Chapter 5
Non-wood Forest Products of the Sundarbans, Bangladesh: The Context of Management, Conservation and Livelihood

Mahmood Hossain and A. Z. M. Manzoor Rashid

Abstract The Sundarbans is the single largest continuous tract of mangrove forest of the World. This forest is rich in biodiversity with a wide array of conventional and nonconventional Non-wood Forest Products (NWFPs). So far, 25 types of NWFPs have been identified from the Sundarbans. Among them, thatching materials, honey, beeswax, bony fish, cartilaginous fish, dry fish, crabs, shrimps, and mollusks are the major types. These NWFPs are generally extracted by the local, poor community living around the Sundarbans for sustaining their livelihood. The annual amount of the extracted NWFPs vary significantly. The increasing and decreasing trends of the respective NWFPs depend on the resource base and their market demand. The extracted NWFPs have to pass through at least two and a maximum of five stages in between collectors to retailers. The percentages of value addition are varied with the extracted resources and steps involved. Assessment of the resource base and identifying the potential threats of the respective NWFPs; strict monitoring of the harvesting rule; proper record-keeping for the extracted amount of NWFPs; proper implementation of field level management interventions for the NWFPs are of prime importance for the sustainable management of the valuable NWFPs of the Sundarbans.

Keywords Beeswax · Fisheries · Honey · Livelihood · Mangroves · Thatching materials

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A. Z. M. M. Rashid et al. (eds.), *Non-Wood Forest Products of Asia*, World Forests 25,
https://doi.org/10.1007/978-3-030-99313-9_5

5.1 Introduction

The Sundarbans is a mangrove or tidal forest or tidal wetland. This forest is an assemblage of different angiosperm plant species of various families having the adaptive capacity to a fluctuating aerobic to anaerobic semi-fluid like substrate and tidally influenced saline environment (Duke 1992; Siddiqi 2001; Mahmood 2015). The Sundarbans is the world's largest single tract of mangrove forest covering about 1,000,000 ha of land and water bodies that covers India and Bangladesh. In Bangladesh, it covers a total of 6, 01, 700 ha which is 4.13% of the total land area and 38.12% of the total forest land of Bangladesh (BFD 2017). This forest is located in the Southwestern coastal region of Bangladesh starting from the Harinbhanga River in the west to the Baleswar River in the east. This forest is about 80 km in the North to South direction and about 100 km in the East to West direction. This landscape of the Sundarbans can be categorized as active to the abundant delta that is crisscrossing by numerous rivers and canals, with a range of elevation from 0.9 to 2.11 m from the sea level (Saenger and Siddiqi 1993; Siddiqi 2001).

The Sundarbans, characterized as an open ecosystem comprising of terrestrial and aquatic ecosystems. This ecosystem is dynamic and highly productive among the other coastal ecosystems. This forest ecosystem is home to diverse species of flora and fauna. 334 plant species are recorded in the Sundarbans and its' adjacent areas (Prain 1903), while Rahman et al. (2015) recorded the highest of 528 plant species. Mangroves and mangrove associates are the floristic elements of the Sundarbans. However, this ecosystem contains about 50% of the world mangrove plant species (Hoque and Datta 2005; Aziz and Paul 2015) and 505 species of wildlife (Khan 2013), 261–320 species of birds, 177–400 species of fishes (Khan 2013), 5530 species of insects (Mitra et al. 2016), and numerous species of fungi, bacteria, algae, lichen, phytoplankton, etc. (Siddiqi 2001). It is believed that a wide range of soil salinity (<2 to >4 dS m^{-1}), lower elevation and frequent tidal inundation, plenty of supply of freshwater from upstream and rainfall control the composition and distribution of non-salt tolerant to salt-tolerant plant species in this forested ecosystem (Iftekhar and seanger 2008; Mahmood 2015).

The floral and faunal composition of the Sundarbans forest ecosystem yields a wide array of resources. The human being had started to utilize these resources before 321 BC as record available on the state supervision and formulation of laws for the utilization of the forest areas during the Muryan period (321-226 BC) (Iftekhar and Islam 2004). This forest has an important role in the economy and climate of the national, regional, and global scale. It provides many direct benefits to the vicinity community starting from the fuelwood collection to the fisheries and maintaining the ecological balance for the southwestern region of Bangladesh. About one million peoples are directly or indirectly dependent on the resources of the Sundarbans for their livelihood. Besides these, Sundarbans protect the lives and properties of the adjacent population from tidal surges, tropical cyclones, and tsunamis (Saenger 2011; Hale et al. 2019). The Sundarbans has a significant role for shelter, nursery, feeding, resting, and breeding ground of many aquatic organisms and supports the coastal

fisheries resources through the supplies of particulate and sub-particulate form of organic matter (Mahmood 2015). This forest also helps to enhance the carbon stock and carbon sequestration, and cycling of other nutrients in forest soil, vegetation (Rahman et al. 2015; Gob 2019).

5.2 Non-wood Forest Products (NWFPs) of the Sundarban

Non-wood forest product generally refers to the tangible biological products other than wood that is originated from forests. Large portions of floral and faunal species of a forest ecosystem provide both wood and non-wood products. Interestingly, most of the non-wood forest products (NWFPs) are usually remain invisible and unaccounted (Muir et al. 2020). The major extractable NWFPs of the Sundarbans are thatching materials, honey, beeswax, and aquatic fauna (Hossain and Acharya 1994). The NWFPs of the Sundarbans can be grouped into plant resources, honey and beeswax, and aquatic resources. Different species of trees, shrubs, palm, climbers, and grasses are the major sources of NWFPs originated from the plant resources of the Sundarbans (Mahmood 2015). *Apis dorsata* and *A. mellifera* are the two honey bee species of the Sundarbans. These bee species use the nectar of flowering plants of the Sundarbans for the production of honey (Baksha 2004). While the fishery resources consist of bony and cartilaginous fish, crustaceans, and mollusk. Different studies noticed that about 120 species of aquatic fauna have commercial uses or values (IUCN 1994; Shah et al. 2010; Ahsan 2014; Habib et al. 2020).

NWFPs are the major sources of livelihood to the people living surrounding the Sundarbans of Bangladesh. Broadly, the NWFPs of the Sundarbans can be categorized into conventional and non-conventional based on resources used by the people. The conventional NWFPs of the Sundarbans are plant resources (Edible fruits, Vegetable, Floating fruits as fuel, Thatching and bedding mats, Cord or Rope, Fodder, Tannin and dye, Fish poison, Perfumes, Chemical and Oil, Folk medicine); honey and beeswax; aquatic resources (Bony fish, Cartilaginous fish, Dry fish, Adult Crabs, Shrimps, Post larva and Fry collection, Baby crabs for crab fattening, Mollusks) (Table 5.1). The non-conventional NWFPs include edible fruits, vegetable, tannin, and dye, perfume and chemicals, folk medicine, cords, or rope from different plant species of the Sundarbans (Table 5.2).

Majority of the NWFPs are collected from the Sundarbans forest areas, but a portion of these NWFPs are collected from the peripheral water bodies and land areas immediately at the outside of the Sundarbans. It includes some edible fruits like *Sonneratia apetala, S. caseolaris*; and floating fruits are trapped from the surrounded rivers, canals, and creeks for fuel; thatching materials; fodder; and a good portion of aquatic resources. However, these products are not included in the resource collection records of the Forest Department. The local community people close to the Sundarbans are rearing domesticated bees (*A. cerana indica*) for honey production as their alternate livelihood. These bees use the nectar of different flowers of the Sundarbans for honey production (Baksha 2004). Bangladesh forest department

Table 5.1 Conventional non-wood forest products of the Sundarbans. NWFPs with '*' mark indicates commercial collection from the Sundarbans

Product	Sources
Plant products	
Edible fruits	*Nypa fruticans*, *Phoenix paludosa, Sarcolobus globosus*, *Sonneratia apetala,* and *S. caseolaris* (Mahmood 2015; Siddiqui 2016)
Vegetable	Young shoots of *Acrostichum aureum*, *N. fruticans* and fruits of *S. globosus* are cooked and also consumed as raw. Stem pith of *P. paludosa* can be eaten raw. Pickle is made from the fruits of *S. apetala* (Giesen et al. 2006; Mahmood 2015; Siddiqui 2016)
Floating fruits as fuel	The floating fruits and seeds of *Aglaia cucullata, Avicennia officinalis, Bruguiera sexangula*, *Ceriops decandra*, *Heritiera fomes, N. fruticans, Pongamia pinnata, S. apetala, Xylocarpus granatum* and *X. moluccensis* are trapped by the local people from the peripheral rivers and canals of the Sundarbans. The local people use the dried fruits/ seeds as fuel for daily consumption
Fodder	Fronds of *Acrostichum aureum;* leaves of *Acanthus ilicifolius, Aegiceras corniculatum*, *A. alba*, *A. marina*, *A. officinalis*, *Clerodendrum inerme*, *Cyperus difformis, C. javanicus, Derris trifoliate, Eriochloa procera, Hibiscus tiliaceus, Kandelia candel, Pongamia pinnata, S. apetala, S. caseolaris* (Giesen et al. 2006; Mahmood 2015; Siddiqui 2016)
Tannin and dye	Barks of *B. gymnorrhiza, B. sexangula, Ceriops decandra, Cynometra ramiflora*, *Heritiera fomes, Kandelia candel, Lumnitzera racemose*, *X. granatum* and *X. moluccensis*; leaves and bark of *Rhizophora apiculate* and *R. mucronata* are the good sources of tannin and dye (Giesen et al. 2006; Mahmood 2015)
Fish poison	The oil from seeds of *Cerbera manghas;* stem and root extracts of *Derris scandens* and *D. trifoliate*; latex of *Excoecaria agallocha*; young fruits of *E. indica*; and roots and seeds of *P. pinnata* used as fish poison (Giesen et al. 2006; Mahmood 2015)
Perfumes	The flower extract of *C. inerme* is used to perfume the coconut oil (Giesen et al. 2006; Mahmood 2015)
Oil	Red-brown thick oil is extracted from the seed of *P. pinnata* that are used for lamp, manufacturing soap and lubricants (Giesen et al. 2006; Mahmood 2015)
Medicinal uses	Wide array of medicinal values of different plant species of the Sundarbans have been recorded (Appendix 1)

(continued)

Table 5.1 (continued)

