Climate Change: Resilience in Bangladesh Cotton Production

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Introduction

Bangladesh, a South Asian country, with an area of 147570 sq. km. bounded by India in the West, North, East, the Bay of Bengal in the South and Myanmar in the Southeast. It is situated at the lower part of the Ganges-Brahmaputra-Meghna basin that emanates from mostly the Himalayans and is home to three mighty rivers, the Padma, the Brahmaputra and the Meghna. Over 200 rivers and tributaries have made this country a land of rivers. It is a deltaic plain divided into three zones, namely hills, terraces and flood plain based on geomorphology and physiographic. On the basis of agro ecology, soil physiographic and climatic factors, the total land area has been classified into thirty agro-ecological zones (AEZ). At different AEZ, the agricultural productivity in Bangladesh has considerable differences because of farming practices, inputs, availability of irrigation facilities, farmer's choice etc. which is also due to some natural phenomena, such as, rainfall, temperature, humidity and some other agro-ecological features.

Due to the geographical location, topography, multiplicity of rivers and the annual monsoon rains Bangladesh is highly vulnerable to climate change which has differential impacts on agriculture. It is evident that climate change and climate variability are affecting the land use patterns, cropping systems, productivity, and optimum agriculture output that in turn affect the rural livelihood. Bangladesh is on course for Middle Income Country status by 2021 while agriculture remains the largest employer in the country. 47, 5% of the population is directly employed in agriculture and around 70% of the population depends on agriculture in one form or another for their livelihood. As main source of economic linkages in rural areas, agricultural productivity plays a fundamental role in rural development and the impact of climate change on agricultural production in Bangladesh are wide spread and devastating for the country's economy. Summary of the characteristics of the climate related vulnerability context by major geographical regions are given in the Table 1.

Table 1
Characteristics of the climate related vulnerability context by major geographical regions

Types of Geographical Areas	Climate change Vulnerability Context and Characteristics
Floodplain	- Changes in flooding characteristics - Increasing coverage of inundated area in monsoon season - Increasing of inundation depth and lingering of inundation period - Increasing of water logging period
Drought prone	- Changes in drought characteristics - Increasing of drought intensity - Expansion of drought prone area - Changes in timing of drought
Coastal zone	- Changes in coastal characteristics - Expansion of saline affected areas - Increase in soil salinity - Cyclone and storm surges
Hilly region	- Changes of distribution in rainfall and intensity - Increase in top soil erosion - Increase possibilities of landslide

Source: GoB and UNDP (2009)

As an adaptation strategy to climate change, Bangladesh has huge potentiality to promote cotton cultivation particularly in the low productivity areas of Bangladesh. Climate change impacts on cotton growth and development, yield and fiber quality that are due to the increases in CO_2 concentration, reduced water availability and increases in temperature. Increased CO_2 levels may increase photosynthesis and water use efficiency of cotton leading to higher yields. Leaves will likely be larger, thereby giving plants a greater photosynthetic surface area, which subsequently facilitates growth. Temperature increases at the start and end of seasons may have a positive effect on yield by extending time for cotton growth. Moreover, cotton is found to be more tolerant to drought in comparison with other field crops in Bangladesh as its tap root can uptake water from the deeper layer. In addition to that cotton is a saline tolerant crop that is suitable for growing in the coastal areas of Bangladesh. Considering the importance of cotton in industrial as well as rural development, the Cotton Development Board in Bangladesh has targeted to expand cotton growing areas in 100000 ha within 2021 from its current level of 42000 hectares as a part of its vision 2020-2021.

Cotton in Bangladesh

Bangladesh has a glorious tradition in cotton and textile production. In medieval age Bengal was famous for production of `Muslin' the finest quality cotton fabric. Cotton required for producing muslin was grown on high lands around Dhaka, where most of the muslin handlooms were located. However, the production and trading of Muslin gradually declined during the British rule ultimately resulting to closure of the industry by early nineteenth century. During Pakistani rule, there had been limited efforts to produce cotton in this part of the country. Before independence, raw cotton requirement of local textile industry was met from the then West Pakistan. Importance of local production of cotton was felt after the independence of Bangladesh in 1971, when the supply of raw cotton was suspended from Pakistan. Our textile industry faced serious problems for non-supply of raw cotton. In these circumstances, Cotton Development Board (CDB) was established under the Ministry of Agriculture in 1972 to promote cotton production in the country. The responsibility of cotton research was transferred from Bangladesh Agriculture Research Institute (BARI) to Cotton Development Board (CDB) in 1991.

