Mitig Adapt Strateg Glob Change (2011) 16:845–863
DOI 10.1007/s11027-011-9298-6

ORIGINAL ARTICLE

Building responsiveness to climate change through community based adaptation in Bangladesh

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Received: 5 March 2011 / Accepted: 10 May 2011 /
Published online: 24 May 2011

Abstract This article explores the drivers, benefits, and challenges to climate change adaptation in Bangladesh. It specifically investigates the "Community Based Adaptation to Climate Change through Coastal Afforestation Program," a 5-year $5 million adaptation scheme being funded and implemented in part by the Government of Bangladesh, United Nations Development Program, and Global Environment Facility. The article explores how the CBACC-CA builds various types of adaptive capacity in Bangladesh and the extent its design and implementation offers lessons for other adaptation programs around the world. The first part of the study begins by describing its research methods consisting of research interviews, site visits, and a literature review. It then summarizes six primary sectors vulnerable to climate change in Bangladesh: water resources and coastal zones, infrastructure and human settlements, agriculture and food security, forestry and biodiversity, fisheries, and human health. The article next describes the genesis and background behind the CBACC-CA, with an emphasis on components that promote capacity development, demonstration projects, risk reduction, and knowledge management. The article concludes that technology by itself is only a partial component of successful adaptation efforts, and that multiple and integrated adaptation measures that cut across sectors and social, institutional, and infrastructural dimensions are needed to truly build resilience and effectiveness.

Keywords Bangladesh · Community based adaptation · Climate change adaptation · Coastal afforestation

1 Introduction

Bangladesh contributes little to global greenhouse gas emissions yet is one of the most vulnerable countries to climate change. Because it sits at the intersection of three major

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river basins and features flat deltaic topography with low elevation (Fig. 1), it is prone to a multitude of climate-related events such as floods, droughts, tropical cyclones and storm surges. Fifteen percent of its 162 million people live within one-meter elevation from high tide (Matthew 2007), yet annual floods inundate between 20 and 70% of the country's landmass each year (Mirza 2002). Bangladesh has high population density and rates of poverty, being the seventh most populous country in the world with a density greater than one thousand persons per square kilometer, and yearly per capita income ranging between $400 and $1,700 (depending on what one counts and whether they adjust for purchasing power parity). Bangladesh also has extreme climate variability, naturally alternating between seasons of monsoon and winter drought, and it is dependent on crop agriculture, highly sensitive to changes in climate (Ahmed 2006). It is reputed to be the most vulnerable country in the world to tropical cyclones and the sixth most vulnerable country to floods.

Thus, building responsiveness to climate change through adaptation has been recognized as necessary to the very political and economic survival of the country (Ali 1999; Sajjaduzzaman et al. 2005). This article therefore investigates one prominent, and successful, adaptation project currently being implemented there: the "Community Based Adaptation to Climate Change through Coastal Afforestation" Program, or CBACC-CA. The CBACC-CA is a 5-year $5 million adaptation scheme being funded and implemented by the Government of Bangladesh, United Nations Development Program, and the Global Environment Facility. The article asks: in what ways does the CBACC-CA strengthen adaptive capacity, and what lessons does its design and implementation offer other adaptation programs around the world?

The first part of the article summarizes its research methods, consisting of research interviews, site visits, and a literature review. The article then identifies six primary sectors vulnerable to climate change in Bangladesh. It next emphasizes components of the

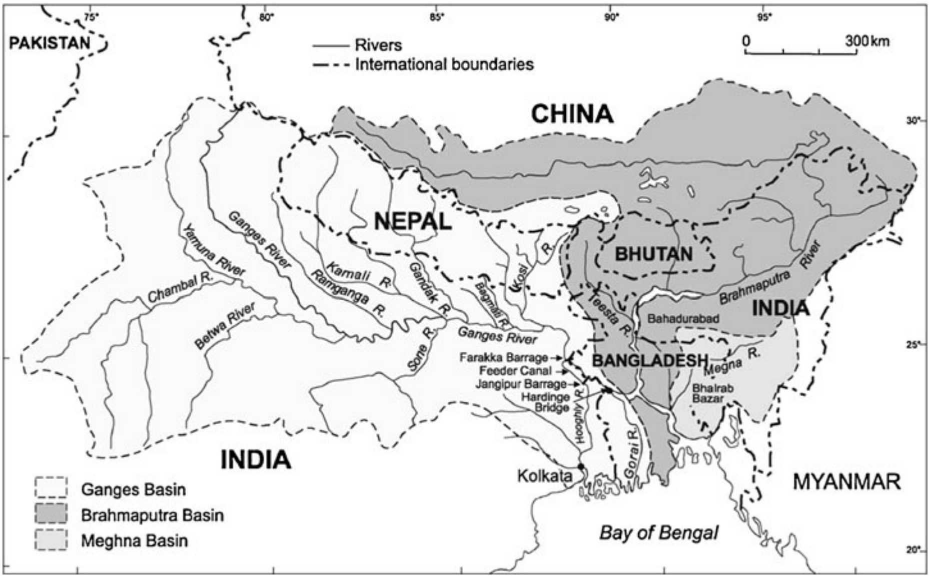

Fig. 1 The river systems of Bangladesh. Source: Mirza 2002: 128

CBACC-CA that promote capacity development, demonstration projects, risk reduction, and knowledge management. Achieved and anticipated benefits include improving physical responsiveness by deploying "soft" and "indigenous" infrastructure through the creation of green coastal belts, the enhancement of institutional effectiveness by training policymakers, and the strengthening of community knowledge by providing alternative livelihood options and establishing early warning systems. Challenges include ensuring that adaptation efforts are enough to truly respond to climate vulnerability, lack of coordination, and growing yet still constrained institutional capacity to ensure successful implementation.

The novelty of such an exploration is fourfold. First, our study focuses intimately on the benefits to climate change adaptation, which may be more appropriate and effective than mitigation for least developed countries such as the Bangladesh as well as other coastal countries and Small Island Developing States. Adapting to climate-related impacts will only become more salient over time for these countries. Second, the article treats adaptive capacity as multidimensional, inclusive of physical measures such as improved infrastructure or stronger technology alongside institutional measures such as good governance and political awareness and social measures such as standards of living and community assets. Third, it investigates the challenges facing adaptation efforts in practice, barriers that will have to be overcome on the ground of infrastructural, institutional, and community effectiveness are to be meaningfully strengthened in Bangladesh and elsewhere. Fourth is our utilization of a mixed methods approach that relies not only on original primary data collected through in-country interviews and visits but also secondary data from peer-reviewed literature and reports.

