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# Evaluation of Trees Outside Forests in India with special reference to Manipur State: A Review

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**Abstract**
In India, trees outside forest (TOF) are promising area of timber supply to fulfil the timber needs. All the states in India, followed designated guides to expand the timber supply from TOF. Traditional systems of growing trees in and around urban areas, agriculture fields, raising arable crops or grasses, etc., have provided life support and sustainability to the agro-ecosystems in all regions. In the present paper, the notion of TOF, is discussed in relation to the general definition of forests.The total growing stock of wood in the TOF in India is estimated to be 1, 616 million $m^3$, with maximum growing stock in TOF area was found in Western Himalayas followed by Eastern Deccan and West Coast. In Manipur forest, carbon stock in the aboveground biomass was recorded to be highest in the sub-tropical forest (319.18 mg ha-1), followed by temperate (54.45 Mg ha-1) and tropical forest (38.35 mg ha-1). The significance of TOF, particularly in agro-forestry and pasture development, and urban environment has also been dealt with scientific methods of carbon stock and carbon sequestration. Assessment of TOF in India as well as in the state of Manipur, is also summarised, giving more emphasis on the conservation of indigenous trees which are depleted day by day.

**Keywords:** Trees outside forests, FSI, FAO, extent of TOF, Urban ecosystem, carbon sequestration, Traditional methods, India, Manipur State.

## 1. Introduction

In India, Trees Outside Forests (TOF) are the trees, developing external to the public authority Recorded Forest Area (RFA). However, woods are considered as the ‘wellspring of timber’ in every one of the states yet with the presence of protected arrangement woodlands commitment in wood is decreased. TOF comprise a heterogeneous and locally very different natural resource, also referred to as tree resource outside the forest (TROF). TOF are characterised by FAO as "trees ashore not characterised as timber land or other lush land". Thus, TOF are characterised according to the two other tree assets and these three classes ought to in this way be talked about at a scene level [1]. In India, TOF, is characterised as that multitude of trees, which have achieved 10 cm or more DBH and are accessible on lands isn't told as 'backwoods' or 'other lush land'. TOF remember trees for horticultural grounds, in metropolitan and settlement regions, along streets, in home nurseries, in support lines, dissipated in the scene and on field and range lands.

TROF, is an exceptionally assorted and locally unique normal sustainable asset. TOF happen in normal and in developed scenes and serve than various environmental and monetary

capacities [2]. In numerous locales they assume a conspicuous part in getting rustic jobs (like arrangement of timber, kindling, feed, organic products, shadow for cows), especially, however, not just where the tree asset in woods isn't available, for instance on the grounds that the woodland is so scant or it is actually safeguarded and outside usage. Trees and other woody plants in the scene serve likewise significant biological capacities, especially for the protection of biodiversity, offering haven and food, and settling locales[3]; other biological capacities are disintegration control, water assurance and carbon sequestration.

Contrasted with woods, notwithstanding, moderately little is had same significant awareness of tree assets outside the forest on an enormous region premise, however the quantity of studies on the subject has expanded essentially during the beyond 5 years. In reality, India is among the principal tropical nations remembering TROF into enormous region timberland appraisals for a standard premise [4]. The meaning of TROF has been underlined in a few settings and previously the year 2000 for the most part on a nearby premise [5, 6]. Little backwoods fixes and trees that don't fall under the current part, especially in tropical scenes, and should be consolidated in local ranger service and regular asset advancement programs.Predominantly in developing countries, environmental quality is largely a representation of social equity and quality of life for the rapidly growing number of urban residents.Trees matter for climatic, social and environmental reasons worldwide, so also in the Indian urban environment.

TOF were tended to as a significant asset in the worldwide woodland appraisals of FAO without precedent for Forest Resources Assessment Program FRA 2000 [7]. In any case, it has not been remembered for the overall information assortment part however as one of a progression of exceptional examinations FAO FRA 2001a [8]. FAO committed a volume of its ranger service dairy Unasylva to TOF, where, there is likewise a paper resolving issues of enormous region evaluations [9].

