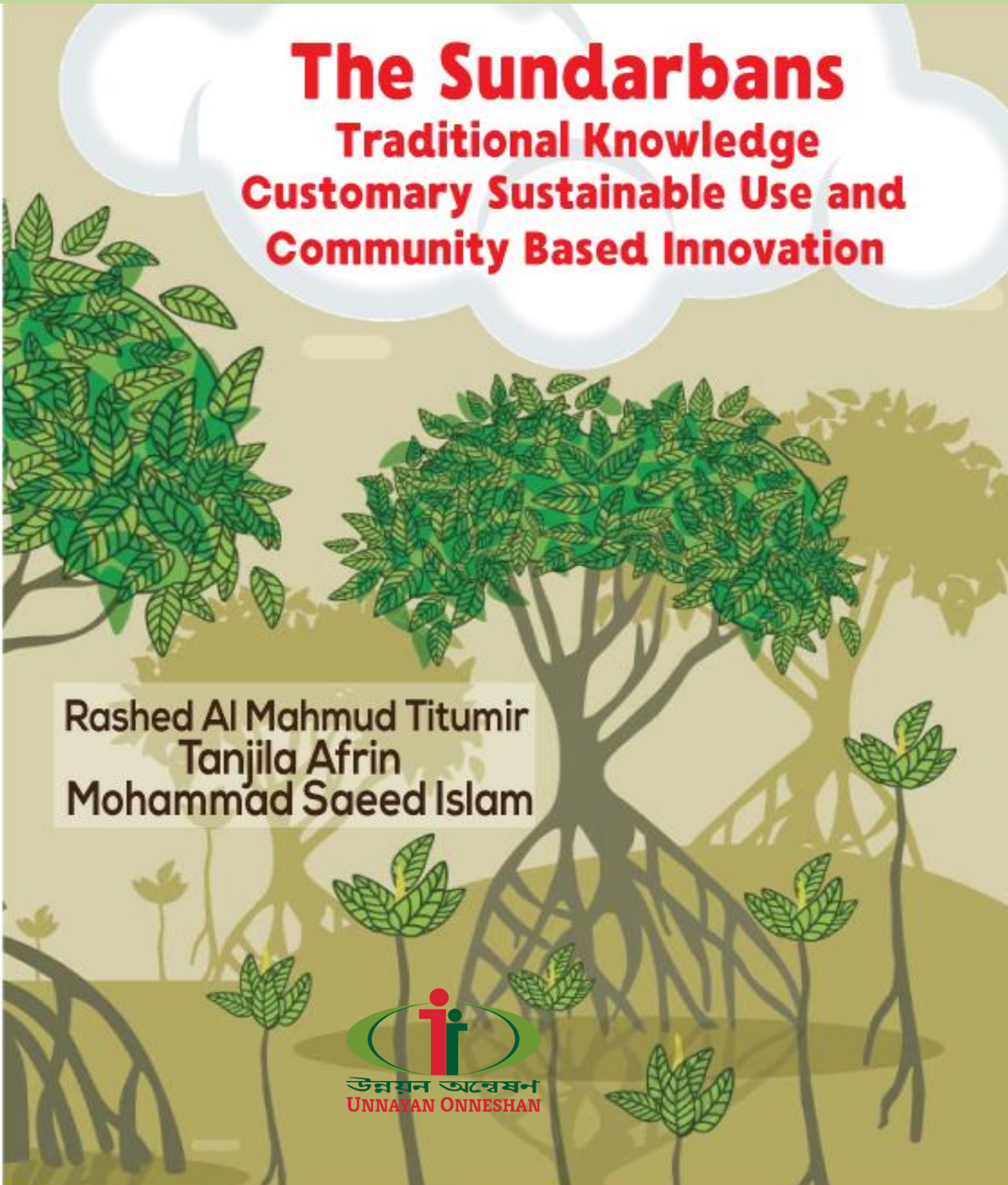
The Sundarbans

Traditional Knowledge Customary Sustainable Use and Community Based Innovation



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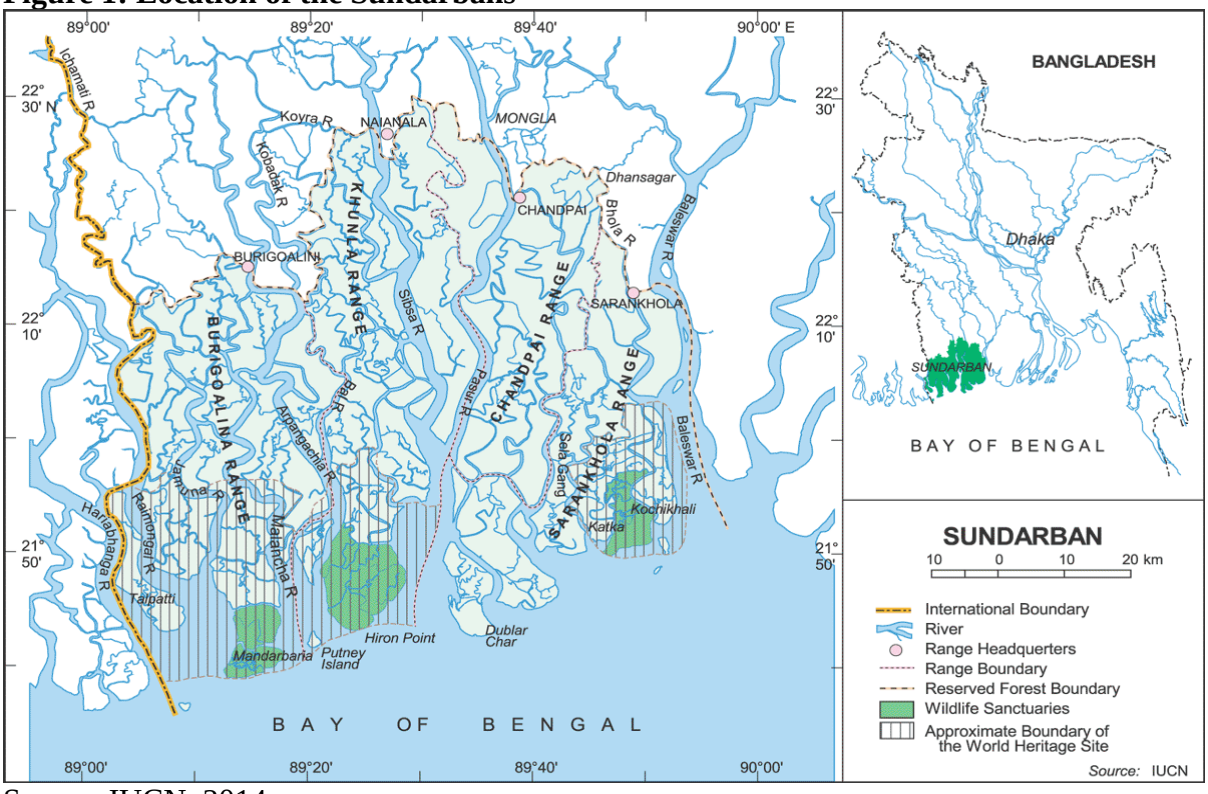
CHAPTER ONE
Current State: Evidence of Resource Vulnerability

Profile of the Sundarbans

The Sundarbans is located at the great delta of the Ganges, Brahmaputra and Meghna (GBM) rivers at the edge of Bay of Bengal and is the largest contiguous single-tract mangrove ecosystem in the world (Figure 1). It is a symbol of majestic beauty, tranquillity and wilderness of nature and a hotspot of biodiversity. It is located in the southwest corner of Bangladesh, between $21^0$30' and $22^0$30' North and $89^0$00'and $89^0$55' East (Islam, 2010). A significant part of the total area of this mangrove, however, lies within India (West Bengal State). The Bangladesh portion is larger than the portion in India, with an area of 6,071 km^2 (62 per cent of total area), and which constitutes 39.5 per cent of the total forest area of Bangladesh (Roy &Alam, 2012).

Of the Bangladesh part, 70 per cent is land area and the rest (30 per cent) is water (Kabir & Hossain, 2008). The wetlands of the Sundarbans consist of about 200 islands separated by about 400 interconnected tidal rivers, creeks and canals (Rahman, et al., 2010). The Sundarbans was recognized as a Natural World Heritage Site (1, 39,700 hectares of forest land comprising Sundarbans East, Sundarbans West and Sundarbans South)in 1997 by UNESCO and as a Ramsar Site of international importance in 1992 (IUCN, 2014). It was also included for the selection of 7wonders of the world.

Figure 1: Location of the Sundarbans



Source: IUCN, 2014

Biodiversity Resources of the Sundarbans

The combination of various types of ecosystem (forest, coastal and wetland) makes the Sundarbans a home to several uniquely adapted aquatic and terrestrial flora and fauna. The Sundarbans is unique in terms of supporting viviparous plant species. It harbours 334 species of trees, shrubs, herbs and epiphytes and about 400 species of wild animals (Behera & Haider, 2012).

Of the 50 true mangrove plant species recorded throughout the globe, the Sundarbans alone contain 35 species (Rahman & Asaduzzaman, 2010). The Sundri (*Heritiera fomes*) is the most climax tree species upon which it is named. Other prominent species are: Gewa (*Excoecaria agallocha),* Baen *(Avicinnia officinalis),* Passur (*Xylocarpus mekongensis*), Keora (*Sonneratia apetala*), Goran (*Ceriops decandra*), Ora (*S. caseolaris*) and Hental (*Phoenix paludosa*). The Sundarbans also offers high value non-timber forest products like Golpata (*Nypa fruticans*), honey, wax etc. It is the largest honey producing habitat in the country with giant honey bees (*Apis dorsata*). There are about 13 and 23 species of orchards and medicinal plants also exist in this forest.

This forest region is also rich in its faunal diversity. There are 448 species of vertebrates including 10 amphibians, 58 reptiles, 339 birds and 41 mammals (DoE, 2015). This forest provides habitats for diverse aquatic wildlife such as the estuarine crocodile (*Crocodylus porosus*), turtles (*Lepidochelys olevacea*), dolphins (*Platanista gangetica* and *Peponocephala electra*) and molluscs like the giant oyster (*Crassostrea gigas*). The rich avifauna of the forest includes mangrove pitta (*Pitta megarhyncha*), mangrove whistler (*Pachycephala grisola*), brown-winged kingfisher (*Halcyon amauroptera*) and collared kingfisher (*Todiramphus chloris*) (Khan, 2005). Some other species are purple heron, pond heron, cattle egret, little egret, spotted dove, tailor birds, magpie robin, woodpeckers, barbets, bee-eaters, bulbuls, shrikes, starlings, babblers, thrushes, orioles, flycatchers etc. (Kabir & Hossain, 2008; Rahman & Asaduzzaman, 2010). Nevertheless, the Royal Bengal Tiger (*Panthera tigris*) is the most magnificent animal. According to the census of 2004, around 440 tigers resided in the Bangladesh part while the most recent estimate puts such to around 106 tigers (Bangladesh Foreset Department [BFD], 2015)[1]. It is also home to thousands of spotted deer (*Axis axis*) and barking deer (*Muntiacus muntjak*). Other animal species are wild boars (*Sus scrofa*), monkeys, jungle cats (*Felis chaus*), rhesus macaque (*Macaca mulata*),otters (*Lutrapers picillata*), fishing cat, civet cat, bengal fox and jackle.

These biotic along with other abiotic resources of the Sundarbans contribute directly or indirectly to the economy both at local and national levels. Figure 3 shows how the resources of the Sundarbans have been utilized for different purposes, contributing both to the lives and livelihoods of local people and to the economy of the country.

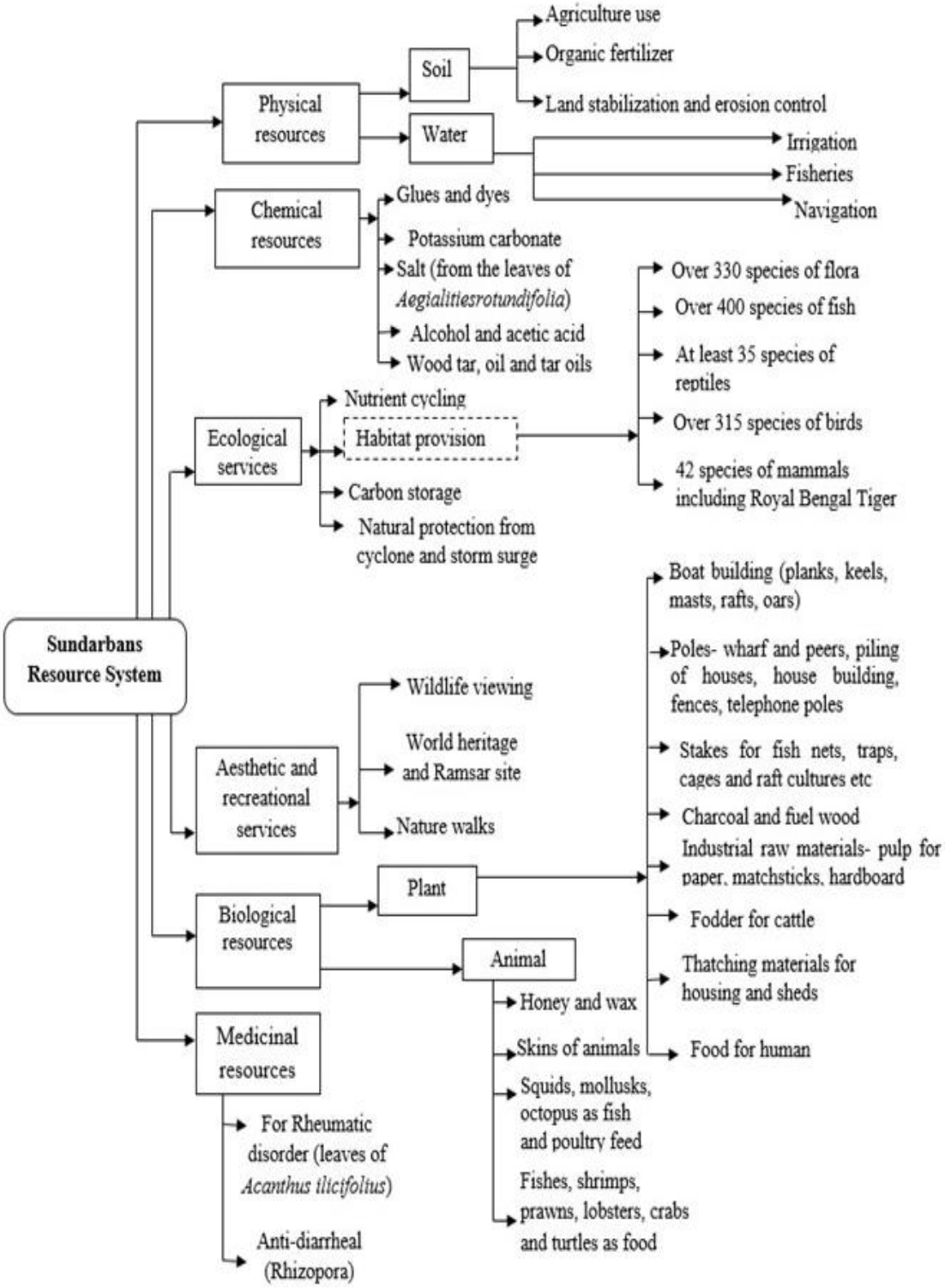
Wood and golpata collectors (*Bawalis*), fishermen (*Jele*), honey and wax collectors (*Mouals*), shell collectors (*Chunary*) and crab collectors are among the major occupational groups of the

[1] *The Guardian*, 27 July 2015.

adjacent forest region. The lives and livelihoods of these local people are mainly related to the physical and biological (or, biodiversity) resources as depicted in Figure 3.

Figure 2: A Honeycomb in the Sundarbans, Source: Unnayan Onneshan, 2018

Figure 3: The Sundarbans resource system



Source: Unnayan Onneshan

Current State: Evidence of Resource Vulnerability

The Sundarbans has been experiencing major ecological and physiographical changes due to both anthropogenic pressures and natural disorders which are taking a heavy toll on the regenerative capacities of the forest and its ability for maintenance of sustainability. Such pressures have been resulting in the continuous decline of the forest coverage and of its biodiversity resources. This section attempts to present this trend of declination of resources as well as the driving forces that have caused this declination.

Trend of biodiversity resources of the Sundarbans

The world's largest stretch of mangrove ecosystems is facing serious threats of loss of biodiversity in the face of man-made pressures and natural disorders. Some studies argued, however, that although the boundary of the Sundarbans is almost unchanged, its quality is degrading (Hussain & Karim, 1994; Siddiqi 2001; Iftekhar & Islam 2004b). A recent study by Aziz & Paul (2015) has also indicated that from 1970s to 2000s a non-significant decrease (1.1%; 66 km^2 of 6017km^2) can be observed in the forestlands of the total Sundarbans based on Landsat satellite data. The same study has also reported based on Landsat images and GIS data from 1989 to 2010 at the extreme northern part of Khulna and Chandpai ranges and revealed that formation of a large number of small rivers and creeks shortly before 2000 reduced the 443 km^2 forestland by 3.61%, *H. fomes* by 28.75% and total tree cover by over 3.0%.

Table 1: Changes (in ha) of forest cover, marsh and water area from 1989 to 2000 and 2010, determined by GIS technique at Khulna and Chandpai ranges (one spot from each and together).

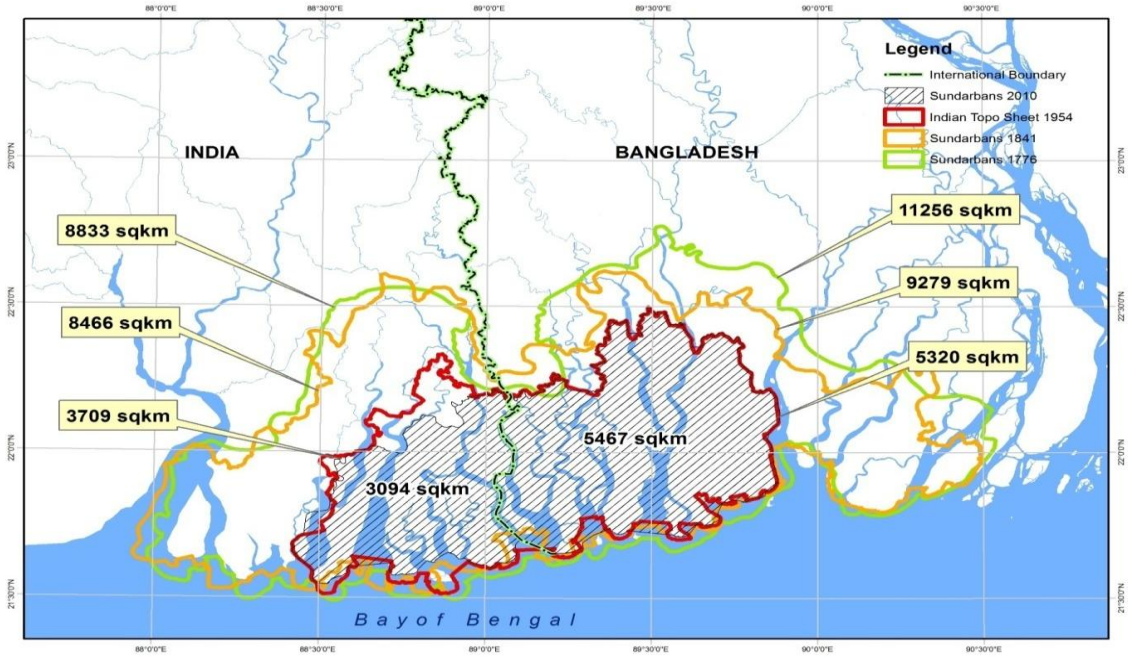
Classes	Plant cover and water area			Changes		
	1989	**2000**	**2010**	**1989-2000**	**2000-2010**	**Overall**
Heritiera fomes	23,028	19,309	16,408	−3719 (16.15)	−2901 (15.02)	−6620 (28.75)
Excoecaria agallocha	15,184	15,828	16,200	644 (4.24)	+372 (02.35)	+1016 (6.7)
Sonneratia apetala	44	1906	109	+1862 (4231)	−1797 (94.28)	+65 (148)
Bruguiera sexangula	191	8169	3026	+7978 (4177)	−5143 (63)	+2835 (14.84)
Marshes	-	387	585	+387 (100)	+198 (33.85)	+585 (100)
Shrubs	570	463	367	−107 (18.77)	−96 (20.73)	−203 (35.61)
Water	4727	5581	6009	+854 (18.07)	+428 (7.67)	+1282 (27.12)
Total area	44,301	44,328	42,704	+27 (0.06)	−1624 (3.66)	−1598 (3.60)

* Values within parentheses is percent
Source: Prepared based on Ahmed et al., 2011 and Aziz & Paul, 2015

From the above table (Table 1), it can be observed that Sundari *(H. fomes)* tree has been declined in both the time span of 1989-2000 and 2000-2010. The percentage of declination (28.75%) is the highest among all types of floral species. Gewa (*Excoecaria agallocha),* another prominent species of flora, is found to be increased in numbers of the years. The increasing rate, however, is quite small (6.7%). According to a tree survey conducted between 2008 - 2014, the most abundant mangrove was *E. agallocha* (59.69% of total trees), followed by *H. fomes* (30.89%), *C. decandra* (6.12%), and *X. mekongensis* (0.82%) (Sarker et al., 2016). The key cause of decrease of *Sundari* and increase of *Gewa* and *Goran* plants can be stated as the result of increase in salinity of the forest land. Some other species are also found to be increased in percentage except marshes. The water area is also found to be in an increasing trend. The overall change of the total area signifies a negative trend (by 3.60%); though during 1989-2000 the total area was found to be increased.

