

## Study on Utility and Revival through Community approach in Sundarbans Mangrove

Chandan Kumar Mondal<sup>1</sup>, Bholanath Mondal<sup>2</sup> and Debashis Sarkar<sup>3</sup>

<sup>1</sup>Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, South 24 Parganas, West Bengal, India

<sup>2&3</sup>Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal, India  
Corresponding author: bholanath.ppvb@gmail.com

### ABSTRACT

Mangroves are salt tolerant group of tropical plants that generally grows in the inter-tidal zones of land and sea. The Sundarbans is the world's largest mangrove forest covering Ganga-Brahmaputra-Meghna delta of India and Bangladesh. It protects the coastline of Bangladesh, and West Bengal of India from different environmental catastrophes and act as means of livelihood for numbers of people of both the countries. The population of mangrove species is declining rapidly due to continuous deforestation by the wood pirates, mafias and some other causes. Mangroves are normally propagated by seeds which are usually vivipary in nature. Seeds are buoyant and hence short and long distance dispersal occurs by tidal water. Attempt was made to propagate some of the true mangrove plants artificially. Nursery was raised collecting seeds in different ways. Vegetative propagation like cutting and layering were also tried and proved successful but tedious and time consuming. Seedlings from the seeds are better option for reproduction of the endangered species as well as for other species. Community involvement is a major factor in restoration of mangroves as different livelihood activities like *bagda meen* (seeds of tiger prawn- *Penaeus monodon*) collection, crab collection, fishing from the brackish water; establishment of brick industry and funeral place in river/coast bed, and conversion of river bed for other livelihood activities not only kills many seedlings but also posed a severe threat to the mangroves. Suitable propagation technique in proper time, particularly during August to October, with active participation of adjacent village people may protect this unique mangrove forest.

**Keywords:** Conservation, Community participation, Livelihood opportunity, Mangrove, Propagation, Ritual, Sundarbans, Tourism

Mangroves are salt tolerant group of tropical plants that generally grows in the inter-tidal zones of land and sea. Mangrove forests are visible in different parts of world especially in Indo-West Pacific (IWP) region and Atlantic-Caribbean-East Pacific (ACEP) region. In the IWP bio-geographical region, the most important one is the Sundarbans, the world's largest mangrove forest covering Ganga-Brahmaputra-Meghna delta of both India and Bangladesh. The Sundarbans

protect the coastline of Bangladesh, and West Bengal of India from different environmental catastrophes like cyclones, high-tides, erosion etc., and it act as means of livelihood for numbers of people of both the countries. Sundarbans has its own social, cultural and ethnic identity since 200 to 300 AD as mentioned in the story of Chand Saudagar (Radice, 2001). Most of the inhabitant of the Sundarbans belong to a very low income group category, and with hardly any substitute option of employment, the populace of Sundarbans depends on their traditional skills of fishing and honey collection as well as agriculture for survival. The Sundarbans ecosystem is a vital ecological bridge between the terrestrial and aquatic bio network which is an important part of the natural resource base of both the country, so that its preservation is essential to maintain ecological balance and biodiversity (Deshmukh and Choudhury, 2002). Among 69 intertidal plant species recorded in Indian Sundarbans, 30 species belong to true mangrove, 20 species are mangrove associates and 12 species are back mangrove; and importantly Indian Sundarbans alone represent 30 true mangrove species out of 48 true mangrove species reported in the Old World Tropics (comprising 40 true mangrove) and New World Tropics (comprising 8 true mangrove) in global perspective (Mandal, *et al.*, 2010). The population of mangrove species is declining rapidly due to continuous deforestation by the wood pirates and mafias and due to some other reasons. There are some mangrove species already declared as ‘threatened’ viz. *Sundari* (*Heritiera fomes* Buch.-Ham), *Genwa* (*Excoecaria agallocha* L.), *Golpata* (*Nypa fruticans* Wurmb.), *Kalo Bain* (*Avicennia alba* Blume), *Ban Lebu* (*Atalantia corea* M. Roem.) and *Lata Harguza* (*Acanthus vulubilis* Wall.) (Naskar and Bakshi, 1995, Mandal *et al.*, 2010). It is reported that the species *Nypa fruticans* is found only in Sundarbans of West Bengal and the species is sensitive to high salinity (Selvam *et al.*, 2004, Mandal *et al.*, 2010). Among all the mangrove forests in India, the Indian Sundarbans is the largest one in consideration of both area coverage (62%) and floral diversity (90%) (Mandal *et al.*, 2010). Rodriguez *et al.*, (2012) documented a comparative study on morphology and anatomy of some mangrove species and their adaptation to saline habitat in Indian Sundarbans. Mangroves are normally propagated by seeds which are usually vivipary in nature. Seeds are buoyant and hence short and long distance dispersal occurs by tidal water. Restoration of mangrove forest is of prime importance to save the Sundarbans, the environment and the livelihood of the local people as well. Community involvement is a major factor in restoration of mangrove. Suitable propagation technique in proper time, with participation of adjacent village people can protect the Sundarbans Mangrove Forest and also the environment. Alternate livelihood options for the local people are of utmost necessity to minimize their dependence upon natural flora and fauna. Mangrove forest cover in the Sundarbans is declining every year due to wood pirates and other causes. Earlier, large-scale deforestation for human settlement in Sundarbans has seriously affected the entire ecosystem and the surrounding environment. The coastline and foreshores on both sides of tidal rivers are under

