Chapter 12
Local Strategies to Build Climate Resilient Communities in Bangladesh

Estiaque Bari, A. K. Enamul Haque, and Zakir Hossain Khan

Key Messages

- Creating alternative market chains for fuel (e.g. LPG) reduces forest dependency for fuelwood and is supportive towards forest conservation.
- *Bandalling*—an indigenous bamboo structure still has the merit to reduce river erosion in smaller river basins and to reclaim agricultural lands.
- Floating agriculture (e.g. *Baira)* enables communities to become resilient against waterlogging and also offers income generating opportunities.

12.1 Introduction

Erratic changes in climate parameters such as precipitation rate, temperature, wind pressure and solar radiation threaten communities in Bangladesh by exposing them to various natural disasters like floods, riverbank erosion, drought, waterlogging, cyclones and earthquakes (Banholzer et al., 2014; Kharin et al., 2007). Despite having achieved some degree of resilience in flood management through community adaptation alongside supportive flood management policies (Sultana et al., 2008; Younus & Harvey, 2013), the country is likely to face risks of greater frequency and intensity in the future. One estimate suggests that a 1 m increase of sea-level rise (SLR) may inundate one-sixth of total land area displacing more than 13 million people from

E. Bari (✉) · A. K. Enamul Haque
Department of Economics, East West University, Dhaka, Bangladesh
e-mail: estiaque@ewubd.edu

A. K. Enamul Haque
e-mail: akehaque@gmail.com

Z. H. Khan
Fellow, Asian Center for Development, Dhaka, Bangladesh
e-mail: zhkhaneco@gmail.com

A. K. Enamul Haque et al. (eds.), *Climate Change and Community Resilience*,
https://doi.org/10.1007/978-981-16-0680-9_12

Southern Bangladesh (Huq et al., 1995). The intrusion of salinity in agricultural lands will lead to a shift in cropping patterns (Dasgupta et al., 2014). Agricultural lands may turn into a waterbody in one place while in another there may be barren lands emerging in the absence of water. Communities (farmers in particular) must adapt with the evolving climate situations (Rounsevell et al., 1999). While afforestation is a means of combating climate risks (Noss, 2001), the forest cover in Bangladesh is only 10.7%, well below the 17.5% area designated forest land in the country (Forest Department of Bangladesh, 2017). The high density of population causes severe pressure on forests due to the demand of fuelwood and timber for other uses (Iftekhar, 2006; Iftekhar & Hoque, 2005; Salam et al., 1999). This chapter will highlight three cases of local adaptation strategies to combat climate change.

The first case is an example of community engagement using external assistance to reduce pressure on a protected forest area. With the influx of over 700,000 Rohingya refugees threatening the forest due to demand for fuelwood, support from the United Nations High Commissioner for Refugees (UNHCR) was used to develop a market chain for gas supply (United Nations High Commissioner for Refugees, 2020) that resulted in significant reduction on collection of fuelwood from the forests. The second case illustrates how communities use indigenous technology to effectively protect their village from river erosion. The third case presents a unique scenario where farmers used indigenous technology—the floating agricultural bed—to adapt to permanent waterlogging. These strategies are supported by the government and the non-government organizations (NGOs) working in Bangladesh.

12.2 Case I: Market Development and Forest Conservation

This case is based on research that the authors carried out with the International Union for Conservation of Nature and Natural Resources (IUCN), Bangladesh (International Union for Conservation of Nature and Natural Resources, 2019) and estimates the impact of supply of liquefied petroleum gas (LPG) to the refugee families on replacing fuelwood demand. The project began in 2018 and by 2019, nearly all the refugee families residing in the camps of Ukhiya and Teknaf received LPG for cooking from the UNHCR (Inter Sector Coordination Group et al., 2018).

Nearly 711,000 Rohingya refugees have entered Bangladesh since 25 August 2017, the majority arriving in the first three months of this crisis (United Nations High Commissioner for Refugees, 2020). They were settled in the refugee camps of Ukhiya and Teknaf of Cox's Bazar district of Bangladesh—occupying nearly 6% of the land (Inter Sector Coordination Group, 2019) of the 650 km^2 forest (Bangladesh Bureau of Statistics, 2015). While the UNHCR and the International Organization for Migration (IOM) distributed food, clothing and shelters, the supply of fuel initially remained outside their lens. The demand of fuelwood was so high that a market for fuelwood began to appear (Fig. 12.1). With both locals and the refugees extracting fuelwood, there was degradation of the forests and reduction of water supply in the streams which affected the livelihood of the local people.

