INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 16, No. 4, p. 173-183, 2020
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Status of commercial and non-commercial tree species in Sitapahar Reserve Forest of Bangladesh

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Article published on April 30, 2020

Key words: Widely used species, Traditional uses, Lesser used species, Conservation status, Bangladesh

Abstract

Sustainable wood supply can only be assured by the rational utilization of all available wood resources of the forest areas of a country. But the bulk of tropical wood species, also termed as noncommercial species, remains unutilized or underutilized due to insufficient information. This study aimed at finding out the status of commercial and non-commercial tree species of the Sitapahar Reserve Forest, Bangladesh, and also comparing the findings with eleven forest areas of this country. By applying the 'systematic sampling' method, 50 quadrats (20×20m) were placed on the study site. All recorded tree species were broadly categorized as commercial species or Widely Used Species (WUS) and non-commercial species or Lesser Used Species (LUS). The LUS are further divided into Well-known Lesser Used Species (WK-LUS) and Least-known Lesser Used Species (LK-LUS) according to the availability of information regarding their wood properties and potential end-uses. In total 86 tree species were recorded in the study site. The maximum number of WUS and LK-LUS were found under family Meliaceae and Euphorbiaceae respectively. The study revealed that the LK-LUS category was found possessing the highest number of species (about 55%) and also the highest tree density (about 54%) in the study area. Moreover, LK-LUS possessed about 46% of the total basal area. This is the most common scenario found while comparing the findings with other forest areas of Bangladesh. So, this study recommends further research to find out the wood properties and potential end-uses of LK-LUS as well as to introduce both LK-LUS and WK-LUS in the timber market for ensuring sustainable wood supply.

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Introduction

According to Bangladesh Forest Department (BFD), the total forest area of the country is 2.6 million hectares (17.4% of total landmass), whereas Global Forest Resource Assessment (GFRA) estimates that of 1.429 million hectares (11% of total landmass) as GFRA doesn't include the village forest (BFD, 2016; FAO, 2015). About 84% and 16% of the total forest area of the country belong to natural and plantation forests respectively. The Hill and Mangrove forests altogether possess 68% of the total forest area of the country (Altrell *et al*., 2007). About 4% of the forested area has declined over the last two decades with an annual deforestation rate of about 0.2%. Overexploitation or unscrupulous felling of commercial species and fuelwood collection are two major causes of deforestation of the country along with other causes (FAO, 2015; Ahmed, 2008).

Although per capita wood consumption of Bangladesh is lower than that of neighboring developing countries, the population growth leads to a continuous increment in wood demand. The projected demand and supply of wood are 28.89 million m^3 and 14.45 million m^3 respectively in 2020 creating an enormous gap of 14.44 million m^3 (Rahman, 2011). Although scattered village forests throughout the country collectively cover a small area of 0.27 million hectares, these are the major suppliers of wood resources (Douglas, 1982; Hammermaster, 1981). About 55% of the national wood requirement is met from the village forest as less productive state forest has only 61% tree cover (Iftekhar, 2006; Millat-e-Mustafa, 2002). Besides, social forestry plantation in the country has supplied 42.6 million m^3 of sawn timber from the fiscal years 1999-2000 through 2011-2012. The supply of timber from internal sources isn't sufficient enough to run with the increasing timber demand, which intensifies the timber import from neighboring countries (BFD, 2012; FAO, 2000).

The unique geophysical location and favorable climatic conditions of Bangladesh support a large variety of biological diversity due to its vicinity of the Indo-Burma biodiversity hotspot (Barua *et al*., 2001; Chowdhury, 2001; Hossain, 2001; Mittermeier *et al*., 1998; Nishat *et al*., 2002). The country has more than 3600 angiosperms, of which 500 are hardwood species. Only 40-50 species out of 500 hardwood species are commercially exploited and widely used which results in the rapid disappearance of these widely-used species from the forest areas as well as underutilization or misutilization of remaining lesser-used species (Ahmed, 2008; Das and Mohiuddin, 1999; Sattar, 1997). Thus about 50% of the total growing stock is being burnt as fuelwood or remains unused regardless of their potentiality (Chowdhury *et al*., 2017; Das and Mohiuddin, 1999). This scenario leads to the shortage of wood supply in the national timber markets of the country during the last few decades (FAO, 2009).

