Chapter 14
Coastal Livelihood Adaptation in Changing Climate: Bangladesh Experience of NAPA Priority Project Implementation

Mesbahul Alam, Ronju Ahammad, Paramesh Nandy, and Shahinur Rahman

Abstract Climate changes are increasing vulnerability of natural resource dependent livelihood practices of large population in Bangladesh. Extreme events such as cyclones, tidal surges, flood, river erosion and salinity stress have been severely affecting agriculture, fishing or fish cultivation and livestock rearing. Communities remain extremely vulnerable to disasters that impeded the key livelihoods in the coastal areas than any other place. The traditional agriculture cropping is decreasing in coastal areas due to variation of fresh water and salinity level and increasing abrupt weather events, tidal inundation and water logging. Large coastal population lacks of climatic information, improved crop varieties and diversified livelihoods to continue adaptation practices. In particular the marginalized and landless coastal people who have limited access to natural, social and institutional services of local govt. institutions are losing adaptive capacity in the long-run. The paper presents livelihood adaptation practices of coastal communities in Bangladesh. Particular emphasis is given on an innovative livelihood model-Forest, Fish and Fruit (Triple F) which shows integrated community based livelihood practices for short-, mid- and long-term adaptation. Drawing the discussion the paper highlights for improving the livelihood practices in a way that incorporates climatic risks in collective resource management and income generation enhance adaptive capacity of coastal community. Strengthening local institutional capacity to enabling collaboration between govt. departments and community effectively bring diversity of knowledge

M. Alam
Ministry of Disaster Management and Relief, Government of Bangladesh, Dhaka, Bangladesh

R. Ahammad • S. Rahman
Community Based Adaptation to Climate Change through Coastal Afforestation Project, UNDP, Dhaka, Bangladesh

P. Nandy (✉)
CBACC-Coastal Afforestation Project of UNDP-Bangladesh, Dhaka, Bangladesh
e-mail: pm.cbacc@gmail.com

R. Shaw et al. (eds.), *Climate Change Adaptation Actions in Bangladesh*, Disaster Risk Reduction, DOI 10.1007/978-4-431-54249-0_14,

in climatic risk reduction measures, cost-effective implementation of the new adaptation technology and ensure social equity and empowerment in the access to livelihood resources. Collective livelihood practices can create pro-active attitudes, cross-learning opportunity and participatory decision-making which are important for claiming relevant govt. services, disseminating best experiences and facilitating adaptation practices across the community. Despite the fact, current adaptations will not supersede dynamic vulnerability of livelihoods in coastal areas to large extent due to multi-fetched threats and lack of sustainability in resource generation. The potential strength and weakness of adaptation innovations must be analyzed within immediate timeframe to address the short- to mid-term benefits for long-term policy making. More collaboration of local institutions and diverse stakeholders through enhancing the financial and technical capacity, and as a whole, inclusive governance are important for sustaining the livelihood resource benefits.

Keywords Climate change • Coastal community • Livelihoods • Triple F • Vulnerability

14.1 Introduction

Coastal communities are facing much more vulnerability across the globe (Shaw and Krishnamurthy 2012). Anthropogenic stress in terms of over exploitation of coral reef and fisheries and land based activities (i.e., agriculture intensification) already increased stress in natural system of the coasts. Climate change adds to lower recovery or resilience of the natural system for human well-being and livelihoods (Adger et al. 2005; Lebel 2012). Various nature and impacts of climate change shocks affect coastal livelihoods differently and govern vulnerability and adaptive capacity. Some of the disasters are fast in coastal areas in terms of its sudden affects to coastal life and livelihoods like tropical cyclone and storm surges, where others are slow in events like salinity or inundation increase, but these have long-term impacts on social and economic functions (Nicholls et al. 2007). The tropical cyclone of 2007 caused loss of valuable mangroves, social and physical resources and livelihood bases that post-disaster recovery has not yet been possible in Bangladesh (Mallick et al. 2011). With changing frequency of cyclonic wind and storm surges and inundation coastal agriculture and domestic fisheries and open fishing have been highly affected which are significant livelihoods sources to majority coastal people. Salinity level is slowly increasing over the time and causing serious threats to traditional agriculture farming and mangrove ecosystems (Moniruzzaman 2012).

High climate sensitive livelihood characteristics and different socio-economic level and access of community and households to assets determine adaptive capacity. Large coastal population is less capable to share the majority of the natural resources effectively in livelihood practices due to lack of effective coastal zone policy and regulation, collaborative resource management and local institutional capacity.

Social inequality in terms of limited resource ownership and external support affect adaptive capacity of particular poor and marginalized groups in coastal areas (Nandy and Ahammad 2012). Coastal development interventions largely focused on land stabilization, structural protection measures for disaster risk reduction (Agrawala et al. 2003) and by contrast, ignored embedded social construction and resource ownership legacy in changing climate (Nandy and Islam 2010). As result, long-term institutional inertia caused fragmented resource management which was neither integrative livelihood practices nor socially inclusive towards incorporating the emergent coastal adaptation in Bangladesh. Though protective engineering measures by building earth embankment reduced physical vulnerability to storm surges this was not planned and based on anticipatory impacts of climate change related stress like increased storm surge height and water logging on livelihood to adjust to current and future changes (Mallick et al. 2011). The paper mainly presents livelihood adaptation practices in coastal areas by drawing experiences of Bangladesh NAPA priority project implementation. Several adaptation practices are also discussed to understand the diversity of practices and strength towards long-term adaptation.

14.2 Climatic Vulnerability and Coastal Livelihood Adaptation

Climate related risks largely trigger extreme events and impacts on social and ecological systems in Bangladesh. Based on Intergovernmental Panel on Climate Change (IPCC) evidences of climatic risks in relation to coastal ecosystems Bangladesh has much emphasis on increased sea surface temperature; CO_2 concentration; change in storm frequency, intensity and track; altered wave and water runoff; and sea level rise (Nicholls et al. 2007). Increase sea surface temperature has already recognized for coral mortality and algal blooming. Coastal people substantially depend on sea and river fish for food and protein demand and only livelihoods in Bangladesh. There is another reason that sea surface temperature can damage coral reef of St Martin's Island in its south-east coastal zone. CO_2 concentration due to increased fertilization and decreases P^H are likely to change coral and mangrove habitat and optional livelihoods of adjacent coastal communities. Whereas coastal fisheries contribute to large scale protein food, understanding temperature impacts on fish catch and reproductive behavior in Bangladesh is yet to be satisfactory.

Changes in tropical cyclonic and storm surge events are highly consistent for Bangladesh based on different findings of the studies drawn in IPCC report. Increasing frequency of cyclonic wind and storm surges are recorded though IPCC findings show little variation of regional average to country context. Storm surges are relevant to climate change prediction for increase of extreme water level and height in Bangladesh though uncertainty of origin and impacts remains a critical issue. Storm surges cause serious flooding and structural failure to loss of livelihoods. Altered wave rate and relationship is not correctly assessed in country scale

though erosion and accretion is a continuous process in Bangladesh. Regional context of sediment run off is assessed for 40 large deltas which lead Bangladesh at risk to altered sediment flow, water quality and nutrient supply in mangroves and aquatic habitats.