A recent study by Islam (2014) also showed, by analysing the vegetation cover of Sundarbans (1975-2006) using Landsat imagery during 1975-89 and 1989-00, that the land area was decreased by ~5.1% and ~ 4.5%, respectively and then during and 2000-06, it was increased by ~3.9%. Another study estimated the mangrove forest coverage (gain and loss) from 2000 to 2012 in South Asia using Landsat satellite data and it showed that from 1970 to 2000 the forest coverage of the Sundarbans decreased by 1.2%. But during 2000-2012 net deforestation has slowed down, and this happened partly because of increased awareness and plantation and forest protection initiatives, as the study argued (Giri et al., 2014). These are two studies which offer a positive picture of the total coverage of Sundarbans. Islam & Gnauck (2009), on the contrary, reported that in 1776, the size of the Sundarbans was 17,000 km² and at present it is almost half the total area.

Figure 4: Mangrove forest change of the Sundarbans from 1776 to 2010



Source: Joint Landscape Narrative by India and Bangladesh, CEGIS, 2016

A recent report (CEGIS, 2016) also shows the declining trend of the forest areas in both of India and Bangladesh from 1776 to 2010 (Figure 4). Reduction of volume of important tree species of the Sundarbans can also be analyzed through forest inventories (Table 2). Three important inventory reports on the Sundarbans were prepared in 1959, 1983 and 1996 (FAO, 2011). The trend of growth of trees in each case is found to be declining. The Sundari growing stock has declined by 50% and Gewa growing stock by 67% in 37 years (between 1959 and 1996).The growing stock of trees, on a whole, has declined by 51% and the rate of depletion is roughly 1% per year.

Table 2: Growing stock of the Sundarbans according to different inventories

Year of publication of inventory results	Inventory done by	Sundari (number of trees per hectare)	Gewa (number of trees per hectare)	All tree species (number of trees per hectare)
1959	Forest and Forestal Engineering, Canada	211	61	296
1983	Overseas Development Authority	125	35	180
1996	Forest Resource Management Project, FD, GoB	106	20	144

Source: FAO, 2011

The Sundarbans is also the provider of several types of non-wood forest products (NWFPs). The following table (Table 3) shows the production trends of main NWFPs of the Sundarbans over a period of time.

Table 3: Production trends of the main NWFPs of the Sundarbans

Year	Golpata (in million kg)	Hental (in tonnes)	Honey (in tonnes)	Fish (in tonnes)	Shell (in tonnes)
1980-81	2.48	6.20	311	-	-
1986-87	2.63	6.10	229	6.80	1.10
1989-90	2.48	7.20	147	5.10	1.64
1990-91	2.63	6.70	211	4.80	1.64

Source: Adapted from Roy 2009 and Roy &Alam, 2012

The table shows that the production of Golpata increased in 1986-87 compared to 1980-81 but decreased in 1989-90 again. The production again increases during 1990-91. A similar trend of fluctuations of increase and decrease can be noticed in case of production of Hental and honey.

Most importantly, production of fish is found to be decreased over the years. Production of shells, however, remained constant to some extent.

The degradation of floral diversity also puts negative impacts on the faunal diversity. The forest structure is becoming simpler and the average height ofthe trees is decreasing which causes a decline in the habitat for birds, monkeys and other treed welling species. As many as 20 globally threatened species inhabit the Sundarbans. One of the world's most endangered turtle species *Batagur baska*is found in the Sundarbans (Behera & Haider, 2012). Two other endangered cetacean species are Ganges river dolphin (*Platanista gangeticus*)and Irrawaddy dolphin. Other threatened wildlife species are Bengal tiger, python, King cobra, Adjutant stork, White-bellied sea eagle, Clawless otter, Masked fin-foot, Ring lizard and River terrapin, Fishing cat, Spoon-billed sandpiper, eagle and lesser adjutant (Hossain, 2014 as cited in DoE, GoB, 2015).Aziz & Paul (2015) reported a total of over 40 species of amphibian, reptilians; avis and mammalian are listed as critically endangered or vulnerable. The most important faunal species, the Royal Bengal Tiger, is also enlisted as an endangered species by the IUCN and in fact a very limited number of tiger is available in this forest at present which signifies the extinction of it in the near future. The following table (Table 4) provides, here, a list the animals which became extinct in the last 100 years of the Sundarbans.

Table 4: Floral species that became extinct in Sundarbans

Scientific name	Local name
Rhinoceros sondaicus	Javan rhinoceros
Bubalus bubalis	water buffalo
Cervus duvauceli	swamp deer
Bos gaurus	Guar
Axix porcinus	hog deer
Crocodiles palustric	marsh crocodile

Source: Adapted from Behera & Haider (2012)

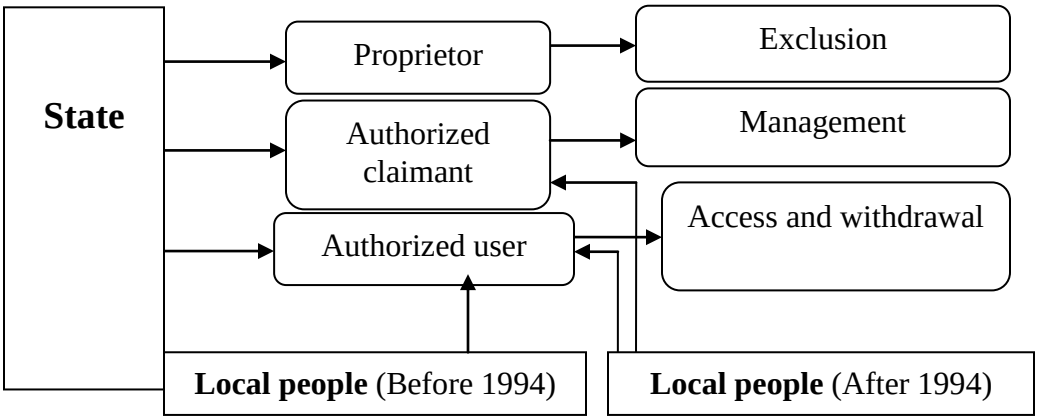
It is clear, therefore, that the Sundarbans has been losing its value gradually in terms of loss of its extent or coverage as well as in terms of its rich biodiversity resources. In the following sub-section the current management approach has been critically scrutinized to find out the major problems and challenges in case of ensuring sustainable utilization and conservation of the biodiversity resources of the Sundarbans.

Current management approach and associated problems and challenges

The previous sub-section exhibits the declining trend of resources of the Sundarbans though there is a particular management approach for the conservation of this mangrove forest. The forest was declared as Reserved Forest (RF) during British regime and in the post independence period also (after 1971) it was again declared as RF under the Forest Act of 1927 where everything was prohibited without any formal permission. The key management right, therefore, has been remaining under government control. Forest policy of 1994, however, recognized the community participations in the management process and also recognized the rights of the local people. The property rights structure of the Sundarbans, thus, cannot be defined in terms of specific type of property (common or public) rather the rights are being distributed among the state authority and local people. The overall structure of property rights can be explained through

a diagrammatic representation prepared based on Schlager & Ostrom's (1992) typology of bundle of property rights (Figure 5).

Figure 5: Property rights structure of the Sundarbans



Source: Prepared by the authors

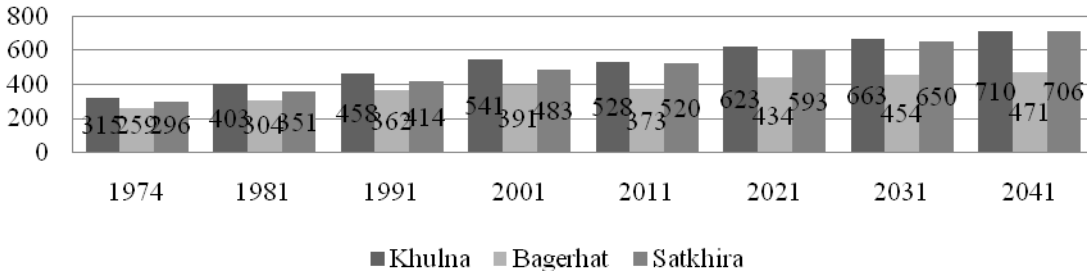
The Sundarbans has been taken under government control with a view to conserving the resources from the over use of the people. The state authority, particularly the Forest Department (FD) has taken the responsibility to ensure the efficient use of resources of the Sundarbans. The TRUs have the right to access and use resources only with regard to the permission of FD. More specifically, the local people had only the right to access and withdrawal before the adoption of 1994 Forest Policy. Since 1994 the local people have been recognized as authorized claimant at policy level. It signifies that they have management rights also along with the access and withdrawal rights. According to the policy, under a co-operative mechanism the people should have been consulted in terms of determining the management policy of the forest resources as they have the right to regulate the internal usage pattern of the resources. The practical scenario signifies that this formal institutional arrangement is not stable. The local people are hardly consulted in the decision making process. They also have to face many barriers to exercise their rights to have access inside the forest in harvesting the resources. On the contrary, the state authority (FD) has been exercising the rights as owner, proprietor, authorized claimant as well as authorized users. Under this management framework the conservation process of the resources are so far found to be ineffective. The management approach largely fails to halt the degradation process of the resources. Several challenges have been emerging continuously. The major drivers or causes of the excessive extraction or degradation of the resources have been tried to present below in brief.

- Increasing habitation and illegal encroachment

The existence of instable and ill-defined property rights creates scope for the politically and economically powerful groups to encroach into the forest of the Sundarbans in illegal ways. The Sundarbans, particularly, locates within thethree districts of Khulna, Shatkhira and Bagerhat. The density of settlement across these three regions has been increasing over the years and the trend will continue as the projection indicates (Figure 6). Shear dependence on natural resources of the

Sundarbans, therefore, is also increasing. Such increasing habitation is largely an outcome of fragile property rights regime by the community over this ecological landscape. A significant number of migrated people find it possible to encroach into the forest and therefore, intend to live in the nearby districts of the Sundarbans.

Figure 6: Population density in the districts encompassing the Shundarbans (in number)



Source: Author's calculation based on population census of 2001 and 2011 by BBS (2011)

They are not the indigenous local people and therefore, they do not respect the local customary practices to conserve the forest resources and always intend to extract the resources as much as possible and thus enhances the process of degradation. Moreover, politically and economically powerful groups are also found to continuously encroach into the forest region by making coalition at different levels.

- Land shortage, land reclamation and shrimp cultivation

The land area of Bangladesh is not much large and therefore, there is always a competition to capture the land resources. In this process, the politically powerful ones have larger scope to exercise their choices. The adjacent regions of the Sundarbans are potential sites for shrimp cultivation due to the availability of saline water. But, this conversion of land into commercial shrimp farming is the largest human threat to the balance of the mangrove ecosystem of the Sundarbans.

- Rent-seeking tendencies and extralegal management

Forest Department officials reportedly harass collectors of forest produce for extra tolls. There is evidence on the cutting and selling of trees by timber traders and smugglers, and the killing of animals by poachers with the alleged involvement of forest officials.

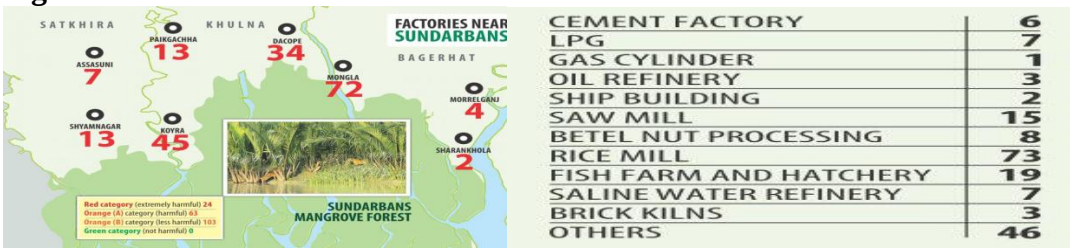
- Marginalization of local and indigenous people and existence of poverty

The current management system marginalized the local and indigenous people to exercise their rights. Forest Department is characterized by elitist and bureaucratic culture and has rigid, hierarchical and top-down working practices. In this process, the TRUs can hardly enrich their economic conditions as in one hand they cannot cultivate resources according to their needs and on the other hand have to spend money for giving extra tolls, bribes and for other illegal claims by the locally powerful ones (e.g. high interest rate of money lenders, money claimed by dacoits). As a result of that, the TRUs often are bound to extract resources beyond the sustainable limit as they have to survive.

- Industrialization and development projects near (or around) the forest

In recent decades, powerful agents at both national and international levels have successfully pursued the government to approve many development projects. Going against its own policy, the government over the last few years permitted setting up of 190 industrial and commercial units in the ecologically critical area (ECA) of the Sundarbans, which poses a serious threat to the biodiversity. The government declared the 10-kilometre periphery of the mangrove forest as the ECA in 1999, after the UNESCO listed it as a natural world heritage site. As per Bangladesh Environment Conservation Act 1995 (amended in 2010), no one is allowed to set up any factory in the ECA.

Figure 7: Factories near the Sundarbans



Source: The Daily Star, 6 April 2018

Most of these agents and interest groups of land grabbers are businessmen and industrials units who have powerful political linkage. The most recent and controversial project is the 'Rampal Power Plant Project,' a coal-based power plant, fraught with triple jeopardizes in the three domains of environment, economic and technical feasibility, which may cause dangers to the integrity of the Sundarbans. The project is under the process of implementation.

- Climate change and natural disasters

Climate change puts negative impacts by increasing the salinity of water and soil composition of this mangrove forest ecosystem. It is also becoming vulnerable to sea-level rise, which is also a resultant of climate change. A projection by CEGIS (2005) signifies that the most bio-diverse areas in the Sundarbans will be reduced from 60% to 30% in the year 2100 with 88 cm sea level rise. In the worst-case scenario, Mohal et al. (2006) in their paper projected that 32 cm of sea level rise may flood 84% of the Sundarbans possibly by 2050 and with an 88 cm sea level rise possible by 2100 the whole of Sundarbans will be lost.

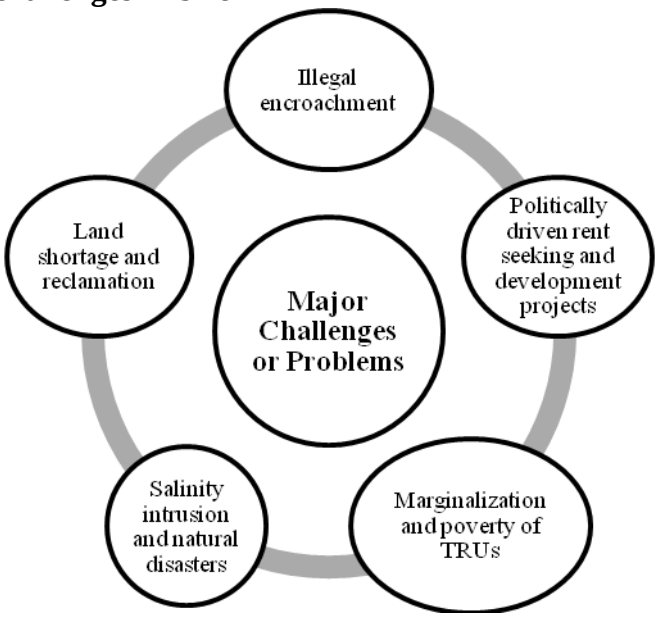
Moreover, the natural disasters mainly cyclones have increased in frequency and intensity that also have been taking a heavy toll on the Sundarbans. The Sundarbans, being located at the apex of the Bay of Bengal, places it in the immediate path of cyclonic storms. During the last 135 years, more than 45 cyclones have crossed the coastal belt of Bangladesh, of which 13 trekked through the Sundarbans (BFD, 2010). Cyclone, *Sidr* and *Aila*, among the most devastating cyclones of recent past, mainly caused by the climatic disorder, had a devastating effect on the coastal zone of Bangladesh and particularly on the Sundarbans.

Sidr hit Bangladesh's south-west coast on 15 November, 2007 and the incurred loss from this single event was estimated to be USD 1.7 billion or 2.6% of GDP (Shamsuddoha et al., 2013).The cyclone caused huge damage to the Sundarbans in terms of biodiversity loss and physical infrastructure damage. It hit the eastern parts of the forest, especially the Chandpai and

Sarankhola range including the Kochikhali, Kotka, Hiron point, and the Dublarchar,leaving a trail of severe devastation[2]. According to the Forest Department, one fourth of total forest area had been damaged; specifically, 8% - 10% had been destroyed completely, while 15% had been partly damaged[3].Another report claimed that around 1,900 sq. km. (31% of total Sundarbans area) was affected by Sidr (CEGIS, 2007). Land change (due to *Sidr*) analysis by Bhowmik and Cabral (2013) has shown that three important floristic taxa - Sundari, Gewa and Kewra have been significantly affected by this cyclone. The Sundarbans, in fact, absorbed the main blow of the *Sidr*, saving human lives by slowing down nature's wrath.

Cyclone *Aila*, occurred on 25 May, 2009 had also disastrous impact on the Shundarbans, mainly on the western part. The wave hitting the Sundarbans was 20 feet high (>6 meters). Alarge numbers of trees were uprooted and several species of flora and fauna lost their lives. Many animals have been washed away by the tidal surges created by cyclones or fall under the broken trees. The dead animals again caused environmental hazards to the remaining ecosystem. Cyclones, thus, have caused tremendous disruption to the wildlife as well as other biodiversity resources of Sundarbans.