Product	Sources
*Thatching and bedding mates preparation materials	Leaves of *N. fruticans* are principle and widely used as thatching and partition materials at the southwestern village areas of Bangladesh. Beside this, *Imperata cylindrical*, leaves of *P. paludosa* are also used as thatching materials. Older fronds of *A. aureum* are used for light construction like roofing of country boat, weaving and wall of cottage. While, stem of *Phragmites karka* are used for partition, ceiling, and often as outside wall of house with mud. However, *Typha elephantis, C. javanicus, I. cylindrical,* leaves of *P. paludosa* and *P. karka* are frequently used for preparing the bedding mates (Giesen et al. 2006; Mahmood 2015; Siddiqui 2016)
Cord	The common climbers (*Derris scandens*, *D. trifoliate*, *Flagellaria indica* and *Sarcolobus globosus*) are frequently used as rough cord or rope by the resource collectors. Beside this, cord or rope also be prepared from the mature fronds/ leaves of *A. aureum*, *Pandanus foetidus*; and fibers from barks of *H. tiliaceus* (Giesen et al. 2006; Mahmood, 2015)
Others use	Baskets are made from the bark and stem of *F. indica* and leaves of *N. fruticans.* Hats are also made from the stems of *Phragmites karka.* Young branches of *Brownlowia tersa* are traditionally used as *Miswak* (teeth cleaning twig). Dry petioles of *N. fruticans* are used as floater of fishing net. Hard round seed of *E. indica* used as marbles by children (Mahmood 2015)
***Honey and beeswax**	The honey bees (*A. dorsata* and *A. mellifera*) produce the bulk of the honey from the nectar of *A. ilicifolius, A. corniculatum, A. officinalis, Aegialitis rotundifolia, B. gymnorrhiza, B. sexangula, C. decandra, C. ramifolia, E. agallocha*, *R. apiculate, R. mucronata S. apetala, S. caseolaris, X. moluccensis.* But the best quality honey is produced from the nectar of *A. corniculatum* (Baksha 2004; Mahmood 2015; Siddiqui 2016). The proportion of beeswax is approximately 25–30% of the produced honey (BFD 2020b)
Aquatic resources	
*Bony fish	Hilsa shad (*Tenualosa ilisha*) is the most common and commercially important fish species of the Sundarbans. The other common bony species of the Sundarbans are King Soldier Bream (*Argyrops spinifer*), Paradise Thread Fin (*Polynemus paradiseus*), Asian sea bass (*Lates calcarifer*), Fatty cat fish (*Pangasius pangasius*), Pama Croaker (*Otolithoides pama*), Small head Ribbon Fish (*Eupleurogrammus muticus*), Gray eel-catfish (*Plotosus canius*), Long-whiskered Catfish (*Mystus gulio*), Bombay duck (*Harpadon nehereus*), and Gold Spot Mullet (*Liza parsia*) (Shah et al. 2010; Ahsan 2014; Habib et al. 2020)

(continued)

Table 5.1 (continued)

Product	Sources
*Cartilaginous fish	The cartilaginous fishes are mainly marine, but they are also available in the aquatic ecosystem of the Sundarbans. Some of them have economic value and sold in the local market. The important species area Blacktip reef shark (*Carcharhinus melanopterus*), Spadenose shark (*Scoliodon laticaudus*), Dog fysh (*Scoliodon sorrakowah)*, Milk shark (*Scoliodon walbeehmii*), Hammerhead shark (*Eusphyrna blochii*), Gulter fish (*Rhynchobatus djeddensis*), Skate (*Rhinobatos granulatus*), Pale-edged ray (*Dasyatis zugei*), Gangetic stingray (*Himantura fluviatilis*), Scaly stingray (*Himantura imbricate*) and Stingray (*Himantura uarnak*) (Shah et al. 2010; Habib et al. 2020)
*Dry fish	Dubla island of the Sundarbans is the place for fish drying (both the marine and brackish species). Bombay duck (*Harpadon nehereus*), Small head Ribbon Fish (*Eupleurogrammus muticus*), Chiense pomfret (*Pampas chiensis*), King Soldier Bream (*Argyrops spinifer*) and different species of shrimps are the most prominent (Shah et al. 2010)
*Adult Crabs	There are 12 species of carbs are found in the Sundarbans ecosystem. But, the mud crabs (*Scylla serrata* and *Scylla Olivacea)* are the most important for food and trade (Saha and Ahmed 1999; Shah et al. 2010)
*Shrimps	Twenty sixspecies of shrimps are available in the Sundarbans ecosystem. But, giant freshwater prawn (*Macrobrachium rosenbergii*) and giant tiger prawn (*Penaeus monodon*) are the most commercially important shrimp species (Hoq 2007; Shah et al. 2010; Habib et al. 2020)
Post larva and fry collection	Post larvae of *Macrobrachium rosenbergii* and *Penaeus monodon*, and fry of *Liza parsia* are usually collected from the surrounding waterbody of the Sundarbans for the commercial aquaculture. However, the collection of post larvae of *Macrobrachium rosenbergii* and *Penaeus monodon* from the Sundarbans was ban in 2000 for the conservation of the fisheries of the Sundarbans (Shah et al. 2010)
Baby crab for crab fattening farm	The wild baby crab of *Scylla serrata* and *S. olivacea* are collected from the Sundarbans and the surrounding waterbody of the Sundarbans for the crab fattening farms (Mia 2013)
*Mollusks	There are about 31–36 species of mollusks in the Sundarbans. Very small quantities of mollusks are consumed as food in Bangladesh. However, most of them used in shrimp farm as food and shells are used for the production of lime (Shah et al. 2010; Habib et al. 2020)

Table 5.2 Non-conventional non-wood forest product of the Sundarbans

Product	Sources
Edible fruits	The seeds of *A. alba, A. marina*, *A. officinalis* are roasted and consumed. Seed powder of *F. indica* is also edible. Mature fruits of *Pandanus foetidus* can be consumed (Giesen et al. 2006)
Vegetable	Seedlings of *A. alba*; tender leaves of *P. foetidus*; and young shoots of *P. karaka* and *F. indica* can be cooked and consumed as vegetable. The hypocotyls of *B. gymnorrhiza*, *B. sexangula*, *R. apiculata* and *R. mucronata* can be cooked after scraped, washed, soaked, and boiled
Tannin and dye	Bark of *A. rotundifolia*, *D. trifoliate*, *E. indica*; and leaves of *E. indica* and *N. fruticans* are potential sources of tannin and dye
Oil, perfume and chemicals	Fruit pericarp extract of *A. cucullata*; and seed oil of *C. manghas*, *X. granatum* can be used to illuminate. Perfumes can be extracted from the barks of knee root of *B. gymnorrhiza* and *B. sexangula*; and flowers of *P. foetidus*. Bio insecticide are prepared from the fruits and seeds of *C. manghas*
Cords or ropes	Cords or ropes can be prepared from the leaves of *P. paludosa*, barks of *P. pinnata* and leaf stem fiber of *N. fruticans*
Others use	Mates and hats can be made from leaves of *N. fruticans, P. foetidus*, *P. paludosa*. Stem of *F. indica* can be used for woven into fish trap and considere as a good alternative for rattan. Young leaves of *N. fruticans* can be obtain for cigarette-wrapper, and midribs for brooms making. Vinegar, alcohol and molasses are prepared from the inflorescence sap. Aromatic tea can be also be obtained from the processed petals of *N. fruticans*. *Cryptocoryne ciliate* can be used as aquarium plants. Pneumatophores of *S. apetala*, *S. caseolaris* are used in making corks or floats. The ash of *I. cylindrical* can be used as a substitute of salt. The inflorescences can be used for stuffing pillows and cushions and the fiber of leaves can also be used in making paper

Source Bandaranayake (1998), Giesen et al. (2006), Mahmood (2015)

established 93.5 ha plantation of *Nypa fruticans* (the most important thatching material) at the outer side of the embankment close to the Sundarbans in cooperation with the Bangladesh Water Development Board (BFD 2020a). Moreover, plantations of this species have also been established on the private lands close to the Sundarbans for commercial production of thatching material.

5.3 Extraction of NWFPs from the Sundarbans

The use of both the wood and non-wood forest resources of the Sundarbans had started with the beginning of human settlement in that area for their housing, food, daily consumption, and livelihood. The southern parts of the Ganges floodplain where the

Sundarbans is situated was recognized as economic, cultural, and political frontiers during the period of 1200–1750, which ultimately govern the human settlement in the Sundarbans areas (Eaton 1990). With time, people learnt to identify and use different NWFPs from the Sundarbans. Hunter in 1875 recorded that people collected reeds, thatching leaves, honey, beeswax, shell-line, and fishes from the Sundarbans for their household consumption and livelihood. We have identified 21 categories of NWFPs in the Sundarbans (Table 5.1), but 8 of them are commonly collected (BFD 2020b). The NWFPs are collected from the Sundarbans by following a defined harvesting rule for each category (BFD 2010). The extraction procedures and harvested amount of each category of NWFPs from the Sundarbans have been discussed here.

5.3.1 Thatching Materials

The Sundarbans is the major source of thatching materials for the rural settlement of southeastern Bangladesh science long. Leaves of *N. fruticans* are the principle and widely used thatching materials. Along with this, *I. cylindrical* is also used for the same purpose. Bangladesh Forest Department (BFD) has set harvesting rule for the collection of *Nypa* leaves and *I. cylindrical* from the Sundarbans. The mean and range of extractions of *Nypa* leaves are about 38,409 ± 3902 ton and 440–72,428 ton respectively for the last 29 years. However, the mean and range of extractions of *Imperata cylindrical* are about 3705 ± 508 ton and 32–10,157 ton respectively for last 29 years (1991–92 to 2018–2019) (Fig. 5.1) (BFD 2020b). The extracted amount of these resources found to fluctuate significantly with the stocking, market demand, and natural calamities. Frequently tropical cyclones hit the coast of Bangladesh. The super cyclone "Sidor" and "Aila" cross the Sundarbans coast of Bangladesh on 15 November 2007 and 23 May 2009 respectively. The extracted amount of *Nypa* leaf was lowest (only 440 ton) during 2007–2008, which was the intimate effect of the super cyclone "Sidor" that impacted at the beginning of the harvesting time. Interestingly, the extracted amount of *Nypa* leaves during 2009–2010 was not affected because the cyclone "Aila" struck at the end of harvesting time of 2009–2010. The extracted amount of the thatching materials reduces with time and showed a sharp negative trend (Fig. 5.1). This negative trend could be the result of frequent use of corrugated iron sheets in the last two decades instead of *Nypa* leaves and *I. cylindrical* as thatching materials. Nowadays the corrugated iron sheets are more available and durable, and socially prestigious compared to these natural sources of thatching materials.