Though the existent commercial demand of lesser-used species (LUS) or lesser-known species (LKS) is lower than their actual production potentials, this type of species is considered as a vital element of reducing pressure on the commercial or widely used species (WUS) as well as of sustainable forest management (Ali *et al*., 2008; Barany *et al*., 2003; Coleman, 1998; Hansom, 1983; ITTO, 2007). Appropriate replacement of WUS requires the induction and promotion of LUS in both the national and international timber markets. So adequate information regarding wood properties, potential uses, availability, and abundance in forest areas is needed for efficient utilization of LUS (Aiyeloja *et al*., 2011; Eastin *et al*., 2003; Eddowes, 1980). This information regarding native LUS will help planter to prioritize native LUS over fast-growing exotic tree species for plantations and homestead forests of the country to secure sustainable wood supply with conserving native gene pools (Chowdhury *et al*., 2017; Dutta *et al*., 2015).

The hill forests possess rich biodiversity which altogether constitutes about 45% of the total forested land of Bangladesh (FAO, 2000). The study site is the Sitapahar Reserve Forest of Kaptai National Park under Chittagong Hill Tracts South Forest Division, Bangladesh.

As the forest harbors native flora and is a perfect representative of southeastern hill forests of the country, the study was conducted at the site to find out the natural status of commercial (WUS) and non-commercial (LUS) tree species. None of the previous studies on the floristic composition of different forest areas of the country attempted to incorporate such type of categorization of tree species. So, the study was a pioneer in the categorization of tree resources of the forest from an economic or utilization viewpoint. The study also attempted to create a baseline for future research on the composition of commercial and non-commercial tree species in the different forest areas of the country.

Materials and methods

Site description

The study site is 'Sitapahar Reserve Forest' of sub-district Kaptai under Rangamati district, the largest hill district of Bangladesh (Fig. 1). The forest area lies between 22°26'N to 22°38'N latitude and 92°08'E to 92°17'E longitude occupying approximately 373.12 ha (IRG, 2012; Uddin *et al.*, 1998). This tropical rain forest declared as a reserve forest in 1875, is managed under Rampahar Forest Beat of Kapatai Forest Range. It is part of Kaptai National Park under the jurisdiction of Chittagong Hill Tracts South Forest Division.

The hill is very irregularly rugged consisting of a series of ridges and valleys. The maximum elevation of the hill is about 460 m and the level of valley bottom ranges from 30 to 90m above the mean sea level (Nath *et al.*, 2000; Uddin and Hassan, 2012).

The climate of the study site is tropical warm-humid with an average temperature of 19.9°C to 28.3°C and the average annual rainfall of about 2,900mm (Uddin *et al.*, 1998). About 90% of the total rainfall occurs during the period between June to September, whereas, the period between December to March remains dry. The mean relative humidity generally varies from 66 to 85% throughout the year (Uddin and Hassan, 2012).

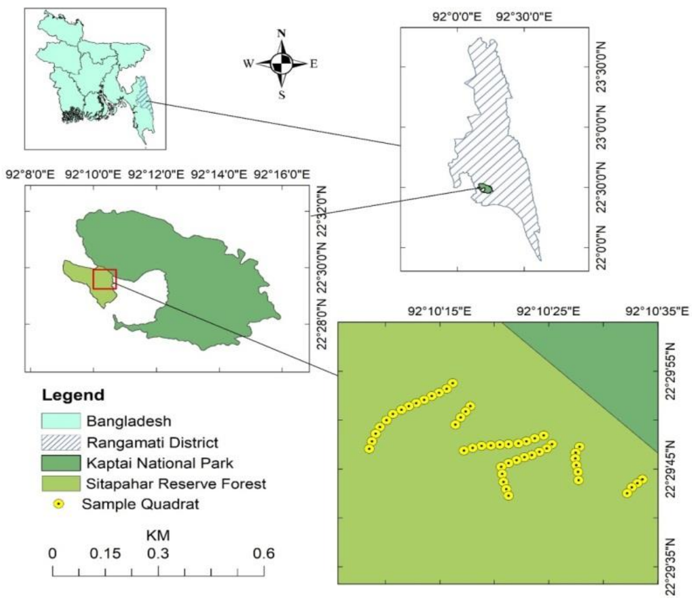

Fig. 1. Location map of the study site and position of sample quadrats in the study site

