Biodiversity Conservation and Response to Climate Variability at Community Level

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Biodiversity Conservation and Response to Climate Variability at Community Level

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Abbreviations

ABS	Access and benefit sharing
ADB	Asian Development Bank
AEZ	Agro-ecological zone
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCMDP	Bamboo, Cane and Murta Development Project
BCSIR	Bangladesh Council of Scientific and Industrial Research
BFRI	Bangladesh Forest Research Institute
BRRI	Bangladesh Rice Research Institute
CBD	Convention on Biological Diversity
CHT	Chittagong Hill Tracts
CICMEA	Community-based Implementation and Compliance of MEAs — Biodiversity related issues in linkage to climate variability
DAE	Department of Agriculture Extension
FAO	Food and Agricultural Organization
FD	Forest Department
FGD	Focused group discussion
FMP	Forestry Master Plan
FSP	Forestry Sector Project
FSR	Farming System Research
HYV	High yielding variety
IARI	Indian Agricultural Research Institute
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
IUCN	International Union for Conservation of Nature
MoEF	Ministry of Environment and Forest
NAPA	National Adaptation Programme of Action
NGO	Non-governmental organization
NWFP	Non-wood forest product
SST	Sea surface temperature
TK	Traditional knowledge
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNU	United Nations University

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Biodiversity Conservation and Response to Climate Variability at Community Level: An Overview

It has long been realised that alarming issues like vanishing biodiversity and the impacts of climate change are concerns of the whole globe. There are a number of international agreements (Multilateral Environmental Agreements, MEAs), for example the Convention on Biological Diversity (CBD) and United Nations Framework Convention on Climate Change (UNFCCC), in place for sometime now, accepted by almost all countries of the world, to tackle these upsets. An increasing need for synergising these conventions is felt at the national, regional and global levels. The reasons are multifaceted. In most of the countries only one agency, like the Ministry of Environment and Forest (MoEF) in Bangladesh, deals with all the MEAs. Further, issues like awareness, capacity building, education, communication, and technology transfer not only cut across different relevant sectors, but also between the conventions. Efficient coordination of activities under the conventions will improve the effectiveness of implementation of compliances under the MEAs, on the one hand, and enhance fund utilization efficacy, on the other. Such a synergistic approach is very much pertinent when we talk about sustainable use of biodiversity and conservation of associated traditional knowledge in light of climate change adaptation involving local communities.

Against this backdrop, IUCN Bangladesh has implemented the 'Community-based Implementation and Compliance of MEAs – Biodiversity related issues in linkage to climate variability (CICMEA)' project with support from the UNEP and the UNU for improving the role of communities of Bangladesh for better understanding and effective implementation of MEAs. The initiative reviewed, assessed and validated the role of communities and community-based knowledge in effective implementation of CBD with specific focus on issues of ABS and traditional knowledge, and also validated the role of traditional knowledge and practices in conservation and sustainable use of biodiversity and adaptation to climate variability and climate change.

At first, the initiative appraised the role of community identified in MEA-related national documents, namely the National Biodiversity Strategy and Action Plan (NBSAP) and the National Adaptation Programme of Action (NAPA), and identified the opportunities to improve communities' participation in implementing these strategies and action plans. Through consultations in different bio-ecological zones[1] of the country, an attempt was made to understand communities' perception of biodiversity conservation and adaptation, and to register the existing capacities and knowledge embedded within the local communities along with the gaps and limitations deterring sustainable environmental management in Bangladesh. The information gathered from these consultations was utilized to develop printed communication materials to enhance awareness among the local communities and stakeholders at the grassroots level on their role in biodiversity conservation and adaptation.

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1 Nishat, A., Huq, S.M.I., Barua, S.P., Reza, A.H.M.A., Khan, A.S.M. (Eds). 2002. Bio-ecological Zones of Bangladesh. IUCN Bangladesh Country Office, Dhaka, Bangladesh, pp. xii+141.

Communities in the local consultations identified changes in the local climate and biodiversity, and traditional or local approaches to climate change adaptation and conservation measures. A key observation was that weather patterns are no longer as predictable as people felt they were in the past (Table 1). This has had impacts on livelihoods dependent on agriculture as farmers have not been able to predict optimal times to plant and harvest various crops, and have suffered losses through adverse weather conditions. They also noted lower agricultural productivity as a result of phenomena such as salinity intrusion, erosion, water-logging and abnormal rainfall. Communities reported on various ways in which they were acting to safeguard livelihoods, through advance and mixed cropping, traditional practice and collective action (Table 2). With regard to changes in biodiversity, the majority of observations related to agro-biodiversity, and reductions in the numbers of local rice varieties and fish species.

Table 1. People's perception on climate variability & climate change, and consequences & impacts of such phenomenon in seven bio-ecological zones*.

Bio-ecological zones →	1				2				3					4	5	6				7
Climate change																				
Shorter milder winters	■	■	■	■			■	■	■		■		■	■	■	■		■		
Hotter weather	■	■	■	■	■	■	■	■	■		■	■	■		■		■	■		
Increased storms	■	■	■	■	■											■				
Abnormal rainfall		■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■		■
Drought conditions													■							
Increased fog										■		■				■				
Higher water levels											■				■	■				■
Fewer identifiable seasons		■	■			■					■				■		■	■		■
Increased siltation	■	■	■	■	■										■	■	■	■		
Soil erosion					■		■			■					■	■				
Salinity intrusion		■	■	■	■										■					■
Lower ground water levels					■								■	■						■
Low agricultural productivity	■	■	■	■	■	■	■	■				■	■		■	■		■		
Water logging	■	■	■	■							■				■	■				■
Biodiversity																				
Reduced fish catch	■	■	■	■			■	■	■	■		■			■		■	■	■	
Reduced fish species		■	■	■			■	■		■				■	■		■	■	■	
Deforestation	■				■									■						
Reduced varieties of rice	■								■				■	■			■	■	■	■

* Bio-ecological zones: 1: Coastal areas (Teknaf, Satkhira, Hatiya, Subarnarchar); 2: Hill areas (Teknaf, Bandarban, Rangamati, Khagrachhari); 3: Floodplain (Rangpur, Tangail, Nawabganj, Jessore, Barisal); 4: Barind Tract (Dinajpur); 5: Mangrove (Khulna); 6: Wetland (Haor basin: Kishoreganj, Sunamganj, Bishwambarpur, Chalan beel: Natore); 7: Peatland (Gopalganj wetlands)

Table 2. Examples of major problems and challenges identified by communities of different regions and local or traditional remedies practiced by them.

Location	Problem / challenge	Local / traditional solution
Itna, Kishorganj	Cropping patterns not matching current climate	Shift in harvest times
Bhuapur, Tangail	Improve soil quality / moisture	Planting shon (a type of grass) seeds to retain moisture and act as organic fertilizer
Hatiya, Noakhali	Assessing seed quality	Placing seeds in water, good quality seeds remain submerged
Rangamati	Agricultural pests	Neem trees planted in crop fields; neem leaves put in seed bags
Sunamganj	Reconstruction of dams / roads	Traditional system of fundraising
Itna, Kishorganj	Flooding	Raising the base of houses
Satpar, Gopalganj	Flooding	Cattle kept on floating platforms
Keshobpur, Jessore	Waterlogging	*Gher* (fish) culture in summer and rice cultivation in winter in the same area
Banaripara, Barisal	Waterlogging	Floating gardening
Dacope, Khulna	Salinity	Compost with hay, mehghani, shirish and chandan leaves with cow-dung for one year; mixed to prepare nursery beds
Hatiya, Noakhali	Maximising resources	*Bajal* – fish farming and rice cultivation together
Panchhari, Khagrachhari	Maximising resources	Privately initiated plantation cooperatives of 20 people. Short-term: jackfruit and sugarcane, long-term: teak
Teknaf	Capsizing boats	Daily fishing to avoid dangerous cyclones/tidal surges

For further validation of the importance of community involvement in conservation and adaptation, five case studies were conducted on best practices, local traditional knowledge and resource use modality as well as adaptation actions at local level. The aim of this activity was to support better implementation of Article 8(j) of the CBD concerning ABS issues and also UNFCCC provision as indicated in the Bangladesh NAPA. The five case studies compiled in this publication highlight five different aspects of biodiversity conservation and climate variability adaptation, mainly focusing on agricultural practices and forest resource management. The topics were selected on the basis of information gathered through consultations across the country, field surveys and expert consultation on different occasions.

The first case study questions whether floating cultivation – an age-old agricultural system in Bangladesh and a potential answer to adaptation has already started to be affected by climate variability or not. Floating gardening is a very common practice in the Barisal and Gopalganj areas of Bangladesh to raise crop seedlings and grow vegetables in monsoon on stagnant water. Here water hyacinth and other plant materials are used to make a platform. In winter the platform is dismantled and used as fertilizer to grow vegetables on soil. Bangladesh, being a low-lying country, would be the worst victim of climatic variation and water-logging situation will cause devastation in the coming years. In this country, floating gardening has been identified as an adaptation technique to withstand water-logging conditions. The present study attempts to answer the question, whether this potential coping mechanism itself is being threatened by the varying climatic conditions or not. The study identified some notable changes in the extent and cropping pattern on floating gardens, but climatic variability is often coupled with or even masked by economic concerns of the farmers. Local perceptions on climate variability and its apparent impacts on floating farming were also documented under the study along with adaptive measures taken up by the farmers. Finally, the study concluded that it would be useful to undertake further investigations on the impacts of climate variability on floating gardening to make the technique a reliable adaptive measure for rural community under a changing climate situation.

In the second study, some interesting data on dye-producing plants of the Chittagong Hill Tracts (CHT)–a land of biological and ethnic diversity–were presented. Different ethnic communities living in the CHT used to extract natural dyes from plants. But over the years, use of these dyes has drastically declined. The case study revealed a total of 20 dye-producing species in three hill districts of the CHT used by different ethnic communities. The account registered different information on these plants including plant parts used to produce dyes, extraction methods and traditional uses. On the causes behind the decline in use of natural dyes now-a-days, the foremost reason identified is longer and costlier extraction process of natural dyes compared with artificial dyes readily available in the market. The study raises an alarm about the erosion of traditional knowledge and practices associated with dye-producing plants in the CHT. It, therefore, stressed the promotion of local awareness of natural dyes and needs to create market demand for natural dye production along with research on dye-producing plants including their propagation techniques for *ex situ* conservation.

The third case study of this publication highlights the issues, concerns and opportunities of the highly degraded forest ecosystems of northern Bangladesh (greater Dinajpur district) – the sal (*Shorea robusta*) forests. A comparison between the past and recent conditions of these forest patches revealed alarming degradation principally through encroachment of forest land and unwise harvesting systems. Despite strong dependency of local communities, particularly indigenous santal people, on these patches, the sal forests of Dinajpur area still lack sufficient management efforts. The account provides a brief on current management regime putting emphasis on participatory afforestation, which is also not without constraints and limitations. Although a national heritage, the northern sal forests still suffer from a dearth of conservation initiatives. The paper advocated for effective participatory management options for a successful afforestation programme with native species as opposed to exotic species, integrated planning and management of the forest areas keeping productivity in mind, and homestead forestry as an option for reducing pressure on forest resources.

The fourth case study was undertaken to identify the varying factors related to climate change and variability that poses a threat to the agriculture and cropping pattern in the Noakhali district–an extremely vulnerable coastal area. This study also provided an insight into the traditional knowledge and existing coping mechanism practiced by local farmer folks to withstand existing changes in the climatic condition. In the process the case study also reveals such environmental and non-environmental agricultural constraints commonly faced by the local farmer communities at the particular locality. Interestingly, the farmer community of Noakhali highlighted some of the major causes behind the changes in the cropping pattern which combines both climatic variation as well as economic aspects. The study also suggested a number of recommendations, such as to carry out further studies and research on the topic in various areas of Bangladesh and promote these as best practices to tackle similar climatic threats in other parts of the country. Agricultural extension services may also take a lead to equip the local people through training to deal with future changes or variations in climate.

The last case study shares the rich agro-biodiversity and associated traditional knowledge available in Bangladesh as raw materials for climate variability adaptation, basically focusing on native rice varieties. Although numerous native varieties are already lost failing to compete with improved varieties, the study tried to provide a glimpse of the stock of the indigenous rice varieties based on secondary sources, consultations and experiences of the author. The study showed different attributes of native rice varieties which include not only cultural or farming preferences, but also tolerance to abiotic stresses, such as drought, salinity, tidal submergence and water-logging. The latter characteristics would be useful to select a variety while considering the local climatic variations to face the threats posed by the same. The study also noted significant cultural, economic and research values of these varieties and emphasized efforts to conserve them. The study concluded by stressing the necessity of an extensive survey on native crop varieties followed by collection and characterization of the same, and specific adaptive research on them across agro-ecosystems with potential exposure to specific climate variability.

All these studies have recommended some useful research and practical actions on the ground for biodiversity conservation and/or climate change and variability adaptation. Traditional knowledge and practices, and community involvement have been found in the centre of all the studies. In addition, these accounts also put forward some thought-provoking questions that need to be considered while setting priority actions under the CBD and UNFCCC.

The CICMEA initiative has reconfirmed the importance of community involvement in the successful implementation of MEAs. Such participation not only needs national frameworks and mechanisms, but also pragmatic actions, like development and utilization of participatory GIS mapping, establishment and maintenance of village-based biodiversity registers, documentation of ethno-botanical information by ensuring custodianship of TK and utilization of communication networks and grassroots organizations for better outreach of information and knowledge at local level. A valuable combination of traditional knowledge and practice with advanced technology could make a significant difference in biodiversity conservation and climate variability adaptation in a country like Bangladesh.

1 Floating Gardening in Bangladesh: Already Affected by Climate Variability?

Haseeb Md. Irfanullah

Floating gardening, Bangladesh and Climate variability

Floating gardening or baira cultivation is an age-old technique in Bangladesh. This form of hydroponics is mainly confined to the southern wetlands of the country (Haq *et al.*, 2002; IUCN Bangladesh, 2005; Tawhid and Atkins, 2007). In this technique, aquatic plants are used to construct floating platforms on which vegetables and other crops are cultivated, and seedlings are raised in the rainy season. In the subsequent winter, the platform is dismantled and the residue is used to make winter vegetable gardens. Water hyacinth (*Eichhornia crassipes*), one of the most common aquatic plants of Bangladesh, is now the major material for floating platforms. This cultivation technique is, therefore, an environment-friendly means to utilize the natural resources of wetlands to grow vegetables and other crops almost all-the-year-round. Figure 1 summarizes the technique. Details of floating gardening technique could be found elsewhere (IUCN Bangladesh, 2005; Irfanullah *et al.*, 2008a).

