12.		Supplemental irrigation	It is a good practice to avoid intermittent drought during T.aman cultivation
13.	Water resources exploitation	Shallow and deep tube wells	Possibility of extending the deep tube well scheme for non-irrigated areas may be explored
14.	Water use efficiency	System of rice Intensification	The SRI practice may be demonstrated during boro season

15.		Direct sown rice (Drum Seeder)	The direct sown rice cultivation is a useful technique for kharif II season to reduce the water requirement and also to reduce main field duration
16.		Drought resistant rice varieties	Drought resistant short duration rice varieties are highly useful for the Barind region
17. a)	Crop intensification	Green Manure – T.Aman system	The practice can improve water storage capacity of the soil and nutrient enrichment
b)		T. Aus – Chini Atap system	Improved cropping intensity and household income; new export opportunities
c)		T. Aman – Mustard/ Linseed system	The practice can increase the cropping intensity and improves the nutritional security
d)		T. Aman – Chickpea	The practice can increase the cropping intensity and improves the nutritional security and soil fertility
e)		T. Aman – Mung Bean	The practice can increase the cropping intensity and improves the nutritional security and soil fertility
f)		Famine reserve crops (Yams and Cassava)	Need to be included in the homestead area to facilitate effective utilization of available resources
18.	Alternate enterprise	Mango cultivation	Mango cultivation is an automatic adaptation practice in the region. Drought resistant, stable mango varieties may be identified and disseminated to the local people. The private mango seedling growers need to be advised about these latest varieties.
19.		Homestead gardens	Suggested to develop model demonstration plots. The homestead garden model developed by BARI needs to be included.
20.		Mulberry intercropping in rice	The practice is not prevalent in the pilot upazillas and hence suitability may be assessed.
21.		Fodder cultivation	The practice is highly suitable for non-irrigated areas
22.		Fish cultivation in mini ponds	The practice needs to be demonstrated in both irrigated and non-irrigated areas
23.		Cottage industries	All possible practices and livelihood strategies needs to be documented.
24.		Manufacturing industries	All possible manufacturing industries may be documented and assessed for their suitability.
25.	Alternate energy sources	Community based bio-gas plants and tree planting	Suitable tree sp. may be identified and proposed for policy advocacy
26.	Post harvest operations	Seed storage bins	Suitable technology and gender integration would be ensured.

Based on the experts comments and initial evaluation process a number of adaptation practices were short listed for demonstration at field level. It has been decided to give high priority to following adaptation practices under overall thematic areas:

- rain water harvesting and recycling
- alternate livelihood activities
- improving water use efficiency and
- crop diversification and intensification in drought prone areas.

However, to include objectivity in the evaluation process the adaptation practices are further prioritized based on a criteria based approach.

3.4 Criteria based prioritization

The adaptation options evaluated by the technical implementation working groups were prioritized based on several criteria. About 16 criteria were included in the prioritization process. Most important ones are related to drought mitigation potential, suitability and sustainability under future climate change conditions, relevancy to vulnerable communities, employment opportunities, gender integration and social acceptability.

Table 3. Adaptation option menu and acceptability ratings for each criterion

Sl. No	Adaptation practice	Prioritization criteria[6]															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	Seedbed method for T.Aman rice																
2.	Manures and composting																
3.	Depth of transplanting for T.Aman																
4.	Weed control-reduce water seepage																
5.	Manual closing of soil cracks																
6.	Strengthening field bunds (Ail lifting)																
7.	Re-excavation of traditional ponds																
8.	Re-excavation of khari canals																
9.	Canals																
10.	Water control structures																
11.	Mini-ponds																
12.	Supplemental irrigation																
13.	Shallow and deep tube wells																
14.	System of rice Intensification																
15.	Direct sown rice (Drum Seeder)																
16.	Drought resistant rice varieties																
17. a)	Green Manure – T.Aman system																
b)	T. Aus – Chini Atap system																
c)	T. Aman – Mustard/Linseed system																
d)	T. Aman – Chickpea																
e)	T. Aman – Mung Bean																
f)	Famine reserve crops																
18.	Mango cultivation																
19.	Homestead gardens																
20.	Mulberry intercropping in rice																
21.	Fodder cultivation																
22.	Fish cultivation in mini ponds																
23.	Cottage industries																
24.	Manufacturing industries																
25.	Community based bio-gas and tree planting																
26.	Post harvest seed storage																

Green – High; Blue – Medium; Orange - Low

[6] Prioritization criteria along with explanation is listed in section 2.4

Table 4. Assessment of Adaptation options for their effectiveness, current state and future prospects

Sl. No	Categories	Adaptation practice	Water availability situation	Effectiveness/ Feasibility	Current state of implementation &/or requirements for improvement	Priority for future incremental action
1.	Agronomic management	Seedbed method for T.Aman rice	Rainfed	High	Not existing	High
2.		Manures and composting	Rainfed and irrigated	Medium	Not followed widely due to non-availability of raw materials	Medium
3.		Depth of transplanting for T.Aman	Rainfed and irrigated	Low	Not tried yet	Low
4.		Weed control-reduce water seepage	Rainfed and irrigated	Medium	Followed only to control weeds; not to close soil cracks	Low
5.		Manual closing of soil cracks	Rainfed and irrigated	Low	Some times followed; but not widely practices as labour intensive	Low
6.		Strengthening field bunds	Rainfed and irrigated	Medium	Some times followed; but not widely practiced	Medium
7.	Water harvesting	Re-excavation of traditional ponds	Rainfed	High	Not followed regularly	High
8.		Re-excavation of khari canals	Rainfed	High	Needs social persuasion and policy advocacy; institutional support is required	High
9.		Canals	Rainfed	Medium	Implemented in places close to river	Low
10.		Water control structures	Rainfed	Medium	Some efforts met with limited success; needs community involvement	Low
11.		Mini-ponds	Rainfed	High	Poor dissemination; Needs institutional support	High
12.		Supplemental irrigation	Rainfed	Medium	Already practiced widely	Low
13.	Water resources exploitation	Shallow and deep tube wells	Rainfed	Medium	Implemented in many villages; but not in all villages	Medium
14.		System of rice Intensification	Rainfed and irrigated	Medium	Not widely practiced; but evaluated intensively; showed high level of yield increase and water saving	Medium
15.		Direct sown rice (Drum Seeder)	Irrigated	Medium	Not practiced; cost intensive and weeding becomes a problem	Medium
16.		Drought resistant rice varieties	Rainfed and irrigated	High	Not widely accepted by the farmers as they prefer traditional varieties; needs extra efforts to disseminate short duration drought resistant varieties so as to fit a residual crop after T.Aman	High

17. a)	Crop intensification	Green Manure – T.Aman system	Rainfed	Medium	Not practiced; dissemination is very poor	Medium
b)		T. Aus – Chini Atap system	Rainfed	Medium	Practiced in one of the villages; needs wider dissemination	Medium
c)		T. Aman – Mustard/Linseed system	Rainfed	High	Practiced in some places; needs further expansion; promising results expected	High
d)		T. Aman – Chickpea	Rainfed	Medium	Followed in low Barind areas. Some research is required to identify high temperature tolerant chick pea varieties	Medium
e)		T. Aman – Mung Bean	Rainfed	High	Not followed widely; DAE is advocating a short duration Mung Bean variety; promising results expected	High
f)		Famine reserve crops	Rainfed	Medium	Not practiced widely	Medium
18.	Alternate enterprises	Mango cultivation	Rainfed and irrigated	High	Already spreading widely; but needs some scientific intervention such as introducing drought resistant varieties	High
19.		Homestead gardens	Rainfed and irrigated	High	Followed occasionally; Poor combination of crops. No structured model gardens with drought resistant crops	High
20.		Mulberry intercropping in rice	Rainfed	Medium	Not practiced in pilot areas; but is promising for the future in Barind areas; requires institutional support	Medium
21.		Fodder cultivation	Rainfed	High	Not followed due to lack of awareness; identification of drought tolerant fodder crop is required	High
22.		Fish cultivation in mini ponds	Rainfed and irrigated	Low	Not practiced; water availability is very poor	Low
23.		Cottage industries	Rainfed and irrigated	High	Not systematically followed due to lack of institutional support	High
24.		Manufacturing industries	Rainfed and irrigated	Medium	Not systematically followed due to lack of institutional support	Medium
25.	Alternate energy source	Community based bio-gas and tree planting	Rainfed and irrigated	High	Limited implementation, but needs to be promoted with institutional support	High
26.		Post harvest practices	Rainfed	High	Limited use at local level	High

Qualitative and objective assessment of adaptation practices through systematic methodologies yielded viable adaptation menu. The following adaptation practices were identified as viable and posses high level of priority for future incremental action at community level to mitigate future drought impacts.