The mangrove forest of Sundarbans has its own unique system that supports life and living of thousands of local communities who are heavily dependent on the resources of mangrove forests. Bawali (popularly called wood cutters and golpata collectors) are the dominant group of Sundarban who has significant influence in the conservation and sustainability of resources and of the Sundarbans. The following case study reveals the insights of the life and living of a *Bawali*:

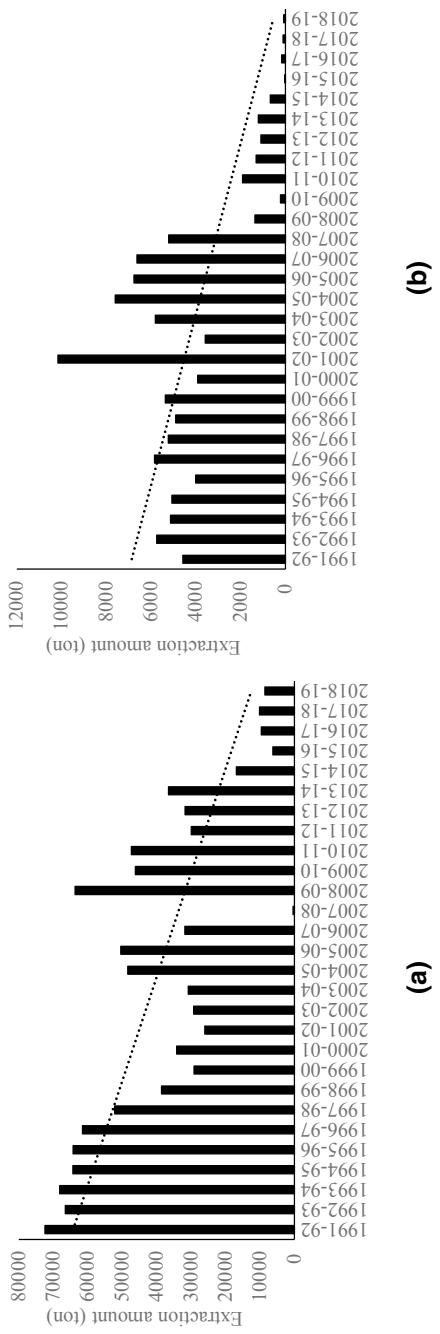


Fig. 5.1 Yearly (1991–92 to 2018–19) extraction of thatching materials **a** *Nypa fruticans* and **b** *Imperata cylindrical* from the Sundarbans (*Source* BFD 2020b)

Box 1: Life of a Bawali (Thatching material collector)

We met Talebur (pseudonym) a man of 50's at Shorankhola forest range while we were resting in a camp and planning our next day field work. Our discussion was mainly centered on Nypa fruticans (golpata- a common thatching grass of the Sundarban mangrove forest).

We started [our chat] to know Talebur's family, [his] hopes, aspirations and the future

(both him and the Sundarban).

For how long have you been engaged in this profession? Answering this question, Talebur stopped a while [to recall] and replied (with a smile) at least 30 years [a vanishing memory].

I, my father, uncle and neighbors used to get into the Sundarbans during the harvesting season [October-February].

Inquiring about the life and livings of Bawalis who are harvesting golpata…. Talebur replied with uncertainty …..look [this resource] grows only in areas [where salinity is less or moderate] nearby river bank, canal side etc. You [will not] find them everywhere. We have a struggle a lot to get a [descent] amount.

Any challenges you [generally] face while harvesting [golpata]?… answering this [question] Talebur stared at the sky for a while and said.. See our [harvesting territory] is shrinking day by day… You know why? …. Growing restriction in accessing and [harvesting resources] to the Sundarbans since protected area [and world heritage site too] coverage is increasing, declining production [due to salinity and natural calamities and availability of alternative thatching materials.

Sustaining livelihood on golpata collection is difficult for many reasons….[harvesting of other tree species is totally banned] posing threat to our profession. Sometimes realizing [your] investment [boat license, revenue, other expenditures during the voyage] became utterly difficult. Pirates disturbances for ransom, illegal influence of the forest staff all add extra [burden] on us. This profession is no more a lucrative means of [survival].

Any clues for future improvement? …..Talebur suggested few important issues [based on his long experience he gained] namely …..plantation initiative of golpata by forest department at all feasible sites, registering authentic bawalis for the sustainable harvesting and management, product diversification [the juice can be used for making molasses, drinks and so on], law enforcement to restrict all sorts of illegal harvesting of natural resources from the Sundarban and the positive mindset of the governing authority.

5.3.2 Honey and Beeswax

Sundarbans is a good source of honey and beeswax. About 50% of the harvested honey of Bangladesh comes from the Sundarbans (Burgett 2000). The hives are found at low height in the Sundarbans. *P. paludosa* and *E. agallocha* dominated sites are preferred by the bees and *E. agallocha* is the most preferred nesting tree for the bees (Baksha 2004). The mean annual and range of harvested amount of honey and beeswax are 175 ± 14 and 46 ± 4 ton; 87–460 ton and 22–116 ton respectively for the last 29 years. Twenty-nine years of harvested data of honey and beeswax showed a slightly positive trend (Fig. 5.2) (BFD 2020b). There are no surveys or inventories on the stocking of honey and beeswax, but expected yearly production of honey and beeswax are forecasted from the harvested amounts of previous years. About 2000 honey collectors (widely dubbed as Mouali) usually enter annually into the Sundarbans for the collection of honey and beeswax.

The following case story (Box 2) reveals the current context of the Moualis in connetion with their livelihood and conservation:

Box 2: Life of a Mouali (Honey collector)

Qumrul Sheikh (a pseudonym), a man of 25 from Joymuni bazar of Mongla Upazilla is a honey collector commonly known as Mouali.

Qumrul was accompanying us in a research expedition (his optional occupation to support his livelihood) as a field crew hence had the opportunity of sharing the extensive experience regarding the non-wood forest products (NWFPs) of the Sundarbans particularly honey.

How long have you been in this profession?…in answer to that, Qumrul started sharing the ins and outs of his profession.

……I am in this occupation for the last five years…. for honey collection. You don't need any critical skills. All you need is the mental and physical strengths. I have learned these from my fellow mates while accompanying them during the honey collection season.

While focusing on the official procedures…. Qumrul started sharing more…

The official season starts at March (fluctuates between mid to late March depending on the rainfall intensity) and ends in May. Forest department issues permits for 15 days (generally 4 times in a season). We enter the forest (5–7 people per boat) and stay until the permit expires.

How about the amount and the variety of the honey (sources)?…

In reply to this (he answered)……It totally depends on luck (favored by the season too). Last season, I had 82 kg of raw honey as share. Goran and khalsi are the major sources of honey.

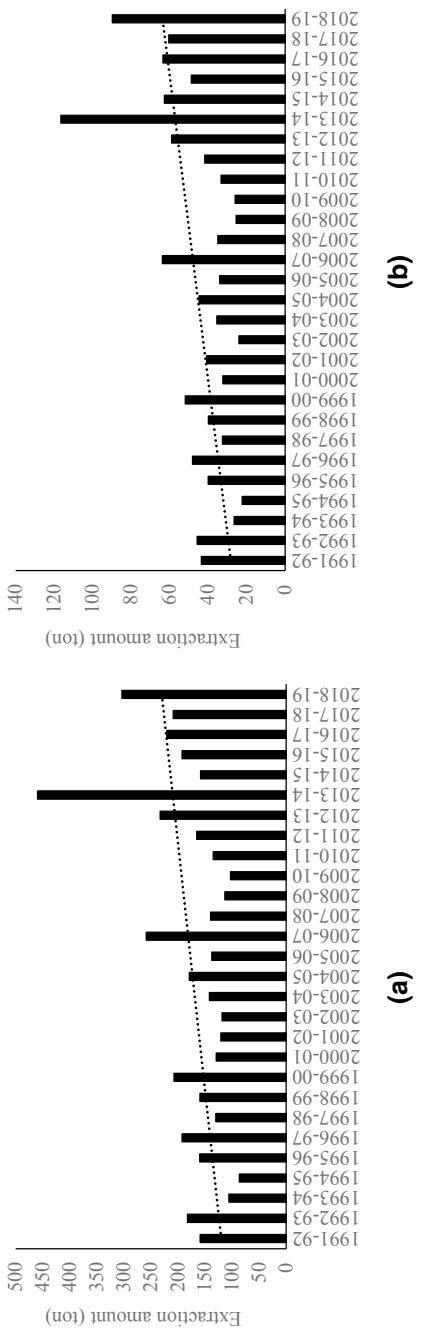


Fig. 5.2 Yearly (1991–92 to 2018–19) extraction of **a** Honey and **b** Beeswax from the Sundarbans

While asking about the factors determining the production of honey.. Qumrul answered confidently-forest health. The less you enter and destroy forest (trees, animals, foods etc.) and favourable weather help boosting production.

Can you sustain your livelihood based on honey collection?….. Qumrul replied with a smile expressing both hopes and dissatisfaction. [No] it is a seasonal occupation (3 months in a year). So [I] need to depend on other options like fish spawn and crab harvesting from the Sundarbans to support my 8 membered family.

How do you see the future of Non-wood forest products of the forest. He replied.. it (The Sundarbans) is a treasure house of NWFPs, sustaining thousands of peoples like me (through thick and thin). All you need to do is possess acceptable [by us and you (FD)] level of empathy for the Sundarbans.

The Sundarbans is like our mother…[we] were born here and want to live the rest of our lives along it by keeping it alive.