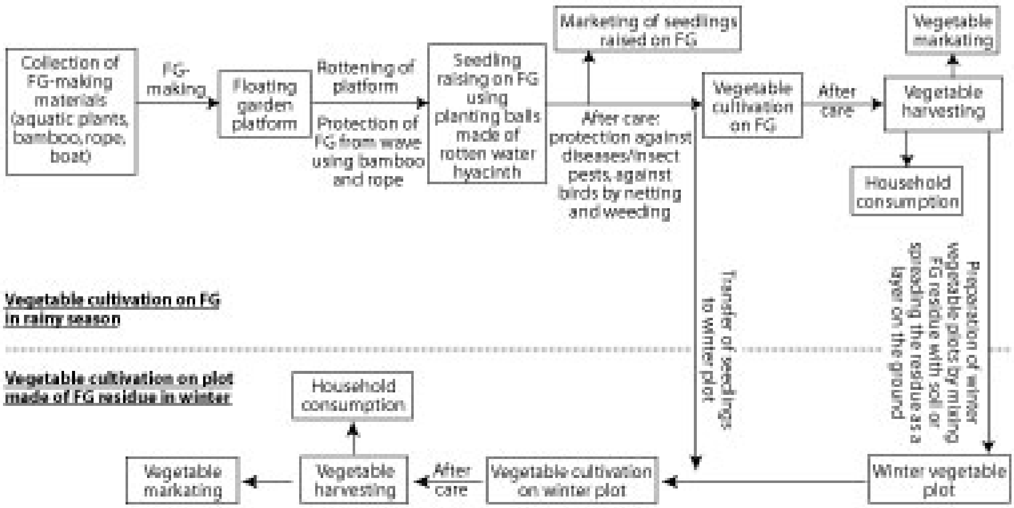

Figure 1. Flow-chart showing floating and winter vegetable gardening traditionally practiced in Bangladesh (FG, floating garden). Reproduced from Irfanullah *et al.* (2008a).

In recent years, baira cultivation has generated huge interest in the field of agriculture. Given its possible contribution in improving livelihoods and food security in rural Bangladesh, this agro-technique has recently been extended in northern Bangladesh (Practical Action, 2007) and in north-eastern Bangladesh by IUCN Bangladesh with CARE Bangladesh in recent years (Irfanullah *et al.*, 2008a, 2008b). Moreover, this farming system has already shown its potential in tackling the consequences of climatic variability and climate change like prolonged water-logging (IUCN Bangladesh, 2005). For example, the Reducing Vulnerability towards Climate Change (RVCC) Program of CARE Bangladesh has tried this technique in several districts of southern Bangladesh facing water-logged conditions. The National Action Programme for Adaptation (NAPA) document of Bangladesh included floating gardening in one of the 15 major projects (MoEF, 2005).

Given its potential to adapt to the consequences of climatic variability, an attempt has been taken to investigate if baira cultivation has already been facing the impacts of climate variability in recent years.

Approach

A number of upazilas of Gopalganj (Sadar, Muksudpur and Kotalipara), Barisal (Banaripara) and Pirojpur (Najirpur) districts of Bangladesh were selected to conduct the present study. The study areas (Gopalganj and Barisal region (Barisal and Pirojpur)) had some distinct features in terms of floating gardening. The platforms in Barisal region are much longer, made on almost stagnant waters in canals. Here most of the baira farmers consider this agro-system as their sole livelihood option. In winter, kandi cultivation can be seen here when raised mounds of soil on water-logged areas are built on which baira residues are spread and other plant materials like ground coconut-husk is spread and crops are cultivated. In Gopalganj, on the other hand, platforms are relatively shorter, made in beels (a kind of wetland) and brought by homesteads. Here most of the farmers have not taken this as the only income generating option. Here, therefore, seedling raising on baira is not as extensive as in Barisal. In winter, baira residue is spread over or mixed with soil of dried out beel areas where winter vegetables are grown. Kandi cultivation cannot be seen in Gopalganj.

Floating gardening (left panel) and winter gardening (right panel) in the Barisal (top panel) and Gopalganj (bottom panel) regions.
PHOTO: H.Md. Irfanullah

In October 2008, two group discussions were conducted in the study areas on understanding agricultural changes over the last 5-7 years in the area with special emphasis on floating cultivation. Further, a survey was conducted in the same areas using a structured questionnaire to get responses and perspectives from individual baira farmers on different pertinent issues. The age of the respondent ranged from 25 to about 80 years (average 46 years). The respondents had been practicing baira cultivation on average for 20 years (ranged from 7 to 60 years). All the questions the farmers were asked revolved around the following three main issues.

1. Changes in floating cultivation: extent, crops and expense
2. Changes in weather patterns and apparent effects on baira cultivation
3. Adaptive measures practiced to tackle climate variability

Changes in floating cultivation: extent, crops and expense

Extent of floating gardening

About 75% of respondents learnt the technique from their fathers, and some from grandfathers, relatives and neighbours. A couple of farmers from Gopalganj informed that they learned the technique from vendors from Barisal. Therefore, baira cultivation was a traditional practice for most of the respondents.

On average, there has been 44% increase in baira cultivation at individual level over the last 5-7 years. Most of the respondent indicated that they have expanded their baira cultivation over the last few years (Table 1). The proportion was, however, greater in Barisal than Gopalganj.

Table 1. Changes in the extent of baira cultivation by individual farmers calculated from the numbers of platform they built in 2008 and 5-7 years back in Barisal and Gopalganj districts. (Total no. = 79; Barisal 45, Gopalganj 34)

Extent of baira cultivation	Total data (%)	Districts (%)
Increased	60	Barisal (67) Gopalganj (47)
Decreased	30	Barisal (33) Gopalganj (26)
Unchanged	10	Barisal (0) Gopalganj (27)

In Barisal, the main reason for a decrease in baira cultivation was increase in input costs. Whereas in Gopalganj, i) lack of water hyacinth, ii) not being profitable like before, and iii) environmental issues like less water, storm, floods were the main reasons causing decline in baira cultivation in recent years.

Up taking new crops

About 63% of the baira farmers accepted new crops in monsoon seedling raising and 93% of them did it because new crops are more profitable. The remaining farmers up took new crops because old ones were not that productive. Environmental reasons were not mentioned for any new-crop-uptake.

In winter, more than 75% farmers accepted new crops over the last 5-7 years. Of them, 72% were cultivating new crops since these were more profitable, and 12% left old crops because these became less profitable. Interestingly, 12% mentioned that they shifted to new crops because the weather was no longer suitable for some old crops.

Table 2 compares the numbers of crop varieties cultivated and seedlings raised in two districts. In the case of vegetable cultivation, no significant changes could be noted. But in the case of seedlings raising, the number decreased in Gopalganj (26%), but increased in Barisal (23%). Therefore, individual farmers may have started cultivating new crops, but as a whole no significant introduction of new crops occurred in the areas. This was also supported by the analysis of the extent of individual crop as described below.

Table 2. Comparison between number of crop varieties cultivated or seedlings raised in Barisal and Gopalganj districts present and 7 years back.

	Barisal		Gopalganj	
	Present	7 years back	Present	7 years back
Seedlings (in 2008)	21	17	14	19
Monsoon vegetables (in 2008)	14	12	17	18
Winter vegetables (in 2007)	30	28	19	19

Changes in cropping pattern

Seedling raising

Bottle gourd has always been the most widely raised seedlings followed by hyacinth bean in both districts (Figure 2). Other cucurbits, like pumpkin and wax gourd seedlings are moderately to widely raised in both districts. Papaya and beetroot seedlings, on the other hand, are only raised in Barisal with a significant increase in the recent years. Besides, seedlings of vegetables like bitter gourd, brinjal, cabbage, cauliflower, chili and tomato seedlings are always widely raised in this district. Raising of these seedlings is quite limited in Gopalganj except for tomato, which has a good increase in the recent years, but could hardly be found 7 years back. Turmeric is only raised in certain parts of Gopalganj (e.g. Kolabari union). Cucumber showed some decrease in both the districts.

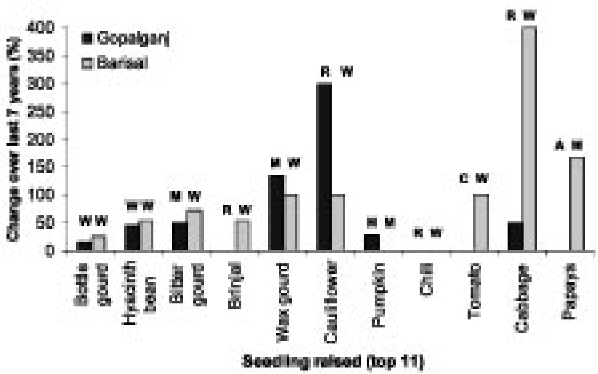

Figure 2. Change in seedling raising on floating gardens in Gopalganj and Barisal over the last 7 years and the current extent (W = widely cultivated, C = commonly cultivated, M = moderately cultivated, R = rarely cultivated, A = absent).

Monsoon cultivation

In the monsoon (Figure 3), vegetable cultivation on floating platforms is limited compared with seedling raising in both districts. Red amaranth (lal shak) has always been widely grown in both districts, whereas Ceylon spinach and amaranth (daata shak) have been moderately cultivated. Kang kong (gima kolmi) are now common only in Gopalganj. Wax gourd has always been moderately grown in rainy season on floating platforms in Barisal, whereas spinach and okra are found to be moderate in Gopalganj. Okra, however, has reduced cultivation in 2008.

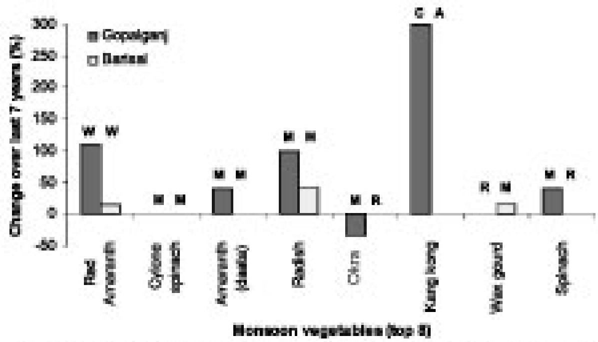

Figure 3. Change in vegetable gardening on floating gardens in Gopalganj and Barisal over the last 7 years and the current extent (W = widely cultivated, C = commonly cultivated, M = moderately cultivated, R = rarely cultivated, A = absent).

Winter cultivation

Cauliflower has always been widely cultivated on kandi (Barisal) or land made with baira residues (Gopalganj), with a good recent increase in Gopalganj (Figure 4). Cabbage, brinjal, chilli, tomato, spinach and amaranths also showed good increase in recent years in this area. Cabbage and chilli have always been common in Barisal in winter. Plantine is now commonly cultivated on kandi in Barisal in winter, which was absent in several years back. Different pulses used to be cultivated in winter in Barisal, but rarely in recent years.

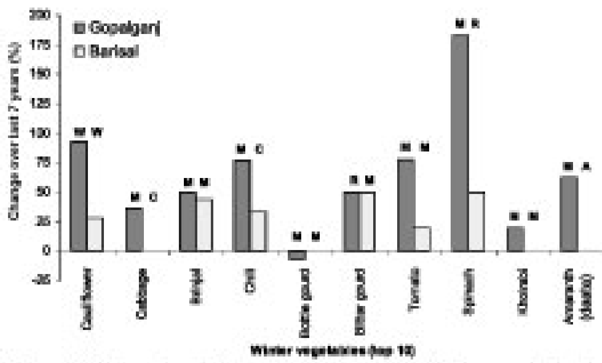

Figure 4. Change in winter gardening following floating gardening in Gopalganj and Barisal over the last 7 years and the current extent (W = widely cultivated, C = commonly cultivated, M = moderately cultivated, R = rarely cultivated, A = absent).

Cultivation expense

On average there has been more than 3 times increase in monsoon cultivation cost (per baira) over the last 5-7 years with a maximum of 11 times. On the other hand, in winter, the increase in cultivation cost was as high as 5 times over the same period with an average of 3 times. According to the respondents, the reason for increase in cost of baira farming are multiple in both the seasons (Table 3). In some rare cases, the labour cost increased not only because of increase in wages, but also because people expanded their baira cultivation, thus instead of putting their own labour, they employed labourers to support them.

Table 3. Sources of increased cost of baira cultivation in monsoon and subsequent winter cultivation in Barisal and Gopalganj calculated on the basis of percentage of respondents. % is of total number of respondents under took each type of cultivation. Multiple responses considered.

Source of expenses	Monsoon (%)	Winter (%)
Labourer	95	93
Seed	63	69
Fertilizer	56	65
Pesticide	56	61
Raw material	43	
Irrigation	2	3
Land rent		3

Climate variability and its impacts

Changes in weather pattern

Most of the respondents suggested that there have been significant changes in weather (multiple responses): it now rains at odd times (79%), monsoons are very hot (55%) with less rain (31%), and storms / cyclones also increased (23%). Seasons cannot be separated now. Ashar-Sraban Bangla months (mid June - mid August) used to be rainy season even 15-20 years back, but not now. Random rainfall spells are seen now-a-days; high rainfall is even seen in Ashwin (mid September - mid October) month. Temperature is also high in recent years. Temperature sometimes reduces after rain, some times not; so no pattern is now observed. Wind direction also does not follow any patterns. Regular Kalboishakhi storm does not occur now in Boishakh (mid April - mid May) even like 8-10 years back. As noted in Gopalganj, it now floods intensively with shorter gaps. Depression in the Bay of Bengal now starts much earlier than Kartik month (mid October - mid November). Winter lingers till Falgun (mid February - mid March), which is considered a spring. Besides, some individuals indicated increases in thunder storms, late winter, and long spells of rains as signs of changing weather. Nonetheless, only a few had clear knowledge on 'climate change' as a phenomenon, and its impact on baira cultivation.

Impacts of climate variability

According to the respondents (multiple responses) the three main apparent consequences of climate variability are increases in pest attacks (88%), increased requirements of fertilizers (29%) and less availability of raw materials (water hyacinth) to make platforms (14%). It was told that continuous unexpected rainfall is bad for seedlings of certain crops. For example, in the last week of September 2008, heavy rainfall for about 5 days damaged bottle gourd seedlings, making them yellow, rotting their roots. Many people now have doubled their floating gardens, but low production, thus low income prevails. Fertilizer application has increased a lot in recent years to make seedlings green and fresh to get better price. Earlier, farmers used to apply small amount of fertilizer, but now apply a lot. Moreover, previously people used to give cow-dung as fertilizer on their baira in Barisal. Now, since cattle number has decreased, cow-dung availability has decreased as well.

Adaptive measures practiced

About 90% of baira farmers practiced one or more methods in the monsoon to adapt to climate variability as listed in Table 4. On the other hand, more than 50% of farmers who cultivated in winter up took measures to tackle changing weather. Some people sprayed water during heavy fog to save seedlings on platforms.

