Scientific Research Publishing

Open Journal of Forestry, 2022, 12, 443-458
https://www.scirp.org/journal/ojf
ISSN Online: 2163-0437
ISSN Print: 2163-0429

The Genesis and Paradigm Shift in Forest Inventory: Bangladesh Chapter

Mahmood Hossain

Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh
Email: mahmoodhossain@hotmail.com

How to cite this paper: Hossain, M. (2022). The Genesis and Paradigm Shift in Forest Inventory: Bangladesh Chapter. *Open Journal of Forestry, 12,* 443-458.
https://doi.org/10.4236/ojf.2022.124025

Received: September 1, 2022
Accepted: October 15, 2022
Published: October 18, 2022

Abstract

Bangladesh (Indo-Bangladesh to independent Bangladesh) has more than 250 years of history in forest inventory. The Boundary demarcation of the Sundarbans forest in 1764 was the first record of forest inventory. A total of 30 inventories have been recorded that were started to form the boundary demarcation to complex biodiversity, biomass, and carbon stock assessment. These inventories used simple cartographic to complex satellite image processing techniques, software base data/information collection methods, and sophisticated statistical procedures in data analysis. Eventually, the history of the forest inventory of Bangladesh is about 100 years older than the history of forest management. This study aimed to classify the inventories into distinct time frames based on outputs and align them with the motive of rulers, existing forest policy, and contemporary global and national issues. The historical records forest inventory has been divided into four distinct periods, e.g., Mid eighteenth to the late nineteenth century: 1764-1876; Early twenty century: 1905-1924; Mid-twenty to late twenty century: 1958-2000; and Early twenty-first century: 2001-present). The objectives/outputs of each inventory were highly linked with the motive of rulers, policy statements, available technologies, and recent issues from national and global perspectives.

Keywords

Biomass Stocking, Carbon Assessment, Forest Policy, Inventory, Sustainable Management, Volume Stocking

1. Introduction

Ancient populations were highly dependent on the forest for food and shelter. The utilization, and destruction of forest resources, have increased significantly

with the progress of human civilization (Williams, 2003; FAO, 2016). Large-scale conversion of forests to agricultural lands was observed in the middle age to meet the demand for food for the increasing population. The forests were converted for other land uses (e.g., urban areas, industrial estates, sea, airports, etc.) (Lambin & Meyfroidt, 2011; FAO, 2016). The 1st, 2nd, and 3rd industrial revolutions also accelerated these conversions (Lambin & Meyfroidt, 2011) and led to the establishment of many governments and privately-owned wood-based industries in Bangladesh in the last century (Banglapedia, 2021a). At present, large-scale wood-based industries, e.g., furniture, pulp, paper, etc., are also operating around the globe to fulfill the demand of society (Hetemäki & Hurmekoski, 2016; Ramage et al., 2017). With time, people realize the importance of forests for national and household demand, livelihood, and environmental well-being (Turner et al., 2006). Assessment of forest resources is essential to ascertain the present and future uses (FAO, 2015). On the other hand, the conversion, protection, and conservation initiatives for the forests of Indo-Bangladesh have changed with time (Millat-e-Mustafa, 2002). Knowledge of the importance of forests at the local, regional and global scale and the utilization of forest resources help to formulate forest policy, conservation, and utilization strategies. Therefore, the existing forest policy, the demand of society and nation, available knowledge and technologies, and contemporary national and global issues ultimately govern the extent and objectives of forest inventory (FAO, 2020). Forest inventory is the footing of forest management. Bangladesh (Indo-Bangladesh region) has a long history of scientific forest management that started in 1869 with the appointment of an Assistant Conservator of forest for the region (Bhattacharyya, 2011; Adrija, 2017). However, good numbers of forest inventories have been reported for the Indo-Bangladesh since 1764. The initial inventories delineated the forest boundary and the latter assessed the biomass and carbon stocking in a forest ecosystem, land use, and community dependency on the forest using a field survey of high-resolution satellite image (Costello et al., 2016).

This study reviewed all the available inventories of Indo-Bangladesh to independent Bangladesh based on objectives, use of technologies, outputs and tried to align with the motive of the rulers, existing forest policy and contemporary national and global issues. This study will give an insight into each inventory that can help to classify them into the distinct time frame and help to understand the drivers and their role in changing the outputs of inventories with time. It organizes the findings of the evaluation of forest inventory into four distinct periods and ends with a conclusion.

2. Forest Inventories in Bangladesh

A total of 30 forest inventories have been identified for the Indo-Bangladesh region since 1764. Among these inventories, six inventories/surveys were conducted during the British colonial period. Only 3 inventories were conducted by the Pakistan regime, while 21 inventories were led after the independence of

Bangladesh including two national forest inventories (**Annex 1**). The forests of Bangladesh can be classified into five zones as Sundarbans, Hill, Sal, Coastal and Village (GoB, 2019) and all the inventories were categorized according to the forest zones for further discussion. Early inventories (1764 to 1960) were vested only for the Sundarbans, but the highest number of inventories were conducted for the Hill zone followed by the Sundarbans (**Figure 1**) (**Annex 1**). All the inventories used the field survey method and only 7 included both the field survey and remote sensing techniques for the production forest maps (**Figure 2**). A wide array of output was observed for these inventories and the outputs were organized into 15 distinct categories starting from forest boundary demarcation to biodiversity, biomass and carbon stock, and social and economic considerations. However, growing stock assessment in terms of volume was the highest parameter of interest followed by the production of maps (**Figure 3**). The objectives/outputs of