Figure 8: Major challenges in brief



Source: prepared by the authors

The above figure tries to present the major challenges or problems that exist in the current management framework for the conservation of the resources of the Sundarbans (Figure 8).
It can be said, as a whole, that a long-term ecological change is taking place in the Sundarbans. The illustrations of this section, firstly has outlined the *structure* of the forest by describing the key characteristics of this mangrove ecosystem including its location and dynamic nature of different types of habitats (forest, wetlands, coastal). The diverse *benefits* the Sundarbans provides in the forms of maintenance of biodiversity and supply of goods and services are

[2]*The Daily Star*, 17November, 2007
[3]*The Daily Star*, 20 November, 2007

highlighted thereafter. The last part shows the major *changes* of the Sundarbans, resulting from the interactions between people and nature[4]. The Sundarbans, thus, can be identified as a Socio-Ecological Production Landscape and Seascape (SEPLS) (Table 5) that has continuously been threatened resulting from different pressures.

Table 5: Sundarbans as a SEPLS

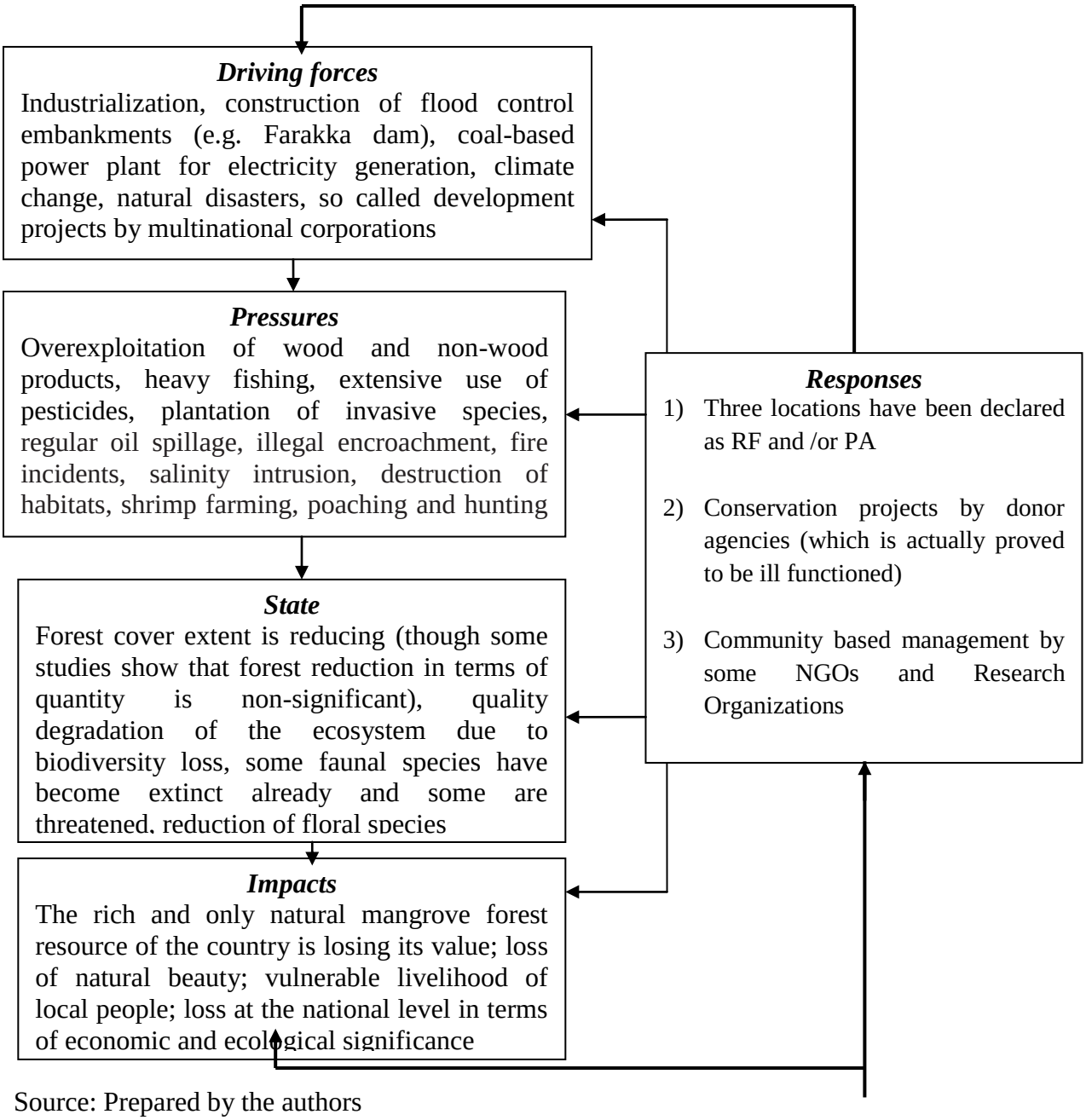
Indicators	Relevant to Sundarbans?(Yes/No)	Why Relevant?
Mosaic of production landscape/seascape	Yes	It is a mangrove forest that includes forest, coastal and wetland ecosystems, supporting diverse production activities.
Harmonious interaction between human and nature and well-being of both	Yes	It provides the IPLCs different options for maintaining livelihoods and the IPLCs provide protection to the forest and its' resources through traditional livelihood practices.

Source: Prepared by the authors

The overall scenario of the Sundarbans can also be depicted in the following diagram (Figure 9) under the DPSIR Framework as:

[4]The three perspectives drawing on the SEPLS concept- *structure, benefits and changes*- deepen understanding on various types of production landscape and seascapes(Ichikawa, 2013).

Figure 9: Present state of the Sundarbans



Source: Prepared by the authors

Figure 10: Golpata *(Nypa fruticans)*, Source: Unnayan Onneshan, 2018

Figure 11: Tow Jele (Fishermen), Source: Unnayan Onneshan, 2018

CHAPTER TWO
Role of "Traditional Knowledge" of Traditional Resources Users (TRUs) in Effective Conservation, Sustainable Utilization and Restoration of Biodiversity Resources

Introduction

The mutuality between human sociality and nature can be ensured in one way in which the local and indigenous people apply their traditional ecological knowledge (TEK) to sustainably utilize the resources of that locality or ecosystem because, traditional knowledge is generally accumulated through the experiences of close contact with the natural environment. In line with this, it can be argued that local people know the best strategies to use the resources in a sustainable way and they try to do it for the sake of the protection of themselves in the future life. They follow some specific rules and practices in harvesting resources based on their traditional knowledge. Then, they have also some traditional customs and beliefs which are also relevant to resource conservation. Finally, they also are involved in innovation process of newer techniques and methods based on their own knowledge for cultivating crops in the challenging situations, particularly in the context of changing pattern of climate and natural environment. Against this backdrop, the following discussion are divided into three parts: (1) Traditional rules and practices followed by TRUs during the harvesting of resources; (2) Cultural beliefs of TRUs and indigenous communities; (3) Innovations in livelihood options.

Traditional rules and practices followed by TRUs during the harvesting of resources

This sub-section illustrates that traditional rules and practices of harvesting lead the TRUs to harvest the resources of Sundarbans in a manner that is fully compatible with the requirements of conservation and sustainable use. The communities sensibly believe that the forest provides their livelihoods and that it must be protected from all sorts of misuse and abuse for the present and future generations. Therefore, they follow certain rules according to which they harvest resources with the utmost care and love for the nature.

Rules followed by Mouals (honey/wax collectors)

Honey is considered to be an important non-wood forest product. The giant honeybee (*Apis dorsata*) is the principal honey producing species of the SRF. When collecting honey from honeycombs, usually during the months of April, May and June, the *Mouals* (honey/wax collectors) usually cut a specific section (about two-thirds) of the honeycomb and leave the rest for reproduction. They also try to make sure that no young bees are killed while collecting honey and squeeze beehives by hand, never using metal tools. They revisit the colonies after a period of one month or more depending upon the size of the colony and the flowering conditions of nearby vegetation. When collecting the honey, the *Mouals* produce smoke using dry leaves but never put fire on beehive.

Rules followed by Bawalis (wood collectors)

The *Bawalis* (wood collectors) leave at least one stem in each clump of trees after cutting. Once the *Bawalis* have harvested wood from a compartment, they will not use the same compartment

for harvesting the following year but will harvest on a cyclical basis so that there is an adequate re-growth of plants. They usually cut wood where there is abundance. They do not cut young and straight trees.

Traditional practices of Golpata (Nypa fruticans) harvesters

According to the rules followed by *Golpata* harvesters, exploitation in any area is not allowed more than once a year and is not allowed during June to September specifically as it is the growing period of *Golpata*. They cut only leaves that are approximately nine feet long, and the leaves are cut in a way so that the central leaf and the leaf next to it in each clump are retained. They maintain the rule that the flowers and fruits shall in no way be disturbed when cutting leaves. They also maintain that young plants with only one utilizable leaf should not be cut.

Customary rules followed by Jele (traditional fishermen)

The *Jele* (traditional fishermen) know that catching fry (young fish) will ultimately deplete the number of fishes in the water bodies and thus they try to avoid doing so. They usually do not use *jal*/nets (very small-meshed nets). Rather, they use nets *behundijaal* (bag nets) or *char-paataa* and *khaal-paataajaal*(stake nets), which have been innovated and customized scientifically to benefit the Sundarban's unique waterscape. They use big-meshed nets for rivers and small-meshed nets for closed water bodies. They do not catch all species of fish and also avoid fishing during spawning periods.

Figure 12: Traditional rules and practices followed by TRUs at a glance

Source: prepared by the authors, Titumir& Afrin, 2017

Cultural beliefs of TRUs and indigenous communities

Bawalis

The *Bawalis* believe that this tidal forest is a sacred place and that the Creator washes the forest twice a day and maintains its sanctity. Irrespective of religion they believe in the existence of *Banabibi* (the main Goddess of the Sundarbans) and other Gods and Goddesses. They feel that their minds become cool when they stay in the forest. When the *Bawalis* cut wood, they are guided by such beliefs and try to maintain sustainable use of the forest.

Mouals

The *Mouals* also believe in *Banabibi's* existence and pray to her while entering into the forest by asking for honey and their safe return as many of them die every year in the deep of the Sundarbans in their venture for honey hunting because of tigers. The Hindus, however, also believe that there is another special God for honey whose name is "*Dakshina Roy*". So, they offer prayer to that God. Thus, the *Mouals* as a whole consider the forest region a holy place because of existence of God and Goddess and therefore try to keep the forest safe and pure and use the resources accordingly. Honey is a sacred food to them and therefore, they are careful not to adulterate honey.

Traditional fishermen

Fishing community, like other resource users' groups, consider the forest as a holy place. The specific reasons are: (a) as nobody lives inside the forest, no sinful acts occur there; (b) they also believe God and Goddesses live inside the forest; (c) they strongly believe that the forest is a gift of God for them.

Munda community

The *Mundas* are the particular indigenous people who were the first people to settle near the Sundarbans area. They consider themselves as part of the forest. They believe the outsiders have destroyed the whole ecological and social balance of the area, and the *Mundas* want to keep their own land, forest and natural resources limited to them.

Figure 13:Community Resource Centre of the Munda Community © Loban Rahman, *Unnayan Onneshan*

Figure 14: Glorious History of Munda Community © Loban Rahman, *Unnayan Onneshan*

Innovations in livelihood options

In addition to the above-discussed traditional rules, practices and cultural beliefs, the IPLCs have diversified their livelihood options by utilizing their traditional knowledge and experiences. They continuously try to cope with changing conditions through initiating innovative management practices.

Innovative techniques in agriculture

Local small farmers grow their rice seedlings in raised land with less risk of saline water contamination to ensure maximum survival before transplantation in fields. The local communities harvest rice plants at 8 to 12 inches high from the ground, responding to high salinity contents in soil and water. Then, since most of them are landless, local small farmers grow vegetables on sheds or roofs, in yards or the backyards of their houses. These techniques are adaptive to local biophysical conditions while ensures environmental sustainability.

Community-based Mangrove Agro-Aqua Silvi (CMAAS) culture

CMAAS refers to the practice of integrated cultivation of some mangrove faunal species such as crabs, oysters or fishes (e.g.: shrimps, *bhetki* [*Latescal carifer*]) and floral species such as *golpata*(*Nypa fruticans)*, *keora* (*Soneratia apetala*), and *goran* (*Ceriops decandra*), at the same time on any swampy land of brackish water. In addition, integrated cultivation of some mangrove floral species like *golpata* and a few faunal species like tengra (*Mystus tengara*), *baila* (*Awaous guamensis*), and tilapia (*Tilapia nilotica*), are practiced on fresh water swampy land.

Figure 15: A CMAAS Farm © Loban Rahman, *Unnayan Onneshan*

Figure 16: The Pioneer of CMAAS Culture-Khaibar Sardar in his farm © Loban Rahman, *Unnayan Onneshan*

CMAAS culture is found to be more profitable and have negligible environmental impacts, whereas commercial shrimp culture is cost effective but wreaks havoc on the environment. The economic and ecological returns of CMAAS culture are presented in Table 6.

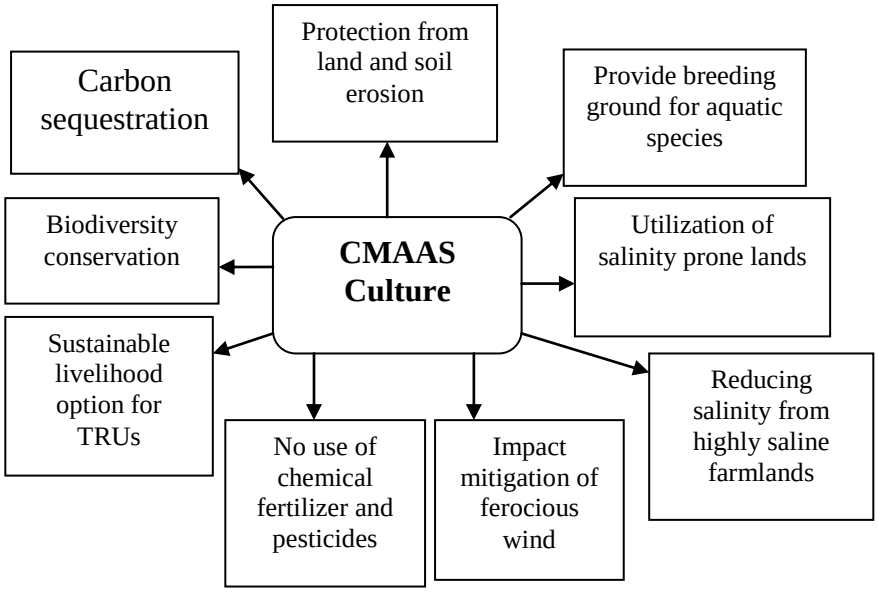
Table 6: Economic returns of CMAAS culture

CMAAS		
Economic Returns (Benefits>Cost)	**Mangrove Cultivation (flora):** Total income (per *bigha*/per year): BDT 56,250 Total cost (per *bigha*/per year): BDT 1,800 Net benefit: BDT 54,450 Cost Benefit Ratio: 1:32	**Mangrove Aqua Farming (fauna):** Total income (per *bigha*/per year): BDT 183, 000 Total cost (per *bigha*/per year): BDT 14,750 Net benefit: BDT 173,250 Cost-Benefit Ratio: 1:12

Note: A *bigha*, a unit of land measurement, is 1,600 yd^2 (0.1338 hectares or 0.3306 acres) and is often interpreted as being 1/3 acre (precisely 40⁄121 acres). In metric units, one *bigha* is hence 1,333 m^2.
Source: prepared based on findings of research by UO, 2010

Apart from the economic returns the CMAAS culture also offers a number of invaluable ecological services (Figure 17).

Figure 17: Ecological services of CMAAS culture practice



Source: Prepared by the authors based on data reservoir of *Unnayan Onneshan*

The CMAAS culture is generally practiced in lowlands (near the homestead of the local people) which were hardly used for any productive purpose during previous time. Moreover, many agricultural lands of the coastal region now become saline contaminated due to climate change and natural disasters (e.g. cyclone like *Sidr* and *Aila*) and in which lands it is impossible to grow any traditional crops varieties with extreme salinity level, let alone the paddy cultivation.

These lands can be successfully used for CMAAS culture. CMAS culture, therefore, deserves to be recommended as one of the best coastal adaptation practices.

The CMAAS culture, as a whole, is more economically profitable, environmentally beneficial and socially acceptable than commercial shrimp culture in the coastal region of the Sundarbans. In fact, it may be the best alternative to traditional paddy and commercial shrimp cultivation as it is more profitable and does have less bad impact on local environment and biodiversity. The culture is a unique adaptation method in the face of climate change in the coastal region and the local people are the ones who have invented this method.

Joint cultivation of crab and duck

As the TRUs are often restricted to enter into the forest for resource harvesting they have to find out alternative sources of livelihoods and a recent practice is the joint cultivation of crab and duck in one farmland. This practice is so far found to be much profitable for the cultivators. However, intensive research needs to conduct on this practice to understand its actual potentiality in terms of both economic and environmental sustainability.

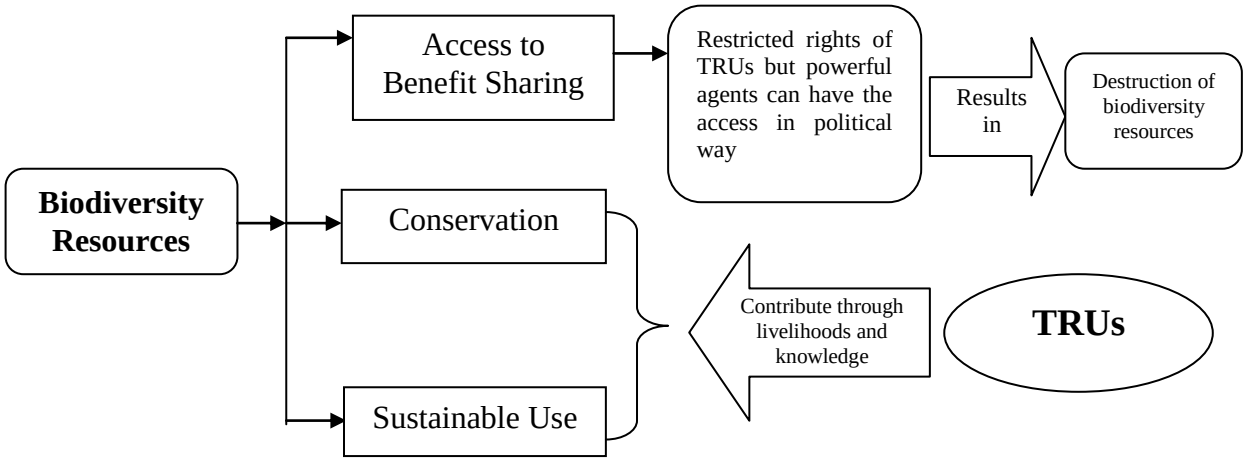
Figure 18: Crab Culture © Loban Rahman, Unnayan Onneshan

Figure 19: Crab Culture 2 © Loban Rahman, Unnayan Onneshan

Discussion

The Local and Indigenous Peoples or TRUs have limited rights to access to the benefits that can be acquired from the utilization of the resources of the Sundarbans. The Sundarbans has been considered as a Reserve Forest area since the British regime and specific regions are also regarded as Protected Areas. The TRUs, therefore, have to take permission to enter into the Sundarbans to harvest the resources. This can be argued as a step to reduce the degradation of biodiversity resources. But, this paradigm of protected area management has been unable to achieve the desired outcome – either in respect of biodiversity conservation or in respect of the livelihood security of the TRUs.

