

CHAPTER **6**

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**COASTAL RESOURCE MANAGEMENT  
AND SUSTAINABLE DEVELOPMENT**

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## 6.1 Forest management plan

Ganga–Brahmaputra estuary of lower Bengal lies the world-renowned tidal mangrove forest. Biologically it is very productive and sensitive zone. In terms of ecology, mangrove forestry, brackish water aquaculture, fisheries, mangrove wetlands they are unique in nature. According to the State of Forest Report of Ministry of Environment and Forest, in India the erstwhile mangrove area of 9630 km<sup>2</sup> has been reclaimed for settlements and remaining 4264 km<sup>2</sup> which forms 61% of India's total mangrove forests. Mangroves naturally grow over intertidal zones of delta (Naskar, 1999). Sheltered shallow coast, estuarine mouth, saline mud flats are the favorable condition for the growth of mangroves in tropical and subtropical region. The Department of Environment, Government of West Bengal has estimated about 1952.87 km<sup>2</sup> dense mangrove cover and 226.18 km<sup>2</sup> as sparse mangrove (total 2179.05 km<sup>2</sup>). The remaining 2100 km<sup>2</sup> are the saline water spread under 6 major estuaries. Saptamukhi and Muriganga are two of them. Henry's and Patibania island are the two islands situated at Saptamukhi and Muriganga estuary. Being the reserve forest located beside Muriganga, Patibania has rich biodiversity and productive ecosystem. 26 types of mangroves have been identified in Patibania through field survey. Whereas in the Henry's island, which is a famous for eco-tourism complex and fisheries projects, mangroves are in danger due to anthropogenic causes and the open sea environment.

Mangrove forest ecosystem provide wide array of living resources and protect coastal zones, it improves socio-economic condition of coastal communities by protecting marine environment. However, mangrove forests are facing severe anthropogenic threats due to increase of population pressure and mangroves are used for fuel, fodder, timber, immense cutting of mangrove trees for aquaculture and other development activities. The degradation of mangroves negatively affects coastal ecosystem and biodiversity of the area. Loss of mangroves is serious ecological and environmental concern therefore it requires immediate efforts to mitigate the problem and provide forest management plan.

Mangroves of Henry's island are encroached due to expansion of aquaculture. 1.23 km<sup>2</sup> area are deforested out of 6.47 km<sup>2</sup> of total island area for the expansion of commercial activity. Mangroves are cut for the tourism complex and for food and fodder. Biodiversity of this island has been altered due over-utilization of forest products, not only that salt encrusted areas and wetlands are converted into fishing *bhery* for shrimp cultivation recently. Apart from the anthropogenic activities, sea level rise, climate change, lack of fresh water influx, beheaded creeks, dry tidal inlets all plays significant role in the degradation of mangrove forest in Henry's.



Over exploitation of ground water by tourism activity, coastal pollution by using plastics is also severe threats to the mangroves and coastal system. On the other hand, in Patibania which is a part of Susnir char, a reserve forest area (1.23 km<sup>2</sup>) also faces the problem of mangrove degradation. Though this island is protected from anthropogenic activities or commercial utilization of forest products but sea level rise, climate change, loss of fresh water influx, wash over deposits are the major factors behind the degradation of mangrove forest at Patibania island. Forest Department along with local NGO's take initiatives to restore the mangrove forest from ongoing threats of degradation. Basic function of Sundarban mangroves is trapping of sediments and land formation, protection of human lives and habitations from frequent cyclones. It is a habitat for biotic community, waste recycling, great role in carbon sequestration, timber production, supply food and building material. Mangrove maintain the balance of terrestrial ecosystem and its communities. To maintain its ecological role, these forests must be conserved with proper management techniques. Major objectives of taking forest management plans in coastal area of Sundarban including Henry's and Patibania islands are-

- Restoration of mangrove ecosystem and conservation of biodiversity.
- Forests and terrestrial resource, wetlands and aquatic resources maintenance and sustainable utilization.
- Provide resilience-based food security through provision of a variety of subsistence uses including fisheries, forest products, etc.
- To provide enhance eco-tourism and visitor recreation opportunities.
- To improve and support community-based co-management approaches for the activities taking in forest and its surrounding area.
- Providing appropriate implementation of climate change mitigation and adaptation options and opportunities.

In [Gopal \(2014\)](#), it was stressed that a management plan for the mangroves should be devised with treating the mangrove habitat as a wetland and not forest. To restore the degraded forests and maintain ecosystem services local people along with NGO's implement afforestation of mangroves following certain strategies. According to Sundarban Biosphere reserve, management scheme they divide the total Biosphere area into three zones likely Core, buffer and

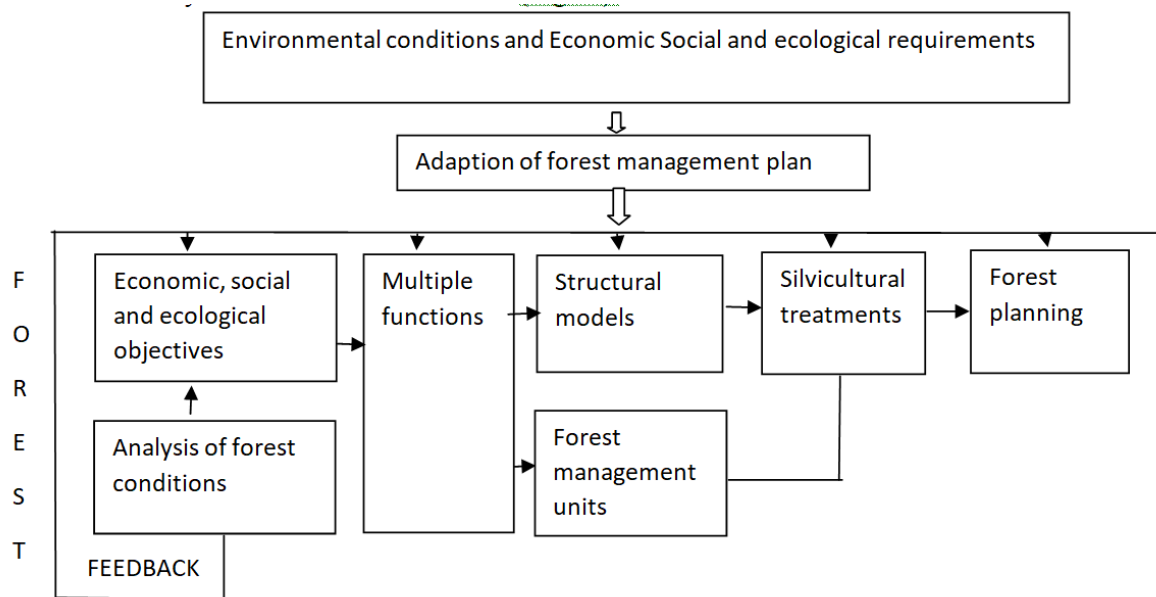


Figure 6.1: Forest management plan (after Tudoran and Zotta (2020)).