1. Alternative seedbed method for T.Aman rice to manage variability in rainfall pattern
2. Re-excavation of traditional ponds to collect excess rain water and to use as supplemental irrigation during intermittent drought at community level
3. Excavation of mini-ponds to store rain water and re-use during drought at farm level
4. Cultivation of drought resistant varieties of rice and other crops to improve the productivity and also increase nutritional security
5. Crop intensification by adopting T. Aman – Mustard/Linseed cropping system to use the residual moisture after T.aman rice
6. Crop intensification by adopting T. aman – Mungbean cropping system to utilize the residual moisture after T.aman rice
7. Promoting Mango cultivation in Barind tracts to increase income and to mitigate seasonal drought
8. Establishment of model homestead gardens
9. Fodder cultivation
10. Promoting cottage industries as an alternate income generating activities
11. Promoting community based bio-gas and tree planting in drought prone areas
12. Advocating post harvest practices to maintain good quality seeds

The above practices are prioritized for future incremental action. However, other practices are also considered as potential and significant with respect to drought risk management in future.

3.5. Description of adaptation practices

3.5.1 Seedbed method for *T. Aman* rice

In the northwestern Barind areas of Bangladesh, summer monsoon starts in mid June and ends in the last week of September. Inter-annual rainfall variability is relatively higher compared to other parts of the country. Intra-seasonal rainfall variability in monsoon rainfall distribution often creates water scarcity situations at critical stages of crops. Delayed onset of rains shortens the length of growing period. Transplanted Aman is a major rice crop in Barind tracts under rainfed conditions. The crop is frequently affected by drought at different stages of the growth in varied intensities. Farmers start preparing seedbed during early June on receipt of first rain and transplant the seedlings in early July. Often transplanting is delayed by a month due to delayed onset of monsoon, putting the crop under terminal drought in October/November. Under this situation, farmers require alternative dry seedbed method to enable them to start producing seedlings in June/July even under delayed onset of monsoon.

It is also recognized that the dry seed bed method poses few other difficulties such as:

- pulling out of the seedlings is considered difficult under dry conditions and require more labor (twice than conventional wet seed bed)
- Damage to root system while pulling out due to insufficient moisture in the soil

The above deficiencies can be minimized by adopting new dry seedbed preparation method. By adding more fine red earth, farm yard manure or compost, and sand it is possible to produce healthy seedlings and reduce the damage.

Seedlings produced from dry seedbeds are known to have greater resistance to drought. In dry seedbed method seeds are sown after thorough ploughing of the soil and also covered with soil unlike wet seedbed method, where seeds are exposed. It has been recognized that the root length of seedlings from dry seedbed is comparatively longer. Farmers perceived that the seedlings from dry seedbed can withstand dry spell (rainless days) up to 12 days against 7 days for seedlings produced from wet seedbed.

Timely transplanting of rice not only helps good crop establishment but also increases the yield level. Generally farmers face many difficulties like inadequate water, irregular monsoon and proper land preparation to raise the seedlings at proper time. These problems indirectly affect timely transplanting and reduce the yield. In order to overcome above problems, the techniques of raising rice nursery like mat type seedlings, dry seed bed and dapog nursery, are developed. Details of the techniques are described below.

a) Raising mat type seedling in trays: In this method, seedlings are raised in trays. The tray size is 48 x 22 x 1.5 cm. The quantity of soil required to fill one tray is 1.5 kg. Ten trays cover an area of one square meter of nursery. Twenty square meters of nursery will be required for one hectare. The seed rate is about 100 to 125 gm/tray. Therefore, seed rate for raising nursery for one hectare is 25-30 kg. The procedure for raising nursery is as follows:

- Dry clean seeds have to be treated with fungicides.
- Dry powdered soil and mix with organic manure has to be filled in trays @ 20 gm/tray.
- The trays have to be filled with soil up to 10-12 mm depth. The treated seeds can be spread uniformly in the soil and cover with 2 to 3 mm of soil layer.
- The trays need to be kept in the field, which is cleaned, properly leveled and nearer to the water source.
- The trays may be sprinkled with water regularly. Initially one jerry can of water is sufficient to cover one square meter area of seedling trays. Water application depends on age of seedlings. Generally, 25 days old seedlings are used for transplanting. Therefore, watering of trays is to be planned according to the transplanting schedule.
- Staggered sowing may be taken up according to transplanting in the main field by manual transplanter.

The advantages of raising rice seedlings by this method over the other methods are:

- Seedlings can be prepared with less seed, water, labour and seedbed area.
- Seedlings will be very healthy and uniform in growth.
- Uprooting of seedlings is very easy with less labour and cost involved.
- Seedlings can be protected from drought

The initial cost on trays for adopting this technique is Tk..500/- for raising seedlings per Bhiga. However, these trays can be used for more than 10 years. Locally available trays can be used to reduce the cost.

Resources required: Plastic trays, soil and manure mixture and paddy seeds
Potential maladaptation: none
Non-climatic benefits: Saving seeds, low water requirement, low labour costs for seedling establishment

b) Dry bed method: This system of nurseries is prepared in dry soil conditions. Seed beds of convenient dimensions are prepared by raising the soil to a height of about 5-10 cm. A layer of half burnt paddy husk or saw dust could be distributed on the nursery bed mainly to facilitate uprooting. In this method, dry or seeds that just sprouted are sown in rows, which are about 10 cm apart to the dry nursery bed. Sowing of seeds could also be done as random (broadcast) but random sowing should be discouraged as the weed control is difficult. The site should be free of shade and should have irrigation facilities. Nursery area should be about 1/10 of area to be transplanted. Seed rate should be higher than for wet-bed (about 40 kg/ha) because the germination could be lower. Uprooting of seedlings should be done between 15 - 21 days after germination. The nursery should be without any moisture stress.

Resources required: Seed bed of convenient size, layer of half burnt husk, paddy seeds
Potential maladaptation: High soil temperature before monsoon onset may reduce the germination percentage
Non-climatic benefits: Seedlings are short and strong, has longer root system than wet bed. Seedlings will be ready in 25 days.

c) Dapog method: Dapog nurseries could be located anywhere on a flat surface. However, if low land paddy field is used, water supply/control should be very reliable. The area needed is about 10 m^2/ha of the transplantable land which is much smaller than conventional nurseries. Seed rate is about 125 kg/ha. Seed bed should be levelled and make the centre slightly higher than the edges to permit water to drain off the surface. The surface should be covered with either banana leaves with the mid rib removed, polyethylene sheets or any flexible material to prevent seedling roots from penetrating to the bottom soil layer. Cemented floors can also be used for this purpose. Cover the seed bed with about 1/4" layer burnt paddy husk or compost. Sow pre-germinated seeds uniformly on the seed bed to a thickness of 2-3 seeds. Splash the germinating seeds with water and press down by hand or with a wooden flat board in the morning and afternoon up to 3-4 days to prevent uneven growth. Too much watering should be prevented. More frequent irrigation is necessary if seeds were sown without the bedding. The nursery should be transplanted in 12-14 days after germination of seeds. Disadvantage of dapog seedling is that the field should be very well levelled and free of water because the seedlings are very short.

Fig.3. Depth of transplanting for the seedlings from wet seedbed and dapog

Resources required: Banana leaf, polythene sheet, paddy husk, manure and paddy seeds
Potential maladaptation: None
Non-climatic benefits: The advantage of the "dapog" over wet/dry bed nursery is that less area is needed and the cost of uprooting of seedling is minimal. Very young seedlings from dapog nurseries are subjected to less transplanting shock than the ones from other nurseries, thus these seedlings are more suitable for short duration varieties.

3.5.2 Manures and composting

Farmers recognized that application of organic manures can improve fertility status and water holding capacity of the soil. Preparation of composts from locally available materials is an age-old practice. However, availability of raw materials for preparation of organic manure is a major limiting factor. Water hyacinth is one of the locally available raw materials showing promise for the preparation of compost. Farmers in rainfed Barind areas apply 20-30 monds of decomposed cow dung before transplanting. Application of organic manure increases water holding capacity of soil. Soil applied with organic manure/compost can supply water for 11-12 days even without rain, while soil without adequate organic manure can support for 7 days in high Barind tracts.

Fig.4. Water hyacinth compost applied in young mango plantations

Water hyacinth (*Eichhornia crassipes)* has been of greet concern to environmentalist, especially in tropical countries as it interference with water flow, prevent fish activities leading to reduction of fish yield. One of ways to get ride of water hyacinth and at the same time make used of it, is converting it to organic fertilizer through a composting process.

In Bangladesh, water hyacinth is abundantly found in small traditional canals and ponds during rainy season. The most important uses of water hyacinth have been as cattle feed, mulch and compost, source of energy, and pollutant remover. Biogass production from water hyacinth as energy source is also common in many countries.

