Mangrove plant utilization by local coastal community in Indonesia

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Abstract. As an archipelagic country amounted to 17,504 islands with about 95,181 km length of coastal line, Indonesia is endowed by about 3.2 million ha of mangrove forests from several meters to several kilometres in width, in which 70% of them have been destroyed. They are inhabited by about 202 species of plants (89 species of trees, 44 species of shrubs, 19 species of lianas, 5 species of palms, 44 species of epiphytes, 1 species of fern). For centuries, the Indonesian people have traditionally utilized mangrove plants to support their daily life. The main genera used are Rhizophora, Bruguiera, Ceriops, Avicennia, Nipa, and Sonneratia. Those various utilizations are as follows: (1) food and beverage (taffy, syrup, salad, “kecap”, “peyek”, chip, cake, tannin for cloth painting, sugar, jelly, “getuk”, starch/powder); (2) wood-based products (charcoal, housing material, firewood); (3) fodder (leaf of Sonneratia spp., Avicennia spp., Rhizophora spp.); (4) medicine (Acanthus tea, tonic of Rhizophora young root decoction, poison from Excoecaria agallocha saps, resin of Avicennia spp. for anti-fertility). Meanwhile, almost all of them use mangrove land for fishpond (tambak) with various models (silvofishery, open fishpond, agrosilvofishery, agrosilvofisherypastoral). Through the model of agrosilvofisherypastoral system they get agricultural crops, fish, firewood, meat, all at once. However, almost all of products are used subsistently, except for firewood or charcoal. Those products are still not well marketed because several reasons, such as less promotion, has not yet been clinically-tested for human health, less government attention, unstable raw material supply, etc. Recently, many groups of local coastal communities manage mangrove forest for ecotourism. In the near future, mangrove plants can enrich food diversity to strengthen food security in Indonesia.

1. Introduction
Mangrove is a renewable resources that provide various types of product derived from various flora and fauna as well as environmental services, such as protection against abrasion, sea water intrusion control, reducing the height and speed of the sea wave, water pollutants cleaners, and others that are critical to supporting human life. Therefore, the mangrove plays an important role as bio capital for development, especially for improving the well-being of coastal communities.

Mangrove forests are currently grown in 124 tropical and subtropical countries with an area of approximately 15.2 million ha, of which about 36% (5.4 million ha) grown in Southeast Asian countries. Most of the mangrove forests in the Southeast Asia region is growing in Indonesia, the current extent area is about 3.2 million ha (59% of the Southeast Asia mangrove forests area, or 21% of the mangrove forest in the world). The region of Southeast Asia, especially Indonesia, not only has an extensive mangrove forest, but also has a lot of mangrove species.
Nowadays, in Indonesia mangrove grow in the coastal areas on about 257 districts/cities with an area about 3.24 million ha. The mangrove area covered by approximately 202 mangrove species consisting of 89 tree species, 5 palm species, 19 liana species, 44 shrub species, 44 epiphyte species, and 1 fern species. There are 43 species of true mangrove from total 202 species and the rest are mangrove association species.

Mangrove plant as one of the mangrove forest ecosystem components are renewable resources that potentially can be processed to produce various types of food products. Based on historical records, local communities in the Southeast Asia coastal area has been long traditionally utilize various types of mangrove plants for daily foodstuffs and beverages. However, the number of mangrove plant species, the way of processing, and the type of food/drink product that is produced are still limited in accordance with the limitations of their knowledge. Although mangrove plants can be processed to make various types of foodstuffs and drinks, but locals communities have not yet used the materials as a source of mangrove plant staple foods to support his daily life. For example, local communities will be consuming food/drink from mangrove plants at the famine time. On the other hand, security-related scientific empirical evidence of consuming food ingredients from mangrove plants until now is still very limited.

A few centuries ago coastal communities in Indonesia have traditionally been utilizing mangrove plants for food, clothing, house, and traditional medicines. In connection with that, this study aimed to identify a variety of mangrove plant utilization by local communities in Indonesia coastal areas. The study was expected to be beneficial for consideration in formulating the sustainable mangrove ecosystem management.

2. Methods

The study was carried out using historical documents reviewed related to information about the utilization of mangrove plants by coastal communities in Indonesia. Some information regarding to the uses of Rhizophoraceae, Avicenniaceae, Sonneratiaceae, and Nipa fruticans noticed on those documents were validated by researcher personal direct observation to the local community lived in the coastal northern part of Java.