Vegetation sampling

Information about topography, vegetation, and accessibility of the forest area was gathered by conducting a reconnaissance survey. The 'systematic sampling' technique was adopted to enumerate the tree species, where the first quadrat was selected randomly and posterior quadrats were placed at 15 m interval along each of six trails of the study site. The quadrat size (20m × 20m) was determined by applying the species-area curve following Williams (1991). A total of 50 sample quadrats were established in the study site (Fig. 1).

From each quadrat, the name and number of tree species having a diameter at breast height (DBH) of ≥ 4cm (over bark), were recorded and counted along with measuring DBH of each individual by diameter tape. 'Garmin Oregon 550T' was used to find out the coordinates of each quadrat. Collected tree specimens were identified and verified in the Forest Botany Division, Bangladesh Forest Research Institute (BFRI).

Data analysis

Recorded tree species were categorized into two broad categories, viz. commercial species or Widely Used Species (WUS) and non-commercial species or Lesser Used Species (LUS) according to Chowdhury *et al.* (2013), Das and Mohiuddin (1999), MoEF (2010), and Sattar *et al.* (1997). Two new terms viz. 'Well-known LUS (WK-LUS)' and 'Least-known LUS (LK-LUS)' were coined to subcategorize LUS according to the availability of information regarding wood properties and potential end-uses. LUS found in Chowdhury *et al.* (2013), Das and Mohiuddin (1999), and Sattar *et al.* (1997) were renamed as 'WK-LUS' as their wood properties and potential end-uses were already revealed. Remaining LUS were grouped as 'LK-LUS' due to insufficient information. Tree density (stem ha^{-1}) and basal area per hectare (BA ha^{-1}) of both WUS and LK-LUS were determined by analyzing primary data from quadrats following Chaturvedi and Khanna (1982), and Shukla and Chandel (2000). As the present study was the continuation and extension of a study on 32 WK-LUS (previously termed as LUS) of the study site which was conducted by Chowdhury *et al.* (2017), so the total stem ha^{-1} and BA ha^{-1} of 32 WK-LUS were used as the secondary data source to complete the enumeration. The conservation status of both WUS and LK-LUS was determined according to Ahmed *et al.* (2008). Besides, traditional uses of WUS and LK-LUS were categorized into six categories, viz. F (Fuelwood), Fd (Food and Fodder), M (Medicinal), Nk (Not known), Nt (Miscellaneous non-timber uses except fuel, food, fodder, and medicinal) and T (Timber) following Ahmed *et al.* (2008). To demonstrate comparative status with the present study, the species composition data of eleven forest areas of the country viz. Bamu Reserved Forest (BRF) (Hossain *et al.,* 1997), Chunati Wildlife Sanctuary (CWS) (Hossain and Hossain, 2014), Dhudhpukuria-Dhopachori Wildlife Sanctuary (DDWS) (Hossain *et al.,* 2013), Durgapur Hill Forest (DHF) (Rahman *et al.,* 2019b), Fasiakhali Wildlife Sanctuary (FWS) (Das *et al.,* 2018), Kamalachari Natural Forest (KNF) (Hossain *et al.*, 2015), Lawachara National Park (LNP) (Uddin and Hassan, 2010), Madhupur National Park (MNP) (Rahman *et al.,* 2019a), Rampahar Reserve Forest (RRF) (Chowdhury *et al.*, 2018), Sitakunda Botanical Garden and Ecopark (SBE) (Dutta *et al.,* 2015), and Satchari National Park (SNP) (Hossain *et al.*, 2018) were categorized and analyzed following Chowdhury *et al.* (2013), Das and Mohiuddin (1999), MoEF (2010), and Sattar *et al.* (1997).