Compost prepared with water hyacinth or locally-available organic matter can be applied to perennial crops like Mango for retaining soil water for longer period.Water hyacinth and domestic solid waste can be used as raw materials for composting process. Water hyacinth may be collected from waste stabilization pond and canals. Upon retrieval, it was chopped to a side of about 5 cm with a manual chopper. The pieces should be then collected and spread on a cement floor and dried on sunlight for 3 days.

Domestic solid waste may be collected and only organic waste (decomposable matter) needs to be used for composting. The size of waste should be reduced to about 5 cm to meet the requirement of composting process.

Resources required: water hyacinth and organic waste
Potential maladaptation: None
Non-climatic benefits: Improving soil fertility and moisture storage

3.5.3 Depth of transplanting

Maintaining optimal depth of transplanting is considered very important for *T.Aman* rice crop. Transplanting at 2.5 cm depth leads to production of more tillers than transplanting at deeper depth of 5 cm or more. It is generally perceived that planting at shallow depth could increase the yield compared to deeper transplanting because deeper planting reduces root development.

Resources required: Paddy seedlings
Potential maladaptation: None
Non-climatic benefits: Improving drought resistance

3.5.4 Weed control and reducing water loss

Rice require effective weed free period during critical stages like active tillering and panicle initiation stages. Generally weeds are removed between 18 and 25 days after transplanting depending on the weed population and soil moisture conditions. Sometimes farmers use hand hoe (*Kodal*) to remove the weeds especially when the soil is dried and soil moisture reaches below saturation under extended dry spell. During weeding operation, soil surface cracks formed already due to extended dry spell also closed. It is perceived that 60 mm rainfall is required to close the surface cracks and also to maintain standing water to a height of about 4-5 cm. Surface cracks consume more water as the water drains into the deeper layers quickly. The practice of weeding and simultaneous closing of surface cracks using had hoe is helpful to minimize the impact of drought and also consumes less water to break the drought after extended dry spell.

Fig.5. Use of hand hoe to close the soil cracks and reducing water loss

Resources required: Kodal and no other specific resources required
Potential maladaptation: In light textured soils the practices exposes the top soil and hence subsequent water loss
Non-climatic benefits: Proper use of household members for weeding

3.5.5 Manual closing of soil cracks

Fig.6. Closing soil cracks manually to reduce percolation loss

Barind soils are clayey; cracks are formed even at high moisture level immediately after the disappearance of ponded water. Once surface cracks are formed, it becomes wider and very quickly exposes the subsurface leading to higher rate of evaporation and percolation of subsequent rainfall. Once cracks are allowed to form, twice the amount of water is required to close the cracks. Traditionally, farmers stir the surface soil manually by hand to avoid development of early cracks when the soil is nearing to saturation. Such practice avoids development of cracks for few more days even the rainfall is not received. The practice is locally known as "Ghata Ghati" in one of the pilot villages. This practice may be familiarized with the farmers to minimize the impact of dry spells during *T.Aman* season.

Resources required: Family labour
Potential maladaptation: None
Non-climatic benefits: Effective engagement of family labour in on-farm activities and improving water use efficiency

3.5.6 Strengthening field bunds

In-situ rain water conservation within the rice field is one of the best rainwater harvesting techniques during monsoon season. Field bunds with shorter height hold less water that is not sufficient to support crop growth during extended dry spells of more than 10 to 15 days. In high Barind tracts, standing rain water is retained only for about 5 to 6 days and then the soil reaches saturation and then surface cracks starts developing. Once surface cracks are developed, soil quickly dries out and the crop suffers from water scarcity. Strengthening field bunds and increasing the height (ail lifting) by 10 cm could delay the development of surface cracks for additional two to three days.

Fig. 7. Strengthening field bunds (ail lifting) to capture rainwater

Resources required: Limited family labour and low cost farm implements
Potential maladaptation: none
Non-climatic benefits: Reduced water use and improved crop yield

3.5.7 Re-excavation of traditional ponds

In Barind areas dry spells occur more frequently during the monsoon season and affects *T.Aman* rice crop. Farmers draw water from traditional ponds during scarcity for supplemental irrigation at critical stages of the crop growth cycle. The traditional ponds in village are leased out to private people and are poorly maintained. Mostly these ponds are under the control of big farmers in the village.

Fig. 8. Comparison of poorly managed traditional ponds with re-excavated and well managed ponds

The traditional ponds are now used for fish culture during monsoon season. As fish culture is also requiring considerable quantity of water, water is not allowed for irrigation to the small and marginal farmers. Whenever water is available in the pond above the required level (above 6 feet), it is allowed for irrigation to other farmers. The cost of water for irrigation is Tk.100/hr. Normally 7.5 cm diameter plastic pipes are used for pumping water. Sometimes, the cost of water is charged based on land area irrigated. About Tk.60 is required to irrigate one Bhiga of land.

Water level above threshold could be effectively used as supplemental irrigation during drought. But the ponds are silted and are managed poorly. Re-excavating the traditional ponds can increase the capacity to sufficiently irrigate the rice crop during *T.aman* season.

Resources required: Limited family labour
Potential maladaptation: none
Non-climatic benefits: Benefits short duration rabi crops which would fetch additional family income

Fig.9. Rain water storage in a khari canal

3.5.8 Re-excavation of Khari canals

Khari development is encouraged in the Barind area to enable storage of water by making embankment in some segments of a

drainage/ irrigation channel. Khari is a lengthy pond like structure to a length of 2 to 3 kms with a width varying from 10 to 15 meters. Trees and shrubs are planted in the embankments to reduce further evaporation. Pond digging is done to facilitate judicious use of storage water for domestic and agricultural purposes. People of the entire village or community decide where to dig the pond and entire operation and digging and maintenance thereafter are being done on a cooperative basis. In the past, such ponds were also used as storage of rainwater. Nowadays they do not get sufficient water in the dry season as ground water recedes further below. It is important to improve upon this technique to increase rainwater harvesting and storage.

Resources required: Digging implements and labour
Potential maladaptation: none
Non-climatic benefits: Community empowerment and community participation

3.5.9 Canals

Natural canals which have potentials for conserving water and providing water for irrigation and other purposes, may be taken up for re-excavation. In the embankments of such canals, afforestation with multipurpose tree species need to be undertaken. While considering afforestation, tree species with bio-fuel value may be promoted for climate change mitigation. Such canals can be used to transfer water from nearby streams.

Resources required: High level of initial investment
Potential maladaptation: Soil salinity may develop if water is not available continuosly
Non-climatic benefits: Crop diversification and tree planting in embankment and additional bio-fuel availability for household needs

3.5.10 Water control structures

Low-cost water control structures of appropriate design need to be built across the re-excavated canals for conserving water, which will be used for supplemental irrigation for rainfed paddy (T. Aman) and for low water consuming crop cultivation. The water thus stored in the section of the canal may be leased out to groups/individuals having land on its vicinity to cultivate fish and supplemental irrigation on annual basis. Small to medium check dams are more advantageous and less expensive.

Fig.10. Water control structures across the canals to conserve water

Resources required: Locally available materials and limited labour
Potential maladaptation: none
Non-climatic benefits: Ground water recharge and tree planting in embankment

3.5.11 Mini Ponds

Fig.11. Mini ponds in rainfed Barind tract to conserve rain water

Re-excavation of ponds is to be undertaken in areas of extreme water scarcity preferably in high Barind areas. If land is found on voluntary basis, new excavation may be taken up with the concurrence of the owner. In farmlands having no source of irrigation, harvesting of rainwater can be done through these mini ponds for supplemental irrigation. Mini pond of 5m X 5m X 2m (length x breadth x depth) size is preferred in small farms. It is also proposed to excavate bigger size ponds (10m x 10m x 2m) as per requirement. Some farmers wanted to have these mini ponds in a corner of the field. Adequate awareness about the utility of ponds is to be created with the local community.

Resources required: Limited family labour
Potential maladaptation: none
Non-climatic benefits: Growing short duration vegetables along the farm pond; supplemental irrigation

3.5.12 Supplemental irrigation

Fig.12. Plastic pipes supplied by DAE to transfer water for supplemental irrigation

Department of Agricultural Extension (DAE) has a program to supply plastic pipes to pump water from the traditional ponds or mini ponds. Since purchase of plastic pipe is not affordable by the farmers, provision from the DAE is very helpful during drought. Farmers need to transfer water to a distance of about 100 – 150 meters to irrigate their crops. The cost of the pipe varies from Tk. 40 to Tk. 50/meter. Normally, low lift suction pumps are used to pump water from the ponds. The entire assembly consists of a 5 meter suction pump, an engine with a pump and 1 meter delivery pipe. The cost of the entire assembly works out to Tk.15,000. The practice is very useful, but non availability of water in the ponds is a major concern. Further, all the farmers are not able to maintain

such infrastructure. Re-excavation of ponds and continuance of supply of plastic pipes would enhance the adaptive capacity of the farmers during drought.

