Section 5:

Criteria 3 - Growing stock, biomass and carbon

Photo: Swamp forest, Ratargul, *@Iqbal Z.*

Criteria 3

Growing stock, biomass and carbon

Section Highlights

- The most common native species by volume are *Mangifera indica* (Aam), *Heritiera fomes* (Sundri), *Sonneratia apetala* (Keora). The most common introduced species by volume are *Swietenia mahagoni* (Mahogany), *Areca catechu* (Supari), and *Cocos nucifera* (Narikel).
- TOF account for 66% of the country's total volume and 66% of the total biomass.
- Bamboos account for nearly 17% of the nation's total tree volume.
- There are 10,326 tons of dead wood considered usable as fuelwood (CWD, FWD, litter) and most of this stock is supplied by the Hill Forest (33%) and Rural Settlement (25%) land cover classes.
- The Sundarban zone contains extremely high densities of aboveground and belowground biomass carbon stocks, having 3.4 times and 9.6 times higher densities, respectively, than the national average. The total carbon density of all five carbon pools in the Sundarban is 345 t/ha (soil to 1m depth).

Introduction

This criterion describes the status, productive capacity, and spatial distribution of the country's trees and forests. It answers questions such as – in what species and in what areas are carbon stocks the highest? Growing stock is mostly used to indicate the availability of resources for commercial extraction. Biomass is the estimate of productive capacity of ecosystems and is useful for mapping. Carbon stocks indicate the contribution of the country's trees and forest to the global terrestrial carbon cycle. Changes in forest areas and land management impacts the rate of capture or release of carbon between terrestrial ecosystems and the atmosphere (e.g. Houghton 2005). Future inventory cycles will monitor the trends of these indicators over time. This section also contains estimates of TOF following the FAO definition, which is simply all trees that occur in the Other Land category in FAO's Global Forest Resource Assessment (Schnell et al. 2015; FAO, 2018). See Appendix 5 tables for details about which classes were aggregated to Forest and Other Land

(i.e. TOF). Besides trees, estimates of dead wood biomass, soil carbon and other soil properties are presented.

Methods

Tree and saplings were surveyed in small, medium and large nested subplots (Section 2.3.3). Growing stock is volume over bark of all living trees with a minimum diameter of 10 cm at breast height (FAO 2018b). There were 28 species specific and one general volume equations used to estimate tree volume (see Appendix 2.3) (Hossain, Anik et al. 2019). Growing stock was estimated using total tree height (commercial volume was not estimated). Bamboos were recorded and measured in the medium (8 m radius subplot) plot. Bamboos were measured by average height, average DBH and number by clump. Bamboo culm volume was calculated directly using a general equation following Altrell (2007). All equations used are found in the Appendix 2.3 to 2.6 and Hossain, Anik et al. (2019).

There were seven species specific and four zone specific allometric equations used to estimate aboveground biomass. A decision tree was followed for appropriate selection of allometric equations (Hossain, Anik et al. 2019). Aboveground biomass includes biomass from live tree (DBH ≥ 10cm), saplings (DBH ≥ 2cm), bamboo and live stumps. The wood density at species level was collected from local sources found in Bangladesh's online wood density database (BFD 2016a) and other global sources. Genera or family level wood density was also used in cases when species level wood density was not available. Biomass from palms, such as *Areca catechu*, *Borassus flabellifer*, and *Phoenix sylvestris* which were recorded as trees during the biophysical survey were also included. Aboveground biomass was also estimated at the Forest Division level and is included in the Appendix 5.2.4.

Each of the five main carbon pools were estimated - above ground biomass, below ground biomass, down woody debris, litter and soil organic matter. Carbon in aboveground biomass was estimated with five species specific allometric equations and three zone-specific equations (Hill, Sal and Sundarban) and assumed 50% carbon content in wood, except for bamboo species which was assumed to be 54% (Allen 1986). Similar to volume and biomass, a decision tree was followed for proper selection of allometric models (BFD 2016a).

Carbon in belowground biomass (CBGB) includes all live plant parts including roots of trees, saplings, bamboos and live stumps. CBGB is estimated as 50% of BGB of trees, saplings, live stumps and bamboo. Below Ground Biomass (BGB) estimation procedure varied with the trees and saplings, stumps, bamboo and zones. In case of Sundarban tree and sapling DBH and species-specific wood density was used to calculate the BGB following Komiyama, Ong et al. (2008). For trees and saplings of other four zones the BGB was calculated from AGB following Pearson, Brown et al. (2007). A diameter based equation following Hjelm (2015) was used to calculate the BGB of live stumps, where the top diameter was used. Bamboo BGB is comparatively less and estimated following Lobovikov, Ball et al. (2007) for *B. vulgaris* and Bijaya and Bhandari (2008) for other bamboo species.

Dead wood biomass and carbon is composed of standing dead tree, dead stumps (and their belowground portion), coarse woody debris and fine woody debris, and carbon in biomass, litter, and soils. Dead stumps were calculated using a cylindrical volume equation (Jenkins, Chojnacky et al. 2003) and then volume was multiplied with species-specific or general wood densities to calculate biomass. Carbon in dead wood biomass assumed a carbon content of 50% of the dead wood biomass. The diameters of coarse woody debris (CWD) were measured along a transect to estimate CWD volume following Marshall, Davis et al. (2000). For fine woody debris (FWD) an average diameter was assumed for small, medium and large FWD and then the volume was estimated following Marshall et al. (2000) and summed up for getting total FWD volume by subplot. CWD and FWD wood density reductions were used to calculate their biomass (Jenkins, Chojnacky et al. 2003, Harmon, Woodall et al. 2011). Standing dead tree biomass was estimated using the height, DBH, decay status and reduced wood density and biomass models. The wood density reduction factor was calculated considering the wood decay classes prescribed in BFI manual and the raw data collected for allometric equation development (BFD 2016a, BFD 2016c). For litter, a sample collected from the field was processed in the laboratory and litter carbon was assessed multiplying the oven dry litter mass by its organic carbon percentage (BFD 2016d).

Soil samples were collected and analyzed for bulk density and soil organic carbon (SOC) density. Samples were collected from 0-15 cm and 15-30 cm depths from all zones whereas an additional sample from 30-100 cm depth was collected in Coastal and Sundarban zones. Soil organic carbon was estimated by plot and land feature using the bulk density and SOC percentage data (Donato, Kauffman et al. 2009, BFD 2016d). Soil organic carbon percentage was determined by loss on ignition (LOI) method without removing carbonates,

Estimates are presented by species, zone, land cover class, Forest Divisions, height class and DBH classes (Hossain, Anik et al. 2019). The Bangladesh National Herbarium Tree Species Database was used for tree species identification. When summary statistics are by species, only the ten most dominant species are shown whereas the complete list can be found in the Appendix 5.1 tables. Zone level estimations of volume, biomass, and carbon followed estimators prescribed for stratified random sampling (Hossain, Anik et al. 2019). For estimates by land cover class, the classes were assigned to the land feature of the biophysical inventory plot *post hoc* by overlaying the 2015 Land Cover Map onto the subplot perimeters and extracting the areas. The R code for the estimations can be found in the BFIS e-Library (see also Hossain, Anik et al. 2019). Note that all data were collected from the biophysical inventory, except in the case of Sections 4.6 to 4.7 which show data from the socio-economic survey. Cells were left blank where there was no sample of that condition and a 0 value indicates < 0.01 of the respective unit. Volume and biomass estimates for all families and species can be found in the Appendix 5.1 and 5.2 tables.

Maps were produced by applying the mean estimate by land cover class and zone to the polygons of the 2015 Land Cover Map. When there was no or little data for very small land cover areas, values were substituted from other classes. For example, as there was no plot occurring in Herb Dominated Area in the Coastal or Sal zones to estimate growing stock value, the value for Herb Dominated Area in the Village zone was substituted.

5.1

Growing stocks

5.1.1 Growing stocks by native and introduced species

Description

Among the 392 tree species inventoried, there are 354 native species, or 90% of the total number (Section 4.4). Among all species, *S. mahagoni* was the most abundant (Table 5.1). *S. apetala* was another important species which almost exclusively occurs in the Coastal zone. In contrast, the third most dominant species, *M. indica* (mango), grows in all the zones except Sundarban.

Two palms, *C. nucifera* and *A. catechu*, are notably abundant. *A. catechu* occurs in every zone except Sundarban and most abundantly in the Village zone (Table 5.2). The popularity of some of these introduced species in homestead plantations is partly the reason for their high volumes. Growing stock estimates for all families and species can be found in the Appendix 5.1 tables.

Highlights

- The most common trees of each zone are Sundri in Sundarban, Keora in Coastal, Sal in Sal zone, Shegun (teak) in Hill zone, and Mehogoni in Village zone.
- The Sundarban and Coastal zones are dominated by native tree species whereas the Sal and Village zones have many introduced species.
- Overall, the top ten native and introduced species by volume possess 27% and 40% of total national tree volume, respectively (Section 5.1.2).

Table 5.1. Top ten native species ranked by total growing stocks. Common names are given below the scientific names.

Native species			Introduced species		
Species	Growing stock (m^3/ha)	Total growing stock (million m^3)	Species	Growing stock (m^3/ha)	Total growing stock (million m^3)
Mangifera indica (Aam)	1.77	23.75	*Swietenia mahagoni* (Mahagoni)	2.59	34.84
Heritiera fomes (Sundri)	1.75	23.57	*Areca catechu*[1] (Supari)	1.85	24.90
Sonneratia apetala (Keora)	1.00	13.39	*Cocos nucifera*[1] (Narikel)	1.84	24.77
Excoecaria agallocha (Gewa)	0.84	11.26	*Samanea saman* (Rain tree)	1.19	16.02
Albizia lebbeck (Kala koroi)	0.51	6.88	*Borassus flabellifer*[1] (Tal)	0.87	11.76
Bombax ceiba (Simul)	0.38	5.16	*Eucalyptus camaldulensis* (Eucalyptus)	0.87	11.69
Albizia chinensis (Chakua Koroi)	0.37	4.93	*Artocarpus heterophyllus*[1] (Kanthal)	0.76	10.27
Phoenix sylvestris (Khejur)	0.35	4.69	*Acacia auriculiformis* (Akashmoni)	0.58	7.84
Shorea robusta (Sal)	0.35	4.64	*Albizia richardiana* (Raj Koroi)	0.51	6.82
Dipterocarpus alatus (Sil Garjan)	0.33	4.39	*Eucalyptus alba* (Eucalyptus)	0.44	5.86

[1]These species are introduced but considered naturalized in Bangladesh

Table 5.2. Top five species by zone and ranked by growing stock.