Direct observations were done to coastal communities of Tangerang, Kapuk Muara, Bekasi, Indramayu, and Subang, West Java Province. Selected one experienced Forest Farmer Group of each observed place was interviewed regarding to the uses of various species of those families as well as that of N. fruticans.

The obtained information was analysed using qualitative descriptive analysis. Those information was showed on a table contained information of species and their uses by local coastal communities.

3. Results and discussions

Utilization of mangrove plants by coastal communities in Indonesia can be classified into products in the form of timber and non-timber forest products (NTFP). Wood products include firewood, charcoal, construction wood, wood homewares, and fishing tools, while the NTFP form products include tannin for colouring fishing nets and cloth, medicines, fodder, fertilizers, food, roof, honey, and drinks. Utilized mangrove species were quite diverse, covering the major mangrove, minor mangrove, and associate mangrove species.

The most significant value of mangrove utilization is the gathering of forest products, classified into timber and non-timber products. The timber refers to poles and firewood, charcoal, and construction materials (e.g. housing material and fishing gears); the latter include tannin, medicines, dye, nipa thatch and shingles, nipa sap for vinegar and wine-making, and food drinks. Traditional uses of mangrove forest products are mainly the direct utilization of the products, usually in small scale. Some uses of mangrove plants by coastal communities in Indonesia is shown on table 1, by mainly local community in eastern Indonesia on table 2, and by mainly local community in Java, Sumatra, Kalimantan, and Sulawesi on table 3.
| Species | Uses |
|---------|------|
| *Acanthus ebracteatus* Vabl. | Leaf juice applied to the scalp to preserve the hair |
| *Acanthus ilicifolius* L. | Crushed fruit is said to make a good blood purifier and dressing for boils and snake bite |
| *Acrostichum aureum* L. | Succulent fiddleheads are edible raw or cooked |
| *Acrostichum corniculatum* Blanco | Bark and seed contains a fish poison. |
| *Avicennia alba* Bl. | Bark and seed contains a fish poison. |
| *Avicennia marina* (Forsk,) Vierh. | Source of pollen and strong flavoured honey for supporting bee colonies |
| *Avicennia officinalis* L. | Seeds eaten after leaching and cooking. |
| *Bruguierra gymnorrhiza* (L.) Lamk | Bark used as seasoning for raw fish |
| *Bruguierra parviflora* (Roxb.) W.A. ex Griff | Bark used as seasoning for raw fish |
| *Bruguierra sexangula* (Lour.) Poit | Young leaves, fruit embryos, centre of radicals are cooked and eaten as vegetable |
| *Ceriops tagal* (Perr.) C.B. Rob | Dye from the bark is used for colouring and preserving fishing nets and is important in batik and mat-making in Java. |
| *Excoecaria agallocha* L. | Copious milky sap is exceedingly irritant and toxic; used as fish and arrow head poison |
| *Lumnitzera littorea* (Jack) Voigt | Fleshy fruits preserved |
Table 1. Medicinal and other uses of some mangrove plants by coastal communities in Indonesia.

| Species                               | Uses                                                                 |
|---------------------------------------|----------------------------------------------------------------------|
| *Oncosperma filamentosa* Blume        | - Terminal buds for vegetable;                                       |
|                                       | - Flowers added to rice as seasoning                                 |
|                                       | - Leaves are boiled, dried, powdered and mixed with water for stomach upset |
| *Pluchea indica* L.                   | - Young leaves are edible                                            |
|                                       | - Fruits scraped and eaten                                           |
| *Rhizophora muncronata* Lamk          | - Honey produced from the nectar                                     |
|                                       | - Fruit is eaten                                                     |
| *Sonneratila caseolaris* (L.) Eng     | - Roots used as natural carvings for decorative purposes.            |
| *Xylocarpus moluccensis* (Lamk) Roem  | - Bark astringent and used as cure for diarrhoea                    |
|                                       | - Oil from seed is applied to hair and serves as illuminant         |

Table 2. Traditional uses of mangrove plants by local communities in eastern part of Indonesia (Maluku, Papua) [1].