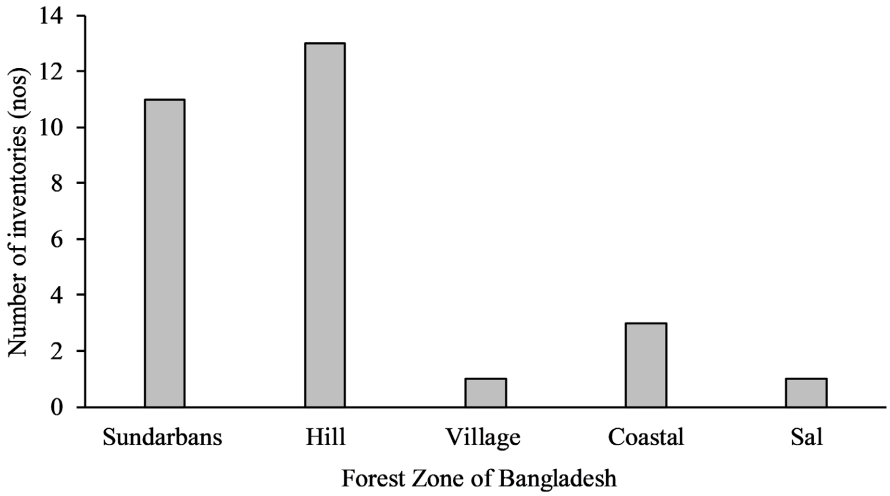

Figure 1. Number of forest inventories (2 National Forest inventories are excluded) for forest zones of Bangladesh since 1764 (Annex).

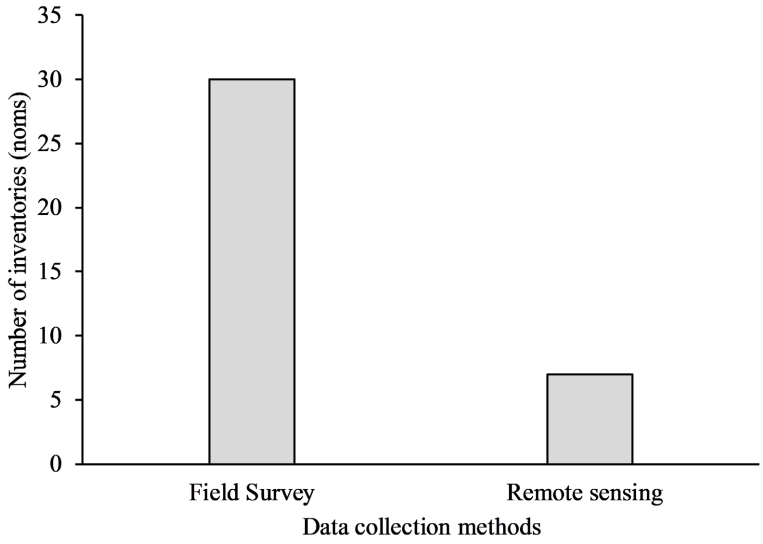

Figure 2. Data collection methods for forest inventories in Bangladesh since 1764 (Annex).

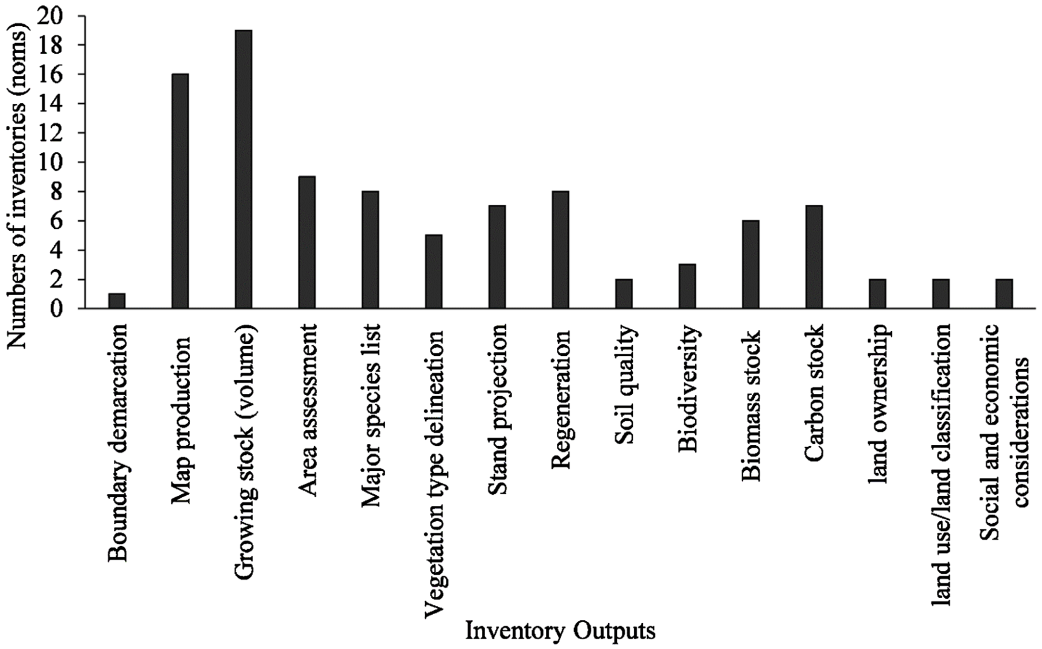

Figure 3. Major outputs of forest inventories in Bangladesh since 1764 (Annex).

inventories were found to vary in time, availabilities of technologies, resources utilization, quality and quantity of forest resources, forest policy and needs of the society and country (Kohl et al., 2006).