Scientific name	Local name	Growing stock (m^3/ha)	Origin
Coastal Zone			
Sonneratia apetala	Keora	25.60	Native
Areca catechu[1]	Supari	5.14	Introduced
Samanea saman	Siris	4.90	Introduced
Cocos nucifera[1]	Narikel	3.33	Introduced
Sonneratia caseolaris	Ora	1.61	Native
Hill Zone			
Tectona grandis[1]	Shegun	3.00	Introduced
Dipterocarpus alatus	Sil Garjan	2.65	Native
Gmelina arborea	Gamari	2.01	Native
Swintonia floribunda	Civit	1.54	Native
Schima wallichii	Kanak	1.31	Native
Sal Zone			
Shorea robusta	Sal	8.11	Native
Acacia auriculiformis	Akashmoni	5.19	Introduced
Borassus flabellifer[1]	Tali palm	3.16	Introduced
Artocarpus heterophyllus[1]	Kanthal	2.72	Introduced
Hevea brasiliensis	Rubber	2.63	Introduced
Sundarban Zone			
Heritiera fomes	Sundri	58.42	Native
Excoecaria agallocha	Gewa	26.44	Native
Xylocarpus mekongensis	Dhundol	4.06	Native
Avicennia officinalis	Baen	3.83	Native
Bruguiera sexangula	Kankra	1.35	Native
Village Zone			
Swietenia mahagoni	Mehogoni	3.13	Introduced
Cocos nucifera[1]	Narikel	2.19	Introduced
Areca catechu[1]	Supari	2.11	Introduced
Mangifera indica	Aam	2.04	Native
Samanea saman	Siris	1.27	Introduced

[1]These species were introduced but considered naturalized in Bangladesh

5.1.2 Growing stocks, national estimate by zone and land cover class

Description

The total gross tree volume of the country is 383.92 million m^3. This amounts to 2.38 m^3 per person.

The national average gross volume is 28.5 m^3/ha (Table 5.3). By comparison, the national level volume reported in the NFA was only 14 m^3/ha (MoEF and FAO, 2007). However, in the NFA only one common volume equation was used compared to the 29 equations used in the BFI. When the same NFA equation was used in the BFI, the resulting mean volume was still higher at 26 m^3/ha. The difference between the two estimates may be due to differences in sample design and/or some growth between the two periods.

Among the five zones, the Sundarban zone has the highest volume density followed by Coastal zone (Figure 5.1; Table 5.3). However, the Village zone has the highest total tree volume due to its extent, containing 222 million m^3.

Among the 33 land cover classes, there are 22 which have trees (Table 5.4). The Mangrove Plantation and Mangrove Forest have the highest volume density (Table 5.4). Tree Orchards and Rural Settlement volume densitites are also substantial. In terms of total volume, the Rural Settlement and Hill Forest are the highest.

TOF are an important resource in Bangladesh however there was previously no national level estimate to quantify the growing stock until now. Although the volume density in Forest was 3 times greater than TOF, TOF have almost two times more total gross volume than Forest.

Highlights

- 58% of the country's total gross tree volume (m^3) occurs in the Village zone followed by 20% in the Hill zone (Figure 5.2).
- The Sundarban zone volume (m^3/ha) is 3.4 times higher than the national average and more than 4.6 times higher than the Village zone.
- Notably high volume densities within zones include Mangrove Plantation (Coastal), Forest Plantation (Hill zone) and Plain Land Forest (Village zone).
- TOF accounts for 66% of the country's total tree gross volume.

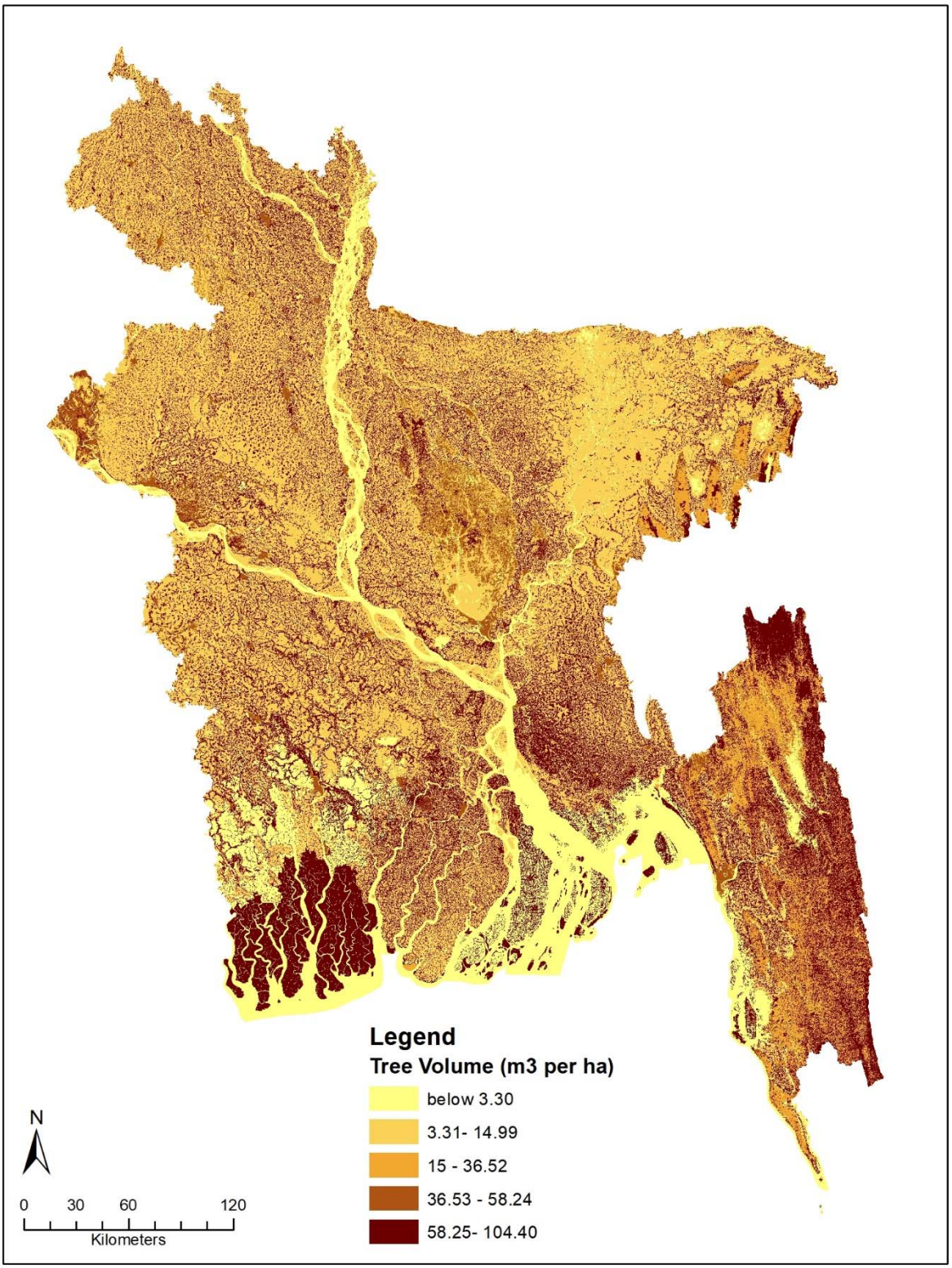

Figure 5.1. Spatial distribution of gross growing stock volume.

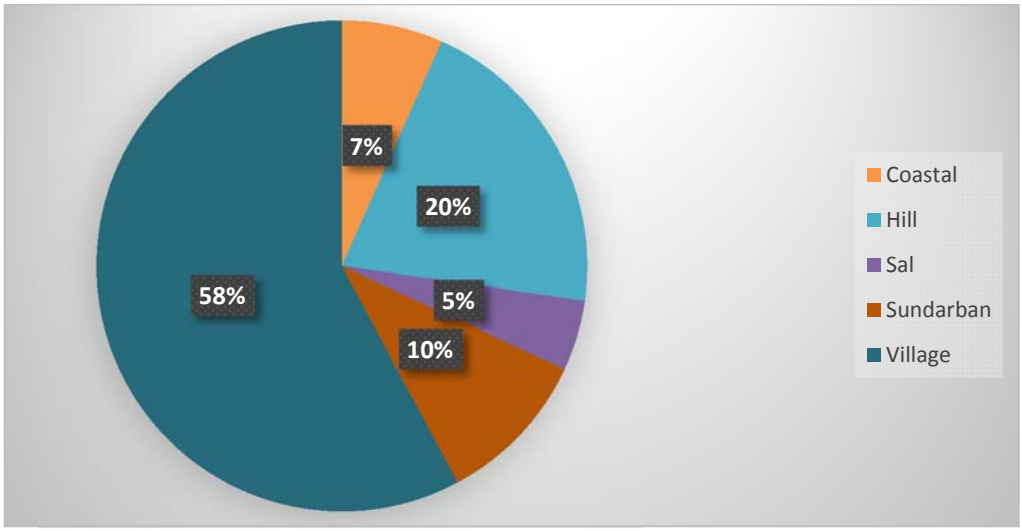

Figure 5.2. Percent total gross tree volume by zone.

Table 5.3. Gross tree volume by zone.

Zone	Volume (m^3/ha)	Total volume (million m^3)	Sampling error (±%)
Coastal	50.08	25.55	22.80
Hill	47.69	79.12	18.75
Sal	34.17	17.84	17.03
Sundarban	97.75	39.44	12.36
Village	21.44	221.98	10.85
National	28.54	383.92	7.67

Table 5.4. Gross tree volume by zone and land cover class, ranked by volume (m^3/ha).