| Species                               | Uses                                                                 |
|---------------------------------------|----------------------------------------------------------------------|
| *Rhizophora stylosa*                 | Firewood for cooking food, smoking fish, charcoal; tannins for fishing net and line preservation; woody middle layer (between the bark and the pith) of prop and aerial roots for stringing fish to facilitate their transport; prop and aerial roots for making *Thalassina anomala* traps; bark to enclose *Scylla serrata* bait (made up of crushed *Sesarma* mixed with mangrove mud); stakes for husking coconut; aerial roots for making plaited fish traps, and bows; timber for building, scaffolds, tool handles, poles for fish traps, boats, fence posts; charcoal. |
| *Bruguiera gymnorrhiza*              | Firewood for cooking, smoking fish, cremation, charcoal; timber for scaffolds, boat-building, beams, rafters, purlins, furniture, tool handles, poles for fence posts, fish traps, boats, tanning for fishing net and line preservation; stakes for husking coconuts; dye saplings for making *T. anomala* traps. |
| *Xylocarpus granatum*                | Firewood, timber, fence posts, beams and used medicinally            |
| *Xylocarpus moluccensis*             | Firewood, timber, fence posts, beams, pole                          |
| *Lumnitzera littorea*                | Firewood, timber, fence posts, beams, poles for fish traps, tool handles, canoe making, and medicine |
| *Terminalia catappa*                 | Trunk used to make ‘lali’ (canoe-shaped drum, truncated at both ends for transmitting messages); seed as food; poles for building; canoe making; used medicinally |
| *Calophyllum inophyllum*             | Timber, boat-building (ribs); infusion of leaves as eyewash; oil from fruits as liniment, hair-dressing oil; for making ‘lali’; used medicinally |
| *Excoecaria agallocha*               | Medicine for curing leprosy. Malays used to place people suffering from the diseases in an empty house and light a small fire on which they would place wood of *E. agallocha*. The ensuing smoked is believed to have cured the patients, besides causing them intense pain); the sap is an irritant and is believed to cause blindness; used as medicine [2] |
Table 2. Traditional uses of mangrove plants by local communities in eastern part of Indonesia (Maluku, Papua) [1].

| Species                        | Uses                                                                 |
|--------------------------------|----------------------------------------------------------------------|
| *Heritiera littoralis*         | Firewood, timber, fence, spots, used as medicine                     |
| *Barringtonia asiatica*        | Dry fruits are used as floats for fishing lines; as fish poison; used as medicine |
| *Barringtonia racemosa*        | Fruits are used as fish poison                                       |
| *Inocarpus fagiferus*          | Fruits as food; young leaves as vegetables; buttress roots for making knife handles |
| *Intsia bijuga*                | Exceptionally dense, hard timber; considered sacred by Papuans; used for beams; posts, canoes, yaqona (an infusion of pounded stem and/or root of *Piper methysticum*) bowls, clubs, head rest; used for medicine |
| *Entada phaseoloids*           | Young stems are used as ropes; seeds as necklace; thicker stems may be used as a source of water -30-40 cm sections of the cut stem (5-7 cm across) can provide a good drink of water |
| *Abras precatorius*            | Seeds are used for making necklaces for tourist (as the seeds are extremely poisonous, they are boiled beforehand to dissipate the poison and also to prevent them from shrinking) |
| *Derris trifoliata*            | Fish poison, stem for stringing fish, immobilizing crabs, trying up firewood; used as medicine |
| *Pongamia pinnata*             | Poles for construction, used as medicine                             |
| *Clerodendrum inerme*          | Sap of leaves is used for washing dishes; used as fish poison; used as medicine |
| *Vitex trifolia*               | Used as medicine                                                     |
| *Cerbera manghas*              | Used as medicine [3]; the leaves, after reducing to pulp by chewing, were employed for stuffing hollow teeth |
| *Thespesia populnea*           | Used for boat building (ribs), fruit is used as toy, also as medicine |
| *Derris spp.*                  | Used as medicine                                                     |
| *Pyrrrosia adnascens*          | Used as medicine                                                     |
| *Hibiscus tiliaceus*           | Dry stem is used as floats for gill nets; fibrous bark for making ropes, grass skirts, straining yaqona (an infusion of pounded stem and/or root of *Piper methysticum*), making noose of *T. anomala* traps, seed as medicine |
| *Stenochlaena palustris*       | Leaves are used as food, used medicinally                            |
| *Asplenium sp.*                | Used as medicine                                                     |
Table 3. Current traditional and potential uses of some mangrove species by local community in Java, Sumatra, Kalimantan and Sulawesi [1].