Fig. 12.1 Fuelwood shop inside the Rohingya refugee camp. *Photograph credit* A. K. Enamul Haque

Estimates from our study suggest that immediately after the arrival of Rohingya refugees the demand for fuelwood was nearly 4.76 kg per household per day and the annual biomass extraction rose from a regular 95,000–462,000 tons in a year (International Union for Conservation of Nature and Natural Resources, 2019), well beyond the sustainable yield of the forest. With depletion of forest land, human–wildlife conflicts began in the area. Attacks by elephants and snakes were on the rise and IUCN, Bangladesh, was invited by the UNHCR to step in to devise strategies to reduce such incidents.

The situation also demanded a change in the strategies of managing refugees inside a national forest and the UNHCR agreed to supply LPG in addition to other supplies. The programme designed by UNHCR in collaboration with other partners was primarily aimed at protecting the forest area and reducing carbon emission (Inter Sector Coordination Group et al., 2018).

12.2.1 Case I: Intervention

As per the arrangements, the UNHCR and the IOM provided LPG to every refugee household every 26–45 days (determined by family size). All refugee households

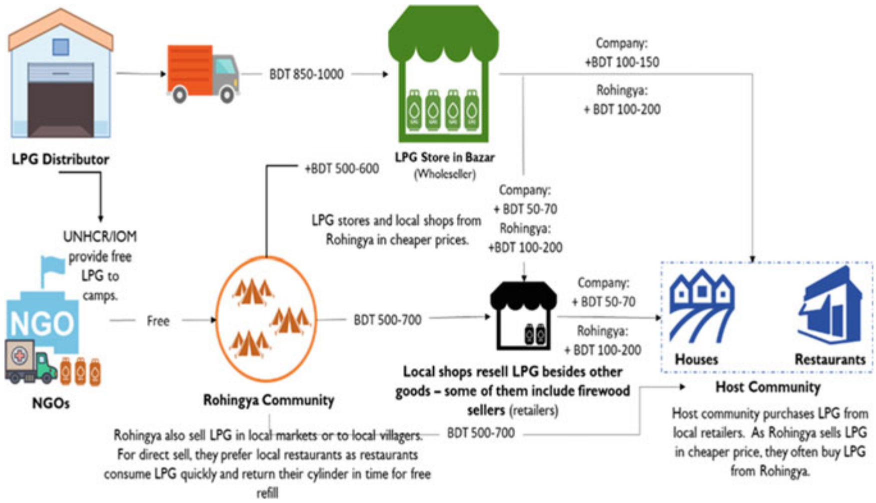

Fig. 12.2 LPG supply chain in Ukhiya Upazila, Cox's Bazar. *Source* Developed by Authors. *Note* 1 USD = 80 Taka

were also given a stove to switch to LPG-based cooking instead of using fuelwood in their regular stoves. The LPG supply programme initially also included local non-refugee families (called host families) living nearby for at least six months in order to maintain the social cohesion between two communities.

In addition to more than 0.7 million refugees inside the 29 camps, there are hundreds of restaurants and markets, local communities, NGOs working with the refugees, government offices and security personnel who are the potential users of LPG. As such, a network of supply chains began to emerge once LPG distribution started in the camps. The distribution centres for LPG were developed in the camp areas as well as in the local markets and a supply chain developed to ensure stable supply of LPG and repair and maintenance of LPG stoves. The supply chain of LPG is shown in Fig. 12.2.

12.2.2 Case I: Impact

We conducted a randomized survey[1] of 1200 refugees and 200 local households (International Union for Conservation of Nature and Natural Resources, 2019) and found

[1] Randomization was done based on two stages: a) randomized the camps by numbers; b) randomized the refugee households by their unique ID. Host households were selected using proximity to the selected camps.

(a) Among the refugee households there has been an 80% drop in the demand for fuelwood and among the local households it fell by 53%. It is important to note that local households were not given free LPG refills after the first six months of the programme.

(b) Total demand for fuelwood fell from 462,000 tons to 38,000 tons, much below the pre-refugee demand for fuelwood in the area (which was 95,000 tons/year). The chain of events that led to such fall in demand for fuelwood is more interesting as a lesson learned.