Land Cover Classes	Volume (m^3/ha)	Total volume (1000 m^3)	Distribution of volume by zone (m^3/ha)				
			CZ	HZ	SZ	SuZ	VZ
Forest							
Mangrove Forest	97.85	39,436.74				97.85	
Mangrove Plantation	88.63	14,614.60	88.63				
Plain Land Forest (Sal Forest)	84.10	3,546.79			82.22		104.22
Hill Forest	82.77	51,232.49		83.77			5.89
Forest Plantation	65.95	6,188.85		83.14	45.15		
Rubber Plantation	51.68	2,566.93		36.53	81.00		
Shrubs with scattered trees	23.47	13,408.02	104.41	23.35	13.67		
Bamboo Forest	0.65	3.25		0.65			
Total Forest	**67.21**	**130,997.70**	**88.75**	**55.21**	**64.07**	**97.85**	**34.22**
Other Land (TOF)							
Rural Settlement	66.58	192,526.60	85.97	50.31	52.07		67.04
Orchards and Other Plantations (Trees)	56.84	11,266.76		25.69	64.36		58.14
Built-Up Non-Linear	37.54	3,126.53	58.24		4.45		40.41
Orchards and Other Plantations (Shrub)	36.85	3,595.71		29.51			99.06
River Banks	17.82	421.10		62.21	16.10	7.83	6.96
Swamp Reed Land	15.00	149.03					15.00
Ponds	13.42	108.09			46.80		
Shifting Cultivation	9.27	283.28		9.27			
Multiple Crop	5.86	18,657.42	2.42	10.54	7.92		5.78
Single Crop	4.91	22,285.83	2.17	8.29	10.70		4.73
Brickfield	3.20	80.99					3.30
Fresh Water Aquaculture	2.82	316.52	16.1				2.47
Herb Dominated Area	1.31	75.34			0.70		1.48
Sand	0.24	33.11					0.24
Total Other Land (TOF)	**21.99**	**252,926.30**	**31.39**	**23.39**	**27.04**	**7.83**	**21.42**

5.1.3 Growing stocks by diameter class and height class

Description

Tree diameters were grouped into 10 classes, and there were few trees having more than 100 cm DBH. The highest volume density occurs in the 10 - <20 cm DBH class and was closely followed by the 20 - <30 class (Figure 5.3; Table 5.6). The greatest proportion of growing stock density within the first two classes was found in the Sundarban zone, however it was more equally distributed among zones for larger classes. In the Sal zone there are no trees having ≥80 cm DBH. However, Hill, Sundarban and Village zones have trees in all diameter classes.

Tree heights were also grouped into 10 classes. Growing stock density reached a maximum in the 10-<15 m height class indicating higher occurrence of trees in this class (Figure 5.4; Table 5.7). Similar to DBH classes, the Sundarban zone has the highest growing stock in the lower height classes. The height range 10-<20m has maximum volume density in all zones except Sundarban.

Highlights

- Trees with DBH < 40 cm make up 80% of the total tree volume.
- Nearly 90% of the total volume is made up of trees with heights less than 20m.
- The Sundarban zone has comparatively higher DBH trees due to the presence of species such as *H. fomes* and *E. agallocha* (Section 5.1.1).

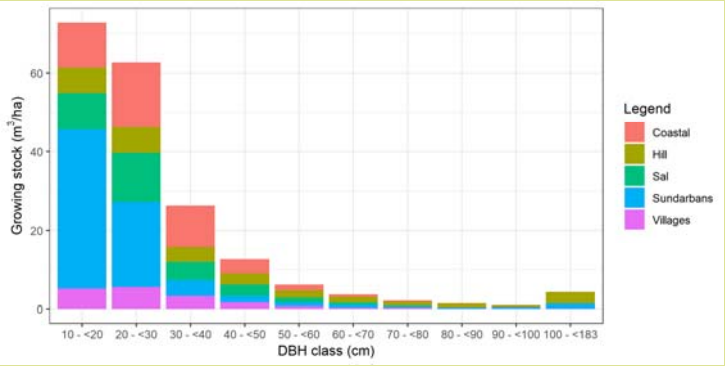

Figure 5.3. Growing stock by DBH class and zones.

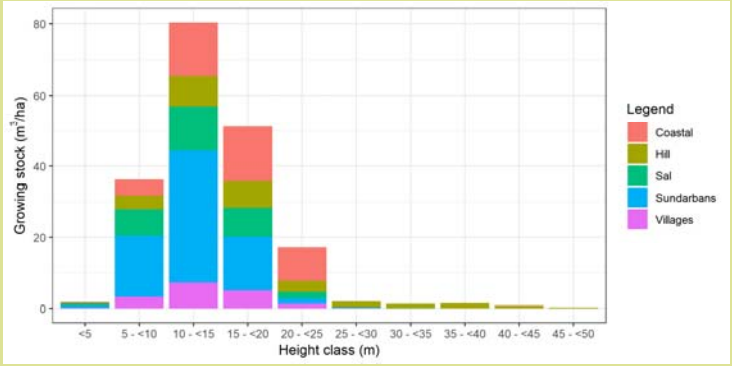

Figure 5.4. Growing stock by height class and zone.

Table 5.6. Growing stock by DBH class and zones.

DBH class	Volume (m^3/ha)	Total volume (million m^3)	Distribution of GS by Zone (m^3/ha)				
			CZ	HZ	SZ	SuZ	VZ
10-<20	8.76	117.87	14.02	9.42	9.95	56.16	6.49
20-<30	8.60	115.77	18.18	10.18	13.46	29.88	6.81
30-<40	4.67	62.84	11.35	6.02	5.19	5.36	4.074
40-<50	2.44	32.88	3.89	4.71	3.48	2.12	1.97
50-<60	1.26	16.95	1.50	3.41	1.46	1.02	0.90
60-<70	0.73	9.80	0.62	2.61	0.54	0.78	0.44
70-<80	0.57	7.73	0.33	2.23	0.09	0.39	0.35
80-<90	0.40	5.41	0.12	2.42		0.34	0.12
90-<100	0.19	2.56	0.07	0.64		0.47	0.12
≥ 100	0.90	12.11		6.06		1.23	0.15

Table 5.7. Gross volume by height class and zone.

Height class	Volume (m^3/ha)	Total volume (million m^3)	Distribution of GS by Zone (m^3/ha)				
			CZ	HZ	SZ	SuZ	VZ
<5	0.32	4.30	0.42	0.21	0.60	0.84	0.30
5-<10	4.98	67.00	5.51	5.19	8.35	23.72	4.02
10-<15	11.32	152.19	18.05	12.55	14.16	50.98	9.10
15-<20	7.80	104.94	16.36	11.93	8.75	20.19	6.19
20-<25	2.49	33.54	9.63	6.68	1.87	1.96	1.52
25-<30	0.66	8.89	0.02	3.62	0.32		0.26
30-<35	0.40	5.41	0.02	3.01	0.08		0.04
35-<40	0.38	5.11		3.04			0.01
40-<45	0.15	1.98	0.07	1.16	0.04		
≥ 45	0.04	0.55		0.30		0.06	0.00

5.1.4 Bamboo stock, national estimate by zone and land cover class

Description

Most of the bamboo volume occurs in the Village zone (68% of the total national bamboo volume), even though the Bamboo forest type by definition never occurs in this zone (Section 3.1) (Table 5.8). In terms of bamboo volume density (m^3/ha), the Hill zone is 2.6 times higher than the Village zone.

Bamboos occur in 14 land cover classes (Table 5.9). *Melocanna beccifera* mainly grows in the Hill zone whereas *Bambusa vulgaris* was the main bamboo in Rural Settlement (Appendix 5.1.1a). Not surprisingly, bamboo volume was highest in the Bamboo Forest and Hill Forest land cover classes. However somewhat surprising are that Orchard and Other Tree Plantations and Rural Settlement have medium bamboo volume densities. Rural Settlement by itself holds the most bamboo volume. Similarly, River Banks, and Multiple and Single Crop each have bamboo occurring at their margins, though the density was low.

Highlights

- Bamboo volume is about 17% of the country's total tree volume (Section 5.1.2).
- The most common bamboo species are *Bambusa vulgaris* and *Melocanna baccifera*.
- The Rural Settlements land cover class contains 59% of the total bamboo volume.
- Though Bamboo Forest has highest bamboo density it possesses less than 1% of the total bamboo stock due to the small spatial extent of this land cover class.

Table 5.8. Bamboo volume by zone.

Zone	Volume (m^3/ha)	Total volume (1000 m^3)	Sampling Error (±%)
Coastal	0.14	73.94	112.09
Hill	11.06	18,346.99	32.80
Sal	3.83	1,999.85	62.07
Village	4.19	43,406.56	27.64
National	4.75	63,827.34	21.12

Table 5.9. Bamboo volume by land cover class.

Land Cover Classes	Volume (m^3/ha)	Total volume (m^3)
Forest		
Bamboo Forest	26.15	131,288.11
Hill Forest	23.86	14,765,782.74
Shrubs with scattered trees	3.25	1,855,935.83
Forest Plantation	1.1	103,623.90
Total Forest	**8.95**	**16,856,630.58**
Other Land (TOF)		
Orchards and Other Plantations (Trees)	15.65	3,102,210.05
Rural Settlement	13	37,598,496.21
Shifting Cultivation	8.09	247,098.94
River Banks	4.06	96,016.18
Plain Land Forest (Sal Forest)	1.33	56,148.94
Single Crop	0.77	3,518,343.13
Multiple Crop	0.72	2,286,961.29
Sand	0.31	43,616.13
Fresh Water Aquaculture	0.16	17,915.60
Orchards and Other Plantations (Shrub)	0.04	3,904.11
Total Other Land (TOF)	**3.65**	**46,970,710.58**

Photo: Bamboo rafting, Kassalong, Rangamati, *©Iqbal Z.*

5.2 Tree biomass

5.2.1 Above ground biomass by species

Description

Certain tree species dominate their respective zones. Here, the top five species in aboveground biomass in each zone were ranked (Table 5.10). The local names of the most dominant species per zone are well recognized by the people living within them – Keora (Coastal), Shegun (Hill), Kanthal (Sal), Sundri (Sundarban), and Mahagoni (Village).

