6.5.12 Supplemental irrigation

Department of Agricultural Extension (DAE) has a programme to supply plastic pipes to pump water from the traditional ponds or miniponds. Since plastic pipe is not affordable by the farmers, provision from the DAE is very helpful during drought. Farmers need to transfer water from 100 to 150 meters to irrigate their crops. The cost of the pipe varies from US$0.58 to US$0.72. 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 a 1-meter delivery pipe. The cost of the entire assembly works out to US$217. The practice is very useful, but non availability of water in the ponds is a major concern. Further, all farmers are not able to maintain such infrastructure. Re-excavation of ponds and assured continuation of the plastic pipe supply 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:	additional area under cropping and improved yield.

6.5.13 Shallow and deep tubewell

In the early 1970s and 1980s, agricultural development projects were implemented in Barind Tract areas to provide groundwater irrigation through shallow and deep tubewells. Since scarcity of water was the main obstacle against intensive agriculture, pumping up groundwater helped crops grow year round. Through shallow and deep tubewells, high yielding varieties (HYVs) of paddy was introduced to hundreds of acres of marginal and sloped lands, especially during *boro* season.

Resources required:	high level of initial involvement.
Potential maladaptation:	fast decline in groundwater may reduce future coping mechanisms.
Non-climatic benefits:	crop diversification and increased cropping intensity.

6.5.14 System of Rice Intensification

Generally farmers plant 40- to 50-day-old seedlings at the rate of 5 to10 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, wherever deep tubewells 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 increased rice yield by 50-100 percent 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-day-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,
- spacing plants widely in square patterns 30 cm x 30 cm to 50 cm x 50 cm,
- aerating the soil with an 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 with approximately 40 percent water more savings under SRI system than with conventional systems.

6.5.15 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 from June to October. Limited irrigation potential in non-irrigated areas restricts cropping intensity to 100 percent, 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 percent 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 one to two 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 labour and draught-power requirements for rice establishment by 16 percent and 30 percent, 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. Labour shortages for many households prevent timely first weeding of transplanted rice. With these current practices, 34 percent of farmers lose more than 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: duration shortened by seven to ten days.

6.5.16 Drought tolerant rice varieties

BRRI has evaluated drought-resistant rice varieties for the 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 yields while BR5543-5-1-2-4 and BR6058-6-3-3 were comparable with Parija (Table 19; Fig. 28). The majority of the IR lines obtained from aerobic trials did not perform well under transplanted conditions.

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 10 days longer than local check Parija, while IR 50 was 5 days earlier. The results also revealed that among the lines, PSBRC80 has 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. PSBRC 80 was almost free from BLB and sheath blight.

Table 19. 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

At present, farmers are growing Parija mainly because they do not have the short-duration variety. It has been recommended to provide viable and pure IR 50 seeds to farmers as this variety has 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

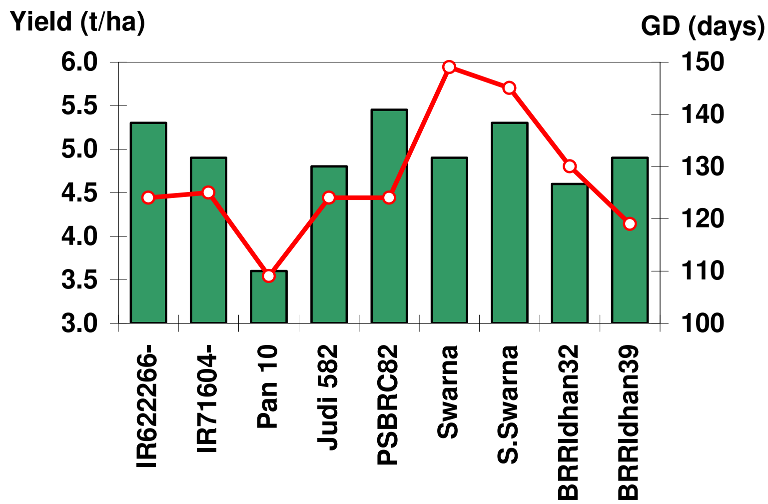

Fig. 28. Yield and growth duration of exotic rice in rainfed *T. aman* (BRRI, 2005)

6.5.17 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 green manure crops before *T. aman* rice. Summer showers in April and May can be utilized effectively for growing a green manure crop during *kharif* I. Green manure crop, about 50 to 55 days old, 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 that can fix atmospheric nitrogen ranging from 25 to30 kg/ha.