In November 2001, FAO assembled an expert consultation on TOF [10], named "Improving the commitment of TOF to manageable livelihoods", where various key perceptions and proposals were made. A general perception was that the database being inadequate and scant in many areas and that, especially regarding the executive’s choices there are yet open inquiries, topographically contrasting in character yet a large number of them essentially all over.

Tropical forests play an important role in reducing atmospheric carbon because they dominate the dynamics of the terrestrial carbon cycle. Tropical forests have the largest potential among the world’s forests to mitigate change through conservation of existing carbon pools, expansion of carbon sinks, and substitution of wood products for fossil fuels [11,12]. Forests contain about 50 % of the carbon stored in vegetation and about 50 % of the carbon stored in the soil TBFRA 2000. Biomass is the organic matter fifixed by trees and is the source of all other productivity in the forest.

Biomass can be used to: (a) determine energy fixation in forest [13,14]; (b) quantify increment in forest yield, growth, or productivity [15, 16, 17] and (c) assess changes in forest structure [14]. About 1–2 Gt of carbon are sequestered annually on land in temperate and boreal regions [18]. Tipper (1998) estimated that deforestation contributes about 1.8 Gt of

carbon per year to the atmosphere [19]. 1.1–1.8 Gt carbon per year can be sequestered in 50 years in tropical forests [20]. By estimating the role of forest vegetation in the storage and sequestration of carbon in the different forest ecosystem of the world, especially in the tropics, the data generated may be used to compute carbon cycling at the regional as well as the global level.

Forests play an important role in reducing atmospheric $CO_2$ which contribute to global warming of earth surface. Human activities result in the emission of certain greenhouse gases predominantly $CO_2$ into atmosphere and that affect the global climate. The forests play a vital role to mitigate the climate changes in reducing the carbon dioxide which is being utilised through process of photosynthesis. Therefore forests are significant reservoir of carbon which is stored in living, dead biomass and soil. The loss of forests on global scale is a significant contributing factor in climate change. The United Nation Framework Convention on Climate Change (UNFCCC) and Clean Development Mechanism (CDM) have considered a new initiatives to reduce emissions from deforestation and degradation in developing countries (REDD). These activities are involved in new plantations and protection of young forests but the old-growth forests are not protected because it is generally thought that they cease to accumulate carbon. Enhancing carbon sequestration by increasing forested land area is an effective measured to mitigate the climate change and contribute toward the prevention of global warming [21].

Thus assessment of carbon stock in vegetation in different forest ecosystems is basic step in evaluating the carbon sequestration potential of an ecosystem. In Manipur three major forest types i.e. tropical, subtropical and warm temperate occur along the altitudinal ranges in valley and hills. Carbon stock and rate of carbon sequestration were estimated, in the three different forest ecosystems of Manipur to ascertain its role as potential carbon sink and to meet the challenges in mitigation of $CO_2$ increase in the atmosphere in the light of international agreement on climate change [22]. Further, the study will fifill the gap on the current state of knowledge on carbon budget of forest ecosystems of Manipur, Northeast India and to enhance the understanding of the role of forests in mitigation of climate change[22].

## 2. Materials andMethods

### 2.1. *Evaluation of TOF*

The evaluation of TOF in India is being finished by the Forest Survey of India which incorporates area of TOF (10.485 million ha) happening in squares of more than 1 hectare and overhang cover in excess of 10% under "forest" cover. FSI likewise evaluates TOF, happening in squares of under 1 hectare (around 8.147 million ha) and refers to it as "tree cover"[23]. The region is notional (factual) in nature since it has been figured in view of notional thickness of trees per hectare to give a shelter front of in excess of 70%. This region at spots might be more than 0.5 ha and at different spots beneath 0.5 ha. It is accepted that something like 10% of this national region comprises of squares more prominent than 0.5 hectares for example can be delegated "other land with trees" of Forest Resource Assessment (FRA) 2005 [24].