serious threat of erosion and the river embankments are becoming vulnerable to natural catastrophe. This has not only affected the land structures and disturbed the siltation process of this deltaic region but also adversely affected the natural habitat of flora and fauna. The region being famous as a 'nursery' of the marine fauna is under serious threat due to degeneration of mangroves in the intertidal zones. Involvement of local community in the afforestation of mangroves in the inter-tidal zones was studied.

## MATERIALS AND METHODS

The study has been conducted in 24-Parganas district of West Bengal, India based on primary data. At the first stage three blocks adjacent to Sundarbans viz. Basanti, Kultali and Gosaba have been selected. In the next stage one village from each block i.e. three villages viz. Jharkhali of Basanti block, Kaikhali of Kultali block and Kachukhali of Gosaba block have been selected purposively. The rationale behind the selection of these three villages is that most of the inhabitants in these three villages are either directly or indirectly dependent on Sundarbans for their daily life beside cultivation. In the next stage the list of households of these villages has been collected and sub-divided into ten groups according to their occupation and age. These are aged person, fishermen, honey collectors, wood pirates, Boules, Priests, young generations, members of NGOs, educationists and folk culture performers. Then 30 households from each group have been selected randomly. Thus all total 300 households have been selected for the ultimate sample unit of the study. The data has been collected through survey schedule specially constructed for this purpose. Open discussion, informal meeting and group discussions have also conducted in addition to the survey schedule in order to collect data on (i) importance of Mangroves in the livelihood, (ii) individual techniques of the inhabitants in protecting mangrove plants, and (iii) other livelihood options that affect negatively to mangrove plants. The entire work has been conducted during 2010 and 2012.

In the second phase, small group (total 15 groups, 5 group per village under study area, each group comprises of 13-20 members) were motivated for afforestation of few mangrove species like Sundari (*Heritiera fomes* Buch.-Ham), Math Garan (*Ceriops tagal* (Perr.) C. B. Robins, Genwa (*Excoecaria agallocha* L.), Garjan (*Rhizophora apiculata* Blume), *Rhizophora mucronata* Lam.), Dhundul (*Xylocarpus granatum* Koenig), Keora (*Sonneratia apetala* Buch.-Ham), Kankra (*Bruguiera gymnorrhiza* (L.) Lam., Khalsi (*Aegiceras corniculatum* (L.) Blanco and Bain (*Avicennia* sp.). Attempt has also been made to propagate these mangrove plants artificially in different ways like seedling from seed/propagule (Propagule is a typical kind of seed of mangrove plants that germinate in the mother plant itself), air-layering on mature shoot and direct seeding in the river banks. Nursery was raised collecting seeds in different ways like directly from plant or buoyant

seeds from tidal rivers. Plantation techniques followed under this programme were: (i) raising of nurseries of mangrove plants and subsequent transplantation in the silted up trenches and pits and (ii) direct seeding of mangrove species.