Resources required: Limited investment on plastic pipes but high initial investment for purchase of engine
Potential maladaptation: Low energy use efficiency and use of diesel for engines
Non-climatic benefits: Aditional area under cropping and improved yield

3.5.13 Shallow and deep tube well

In the early 1970s and 1980s, agricultural development projects were implemented in Barind areas to provide ground water irrigation through of Shallow and Deep Tube Wells (DTW). Since scarcity of water was the main obstacle against intensive agriculture, pumping up groundwater helped to grow crops year round. Through shallow and deep tube wells, High Yielding Varieties (HYV) of paddy was introduced to hundreds of acres of marginal and sloped lands especially during *Boro* season.

Fig. 13. Deep tube well as an irrigation source in Barind areas

Resources required: High level of initial involvement
Potential maladaptation: Fast decline in ground water may reduce the coping mechanisms in future
Non-climatic benefits: Crop diversification and increased cropping intensity

3.5.14 System of Rice Intensification

Generally farmers plant 40-50 days old seedlings at the rate of 5-10 seedlings per hill. Farmers also maintain continuous submergence throughout the crop growth cycles without giving any opportunity for aeration to the root zone. Within the Barind tract, where ever deep tube wells are present, abundant water is being used. The water productivity in this region during boro season is very low.

System of rice intensification (SRI) is a new rice production technology developed in Madagascar two decades ago. The SRI package has showed increased rice yield by 50-100% in different parts of the world compared to traditional practice. The main practices of the SRI technology are as follows:

- Transplanting younger seedlings (8-15 days old seedlings) that preserve full genetic potential to produce more viable tillers
- Transplanting seedlings within 30 minutes after uprooting from the nursery bed
- Transplanting using single seedlings
- Giving the plants a wider spacing in square pattern like 30 cm x 30 cm to 50 cm x 50 cm

- Keeping the soil under well aerated condition by practicing alternate water regime that allows prolific root growth and maximum uptake of nutrients

Resources required: None
Potential maladaptation: Care is required during initial stages. High intensity rain may damage the sprouted seeds and young seedlings
Non-climatic benefits: High water productivity. Approximately 40% water saving under SRI system compared to conventional system

3.5.15 Direct seeded rice

The High Barind Tract of northwest Bangladesh is drought prone, with the majority of the 1,200–1,400-mm mean annual rainfall occurring in June to October. Limited irrigation potential in non-irrigated areas restricts cropping intensity to 100%, considerably less than in districts where irrigation allows two or three rice crops each year. The majority of farmers produce a single crop of transplanted rainfed rice, grown in monsoon season. Some 80% of the area then lies fallow in the post-rice *rabi* season. The challenge in the Barind is to simultaneously improve the reliability and yield of rice while increasing total system productivity by increasing the area planted to post-rice rabi crops, including chickpea, linseed, and mustard. Reports from BRRI proposed that the productivity of Barind soils can be increased by switching from transplanted rice (TPR) to direct-seeded rice (DSR) to allow more reliable establishment of rabi crops on residual moisture immediately after the rice harvest. Chickpea, a drought-tolerant and high-value crop, can be grown successfully when seeded after rice in late October to mid-November. This can make significant contributions to higher productivity and improved farm income.

A late onset of the monsoon delays transplanting as a minimum of 600 mm of cumulative rainfall is needed to complete ploughing, puddling, and transplanting. Direct seeding can be completed after ploughing, however, following only 150 mm of cumulative rainfall. Earlier planted DSR matures 1–2 weeks before transplanted rice, thus reducing the risk of terminal drought and allowing earlier planting of a following non-rice crop. An earlier rice harvest can also be achieved by planting early-maturing rice varieties. Swarna, the most widely grown cultivar, matures after 140 to 145 days and, when transplanted, may not be harvested until early to mid-November. In many years, soil dries rapidly at this time, reducing the likelihood of successful chickpea establishment. DSR reduces labor and draft power requirements for rice establishment by 16% and 30%, respectively, compared with TPR.

However, weeds are a major constraint to the adoption of DSR as the inherent advantage of weed control afforded by transplanted rice in standing water is lost. Labor shortages for many households prevent timely first weeding of transplanted rice so that with current practices 34% of farmers lose over 0.5 t ha^{-1} of the attainable rice yield because of weed competition. The additional weed problems in DSR may be overcome, however, by applying a pre-emergence herbicide.

Resources required: Pre-germinated sprouted seeds
Potential maladaptation: Anticipated problem of high intensity rainfall in future
Non-climatic benefits: Sorter duration by a week to ten days

3.5.16 Drought tolerant rice varieties

Bangladesh rice research institute has evaluated drought resistant rice varieties for drought prone Barind tract. Among the varieties (lines), the highest yield was obtained from PSBRC80 followed by IR 50. Compared to the local check Parija, PSBRC80 and IR 50 gave significantly higher yield while BR5543-5-1-2-4 and BR6058-6-3-3 were comparable with Parija (Table 5). Majority of the IR lines obtained from aerobic trial did not perform well under transplanted conditions.

Table 5. Yield and other characters of promising advance breeding lines (BRRI, 2005)

Sl.No.	Designation	Yield (t/ha)	Sterility (%)	Panicles /hill	Growth duration (days)
1	IR69715-7-31-3-19-8	2.7	31.5	12.4	116
2	IR71604-4-14-7	2.3	29.6	14.1	114
3	IR71700-247-1-1-2	3.2	34.3	14.7	117
4	IR77298-14-12	2.4	33.2	14.2	110
5	IR77298-5-6	2.4	36.5	15.1	110
6	PSBRC80	4.4	21.3	14.2	115
7	BR6058-6-3-3	3.7	21.4	11.6	100
8	BR5543-5-1-2-4	3.9	19.8	11.6	98
9	BR5563-3-3-4-1	3.0	28.3	12.8	105
10	BRRIdhan28 (Ck)	2.9	32.3	13.5	105
11	Parija (Ck)	3.6	20.3	14.0	105
12	IR50 (Std. Ck)	4.2	22.1	15.2	100

Panicle per hill ranged from 11 to 15.2. Apparently panicle per hill had a little effect on yield. Growth duration of the highest yielding variety PSBRC80 was 115 days which was delayed by 10 days than local check Parija, while IR 50 was 5 days earlier.

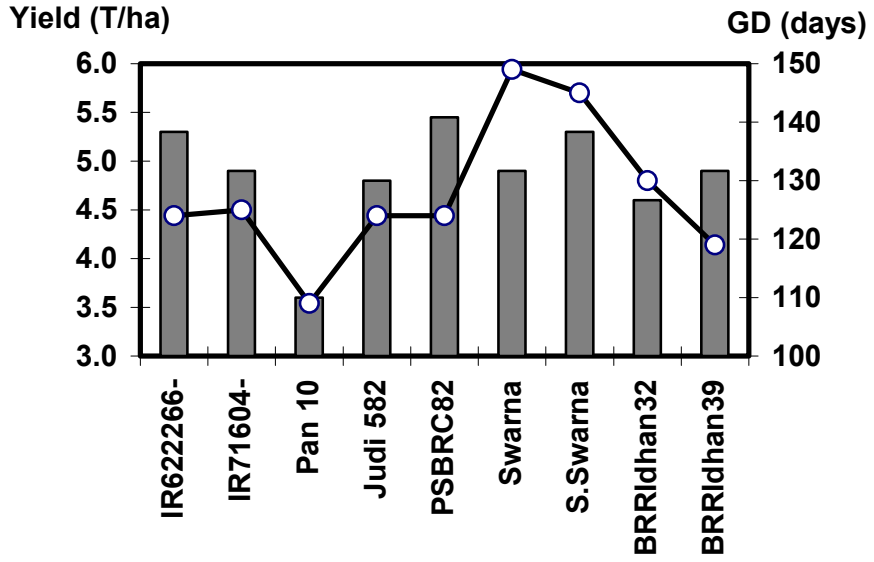

Fig. 14. Yield and Growth duration of exotic rice in rainfed T. Aman (BRRI, 2005)

The results also revealed that among the lines, phenotypic acceptability was best for PSBRC80, uniform canopy and better grain shape and size than Parija. At grain filling stage, natural incidence of Bacterial Leaf Blight (BLB) and Sheath blight were reported to be high in Parija and much lower in IR50. While PSBRC 80 was almost free from BLB and Sheath blight.

At present, farmers are growing Parija due only to lacking short duration variety. It has been recommended to provide viable and pure IR 50 seeds to farmers as this variety have performed well in BRRI experiments.