3. Evolution of the Forest Inventory

The number of inventories for the particular forest zone, the method of data/information collection, and the outputs of each inventory varied significantly (Costello et al., 2016). Bangladesh (Indo-Bangladesh to independent Bangladesh) has more than two hundred fifty years of history in forest inventory starting from 1764, which can be divided into four distinct periods (Mid eighteenth to the late nineteenth century: 1764-1876; Early Twentieth century: 1905-1924; Mid-twenty to the late twentieth century: 1958-2000; and Early twenty-first century: 2001-present) based on outputs and technology used. The number of inventories has increased significantly and also the outputs of inventories were getting complex and diversified with time and technology of data/information collection (**Figure 4**). The comparatively highest rate (3.81 inventory/10 years) was observed for the early twenty-first century (2001-present) and the lowest (0.04 inventory/10 years) was observed from the mid-eighteenth to the late nineteenth century (1764-1876) (**Figure 5**). However, we are interested in finding the linkage between the objectives/outputs of these forest inventories and the intention of rulers/administrators, available technologies, existing forest policy, and contemporary national and global issues.

3.1. Mid Eighteenth to Late Nineteenth Century (1764-1876)

The mid-eighteenth to the late nineteenth century (1764-1876) was the British

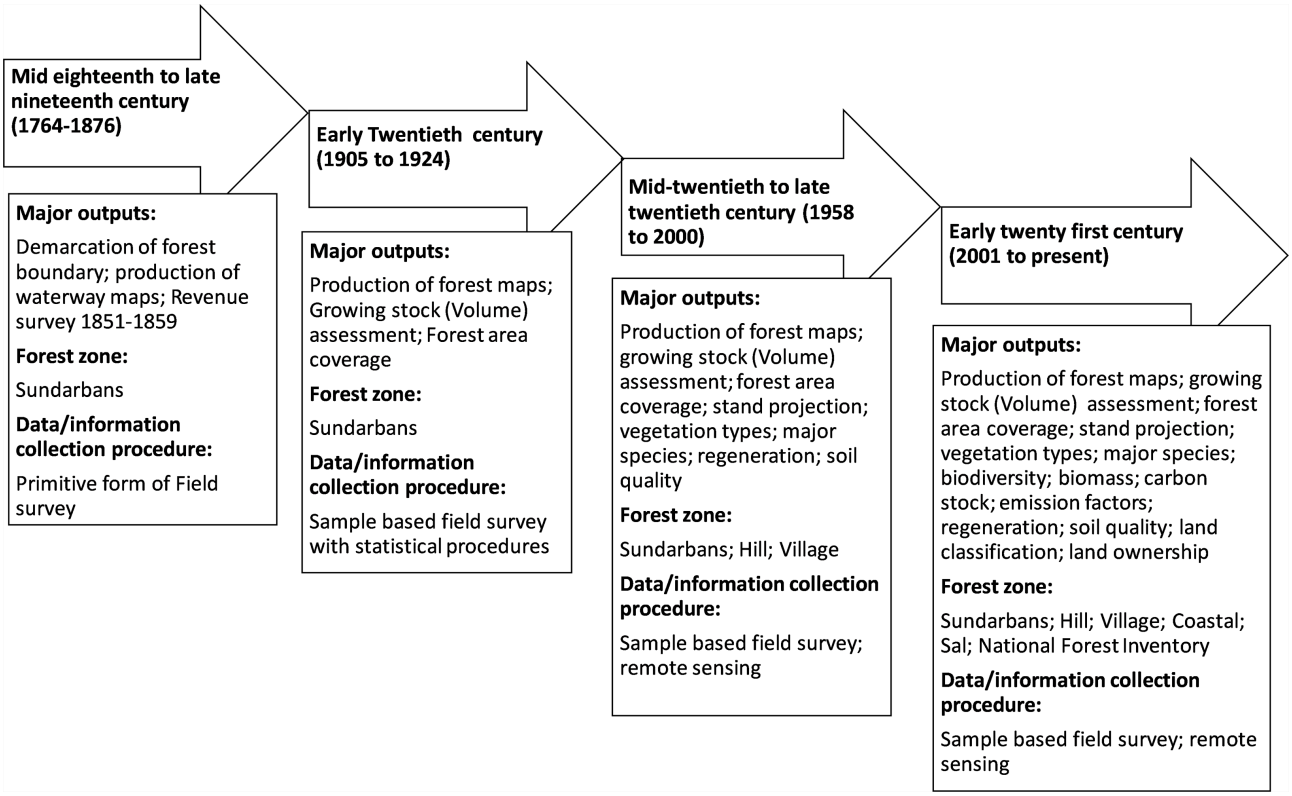

Figure 4. Time period of forest inventories along their outputs, forest zones and data/information collection procedure (Annex).