transition zone. Core area should be identified to that area is which protected and devoted for biodiversity only. Sundarban Reserve Forest management authority designate eastern portion of Sundarban beside Bangladesh which is considered as core area. Buffer zone considered the mangrove forest zone including reserve forest areas adjoining core area. Transition zone is demarcated to the area which is non forest areas and reclaimed areas. According to Tudoran and Zotta (2020), forest management plan should be based on the species of the vegetation and their adaptive capacity. They have identified a forest management plan which include the factors of environmental conditions, economic, social and ecological objectives followed by analysis of the forest conditions (Figure 6.1).

West Bengal forest department has taken initiatives in to promote forest management plan in Henry's and Patibania islands, they are as follows:

**(A) Intensification and surveillance** Henry's island is popular for its tourist activity. Therefore, it results into biotic pressure on the forest. Mangrove forests are under severe threat from fishermen, wood collectors, honey collectors and poachers. Forest department. Forest department strengthen their infrastructure to monitor over the coastal resources like setting up watch tower, check post at the transit routes. Radio and telephone communication establishment under unified RT network. Posting of forest guards at Patibania island to monitor the conserve the protected forest from illegal intruders in the forest and immense cutting of trees (Plate 6.1).

**(B) Afforestation and soil conservation** Afforestation with mangrove species is the first



Plate 6.1: Watch tower of Kiran beach at Henry's island (left), with forest guard at Patibania island (right).

attempt is being made by the local people and forest department to stabilize mudflat, restore ecosystem. To conserve threatened species plantation is being done along the shore line, and on the intertidal zone of coast. Extreme salt tolerant mangrove species like *Salicornia Brachiata*, *Aegiceras Corniculatum*, *Avicennia Merina* are selected for afforestation. Saltmarshes are planted along the sand dunes for trapping sediment and protect island from storm surge. Local people also take initiative in afforestation programme with NGO's (Plate 6.2). Second method are opted that selection of indigenous and fast-growing mangrove at the mud flat to meet the demand of local people for fodder, fuel and timber.



Plate 6.2: Afforestation along mudflat (Henry's island).

**(C) Land development and improvement of soil moisture** Interior part of the Henry's island does not experience any tide water due to tidal drainage loss and beheaded creek system. This results into increase of salinity and formation of saline blanks which do not support any vegetation. Low soil moisture, high salinity, low organic matter make the soil infertile. It has





Plate 6.3: Saline blanks (left) and canal (right) in Henry's island

been proposed to dig canals across this islands for experimental basis to facilitate tidal flooding and increased moisture in such barren lands (Plate 6.3). Artificial and natural introduction of mangrove seeds may improve the vegetation cover (Plate 6.2).

**(D) Eco development and joint forest management** No forest management program would be succeed until local people actively participate in planning and management of the forest resource. On the basis of people's participation in forest management in these islands, West Bengal forest department has issued Govt. orders facilitating the formation of forest protection committees. This committee stand against exploitation of forest resources. They propose alternate livelihood options to the target group and aware people to the issue of forest conservation. Officers of the forest protection committee give the lesson of sustainable utilization of resource like how to conserve fresh water by roof top rain water harvesting. How to control extraction of ground water for fishing and other commercial work. The sweet water ponds and canals can also be used for fresh water aquaculture to generate additional income for the beneficiaries selected from the BPL categories of people.



Plate 6.4: Artificial ditches for the plantation of mangroves:.

**(E) Bio-restoration of mangroves** The Forest Department attempted to restore the mangrove

ecosystem in the island interiors through ecological engineering methods. Tidal drainage loss is a major problem in the interior parts of the islands, and therefore a series of ditches have been constructed to supply the tidal water during high tides into the island core and buffer areas (Plate 6.4). Ditches are utilized for mangrove afforestation, and ridges between parallel ditches are used for planting the salt marshes and heaths for a gradual restoration of the mangrove ecosystem.

The mangrove restoration ditches are constructed mostly in the salt flat areas, not salt pan areas. This is because in the depressions which contain the salt pan regions, construction of ditches and ridges are not fruitful for the regeneration of mangroves. Photographic documents show the method of such engineering techniques applied in Bakkhali and the Henry's island as well as practiced in the Patibania island (Plate 6.4).

## 6.2 Fisheries management techniques

The coastal region of Sundarban presents favorable conditions for the establishment of aquaculture and fisheries. Being situated in an estuarine environment, both freshwater and marine fishes are found in this region. The dense networks of roots of the mangroves in the coast and the intertidal region serve as relatively safe breeding sites and nurseries for the fish hatchlings. The abundant organic matter and the associated algae in the intertidal regions and the shallow littoral zones satisfy the nutritional requirement of the hatchlings. However, beside the mangrove habitat providing a favorable environment for the growth of a variety of fish species, there are other factors which has caused the booming of fisheries in Sundarban.



Plate 6.5: Aquacultural ponds of Henry's island (left), Conversion of saltpan into fish pond for shrimp cultivation (right).

One of the principal factors behind the proliferation of aquacultural activities in Sundarban is the low-lying nature of the land that is periodically inundated by tides. The frequent tidal water intrusion makes the soil saline, which is unsuitable for growing most of the usual crops. Inundation of the soil surface is itself detrimental to many crops as it damages the lower stems of the plants. Only a few soil tolerant varieties are suitable for growing in Sundarban, which limits the prospect of agriculture being a suitable and profitable mode of employment for the populace. On the other hand, frequent inundation does not hinder the rearing of fish in the coastal areas. The brackish water of Sundarban is suitable for rearing prawns, shrimps, crabs, and other fishes. Prawns and shrimps grown in Sundarban fetch a good price in both the domestic and the international market. All these factors have made fisheries and aquaculture flourish in the coastal area of Sundarban, and being the source of livelihood of a significant portion of the populace.