## RESULTS AND DISCUSSION

### Importance of Mangrove forest in livelihood opportunities

The Sundarbans forest has immense protective and productive functions. It provides natural protection to life and properties of the coastal population from different environmental catastrophes like cyclones, high-tides, erosion etc. The Sundarbans plays a significant responsibility in the livelihood opportunities of the local people. Wide range of variations in flora and fauna bioresources offer enormous economic benefits in terms of mangrove products and the ecosystem of Sundarbans as a whole. The utilization of these natural resources are mainly depends on (a) accessibility (b) purpose of use (c) manner of collection (d) conveyance and transport (e) the number of users, and (f) availability of other alternative natural resources. While, harvest of all the woods and some non-wood products of Sundarbans are restricted, a variety of non-timber forest produce (NTFP) may facilitate to generate significant employment and income generation openings. The Sundarbans was declared a reserved forest in 1875-76, under the Forest Act 1865 (Act VIII of 1865) (Laskar, 2000). Before that, for making furniture and building boat the local people used to obtain timber producing species *Sundari* (*Heritiera fomes* Buch.-Ham), Keora (*Sonneratia apetala* Buch.-Ham), Pasur (*Xylocarpus mekongensis* Pierre.), Jat Bain (*Avicennia officinalis* L.), Kankra (*Bruguiera gymnorhiza* (L.) Lam.; for making roof- and other wooden structures of muddy house Math Goran (*Ceriops tagal* (Perr.) C. B. Robins, Jele Goran (*Ceriops decandra* (Griff.) Ding Hou. and Tora (*Aegialitis rotundifolia* Roxb.); and for fuel *Sundari* (*Heritiera fomes* Buch.-Ham), Jele Goran (*Ceriops decandra* (Griff.) Ding Hou.), Garjan (*Rhizophora mucronata* Lam.), Bhola (*Hibiscus tiliaceus* L.), and Singra (*Cynometra iripa* Kostel) etc. Datta *et. al.*, (2011) reported that with the establishment of National Park and Biosphere Reserve, commercial harvesting of these plants including *Golpata* (*Nypa fruticans* Wurm.) and Hental (*Phoenix paludosa* Roxb.) from the wild is absolutely banned by law.

From the un-reserved forest, the local people use to collect grasses, leaves and tender twigs of different mangroves as fodder for cattle and other ruminants. Several mangroves yield edible fruits (Keora - *Sonneratia apetala* Buch.-Ham) and other food materials (central shoot portion of Hental - *Phoenix paludosa* Roxb.) usually used by the local people. The mangroves having medicinal values are also important for local medical practitioners and traditionally who are practicing ayurveda. These resources are one of the sources of income to the coastal communities.

A comprehensive documentation for medicinal uses of Sundarbans mangroves from local people including traditional ayurvedic practitioners (*Vaidyas, Gunin, Baule, Ojha etc.*) were made by Mondal *et. al.*, (2012) which indicated uses of 35 mangrove species for curing a large numbers of common ailments, chronic diseases as well as animal bite. Besides, plant parts like leaves of *Golpata (Nypa fruticans* Wurm.), Hental (*Phoenix paludosa* Roxb.) etc are used in thatching their huts, making ropes and handicrafts by the Sundarbans people. Some other plants like Dhani grass (*Oryza coarctata* Roxb.), Ulu (*Sacharum cylindricum* L.) grown around the riverbank and riversides, and Hogla (*Typha elephantina* Roxb.) grown in more inland waterways are used locally for making mat and some handicrafts. These plants also have remarkable possibilities for small scale handicrafts, straw, plate, rope and mat making industries in the rural areas of Sundarbans if appropriate technological and marketing interventions are executed.

The important non-timber forest produce (NTFP) collected from the Sundarbans ecosystem by local people are honey, wax, crab, fish, prawn, shrimp, etc. Mollusk resources are also collected regularly by them for medicinal purpose as well as for preparation of calcium carbonate.