2 Research methods

In order to better understand the expected impacts from climate change in Bangladesh, the authors conducted research interviews at various institutions throughout the country including the Bangladesh Ministry of Environment and Forests, United Nations Development Program Bangladesh, Bangladesh Forest Department, and the Bangladesh Forest Research Institute. Questions were qualitative, open-ended, and mainly related to Bangladesh's vulnerability to climate change, strengths and weaknesses of its national climate policy, and specific details of the CBACC-CA project. Reponses were transcribed and then coded, although data from these interviews is quoted throughout the article as anonymous in order to maintain confidentiality at the request of participants and adhere to institutional review board guidelines. To further study the conditions of the vulnerable coastal communities, three site visits were made to the districts of Noakhali, Chittagong and Cox's Bazaar, where the authors arranged meetings with local scientists, community leaders, farmers, and residents of vulnerable communities, and asked them about the costs and benefits of local efforts related to the CBACC-CA project.

In structuring the interview questions, the authors elected to employ an inductive approach to minimize interpretative bias caused by researchers trying to force responses into preset cognitive frameworks. This inductive approach was implemented by fixing our initial questions for each interview and then allowing interview subjects to respond in as much detail as they wanted. The four questions were: i) "What are the primary climate change risks facing Bangladesh?;" ii) "How well does national policy address these risks?;" iii) "What are some of the challenges facing adaptation projects such as the CBACC-CA?;" and iv) "What are some of the benefits and lessons learned from the

CBACC-CA?". The authors supplemented these four questions with "probing response techniques" when clarification or elaboration was sought and "reflecting response techniques" in order to elicit deeper responses when warranted (Sovacool and Valentine 2011). In response to these interviewing strategies, participants introduced new topics into the conversation not anticipated by the authors. Interviews lasted between 30 and 90 min, site visits between 1 and 4 h.

These interviews and site visits were reinforced by a review of the academic and policy literature. The review consisted of project reports prepared by the World Bank, Global Environment Facility, and United Nations Development Program in addition to peer-reviewed articles offering insight into climate change adaptation efforts in Bangladesh published in the past 10 years. When laying out the study below, we shift back and forth from data collected from the interviews and site visits to analysis from the literature to fit the material around our central case study (Strauss 1990)

3 Country background

The authors selected Bangladesh for analysis due to its extreme vulnerability to climate related impacts. Most of Bangladesh lies in the delta of three of the largest rivers in the world – the Ganges, the Brahmaputra, and the Meghna, or GBM (Fig. 2). These rivers have a combined peak discharge of 180,000 cubic meters per second during the flood season, the second highest in the world after the Amazon and carry about two billion tons of sediments each year. Bangladesh is at risk not only to flooding and tidal inundation on the coasts, but also advanced melting of the Indian and Nepali Himalayan glaciers. This effectively means the country is hit on "both geographic sides" as well as during "both seasons:" climate change is disrupting natural cycles of rainfall and snowpack on the Tibetan Plateau which feed Bangladesh's major rivers, and also increasing flooding, saltwater intrusion, and storm surges on the coastal belt; it is also creating excess rain during the monsoon season, and inducing a shortage of it during the winter drought (Matthews 2007; Belt 2011).

Further compounding matters, the topography of the country is low and flat. Two-thirds of its critical infrastructure is less than 5 m above sea level and is therefore susceptible to naturally occurring river and rainwater flooding and, in lower lying coastal areas, to tidal flooding during storms. Indeed, Mirza (2002) documented that Bangladesh is perpetually at risk to four distinct types of flooding: *flash floods* which occur on the eastern and northern rivers, along the borders of Bangladesh, resulting from heavy rainfall; *riverine floods* which result when the GBM rivers or their tributaries simultaneously reach their peaks, which tend to rise and fall slowly over a 10–20 day cycle; *rain floods* due to high intensity local rainfall during the monsoon; and *storm surge floods* caused by tropical storms and cyclones which affect tidal flats and low-lying islands.

However, once every 4–5 years, severe flooding induces substantial damage to infrastructure, housing, agriculture and livelihood. Table 1 shows serious floods in Bangladesh in the last 25 years and their impacts. A severe tropical cyclone also hits Bangladesh, on average, every 3 years resulting in extensive damage to houses, livestock, and human health (Government of Bangladesh 2005: 7). One cyclone in November 1970 produced winds as strong as 220 km per hour and a storm surge 9 m high, resulting in 300,000 (Agrawala et al. 2003) to 500,000 deaths (Thomalla et al. 2010). Another cyclone in April 1991 generated a storm surge 8 m high that displaced 11 million people and caused 138,000 deaths.