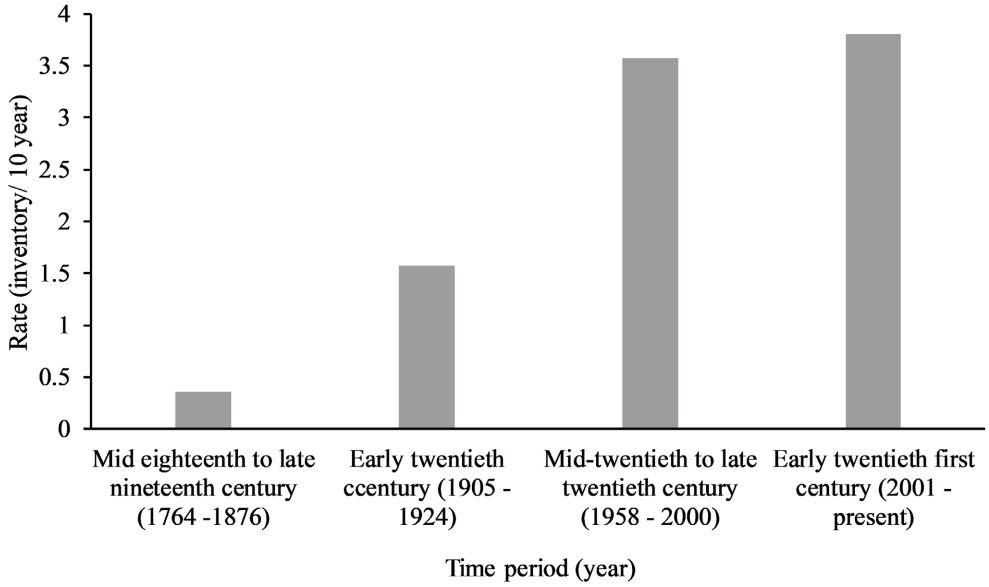

Figure 5. Rate (number of inventory/10 years) of forest inventory in each period (Annex).

colonial regime in India. The forest inventories during this period were only vested for the Sundarbans. The British East India Company took absolute control over the Indo-Bangladesh after the battle of Plassey in West Bangle and Buxar in Bihar in 1757 and 1764 respectively. As new administrators, they developed maps to demarcate the boundary of important places and areas of inter-

est, which enabled them to ensure their strategic, administrative, and economic activities over the territory (Adrija, 2017). As part of these activities, the British administrator took the first initiative to demarcate the boundary of the Sundarbans in 1764. They also prepared a map of the larger waterways of the Sundarbans from 1767 to 1773. Eventually, it was the part of The Bangal Atlas that was published in 1779 by James Rennel (Bhattacharyya, 2011; Banglapedia, 2021b).

The trigonometric methods of the survey gained popularity and accuracy over the previous technology of cartographic at the beginning of the nineteenth century (1802) in India (Gill, 2001). From 1821 to 1829, Lt. Princep, and Lt. Hodges used trigonometric method of the survey to delineate the accurate boundary between the Sundarbans and cultivated lands and they produced a map (scale: 1 inch = 1 mile) for the Sundarbans. Again, Mr. James Ellison 1851 to 1859, produced another map of the Sundarbans at a smaller scale of 1 inch = 4 miles. He also conducted a revenue survey for the Sundarbans for the first time in the history of the forest inventory of Indo-Bangladesh (**Annex 1**) (Costello et al., 2016). Delineation of forest boundaries and prepared forest maps were used to convert a part of the Sundarbans to cultivable lands and a significant forest area was converted to agricultural lands within 1875 (Bhattacharyya, 2011). However, this conversion was not profitable due to the unfavorable environmental conditions and less productive capacity of the soil (Mahmood et al., 2021).

After 1865, a significant improvement was noted with the declaration of the Indian Forest Act 1865. The appointment of an Assistant Conservator of Forests in 1869 was the first step of Forest Administration in Indo-Bangladesh, which was the starting of scientific forest management in Indo-Bangladesh. Moreover, the first forest policy was declared in 1894 with the objective of revenue generation from the forests and giving importance to advancing the agriculture sectors (Millat-e-Mustafa, 2002).

3.2. Early Twentieth Century (1905-1924)

The forest policy of 1894 likely influenced the revenue generation from the forest through production forestry as well as continued to convert forest areas to agricultural lands (Bhattacharyya, 2011; Mahmood et al., 2021). It can be believed that the objectives/outputs (e.g., demarcation of forest areas, preparation of forest maps, and stock assessment) of the subsequent inventories were to detect the change dynamics over time. Dhaka, Chittagong, and Sundarbans forest divisions were established at almost the same time. But, the Sundarbans got the attention of the forest inventory during this period. The fifth forest inventory was conducted from 1905 to 1909 to produce maps (scale: 1 inch = 1 mile) to assess the changes in forest land cover after the conversion to agricultural lands. In 1924, Mr. Curtis produced the largest map of the Sundarbans with a scale of 2 inches = 1 mile and assessed the growing stock (volume) of the important tree species of the Sundarbans and assessed the gain and loss of forest land areas due to accretion and erosion over the time (**Annex 1**). The inventory by Curtis was

complex compared to the previous and he used statistical calculation for the first time. Until that time, extraction of forest resources and revenue earning were the central concerns of forest management (Mahmood et al., 2021).

A comprehensive new Forest Act was adopted in 1927. The administrative capacity of the forest personnel was enhanced significantly for the management of the forests (Rahman, 2005). On the other hand, the forest policy 1894 was revised in 1955 to address the contemporary issues after the independence of Pakistan, and a new forest policy was declared in 1955. This policy was significantly updated with the view of the utilization of forest resources for the national demand as well as conservation of forests and protection of wildlife (Millat-e-Mustafa, 2002; Biswas & Choudhury, 2007). The policy statements influenced the outputs of the subsequent inventories for the period from 1958 - to 1984 (**Annex 1**).