Resources required:	quality green manure seeds, low-cost implements 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 rainfall is received during May (~150 mm). If lands are prepared well in advance to take advantage of early summer rainfall 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 has been successfully implemented and cropping intensity has increased substantially under rainfed conditions. The system helps to increase the opportunities for higher income.

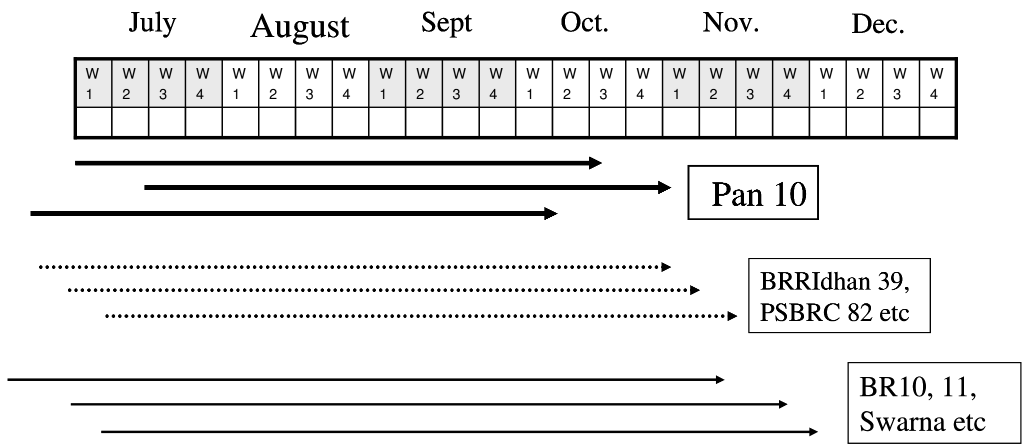

Fig. 29. Cultivation plan of monsoon season rice *(T. aman)*.

Resources required: quality seeds and appropriate seedbed method.
Potential maladaptation: shorter growing period may add additional risk from future droughts.
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* is harvested 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 residual moisture (Fig.29).

Resources required: quality seeds of mustard.
Potential maladaptation: shorter growing period may add additional risk from future droughts.
Non-climatic benefits: nutritional security and crop diversification.

d) *T. aman* – chickpea system: Large areas of the 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 the harvest of T.*aman* rice. If short duration rice varieties such as BRRI 39, BRRI 32 and early sharna are grown during *kharif* II season, land can be made available to subsequent pulse crops such as chickpea (Fig.1). Introduction of chickpea helps improve the nutritional security of the local population. BARI has developed short-duration drought-resistant chickpea varieties for Barind tracts.

Resources required: quality seeds of chickpea.
Potential maladaptation: shorter growing period may add additional risk from future drought.
Non-climatic benefits: nutritional security and crop diversification.

e) Famine-reserve crop: The northwestern region of Bangladesh is often hit by *monga*, a seasonal famine condition where food is scarce and prices of whatever food is available are high. The vulnerable groups during *monga* are small and marginal farmers, farm labourers, women, children and elders. After transplanting *aman* crops, the men and women have no work to earn money for investment in food. Seasonal crises that occur with various degrees of severity during approximately the same period lead to food deprivation. Small deviations in normal rainfall can aggravate the situation further. The *monga* period generally lasts from September until the end of November when the new paddy harvest begins. In the *monga* season, the vulnerable groups often take loans from local money lenders with higher rates of interest. The daily labourers sell their labour at reduced rates in advance. Selling domestic animals and essential properties is normal in the area. The workers are bound to migrate temporarily in search of work to other districts. Starvation or near starvation during *monga* has a highly adverse impact on health of the people living in *monga*-hit areas.

Cassava (*Manihot esculenta)* and yams (*Diascorea spp*) can be suitable for cultivation as a famine-reserve crop on highland soils if they do not become waterlogged. The high Barind Tracts with moderately light textured soils are more suitable. These crops are drought resistant and can be cultivated with little water. They can be grown on homestead land and raised cultivation platforms to 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.

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.

6.5.18 Mango and Jujube cultivation

Mango and jujube (*Ziziphus jujuba* Mill) are alternative and promising crops to manage drought in Barind areas. The region is known for its quality mango production and higher yield and area under mango is increasing every year. The crop is many times more 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 20).