Figure 20: Role of TRUs in the conservation and sustainable usage of biodiversity resources



Source: Prepared by the authors

The above figure tries to depict the overall scenario on the basis of three pillars of access and benefit sharing, conservation and sustainable usage of the resources. The biodiversity resources of the Sundarbans continuously have been degrading due to several anthropogenic pressures. These pressures have mainly intensified with the advent of neo-liberalism as the sole strategy of accumulation of wealth at the expense of the loss of intrinsic ecological value of nature. The commercial enterprises, formal and informal, are highly organized in their extractions of resources, and most often are politically patronized and administratively supported. Therefore, restricting the entrance of the TRUs inside the forest region only cannot be the fruitful solution to the problem of biodiversity degradation. The framework, moreover, argues that the traditional resources users (TRUs) can significantly contribute to the conservation and sustainable use of the biodiversity resources through means of their traditional livelihoods and knowledge.

CHAPTER THREE

Community Based Mangrove Agro Aqua Silvi (CMAAS) Culture

Introduction:

In coastal Bangladesh particularly in some parts of Khulna, Satkhira and Bagerhat districts, quite a small section of the disasters vulnerable communities have been trying to cultivate a few floral and faunal species of the Sundarbans mangrove ecosystem on the lands – the lands which were earlier utilized for other purpose. This practice is termed as Community Based Mangrove Agro Aqua Silvi (CMAAS) Culture. This is in fact an alternative practice to the commercial shrimp culture. This paper aims at presenting the overall picture of the CMAAS Culture in the coastal region of Bangladesh as per the findings from different research activities and project running activities by Unnayan Onneshan.

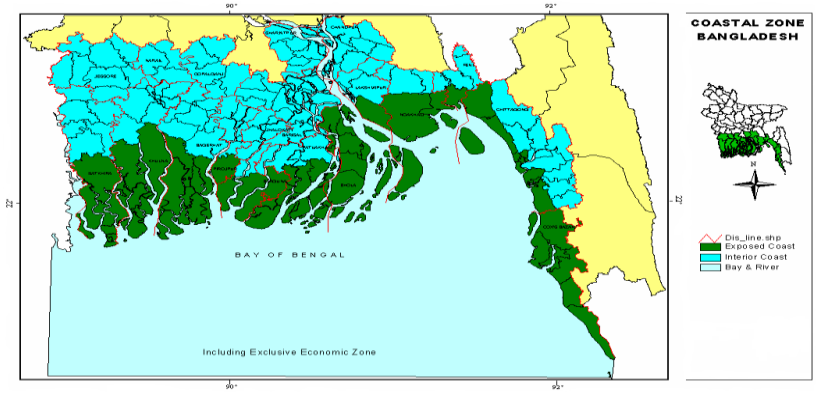
Defining CMAAS Culture:

The CMAAS culture refers to the practice of integrated cultivation of some mangrove faunal species such as crabs, oysters or fishes (e.g: shrimps, *bhetki* [*Lates calcarifer*]) and floral species such as *golpata* (*Nypa fruticans)*, *keora* (*Soneratia apetala*), and *goran* (*Ceriops decandra*), at the same time on any swampy land of brackish water. In addition, integrated cultivation of some mangrove floral species like *golpata* and a few faunal species like tengra (*Mystus tengara*), *baila* (*Awaous guamensis*), and tilapia (*Tilapia nilotica*),are practiced on fresh water swampy land.

Emergence of CMAAS Culture – Background Reasons:

Coastal area in Bangladesh constitutes about 32% of the country (Parvin et al. 2017). This vulnerable coastal zone covers 19 out of 64 districts, where 30% of the total populations of Bangladesh live and more than half of them are poor (Parvin, et al., 2009). The most of the coastal areas is low-lying, almost one meter above the mean sea level and accordingly, the low lands are normally inundated sea water during the high tide. The coastal Bangladesh harbors a wide variety of ecosystems and biological resources and homes about 36 million people. The livelihood options of the inhabitants are usually based on agriculture, fishery, forestry, shore transportation and salt panning. The major resource system, a natural power house, belonged to coastal zone is the Sundarbans which lies along the south-western belt of the coast.

Figure 21: Map of the Coastal Zone of Bangladesh



Source: ICZMP, 2004

Over the last half-century coastal land uses of Bangladesh have gone through major changes. Since 1950s natural disasters like cyclone and tidal flooding induced by climate change, salinity intrusion, large-scale polderization and intensive shrimp farming have changed the whole coastal area of Bangladesh and it is more evident in south-western coastal region. Consequently, these changes in coastal land uses have induced significant impacts on agriculture, crop production, food and water supply and livelihood of south-western coastal community. As a response to it, those local communities have been practicing different production methods in order to adapt to the changing situation. CMAAS culture is one of those methods which are practiced based on their own knowledge to enrich their resilience capacity in the face of climate change. Nevertheless, it is crucial to discuss briefly on the background reasons for the emergence of this culture before going to discuss on the culture in more detail.

Climate change, natural disasters and salinity intrusion:

The whole of Bangladesh is not equally vulnerable to climate change. The most climate change sensitive part of the country is the coastal region. To climate scientists, coasts are usually projected to be exposed to increasing risks climatic extreme events. On the face of emerging climate change, frequency and intensity of climatic hazards and disasters are likely to increase further. Most importantly, it is vulnerable to sea-level rising that is being resulted from climate change. It has been increasing the salinity of the region's water and soil composition. A projection by CEGIS (2005) signifies that the largest mangrove ecosystem of the Sundarbans of coastal Bangladesh will be reduced from 60% to 30% in the year 2100 with 88 cm sea level rise. In the worst case scenario, Mohal et al. (2006) in their paper projected that 32 cm of sea level rise may flood 84% of Sundarbans possibly by 2050 and with an 88 cm sea level rise possible by 2100 the whole of Sundarbans will be lost. This obviously poses a great threat on the lives and livelihoods of the local forest dependent communities.

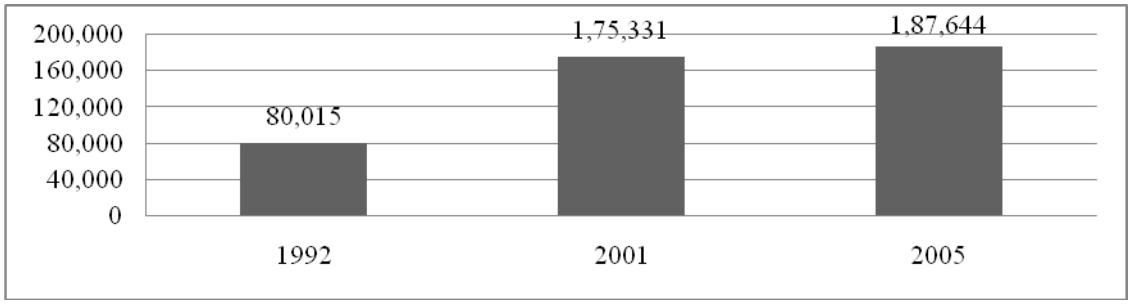
Moreover, natural disasters induced mainly by climate change have increased both in terms of frequency and intensity and in this case also the coastal region is the most vulnerable. During the last 135 years, more than 45 cyclones have crossed the coastal belt of Bangladesh (IUCN, 2014). Among themost devastating cyclones of recent past cyclone - *Sidr* and *Aila* can be particularly concentrated in this regard. On 15 November 2007, Sidr hit Bangladesh's south-west coast and the incurred loss from this single event is estimated to be USD 1.7 billion or 2.6 percent of GDP (Shamsuddoha et al., 2013).The cyclone caused huge damage to the Sundarbans in terms of biodiversity loss and physical infrastructure damage and destruction. Cyclone Aila, occurred on 25 May, 2009 had also disastrous impact on the coastal region as well as on the Sundarbans. It destroyed thousands acres of crop fields, damaged water resources and forced approximately 50,000 people to be homeless (Roy et al., 2009). 60 thousand hectares of land in coastal districts has damaged fully by Aila (Hossain, 2009). The storm surges that accompanied cyclone Aila increased soil salinity, leading to a loss of agricultural productivity, and contaminated groundwater sources. A large number of trees were uprooted and several species of flora and fauna lost their lives.

Thus, climate change and concomitant natural disasters and salinity intrusion create a vulnerable situation for the people of that region in case of maintaining their lives and livelihoods. Those people, therefore, search for different alternative livelihood options and try to adapt to the changing situation.

Intensive shrimp cultivation and salinity intrusion:

Conversion of land into commercial shrimp farming is the largest human threat to the Sundarbans mangrove ecosystem. The increase of the farms is mainly caused through quasi-legal intervention. The farms are put in place by the powerful local stakeholders, specifically, by the rich fishermen (not part of the indigenous people), connected with political and administrative structures at local and national levels. There is an increasing trend of shrimp (Bagda– *penaeus monodon*) cultivated areas adjacent to the Sundarbans (in hectares) from 1992 to 2005 (Figure 20). The constructions of shrimp ponds contribute to degradation and loss of mangrove habitats in several ways. For instance, a shrimp cultivating pond exhausts its usefulness within three to six years of construction.

Figure 22: Bagda shrimp cultivated areas adjacent to the Sundarbans (in hectares)

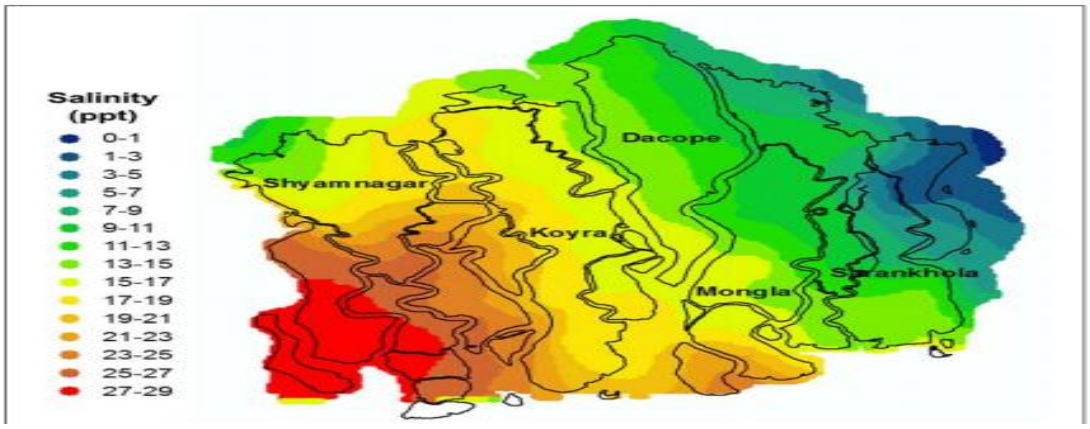


(Data Source: IUCN, 2014)

So, the cultivators have to move along the coast, destroying mangroves to make room for more ponds. Moreover, it increases salinity in the soil and thus alters the soil composition of that region.

In fact, southwest coastal region of Bangladesh is already facing increasing salinization**,** especially between October and May. Laboratory analyses of water and soil samples show an increase of salinity over time in the region (World Bank, 2016).The salinity has been increasing due to sea-level rising and intensive shrimp cultivation as has been described above. For instance, the extent of aquatic salinity intrusion can be visualized in the following figure very clearly (Figure 23).

Figure 23: Estimated Aquatic Salinity in 2012

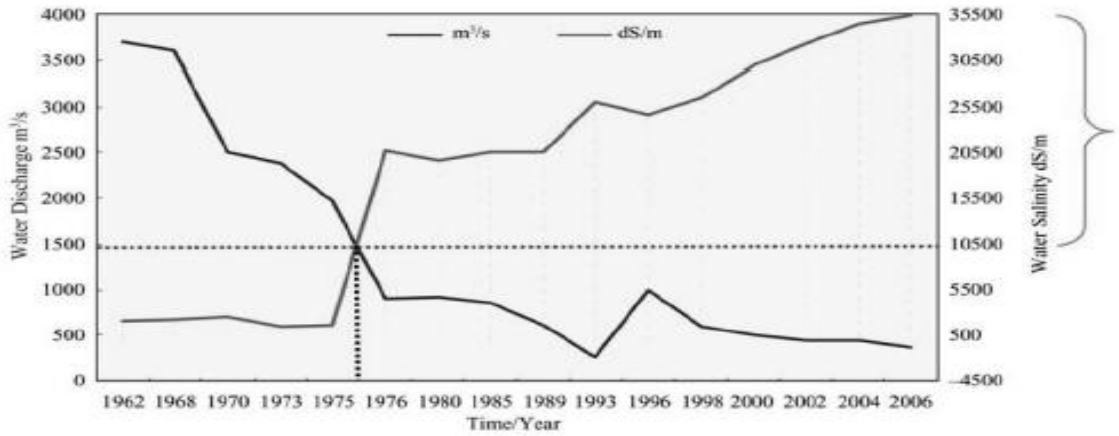


Source: World Bank, 2016

Polders, embankments and dam construction:

Embankments and the loss of smaller tidal flow in the hinterland, due to the construction of large polders, not only negatively influence natural hydrologic systems but also hamper tidal brackish and monsoonal fresh water inundation. Two direct consequences of this are a negative sediment ratio, which cannot sufficiently compensate land subsidence anymore and increased salt concentrations in the surface layers (Falk, 2015). Large upstream dams like the Indian Farakka Barrage, constructed in 1974, are reducing river discharge or the freshwater flow in the downstream rivers- particularly during the dry season. Islam and Gnauck (2008) showed that "the Ganges flow was 3700 m3/sin 1962 whereas it was reduced to only 364 m3/s in 2006". Sarker et al. (2016) reported in another report that Ganges' freshwater flow into the Sundarbans has dropped from 3700 m^3 s−1 to364 m^3 s−1 since the construction of the Farakka dam. Such, lower flow of water has increased the siltation and salinity in the Sundarbans as well as in the coastal area of Bangladesh.

Figure 3: Ganges water flow decrease and salinity increase, as measured at Passur-Mongla point



Note: Vertical dotted line indicating building of Farakka dam in 1975.
Source: Islam and Gnauck (2008).

The above figure shows that after the construction of Farakka dam water discharge in the downstream rivers has decreased while salinity of water has increased.

Industrialization and development projects:

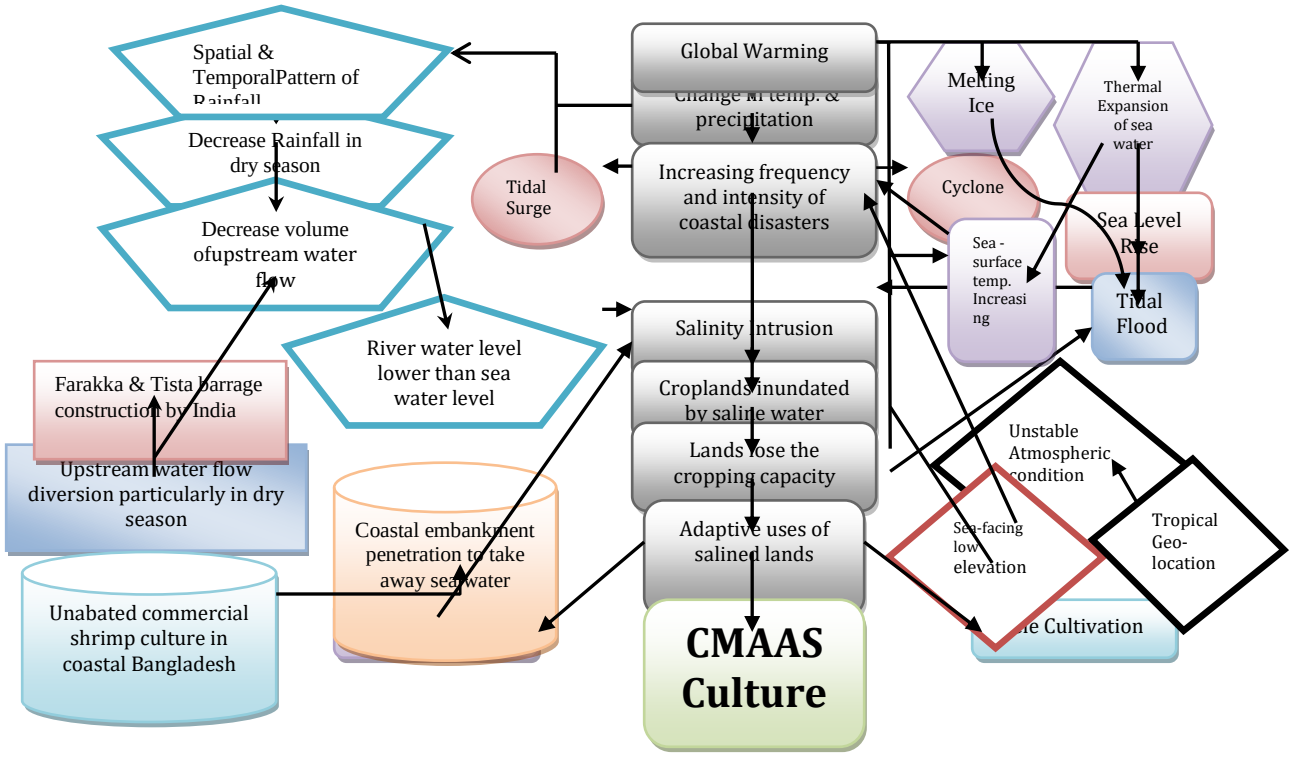
Sometimes development projects in the name of conservation impose negative externalities to the forest. For example, the so-called Sundarbans Bio Diversity Project (SBCP)[5]is being strongly criticized because of the infrastructures for ecotourism built in the heart of the mangrove and the non-transparent way in which the whole project is being implemented, disregarding the viewpoints and interests of local communities (Hossain and Roy, 2007 as cited in Baten and Kumar, 2010).Oil and gas exploration activities and exploitation by the multinational companies in the name of development also cause destruction to the Sundarbans. Going against its own policy, the government over the last few years permitted setting up of 190 industrial and commercial units in the ecologically critical area (ECA) of the Sundarbans, which poses a serious threat to the biodiversity. The government declared the 10-kilometre periphery of the mangrove forest as the ECA in 1999, after the UNESCO listed it as a natural world heritage site. As per Bangladesh Environment Conservation Act 1995 (amended in 2010), no one is allowed to set up any factory in the ECA.

In this way, the combined impact of nature and human induced hazards and disasters are threatening both the social and the physical environment of the coastal zone in many ways on different degrees. It has paradoxically touched almost every aspect of life in the coastal zone. Agriculture, the greater livelihood option of the coastal people, is one of the most vulnerable systems to be affected by salinity intrusion. Hundreds of acre of arable lands fall victim to very high soil salinity every year and consequently coming out of crop growing ability. Again, the saline experienced lands cannot be brought under any other productive use. Virtually, these remain nothing but fallow lands. Moreover, it is inferred that agricultural vulnerability will be further exacerbated under climate change scenarios in this country with extreme population burden. On these days, the dependency of the coastal people on crops culture is on fall pushing them into livelihood crisis situation.

To adapt to the emergent adverse condition, to utilize the salinity rich croplands, the local communities have spontaneously promoted a number of interesting adaptation measures applying their innovative ideas and traditional knowledge and subsequently applied in the south-western coastal Bangladesh. They include the mele cultivation, crab culture, CMAAS Culture, oyster culture, double decker crop cultivation and so on. This paper, here, particularly focuses on the CMAAS culture. The commencement of the combined cultivation was merely motivated by the curiosity of a few local innovative minds and the practice was on very small scale. The following diagram depicts the reasons behind the emergence of the CMAAS culture.

[5]This project was designed to restore the original ecosystem and funded by the Asian Development Bank (ADB), the Global Environment Facility (GEF), and the Netherlands Development Fund.

Figure 24: Schematic Diagram of Representing Natural and Anthropogenic Drivers, Impacts of and Responses to Climate Change and Salinity Intrusion at Coastal Bangladesh and their linkages to the emergence of CMAAS Culture



Cultivation Method of Mangroves under CMAAS Culture:

Mangroves naturally grow in the intertidal areas. So, how they are grown by the community people in fresh water or brackish water swampy lands usually develops curiosity and accordingly, needs to be clearly understood. Despite CMAAS Culture is an integrated cultivation of mangroves and aquatic species on the same piece of swampy land, their cultivation methods are independently discussed here for better understanding along with distinguishing their individual contribution to the net yearly income from per *bigha* CMAS Culture practice. Mode of cultivation is largely extensive and semi-intensive with low capital inputs.