First, development of the LPG supply chain created local demand for LPG—restaurants, local communities (living outside the camp area) began to take part in the market and their demand for fuelwood fell sharply. Second, a private market for unused LPG gas began where refugee families also supplied their unused LPG at a discounted price to receive free refills from the camp. Shops which used to sell fuelwood became resellers of unused LPG supply in the market.

Third, wide-scale adoption of LPG for cooking in and outside the camp area resulted in a significant reduction in CO_2 equivalent emissions. Estimates show that there was a net reduction of 0.82 million tons of CO_2 (equivalent) due to the introduction of the LPG use among the refugees and in local communities (Fig. 12.3).

Fig. 12.3 LPG distribution centres inside the camps. *Photograph credit* A. K. Enamul Haque

Fourth, because of the drop of demand for fuelwood, the need for locals and refugees to enter the reserve forest area has been reduced. It is now expected that the forest department will be able to restore the degraded forest lands and the natural barriers against the cyclones and storms may be rehabilitated. Also, the wildlife will once again find an undisturbed habitat.

Building resilience has been one of the primary goals for adaptation in coastal areas across the world. Most often threats to this come from the pressure of economic development and increased economic activities. In this particular case, the threat was external—through an influx of refugees which outnumbered local communities by 4:1. As such, the scale of the threat was unprecedented and abrupt and the ecosystem was incapable of dealing with such massive extraction with no respite. The huge pressure of population created conflicts and caused degradation of forest land which dried up many natural streams on which local people were dependent.

Introduction of LPG distribution in the camps created a market for LPG in the local area. This resulted in a reduction in demand for fuelwood from the refugee households as well as significant changes in the demand for fuelwood from local communities. Our study also revealed that the average monthly cost of LPG and that of fuelwood are very similar in the area and it created incentives for local people to adopt LPG as a new fuel for cooking (International Union for Conservation of Nature and Natural Resources, 2019). It shows the power of markets—development of market chains and how it led to reduction of fuelwood collection from the forest area. In addition, it has created incentives to reduce carbon emissions without large-scale public subsidies. Thomas et al., (2021, Chap. 13 of this volume) have also shown how it can also be part of government strategy to increase rural employment.

12.3 Case II: Bandalling—A Traditional Approach to Reduce Riverbank Erosion

The river in its pristine state is supposed to flow through a main channel and gradually bring changes in its depth, width and riverbanks by adjusting to the changes in sediment layers. Both flooding and river erosion are natural processes in a vibrant river life cycle, and it carries sediments that changes the landscape and the climate regime (Smith & Roy, 1998). However, several man-made interventions such as dams, barrages, embankments, as well as economic activities at upper-stream and lower-stream areas disturb the natural flow of rivers forcing the river to change course abruptly, causing erosion of its banks (Intergovernmental Panel on Climate Change, 2007). Climatic changes are likely to further aggravate the situation as it causes changes in the rainfall pattern in the watershed region of the river and/or because of glacier-melts in the Himalayas. While governments spend a significant amount to protect economic hubs, communities living far-off from the major hubs of economic activities are left on their own. River-dependent communities must, therefore, adjust to the changes in river flows to reduce their vulnerability against bank erosion with or without external resources.

The latest survey on riverbank erosion by the Bangladesh Bureau of Statistics (BBS) shows that from 2009 to 2014 about 215,880 households were affected by river/coastal erosion (Bangladesh Bureau of Statistics, 2016). Loss of crops, livestock, poultry and fishery and damage of land, houses, homestead and forestry alone amounted to 36,410-million-taka in damage and losses. On aggregate, it accounts for nearly 20% of all disaster-related damage and losses caused in this period (Bangladesh Bureau of Statistics, 2016). River erosion not only forces millions of people to migrate but also adversely affects rural agriculture and its economy (Bhuiyan et al., 2017). Though riverine communities have continuously adjusted to the hazards of riverbank erosion though different adaptation strategies, there is not much mention of these mitigation strategies in literature (Haque, 1988). One measure being used by communities for centuries is the traditional bamboo-made structures to protect the banks. The practice is more common in communities living in far-off from cities and towns. These structures are locally known as 'bunds' and as such the word 'bund' also refers to river-front areas in a community. Bunds are horizontal to the river and is filled with soil.