Table 20. 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

All varieties flower at the same time, normally in February, showing a synchronized flowering behavior. Maturity of these mango varieties depends on the temperature pattern during summer months from March to May, and their harvest windows vary from 15 May to 15 August. A hotter than normal summer season results in synchronized maturity and low quality. In 2004, synchronized maturity caused farmers to lose their profits due to a fall in market price. The price during the season was 50 percent below normal. During hotter than normal summers, all varieties tend to mature at the same time, leading to more supply. Further, even cloudy weather with slight rain during flowering damages the flowering pattern.

Abnormal flower dropping can cause yield loss of 60-70 percent. According to farmers' experience, varieties such as *langra* are highly suitable for the region as damage due to abnormal weather during flowering is not significant compared to other varieties.

Jujube is a tropical fruit crop able to withstand a wide temperature range. One of the outstanding qualities of the jujube is its tolerance of drought conditions. The crop can be cultivated successfully in Barind Tracts with little irrigation. The jujube filed can be intercropped with T.*aman* rice during *kharif II* season.

Resources required: pits for planting mango or jujube saplings, drought tolerant mango or jujube saplings; low-cost fencing and limited labour.
Potential maladaptation: synchronized maturity under high temperature and associated market problems. Jujube has the potential to withstand high temperature.
Non-climatic benefits: improved standard of living, additional employment opportunities if pulp industries are developed.

6.5.19 Homestead gardening

The indigenous knowledge of the local population regarding environmentally friendly land management needs to be encouraged. In the Barind Tract, tree species such as mango, mahogany and jackfruit are being grown in uplands (*chalas)* around homesteads, and are some times used for growing vegetables. The lowlands (*baid*) are generally used for growing paddy. This practice increases moisture retention, improves soil fertility and crop yield and reduces surface runoff , thus halting soil erosion.

Home garden systems in drought-prone areas provide healthy ecosystem for humans, animals, birds, livestock and miscellaneous flora and fauna. Homestead bamboos are also planted because they develop rapidly and are good soil binders. Use of homestead litter, ash supplements and organic matter in the soil keeps insects away. Homestead gardening helps produce vegetables for household requirements 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 ensure household nutrient security. Practicing homestead gardening in drought-prone areas helps integrate gender concerns within the climate change adaptation framework.

BARI has developed economically feasible homestead garden models for Barind Tract 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.

6.5.20 Mulberry intercropping in rice

In rainfed areas, rice suffers from drought at different stages of the 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, there is no employment for farm families 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 – silkworm larvae (*Bombyx mori* L.) are reared to produce silk cocoons by feeding them mulberry leaves. It is a labour-intensive industry and both male and female members of the household can participate. Women participate mainly in larvae feeding, cocoon production and knitting at home. Men 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 numbers of unemployed family labourers in the Barind Tract area. Participation of family labour, particularly women, helps to increase family income, improve livelihoods and, ultimately, ensure gender mainstreaming in the agriculture sector.

The Bangladesh Sericulture Board (BSB), established in 1978, provides sericulture extension and has reached a target of about 8 000 ha including roadside plantation. However, due to low price and quality, the industry has not flourished and many of the mulberry fields have been converted to other crops such as mango, vegetables, rice, wheat, pulses, etc. However, these crops will face serious consequences in the future due to climate change. Thus, a strategy needs to be developed to keep the sericulture industry alive in the Barind Tract because of the employment opportunities it provides.

The Bangladesh Sericulture Research and Training Institute (BSRTI) and BRRI, Rajshahi, have been working to develop sericulture technologies. To address the growing need of the farmers and also to factor in the current climate variability and future climate risks, inter-cropping of rice, wheat, mung bean, garlic, chickpea and mustard in mulberry fields might be a good adaptation practice. Single crop mulberry is not as profitable as the other crops so the cultivation of other crops could increase farm profitability and ensure family food security. The intercropping technology, developed jointly by BSRTI and BRRI, recommends for cultivation of rice, wheat, garlic, mustard, chickpea and mungbean in mulberry fields, following the cropping pattern: rice in the monsoon season, wheat/mustard/garlic/chickpea in winter, and mung bean in pre-*kharif*. The results of the field experiments indicate good performance of the mulberry plus 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.