3.3. Mid-Twentieth to Late Twentieth Century (1958-2000)

A total of 15 forest inventories were conducted during this period. Among them, three were during the Pakistan regime, and the rest of the twelve were after the independence of Bangladesh, which covered the Sundarbans, Hill, Village and Coastal zone (**Annex 1**). This period experienced the implementation of four forest policies, e.g., Forest policy 1955, Forest policy 1962, Forest policy 1979 and Forest policy 1994. The forest policy 1955 and 1962 emphasized the commercial utilization of forest resources as production forestry, development of forest base industries, improvement of forest stock through natural regeneration and plantation. It is believed that these policy statements had a significant influence on the utilization and management of forest resources and the formulation of objectives of the concerned forest inventory. It could be the reason for experiencing different categories of forest inventories in terms of the use of technologies, parameters of interest, extent, inclusion of forest types/zones, and outputs. However, the inventory outputs increased significantly compared to the early twentieth century (1904-1924).

Remote sensing (aerial photo) technology was used in 1958 for the first time in the forest inventory with the field survey (**Annex 1**). It was the evolution in the preparation of more accurate forest maps on a larger scale. FORESTAL (Forestry and Engineering International Limited, Canada) conducted forest inventories for the Sundarbans, Sangu-Matamuhuri reserved forests, Kassalong and Rankhiang reserve forests during 1958-59, 1961-63 and 1964, respectively. The objectives of these inventories were to prepare forest maps, assessment of growing stock (volume), and supply of raw materials for the forest-based industries, e.g., Karnaphuli Paper Mill Ltd., Khulna Newsprint Mill Ltd., Khulna Hard Board Mill Ltd., and Karnaphuli Rayon & Chemical Ltd. those were established in-between 1953 to 1967.

The first forest policy was approved in 1979 after the independence of Bangladesh, which continued until 1994. The Forest Policy 1979 focused on the

scientific management of forests, development and raw material support to forest-based industries, discouraging the conversion of forest areas to other uses, enhancement of plantation activities in coastal areas and depleted hills, ensuring the mass participation in plantation (Millat-e-Mustafa, 2002). The first inventory of village forest (village zone) was conducted in 1980-81 to estimate the wood and non-wood stocking. From 1981 to 1984, a total of four inventories was conducted for hill zone (Kaptai reserved forest; Sangu and Matamuhuri Reserve Forests, Kassalong and Rankhiang reserves; Sitapahar reserved forest and Chittagong and Cox's Bazar Forest Divisions) to assess the growing stock (volume), delineation of forest type and preparation of maps using field survey and aerial photos. On the other hand, Overseas Development Administration (ODA) in 1980 conducted a comprehensive inventory of the Sundarbans. It was the first generation of modern inventory comprising seven outputs (**Annex 1**). Till today, this inventory is considered a basis of comparison for the vegetation types of the Sundarbans and growing stock (volume) (Mahmood et al., 2021). Piloting of coastal plantation was mentioned in Forest Policy 1962, while Forest Policy 1979 gave further importance to the implementation of coastal plantation on the coasts and offshore islands. In 1987, the first inventory was conducted on the coastal afforestation with mangrove species. In this inventory, Bangladesh Space Research and Remote Sensing Organization (SPARRSO) produced land accretion and plantation maps. They also assessed the growing stock (volume) and growth of the coastal plantation (Drigo et al., 1987). Here the linkage between the Forest Policies and inventories inventory was identical. At the same time, Bangladesh Forest Department with SPARRSO conducted another inventory for the Southern Sylhet Forest Division and assessed the growing stock (volume) and produced maps for vegetation and forest area (Drigo et al., 1988).

At the end of this period, a new forest policy evolved in 1994. This policy highlighted the mass scale afforestation on both public and private lands; conservation and protection of biodiversity and natural habitats; implementation of various efforts and government ratified agreements relating to global warming, desertification; encroachment, illegal felling of trees and hunting of wild animals; and effective utilization of forest products/resources. This policy opened a new horizon of forest management in Bangladesh, which is reflected in all aspects of subsequent forest inventories for the different forest zones. On the other hand, National Environmental Management Action Plan was developed for the period of 1995 to 2005 to address the actions required to reduce the rate of environmental degradation, improvement of the natural environment, conservation of habitats and biodiversity, which were very much related to the forestry sector (GoB, 1995). In 1998, Bangladesh Forest Department also conducted several inventories to develop Forest Resource Management Plan (FRMP) for different forest divisions. These inventories derived growing sock (volume), stand projection, forest area map, listing of the major species and regeneration status (**Annex 1**). Thus, these inventories addressed the focal statements of the Forest Policy

1994 and National Environmental Management Action Plan 1995.

3.4. Early Twenty First Century (2001-Present)

At the beginning of the twenty-first century, the Sal zone of Bangladesh (Sal Forests of Dhaka, Tangail, Mymensingh, Dinajpur, Rangpur, and Rajshahi forest divisions) was bought under inventory for the first time to assess the growing stock (volume), forest structure, list of the major species, and regeneration status. Two nationwide inventories were conducted in 2005-2007 and 2017 to assess the forest cover, land classes and other parameters. These nationwide inventories were vast and comprehensive in nature (**Annex 1**). However, the nationwide forest inventory of 2017 used the latest modern equipment and data/information collection methods with a higher degree of accuracy compared to all inventories in the past (Hossain et al., 2019). A special inventory on the floral diversity of the Sundarbans was also conducted in 2014. Besides these, there were four inventories in different protected areas of the Hill and Coastal zones of Bangladesh (**Annex 1**).