12.3.1 Case II: Intervention

Bandalling is a temporary traditional structure made of local materials, e.g. bamboo and wooden log, mainly to maintain or improve navigation channels in lean periods and protect riverbanks from erosion (Nakagawa et al., 2011). Similar to a fence with cross-pieces, the structures reduce the speed of the monsoon water flow creating a natural flood barrier and channelling the water midstream. There are two parts to this structure; while the top part is blocked diverting the high velocity water flow, the lower part is opened to secure the flow of water (Rahman & Osman, 2015; Nakagawa et al., 2011). This structure allows the lower velocity flow to pass through the bottom and deposit sediments at the bottom of the *Bandals* (Rahman & Osman 2015; Nakagawa et al., 2011). The angle of bamboo struts and the space between bamboos mats placed at the top for blocking the water flow are critically important to gain structural stability (Rahman, 2019) and vary according to the intensity of the river flow.

Despite attaining certain structural stability, the bandals need to be rebuilt almost every year. However, the cost of construction is significantly low when compared to alternative means of protecting riverbanks. Alternatives which are also used in Bangladesh to protect townships, ports and other valuable installations are much costlier. They include: spurs, groynes (permeable and impermeable), sand-filled mattresses, revetments or a combination of these to build embankments to mitigate riverbank erosions and safeguard thousands of houses, agricultural lands and other administrative and non-administrative structures.

Fig. 12.4 Construction of bandalling. *Photograph credit* Bokhtiar Hossain Shishir

Villagers in Rowmari upazila have recently used 'bandalling' to protect the bank of Jinjiram—a distributary of the Brahmaputra River, from erosion. Namapara is a village on the bank of the river with nearly 200 families who depend on agriculture for their livelihood. The river has been a constant threat because of bank erosion in rainy seasons, and to protect against this, they have got together and built several 'bandals' at different places. During 2017, the villages of Namapara raised a community fund to develop nearly twenty-four single-layer bandal structures (Fig. 12.4). The width of each bandal structure was between 10 to 30 feet. The combined length of these structures was about 400 feet long and primarily helped to protect villagers from riverbank erosion (Shishir, 2020; Siddique, 2020).

These types of fences are built every few hundred metres in the river, and it eventually shifts the main course of the river away from the banks, stops erosion and recovers land. By bringing in more water into the main channel of the river, it also increases navigability.

The Bangladesh Water Development Board (BWDB) which is responsible for building and maintaining large structures also encourages local communities to build 'bandalling' as a solution to bank erosion on smaller rivers. It is argued that *bandalling* may be a feasible solution only to protect riverbanks in relatively smaller river basins (Rahman, 2019). The Bangladesh River Research Institute (RRI) has initiated three pilot projects including one project in Brahmaputra basin in an attempt to find a feasible bandalling structure that will sustain against the physical characteristics of the river (River Research Institute, 2018).

12.3.2 Case II: Impact

The discussion with the local NGO officials in July 2020 reveals that due to lack of proper structural know-how the Namapara community did not achieve the optimal level of stability from bandalling in the first year. However, the experience helped them to learn and improve the design of the structure. They also dredged the riverbed and piled the sand near the bandal. Less bank erosion was observed in the Namapara village but as the seasonal river Jinjiram carries relatively lower sediment the expected reclamation of agriculture land from bandalling was not observed in this case.

The success of the methodology, however, has some caveats. First, the communities do not get the rights on the reclaimed land—which is a bone of contention in the community. The right, as per the law, belongs to the owner of the land who had lost it previously or it automatically becomes a government land. Second, communities need technical know-how to build a stable structure and for this support may be needed from government agencies such as the BWDB which are mandated to provide this. This case shows how communities used local knowledge and used community participation to halt bank erosion. Udayakumara (2021, Chap. 19 of this volume) has shown using training to promote adoption of erosion control technologies in rural areas.

12.4 Case III: Baira—The Floating Agriculture Technique

The Government of Bangladesh constructed many polders and embankments in the late 1960s to block the ingress and egress of tidal waters and facilitate irrigation for agricultural (Dev, 2013). Failure to manage locks or gates of these structures results in the gates of these enclosures often getting silted and the agricultural land inside becoming waterlogged (Rahman, 1995). As a result, thousands of acres of land in coastal areas have become permanently waterlogged. In Bangladesh, about 5% of potential agricultural land remains waterlogged during monsoon and the latest survey report shows that between 2009 and 2014, about 605,300 households were affected by waterlogging (Bangladesh Bureau of Statistics, 2016). Nearly 16,060-million-taka damage and losses were caused by waterlogging alone; of which, 50% was due to loss of crops (Bangladesh Bureau of Statistics, 2016).