Biomass will often show the same patterns of spatial distribution as volume. For example, similar to volume, *H. fomes* has the highest above ground biomass in the Sundarban (Table 5.10). *S. mahagoni* was the highest introduced species, occurring mostly in the Village zone. *E. agallocha* was a top five species in both the Coastal and Sundarban zones. Aboveground biomass estimates for all species can be found in the Appendix 5.2.1.

Highlights

- *H. fomes* and *S. apetala* each dominate in their respective zones, having 4.0 and 2.4 times higher biomass than any other species in their respective zones.
- *M. indica* is a top species in both the Sal and Village zones, indicating its popularity as a planted tree.
- In contrast to other zones, no single species in the Village and Sal zones dominated as species there are more evenly distributed and diverse (see Section 4).

Table 5.10. Above ground biomass by species, ranked by top five occurrence in each zone.

Species	Local name	AGB (t/ha)
Coastal		
Sonneratia apetala	Keora	20.52
Samanea saman	Rain tree	5.14
Areca catechu	Supa	4.27
Cocos nucifera	Narikel	2.24
Excoecaria agallocha	Gewa	2.21
Hill		
Tectona grandis	Shegun	5.74
Gmelina arborea	Gamar	1.45
Albizia procera	Sada koroi	1.25
Dipterocarpus alatus	Dholi Garjan	1.24
Acacia auriculiformis	Akashmoni	1.03
Sal		
Artocarpus heterophyllus	Kanthal	7.72
Hevea brasiliensis	Rubber	6.42
Borassus flabellifer	Tali	6.37
Shorea robusta	Sal	5.73
Mangifera indica	Aam	5.27
Sundarbans		
Heritiera fomes	Sundri	56.01
Excoecaria agallocha	Gewa	23.17
Avicennia officinalis	Baen	5.70
Ceriops decandra	Goran	4.72
Xylocarpus mekongensis	Passur	2.80
Village		
Swietenia mahagoni	Mahagoni	2.21
Mangifera indica	Aam	2.08
Areca catechu	Supari	1.46
Cocos nucifera	Narikel	1.40
Samanea saman	Rain tree	1.30
National		
Mangifera indica	Aam	1.93
Swietenia mahagoni	Mahagoni	1.90
Heritiera fomes	Sundri	1.68
Areca catechu	Supari	1.31
Samanea saman	Rain tree	1.27

5.2.2 Above ground biomass, national estimate by zone and land cover class

Description

The above ground biomass density is highest in Sundarban (98.37 t/ha) perhaps due to its high stem density (Figure 5.5; Table 5.11; see also Section 4.1.1) and is 3.4 times higher than the national average. Similar to tree volume, the aboveground biomass density (t/ha) is lowest in the Village zone, yet it contains the highest total amount of biomass.

The national average aboveground biomass across the zones is 28.78 t/ha (Table 5.11). By comparison, the national level biomass reported in the NFA was 57 t/ha (MoEF and FAO, 2007). However, in the NFA, one common volume equation and biomass expansion factor were used for the estimation compared to the 11 biomass equations used in the BFI. When the same NFA equation is used in the BFI, the resulting mean volume is 88 t/ha. The difference between the two estimates may be due to differences in sample design or some growth between the two periods. See Appendix tables for more NFA comparisons.

Among the 22 land cover classes where trees occur, aboveground biomass density is highest in the Mangrove Forest (Table 5.12). The Rural Settlement is highest in total stocks, containing about 50% of the total country's biomass.

Notably high values among land cover and zones include Mangrove Plantations (Coastal), Forest Plantation (Hill), Rubber Plantations (Sal), and Plain Land Forest (Village).

Biomass density in Forest is three times higher than in TOF (Table 5.13). Yet, TOF have almost two times higher total biomass.

Highlights

- TOF contain 66% of the total biomass stock.
- The Sundarban zone has the highest biomass density (t/ha), about five times higher than the Village zone.
- Plain Land Sal Forest biomass density (t/ha) is 3.3 times higher than the national average.
- Rubber Plantation in the Sal zone have extremely high biomass density (198 t/ha).
- The highest biomass density by land cover occurring in the Hill zone is Hill Forest followed by Forest Plantations.

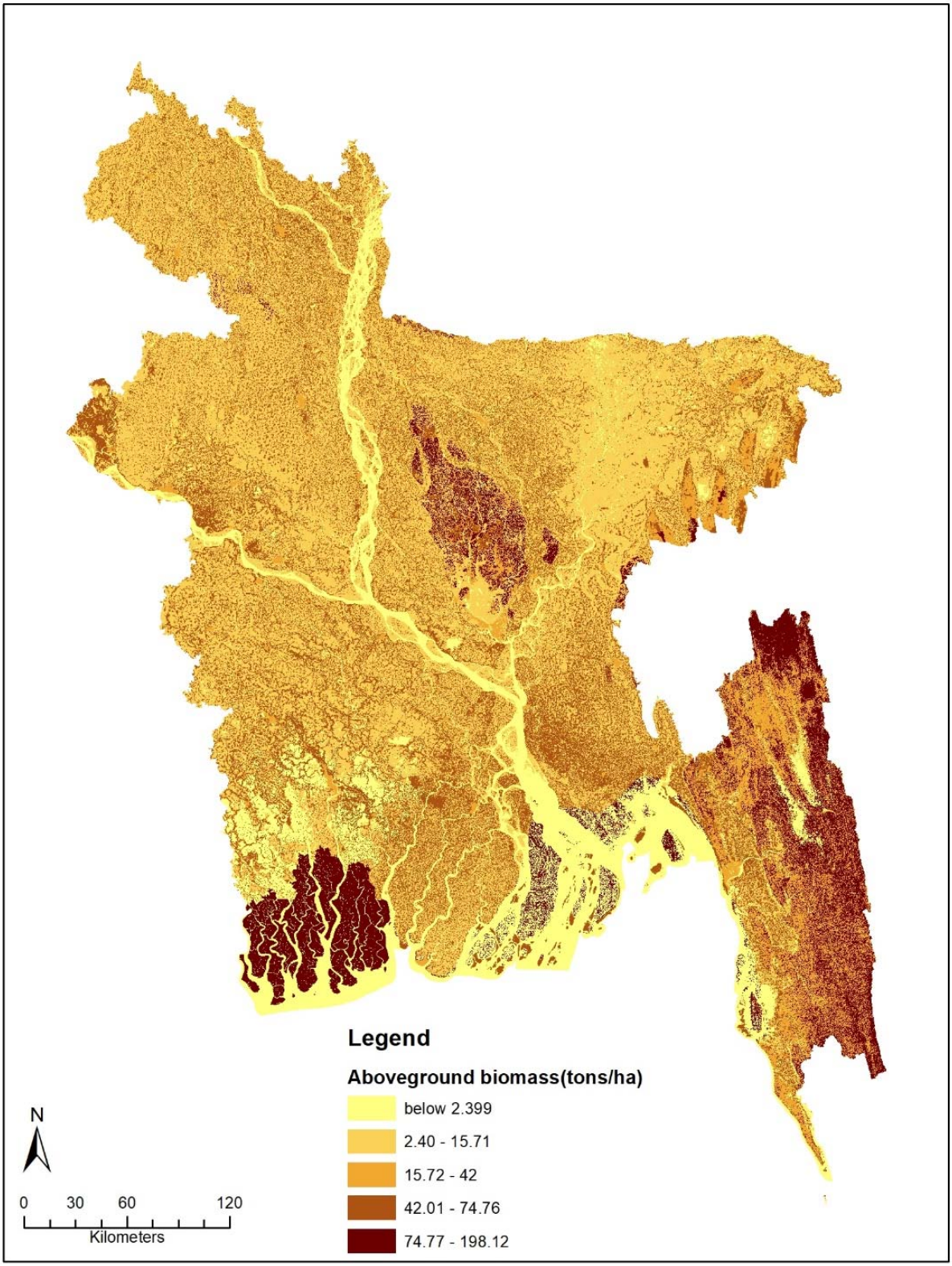

Figure 5.5. The spatial distribution of biomass stocks.

Table 5.11. Above ground biomass by zones.

Zone	AGB (t/ha)	Total AGB (million t)	Sampling Error (±%)
Coastal	43.63	22.26	20.25
Hill	48.32	80.15	14.27
Sal	59.43	31.03	17.14
Sundarban	98.37	39.69	8.18
Village	20.66	213.97	10.12
National	28.78	387.09	6.63

Table 5.12. Above ground biomass by land cover class and zone.

Land Cover Classes	AGB (t/ha)	Total AGB (1000 t)	Distribution of AGB into Zones (t/ha)				
			CZ	HZ	SZ	SuZ	VZ
Forest							
Mangrove Forest	98.34	39,633.33				98.34	
Rubber Plantation	95.19	4,728.14		42	198.12		
Hill Forest	82.76	51,222.09		83.38			34.79
Mangrove Plantation	74.76	12,328.46	74.76				
Plain Land Forest (Sal Forest)	67.06	2,828.23			66.86		69.21
Forest Plantation	58.52	5,491.15		63.07	53.78		0
Bamboo Forest	33.15	166.39		33.15			
Shrubs with scattered trees	27.06	15,459.94	87.72	27.03	12.25		0
Total Forest	**67.66**	**131,857.73**	**74.86**	**56.11**	**81.32**	**98.34**	**42.67**
Other Land (TOF)							
Orchards and Other Plantations (Trees)	70.41	13,957.97		23.15	135.99		64.43
Rural Settlement	66.27	19,1622.1	77.96	50.97	101.46		64.22
Ponds	31.52	253.87			109.91		0
Orchards and Other Plantations (Shrub)	28.06	2,738.23		22.86			72.11
Built-Up Non-Linear	25.4	2,115.74	45.46		11.57		26.12

Land Cover Classes	AGB (t/ha)	Total AGB (1000 t)	Distribution of AGB into Zones (t/ha)				
			CZ	HZ	SZ	SuZ	VZ
Other Land (TOF)							
Swamp Reed Land	25.37	252.05					25.37
Shifting Cultivation	24.28	741.70		24.28			
River Banks	19.12	451.94		56	41.65		5.86
Multiple Crop	5.9	18,778.67	2.4	10.66	15		5.5
Single Crop	5.24	23,819.92	2.19	8.43	24.41		4.76
Fresh Water Aquaculture	2.59	291.37	15.71				2.25
Herb Dominated Area	1.79	102.91	0		1.74		1.97
Brickfield	1.62	41			0		1.67
Sand	0.45	62.48					0.45
Brackish Water Aquaculture	0.03	1.13					0.03
Mud Flats or Intertidal Area	0.03	0.67	0.03				0
Total Other Land (TOF)	**22.19**	**255,231.80**	**28.53**	**23.14**	**54.21**	**0.00**	**20.64**

Photo: Oven dried leaf, Nutrient dynamics lab, Khulna University,
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5.3

Dead wood biomass and potential fuelwood

Description

Dead wood and litter biomass is important to ecosystem function and stores carbon (Section 5.4). It is also major source of fuel for households (see Section 9.5.1). The main pools of dead biomass used for fuel are coarse woody debris (CWD), fine woody debris (FWD), and litter.