Table 4. Methods of tackling impacts of climate variability in baira cultivation in monsoon and subsequent winter cultivation in Barisal and Gopalganj. % is of total number of respondents under took each type of cultivation. Multiple responses considered.

Methods of tackling apparent impacts of climate variability	Monsoon (%)	Winter (%)
Use more pesticide	44	41
Organic ways (e.g. ash) of tackling pests	4	
Make the baira platforms earlier / early planting of crops in winter	19	1
Use more fertilizer	16	22
Save seedlings from hot weather (watering or use shades)	16	8
Grow different seedlings / mixed crops (if one gets damaged, others would survive)	19	15

Conclusion

Changes in climate has been well-recognized by the baira farmers in Barisal and Gopalganj regions. But, the changes in cropping pattern may not directly be stated as a sole response to apparent climate variability. In general, now the baira cultivation is not as profitable as it used to be given the price hike of commodities in recent years. The input costs have become much higher than before. Baira farmers are switching to new crops like plantine to get more profit. According to them, the market has become very competitive. Some farmers are also planning to switch from baira cultivation to something else as a livelihood option. On many occasions, baira cultivation is now practiced as a part of agricultural tradition. But, sons may not continue it after their fathers. Nonetheless, some farmers were found to be very happy to cultivate baira which made them well-off.

Floating gardening has been actively considered as an adaptive option to climate change and climate variability and is being promoted widely in different parts of Bangladesh by different agencies. It would be worthwhile to undertake research on the impacts of climate variability on floating gardening in near the future. This may help making the dissemination of baira technique to rural community as a stronger, reliable measure adaptive to the changing climate scenario.

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2 Dye-producing Plants Used by Ethnic Communities of Chittagong Hill Tracts of Bangladesh

Mohammad Abdul Motaleb

Introduction

Plants are important sources of medicine, aromatic substances and dyes. Over the last couple of decades, much discussion has been taking place on the conservation of medicinal and aromatic plants at different national and international fora around the globe. On the contrary, global attention to conservation of dye-producing plants is still limited. Since the flourishing dye industry is currently dominated by synthetic dyes, the knowledge of dye-producing plants mostly survives among some isolated dyers, who still use plant dyes to limited extents (Kala, 2002; MacFoy, 2005; Mahanta and Tiwari, 2005; Siva, 2007). The indigenous knowledge associated with these plants is also rapidly eroding since passing of it on to subsequent generations is limited. But over recent years, the demand for natural dyes is increasing at a moderate pace (Siva, 2007).

Despite its small area, Bangladesh possesses rich and diverse flora and fauna because of her diverse ecosystems, climate and geographic position. Like any other part of the world these natural resources are diminishing day by day. Traditional knowledge (TK), especially that related to agriculture and biodiversity, has always played an important role in country's food supply, natural resource management, economy and people' livelihoods. In addition, TK and experience of different ethnic groups can play a vital role in the identification, conservation and use of various plant resources. Many recent studies highlight this fact, but mainly focus on medicinal plants (e.g. Alam, 1992; Uddin *et al*., 2001; Yusuf *et al*., 2006; Partha and Hossain, 2007). Dye-producing plants and TK associated with them get less priority in current ethnobotanical research in Bangladesh. At present, dye is mainly produced from chemical sources in Bangladesh. Governmental research organizations, for example, Bangladesh Council of Scientific and Industrial Research (BCSIR), Bangladesh National Herbarium and Bangladesh Forest Research Institute (BFRI), and non-governmental research organizations such as Unnayan Bikalper Nitinirdharoni Gobeshona (UBINIG), Bangladesh Resource Centre for Indigenous Knowledge (BARCIK) and others are currently working on agro-biodiversity, ethnobotany and also on medicinal and aromatic plant conservation, but comparatively lower emphasis is given to the conservation of dye-producing plants (SU/SSC, 2000; RIB, 2002; Islam *et al*., 2007). It is reported that there are about 150 commercially important dye-producing plants in the world, but published information on those found in Bangladesh is very limited (Pasha, 2003).

The Chittagong Hill Tracts (CHT) is the most resource dense region of Bangladesh in terms of biological and ethnic diversity. In this area of eroding biodiversity, ethnic communities play a very important role in safeguarding TK related to plant usage. Along with other different uses, ethnic communities of the CHT used to extract natural dyes from different plants in the past. But the use of vegetative dyes is seemingly limited in recent time. Given the small amount of published information on dye-producing plants in the CHT and Bangladesh in general, there exist needs to explore the present status of dye-producing plants of an important region like the CHT.

Raw materials for natural dye production (clockwise from top left): fruits of haritaki, fruits of jarul, young leaves of shegun and stem of khoir. PHOTO: M.A. Motaleb

Against this backdrop, a case study has been conducted in the CHT with two major objectives:

1. To document dye-producing plants used by the ethnic communities of CHT including indigenous techniques used by them; and
2. To identify the scope of preserving the traditional practices associated with dye-producing plants in the region.

Approach

The present investigation was carried out in three upazilas of three hill districts of Bangladesh namely, Rangamati Sadar of Rangamati district, Panchhari of Khagrachhari district and Thanchi of Bandarban district from October to December 2008. A literature survey was conducted for secondary information on dye-producing plants of these areas, but no such information was found. Information was primarily gathered through semi-structured questionnaires, FGDs and one-to-one discussions. A number of field visits and FGDs were conducted in three upazilas at union level. One-to-one discussions were conducted with older persons and the Headmen (head of a mouza or village) of the ethnic communities. A total of 15 cottage industries were visited randomly in the study areas to gather information on dye-producing plants. For information collection, FGDs and one-to-one discussions were given more priority. Owing to limited resources, scope and time for the present study, the author could spend only a few trips to the mentioned areas and could stay for a short while with the informants to collect information. In those trips, local NGOs helped in introducing to the informants to gather information. Secondary information was also collected from BFRI and BCSIR offices in Chittagong. During information collection on dye-producing plants, species were identified during field visits with help from the community people.

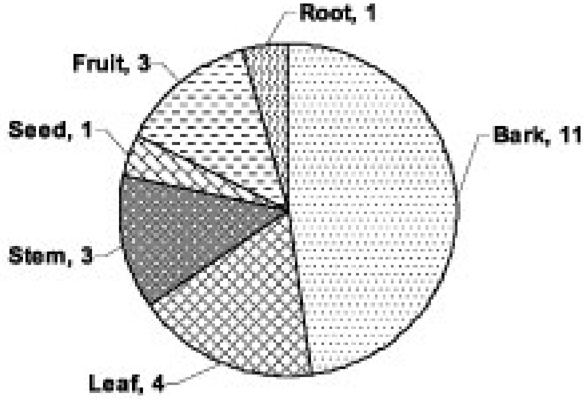

Figure 1. Different plant parts as sources of natural dyes in the CHT. Individual number indicates the total number of species under each part.

Dye-producing plants and their uses

The present study reveals a total of 20 species, including two unknown species, of dye-producing plants used or formally used by the ethnic communities of the CHT (Table 1). Among them, chakua koroi (*Albizia chinensis*) was found both in Rangamati and Khagrachhari districts, and kanthal (*Artocarpus heterophyllus*) and gaab (*Diospyros peregrine*) were found in Bandarban and Khagrachhari. In Rangamati, information on one dye species was found, while 12 and 10 species were found in Khagrachhari and Bandarban, respectively. Most dyes were produced from the bark of plants and others from other plant parts (Figure 1). Different colours such as yellow, brown, black, violet, green, red, pinkish red, pink, golden and orange can be found from different plant species (Table 1). One dye (chakua koroi) is produced in the form of powder and the rest are produced in the form of liquid. Dyes produced from aam (*Mangifera indica*), kanthal, kagji lebu (*Citrus aurantifolia*), minjiri (*Cassia siamea*), and shegun (*Tectona grandis*) are temporary and those produced from the remaining 15 are permanent dyes.

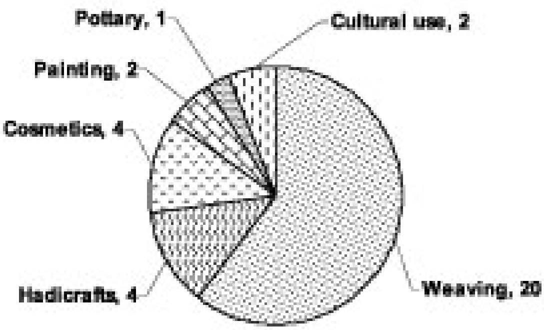

Figure 2. Use of plant dyes found in the CHT. Individual number indicates the total number of species with each use.

Most of the dyes are used for weaving and some are used for handicrafts and cosmetics (Table 1, Figure 2). Some dyes also have cultural importance. Dyes were mainly used by Chakma, Marma, Murong, Bom, Khumi and Tripura ethnic communities.

It was observed that in all the cases boiling is the sole extraction method by which the ethnic communities produce dyes. Except cha gach or tea plant (used by bhantee or Buddhist monks), all the species are not in use at the moment for dye production.

Dye-producing plants documented in the present case study are enumerated in the Table 1 alphabetically by their scientific names.

Earlier, Islam *et al.* (2007) found that the tribal people of the CHT dye their yarns with natural dyes produced from karma gach, rang gach, bark of mango and turmeric. The present study validates most of these observations. Pasha (2003) reported that in Bangladesh, the most textile industry dyes are produced from khoir (*Acacia catechu*) which is extracted from the heart wood of the tree. In the CHT, this practice was also observed.

Table 1. Dye-producing plants recorded from three upazilas of Bandarban, Khagrachhari and Rangamati hill districts.

Sl. no.	Local name	Scientific name (Family)	Upazila, District (Location)	Producer & user	Use*	Form of dye; Colour; Permanency	Parts uses & dye production process
1.	Khoir	*Acacia catechu* [Mimosaceae]	Thanchi, Bandarban	Bom, Chakma, Marma, Murong, Tripura	Weaving	Liquid; Brown; Permanent	**Stem.** Small pieces of stem are first soaked into water for 3-4 days and then boiled 2-3 times for at least 4-5 hours each time. 3-4 kg stem needed for 1 litre liquid dye.
2.	Babla	*Acacia nilotica* [Mimosaceae]	Thanchi, Bandarban	Bom, Chakma, Khumi, Marma	Weaving	Liquid; Brown; Permanent	**Bark.** Bark is boiled for 2-3 hours with great care, left for 2-3 days, and boiled again. 2-3 kg bark needed for 1 litre liquid dye.
3.	Chakua koroi	*Albizia chinensis* [Mimosaceae]	Panchhari, Khagrachhari; Rangamati sadar, Rangamati	Chakma	Weaving, handicrafts	Liquid; Light brown; Permanent	**Bark.** Bark is boiled at high temperature for 2-3 hours, blackish colour appears, and then boiled again with cotton to dye. 4-5 kg bark needed for 1 litre liquid dye.
4.	Peyanj	*Allium cepa* [Liliaceae]	Thanchi, Bandarban	Khumi, Marma, Murong	Weaving, cosmetics (girls use the paste in their hair to make it shinny)	Liquid; Golden; Permanent	**Bark.** Some bark is boiled in water for 2-3 hours. When light golden colour appears, some more bark is added to the solution and boiled again. 0.5 kg bark needed for 1 litre liquid dye.

Table 1. (Contd)

Sl. no.	Local name	Scientific name [Family]	Upazila, District (Location)	Producer & user	Use*	Form of dye; Colour; Permanency	Parts uses & dye production process
5.	Kanthal	*Artocarpus heterophyllus* [Moraceae]	Panchhari, Khagrachhari; Thanchi, Bandarban	Chakma, Marma	Weaving	Liquid; Light yellow; Temporary	**Bark**. Dye is produced by boiling bark. Some people first make paste of bark then boil. 7-8 kg bark needed for 1 litre liquid dye.
6.	Latkan	*Bixa orellana* [Bixaceae]	Thanchi, Bandarban	Bom, Chakma, Khumi, Marma	Weaving	Liquid; Orange; Permanent	**Seed.** At first seeds are ground by hammer then boiled in water for 3-4 hours. 0.5 kg seeds needed for 1 litre liquid dye.
7.	Cha gach	*Camelia sinensis* [Theaceae]	Thanchi, Bandarban	Bom, Chakma, Marma	Weaving	Liquid; Brown; Permanent	**Leaf.** Leaves are boiled for 4-5 hours and left for 24 hours. After that some more leaves are added and boiled again. 1-2 kg leaves needed for 1 litre liquid dye.
8.	Minjiri	*Cassia siamea* [Caesalpiniaceae]	Panchhari, Khagrachhari	Chakma	Weaving	Liquid; Light brown; Temporary	**Bark.** Bark is boiled for 3-4 hours and then cotton is soaked in this solution directly. Then the cotton is dried in the sun. 2-3 kg bark needed for 1 litre liquid dye.
9.	Kagaji lebu	*Citrus aurantifolia* [Rutaceae]	Thanchi, Bandarban	Bom, Chakma, Khumi, Marma	Weaving, in cultural programmes they colour each other by this dye	Liquid; Light green; Temporary	**Leaf.** At first leaves are boiled for 7-8 hours and then cooled off. More leaves are added to the cooled solution and the solution is boiled for 4-5 hours. 1-2 kg leaves needed for 1 litre of liquid dye.
10.	Gaab Jarul	*Diospyros peregrina* [Ebenaceae]	Panchhari, Khagrachhari; Thanchi, Bandarban	Marma, Tripura	Weaving, net colouring	Liquid; Light black; Permanent	**Fruit.** Fruit is dipped into water for 3-4 days and then boiled for 4-5

Table 1. (Contd)

Sl. no.	Local name	Scientific name [Family]	Upazila, District (Location)	Producer & user	Use*	Form of dye; Colour; Permanency	Parts uses & dye production process
							hours. 7-8 kg fruit required for 1 litre liquid dye.
11.	Jarul	*Lagerstroemia speciosa* [Lythraceae]	Panchhari, Khagrachhari; Thanchi, Bandarban	Chakma, Marma, Tripura	Weaving, handicrafts	Liquid; Light violet; Permanent	**Bark & fruit.** Bark and fruits are soaked into water separately for 24 hours then both the waters are mixed and then boiled for at least 4-5 hours. 2-3 kg bark and 2-3 kg fruit needed for 1 litre liquid dye.
12.	Aam	*Mangifera indica* [Anacardiaceae]	Panchhari, Khagrachhari	Chakma, Marma, Tripura	Weaving, pottery	Liquid; Yellow; Temporary	**Bark & stem.** Bark and stem are boiled together for 3-4 hours and left for 4-5 days. When a yellow layer appears over the solution, some bark and stem are added to it and boiled. 2-3 kg bark and 4-5 kg stem are needed for 1 litre liquid dye.
13.	Rang gach	*Morinda angustifolia* [Rubiaceae]	Panchhari, Khagrachhari	Chakma, Marma, Tripura	Weaving, handicrafts	Liquid; Red; Permanent	**Stem.** At first the stem pieces are dried in the sun and then soaked into water for 2-3 days. The solution is then boiled at high temperature for 3-4 hours. 3-4 kg stem needed for 1 litre liquid dye.
14.	Kala jam	*Syzygium cumini* [Myrtaceae]	Panchhari, Khagrachhari	Chakma, Marma, Tripura	Weaving, handicraft	Liquid; Black; Permanent	**Bark.** Bark is boiled at high temperature for 2-3 hours and when blackish colour appears, it is boiled with cotton to dye. 2-3 kg bark needed for 1 litre liquid dye.