The problem has been aggravated by increased precipitation due to climate change. As such, communities need to solve it. One solution is to improve maintenance of the gates but this often runs into conflict between shrimp and rice farmers. Climate change and potential sea-level rise may inundate more crop lands permanently. Prolonged waterlogging would create additional adaptation challenges such as salinisation of agricultural land in these areas and migration, and mitigating this requires urgent solutions. One such solution is known as *Baira*—a technique to build floating agricultural beds using water hyacinth and soil in order to cultivate agricultural crops on a wetland.

Describing the role of Baira, the Ministry of Agriculture of the Government of Bangladesh states '… the system generating goods and services sustainably for the locals and practitioners date back a few thousand years in southern Bangladesh. … Without the system, cultivating only Aman rice in deep water would be still prevailing in this region' (Ministry of Agriculture, 2017). The Ministry states that the centuries-old system has undergone several environmental and socio-economic changes and includes the latest technologies to enable farmers to cultivate diverse crops. Adoption of new crop varieties and cultivation methods enables local farmers to ensure food and livelihood security by improving cropping intensity on these platforms. Initiatives from local and international NGOs have helped to scale this up as they disseminate this indigenous knowledge and technology among farmers through several training sessions. '… From 2011, the government also took part in dissemination collaborating with NGOs' (Ministry of Agriculture, 2017).

The technique requires farmers to use country boats to move along the floating platforms and to prepare the bed, do the weeding and also the harvesting (Fig. 12.5). It is an older form of modern 'hydroponics' and requires less inputs. The technique has several names—*Baira, Dhap, Gaota, Geto,* Floating Cultivation (*Vashoman Chash*) and others (Anik & Khan, 2012; Irfanullah et al., 2008). *Baira* is the most popular name among all.

Studies have shown that floating agriculture practices if effectively managed could reduce adverse impacts of waterlogging and turn a temporarily inundated waterbody into a potential soil-less agricultural land. Besides Bangladesh, floating gardens of Xochimilco in Mexico and Dal Lake in India also have historical backgrounds. Originally, Baira was used for seedbeds for seedlings of rainwater varieties of rice in Bangladesh. However, with interventions from the government and from the NGOs,

Fig. 12.5 Floating beds. *Photograph credit* Food and Agriculture Organization

the practice has been expanded for cultivation of vegetables such as cucumber, okra, ginger, bitter gourd, Arum, potato, turmeric, brinjal, Lal sak, Palang sak, Danta, cauliflower, pumpkin and chilli (Anik & Khan, 2012; Chowdhury & Moore, 2017; Islam & Atkins, 2007).

The process of preparing a floating bed requires several steps. First, a stack of mature water hyacinths (a weed which has a slow rate of decomposition) is used to prepare the base of the floating bed and to create stability and buoyancy (Irfanullah et al., 2008). In the second layer, farmers use other forms of manure to speed up the rate of decomposition. Usually within 8 to 10 days, beds are ready for farmers to transplant seedlings (Dev, 2013). Typically, I-shaped (narrow) floating agricultural beds are common, and however, the size and shape of beds vary upon the volume of the ditch or waterbodies (Chowdhury & Moore, 2017; Hasan et al., 2017; Islam & Atkins, 2007). In general, the length of the beds is between 60 and 10 m and the breadth is between 1.25 and 4.0 m. The fully prepared beds are anchored using bamboo poles to safeguard against the currents and wind. The residuals of floating beds prepared during monsoon are usually utilized to prepare winter gardens to grow vegetables (Irfanullah et al., 2008). The preparation requires about two to three weeks' time and involves only labour as water hyacinths are readily available in all wetlands in Bangladesh except in highly saline areas (Dev, 2013). Productivity is about five times higher than in traditional land-based agriculture (Dev, 2013). The production system not only builds resilience against waterlogging but also ensures greater food security, local employment and better management of water drainage systems (Dev, 2013). To improve the sustainability of the production system, farmers need training on creating the beds, selecting the crop and on maintenance of the bed during the season. These are done with support from the government and NGOs.