The dead wood biomass across the zones is 0.89 t/ha and varied greatly among zones (Table 5.14). The Sundarban zone shows the highest dead wood biomass density which is 5.7 times higher than the national average. Low fuel wood collection, natural disasters (e.g. cyclones) and top dying of Sundri are potential reasons for high dead wood biomass in the Sundarban and Coastal zones. Standing dead tree and FWD biomass density is highest in Sundarban whereas dead stump is highest in the Coastal and CWD in the Hill zone.

Dead wood and litter biomass used as fuel (CWD, FWD, litter) occurs in 22 land cover classes among which Mangrove Plantations, Shifting Cultivation, Hill Forest, and Mangrove Forest showed the highest biomass density (Table 5.15). The high values for Shifting Cultivation indicate the large amounts of CWD and FWD that are left behind after cutting the trees. Hill Forest, Rural Settlement and Shrubs with scattered trees have the highest total volume, indicating these as major suppliers of dead wood potentially used for fuel. Notably low amounts are found near urban areas and areas surrounding the Sundarban (Figure 5.6).

Highlights

- The Hill zone has 43% of the total dead wood and litter biomass followed by Village zone at 26%.
- The high dead wood and litter biomass density in the Coastal and Sundarban zones may indicate lower pressure from collection (e.g. more difficult access) (see Section 9.5).
- There is 10,326 tons of dead wood that could potentially be used for fuel (CWD, FWD, litter) and 33% of this is supplied by Hill Forest while 25% is supplied by Rural Settlement.

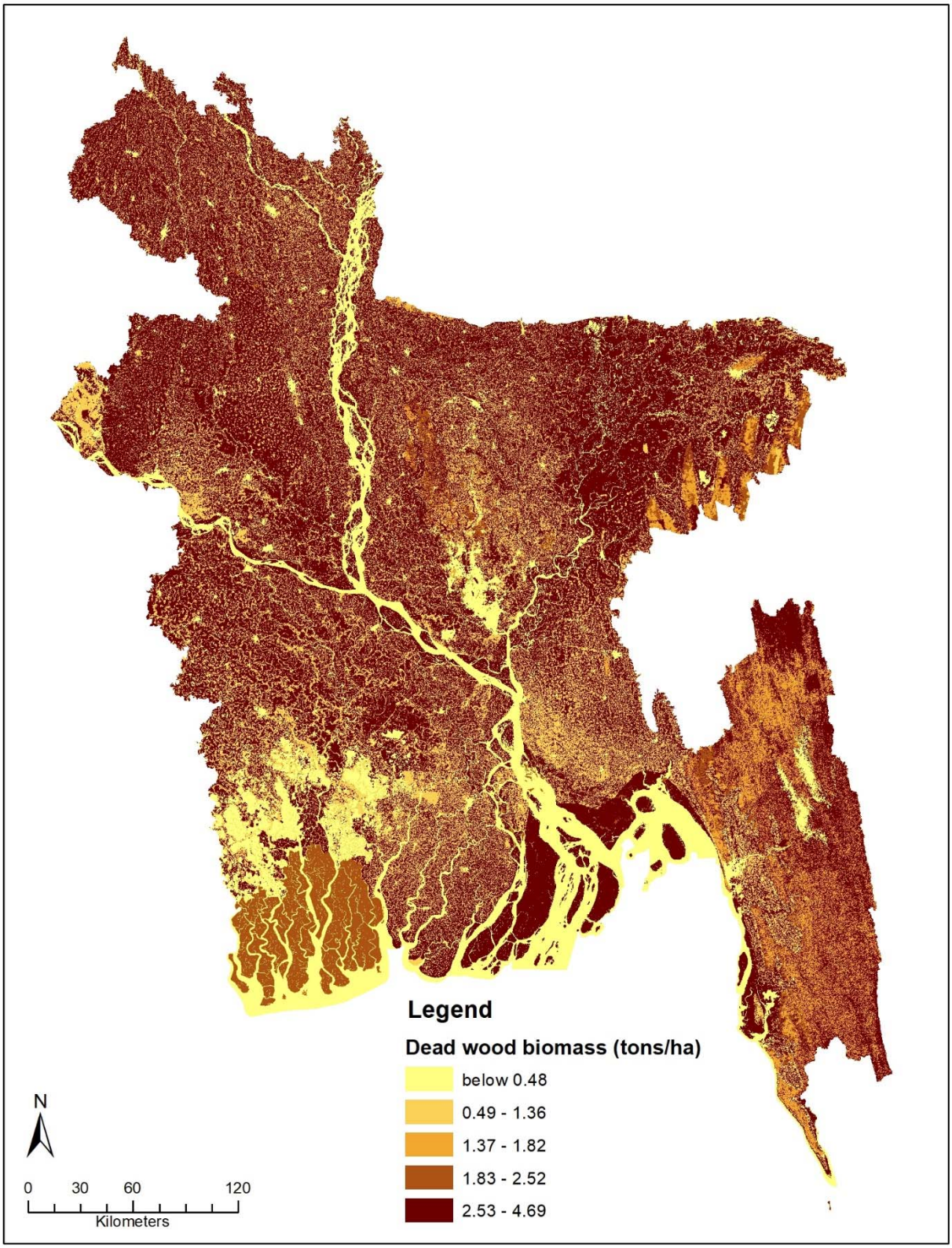

Figure 5.6. Spatial distribution of dead wood (CWD, FWD and litter) biomass.

Table 5.14. Dead biomass and standard errors by zone.

Zone	Standing dead tree		Dead Stump		CWD		FWD		Litter		All Dead Biomass (t/ha)	Total Dead Biomass (Million t)
	Biomass (t/ha)	SE (±%)	Biomass (t/ha)	SE (±%)	Biomass (t/ha)	SE (±%)	Biomass (t/ha)	SE (±%)	Biomass (t/ha)	SE (±%)		
Coastal	0.69	73.27	0.16	61.53	0.66	89.96	0.92	23.27	0.11	36.80	2.43	1.24
Hill	0.50	72.43	0.10	27.82	1.23	45.43	1.24	6.00	0.57	10.69	3.06	5.08
Sal	0.23	72.35	0.02	105.98	0.01	195.87	0.64	15.38	0.33	25.12	0.89	0.46
Sundarban	3.03	26.48	0.11	53.70	0.42	35.14	1.54	5.93	0.32	15.72	5.10	2.06
Village	0.05	34.44	0.01	43.58	0.01	111.90	0.23	14.62	0.05	19.12	0.30	3.10
National	0.23	24.75	0.03	21.33	0.19	37.57	0.44	6.67	0.14	8.36	0.89	11.93

Table 5.15. Dead wood biomass that could potentially be used for fuel (i.e. CWD, FWD and Litter) by land cover class and zone, ranked by total biomass.

Land Cover Class	CWD, FWD and Litter (t/ha)	Total (t)	Distribution of CWD, FWD, and Litter into zones (t/ha)				
			CZ	HZ	SZ	SuZ	VZ
Forest							
Hill Forest	5.16	3407.78		5.18			4.27
Shrubs with scattered trees	1.82	986.66	1.07	1.83	0.67		0
Mangrove Forest	2.28	919.62				2.28	
Mangrove Plantation	3.49	579.23	3.49				
Forest Plantation	2.25	222.05		2.57	1.92		0
Rubber Plantation	1.93	108.03		2.09	1.64		
Plain Land Forest (Sal Forest)	1.97	80.72			2.01		1.00
Bamboo Forest	2.28	12.67		2.28			
Total Forest	**0.0034**	**6316.76**	**3.11**	**3.55**	**1.86**	**2.28**	**0.89**
Other Land (TOF)							
Rural Settlement	0.93	2586.83	2.14	1.41	1.29		0.85
Single Crop	0.12	579.95	0.18	0.65	0.44		0.10
Multiple Crop	0.10	341.77	0.06	0.55	0.34		0.09
Orchards and Other Plantations (Trees)	1.13	233.77		1.95	1.78		0.95
Orchards and Other Plantations (Shrub)	1.57	157.17		1.64			0.76
Shifting Cultivation	1.94	51.14		1.94			
Built-Up Non-Linear	0.34	32.09	1.60		0.26		0.30
River Banks	0.38	8.46		1.75	0		0.06
Fresh Water Aquaculture	0.06	7.62	0.05				0.06
Brackish Water Aquaculture	0.08	2.98					0.08
Swamp Reed Land	0.22	2.20					0.22
Ponds	0.24	1.92			0.83		0
Herb Dominated Area	0.03	1.65	0		0.58		0
Mud Flats or Intertidal Area	0.05	1.39	0.05				0.00
Total Other Land (TOF)	**0.0003**	**4008.94**	**0.32**	**1.01**	**0.73**	**0.00**	**0.30**

CZ: Coastal zone, HZ: Hill zone, SZ: Sal zone, SuZ : Sundarban zone, and V: Village zone.

5.4

Carbon

5.4.1 Carbon pools, national estimate by zone

Description

Most of the carbon stock is contained in the top 30 cm of the soil (80%), followed by the above ground component (15%) (Figure 5.7). The density of carbon in above ground, below ground and dead biomass is highest in the Sundarban zone followed by the Sal (Table 5.16).