Sea level rise is among others the critical threat which can trigger associated climate changes to extremely vulnerable coastal ecosystems of Bangladesh. The large deltaic plain of Ganges–Brahmaputra–Meghna rivers receive sediment flow that increase subsidence. Natural compaction of subsidence and upstream human activities (dam) are likely to enhance sea level rise in Bangladesh. The findings of subsidence and change of sediment flow is currently based on regional scale that Bangladesh are likely to be affected with sea level rise. Neither of the interconnection between subsidence rate and sea level rise is distinctively found, but the associated impacts are already observed and increasingly severe to affect the livelihoods.

There are relative variations of sea level rise at 10 cm, 20 cm to 1 m by 2030, 2050 and 2100 (Ali 1996). Scientific predictions may vary though upward water level in storms and tidal inundation (4–7.5 mm/year) in Bangladesh are plausible evidences of sea level rise in coastal areas. The key impacts of sea level rise in coastal ecosystems are large scale inundation, storm and flood damage and salt water intrusion. All the impacts have different degree of relation to vulnerability of coastal ecosystems in Bangladesh. In qualitative view, the impacts cause drainage congestion to embankment loss, ecological degradation of agriculture, wetlands and mangrove habitats, and social vulnerability to livelihoods. IPCC predictions of sea level rise may displace more than 1 million people by 2050 in Bangladesh.

14.2.1 Key Risks and Vulnerability of Coastal Livelihoods

Coastal ecosystems comprise diverse social and ecological features in Bangladesh. Natural and planted mangroves; newly accreted chars; agricultural lands; aquatic resources; human settlements; urban centers; and small and medium size business attributes shape the coastal ecosystems into highly dynamic confluence of human and environment. Agriculture practices cover the largest 59 % of total land use followed by shrimp, fisheries and wetlands (13 %), mangrove (11 %) and others including urban centres (17 %). Mangroves, one of the valuable functional ecosystems serves protection against disasters and produce benefits to coastal communities and national economy through forest products. Fisheries are the major concentration of social and institutional activities ever increasing due to population growth and subsistence demand for food and profit oriented business (i.e., shrimp farming) in coastal areas. Newly accreted Char land management is largely influencing social and ecological factors of the area due to its potential and multiple uses for afforestation, livelihood and human settlement. There has been estimated an increasing landmass accretion of 137,168 ha over erosion of 86,000 ha lands during a period from 1973 to 2000 (MES 2001). Between 1990 and 2005, almost 79,500 ha of accreted lands have been stabilized by mangrove plantation

(FAO 2010). In practice accretion of lands shaped coastal ecosystems into functional (land stabilization) and productive (agricultural practices, pastures) resource (Nandy and Islam 2010).

The diversity of coastal resources has different scales of functional capacity and roles to benefit coastal communities for livelihood and national economic growth. Long-term benefits of these multiple resource regime are even larger depending on the subsequent resource management capacity. Morphological shifting of coastal boundary and extreme events has threatened social and ecological functions in spatial and temporal scale. Over the time and space, coastal livelihoods have been vulnerable to extreme events in different ways. Morphological change caused land erosion hazard and social displacement of coastal communities. Tropical cyclone and storm surges already affected three coastal regions of the country with massive loss of life and property. The Bay of Bengal is the breeding ground of 40 % of the world cyclones and storm surges affecting coastline of Bangladesh. Nine cyclonic winds were recorded in the Bay of Bengal for 1991–2000 periods, almost of these affected the country in different scales (Hossain et al. 2012). The super cyclone 'Sidr' killed 3,500 people and destroyed human settlement, property and valuable mangrove resources in 2007. The associated social and economic impacts from the tropical cyclone and storm surge are however neither assessed, nor, documented for providing effective interventions.

Salinity intrusion is slow and steady event affecting the coastal ecosystems by degrading soil fertility, freshwater bodies and regeneration capacity of mangroves. Storm surges and sudden tidal inundation cause direct inland intrusion of salinity and destroy standing crops. Conversion of agricultural lands or mangroves for shrimp farming and salt pan already contributed to change of coastal ecosystem beyond threshold into undesirable states. Documented in many literatures salinity intrusion has received much discussion for large scale coverage in 32 % land areas of the country. The landward intrusion of salinity level puts coastal livelihoods at higher risks and has been extreme with climate change. About 70 % of the coastal lands are affected with salinity for particular 4–6 months in a year (Nandy et al. 2003). About 50 % of coastal lands are somewhat untenable for agriculture in a year. Rahman et al. (2011) noted that 50–60 % of summer and winter crop varieties declined due to salinity in south-western coastal districts from 1975 to 2006. They also identified loss of rice varieties and homestead forest species with salinity intrusion in terrestrial ecosystem.

Coastal flooding increase risks to livelihoods by sudden submersion in agriculture lands inside the coastal embankment. Storm surges usually create large scale flooding with rapid pace and impacts harvestable crops, freshwater ponds, and fisheries, and mangrove vegetation. Tidal inundation is a regular phenomenon though it becomes devastating with erratic heavy rainfall and cause monsoon flooding for 1–2 weeks. Observation shows that flooding or waterlogging from inundation is increasingly occuring 3–4 times in a year. Increase subsidence of rivers by sediment deposit decrease river navigation and subsequent withdrawal of excess water from the coastal areas. Drain out of excess water is often not possible due to imbalance water height between inner and outer part of the coastal embankment. Different studies

referred to both natural water flow (erosion of land) and human actions (e.g., hill cutting) increase sediment deposit in different coastal points over the years. There is until inadequate assessment available in relation to the rate of subsidence and the possible interventions taken for effective drainage management.

14.2.2 Linking Livelihood and Adaptation

Livelihoods influence exposure and sensitivity to current and future climate change related stresses (Pouliotte et al. 2006). The principal and key determinant of adaptive capacity is related to the ability of livelihoods to withstand shocks and stresses which dominates the degree of livelihood risks. Any strategy to reduce vulnerability is based on understanding of how people currently sustain their livelihoods. The traditional natural resource oriented livelihood strategies is highly climate sensitive in coastal areas. Almost 80–90 % people depend on both agriculture and fisheries directly, or partly in any of these in different seasons for livelihoods. Climatic change related stress is creating surprises beyond community perception, access to information and capacity to take pre-planned adaptation measures. Lower productive lands and inequity in user groups and lack of access to external supports for additional livelihood measures is weakening coping capacity of coastal people, and so require adaptation measure. Coastal adaptation can be understood through adjustment of ecological, social, or economic systems to actual or expected climatic stimuli and their effects or impacts. Adaptation as a process can provide opportunities to prevailing capacity of individual and community for transforming into new livelihood approaches. Effective adaptation measures refer to identification of current livelihood problems and innovating policies and practices with respect to historical vulnerability trend line and considering future uncertainty.