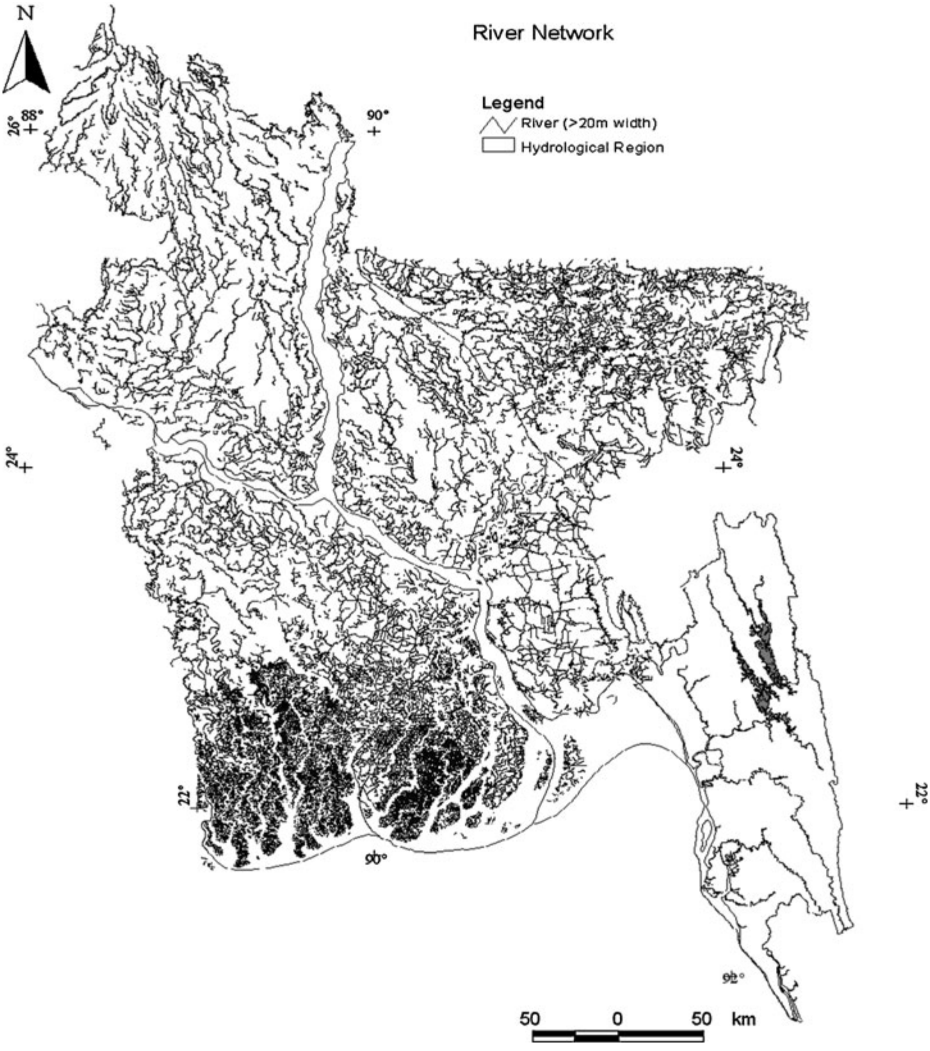

Fig. 2 The Ganges, Brahmaputra, and Meghna River Basins and their tributaries in Bangladesh. Source: Ahmed 2006

Indeed, Bangladesh has been hit by 154 cyclones from 1877 to 1995, a rate of more than one major cyclone per year (Ali 1999), and it has also been subject to 174 separate natural disasters from 1974 to 2003 (Reid et al. 2007). Bangladesh, what one respondent even called "the most flood prone country on the globe," experienced 21 above normal foods, four exceptional floods, and two catastrophic floods from 1954 to 2010 (Ali 1996; Chowdhury et al. 1993; Haque 1997). One flood in 1988 reduced agricultural production by 45%, and a 1998 flood resulted in the loss of more than two million hectares of arable land used for rice cultivation (Ahmed 2006). The most recent severe flood in 2007 inundated 42% of the country's land area (62,300 square kilometers), caused 1,110 deaths, submerged 2.1 million hectares of cropland, destroyed 85,000 homes, damaged 31,000 km of roads, affected 14 million people, and induced $1.1 billion in damages (Dasgupta et al.

Table 1 Impacts of major floods in Bangladesh 1984–2007

Year	Land inundated (square kilometers)	Fatalities	Refugees/Homeless	Damage (Millions of USD)
1984	50,000	445		378
1987	50,000	2,055		1,000
1988	85,000	6,500	45 million	1,200
1998	100,000	1,100	30 million	2,800
2004	60,000	700	15 million	6,600
2007	62,300	1,100	1.1 million	1,100

Adapted from Government of Bangladesh 2009

2010: 3). To put the damage in perspective, $1.1 billion is equal to all public debt listed by the government in 2008. Figure 3 illustrates how between 1954 and 2009, six major floods have inundated more than one-third of the country's landmass. Another respondent mused that "if Bangladesh was part of a country like the United States, it would have been permanently evacuated by now."

4 Bangladesh's vulnerability to climate change

Disturbingly, such floods and natural disasters are projected to get worse over the next few decades. A synthesis of 16 General Circulation Models and three emissions scenarios in the Intergovernmental Panel on Climate Change's AR4 expects Bangladesh to see a temperature increases of 1–3°Celsius by 2050 (Dasgupta et al. 2010: 4). Basically, this warming will create problems associated with water: too much of it during the monsoon seasons, and too little of it during the winter. Temperature increases will likely see sea levels rise, increasing river water levels, water logging, erosion, and flooding during the monsoon; and salt water intrusion and shortages of water for irrigation and agriculture

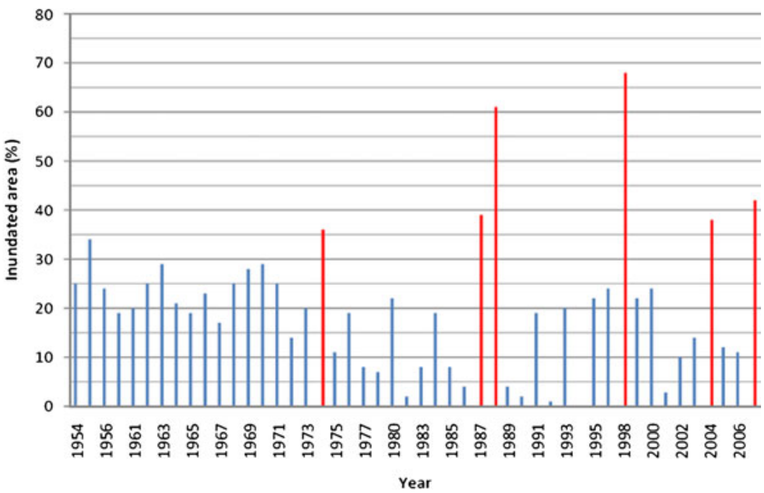

Fig. 3 Extent of above normal flooding in Bangladesh, 1950–2009. Source: Dasgupta et al. 2010: 29

during the winter (Ahmed et al. 2010). Agrawala et al. (2003) anticipate four primary negative changes in climate and precipitation: accelerated glacier melting from increased runoff from the neighboring Himalayas, increased rainfall during the monsoon season, sea level rise leading to flooding under ambient conditions and severe flooding during storm conditions, and increased frequency and intensity of cyclones. Figure 4 shows that every area in Bangladesh is prone to at least one of these four types of floods. The academic literature and interview respondents we spoke with for this study suggested that these four causal factors will create significant damage in five key sectors in Bangladesh.