Results and discussion

Tree composition

Among the recorded 86 tree species, the study divulged 7 commercial species (WUS) and 79 non-commercial species (LUS). Among LUS, 32 and 47 species were subcategorized as WK-LUS and LK-LUS respectively. Recorded 7 WUS belonged to 6 genera and 5 families. Family Meliaceae (2 species under 2 genera) and Lythraceae (2 species under 1 genus) showed the maximum number of WUS whereas remaining each of 3 families was represented by only one species. Contrariwise, 47 LK-LUS belonged to 37 genera and 24 families. Among 24 families, Euphorbiaceae was represented by the maximum number of LK-LUS (15 species under 10 genera) followed by Lauraceae (3 species under 3 genera), Meliaceae (3 species under 2 genera), Ebenaceae (3 species under 1 genus), Fagaceae (2 species under 2 genus), Elaeocarpaceae (2 species under 1 genus), Fabaceae (2 species under 1 genus) and Tiliaceae (2 species under 1 genus). Each of the remaining 16 families was represented by one species (Table 1).

Tree density (Stem ha^{-1})

Within a total tree density of 86 species (1,732 stem ha^{-1}); WUS, WK-LUS, and LK-LUS showed 261 stem ha^{-1}, 528 stem ha^{-1}, and 943 stem ha^{-1} respectively.

Among WUS, *Dipterocarpus turbinatus* exhibited maximum tree density (175 stem ha^{-1}) followed by *Artocarpus chama* (27 stem ha^{-1}), *Chukrasia tabularis* (20 stem ha^{-1}), *Lagerstroemia parviflora* (11 stem ha^{-1}), *Toona ciliata* (11 stem ha^{-1}), *Lagerstroemia speciosa* (10 stem ha^{-1}) and *Syzygium firmum* (7 stem ha^{-1}). Contrariwise, *Sapium baccatum* showed maximum tree density (145 stem ha^{-1}) among LK-LUS followed by *Macaranga denticulata* (106 stem ha^{-1}), *Knema clarkeana* (96 stem ha^{-1}), *Hydnocarpus kurzii* (59 stem ha^{-1}), *Mallotus tetracoccus* (54 stem ha^{-1}), *Baccaurea ramiflora* (45 stem ha^{-1}) and *Carallia brachiata* (39 stem ha^{-1}). Minimum tree density (1 stem ha^{-1}) was represented by each of the six LK-LUS (Table 1).

Basal area per hectare (m^2 ha^{-1})

Within a total basal area of 86 species (27.443 m^2 ha^{-1}); WUS, WK-LUS, and LK-LUS possessed 4.285 m^2 ha^{-1}, 10.47 m^2 ha^{-1}, and 12.688 m^2 ha^{-1} respectively. Among WUS, maximum basal area (1.822 m^2 ha^{-1}) was recorded for *Dipterocarpus turbinatus* followed by *Syzygium firmum* (0.782 m^2 ha^{-1}), *Lagerstroemia parviflora* (0.566m^2 ha^{-1}), *Artocarpus chama* (0.456 m^2 ha^{-1}), *Chukrasia tabularis* (0.352 m^2 ha^{-1}), *Toona ciliata* (0.204 m^2 ha^{-1}) and *Lagerstroemia speciosa* (0.103 m^2 ha^{-1}). Among LK-LUS, maximum basal area (3.559 m^2 ha^{-1}) was possessed by *Sapium baccutum* followed by *Macaranga denticulata* (1.216m^2 ha^{-1}), *Knema clarkeana* (0.794 m^2 ha^{-1}), *Mallotus tetracoccus* (0.731 m^2 ha^{-1}), *Walsura robusta* (0.618 m^2 ha^{-1}), *Cinnamomum iners* (0.535 m^2 ha^{-1}) and *Carallia brachiata* (0.533 m^2 ha^{-1}). The minimum basal area (0.002 m^2 ha^{-1}) was possessed by *Bridelia retusa* (Table 1).

Conservation status

Recorded species were found to be represented by four conservation categories, viz. Conservation Dependent (CD), Least Concern (LC), Not Evaluated (NE), and Vulnerable (VU). Among WUS, the LC and NE categories were represented by 6 and 1 species respectively, although these species are more or less subjected to illicit felling throughout the hill forests (Table 1). In the case of LK-LUS, about 64% (30 species), 21% (10 species), 13% (6 species), and 2% (1 species) of recorded LK-LUS were found under LC, NE, CD, and VU categories respectively (Fig. 2).