Livelihood is interrelated with social, ecological and institutional drivers which imply innate capacity of coastal community that enables them or may not to adapt to changing situation. Social construction in resource ownership pattern and ecologically pre-determined physical risks can limit livelihood practices and adaptation processes in coastal areas. Avoiding social limits to continuous livelihood practices of majority coastal people are as important as to secure their household income and access to institutional services. External institutions have critical roles in developing any risk reduction policy while drawing cross-scale interplay of relevant stakeholders, and fit of new approaches at local level. Adaptation policy broadly includes international negotiation and funding process where national level can arrange priority based interventions for target people at risks, locally driven and accepted measures.

Protection and improvement of livelihood practices can provide additional and at the same time alternative means of adaptation practices. Depending on timing and purposes any of the adaptation, livelihood practices also vary within planned or autonomous; short to mid- and long-time interventions. Protection of coastal

livelihoods is thought in most cases by building embankment and cyclone shelters which are hard adaptation measures. These adaptation interventions are yet to be adequately assessed with changing shock levels of increased storm surges and salinity intrusion as well as water logging. Adaptation of coastal communities or individual household needs innovative livelihood inputs which can be alternative to adjust to new shocks for maintaining their life supporting functions. The livelihood based adaptation in prolonged water logging or saline situation requires salinity tolerant rice varieties, fast growing fish cultivation or alternative land uses.

14.3 Experience of NAPA Priority Project

14.3.1 Multi-scale Adaptation through Forest, Fish and Fruit (Triple F Model)

The Community Based Adaptation to Climate Change through Coastal Afforestation (CBACC-CF) is the first priority project of NAPA Bangladesh that has introduced the Triple F livelihood model for enhancing adaptation capacity of coastal communities in Hatiya of Noakhali; Char Fassion of Bhola and Barguna Sadar of Barguna coastal districts (Fig. 14.1). Different livelihoods types including agriculture and fish cultivation, tree plantation and duck rearing are integrated in the model considering the salinity risks and freshwater scarcity in coastal areas. The basic structure for executing the model is preparation of ditch and dyke. Each ditch is 54 m length × 6 m width × 2 m depth and dyke is 60 m length × 3 m width × 2 m height. Ditch is suitable for irrigation and fresh water fish cultivation; dyke is cultivated with seasonal agricultural vegetables, improved fruit varieties and forest trees. In 1 ha of land, eight ditches and nine dykes can be constructed. Each family has been distributed one ditch and dyke and a total of 896 households will be involved in the Triple F model of the project.

Fish: Each ditch is suitable for fish culture with fast growing and improved varieties. Though coastal areas are dominated by fishermen groups, with changing extreme events, most of the people are losing seasonal fish catch from the sea and river. The ditch system can secure additional or alternative source of income through fish cultivation in two seasons of a year. By excavating a single ditch a family can produce an estimated 150–200 kg of fishes annually which secures their household protein and additional income after consumption. Harvesting of rain water in the ditches also supports regular water supply to plantations on dyke and increase fresh water security as it doubles as a reservoir.

Fruit trees: Dyke is planted with high yielding fruit varieties BAU-Kul (*Ziziphus mauritiana*) and BAU-Guava (*Psidium guajava*), developed with the technical support from the Fruit Tree Improvement Centre of Bangladesh Agriculture University (BAU). The significant feature of the fruit varieties is twice yielding in a year and

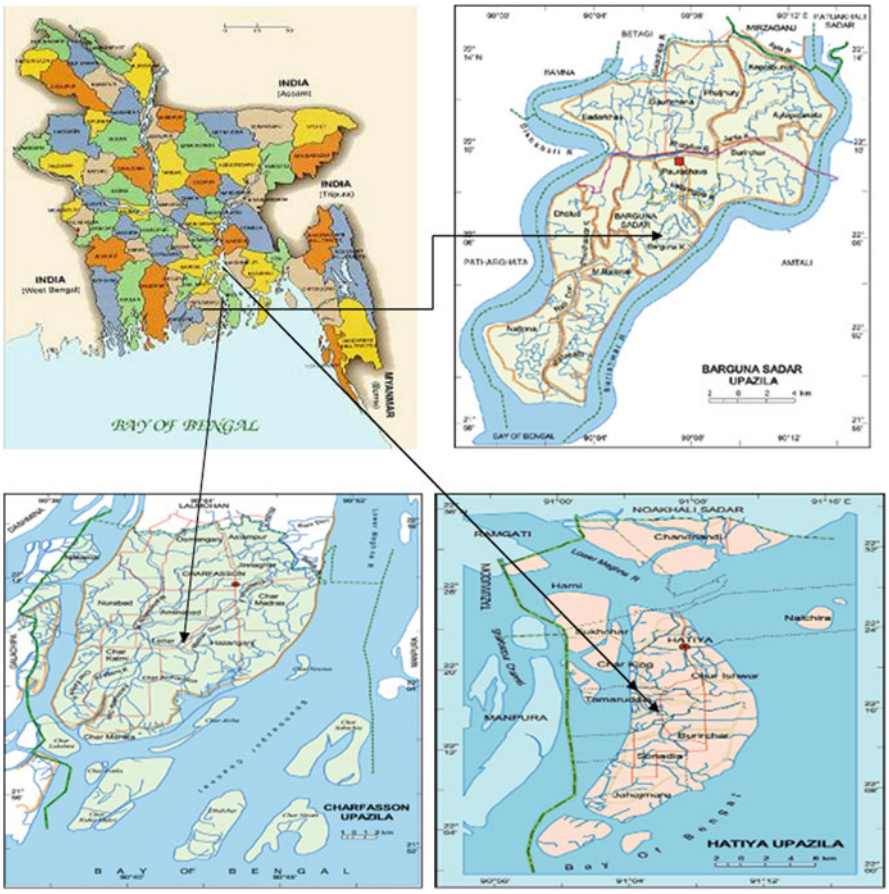

Fig. 14.1 Arrow indicated the potential sites of Triple F

enriched vitamin and mineral source in household food. On a dyke 24 seedlings (12 nos. of each variety) of these fruit varieties can be planted in between forest tree species. Fruiting starts in eight months of out planting on each dyke though sizeable harvesting of the fruit takes 2–3 years.

Forest trees: Different forest trees and palms (*Cocos nucifera*) are planted on dyke to provide communities with long-term timber, mid-term fuel-wood from branch pruning and food products. These add to the protection services of the Triple F model and the surrounding land and community from climatic impacts.

Fig. 14.2 Community based livelihood adaptation practices

14.3.1.1 Short-Term Adaptation Measures

Planting of improved varieties of vegetables on long top surface of each dyke provides immediate opportunity for household consumption of communities. Further expansion of the dyke area for cultivation is possible through special supporting arrangements (scaffolding) on the margins of the ditch to support hanging vegetables including; country bean, cucumber, bottle, bitter and sweet gourds (cucurbitaceous vegetables) and other creeper vegetables. Each family is currently cultivating six to seven types of leafy vegetables on the 60 m long and 3 m wide top surface of the each dyke (Fig. 14.2). In 6 months of dyke preparation for the model, each beneficiary has been capable to produce 80–100 kg of leafy vegetables which increase family income up to US$25 per month by selling vegetables after household intake.