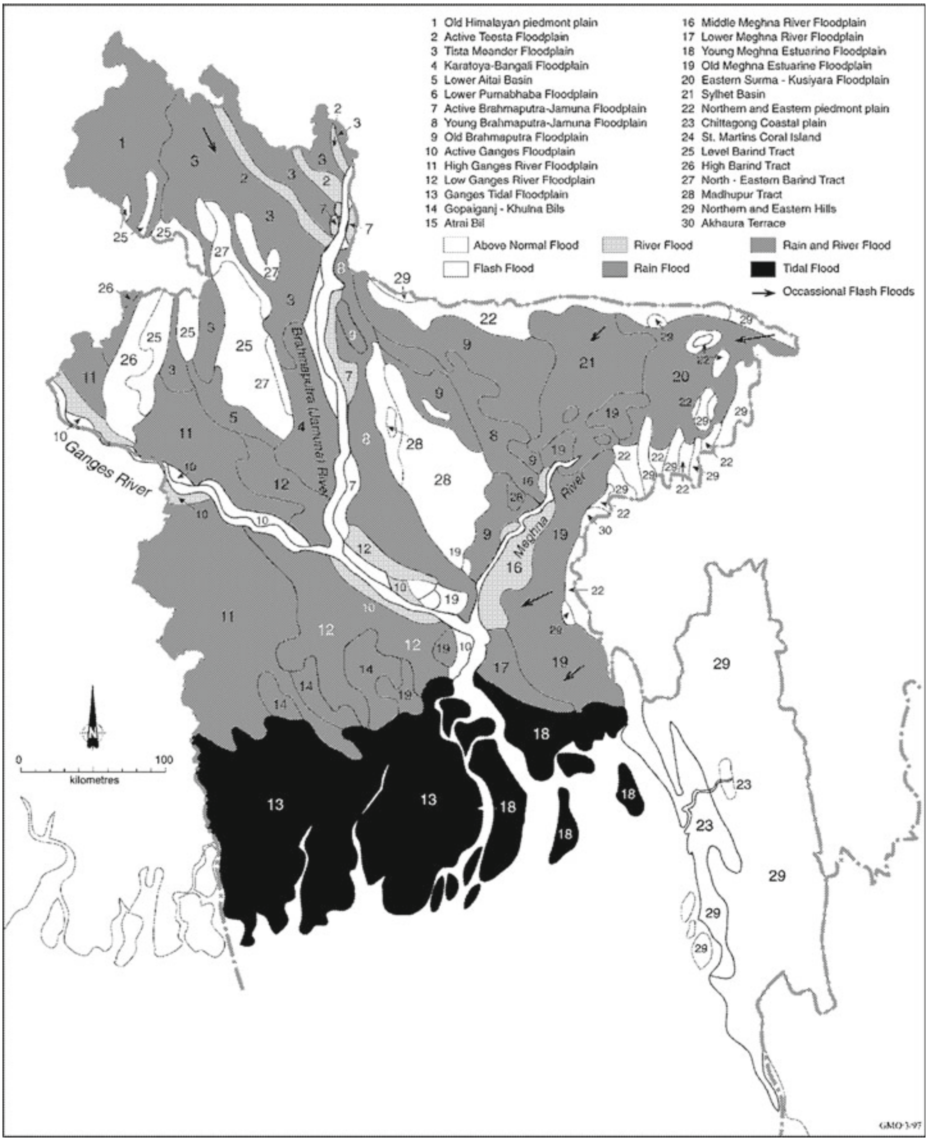

Fig. 4 Vulnerability of Bangladesh to different climate risks and flood types. Source: Mirza et al. 2003

First, and most critical, is *water resources and coastal zones.* Agrawala et al. (2003) identify coastal zones as "the highest priority sector" in terms of certainty, urgency, and severity of climate-related impacts, as well as the economic importance of the resources being affected. Coastal areas comprise some 32% of the country's total area and more than 35 million people live in coastal areas less than 1 m above sea level. Several studies indicate that the vulnerability of the coastal zone to climatic changes could worsen in the near term due to the confluence of sea level rises, subsidence, changes of upstream river discharges, cyclones and the erosion of coastal embankments (World Bank 2000).

These pressures produce four key types of primary physical effects:

- Saltwater intrusion: the effect of saline water intruding into estuaries and contaminating groundwater will increase as sea levels rise and river flows decrease. Water supplies for coastal agriculture, public consumption and industrial use will be severely affected. As one of the respondents noted, "Salinity encroachment towards the fresh water zone is phenomenal. Studies show that at present, almost 100 km inward salinity has encroached in the fresh water zone. We have found that in the areas where a person used to grow rice paddies, now salt is being processed. As a result there is a complete change in economic activities of these coastal communities."
- Drainage congestion: the combined effect of higher sea levels, subsidence, siltation of estuary branches, higher riverbed levels and reduced sedimentation in flood-protected areas impedes access to water for irrigation and drinking. One respondent noted that "poor drainage capacity will gradually increase water problems particularly in the coastal zone. The problem will be aggravated by the continuous development of infrastructure like roads reducing further the limited natural drainage capacity in the delta. Increased periods of inundation may hamper agricultural productivity, and will also threaten human health by increasing the potential for water borne diseases."
- Damage from natural disasters: in the coming decades, the number of coastal populations in need of annual emergency relief such as medicine and food will continue to increase as more frequent and severe climate events occur.
- Coastal morphology: Bangladeshi coastal morphological processes are extremely dynamic, partly because of the tidal and seasonal variations in river flows and runoff. Climate change is expected to increase bank erosion and bed level changes in coastal rivers and estuaries, and accelerate disturbance of the balance between river sediment transport and deposition in rivers, flood plains, and coastal areas. Disturbances of the sedimentation balance will result in higher bed levels of rivers and coastal areas, which in turn will lead to higher water levels.

Second is *infrastructure and human settlements.* Respondents expressed concern that high water levels in rivers surrounding polders—human made low lying tracks of land enclosed by dykes—may increase in the range of 30–80 cm, completely flooding them by 2100. Earthen embankments constructed by the Bangladesh Water Development Board are subject to erosion, and with a 45 cm rise of sea level, respondents told us they expect 15% of the land in Bangladesh to be inundated by the year 2050, resulting in more than 25 million climate refugees from the coastal districts. Indeed, during our own site visits we witnessed the flooding of villages shown in Fig. 1. Especially vulnerable in these locations would be *char* dwellers and women: *char* dwellers because they live in constantly changing islands, or chars, in the coastal district but build *kacha* homes made of *muli* bamboo, mud, and tin roofs that can be easily swept away in floods (Belt 2011; Ahmed 2008); and women because they contribute a disproportionate amount of their time rebuilding homes and caring for family members (Cannon 2002) (Fig. 5).

Fig. 5 The flooded village in Boyer Char in July 2010. Source: Authors

Third is *agriculture and food security*. Bangladesh is a highly agricultural society; agriculture accounts for 63% of its labor force and 35% of its Gross Domestic Product. Rice occupies 80% of total cultivated land area but droughts during the winter season threaten all three major types: *aman*, *aus*, and *jute*. Adjusting is a costly option for farmers who usually need to mortgage assets or borrow money to re-sow seedlings, replace crops, pay for irrigation, or migrate. Over the past six decades, the seasonal cycle has changed dramatically, pests and diseases have increased, average temperature has increased, the winter has shortened, and Fig. 6 shows significant deviations in expected rainfall. Baas and Ramasamy (2008) predict that by 2050, dry season rainfall could decrease 37% further.