Site Selection:

Site selection for farm development is one of the most important issues in CMAS Culture. Soil and water are the main considerations in the site selection process in CMAS Culture. The lands of yielding, mud-spattered and water-logged soils with all time availability of brackish or fresh water access are selected by farmers as sites for CMAAS Culture farm development. Most of the farms are located by the coastal rivers which always contain water and moreover periodically

derive water from the rivers. The rest ones are located at homestead adjoining ditches.Cultivation sites may range in size from a few decimals to a few *bighas*.

Species Selection:

Species selection mainly depends on the water quality of the farm site because all types of mangrove floral and faunal species cannot survive or grow well in fresh water body. Again, there are some fresh water species of fish, molluscs and crustaceans which cannot be cultivated in brackish water farm. For the fresh water farm, Goalpata, Bagda and Horina shrimp, Tengra, Telapia, Khorkono and the like are usually selected. On the contrary, for brackish water farm mangroves like Goalpata, Keora, Goran, Baen and mangrove fish like Golda, perse, vetki, mudcrab and so on are usually opted for cultivation.

Farm Construction:

The next step to site selection is farm construction. The farm consists of a plot of swampy land with 1-1.5 feet deep water bordered by dyke of 0.5-1.5 feet height from the water level. There is an unexcavated central platform that usually remains flooded. Sometimes, mostly during dry season, the platform exposes. The mangroves including Goalpata, Keora and the like are planted on the platform. Besides, there is a canal of about 2-2.5 feet depth that runs along the farm dykes where fish, shrimp and crabs are cultured. The farms usually hold water all the year round and hence they do not need to supply water to the farming ponds.

Figure 23: Model of CMAAS Culture Farm

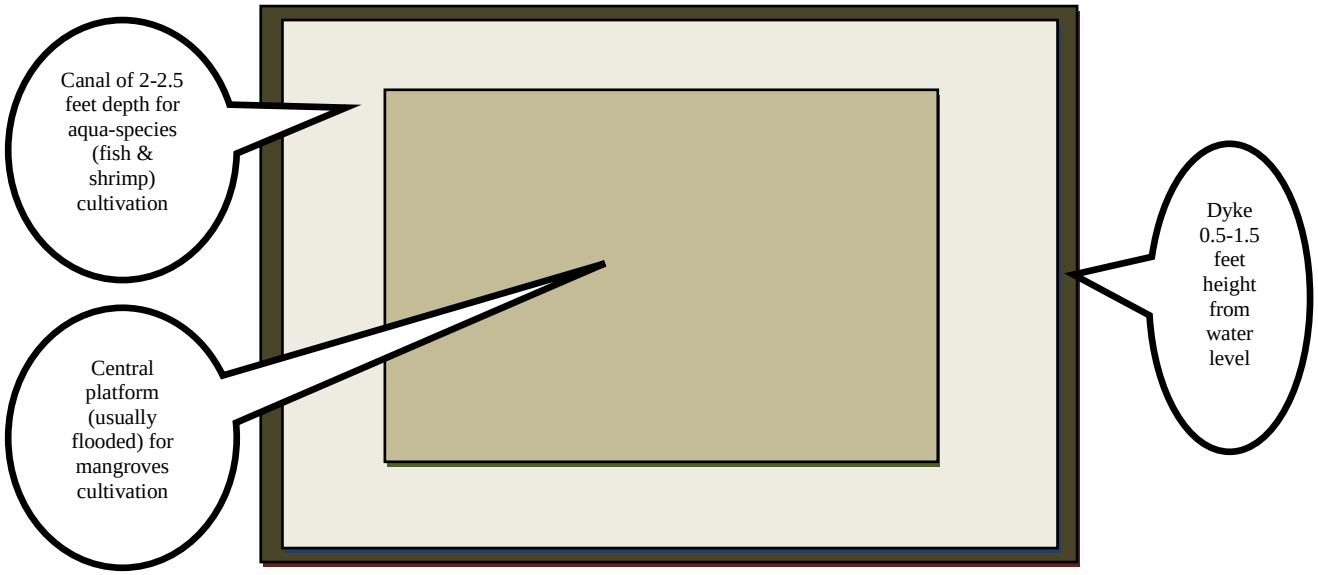


Figure 26: A CMAAS Farm © Loban Rahman, *Unnayan Onneshan*

Figure 27: Pioneer of CMAAS Culture, Khaibar Sarder in his Farm© Loban Rahman, *Unnayan Onneshan*

Cultivation of Mangrove Trees:
Mangroves are the plants that can live in freshwater swampy lands and along brackish and salt water coastal areas. They possess an excellent knack to live in sea water by spraining freshwater from the saltwater. The mangrove flora consists of 47 true mangroves and associated species belonging to 26 families (Melana and Gonzales 1996). A handful species of mangrove plants are cultivated in the CMAAS Culture farms. They include Goalpata *(Nypa fruticans),* Goran *(Ceriops tagal),* Keora *(Sonnerata species),* Hargoza (*Alanthus ilicifolius*) and Baen *(Avicennia Species).* Among them, the most common and dominant mangrove plant species cultivated in the CMAAS Culture farms include the Goalpata followed by Keora. This is because Goalpata is more adaptive mangrove floral species which normally grows in fresh water swamp with little or no care and maintenance.

Seed Collection:

Most of the farm owners collect mangroves saplings from the nearby riverbank areas or from Khulna Port adjacent areas. The seeds after dropping off from the mangroves in the Sundarbans enter into the coastal rivers carried by the tide. They often have opportunity to settle down on river banks or get carried into brackish water shallows and is lodged into muddy bottom. Without delay, they send out roots to take hold in the soil and accordingly stems grow and produce leaves. Interested any one can collect the saplings without any permission from any authority. Some others gather the mangrove seeds floating in the river water carried by tide whereas the rest of the farm owners collect seeds from the forest when they go for mangrove resources extraction. Later, they grow saplings from the seeds establishing nursery at homesteads. Seed collection season of all types of mangroves cultivated in the CMAAS Culture farms is almost the same. The seeds of all relevant mangroves have to be collected from July to August.

Nursery Establishment and Management*:*

Mangrove nursery is a place where mangrove seedlings are grown with extra care till they are ready for planting in the farms. It helps develops good quality seedlings of optimum quantity at the right time Seed beds are prepared just after collection of seeds from any source. The study discloses that the seedbeds are prepared for all types of concerned mangroves from July to August each year.

Maintenance of the Mangrove Plant Seedlings:
The mangrove seedlings require some maintenance activities for their uninterrupted development particularly at nursery stage.

Fencing: The nursery should be well fenced so that any other animal, wide or livestock, cannot nip the seeds in the buds and do harm to the seedlings. Bamboo is commonly used in fencing nursery.

Watering: Seeds and seedlings essentially need watering daily. Even prior to introduction in hardening beds, seeds require use of tap or brackish water. But for hardened seedlings, brackish water must be used in order to adapt them to the field setting. Watering at the plants should be

made in everyday early in the morning. Failure to water even for a day may have adverse effects on the growth trend and even can threat the very survival of the plants.

Weeding out and Inspection: The seed beds should be weeded out at an interval of time as necessary to keep the seedlings away from competition for survival. Daily inspection should be ensured to protect the seedlings from the attack of insects and pests.

Plantation in the Farms:

In the nursery, over a period of 1-1.5 month, the seedlings experience a minimum height of 1.5-2 feet when they are planted at the central part of the farm. The general planting season starts in August and ends in September. The density of mangrove trees planted in the platform varies from farm to farm depending on the farmers' preference on mangroves cultivation or fish cultivation. The mangrove tree density influences the intensity of aquaculture in the farm because plantation density does have an effect on the production level of litter and creation of organic load. It ultimately influences on production and diversity of non-mangrove micro floral and faunal species that may cover the lion's share of diet of fish and other species cultured in the farm. In addition, mangrove density may vary based on the aquatic species to be cultured.

Farmers may go for less dense mangroves (e.g. 1 tree per sq. meter) for white fish culture like *Telapia, Vetki, Tengra and carps*. Again, mangroves density no matters for shrimp and crab culture because these species find interest and feel free in the shelter generated by the mangroves.

Care and Maintenance of the Mangroves:

It needs little care and maintenance cost is in a word negligible. Farm water exchange at a particular interval of time is not essential for mangroves. They can survive both in fresh and brackish water swampy lands. The main concern to mangroves cultivation is that they are sometimes attacked by viral diseases. Use of insecticide and pesticide can protect them well. Care continues until they grow to harvest size. Keeping a watch on mangroves is necessary to some extent if the farms are isolated.

Harvesting:

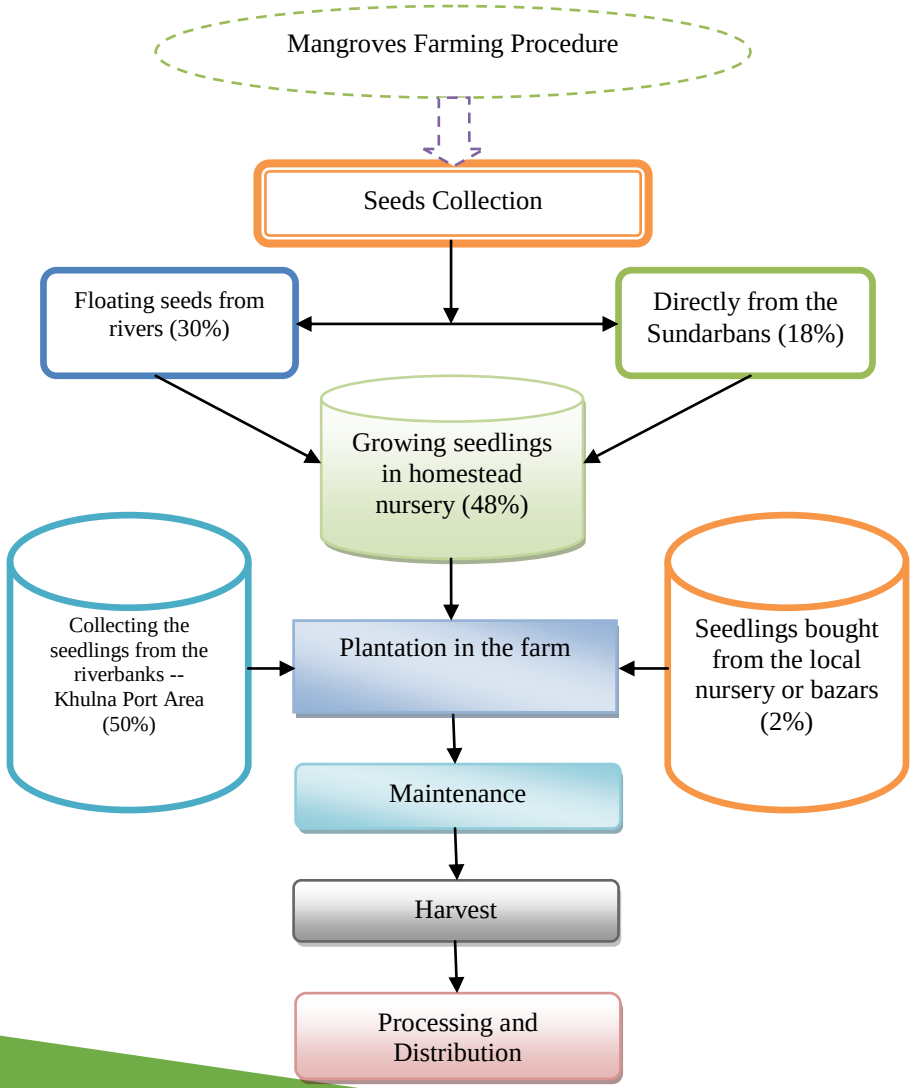
The nursery development and plantation seasonality of the mangroves cultivated in the CMAAS Culture farm is almost the same. But they widely vary from one to another in terms of harvesting period. Only *Goalpata* and *Goran* possess the shortest harvest period. After 13 to 14 months of plantation, these can be harvested and processed for sale in the market. Except these two, all the other ones need minimum 5 years to be ready of harvest whereas *Possur* requires the lengthiest period of time as like as more than 8 years. In case of *Goalpata*, only dominant mangrove plant in CMAAS Culture farm, the season of harvesting is January to February as new shoots begins growing in March. *Goalpata* is cut at an angle of 45º angle.

Table 7: General Farming Pattern (Temporal) of Mangroves Cultivation

Name of Mangrove	Seed collection and seed bedding	plantation	Time from seed bedding to harvesting (month)
Goalpata	July	August	13-14
Keora	August	September	62
Hargoza	July	August	62
Baen	August	September	62
Possur	July	August	98
Goran	August	September	14

Source: Unnayan Onneshan

Figure 28: A Schematic Diagram of General Farming Procedure of the Mangroves in CMAAS Culture



Uses of Mangroves:

Goalpata (Nypa fruticans), the dominant plant species of CMAAS culture, is one of the valuable non-wood mangrove plant species. The uses of this palm are many and diverse. Its leaves, popularly known as the poor man's tin-sheet, are extensively used in roofing the thatched houses in coastal Bangladesh with a prolonged durability of about 2-3 years. Upon taken preservative treatment the thatching materials may prolong the durability up to 10-15 years.

The dried up petioles, leaves, stems and fruit residues of Goalpata are excellent sources of firewood while the skin of fresh petioles can be made into good quality ropes. It bears fruits that are edible and hence have monetary value in the market. Fresh fruits can be eaten and also preserved for longer hour. Goalpata also deserves important medicinal uses. Ash from *Goalpata* is reported to be used as an analgesic against tooth and headache.

The dominated mangrove in CMAS Culture next to Goalpata is Keora which possesses a number of provisioning uses. It is extensively used in house building, furniture. Besides, the leaves, stems and roots are usually used as fuel wood. Hargoza is only used as fuel wood. Possur and Baen are also woody mangroves which valuable woods are broadly used in house construction and furniture.

Table 8: Provisioning Uses of the mangroves cultivated in the CMAAS culture farms

Mangrove	Provisioning Uses	
Goalpata	- House Roofing - Fencing - Sweet meat - Bags - Basket - Firewood - Wrapper - Rope - Vinegar - Edible fruits - Hat	- Mat - Rain Coat - Alcohol - Address poverty - Medicinal Use (Vermicide, analgesic) - Fishing - Wine & Toddy - Transport fuel (potential use)
Keora	- Cot - Fuel wood - Showcase - Chair - Fencing	- Table - Roofing - Ceiling - House column
Hargoza	- Fuel wood	-
Possur	- Cot - Almirah - Showcase - Ceiling	- House column - Chair - Table - Roofing

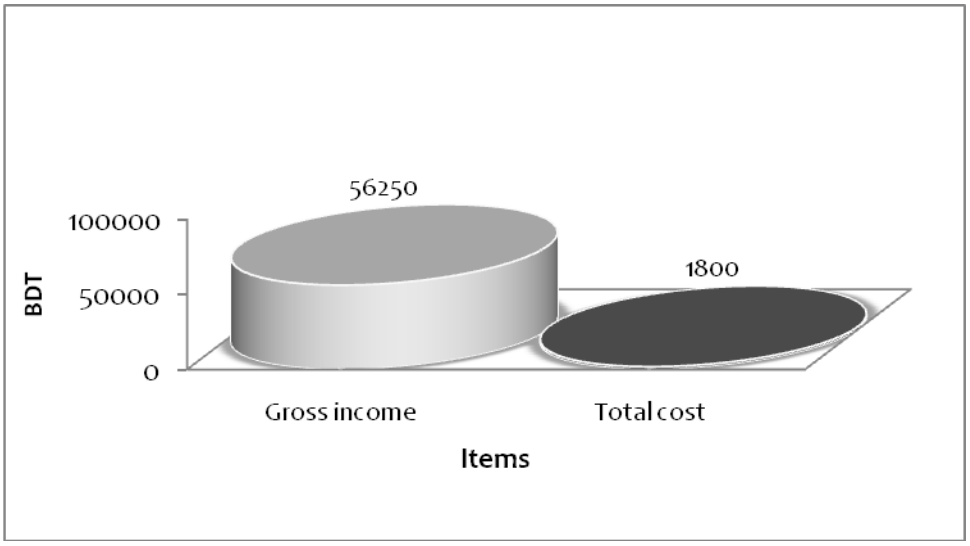
Baen	- Fencing - Box - Roofing - Cot - Fuel wood	-

Source: Unnayan Onneshan

Economic Cost and Return:

The most important thing in any investment or project is the ratio of economic cost and return. The ultimate decision as to continuation or discontinuation of any investment or project almost entirely depends on it. Community-based mangrove cultivation is found to be a highly profitable coastal adaptation practice. Yearly average gross income from per *Bigha* mangrove cultivation yields about BDT 56250 whereas total cost only amounts to BDT 1800 leaving a net benefit of about BDT 54450 (Figure 29). Accordingly, the ratio of cost-benefit equals to 1:32.

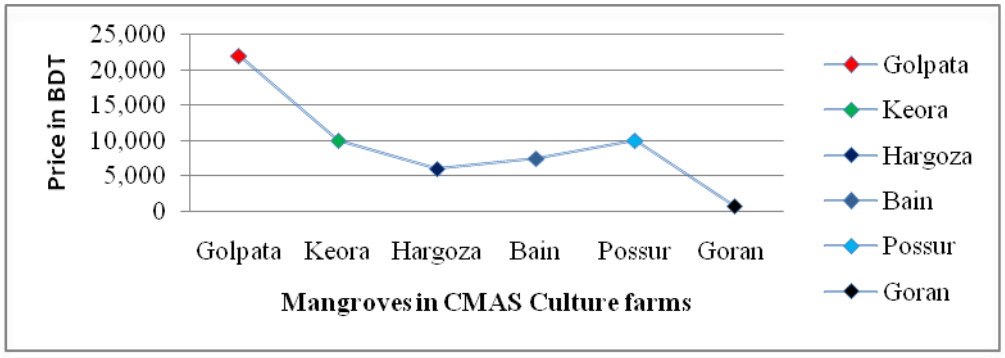
Figure 29: Average Yearly Total Cost and Income in Community-Based Mangrove Silviculture



Source: Unnayan Onneshan

Yet, it is not that all types of mangroves equally contribute to the gross income. Rather contribution verily varies from one mangrove species to another. As an individual species, the greater contributor to the gross income of community mangrove cultivation is Goalpata.