Between the two islands under study, the Henry's island has major aquacultural enterprises. Fisheries in the Henry's island are mainly involved in raising shrimp. It is described in the earlier part of the thesis that the aquacultural enterprises occupy the central part of the island. These enterprises were started around 1980's, and have expanded gradually afterwards. Other than tourism, these are the principal source of employment in the Henry's island. A significant portion of the mangrove habitat in the island is cleared to establish these enterprises. Though tidal saline water is used occasionally, most of the water requirement of the fisheries in this island is met through groundwater extraction. Apart from inland fisheries, the the Henry's island also has some infrastructure to support marine fishing in the Bay of Bengal. Parts of the beaches are utilized as drying platforms for the captured fish by the returning trawlers.

The Patibania island, being a protected area, has no established fishing activities.

Saptamukhi estuarine system supports major commercial activities of fisheries. The entire island of Henry's is crisscrossed by many major and minor creek systems. Henry's island is famous for its fisheries project since it has favorable environmental condition and ground for aquaculture. This island receives brackish water through estuarine inlets on the other hand it receives run off fresh water during monsoon which favors the shrimp cultivation. Most of the inlets are interconnected with Hooghly estuary which get additional fresh water from Hooghly river mainly after initiation of Farakka Barrage in 1975 [Sinha et al. \(1996\)](#). These factors help Henry's to establish commercial fishing harbour for shrimp cultivation. But Patibania island do not have any condition for commercial activities. This island does not allow any one to interrupt

its own resource.

The issue fisheries management techniques are relevant for the Henry's island since fisheries extract huge amount of ground water through deep tube well and over utilization of fresh water from creek through canals. To mitigate the demand of population this fishing system demands huge fish production so over utilization of fresh water, withdrawal of ground water destroy the balance of environment and hamper the growth of mangrove. Shortage of drinking water, destruction of biological community are major consequences of over-utilization. Therefore, Fishing management is necessary to combat the problem of shortage of water. A fishing management plan has been suggested by [Cochrane \(2002\)](#) for proper utilization of coastal resource (Figure 6.2).

Principle of fishing management can be implemented in the Henry's island to channelize the proper commercialization of fishing with a sustainable manner. Some techniques should be implemented to make the fishing practices in a simpler way. Major aims of implementation of fishing techniques are-

- To minimize the impact of fishing on the physical environment and on non-target dependent biological species.
- To maximize the employment opportunities for those dependent on the fishery for the livelihoods
- To conserve fresh water and control over utilization of water in fishing.
- To maximize net incomes of the participating people in fishing activities.

To achieve these goals, some techniques are tried to adopt by the Fishing Department of West Bengal in Henry's island. The techniques are: -

- A The total shrimp production is estimated first then biological constraints identified.
- B Environmental impacts of fishing are identified and monitored then management strategies are adjusted as its response.
- C Target reference points are establishing through data collection then fisheries assessments are done.
- D To maintain the balance of eco system fishing and species management interactions are done.