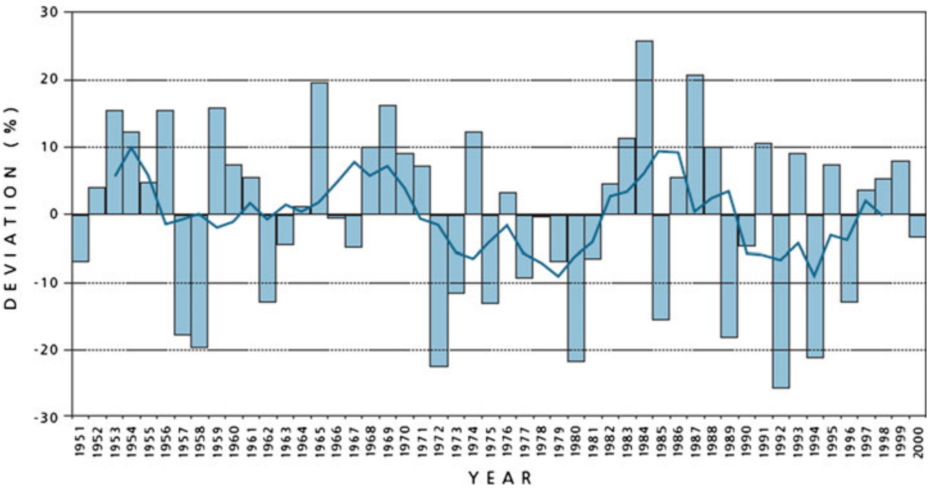

Fig. 6 Deviation of Monsoon Rainfall from Normal Rainfall, 1961–2000. Baas and Ramasamy 2008: 26

Anticipated higher temperatures and changing rainfall patterns, coupled with increased flooding and rising salinity in the coastal belt are likely to reduce crop yields and crop production, taking their toll on food security. The Bangladeshi government estimates that, by 2050, rice production could decline by 8% throughout the country and wheat production by 32%. In eastern Bangladesh alone the Government of Bangladesh (2009: 17) projects that 14,000 t of grain production could be lost to sea level rise in 2030 and 252,000 t lost by 2075. Ahmed and Alam (2010) assessed agricultural vulnerability to climate change in Bangladesh and concluded that drastic changes in evaporation and precipitation for both the winter and monsoon seasons were highly probable. Karim et al. (2010) calculate that a 17% loss in overall rice production and as much as a 61% decline in wheat production in the next few decades is likely; they caution that any positive increases in yield will be more than offset by moisture stress. Habibullah et al. (2010) project a significant loss of food grain production in coastal belts due to soil salinity intrusion, making affected lands unsuitable for a variety of crops. Such stark projections have been confirmed by a number of other studies (Reid et al. 2007; Ahmed 2001, 2006; Mirza et al. 2002, 2003; Paul and Rashid 1993; Faisal and Parveen 2004).

Also, respondents expressed worry that increasing temperature could alter soil composition, further affecting crop yields. As one explained:

> Climate change can bring major changes to agricultural productivity in Bangladesh. During the last 30–40 years a typical farmer has made continuous changes in farming practice. From initially growing rice paddies, farmers have generally moved to grow wheat and then to potatoes because of declining yields over the period of time as a result of changes to temperature and soil moisture …. However only rich farmers have been able to afford such changes and marginal farmers are still following traditional practices and have not been able to sustain their livelihoods due to low yields. As a result, they are selling their lands and migrating elsewhere.

Seasonal droughts in the country are another climatic threat to crops, causing hardship to poor agricultural laborers and others who cannot find work (Government of Bangladesh 2005: 7).

Fourth is *forestry*. Bangladesh is endowed with a number of natural forest ecosystems including inland Sal forest, dipterocarp forest, savanna, bamboo bushes in the hilly regions and freshwater swamp forests (Government of Bangladesh 2005: 15). One study qualitatively analyzed the impact of climate change on forest resources of Bangladesh and found that increased rainfall during the monsoon would accelerate runoffs in forest floors instead of infiltration into the soil, causing severe erosion (Rahman and Alam 2003). Prolonged floods would severely affect growth of many timber species, causing a high incidence of mortality for Artocarpus species. Tea plantations in the northeast could also suffer from changes in moisture and humidity. The Sundarbans mangrove forest could be the most severely affected since climatic changes would alter evapotranspiration and flow rates in the winter, increasing the salinity of the soil. Respondents cautioned that eventually non-woody shrubs and bushes would replace healthy indigenous species offering dense canopy cover, and overall forest productivity would decline significantly. Coastal forests are also at grave risk to flooding and erosion, threats discussed in greater detail above, and summarized by Islam and Nandy (2001); Nandy (2003); Nandy et al. (2001, 2004); and Siddiqi (2001).

Fifth is *fisheries*. Fish are a staple of Bengali culinary fare, with 80% of the daily animal protein intake in Bangladesh coming from fish and the fisheries sector contributing 3.5% to GDP (Ali 2010). Yet storm surges and increasing tidal waves from climate change could negatively influence commercial and subsidence fishing activities, especially for shrimp and prawn farms and riverine fish. One respondent argued that:

> The main source of livelihood of most of the communities living in coastal areas is either through farming or through fishing. Yet climate change can majorly affect fishers and fisheries. Last year fishermen complained that they lost 50% of their work due to increased storm surges, which either prevented them from fishing that day or catching nothing when they did fish.

Other respondents mentioned how the altering acidification of the oceans, and changing ocean temperature, could change the migratory patterns of various fish species and alter the productivity of plankton.

Sixth is *human health*. Respondents argued that flooding and cyclones directly affect health and nutrition by causing physical damage and disruptions in the supply of food and basic services, and indirect consequences by spreading waterborne diseases and creating prolonged periods malnutrition. Many of the most vulnerable communities are also reputed to have poor drainage and sanitation facilities. During the monsoon season in 2004, flooding placed 60% of the country under a solid pool of water mixed with industrial and household waste. More than 20 million people were affected and many suffered shortages of water, skin infections, and communicable diseases (Matthew 2007).

Taken collectively, these factors combine to make Bangladesh exceptionally exposed to the impacts of climate change. The World Bank (2000) has warned that a 25 cm increase in sea level, more than likely given recent projections, would force Bangladesh to lose 6,300 square kilometers (4% of its land), make the country prone to a 1991 level cyclone of 10% greater intensity, provoke monsoonal floods increase crop losses, inundate 40% of the Sundarbans, and increase the salinity of soil and water. Some of our respondents estimated that six to eight million people could be immediately displaced by climate-changed related disasters and would have to be resettled if sea levels rise faster than currently expected and coastal polders remain un-strengthened. Belt (2011) reports that rises in sea level could place as many as 30 million people along the southern coastal belt of Bangladesh at risk to displacement, and that a recent study of 136 port cities concluded that the two with the greatest proportional increase in people exposed to climate extremes by the year 2017 were Dhaka and Chittagong, both in Bangladesh. Agrawala et al. (2003) similarly projected that a 1 m rise in sea level would threaten 18% of population, inundate one-eighth of the country's agricultural land, damage 8,000 km of roads, threaten the major port of Mongl, and require the resettlement of communities living in entire Khulna region, resettlement alone costing $13 billion. Table 2 shows how climate change affects virtually every area of social, political, or economic activity in Bangladesh. The next section therefore discusses how the government has begun rigorously promoting adaptation efforts to mitigate many of these risks.