Figure 30: Species-wise average Yearly Gross Income from Mangrove Cultivation (Per Bigha)



Source: Unnayan Onneshan

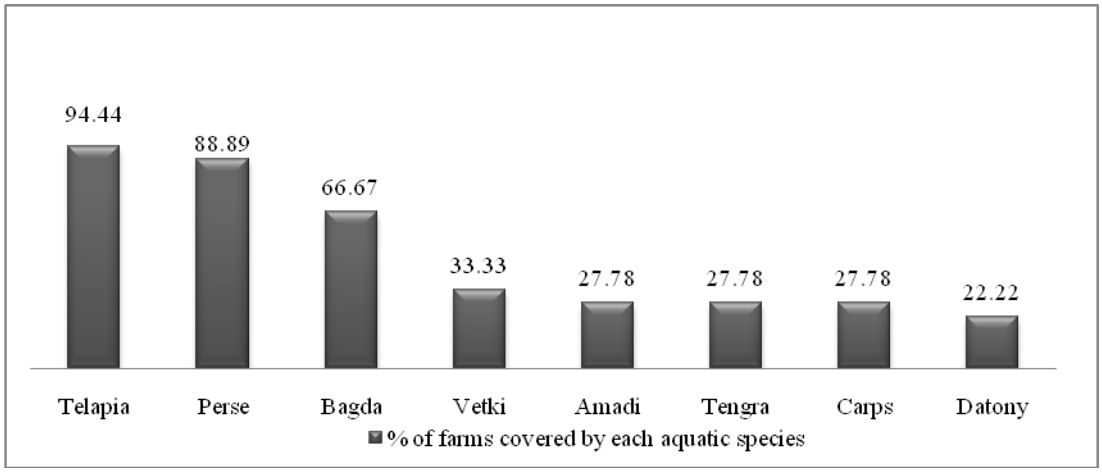
Cultivation Method of Aquatic Species under CMAAS:

Aqua-faunal species' cultivation is one of the two parts of CMAS Culture. Generally, the silvo fishery combined cultivation farms vary from one to another in proportion of silvo and fishery cultivation coverage. The degree of variation varies from country to country and also from farming model to model. Some farms are silvo-culture dominated while others are aqua-culture focused. In Bangladesh, the CMAS Culture farms are aqua-culture predominant. The aquatic cultivation includes both the fresh and saline water species of molluscs, crustaceans and fish. The fresh water species of molluscs, crustaceans and fish are cultivated in fresh water farms whereas the saline water species of fish, molluscs and crustaceans are cultivated in the brackish water farms.

Aquatic Species Cultivated in Farms:

The CMAAS Culture farms generally experience cultivation of a few species of shrimps and fish. The shrimp species include Bagda while the fish species encompass *Telapia, Perse, Vetki, Amadi, Tengra, Carps and Datony.*

Figure 31: Percent of Farms Cultivating Different Types of Aquatic Species



Source: Unnayan Onneshan

The Figure shows that there are three types of fish like *Telapia, Perse and Bagda* which are commonly cultured in the farms. Among them, Telapia is the most cultivated fish species in the CMAAS Culture farms which is cultivated at about 94.44 percent of the total farms. Besides, *Perse* and *Bagda* are two other widely farmed fish species which cover about 88.89 percent and 66.67 percent of the farms respectively. The minor fish species cultivated in the farms include *Vetki, Amadi, Tengra, Carps and Datony* which almost equally exist in the farms.

Fry Collection:

The farming is entirely based on fish and shrimp fries release into the farms periodically. However, they collect the fries in three ways including self collection from the rivers, buying fries collected from rivers and grown in hatchery. About 22 percent farmers particularly the marginal ones directly catch the wild-fries from the coastal rivers while another 18 percent buy from nearby hatcheries. The rest 60 percent farmers buy the fries from the local sellers who collect them from the rivers. Fish fries and shrimp larvae catching in the coastal rivers arecommon sights in the south-west of Bangladesh.

Seasonality of Farming:

Farming seasonality of fish and shrimps in the CMAAS Culture farms varies from species to species. Fries release period of all fish and shrimp species in the farm is mainly confined to February from December of every year. Similarly, harvesting season is almost the same with a slight variation and mostly confined to June from May. This is because almost all the fish and shrimp species spawn fries at the same period. Besides, from late May on ward, there is very high probability of tropical cyclone coupled with tidal surge and tidal floods. If any of the catastrophes occurs, fish and shrimp of the farms wash away leaving a huge loss for the farmers. This is why, in most parts, fish and shrimps are harvested before the occurrence period of the disasters mentioned thereof (Table 9).

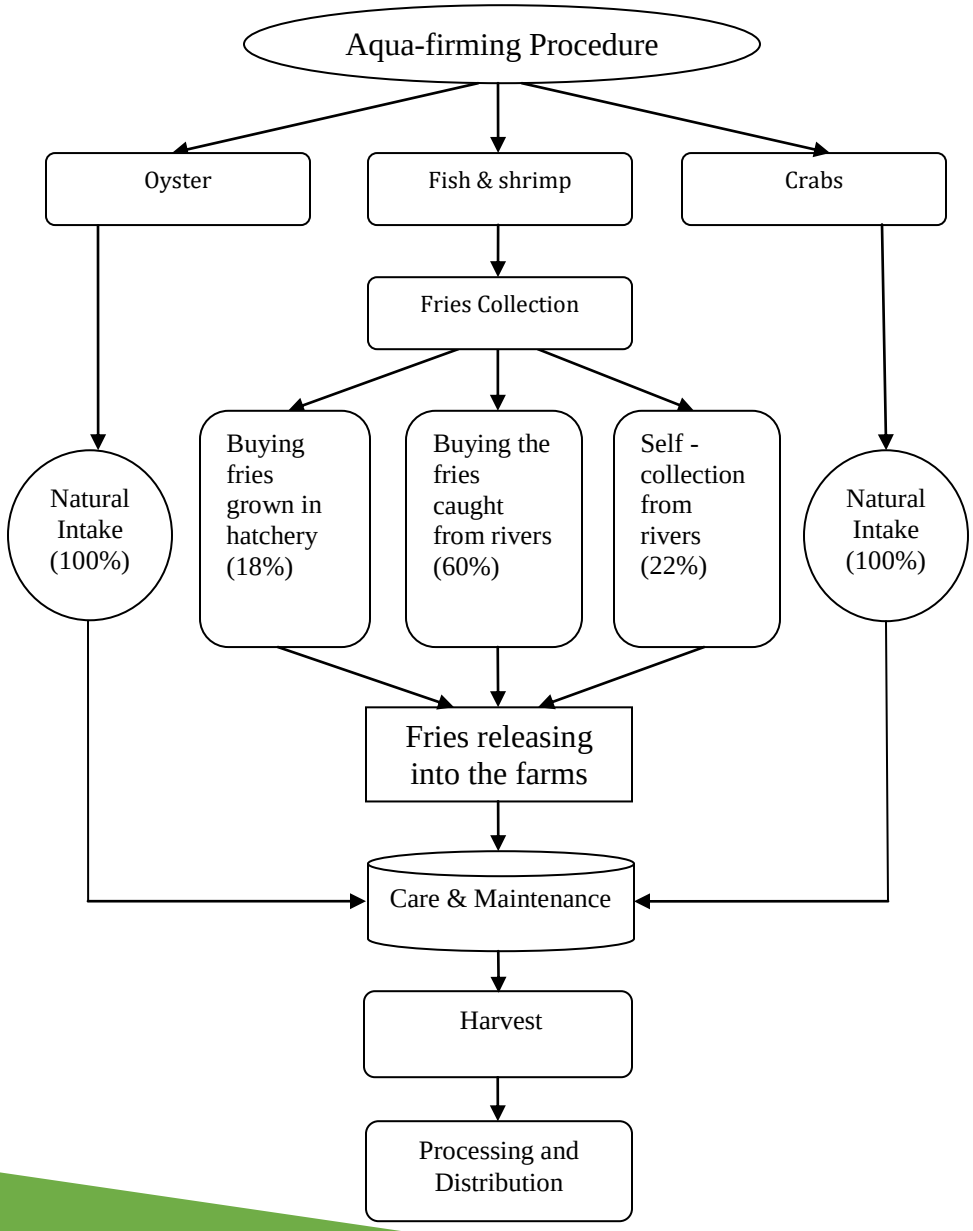
Table 9: The Farming Seasonality of the Fish Species Cultivation

Name of fish	Period of fries release	Fish harvesting period	Time needed for harvest
Fish species of brackish water farm			
Telapia	December	April-May	3 months
Parse	February	May	2.5 months
Bagda	February	June	4 months
Vetki	February	May	3 months
Amadi	January	May	4 months
Fish species in fresh water farms			
Tengra	February	May	3 months
Carp	December	August	8 months
Datony	February	June	4 months

Care and maintenance:

Aqua-farming in CMAAS Culture does not need as much care and maintenance as other types of farming requires. Care and maintenance of this farming is very simple and accordingly cost a negligible amount of money. Farm water does not essentially need to be exchanged at a particular interval of time. Water is changed at any time when it becomes easily possible. The shrimp and fish usually live on natural feeding during the entire grow out period. Shrimp and fish feeding are available to buy. The best home-made feeding for fish is rice bran. Most of the farmers depend on natural feeding and hardly use chemical fertilizers in the farms. The farms need to be recurrently patrolled so that no intruders can catch fish and shrimp and cut the mangroves. From time to time, the farms dykes require to be heightened as they face lowering with the passage of time. Generally, initiative is hardly made to for fencing the farms. Isolated farms essentially need to be fenced where there is probability to a considerable degree of theft of fish and shrimps. Sometimes, the fish and shrimps are attacked by viral diseases that need the use of medicines and insecticides. Care continues until they grow to market size. The study reveals thaton an average care and maintenance of the aqua-farming yearly cost about BDT 5000 per *bigha.*

Figure 32: Production Cycle of Aquatic Species in CMAAS farm



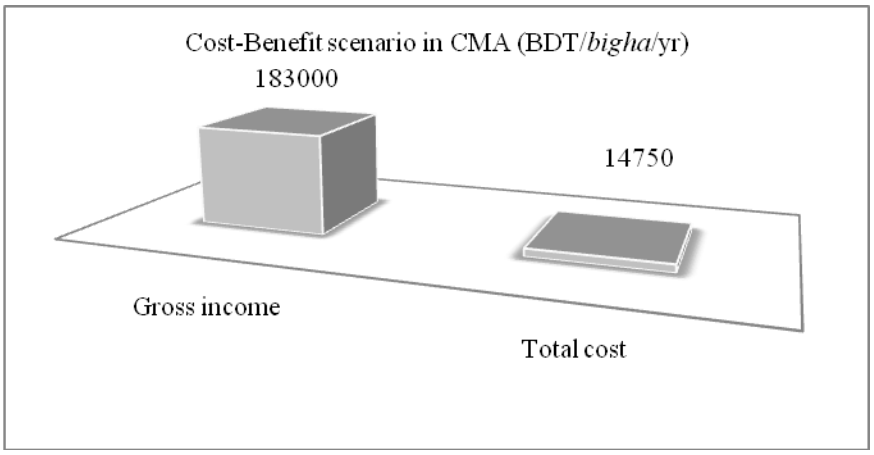
Harvesting:

Almost all the fish and shrimps need 3-4 months following the release to grow to marketable size. In fact, harvesting and releasing follow a cycle. Partial harvesting of marketable shrimp commences just following the initial stocking with fries. The shortest and the longest period fish species include *Perse* and *Carps* respectively.

Economic cost and return:

Yearly average gross income from per *bigha* aqua-farming is about BDT 1, 83, 000. The total cost, on the other hand, only amounts to BDT 14,750 offering a net benefit of about BDT 173250. Accordingly, the ratio of cost-benefit equals to 1:12.

Figure 31: Average Yearly Total Cost and Income in Community-Based Mangrove aqua-farming

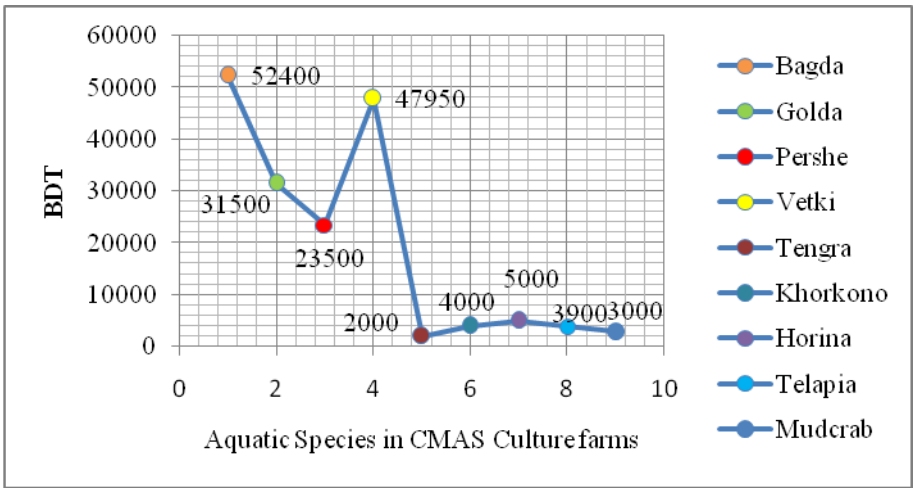


Source: Unnayan Onneshan

Quite a few factors have acted behind the emergence of this lucrative profit scenario. They include very low care and maintenance cost, highly dependency on natural feeding of fish and shrimp and limited use of fertilizer. The most important factor is labor cost. CMAAS Culture farms need patrolling all day and even at night. Generally, self-labor is employed in this sector and the labor cost is not calculated in monetary value that lowers the total cost greatly. Besides, much of care maintenance cost is shared by both segments of CMAAS Culture including Community Mangrove Aqua-firming and Community Mangroves Cultivation.

Again, yearly average gross income of all the aquatic species cultivated in the CMAAS Culture farms is not the same. Rather it widely varies from one species to another. The Figure 14 shows that the major contributors to the gross average yearly income of CMS include Bagda, Golda, Perse and Vetki where, as an individual species, the highest yearly income is derived from Bagda cultivation and it is followed by Vetki.

Figure 34: Species-wise average Yearly Gross Income from Mangrove Cultivation (Per *Bigha*)



Source: Unnayan Onneshan

The fact that the study has uncovered behind the reverse relationship of total farm area coverage and contribution to gross income in case of Telapia and Perse is that the cultivation cycle of Bagda and Vetki are comparatively short and market price is very high. The price of per kg Telapia normally ranges from BDT 100-180 whereas the price of per kg market price of Bagda rages from BDT 550-900.

The summary of economic returns of flora and fauna species under the CMAAS culture is presented in Table 10.

Table 10: Economic returns of CMAAS culture

CMAAS		
Economic Returns(Benefits>Cost)	**Mangrove Cultivation (flora):** Total income (per *bigha*/per year): BDT 56,250 Total cost (per *bigha*/per year): BDT 1,800 Net benefit: BDT 54,450 Cost Benefit Ratio: 1:32	**Mangrove Aqua Farming (fauna):** Total income (per *bigha*/per year): BDT 183, 000 Total cost (per *bigha*/per year): BDT 14,750 Net benefit: BDT 173,250 Cost-Benefit Ratio: 1:12

Note: A *bigha*, a unit of land measurement, is 1,600 yd^2(0.1338 hectares or 0.3306 acres) and is often interpreted as being 1/3 acre (precisely 40⁄121 acres). In metric units, one *bigha* is hence 1,333 m^2.

Source: prepared based on findings of research by UO, 2010

A Comparative Analysis of CMAAS Culture and Commercial Shrimp Culture:

Here, a comparative analysis of these two types of culture is provided in summary based on the findings of research of *Unnayan Onneshan*. The comparison in economic terms[6] can be depicted in summary in the following table (Table 11). In terms of Net Present Value (NPV) and Net

[6]The Cost Benefit Analysis (CBA) approach was used to compare the economic returns in this case.

Benefit (NB) CMAAS culture looks more profitable than CS Culture. But the scenario is quite different when considering Benefit Cost Ratio (BCR). The BCR scenario implies that the cost effectiveness of CS culture is comparatively higher. Shrimp cultivation is, therefore, no doubt profitable. But beneficiaries are a selected group of people and regrettably it has badly affected the livelihoods of landless and marginal farmers. Moreover, the ecological comparison (Table 12) proves that the CS culture is highly detrimental to the environment whereas CMAAS culture has negligible or no harmful impact on the environment.

Table 11: Value of BCA measures of CMAAS and CS culture

Measures of CBA	CMAAS Culture (BDT/*bigha*/yr)	CS Culture (BDT/*bigha*/yr)
Present Value of Costs (PVC)	16550	8860
Present Value of Benefits (PVB)	217500	177272.72
Net Present Value (NPV)	202454.54	169218.18
Net benefit (NB)	200950	168412.72
Benefit-Cost Ratio (BCR)	13	20

Source: Unnayan Onneshan

Table 12: Ecological Comparison between CMAAS and CS culture

Criteria	CS culture	CMAAS Culture
Salinity	Increases salinity in soil (in farmland and in adjacent lands)	No use of saline water; no salinity intrusion
Use of lands	Used ponds exhaust usefulness within three to six years of construction. So, destruction of mangroves occurs to make room for more ponds.	Homestead adjacent fallow lands are used, and no conversion of forest lands into cultivation lands.
Use of chemical fertiliser, pesticides, insecticides	Chemical fertiliser, insecticides etc. are used, causing pollution.	No usage of chemical fertiliser or insecticides, natural feeding, and therefore, no pollution.
Impact on agricultural productivity	Restricts crop production in agricultural land (by increasing salinity of lands) and conversion of agricultural lands to shrimp farming ponds reduces land availability.	Does not affect the agricultural productivity.
Impacts on the Sundarbans (in particular)	Eradication of natural mangrove vegetation, and pollution of aquatic resources (negative).	Eases and reduces the increasing anthropogenic pressures, making an alternative source of livelihoods for the local people who are dependent on the Sundarbans.
Adaptation to climate change	Increases the vulnerability to climate change.	An innovative adaptation method to climate change for the vulnerable.

Source: Unnayan Onneshan

The ecological benefits resulting from the practice of CMAAS culture are clearly identifiable. It protects lands and soil from erosion, ensures better utilisation of fallow lands, protects environment from pollution, helps conserve biodiversity resources of the Sundarbans and most importantly provides alternative and sustainable livelihood options for the IPLCs. The CMAAS culture, as a whole, therefore, is a unique adaptation method in the face of climate change in the coastal region, and the local people are the ones who have invented this method, providing a strong ownership and a scope for scalability.

Conclusion:

The CMAAS culture, as a whole, is more economically profitable, environmentally beneficial and socially acceptable than commercial shrimp culture in the coastal region of the Sundarbans. In fact, it may be one of the best alternatives to traditional paddy and commercial shrimp cultivation as it is more profitable and does have less bad impact on local environment and biodiversity. Given the physiographic and socio-economic conditions coupled with vulnerabilities and disasters statistics of the coastal region, CMAS culture, therefore, deserves to be recommended as one of the best coastal adaptation practices.

Appendices

Box-1

Case Study of a Practitioner of CMAAS Culture

Md. Faruk Sardar, aged about 35, son of Md. Jonab Ali Sardar, is an enthusiastic farmer having no formal education who resides in the village of Jamalnagar, union of Borodol, upazila of Ashasuni and the district of Shatkhira. He is a nuclear family consisting of his spouse, two daughters and one son.

Mr. Faruk Sardar has a piece of flood plain land amounting to 50 decimals. The land having proximity to the coastal river Gabura is occasionally inundated by saline water and it is impossible to grow any of the traditional crop varieties on land with extreme salinity level, let alone the paddy cultivation. He started brainstorming over the possible alternative uses of the land and about 10 years ago being motivated by self curiosity, started collecting the seeds of Golpata bearing by the river from the Sundarbans while he along with others was fishing in the river mentioned thereof and prepared a seedbed in his home-yard. Interestingly, nice saplings came out from the seeds and grew well. Then he planted out them in a part of the farming plot. He elevated the dyke of the plot so that it can store water for longer and accordingly could cultivate different kinds of shrimp and fin fish (Bagda shrimp, veltki) there. Successive fruitfulness boosted his confidence and enthusiasm to a higher level. Hopefully, He brought the whole of the plot under CMAS Culture.