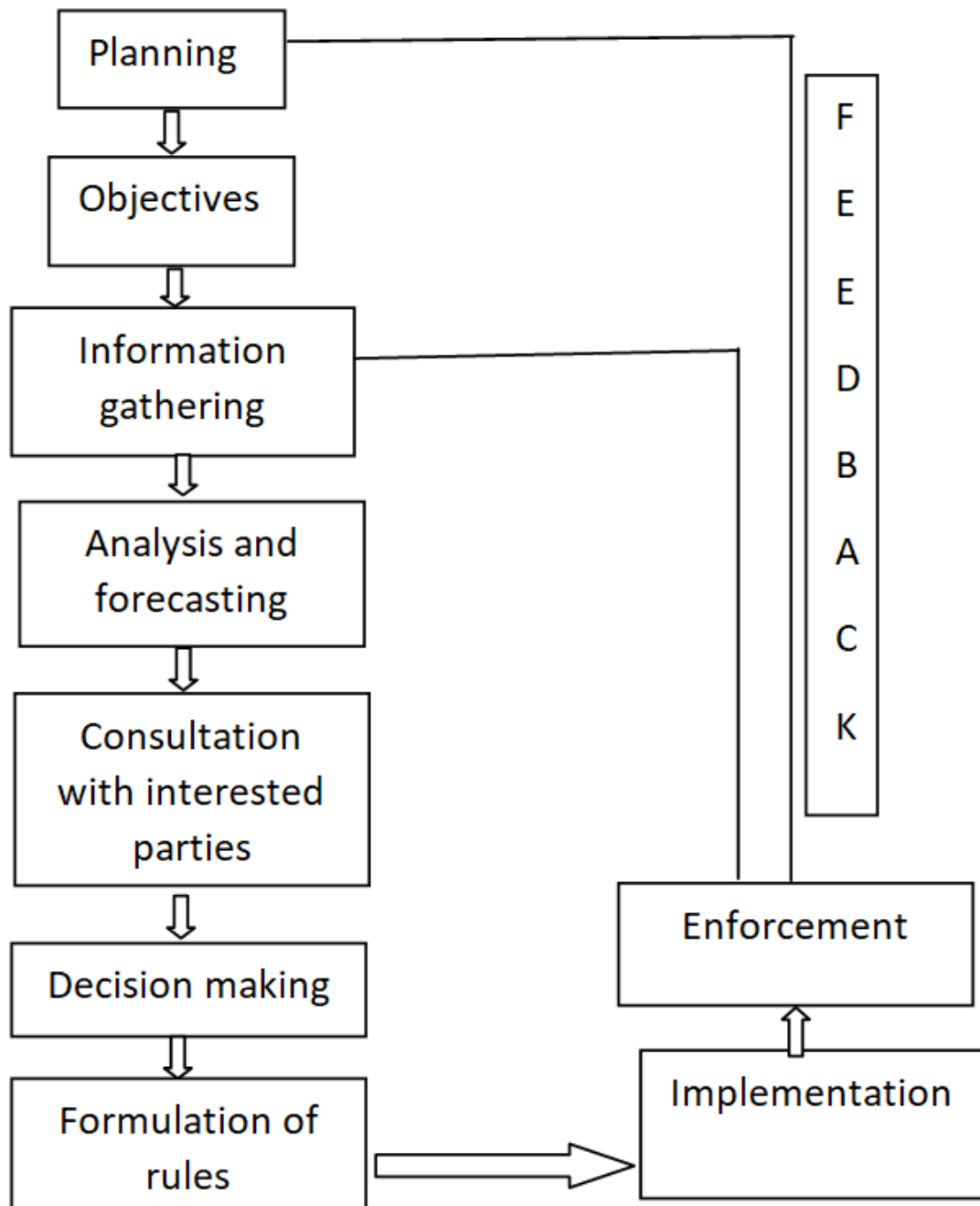


Figure 6.2: Working principle of fishing management (after [Cochrane \(2002\)](#))



- E Risk assessment are done to implement management plans and measurements.
- F Fishing techniques are associated with coastal zone management and national fishing policies.
- G Communication, co-management and consultation are being employed for smooth running of the commercial activities.

Therefore, it can be said that to maintain ecological balance and proper utilization of coastal resources fishing should be done in a scientific proper way so that environment should not be hampered by this commercial activity.

### **6.3 Ecotourism development and sustainability**

Sundarban is one of the main tourist destinations of West Bengal. It gains immense popularity as tourist spot for both domestic and foreign tourists. Visitors frequently reaches and surpasses appropriate limit of growth with little notice of planning and management (Amin, 2018). Tourists get attracted to the Henry's island for the fisheries project and scenic beauty of mangroves. Tourism activity exploits coastal resources and pollute environment. If tourism is not properly planned and manage it can harm the environment and create cultural and social conflict. Recently policy makers have begun to advocate sustainable destination planning for tourism with set of management approaches. The new tourism activity is called 'Eco tourism' which came from the concept community-based ecotourism by Kersten in 1999. This eco-tourism activity is not environmentally damaging, contributes to the conservation of resources and local community development. It provides opportunities for enhanced conservation and sustainable development of that destination. Henry's island has delicate and fragile ecosystem where over pressure of tourist activity act as a stressor on environment. Therefore, implementation of eco-tourism is a great initiative by the forest department and policy makers, environmentalists to ensure coastal resource protection and conservation of natural resources. The main approaches of eco-tourism which has been proposed by National ecotourism policy and guidelines (1998) ,to regulate in Henry's and other part of Sundarban are as follows-

- Environmental preservation and community development.
- Through this approach local community has full control over the management of coastal resources and environment.

- This ensures the involvement of marginalized sector or indigenous group for protection of the coastal system.
- It would help the ecosystem and natural areas with high tourism potentials.
- Eco tourism would create awareness among local people and tourists about the damaging effect of unscientific and over utilization of coastal resources.
- It ensures communal ownership and control and that part of the profiles that flow into community development programs
- Socio-economic development of the area would be accelerated by the initiatives of eco-tourism.
- Environmental security would be enhanced and less dependency on ecology for income.
- Eco tourism approach helps to grow employment opportunities and various other economic activities of income generations for the local community.
- The sustainable tourist development act would emphasize alternate livelihood option like organic farming, medical plant or mushroom cultivation, establishment of repairing shops and local craft.
- Improvement of sanitation, health service entrepreneurship, health insurance system of local community is included in the schemes of eco-tourism.

Implementation of such initiatives would help to maintain the resources and tourism activity would be going in sustainable manner. According to environmentalists impacts of ecotourism on coastal environment is both negative and positive. Negative impacts like there must exist a strong communication and coordination within local people and tourists. Otherwise, there may arise problem of excessive pressure of tourists and damaging effect on resources. If the total ecotourism process is governed by particular community then low incentives generation of local people might create lack of interest in protection of coastal systems. On the other hand, if local people strongly support that initiatives then it would create a positive effect on the community and help in sustainable development and maintenance of ecosystem. Biosphere reserve and World heritage site would get beneficiary effect. This approach would have positive impact on domestic and foreign tourists visiting the destination.

Tourism infrastructure would be developed and culture of the tourists will be enhanced. Proper program of ecotourism help to develop the awareness of visiting people along with the local ones. Pollution rate, damaging effect on the environment would be lowered. If all the benefits are given to the tourists and local people, they both protect environment from all odds. Diversification of ecotourism products like boats, trail walks etc. which will help in retaining majority of the income generated with the local people. So.it can be said that ecosystem approach would really help to maintain sustainable utilization of resources along with the maintenance of tourist activities.

## 6.4 Coastal resource management in the islands

Coast is a zone of dynamic activities which bestowed with enormous resources both living and nonliving things. Coastal system always try to balance among all the resources which are immensely exploited. It has diverse ecosystem like mangrove, beaches, wetlands, estuaries, lagoon, backwater Coastal resource management attempts to integrate and balance among the competing uses of the marine environment in an ecologically sustainable manner. Study are Henry's island which appears to be a tourist spot has been facing severe threats on the coastal resources due to immense pressure of tourism and dependency of local people. Anthropogenic activity like marine fishing, dumping ground for waste disposals all have been bringing about changes in the coastal environment. Patibania being a reserve forest area, no tourism activity hampers the natural coastal resource. Therefore, the natural ecosystem and coastal resources are undisturbed in this virgin land. The need of management of coastal resources for future generation. Coastal resources like fish, mangroves, corals, every aspect needs to be protected and conserve in a sustainable utilization for benefits of future.