The nationwide forest inventory of 2005-2007 assessed the biomass and carbon stock in the forested and trees outside the forest with other parameters of interest for the first time in the history of forest inventory (**Annex 1**). Climate change issues and their mitigation measures and the role of forests are well-discussed agendas around the globe and in Bangladesh at the beginning of this century. Along with these, The Clean Development Mechanism (CDM) under the Kyoto Protocol, Millennium Development Goals (MDGs) (Goal 7 Ensure environmental sustainability), Sustainable Development Goals (SDGs) (Goal 13 Climate action: Take urgent action to combat climate change and its impact), Bangladesh Climate Change Strategic Action Plan 2009, UU-REDD Bangladesh Programme and The Bangladesh National REDD+ Strategy (BNRS) or action plan have significant contributions in formulating the objectives/outputs of the forest inventories in the early twenty-first century. It could be the reason for estimating the biomass and carbon stock in the forested and protected areas by most of the inventories (7 out of 9) in this period (**Annex 1**). These measurements and outputs of the recent forest inventories have made them compatible with the national and global interest in climate change mitigation measures.

4. Conclusion

The forest inventories in Bangladesh were started before starting forest management initiatives during the Indo-Bangladesh regime. With time, the objectives and outputs of forest inventories were aligned with the demand of society, administrators of the country, and forest policies. It is evidenced that the forest inventories of Bangladesh have addressed the national and global climate change perspectives, which is the prime concern at this time. It is believed that the present form and extent of forest inventories in Bangladesh will be able to support sustainable forest management and sustainable development of the country.

Acknowledgements

The author acknowledges the cordial support of the Bangladesh Forest Department for providing access and collection of information from their achieve.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Adrija, R. (2017). *Survey of India Turns 250: Remembering a British Past When Mapping Was for the Sake of Conquering*. The Indian Express. https://indianexpress.com/article/research/survey-of-india-turns-250-remembering-a-british-past-when-mapping-was-for-the-sake-of-conquering-4609008

Banglapedia (2021a). *Forest Industries*. https://en.banglapedia.org/index.php?title=Forest_Industries

Banglapedia (2021b). *Rennell's Atlas*. https://en.banglapedia.org/index.php/Rennell's_Atlas

Bhattacharyya, S. (2011). *A History of the Social Ecology of Sundarbans: The Colonial Period*. PhD Thesis, Jadavpur University.

Biswas, S. R., & Choudhury, J. K. (2007). Forests and Forest Management Practices in Bangladesh: The Question of Sustainability. *International Forestry Review, 9,* 627-640. https://doi.org/10.1505/ifor.9.2.627

Costello, L., Sola, G., Akhter, M., Aziz, T., Akhter, H., & Henry, M. (2016). *Forest Biomass in Bangladesh: An Historical Review of Forest Inventories to Assist National Estimates* (38 p.). Dhaka, Bangladesh Forest Department, Food and Agriculture Organization of the United Nations.

Drigo, R., Latif, M. A., Chowdhury, J. A., & Shaheduzzaman, M. (1987). *The Maturing Mangrove Plantations of the Coastal Afforestation Project*. Food and Agricultural Organization of the United Nations, FAO/UNDP Project BDG/85/085, Assistant to the Forestry Sector.

Drigo, R., Shaheduzzaman, M., & Chowdhury, J. A. (1988). *Inventory of Forest Resources of Southern Sylhet Forest Division*. Food and Agricultural Organization of the United Nations, FAO/UNDP Project BDG/85/085, Assistant to the Forestry Sector.

FAO (2015). *Global Forest Resources Assessment 2015: How Are the World's Forests Changing*? Food and Agriculture Organization of the United Nations.

FAO (2016). *State of the World's Forests 2016. Forests and Agriculture: Land-Use Challenges and Opportunities*.

FAO (2020). *Global Forest Resources Assessment 2020: Main Report*. Food and Agriculture Organization of the United Nations.

Forestal (1960). *Pakistan Industrial Development Coorporation—Khulna Newsprint Mill Forest Inventory 1958-1959, Sundarbans Forest*.

Gill, B. (2001). The Big Man. Surveying Sir George Everest. *Professional Surveyor Magazine, 21,* 10. https://www.krcmar.ca/resource-articles/2000_Winter_The%20Big%20Man-%20Surveying%20Sir%20George_1.pdf

GoB (1995). *National Environmental Management Action Plan (NEMAP) Volume II*

Main Report. Ministry of Environment and Forest, People's Republic of Bangladesh.

GoB (2019). *Tree and Forest Resources of Bangladesh: The Results of the Bangladesh Forest Inventory Cycle 1*. Forest Department, Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Hetemäki, L., & Hurmekoski, E. (2016). Forest Products Markets under Change: Review and Research Implications. *Current Forestry Reports, 2,* 177-188. https://doi.org/10.1007/s40725-016-0042-z

Hossain, M. A., Aziz, A., Chakma, N., Johnson, K., Henry, M., Jalal, R., Carrillo, O., Scott, C., Birigazzi, L., Akhter, M., & Iqbal, Z. (2019). *Estimation Procedures of Indicators and Variables of the Bangladesh Forest Inventory*. Forest Department and Food and Agricultural Organization of the United Nations, Dhaka, Bangladesh.