12.4.1 Case III: Intervention

In this section, we will primarily highlight a project-based case assessment documented in a journal article by Irfanullah et al. (2011). The project of promoting floating agriculture was implemented by the NGO Practical Action under the funding of UKaid. The assessment of the first project was carried out among the *haor* (a wetland ecosystem situated in the north-eastern part of Bangladesh) communities from 53 villages of Kishoreganj and Sunamganj districts of Bangladesh in 2007—a year which saw major flooding (Irfanullah et al., 2011). The selected households were based near relatively stagnant water and had access to water hyacinths to make floating agricultural beds. Despite being affected by monsoon floods these communities managed to cultivate the following six vegetable seeds amaranth (*data shak*), red-amaranth (*lal shak*), bottle gourd, hyacinth bean, kang kong (*gima kolmi*) and pumpkin in 177 floating platforms while 23 platforms were damaged in the rainy season (Irfanullah et. al., 2011). Similarly, the same communities managed to cultivate diverse vegetables in the winter season in early January 2008. About 83–90% of vegetables cultivated were consumed by the participants while the rest were sold in the marketplace or distributed among neighbours or relatives. This intervention highlights that despite being affected by floods—floating agriculture in relatively stagnant *haor* water was cost effective, generated employment, ensured food and nutrition and in the best-case scenario created profitability. Similar outcomes were found later in between 2010 and 2012 when Practice Action trained and promoted floating agriculture in 700 relatively poor families in the four northern districts of Bangladesh including Gaibandha. A total of 131,600 kg of vegetables, grown on about 1,500 floating beds, helped these communities to meet local food demand at the community level and generate additional income at the household level (Irfanullah, 2013).

12.4.2 Case III: Impact

Success in floating agriculture in the coastal and waterlogged areas in Bangladesh led Bangladesh Agriculture Research Institute (BARI) to research and develop improved strategies to produce more. It has also induced the Department of Agricultural Extension to develop strategies to promote such practices as a resilience building exercise in areas suffering from waterlogging in Bangladesh. In addition, several local, national and international NGOs are supporting projects to promote floating agriculture in Bangladesh as part of climate adaptation programmes (Chowdhury & Moore, 2017).

Though the floating agricultural production system is not particularly suitable for open water or extreme flood-prone areas, the scope of scaling up of this system in wetlands in different parts of Bangladesh is immense. As this system coincides with features of climate change adaptation, international donors, especially FAO, would be interested in providing funds for promotion of *'Baira'* across waterlogged lands in Bangladesh.

At present, floating agricultural practice in Bangladesh has been recognized as a successful strategy for building resilience in waterlogged areas and so it is seen as a possible adaptation strategy against climate threats. In addition, it is also linked to several sustainable development goals as it fulfils the objective of reducing hunger and poverty, increasing food security and even empowering women. Many of the workers in such farms are women as it requires less physical labour. Little investment is required as country boats are used for collection of water hyacinth, carrying of produce and other inputs. It is also an environmentally friendly agricultural practice as it requires no pesticides and uses fewer chemical fertilizers. Vidanage et al., (2021, Chap. 15 of this volume) and Kattel and Nepal (2021, Chap. 11 of this volume) have also showed examples of communities-level mobilization to promote adoption of climate resilient technologies in rural areas.

12.5 Conclusions

This study gives three examples from three communities in rural Bangladesh. In the first case, a local ecosystem was threatened by an influx of refugees from Myanmar where the community was outnumbered by 4:1 because of their entry. The community welcomed them in open arms and provided shelters in their locality. However, the pressure on the ecosystem was enormous. It led to depletion of forest cover, exposed the community to storms and cyclones, dried up the streams and increased human–wildlife conflicts. Recognizing the threat, the international community which provided support to settle the refugees has developed alternative fuel supply. As a result, a supply chain of LPG was created and led to 80% reduction in use of fuelwood compared to the pre-influx level. This happened through a market mechanism and shows how markets can be used to develop resilience in communities and also to protect ecosystems.

The second case is about riverbank erosion. This has been a threat for communities who are living on riverbanks. With climate change the threat is likely to increase. Governments are spending millions to build structures to stop erosion. However, communities in remote areas often live outside the radar of government policymakers. This case shows how a small community used local knowledge to build simple structures to reduce bank erosion. The knowledge that existed in the local communities was centuries old and yet very effective but required community participation. It is a shining example of low cost, low carbon and a green solution to a huge problem.

The third case is about floating agriculture. It shows how local farmers, using a small amount of support from government and NGOs developed the knowhow to overcome the challenge of waterlogging. The small technical support from NGOs and the government worked like magic to build resilience in a community which was suffering from long-term waterlogging.

References

Anik, S. I., & Khan, M. A. S. A. (2012). Climate change adaptation through local knowledge in the north eastern region of Bangladesh. *Mitigation and Adaptation Strategies for Global Change, 17*(8), 879–896.