5.3.3 Aquatic Resources

5.3.3.1 Fishes (Bony and Cartilaginous Fish)

Fishes are the most important NWFPs of the Sundarbans ecosystem. It includes both the bony and cartilaginous fish species. Since the beginning of the human settlement in the southwest region of Bangladesh, this resource is extracted for household consumption and livelihood. Thousands of people living around and outside the landscape area are directly and indirectly dependent on the fisheries of the Sundarbans. It contributes about 2–5% of the total capture fishes of the country (Shah et al. 2010). The fishermen use 15 categories of gears in the Sundarbans (Hoq 2008), but 8 gears (cast net, canal gill net, gill net, Hilsha gill net, long line, Otter gill net, Pangash gill net, and set bag net) are frequently used for harvesting the bony and cartilaginous fishes of the Sundarbans (Shah et al. 2010). So far there is no formal inventory on the fish stock in the Sundarbans (BFD 2010). But, the yearly harvested amount of fishes are recorded by the BFD for forecasting the stock for the next year. These records showed fluctuation in yearly harvested amount with a mean of 3445 $\pm$ 221 ton and ranged from 1127 to 6192 ton for last 29 years (BFD 2020b). Overall the yearly harvested amount shows a negative linear trend (Fig. 5.3). The yearly harvested amount of fishes from the Sundarbans reported decreasing with time. Fishers, BFD, and people involved with fish marketing business reported that fishery resources of the Sundarbans have decreased about 50% over the years during 2001–2010 (BFD 2010). It is important to consider the long time series data on

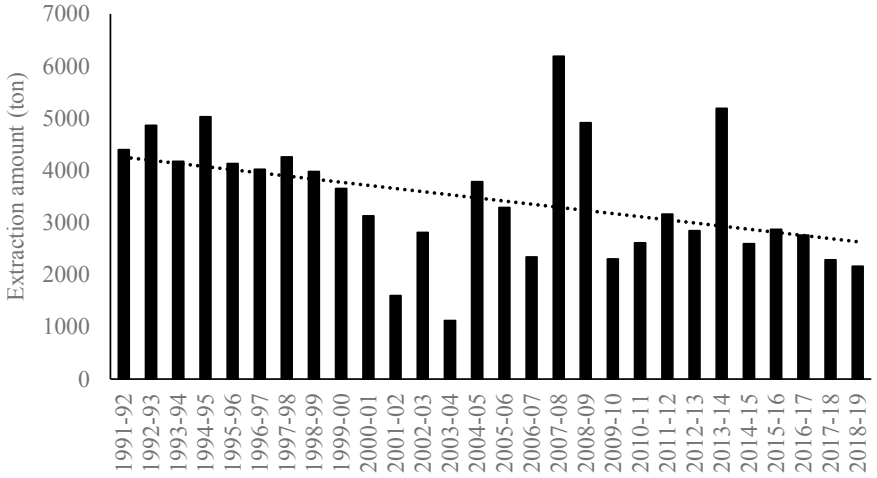


Fig. 5.3 Yearly (1991–92 to 2018–19) extraction of bony and cartilaginous fishes from the Sundarbans

fish harvest, an outbreak of the disease in fish, management and monitoring initiatives at different time period, expansion of the sanctuary areas, the yearly number of permits issued, increase the rate of royalty, the yearly number of precautionary weather signals and cyclonic events, and safety and security condition (the activities of pirates) during the fishing seasons need to be considered before come to a candid conclusion.

Fish—a major non-wood forest products of the Sundarbans playing a crucial role in sustaining livelihood of many of the forest dependent community. The following story (Box 3) of a fisherman reveals some of the context having relation to conservation, knowledge and livelihood context:

Box 3: Life of a fisherman

Montaz mridha (pseudo name) a fisherman aged 52 from Gabura Union under Satkhira Range is engaged in the profession since his childhood. His six membered family solely depends on fishing and related activities.

The scorching sun was melting while we met Montaz near a fishery ghat (went to sell his catch). We started chatting [once he has finished delivering the catch] siting nearby a tea stall. Our (discussion) proceeds while sipping tea…

Being asked about the profession and related aspects…Montaz manifested the gradual development of becoming a fisherman. I used to accompany and help my father to collect shrimp spawn from the river bank while I was young… that was the beginning. [gradually] I came to know the formal (legal) process of fishing [royalty, timing and types of fishing gear to be used].

Fish resources are increasing or dwindling? In reply to this question, he replied.. there is no [short cut] answer to (this). It depends on many [things].. seasonal blessings, good behavior of the water (meant tidal dynamics) and weather (cyclonic events), sufficient offspring in the river, canal and channels and your [skill].

Defining the issues of sustainability and conservation... Montaz [his community as a whole too] reveals some crucial issues [in front]…the fishing areas are reducing day by day [in the name of protection]. Dolphin sanctuary and protected area coverage are expanding and [we] are [confined]… how we can survive with growing [restrictions]. We have [no] other skill to sustain livelihood. Hostage for ransom is also a [big] issue.. you have to satisfy them[the pirate gangs]..otherwise your life and livelihood both will be threatened.

What is your expectation to sustain livelihood and the conservation…. he stared at me and starts saying….Government [Forest department] must find a way for us (alternative livelihood options) otherwise allow us fishing inside the Sundarbans. Controlling [poison fishing] is a must… it is killing our mother nature [The Sundarbans] and our existence [too]. Aquatic plant habitat conservation is also important that in turn [helps] to support fish population.

5.3.3.2 Dry Fish

Fish drying is a quite old-time practice in the Sundarbans and it is the 2nd largest fish drying industry in Bangladesh. The fishing is associated with both the inshore and offshore water, but not to allow fishing inside the Sundarbans. About 60% of the catch is consists of bony and cartilaginous fish and 20–30% are small-sized shrimps. Mostly the small-sized shrimps are smoked dried (Hossain 1984). The produced dry fish are locally consumed and also exported to foreign counties. Fish drying activities are operated at the sea-facing islands like office kella, Majer kella, Alorkol, Narikel baria, Shelar char during the winter season starting from October and ends in the month of March. Every batch of fish requires two to eight days for sun-drying depending on the size and species of fishes. Yearly about 25,000–30,000 fishermen are engaged with fish dry in the Sundarbans. The fishermen mostly from the Southwest region of Bangladesh. BFD issued Boat License Certificate (BLC) to the fishermen as a permit of fish drying for a season. The mean annual and range of produced dry fish for the last 18 years (2001–02 to 2018–19) are 2501 $\pm$ 348 ton and 468–6739 ton respectively (Fig. 5.4) (BFD 2010).

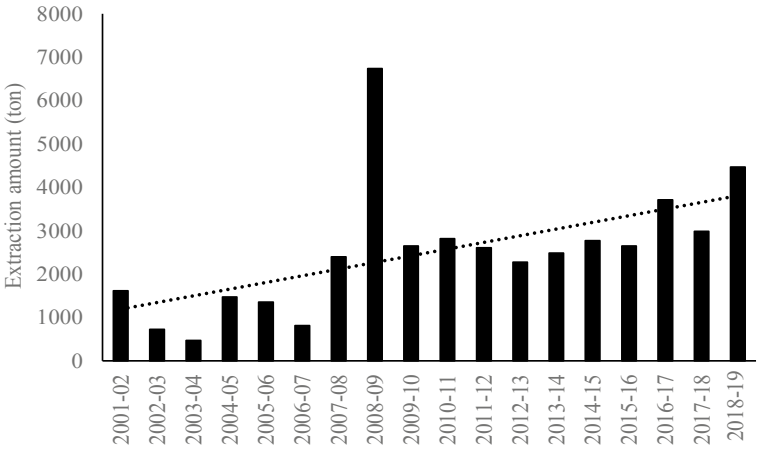


Fig. 5.4 Yearly (2001–02 to 2018–19) extraction of Dry fish from the Sundarbans

5.3.3.3 Crabs

Crabs are the important aquatic resources of the Sundarbans. Crabs are not included in the daily diet of the local people of Bangladesh due to the religious believes. Therefore, major portions of the harvested carbs are exported to foreign countries. *S. serrata* and *S. Olivacea* are the important targeted crab species for harvest. Crab hook and line, and trap with bait are the most common modes of crab harvesting (Shah et al. 2010). The annual mean harvested amount of crabs is 1151 ± 177 ton, and the yearly amount of harvest is found to vary from 71 to 2570 ton from 2001–02 to 2018–19 at a sharp increasing trend (Fig. 5.5) (BFD 2020b).

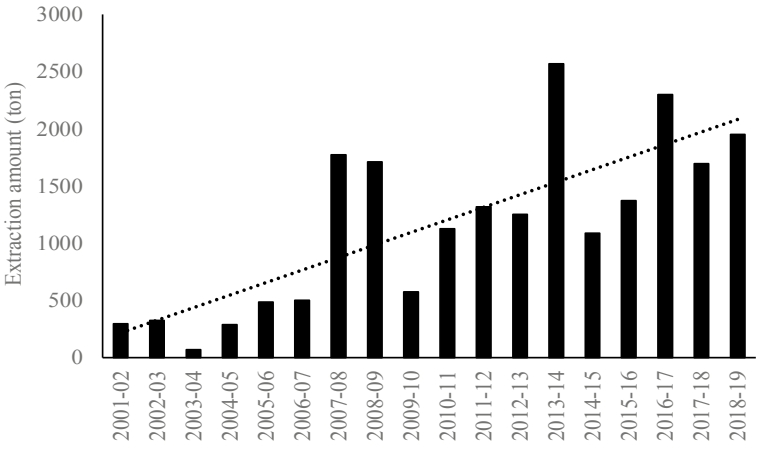


Fig. 5.5 Yearly (2001–02 to 2018–19) extraction of Crabs from the Sundarbans

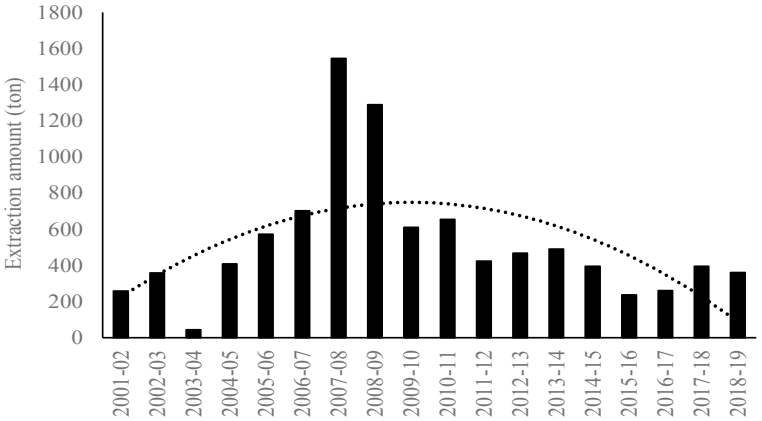


Fig. 5.6 Yearly (2001–02 to 2018–19) extraction of Shrimp from the Sundarbans

5.3.3.4 Shrimps

Twenty six (26) species of shrimps are generally available in the Sundarbans ecosystem. Of which, *P. monodon, P. indicus, Metapenaeus monoceros, M. brevicornis, Palaemon styliferus, Macrobrachium rosenbergii*, *M. villosimanus, M. dyanus, M. dolichodactylus* and *M. rude* are frequently occurs in the river system of the Sundarbans. Most of the shrimp species are locally consumed, but *P. monodon* and *M. rosenbergii* are mostly exported to foreign countries for their higher demand and value (Huq et al. 2001; Shah et al. 2010). Shrimps are caught by different gears, which are used for harvesting the bony and cartilaginous fish. But, rod and line are used to catch giant freshwater prawns (Shah et al. 2010). The annual harvested amount found to fluctuate considerably from 2001–02 to 2018–2019. However, the mean annual harvest and range were 534 ± 91 ton and 45 to 1545 ton respectively (BFD 2020b), and showed a polynomial trend for the last 18 years (Fig. 5.6).