The Sundarbans offer an amazing aesthetic attraction not only for national and international visitors but also scientists, researchers and students. Usually, October to February is the peak time of tourism. The local people have taken initiatives for increasing tourism activities and they earn money by different kinds of tourist recreation activities like serving tourist guide, parking lots, showing local cultural programmes (*Dukhey yatra, Manasa yatra etc.*), investing in tourism business like construction of hotels, restaurants, selling different types of traditional articles, honey, molasses of date palm and palmyra palm, *moya* [a Especial type of round shaped sweet item made up of puffed paddy (*Khai*) (var. *Kanakchur* - a scented rice), *nalen gur* (molasses of date palm) and *kheer* (milk item); *moya* of Jaynagar is famous for its quality and taste], other food items, etc. Another way of earning of the local people is tourist boat which is the key water vehicle for communication and visiting the Sundarbans.

Some of the local inhabitants and NGOs are working to protect mangrove species, secure natural habitat for wild animals, secure visitors from theft and other unwanted circumstances, and create awareness about protection of wild lives and mangroves etc. They have demand to develop modern infra-structure including communication for attracting tourists. Mbuvi and Boon (2008) stated that forestry is a productive sector with significant effects on meeting natural socio-economic and environmental functions as well as the improvement of rural livelihoods. Sharma (1998) reported that the buffer zones of forest provide not only an additional layer of protection to existing protected area but also give an opportunity of sustainable resource use to local people.

### Rituals related to protecting Mangrove Forest

The inhabitants of Sundarbans believe a numbers of characters as gods, goddesses, heroes and heroines specific to the Sundarbans for their prosperity (Table 1, 2 and 3). They worship to such characters at different times like before entry into the jungle, during pumping out water from water bodies to harvest fish, before going to river/sea for fishing, to defend several stresses (i.e. leprosy, pox, snake bite etc.) in some specific months/seasons and for protection of livestock etc.

**Table 1:** The Sundarbans related gods and goddess

Name	Description
The gods of Sundarbans	
Dakshin Rai	The incarnation of tiger god and the lord of the south.
Kalu Roi	The god of crocodile
Shah Jangalee	The son of Ibrahim Gaji and Golalbibi, brother of Bonobibi, the savior of the forest.
Dharmathakur	Also known as <i>Barothakur</i> and <i>Shanithakur</i> , he protect human from leprosy and other stresses.
Shiva	The ancient god, Mahadev.
Bishyakarma	The god of architecture.
Panchananda	The Shiva, ancient god.
Dayal Manik Pir	The another name of Satyanarayan, the god of livestock, for escape livestock from different diseases local people worship to Dayal Manik Pir in cowshed by offering songs.
Machal	The god of fishes
The goddesses of Sundarbans	
Bonbibi	The daughter of Ibrahim Gaji and Golalbibi, sister of Shah Jangalee, the savior of the forest.
Manasa	Also known as <i>Bisahari</i> , the daughter of Shiva and Parvati, goddess of snake.
Ganga	The goddess of water world.
Kamale Kamini	The incarnation of Chandidevi, the goddess of wealth.
Sasthi	The goddess who protects the children.
Sitala	The goddess who save human and other animals from pox.
Narayani	The incarnation of Durga.

**Table 2:** The Sundarbans related heroes and heroines

Name	Description
The heroes of Sundarbans	
Chand Saudagar	The famous merchant and devotee of the god Shiva
Lakhindar	The seventh son of Chand Saudagar.

Dannyantwari	The ayurvedic practitioner ( <i>Kabiraj</i> ).
Dhanapati and Sreemanta	They are merchant, devotee of the god Shiva.
Dukhey	A poor posthumous boy of Sundarbans.
Bhagirath	The son of the king Sagar who invited ganga river in the plain.
Kalketu	A poor hunter, the son of Dharmaketu, devotee of the god Shiva.
The heroines of Sundarbans	
Behula	Daughter of Say bene, wife of Lakhindar, an archetypal Bengali woman with full of love and courage.
Phullara	Wife of Kalketu,
Sanaka	Wife of Chand Saudagar, an ideal Bengali affectionate mother with serenity.
Lahana and Khullana	Wives of Dhanapati, Khullana is the co-wife of Lahana