Highlights

- Most of the national carbon stock is in the Village zone (70%, soils to 30cm depth) due to its large spatial extent.
- Carbon density in below ground biomass is 9.6 times higher in the Sundarban zone compared to the national average.
- The Hill zone is highest in soil carbon (up to 30 cm) and litter carbon compared to other zones.
- In the Coastal and the Sundarbans zones soil carbon density in 100 cm depth is more than double the 30 cm depth.

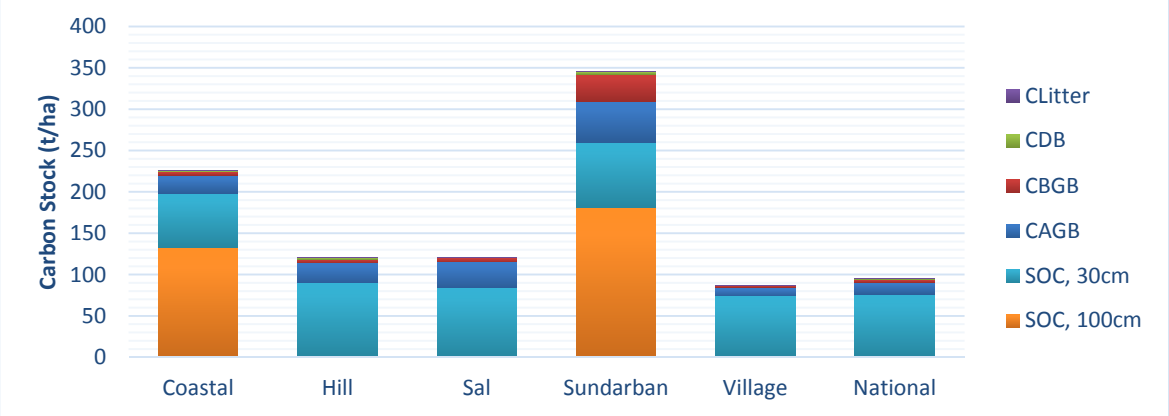

Figure 5.7. Carbon stock densities in the major pools by zone (DB: dead biomass, BGB: belowground biomass, AGB: aboveground biomass, SOC: soil organic carbon for 0-30cm depth soil layer and 30-100 cm depth soil layer). Note that soil data for 30-100cm depth was not collected in the Hill, Sal and Village zones.

Table 5.16. Five carbon pools by zone.

Zone	All Carbon pools															
	CAGB		CBGB		CDB		CLitter		SOC, 30cm[1]		SOC, 100cm[2]		All pools (incluing SOC 100 cm)[1]	All pools (including SOC 30 cm)[1]	Total Stock (including SOC 100 cm)[1]	Total Stock (including SOC 30 cm)[1]
	t/ha	SE (±%)	t/ha	SE (±%)	t/ha	SE (±%)	t/ha	SE (±%)	t/ha	SE (±%)	t/ha	SE (±%)	t/ha	t/ha	Million t	Million t
Coastal	21.79	20.26	4.15	19.89	1.21	46.78	0.05	37.2	65.77	7.20	132.48	9.15	225.46	92.98	115.01	47.43
Hill	24.03	14.48	4.65	14.46	1.53	27.4	0.28	10.31	89.97	3.50				120.46	199.83	199.83
Sal	31.36	17.23	5.09	16.84	0.44	23.45	0.16	24.92	84.05	6.38				121.10	63.23	63.23
Sundarban	49.28	8.10	33.03	7.14	2.55	18.10	0.16	16.09	78.68	3.87	181.52	4.33	345.21	163.70	139.28	66.04
Village	10.47	10.18	1.99	10.61	0.15	14.69	0.03	19.15	74.18	3.03				86.82	899.02	899.02
National	14.55	6.68	3.45	5.82	0.44	13.59	0.07	8.23	76.33	2.35	154.13		248.97	94.84	1,416.37	1,275.55

[1] Soil organic carbon (SOC) was determined by LOI without removing inorganic carbonates which typically results in higher values than other methods. Samples for 100 cm soil layer were collected from the Sundarbans and Coastal zone only. Carbon density and total carbon stock is calculated for both 30cm and 100cm depths. The 30cm depth estimates may be used for most consistent comparisons among zones and for the national level estimate.

5.4.2 Carbon pools by administrative division

Description

Administrative divisions are often used for policy and planning purposes. The five carbon pools were summarized by administrative units for the purpose that planners may understand the status of carbon stocks in their divisions and use the information as a baseline for climate change policies. Overall, the carbon densities are higher where there are more forests. For example, in Chittagong and Khulna where the Mangrove and Hill Forest is common (Table 5.17).

Highlights

- The Khulna division has the highest carbon stocks by density, and Rangpur has the lowest.
- The total carbon stocks are highest in Chittagong and Khulna divisions which together have 38% of the total carbon stock.

Table 5.17. Five carbon pools by administrative division.

Division	Carbon density by pool (t/ha)						
	CAGB	CBGB	CDB	CLitter	SOC, 30 cm[1]	Total	
						Mean	Total (million t)
Barisal	24.61	4.62	0.72	0.06	69.83	99.85	89.91
Chittagong	20.46	3.93	1.03	0.18	79.37	104.97	284.05
Dhaka	13.97	2.51	0.21	0.06	73.57	90.33	152.86
Khulna	18.84	8.47	0.61	0.06	79.80	107.77	203.82
Mymensingh	10.12	1.88	0.06	0.02	73.50	85.57	81.83
Rajshahi	11.20	1.94	0.14	0.03	66.90	80.21	137.98
Rangpur	8.36	1.70	0.14	0.02	65.29	75.52	160.18
Sylhet	6.83	1.24	0.21	0.03	101.79	110.12	164.91

[1] Soil organic carbon (SOC) was determined by LOI without removing inorganic carbonates which typically results in higher values than other methods. Samples for 100 cm soil layer were collected from the Sundarbans and Coastal zone only. The 30cm depth estimates may be used for most consistent comparisons among divisions.

5.4.3 Total Carbon by zone and land cover class

Description

Total carbon includes the five carbon pools - aboveground, belowground, deadwood, litter, and soil to 30cm depth. Generally speaking, total carbon is mostly concentrated in the forested areas of the country and varied widely, ranging from 14.6 t/ha in Sand to 176.6 t/ha in Bamboo Forest (Figure 5.8; Table 5.18). Especially large and extensive amounts of carbon are found in the Mangrove Forest and Hill Forest. The large area of Multiple and Single Crop and Rural Settlement resulted in their high total carbon stocks.

Highlights

- Forest areas hold 21.5% of the total carbon stock in the country. Hill forest and Mangrove forest alone hold 9.7% and 5.2% of the total, respectively.
- Multiple and Single Crop and Rural Settlement together hold 72.4% of the total carbon stock in the country.

Photo: Royal Bengal Tiger, The Sundarban,
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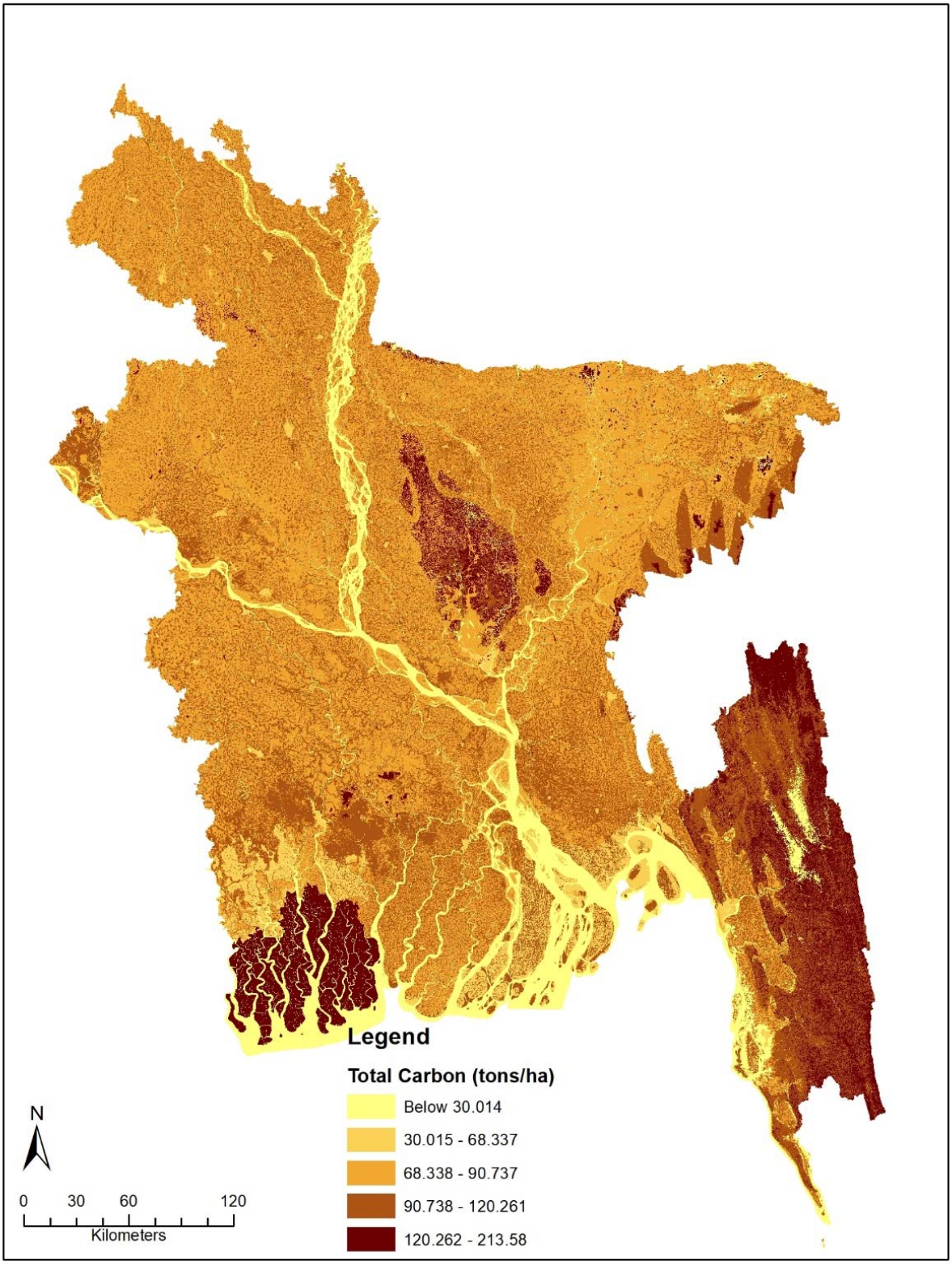


Figure 5.8. Spatial distribution of all five carbon pools (SOC to 30cm).