Bangladesh Bureau Statistics. (2015). *District statistics 2011—Cox's bazar. Census 2011*. Bangladesh Bureau of Statistics.

Bangladesh Bureau of Statistics. (2016). *Bangladesh disaster-related statistics 2015: Climate change and natural disaster perspectives*. Ministry of Planning. Government of People's Republic of Bangladesh.

Banholzer, S., Kossin, J., & Donner, S. (2014). The impact of climate change on natural disasters. In A. Singh, & Z. Zommers (Eds.), *Reducing disaster: Early warning systems for climate change*. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-8598-3_2. https://link.springer.com/chapter/10.1007/978-94-017-8598-3_2

Bhuiyan, M. A. H., Islam, S. M. D. U., & Azam, G. (2017). Exploring impacts and livelihood vulnerability of riverbank erosion hazard among rural household along the river Padma of Bangladesh. *Environmental Systems Research, 6*(1), 1–15.

Chowdhury, R. B., & Moore, G. A. (2017). Floating agriculture: A potential cleaner production technique for climate change adaptation and sustainable community development in Bangladesh. *Journal of Cleaner Production., 150*, 371–389.

Dasgupta, S., Kamal, F. A., Khan, Z. H., Choudhury, S., & Nishat, A. (2014). *River salinity and climate change: Evidence from Coastal Bangladesh.* Policy Research Working Papers: The World Bank Group.

Dev, P. K. (2013). Waterlogging through soil-less agriculture as a climate resilient adaptation option. In W. Leal Filho (Ed.), *Climate change and disaster risk management. Climate change management.* Springer.

Forest Department of Bangladesh. (2017). *District-wise forest land. forest department*. Government of the People's Republic of Bangladesh.

Haque, C. E. (1988). Human adjustments to riverbank erosion hazard in the Jamuna floodplain, Bangladesh. *Human Ecology, 16*(4), 421–437.

Hasan, S., Mohammad, A., Ghosh, M., & Khalil, M. (2017). Assessing of farmers' opinion towards floating agriculture as a means of cleaner production: A case of Barisal District, Bangladesh. *British Journal of Applied Science and Technology., 20*(6), 1–14.

Huq, S., Ali, S. I., & Rahman, A. A. (1995). Sea-level rise and Bangladesh: A preliminary analysis. *Journal of Coastal Research* 44–53.

Iftekhar, M. S. (2006). Forestry in Bangladesh: An overview. *Journal of Forestry, 104*(3), 148–153.

Iftekhar, M. S., & Hoque, A. K. F. (2005). Causes of forest encroachment: An analysis of Bangladesh. *Geo Journal, 62*(1–2), 95–106.

Inter Sector Coordination Group, Energy and Environment, & Government of Bangladesh. (2018). *LPG project: RRRC requirements.* Humanitarian Response. Cox's Bazar.

Inter Sector Coordination Group. (2019). *2019 joint response plan for Rohingya humanitarian crisis—January to December*. Inter Sector Coordination Group: Cox's Bazar.

Intergovernmental Panel on Climate Change. (2007). *Climate change 2007: Synthesis report.* In R. K. Pachauri & A. Reisinger (Eds.), *Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. Core writing team.* IPCC.

International Union for Conservation of Nature and Natural Resources. (2019). Impact of LPG distribution among the Rohingya and Host communities of Cox's Bazar South Forest division on forest resources. UNHCR Assessment Report 73248. United Nations High Commissioner for Refugees.

Irfanullah, H. M. (2013). Floating gardening: A local lad becoming a climate celebrity? *Policy Brief: Practical Action.* https://infohub.practicalaction.org/bitstream/handle/11283/366224/51c01544-ce1c-498a-9c6c-111c0a000075.pdf?sequence=1. Accessed May 21, 2020.

Irfanullah, H. M., Adrika, A., Ghani, A., Khan, Z. A., & Rashid, M. A. (2008). Introduction of floating gardening in the north-eastern wetlands of Bangladesh for nutritional security and sustainable livelihood. *Renewable Agriculture and Food Systems, 23*(2), 89–96.

Irfanullah, H. M., Azad, M. A. K., Kamruzzaman, M., & Wahed, M. A. (2011). Floating gardening in Bangladesh: A means to rebuild lives after devastating flood. *Indian Journal of Traditional Knowledge, 10*(1), 31–38.