In Bangladesh, American Upland Cotton (Gossypium hirsutum) is grown in the floodplain, drought prone and coastal areas as a sole crop or intercropping with vegetables and Hill Cotton (Gossypium arboreum) is grown as mixed crop in the hilly areas of Bangladesh. Recently, efforts are being made by CDB to introduce Upland Cotton in the hilly areas. The vision of the CDB is to increase the cotton production as well as its byproducts to reduce the import dependency of cotton in Bangladesh. To increase domestic cotton production the main activities of CDB are research, extension, seed production, training, marketing and ginning and credit distribution to the small farmers.

Cotton Research

CDB conducts research to develop hybrid and short duration high yielding cotton varieties with desirable fiber characteristics, to generate agronomic management technologies to increase productivity, integrated management of soil fertility combining organic and inorganic sources of fertilizer, development of bio-pesticide in controlling cotton insect pest, cotton disease management, identification of cotton seed health and identification of the factors affecting the cotton fiber quality. Besides, research on stress management has been prioritized to expand cotton cultivation in the hill, char, saline and drought areas combining the traditional knowledge and skill with advanced biotechnology tools.

Cotton research has been carrying out in 5 disciplines (Breeding, Agronomy, Entomology, Pathology and Soil Science) at 5 research centers and 3 research sub-centers located in different agro-ecological zones of Bangladesh. Cotton biotechnology relevant research is conducted at Sreepur (Gazipur) Research Center located in the central region, drought relevant research is conducted at Sadarpur (Dinajpur) Research Center located in the northern region, salinity relevant research is conducted at the Jagadishpur (Jessore) Research Center located in the southern region and research for hill cotton is conducted at the Balaghata (Bandarban) Research Center located at the Chittagong Hill Tracts of Bangladesh. In addition to that CDB has been maintaining 520 cotton genotypes at its Mahigonj (Rangpur) Research Center. These genotypes are continuously being exploited for improving the cotton yield and fiber quality. Till to date, CDB has generated 51 technologies as given in Table 2.

Table 2
Technologies generated by the Cotton Research in Bangladesh

Sl. No.	Discipline	No. of Achievement
1.	Breeding	18 varieties
2.	Agronomy	16 technologies
3.	Entomology	7 technologies
4.	Soil Science	8 technologies
5.	Pathology	2 technologies

Source: Islam (2015)

Extension program

CDB provides extension services to the cotton growers in 37 districts and 127 Upazillas through its 4 regional offices, 13 zonal offices and 187 cotton unit/sub-unit offices. During 2014-15 season, cotton was cultivated in 42700 ha of land and the production was 152534 bales (1 bale= 182 kg). The area and production of cotton over the last few years are given in the following table. Over the last five years cotton yield was found in increasing trend due to the integrated efforts taken by the CDB.

Table 3
Cotton area and production in Bangladesh

Year	Area (ha)	Production (Bales-182 kg)	Yield (kg/ha)
2010-2011	33500	80000	435
2011-2012	35675	103424	528
2012-2013	39756	129000	591
2013-2014	41498	144616	634
2014-2015	42700	152534	650

Source: CDB (2016)

Cotton is the second important cash crop in Bangladesh after Jute. It is the main raw materials of Textile industry. Annual requirement of raw cotton for the textile industries of Bangladesh is estimated at 5.5- 6.0 million bales. Approximately, 2-3% of the national requirement is fulfilled through the local production while the remaining 97% requirement is fulfilled by importing raw cotton from Uzbekistan, India, Pakistan, Turkmenistan and from African countries. Without hampering the food crop production in main area, cotton can be expanded in non-conventional areas.

Marketing and processing of cotton

Cotton is a cash crop and involved in international trade, therefore, its marketing system is relatively complex. The marketing and processing of cotton starts from the farm gate after harvest of cotton and goes through various steps of processing. Private ginners provide ginning facilities of the seed cotton harvested by the cotton growers. Ginning is a process to separate seed and fiber. There are around 20 number of private ginners in the main cotton growing areas who procure seed cotton from cotton growers. These are the middle stage processing centre for the seed cotton produced by the farmers and they play important role in cotton production and marketing. After ginning, fiber is sent to the spinning mills and seed is used for oil extraction by expeller. The crude oil is than brought to the oil refinery factory to produce edible oil.