Coastal resources of Henry's island are utilized in a several way which indirectly affect environment negatively. Resource utilization in Henry's island and their management plans are listed in the following table. (Table 8)

Table 6.1: Resource utilization in the coastal belt (Paul, 2002)

Resources used in coastal belt	Environmental impact	Management plan
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Unscientific cutting of mangrove forest and used for fuel wood	Ecosystem services hampered and coastal disturbance	It should be conserved through JFM, and afforestation.
Coastal sand dunes and marshes are used as food	Dune migration, sand blusts and marsh surface erosion	For binding tidal flat sediments and protect islands from cyclones and other natural phenomena.
Tidal flats are used for crab harvesting	Removal and disturbances of ecosystem components	Optimum use of the benthic animals should be prohibited for ecosystem function.
Tidal swamp are used for land reclamation for housing and agriculture	Tidal breaches, removal of forest problems and immature reclamation. Salinity hazards and destabilization of sand dunes	Forestry is the best way to restore the problem of tidal swamp degeneration .Salt tolerant species of mangroves should be planted for the stabilization of tidal flat.
Tourism at beaches and hamper the coastal dunes	Erosion of cliff top vegetation those trap sediments. Alteration of intertidal community.	Conservation of dune habitat .It should not used for recreational activity.
Shores are used for cremation ground	Disposal of organic and burning waste.	Dumping of burning waste under the ground surface is necessary.
Fishing from deep sea ,near shores and estuaries	Overfishing create imbalance to the marine habitat.	Over fishing must be controlled, Fishermen should be punished if indiscriminate methods are used.
Shrimp farming at estuaries, ponds, saline blanks, back waters	Soil salinity increases, tidal hazards, pollution of coastal water	A patch of vegetation is necessary around the shrimp cultivation areas to protect bank.

Extraction of salts from sea water mainly from tidal flood-plains, tidal channels and backwaters	Breaches of saline water into nearby agricultural field	There should be minimum distance between salt producing ground and agricultural field.
Extraction of ground water	Subsidence, diminishing ground water, low moisture content in the soil	Fresh water reservoir needs to conserve. Extraction of water should be controlled.
Wetland filling	Wetland ecosystem disturbed	Conservation of marsh or wetland is necessary.
Transportation through creeks and through estuary		

## 6.5 Coastal regulation zone

Coastal zone is ecologically, geomorphologically, economically very sensitive area. The significance of coastal zone is increasing day by day due to mis utilization of coast by the people. Population pressure has been increasing and the exploitation of coastal resources has also increased. Spreading of industry, harbour, recreation activities, aquaculture, fishing, create threats to the ecosystem of coastal environment. These create immense effect on coast like coastal erosion, saltwater incursion into the groundwater, depletion of traditional fish stocks by overfishing, pollution, increasing number of environmental refugees. Only sustainable ecological development of coasts may solve the problem of that area. Any harmful developmental activity should be banned in the coastal zone. To protect coastal system and keeping in view the use of resources and activities in the coastal areas, the Government of India has proposed Coastal Regulation Zone to impose restrictions on developmental activities. According to the rule CRZ is the boundary starts from the high tide level to the 500 m on landward side. In this zone no developmental activities are permissible. On the basis of ecological sensitivity, distance from the shore and designation of natural park and wildlife zone CRZ regulation has been implemented by Coastal Zone Management Authorities like CRZ-I, CRZ-II, CRZ-III and CRZ-IV.

Henry's and Patibania island lies within CRZ -I as these areas are ecologically sensitive and

active geomorphic sites such as presence of mangroves, salt marshes, sand dunes, mudflats and associated biodiversity. Patibania is a reserve forest area and both islands are lying within 500 m from high tide line therefore no developmental activities like building of hotels, recreational activities, economic activities, manufacturing small industries, brick kiln etc. CRZ-I has classified into CRZ-IA and CRZ-IB. CRZ-I-A is a eco-sensitive areas where only ecotourism is allowed, sea links, salt harvesting, are permissible. In CRZ-IB is basically a intertidal zone where new land is created by the ocean which has a strong impact of coastal ecology. Coastal regulation zone is being violated in Henry's island as well as in Patibania island by human interference in a damaging way. Various forms of resource exploitation are done in the coastal belt violating CRZ rule (Table 6.2).

Table 6.2: Resource exploitation and violation of CRZ rule

Islands	Forms of exploitation	Economic forms of exploitation	Functional aspects of land units	Environmental exploitation	Violation of CRZ-IA/CRZ-IB
Henry's	Offshore fishing, collection of honey wax, crab harvesting, fuel wood collection, Livestock grazing, shrimp farming	Exploitation of resources by the local people for their livelihood.	Saltmarsh and mangrove swamp used as shrimp farming. Sea beach used for fishing marine fish landing stations.	Ecosystem disturbances, biodiversity loss.	CRZ-IA
	Tourism, recreational activities, misusing coastal resources	Commercial exploitation by the profit-making groups	Coastal sand dune used as a stock grazing and recreational use.	Wetland loss, habitat conversion, coastal pollution	CRZ-IB
Patibania	Collection of timber for fuel, livestock grazing, collection of honey.	Over utilization of coastal resources in a unscientific way.	Saltpan used as a salt manufacturing unit by the local people.	Mangrove forest depletion, biodiversity loss.	CRZ-IA and CRZ-IB

A number of problems emerged due to the lack of systematic evaluation and monitoring of coastal resource stocks. Afforestation programmes have been implemented to solve the problem of coastal erosion and other environmental hazards. Successful land use planning required for

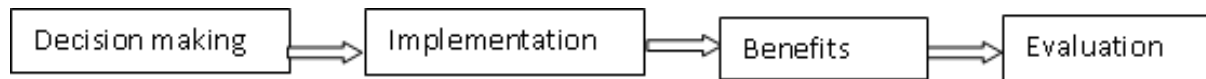


Figure 6.3: Four stages of participatory program.

the protection of coastal zone. Forest department and Government of West Bengal have taken initiatives to overcome the problem of mangrove degradations and maintain ecosystem stability. Several attempts of strict regulation have been made in Henry's and Patibania island to maintain ecosystem services and resource potentiality in the area.

## 6.6 Participatory methods of management in the coasts

Sundarban is the largest mangrove forest on earth, It is a home for large varieties of flora, fauna and it is providing a number of ecosystem services. Presently it has been facing rapid environmental degradation and biodiversity loss due to anthropogenic stresses. So it needs to protect with a suitable conservation measures. Peoples participation in the Sundarban management has become successful initiatives. Sundarban has been managed through wildlife sanctuaries. Forest department is managing their resources by sustainable harvesting of forest products and maintain coastal zone to meet the needs of local people. Sundarban is facing illegal merchant of forest timbers due to high demand of fuel wood. Shrimp cultivation is going without any fishing management techniques. So participatory management techniques is being implemented to conserve coastal resource management ,forest resource management and cultural preservation and rural development of Sundarban.