Table 5.18. Total of all five carbon pools by land cover class and zone (SOC to 30cm).

Land Cover Classes	Total carbon (t/ha)	Total carbon (million t)	Distribution of carbon in zones (t/ha)				
			Coastal	Hill	Sal	Sundarban	Village
Forest							
Bamboo Forest	176.62	1.37		176.90			
Mangrove Forest	163.66	65.99				162.25	
Hill Forest	144.42	123.08		144.65			107.45
Rubber Plantation	139.03	8.09		100.93	213.58		
Plain Land Forest (Sal Forest)	125.47	5.69			126.55		109.80
Mangrove Plantation	121.08	23.52	120.06				
Forest Plantation	116.03	15.12		120.26	111.37		0.00
Shrubs with scattered trees	112.45	`31.21	105.49	112.50	7.91		0.00
Total Forest	**145.47**	**274.07**	**111.54**	**129.08**	**117.99**	**162.18**	**26.16**
Other Land (TOF)							
Perennial Beels/Haors	122.23	4.10			4.37		124.63
Shifting Cultivation	114.60	1.78		114.87			
Fresh Water Aquaculture	104.60	12.22	56.03				104.98
Orchards and Other Plantations (Trees)	103.72	26.00		104.89	171.57		93.50
Rural Settlement	102.50	211.66	104.09	108.78	140.60		100.22
Riverbanks	101.29	0.63		94.55	25.26		125.07
Orchards and Other Plantations (Shrub)	97.34	11.84		94.31			43.22
Ponds	90.27	0.45			67.34		70.96
Single Crop	82.94	389.92	68.34	97.29	110.61		82.36
Multiple Crop	79.95	322.05	54.39	74.58	90.63		80.08
Herb Dominated Area	73.01	4.89	77.71		109.98		66.99
Built-Up Non-Linear	63.64	7.50	83.43		76.69		60.46
Brackish Water Aquaculture	62.97	2.72					63.01
Mud Flats or Intertidal Area	54.70	1.42	54.03				0
Brickfield	49.96	1.11			53.18		49.54
Dump Sites/ Extraction Sites	35.74	0.59					35.74
Swamp Reed Land	15.06	0.15					15.06
Sand	14.64	2.44					14.64
Total Other Land (TOF)	**77.80**	**1001.47**	**33.84**	**83.39**	**110.38**	**0.00**	**81.03**

5.4.5 Soil carbon by zone and land cover class

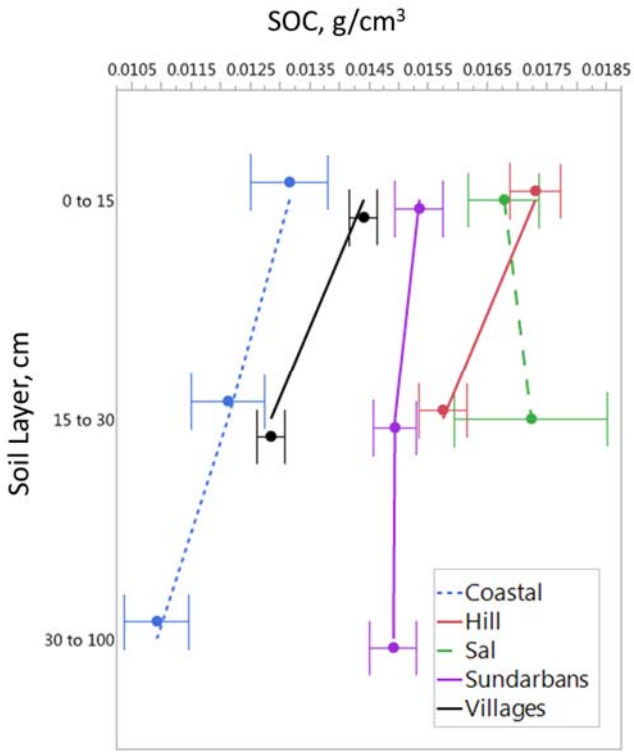


Figure 5.9. Soil carbon (g/cm^3) by depth and by zone. Error bars indicate the stand error of the estimate.

Description

SOC density varies by zone and soil layer. The Hill zone shows highest SOC density up to 30cm depth whereas the lowest SOC density is in the Coastal zone (Table 5.19; Figure 5.10).

Highlights

- The decrease of SOC from 0-15cm to 15-30 cm is highest in the Hill, Village, and Coastal zones (Figure 5.9).
- SOC in the Sundarban zone is about 49 t/ha higher than the Coastal zone in the 30 to 100 cm.
- Among Forest land cover classes, Bamboo Forest shows the highest SOC density (Table 5.20).

Table 5.19. Soil carbon by depth and zone.

Zone	SOC density and stock distributed into different soil depth											
	0-15 cm			15-30 cm			0-30 cm			30-100 cm		
	Mean (t/ha)	Total (million t)	SE	Mean (t/ha)	Total (million t)	SE	Mean (t/ha)	Total (million t)	SE	Mean (t/ha)	Total (million t)	SE
Coastal	34.25	17.47	8.41	31.52	16.08	7.72	65.77	33.55	7.20	132.48	67.58	9.15
Hill	47.21	78.31	3.40	42.76	70.93	3.93	89.97	149.24	3.50			
Sal	42.83	22.36	6.74	41.22	21.52	6.94	84.05	43.89	6.38			
Sundarban	39.86	16.08	4.43	38.82	15.66	4.02	78.68	31.74	3.87	181.52	73.24	4.33
Village	39.16	405.48	2.98	35.02	362.69	3.39	74.18	768.17	3.03			
National	40.13	539.70	2.33	36.20	486.87	2.63	76.33	1,026.59	2.35	154.13	140.82	2.43

Soil organic carbon (SOC) was determined by LOI without removing inorganic carbonates which typically results in higher values than other methods. Samples for 100 cm soil layer were collected from the Sundarbans and Coastal zone only.