Annual Requirement of cotton

Cotton fiber is the main raw materials of textile industries in Bangladesh. Annual requirement of raw cotton for textile industry of Bangladesh is about 5.5-6.0 million bales. Around 3% of the national requirement is fulfilled through the local production while remaining 97% requirement is fulfilled by importing raw cotton from Uzbekistan, India, Pakistan, and Turkmenistan and from African countries. Textile is the largest industrial sector of Bangladesh and any crisis in the sourcing of raw materials will create a serious threat to the development of this sector. Thus, Bangladesh has an urgent need to increase domestic crop production. For increasing domestic cotton production the main constraint is the unavailability of the suitable land in the high productivity areas of Bangladesh those are currently used for food crop production. Without hampering the food crop production, CDB has targeted to expand cotton cultivation in the low productive areas in Bangladesh such as drought, hill, saline and char areas of Bangladesh.

Cotton in drought areas

Drought prone areas are mainly located in the north-western and northern regions of Bangladesh and spread over an area of 5.46 million ha. Among the regions north-western Barind tract is specially drought prone where Transplanted Aman rice is the sole competitive crop of cotton. In these areas the severity of drought is increasing day by day due to the impact of climate change. Droughts are associated with the late arrival or an early withdrawal of monsoon rains and also due to intermittent dry spells coinciding with critical stages of T. Aman rice. Droughts in May and June destroy broadcast Aman, Aus and jute. Inadequate rains in July delay transplantation of Aman in high Barind areas, while droughts in September and October reduce yields of both broadcast and transplanted Aman and delay the sowing of pulses and potatoes. Severe droughts occurred in 1966, 1969, 1973, 1978, 1979, 1981, 1982, 1989, 1992, 1994, 1995, 1998 and 2000, causing substantial reduction in food production. Research conducted by Cotton Development Board revealed that rain fed cotton can be grown successfully by replacing low yielding T. Aman rice in the drought prone areas of Bangladesh. Comparative advantages of cotton over rice production in this area are given in Table 4. Presently, CDB has been implementing a development program to expand cotton cultivation in the drought prone areas of Bangladesh.

Table 4

Cost benefit analysis of T. Aman rice and Cotton production in the drought prone areas of Bangladesh

Description of items	Rice	Cotton
Production cost (Taka/ha)	45000.00	60000.00
Yield (kg/ha)	3000	2000
Gross return (Taka/ha)	52500.00	105000.00
Net Profit (Taka/ha)	7500.00	45000.00

Source: Uddin (2016)

Cotton in hill areas

Chittagong Hill Tracts (CHT) is the only extensive hill area in Bangladesh and it is located in the southern eastern part of Bangladesh. The area of the Chittagong Hill Tracts is about 13,184 sq km, of which 92% is highland, 2% medium highland, 1% medium lowland and 5% homestead and water bodies. Total population of CHT is 1331996 of which about 51% is tribal people.. The upland areas are remote, and are mostly inhabited by many ethnic minorities. The majority of the ethnic minorities are Chakma (48%) and Marma (28%). Shifting agriculture Jjhum) is still the dominant cultivation systems in this region. The incidence of poverty is high due to the low productivity of jhum crops. Poverty caused by traditional agriculture and environmental degradation in the Chittagong Hill Tracts of Bangladesh need policies and programs for environmentally compatible and economically viable agricultural systems. Adaptive trials were conducted by CDB during 2012 to 2015 in the hill slope and generated rice cotton intercropping technology, as an alternative option, which provide more income to the hill farmers (Table 5).

Table 5
Comparison of traditional jhum and rice-cotton production system in the hilly areas of Bangladesh