Fortunately, after only 6 months of cultivation he could harvest both of the Golpata and finfish. At present, yearly about BDT 50,000 and 20,000 come from fish and Golpata cultivations respectively whereas he has to spend only about BDT 10,000 and BDT3000-4000 for the cultivation purpose particularly in buying fish fries and fish fodder respectively. Sometimes they themselves collect fish fries from the river. Yet, Golpata cultivation doesn't need any investment except labor cost. In addition, if it is once planted, it continues growing saplings from its roots. He argued Golpata cultivation is more profitable than that of fish. Besides, it needs minimum care and maintenance. Keora and Goran can also be grown here on small scale. During coastal flood, different types of crabs enter the CMAS Culture farm. Crab is an important exporting item of the country. Yet, earning from crabs varies from year to year depending on its abundance in the farm. He claims that this cultivation has received more attention and popularity in the locality after the paddy lands got inundated by Aila forced tidal flood. Now, he is happy with this cultivation to the content. Yet, his concern is that fish must be harvested before the cyclone and normal coastal flood seasons. Otherwise, the fish may go away with the flood and tidal surge water. He also argued that CMAS Culture may be the best alternative to traditional paddy and commercial shrimp cultivation as it is more profitable and does have less bad impact on local environment and biodiversity than those. He expects positive interference on this culture from all concerned particularly from the government and the local government bodies.

Box-2

Case Study of the CMAAS Culture Pioneer

Khoybor Sardar, aged about 60, is a marginal farmer cum traditional collector (Bowali) of resources from the Sundarbans Mangrove Forest who resides in the village of Nanksha, union of Amadi, upazila of Koyra and the district of Khulna. He is the father of 4 sons and 4 daughters. He lives in an extended family with his wife, sons together with their spouses and children.

The enthusiastic farmer pioneered the integrated cultivation of some mangrove species, both floral and aquatic, like Golpata, Keora , Goran, shrimp (Bagda and *Horina*) and some types of finfish (*Paissha, Vetki, Bangal* and the like) that the present study has taken for CMAS Culture. Being self-motivated and using traditional knowledge and innovative ideas, he started practicing CMAS Culture about 10 years ago as an experiment and eventually the initiative became fruitful. Now he narrates here his success story in brief.

Mr. Sardar had a small plot of lowland with submergence almost all the year round amounting to 12 decimals next to his homestead which was hardly used for any productive purpose. He collects the Golpata seeds floating on the river water and grows saplings from them in a home-made seedbed and planted them on his farm land with knee-deep water. Then he cultivated shrimp and finfish mentioned thereof in that marshy land. After only 5 months of cultivation he started getting harvest. Now his yearly earning from Golpata and fish is about BDT 6000-8000 and 12000-15000 respectively with a cost of about BDT 2000-3000 only for fish culture and minimum care and maintenance. In addition, a few Keora trees have added a new look and economic window to the farm. Interestingly, one of the trees has borne a large beehive which quarterly offers about 3-5 kg honey fetching a market value of about BDT 1000-1500. It is a successful innovation of his life as he claims.

In May 25, 2009 the Cyclonic Storm Aila harshly hit the Coastal Bangladesh, widely breached the coastal embankment. Consequently, almost the whole of Koyra Upazila got inundated by saline water of the sea. The agricultural lands lost growing traditional crop varieties. Mr. Sardar argued that in today's context, CMAS Culture may be one of the best adaptation measures here in the Aila impact coastal zone if it can be effectively disseminated after studying its further feasibility through extended field experiment and research.

The Pioneer of CMAAS Culture-Khaibar Sardar in his farm © Loban Rahman, *Unnayan Onneshan*

CHAPTER FOUR
Enhancement of Resilience Capacity of Biosphere Reserve through Sustainable Conservation based upon Traditional Knowledge: A Case Study

Introduction

The article aims at presenting a sustainable conservation framework which can enhance the resilience capacity of a particular type of ecosystem – here the mangrove ecosystem. In this regard, the study considers the case of the Sundarbans, Bangladesh. The Sundarbans, a UNESCO World Heritage Site, Mangrove Biosphere Reserve and Ramsar Site, is situated at the coastal region of Bangladesh. The various ecosystems (forest, coastal and wetland) make the Sundarbans home to several uniquely adapted aquatic and terrestrial flora and fauna. Yet, this globally important ecosystem is now vulnerable due to anthropogenic pressures (e.g. over-harvesting, pollution, coastal development, destructive fishing and habitat degradation, climate change, intense and frequent natural disasters) amidst fragile institutions and ineffective command-driven governance system. For instance, the size of the Sundarbans of Bangladesh reduced to 5,467 km^2 in 2010 from 11,256 km^2 in 1776 and several floral and faunal species of have been facing threats of extinction (e.g. over 40 species of amphibian, reptilians; avis and mammalian are listed as critically endangered or vulnerable).

On the positive side, this case study demonstrates that customary sustainable practices and traditional knowledge of traditional resource users (TRUs) such as wood collectors (*Bawalis*), fisherman (*Jele*), honey collectors (*Mouals*), shell collectors (*Chunary*) and crab collectors can play a major role in reversing destructive trends. They contribute to conservation, restoration and sustainable uses efforts, if they are given a chance and are supported by government and non-government agencies. The discussion and results include: (a) enhanced understanding about the value of coastal and marine ecosystems (particularly mangroves) for building resilience through bio-cultural diversity, (b) exploring area-based conservation and ecosystem based solutions, and (c) assisting the local coastal communities to become more resilient through ensuring that their rights over marine and coastal ecosystems and their services are better recognised and supported.

The article applies and connects diverse knowledge systems for enhanced ecosystem governance by using multiple evidence based approach, with emphasis on participatory processes in generation of knowledge on application of endogenous, ecosystem based solutions, utilizing the ILK platforms of the local resource users of three cooperatives - *Harinagar Bonojibi Bohumukhi Unnayan Samity*, *Koyra Bonojibi Bohumukhi Unnayan Samity* and *Munda Adivasi Bonojibi Bohumukhi Unnayan Samity*, - which have been facilitated by Unnayan Onneshan to have their own capacity to claim their rights, conserve biodiversity, build resilience and innovate livelihood based solutions.

Current state of the Sundarbans under DPSIR Framework: Evidence of resource vulnerability

The Sundarbans has been experiencing major ecological and physiographical changes due to both anthropogenic pressures and natural disorders which are taking a heavy toll on the regenerative capacities of the forest and its ability for maintenance of sustainability. Such pressures have been resulting in the continuous decline of the forest coverage and of its

biodiversity resources. This section attempts to present this trend of declination of resources as well as the driving forces that have caused this declination.

Since 1994 the Department of Forest (FD on behalf of the state took the responsibility to ensure the efficient use of resources of the Sundarbans as the owner, proprietor, authorised claimant and authorised users. The resource users have the right to access and use resources by obtaining permission from the FD. On the contrary, the local people had got management rights along with the access and withdrawal rights. The practical scenario, however, signifies that this formal institutional arrangement is not stable. They have to face many barriers to exercise their rights to have access inside the forest and to use the biodiversity resources. Moreover, the FD is also found to be inefficient to exercise its legal rights in a stable way. Such instability is apparent through several legal and quasi-legal interventions by different powerful agents into this resourceful region as will be clarified in the discussions below.

Rent-seeking Tendency and Extra-legal Management

The government agencies, officials and functionaries are alleged to be rapacious in their own right too. There are irregularities in fishing, and collection of honey, timber and *golpata*. For instance, in every case the traditional collectors have to get access right (BLC – Boat License Certificate) from FD to enter into the forest by paying extra tolls in form of bribe. To cope with such excessive tolls, the resource collectors have to collect resources more than they are permitted to which adversely affects forests' reproduction capacity. Moreover, the illegal encroachment into the forest, as described in the previous sub-section, by the politically powerful ones has been possible with the direct cooperation of forest officials through bribery and other illegal means such as embezzlement and misuse of power. Going against its own policy, the government over the last few years permitted setting up of 190 industrial and commercial units in the ecologically critical area (ECA) of the Sundarbans, which poses a serious threat to the biodiversity. The government declared the 10-kilometre periphery of the mangrove forest as the ECA in 1999, after the UNESCO listed it as a natural world heritage site. As per Bangladesh Environment Conservation Act 1995 (amended in 2010), no one is allowed to set up any factory in the ECA.

Land Reclamation and Shrimp Cultivation

Conversion of land into commercial shrimp farming is the largest human threat to the Sundarbans mangrove ecosystem. The increase of the farms is mainly caused through quasi-legal intervention. The farms are put in place by the powerful local stakeholders, specifically, by the rich fishermen (not part of the indigenous people), connected with political and administrative structures at local and national levels. There is an increasing trend of shrimp (Bagda– *penaeus monodon*) cultivated areas adjacent to the Sundarbans (in hectares) from 1992 to 2005 (Figure – 35). The constructions of shrimp ponds contribute to degradation and loss of mangrove habitats in several ways. For instance, a shrimp cultivating pond exhausts its usefulness within three to six years of construction.

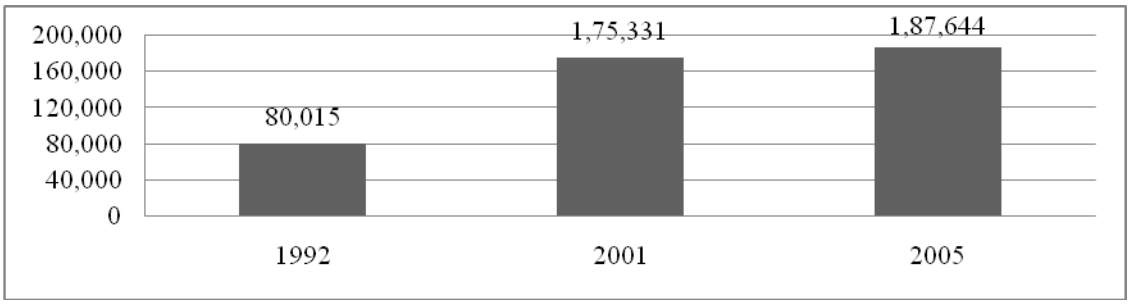


Figure 35: Bagda shrimp cultivated areas adjacent to the Sundarbans (in hectares) (*Data Source*: IUCN 2014)

So, the cultivators have to move along the coast, destroying mangroves to make room for more ponds. Moreover, it increases salinity in the soil and thus alters the soil composition of that region. Southwest coastal region of Bangladesh is already facing increasing salinization**,** especially between October and May. Laboratory analyses of water and soil samples show an increase of salinity over time in the region. Climate change induced sea-level rise will further intensify the problem of river and soil salinization (World Bank, 2016).

Marginalization of Traditional Forest Users

The current management framework of the Sundarbans excludes the traditional forest resource users in the management process. Here exclusion means that the communities cannot apply their customary knowledge to resource management. Their exclusion from managing this forest led them to undermine the process of conservation because of inadequate representation of their interests. Moreover, the current management practice does not manage alternative livelihood options for them.

Conceptual Framework - Informal Institutions, Sustainable Conservation and Resilience Capacity

Means and measures employed for the biodiversity resource management are primarily drawn from market centric theoretical underpinning as a part of the intellective project of neo-liberalism. This school of thought suggests that the degradation of biodiversity resources causes primarily for the non-existence of market and negative externality (Sandmo 2015; Perrings et al. 1992). It argues that valuation techniques can provide useful insights to support policy initiatives by quantifying the economic value of the resources and to devise exchange rule associated with the protection of biological resources (Costanza et al. 1997; Pearce 2001; Bräuer 2003; Kumar 2005; Barbier 2007; McAfee and Shapiro 2010; Hahn et al. 2015). This understanding has been complemented by the institutional economists as establishing a formal property rights regime can efficiently manage the natural resources where the absence of property rights results in resources degradation (Ostrom 2000; Vatn 2009, 2010; Ituarte-Lima et al. 2014).

The political economy framework of resource management, on the contrary, contends that the existence of overlapping property rights regime contributes to the conflicting resources management and degradation. It sheds light on the political elements in resources management

regime and highlights on the hierarchical relationship that exists in society. It argues that institutional arrangements (property rights) are vulnerable to some political economic factors stemming from accumulation by different agents in presence of non-cooperative solution. It emphasizes on the claim that the degradation of natural resources is not only about the non-existence of market but also about unequal power sharing by the stakeholders over the management of resources (Figure 6.4).Existence of vertical relations in society and upward enforcement of rules enable the powerful group to capture resources with impunity (Adhikari and Goldey, 2010). The process prioritises the rule of individuals over the rule of law which ultimately results in institutional fragility, enlarging rent dissipation, rent seeking and seize of property rights.

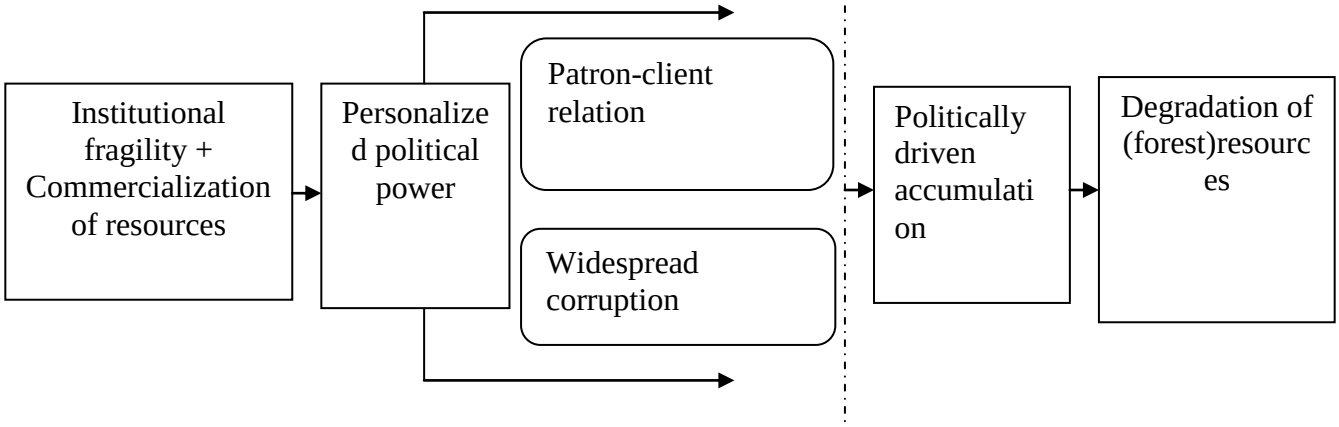


Figure 36: Political economy factors inducing biodiversity resources degradation (*Source:* prepared by the authors)

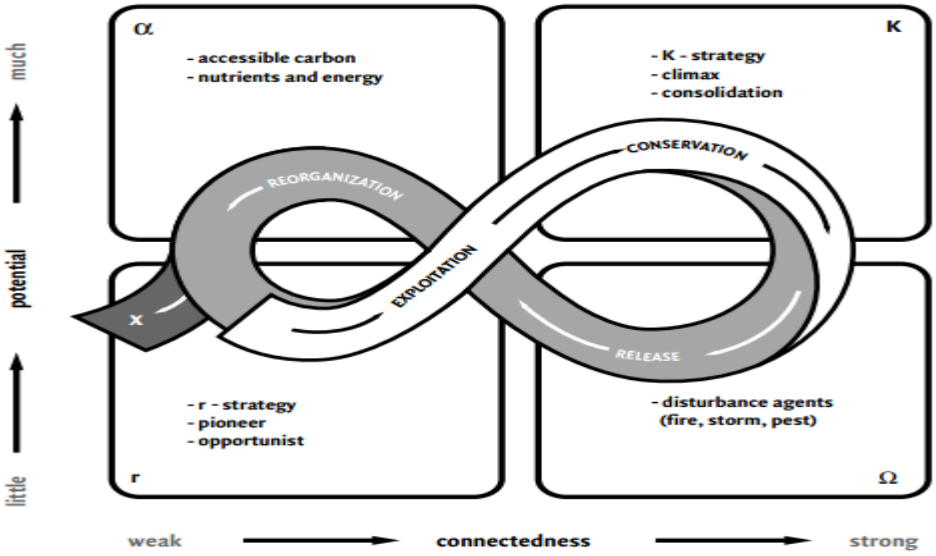
Both of these frameworks fail to offer a sustainable solution in regard to the distinct characteristics of interdependent relationship among humans, biodiversity resources and ecosystems services. Exchange based on economic valuation is found to be faulty (Kosoy and Corbera 2010; Gómez-Baggethun and Ruiz-Pérez 2011; Muradian et al. 2013; Turnhout et al. 2013; Neuteleers and Engelen 2015). It reduces biodiversity into a number of quantifiable parts, subjecting to the utilitarian usage and reducing social-natural relations to market transactions (Turnhout et al. 2013). Such measures provide a narrow conception of ecosystem services and are potentially detrimental to conservation of resources. Alongside, the political economy does not provide any measures but a broad understanding of the contributing elements of the degradation of natural resources.

Against this backdrop, this article here considers an alternative framework derived mainly from the branch of *'sustainability science'* and builds an alternative conservation framework bases upon the components of informal institutions, sustainable conservation and resilience capacity. The key aim of the framework is actually to assess the resilience capacity of the Sundarbans under current conservation framework and under alternative conservation framework.

The framework of sustainability science consists of understanding the limits to growth, the role of innovation along with the adaptation and the resilience of the complex socio-ecological

system (Cumming & Peterson, 2017). This stream proposed that both the anthropocene and the growth causes disturbance in the balance of ecology but the ecology has capacity to reorganize and can persist by the support from innovation. The adaptive capacity of the nature in subtle way after being perturbed determines newer equilibrium in the long run and provides similar ecosystem services which is defined as resilience. Resilience, therefore, has been defined as the capacity to cope with change stemming from exploitation of resources and continue to develop through transformation, adaption or regeneration, relates to social-ecological dynamics in governance of specific resources system (Bousquet et al, 2016; Wilkinson, 2012; Cumming, 2013; Folke, 2005, 2010; Cork, 2010; Miller, 2010; Lebel, 2006; Olsson, 2006; Cote & Nightingale, 2011; Rockstrom, 2009). The ecology adapts with transformation driving from anthropogenic intervention and internalizes the external shocks (Houria & Denis, 2014). The ecology follows an adaptive cycles of organization, collapse and renewal to cope up with the changes (Holling, 1986).

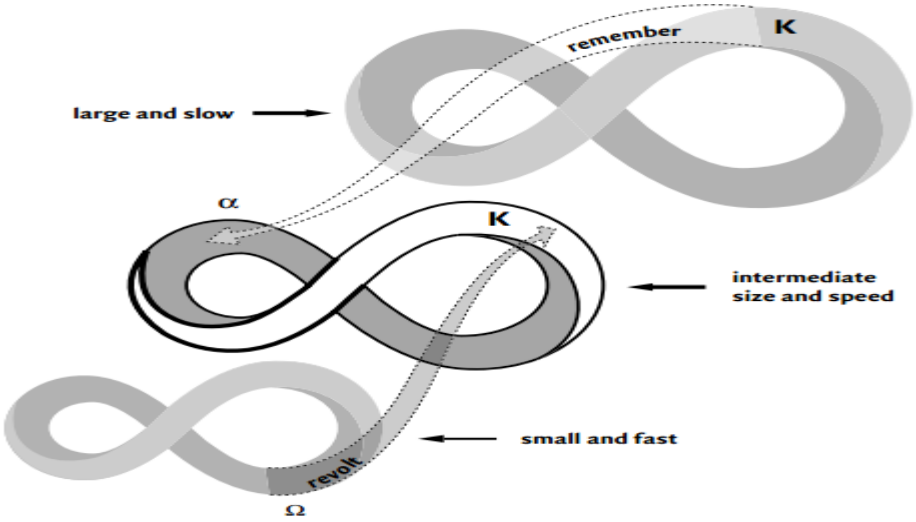
Figure 37: Adaptive cycle of the ecology



Source: Adapted from Berkes et al. (2003)

The school proposes a heuristic model explaining that the ecology follows a cyclical process (Berkes et al., 2003; Holling, 1986). It argues that the stock of ecological services has three stages measured in the vertical axis that are little, potential and much. On the other hand, it postulates that the system has three forms measured in horizontal axis that are weak, connectedness and strong. There are four scenarios that explain the cyclical process of resilience of socio-ecological system. The exploitation of resources starts from the steady state '*r*' and starts reducing the stock of resources. Simultaneously, the ecology starts adapting through the innovations at '*k*', particularly the creative destruction coined from Schumpeter (1950) that creates the window of opportunity for novelty and conservation. With the growing disturbance at '*Ω*' from deferent agents and the resistance generates from the conservation, the ecology accommodate at '*α*' by reorganizing the socio-ecological balances.