5.3.3.5 Mollusks

Mollusks collection from the Sundarbans is an age old practice for the production of lime (Hunter 1875). The mollusk shells are mainly used for the production of lime for chew with Betel leaf, poultry, and fish meal; and the meats are used in shrimp farms as food. But very few quantities are consumed as food in Bangladesh (Shah et al. 2010; Habib et al. 2020). The peak collection season is November to February. BFD issues Boat License Certificate (BLC) to the collectors. The extracted amount of Mollusks found to decrease sharply with time from 1991–92 to 2016–17 with a logarithmic trend. Presently, BFD is not issuing the permit for Mollusk collection. However, the mean annual extraction is 1298 ± 284 tons with a range of 0 to 4363 tons for the said period (Fig. 5.7) (BFD 2020b).

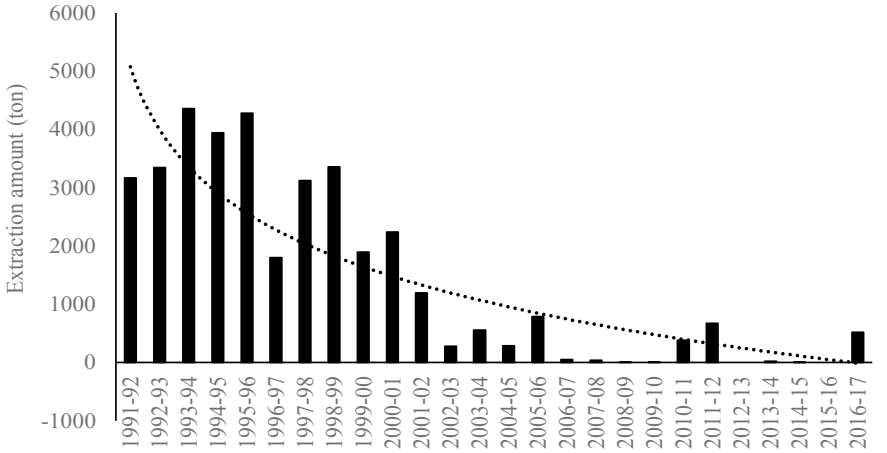


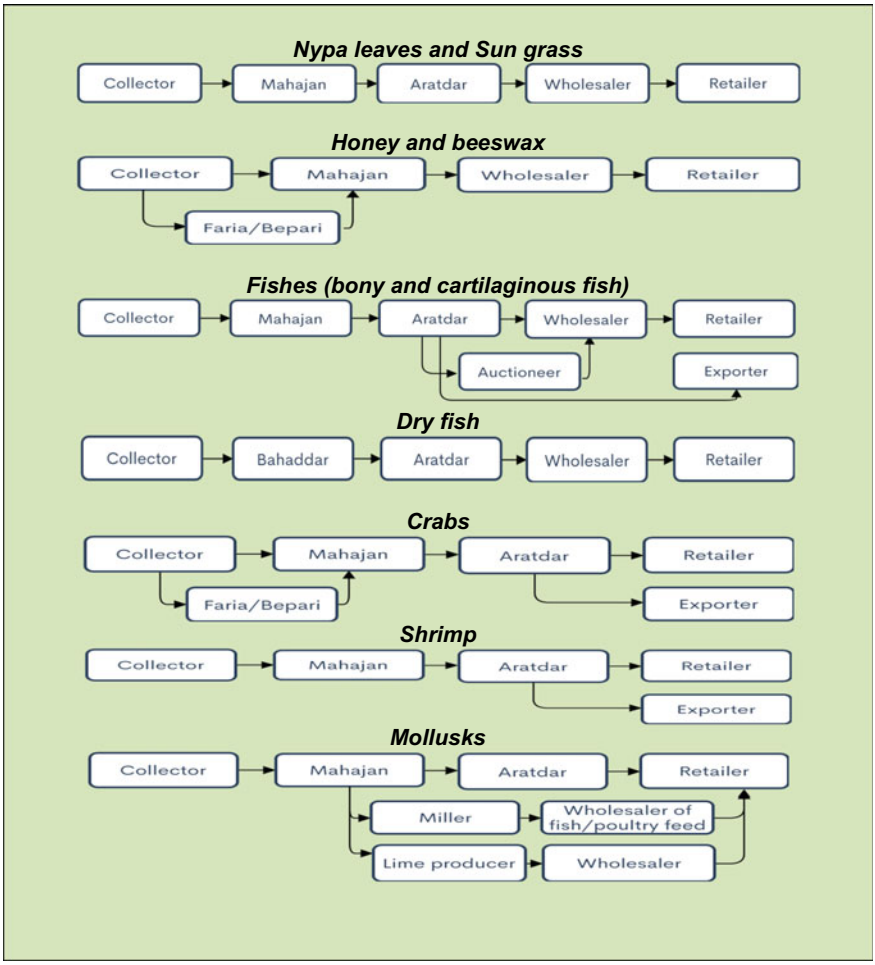
Fig. 5.7 Yearly (1991–92 to 2018–19) extraction of mollusk from the Sundarbans

5.4 Value Chain of NWFPs of the Sundarbans

The resources or products that are extracted commercially from the Sundarbans have to cross at least two and a maximum of five steps in between collectors to the retailers. The basic steps are Collector, *Mahajan, Aratdar*, Wholesaler, and Retailers are commonly involved. Sometimes *Majhi/Faria/Bepari*, *Bahaddar*, Auctioneer, Miller, and Exporters have also involved in certain resources/ products like carbs, large-sized shrimps, shrimp fry, hilsa shad (*Tenualosa ilisha*), mollusks. However, the value chain of some important resources has been presented in Box 4. Considerable value addition is observed in every step of the value chain. The percentages of value addition are varied with the extracted resources and steps involved. However, the maximum percentage of value addition is associated with the resource collector followed by Bepari or Mahajan. The maximum percentage (75%) of value addition at the collector level was observed for giant freshwater prawn and lower percentage (49.7%) was observed for *Nypa* leaf, and Bapari and Mahajon together contribute about 10.7–31.4% of value addition depending on the products (BFD 2010).

(*Majhi*: A boatman usually led a group of collectors; *Faria*: A petty trader with small capital and small volume, and usually, sell their product to Beparies; *Bepari*: Beparis are relatively more professional traders who buy a large quantity of the production from collectors or Farias, and sell directly or through Aratdars to wholesalers; *Mahajan*: Mahajans collect forest products commercially by engaging collectors with medium to high investment. They organize collectors, boats and boatmen, and control trips in overall resource collection; *Bahaddar*: They are the main entrepreneurs in dry fish who invest and manage the whole process of fishing. *Aratdars*: The Aratdars usually serve as the commission agents. They have their own fixed establishment in their market and operate among Mahajans, Farias, Beparis, and wholesalers.

Box 4: The basic steps in common value chain for the NWFPs of the Sundarbans



5.5 Revenue Earned from NWFPs of the Sundarbans

NWFPs of the Sundarbans are extracted based on BLC and permit system. Revenue from NWFPs extractions is earned from issuing BLCs, permits, personnel involved in resource collection, and the extracted amounts. The NWFPs like honey, beeswax, fishes, crabs, and mollusks are weighted at the revenue collection stations of the Sundarbans to get clearance upon the payment of royalty based on weight. However, the revenue rates of NWFPs have been revised with time as demanded. In

some cases, the royalty of certain items and sub-groups of NWFPs are found to identified and include over time. The latest revision of revenue rates was gazette in March 2011. In the last three decades, the revenue rates were revised during September 2003 and January 1986 (GoB 1986, 2003, 2011). The revenue of large sized *M. rosenbergii* and *P. monodon* is highest (294.12 UDS/ton), while revenue for *I. cylindrical* was lowest (0.35 USD/ton) among the NWFPs. The rates of revenue of certain NWFPs of the Sundarbans found to increase significantly especially for crabs and certain groups of fish species. The present and previous rates of royalty (USD/ton) of different NWFPs of the Sundarbans have been presented in Table 5.3.

Table 5.3 Revenue rates (USD per metric ton; 85.00 Bangladesh currency (85.00 = 1 USD) in last 30 years for the extraction of important non wood forest products from the Sundarbans

Resources	Revised on March 2011 (USD/ton)	Revised on September 2003 (USD/ton)	Revised on January 1986 (USD/ton)
Thatching materials			
Nypa fruricans	5.88	1.26	0.63
Imperata cylindrical	0.35	0.25	0.09
Honey and Beeswax			
Honey	88.24	63.04	9.46
Crude Beeswax	117.65	94.56	18.91
Refined Beeswax	235.29	189.12	63.04
Aquatic resources			
Tenualosa ilisha, *Pampas chiensis*, *Pangasius pangasius*, *Lates calcarifer*	141.18	94.56	15.76
Other bony fishes	37.65	25.22	9.46
Cartilaginous fish	44.12	-	-
Dry fish			
Pampas chiensis, and others commercially important fish	176.47	126.08	9.46
Other dry fish	58.82	31.52	9.46
Dry fish trash	2.35	1.26	-
Large sized *Macrobrachium rosenbergii* and *Penaeus monodon*	294.12	189.12	37.82
Small sized other shrimp	29.41	18.91	14.18
Crabs	44.12	0.32	-
Mollusks	2.12	1.58	0.16

Source (GoB 1986, 2003, 2011)

The yearly revenue earned from the NWFPs varied from 89.64 thousand USD to 532.47 thousand USD for the period of 2001–02 to 2018–19 (Fig. 5.8a). This variation in revenue earned is related to the extracted amounts of NWFPs and the revised royalty rate with time (Figs. 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 and Table 5.3). The comparatively higher amount of revenue was earned from the aquatic resources of the Sundarbans, while the lowest was earned from honey and beeswax (Fig. 5.8a). However, the revenue earned from NWFPs contributes about 32 to 74% of the total revenue earned from the Sundarbans (Fig. 5.8b).

5.6 Management of NWFPs

The Sundarbans forest was divided into 55 compartments to ensure the effective management of the resources. These compartments are clearly demarcated by natural features like rivers, channels, and creeks. The whole management is goverened under two administrative division namely Sundarbans East and Sundarbans West Forest Divisions. A substatial numbers of forest stations (16) and petrol posts (the numbers of petrol posts found to vary depending on the demand and harvesting seasons of forest produces) have so far been established to heaeded by forester and forest guard respectively. The petrol posts are responsible for enforcing the relevant legislation against illegal activities, protecting resource collectors, and also monitor the permitted resource collectors in the remote areas of the Sundarbans. Pirates of the Sundarbans sometimes hostages the NWFPs collectors and demand ransom. However, the Forest Department is solely responsible for the management and protection of the Sundarbans. But, other law enforcement agencies such as Police, Coast Guard, Rapid Action Battalion, Border Guard, and Bangladesh Navy) also work with BFD to control the pirates in and around the Sundarbans. In recent time (2010), a paradigm shifts takes place in the context of Sundarbans management. Local forest dependent peoples are now getting involved in the management and protection of the Sundarbans under the collaborative efforts called co-management.