It is apparent from Table 14.1 that each of the beneficiaries have generated more than BDT 35,000 (US$434) per year from adaptation interventions with Triple F model. The income ranges from BDT 23,000 to BDT 67,000 based on the performance of nursing and adequate management of own ditch and dyke. The best performers have been able to earn more than BDT 67,000 (US$827) per family/year from each ditch and dyke (Table 14.1) which is additional income in addition to previous routine livelihood activities of each beneficiary.

Among three types of adaptation measures in the model, aquaculture based intervention showed highly promising followed agriculture based adaptation measures. This may be associated with the fact that the area is dominated by the fishermen groups. Ditch is cultivated with fast growing and locally demanding fish varieties for solving regular protein food demand at household and economic benefit by additional sell at the local market. With the project support, a single ditch generates income up to US$300 per family from fish sell. Of the participated coastal families who depend on fishing or work as day labor in sea/riverboats for seasonal livelihoods (July–September) expect the ditch arrangement may be alternative adaptation practice. To the coastal families ditch system is highly preferred for rain water harvesting and cultivating fishes, irrigating dyke vegetation in even dry seasons.

Table 14.1 Enhancement of adaptive capacity through Triple F adaptation interventions (Nandy and Ahammad 2012)

Beneficiary groups	Annual income—before project (thousand BDT)	Income through adaptation intervention (thousand BDT) AP			Annual income—after project (thousand BDT)	Difference (thousand BDT)	Adaptive capacity ranking (H for high; M for moderate; L for low)
	a	AI1	AI2	AI3	b	a–b	
1	29.00	40.00	15.00	12.00	67.00	38.00	H
2	67.00	18.00	80.00	36.00	134.00	67.00	H
3	25.00		40.00	6.00	46.00	21.00	M
4	50.00	41.00	41.00	10.20	76.20	26.20	M
5	79.00	60.00	60.00	27.40	102.4	23.40	L
AV	50.00	24.50	47.20	18.32	85.12	35.12	–

AI adaptation interventions, *AI1* agriculture, *AI2* aquaculture, *AI3* livestock, *AV* average

14.3.1.2 Mid to Long-Term Adaptation Measures

Dyke system also comprises mid to long term adaptation options and creating mid-term income generation in 2–3 years with two high yielding fruit varieties *Z. mauritiania* and *P. guajava*. The significant feature of the fruit varieties is twice yielding in a year and enriched vitamin and mineral source in household food. Each family expects high potential yield and income profit from the fruit varieties. Each fruit variety produces 10–20 kg of fruit per tree and generates total income up to US$500 of a family per year. Coastal communities secure not only regular, short-term and mid-term alternative income options, but also planted forest species on dyke for long-term benefits.

Case study 1: Masura Begum (35 years) of Barguna, lost her little shelter by devastating Cyclone Sidr-2007. She says "I had sufferings of food. Now accessing to this Triple F model, I have learned how to feed my family not in a day, even in the next months with this project support. We spent 3–4 days without food and survived by eating green banana only. I got access to land and started producing different agriculture vegetables on the dyke, and fish in the ditch of the land. In the three months, I earned $150 USD by selling vegetables only after family consumption. I earned $250 USD from selling fish and eggs of duck supplied by the project. I do not need to buy any vegetable and fish for my family rather I am saving money from selling Triple F resources so that I could pay off my debts".

Case study 2: HasanGorami (29 years) of Barguna, used to sell his labor as a fisherman on big boats during the fishing seasons to support his family, while sits idle in most of the non-fishing seasons. He says "Now I maintain this ditch and dyke and this helps me earn extra money. I grew different vegetables on the top of the dykes and creepers on the scaffolding and various types of fish in the ditch. I already earned $ 300 USD from selling fish and vegetables and expect to double this by the end of the year".

14.3.2 Salt Tolerant Rice Cultivation

Agricultural practice is increasingly constrained with high level of salinity ingress and frequent and severe impacts of natural disasters in coastal areas. Given the impacts of seasonal water logging and salinity on land, and lack of irrigation in dry seasons, alternative cropping practice through use of climate resilient rice varieties have been a vital need for agricultural production in the area. The CBACC-CF project has introduced salt tolerant rice variety (BR 47) in four coastal districts. Considering lower land productivity, the rice variety has been found potential crop in coastal areas. The BR 47 variety has increased annual production from previously fallow and salinity affected lands and eventually fulfilled household food consumption (Fig. 14.3). Largely coastal people depend on the traditional rain fed *Aman* which is the single crop. The yield benefits from the demonstration reflect increasing people's

Fig. 14.3 Shifting single crop to double crop through introduction of salt tolerant rice variety

attention in coastal areas for cultivating additional land in subsequent years. In only one project site of Barguna sadar upazila, there is currently 500 ha of lands cultivated with the rice varieties in dry season (Nandy 2012).

The paddy has yielded three times more production compared to any local varieties for equal land unit. Most of the coastal farmers in the project areas are accepting the double cropping pattern with the new variety to reduce seasonal risks and adapt to food crisis. Otherwise, it is not possible to secure household foods only depending on traditional rice cropping. The cultivation of the BR 47 variety requires less water and has tolerance capacity to certain level of soil salinity in dry season (CBACC-CF 2012). There are additional economic benefits that farmers are receiving income by selling rice and seeds. Access to training of seasonal risk management, improved rice varieties and land use techniques is important for improving capacity building of the farmers in coastal areas. However, the initial cultivation of salt tolerant rice production system requires seed source and irrigation where external supports of extension services must be ensured.

14.3.3 High Yielding Fruit (Guava/Zuzubee)

Planting fruit species around homestead has been a traditional culture of rural community for household food consumption and small source of income. High yielding fruit varieties (*Z. mauritiana*, *P. guajava*) is recently introduced in coastal areas to maximize land use and secure food and income. Agricultural lands are often less suitable for crop farming due to too much of water or less water. People are cultivating additional fruit plants around homestead areas as well as raised bank of the cultivable lands and ponds. When agricultural lands are submerged with water it has been possible for cultivating high yielding fruit varieties on non-affected bank without any risk of salinity. Both the high yielding fruit varieties are fast growing and increasingly produced in coastal areas.

The Guava fruits have high calorific values carotin, vitamin C, B1, B2, calcium, phosphorus, iron that can heal different type of diseases. Three years old Guava plant can yield 100–125 kg of fruit. In local market it has good demand for sell and small farmers can earn additional household income after own consumption. BAU Kul is another improved fruit varieties which can yield two to three times in a year. A 1-year old Kul can yield 8–12 ton of fruit per hectare of lands. People consume the variety as substitute of carbohydrate which has important food values for vitamins and minerals. There are multiple food products can be produced from Guava and Kul to increase economic benefits. Small investment is mostly required in collection of grafted seedlings of both the varieties. Under the technical support of Bangladesh Agriculture University, the CBACC-CF project demonstrated BAU Kul and Guava in four coastal districts. As people have traditional knowledge in pit digging, application of organic manure and out planting system and so promotion of the new varieties are easier.