6.5.21 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 household has livestock, usually three to four animals (cows, buffalo, goats or sheep). The money made from animal enterprises helps families cover their expenses throughout the year. The paddy straw harvested during *kharif* II season is preserved year round to meet fodder requirements. Occasionally, green fodder is also fed to animals wherever there is access to leguminous trees. During rainy season, restricted grazing is allowed in the field bunds and small fallow lands. During earlier times, when more land was left fallow, there was more opportunity for open grazing, Now, due to population pressure and economic motivation, the cropping intensity has become higher, leaving limited land for open grazing. During droughts, sources of animal fodder become limited and animals are sold for lower prices.

The situation created by monsoon season drought may be managed through alternative fodder cultivation practices. Fast-growing fodder crops, such as napier grass, grow with limited water and could help avoid the need to sell animals during drought. These fodder grasses may be cultivated even in homestead gardens, canal embankments and near miniponds and traditional ponds. Other possible adaptation practices in the livestock sector are:

- construction of cattle sheds to manage high temperature stress,
- conserving water for livestock through traditional water bodies,
- vaccination to avoid 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, reduction of migration during drought.

6.5.22 Fish cultivation in miniponds

Installation of miniponds provides an opportunity to cultivate fast-growing fish species. The same practice can be taken up in traditional ponds, *khari* canals and other rainwater conservation structures. The objective is to increase opportunities for higher household income through diversification of enterprises. However, as drought becomes more frequent in the future, additional physical and institutional efforts will be required to sustain the practice in drought-prone areas. Other adaptation practices relevant to the fishery sector in drought-prone areas are:

- re-excavation of ponds;
- cultivation of quick-growing fishes;
- connection of irrigation canals with traditional ponds.

Resources required:	fingerlings and fish pond including miniponds.
Potential maladaptation:	intermittent dry spells during the season may limit the water availability in ponds.
Non-climatic benefits:	alternative livelihood portfolios and income.

6.5.23 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 the Local Government Engineering Department (LGED) has constructed biogas plants, farmers could pay the costs through adaptation-related projects. Community-based biogas plants provide another alternative to meeting household-level energy requirements. Farmers and others in the pilot villages maintain comparatively larger numbers of livestock (on average 3 to 4 animals per household).

Pilot demonstrations of solar-based home lighting are being presented in other areas, under the eco-village concept. This recognizes that the community has to be engaged in order to develop awareness among the poor (preferably women) of the need for checking environmental degradation and climate change. Similar training programmes need to be organized in the pilot villages to make the villagers, particularly the women, more 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.

6.5.24 Seed storage bins

Farmers in drought-prone areas of Bangladesh are affected by non-availability of quality seeds in time of drought. They use the available seeds to grow seedlings with the first rainfall. However, erratic and highly variable early season rainfall patterns have led to droughts that damage seedlings. Extended drought conditions during later stage (terminal drought) also lead to production of poor quality seeds. Farmers in the Barind Tracts have need to store their good quality seeds (harvested from previous seasons) for a longer time. There is no well-equipped community-level storage system in the rural villages but some farmers store their seeds in locally made low-cost storage bins made of mud. The sticky Barind Tract soils are highly suitable to use in constructing the storage bins. The bins are small, slightly elevated to protect from water seepage, the tops can be sealed if the seed needs to be stored for long periods, and they can be constructed inside the house for safety.

The traditional storage methods are excellent for helping 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, simple tools and skills.
Potential maladaptation:	none.
Non-climatic benefits:	Seeds preserved for longer periods and available for re-sowing in the event of early season drought.

CHAPTER 7

DISSEMINATION AND EXTENSION STRATEGIES

The impact of climate change in drought-prone areas have been 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 the following.

- *Demonstrations:* Monitoring the benefits of adaptation in cooperation with agricultural extension staff involving the local community, especially the farmers.
- *Farmer-friendly extension tools:* Several farmer-friendly extension tools such as orientation meetings, demonstration rallies and farmers field schools will be adopted to disseminate information on adaptation practices. There are plans to adopt other extension methods in the future.
- *Awareness-raising strategies:* Awareness raising is an integral part of the extension methods followed for demonstration and dissemination. Printed materials will be developed to describe the salient features of each adaptation practice selected for demonstration. Local-level training programmes will discuss the advantages of the adaptation options identified for drought-prone areas.

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. The following contains details of some of the extension and dissemination strategies.

7.1 Orientation meetings

Extension support to farmers and local people begins with orientation meetings to form local groups. Orientation meetings are helpful to bring extension staff and farmers groups together to discuss and analyse issues and ideas related to climate change adaptation. This orientation is often the way members of the farmers' group first learn about the concept of adaptation.