Resources required: Good quality seeds of short duration rice varieties
Potential maladaptation: High temperature, salinity may cause spikelet sterility
Non-climatic benefits: High yielding and opportunity to plant pulses under residual moisture

3.5.17 Alternate cropping pattern

a) Green manure (Kharif I) – T. Aman system: Introduction of green manure crops in the existing *T.Aman* rice system can improve the fertility status and water holding capacity of the soil. Rainfall climatology in the Barind tract indicates that there is an opportunity to introduce the green manure crops before *T.Aman* rice. Summer showers in the months of April-May can be effectively utilized for growing a green manure crop during Kharif I. About 50-55 old green manure crop could be incorporated into the soil just before transplanting of *T.Aman* rice. The most suitable green manure crop under this situation is *Sesbania rostrata*, a stem nodulating green manure, which could fix atmospheric nitrogen ranging from 25 to30 kg/ha.

Fig.15. Mustard grown under residual moisture and limited supplemental irrigation

Resources required: Quality green manure seeds, low cost implement for improving green manure
Potential maladaptation: None
Non-climatic benefits: Soil fertility improvement and higher crop yields

b) *T.Aus* – fine rice (Chini Atap) system: In the drought-prone Barind tract, considerable quantity of rainfall is received during May (~150 mm). The rainfall pattern shows that the June-July rainfall is assured when ever more quantity of rainfall is received in May. If lands are prepared well in advance using early summer showers in March-April, T. Aus could be planned for Kharif I season. When T. Aus is harvested early, there is a possibility to go for short duration fine rice (Chini atap) during August coinciding with late Kharif II season. In one of the pilot villages the system is successfully implemented and cropping intensity is increased substantially

under rainfed conditions. The system helps to increase the opportunities for higher income.

Resources required: Quality seeds and appropriate seedbed method
Potential maladaptation: Shortened length of growing period may add additional risk of drought in future
Non-climatic benefits: High quality fine rice and export opportunities

c) *T. Aman* – mustard system: Crop intensification in rainfed areas is possible by introducing mustard after T.aman rice. Whenever T.aman harvesting is early, mustard could be sown during November by utilizing residual moisture. This system could be successful in low Barind tracts, where the moisture retention capacity of the soil is relatively higher than high Barind tracts. Several short duration rice varieties have been evaluated to accommodate winter crop cultivation under the residual moisture (Fig.1).

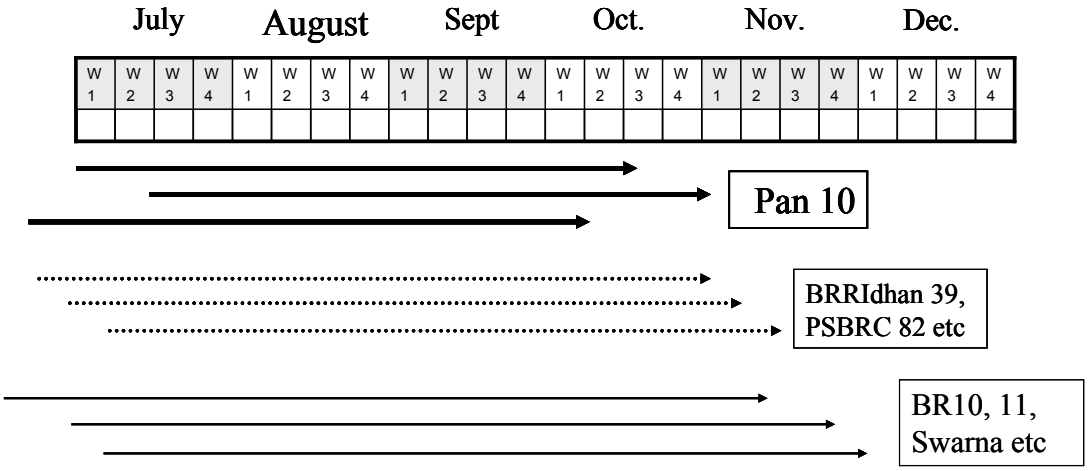

Fig. 16. Cultivation plan of monsoon season rice *(T.Aman)*.

Resources required: Quality seeds of mustard
Potential maladaptation: Shortened length of growing period may add additional risk of drought in future
Non-climatic benefits: Nutritional security and crop diversification

d) *T. Aman* – Chickpea system: Large area in Barind tracts are kept fallow during Rabi season due to non availability of adequate rainfall. However, it is possible to grow chickpea with residual soil moisture after harvest of T.Aman rice. If short duration rice varieties like BRRI 39, BRRI 32 and early sharna are grown during Kharif II season, land will be made available to subsequent pulse crops like chickpea

Fig. 17. Chickpea grown under residual moisture after T.Aman

(Fig.1). Introduction of chickpea helps to improve the nutritional security of the local population. The Bangladesh Agricultural Research Institute has developed short duration drought resistant chickpea varieties for Barind tracts.

Resources required: Quality seeds of chickpea
Potential maladaptation: Shortened length of growing period may add additional risk of drought in future
Non-climatic benefits: Nutritional security and crop diversification

e) Growing famine-reserve crop: The north-western region of Bangladesh is often hit by 'Monga', which is a seasonal famine condition where food is scarce and prices of whatever amount is available are high. The vulnerable groups of Monga are small, some marginal, labourers, women, children and elders. After transplanting Aman crops, the men and women have no works. As there is no work, they spend all money, wealth for investment and for their food without creating any thing. Seasonal crises occur with various degrees of severity in different years during approximately the same period leading to food deprivation. Small deviations in rainfall from the normal can aggravate the situation further. The Monga period is generally from September to last of November in each year. When the new paddy harvest began at the end of November, the Monga goes off. In the Monga season finding no other alternative the aforesaid category of people are bound to take loan from the local money lenders with higher rate of interest. The daily labourers sell their labour at reduced rate of wage in advance. Selling of domestic animals and essential properties are natural phenomena in the area. The workers are bound to migrate temporary in search of work to other districts. Starvation or near starvation during the months of Monga has its highly adverse impact on health of the people living in Monga-hit areas.

Fig. 18. Growing yams in homestead land as a famine-reserve crop

Cassava and Yams (*Diascorea spp*) deserves to be suitable for cultivation as a famine-reserve crop on Highland soils that are not subject to water logging. The high Barind tracts with moderately light textured soils are more suitable. These crops can be grown in homestead land and raised cultivation platforms and could provide families with an emergency food reserve in case of need. However, methods of cultivation and food preparation would need to be demonstrated to farmers. These crops are drought resistant and can be cultivated with little water.

Resources required: Homestead land or raised cultivation platforms, propagation materials, minimum household labour
Potential maladaptation: none
Non-climatic benefits: Women's involvement in crop production; minimizing impact of monga; reduced migration of labour; employment opportunities

3.5.18 Mango cultivation

Mango is an alternative and promising crop to manage drought in barind areas. Area under mango is increasing every year as the region is known for its quality mango production and higher yield. The crop is many times profitable than T.Aman rice. The inter-spaces in the young Mango plantations are intercropped with *T.aman* and *Boro* rice. Many varieties of different maturity groups are widely grown in this region.

Table 6. Harvest window of Mango varieties of different duration groups under normal climatic conditions

Maturity group	Variety	Starting date of harvest window
Early	Gopalbogh	15 May
Medium	Krishabogh	10 June
Late	Langra	25 June
	Pozli	5 July
	Ashwina	30 July

Fig.19. Mango plantations in Barind tract

All the varieties flower at the same time of the year showing a synchronized flowering behavior. Normally, flowering occurs in the month of February. It is observed that maturity of these mango varieties depends on temperature pattern during summer months from March to May. Harvest window of the varieties varies from 15 May to 15 August. However, hotter than normal summer season resulted in synchronized maturity and low quality. The synchronized maturity behaviour was evident during 2004 and farmers lost their profit due to fall in market price. The price during the season was 50% lesser than normal price. During hotter than normal summer all varieties tend to mature at the same time, leading to more supply. Further, even little rain with cloudy weather during flowering damages the flowering pattern. The yield loss is estimated at 60-70% due to abnormal flower dropping. According to farmers' experience, varieties like ***Langra*** is highly suitable for the region as damage due to abnormal weather during flowering is not significant compared to other varieties.

Resources required: Pits for planting mango saplings, drought tolerant mango saplings; low cost fencing and limited labour
Potential maladaptation: Synchronized maturity under high temperature and associated market problems
Non-climatic benefits: High standard of living, additional employment opportunities if pulp industries are developed

3.5.19 Homestead gardening

The indigenous knowledge of the local population regarding land management needs to be encouraged as it is environment friendly. In Barind tracts, tree species like mango, mahogany and Jackfruit is being grown in uplands (*chalas)* around homestead, and are some times used for growing vegetables. The low lands (*bai*d) are generally used for growing paddy. This practice increases moisture retention, improves soil fertility and crop yield, and reduces surface runoff and thus halts soil erosion.