For the appraisal of TOF, the nation has been partitioned into 14 physiographic zones. Every one of the regions countries falls in these zones either totally or to some degree. An example of 10% areas (60 regions) is haphazardly chosen for itemized stock of TOF to gauge of the conveyed over all the physiographic zones is developing stock at zonal and public level on a long-term cycle. These appraisals are additionally worked on constantly in the resulting the

quantity of regions stocked continues to increment with finish of each is without substitution and subsequently each time new regions are chosen [25]. The current gauge of FSI depends on 120 locales including 20,228 example plots. Separate approach is followed for evaluation of rustic and metropolitan TOF. For provincial TOF, an approach in light of high goal satellite is utilized for recognisable proof and separation of TOF assets in areas. The metropolitan rest TOF is evaluated utilizing Urban Frame Survey (UFS) blocks as inspecting unit arranged by National Sample Survey Organization (NSSO).

The all-out developing supply of wood in the TOF in India is assessed to be 1,616 million $m^3$. Greatest developing stock in TOF region is found in western Himalayas followed by Eastern Deccan and West Coast [23]. A tree evaluation was done by the State Forest Department, Gujarat during 2004-05 of every 833 towns of 24 regions in the state. Extrapolating the outcomes, it was assessed that 25,10,33,144 trees are existing in the non-woods' region of the state.

With regards to utilization in Bihar, obviously TOFs are the primary wellspring of lumber to satisfy the needs of the state. TOFs assumes a significant part in improving the financial creation and furthermore contributes in business age in view of earth supported exercises. It is additionally a marker for natural and environmental contemplations. This is recognised in the State Agroforestry Policy of Bihar which sets the promising objective of accomplishing 17% woods in addition to TOF cover by 2022. Under the Hariyali Mission, Bihar state government has executed a few agroforestry projects like Krish Vaniki Yojana and Mukhyamantri Niji Paudhashala Yojana. To advance the wood-based enterprises in the state and increment the tree cover, state government under agroforestry programs is advancing short revolution and business manor of popular in rachers land in north Bihar [7,8, 23].

### **2.2.** *Extent of TOF*

FSI does one end to the other planning of timberland front of the nation utilizing satellite information on a biennial premise. The woodland cover incorporates all regions outside the recorded timberland regions, which are more than 1 ha in degree with a tree overhang thickness of 10% and more independent of the land use and lawful status. Tree cover remembers trees for all arrangements including dissipated trees. TOF and tree cover show up as comparable terms, yet they are two unique elements however firmly connected with one another. TOF alludes to all trees becoming external RFA irrespective of fix size which could likewise be bigger than 1 ha. In this manner tree cover turns into a subset of TOF.

Tree cover is assessed utilizing high goal satellite symbolism alongside test plot information. Consequently, trees remembered for the tree cover establish just a piece of TOF. Extent of TOF thus might be assessed as the amount of degree of woodland cover outside the RFAs and tree cover.Traditionally, integration of drought hardy multipurpose woody perennials farming systems, now referred as agroforestry, has been an established mechanism of drought proofing by ingenuity and centuries old experience of rural folk.

The all-out degree of TOF at the national level is 8.94% of the all out topographical region of the country. The Union Territory of Lakshadweep is having greatest degree of TOF (91.3%). Among the states, Kerala (37.17%) and Goa (36.05%) have greatest TOF region, as rate to their geological region. In outright terms Maharashtra has the greatest region under TOF, trailed by Odisha and Karnataka.