7.2 Demonstrations

Next step is the preparation of the demonstration plan for each of the viable adaptation option. This involves all upazilla officers as well as sub-assistant agricultural officers (SAAOs) who play major roles since they have regular contact with the local groups. An upazilla-level technical implementation working group will actively participate in the entire demonstration and subsequent meetings.

Demonstrations of climate change adaptation practices selected for drought-prone areas may be method or results oriented. The method demonstrations are targeted to impart skill, while results demonstrations are organized to show the relative advantage of a particular practice.

7.3 Community-level training

A community-level training day needs to be organized in a suitable place before each season, with a proper training schedule and curriculum, and handouts and other relevant training materials 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 need to be agreed by the group, and then discussions need to cover the procedures for implementing each adaptation measure, cost requirements, advantages, season and other relevant aspects.

7.4 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. SAAOs organize field days in respective (*kharif* I, *kharif* II and *rabi*) seasons. At the end of *kharif* II season, a farmer rally needs to be organized. During the field day, the group members should present successful demonstrations. Each member of group can invite at least two neighbor farmers for the field day and the farmers who present the demonstrations should be available to explain the new adaptation practice to the visiting farmers. Local leaders should be present and take part in the discussion.

Upazilla agricultural officers, agricultural extension officers, SAAOs, DMC members and UTIWG members should attend the field day in every season. They should be organized at a time when the technology can be demonstrated and the Upazilla Agricultural Officer (UAO) can explain to the participants about the objectives of demonstrations. Representatives from financial organizations should be present to explain about agricultural credit facilities available to implement adaptation practices. Representatives from research organizations should be present to clear technical doubts arising out of discussions.

7.5 Farmer Field School

The farmer field school 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. The curriculum encourages community involvement throughout the crop growth period and stresses learning from peers and strengthening communication skills and group cohesion. The farmer field school approach can be utilized for disseminating the advantages of viable adaptation options to climate change in drought-prone areas.

7.6 Extension materials

During field days and demonstrations, maximum use should be made of locally or centrally produced training material, such as leaflets, banners and flipcharts. Role play is another option. 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/ planner for effective implementation of demonstrations. It is essential to maintain, as far as possible, audio-visual material, including folk songs, video and slide show or other entertainment that can be included under the list of extension materials.

7.7 Demonstration farmer rally

The end of *kharif* II season provides an opportunity to organize a farmer rally. Farmer rallies are large extension events with a combination of group motivation activities covering practices that deal with viable adaptation, crop intensification, water-saving or rainwater harvesting.

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

- A programme of activities should be agreed in advance and should include opening remarks, presentations, audience participation, folk songs, etc., organized in a way to keep people involved and interested. Supporting materials such as leaflets and banners should be created and produced.
- Select adequate venue, ensuring there is enough seating space for a large audience.
- The date and venue, once decided, should be advertised and invitations should be sent to potentially interested parties.
- Partner agencies, when appropriate, should be involved and provided the opportunity to share experiences and resources.

Members of the demonstration group should be active during the rally, and available to explain the adaptation practices to the visiting farmers. 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 should be initiated on adaptation options for the following year's crops, and decisions should be taken on how the group should function in the future. Also, discussions about specific seasonal activities for women should be included in the programme.

The extension staff should meet with the demonstration farmers at some point after the rally to discuss i) the main messages from the rally in order to stimulate their interest in new ideas, and ii) agree on a work plan for the group after demonstration support has stopped.

7.8 Women's involvement

One-day training opportunities for female representatives in the demonstration should be organized in a suitable place near the demonstration site before each season. Training topics can include various drought management practices and household activities. A female SSAO who has received three days of special training on "climate change impacts and disaster risk management", should be engaged to handle this training. After training, all female representatives of selected demonstration farmer groups can participate as a group in implementing some season-wise specific adaptation practices. Each woman of the group can take up specific activities:

- establish a homestead garden with drought-resistant vegetables (BARI model);
- preserve crop seeds in better ways to be used during drought;
- prepare water hyacinth compost or compost from waste materials;
- plant mango saplings and maintain proper husbandry/management of existing plants;
- use environmental friendly energy sources at household level.

CHAPTER 8

COORDINATED ACTIONS FOR CONTINUOUS ADAPTATION

Adaptation to reduce the vulnerability of agriculture and allied sectors to the impacts of climate change requires coordinated actions, proper planning, financial resources and community involvement. Typical planning mechanisms or activities would include the following issues.