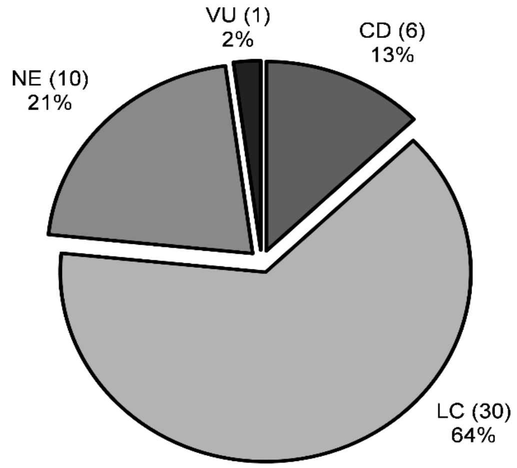

Fig. 2. Percentage distribution of LK-LUS in different conservation categories [Here, CD= Conservation Dependent, LC= Least Concern, NE= Not Evaluated, VU= Vulnerable].

Traditional uses of WUS and LK-LUS

All recorded WUS was found as timber-yielding species (T). Among WUS, 4 and 2 species were also found to be used as medicine (M), and food & fodder (Fd) respectively. Besides, the 'miscellaneous non-timber use (Nt)' category was represented by 4 WUS. Twenty-five LK-LUS were found as timber-yielding species (T). Moreover; 24, 17, and 7 LK-LUS were found to yield medicine (M), food & fodder (Fd), and fuelwood (F) respectively. The 'miscellaneous non-timber use (Nt)' category was represented by 16 LK-LUS. There was no information about the specific uses of 5 LK-LUS recorded from the study site (Table 1).

Comparative status of WUS and LUS in different forest areas

The present study revealed about 8% (7 species), 37% (32 species), and 55% (47 species) of recorded tree species were WUS, WK-LUS, and LK-LUS respectively in the Sitapahar Reserve Forest (SRF) (Fig. 3A). Besides, Fig. 3A also showed the percentage distribution of tree species under three categories (WUS, WK-LUS, and LK-LUS) in different forest areas of the country. WUS possessed the highest (44.4%) and lowest (4.5%) percentages of recorded species in the SNP and LNP respectively. In the case of WK-LUS, the highest (48%) and lowest (9.6%) percentages of recorded species were found in the RRF and LNP respectively.

Besides, LK-LUS possessed the highest (85.8%) and lowest (25%) percentages of recorded species in the LNP and FWS respectively (Fig. 3A). From Fig. 3A it was also found that non-commercial species (LUS) occupied a larger percentage of tree species than commercial species (WUS) in all forest areas. Moreover, LK-LUS occupied a greater percentage of tree species than WK-LUS in most of the cases. It denotes that a large portion of tree resources is either unused or underused regardless of their potentiality due to insufficient information.

Table 1. Scientific name, local name, family, stem ha^{-1}, BA ha^{-1}, conservation status and traditional uses of recorded commercial (WUS) and non-commercial (LUS) tree species of the Sitapahar Reserve Forest.