Fig.20. Model homestead garden in a drought prone area managed by women

Home garden system in drought prone areas provide healthy ecosystem for humans, animals, birds, livestock, and miscellaneous flora and fauna. Homestead bamboos are also planted because these develop rapidly and are good soil binders. Use of homestead litter and ash supplements k and organic matter in the soil and keeps insects away. Homestead gardening helps to produce vegetables for household requirement and sometimes for external marketing. Women are engaged in homestead gardening as an income diversification activity. As the rainfed barind tract is mostly dominated by rice during Kharif II season, integration of homestead gardening within the household system provides varied nutrients and thus helps to ensure household nutrient security. Practicing homestead gardening in drought-prone areas helps to integrate gender concerns within the climate change adaptation framework.

Fig.21. Intercropping Mulberry + Rice

Bangladesh Agricultural Research Institute (BARI) has developed economically feasible homestead garden models for barind areas. The components of the homestead garden models include drought resistant fruit trees and vegetables.

Resources required: Homestead land, propagation materials and seeds of drought resistant vegetable seeds
Potential maladaptation: None
Non-climatic benefits: Gender integration in agriculture, nutritional security, year round income

3.5.20 Mulberry intercropping in rice

In rainfed areas, rice suffers from drought at different stages of crop growth cycle. Although farmers are able to produce some rice for their household requirements, they do not have sufficient produce to earn money for their household expenditure. During intensive drought, farmers are not able to meet even household food requirements. After rice cultivation during monsoon season, farm families do not find any employment in rural areas. Mulberry *(Morus* sp.) is one of the promising crops for dry areas which can come up well throughout the year and is resistant to drought. Further, the silkworm cocoon fetches good market price if managed properly. Mulberry is mainly cultivated for sericulture industry where silkworm (*Bombyx mori* L.) larvae are reared by feeding mulberry leaves to produce silk cocoons. It is a labor intensive industry where both male and female members of the household can participate. Female members of the family participates mainly in larvae feeding, cocoon production, and knitting at home while male farmers work in the field for mulberry cultivation. Involvement of women in income generation activities can be very well achieved by introducing this practice. Sericulture industry has plenty of scope for utilizing huge unemployed family labor in Barind area. Participation of family labor, particularly women, helps in increasing family income and livelihood that ultimately ensures gender mainstreaming in agriculture sector.

The Bangladesh Sericulture Board (BSB) with its full efforts started sericulture extension first under Switch Bangladesh bilateral Program and reached a target of about 8000 hectares including roadside plantation. Due to low price and quality the industry was not flourishing. Many of the mulberry fields have already been converted to other crops like mango, vegetables, rice, wheat, pulses etc. However, growing concern related to drought frequency and intensity, these crops would also face serious consequences in the future due to climate change. Thus, a strategy needs to be developed to keep sericulture industry alive in Barind tract as it provides more employment opportunities.

The Bangladesh Sericulture Research and Training Institute (BSRTI) and Bangladesh Rice Research Institute (BRRI), Rajshahi have been working in this area in order to develop technologies on sericulture. To address the growing need of the farmers and also to realize the current climate variability and future climate risks, inter cropping rice, wheat, mung-bean, garlic, chickpea and mustard in mulberry field might be a good adaptation practice. Single crop mulberry is not profitable like other crop however; cultivation of other crops may increase the whole farm profitability and may ensure family food security. The BRRI and BSRTI have jointly developed the intercropping technology to cater the needs of the farmers.

In this practice, it has been recommended that one row from every two alternate rows needs to be uprooted to create interspaces for cultivation of rice/wheat/garlic /mustard /chickpea /mungbean following the cropping pattern Rice (monsoon season) – winter crops (wheat/mustard/garlic/chickpea) - mungbean. The results of the field experiments indicate good performance of mulberry + rainfed rice cultivation in monsoon season. In addition, successful crop cultivation could create a unique opportunity for mulberry farmers to increase income and family food security.

Resources required: Quality mulberry cuttings

Potential maladaptation: High temperature may lead to additional diseases
Non-climatic benefits: Additional household income and employment opportunities

3.5.21 Cultivation of fodder for livestock

Rural people in the Barind tracts domesticate many kinds of animals as a drought risk management strategy. On average, every farming houselhod has about 3-4 cows, buffalo, goats and sheep. The animal enterprises meet most of the household expenditure throughout the year. Fodder requirement of the animals are met from the paddy straw they harvest during kharif II season. The paddy straw is preserved year round to meet feed requirement. Occasionally, green fodder is also fed where ever there is an access to leguminous trees. During rainy season, animals are allowed for restricted grazing in the field bunds and small fallow lands. During earlier times, the opportunity for open grazing was more as lands were left fallow. But currently, due to population pressure and economic motivation, the cropping intensity becomes higher and thus limited land available for open grazing. However, during drought sources of these animal fodders become limited and hence animals are sold for lower price.

The situation created by monsoon season drought may be managed through alternative fodder cultivation practices. There is an opportunity to grow fast growing fodder crops such as Napier grass with limited water, which could avoid fast selling of the animals during drought. These fodder grass may be cultivated even in homestead gardens, embankments of canals, mini-ponds and near the traditional ponds.

Other possible adaptation practices in livestock sector are:

1. Construction of cattle sheds to manage high temperature stress
2. Conserving water for livestock through traditional water bodies
3. Vaccination to livestock to manage possible outbreak of diseases during drought

Resources required: Vegetative propagation materials
Potential maladaptation: None
Non-climatic benefits: Enterprise mix, manure availability, alternate sources of protein from animals and income. Reduces migration during drought

3.5.22 Fish cultivation in mini-ponds

Installation of mini ponds provides an opportunity to cultivate short growing fish species. The same practice can be taken up in traditional ponds, khari canals and other rain water conservation structures. The objective of this practice is to increase the opportunities for higher household level income through diversification of enterprises. However, as drought become more frequent in the future additional physical and institutional efforts are required to sustain such practice in drought prone areas.

Other adaptation practices relevant to fishery sector in drought prone areas are:

- Re-excavation of ponds
- Cultivation of quick growing fishes

- Connect irrigation canals with traditional ponds

Resources required: Fingerlings and fish pond. Mini ponds can also be used for fish culture
Potential maladaptation: Intermittent dry spells during the season may limit the water availability in ponds
Non-climatic benefits: Alternative livelihood portfolios and income

3.5.23 Alternate sources of energy

Improved fuel use for women in rural areas and introduction of renewable energy through constitution of biogas plants is considered important. In areas where Local Government Engineering Department (LGED) construct biogas plants the costs to be paid by the farmers may be borne from adaptation related efforts if necessary. Community based biogas plants is another alternative to meet the household level energy requirement. Importantly, farmers and other livelihoods in the pilot villages maintain comparatively larger number of livestock (on average 3 to 4 animals/household).

Similarly pilot demonstration of solar based home lightening is being done some other areas under eco-village concept. Community has to be engaged for developing awareness among the poor preferably the women for checking environmental degradation and climate change. Training programs needs to be organised in the pilot villages to train the villagers particularly the women to make them aware of alternative energy sources.

Resources required: Locally available energy source
Potential maladaptation: None
Non-climatic benefits: Potential mitigation options reduces green house gas emissions

3.5.24 Seed storage bins

Farmers in drought prone-areas of Bangladesh are affected by non-availability of quality seeds in the event of drought. They use the available seeds to grow seedlings on receipt of first rainfall. However, erratic and highly variable rainfall pattern led to early season droughts and so seedlings are damaged. Extended drought conditions during later stage (terminal drought) also lead to production of poor quality seeds. Farmers in the Barind tracts wanted to store their good quality seeds (harvested from previous good season) preferably for longer time. There is no well equipped community level storage system in the rural villages. However, some individual farmers store their seeds in a locally made low cost storage bins made out of mud. As

Fig.22. Low cost seed storage bins for drought prone areas

the Barind soils are sticky, it is highly suitable to make such kind of storage bins. The storage bins are small and can be constructed inside the house in a safer place. The bins are slightly elevated to protect from water seepage. The top of the storage bins are sealed if the seeds are required to be stored for long period.

The traditional storage methods are excellent for helping to prevent or control pest infestation. The seed moisture content is maintained at appropriate level. This eliminates some insect pests and inhibits the movement of others. The storage bins can also be used for stocking foodgrains such as cereals and pulses.

