Protecting the protectors: Lessons for adaptation strategies of mangrove forests from Bangladesh

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Introduction: Bangladesh has more than 3% of global mangroves' share. The proportion of mangrove area to coastline length is the second highest in Bangladesh as she hosts around 576700 ha of mangroves along her coastline stretching only about 580 km. The mangroves of Bangladesh includes the largest single expanse of natural mangroves, the Sundarbans and one of the most extensive coastal mangrove afforestation. These mangrove areas are exclusive because of their biodiversity, dynamism and complexity in ecological terms. Despite of having the highest land-man ratio, Bangladesh managed to maintain its mangrove area over the last decades. Thanks to extensive mangrove plantations over last fifty years which could compensate the loss of natural mangroves, even protected ones. Bangladesh also has the oldest formally managed mangrove forests in the world. Thus experience of Bangladesh in managing, conserving, protecting and afforesting mangrove is exceptional. There are both success stories and soaring failures, both offering distinct opportunities to learn from. So, this experiences needs to be reviewed and shared for avoiding the mistakes and to build climate conducive mangrove management strategies.

Success tracks in mangrove forest management: ***Large scale mangrove afforestation***

Starting in early 1960's, Bangladesh coastline has been successfully afforested with more than 0.13 million ha mangroves. The amount approaches 0.80% of the global mangroves. The afforestation was carried out mainly with two light demanding primary mangrove pioneers, *Sonneratia apetala* and *Avicinnia officinalis*. These species are able to cope with high tidal fluctuations in new accretions favouring clayey and sandy sites respectively. Relatively sheltered coastlines are favoured by *Sonneratia* as fine silts are in plenty from Ganges- Brahmaputra discharge. The coastlines with direct wave action leave the sites sandy due to winnowing effect and therefore *Avicenna* is preferred there. The success of mangrove afforestation has come through dedicated long-term investment and more importantly, logical choice of species based on ecological principles rather than commercial consideration.

Silvicultural practices to maintain ecosystem integrity

Natural mangroves of the Sundrbans are being managed formally from 1880's with the first workplan for the forest prepared in 1892. The forest was classified productive and workplan was in place for maximising revenue generation. Workplans got modified with evolving understanding and changed from 'sustained yield principle' to 'integrated ecosystem management'. The silvicultural system practiced for major species is diameter based selection with coupe rotation rather than age rotation. This management approach, based on ecological principles, is now found to be more resilient to changing climate. Summary of silvicultural practices for major mangrove species in the sundarbans are as follows:

Species	***Silvicultural system***	***Regeneration/ Coupe rotation***	***Felling rules/ restrictions***	***Mitigation prospective***	***Adaptation prospect***	***Species self protection***	***Protection to the forest itself***
Heretiera fomes	*Selection*	*Natural 40 years*	*Site class based diameter ; Seed trees are retained if a patch is deemed removable*	*Sunk Carbon is protected as soil is not completely exposed*	*Smoothers cyclone and tidal surges*	*Maintains habitat for regeneration and growth*	*Potential gap phase effects are minimized*
Sonneratia apetala	*Clear felling*	*Natural As necessary*	*Only in mature dying patches with scattered individuals*	*Below ground carbon is retained*	*Smoothers cyclone and tidal surges; helps accretion and site stabilisation*	*Trees removed only when site is unsuitable for the species*	*Supports natural succession process*
Ceriops decandra	*Coppice*	*Coppice 10 years*	*At least one vigorous shoot on each trunk should be retained*	*Significant amount of above ground biomass is retained at site*	*Smoothers cyclone and tidal surges*	*Structural composition of the species is maintained*	*Helps maintain forest cover and minimize invasion*

Excoecaria agallocha	*Selection*	*Aided natural/ Plantation 20 years*	*Site class based diameter*	*Low*	*Smoothers cyclone and tidal surges*	*Its habitat range is trusted over management*	*Wide habitat range including disturbed sites helps maintain forest cover*
Nypa fruiticans	*Selection*	*From Rhizome 10 years*	*Sprouting shoot and at least one protecting leaf must be left on each clump*	*Low*	*Smoothers tidal surges; helps accretion and site stabilisation*	*Vegetative propagation is supported*	*River channels*

Handling restoration after natural disaster

Bangladesh has learnt that natural mangrove stands are better to be left alone after catastrophic events such as cyclones. The natural revitalization of the Sundarbans after SIDR of November, 2007 is the prime example. Bangladesh restricted any sort of resource extraction from the Sundarbans for one year. This was a huge economic decision for a forest producing at least 3% GDP of the country. The decision paid off as the forest has restored significant productive capacity within a year.

Considering multifaceted benefits from mangrove forests

Current forest policy of Bangladesh, adopted in 1994, considers multiple benefits from mangrove forests, especially the Sundarbans. This consideration at policy level actually supports forest management prescriptions which are not entirely focusing on timber production. The 'Non Major Ecosystem Products(NMEPs)', mostly known as NTFPs or NWFPs for forest ecosystems are valued in terms of livelihood support and even for revenue generation. Mangroves NMEPs includs ecosystem services such as protection from cyclones, ecotourism and tangible products such as fisheries, thatching material, honey etc. These benefits are extractable without compromising the adaptive and mitigative prospect of the mangroves and even without posing threat to ecological processes of the forest.