8.1 Incorporation of livelihood adaptations in long-term planning

Involvement of BARI and BRRI in a project on livelihood adaptation to climate change would give further direction to the agriculture research community. The efforts to mitigate the impact of climate change in drought-prone areas need to be integrated into the long-term planning of the national and local institutions. In this context, efforts have been made to involve several national and local-level institutions in the entire process including: the 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 the 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.

8.2 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 takes approximately eight to 15 years to develop new varieties and three to four years to adapt them at field level. Thus research on new crop varieties needs to begin now, based on the requirements that are decided by community preference and local growing environments. Further analysis of potential climate change and crop attributes is needed to offset the effects. To continue adaptation, climate change adaptation units that focus on the Barind Tract areas should be established in local research institutions such as BARI and BRRI.

8.3 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 inefficient institutions and markets. For changes to occur quickly and efficiently, farmers need to be aware of changes in crop varieties, crops, practices and technologies that can help in coping with climate change. Often, farmers can make the changes themselves, based on indigenous knowledge. However, 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 addressed.

8.4 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 crops inhibit farmers from changing practices or crops. This means detailed analysis and interpretation are needed of the location-specific impacts of policy interventions related to livelihood adaptation to climate change. Strong institutional and market support would be required for physical adaptation of some high value crops, such as mango.

8.5 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 equipment such as low-lift pumps, adopting new technologies such as rainwater harvesting tools, and for investment in alternative crops such as mung bean. An accessible and reliable credit system that would help farmers expand their production capabilities under current climate as well as in response to future climate change 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 provide timely and safe credit to poor farmers. However, most of the micro-credit activities of NGOs are small and handled by women. Such facilities can help strengthen household-level adaptation strategies, but farm-level adaptations require a different kind of credit facilities.

8.6 Developing enabling institutions and favourable socio-economic conditions

Despite coordinated efforts, institutional and socio-economic conditions may limit adaptation efforts. Lack of access to capital and inputs at proper time is the major impediment to improving agricultural production in drought-prone areas. If the situation does not improve, it will also limit climate change adaptation possibilities in these vulnerable areas. The high number of small land holdings in Barind Tract areas makes the situation more difficult. Average landholding size in pilot villages is about 3 *bhiga*. Further, more than 50 percent of farmers in pilot villages are tenants and highly vulnerable to climate shocks.

8.7 Institutional guidelines

This section recommends measures that can facilitate institutional adaptation to climate change. The recommendations are based on a review of the existing institutional arrangements for livelihood adaptation, actors and stakeholders, policies and processes and their roles and mandates. They also offer interpretations of needs and gaps, and address the needs of the rural population in the Barind Tract, particularly the poorest and must vulnerable and women who are targeted by poverty reduction measures. The recommended adaptation strategy measures included in this section are meant to promote and facilitate a supportive institutional arrangement for adapting and coping with the consequence of climate.

In addition to a range of specific recommendations to changes in institutional arrangements, it is important to emphasize the need to empower local communities and build on their traditional coping mechanisms and the need for greater flexibility in how government institutions respond to climate change. Efforts to deal with climate change at the individual level should receive more support and their focus should be on improving the effectiveness of traditional coping and adaptation mechanisms.

- In view of the growing scarcity of farmland, tree planting should be undertaken around homestead villages, schools and public buildings, along roads and on the banks of common water bodies.
- Traditional water bodies, canals, and ponds need to be dredged and re-excavated to enhance water storage and drainage capacities.
- More effective planning, operation and maintenance is needed of physical infrastructure such as miniponds, water-control structures etc.
- A massive programme to create greater public awareness is required. Government agencies and NGOs should mobilize people by providing education and awareness campaigns.
- Government arrangements should be made so that the poor can get credit, on easy terms, to invest in their adaptation practices.
- High priority should be given to enable women, children, disabled and elderly people to improve their adaptive capacity during drought.
- Proper sanitation systems and medical facilities should be developed in drought-prone areas to respond to increased health threats.

A drought-monitoring centre with responsibility for collecting climatic change and water balance data should be established in Northwest Bangladesh. Such a data source can facilitate regular regional weather/climate forecasts for farmers and predict possible drought conditions in the region.