Since the introduction of the varieties, there has been growing interests among community for using and planting around homestead and fallow part of the agricultural lands. Any farmer can adopt the practice where women can contribute for maintenance activities of the fruit garden. This is also possible to cultivate under vegetation along with the fruit varieties which increase short-term income and multiple uses of lands. While high yielding fruit varieties has year round demand, there is lack of people's skill on the quantity of inorganic fertilizers to be applied, as well as remedy measures for reducing risks of diseases and pest attacks. Proper selection of the planting site height above regular inundation or water logging is important to avoid seasonal weather risks and enhance the benefits of the adaptation practice.

14.4 Other Examples of Coastal Adaptation Practices

Local communities have been practicing diverse livelihood practices depending on their needs and capacity to use traditional knowledge and external resource available in coastal areas. Some adaptation practices have been explored from "Reducing Vulnerability to Climate Change (RVCC)" project documents for further understanding and dynamics of livelihood in coastal areas (Ahammad 2010).

14.4.1 Crab Fattening

Crab fattening is increasingly accepted livelihood practices of many families in south-west coastal districts of Satkhira, Bagerhat and Khulna. In the past years, rural women experienced collection of young crab with simple technique and sold in local market for income. Due to saline habitat and the largest mangrove "Sundarbans" close to the region, collection of young crab and nurturing in separate ponds are increasingly preferred for income generation. The initial cost of crab

collection is not as much as those farmers can collect young/juvenile crabs from fishermen at low-price. The local sell of young crabs is vital income source for poor fishermen families where alternatively the farmers continue the business for almost a year. There is a less span of time for maturing of the crabs (<28 days) to be suitable for export size.

The livelihood practice can be easily promoted in extended coastal communities due to tidal inundation and water logged saline conditions and locally available feed favors the crab cultivation. There is not much required of additional lands and particular seasonal weather variability as threats to crab fattening. Coastal landless families or marginalized farmers who cannot undergo minimum agricultural cultivation due to salinity in a year they can adopt the practice for regular income. Using community ponds and sharing system there is also opportunity for poor families who have no own ponds for crab fattening. While crab production has local demands, much of its secured benefits are not equally shared by poor people. To optimize the benefits of small scale livelihood practices for adaptation, access to local market and international exports are highly required.

14.4.2 Mele Cultivation and Mat Preparation

Mele is produced locally from a type of reed and traditionally used by coastal families in south-west coastal districts. While raw *mele* is used for animal fodder, the dry *mele* has large demand for producing durable mats. *Mele* mats have local and countrywide market which farmers can use for their livelihoods. As a saline prone areas considering *mele* are grown and practiced within certain limit of tidally influenced brackish and fresh water. *Mele* production can be continued throughout the months of a year and providing minimum income. There is yet environmental risks in *mele* cultivation due to its less salinity tolerance and much requirement of irrigation in cultivation seasons.

14.4.3 Poly Culture

This is a traditional practice for consecutive use of agricultural land in coastal districts Khulna and Satkhira. Farmers use their paddy lands for combined cultivation of paddy, shrimp and fin-fish in different seasons. The practice requires less cost and time initially due to same unit of land which can be used for production. The paddy cultivation begins with monsoon rain when salinity is about to leach out with freshwater inflow around June onwards. At that time, there is a particular system locally people adopting to raise their surrounding lands in a dyke form, or locally called "Gher"/pond to retain fresh water which is simultaneously used for Aman rice and Sweetwater shrimp "Galda". Freshwater reduce the salinity level and restore natural

quality of the pond where additional organic matters are enriched in soil and planktons available for food of shrimp. To farmers few white fishes are also naturally grown in the land with paddy and *Galda* shrimp.

The poly culture provides twofold household income at a time as people usually harvest both paddy and shrimp between October and November. Following double harvesting the pond owner also adds income from the remaining fishes. With onset dry season saline water starts growing, and farmers converts the land into salt water shrimp (*Bagda*) in pond and continue up to June. A complete income turnover per year by the land use system can be effective adaptation practice for any farmer irrespective of land size. There is yet local people less capable in managing the traditional practices for crop rotation management and fish culture with respect to fresh and salt water as well as uncertain whether hazards.

14.4.4 Floating Garden

Floating garden is a special kind of traditional livelihood practice which people are adopting over the years in flood-prone southern districts (Pirojpur, Gopalganj). Following monsoon rain or flood events, water logging creates periodical water stress to land based agriculture system when people have no alternative livelihood means. The floating garden provides alternative agriculture practice to people for producing vegetables in the water logged conditions through "Hydroponic" system. The size of each garden (locally called *Baira*) is flexible and it can be around 4–6 ft width, 25–30 ft long and 3–4 ft height. A farmer can easily prepare a bed with own labor and locally available raw materials namely, water hyacinth, rice stub, coconut husk and other plant materials. In the initial phase of preparation, the collected water hyacinth is tied together and overlaid with bamboo. In consecutive turns or days additional water hyacinth is put on bamboos to ensure the thickness of the garden. Once the basic structure of the bed is prepared, the water hyacinth is allowed to rot. In 3–4 weeks of rotten, the top portion of the bed is enriched with primary nutrients (phosphorus, nitrogen and magnesium) which acts as organic manure and make suitable for transplanting of different vegetable seedlings. The naturally grown quality and eco-friendly garden without soil also reduces the application of additional chemical fertilizers for improving crop productions.

The practice mostly replaces the soil based agriculture which is entirely not possible in this period. By adopting the technique, farmers usually produce short-rotation vegetable varieties on the floating garden which are important for household foods, nutrition and alternative income generation. Not less than 31 different vegetable varieties can be cultivated in the garden depending on water depth and duration in monsoon and winter seasons. Of the vegetables, there are spinach, beans, cabbage, cucumber, eggplants etc. which becomes harvestable within 20–25 days of the transplanting. The significant note of the practice is three to four times high yielding capacity of vegetables around a year than soil based production system.

To some extent the practice is observed in water logged lands and adjacent homestead areas. Farmers who are entirely dependent on agriculture, receiving double benefits by using the organic residual of the garden even after water recedes for winter vegetation in farming lands. To adapt to frequent and intense floods and water logging areas, floating garden practice is increasingly found as an alternative and easily replicable land use technique for household income generation in Bangladesh. With the external support and improved knowledge the practice can be strengthened with sustainable benefits as asset to adaptation of seasonally vulnerable people.