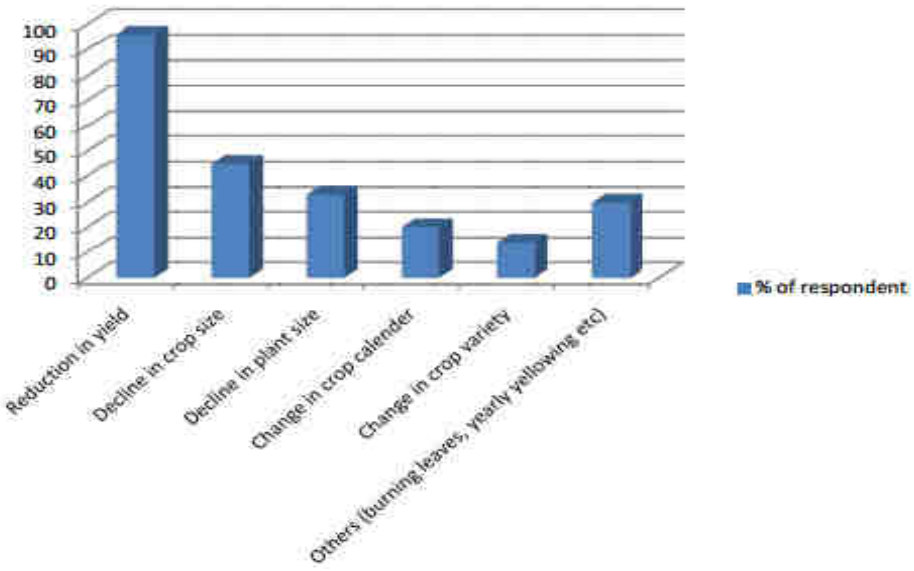
	Jhum system	Rice-cotton intercropping system
Sowing method	Mixed	In line
Crops	Rice, cotton with other 5-7 crops	Rice and cotton
Rice yield (kg/ha)	1988	2713
Cotton yield (kg/ha)	468	1060
Production cost (Taka/ha)	66,492.00	73,902.00
Gross return (Taka/ha)	77,720.00	1,17,860.00
Net profit (Taka/ha)	11,228.00	43,958.00

Source: Uddin (2016a)

Cotton in saline areas

The coastal region covers almost 29,000 sq. km i.e. about 20% of the country with more than 30% of the cultivable lands of the country. About 53% of the coastal areas are affected by salinity. Agricultural land use in these areas is very poor, which is much lower than country's average cropping intensity. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. The factors which contribute significantly to the development of saline soil are, tidal flooding during wet season (June-October), direct inundation by saline water, and upward or lateral movement of saline ground water during dry season (November-May). The severity of salinity problem in Bangladesh increases with the desiccation of the soil. It affects crops depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost. Local farmers' perceptions about the impact of salinity intrusion are reduction in yield, decline in crop size, decline in plant size, change in crop calendar, change in crop variety (Figure 1).

Figure 1
Local farmers' perception on the impact of salinity on crop production
(adopted from M. A. Baten et al., 2015)



The dominant crop grown in the saline areas is local Transplanted Aman rice with low yields. The cropping patterns followed in the coastal areas are mainly Fallow-Fallow-Transplanted Aman rice. It has become imperative to explore the possibilities of increasing potential of these (saline) lands for increased production of crops. Cotton is considered as 2nd saline tolerant crop after barley among all crops.

Although, cotton is considered a pioneer crop in reclamation of saline soils, salinity stress usually delays and reduces germination and emergence rates, decreases cotton shoot growth and may finally lead to reduced seed cotton yield and fiber quality. There is, however, a substantial variation in tolerance to salinity between cotton cultivars. Development of salt tolerant cotton varieties was initially attempted through direct selection from the existing cotton varieties and genotypes. After extensive research, CDB has identified the cotton cultivars that can be grown successfully in the coastal areas of Bangladesh.

Cotton in Char areas

Char lands are the sandbars that emerge as islands within the river channel or as attached land to the riverbanks. 5% of Bangladeshi population lives on the Chars. The char lands are mostly sandy with low organic matter and low water holding capacity. Cotton is a deep rooted crop and can uptake nutrients from subsoil and adds biomass to the top soil by their big leaves and improves the soil fertility. Last couple of years, CDB has been conducting research and developments in the char area with the success to grow cotton with reasonable yield. With the progress of expansion of cotton cultivation in the above discussed low productive areas, the vulnerability of the rural peoples living in those areas are decreasing by increasing their food security in the context of climate change.

Cotton and food security

Cotton increases food security of the rural farmer's in many ways. Cotton seed is sown manually in furrow by maintaining 90 × 45 cm spacing. At the early growing stage of cotton, intercropping with vegetables, chili, mungbean is adopted by the farmers of Bangladesh. Moreover, relay cropping of turmeric, ginger, banana, chili, wheat and sugarcane also gains popularity among the farmers. These practices by increasing farmer's income, improve the farmer's food purchasing capacity. Tabib et al. (2014) conducted research to maximize the benefit of cotton + mungbean intercropping system. Performances of eight different planting arrangements were compared against sole cropping. The highest seed cotton equivalent yield (2951 kg/ha) was obtained from the pair row cotton + 4-row mungbean with 31% yield advantage over sole cotton that gave the highest gross return (118039.00 Taka/ha), gross margin (60220.00 Taka/ha) and BCR (2.04).