Table 1. (Contd)

Sl. no.	Local name	Scientific name [Family]	Upazila, District (Location)	Producer & user	Use*	Form of dye; Colour; Permanency	Parts uses & dye production process
15.	Shegun	*Tectona grandis* [Verbenaceae]	Panchhari, Khagrachhari	Chakma, Marma	Weaving, in cultural programmes people colour white cloths	Liquid; Pinkish red; Temporary	**Young leaf.** Dye is produced by boiling young leaves. Some times white dresses are coloured by rubbing young leaves. 1-2 kg young leaves needed for 1 litre liquid dye.
16.	Arjun	*Terminalia arjuna* [Combretaceae]	Thanchi, Bandarban	Chakma, Murong, Marma	Weaving, cosmetics (people use paste to remove spots on body)	Liquid; Pink; Permanent	**Bark.** Bark is soaked into water for 1-2 days. When colour appears in the solution, it is boiled for 3-4 hours. 1-2 kg bark needed for 1 litre liquid dye.
17.	Haritaki	*Terminalia belarica* [Combretaceae]	Thanchi, Bandarban	Bom, Chakma, Khumi, Marma	Weaving, cosmetics (girls use paste to remove spots on face)	Liquid; Golden; Permanent	**Fruit.** At first fruits are soaked into water for 2-3 days, and then boiled for 4-5 hours. 2-3 kg fruits needed for 1 litre of liquid dye.
18.	Goda	*Vitex glabrata* [Verbenaceae]	Panchhari, Khagrachhari	Chakma	Weaving, cosmetics (people use bark paste to remove spots on face)	Liquid; Yellow; Permanent	**Bark & root.** At first paste of bark and root is made, then it is boiled for 2-3 hours, left for 3-4 days and then again boiled. 6-7 kg root and bark needed for 1 litre liquid dye.
19.	Karma gach	Unknown 1	Panchhari, Khagrachhari	Chakma, Marma	Weaving, painting	Powder; Green; Permanent	**Leaf.** At first leaf is dried in the sun and then crushed to powder. The powder is soaked in water for 7-8 hours, and then boiled. 2-3 kg leaves needed for 1 kg dye.
20.	Kojo gach	Unknown 2	Panchhari, Khagrachhari	Chakma, Marma	Weaving	Liquid; Black; Permanent	**Bark.** Bark is boiled for 3-4 times for 2-3 hours each time. When colour appeared the solution is left for 1-2 days. 3-4 kg bark needed for 1 litre liquid dye.

*All the species are presently not in use for producing dye, except cha gach, which is used by Buddhist monks of keyang (temple) to colour their cloths.

Plant dyes and artificial dyes

About 20-30 years ago natural dyes were produced and used by local people. But now, as FGDs revealed, they do not use them and most of the people, except the older generation, do not know which the dye-producing species are and how to extract dye from them. Mahanta and Tiwari (2005) also reported similar erosion of knowledge from the younger generation of ethnic people in Arunachal Pradesh. As motioned above, in some remote areas Buddhist monks still use natural dye to colour their own cloths. Alarmingly enough, even the owners of the cottage industries of the study areas do not know about natural vegetative dyes, they are only aware of the artificial ones.

The virtual absence of natural dye use is due to complete dependence on artificial dyes by local people. Artificial dyes are easily available in the local markets and are much cheaper. On the contrary, extracting natural dye needs more time, effort and expense, without attracting sufficient price. Therefore, opportunity cost and unavailability of market incentives for producing natural dye in fact guide local people to use artificial dyes. Moreover, in the past, different dye-producing plants were available in the locality, but now these species have also became rare and even locally extinct. This may hinder any effort to revive the natural dye production in the locality. Most of our findings match with reports by other workers (e.g. Siva, 2007).

Local people indicated that artificial dyes may have apparent injurious effects on user's health. They noted that when started using cloths made of artificial dye, different skin diseases or discomforts increased among local girls, and the portion of the body which is covered by these cloths became darkish. This, however, could not be substantiated under the present study.

Medicinal values and dye production

As the study suggests, multipurpose use of plants might affect dye-production in the CHT. For example, plants like arjun, bohera (*Terminalia bellirica*) and some other species have the medicinal values. People now believe that medicinal values of these plants are more important than any other use, like dye production. Hence, they do not use these species for dye production. In Bandarban, more priority is given to the medicinal use of plants than to dye production, which was not observed in Rangamati and Khagrachhari. The present natural stock also cannot support the amount of raw materials required for producing dye. Denuding supply may also have caused people to shift their choice to readily available chemical dyes.

Noteworthy conservation initiatives for dye-producing plants at any level are absent in the study areas. Government or NGO initiatives on dye production were also not seen. Some local people tried to collect seedlings of dye plants and replanted in their homesteads, but the mortality rate was very high among the transplants. Although the reason was not clearly understood, incorrect propagation techniques and other silvicultural factors could be reasons behind it.

Conclusion

Limited research has so far been conducted in the field of dye-producing plants of Bangladesh. TK on dye-producing plants registered under the present study is quite useful and may help in future study on this economically important plant group. The local people of the CHT used to extract and use vegetative dyes widely even a couple of decades back. But, as appears from the study, market demand is one of the major issues for current diminishing plant dye production and use in the CHT since low market price of and easy access to artificial dyes pushed people away from natural dyes. Users' preference in using a species for medicine or dye production is also another issue. Limited awareness of importance of dye plants also deters conserving these species in the locality. Increased population pressure governs the land use in the CHT. This also directs apparent low priority in establishing dye-producing plant conservation areas in the region.

Under this circumstance, some specific suggestions are articulated below to guide the future course of action for conserving the plant group.

- Comprehensive research work is needed to document knowledge and practices associated with dye-producing plants in the whole CHT region.
- Research is needed on propagation techniques of these plants for their conservation.
- Local people of the CHT should be more aware of the production of natural dyes through various communication media.
- Dye-producing plants are currently not included in ABS discussions in Bangladesh. There is a good opportunity for highlighting the issue in future dialogues.
- Dye production and use by different ethnic groups should be supported by concerned authorities from conservation of cultural heritage point of view. Local NGOs should be encouraged to take up initiatives to preserve cultural heritage.
- Market can play a major role in conservation. Local boutiques are selling natural dye products with good price and a good market has been created in urban fashion trend. Since demand for natural dye is growing it can be harnessed as a driver to encourage planting more natural dye-producing plants. Local growers and producers can be linked with the market chain and this may provide incentives to conserve both the plants and knowledge of dye producing. Market can also be a double-edged sword may induce higher extraction from wild. GO-NGO collaboration in conservation and monitoring is necessary to avoid such undesirable situation.

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3 Remnant Sal (*Shorea robusta*) Forests of Northern Bangladesh

Mohammed Kamal Hossain

Introduction

Sal (*Shorea robusta*) occupies several forest types from tropical moist deciduous to tropical dry deciduous forests (Troup, 1921; Champion *et al*., 1965) and naturally grown in India, Nepal and Bangladesh (FAO, 1985). The tropical moist deciduous forests of Bangladesh are known as sal forests. The central and northern districts of Bangladesh covering an area of 1,20,255 ha are bestowed with sal forests. The sal in Bangladesh is distributed in Dhaka, Gazipur, Tangail, Mymensingh, Sherpur, Jamalpur, Netrokona, Rajshahi, Naogaon, Dinajpur, Rangpur, and in much degraded form in Comilla (Chowdhury, 1994). Of these, about 86% is distributed in the central region and 14% in the northern region (Ghani *et al*., 1990). However, most of the original sal forests are now shrub lands with only 20% tree cover (Davidson, 2000).

Importance of sal forests

Sal forests play a contributory role to the economy of the northern areas by providing timber, firewood, fodder, non-wood forest products (NWFP), etc. People living in and around as well as in the nearby habitation depend on these forests for meeting their demands of timber, poles, firewood etc. (Chowdhury, 1994; Uddin *et al*., 2006). Local people also depend on the forest for meeting their other basic needs for agricultural implements, cart wheels and other parts of cart, thatching grasses, etc. Sal forests are the sources of generating income for the people, specially those living in and around the forest areas, by providing employments in various forestry activities, supplying medicinal plants for trading, myrabolams for manufacturing tannin, sal fruits for extracting oil, sal and shoti (*Pennisetum setosum*) leaves for wrapping groceries (Chowdhury, 1994; Uddin *et al*., 2006). The bark and roots of sal are known to have medicinal value for various ailments (Troup, 1921). The forests also influence the climate, particularly the micro-climate in the region. The forest has bearing on the hydrological regime in the area, particularly in re-charging the ground water table. Thus, the sal forests have a great importance in maintaining the ecological and environmental equilibrium in the area (Chowdhury, 1994). The productivity of the adjacent low-lying agricultural lands is also influenced by these forests. The leaf-litters of sal also extensively used as organic matter for agricultural activities. The forests also provide the recreational facilities for the urban and city dwellers. As well, the sal forests are the traditional abode of Santal (indigenous community) of the area.

In sal forests, the predominant species is sal. The forests of the northern region are isolated patches of sal coppices surrounded by agricultural crops, homesteads and habitation (Uddin *et al*., 2006). This region historically was a part of Kamrup Kingdom, covering forests extending from Himalayas to Tarai region (Chowdhury, 1994). The area of the sal forests varied with sources. However, the total area of notified forests in the northern region, scattered in small patches of sal mainly in Dinajpur, Rangpur and Rajshahi is 15,626 ha. Out of these, the Social Forest Division Dinajpur comprises forest areas of Dinajpur, Thakurgaon and Panchagarh civil districts are shown in Table 1 (Chowdhury, 2006).

Table 1. District-wise forest land of Dinajpur Social Forest Division (Chowdhury, 2006).

District	Reserved Forest (ha)	Vested Forest (ha)	Acquired Forest (ha)	Khas land* (ha)	Total (ha)
Dinajpur	4,609.81	2,467.02	370.03	115.81	7,562.67
Thakurgaon	452.27	331.92	16.05	106.48	906.72
Panchagarh	13.47	1,851.67	0.73	1.06	1,866.93
Total	*5,075.55*	*4,650.61*	*386.81*	*223.35*	*10,336.32*

* Government-owned land.

The local timber merchants of Dinajpur area also think that once the whole area of greater Dinajpur district was covered by the natural sal forest and this forest has gone under soil due to natural calamities like earthquakes in the past. The wood of panniya sal (sal logs usually collected excavating river beds in the Dinajpur area) has been identified as *Shorea robusta* by studying the anatomical characters (Mohiuddin, 1991).

Most of the remnant sal forests are now severely degraded and poorly stocked (Islam, 1982). Some three decades ago, more than 60% of these forests were fairly densely wooded. But today, the forest has been reduced both in extent and tree density as well as stand quality. Despite a moratorium imposed in 1972 on extraction of wood from sal forests, illicit felling has continued unabated to date (Chowdhury, 1994; Uddin *et al.*, 2006). The encroachment of forest land is a major problem in Social Forest Division Dinajpur (Table 2).

Table 2. Encroached forest land of Social Forest Division Dinajpur (Chowdhury, 2006).

District	Encroached forest land (ha)				
	Reserved Forest	Vested Forest	Acquired Forest	Total Encroached	% of encroached land
Dinajpur	1631.77	1646.96	321.33	3600.06	47
Thakurgaon	73.99	250.72	7.46	332.17	40
Panchagarh	-	1131.41	-	1131.41	60
Total	*1705.76*	*3029.09*	*328.79*	*5063.64*	*48.98*

The sal forests of Bangladesh were managed under coppice system with a rotation of 25 years (Das, 1980, 1982). Areas where sal trees are comparatively less are managed under clear felling system followed by artificial regeneration mostly with sal and other suitable species (White and Ali, 1979; Das, 1980; Mohiuddin, 1982). The forest areas are shrinking day by day, natural sal has lost its coppicing ability and in fact, there is no record of coppice management and its growth. The forests are being destroyed at an unprecedented rate to clear land for agriculture and habitation. The great destruction occurred during the liberation war of Bangladesh in 1971 in the whole country and in the sal forests as well. The government banned the felling realizing the fact that the forest had degraded due to excessive felling and coppicing. But, the law was unable to protect these natural deciduous forests. The main cause of depletion of this forest was due to the land clearance for agriculture and forest land encroachment. Almost half of the total sal forests of the country have been already depleted. In Dinajpur area, sal forest areas have been drastically reduced to small patches due to human settlement, agricultural encroachment and mining activities (Alam, 1995; Chowdhury, 2006; Uddin *et al*., 2006).

Past status of plant diversity of sal forests

The biodiversity of sal forests was very wide and interesting both from ecological and conservation point of views (Alam, 1995), but no information was mentioned about sal forests of Bangladesh by Troup (1921). Prain (1903) emphasized the exploration on the Madhupur forests which occupy the major sal forests of the country. The list of important forest species are available in the Working Plans of Mymensingh Division (Chowdhury, 1960) and Northern Forest Division (Sattar, 1976). Cowan and Cowan (1929) prepared a list of plants from northern Bengal which included the plants of Darjeeling and Jalpaiguri districts. The ethnobotanical survey of Northern Sal forests (Phulbari upazila) includes a wide variety of flora (Uddin *et al*., 2006). The dominant species found in the Mymensingh - Dhaka forests is sal (*Shorea robusta*) ranging from 81-100% (Ismail, 1968). Some other common associates of sal are also reported by Ismail (1968), S. Das (1977) and D.K. Das (1990). It was found that sal forest stands comprise about 35 tree species of which *Shorea robusta* was the predominant one (Das, 1977). More recently, Alam (1995, 1999) prepared a checklist of the flora of Bangladesh sal forests. Some common associates of sal are given in the box.

Common associates of sal (*Shorea robusta*) in Bangladesh sal forests. Bangla names are given within parentheses.