Participatory management program is required at the outset for the involvement of the participation of people. Local people take part in the design of the program and the benefits must pass directly to the rural communities. People should not remain voiceless and invisible in participatory program, it is a full aspect of development program. There are four stages of participatory program implemented in Sundarban coastal belt. These four steps proposed by [Sanyal and Bal \(1986\)](#). It says that Decision making includes identification and design, timing and activity, implementation indicates contribution of labour, money, material, awareness etc. Participation in benefits include social, political and economic benefits. Lastly participation in evaluation means formal and informal. The basic features of participatory plannings implemented in Sundarban are-

- Active participation by members of whole community to implement management strategy and sustainable use of the resources.
- Increase awareness of resource users of the pressure exerted on their resource by themselves.
- Direct involvement of all stakeholders across a wide cross section of community ensures the decision better reflect local, social and economic, environmental condition.
- It engages traditional knowledge system as a tool for natural conservation.
- This adopts alternative conservation approach like bio cultural approach,
- Participatory management ensure community participation in conservation efforts.
- It is a integrated spatial planning approach for land, coast and marine areas will have the link between socio cultural economic needs and environmental conservation.
- People raise their voice and concerns for sustainable forest resource management and conservation.

It appears from the above points that increase participatory management do not support a whole-sale swing towards the strategies. It provides an effective and democratic way of addressing the main objective of participatory management.

## **6.7 Increasing stress in the livelihood and adaptive measures in the coasts**

The coastal zone has undergone a rapid change in recent times. 40% of the people of the world living within 100 km of the sea. Key concern of this area is natural habitat principally mangrove and salt marshes. They have been cleared and converted into shrimp farming. So sustainable development of coastal areas and proper management of coastal resources are vitally important for every community. Expansion of shrimp cultivation encroaches agricultural land. Initially it was a traditional practice but recently due to overwhelming pressure of population it has been extended as a unplanned way to mitigate the demands. This creates conflicts among the other livelihood pattern of coast, like agriculture, shrimp farming and fishing [Habiba et al. \(2014\)](#).



The coastal zone is characterized by different resource ownership and complex interactions among people, resources and ecosystems. Conflicts arise between demand and long-term sustainable development. There are several threats that have been imposed on livelihoods of human beings due to natural causes or may be due to the work of their own. This section deals with how people accept the stresses and how they manage their livelihood by managing crops, fisheries, aquaculture, ecosystem related activities in the coastal zones. The issues which change the livelihood patterns are-

- People are dealing with water management techniques.
- Dealing with brackish water shrimp cultivation.
- Adapting them with changes of shoreline.
- Adapting with aquaculture.
- Livelihood changes with land use pattern
- Salinity management and impact on agriculture.
- Coastal resource depletion and dealing with poverty

Extensive shrimp farming has been practiced for a long time in a traditional livelihood system but recent strong demand in global markets together and technological advances has fuelled rapid expansion and intensification. Mangrove forest depletion by the people for timber, fuel, wood expansion of shrimp in the large tract of mangrove create depletion. Coastal rice system suffering from saline intrusion that present crop production. Seasonally varying fresh water create problem to rice cultivation. Impact of land use change and resource dependent livelihood like honey collection from bee hive, crab farming are many cautionary tales about environment and social problem arising from the inputs of land use change. Coastal erosion, loss of productivity, water acidity and contamination also create problem to the livelihood of people. Coastal people are adopting diverse livelihoods for adaptations which are related to local climatic risks and seasonal variability as well as availability of resources for them. Few approaches which are adopted by the people are-

**I. Salt tolerant rice cultivation** Agricultural practice is constrained in high level of saline soil due to salt water intrusion, frequent storms and natural disaster in the coastal areas, water logging in agricultural field, lack of irrigation in dry seasons, alternative cropping practice