Islam, T., & Atkins, P. (2007). Indigenous floating cultivation: A sustainable agricultural practice in the wetlands of Bangladesh. *Development in Practice, 17*(1), 130–136.

Kattel, R. R., & Nepal, M. (2021). Rainwater harvesting and rural livelihoods in Nepal. In A. K. E. Haque, P. Mukhopadhyay, M. Nepal, & M. R. Shammin (Eds.), *Climate change and community resilience: Insights from South Asia* (pp. 159–173). Springer.

Kharin, V. V., Zwiers, F. W., Zhang, X., & Hegerl, G. C. (2007). Changes in temperature and precipitation extremes in the IPCC ensemble of global coupled model simulations. *Journal of Climate, 20*(8), 1419–1444.

Ministry of Agriculture. (2017). *Floating garden agricultural practices in Bangladesh: A proposal for globally important agricultural heritage systems (GIAHS).* Food and Agriculture Organization. http://www.fao.org/publications/card/en/c/4c57fc69-e538-46e0-969c-d197be845a5f/. Accessed May 21, 2020.

Nakagawa, H., Hiroshi, T., Kenji, K., Yasuyuki, B., & Hao, Z. (2011). Analysis of bed variation around bandal-like structures. *Annuals of Disaster Prevention Research Institute, Kyoto University, 54(B)*, 497–510.

Noss, R. F. (2001). Beyond Kyoto: Forest management in a time of rapid climate change. *Conservation Biology, 15*(3), 578–590.

Rahman, M. L. (2019). Study of Bamboo bandalling structures in the tidal river for riverbank erosion. In K. Murali, V. Sriram, A. Samad, & N. Saha (Eds.), *Proceedings of the fourth international conference in ocean engineering. Lecture notes in civil engineering* (vol. 23, pp. 49–57). Springer.

Rahman, A. (1995). *Beel Dakatia: The environmental consequences of a development disaster*. University Press.

Rahman, L., & Osman, S. (2015). Riverbank erosion protection using bamboo bandalling structure: A case study. *Journal of Civil Engineering, 43*(1), 1–8.

River Research Institute. (2018). *Annual Report 2017–18* (Serial no. 45/17–18). River Research Institute.

Rounsevell, M. D. A., Evans, S. P., & Bullock, P. (1999). Climate change and agricultural soils: Impacts and adaptation. *Climatic Change, 43*(4), 683–709.

Salam, M. A., Noguchi, T., & Koike, M. (1999). The causes of forest cover loss in the hill forests in Bangladesh. *Geo Journal, 47*(4), 539–549.

Shishir, B. H. (2020, July 30). Bandal can transform the life of river and its people. *Oxfam Blogs.* August 9, 2020. https://oxfamblogs.org/bangladesh/bandal-trasnfrom-life-river-people/19

Siddique, A. (2020). Locals use nature-based solution to tame river in Bangladesh. *The Third Pole.* June 30, 2020. https://www.thethirdpole.net/2020/06/30/nature-based-solutions-bangladesh/. Accessed December 19, 2020.

Smith, K., & Ward, R. (1998). *Floods—Physical processes and human impacts.* Wiley.

Sultana, P., Johnson, C., & Thompson, P. (2008). The impact of major floods on flood risk policy evolution: Insights from Bangladesh. *International Journal of River Basin Management, 6*(4), 339–348.

Thomas, L., Balakrishna, R., Chaturvedi, R., Mukhopadhyay, P., & Ghate, R. (2021). What influences rural poor in india to refill their LPG? In A. K. E. Haque, P. Mukhopadhyay, M. Nepal, & M. R. Shammin (Eds.), *Climate change and community resilience: Insights from South Asia* (pp. 191–203). Springer.

United Nations High Commissioner for Refugees. (2020). *Population Arrivals after 25 August 2017*. Operational Portal of Refugee Situations.

Vidanage, S. P., Kotagama, H. B., & Dunusinghe, P. M. (2021). Sri Lanka's small tank cascade systems: Building agricultural resilience in the dry zone. In A. K. E. Haque, P. Mukhopadhyay, M. Nepal, & M. R. Shammin (Eds.), *Climate change and community resilience: Insights from South Asia* (pp. 225–235). Springer.

Younus, M. A. F., & Harvey, N. (2013). Community-based flood vulnerability and adaptation assessment: A case study from Bangladesh. *Journal of Environmental Assessment Policy and Management, 15*(03), 1350010. https://www.worldscientific.com/doi/abs/10.1142/S1464333213500105