**Table 3:** Characters and their relation with flora and fauna of Sundarbans

Characters	Epic/Story/ <i>Kavya/Songs etc.</i>	Flora and Fauna
Banabibi, Dakshin Rai, Kalu Rai, Dukhey	<i>Manasamangal</i> , <i>Dukhey yatra</i>	All types of flora and fauna in Sundarbans specially Tiger ( <i>Panthera tigris tigris</i> Pocock) and Crocodile ( <i>Crocodylus porosus</i> Schneider)
Shiva, Panchananda	All <i>Mangalkavya</i> , <i>Shivamangal</i> , <i>Gajan</i>	Especially some non-mangrove species <i>Datura</i> ( <i>Datura</i> spp.), Bhang/Ganja ( <i>Cannabis indica</i> Lam.), Akanda ( <i>Calotropis gigantea</i> R.Br.), rice ( <i>Oryza sativa</i> Linn.); and fauna snake ( <i>Uday Naag</i> – a type of snake, <i>lord Shiva</i> have the <i>snake</i> in his neck), bull ( <i>Bos taurus indicus</i> Linn.), tiger, leach ( <i>Hirudinaria granulose Savigny</i> ), mosquitoes etc.
Manasa	<i>Manasamangal</i> , <i>Manasar vasan</i> , <i>Swati Behula</i> , <i>Manasa yatra</i>	Especially Manasa plant ( <i>Euphorbia drupifera</i> Thonn.) and a non-mangrove aquatic flora Lotus ( <i>Nelumbo nucifera</i> Gaertn.); and also fauna like snake ( <i>Kalnagini</i> - <i>Chrysopelea ornate</i> Shaw), duck ( <i>Anas platyrhynchos</i> Linn.), Boal fish ( <i>Wallago attu</i> Bloch & J. G. Schneider)
Kamale Kamini, Chandi, Dhanapati, Sreemanta, Lahana and Khullana	<i>Chandimangal</i>	Especially a non-mangrove aquatic flora Lotus; and also fauna Goat ( <i>Capra aegagrus hircus</i> Linn.)

Chand Sadagar, Lakhindar, Behula, Dannyantwari,	Manasamangal, Manasar vasan, Sati Behula, Manasa yatra	All types of flora in Sundarbans especially Hental ( <i>Phoenix paludosa</i> Roxb.) and other non-mangrove medicinal plants with Banana ( <i>Musa</i> spp.); fauna like snake, boal fish
Shitala	Shitalamangal	Coconut tree ( <i>Cocos nucifera</i> Linn. – Maa Shitala is holding a broom made with midrib of coconut leaflet), neem ( <i>Azadiracta indica</i> A. Juss.) and a fauna Ass ( <i>Equus hemionus khur</i> Lesson)
Kalketu, Phullara	Chandimangal	Bengal Monitor ( <i>Varanus bengalensis</i> Daudin)
Viswakarma	Manasamangal	Elephant ( <i>Elephas maximus indicus</i> Cuvier)
Bhagirath, Ganga	Gangamangal	Makara - is a sea-creature in Hindu mythology. It is generally depicted as half terrestrial animal (in the frontal part in animal forms of elephant or crocodile or stag or deer) and in hind part as aquatic animal, in the tail part, as a fish tail or also as seal. Sometimes, even a peacock tail is depicted. Makara is the <i>vahana</i> (vehicle) of the Ganga - the goddess of river Ganges.
Machal	Unknown	Fishes
Dayal Manik Pir	Unknown	Cattle ( <i>Bos taurus indicus</i> ) and buffaloes ( <i>Bubalus bubalis</i> Linn.)
Dharmathakur	Dharmamangal	Peacock ( <i>Pavo cristatus</i> Linn.), Aswatha/ Pipul ( <i>Ficus religiosa</i> Linn.)
Sasthi	Unknown	Cat ( <i>Felis catus</i> Linn.), Bot/ Indian Banyan ( <i>Ficus benghalensis</i> Linn.)