Resources required: soil, seeds, labour, tools required and skills needed are very simple
Potential maladaptation: none
Non-climatic benefits: Preserving seeds for longer period and would be used for re-sowing purposes in the event of early season drought

4. DISSEMINATION AND EXTENSION STRATEGIES

The impacts of climate change in drought prone areas were translated into a menu of good practices. The viable adaptation options described in the previous chapter need to be tested and disseminated at pilot villages for their acceptance. The approaches followed initially for this purpose are limited to:

1) *Demonstrations:* Monitoring the benefits of adaptation in cooperation with agricultural extension staff involving the local community especially the farmers
2) *Farmer friendly extension tools:* Several farmer friendly extension tools like orientation meetings, demonstration rallies and farmers field schools will be adopted. However, these methods are only some ways of disseminating the adaptation options. Emphasis will be given for other extension methods in future based on the requirement
3) *Awareness raising strategies:* Awareness rising is an integral part of the extension methods followed for demonstration and dissemination. Printed materials will be used to describe the salient futures of each adaptation practice selected for demonstration. Advantages of the adaptation options identified for drought prone areas will be discussed during the local level training programmes

The extension tools include written and explanatory pamphlets, brochures and pictures of good practices. The printed materials will contain good practice menus with cost benefit analysis. The successfully tested options would be disseminated through radio. Details of some of the extension and dissemination strategies are provided in this chapter.

4.1 Orientation meetings

The extension support to farmers, local people starts when the local group is formed through orientation meetings. Orientation meetings are helpful for extension staff and farmers groups to come together to discuss and analyze issues and ideas related to climate change adaptation. The Farmers Group will receive the first idea on the concept of adaptation during their close involvement.

4.2 Demonstrations

Next step is the preparation of the demonstration plan for each of the viable adaptation option. It is expected that all Upzila officers will be involved, though the sub-assistant Agricultural Officers (SAAO) will play a major role since they are having regular contact with the group at the local level. The Upazilla level technical implementation working group will actively participate in the entire demonstration and subsequent meetings.

The demonstrations may be a method or result oriented. The method demonstrations are targeted to impart skill, while result demonstrations are organized to show the relative advantage of a practice over control. The climate change adaptation practices selected for drought prone areas fall under either one of these demonstrations.

4.3 Community level training

A community level training day need to be organized in a suitable place before each season. It is expected that proper training schedule and curricula are made, and handouts and other relevant training materials will be prepared. All training activities should be filed properly, for monitoring by District officers. The selected farmer group leaders and community workers need to be present. Practical issues such as package of practices need to be discussed and agreed. Procedure for implementing each adaptation measure, cost requirement, advantages, season and other relevant aspects needs to be discussed.

4.4 Field days

A field day is a group extension event conducted at the demonstration site. Successful field days are the most important aspect of the demonstration programme. Sub-Assistant Agricultural Officers (SAAO) shall organize field days in respective (kharif I, kharif II and rabi) seasons. At the end of Kharif II season, Farmer rally needs to be organized. The group members should be active during the Field Day in successful demonstrations. Each member of group will invite at least 2 neighbor farmers for the field day and the demonstration farmers will all be available to explain about the new adaptation practice to the visiting farmers. Local leaders could be present and take part in the discussion.

Upazilla Agricultural Officers, Agricultural Extension Officers, Sub-Assistant Agricultural Officers, DMC members, UTIWG members will attend the field day in every season. The representative from the financial organizations will be present and inform about agricultural credit facilities available to implement adaptation practices. Representatives from a research organization will be present to clear technical doubts arising out of discussions. Upazilla Agricultural Officer (UAO) will inform about objectives of demonstrations, field days will be arranged at a time when the technology can be demonstrated.

4.5 Farmer Field School

The Farmer Field School (FFS) approach was initially developed to help farmers and promote Integrated Pest Management (IPM) practices in agriculture. It is a form of adult education, involving practical, field-based learning in weekly sessions during a complete crop cycle. The aim of the field school is to increase farmer expertise on a particular subject so that appropriate decisions may be made. A Field school curriculum encourages learning from peers and strengthening communication skills and group cohesion. Farmer's field school approach can be utilized for disseminating the advantages of viable adaptation options to climate change in drought prone areas. Farmer Field School encourages community involvement through out the crop growth period.

4.6 Extension materials

During field days and demonstrations maximum use of locally or centrally produced training material, e.g. leaflets, banners, flipcharts, etc. needs to be used. Possibly the group could also use role play as an extension tool. The seasonal planner is one of the

important tool guides for successful conduct of demonstrations. The local resource groups need to prepare a seasonal calendar cum planner for effective implementation of demonstrations.

It is essential to maintain, as far as possible, of audio-visual material, e.g. leaflets, posters, banners, flip charts, displays, etc. If possible, folk songs, video and slide show or other entertainment can be included under the list of extension materials.

4.7 Demonstration farmers rally

At the end of Kharif II season a Farmers rally would be organized in successful demonstrations. Farmer rallies are large extension events, which involve a combination of activities to motivate in a group about viable adaptation practices, crop intensification, new water saving practices, rain water harvesting methods etc.,

Farmer rallies are usually organized outside, like a big field day, gathering 80-100 farmers from neighboring villages/blocks. Representatives from local banks, input dealers, local NGOs and other agriculture-related organizations, along with DAE, District and Upazila level officers and research officials will be present. They also provide the opportunity for partnership with other extension providers. The following points are to be considered while organizing farmer's rallies.

- A program of activities should be agreed e.g. opening, presentation, folk song, presentation with audience participation, etc.
- Supporting materials should be (e.g. leaflets, banners) chosen and produced
- The venue should be selected carefully making sure there is enough space for seating a large audience.
- Once a date and venue have been agreed, this should be advertised invitations should be sent to interested parties.
- Where possible other partner agencies should be involved. This provides good opportunity to share experiences and resources.
- The content of the rally is planned so that people are kept interested

The demonstration group member should be active during the farmer rally and explain visiting farmers about the adaptation practices. Calculations and discussions on benefit-cost ratio (BCR) and economic benefits for the drought adaptation practice need to be compared with control practice or surrounding farmer practice. Discussions will be initiated on adaptation options for next year's crops, and decisions will be taken on how the group will function in the future. Also discussions about season-wise women's activities will be carried out.

Sometime after the farmers rally the extension staff will meet with the demonstration farmers to discuss the main messages from the rally to stimulate their interest in new ideas presented at the rally and also to discuss and agree on a work plan for the group after demonstration support has stopped.

4.8 Women involvement

One day training for female representatives in the demonstration will be organized in a suitable place near the demonstration site before each season. Training topics will

include various drought management practices and household activities. The female SSAO, who received three days of special training on "climate change impacts and disaster risk management", needs to be engaged in this activity.

After training all female representatives of selected demonstration farmer groups will participate as a group in implementing some season-wise specific adaptation practices. Each woman of the group will take up specific activities:

1. Establish a homestead garden with drought resistant vegetables (BARI model)
2. Preserve a crop seed in better ways to be used during drought
3. Prepare water hyacinth compost or compost from waste materials
4. Plant mango saplings and proper husbandry/management of existing plants
5. Use environmental friendly energy sources at household level

5. COORDINATED ACTIONS FOR CONTINUOUS ADAPTATION

Reduction of vulnerability of agriculture and allied sectors for impacts of climate change through the suggested adaptations require coordinated actions, proper planning, financial resources and community involvement. Typical planning mechanisms or activities would include the following issues:

5.1 Incorporation of livelihood adaptations in long-term planning

The potential impacts of climate change on agriculture and allied sectors should give directions to the Agriculture Research community which is now being initiated with BARI and BRRI. The efforts to mitigate the impact of climate change in drought prone areas needs to be integrated into long-term planning process of the national and local institutions. In this context, efforts were made to involve several national and local level institutions in the entire process. The institutional landscaping include Comprehensive Disaster Management Programme (CDMP) of ministry of Food and Disaster Management (MoFDM), Disaster management Bureau (DMB), Department of Relief (DoR), Ministry of Environment and Forests (MoEF), Department of Environment (DoE), Ministry of Agriculture (MoA), Department of Agriculture Extension (DAE), Department of Livestock (DoL) and Department of Fisheries (DoF). Several other agencies such as Barind Multipurpose Development Agency (BMDA) were also involved in the process of finding viable adaptation options for drought prone areas. Research Agencies such as Bangladesh Rice Research Institute (BRRI) and Bangladesh Agriculture Research Institute (BARI) have been involved in the demonstration process.

5.2 Implementation of research and development on new crops

Research and development efforts should include crops better suited to grow under climate change conditions. Crop varieties that are more resistant to extreme weather events will be needed under climate change. However, it might approximately take 8 to 15 years to develop new varieties and 3 to 4 years to adopt them at the field level. Thus research on new crop varieties needs to begin now based on the requirement, which is decided by community preference and growing environment. Further analysis of potential climate change and crop attributes needed to offset the effects may be initiated. To continue adaptation, a climate change adaptation unit may be initiated in local research institutions such as BARI and BRRI, which focuses on Barind areas.