Figure 38: The interconnectedness of the global ecological cycle

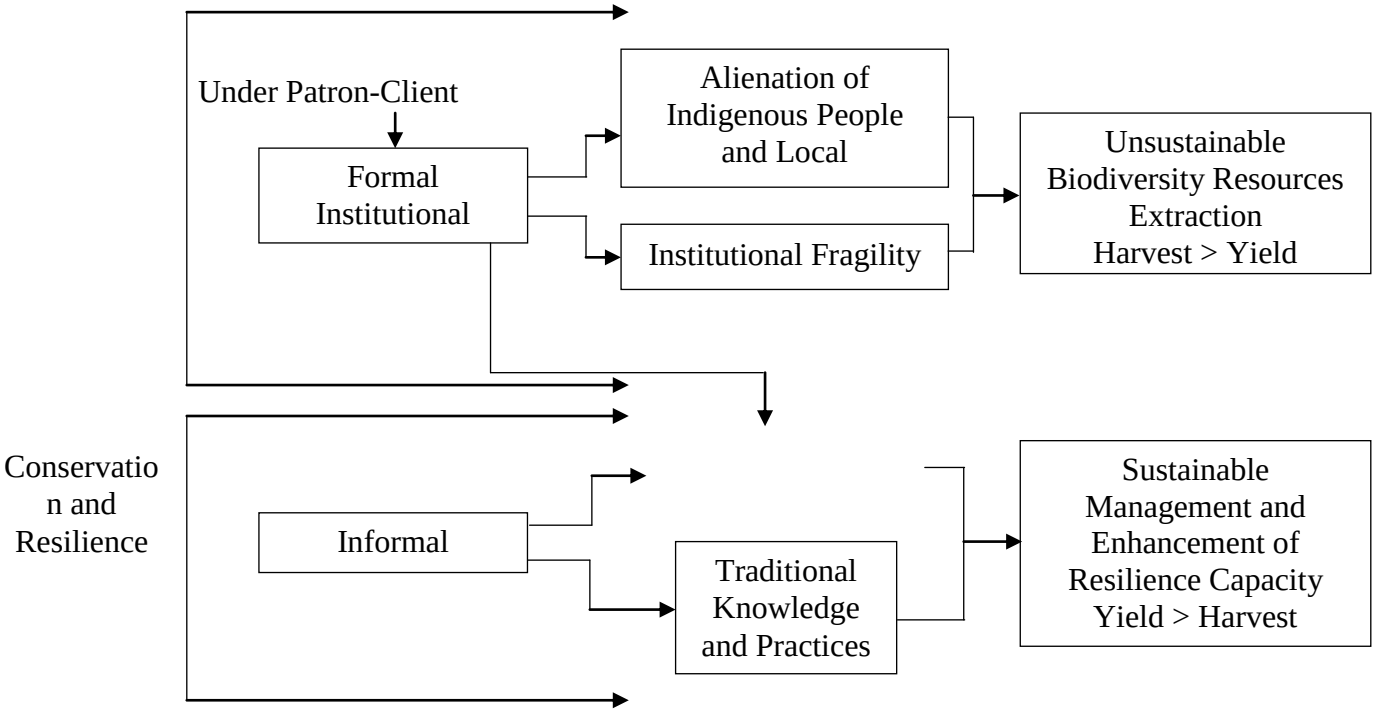


Source: Adapted from Berkes et al. (2003)

It further extends the cyclical process by connecting the small ecology to the global ecological balances called Panarchy (Gunderson et al., 2010; Gunderson & Holling, 2002). The concept Panarchy states that the ecology follows the hierarchical relationship. The micro level ecological change is small and fast that contributes to the intermediary stock of ecology to the global stock of ecology which is large and slow in adaptation cycle. The micro level release (which is the disturbance of agents) affects the macro level conservation and the micro level reorganization further increase the macro level conservation. The interconnectedness of the global environment and the global ecology, thus, runs into the adaptive cycle. These are main arguments of sustainability science in the context of explaining the meaning of 'resilience' in case of resource management.

The article bases upon this understandings, tries to depict a framework for resource management where both nature and human beings are endogenous. The argument is that human beings are part of the ecology not merely the exclusive agents who extract resources. The long standing embeddedness of the human beings into the ecology and the roles they play into the system remains unexplored and sometimes has been identified as external to the system. Being a part of this system, human beings have been maintaining an interwoven, intimate and reciprocal nexus with the nature. This nexus can be explored from 'human sociality' perspective. Human sociality refers to the human beings, as a collective organization, and is part of the larger ecosystem, which possess distinct knowledge and practices that systematically and sustainably contributes to the conservation and regeneration of the resources along with maintaining provision of ecosystem services. It stresses upon that societies in harmony with nature contribute to the biodiversity conservation through revitalization and supporting SEPLS where informal institution plays a crucial role. Informal institutions which include norms, values and traditional knowledge not only contributes to the SEPLS but also conserve and regenerate the resources for making a more resilient ecology and society. These types of informal institutions are in fact the innovations which are necessary for enhancement of resilience capacity of a particular type of ecosystem. As a whole, the framework claims that conservation requires acknowledging a diversity of values, knowledge and framings of socio- ecological productions landscapes which build the cooperation and incentivize conservation for long term sustainable use of those resources which ultimately results in a resilient ecosystem structure (Figure 39).

Figure 39: Conceptual framework (*Source*: prepared by the authors)



This framework argues that in the presence of neoliberal means and measures, the exchange process constitutes a patron-client relationship. In this process, the TRUs become external agents to the ecological milieu and it brings institutional fragility because of unequal power sharing between political elites and TRUs. Such, exchange relationship culminates into primitive accumulation of the resources and unsustainable extraction of resources (where, harvest is greater than the yield due to maximum realization of the resources rent). Alternatively, the sustainable conservation framework suggests that allocation of resources regime to the TRUs is sustainable. They together with their traditional knowledge and practices constitute a socio ecological production network. They contribute to sustain this production network because of its symbiotic nature to the stock of resources. This incentivises TRUs to innovate knowledge as regards to conserve the resources and to practice for ensuring a sustainable value chain. Thus, altogether the TRUs and their TK practices make the biodiversity resources more resilient (where, yield is greater than harvesting) and sustainable.

Assessment of Resilience Capacity of the Sundarbans

This sections attempts to assess the resilience capacity of the Sundarbans under two different scenarios: (a) under current conservation framework and under alternative conservation framework. The current management approach has already been discussed. This section, accordingly, first of all will provide a brief overview on the 'resilience indicators' as has been

chosen by the authors for this study. Then it presents the informal institutional arrangement that can be found to be practiced by the TRUs groups which are the key components of alternative conservation framework as has been argued in the previous section. Along with that, the resilience capacity will be assessed based on those indicators.

Resilience Indicators for SEPLS

The resilience approach is argued in the conceptual framework section to beuseful when considering the potential to maintain, revitalize and rebuild a particular type of ecosystem. While discussing on the profile and state of the Sundarbans, the article has showed that the Sundarbans can be identified as a perfect case of Socio Ecological Production Landscape and Seascape (SEPLS). The study, therefore, considers the "resilience indicators of SEPLS"[7] to assess the case of the Sundarbans. Fundamental changes to SEPLs have the potential to unbalance customary sustainable use processes, leading to decreased resilience and increased vulnerability. To avoid such negative trends, it is therefore crucially important not only to obtain a clearer understanding of the "components" of resilience, but also to empower local communities and provide them with the tools to understand their resilience. Such indicators would provide a strong foundation upon which to recognize negative trends and potential opportunities for further strengthening resilience. The following table exhibits the indicators and their components in detail (Table 13).

Table 13: Resilience Indicators for SEPLS (Source: UNU-IAS)

Resilience Indicators and Questions for Scoring	Scores
Landscape/seascape diversity and ecosystem protection	
1. Landscape and seascape diversity Is the landscape/seascape composed of diverse natural ecosystems (terrestrial and aquatic) and land uses?	(5) Very high (There is a large number of natural ecosystems and land uses) (4) High (3) Medium (2) Low (1) Very low (There is only one or a very small number of natural ecosystems and land uses)
2. Ecosystem protection Are there areas in the landscape or seascape where ecosystems are protected under formal or informal forms of protection?	(5) Very high (Key resources are under some form of protection) (4) High (3) Medium (2) Low (1) Very low (There are no areas under protection)
3. Ecological interaction considered	(5) Very high (Ecological interactions are considered while managing natural

[7]The indicators are jointly developed by Biodiversity International and UNU-IAS.

Are ecological interactions between different components of the landscape or seascape considered while managing natural resources?	resources) (4) High (3) Medium (2) Low (1) Very low (Ecological interactions are not considered while managing natural resources
4. Recovery and regeneration Does the landscape or seascape have the ability to recover and regenerate after extreme environmental shocks?	(5) Very high (Very high ability to recover and regenerate) (4) High (3) Medium (2) Low (1) Very low (Very low ability to recover and regenerate)
Biodiversity	
5. Diversity of local food system Does the community consume a diversity of locally-produced food?	(5) Very high (Diversity of locally-sourced foods is very high and these foods are widely consumed) (4) High (3) Medium (2) Low (1) Very low (There are very few or no locally-sourced foods
6. Maintenance and use of local crop varieties and animal breeds Are different local crops, varieties and animal breeds conserved and used in the community?	(5) Very high (Local crop varieties and animal breeds are widely conserved and used) (4) High (3) Medium (2) Low (1) Very low (There are few or no local crop varieties and animal breeds)
7. Sustainable management of biodiversity resources Are common resources managed sustainably?	(5) Very high (Common resources are managed sustainably) (4) High (3) Medium (2) Low (1) Very low (Common resources are overexploited or depleted)
Knowledge and innovation	
8. Innovation in agriculture and conservation practices Does the community develop, improve and adopt new agricultural, fisheries, forestry and conservation practices and/or revitalizes traditional ones to adapt to changing	(5) Very high (The community is receptive to change and adjusts its practices) (4) High (3) Medium (2) Low

conditions, including climate change?	(1) Very low (The community is not receptive to change and makes few innovations)
9. Traditional knowledge related to biodiversity Are local knowledge and cultural traditions related to biodiversity transmitted from elders and parents to young people in the community?	(5) Very high (Local knowledge and cultural traditions are transmitted to young people) (4) High (3) Medium (2) Low (1) Very low (Local knowledge and cultural traditions are lost)
10. Documentation of biodiversity-associated knowledge Is agricultural biodiversity, and associated knowledge, documented and exchanged?	(5) Very high (Documentation is robust) (4) High (3) Medium (2) Low (1) Very low (There is little or no documentation in the community)
11. Women's knowledge Are women's knowledge, experiences and skills recognized and respected at household, community and landscape levels?	(5) Very high (Women's knowledge, experiences and skills recognized and respected at all levels) (4) High (3) Medium (2) Low (1) Very low (Women's knowledge, experiences and skills are not recognized and respected)
Governance and social equity	
12. Rights of the community in resource management Does the community have customary and/or formally recognized rights over land,(seasonal) pastures, water and natural resources?	(5) Very high (Rights are fully recognized and not disputed) (4) High (3) Medium (2) Low (1) Very low (Rights are not recognized and heavily disputed)
13. Community-based governance Is there a multi-stakeholder landscape/seascape platform or institution able to effectively plan and manage landscape resources?	(5) Very high (Platform or institution is capable of transparent, participatory and effective decision making) (4) High (3) Medium (2) Low (1) Very low (There is no multi-stakeholder platform or institution)
14. Social capital as cooperation and coordination in resource management Is there connection, coordination and cooperation within and between communities for the management of natural resources?	(5) Very high (There is a very high level of cooperation and coordination in natural resource management) (4) High (3) Medium

	(2) Low (1) Very low (There is little or no cooperation and coordination in natural resource management)
15. Social equity Is access to opportunities and resources fair and equitable for all community members, including women, at household, community and landscape level?	(5) Very high (Access to resources and opportunities is fair and equitable at all levels) (4) High (3) Medium (2) Low (1) Very low (Access to resources and opportunities is not fair and equitable)
Livelihood and Well-being	
16. Socio-economic infrastructure Is the socio-economic infrastructure adequate for the needs of the community?	(5) Very high (Socio-economic infrastructure meets all community needs) (4) High (3) Medium (2) Low (1) Very low (Socio-economic infrastructure does not meet community needs)
17. Human health and environmental conditions What is the general health situation of local people also considering the prevailing environmental conditions?	(5) Very high (Health situation and the environmental conditions are good) (4) High (3) Medium (2) Low (1) Very low (The health and the environmental conditions are bad)
18. Income diversity Are households in the community involved in a variety of sustainable, income generating activities?	(5) Very high (Households are involved in a variety of sustainable, income generating activities) (4) High (3) Medium (2) Low (1) Very low (Households have no alternative economic activities)
19. Biodiversity-based livelihoods Does the community develop innovative use of the local biodiversity for its livelihoods?	(5) Very high (Livelihoods are being improved by innovative use of local biodiversity) (4) High (3) Medium (2) Low (1) Very low (Livelihood improvementsare not related to local biodiversity)
20. Socio-ecological mobility Are households and communities able to move around	(5) Very high (There are sufficient opportunities for mobility) (4) High

between different production activities and locations as necessary?	(3) Medium (2) Low (1) Very low (There are no opportunities for mobility)

TRUs, Livelihood Strategies and Informal Institutions

The TRUs sensibly believe that the forest provides their livelihoods and it must be protected from all sorts of misuse and abuse for the present and future generations. They, therefore, follow some rules according to which they harvest the resources with utmost care and love for the nature.

Innovation and Diversification of Livelihood Patterns

In addition to the above discussed traditional rules and practices, the IPLCs have diversified their livelihoods options by utilising their traditional knowledge and experiences as responses to the continuous deterioration of their livelihood opportunities due to man-made pressures and climate change. They continuously try to cope with changed conditions through initiating innovative management practices.

Innovative Techniques in Agriculture

The local small farmers grow their rice seedlings in raised land with less risk of saline water contamination to ensure maximum survival than transplantation in field. The local communities harvest rice plant at 8-12-inch-high from the ground to respond to high salinity contents in soil and water. Practically this saline contaminated rice straw is decomposed within very short time if these are used as roofing materials. They, therefore, let those to be decomposed in the field whichin turn add organic matter, mainly nitrogen, in soil and also reduce saline intensity, which is beneficial for the growth of their next crop. Since most of them are landless, they grow vegetables on shed or roofs, yard or back yard of their houses.

Enhancement of Resilience under Informal Institutions based Conservation Framework

The study relates twelve indicators out of twenty to the case of the Sundarbans here. A comparative analysis of two conservation approach shows that informal institutions based alternative framework contributes significantly to the conservation of the Sundarbans biodiversity by making more resilient ecology and society (Table 14). This conservation practice directly impacts on 12 resilient indicators indicating a positive relationship. It signifies that this framework is more ecologically responsive regarding the context of a SEPLS. For instance, under the current management approach the ecosystem is hardly protected and the regeneration capacity is hampered as a result of failure of checking anthropogenic pressures. On the contrary, the alternative framework tries to ensure the protection of the ecosystem at a higher level and revitalise the regeneration capacity at the fullest (indicator 1, 2, 3). This is possible as the alternative one puts high emphasis on the importance of the traditional knowledge system whereas the current regime does not fully recognise the traditional knowledge (indicator 5, 6). In

fact, in terms of the governance and equity indicators, the community based governance is only envisioned in the policy paper but in practice such governance system is undermined by agencies of the government. The alternative suggestions, on the other hand - the participation of the community - builds a social capital that contribute to the cooperation, social equity and efficient governance (indicator 7, 8, 9, 10). Such framework, in fact, tries to sustain the biodiversity based livelihoods pattern (therefore, there will be no change in this indicator) that has been found to be existed in that mangrove ecosystem but it argues that such should be acted upon in a sustainable way that conserves the biodiversity resources (indicator 4) as well as provides alternative livelihoods to the human beings under the changed circumstances by diversifying their income sources (indicator 11).

Table 14: Comparative analysis of resilience capacity of the Sundarbans under two different scenarios (prepared by the authors)

Resilience Indicators	Scenario under Current Practice of Management					Scenari
	Very High	High	Medium	Low	Very Low	Very Hig
Landscape and seascape diversity and ecosystem protection						
1. Ecosystem protection				√		
2. Ecological interaction considered				√		√
3. Recovery and regeneration					√	√
Biodiversity						
4. Sustainable management of biodiversity resources					√	√
Knowledge and innovation						
5. Traditional knowledge related to biodiversity			√			√
6. Documentation of biodiversity-associated knowledge					√	√
Governance and social equity						
7. Rights of the community in resource management				√		√
8. Community-based governance				√		√
9. Social capital as cooperation and coordination in resource management					√	√
10. Social equity					√	
Livelihood and well-being						
11. Income diversity				√		
12. Biodiversity-based livelihoods	√					√

The alternative conservation framework also helps achieve some of the important targets under "Aichi Biodiversity Targets" as is illustrated in a table below (Table 12). Firstly, it helps to contribute to the Target no. 10 by reducing pressures on vulnerable (here, mangrove) ecosystem. Secondly, it promotes restoration and enhanced resilience of that ecosystem and thus helps achieve Target no. 15. Finally, and most importantly, it contributes to achieve Target no. 18 by respecting the TK system practised by the local and indigenous communities (Table 15).

Table 15: Achievement of Aichi Biodiversity Targets under the Alternative Conservation Framework

Targets	Relevant Indicators/Issues	Contribution of this Case Study
Target 10: *Pressures on vulnerable ecosystems reduced*	• Trends in extent, of vulnerable ecosystems (here mangrove) • Anthropogenic pressures • Climate change	• Multiple anthropogenic pressures identified on a mangrove ecosystem • Presenting and promoting the TK based climate adaptation methods and sustainable agricultural methods
Target 15: *Ecosystem restored and resilience enhanced*	• Ecosystem resilience • Restoration	• Traditional rules and method followed by IPLCs promotes the restoration process and enhances resilience capacity • Climate change adaptation methods like CMAAS innovated by the IPLCs enhances resilience capacity
Target 18: Traditional Knowledge Respected	• Traditional knowledge, innovations and practices • Customary use of biological resources	• Promotes TK knowledge system practised by the IPLCs • Urges to recognize the traditional practices in the resource management framework • Emphasises on the participation of IPLCs in the resource management

Conclusions

There is significant number of anthropogenic pressures that cause the degradation of biodiversity resources of the Sundarbans. These anthropogenic pressures have mainly intensified with the advent of neo-liberalism as the sole strategy of accumulation of wealth, with profits being considered more important through commercialization of forest products, neglecting intrinsic ecological value of biological resources. These commercial enterprises, formal and informal, are found to be highly organised in their extractions of resources, and most often being politically patronized and administratively supported. The chapter, thereafter, has scrutinized the livelihood strategies of the IPLCs, the resource dependent communities of the Sundarbans and the results show that their livelihood strategies (both traditional practices and innovative tools) are largely

effective and beneficial for the protection and maintenance of natural mangrove ecosystem. The assessment of the Sundarbans on basis of the resilience indicators of SEPLS also shows that the current resilience capacity can be improved by mainstreaming the traditional knowledge base and participation of the indigenous people into the resource management framework.

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