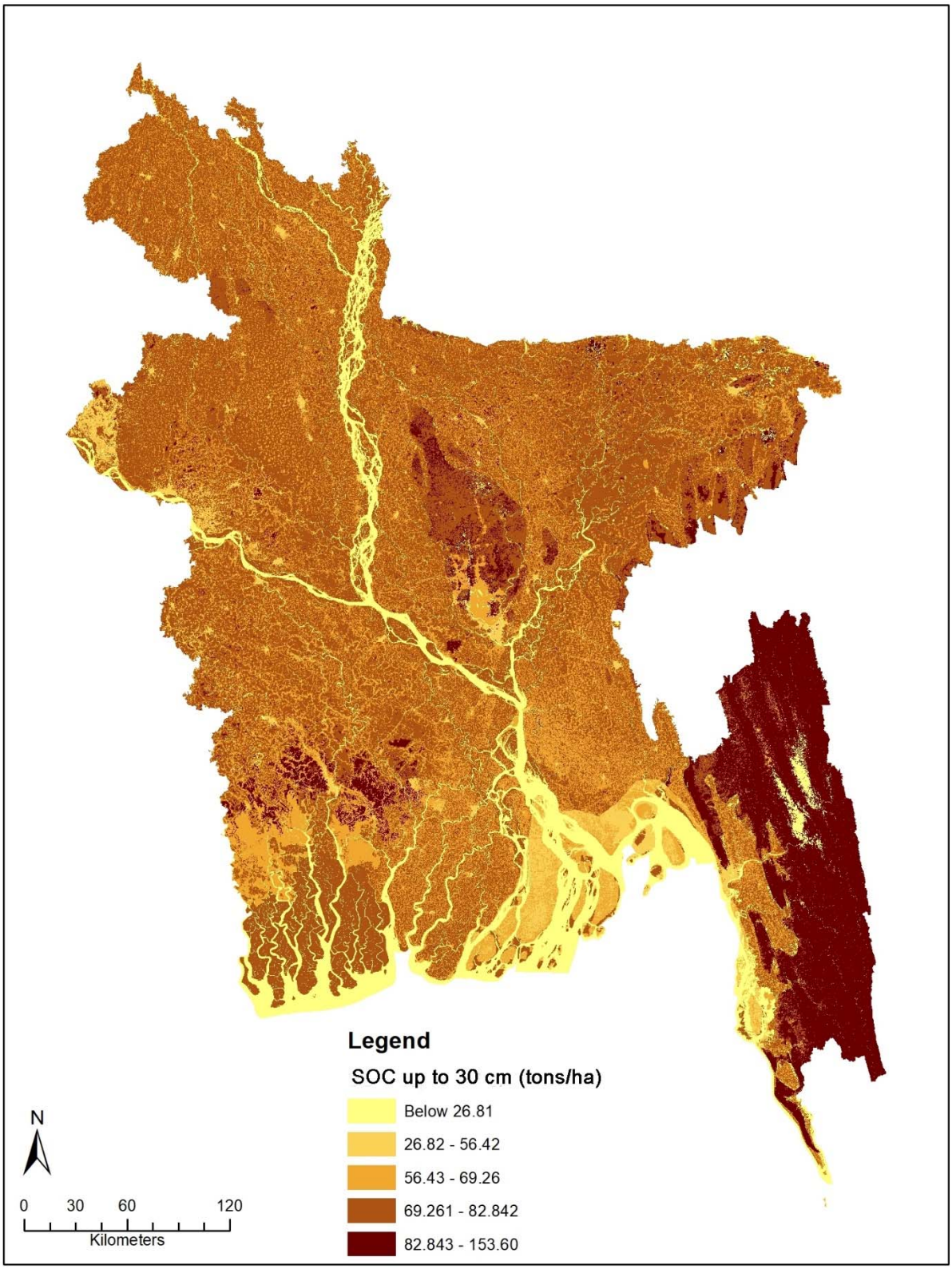


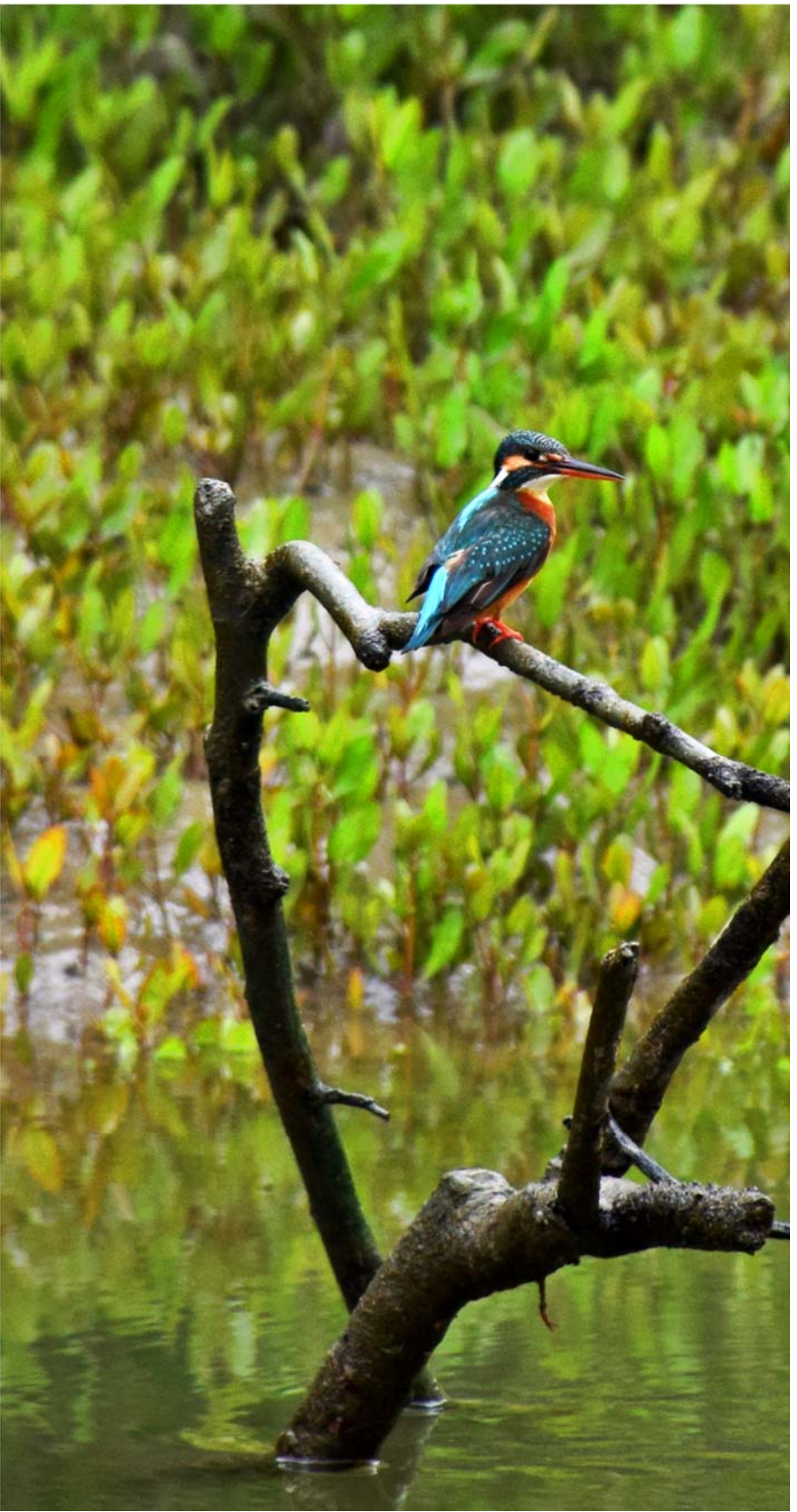
Figure 5.10. Map of the spatial distribution of soil carbon.

Table 5.20. Soil carbon by depth and land cover class.

Land cover class	Number of plots	Distribution of SOC (t/ha) by layer (cm)			SOC to 30cm (t/ha)	Total SOC to 30 cm (million t)
		0-15	15-30	30-100		
Forest						
Bamboo Forest	1	79.04	74.56		153.60	1.26
Shrubs with scattered trees	34	49.23	46.10		95.33	21.45
Hill Forest	214	48.57	43.15		91.72	90.37
Plain Land Forest (Sal Forest)	9	40.53	41.54		82.07	3.86
Rubber Plantation	11	43.15	37.73		80.88	5.20
Forest Plantation	26	42.06	38.62		80.68	11.80
Mangrove Forest	167	39.86	38.82	181.52	78.68	31.74
Mangrove Plantation	35	38.41	35.44	160.00	73.84	15.73
Total Forest	**497**	**46.28**	**42.76**	**43.43**	**89.04**	**181.41**
Other Land (TOF)						
Perennial Beels/Haors	3	66.28	55.96		122.23	4.10
Fresh Water Aquaculture	15	57.24	45.79	79.50	103.02	12.04
Shifting Cultivation	5	53.33	45.43		98.76	1.30
Riverbanks	4	48.33	40.60		88.94	0.33
Orchards and Other Plantations (Shrub)	17	41.54	38.87		80.42	10.19
Single Crop	434	41.67	38.03	123.42	79.71	375.24
Multiple Crop	442	40.20	36.13	99.86	76.34	310.54
Herb Dominated Area	10	38.42	33.50	127.28	71.92	4.83
Ponds	1	40.66	30.30		70.96	0.30
Brackish Water Aquaculture	5	35.94	26.97		62.91	2.72
Rural Settlement	204	32.98	28.97	102.82	61.95	94.45
Orchards and Other Plantations (Trees)	34	32.68	27.87		60.56	17.44
Mud Flats or Intertidal Area	5	27.32	26.66	121.97	53.99	1.41
Brickfield	3	27.60	21.41		49.02	1.09
Built-Up Non-Linear	15	26.22	22.16		48.38	6.22
Dump Sites/ Extraction Sites	1	15.39	20.35		35.74	0.59
Sand	13	7.69	6.65		14.35	2.40
Total Other Land (TOF)	**1211**	**34.20**	**30.56**	**41.49**	**64.77**	**845.19**

Soil organic carbon (SOC) was determined by LOI without removing inorganic carbonates which typically results in higher values than other methods. Samples for 30-100 cm soil layer were collected from the Sundarbans and Coastal zones only.

5.4.6 Soil properties by land cover class



Description

Soil carbon was not the only soil property measured in the BFI. Texture, pH, and Salinity (EC, electric conductivity) were also measured and can give an indication of the quality of soils for certain land cover classes. Soil texture sampled were collected for all soils and depths. In contrast, pH and EC were only measured in the Coastal and Sundarban zones (Table 5.21).

Highlights

- Sandy soils occur in land cover classes typically occurring in hilly areas such as Bamboo Forest, Hill Forest, and Shifting Cultivation.
- EC is noticeably higher, i.e. more saline, in the Mangrove forest compared to the Mangrove Plantation.
- Shrubs with scattered trees and Salt Pans have soils with the lowest pH, i.e. most acidic.

Photo: River Kingfisher, The Sundarban, *©Mondal F.K.*

Table 5.21. Soil properties by depth and land cover class.

Land Cover Classes	Texture (%)			pH in different soil depth (cm)			Salinity (mS/cm in different depth (cm)		
	sand	silt	clay	0-15	15-30	30-100	0-15	15-30	30-100
Forest									
Mangrove Forest	2.28	50.67	47.05	7.43	7.48	7.34	2.82	2.58	2.90
Mangrove Plantation	3.90	56.96	39.14	7.47	7.62	7.73	1.88	1.67	1.63
Bamboo Forest	42.93	19.63	37.45						
Plain Land Forest (Sal Forest)	29.58	40.96	29.47						
Shrubs with scattered trees	51.37	23.44	25.19						
Forest Plantation	48.89	27.46	23.64						
Rubber Plantation	52.38	25.43	22.20						
Hill Forest	58.96	20.01	21.03						
Total Forest	**41.90**	**29.34**	**28.72**	**7.40**	**7.46**	**7.30**	**2.68**	**2.44**	**2.72**
Other Land (TOF)									
Brackish Water Aquaculture	6.65	52.19	41.16						
Fresh Water Aquaculture	27.31	35.76	36.93	8.10	8.18	8.18	0.87	0.66	0.53
Herb Dominated Area	34.53	33.10	32.36	7.18	7.31	7.37	2.42	1.44	1.24
Single Crop	37.38	35.27	27.35	7.49	7.54	7.70	0.34	0.37	0.41
Perennial Beels/Haors	62.46	10.43	27.11						
Ponds	52.49	20.69	26.83						
Multiple Crop	40.04	35.12	24.84	7.34	7.48	7.59	0.29	0.25	0.28
Orchards and Other Plantations (Shrub)	55.77	20.23	24.01						
Shifting Cultivation	59.99	16.23	23.79						
Rural Settlement	36.24	40.39	23.37	7.24	7.54	7.63	0.56	0.46	0.39
Mud Flats or Intertidal Area	5.22	72.68	22.11	7.56	7.64	7.77	1.10	0.95	0.78
Orchards and Other Plantations (Trees)	42.92	35.67	21.42						
Riverbanks	45.46	34.93	19.61						
Brickfield	56.1	25.73	18.18						
Built-Up Non-Linear	59.88	25.56	14.56	7.37	7.49		0.57	0.27	
Sand	72.99	20.02	7.00						
Dump Sites/ Extraction Sites	96.43	1.63	1.95						
Total Other Land (TOF)	**38.19**	**36.44**	**25.37**	**7.30**	**7.44**	**7.54**	**0.54**	**0.48**	**0.45**

Samples for pH, salinity, and 30-100 cm soil layer were collected from the Sundarbans and Coastal zones only.