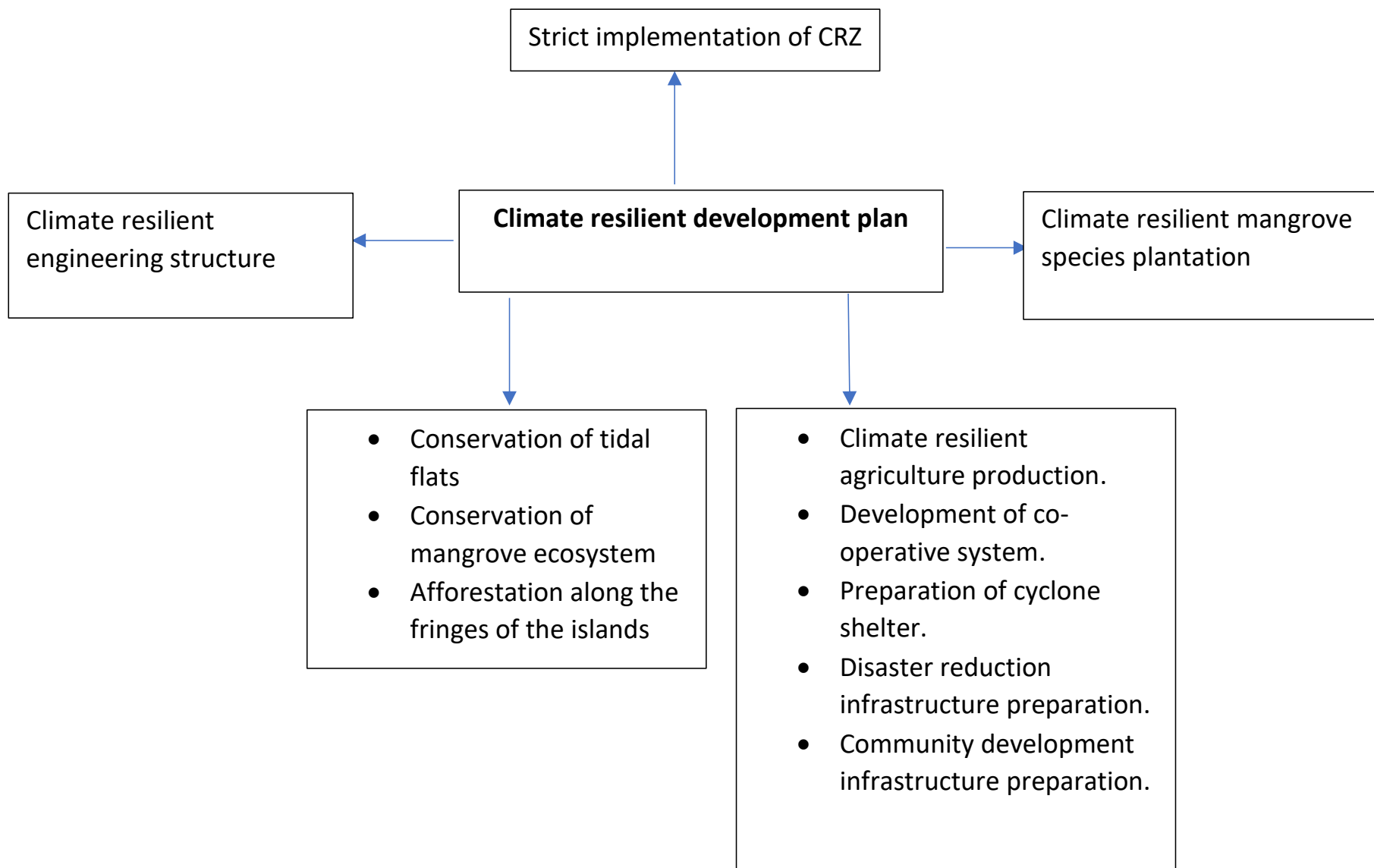


Figure 6.4: Climate resilient development plan for Sundarban.

through use of climate resilient rice varieties are used for agricultural production. People shift from single crop to double crop cultivation due to high yielding variety seeds which are salt tolerated too.

**II. Crab fattening** These techniques are adopted by rural women, they collect young crabs with simple techniques and sold in market. The livelihood practice can be easily promoted in extended coastal communities due to tidal inundation and water-logged saline conditions and locally available feed favours the crab cultivation ([Ahmed et al., 2018](#)).

**III. Poly culture** This is a different type of agricultural pattern where agricultural lands are used for paddy, shrimp and fin fish in different season. Paddy is being cultivated during monsoon season when fresh water arrives. At the same time local people raise the land by digging dykes and conserve fresh water which is used for Aman rice cultivation and fishing.

**IV. Floating garden** This is unique system of vegetable production. Those are done during water logged condition. This replaces soil-based cultivation which is not possible during water logged condition. To adapt frequent flooding and inundation it is very easy and replicable land use techniques for seasonal vulnerable people.

**V. Mele cultivation and Mat preparation** Mele are produced at tidally inundated brackish and fresh water areas, which are used for animal fodder. Dry mele used as durable mats. Mele cultivation can be done throughout the year. It is a permanent source of income to the people though it earns very less.

### 6.7.1 Livelihood adaption with changing climate

Most of the coastal population is less capable to share the majority of the coastal resources with the changing climate due to lack of effective coastal zone policy, regulation, resource management techniques. Extreme climatic events like cyclone, super cyclone trigger extreme events on physical, ecological and social system on Sundarban. Storm surges causes flooding, structural failure and loss of livelihoods. Sea level rise help to salt water penetration in the islands which puts coastal livelihoods to a higher risk, Sediments deposition within creeks, increasing rate of inundations, failure of coastal embankments also create stress on people of the islands. Livelihoods influence exposure and sensitivity to current and future climate change related stresses ([Pouliotte et al., 2009](#)). Protection and improvement of livelihood practices can provide additional and at the same time alternative means of adaptation practices. Short term adaptation measures are used by people like planting of varieties vegetables on the long top

surface of dykes for household consumption and for commercial use.

So finally, it can be said that livelihoods are embedded with integrated ecological social functioning that enhance adaptive capacity of the system. People used intensified, extensified, diversified, migration strategies for coping with periodical stresses.



Plate 6.6: Salt manufacturing in Sundarban.

There are extensive dykes along the creek banks in Sundarban to prevent saline water intrusion in the agricultural fields (Paul, 2002). However, this infrastructure is still inadequate to completely prevent saline water intrusion, particularly during storm surges. Consequently, the intruded saline water becomes stagnant on the agricultural fields and damage crops due to its high salinity. To cope with this recurrent problem, a proper way out may be sowing salt tolerant or salinity resistant varieties of crops (DasGupta et al., 2019). Though rice is the chief agricultural produce in this region, growing other salinity tolerant vegetables along with rice is often economically more profitable. Establishment of orchards including fruits like watermelon, cultivating vegetable like cucumber and pumpkin generally bring better economic prospects to the local farmers. Also, cultivation of cash crops, e.g., betel leaves, is often more profitable compared to rice monoculture.

Livestock like ducks, poultry, goats and cattle are also often raised along with agricultural activities. Generally, the livestock survives on the agricultural by-products, and require little to no outside expense for their sustenance.

Along with the adaptation in agriculture with the local environment, other natural resources are also tapped into to generate livelihood in this region. The natural mangrove forests here are tolerant of the saline conditions, and cope relatively better with the changing environment. Harvesting the forest produce in a sustainable way is a profitable economic venture for the local

populace. Afforestation drive in the degraded mangrove regions would bring rich dividends in this way when the mangroves get established and the ecosystem gets regenerated.

There are innumerable ponds and water bodies in this region as it is a wetland in nature. Fishing in the village ponds and water bodies and also the creeks is thus also a profitable economic venture for the local populace, which would be relatively less affected by the changing environment compared to agriculture.

## **6.8 Livestock population and management in the region**

Sundarban is specially a mono cropped land but presently suffering from poor productivity due to many physical and socio-economic constraints. Livestock is the old practice of Sundarban. It plays a vital role in increasing the income of farm family of the areas. Poverty rearing, cattle controlling rearing of garole sheep are intervened by Government organisation in Sundarban. Government and non-governmental organisation (NGO) are concerned with the livestock population of entire Sundarban. Maximum people of this area paid attention to the livestock rearing mainly by marginal and small-scale farmers.