14.4.5 Cage Culture

The practice has been introduced in inundated and water logged areas for fish production. With submergence of agricultural lands and seasonal wetland, the cage system has been effective, alternative and small scale income generation source for farmers and single family. The cage is rectangular or square shaped and prepared with net that can be submerged in 2–3 m water. The cage can be locally purchased with nominal cost and no additional materials. The fast growing fish larvae or finger lings with food is put inside the cage where it can grow up in natural aquatic habitat. This is possible for a family to harvest matured fish for household consumption as well as market sell in 8–12 weeks. The production and benefits by cage culture can be increased depending on the numbers of cages are practiced in private and public common lands.

The significant advantage of the culture is to adjust with tidal inundation and water logged risks in coastal and flood prone areas of Bangladesh. Without agriculture farming opportunities, there would otherwise be no functional livelihoods of majority people in this period. The minimum livelihood activities can be secured by the practice as regular income to marginalized farmer families. The practice neither requires additional knowledge and cost, nor much labor and so women can also adopt the practice easily. There are no environmental risks in the practice and lack of viral infestation in the fish culture. People can multiply the economic benefits of the system by investing income in consecutive agricultural farming as a part of short to mid-term adaptation practices. The adaptation practices is significant response to growing water related climatic stress where promotional trainings and access of marginalized and landless people to submerge and community based wetland management in particular seasons must be secured.

14.5 Coastal Livelihood Adaptation: What Is Needed

Coastal people are increasingly adopting diverse livelihoods for adaptation which are related to local climatic risks and seasonal variability as well as availability of the resources for them to access and generate benefits immediately. Some of the

livelihoods are traditionally preferred at household level for regular or additional income generation. A few other livelihood practices are also found as community resources for group based income generation. The most striking issues of livelihood for adaptation is whether these practices secure income, what extent these are capable for seasonal risk management (e.g., tidal inundation, water logging, salinity increase etc.) and how local and external support mediate resource ownership for suitable benefit distribution. Coastal communities are often forced by socio-economic changes at large scale process which shapes their linkage to institutions (norms and rules) and organizations at other scales (Craig and Ruhl 2010). Drawing current evidences of changing coastal livelihoods from field experience are important for understanding, developing knowledge on existing risks to promote adaptation measures.

Different degree of seasonal and periodical threats as well as change in temperature and precipitation are important in coastal livelihoods to understand adaptation. The external climate stimuli are pressing traditional practices beyond agricultural practices; rather than people are improving the techniques with own knowledge and innovation as well as supports of govt. and NGOs. The traditional agriculture and fishing practice is changing in different scale of management capacity, from individual response to community actions. Landless and marginalized farmers who have no options for agriculture farming or fish culture due to water logging or saline ponds, the Triple F arrangement of ditch system secures their household protein sources and periodical income. By protecting the ditch there is possible duck rearing which can generate fish food and additional household protein sources.

People perceive the changing seasonal threats from their experience and adopt new information, innovative techniques and skills to blend with traditional practices. Changing cropping practices with respect to seasonal risks are currently envisaged for introducing new rice varieties to withstand higher salinity and temperatures in coastal areas (Ali 1999). Farmers are not entirely depending on agriculture, or fishermen on pond culture and open fishing. In several cases, people are emphasizing on small scale agriculture by changing cropping cultivation pattern; mixed cultivation with agriculture and fish cum duck rearing. Much of the traditional practices can only secure household foods and limited incomes where it has been noted of changing land uses to enhance livelihood income resilience. Traditional practices cannot be referred to sustainable as these are often isolated and characterized by weak financial inputs (internal/external) and protective infrastructure (Mallick et al. 2011) for continuing the benefits in extended seasons. The CBACC-CF project incorporates traditional knowledge of local community for seasonal risk reduction through improved cropping pattern with innovative dyke system which has been found to increasing annual production and income beyond regular incomes.

The significant point of coastal livelihood in current paradigm is sustainability of practice and actions. Among the documented adaptation experiences except the Triple F, many of the household livelihood practices are only managing seasonal risks to some extents which are neither sustainable nor increasing income to adapt to subsequent shocks around a year. Depending on only current practices, small landholders and poor disadvantaged groups can maintain coping strategies through

taking loan, selling labors or leasing lands (Parvin et al. 2008; Pouliotte et al. 2006), but integration of livelihoods pattern are important for adaptation at individual and community level. The Triple F model of CBACC-CF project provides integrated livelihood measures over seasonal risks to multiple year targeted resource management (Nandy 2011, 2012). The practice is innovative in type, at the same time supplementary to traditional agricultural cultivation or fish culture for income source of coastal people. For instance, the involved community applied their traditional knowledge for hanging vegetables in scaffolding system on dyke. Freshwater has been irrigated by themselves for shrimp farming apart from project inputs to increase income in extended seasons. It has been observed from the project experience that community based resource management can provide better identification of the risks, shared learning and strengthening household income not on seasonal basis as well as annual.

Strengthening adaptation capacity requires blending individual skills and household capacity with external institutional supports for technological acceptance. The dynamic geo-morphological nature and disaster surprises in coastal areas often override the knowledge of local people and use of available resources to reduce the problems in the long-run. Livelihood expresses the capacity of marginalized vulnerable groups to cope with climatic shocks and access to resources and technology. This has been possible to blend individual experiences in continuous livelihood development in the NAPA project. Some of the households who have very other limited livelihoods (farmers or landless) find the Triple F practices as additional and only resource generating sources. The significant part of the resource access and sharing is land ownership arrangement and external support for incorporating climatic risks in building particular ditch and dyke system.

Evidently land is important resource for adaptation, and important for coastal people how to rearrange and engage its multiple uses in resource management by reducing the seasonal risks. Drawing experience of the NAPA project, institutional support for land access and knowledge transfer of improved crop varieties through training and awareness building can strengthen land use capacity and reinvigorate livelihood approach. The statement is important for any adaptation practice promoted by other organizations to incorporate cost-effective values of new interventions how community accepts and sustain the benefits in the long-term adaptation. To note that institutional interventions for coastal land acquirement and sharing among local community must be carefully followed to ensure adaptation benefits in the long-run.

Community can sustain livelihood benefits in changing climatic risks by ensuring their access to local resource ownership. Depending on current resource capacity, people have different level of understanding and needs for managing new innovation practices. While transferring innovation practice at the local level very often pro-poor resource distribution and selection of the right innovation is important, and remain challenges. For instance, landless and marginalized farmers largely accepted the ditch and dyke arrangement as significant resource than any other

group of people. Despite the fact, empowering particular vulnerable coastal people through land ownership distribution in the CBACC-CF project remains critical task. This is not for differentiated vulnerability and capacity of economically land owners that they can manage risks; the group also receives the major advantages due to their access to local institutions. Access to new innovation opportunity and optimize benefits is interrelated with user interface between community and institutions. Some other adaptation practices (crab fattening, poly culture, floating garden etc.) require initial investment cost and labor, access to land, improved technology, skills and market. All these associated factors are socially and institutionally driven and often mediating the individual capacity whether the practice can be empowering the vulnerable groups.