| Products   | Species                          | Uses                                                                 |
|------------|----------------------------------|----------------------------------------------------------------------|
| Tannin     | Most Mangrove spp. but Ceriops spp. give the best quality | Leather manufacture, inks, plastics, boiler water, oil-well drilling, formaldehyde glues, rust preventives, insecticides, medicine. |
| Dyes       | Xylocarpus spp.                  | Dyeing fishnets, ropes, sails, textiles.                             |
| Colouring  | Ceriops spp.                     | Colouring rice and tuba (local wine).                               |
| Oil        | Xylocarpus seeds                 | Burning and hairdressing                                             |
| Food       | Bruguiera spp.                   | Source of honey, bees wax, tea substitutes; leaves eaten as vegetable (raw or boiled), seasoning for raw fish |
| Foliage    | Avicennia spp.                   | Fodder for goat, cattle, livestock supplement                       |
| Extractives| Cerbera spp. and other mangrove species | Premature falling of hair, good dressing for boil and snake bites, relieve small pox ulcerations and sore eyes, inhibit tumours, effective contraceptives, medication for toothache, purgative, mosquito repellent |

3.1. Timber and wood products
Mangrove forests are exploited due to their valuable trees that can be used for various purposes. Timber is the most important product from the Indonesian mangrove forests e.g. Bengkalis [4]. Some of the important timber-producing mangrove species are Rhizophora spp., Bruguiera spp., Ceriops spp., Xylocarpus spp., Sonneratia spp., Avicennia spp., Lumnitzera spp. and Heritiera littoralis, due to their durability (hard) and heavy wood structure. All the species provide marketable prices at the local, national and international levels. Timbers from these species are used for poles, piles, ship building, crafts, tool handles, railroad ties, furniture, and for other construction materials.

3.2. Firewoods
Mangrove woods are still widely used as energy source by rural coastal communities in many islands of Indonesia. The role of mangroves as potential sustainable source of fuelwood is important to meet the increasing needs for wood energy. However, large scale commercial exploitation of mangroves for fuelwoods seems to be rare.

Firewood is one of the earliest known uses and at one time, it was the most important direct product of mangroves [5]. Firewood production is mostly small scale, done by villagers, very often without any legal documents to back them up e.g. Muna Island. It is used for cooking daily family meals, but also for energizing home industries like brown-sugar and lime production in Java, Batu Ampar-West Kalimantan, Sulawesi, and salt production in Java and Bali.

3.3. Charcoals
Woods from mangrove forests are mainly harvested for charcoal production (90%), such as in Sumatra [6]. Among the mangroves, Rhizophora spp is preferred due to its high heating value. Basically, charcoal is firewood that appears under a slightly different form. However, charcoal offers some other uses which are lacking in uncarbonized firewood, for example as an ingredient in the dry cell industry and metallurgical works.

3.4. Housing material and fishing gear
To the rural coastal villagers in many islands of Indonesia, mangroves are among the most beneficial plants on earth. They occur abundantly near the villages and are very handy to be harvested to meet the needs for housing materials, household articles, as well as fishing gears.
Mangrove woods are widely used for housing construction by people who live in or close to the mangrove forests. Woods of various mangrove species can be used for different parts of the house. The quality of mangrove woods that are used for house construction by the mangrove dwellers, varied according to size and shape of the house. Ceriops species are the most durable of all mangroves, Rhizophora and Bruguiera are not as durable, but all three have been used for house construction, paving blocks and tool handles.

Various types of fishing gear are used by mangrove dwellers but only some that are constructed from mangrove woods. Most mangrove poles made from Rhizophora spp. and Bruguiera spp. are used to trap crabs. Drift gill-nets and winged set-bag are fish traps made from Rh. apiculata and Bruguiera spp.

3.5. Non-timber forest products
Among the non-timber products derived from the mangrove forests are tannin, dye, medicine, nipa thatch and single, nipa sap for vinegar, wine making and food, and honey.

3.5.1. Tannin and dye. Among the non-timber products derived from the mangrove forests, tannin is very popular. The extraction of tannin from mangrove barks has been recorded in early 1900’s, but never developed into industry. Most mangrove trees are rich in tannin, so they can tolerate sea water logging.