**2.3.** *Carbon sequestration*

Carbon sequestration alludes to the arrangement of long-haul stockpiling of carbon in the earthly biosphere, underground, or the seas so the development of carbon dioxide (the essential ozone depleting substance) fixation in the environment will diminish or dial back. The Intergovernmental Panel on climate change (IPCC) characterizes it as "how much carbon assimilated from the air by plants (comparable to net photosynthesis), however which can then be lost to some degree to the environment through ensuing disintegration of dead buildups". It assumes a significant part in the worldwide carbon cycle. The way that we have briefly tossed the worldwide cycle out of equilibrium proposes that we can likewise rebalance that framework by further developing vegetation the executives and normal sequestration of climate carbon through photosynthesis.

To measure tree density, 20 quadrats of 10 m 9 10 m were laid out randomly, based on line transects in each forest. The harvesting was done between October and November in two years respectively. Three individuals of each tree species were harvested from the quadrats for each girth class for all the species present in the forest stands. After harvesting, various parameters like diameter of the bole, at the base, the middle or center of the bole, total height of the tree, and total numbers of the leaves were recorded. The fresh weight of all boles, branches, leaves and fruits were determined at the site. The sub-samples (three replicates) of different components were brought to the laboratory in polythene bags. All the sub-samples were oven dried at $80^0$C to constant weight. Leaves of varying size (15 leaves) were also taken from each tree of different constituent tree species for determining leaf area [26].

The biomass estimates for the standing crop of different tree species were computed using wood density values of different girth classes [27]. The tree biomass was computed by multiplying tree density with biomass at each girth class of the species on hectare basis. The stand biomass was calculated by summing the biomass value across the girth class of all the species. Herbs and shrubs were harvested and weighed. Average biomass for herb and shrub species was multiplied by its respective density (individual ha-1 ) in the stand. Litter was collected from permanently laid quadrats of 1 m 9 1 m (10 each) randomly from both the stands and samples were oven dried at $80^0$C to constant weight. Estimated biomass was used to estimate carbon stock [14]. Aboveground net primary production was estimated by summing up the annual increment in the biomass and the corresponding litter fall deposited on the forest flfloor. Annual biomass increment was calculated by subtracting biomass in (year 1) from that of (year 2). The net productivity data is used to estimate the rate of sequestration by using a conversion factor of 50 % [27].

## 3. Results and Discussion

*Assessment of TOF in India*

The assessment of TOF in India is being done by the Forest Survey of India which includes area of TOF (Trees out side recorded forests) (10.485 million ha) occurring in blocks of more than 1 hectare and canopy cover more than 10 % under “forest” cover. FSI also assess that TOF, occurring in blocks of less than 1 hectare (about 8.147 million ha) and calls it “tree cover”[23]. The area is notional (statistical) in nature because it has been computed based on notional density of trees per hectare to provide a canopy cover of more than 70 %. In reality, this area at places may be more than 0.5 ha and at other places below 0.5 ha. It is assumed that at least 10 % of this notional area consists of blocks greater than 0. 5 hectares i.e. can be classified as “Other land with trees” of Forest Resource Assessment (FRA) 2005 [24].

For the assessment of TOF, the country has been divided into 14 physiographic zones. All the districts of the country fall in these zones either completely or partially. A sample of 10% districts (60 districts) distributed over all the physiographic zones is randomly selected for detailed inventory of TOF to estimate growing stock at zonal and national level on a two year cycle. These estimates are further improved continuously in the subsequent cycles as the number of districts inventoried keeps on increasing with completion of each cycle. The random selection is without replacement and hence each time new districts are selected [25]. The present estimate of FSI is based on 120 districts comprising of 20, 228 sample plots. Separate methodology is followed for assessment of rural and urban TOF. For rural TOF, a methodology based on high resolution satellite is used for identification and stratification of TOF resources in districts. The urban TOF is assessed using Urban Frame Survey (UFS) blocks as sampling unit prepared by National Sample Survey Organization (NSSO).