5 Adapting to climate change in Bangladesh

Because of this extraordinary susceptibility to climate change, the Government of Bangladesh, with the support of development partners, has invested more than $10 billion over the last 35 years to manage disaster-related risks. These investments have included flood management schemes, coastal polders, cyclone and flood shelters, and the raising of roads and highways above flood levels (Government of Bangladesh 2009: xvii). However, as a response to the country's increased vulnerability and the severity of cyclone Sidr in

Table 2 Areas and impacted sectors vulnerable to climate change in Bangladesh

Climate &related elements	Critical vulnerable areas	Most impacted sectors
Temperature rise and drought	• North West	• Agriculture (crops, livestock, fisheries) • Water • Electricity supply • Health
Sea level rise and salinity intrusion	• Coastal areas • Islands	• Agriculture (crop, fisheries, livestock) • Water (water logging, drinking water) • Human settlement • Electricity supply • Health
Floods	• Central Region • North East Region • Char Land	• Agriculture (crops, fisheries, livestock) • Water (urban, industry) • Infrastructure • Human settlement • Health • Energy
Cyclone and storm surge	• Coastal and Marine Zone	• Marine fishing • Infrastructure • Human settlement • Life and property
Drainage congestion	• Coastal area • South West • Urban areas	• Water (navigation) • Agriculture (crops)

Adapted from Government of Bangladesh 2005: 18

2007, the government for the first time developed and implemented an integrated climate change strategy and action plan in 2008. A local fund of $100 million was established for exclusively for adaptation and mitigation efforts.

Currently, the Ministry of Environment and Forests is tasked with monitoring and managing climate change affairs. The government has established an inter-ministerial committee on climate change headed by the Ministry for Environment and Forests (MOEF) composed of relevant government ministries and departments as well as key nongovernmental organizations and research institutions. The Department of Environment under the MOEF has also set up a Climate Change Cell to act as Secretariat for climate change related work within the government. There is also a National Environment Committee to determine environmental policies chaired by the Prime Minister and with representation from Members of Parliament as well as government and civil society.

The national climate change adaptation plan espouses a "pro-poor climate change management" strategy, prioritizing adaptation and disaster risk reduction. It aims to address national concerns with respect to climate change including food security, social protection and health, comprehensive disaster management, infrastructure, research and knowledge management, mitigation and low carbon development, and capacity building and institutional strengthening (Government of Bangladesh, Ministry Environment and Forests 2009: 27–29).

To further bolster national efforts, the Global Environment Facility and United Nations Development Program partnered with the government of Bangladesh to manage a project entitled "Community Based Adaptation through Coastal Afforestation," or CBACC-CA. The Executing Agency of the project is the MOEF and other implementing partners include the Forest Department, Bangladesh Forest Research Institute, Department of Agricultural Extension, Ministry of Fisheries and Livestock, and Ministry of Land. The project aims to reduce the vulnerability of coastal communities to the impacts of climate change by afforestation in four *upazilas* in the coastal districts of Barguna and Patuakhali (Western region), Chittagong (Eastern Region), Bhola (Central Region) and Noakhali (Central Region). The sites were selected by the Bangladesh on the basis of extreme vulnerability and also through public participation. Figure 7 depicts these zones on a national map. The total value of the project, expected to run from June 2010 to 2013, is $5 million, with core support coming from the Global Environment Facility and United Nations Development Program as grants. In addition, the Government of Bangladesh has in kind contributed about $1 million. In essence, the CBACC-CA project seeks to promote adaptation to climate change through more climate aware development and better risk management.

The project is based on four components. First is enhancing the adaptive capacity of coastal communities and protective ecosystems through community-led interventions focusing on coastal afforestation and the diversification of community livelihood. Second is strengthening national, sub-national, and local capacities of government authorities and sectoral planners so that they better comprehend climate risk dynamics in coastal areas and implement appropriate risk reduction measures. Third is reviewing and revising coastal management practices and policies with a view on increasing community responsiveness. Fourth is developing a functional system for the collection, distribution and internalization of climate related knowledge.

Bangladesh's coastal forest today is almost a monoculture of mangroves. These monoculture forests have a limited ability to mitigate the impacts of climate change as they have been viciously prone to pests, deforested, and logged. Respondents mentioned how historically Bangladesh had a 500 m buffer of natural mangroves to reduce the shocks of incoming storms and monsoons that has now been reduced to 12–50 m in most locations. Attacks from stem borers, a pest, have felled thousands of hectares and a lack of preferred mangrove species for regeneration and illegal deforestation and logging have worsened the situation.

The Forest Department has shifted from their traditional custodial role to a more participatory approach in forest management known as "social forestry" over the last two decades. Yet respondents noted that past projects did not adequately develop a sense of ownership of coastal mangroves among the local population, which resulted in over-harvesting and drainage. Average per capita income for an entire year in many parts of these coastal forests is only about $130, far below the national average, making people completely dependent on wetlands and forests along the coast to meet their subsistence needs (Matthew 2007). The downside is that local communities were thus often viewed by national planners as a threat to the forest rather than potential protectors and managers. A total of over 40,000 ha of natural and manmade forest have already been destroyed along the eastern and central coasts of Bangladesh due to poor policy and management.

6 The benefits and challenges of the CBACC-CA

Because of the unique history of forestry in Bangladesh, the CBACC-CA project implicitly recognizes that protection from climate hazards or livelihood benefits from these mangroves will be short-lived without the inclusion of communities, fishers, and farmers.