Presently Sundarban has been suffering from wide range of environmental fluctuations like monsoon rainfall accounts 1700mm which inundate the region and create acute problem of grazing land. People of Henry's and Patibania are mainly fisherman, farmer. They prefer to rear domestic animals as an alternative source of income. Grazing of cattle's in forest meadow consumes 5 to 7 kg of freshly cut grass added to dry paddy straw. They added 1.5 to 2.0 kg of rice gruel and sufficient quantity of salts are provided. In Patibania island cattle grazing on the forest surface destroy small twigs of mangroves and salt marshes. This will eventually restrict the germination process of mangroves. Mangrove seeds are distributed every where by the cattles. 70% of the people in Henry's island are engaged in cattle grazing. There are some areas of Henry's where livestock is common practice.

Sundarban is a natural habitat of garole sheep which are owned by marginal and smaller farmers. Goat rearing has been declining in recent years due to lack of grazing ground. Initially goat rearing was allowed with monocrop cultivation but the trend has been changed, with the changing of monocrop to double crop cultivation (Saha 1999).

Livestock and poultry rearing are mainly tended by women. They moved with their cattle for grazing throughout the day. Mixed farming, animal feeding, cooperative, dairy farming all

are done by woman in self help group for organized farming and training and motivation by Government personnel.

## 6.9 Achieving the management of saltpans and salt flats

It is observed in earlier parts of this thesis (see, e.g., Section 2.7 and Section 4.4) that the formation of saltpans and salt flats hinders the growth and generation of mangroves in Sundarban. Though halophytic in nature, for almost all mangrove species, the salinity levels in the saltpans and salt flats are too high to be tolerable. It is seen earlier in this thesis that this condition in the saltpans and salt flats make these areas almost devoid of any vegetation. It is also observed that in some regions of the two islands under study, the area of the saltpans are increasing. If unchecked, this creeping increase in the saltpan area would further degrade the surrounding mangrove habitats over time. For this reason, devising an effective and implementable management plan for saltpans and salt flats are necessary.

It is observed in the earlier parts of the thesis that the saltpans primarily form in topographic depressions, which facilitate evaporative build up of salt from the saline water trapped in those depressions. Also, it is notable that those depression are often surrounded by regions with higher elevation, which prevent tides except those with sufficiently high tidal heights from reaching and inundating the saltpan areas. However, perhaps the most important factor in the formation and propagation of saltpans is tidal drainage loss. Due to heavy siltation in the creeks, the elevations of the creek-beds increase, which decreases the carrying capacity of those creeks. Consequently, the amount of tidal water reaching the inland areas of the islands declines. On the other hand, it is also observed in Section 5.10 that the likelihood of saltpan formation is the least on or near the banks of functioning creeks or canals supplying water in the inland areas of the islands. This indicates that sufficient availability of water, even if saline, can stop the propagation of saltpans. The tidal saline water is able to flush the excess salt from the soil, preventing further increase in salinity.

The factors facilitating or hindering the formation of saltpans are summarized below. Proper management and exploitation of these factors will be imperative in a saltpan management plan.

- *Topographic depression:* Saltpans and salt flats tend to form in depressions, which remain untouched by tides except the ones with sufficiently high tidal heights.
- *Evaporative environment:* The evaporation of saline water, which is brought by the tides

with high tidal heights that could reach the saltpans and then is trapped in the depression, results in the deposition of salt on the soil surface. The continued build up of salt results in the formation of saltpans over time.

- *Tidal drainage loss:* The loss of tidal drainage and associated decline in water intrusion in the inland areas create a favorable environment for saltpan formation. The remaining water available is insufficient for adequately flushing excess salt from the soil surface.
- *Water availability:* Saltpans tend to be absent near the channels carrying water in the inland areas of the islands, which indicates that the availability of adequate water deters saltpan formation.
- *Salinity of water:* Though the channels in the coastal area of Sundarban carry predominantly saline water, it is observed that even this saline water can effectively deter saltpan formation, if it is available in an adequate amount. This indicates that the salinity of the water is not so important compared to its amount.

Based on the above factors, a prospective management plan for the saltpans and salt flats can be devised based on exploiting the factors that prevent the propagation of saltpans and deterring the effects of the factors facilitating saltpan formation.

It can be concluded that the most effective strategy to prevent saltpan propagation is increasing water availability in the inland areas. It is seen in Section 5.10 that several canals exist in the two islands, which carry tidal water in the interior of the islands. Increasing the number of such artificial canals would be effective in deterring further saltpan formation. Dredging the natural creeks suffering from siltation or digging the creek-beds to increase their depths will also achieve similar results.

The regions with higher elevation surrounding the depressions play a significant role in the formation of saltpans. This can be disrupted by constructing channels connecting the depressions with functioning creeks or canals, so that the depressions are easily and frequently inundated by tidal water brought through the creeks and canals. This would flush the soil build up, and prevent the creation of an evaporative environment by increasing soil moisture.

The almost barren surfaces of the saltpans facilitate evaporation. This can be blocked with the presence of canopy-forming woody mangrove trees. However, a plantation of mangrove trees would not survive in a saltpan easily. So, to achieve an establishment of an artificial plantation of large mangrove trees in an existing saltpan region, it has to be coupled with the

construction of artificial canals bringing an adequate amount of water to this region. The water availability will encourage the growth of mangrove trees, that would in time form a canopy cover and reduce evaporation. While establishing such artificial plantation, it is desirable to choose the mangrove species that can tolerate higher salinity and also grow up to become a large canopy-forming tree with dense vegetation.

The saltpans and salt flats generally have the highest salinity in the topsoil. So, another approach to temporarily reduce salinity is to physically remove the topsoil. This would be also favorable for the establishment of a new mangrove plantation in the saltpan region. However, it is imperative to take care of the underlying factors that caused the saltpan formation. Otherwise, the same conditions will again generate another saltpan over time in the same area.

The strategies described above can be combined to form a coherent and effective saltpan management plan. However, this can also be augmented by adding an economic dimension to the saltpan management plan. The topsoil of the saltpans and salt flats can be a commercially valuable source of salt. Setting up the required facilities for the extraction of salt from the saltpans and salt flats will both reduce the salt deposits as well as generate income and create livelihoods for the local communities.