Scientific name	Local Name	Family	Stem ha^{-1}	BA ha^{-1} (m^{2}ha^{-1})	CS	TU
Commercial species/WUS						
Artocarpus chama Buch. Ham. *ex* Wall.	Chapalish	Moraceae	27	0.456	NE	Fd, T
Chukrasia tabularis A. Juss.	Chikrassi	Meliaceae	20	0.352	LC	M, Nt, T
Dipterocarpus turbinatus Gaertn.	Teli garjan	Dipterocarpaceae	175	1.822	LC	M, Nt, T
Lagerstroemia parviflora Roxb. var. benghalensis C. B. Clarke	Sidha jarul	Lythraceae	11	0.566	LC	T
Lagerstroemia speciosa (L.) Pers.	Jarul	Lythraceae	10	0.103	LC	M, T
Syzygium firmum Thw.	Dhaki jam	Myrtaceae	7	0.782	LC	Fd, Nt, T
Toona ciliata M. Roem.	Toon	Meliaceae	11	0.204	LC	M, Nt, T
Subtotal of WUS			261	4.285		
Non-commercial species/LK-LUS						
Actinodaphne angustifolia Nees	Modanmosta	Lauraceae	31	0.240	NE	Nk
Aglaia chittagonga Miq.	Thitpasing	Meliaceae	34	0.216	CD	T
Aglaia spectabilis (Miq.) Jain & Bennet	Lali	Meliaceae	3	0.011	CD	T
Alstonia scholaris (L.) R. Br.	Chatim	Apocynaceae	1	0.011	LC	M, Nt, T
Antidesma acidum Retz.	Amrul	Euphorbiaceae	6	0.018	LC	Fd, M
Antidesma bunius (L.) Spreng.	Banshialbuka	Euphorbiaceae	10	0.476	LC	Fd, M
Antidesma velutinum Tulasne	Elena	Euphorbiaceae	9	0.061	CD	F
Aporosa aurea Hook. f.	Kechuan	Euphorbiaceae	13	0.097	NE	Fd, T
Aporosa diocia (Roxb.) Muell. -Arg.	Pat kharolla	Euphorbiaceae	2	0.014	NE	Fd, Nt
Aporosa wallichii Hook. f.	Kokra	Euphorbiaceae	1	0.025	NE	Nk
Aquilaria agallocha Roxb.	Agar	Thymeliaceae	1	0.025	LC	Nt
Baccaurea ramiflora Lour.	Lotkan	Euphorbiaceae	45	0.343	LC	Fd, M, Nt
Bischofia javanica Blume	Kanjal bhadi	Euphorbiaceae	6	0.326	LC	M, Nt, T
Bridelia retusa (L.) A. Juss.	Kantokushi	Euphorbiaceae	1	0.002	LC	Fd, M, Nt
Callicarpa arborea Roxb.	Bormala	Verbenaceae	12	0.151	LC	F, Fd, M
Carallia brachiata (Lour.) Merr.	Roskao	Rhizophoraceae	39	0.533	LC	M, Nt, T
Caryota urens L.	Fish-tail palm	Arecaceae	1	0.011	LC	Fd, M, Nt
Castanopsis tribuloides (Sm.) A. DC.	Batna	Fagaceae	14	0.092	NE	T
Cinnamomum iners Reinw. ex Blume	Tez-bohu	Lauraceae	21	0.535	CD	M, T
Crypteronia paniculata Blume	Nishamba	Crypteroniaceae	5	0.148	NE	M, T
Derris robusta (Roxb. *ex* DC.) Benth.	Jumurja	Fabaceae	4	0.017	LC	F, T
Diospyros montana Roxb.	Ban gab	Ebenaceae	8	0.071	LC	Nt, T
Diospyros pilosula (A. DC.) Hiern	Khalta	Ebenaceae	7	0.119	LC	T
Diospyros toposia Buch. -Ham.	Katgula	Ebenaceae	6	0.043	LC	M, T
Elaeocarpus floribundus Blume	Jalpai	Elaeocarpaceae	2	0.117	LC	Fd, Nt, T
Elaeocarpus tectorius (Lour.) Poir.	Tekopai	Elaeocarpaceae	2	0.004	LC	Fd, T
Garcinia xanthochymus Hook. f. *ex* T. Anders.	Dephal	Clusiaceae	11	0.057	LC	Fd, M, Nt, T
Garuga pinnata Roxb.	Shil bhadi	Burseraceae	24	0.364	LC	Fd, M, T
Grewia nervosa (Lour.) Panigr.	Asar	Tiliaceae	17	0.239	LC	F, M
Grewia tiliifolia Vahl.	Dhamin asar	Tiliaceae	6	0.161	LC	Nt, T
Hydnocarpus kurzii (King) Warb.	Chaulmugra	Flacourtiaceae	59	0.291	CD	M
Knema clarkeana Warburg	Kina barala	Myristicaceae	96	0.794	NE	Nk
Leea aequata L.	Kakjonghla	Leeaceae	25	0.089	LC	Nk
Lithocarpus acuminatus (Roxb.) Rehder	Kali batna	Fagaceae	15	0.222	NE	T
Litsea monopetala (Roxb.) Pers.	Menda	Lauraceae	5	0.036	VU	M
Macaranga denticulata (Blume) Muell. -Arg.	Bura	Euphorbiaceae	106	1.216	LC	M
Mallotus roxburghianus Muell. -Arg.	Noon kocho	Euphorbiaceae	24	0.126	NE	M, T
Mallotus tetracoccus (Roxb.) Kurz	Kumari bura	Euphorbiaceae	54	0.731	LC	F
Neonauclea sessilifolia (Roxb.) Merr.	Kom	Rubiaceae	5	0.160	CD	F, M, T
Phyllanthus emblica L.	Amloki	Euphorbiaceae	2	0.007	LC	Fd, M, Nt
Sapium baccatum Roxb.	Chamfata	Euphorbiaceae	145	3.559	LC	F, Fd, T
Saraca asoca (Roxb.) de Willd.	Ashok	Caesalpiniaceae	30	0.177	LC	M, Nt
Spondias pinnata (L. f.) Kurz	Amra	Anacardiaceae	4	0.059	LC	Fd, T