The management of NWFPs (only the *Nypa* leaves) of the Sundarbans was first noticed in the Working Plan for the period from 1931 to 1951 to ensure its' sustainable supply (Curtis 1933). This working plan was modified by Chowdhury for 1937–51 with the provision of the collection of Nypa leaves and fuel-wood (Pandit 2013). With time, others like thatching materials, honey, and beeswax, aquatic resources have come under management for the sustainable production. A set of management rules are employed for each category of NWFPs of the Sundarbans . Boat License Certificate (BLC) along with permits are issued by the Forest Department for the harvesting of the NWFPs from the Sundarbans. Every boat must have BLC before entering into the Sundarbans for the resource collection. BLC is issued for a single year at the beginning of the financial year (1st half of July) from the revenue stations of Sundarbans forest Divisions. The Revenue Officer inspects the boat capacity (in Quintal) and charge revenue for the boat as a prescribed rate of BLC. In addition to BLC, the resource collector also needs to pay revenue for the collected NWFPs on

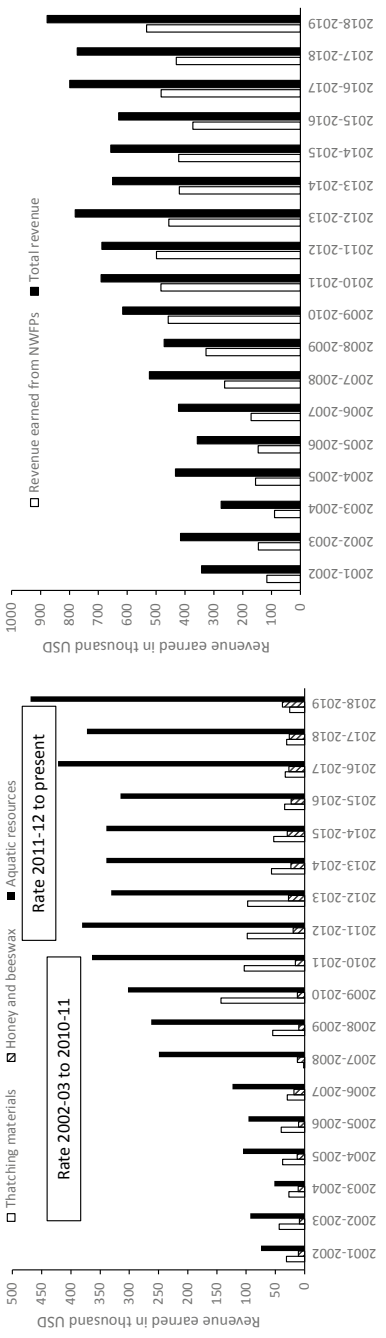


Fig. 5.8 Revenue earned from 2001–02 to 2018–19 **a** NTFPs (hatching material, honey and beeswax and aquatic resources), **b** Comparison of total and earned revenue from the NWFPs

a weight/number basis depending on the product types; and additional revenue has to pay for the overstay than the permitted (GoB 2011).

5.6.1 Management of Thatching Materials

The extraction of *Nypa leaves* is allowed in the non-growing season (November to March) and *I. cylindrical* before the flowering season (November–December). BFD issues permit based on BLC for the extraction of *Nypa* leaves and *I. cylindrical* for the identified annual coupes on first-cum-first serve basis. Harvesting of *Nypa* leaves from the wildlife sanctuaries is strictly prohibited. *Nypa* leaves are harvested on a three-year cycle. The central leaf and one supporting leaf have to remain during the harvesting for the sustainability of the clump. On the other hand, *I. cylindrical* are harvested annually at the ground level which facilitates regeneration. The total stocking and the prescribed Annual Allowable Cut (AAC) for *N. fruticans* in the Sundarbans were 113,887 ton and 64,300 ton respectively (Revilla et al. 1998). BFD monitors the harvesting operation throughout the harvesting season. The collectors need to get a clearance certificate from the BFD before leaving the forest. The Revenue Officer inspects the loaded boats and charges additional revenue for the extra loads and illicit felling of other forest produces (if any).

5.6.2 Management of Honey and Beeswax

Annual harvesting of honey and beeswax starts from 1st April and ends at 15th June (Baksha 2004; BFD 2010). The collectors need to pay advance revenue for one quintal of honey and crude beeswax to get the permit from BFD revenue stations (BFD 2010; GoB 2011). The honey collector needs to follow a set of prescribed rules for honey collection. The honey collectors have to use smoke instead of fire for driven away the bees from the hives, harvest only the portion that containing honey and one-third portion of the hive has to retain for the shelter of bees (Baksha 2004). Proper monitoring during the harvesting operation is not possible for the BFD field staff. But, the Revenue Officer weighs the harvested amount of honey and beeswax; and claim the revenue for the extra harvest before leaving the Sundarbans.

5.6.3 Management of Aquatic Resources

The inshore and offshore fishery are associated with the aquatic resource harvesting from the Sundarbans. The harvested produces from the offshore fishery dedicated only for the production of dry fish during the winter season. The inshore fishing is

permitted all over the Sundarbans except the sanctuary areas and the some designated protected canals as delineated as breeding and shelter ground (BFD 2010). Fishing of certain species is banned during their breeding seasons. Boat License Certificate (BLC) is issued to the fishermen for collecting fish from the Sundarbans. Each boat having BLC will get 8 permits in a year with a maximum of 3 permits in a month. Generally, 5–7 days are allowed for fishing under a permit (GoB 2011). BFD strictly monitors the fishing locations, use of destructive gears, and poison fishing inside the Sundarbans. The harvesters need to collect a clearance certificate from the BFD before leaving the forest at the end of the permitted time. The Revenue Officer inspects the boat, weighted the harvested aquatic resources, and claim revenue according to the prescribed rate for each category of aquatic resources as fixed by BFD (GoB 2011).

5.7 Conservation of NWFPs of the Sundarbans

In most cases, the conservation initiatives of NWFPs are related or linked with the overall biodiversity conservation efforts of the Sundarbans. The Sundarbans was declared as Ramsar site and a World Heritage Site during 1992 and 1997 respectively. Thus Sundarbans received much attention for conservation, which ultimately covers the protection of all the resources of the Sundarbans. At the same time, the Government of Bangladesh has increased the areas coverage of sanctuaries from 15 to 52% during 2017. It is hard to separate the conservation initiatives for the *Nypa fruticans* and harvesting of honey and beeswax from the overall biodiversity conservation of the Sundarbans. But, there are some initiatives and conservation prescriptions for the aquatic resources of the Sundarbans.

The conservation of thatching materials especially the *Nypa* leaves associated with the restricted feeling. Harvesting of *Nypa* leaves is strictly prohibited inside the sanctuary areas and harvesting also restricted during the growing season (April to September). The increase in sanctuary area coverage (52% of the total forest areas) not only restrict the felling of *Nypa* leaves but also restrict the collection of other NWFPs like honey and beeswax, and aquatic resources. The Health and hygiene of *Nypa* clump are important for leaf production for the upcoming years. Therefore, the leaf collectors are given the training to cut the *Nypa* leaf at a height of 22.5 cm from the ground level and to remove the dead or damaged leaf during harvesting (Zohora 2011). On the other hand, the use of smoke instead of fire to drive bees from the hives is recommended and encouraged for the honey collectors. Hand operated honey extractor machine are recommend instead of the traditional squeezing method of honey extraction (Baksha 2004).

Sundarbans is crisscrossed by numerous rivers and canals, which constitutes about one-third of this forest. This waterbody is rich in biodiversity and good habitat for fish and other aquatic animals. It acts as a shelter and nursery ground for numerous marine fauna. The mangrove forest and mudflats provide a crucial breeding ground for wide varieties of finfish, crustaceans, and mollusks (Shah et al. 2010; Mahmood 2015). However, the extracted amount of aquatic resources are

decreasing over time. Considering the decreasing trend, BFD has taken specific conservation initiatives for the fishey resources of the Sundarbans. Among the initiatives, BFD imposed ban on commercial fishing in the identified 18 creeks/canals of the Sundarbans during 1987–1994 to secure undisturbed breeding ground of different species of fish. In addition, a number of fishery resource conservation interventions are practicing in the Sundarbans like fishing ban inside the sanctuary areas, strict control on poison fishing, the seasonal ban on fishing of certain species, ban on specific species, ban on collection of post-larvae of shrimp, seasonal gear ban, prohibited gear, prohibited mesh, the limit of Boat License Certificate (BLC) and fishing permit, the limit of fishing duration under each permit (Shah et al. 2010). Regular patrolling throughout the forest is needed to ensures protection and act as an effective tool of monitoring as well as conservation of resources. In Sundarbans, Spatial Monitoring and Reporting Tool (SMART) has been started since 2011 under a development project "Sundarbans Environmental and Livelihoods Security (SEALS)", which is still continuing from the revenue budget of BFD (BFD 2020b). The suggested conservation initiatives for the aquatic resources of the Sundarbans made by the present Integrated Resource Management Plan for the Sundarbans 2010–2020 have been presented in Box 5 (BFD 2010).

Box 5: Suggested conservation guideline for the aquatic resources of the Sundarbans

- No fishing in the sanctuaries and identified 18 creeks/canals
- No fishing in the 1 km wide zone at the northern periphery of the sanctuary areas.
- Fishing ban in canals less than 8 m wide within 3 km area of BFD field offices throughout the Sundarbans.
- Periodic assessment of the aquatic resources need to conduct.
- Fishing ban in all canals during July–August and in beels (depressed areas inside the forest) during February-May.
- Seasonal ban of *Tenualosa ilisha* and Liza parsia net during September and October.
- Fishing of Pangasius pangasius and Lates calcarifer will be banned on each alternating year.
- Mollusks harvesting will be banned during March to October.
- Harvesting of Crab will be banned in January and February.
- No fishing of *Tenualosa ilisha* and Pangasius pangasius having <23 cm in size.
- Male and female crab having weight of 200 g and 120 g respectively and below are restricted for harvesting.
- Complete ban on set bag net, net jal or current jal and no dewatering for fishing.
- Fishing net with 15 mm mesh is prohibited.