5.3 Improvement of information dissemination network

Agriculture is a relatively flexible economic sector because farmers can change crops and practices on an annual or more frequent basis. However, in practical terms change is very slow due to disabling institutions and market opportunities. For these changes to occur quickly and efficiently, farmers need to be aware of changes in crop varieties, crops, practices, or technologies that will help in coping with climate change. Farmers can often make the changes themselves, mostly based on indigenous knowledge. In other instances, training and demonstration may be necessary. The capacity of the

information dissemination networks involving public and private sectors should be examined and institutional weaknesses should be adequately addressed.

5.4 Market risk management in agriculture

Lifting price supports on crop production and water could induce farmers to switch crops more rapidly in response to climate change. Subsidies or restrictions on the types of crops inhibit farmers from changing practices or crops. However, it needs detailed analysis and interpretation. Location specific impacts of policy interventions related to livelihood adaptation to climate change needs to be carefully considered. Some of the physical adaptations in Barind tracts require strong institutional and market support for high value crops like mango in the future.

5.5 Access to credit

For the agriculture sector to adapt quickly to climate change, farmers need ready access to credit for financing the purchase of new equipments (eg. low lift pumps), adopting new technologies (eg. rain water harvesting technologies) and for investment in alternative crops (eg. mung bean). An accessible and reliable credit system will help farmers expand their production capabilities under current climate, and in response to climate change, and is a high priority future action. The state operated Krishi (agricultural) Bank and private and non-government sector micro-lending institutions (Grameen Bank and other NGOs) could play a vital role to provide timely and safe credits to the poor farmers. However, most of the micro-credits from NGOs are very small and handled by women. Such facilities can help to strengthen household level adaptation strategies, but farm level adaptations require different kind of credit facilities.

5.6 Developing enabling institutions and favourable socio-economic conditions

Despite the coordinated efforts, there will be some institutional and socio-economic conditions may limit the adaptation efforts. Access to capital and inputs at proper time are the major impediments to the improvement of agricultural production in drought prone areas. If the situation does not improve, it would also limit climate change adaptation possibilities in these vulnerable areas. The high number of small land holdings in Barind areas makes the situation more difficult. Average land holding size in pilot villages is about 3 bhiga. Further, more than 50% farmers in pilot villages are tenants and they are highly vulnerable to climate shocks.

Annex 1. Adaptation option menu and demonstration strategy for drought prone areas (2006 – 2007) developed during the training cum evaluation workshop

Sl. No	Adaptation practice	Demonstration strategies			
		Expert's remarks	Season	No.of demonstrations	Role of lead organisations
1.	Seedbed method for T.Aman rice	Demonstration	Kharif II	8 non-irrigated villages; 3 in each village	DAE and BRRI to lead the demonstration; FMO to identify the field and farmers; U'TIWG members and DD to involve in field days and farmer's discussions
2.	Manures and composting	Demonstration	Rabi/Summer	12 villages; 3 in each village for mango trees	DAE and BARI to lead the demonstration; FMO to identify the field and farmers
3.	Depth of transplanting for T.Aman	Information	-	-	National consultant and ADPC to share the information during training programs
4.	Weed control using hand hoe to reduce water seepage	Information	-	-	National consultant and ADPC to share the information during training programs
5.	Manual closing of soil cracks to reduce water requirement	Information	-	-	National consultant and ADPC to share the information during training programs
6.	Strengthening field bunds to store more water (Ail lifting)	Demonstration	Kharif II	24 (3 in each non-irrigated villages)	DAE to lead the demonstrations with assistance from FMO
7.	Management of traditional water bodies (community level water harvesting)	Additional information required; collaboration needed with Department of Fisheries	-		Field monitoring officers (FMO) to collect the details about traditional ponds in each village (number, status and potentials)
8.	Re-excavation of khari canals	Additional information required; BMDA to be involved			DAE to discuss the possibility of involving BMDA in this effort. Field monitoring officers to document the

					details about Khari canals in each village
9.	Water control structures (check dams) across the khari canals	Demonstration	Kharif II	At least one structure in each village	DAE/UTIWG, FMO to consult with BMDA to identify the locations in each village
10.	Mini ponds	Demonstration	Kharif I & Kharif II	3 mini-ponds in each non-irrigated village	DAE and FMO to identify the voluntary farmers; the agreed size for small farms is 5 m x 5 m x 2 m
11.	System of Rice Intensification	Demonstration	Rabi (boro)	4 irrigated villages (3 in each village)	BRRI to provide technical guidance based on their earlier trials in this area. DAE and FMO to continue the demonstrations during 2006-2007 boro.
12.	Direct sown rice (T.Aman) (Drum Seeder)	Demonstration	Kharif I	4 non-irrigated villages of Naogaon district (3 demonstrations in each village)	DD Naogaon to involve and monitor the demonstration in all the 4 villages. This would be a basis for replication in Chapai Nowobganj during next year (2007)
13.	Direct sown rice (Boro) (Drum Seeder)	Demonstrations	Rabi (Boro)	4 irrigated villages (3 demonstrations in each village)	Continuing the 2005-2006 demonstrations for 2006-2007 boro season. DAE and FMO to involve and collect data
14.	Shallow and deep tube wells	BMDA needs to be involved	-	-	BMDA to initiate an inventory on availability of ground water levels in all the non-irrigated villages and finalise the opportunities for extension of deep tube wells in non-irrigated areas
15.	Supply of plastic pipes during drought	-	Kharif II	-	DAE to continue the supply of plastic pipes under existing projects in non-irrigated villages
16.	Drought resistant short duration T.Aman varieties	Demonstration	Kharif II	8 non-irrigated villages (3 demonstrations in each village)	BRRI to lead this demonstration in close association with DAE and FMO (BRRI to supply seeds of BRRI 33 and BRRI

					39)
17.	Green Manure – T.Aman system	Demonstration	Kharif I & Kharif II	8 non-irrigated villages (3 demonstrations in each village)	BARI and BRRI to lead this demonstration in close association with DAE. FMO to select the fields and farmers
18.	T. Aus – Fine Rice (Chini Atap) system	Demonstration	Kharif I & Kharif II	4 non irrigated villages in Gomestapur and Natchole	BARI and BRRI to lead the demonstration in close association with DAE. FMO to select farmers and fields for demonstration
19.	T. Aman – Mustard/Linseed system	Demonstration	Kharif II & Rabi	8 non-irrigated villages (3 demonstrations in each village)	BARI and BRRI to lead this demonstration in close association with DAE. DAE to select either mustard or linseed based on the local situations.
20.	T. Aman – Chickpea	Demonstration	Kharif II & Rabi	4 non-irrigated villages where ever soil is suitable for chickpea cultivation (3 demonstrations in each village)	BARI to lead this demonstration in close association with DAE. FMO will assist in selecting the fields and farmers. Scientists working under ICRISAT scheme on chickpea may be involved.
21.	T. Aman – Mung Bean	Demonstration	Kharif II and Summer (Jan 15 – Jan 30 sowing)	8 non-irrigated villages (3 demonstrations in each village)	BARI to lead BRRI to support in close collaboration with DAE and FMO
22.	Mango cultivation	-	-	-	Information about the availability of drought resistant varieties to be documented from Horticultural Research Station, Chapai Nowobganj and need to be discussed with private seedling producers
23.	Homestead gardens with fruit trees	Demonstration	Kharif II	36 (3 model homestead	BARI to lead and provide seeds and

				gardens in each village)	technology; DAE and FMO to involve in field selection and identification of farmers
24.	Mulberry intercropping in rice	Not suitable for the region	-	-	Mulberry cultivation is not practiced in pilot villages of Chapai Nowobganj and Naogaon. May be tried in other districts where mulberry cultivation is dominant
25.	Livestock sector Fodder cultivation	Demonstration	Kharif II	8 non-rrigated villages (3 in each village)	DAE to involve district livestock officers to demonstrate drought resistant suitable fodder crops.
26.	Drought preparedness practices in livestock sector	Additional information required	-	-	ADPC to document other drought preparedness techniques in livestock sector
27.	Fisheries sector Fish cultivation in mini ponds (short duration species)	Demonstration	Kharif II	8 non-iirigated villages (1 in each village)	FMO to get help from district fisheries officers of Chapai and Naogaon. District officers already agreed to provide support for such efforts and will also supply fingerlings.

Note: DAE is the implementing agency for all the demonstration programs in pilot locations. DAE will get technical support and assistance from BARI, BRRI, FMO-FAO, ADPC and National Consultants-FAO. Upazilla level technical implementation group (U'TIWG) will involve closely in all the activities