Trees and shrubs

Adina cordifolia (Haldu)
Albizia spp. (Koroi)
Aphanamixis polystachya (Raina/Pitraj)
Artocarpus chaplasha (Chapalish)
Butea monosperma (Palas)
Careya arborea (Kumbi/Gadila)
Cassia fistula (Sonalu)
Cleistocalyx operculatus (Depha jaam)
Dillenia pentagyna (Hargaza/Ajogi)
Garuga pinnata (Kapila)
Holarrhena antidysenterica (Kurchi)
Lagerstroemia parviflora (Sidha jarul)
Litsea polyantha (Menda)
Microcos paniculata (Assar)
Miliusa velutina (Gandhi gazari)
Phyllanthus emblica (Amloki)
Schleichera oleosa (Kusum)
Semecarpus anacardium (Bhela/Beola)
Streblus asper (Sheora)
Sterculia spp. (Udal)
Terminalia bellirica (Bahera)
Terminalia chebula (Haritaki)

Undergrowth and climber species

Asparagus racemosus (Satamuli)
Bauhinia vahlii (Kanchan lata)
Chromolaena odorata (Asam lata)
Clerodendrum infortunatum (Bhat)
Dioscorea spp.
Entada pursaetha (Gila)
Flacourtia spp. (Boinchi)
Glycosmis spp. (Assheora/Matkilata)
Imperata cylindrica (Sungrass)
Mikania scandens (Germany lata/Assam lata)
Mucuna prurita (Shuashim)
Pennisetum setosum (Shoti)
Randia spp. (Mainakanta)
Scindapsus spp. (Gajpipal)
Smilax aspera (Kumari lata)
Vitis sp. (Panilata)
Ziziphus rugosa (Anigota/Jangli Boroi)

(after Alam 1995, 1999)

Present status of plant diversity and forest condition

A tremendous change is noticeable in the degraded sal forest areas of northern Bangladesh. Most parts of the recorded area of sal have poor stocking and quality. All the biotic and abiotic interferences led the forests to an unproductive forest area. Remnant natural sal stock has lost its vigorous coppicing ability to a great extent, bole becomes malformed and the growth of the forests seems to be stunted. The natural vegetation in the mid and high regions is gradually disappearing and some of the native plant species of this region have become potentially endangered. Sal is the major and in most cases the only important species of Dinajpur sal forests. Many associate species of sal disappeared in the very recent past and a remarkable area is now vacant or scrubs or converted to agricultural land. A thin vegetation cover is only seen in rainy seasons, whereas large areas remain barren. The sal forests of northern Bangladesh were degraded heavily by encroachers from neighbouring villages (Chowdhury, 1994; Uddin *et al.*, 2006). A serious dearth of food, fodder, fuel and building materials of plant origin in this area is also accelerating the forest degradation.

Possible impacts of climate change and invasive species

Global climate change is now a reality and the change is mainly happening due to global warming. The impacts of changing climatic conditions on plants, particularly the exotics are immense, insidious and usually irrecoverable. The scope and cost of alien invasions is global and enormous, in both ecological and economic terms. In Bangladesh introduction of alien invasive species of flora were deliberate primarily in order to increase productivity to support the needs of a huge population. The deliberate preferences of fast-growing, high-yielding species, e.g. *Eucalyptus camaldulensis* and *Acacia auriculiformis* eroded some of the native species and the genetic resources of the natural forests. Only scarce information is available about the alien species in Bangladesh and their impacts on the ecosystem. But, more than 300 exotic species are

Degraded sal forests in Dinajpur. PHOTO: Rajib Mahamud supposed to be either wildly growing or cultivated as economic crops in Bangladesh (Hossain and Pasha, 2004). In Bangladesh, some of the invasive species are so well established that they became noxious weeds of forests and wastelands (e.g. *Chromolaena odorata, Mikania cordata,* and *Lantana camara*). Climate change may favour the growth of some of these pioneer colonizing weedy species by replacing the native species (Hossain, 2008), which may be another disaster to the environment of northern Bangladesh. Climate change may also have effects on the phenology (flowering, fruiting, leaf flushing, etc.) and regeneration of some native species including the risk of pest infestation and diseases.

Dependency of local people

With a few exceptions, the majority of the indigenous communities are forest dwellers (Yadama *et al.*, 1997). The ethnic populations in the Bangladesh sal forests include Garo, Bangshi, Santal and Kooch. Forests and forest resources, primarily Minor Forest Products (MFP) or NWFPs play an important role in the viability and survival of tribal households because of the importance of forests in their social, cultural and economic survival (Tewari, 1989; Uddin *et al.*, 2006). The primary workers in the collection, processing and marketing of NWFPs are women who gather the bulk of forest produce, including food and fuel-related forest products. In Dinajpur of Bangladesh, a major share of food, medicine, house buildings materials and firewood of Santal community comes from the natural sal forests (Uddin *et al.*, 2006). Children and women also collect the leaf-litters by brushing the forest floors and a sack of leaf-litter are sold at a rate of Tk 30-40 in the market.

The sal forests in Dinajpur area were never properly managed. Extraction from the forests in 1950 – 1960's did not create the vacant areas because of low population in comparison to large forest areas. Local people and the forest dwellers collect their necessities from the forests whenever they need, but never harvest the produces in an indiscriminate manner. However, later on organized encroachers destroyed the sal forests indiscriminately. Repeated cuttings also damaged the coppicing ability of the sal stands.

Current management regime

In Bangladesh, plantation programmes are increasing day by day, and exotic species are getting preference over the indigenous ones (FMP, 1993). With deforestation, many degraded sites are now available for plantation, although very little is known about how to manage such sites economically. In northern Bangladesh, especially Dinajpur, Thakurgaon, Panchagarh and adjoining areas have been cleared to plant mainly the participatory forestry programmes such as the Asian Development Bank (ADB)-funded Thana Afforestation and Nursery Development Project and Forestry Sector Project of Forest Department (Chowdhury, 2006).

Collection of leaf-litter by an indigenous woman as a livelihood option. PHOTO: Rajib Mahamud

Some significant measures were taken by the government and also non-governmental organizations to involve the local people in the forestry, i.e. agroforestry and community woodlot plantation programmes in Dinajpur sal forest areas. Performance of trees raised in 1985 was felled in 1993. A total production of 455 m^3 of timber from 6.05 ha plot in 8 years was achieved with a mean annual increment of 9 m^3 ha^{-1} yr^{-1} in agroforestry plots (www.bforest.gov.bd). The Forest Department started participatory sal coppice management from 2001 under the Forestry Sector Project. A total area of 5,850 ha sal forest has been brought under coppice management through participatory social forestry in different parts of Bangladesh during 2001-2005, of which 40 ha sal coppices were managed by local participants in Dinajpur district (PFN, 2005; Chowdhury, 2006). Bamboo, Cane and Murta Development Project (BCMDP) along with FSP are two important projects implemented in the Social Forest Division Dinajpur from 1999-2000 to 2004-2005. Plantations raised under both the projects are shown in Table 3.

Expansion of agriculture within sal forest area in Birgonj, Dinajpur. PHOTO: Rajib Mahamud

Table 3. Plantations raised under Forestry Sector Project (FSP) and Bamboo, Cane and Murta Development Project (BCMDP) in Dinajpur sal forest areas (Chowdhury, 2006).

Nature of plantation	Total area or length
FSP	
Woodlot plantation (new)	545.22 ha
Woodlot plantation (2nd rotation)	1160.00 ha
Agroforestry plantation (new)	155.00 ha
Agroforestry plantation (2nd rotation)	306.00 ha
Strip plantation (new)	1380.00 km
Strip plantation (2nd rotation)	1100.00 km
BCMDP	
Bamboo plantation	115.00 ha
Cane plantation	120.00 ha

The species planted in the FSP are *Acacia auriculiformis* (Akashmoni), *Anthocephalus chinensis* (Kadam), *Artocarpus heterophyllus* (Kanthal), *Azadirachta indica* (Neem), *Chukrasia velutina* (Chikrassi), *Ficus* spp. (Bot), *Gmelina arborea* (Gamar), *Lagerstroemia speciosa* (Jarul), *Leucaena leucocephala* (Ipil-ipil), *Mangifera indica* (Aam), *Melia azedirach* (Bokain), *Phyllanthus emblica* (Amloki), *Terminalia arjuna* (Arjun), *T. bellirica* (Bahera), *T. chebula* (Haritaki), *Swietenia macrophylla* (Mahgoni), and *Syzygium* spp. (Jam). The species planted in BCMDP area are different species of bamboo and cane. Moreover, recent activities taken by the Forest Department, e.g. woodlot plantation, agroforestry, strip plantation and reforestation of Ramsagar National Park planted many different species of indigenous and exotic plants, for example, *Acacia auriculiformis, Acacia catechu*, Acacia hybrid, *Albizia procera, A. lebbeck, A. lucida, Azadirachta indica, Cassia fistula, C. siamea, Dalbergia sissoo, Eucalyptus camaldulensis, Gmelina arborea, Leucaena leucocephala, Melia sempervens, Tamarindus indica, Tectona grandis, Terminalia arjuna, T. bellirica*, and *T. chebula* (Chowdhury, 2006).

In Bangladesh, several NGOs are involved in forestry activities including planting trees along the marginal land, private land and even in the forest department lands. In northern Bangladesh, the Rangpur-Dinajpur Rural Services (RDRS) and Thangamara Mohila Sabuj Sangha (TMSS) are two notable NGOs having tree plantation programme in homesteads, institutional grounds as well as raising of local nurseries over the last couple of decades. The Swiss Development Cooperation (SDC) launched the Village and Farm Forestry Project (VFFP) in 1987 in north-western Bangladesh with a view to address the acute shortage of fuel, fodder and timber that affected the poor in the region. Trees were planted in croplands in collaboration with poor and marginal farmers and through the involvement of local NGOs.


Acacia plantation in sal forest area in Dinajpur.
PHOTO: Rajib Mahamud

Presently, participatory forestry programmes are being implemented under social forestry initiatives. However, some persistent constraints in the administrative arrangements and local social system often cause failure of these programmes. Moreover, farmers who participated in the community forestry programmes are not getting their share from the harvesting of the crop in time. Initially all shareholders agreed that under the programme the profit will be distributed to them according to some predetermined ratio. However, due to lack of proper management and prompt response from FD, particularly when the plantations have reached to the harvesting age for the first rotation, the farmers stopped looking after the plantations. Mature trees are now being felled and taken away by illicit loggers taking this opportunity of inactivity of farmers. Once the trust of the farmers are lost, then it will be very difficult for FD to regain, and to implement this type of participatory approach of forestry practice in future (Chowdhury, 1994). However, there are some success stories regarding the benefits of participants (Bhuiyan, 1994).

Conservation needs

There is no doubt that sal forests are the national heritage of the country and it is our foremost duty to preserve and conserve this forest (Kabir *et al.*, 2003). Species-rich natural sal forests are presently faced with numerous problems. Encroachment is the burning problem since significant areas of sal forest land has already been encroached in Dinajpur Forest Division (Table 2). As the forest dwellers move on, they seldom sell their land to agricultural landowners on where they raise agricultural crops, particularly rice. So, with a view to recover the encroached land and also to have immediate canopy coverage through participation, plantation may play a very positive role. Fuelwood and other associated demands for timber are one of the most important issues in the central and northern parts of Bangladesh. There exists a great demand and supply gap for fuelwood and people are bound to cut trees from forests. To mitigate the problem, fast-growing species may be selected to have quick fuelwood supply in these degraded sal forest areas of Bangladesh (Hossain *et al.*, 1994, 1995, 1997; Islam *et al.*, 1997). Various models of alley cropping agroforestry were tried in Dinajpur sal forest areas include exotic tree crops (Bhuiyan, 1994). Farmers also expressed great preference for eucalyptus because of its fast growth, straight stem, narrow cylindrical crown and light shade (Dalmacio, 1989). Despite such inclinations, plantation programmes in sal forest areas should not necessarily be with only short-rotation exotic species. Before going to large-scale plantation programme, forests' diverse flora and fauna should also be considered. The major concern is still the right choice of species for a site whether mixed or in pure stand and the interactions of species and sites, especially where exotic species are used.

Conclusion

Forests are particularly important in the context of present environmental degradation and ecological purposes. Bangladesh needs immediate steps to halt further deforestation and degradation of its small but very important valuable natural forests. There are very few alternatives to protect the environment except the conservation of forests and extension of forestry. There is no comprehensive database for each fragmented sal forest ecosystems in Bangladesh. Most of the studies and reviews describe the general description of the ecosystems mentioning major flora and fauna only. The unresolved issues such as tenurial uncertainty and conflict between private and public titles over forest and forest land, traditional land right issues of the forest dwellers, and anomalies in land records and demarcation existing over decades have caused large destruction of sal forest as well as loss of biodiversity (Chowdhury, 1994).

Pursuance of traditional approach of forest management and protection of forests without local people's participation proved unsuccessful and resulted in frequent direct confrontation with local people (Bhuiyan, 1994). Consequently there is a progressive degradation of forests through depletion of tree cover and loss of forest land due to encroachment. Retention of the existing meager forest areas under tree cover proved to be a difficult task. Considering the situation, a systematic and planned agroforestry practice in Bangladesh was initiated in 1985 in the denuded plainland forests of North-Bengal with active participation and cooperation of the forest dwellers and encroachers. For sustainability, a combination of growing agri-crops and wood (forest) together in the same piece of land under a specially designed agroforestry land use model may be practiced (Bhuiyan, 1994; Kabir *et al.*, 2003; Chowdhury, 2006) which will reduce the pressure on the remnant natural sal forests. This approach may also help in bringing back the remnant natural sal forests and its associates to vegetation cover again.

Recommendations

Plantation: Permanent plant cover must be restored to halt wind and water erosion in this degraded sal forest areas. Although most tree planting efforts over the last few decades were aimed at increasing supplies of marketable timber and wood products, but tree plantation should be taken in environmentally suitable sites by selecting appropriate indigenous species that will not only combat desertification but also fulfill the present and future requirements of timber, fodder and fuelwood. Enrichment planting with native species may be adopted in low density sal forest areas.

Participation: Since the migration and settlement of plainland peoples in the sal forest areas create conflict and encroach forest lands, it must be stopped immediately. Forest dwellers particularly the Santals have the priority in land allocation for participatory forestry programmes. Participatory forestry activities in degraded sal forest area effectively ensure from field planning (site selection, nursery raising, and selection of agri- and tree crops, planning) to cropping module development and marketing. Models should be flexible to accommodate local needs and wisdom. Wild flora (NWFPs, medicinal plants, etc.) have the potential to deliver significant income and employment opportunities to tribal poor people, so forest dwellers must be involved in forest protection and management programmes. People's full participation may be useful in protecting the existing as well as new plantations.

Species selection: Multipurpose fast-growing tree species have the potential to enrich or replace many of the unproductive shrub or herbs, but careful introduction of invasive species is needed. Monoculture of *Acacia auriculiformis*, *A. mangium*, *Eucalyptus camaldulensis*, and *Tectona grandis* dominating over the native species should be discouraged. Native species and associate species of sal must be considered for the remnant sal patches. Tree species in the agroforestry programme should be such that they have a deep root system, cylindrical and smaller crown and compatible with agri-crops.