Adaptation practice is mostly interlocked within institutional response for promotional activities to managing observed risks in Bangladesh and less focusing on integrating other social constructions at community level. Making long term decisions for coastal adaptation now involves consideration of both the climate change uncertainties and complexities and levels of stakeholder support (Tompkins et al. 2008). The NAPA project focused on institutional strengthening through capacity building training of local government officials for improving collaboration and livelihood input delivery. Major activities of the project are attempted to be integrated within the capacity and roles of four departments of Forest, Agriculture, Fisheries and Livestock. These departments have opportunity to share and transfer knowledge and resources to community and local stakeholders for integrated livelihood management. Since the project, the collaboration of these departments is increasing within formal structure and mostly not adequate at the community level. These institutions identified their key adaptation roles though these are not empowered in policy influence and local resource ownership. National land use policy is inadequate to define local institutional capacity with particular focus on coastal areas and develop integrated resource management.

Institutional networking across horizontal and vertical level is important for design and promotion of cost-effective adaptation interventions. In livelihood adaptation project, national institutions must consider changes in relevant policy to open up existing local institutional interface for strengthening support to implementing parties among them and from external departments of same level. Coastal livelihoods are not only related to responsibility of few departments rather than roles of other local stakeholders who are involved in disaster risk management (Rawlani and Sovacool 2011). Protective infrastructure like coastal embankment and effective drainage maintenance can reduce seasonal water logging risks to agriculture cultivation. The major institutional roles of CBACC-CF project has only four departments until recently which often excludes the responses of those other government local institutions involved in water management. While the project initiates local institutional interface for adaptation, the evolving experience may be extended to integrate the support of other departments to reduce overriding resource management problems in coastal areas and eventually adaption costs.

14.6 Conclusions

Coastal livelihoods require modification of traditional land use and integrating practices with respect to risks and people's access to adopt and continue in sustainable manner. Compared to isolated adaptation interventions, the CBACC-CF project innovation created multiple opportunities through livelihood ownership as well as long-term resource generation. Ownership development has been important approach in the Triple F model which opens up particularly integrated livelihood practice for adaptation with the collaboration of local community which is also important for social empowerment of landless and marginalized households. Diversification contributes to household adaptation in Mozambique due to flexible livelihood options though inequality in access to resource and markets impeded resilience among the community. The dual land use system is recognized by local communities as pro-active livelihoods to drought risk management, but household size and labor intensity have characterized the benefits for particular social groups to participate in the coping strategies (Osbahr et al. 2008). The Triple F model can manifold livelihood benefits in the long-time scale upon ensuring effective coastal zone policy and responsive delivery institutions for implementation at the local level.

Livelihoods are embedded within integrated social-ecological functioning that enhances adaptive capacity of the system. The livelihood strategies correspond to different household needs in stress and post-shocking period to fulfill the adaptation gaps. People used extensification, intensification, diversification and migration strategies for coping with periodical stress in Morogoroof Tanzania (Paavola 2008). However, the adaptation strategies of Tanzania has also problems in effective governance of environmental resources; promotion of market participation to stimulate both agricultural intensification and diversification of livelihoods; and building human capital. Coastal people are increasingly adopting diverse livelihood practices at household level in Bangladesh. The livelihood strategies have few weakness which are focusing only seasonal climatic risks without incorporating long-term climate dynamics, social and ecological changes. Use of advanced climatic information, irrigation and salinity management, and integration of single livelihood to multi-level resource generation required within existing adaptation practices of households. Contrary to the point, the Triple F model has substantially focused on integration and protection of livelihoods through capacity building of community and households equally. Adaptive capacity is interconnected at different scales and depending on degree of response from both individual and community as well (Smit and Wandel 2006). The spontaneous interaction of community and individual has advantages in livelihood adaptation for raising voice in service claim and access to potential political and economic institutions.

The adaptation innovations relate to the emerging threats of livelihoods in changing climate and institutional capacity to progressively responding through appropriate technology to the demand (Rodima-Taylor et al. 2008). Social acceptance of innovation, livelihood patterns and strategies shows a great potential for analyzing

climate action in the complex and multi-scale actor environments. Most adaptation measures need to be cost-effective for institutional deploy around community level as well as within much of their capacity to accept and promote at individual context. Community invested their time and labor in developing the ditch and dyke system for diverse resource generation in the Triple F model. In spite of that, the land use innovation practice cannot be said fully cost-effective until initial institutional support to local people is providing additional financial and technical benefits of particular marginalized social groups for their regular livelihood activities. This is equally important consideration in introducing other practices including crab fattening, floating garden and poly culture whether marginalized farmers can invest finances and technology, and then develop capacity to optimize the successive benefits. DaCosta and Turner (2007) emphasis on sustainability of the new practices for sampan dwellers is a matter of fact in Vietnam due to financial and natural risks in the flood prone areas as well as water contamination in the raising aquaculture ponds. The resettlement arrangement of sampan dwellers provides insufficient lands and aquaculture system only considers current income generation. Building financial capital through the aquaculture ponds would take long-time to ensure their future adaptation capacity.

Attention to social actors with their diverse interests, perceptions and purposes helps to contextualize the notions of community and participation. Local networks and associations, and the relationships and patterns of reciprocity and exchange, are therefore paramount to building adaptive capacity. The community based livelihood approach can transfer knowledge and best practices and improve risk management capacity at individual context as well. Edwards and Wiseman (2011) emphasize on community adaptation through proactive, intentionally transformative capacity to address the future shocks. The ditch and dyke approach was based on community level decision making which alternatively improves individual capacity to share and learn from others for transferring knowledge in seasonal crop diversity, application of organic manure as well as fresh water irrigation to enhance future livelihood benefits. Drawing the Triple F experience, any innovation practice may be assessed at the community level for efficiency and acceptability while also disseminating individual best practices as part of knowledge for others.

A significant institutional barrier exists in clarifying authority and improving coordination, or insufficient public involvement and deliberative processes for legitimate and accountable coastal resource management (Lebel 2012). Existing social and economic level of individual families and their access to institutions and market remain important determinants with innovation practices. The effective claim-making on local resources as well as policy support from public institutions are essential part of adaptation strategies for enhancing the climate resilience of the poor. There are often lack of coastal policy review, local institutional monitoring and vested resource interests of particular groups also underscoring livelihood risks of marginalized stakeholders at different levels. Local community experiences in project implementation and effective actions demonstrate relevant basis for systemic policy changes at a national level (Sieghart and Ganapin 2011) and

also fosters partnership with govt. agencies, powerful resource users and other stakeholders.

Large-scale actions strengthen local governance and community groups responsible for managing coastal resources, improvements in coastal infrastructure, and migration to non-coastal areas (Cinner et al. 2012). Medium-term investments in institutional capacity building (i.e., financial planning and management, knowledge and information sharing) and cross-scale linkages will likely be critical to facilitating the success of these emerging institutions. Collaborative Triple F arrangement demonstrates potential inter- and intra-institutional integration and better understanding for climatic risk reduction responses through productive and protective coastal land management with local communities. Informal institutional collaboration has been strengthened among government agencies to the extent for implementing and monitoring of the livelihood system in coastal areas. The new form of institutional adaptation interface exists in only early stage and so inadequately equipped with the required policy changes for sustainable livelihood management in coastal areas. The short-term experience of the project must be opened up for sharing with and/or involving many other influential social and political stakeholders who may have divergent roles in policy making and local resource management process and proliferate the adaptation initiative.