The ways of worshiping are plentiful bengali folk songs, dances, dramas, *bhajans*, *panchali*, *gajan* etc. often centered around some flora and fauna of Sundarbans. The process of worshiping different elements of nature (i.e. trees, animal, snake etc.) is a way of respecting and protecting forest and forest elements. Different places of Sundarbans (Netidhopani, Champaknagari, Kalidah, Sagardwip etc.) have been mentioned in the Bengali folk epic *Mangalkavya* - a genre of Bengali epic poems, used to be rendered as musical plays but with more highlighting on the story than on the music, depicting the greatness of popular, indigenous deities in addition to the social scenario. It is the belief of local people that listening to these poems regarding the deities brought both spiritual and material benefits. All the information collected from local inhabitants during survey, fishermen, honey collectors, wood mafias, *boule* (special men goes with the fishermen, honey collectors or wood mafias to protect them from tiger attack in forest by chanting

and some other special skills), different Mangalkavyas, folk cultural programmes, novel, *gajan* etc.

### **Livelihood options that affect negatively to mangrove plants**

The natural environment and coastal ecosystem of this Biosphere Reserve and World Heritage Site is under threat of physical disaster owing to non-scientific and excessive human interferences. Livelihood activity like *bagda meen* (seeds of tiger prawn- *Penaeus monodon* Fabricius) collection and fishing from the brackish water especially by the village women kills many mangroves' seedlings. Fishermen dig holes to collect crab from river bed, collection of fish especially by *berha jal method* (placing of nylon net tightly over a large area in the river bed during low tide and water inundate with fishes across the whole river bed during high tide, and again during low tide water goes away from river bed whereas fishes are cached by the nylon net and are collected by the fishermen), domestic animal grazing inside the un-reserved forest area of river beds, establishment of brick industry in river bed, excavation of river bed for making *bundh* or road, unauthorized conversion of river beds for different purposes (like refugee colony, agricultural purposes, fisheries, play grounds, funeral/burial places etc.), conversion of brackish water river/cannel to sweet water source for irrigation and fresh water fishery purpose, construction of embankments to protect human settlements, poaching of wild animals (i.e. tiger, spotted deer, wild boar, marine turtles, horse shoe crab-a living fossil, fishing cat, gangetic dolphin, salt water crocodile, Olive Ridley Turtle etc.) mainly for illegal trade, unauthorized collection of furniture woods, fuel woods, thatching materials, fodder, fruits and other food materials by human trespassers etc. are the major threats to the Sundarbans mangroves. Senbeta *et. al.*, (2002) stated that a good cooperation between forest department and forest communities can effectively protect forestlands allowing them to regenerate successfully and thus create a reformation of dense natural forest. Tourism also has some negative effect on Sundarbans Biosphere Reserve as tourists or visitors used to create nuisance like breaking tree branches, trampling seedlings of mangroves etc or through different non-degradable articles, plastics, wine bottles etc in the jungle and river. The natural habitat of wild animals and aquatic lives are disturbed due to sound of machine boat, and mixing of kerosene and other petroleum oils to the river etc. Establishment of shops, hotels and guesthouse at different places of Sundarbans area are also creating hazards. Therefore, a community-based approach needs to be brought about for restricting over-exploitation of mangrove forest. Lack of peoples' awareness and local participation in conservation activities is one of the key hindrances. Co-management system should be adopted for Sundarbans. Awareness programme have to be taken not only by the government side but also NGOs should take care off regarding environmental education, pollution, fishing, importance of mangrove forest, threatened species of both plants and animals,

and other livelihood options that are affecting negatively directly or indirectly the Sundarbans ecosystem. Intensive governmental care, more developmental work and infrastructure for tourism, and strict vigil are needed for proper maintaining of rules and regulations of that biosphere reserve.

**Table 4:** Propagation of mangrove species from seeds and mature propagule cuttings

Vernacular name	Botanical name	Time required to germinate from seed (day)	Plant growth regulators for rooting of mature propagule cutting		
			Hormone	Dose (ppm)	Rooting (%)
Khamu Garjan	<i>Rhizophora apiculata</i> Blume	12-17	IBA	1500	93
Jat Bain	<i>Avicennia officinalis</i> L.	5-8	Not tested		
Keora	<i>Sonneratia apetala</i> Buch.	12-17	Not tested		
Kankra	<i>Bruguiera gymnorrhiza</i> (L.) Lamk.	5-8	IBA	500	83
Sundari	<i>Heritiera fomes</i> Buch.-Ham	24-31	Not tested		
Khalsi	<i>Aegiceras corniculatum</i> (L.) Blanco	24-31	Not tested		
Genwa	<i>Excoecaria agallocha</i> L.	24-31	Not tested		
Jele Goran	<i>Ceriops decandra</i> (Griff.) Ding Hou.	12-17	IBA+NAA	500 + 200	79
Dhundul	<i>Xylocarpus granatum</i> Koen	53-65	Not tested		