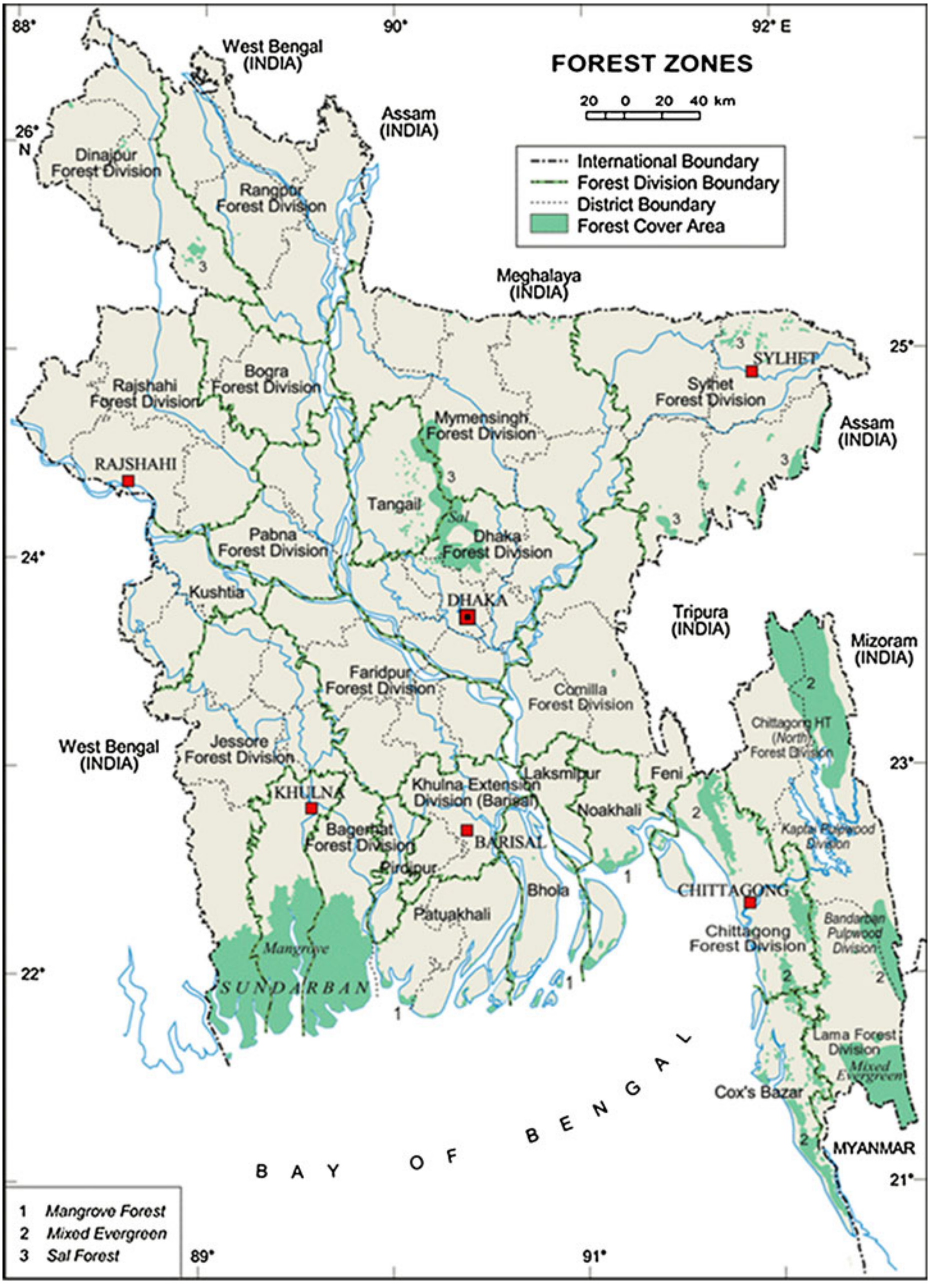

Fig. 7 Coastal districts of Bangladesh along with forest cover. Source: Bangladesh Forest Department

It builds and expands on this community participation model and focuses on creating incomes for communities in addition to protecting forests. As one respondent put it:

> Our hypothesis [with CBACC-CA] is that risk reduction in coastal areas can mainly be achieved if the maintenance of protective natural system is connected with tangible

economic development options in general and development of local community in particular.

Keeping in line with testing this hypothesis, this section details the benefits and challenges of the CBACC-CA.

The most direct contribution the CBACC-CA makes to *infrastructural* effectiveness is creating a natural buffer to climatic hazards through a more robust coastal belt in four vulnerable districts. It sponsors 6,000 ha of community based mangrove plantations, 500 ha of non-mangrove mount plantations, about 220 ha of dykes, and more than 1,000 km of embankments. It also develops early warning information and disaster preparedness systems in vulnerable areas to protect at least twenty villages and towns.

The CBACC-CA creates *community* and *social* responsiveness by offering subsidies to vulnerable communities and attempting to diversify economic training to include forestry, fishing and farming. One especially innovative dimension of this component is its focus on the "Trifle F" model of "Forestry, Fisheries, and Food." The coastal communities most vulnerable to rising sea levels—the places where mangroves need to be planted and forests replenished—are also those where farming and forestry are the primary sources of income. The "FFF" model attempts to maintain community livelihood and adapt to climate change at the same time by integrating aquaculture and food production within reforested and afforested plantations. The FFF model, depicted in Fig. 8, currently accommodates 15 families per hectare and provides an opportunity to grow vegetables such as country beans, cucumbers, and gourds (cucurbitaceous vegetables) and other creeper vegetables. Quick growing and early yielding fruit trees such as *Bau kul* and Apple Guava can also be planted between mangroves and mounds and produce 10–20 kg of fruit per tree within 2 years of

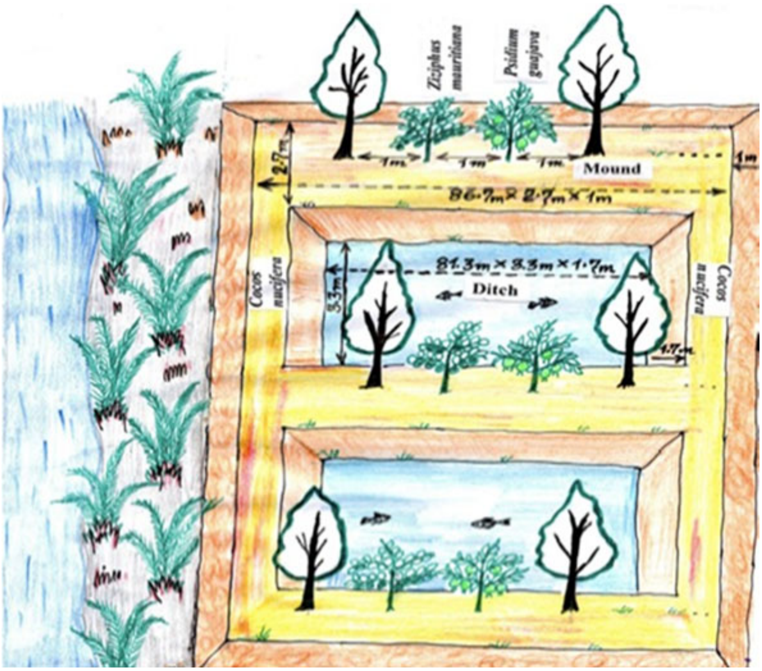

Fig. 8 The Forestry, Food, and Fish (FFF) Model of afforestation in Bangladesh. Source: UNDP Bangladesh and Nandy 2010

planting (or an extra average income of about $700 per mound per year). The ditches between mounds and mangroves creatively support 150 kg of fish with an annual income of about $300 per ditch per year. Some communities have even supplemented these efforts by producing palm oil. The central premise behind FFF activities is that adaptation efforts must also generate a continuous flow of income for local communities. Indeed, respondents calculated that investments in the CBACC-CA will already provide jobs and income generating activities for 1,150 families and community training related to nursery management and plantation establishment to 12,200 coastal people.