In order to alleviate the effects of drought, the government should have an understanding of how and why drought occurs and be prepared to undertake appropriate mitigation programmes. The government should work with the NGOs operating in the region for the same purpose. The farmers may be trained to learn techniques of conservation of soil moisture in dry season, bringing about possible change in cropping pattern as well as cultivating drought resistant crops and exploring the possibilities of crop diversification practices.

8.8 Development of livelihood opportunities in vulnerable areas

The long-term sustainability of measures to respond to and cope with the impacts of climate change in drought-prone areas will be contingent upon the sustainable development of the livelihoods of vulnerable communities, as it is through this that their resilience to the impacts of these changes will be increased. A livelihoods approach puts climate-related vulnerabilities within the context of the overall vulnerabilities that poor people face. The development of vulnerability reduction programmes and support to sustainable livelihoods need to be strengthened in drought-prone areas.

There is an urgent need for an integrated and comprehensive development plan and better understanding of the interactions and causal relationship in Barind tracts. Meaningful individual participation and perception should be the focus of development efforts. Local people have the resilience to adapt to gradual change in climate variability. However, more frequent droughts reduce their resilience and increase need for external interference. An adaptive and flexible approach to livelihoods development in the drought-prone areas is essential, given the high level of uncertainty over the character of key determinants of livelihoods activities in the future.

Activities to encourage and support the diversification of livelihoods opportunities amongst the poorest and most vulnerable communities should be introduced and supported by substantial funds from international development partners. Current efforts of CDMP, through other partners, are working to improve sustainable livelihoods. But these also need parallel actions to sustain and enhance the natural resource base in the region upon which most vulnerable communities, especially the poor, depend. Traditional livelihood activities, such as agriculture, cannot be sustained given the current decline of the resource base and the effects of drought.

Disaster management policy should include better preparation for changes and challenges likely to confront the people. Bangladesh has one of the best disaster management voluntary teams indicating that people are resourceful and resilient. The livelihood adaptation to climate change and related aspects has to be integrated into the national policy and needs to be implemented on a sustainable basis.

8.9 Integration of traditional knowledge and practices into adaptation

Traditionally, it was the local community that had the main role in management of drought and scarcity. As a result, irrigation was not much of a problem. However, the technology-dependant perspective of development took no account of existing management processes and the existing tradition of correspondence between profit and responsibility was undermined. As a result, community initiatives for water management eroded to a level where they became marginal and a dependence upon the state to manage water resources developed. One of the best examples in this regard is that this project's interaction with farmers in non-irrigated villages always looks for BMDA's installation of deep tubewells.

The development of institutional capacities that support efforts to combine traditional knowledge and practices with modern technical and management systems needs to be encouraged. The integration of mechanisms that represent and guarantee the participation of local communities in all aspects of water resources planning and drought management, including the enhancement of capacities in local government institutions, needs to play a leading role in these processes.

CHAPTER 9

THE WAY FORWARD

The adverse effects of climate change will disproportionately affect poorer communities. The most vulnerable people in the rural area are the poor, whose dependence on natural resources and low resilience exposes them to potentially devastating impacts from even minor changes in environmental conditions. In Bangladesh, for example, periods of prolonged dry spells or droughts will result in water shortage in all settlements, particularly those located in the drier regions. Water supply is therefore a crucial issue, and the situation is expected to become worse with population growth and continuing development, both of which are expected to increase the demand for water. Extreme climatic events, such as droughts, can have a devastating impact on the economy and on the livelihoods of vulnerable people. With sensitive ecosystems, narrow economic structures, and high population density, they can cause severe economic shocks that deflect the economy from a long-term growth path. There is a danger that Bangladesh's excellent recent record of economic growth and development could be slowed or even reversed by the effects of climate change upon its people and resource base. As the national development depends on grassroot-level developments, livelihood is poised to be given more importance in the future.

9.1 Developing institutional mechanisms

The ability to adapt to climate change is undermined by a lack of financial resources, adequate technology and stable and effective institutions. Institutional weaknesses in particular have a critical effect on initiatives. These constraints add gravity to the need for success in the implementation of action based on a set of sound adaptive strategies. The successful implementation of adaptation measures outlined in this report will depend upon human and resource capability of Bangladesh, cultural and social acceptability, and integration with other programmes and projects. Adaptation measures to address the major impacts of climate change may include new rainwater harvesting methods, improved drought tolerant varieties and improved agronomic management practices. Adaptations have been recommended in relation to institutional, policy and organizational measures. Effective adaptation policies and actions are not separated from the main thrust of development activities or institutional programmes. They must be mainstreamed into all aspects of life if they are to be truly effective in responding to the challenges that Bangladesh will face in the future. In this initiative, significant capacity building and awareness have been added at institutional level within DAE and other key stakeholder institutions. The implementation group at national (NTIWG) and at local (UTIWG) levels may behave as a catalyst for continuous adaptation.