The main source of rural employment is the agricultural farming activities. From seed sowing to drying of harvested boll 400-450 person/ha is required in Bangladesh. It creates employment opportunity particularly for the rural woman because of dry land farming of cotton is more preferable to them than wet land rice farming. Biomass fuel is the main source of rural household energy in Bangladesh. Cotton is a woody plant and the stalks are used as fuel wood by the farmers. On an average 4.8 tons of stalks are produced per hectare of land.

In addition to the fiber, the main raw material for textile sector in Bangladesh, cotton by-products such as seed oil, oil cake and fuel wood are also contributing to national economy by value addition. The harvested boll known as seed cotton, generally contains 40% lint and 60% seed. Cottonseed contains hull and kernel. The hull produces fiber and linters. The kernel contains oil, protein, carbohydrate and other constituents such as vitamins, minerals, lecithin, sterols etc. Cottonseed oil is extracted from cottonseed kernel. Presently, cotton seeds are used by the 18 crude oil crushing industries to produce crude oil (25%) and oil cake (75%). One oil refinery industry in Bangladesh refines the crude oil to produce edible oil. The oil cake is generally used as organic fertilizer, fish feed or livestock feed. Cotton seed oil is edible oil which is important food item. Cotton oil cake contributes in livestock and fish production which indirectly contribute in farmer's food security.

Considering the national importance as well as the value addition by cotton, the vision 2020-2021 of CDB is to expand cotton cultivation over 100000 hectare of land and to achieve this target CDB has been implementing several development project/program funded by the Bangladesh Government. Upon achievement of the target, the expected lint product and by-products are given in the following table:

Table 6
Vision 2020-2021of Cotton Development Board

1.	Cotton acreage	100000 ha
2.	Seed cotton yield (3 ton/ ha)	300000 ton
3.	Lint /Fiber yield (40%)	659000 bale
4.	Cotton seed (60%)	180000 ton
4.	Cotton Seed Oil (25%)	45000 ton
5.	Cotton Oil Cake (75%)	135000 ton
6.	Cotton stalk	480,000 ton

Source: Uddin (2016a)

For the sustainable increase of the domestic cotton production, the research capabilities of CDB need to be enhanced by research collaboration with the international organization. Collaboration between Nazilli Cotton Research Station, Turkey and Cotton Development Board, Bangladesh was initiated. Moreover, every year one officer from CDB is participated in training on Cotton in Egypt.

Conclusion

The impact of climate change is in Bangladesh is undeniable. Bangladesh is a climate change hotspot with a high frequency of natural disasters such as flood, drought etc. Climate change is putting extra strain on the rural peoples of the low productive areas of Bangladesh, where traditionally grown crops are found no longer profitable to them. Promoting cotton cultivation is found to be a viable option to mitigate the negative impact of climate change. Moreover, increasing of the domestic cotton production will simultaneously contribute to the national economy by reducing the import dependency of raw cotton. However, to sustain the cotton productivity over time, CDB is looking forward international collaboration for the resilience in Bangladesh cotton production.

Bibliography / More information

- Baten, M. A., Lubna Seal, L., Lisa, K. S. (2015). *Salinity Intrusion in Interior Coast of Bangladesh: Challenges to Agriculture in South-Central Coastal Zone.* American Journal of Climate Change, 4:248-262.
- CDB (2016). *Cotton Development Board*, Annual Production Report 2016.
- GoB and UNDP (2009). *Policy study on The Probable Impacts of Climate Change on Poverty and Economic Growth and the Options of Coping with Adverse Effect of Climate Change in Bangladesh.* Bangladesh: General Economic Division, Planning Commission, Government of the People's Republic of Bangladesh and UNDP Bangladesh
- Islam, M. K. (2015). *Cotton research in Bangladesh and its future direction*. Key note paper presented at the Annual Research Review Workshop 2015.June 13-14, Dhaka, Bangladesh
- Tabib, M. F. A. I., Karim, M. A., Haque, M. M., Khaliq, Q. A., Solaiman, A. R. M. (2014). *Effect of planting arrangements on productivity of cotton+mungbean intercropping systems*. Bangladesh Agron. J., 17(1): 11-22.
- Uddin, F. M. (2016). *Prospects of cotton expansion in the northern areas of Bangladesh for economic development of farmer's*. Key note paper presented at the Regional Workshop, 9 April 2016, Thakurgaon, Bangladesh.
- Uddin, F. M. (2016a). *Prospects of rice-cotton intercropping in the hill slope.* Key note paper presented at the Workshop on Pilot Project on up-scaling and campaigning rice-cotton intercropping in Bandarban and Khagrachari Districts, 12 March 2016, Balaghata, Bandarban.