Scientific name	Local Name	Family	Stem ha^{-1}	BA ha^{-1} (m^2ha^{-1})	CS	TU
Sterblus asper Lour.	Sheora	Moraceae	5	0.063	LC	Fd, M, Nt
Suregada multiflora (A. Juss.) Baill.	Maricha	Euphorbiaceae	2	0.006	NE	Fd, M, T
Trevesia palmata (Roxb. *ex* Lindl.) Vis.	Vombal	Araliaceae	1	0.007	LC	Nk
Walsura robusta Roxb.	Bon lichu	Meliaceae	23	0.618	LC	Nt, T
Subtotal of LK-LUS			943	12.688		
Subtotal of WK-LUS [Chowdhury *et al.* (2017)]			528	10.470		
Grand total of all species			1732	27.443		

Note: BA ha^{-1}= Basal area ha^{-1}; CS= Conservation status; WUS= Widely Used Species; WK-LUS= Well-known Lesser Used Species; LK-LUS= Least-known Lesser Used Species; CD= Conservation Dependent; LC= Least Concern; NE= Not Evaluated; VU= Vulnerable; TU= Traditional uses; F= Fuelwood; Fd= Food and Fodder; M= Medicinal; Nk= Not known; Nt= Miscellaneous non-timber uses except fuel, food, fodder and medicinal; T= Timber.

Fig. 3B showed WUS, WK-LUS, and LK-LUS contributed about 15%, 31%, and 54% of the total tree density respectively in the study site (SRF). Fig. 3B also illustrated the percentage distribution of tree density under three categories (WUS, WK-LUS, and LK-LUS) in different forest areas of the country. In the case of WUS, the highest (86.3%) and lowest (15.1%) percentages of the total tree density were found in the FWS and SRF respectively. For WK-LUS, the highest (36%) and lowest (7%) percentages of the total tree density were found in the KNF and MNP respectively. Besides, LK-LUS possessed the highest (54.4%) and lowest (6.4%) percentages of the total tree density in the SRF and FWS respectively (Fig. 3B). Fig. 3B also revealed that WK-LUS and LK-LUS altogether contributed a considerable percentage of tree density in the SRF, DDWS, and KNF which exceeded that of WUS. Contrarily, tree density of WUS exceeded that of LUS in the remaining forest areas due to the natural dominancy and plantation of WUS in these areas. The study showed about 16%, 38%, and 46% of the total basal area was possessed by WUS, WK-LUS, and LK-LUS respectively (Fig. 3C). The percentage distribution of the basal area under three categories (WUS, WK-LUS, and LK-LUS) in different forest areas of the country was also portrayed in Fig. 3C. WUS possessed the highest (89%) and lowest (9%) percentages of the total basal area in the FWS and RRF respectively. In the case of WK-LUS, the highest (60%) and lowest (6%) percentages of the total basal area were found in the RRF and FWS respectively. For LK-LUS, the highest (46%) and lowest (5%) percentages of the total basal area were recorded in the SRF and FWS respectively (Fig. 3C).

