AN OVERVIEW OF MANGROVE FOREST BIOMASS IN THE TROPICS

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'Mangroves' are the intertidal plants dominating by trees and shrubs, distributed in river deltas and coastal estuarine complexes. Mangroves also occur on colonized shorelines and islands in sheltered coastal areas with locally variable topography and hydrology (Lugo and Snedaker, 1974). They may be termed 'mangals', 'mangrove forest' or 'tidal forest'.

Mangrove species consist of different kinds of plants from various genera and families, many of which are not related closely to one another phylogenetically. However, it is difficult to delineate precisely what constitutes the mangrove species. The difficulty comes from the unrestriction of its transition to terrestrial and other seashore communities, since mangroves are an ecological assemblage, and many of the processes of the land-sea interface regulating them have their origin elsewhere. Therefore, various definitions have been given. Based on their fidelity to the mangrove environment, structural and physiological specialization and the ability to form an obvious element, Tomlinson (1986) arbitrarily set limits among three groups: major elements of mangal (or known as 'strict mangrove' or 'true mangroves') with 9 genera and 34 species of 5 families, minor elements of mangal with 11 genera and 20 species of 11 families and mangal associates with 46 genera and 60 species of 27 families. Field (1995) made a consensual list based on IUCN (International Union for Conservation of Nature and Natural Resources) (1983). In his list, 25 genera and 66 species out of 19 families were included as the members of mangroves. More recently, Saenger (2002) provided an updated list of mangroves of the world, consisting of 84 species of plants belonging to 39 genera in 26 families.

It is interesting that mangroves occupy two separate hemispheric regions of tropics, and are more abundant in the Old World than in the New World (Tomlinson, 1986). Most of the mangroves are distributed within the areas between East Africa, India, Southeast Asia, Australia and the Western Pacific, namely the Eastern Hemisphere. These members of mangroves are known as eastern mangroves, with about 68 species. However, in the Western Hemisphere, including West Africa, Atlantic South America, the Caribbean, Florida, Central America, and Pacific North and South America, only 19 of the true mangroves are found (Saenger, 2002). The largest extent of mangrove areas is found in Asia at about 42%. This extent followed by Africa (20%), North and Central America (15%), Oceania (12%) and South America (11%). At about 75% of mangroves are concentrated in just 15 countries (Table 1).

Table 1: The 15 most mangrove-rich countries and their cumulative percentages

Country	Area (ha)	% of global total	Cumulative (%)	Region
Indonesia	3,112,989	22.6	22.6	Asia
Australia	977,975	7.1	29.7	Oceania
Brazil	962,683	7.0	36.7	South America
Mexico	741,917	5.4	42.1	North & Central America
Nigeria	653,669	4.7	46.8	Africa
Malaysia	505,386	3.7	50.5	Asia
Myanmar (Burma)	494,584	3.6	54.1	Asia
Papua Guinea	480,121	3.5	57.6	Oceania
Bangladesh	436,570	3.2	60.8	Asia
Cuba	421,538	3.1	63.9	North & Central America
India	368,276	2.7	66.6	Asia
Guinea Bissau	338,652	2.5	69.1	Africa
Mozambique	318,851	2.3	71.4	Africa
Madagascar	278,078	2.0	73.4	Africa
Philippines	263,137	1.9	75.3	Asia

Source: Giri et al. (2011)

Mangrove forests are known to provide a harsh environment but extremely a productive ecosystem in cycling carbon. Mangrove forest accounts for about 2.4% of tropical forest which essential to include this forest for global carbon sink quantification (Chmura et al., 2003). Donato et al. (2011) stated that coastal mangrove forests store more carbon than almost any other forest on Earth. The carbon density of 25 mangrove areas per hectare across the Indo-Pacific region was found to store up to four times more carbon than most other tropical forests around the world. The ability to accurately and precisely measure the carbon stored and sequestered in forests is increasingly gaining global attention in recognition of the role forests have in the global carbon cycle, particularly with respect to mitigating carbon dioxide emissions (Kauppi and Sedjo, 2001). This accuracy depends on how accurate is the estimation of biomass production.

Since 1980's the trend of biomass studies in mangrove forest are increasing due to deforestation issue and the importance in mitigating tsunami and climate change. The summation of the studies that has been carried out is listed in Table 2 as reported by Komiyama et al. (2008) and other researchers. The highest aboveground biomass at 460 t ha-1 was found in a forest dominated by R. apiculata in Malaysia (Putz and Chan, 1986). Aboveground biomass of more than 300 t ha-1 was also reported in mangrove forests in Indonesia (Komiyama et al., 1988). The aboveground biomass was less than 100 t ha-1 in most secondary forests or concession areas. The lowest aboveground biomass reported was 40.7 t ha-1 for a Rhizophora apiculata forest in Indonesia (East Sumatera). Recent study conducted by Hazandy et al. (2014) found that aboveground biomass values of two locations aged 30 year-old in Matang forest were found different using site-specific equations (Table 2).