Kohl, M., Magnussen, S., & Marchetti, M. (2006). *Sampling Methods, Remote Sensing and GIS Multiresource Forest Inventory* (373 p.). Springer. https://doi.org/10.1007/978-3-540-32572-7

Lambin, E. F., & Meyfroidt, P. (2011). Global Land Use Change, Economic Globalization, and the Looming Land Scarcity. *Proceedings of the National Academy of Sciences of the United States of America, 108,* 3465-3472. https://doi.org/10.1073/pnas.1100480108

Mahmood, H., Ahmed, M., Islam, T., Uddin, M. Z., & Saha, C. (2021). Paradigm Shift in the Management of the Sundarbans Mangrove Forest of Bangladesh: Issues and Challenges. *Trees Forests and People, 5,* Article ID: 100094. https://doi.org/10.1016/j.tfp.2021.100094

Millat-e-Mustafa, M. (2002). *A Review of Forest Policy Trends in Bangladesh—Bangladesh Forest Policy Trends* (pp. 114-121). Policy Trend Report.

Rahman, L. M. (2005). *Policy, Law and Administration for Protected Area Management in Bangladesh*. Nishorgo Support Project, USAID, Bangladesh Forest Department, Dhaka, Bangladesh.

Ramage, M. H., Burridge, H., Busse-Wicher, M., Fereday, G., Reynolds, T., Shah, D. U., Wu, G. L., Fleming, P., Densley-Tingley, D., Allwood, J., Dupree, P., Linden, P. F., & Scherman, O. (2017). The Wood from the Trees: The Use of Timber in Construction. *Renewable and Sustainable Energy Reviews, 68,* 333-359. https://doi.org/10.1016/j.rser.2016.09.107

Revilla, J. A. V., Ahmed, I. U., & Mahbub, A. (1998a). *Forest Inventory of the Natural Forest and Forest Plantations (Chittagong Forest Division) Final Report, Volume 1*. Mandala Agricultural Development Corporation and Forest Department, Ministry of Environment and Forests, Dhaka, Bangladesh.

Revilla, J. A. V., Ahmed, I. U., & Saha, U. K. (1998b). *Forest Inventory of the Natural Forest and Forest Plantations (Sylhet Forest Division), Final Report*. Gob/Wb, Forest Resources Management Project, Technical Assistance Component. (Mandala Agricultural Development Corporation and Forest Department, Ministry of Environment and Forests, Dhaka, Bangladesh).

Revilla, J. A. V., Ahmed, I. U., & Hossain, A. (1998c). *Forest Inventory of the Coastal Plantation of Coastal District of Bangladesh, Final Report, Volume 1*. Mandala Agricultural Development Corporation and Forest Department, Ministry of Environment and Forests, Dhaka, Bangladesh.

Revilla, J. A. V., Ahmed, I. U., & Hossain, A. (1998d). *Forest Inventory of the Sundarbans Reserved Forest, Final Report, Volume 1*. Mandala Agricultural Development Corporation and Forest Department, Ministry of Environment and Forests, Dhaka, Bangladesh.

Turner, J. A., Buongiorno, J., Maplesden, F., Zhu, S., Bates, S., & Li, R. (2006). *World*

Wood Industries Outlook: 2005-2030 (84 p.). New Zealand Forest Research Institute Ltd, Forest Research Bulletin No. 230.

Williams, M. (2003). *Deforesting the Earth: From Prehistory to Global Crisis*. University of Chicago Press.

Annex

Annex 1. List of forest inventory for the Bangladesh and the related information (Source: Costello et al., 2016).

Sl	Inventory period	Institution/ Authors	Coverage	Zone	Procedure	Outputs
1	1764	William Dampire and Lieutenant Hodges	Sundarbans	Sundarbans	Field Survey	Demarcation of boundaries of the Sundarbans.
2	1769-1773	Messrs. Ritchie, Richards and Martin	Sundarbans	Sundarbans	Field survey	Map production of larger waterways of the Sundarbans (scale 1 inch = 5 mile)
3	1821-1823 & 1829	Lt. Princep, Lt. Hodges	Sundarbans	Sundarbans	Field survey	Delineation of boundary between the Sundarbans forest and cultivated lands and production of Maps (scale: 1 inch = 2 mile)
4	1851-1855 & 1855-1859	Mr. James Ellison	Sundarbans	Sundarbans	Field survey	Production of Maps (scale: 1 inch = 4 mile) and revenue survey
5	1905-1909	Bengal Survey Department	Sundarbans	Sundarbans	Field survey	Production of map (scale: 1 inch = 1 mile)
6	1924	Mr. Curtis	Sundarbans	Sundarbans	Field survey	Production of map (scale 2 inch = 1 mile), growing stock assessment; assessment of gain and loss of forest land areas due to accretion and erosion over the time
7	1958-1959	FORESTAL (Forestry and Engineering International Limited, Canada) (Forestal, 1960)	Sundarbans	Sundarbans	Field survey and Aerial photos	Forest cover maps (scale: 5.08 cm = 8.05 km), volume, yields, species for wood supply for the proposed newsprint mill at Khulna
8	1961-1963	FORESTAL (Forestry and Engineering International Limited, Canada)	Sangu-Matamuhuri Reserved Forests	Hill	Field survey and Aerial photos	Inventory report of of timber and bamboo of these forests and produce working plan for Sangu-Matamuhuri Reserved Forests for the period of 1967- to 1986-87
9	1964	FORESTAL (Forestry and Engineering International Limited, Canada)	Hill Forests – Kassalong and Rankhiang Reserve Forests	Hill	Field survey and Aerial photos	Stand and stock tables. Topo maps at 1:15,840 and forest cover maps
10	1980-1981	Mr. Hammermaster-FAO/UNDP Village Forest Inventory,	Surveyed 267 village units (all Districts except Chittagong Hills)	Village	Field survey and Field survey	Report on growing stock of village forests and bamboo, non-wood value trees
11	1981-1982	Forest Inventory Division of the Forest Research Institute - Chittagong	Kaptai Reserved Forests	Hill	Field survey	Report on area, stocking, major species of pulpwood Plantation.
12	1983-1984	FAO/UNDP under 'Assistance to the Forestry Sector of Bangladesh' Project	Sangu and Matamuhuri Reserve Forests-Kassalong & Rankhiang reserves; Sitapahar Reserved Forests	Hill	Field survey and Field survey	Forest type delineation: (i) shifting cultivation (ii) apparently exploitable high forest production of map (scale 1: 50,000)