**Propagation of mangrove species and afforestation programme in participatory approach**

Mangroves are propagated with seeds (partially germinated), nursery grown seedlings/saplings, stem and propagule cuttings and air layers (Table 4 and 5). Mature propagules/seeds were collected year-round from parent trees. Propagules fallen on ground and casted ashore were also used. Seeds/propagules dispersed in tidal water, were also collected.

Germination time required for different mangrove species were *Avicennia* and *Bruguiera* 5-8 days; *Sonneratia*, *Ceriops* and *Rhizophora* 12–17 days; *Aegiceras*, *Excoecaria* and *Heritiera* 24-31 days; whereas maximum 53–65 days was taken by *Xylocarpus*. Seedlings of about 80-110 days old with 2-3 ft height were taken for final planting in the inter-tidal zones. In case of non-availability of sufficient seeds, cutting of mature propagules of 2-5 cm in length were used for the species *Rhizophora*, *Ceriops* and *Bruguiera*. Treating the propagules cuttings in IBA solution of 1500 ppm and 500 ppm proved best for *Rhizophora* and *Bruguiera*

respectively. While, combination of IBA + NAA @ 500+200 ppm resulted to 79% rooting in case of *Ceriops*.

After hormone treatment propagules cuttings were planted in poly-bags having sandy loam soil and kept in cool and moist place. Fresh water was sprayed as and when required to maintain RH to 70-80%. After 19-25 days root come-out and for shoot initiation it took 31-38 days. Saplings from the propagule cuttings become ready in 95–125 days. Before taking them for final planting in the inter-tidal zone, hardening was done applying diluted sea water having salinity level (EC) of about 10-27 dS/m.

Air-layering on semi-hardwood and hardwood branches proved successful in the species *Xylocarpus* (rooting 56-64%), *Heritiera* (51-55%), *Rhizophora* (46-52%), *Avicennia* (42-54%), *Excoecaria* (46-49%) and *Sonneratia* (44-47%) only using different levels of IBA (1500, 2500, 2000, 2500, 2000 and 1500 ppm respectively).

Stem cuttings of 15-20 cm length were also tried as a propagation material and proved successful for the species *Xylocarpus* (rooting 85%), *Heritiera* (72%), *Excoecaria* (68%) and *Avicennia* (56%) using IBA of 2500ppm for the first two and 2000ppm for the others.

Community participation and their opinion finalized that best way of Mangrove aforestation being direct (*in situ*) seeding and seedling transplanting. In case of seed crisis, propagule cuttings were better than the other two alternative methods. Air-layering technique of mangrove propagation was totally rejected by the community due to its' tedious nature and poor success. Even though there are some problems, together with scarce of suitable land for nursery establishment and inadequate level of technical knowhow for quality seedling management, production of mangroves seedlings may be a promising lucrative small scale

**Table 5:** Different levels of IBA for air-layering and stem cutting of mangrove species

Vernacular name	Botanical name	Air-layering		Stem cuttings	
		IBA (ppm)	Rooting%	IBA (ppm)	Rooting%
Dhundul	<i>Xylocarpus granatum</i>	1500	56-64	2500	85
Sundari	<i>Heritiera fomes</i>	2500	51-55	2000	72
Khamu Garjan	<i>Rhizophora apiculata</i>	2000	46-52	Not tested	
Jat Bain	<i>Avicennia officinalis</i>	2500	42-54	2000	56
Genwa	<i>Excoecaria agallocha</i>	2000	46-49	2000	68
Keora	<i>Sonneratia apetala</i>	1500	44-47	Not tested	

business particularly for the rural youth. Similar type of observation regarding urban nurseries was reported by Ahmed *et. al.*, (2008) in Bangladesh.

Post-transplanting seedling mortality due to catching of shrimp seed (*Meen* collection) by village women was a major set-back in earlier afforestation programmes as come out from the primary survey study. Monitoring and continuous vigil involving community participation checked this problem and resulted to successful plant growth.