Planning: Introduction of an integrated land and water use planning for sustainable agroforestry system which needs an ecological management with efficient water catchments, restoration of indigenous vegetation cover and a balanced integration of trees and shrubs into agriculture.

Productivity: The productivity of the remnant natural forests in Bangladesh is very low, ranging from 0.5-2.5 m^3 ha^{-1} yr^{-1}. The low productivity is mainly attributed due to illicit felling, encroachment, poor density, and low soil productivity with proper management and silvicultural treatments. Along with increasing the vegetation cover, the productivity needs to be increased through the use of genetically superior seeds, better planting stocks, hybridization and other silvicultural manipulations, and it is possible to attain an average plantation yield of 10-15 m^3 ha^{-1} yr^{-1}. Increasing the forest productivity, the gap between the demand and supply of forest resources may be minimized.

Homestead forestry: Homestead forestry throughout the floodplain area is an ancient and widespread agroforestry practice with minimal care and investment. But for huge demand, cultivation of trees on homesteads needs to be intensified and diversified, and fruit species and varieties need improvement. Increasing productivity in the homesteads also reduces the pressure on the remnant sal forests in northern Bangladesh.

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4 Changes in Cropping Patterns in Noakhali

Ahana Adrika

Introduction

Ensuring food security in light of the impact of climate change may be one of the biggest challenges we face in this century. It seems obvious that any significant change in climate such as temperature increases and lower precipitation would impact local agriculture and thereby affect the world's food supply. In recent times, a crisis in the food supply has been observed worldwide. Consequently, increases in the price of food grain is also considered a serious issue.

In terms of the impacts of climate change, Bangladesh, being a low-lying country, is considered one of the most vulnerable countries in the world. People in Bangladesh have already been witnessing climatic variability (MoEF, 2005). It is likely that Bangladesh will face increased as well as unusual precipitation in monsoon months along with hotter summers. Apart from that, the expected sea level rise would also be a devastating phenomenon in the near future. The United Nation's Intergovernmental Panel on Climate Change (IPCC) developed a scenario for 2050 that predicts the various types of impact such as sea level increasing by 50 cm affecting 18 million people along the coast of South and South East Asia. Additionally, it predicts decreases in the crop yields particularly in South East Asia due to increasing drought and floods (FAR, 2007). Altogether such events will have tremendous impacts on the lives and livelihoods of the people in coastal areas, as well as the agro-biodiversity and food security of a country like Bangladesh.

In order to reduce the impacts of climate induced change and variability on agricultural production, farmer communities are often encouraged to apply adaptation techniques, such as switching crop varieties, introducing more suitable crops, or shifting crop-cycles, that can be undertaken by individual farmers. It is understood that the farmers of Bangladesh also possess various traditional knowledge and practices and newly-gained experiences as adaptation techniques (Haque, 2009). These adaptation techniques are meant to combat climate variability induced impacts on crop cultivation, thus their lives and livelihoods.

Noakhali, being a part of the coastal area of Bangladesh, is considered one of the most vulnerable areas to climate variability. The people of this area encounter natural disasters, like cyclone, flood and storm surge very frequently (Matin, 2008). Moreover, the area is only 6 m high from the sea level, and as a result, water logging can make the situation worse and the community more vulnerable. In addition, salinity intrusion would be a more acute problem in the coastal Noakhali region. It is predicted that, Noakhali, being a predominantly agricultural area, would face major impacts of climate variability on its cropping pattern (Hussain, 2008).

Against this backdrop, a study was conducted on the current environmental and climatic challenges faced by the farmer community of Noakhali region as well as how they cope with these changes. This study further documents the traditional knowledge, such as alternative cropping patterns, that farmers apply to reduce their vulnerability in terms of crop production. The study also attempts to suggest a set of recommendations to facilitate integration of traditional practices as well as the transfer of technology to equip the farmer communities all over in Bangladesh in order to withstand existing and future climate variability.

Study area and approach to the study

A number of unions (the local government units in Bangladesh) of Noakhali Sadar upazila (Shudharam and Subarna Char) of Noakhali district were selected and visited in July 2008 to gather information for carrying out the case study. The unions are:

i) Hatiya Bazar, Hunni union

ii) Char Wapda union

iii) Binodpur union

iv) Vatirtek 6 no. union

v) 3 no. Dhanshiri union / Old Shundalpur

In order to conduct the case study, information was collected from two sources. The primary information was collected through FGDs with the farmer communities based in different unions. Further, one-to-one discussions were carried out with the Department of Agriculture Extension (DAE) officials based in Noakhali district. The secondary information, on the other hand, on various aspects related to agriculture and livelihoods particularly to the coastal region was collected through a literature review of different existing papers, articles and reports of government and other organizations.

Cropping patterns

There are three cropping seasons found in the study area, namely Aus (mid March - June), Aman (mid June - mid September) and Rabi/ Boro (mid September–mid March). The cropping pattern of the study area is dominant by Rabi crops–Broadcast aus rice–Transplanted aman rice. Both aus and aman are rain-fed. On the other hand, the boro cultivation is very limited in this area as there is scarcity of irrigation water. As the adjacent canals are being silted each year, the farmers have difficulties in providing the required amount of water for boro cultivation. The areas which have severe water logging are mostly dominated by boro cultivation. Now-a-days, different kinds of vegetables are also grown in the winter season on a large scale as it has more economic benefits. Earlier these were mostly grown in homesteads. In addition, various kinds of pulses are also grown to support local livelihoods during the winter season (Rabi season). Besides these, spices, oilseeds are also grown in this area. Table 1 lists some commonly cultivated crops in the study area.

Table 1. Crops usually cultivated in the study area in Noakhali.

Major crop types	Varieties
Rice	Transplanted aman, broadcast aus (IR8)
Other cereal	Corn, wheat
Spices	Chilli, garlic, onion
Pulse	Mungbean, lentil, grasspea
Oil seed	Soybean, sesame, groundnut, mustard, linseed
Winter vegetables	Tomato, cauliflower, cabbage, amaranth, brinjal, spinach, okra, radish
Root crop	Potato, sweet potato, taro, arum
Summer vegetables	Ceylon spinach, snake gourd, spongy groud, hyacinth bean, amaranth, bitter gourd, pumpkin, bottle gourd, cucumber, papaya
Fruit	Water melon

A successful farmer showcasing his water melon yield. PHOTO: Shehzad Chowdhury

Introduction of new crops

A few crops, such as soybean, groundnut, cucumber, corn, wheat and water melon, have been found cultivated in the study area only for a few years now. Through community consultations, two basic reasons were identified behind such promotion of new crops. Firstly, the agriculture productivity in the area has diminished over the recent years, especially due to usual behaviour of weather. To minimize yield loss, local farmers have up taken these new crops to safeguard their income. The second reason is probably the stronger one and purely economy-driven: since these new crops have high market values people started to cultivate them.

The DAE officials also mentioned that crops like soybeans, groundnuts and water melon can withstand salt water and need very little amount of water. That is why these crops have high yield compare with other crops in the study area. DAE officials of Noakhali also stated that salinity tolerant BR 47 is being tested on a pilot basis in Khulna and Satkhira areas – the southern coastal region of Bangladesh. As these areas are similar to Noakhali, it is possible to try and replicate the cultivation of this variety in Noakhali region to combat the increased salinity condition in future.

Major agricultural constraints

The study revealed a number of major constraints usually faced by the farmers as briefed below.

Water logging

Due to heavy rainfall, water-logged situation occurs in the study area. Draining out of the flood and rain water is another problem of this area. The water-logged condition is now very bad since the canals adjacent to the fields are silted up. Moreover, the existing sluice-gates are not working effectively. During the monsoon season due to heavy rainfall the situation gets worse which hampers the broadcast aus cultivation.

Water-logged situation at Vatirtek. PHOTO: Ahana Adrika

Drought and salinity intrusion

Due to less or infrequent rainfall, a drought situation also occurs in the study area. During the month of August, if a drought situation occurs it hampers the transplanted aman cultivation. On the other hand, the rain-less condition during March-April can also cause the salinity situation to worsen, which can affect the broadcast aus cultivation. The salinity problem also causes the irrigation situation to worsen.

Riverbank erosion

Riverbank erosion is one of the major problems in the study area. People who are exposed to the sea and live outside the embankments, locally known as beribandh, often lose their homes and cultivable lands. Consequently, these devastated families have to move or migrate to some safer parts of Noakhali district.

Increased tidal surge and cyclones

Increased tidal surges severely affect crop cultivation since the fields get flooded with salt water. The increased occurrence of cyclones

Riverbank erosion in Noakhali. PHOTO: Ahana Adrika also reduced crop production in the study area. The increased number of cyclones particularly causes harm to the seedlings of transplanted aman.

Siltation of the adjacent canal and inadequate irrigation facility

The adjacent canals of most of the villages are heavily silted up. As a result, during the drought it is difficult to get water for irrigation, especially for the rabi / boro season. On the other hand, during heavy rainfall, a water-logged situation occurs as the rain water cannot drain out through these canals. The water flow has already decreased causing navigational problems.

Improper sluice gates

In the FGDs, the people identified the problem of faulty design and improper management of sluice gates. This has been an added issue regarding crop cultivation as it regulates the flow of water entering into the cultivable land.

Untimely rainfall

Untimely rainfall in the month of September as well as in the winter season creates a lot of uncertainty regarding the production of winter crops. Unemployment crisis is regular during the month of May-August due to heavy rainfall which forces the villagers to migrate to some other areas like, Chittagong, Feni and Sylhet to ensure livelihoods.

Traditional knowledge and existing practices

The study reveals a number of traditional practices and currently exercised coping mechanisms in agriculture to adapt to climate variability as listed below. Besides, there were some traditional practices like putting dried neem leaves in order to protect seeds from diseases and pest attacks, which are also eco-friendly means in agriculture system.

- Coping with water logging
  - some farmers plant aman varieties such as Rajashail, Kajolshail, Greenshail, Kalijeera and Gigoj (for puffed rice) a bit early since these can withstand a certain level of excessive water.
  - farmers also grow BR 22, 23, 27, 40 & 41, amongst which BR 41 is preferred as it is tasty and also with high yield.
  - Moyabazal (native transplanted aman variety) is preferred during heavy rainfall in the month of August-September since it can withstand water-logged situation. It takes only 4 months to harvest.
- Coping with less water
  - People prefer BR 28 more as it needs less water.
- Shifting of cultivation time
  - Broadcast aus used to be planted during Chaitra-Baishakh (mid March–mid May), but now is planted in Falgun-Chaitra (mid February–mid April).
- Coping with climatic variability
  - Farmers now-a-days cultivate some local varieties of rice such as Dholamota,

Lalmota, Lalmoti, Bashmoti, Betician, Modhyamaloti, Bailam, Laljeera, Keromdon, Maricha, Kontaktara and Leiccha.

- Shorter cultivation period
  - A rice variety, locally known as China IRRI, is also very popular because it can be harvested within three months.

Conclusion

Farmer communities have been facing changes in their environmental and climatic conditions for the last few years. It is understood that the farmers of rural Noakhali are not aware of global warming and climate change notion as such. But they can easily relate to the changes in the weather that they are facing on a day to day basis. In addition to that, they have been experiencing low crop production along with increased extreme weather events, which has been an added crisis to their lives and livelihoods. In order to ensure food security as well as the livelihoods of the farmer communities, they have been trying to fight against the odds and came up with native varieties that can withstand some variability in the climatic condition and can provide economic benefit as well. Production of some newly introduced crops has been found to be very successful.

It is evident that changes in cropping patterns do exist in the study area. The foremost important reason for adopting these new crops is better economic benefit to ensure livelihood security, but these crops are also found suitable in the changing climatic situation of Noakhali district. Further studies and research on alternative cropping patterns need to be carried out, especially in light of climate variability and replication of the technique for similar climatic conditions. Agricultural extension services have to extend their outreach and training for local people to equip the farmer communities to tackle the odds of climate variability.

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5 Potentials of Native Crop Varieties for Adapting to Climate Variability in Bangladesh

Md. Fazlul Haque

Introduction

Agriculture, before the days of Gregor Mendel, was supported solely by the knowledge pool of the farmers, which was acquired and enriched in each generation. In specific agro-ecosystems, to address specific stress, this knowledge, with error and trial, was passed through their successors and accumulated for appropriate productive use. This inherited knowledge pool of the farmers, is termed as 'indigenous knowledge'. The process of accumulation of such knowledge in the post Mendelian days of institutional knowledge was also pursued vigorously. In pursuit of such indigenous knowledge, farmers in a specific location, to fulfill their specific needs, could develop some cultivars, management practices and other technologies to overcome stresses, like drought, salinity, flood etc. for earning their livelihoods and to ensure survival. Each of the indigenous technologies / cultivars was unique in possessing some attributes in morphological, anatomical, physiological and biochemical traits. These traits were indispensable for specific needs and responses. For these reasons, the cultivars were unique and valuable. In most cases, farmers, because of their lack of scientific knowledge, were unaware of the scientific basis of the importance of these cultivars. With the development of institutional knowledge newer cultivars with specific attributes were developed, but very often fell short by having only a few of these attributes.

Over the ages, some indigenous varieties tolerant to salinity, others to endure drought, further ones to survive short submergence and others with more traits of late sowing potential, short field duration, shattering resistant, favourable content of protein, amylose etc. were developed. In specific agro-ecosystems, these cultivars with their unique morphological, physiological and biochemical traits and yield potential could satisfy the farmers who developed them. Most of such cultivars were low yielders. Perhaps because of this and other reasons, these indigenous cultivars with their unique genetic makeup are at the risk of extinction. Rapid expansion of modern varieties and demand for more food grain to feed the growing population might have compelled farmers to replace low-yielding native varieties with high-yielding modern ones (Kaul *et al.*, 1982; Razzaque, 2008).

Potential threats of climate change include increases in floods, droughts, hailstorms, tidal bores, cyclones, storms, tornados, sea level rise, salinity, etc. (BBS, 2007). These threats are due to climate variability in respect of changes in temperature, rainfall, evaporation, wind speed, etc. The old or the newer stresses, in intense magnitude and more frequency, in specific locations are affecting agriculture and thus undermining the effort of poverty reduction. A review and compilation of area damage and loss of rice production alone during 1990-2005 owing to natural calamities indicated that, on average, 637.6 thousand acres of rice land was damaged annually, which incurred a production loss of 491.8 thousand metric tons of rice (Table 1).