Continued

13	1984	Overseas Development Administration (ODA)	Sundarbans	Sundarbans	Field survey and Aerial photos	Production of forest type/vegetation maps (scale 1:50,000); Incidence of top dying of Sundri (scale 1:10,000); Stand structure, growing stock (volume) of important species, stand projections and regeneration, soil quality
14	1984	FAO/UNDP	Sitapahar Reserve	Hill	Field survey and Aerial photos	Report on forest type: plantations and natural forests production of map (scale 1:30,000)
15	1984	FAO/UNDP	Chittagong and Cox's Bazar Forest Divisions	Hill	Field survey and Aerial photos	Report on area, number of trees per ha. (dbh classes), bamboo. production of map (scale 1:15,000)
16	1987	Drigo et al. (1987)	Mangrove Plantation – Coastal Afforestation.	Coastal	Field survey and Satellite image	Land accretion (scale 1: 50,000) and plantation map (scale 1:10,000); growing stock (volume), growth of the maturing mangrove stands
17	1988	Drigo et al. (1988)	Southern Sylhet Forest Division	Hill	Field survey and Satellite image	Production of Map for vegetation and forest area; Growing stock (volume);
18	1998	Revilla et al., 1998a, Under Forest Resource Management Plan (FRMP) project	High Forest: Chittagong and Cox's Bazar Forest Divisions	Hill	Field survey	Preparation of forest maps, Growing sock, stand projection, area coverage, major species and regeneration status
19	1998	Revilla et al., 1998b, Under Forest Resource Management Plan (FRMP) project	Sylhet Forest Division	Hill	Field survey	Preparation of forest maps, Growing sock, stand projection, area coverage, major species and regeneration status
20	1998	Revilla, et al., 1998c, Under Forest Resource Management Plan (FRMP) project	Coastal plantations of Coastal districts of Bangladesh	Coastal	Field survey	Preparation of forest maps, Growing sock, stand projection, area coverage, major species and regeneration status
21	1998	Revilla et al., 1998d, Under Forest Resource Management Plan (FRMP) project	Sundarbans	Sundarbans	Field survey	Preparation of forest maps, Growing sock, stand projection, area coverage, major species and regeneration status
22	2001	Bangladesh Forest Department, Forestry Sector Project	Sal Forests of Central and Northwest Bangladesh (Dhaka, Tangail, Mymensingh, Dinajpur, Rangpur and Rajshahi forest divisions)	Sal	Field survey	Growing stock (volume), forest structure, list of major species, regeneration

Continued

23	2005-2007	Bangladesh Forest Department, FAO & SPARRSO	All over the country	NFI	Field survey and satellite image	Land use classes, forest area, forest ownership, trees outside forest, forest products, growing stock (volume), list of major species, biodiversity and regeneration, biomass and carbon stock, soil quality, social and economic aspects.
24	2008	Bangladesh Forest Research Institute (BFRI)	Chunati Wildlife Sanctuary	Hill	Field survey	Growing stock (volume), soil organic carbon, above and below ground biomass
25	2009	Bangladesh Forest Department under the USAID-funded Integrated Protected Area Co-management (IPAC) project	Sundarbans	Sundarbans	Field survey	Biomass and carbon stock
26	2011	Bangladesh Forest Department under the USAID-funded Integrated Protected Area Co-management (IPAC) project	Six protected areas: (Teknaf, Fasiakhali, Dhopachari wildlife sanctuary; Inani, Medakachapia national park; Dudpukuria, Sitakunda eco-park)	Hill	Field survey	Carbon stock
27	2014	European Union under Sundarbans Environmental and Livelihoods Security (SEALS) Project	Sundarbans	Sundarbans	Field survey	Floral diversity of the Sundarbans
28	2014	Bangladesh Forest Department and Winrock International under USAID supported CREL project	Eight protected areas: (Khadimnagar, Lawachara, Modhupur, Kaptai, Himchari, and Satchari national park; Rema-Kalenga and Chunati wildlife sanctuary)	Hill	Field survey	Biomass and carbon stock
29	2015	Bangladesh Forest Department and Winrock International under USAID supported Climate-Resilient Ecosystems and Livelihoods (CREL) project	5 protected areas: (Baroiyadhala and Nijhim Dweep national park; Hazarikhil, and Tengragiri wildlife sanctuary; Ratargul special biodiversity conservation area)	Hill and coastal	Field survey	Biomass and carbon stock

Continued

30	2017	Bangladesh Forest Department and FAO	All over the country	NFI	Field survey and satellite image	Land use classes, forest area, forest ownership, trees outside forest, forest products, growing stock (volume), list of major species, biodiversity and regeneration, biomass and carbon stock, soil quality, social and economic aspects.