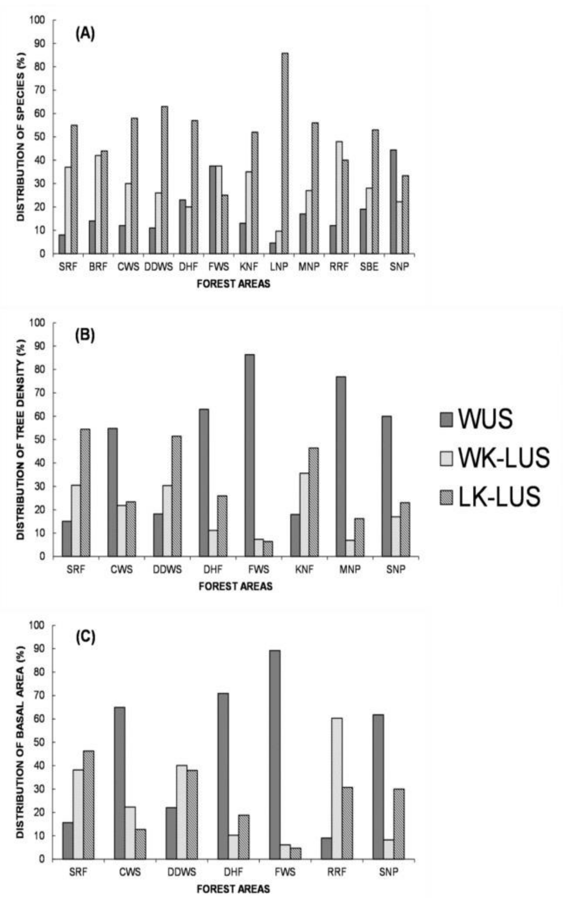

Fig. 3. Percentage distribution of A) tree species, B) tree density, C) basal area in different forest areas [Here, SRF= Sitapahar Reserve Forest, BRF= Bamu Reserved Forest, CWS= Chunati Wildlife Sanctuary, DDWS= Dhudhpukuria-Dhopachori Wildlife Sanctuary, DHF= Durgapur Hill Forest, FWS= Fasiakhali Wildlife Sanctuary, KNF= Kamalachari Natural Forest, LNP= Lawachara National Park, MNP= Madhupur National Park, RRF= Rampahar Reserve Forest, SBE= Sitakunda Botanical Garden and Ecopark, SNP= Satchari National Park, WUS= Widely Used Species, WK-LUS= Well-known Lesser Used Species, LK-LUS= Least-known Lesser Used Species].

Though the total basal area of WUS exceeded that of LUS due to the plantation and over-maturation of WUS in some natural forests, possession of the higher basal area by LUS than WUS was also a common scenario. Thus, a large percentage of basal area, occupied by LUS, remains unutilized or underutilized in forest areas. But the sustainable supply of wood resources can only be assured by rational and worthy utilization of the LUS.

Conclusion

The study incorporated a unique categorization by categorizing tree resources into two broad categories viz. commercial or Widely Used Species (WUS) and non-commercial or Lesser Used Species (LUS) along with introducing two new subcategories under LUS viz. Well-known Lesser Used Species (WK-LUS) and Least-known Lesser Used Species (LK-LUS) based on the availability of information regarding wood properties and potential end-uses of LUS. This categorization aimed at showing the comparative status of tree resources of the study site and other forest areas under these categories (WUS, WK-LUS, and LK-LUS). According to the study, LUS altogether possessed higher species number, tree density, and basal area than WUS in the study site as well as in several forest areas except for some exceptions. Moreover, LK-LUS showed higher species number, tree density, and basal area than WK-LUS in most of the cases. Tree species, categorized as LUS, have the potential to be alternative sources of several wood-based industries by substituting conventional WUS. So, the information regarding natural status, wood properties, and potential end-uses of LUS is needed to introduce and popularize these species in the timber market for ensuring sustainable wood supply. As the wood properties and potential end-uses of WK-LUS were already revealed in several studies, market researches need to be conducted for the immediate induction of these species in the timber market. Besides, future studies are suggested to find out the natural status of WK-LUS and LK-LUS in the remaining forest areas of the country by adopting the categorization as well as to measure the wood properties of LK-LUS to ensure proper utilization, popularization, and marketization of these species.

Acknowledgement

The authors are highly grateful to the personnel of the respective Forest Department for their tremendous support during the field works. The authors also acknowledge the contribution of the taxonomists of the Bangladesh Forest Research Institute (BFRI) to identify collected plant samples from the study site.

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