- No use of poison or insecticide for fishing.
- Not more than 12,000Boat License Certificate (BLC) in the Sundarbans that will be equally distributed between the Sundarbans East and West Forest Divisions.
- Maximum 8 permits will be issued to the BLC holder in a year and not more than 3 times for a month.
- The maximum duration under a permit will be 7 days.
- The commercial extraction of mollusk will be allowed only in Sundarbans West Forest Division and ban on collection from March to October.

In addition, different livelihood supports are also provided to the resource collectors to reduce the pressure on NWFPs of the Sundarbans as conservation strategies. The dependent communities/collectors receive training and financial support based on their choice, experience, and willingness. Most of the common trades are crab farming, goat rearing, van, small business tea stall, cloth business, tailoring, etc. which believed to reduce the pressure on a collection of NWFPs of the Sundarbans significantly. These livelihood supports were operated by different projects like Sundarbans Biodiversity Conservation Projects (SBCP) (1999–2005), Integrated Protected Area Co-Management (IPAC) project (2008–2012), Sundarbans Environmental and Livelihoods Security (SEALS) Project (2011–2014), Climate-Resilient Ecosystem Livelihood Project (CREL) (2012–2018), Expanding the Protected Areas System to Incorporate Important Aquatic Ecosystems (2015–2020) (MEFCC 2019).

5.8 Community Dependency on NWFPs of the Sundarbans

About 4–27% of households of the Sundarbans Impact Zone (20 km from the boundary of the Sundarbans) depend on the Sundarbans for their livelihoods. The households' involvement in resource extraction found to vary with distance from the Sundarbans and resource types. Households situated within 0–10 km of the Sundarbans Impact Zone (SIZ) are largely involved in resource extraction, which is almost double compared to the households located within 10–20 km of SIZ (Fig. 5.9) (IUCN 2012).

The Sundarbans provide the livelihood for about 2.5 million people of Southwestern Bangladesh. A considerable population is involved with the resource extraction and others are linked with transportation and trading of the collected resources. Livelihood depending on the Sundarbans can be grouped broadly into thatch collector (Nypa leaf and thatching grass collectors), Mawali (honey and beeswax collectors), Jele (fisher, crab collectors), Chunery (mollusk collectors), Majhi (Boatman) (Sen and Ghorai 2019). Among the resource collectors, the highest about 35% are shrimp fry collectors followed by fisherfolk (33%), and honey collectors (22%). Comparatively less (1%) are involved in the collection of medicinal plants (Fig. 5.10) (IUCN

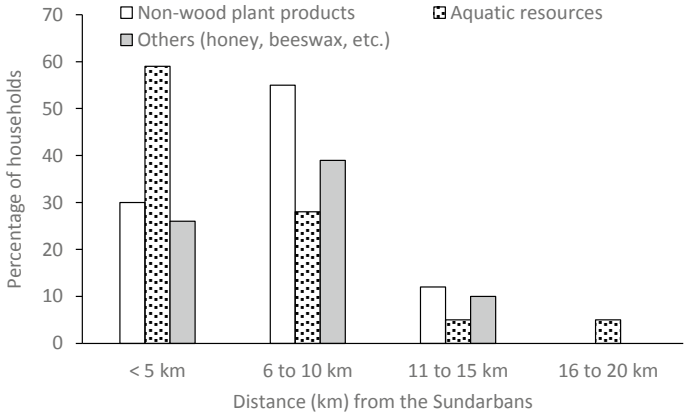


Fig. 5.9 Percentage of households involved in non-wood forest product extraction in relation to distance from the Sundarbans (*Sources* IUCN 2012)

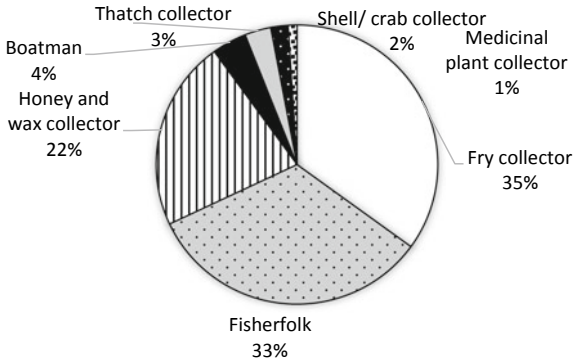


Fig. 5.10 Percentage of livelihood of the resource collectors of the Sundarbans (*Sources* IUCN 2012)

2012). However, these proportions of livelihoods of the dependent people are not constant, it changes with the availability, limit, or ban on extraction of the particular resources. Therefore, resource collectors do not rely on a single type of livelihood; the thatch collectors become honey collector from April to June, and fisher during the monsoon season; the rest of the months (about 6 months) they involved in other livelihoods like agriculture, aquaculture, small trades, day labour, etc. (Shah et al. 2010).

5.9 Issues and Concerns Related to NWFP of the Sundarbans

5.9.1 Over-Exploitation of Resources

The extraction of NWFPs is regulated by issuing boat license certificates (BLC) based on a database indicating the carrying capacity of the boat and the critical harvest limit for each resource. About 30% of unrecorded harvesting was identified by Revilla et al. (1998). Overharvesting of honey and beeswax are also reported. It is recommended to leave one-third of the hive for the bees, but honey collectors frequently collect whole hives and result in dislocation of bees (Baksha 2004). IUCN (2012) estimated about 3.5 times higher extraction of honey and beeswax than the official record. In the case of aquatic resources, monitoring and proper data recording of the harvested amount and scientific database on fish stocks are lacking. The increasing trend of the annual harvest of aquatic resource from the Sundarbans may indicate over-exploitation. Moreover, over-exploitation is thought to be related to the use of destructive fishing gear, fishing and crab collection during the ban season, post-larvae collection, and poison fishing which directly link to the destruction of resources bas (Shah et al. 2010; IUCN 2012).

5.9.2 Habitat Degradation

The Sundarbans is a dynamic mangrove ecosystem that is highly dependent on various environmental factors such as coastal physiography, elevation, climate, current and wave patterns, salinity, dissolved oxygen, soil, and nutrients (Siddiqi 2001; Mahmood et al. 2014). The Sundarbans is rich in both floral and faunal diversity than most other mangrove systems of the World (IUCN 1994; Iftekhar and Islam 2004; Hoque and Datta 2005). However, degraded habitats are also found in the Sundarbans with poor stock on the raised lands, depressions, and vacant canal and riverbanks (Siddiqi 2001; IUCN 2012). The floral and faunal diversity of the Sundarbans believed to relate to the habitat quality, which ultimately influences the production and extraction of NWFPs and other forest products (Siddiqi 2001). However, the habitat quality of the Sundarbans chiefly controls by the soil and water salinity level. The saline intrusion from the seawater and reduced flow of freshwater from the upstream are important factors that are responsible to increase the salinity of soil and water in the Sundarbans (Siddiqi 2001; Islam and Gnauck 2011). It is speculated that higher salinity in the Sundarbans ecosystem may significantly reduce the diversity and abundance of less salt-tolerant species of flora and aquatic resources in the future (Shah et al. 2010; Mahmood et al. 2014).

Pollution from domestic and urban areas, rapid industrialization around the Sundarbans, increased use of agrochemicals in the nearby agricultural fields, large scale aquaculture, mass tourism, increased movement of sea-going vessels, oil spills,

bilge, and ballast water also cause degradation of habitat (Rahman et al. 2009; Begum et al. 2015). Pollution from tourism (e.g. oil and fuel spills from boats and noise) has increased during the last two decades as the Sundarbans has become a more popular destination may cause deterioration of the habitat (Begum et al. 2015). The pollution level has a direct link with the aquatic resources in terms of lower habitat quality which may result in significant loss of aquatic diversity in the Sundarbans.

5.9.3 Influence of Extreme Weather Events on NWFPs

The funnel-shaped Bay of Bengal is the breeding ground for tropical cyclones. Seventy five (75) tropical cyclones and tidal surges have hit the coastal areas of Bangladesh since records began in 1584 and up to the end of 2020. During 2000–2020, five tropical cyclones (Sidr 2007; Rashmi 2008; Aila 2009; Bulbul 2019; Amphan 2020) affected the Sundarbans. The number of Distant Cautionary Signal No. III; (The port is threatened by squally/stormy weather) has increased steadily between 1995 and 2015 (Fig. 5.11). The mangroves are highly resilient against such cyclones, but still suffer consequential effects on vegetation composition, sediment accretion, erosion pattern, and hydrological system. It is estimated that almost 25 years are needed for vegetation structure to recover from each storm (Islam 2008). But, given the frequency of cyclones, the Sundarbans has had little time to recover. This dynamic nature of the mangrove ecosystem, as affected by cyclones and tidal surges, needs to be considered for the future management and conservation of the area. The extreme weather events significantly influence the stocking and extraction of NWFPs from the Sundarbans.

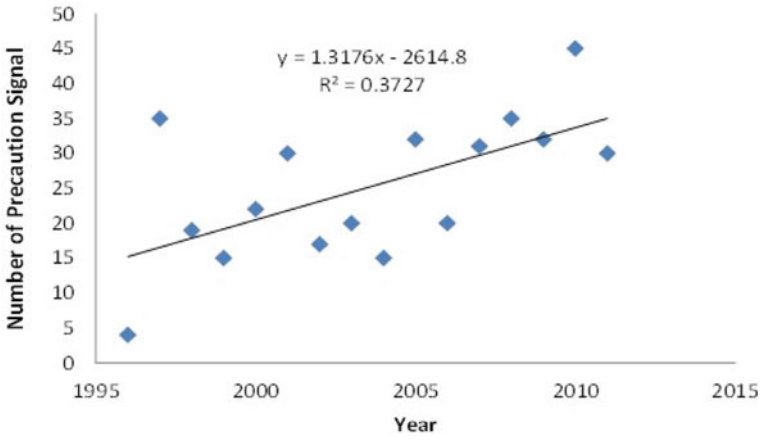


Fig. 5.11 Yearly number of distant cautionary signal No. III (1995–2015) (*Source* Khulna weather office)

5.10 Conclusion and Recommendation

The Sundarbans mangrove forest of Bangladesh provides an array of Non-wood forest products (NWFPs). Mostly the vicinity poor people are engaging in the collection of NWFPs from the Sundarbans for their daily consumption and livelihood for a long time. The extracted amount of some NWFPs found to decrease and the collection of some NWFPs has increased in recent times. Especially the extraction of thatching materials has decreased considerably due to availability, durability, and low price of the corrugated iron sheet (suitable substitute of the thatching materials). Similarly, production of lime from mollusk has decreased due to its' low market demand. In another way, the extractions of honey, beeswax, dry fish, and crabs have increased significantly due to its high market demand. The extracted carbs are mainly exported to foreign countries. In conclusion, the harvested amount of NWFPs depends on the resource base and market demand. The sustainable supply of NWFPs from the Sundarbans is obvious for the livelihood of the local population. Overexploitation of NWFPs eventually reduces the resource base for sustainable supply as well as may influence the loss of biodiversity. Assessing and identifying the resource base and potential threats of respective NWFPs of the Sundarbans; strict monitoring of the harvesting activities at the field level; modernization of record-keeping for the extracted amount of resources; proper implementation of management prescriptions for the NWFPs at the field are prime importance for the sustainable management of the valuable NWFPs of the Sundarbans.