Among the species identified to contain high qualities of tannin are Rhizophora apiculata, Rh. mucronata, Bruguiera parviflora and Xylocarpus granatum [7], [8]. Rhizophora spp. are the best producers of tannins followed by Ceriops spp., but species of Bruguiera are only mediocre. Tannin has a variety of uses such as in the manufacture of ink, plastics, glue, etc. Yet, the extraction of this substance from mangrove barks seems to be negligible at present. However, the traditional use of mangrove bark for tannin is still practiced in Indonesia.

Another use of mangrove bark is in the manufacture of dyes. Dyes extracted from the bark of X. granatum are used in dying fish nets, ropes and textile (batik), while extract from Ceriops tagal is commonly used in colouring rice and local wine tuba, such as in North Sumatra. In recent years, with the development of substitute chemicals, the dependence on mangrove tannin has greatly declined. However, local people still like to use mangroves as a source of tannin to dye fishing nets, clothes and other fishing materials due to their easy extraction.

3.5.2. Food and drink. Although of minor importance, some food products may be tapped, directly or indirectly, from mangrove forests in Indonesia. Some mangrove plants are edible. Direct food products includes among others, the young seeds and the sap of the flowers stalk of Nypa fruticans, the young leaves, shoots and propagules of Avicennia marina, the fruits of Sonneratia alba and the propagules of Bruguiera gymnorrhiza. The fruits of species Avicennia, Bruguiera, and Sonneratia are edible, and seeds of Heritiera littoralis are eaten with fish. Nypa palm is probably the most important food producer from the mangrove forests.

3.5.3. Medicinal elements. Some mangrove species have been used and reported to have medicinal purposes for traditional people [2], [3], [9]. For example, the bark of Xylocarpus spp. is said to be valuable for curing diarrhoea and as astringent; the leaves of Excoecaria agallocha for curing epilepsy; the leaf juice of Acanthus spp. could relieve rheumatism, etc. Local fishermen in mangrove sites in Indonesia still boil mangrove leaves using water as cure for skin diseases.

3.5.4. Fodder and green manure. In Indonesia, mangrove forests often serve as partial range-lands. Cattle, goats, sheeps and buffaloes are the domestic animals commonly known to feed on mangrove foliage. Avicennia marina leaves, for example, are important as a source for fodder. Mangrove leaves are excellent fodder for many domestic animals, e.g. sheeps, goats, buffalos, and cattle, such as those
found in Cimanuk delta complex, northern coast of West Java. Stall feeding using mangrove leaves is practiced in Java [10].

In term of nutritive value, mangrove leaves, rank among the best [11]. It should be pointed out that the fresh leaf may contain more nutrient elements than the litters. Mangrove leaves are used as green manure for the fish-ponds maintenance and ecological productivity of their substrates, e.g. in northern coast of West Java. Green manures from mangrove species of Avicennia spp. and Rhizophora spp. are very popular nutrient inputs to stabilize the productivity of waterlogged soils in many coastal areas in Indonesia.

3.5.5. Thatch. Thatch production from the fronds of Nypa fruticans remains an important traditional industry in Indonesian mangroves [2], [3]. Due to the somewhat dwindling supplies of fronds from the wild, villagers sometimes supplement the resource by planting these palms in their compounds, e.g. Banyuasin, South Sumatra. During fronds harvesting, villagers usually leave behind at least 2 leaves per tree to avoid defoliation. Fronds collected are dried, folded over a wooded rod or bamboo and stitched in place. These shingles are used as walling or roof materials throughout the fishing villages. The durability of these shingles ranges from 2 to 3 years.

3.5.6. Honey. Some species of mangroves are nectariferous plants. When flowering, the forests of Aegiceras corniculatum and Kandelia candel appear a vast scene of whiteness, which lures swarms of bees to gather nectars. Apiculture in mangrove forests has not been developed in Indonesia, though there was some folk work in this field in some areas in Indonesia, e.g. Segara Anakan, Cilacap.

Coastal communities in Java utilize more diverse mangrove plants for the purpose of his life than coastal communities outside Java. This is presumably because Java Island is inhabited by a higher number of population who generally live in coastal areas where mangroves grow. Beside, in the past decade the population of outside Java ignore mangroves, because there are various luxurious forest formation having higher biodiversity than mangroves.

4. Conclusion
For a long time, traditional coastal communities in Indonesia have been utilizing mangrove plants for fulfilling their daily life, either for food or medicine. Utilized-mangrove species (tree, shrub, herb, fern, and grass) are varying, covering major mangrove, minor mangrove, and associate mangrove.

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