The project lastly improves *institutional capacity* by providing training to government planners at national and local scales, and facilitates integration of climate risks, and input from stakeholders outside of government such as civil society and the private sector, into national policies and regulations.

Notwithstanding these benefits, however, respondents also mentioned a web of difficult challenges surrounding CBACC-CA. One respondent put it bluntly that:

> I really want the CBACC-CA to work, but the institutional capacity including human resource quality in most Bangladeshi organizations, public and private, needs substantial improvement if the challenges of climate change are to be faced squarely.

Other respondents commented how afforestation can help reduce vulnerability by strengthening coastal embankments, but such investments “are no guarantee that climate dangers will be completely eliminated.” As another respondent commented:

> The challenge Bangladesh now faces is to cope with changes in climate already happening every year .We are strengthening coastal embankments, yes, but the intensity of erosion and frequency of storms are also increasing, and I feel like we are often in a race against time where time is running out. We have developed saline tolerant rice variety crops but the concentration of salinity is going up. We can’t keep on producing crops when land is flooded and water salty; it’s practically not possible at the moment. Adaptation has its limits.

If the situation worsens, or if adaptation investments are not able to keep pace with vulnerabilities and risks, Bangladesh may have to switch to “retreat” measures such as relocating communities to higher ground. As one respondent lamented, “if the climate change situation becomes truly out of control then the only possible solution we might have is migration and relocation. But that comes with its own set of challenges, given the population density along the coast and the socio-economic status of those most at risk.”

At the institutional level, another challenge is how to ensure consistent and useful cooperation between implementing parties and beneficiaries. One respondent argued, “there is a lack of coordination between different government departments to identify and implement need based adaptation measures. Also the organizational capacity is missing at most of the government departments to ensure the successful and timely implementation of the [CBACC-CA] project.” Another commented that:

> The lack of institutional mechanisms and the poor organizational capacity of various government departments have already created setbacks for the project. First was a delay in the approval of Technical Project Proposal by the Government. This caused a 1-year delay in the project implementation as compared to the proposed date. Hence we missed the July-August seeding time. This is a serious problem as it meant 2 years worth of tasks now needed to be accomplished within a year. Second, there is a lack of coordination between various government departments. The Ministries responsible

for agriculture, fisheries and livestock have yet to nominate their key positions and two consequently nominated Deputy Project Directors from the Ministry of Land have been transferred without participating in any activity of the project assigned by the ministry.

Another respondent cautioned that "the generation of adaptation benefits and integrating climate risk into development and poverty reduction strategies of the government is required simultaneously for the long-term sustainability of the project, but I don't see that happening."

7 Conclusion

Bangladesh must already confront a pernicious and integrated set of climate change related impacts. Due to its low lying geography and population density, millions of people along the coast remain at risk to devastating rises in sea level, cyclones, floods and storm surges resulting in soil erosion, drainage congestion, water logging, and saltwater intrusion of drinking water supplies. These factors are already impacting the livelihood of fishers, farmers, and foresters in Bangladesh.

Rather than address these issues in a piecemeal fashion, the CBACC-CA improves infrastructural adaptation through a mix of hard, soft, and indigenous measures. As Table 3 highlights, some elements of the CBACC-CA incentivize hard measures such as building sea gates for salt water intrusion into rivers and strengthening coastal embankments with dykes. Others rely on self-described "soft" and "indigenous" methods such as the creation

Table 3 The contributions of the CBACC-CA to adaptive capacity in Bangladesh

Infrastructural adaptive capacity	
Physical protection through soft and indigenous measures	• Community driven Coastal Afforestation of over 6000 ha
Food security	• Development of climate- and drought- resilient cropping systems and technologies appropriate to different agro-climatic regions and sub-regions
Institutional adaptive capacity	
Emergency planning	• Improvement of early warning systems for flood forecasting, cyclone and storm surge warnings
Capacity building and institutional strengthening	• Revising national and sectoral policies to promote climate resilience
	• Raising public awareness on climate change through alliances with media and NGOs
	• Educating and training environmental refugees to ease and facilitate their migration into new societies
Research and knowledge management	• Establishment of research centers for climate change modeling and vulnerability assessment
Community and social adaptive capacity	
Technology transfer	• Diffusing appropriate technologies and practices in the l ivestock, fisheries and health sectors
Hazard insurance	• Insuring communities against climate-related losses of income and property
Livelihood protection	• Identification and targeted assistance for vulnerable socio-economic groups

of coastal green belts through mangrove plantation. Still other components focus on institutional effectiveness (such as training and building institutional capacity) and community preparedness (such as hazard insurance and livelihood protection). The single most salient conclusion is that technology is by itself only a partial solution for successful adaptation efforts, and that multiple and integrated adaptation measures that cut across sectors and social, institutional, and infrastructural dimensions are needed.

Many elements of the CBACC-CA hold promise for other countries, and might be ideally replicated. The "FFF" model especially offers a more a sustainable template for building long-term responsiveness for communities because it simultaneously improves infrastructural adaptation (by strengthening forests) and community adaptation (by creating awareness and generating income through fishing and farming). It also helps build institutional capacity through training programs.

Despite being a well-planned strategy, the above-mentioned benefits of adaptation will not accrue automatically unless supplemented with strong government commitment within Bangladesh and a complementary mitigation strategy on a global scale. In case of CBACC-CA, despite its teething issues such as lack of organizational capacity and coordination among various departments and agencies, it has also been observed that adaptation within Bangladesh has absolute limits. Strong "retreat" measures such as rehabilitation of the most vulnerable communities or outright relocation or evacuation may become necessary no matter how successful the CBACC-CA reaches its targets. Here, the CBACC-CA is a depressing reminder that no matter how much an individual country adapts to climate change, or how effectively it strengthens multiple layers of adaptive capacity, it remains at the ever present mercy of the global climatic system.

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