Table2: List of mangrove above ground (ABG) and below ground (BGB) biomass in South-East Asia

Region/area	Forest status/ age	Species	ABG (t/ha)	BGB (t/ha)	Reference
Malaysia (Kuala Sepetang, Matang)	30-year-old	R. apiculata dominated forest	285.54	-	Hazandy et. al. (2014)
Malaysia (Kuala Trong, Matang)	30-year-old	R. apiculata dominated forest	336.24	-	Hazandy et. al. (2014)
Malaysia (Matang)	28-year-old	R. apiculata stand	211.8	–	Ong et al. (1982)
Malaysia (Matang)	VJR	R. mucronata stand	146.61	65.93	Juliana and Nizam (2004)
Thailand (Phuket Southern)	15-year-old	R. apiculata forest	159.0	–	Christensen (1978)
Malaysia (Matang)	>80	R. apiculata dominated forest	460.0	270.0	Putz and Chan (1986)
Thailand (Ranong Southern)	Primary forest	Rhizophora spp. forest	281.2	11.76	Tamai et al. (1986)
Thailand (Ranong Southern)	Primary forest	B. gymnorrhiza forest	281.2	106.3	Komiyama et al. (1987)
Thailand (Ranong Southern)	Primary forest	Rhizophora spp. forest	298.5	272.9	Komiyama et al. (1987)
Thailand (Ranong Southern)	Primary forest	Sonneratia forest	281.2	68.1	Komiyama et al. (1987))
Indonesia (Halmahera)	Primary forest	B. gymnorrhiza forest	436.4	180.7	Komiyama et al. (1988)
Indonesia (Halmahera)	Primary forest	B. gymnorrhiza forest	406.6	110.8	Komiyama et al. (1988)
Indonesia (Halmahera)	Primary forest	R. apiculata forest	356.8	196.1	Komiyama et al. (1988)
Indonesia (Halmahera)	Primary forest	R. apiculata forest	299.1	177.2	Komiyama et al. (1988)
Indonesia (Halmahera)	Primary forest	R. apiculata forest	216.8	98.8	Komiyama et al. (1988)
Indonesia (Halmahera)	Primary forest	Sonneratia forest	169.1	38.5	Komiyama et al. (1988)
Indonesia (Halmahera)	Primary forest	R. stylosa forest	178.2	94.0	Komiyama et al. (1988)
Indonesia (East Sumatra)	Concession area	B. sexangula stand	279.0	–	Kusmana et al. (1992)
Indonesia (East Sumatra)	Concession area	B. parviflora stand	89.7	–	Kusmana et al. (1992)
Indonesia (East Sumatra)	Concession area	B. sexangula stand	178.8	–	Kusmana et al. (1992)
Indonesia (East Sumatra)	Concession area	B. sexangula stand	76.0	–	Kusmana et al. (1992)
Indonesia (East Sumatra)	Concession area	B. parviflora stand	42.9	–	Kusmana et al. (1992)
Indonesia (East Sumatra)	Concession area	R. apiculata stand	40.7	–	Kusmana et al. (1992)
Thailand (Satun Southern)	Secondary forest	C. tagal forest	92.2	87.5	Komiyama et al. (2000)
Thailand (Trat Eastern)	Secondary forest	Mixed forest	142.2	50.3	Poungparn (2003)
Thailand (Southern Pang-nga)	Secondary forest	Mixed forest	62.2	28.0	Poungparn (2003)

Note: Most of the data were retrieved from Komiyama et al. (2008)

Despite accounting for just 0.7% of the world's tropical forest cover (Giri et al., 2011), mangroves play a disproportionately important role in the global carbon (C) cycle. The loss of mangrove cover not only represents a loss of future C sequestration potential but also could result in significant release of C into the atmosphere (Pendleton et al., 2012). Valiela et al. (2001) stated that mangroves are considered to be one of the most threatened ecosystems on the planet with an estimated decline in global cover of about 35% during the period 1980 - 2000. This decline is mainly due to over-exploitation of wood products for charcoals and poles, conversion to aquaculture, coastal development and human settlement. Hence, the best management regimes need to be formulated by the forest managers in order to avoid further destruction to the mangrove forests while maintaining benefits for socio-economic development for the surrounding communities and nation.

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