Failures in mangrove management

Loss of mangrove due to aggression of competing landuse

In the area of Chakaria Sundarbans, the second largest natural mangroves of Bangladesh, intensive shrimp farming was initially encouraged by local policymakers with a prospect of huge financial benefit. The initial success made local elites to go for the 'gold hunt' by clearing the mangroves, even in protected areas. Forest Department, without having proper social management tools, was unable to protect the land with legal instruments. Cases were filed but mangroves got destroyed. Two decades from that period, mangroves are gone and so as the shrimp prospect. And the area became the most vulnerable to climate change having lost its natural protector.

Non-sustained production of industrially valuable species

In persuit to meet the ever increasing demand of raw materials for newspaper production, the extraction of Gewa (*Excoecaria agallocha*) was increased over natural productivity of the Sundarbans. The result is complete shutdown of the paper mill as forest is unable to supply raw material. The situation could have been avoided if principle of ecosystem surplus was considered rather than meeting the production target. The mill would have been sustainable at a smaller scale and forest would have produced more financial benefit. However, the desperate endeavour to feed in the mill, especially in the last few years, resulted in over exploitation of *E. agallocha*, actually felling trees much lower than prescribed diameter. *Excoecaria* stands are important in natural succession as it helps creating habitat for climax *Heretiera*. Loss of *Excoecaria* stands will delay the forest to reach edaphic climax and leaves it vulnerable to invasion, possible retrogression and climate change stresses.

Climate change enforced challenges for mangrove management

Wide fluctuation of water flow over the year and salinity intrusion

Increased monsoon rain, faster melting of glaciers upstream is actually causing more frequent and severe floods in the delta. Floods, as coinciding with water supported seed dispersal timing, affect the Sundarbans with possibility of flushing out more seeds out of the ecosystem into the sea. Flood water also carries in higher amount of invaders like water hyacinth to cause physical interruption in regeneration and recruitment process. With nominal rainfall in winter and diversion of flow upstream, salinity from rising sea intrudes further into the forest to mount up the stress on regeneration and recruitment. Natural flow of freshwater must be ensured in winter to minimize this effect.

Rise of sea level

Sea level rise will alter the habitat condition in natural mangroves. Management tools have to be judiciously applied to encourage species that can survive and grow in the changed condition. Careful and intensive monitoring of the changes has to be ensured. On the other hand, mangrove plantations with seemingly established accretion might have to be reforested once again with pioneers rather than later seral ones. Site specific ecologically agreeable and cautious management choices have to be made. The principles of management are well established, the timing and perception of the management has to be rearranged.

Increased frequency of the hydrodynamic disturbances

Natural restoration capacity of the mangrove is under threat with increased events of natural catastrophes. Magnitude of conventional management interference has to be minimized further to maintain this capacity. For plantations, gap filling may be necessary for relatively young sites. But yet, older sites with seeding trees should better be left alone in the hands of nature to be taken care of.

Lessons for adapting climate change into mangroves

Harmonization of competing landuses is possible and necessary

Competing land uses in mangrove areas, where possible, should be considered complimentary rather than alternative. Clearing out mangroves for other landuse is not the ultimate economic choice. To sustain the productivity and maintain adaptation prospect, mangroves have to be retained in harmony with other demanding landuse.

Integration into general adaptation programme is important

Combining natural and ecologically engineered infrastructures provides better solution for climate change adaptation. Natural resources are not always capable of providing all the elements for adaptation. For example, legitimate shelter for people during cyclone and tidal surges may not be on offer from mangroves. That is why ‘exclusive’ mangrove areas are not the ultimate solution, especially for areas with human inhabitants. Cyclone shelters have to be built. But if these shelters are located completely exposed to sea, it would not serve the purpose. The infrastructures should be placed behind natural mangrove shelters and designed for being in harmony with the ecosystem processes.

Counting on ecosystem services and minor products is crucial

Mangrove resource provides livelihood support to local people and produces manifold benefits and services as by-products. Mangroves carbon sink potential should also be taken into consideration. In true sense, timber should be considered ‘Non Major Ecosystem Product (NMEP)’ for mangrove ecosystems used for coastal protection and climate resilience. Mangrove management should therefore focus on maximizing the ecosystem benefits and services rather than typical timber production agenda of forest management.

Decisions based on ecological principles works well, even in economic terms

This is simply because of the fact that ecosystem services are better sustained to produce more sum of benefit in the long run. From choosing species, opting silvicultural system to fixing rotation, ecological context should be the leading factor in decision making. Especially for sensitive yet resilient mangrove forest areas, ecological considerations should take precedence over anything else.

Conclusion

The science and approach behind the adaptation solution for mangrove forests are well known. But site specific adjustments are necessary. Understanding the natural and ecological process and deliberately aiding and encouraging the beneficial ones, is the key for adapting mangrove forests to climate change.