The total growing stock of wood in the TOF in India is estimated to be 1, 616 million $m^3$. Maximum growing stock in TOF area is found in Western Himalayas followed by Eastern Deccan and West Coast [23]. A tree census was carried out by the State Forest Department, Gujarat during 2004-05 in 833 villages of 24 districts in the State. Extrapolating the results, it was estimated that 25, 10, 33, 144 trees are existing in the non-forest areas of the State. It was observed that 68% trees were in 10-45 cm girth class while 24% trees were in 46-90 cm girth class. The timber and fuel-wood yield was estimated to be 14.88 million $m^3$ and 17.55 million $m^3$ respectively [28]. The average tree density in the non-forest areas was 14 trees/ha. A total of 195 species were recorded. Of the 20 most prevalent species in the State, neem is found in all the districts having 13% share [28].

*Trees in urban areas and environment*

In India particularly urbanisation, is in most parts of Asia, is marked by a process of demographic and cultural change and in the recent decades by a rapid population growth [29]. Industrialisation and ambitious targets of economic growth encourage people to move to the cities. Air (toxic gases, heat and dust) and water pollution, and lack of proper support to the green space and related matters are among the standard problems of public green space management in urban areas in India [29].

The $12^{th}$ Schedule of the Indian Constitution enables municipal bodies to initiate suitable measures on various points like urban planning, regulation of land use, construction of buildings, planning for economic and social development, provision of urban amenities, parks, and gardens [30]. Public open space like parks, meadows, roadside trees and home gardens are important elements in and nearby cities to provide fresh air circulation, shade and space where people can meet their needs [31]. Fruit trees can be grown and the amenities of a green surrounding can be enjoyed. Urban green space is also relevant as water catchment area to feed the water table and store humidity to mitigate the omnipresent air pollution, heat and dust. A few examinations have shown that the incorporation of trees in the agarian scenes frequently works on the efficiency of frameworks while giving chances to make carbon sinks. A normal carbon stockpiling by agroforestry land use framework has been assessed to associate with 9,21,50 and 63 mg carbon ha in semi-dry, sub damp, muggy and calm locales, separately [32].

*Carbon sequestration*

The carbon stock and rate of carbon sequestration was examined in a tropical deciduous forest dominated by *Dipterocarpus tuberculatus* in Manipur, North East India and estimated

aboveground biomass by harvest method and multiplied with density of tree species. The aboveground biomass was between 18.27–21.922 t ha-1 and the carbon stock ranged from 9.13 to 10.96 t C ha-1 across forest stands. Aboveground biomass and carbon stock increased with the increase in tree girth. The rate of carbon sequestration varied from 1.4722 to 4.64136 t ha-1 year-1 among the dominant tree species in forest stands in tropical deciduous forest area [26].

The rate of carbon sequestration depends on species composition, the density of large trees in different girth classes, and anthropogenic disturbances in the present forest ecosystem. Further work is required to identify tree species having the highest potential to sequester $CO_2$ from the atmosphere, which could lead to recommendations for tree plantations in a degraded ecosystem [26]. The rate of carbon sequestration varied from 147.22 to 4641.36 kg ha-1 year-1 in forest stand I, whereas in forest stand II, it varied from 677.18 to 3753.34 kg ha-1 year-1. The maximum rate of sequestration was recorded in *Dipterocarpus* tuberculatus, followed by *Ardisia paniculata*, *Wendlandia wallichii* in forest stands I and II [26].

The carbon density and rate of carbon sequestration in the vegetation in the tropical, subtropical and temperate forests of Manipur, North-East India was estimated [22]. Their study showed that most of the vegetation carbon resides more in the old-growth (high DBH) trees in well protected forests than the young secondary forests having low DBH. However, the rate of carbon sequestration was high in the young tropical forest while comparing with the mature forest of the subtropical. Therefore to mitigate the increasing atmospheric $CO_2$ efforts are also needed to protect the young forest from lodging and fifire and reforestation and afforestation programme could be recommended to enrich the forest stock [22].