## CONCLUSION

The Sundarbans mangroves are well gifted with natural resources that can efficiently be exploited to generate sustainable livelihood for the local populace. The local inhabitants utilized and protect the Sundarbans by their own way that may have negative effects on Sundarbans ecosystem. Establishment of small scale mangroves nursery as well as appropriate exploration of non-timber forest products based rural enterprise generating opportunities in the Sundarbans are of lucrative option, which is economically feasible and ecologically significant. A holistic community based natural resource management programme should be taken. Judicial technological intervention including indigenous knowledge in natural resource management in this aspect is most important. Managing Sundarbans by community participation may be a successful way of keeping this World Heritage Delta alive and protecting a huge bio-diversity of flora and fauna.

## REFERENCES

- Ahmed, R., Hasan, M. S., Halim, M. A. and Alam, M. (2008). State of urban nurseries in Bangladesh: a case study from the North-Eastern Region. *Small-scale Forestry*, **7**: 275-283.
- Datta, D., Chattopadhyay, R. N. and Deb, S. (2011). Prospective Livelihood Opportunities from the Mangroves of the Sundarbans, India. *Research Journal of Environmental Sciences*, **5**: 536-543. DOI: 10.3923/rjes.2011.536.543.
- Deshmukh, S. V. and Choudhury, A. (2002). Preparation of guidelines for facilitating decision-making process as well as ecosystem management practices for the Sundarbans biosphere reserve in India. Final report of the project submitted to UNESCO, New Delhi, pp. 160.
- Laskar, M. R. (2000). The Sundarbans: a unique wilderness of the world. In: McCool, Stephen, F., Cole, David, N., Borrie, William, T. and O'Loughlin, Jennifer, Comps. (eds.). Wilderness science in a time of change conference-volume 2: wilderness within the context of larger systems; 1999 May 23-27; Missoula, MT. Proceedings RMRS-P-15-VOL.-2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, pp. 143-148.
- Mandal, R. N., Das, C. S. and Naskar, K. R. (2010). Dwindling Indian Sundarban mangrove: the way out. *Science and Culture*, **76** (7-8): 275-282.

- Mbuvi, D. and Boon, E. (2008). The livelihood potential of non-wood forest products: the case of Mbooni Division in Makueni District, Kenya. *Environment, Development and Sustainability*. DOI: 10.1007/s10668-008-9163-2.
- Mondal, B., Sarkar, N. C., Mondal, C. K., Maiti, R. K. and Rodriguez, H. G. (2012). Mangrove plants and traditional ayurvedic practitioners in Sundarbans region of West Bengal, India. *Research on Crops*, **13** (2): 669-674.
- Naskar, K. and Guha Bakshi, D. N. (1995). Vegetation pattern of the Sundarbans. In *Mangrove Swamps of the Sundarbans. An Ecological Perspective*. Naya Prokash: Calcutta, India, pp. 27-174.
- Radice, William (2001). *Myths and Legends of India*. Viking Penguin Books Ltd., pp. 130-138.
- Rodriguez, H. G., Mondal, B., Sarkar, N. C., Ramaswamy, A., Rajkumar, D. and Maiti, R. K. (2012). Comparative morphology and anatomy of few mangrove species in Sundarbans, West Bengal, India and its adaptation to saline habitat. *International Journal of Bio-resource and Stress Management*, **3**(1): 1-17.
- Selvam, Y., Eganathan, P., Karunakaran, Y. M., Ravishankar, T. and Ramasubramanian, R. (2004). *Mangrove Plants of Tamil Nadu. Orientation Guide*. M. S. Swaminathan Research Foundation, 3<sup>rd</sup> Cross Street, Institutional Area, Taramani, Chennai, India. pp. 56.
- Senbeta, F., Erwin, B. and Ulrich, L. A. (2002). Exotic trees as nurse trees for the regeneration of natural tropical forests. *Trees – structure and function*, **16**: 245-249.
- Sharma, U. R. (1998). *Buffer Zone Policy Analysis of the Royal Chitwass National Park*. King Mahendra Trust for Nature Conservation, Katmandu, Nepal, pp. 180-189.