9.2 Developing action plans

Many policy measures or strategic action plans have been undertaken by the Ministry of Food and Disaster management (MoFDM), Ministry of Agriculture and Ministry of Fisheries and Livestock. The representative departments or directorates working under these ministries have started adapting innovative approaches to combat the likely threats to Bangladesh agriculture due to climate change in either the short or the long term. Climate change, in the current trend, may not be so alarming, but needs immediate attention. Planning a vulnerability assessment related to future climatic conditions requires long-term vision. There may be many unknown factors that mask the real situation. Therefore, awareness must be increased about climate change impact on human and natural systems such as agriculture, human habitat, forests or biodiversity. Though awareness has been created to some extent, further effort to strengthen the understanding with the local community is essential.

9.3 Awareness raising

In the event of climate change, the agriculture sector of Bangladesh would be very severely affected. This sector contributes 30 percent to the GDP and employs roughly 63 percent of the labour force: nevertheless there has been no concerted effort to create awareness among the different stakeholders of these threats. The initiatives related to climate change adaptations require field-level application and community involvement. Creating awareness among people about vulnerability to climate change and increasing drought frequencies is one of the areas needing the most immediate attention. In order to do so and mitigate the problem of drought, concerted effort should be made by the Government as well as NGOs and international organizations. Investment should be increased in order to mitigate the impact of climate change in drought-prone areas. Institutional mechanisms and appropriate technologies should be developed, in both the public and private sectors to encourage such investments.

9.4 Targeting vulnerable groups and local communities

Climate change may increase the frequency of extreme droughts in vulnerable areas especially in the Barind Tract. To avoid these, priority should be given to plans for rural development that incorporate climate change adaptation. Women and children are the most vulnerable groups within the communities. Therefore, special contingency plans should be made in order to mitigate their suffering and ensure gender issues are mainstreamed in any development process. There were many adaptation practices suggested to improve the resilience of the vulnerable groups especially the women.

9.5 Early warning systems

A greater sense of urgency and interest is needed from policy-makers and the public to ensure adequate and consistent funding of national weather recording systems, early warning systems for climate-related shocks, research on climate-agriculture relationships, regional climatic monitoring, and interdisciplinary analysis of the results and their implications. Well planned activities under this project focused mainly on capacity building and implementation of long-lead climate forecasts. Continuous efforts to institutionalize these forecasts within Department of Agriculture Extension (DAE) would improve the efficiency of adaptation practices.

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Livelihood adaptation to climate variability and change in drought-prone areas of Bangladesh

The impacts of climate variability and change are global concerns, but in Bangladesh, where large numbers of the population are chronically exposed and vulnerable to a range of natural hazards, they are particularly critical. In fact, between 1991 and 2000, 93 major disasters were recorded, resulting in nearly 200 000 deaths and causing US$5.9 billion in damage with high losses in agriculture. Agriculture is the largest sector of the Bangladesh economy, accounting for some 35 percent of the GDP and 63 percent of the labour force. Agricultural production is already under pressure from increasing demands for food and the parallel problem of depletion of land and water resources caused by overuse and contamination. The impacts of climate variability and change cause additional risks for agriculture.

Within this context, FAO and the Asian Disaster Preparedness Center (ADPC) are guiding a project to assess livelihood adaptation to climate variability and change in the drought-prone areas of Northwest Bangladesh. The project, implemented under the Comprehensive Disaster Risk Management Programme (CDMP) and in close collaboration with the Ministry of Agriculture, Department of Agricultural Extension (DAE), specifically looks at: characterization of livelihood systems; profiling of vulnerable groups; assessment of past and current climate impacts; and understanding of local perceptions of climate impacts, local coping capacities and existing adaptation strategies. It is also developing a good practice adaptation option menu, evaluating and field testing locally selected options, and introducing long-lead climate forecasting, capacity building and training of DAE extension staff and community representatives.

This report summarizes the project methodology developed and successfully tested during 2005/06; it discusses interim findings and recommendations resulting from the ongoing pilot learning process.

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