References

Adger NW, Hughes TP, Folke C, Carpenter SR, Rockstrom J (2005) Social-ecological resilience to coastal disasters. Science 309:1036–1939

Agrawala S, Ota T, Ahmed AU, Smith J, van Aalst M (2003) Development and climate change in Bangladesh: focus on coastal flooding and the Sundarbans. OECD Publications, p 70

Ahammad AU (ed) (2010) Reducing vulnerability to climate change: the pioneering example of community based adaptation in Bangladesh. Centre for Global Change (CGC) and CARE Bangladesh, Dhaka, p 156

Ali A (1996) Vulnerability of Bangladesh to climate change and sea level rise through tropical cyclones and storm surges. Water Air Soil Pollut 92:171–179

Ali A (1999) Climate change impacts and adaptation assessment in Bangladesh. Climate Res 12:109–116

CBACC-CF (Community Based Adaptation to Climate Change through Coastal Afforestation) (2012) Training module on rice production technology. CBACC-CF Project, Department of Agriculture Extension Component, Khamarbari, Dhaka, p 24

Cinner JE, McClanahan TR, Graham NAJ, Daw TM, Maina J, Stead SM, Wamukota A, Brown K, Bodin O (2012) Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. Glob Environ Change 22(1):12–20

Craig RK, Ruhl JB (2010) Governing for sustainable coasts: complexity, climate change, and coastal ecosystem protection. Sustainability 2:1361–1388

DaCosta E, Turner S (2007) Negotiating changing livelihoods: the sampan dwellers of Tam Giang Lagoon, Viet Nam. Geoforum 38:190–206

Edwards T, Wiseman J (2011) Climate change, resilience and transformation: challenges and opportunities for local communities. In: Weissbecker I (ed) Climate change and human well-being. International and Cultural Psychology, Springer Science, Business Media, LLC, New York, pp 185–200

FAO (2010) Global forest resources assessment: country report Bangladesh, p 61
Hossain AM, Reza MI, Rahman S, Kayes I (2012) Climate change and its impacts on the livelihoods of the vulnerable people in the southwestern coastal zone in Bangladesh. In: Filho WL (ed) Climate change and the sustainable use of water resources. Springer, Berlin, pp 237–259
Lebel L (2012) Governance and coastal boundaries in the tropics. Curr Opin Environ Sustain 4:243–251
Mallick B, Rahman KR, Vogt J (2011) Coastal livelihood and physical infrastructure in Bangladesh after cyclone Aila. Mitig Adapt Strateg Glob Change 16:629–648
MES (Meghna Estuary Study) (2001) Hydromorphological dynamics of the Meghna estuary. Meghna Estuary Study (MES) project, Bangladesh Water Development Board, Dhaka. In: Ahmed A (ed) Some of the major environmental problems relating to land use changes in the coastal areas of Bangladesh: A review, Journal of Geography and Regional Planning 4(1): 1–8
Moniruzzaman M (2012) Impact of climate change in Bangladesh: water logging at south-west coast. In: Filho WL (ed) Climate change and the sustainable use of water resources, climate change management. Springer, Berlin, pp 317–336
Nandy P (2011) Forest, fish and fruit: new model of climate change adaptation in Bangladesh. In: Abstract, 5th international conference on community based adaptation to climate change, Dhaka, p 188
Nandy P (2012) Community based adaptation through the application of FFF model—a mound-ditch model to adapt to climate risks. http://www.asiapacificadapt.net/adaptationforum2012/sites/default/files/Paramesh%20Nandy_BANGKOK-Adapt-Forum-2011%20%5BCompatibility%20Mode%5D.pdf. Accessed 12 Dec 2012
Nandy P, Ahammad R (2012) Navigating mangrove resilience through the ecosystem based adaptation: lessons from Bangladesh. In: Macintosh DJ, Mahindapala R, Markopoulos M (eds) Sharing lessons on mangrove restoration. Mangroves for the Future and Gland/IUCN, Bangkok, Thailand/Switzerland, pp 243–254
Nandy P, Paul SP, Moula MG, Imam MF, Basak SR, Miah MAQ, Mannan MA (2003) Stakeholder analysis through participatory rural appraisal for land use and joint forest management in raised coastal areas. PRA Bulletin. Plantation Trial Unit Division, Bangladesh Forest Research Institute, p 58
Nandy P, Islam MA (2010) Climate resilient coastal zone development in Bangladesh: participatory governance for common resources management. In: Ramanathan AI, Bhattcharya P, Dittmar T, Prashad MBK, Neupane BR (eds) Management and sustainable development of coastal zone environments. Capital Publishing Company, New Delhi, pp 58–72
Nicholls RJ, Wong PP, Burkett VR, Codignotto JO, Hay JE, McLean RF, Ragoonaden S, Woodroffe CD (2007) Coastal systems and low-lying areas. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, pp 315–356
Osbahr H, Twyman C, Adger WN, Thomas DSG (2008) Effective livelihood adaptation to climate change disturbance: scale dimensions of practice in Mozambique. Geoforum 39(6):1951–1964
Paavola J (2008) Livelihoods, vulnerability and adaptation to climate change in the Morogoro region, Tanzania. Environ Sci Policy 11(7):642–654
Parvin GA, Takahashi F, Shaw R (2008) Coastal hazards and community-coping methods in Bangladesh. J Coast Conserv 12:181–193
Pouliotte J, Islam N, Smit B, Islam S (2006) Livelihoods in rural Bangladesh. Tiempo 59(April Issue):18–22
Rahman MH, Lund T, Bryceson I (2011) Salinity impacts on agro-biodiversity in three coastal, rural villages of Bangladesh. Ocean Coast Manag 54:455–468
Rawlani KA, Sovacool KB (2011) Building responsiveness to climate change through community based adaptation in Bangladesh. Mitig Adapt Strateg Glob Change 16:845–863
Rodima-Taylor D, Olwig MF, Chhetri N (2008) Adaptation as innovation, innovation as adaptation: an institutional approach to climate change. Appl Geogr 33:107–111

Shaw R, Krishnamurthy R (2012) Coast and communities: the Linkages. In: Shaw R, Tran P (eds) Environment disaster linkages. Community, environment and disaster risk management, vol 9. Emerald Group Publishing Limited, Bingly, pp 101–112

Sieghart LC, Ganapin D (2011) Pace of change: climate change and the empowerment of local communities. In: Filho WL (ed) The economic, social and political elements of climate change, climate change management. Springer, Berlin, pp 837–845

Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Change 16:282–292

Tompkins EL, Brown K, Few R (2008) Scenario-based stakeholder engagement: incorporating stakeholders preferences into coastal planning for climate change. J Environ Manag 88: 1580–1592