Appendix 1: Medicinal properties of the most common mangrove plant species of the Sundarbans

Species	Medicinal uses
Acanthus ilicifolius	Leaves, fruits and seeds are used to treat cough, asthma, indigestion, rheumatism, neuralgia, internal worms, burns, snakebite (Giesen et al. 2006). Stem and root have anti-cancer properties, and can treat chronic fever (DeFilipps and Krupnick 2018). The whole plant is boiled in water, and the extracted decoction can be consumed to remove kidney stones (Ravindran et al. 2005)
Acrostichum aureum	Rhizome, young and mature fronts have medicinal properties that can cure the fever, constipation, aches, pain, malnutrition, cooling the body and diabetic (Giesen et al. 2006; Mahmood 2015)
Aegiceras corniculatum	Leaf extract/ decoction has an effect on chronic inflammatory diseases due to rheumatism and enhance the cellular immune responses (Roome et al. 2014). Fruit extract can be used to treat diarrhea (Hosen et al. 2021)
Aglaia cucullata	Leaves are used to treat inflammation and *seeds for* rheumatism (DeFilipps and Krupnick 2018)

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Species	Medicinal uses
Avicennia alba	Seed paste used as ointment to treat skin diseases and wounds (Giesen et al. 2006, Mahmood 2015, DeFilipps and Krupnick 2018)
Avicennia marina	Leaves are used to treat burns (Giesen et al. 2006; Mahmood 2015)
Avicennia officinalis	*Roots have* aphrodisiac properties and seeds are used to treat soreness and inflammation (Giesen et al. 2006; Mahmood 2015; DeFilipps and Krupnick 2018)
Brownlowia tersa	Leaf extract has anti-inflammatory properties and roots have antibacterial properties. Traditionally, it is used to treat diarrhea, dysentery, wounds and boils (Mannan et al. 2019)
Bruguiera gymnorrhiza	The bark is used as an abortifacient, and treating for burns, diarrhea, fever and malaria. The fruits have antiviral properties (Allen and Duke 2006)
Bruguiera sexangula	Leaf and roots are used to treat burns. Bark extracts has anti-cancerous properties. Fruits are used to treat *Shingles* (a viral infection that causes a painful rash) (Giesen et al. 2006)
Cerbera manghas	The seed extract is used to treat scabies and itch and ingredient of hair tonic. The bark is used as a laxative, and to treat fever, painful or difficult urination, and ringworm. The flowers are used to treat hemorrhoids (Islam and Ahmed 2017)
Ceriops decandra	The bark has antiseptic properties and used to treat malaria (Mahmood 2015). Leaf decoction is used to stop hemorrhage (Ray 2014)
Clerodendrum inerme	Seeds and roots are used to treat poisoning effect caused by fish and other marine organisms. Leaf extract is used to treat wounds and fruit extract to treat dysentery (MPBD 2012; Giesen et al. 2006)
Crinum viviparum	Leaf extract has antibacterial properties, which is used to treat foot sores. The paste of bulb is applied externally to treat boils and skin allergy (Sharma et al. 2013)
Cynometra ramiflora	The leaves and seeds have anti-herpetic properties. Honeyed lotion can be made from leaves and seed oil. It boiled with milk and applied to treat scabies, leprosy, and other skin lesions (Haryoto et al. 2013)
Dalbergia spinosa	Leaves and stem bark are applied to treat fever and to control internal parasite (Naskar 2004). Root extracts have antimicrobial activity (Senthamarai et al. 2003)
Derris scandens	Dry stem powder and ethanolic extract are used to treat musculoskeletal pain (Puttaraka et al. 2016). Stem extract has also anti-biotic properties (Sittiwet and Puangpronpitag 2009)
Derris trifoliata	Leaf extract has strong antibacterial properties (Suganya and Thangaraj 2014). It is used as a stimulant, antispasmodic and counter-irritant, and against rheumatism, chronic paralysis. Concentrated extract of the roots is used to treat fever and sores (Behera et al. 2006)

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Species	Medicinal uses
Excoecaria agallocha	Plant parts have anti-microbial, anti-cancer and anti-diabetic agent (Kaliamurthi and Selvaraj 2016). Bark is used to treat severe constipation. The root is used as an abortifacient. The root is crushed with ginger and used as an embrocation to reduce swellings. Oil extracted by distillation of the wood or latex is applied to skin diseases (de Padua et al. 1999). The latex is used as a caustic for removing obstinate ulcers. It has vomiting and strongly laxative effect. Small amount of latex are taken orally with coconut juice to treat pneumonia or asthma (de Padua et al. 1999, WHO-Regional Office for the Western Pacific 2009a, b)
Excoecaria indica	Leaf extract has anti-nociceptive properties. Milky juice of leaves is used to treat irritating pain from the fish sting (Ahmed et al. 2007). Leaves are used to cure fever and gonorrhea. Decoction of the root bark is used as purgative and emetic (de Padua et al. 1999)
Flagellaria indica	A decoction of the leaves is drunk to treat asthma, wound, shortness of breath and fevers. The fresh stalk is chopped into small pieces in water and the leached extract is drunk to get relief from stomachaches, dysentery and diarrhea (Kulip 1997, WHO-Regional Office for the Western Pacific 1998, 2009a, b). The root is boiled and the infusion is used as health tonic (de Padua et al. 1999; Kulip et al. 2012). The plant is used as a contraceptive, and the stem is eaten to cause sterility (WHO-Regional Office for the Western Pacific 2009a; b). The whole plant is boiled and the boiled water is used for bathe of the semi-paralytic patent (Kulip 1997)
Heritiera fomes	Different parts of this species have been using as folk medicine to treat diabetes, hepatic disorders, gastrointestinal disorders, goiter, and skin diseases. Leaf decoction is used to stop haemorrhage. A number of investigations indicated that the plant possesses significant antioxidant, antinociceptive, antihyperglycemic, antimicrobial, and anticancer activities (Mahmud et al. 2014; Ray 2014)
Hibiscus tiliaceus	Different parts of this plant are used to treat fever, coughs and dry throat, ear infections, chest congestion, diarrhea, dysentery and typhoid (Giesen et al. 2006, Shaikh et al. 2011). Leaves are wrapped around fractured bones, sprained muscles, skin disease and leaves juice is used to treat gonorrhoea. Bark extract is used to promote menstruation, and to treat skin diseases, eye infections and injuries, and stomachaches. The flowers paste is used to treat sores, cuts, boils and swellings (WHO-Regional Office for the Western Pacific 1998)
Kandelia candel	Bark and leaf is used to treat diabetes (Ray 2014, Sachithanandam et al. 2019)
Lumnitzera racemose	Plant parts are used to treat, herpes, asthma, snakebite and skin disease. They have antifertility, antidiabetic, antibacterial, hepatoprotective and cytotoxic activities (Bandarnayake 1998; D'souza et al. 2010; Ravikumar and Gnanadesigan 2011; Ray 2014; Thao et al. 2014; Jadhav et al. 2019)

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Species	Medicinal uses
Nypa fruticans	Plant parts (young shoots, decayed wood, and the burned roots and leaves) are also used as traditional medicine to treat headaches, toothaches, ulcers, herpes and bites of centipedes (Burkill 1966). Juice from the fruits is used as a digestive agent and to cure stomach infection (Ray 2014)
Pandanus foetidus	Leaves extract is used to treat leprosy, small pox, syphilis, scabies besides heart, brain diseases and diabetes (Yusuf et al. 1994; Joshi 2000). Methanol extract of leaves work on central nervous system (Uddin et al. 2004)
Phoenix paludosa	Plant parts are used to treat fever and anti-inflammation. It has analgesic, antidiarrheal (Saha et al. 2012), and cytotoxic properties (Samarakoon et al. 2016)
Pongamia pinnata	The juice of leaves is used to treat itches, diarrhea, leprosy, herpes and gonorrhea. Leaf decoction used to treat bronchitis, whooping cough. While, young shoots are used to treat muscular and articular rheumatism. Seed oil is used to treat itches and other skin diseases. Flowers are prescribed for diabetes (Giesen et al. 2006; Ghumare et al. 2014)
Rhizophora apiculate	Leaves have inhibitory properties of pathogens and used to treat dysentery and stomach disorder (Onrizal 2010). Root extract is used to treat diarrhea, skin diseases (Pattanaik et al. 2008; Bibi et al. 2019)
Rhizophora mucronata	Plant parts have medicinal properties and used to treat diarrhea, constipation, nausea, elephantiasis angina, haemorrhage, hematuria, and interestingly hematuria, and menstruation disorders (Bibi et al. 2019). Dust of stem bark is used to cure diabetes and to stop haemorrhage (Ray 2014). The mature leaves and roots are used to treat ulcers, diarrhea, fever, burns, and stings of poisonous fish (Ray 2014; Bibi et al. 2019)
Sarcolobus globosus	Traditionally, the plant is used as a relief for rheumatism, dengue and fever (Wangensteen et al. 2005)
Sonneratia apetala	Leaf decoction is used to treat sores, haemorrhage, hepatitis and fruits are used to prevent in diarrhea (Bandaranayake 1998; Ray 2014)
Sonneratia caseolaris	Fruits and leaves are used to treat haemorrhage, piles, sprain poultices (Bandaranayake 1998, 2002). Fruit extract can be used to treat diarrhea (Hosen et al. 2021)
Tamarix indica	Plant parts are used to treat piles, sore throat, ulcers, diarrhea and dysentery. The plant finds its use in infectious diseases, which include skin disease, leukoderma, leucorrhoea and eye disease (Bahramsoltani et al. 2020)
Xylocarpus granatum	Seed oil is used for grooming hair. Plant parts are used to treat cholera, diarrhea, elephantiasis, inflammation, pain, swelling of breasts, fever, malaria, dyslipidemia, hyperglycemia and insect bite (Ravindran et al. 2005; Giesen et al. 2006; Das et al. 2014; Rout and Basak 2014)
Xylocarpus moluccensis	Plant parts are used to treat intestinal problem, aphrodisiac, fever, malaria, (Bandaranayake 1998; Giesen et al. 2006)

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