Contemporary findings indicated an increase of temperature of about 0.6-0.8°C during the past one hundred years over the area adjoining Bangladesh (Haque *et al.*, 1995). Small warming of 0.2-0.4°C per hundred years over the areas of India surrounding Bangladesh was also reported

(Srivastava *et al.*, 1992). Sea surface temperatures (SST) in the Bay of Bengal have also registered an increasing trend (Singh *et al.*, 2000). These studies predict a rise in annual mean surface temperature between 1.5 to 2.5°C over Bangladesh by the end of the current century. The National Adaptation Programme of Action (NAPA) for Bangladesh predicts a rise in local temperatures by 1, 1.4 and 2.4°C by the years 2030, 2050 and 2100, respectively (MoEF, 2005). The cumulative effect of local and global rises in temperatures increases the sea level due to melting of ice. Air temperatures in the regions of Nepal and Bhutan are rising at a rate of 0.06°C per year. The present temperature is one degree higher than that in the 1970s. Consequently some glaciers in Bhutan are retreating at a rate of 30-40 meters a year filling the glacial lakes in Nepal and Bhutan, which may burst their banks in 5-10 years time. The falling water may cause damage to structures, other properties, crops and life (UNFCCC, 2002). Heavy sediment load brought down by the falling water gets deposited in the riverbed. Consequently the rivers become incapable of carrying the sudden increased discharge during the monsoon. This causes riverbank overflows and extensive flooding of wide areas leading to serious damage of life and property (Mukhopadhyay, 1995). The mean tidal level at Hiron point (West Bay of Bengal), Char Changa (in the Meghna Estuary) and Cox's Bazar (East Bay of Bengal) has shown an increasing trend of about 4, 6 and 7.8 mm per year, respectively. This is a pronounced rate compared to the global one. The present estimate of sea level rise is around 19 cm by 2030 and as much as one meter by the end of this century, forcing nearly 17% of Bangladesh territory to go under sea. This will displace at least 10% of the population and will cause an annual loss of 2 million tons of crop production (BARC, 2000).

Table 1. Rice area affected and production loss due to natural calamity (1990-2005).

Crops	Cyclone tidal surge, flood	Excessive rainfall and flood	Rush of water from across boarder	Hailstorm	Tornado	Drought	Total	Average
			Area in '000' acres					
Aus (Local)	433	573	15	0	0	1.9	1022.9	68.20
Aus (HYV)	203	393	16	0	0	0	612	40.8
B. Aman	60	2330	17	0	0	3.7	2410.7	160.71
T. Aman (Local)	0	1339	102	0	79	0	1520	101.33
T. Aman (HYV)	0	1489	274	0	142	0	1905	127.0
Boro (Local)	22	0.78	172	148	0	0	342.78	22.85
Boro (HYV)	316	51	59	990	334	0	1750	116.67
Total	*1034*	*6175.78*	*655*	*1138*	*555*	*5.6*	*9563.38*	*637.56*
			Production in '000' metric tons					
Aus (Local)	170	321	9	0	0	1.2	501.2	33.41
Aus (HYV)	152	427	20	0	0	0	599	39.93
B. Aman	25	1154	5.2	0	0	2	1186.2	79.08
T. Aman (Local)	0	810	53	0	46	0	909	60.60
T. Aman (HYV)	0	1483	220	0	165	0	1868	124.53
Boro (Local)	13	0.56	137	119	0	0	269.56	17.97
Boro (HYV)	298	63	632	742	309	0	2044	136.27
Total	*658*	*4258.56*	*1076.2*	*861*	*520*	*3.2*	*7376.96*	*491.80*

Source: BBS (1996, 2000, 2004, 2007)

This damage due to temperature rises does not end with engulfing the territorial habitat of the people of Bangladesh at the coast. A rise in SST would enhance evaporation in the Bay, which might release heat in the atmosphere to develop stronger winds. This might increase cyclones. Human suffering due to cyclones and tidal surges will not be bound to the recent past and are likely to repeat frequently in the future due to changes in the climate.

Owing to sea level rise, cyclonic storms and tidal surges, saline water intrudes the surface of the main land and during dry (no rainfall) period saline water penetrates the sub-surface. Both these processes add to increasing coastal salinity in space and magnitude. Salinity affects crop production. During 1973-2003, about 0.17 million hectares (20.4%) of new land has been salt affected. This increase is more in salinity class S3 (8.1-12.0 dS/m) (SRDI, 2003).

Other than the above disastrous consequences of climate change, extreme variations in temperature also affect crop production. Every crop has a threshold temperature below which no crop growth takes place. The threshold temperature of most of crops is about 5°C (IARI, 1988).

Lives and livelihoods in rural Bangladesh depend upon good harvest. PHOTO: H.Md. Irfanullah

Rajshahi experiences the lowest temperature. Occasionally it comes down as low as 4-5°C and the highest one rises as high as 44-45°C (Ahmed, 1995). This extreme variation of temperature often affects crop performance, especially rice (Islam *et al.*, 1995).

Global warming has also changed the rainfall patterns of Bangladesh. Precipitation has increased during the peak monsoon and reduced in the dry months. It is predicted that precipitation would increase by 5, 6 and 10% by 2030, 2050 and 2100 years, respectively (MoEF, 2005). This would aggravate the flooding situation of the country, the frequency and intensity of which have increased over the years. This is because catchment areas of the rivers flowing through Bangladesh experienced the highest rainfall of the world in recent years. Moreover, flash flood is a regular event in the foothills of the north-east and south-east territory of the country.

In view of the above natural disasters, it is logical to infer that Bangladesh cannot avoid these consequences of climate change, rather the people have to live with these natural disasters in the future too. To this end, there is little option but to adapt to these changes of climate. Bangladesh being a least developed country, its people have very little ability to adapt and combat these natural disasters (IPCC, 2001).

Nevertheless, to address these stresses and adapt to the climate variability, the indigenous varieties might be helpful in two dimensions. These varieties might be used to address specific climate variability on the one hand, and incorporate the desired genes in the crop improvement programmes, on the other. Thus, the identification and conservation of these varieties is of the utmost importance. The present study attempts to evaluate the potentials of indigenous crop varieties of Bangladesh, mainly the rice varieties, in adaptation to the consequences of climate variability in the country.

Approach of the case study

The case study was prepared mainly with the information available from secondary sources and community meetings and the experience of the author. To gather relevant information resource materials were consulted. Some 17 meetings at the community level through open discussion, across the country, were conducted to assess the existing status of use as well as potential of the native varieties in crop production (Table 2). The meetings were held in 10 agro-ecological zones (AEZ) and were conducted by the staff members of IUCN Bangladesh. The discussion in the meetings also put emphasis on changes in natural resources of the area, and the changing climate to influence agro-biodiversity and agricultural production.

Potentials of indigenous crops varieties

The potentials of native varieties were examined in terms of adaptability to natural calamities, cultural heritage value of the varieties, their economic values in the long run, limitation of using the native varieties in production systems, and present conservation efforts for the varieties. Following paragraphs were developed in line with the above settings.

Review of literature

Literature, searched so far, indicated that rice scientists during 1920-1925 estimated the prevalence of about 15,000 native cultivars in Bangladeshi territory (Hasanuzzaman, 2001). Variability of the cultivars ranged from small-grained aromatic Radhuni Pagal to long-grained Jhingsail or Patnai, black-husked aromatic rice Kala Manik to golden-brown Kataktara, bunchy panicles with spikelets in Khajur Jhupi to very long gummed rice Pankhi Raj. For specific food items like puffed rice and special cakes there were specific varieties.

Table 2. Crop varieties and summary of agricultural and environmental concerns reported in the community consultations under the CICMEA project during March-October 2008.

Sl. No.	Location	AEZ*	Native varieties reported	Remarks
1.	Telmol, Betgari, Sadar, Rangpur	3b	Malshira, Panishail, Jashua, Shilkumur, Nilkumur, Noyaraj	Varieties have gone out of cultivation
2.	Susua, Arjuna, Bhuapur, Tangail	8c	No native variety reported	Diversified cropping in winter with boro rice and a large number of vegetables, pulses oil crops.
3.	Hatianda, Sadar, Natore	11	Aman: Digha, Muktahar, Beniguchi, Babu Aus: Shonidhan, Hijlidhan, Dhalohoir, Pathorkuchi, Kailashuli	Cultivation of the varieties squeezed because of low yield
4.	Baliadanga, Sadar, Chapai Nawabganj	11	Aman: Chiniatap, Latishail, Jhingashail, Magurshail Aus: Shaita dhan, Shankarboti, Ujjaldhan	Cultivation of the varieties greatly reduced
5.	Keshobpur, Jessore	11	No variety was named. Around 20 varieties were cultivated.	Water logging and introduction of HYV pushed local variety out of cultivation.
6.	Mohotpur, Sadar, Kaligonj, Satkhira	13d	No native variety was named.	Increase in salinity and water logging and introduction of HYV pushed them out of cultivation.
7.	Dakope , Khulna	13f	No native variety was named.	Increase in salinity due to shrimp culture pushed local crops out of cultivation.
8.	Satpar, Gopalganj	14a	No native variety was reported.	Cultivation of local varieties was reduced due to salinity. Hybrids of vegetables also replaced aus rice.
9.	Bisharkandi, Banaripara, Barisal	13a	No native variety was reported.	Less winter crops due to climate change. Fog damaged winter crops during the last 2-3 years.
10.	Chowganga, Itna, Kishoreganj	19, 21	Pajam, Madhobsail, Latisail, Mongiri, Birui, Tepi, Rata and Rajasail were replaced by modern varieties.	Fog in winter remains up to March, affects boro rice. Frequency of flood increased.
11.	Adukhali, Polash, Bishwambarpur, Sunamganj	20	Gochi, Rata, Tepi, Chhotrisail, Bichbhgaroi, Kwla/ Lacki and Binni of boro rice and Tulshimala, Modhumadhab, Kalijeera, Goinna and Bookpuraye of aman rice were almost out of cultivation. Variety Panitarial could grow along with increase in water depth.	Severe cold affected boro rice to develop hollow hull. Yield loss was to the tune of 75-100%.
12.	Jalalpur, Mollahpara,	21	Variety Gochi could be cultivated under high temperature, but yield	Vast area remains fallow due to delay in onset of rainfall and less

Table 2. (Contd)

Sl. No.	Location	AEZ*	Native varieties reported	Remarks
	Sunamganj		low (2 t/ha). Badal and Aishna could grow along with increase in water depth.	availability of irrigation water in the silted canals.
13.	Char Wapda, Subarnachar, Noakhali	18f	Rajasail, Betisail, Modhumalati, Pajam and Kalijeera were cultivated in the locality. New crops like maize, water melon, wheat and soybean were introduced.	Rainfall delayed. Excess in August-October. Water logging and salinity were the major problems.
14.	Boyer Char, Honni, Hatiya, Noakhali	18f	Rajasail, Kajolsail, Kalijeera, Lalmoti, Lalmota, Dholamota and Gigoj (used for puffed rice) were reported in the locality. Modern varieties like BR11, BR14, BR22, BR23 and Purbachi were reported.	Salinity and unavailability of salt free irrigation water, water logging, delayed rainfall and excess rainfall during August-October, and cyclone were the main problems.
15.	Bolipara, Thanchi, Bandarban	29	No variety for rice was mentioned. Jhum (slash and burn) was the major system of cultivation. Cultivate rice, vegetables, fruits like papaya, pineapple, banana and spices like turmeric and ginger.	Shortening of jhum cycle from 10-12 years to 2-3 years reduced soil fertility, and thus reduced crop yield.
16.	Uttar Moheshkhalipara, Teknaf Sadar, Cox's Bazar	29	No variety of rice was reported.	Winter short, severity of winter cold less, summer was warmer after cyclone of 1994. Water logging and deforestation were major problems.
17.	Teknaf Sadar, Cox's Bazar	29	No variety of rice was reported.	Increase in temperature, frequency of storm, delayed monsoon, change in precipitation were the major concerns in agriculture.

** AEZ, Agro-ecological Zone*

Bangladesh Rice Research Institute (BRRI) during 1982 compiled names of some 12,487 native varieties that were cultivated at the upazila level (Hamid *et al.*, 1982). They, out of 467 upazilas, compiled names of the native varieties from 359 upazilas and recorded 3,427 aus, 3,820 broadcast aman, 4,032 transplant aman and 1,200 boro rice varieties. It was estimated that, by then, in a time span of about 50 years, about 2,500 native varieties were lost or extinct. Literature pertaining to number of these native cultivars cultivated at present could not be traced. Field experience suggested that farmers, in some locations, have stopped cultivation of aus and broadcast aman rice from the early 1980s or late 1970s. This indicated that the native cultivars were totally lost from those areas. This context might be justified with data in Table 3. Yield of local aus rice was very low and their area reduced almost to the tune of half in 2005 compared with 1991.

Table 3. Changes in area and yield of rice crops over the recent years. (Area in '000' acres and yield in kg/ac)

Rice Crops	1991-1992		1999-2000		2004-2005	
	Area	Yield	Area	Yield	Area	Yield
Aus (Local)	3710	380	2255	415	1418	450
Aus (HYV)	1025	751	1045	727	1115	774
Total	*4735*	*460*	*3340*	*519*	*2532*	*593*
B Aman	2072	412	1914	448	1221	375
T Aman (Local)	6786	554	5362	597	4645	574
T Aman (HYV)	5210	894	6822	915	7181	932
Total	*11996*	*701*	*12184*	*775*	*11826*	*792*
Boro (Local)	744	587	561	633	464	841
Boro (HYV)	5659	1107	8463	1261	9578	1404
Total	*6511*	*1045*	*9024*	*1222*	*10042*	*1378*

Source: BBS (1996, 2004, 2007)

The area under broadcast aman rice, which was entirely cultivated with native varieties, has also been reduced significantly. The yield was stable, but very low. This signified that many native varieties of broadcast aman rice have gone out of cultivation. The area under local transplant aman rice has also declined over the period. Yields of the crop, however, registered slight falls. In spite of slight increases in the yield of local boro rice over 15 years, the area under local varieties of boro rice was very small and has declined over the period. Because of higher yields and relatively low risk, areas under HYV boro rice made a big jump. Areas under HYV aus and aman have also increased. The area gain by the HYVs put the native varieties of rice in a disadvantageous position.

So far, literature concerning the suitability of traits of the native varieties to address specific stress owing to climate variability is limited. In the sort span of time of the study, field visits, also, could not be made to tap farmers' indigenous knowledge concerning the suitability of these varieties. However, available literature concerning the potential of native varieties is discussed in the following paragraphs.

Box 1. Some attributes of the native varieties (Satter *et al.*, 1988).

Drought tolerant: Noroi, Gambir, Parangi, Baktulshi, Hashikalmi, Khukni / Chiruti, Kaila, Chendra, Moshdal, Sodo, Katarmon, Shandhyamoni (highly drought tolerant), Latabhog

Insect pest tolerant: Noroi, Manikmandel, Dudraj Sodo, Gareshwar

Short duration: Noroi, Hashikalmi, Kaila, Maniksonda, Shaita, Boyale, Dudmallik

Long duration: Gambir, Pykejata, Manikmandel, Benaphul, Gareshwar, Baktulshi

Lodging resistant: Gambir

Grain quality & taste: Kataktara, Pykejata, Karchamuri,

Good yield & taste: Baktulshi, Hashikalmi, Kataktara, Khukni / Chiruti, Baralaxmi, Manikmandel, Moshdal, Laxmikajal, Benemutha

Special food like rice flakes & parched rice: Karchamuri

Suitable for mix cropping with broadcast aman rice: Bakoi / Natol

Fertilize responsive: Laxmikajal, Benemutha

Field trials were conducted at Sailkupa, Magura, Jhenaidha, Keshobpur and Narail during

1987-1988 with native aus varieties, like Hashikalmi, Hasha, Baktulshi, Noroi, Parangi, Kaila and Gambir, and modern varieties like BR20 and BR21 (Table 4). The results indicated that the native varieties out yielded the modern ones in specific locations (Akter *et al.*, 1988).

Table 4. Yield performance (in tons/ ha) of seven native varieties of aus rice and two modern varieties (Akter *et al.*, 1988).

Variety	Locations					Mean	Field duration (days)
	Magura	Keshobpur	Narail	Sailkupa	Jhenaidha		
Hashikalmi	2013 AB ab	2.22 A bcd	1.45 C cd	1.83 B b	2.09 AB d	1.94	94
Hasha	1.93 B bc	1.91 B de	1.75 B bc	1.20 C c	2.28 A cd	1.81	97
Baktulshi	2.35 A a	2.35 A ab	1.31 B d	2.22 A c	2.48 A bc	2.14	102
Noroi	1.56 A a	1.84 A e	1.82 A ab	1.63 A b	1.23 B f	1.62	89
Parangi	2.15 A ab	2.00 AB cde	1.95 AB ab	1.62 C b	1.68 BC e	1.88	96
Kaila	1.95 A bc	2.08A bcde	2.07 B ab	1.62 B b	2.03 A d	1.95	96
Gambir	1.95 B bc	2.58 A a	2.15 B	2.19 B a	2.63 A b	2.30	104
BR20	1.10 B e	1.07 B f	0.99 B e	0.67 C d	2.78 A b	1.32	113
BR21	1.65 C cd	2.33 B abc	1.37 C d	0.73 D d	3.27 A a	1.87	107

Note: Small letters stand for comparing within location and capital letters for comparing across locations.

A field survey was conducted at the Farming System Research (FSR) and multi-location test sites (MLT) of Sailkupa, Magura, Jhenaidha, Keshobpur, Bagherpara and Narail during 1987-1988 to obtain farmers' perceptions about potential attributes of the native varieties that were cultivated by them (Satter *et al.*, 1988). Findings revealed that the native varieties were cultivated for their different attributes (Box 1).

Box 2. Abiotic stress tolerant native varieties (Bashar and Akter, 2008).

Submergence:	Soitedhora, Lohtang, Kumari, Kaliraj, Kaladhan, Hijaldhiga, Sada gabura, Khoia motor, Kumragoir, Ashfol
Tidal submergence:	Kumragoir, Dudmona
Salinity:	Pokkali, Reyasail, Nonabokra, *Porterisia coarctata*, Nonakochi, Sabrimaloti
Drought:	Hashikalmi, Dular

Evaluation and characterization of the native varieties at the Genetic Resources and Seed Division of BRRI indicated that a number of the native varieties were resistant to diseases and/or insect pest attack. Some of the varieties were resistant to abiotic stresses, like submergence, tidal submergence, salinity and drought (Bashar and Akter, 2008) as listed in Box 2.

As a result of the institutional research, beginning in 1910, some local varieties of aus, broadcast aman, transplant aman and boro rice were developed either through selection from the native ones or by hybridization. These varieties were developed on the basis of adaptability to local field situations and better yield. But consumers' demand and market values as well as export potentials of some of these varieties were also taken into consideration. With the results of trials and demonstrations the then Department of Agriculture recommended some rice varieties for cultivation in all the three crop seasons (Table 5). In recommending the varieties, along with other considerations, adaptability and low input requirement were considered first. This was because the farmers were poor and unable to bear high costs of input. For aus season, varieties, like Kataktara, Dular, Pusur, Hasikalmi, Surjamukhi, Dharial, Morichbati, Panbira, Chartnock etc. were recommended. Indrasail, Bhasamanik, Dudsar, Tilockkachari, Daudkhani, Latisail, Chitraj, Badshabhog, Patnai-23, Naizersail, Rajasail, Nagra, Jhingasail etc. were recommended for cultivation as transplant aman rice. Tilockkachari, Baisbish, Gabura, Gutak, Maliabhangar etc. were named for cultivation as deepwater rice. Tilockkachari was recommended for shallow flooding (Hasanuzzaman, 2001; Bashar and Akter, 2008). Other than these, there were some location specific native varieties widely cultivated.

Table 5. Recommended local varieties of rice. Based on Hasanuzzaman (2001) and Bashar and Akter (2008)

Varieties	Main characteristics
Aus rice	
Kataktara	Medium fine grained variety
Dular*, Hashikalmi, Pukhi, Pusur*	Early, suitable for aus-T aman-rabi crop patterns
Dharial, Morichbati, Panbira,	Course grained varieties
Dhalasaita, Harinmuda, Paspai, Atiai, Kumari Surjamukhi, Pakbi, Charnock	Normal varieties for wide adaptation.
Broadcast aman rice	
Baisbish, Gabura	Withstands flooding depth of 150-200 cm and can tolerate short submergence
Maliabhangar	Recommended for eradicating shattering rice
Hbj. Aman I (Katyabagdar), Hbj aman II (Godalaki), Hbj. Aman III (Gowai), Hbj. Aman IV (Dudhlaki), Hbj. Aman V (Dhala Aman), Hbj Aman VI*, Hbj. Aman VII*, Hbj. Aman VIII (Lal Aman)	Satisfactory yield, with wide adaptability
Germplasm: Laki, Gowai, Bagdar, Dholoa Aman, Lal Aman, Khama, Bamoia, Bajails, Dighas, Bajails, Chamara, Kartiksail	Wider adaptability in 2-3 meters flooding depth
Transplant aman rice	
Tilock kachari, Naizersail	Recommended for late /early receding flood
Latisail	Non-lodging & non-shattering
Dudhsar	Drought tolerant
Chitraj*	Early, harvested in October
Indrasail, Jhingasail	Semi-long and medium grains with good milling efficiency, taste and cooking characters
Daudkhani, Badshabhog	Finest T aman rice variety
Bhasamanik	
Rajasail	Moderate salt tolerant
Patnai-23	Salt tolerant, long grained

Table 5. (Contd)

Varieties	Main characteristics
	Boro rice
Hbj. Boro II (Tupa or Tepi Boro or Basfool)	Aromatic, exploding, oval grain, elongate almost three times at cooking. May be compared with standard Bansmoti
Hbj. Boro IV (Khoia Boro)	Very early variety
Hbj. Boro V (Banajira)	
Hbj. Boro VI (Pushu sail)	Aromatic
Hbj. Boro VII *, Hbj. Boro VIII*	

*Indicates hybridized variety

Some varieties had morphological markers (e.g. Maliabhangar and Gota) that were used to eliminate shattering rice, which was a great problem in broadcast amon cultivation. Aromatic rice (e.g. Kalamanik, Badshabhog and Kalijeera) was known for their aroma and heritage values.

Besides rice varieties, there were native varieties of other crops. There were 4,111 germplasms of jute, 5,656 of wheat, 900 of sugarcane, 854 of pulses, 242 of bottle gourd, 103 of bitter gourd, 248 of egg plant, 126 of chilli, 200 of mango, 475 of tea, and 40 of jackfruit (Razzaque, 2008). With the change in the crop production system, most of the crop varieties, like that of rice, also have gone out of cultivation. Some of them are conserved in the genetic resource bank of different research institutes.

Farmers also noticed the potentials of native varieties in respect of threshing quality as well as palatability of the straw as cattle feed (Satter *et al.*, 1988; Paul *et al.*, 1989). The straw of broadcast aman rice was long. Farmers used to use the straw as fuel for cooking. Reductions in area of broadcast aman reduced availability of straw. This was also true for other local rice varieties. Modern varieties produce less straw. Harvesting time of modern boro rice coincided with advent of monsoon rainfall when straw could not be dried and preserved. Thus, the availability of rice straw was limited. Unavailability of straw reduced availability of cattle feed on the one hand and reduced cooking fuel on the other. This crisis induced felling of trees, which in turn created further environmental problems.

Community consultations

In all the community meetings it was transpired that people noted significant changes in the climate over the last several years or so and its impacts on their livelihoods (Table 2). But they in general were not responsive enough or have not thought about any significant actions to adapting to the climate variability or concept of using agro-biodiversity as a tool except in a few cases.

Information in Table 2 indicates that some of the local varieties were in possession of some attributes to endure stresses, like salinity, drought and flood. The varieties were almost always low yielders. Most of the native varieties have gone out of cultivation owing to low yield and extensive use of HYVs to fulfill demands for higher production. Some of the varieties were in use in specific location to suit farmers' demands.

Availability of the native varieties

Logically the large number of native varieties listed by different workers (e.g. Hamid *et al.*, 1982) might be available from farmers of respective locations. But most of these varieties might not be available now in those areas because of the changed field situation (Table 3). Farmers probably have lost those varieties or have abandoned cultivation of those varieties. If available, these could have been mixed with other varieties. Considering importance of the genetic value of these varieties, BRRI in the recent past established a gene bank. By now, scientists in BRRI has collected 8,144 varieties / lines, and registered in accession a total of 6,745 varieties / lines (Bashar and Akter, 2008). For upland crops BARI also maintains a genetic resource bank. This facility is also used to preserve crop varieties and lines. In times of necessity, these native varieties might be available with BRRI and BARI.

Cultural heritage

As discussed earlier, some of the native varieties were suitable for different stress conditions and some might also be suitable for desired biotechnological values (Table 2, Boxes 1 & 2). Details of cultural or heritage values of individual varieties are beyond the scope of the present study. Culturally in Bangladesh, local people like non-sticky rice. This trait is attributed to the amylose content of the grain. Biswas *et al*. (2000) studied the biochemical attributes of native as well as modern varieties of rice. Local varieties were better in respect of this trait. For some details the aforesaid reference and Box 1 might be consulted. Khoi (puffed rice) of Binni dhan and chira (rice flakes) of Sail dhan are popular food items of the local communities.

People also like native varieties of some of spices for their special attributes. A local variety of chilli from Chittagong provides the best red colour to cooked dishes. Taherpuri onion from Faridpur was known for its pungent smell and better shelf life. Local turmeric variety was used in some cultural activities of weddings (Hasanuzzaman *et al*., 2006).

Potential of adapting to climate variability

The native varieties are already accustomed to diverse agro-ecological situation. Over the years, they might have gone through some climate variability, like heat, cold, flood and drought. Thus, they have, at least, some attributes to face current and future climate variability. Some of the improved varieties developed from the native pool are already having quality to endure such stress of climate variability (Tables 2 & 5).

Economic values

Due to their low yield, native rice varieties have failed to compete with the modern varieties. Nevertheless, economic values of the varieties might be seen in two main facets. Firstly, these varieties are sources of a good pool of genes. These might be used in hybridization for transferring the desired genes in the progenies to develop desired varieties. Secondly, if there would be any climatic catastrophe when the modern varieties would not be able to sustain production, whereas the native varieties would be required to bring back to production systems, the value of latter varieties would be immense.

Conservation of native varieties

In specific locations of the varieties some farmers might have conserved a few of them. Genetic resource banks of BRRI and BARI are also conserving some of the varieties (Bashar *et al.*, 2008; Razzaque, 2008). But as to promotion of these native varieties, no significant effort is visible. Other than BRRI and BARI, IARI and IRRI also conserved some of the varieties. Even the author noticed that some of the native aus varieties, like Hashikalmi, Dharial and Morichbeti were used in some Kenyan agricultural farms. Immediate attention needs to be given to locate these indigenous varieties for *in situ* conservation.

Utilization of native varieties

There was no legal or other bar in using these native varieties in the production system. The most determining factors to this effect was their low or no input response and low yield potentials. Farmers would not be satisfied with such low yield. Moreover, in the mean time, new virulent strains of biotic agents might have developed to confront performance of these varieties. All these would require new adaptive trials to be conducted in different agro-ecosystems and to observe the economic performances. This effort would be required to prepare for any vulnerability to climate variability.

Recommendations

From the findings of this study a number of important issues have been identified. In light of that, several specific suggestions are recommended.

- A baseline survey needs to be conducted to assess the prevalence of indigenous crop varieties in the different production environments.
- The specific utility and potential of specific variety to address specific climatic variability need to be updated and documented.
- Collection, characterization and conservation of valuable native varieties need to be strengthened.
- Adaptive research with native varieties across agro-ecosystems with particular exposure to climate variability should receive attention.
- Specific breeding programmes could be on the cards to synthesize genes addressing climate variability.
- The necessary finance and logistics need to be made available to this effect.

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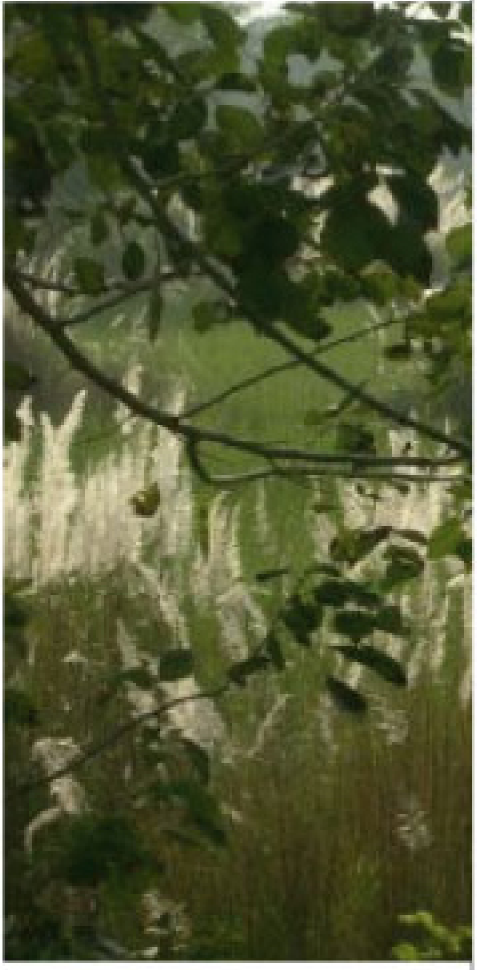

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