Rate of carbon sequestration potential were assessed in tropical, sub-tropical and temperate forest ecosystems of Manipur, Northeast India. Carbon stock in the aboveground biomass was recorded to be highest in the sub-tropical forest (319.18 Mg ha-1) followed by temperate (54.45 Mg ha-1) and tropical forest (38.35 Mg ha-1). The rates of carbon sequestration was in the order of the tropical>temperate> sub- tropical forest thus tropical forest being young sequestered more carbon than the other two old forests. Thus our study indicates that the young forests have a huge potential in the reduction of carbon dioxide levels in the atmosphere and could be used as carbon-sinks in the Northeast India depending upon the level of protection [22]. The annual rate of carbon sequestration was estimated to be highest in tropical ]forest (11.41Mg C ha-1) followed by temperate (10.34 Mg C ha- 1) and sub-tropical (9.84 Mg C ha-1) forests which is just a reverse with the carbon stock being lowest in tropical and highest in sub-tropical forest. Thus large carbon stock does not necessary for high carbon sequestration potential and similar result was in the mid hill of Indian Himalayas [33].

TOF were assessed after the year 2000, and not assessed in the global forest resource assessment [7] and the interaction between these categories we need to be further investigated. People's participation is a key factor in the sustainable management of TOF. Group consensus should be encouraged in decision, making and also to avoid possible conflicts. One of the important tools is Remote sensing for the assessment of TOF in large areas and these data should extensively be used to monitor the status of TOFs and productivity of the non-forest lands. Important Research Programme should be undertaken to identify such production systems for TOF that are efficient, ecologically sustainable and financially viable. The development of planning tools, including decision support systems

that assist producers to cope with climate variability was given main emphasis [30]. A proper management of inputs, the productivity of the lands involving trees outside forests can be increased in many fold [34].

There are highest enough wastelands in arid zones with larger proportion in India, in Rajasthan it is estimated to be 30% of the total land mass. Trees may be grown in these areas to meet both ecological and social challenges. This requires development of sites with specific packages of practices for promoting the agro-forestry and sylvo-pastoral systems in the region. Agro-forestry should be looked upon as a means for improving the socio-economic conditions of the rural poor and should be the main plan of integrated rural development programme. In order to increase fuel, timber, and forage production agro-forestry programmes should be adopted on a large scale, this would include rural woodlots for the rural areas. Such programmes should be time-bound and target-oriented. People participation is a critical factor of success of such programmes [7].

Urban forestry in India should be much more considered as a domain of partly self-management and partly joint management in cooperation with municipal services of green space resources in which social objectives are tried to be achieved through and in combination with urban environmental management [29] . Social cohesion may be enhanced through co-operation of members of forest user groups, neighbourhood and religious communities who are willing to care for the quarter's green space, as well as through government institutions and non-governmental organisations, at the national, regional and local level. TOF is less studied than other wood resources and is not addressed explicitly in forest policies and legislation. The current repress if legislation, intending to prevent farmers to exploit the TOF for wood-fuel and fodder, do not encourage farmers to develop TOF at farm and landscape level [35]. It is urgently needed to adapt forest policies and legislation to these facts and to promote techniques, which can accelerate the transformation of residual TOF into constructed parklands.

*Shifting Cultivation*

Shifting cultivation i.e., slash-and-burn, otherwise known as *Jhum*, to grow food, is a major threat to forests of India particularly in northeastern states viz., it supports about 450,000 families in Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Assam and Meghalaya [36]. Approximately 15,000 square kilometers of forest land is under *jhum* cultivation, and just a sixth of this land is actually producing any crop at any given year. The tribal people consider it a tradition, and economic ecosystem. However, the slash and burn causes damage to a dense forest, to soil, to flora and fauna, as well as pollution. The crop yields are very poor with *jhum* cultivation. Between 2010 and 2012, satellite studies confirmed a net loss of forest cover over these northeastern states [36]. The lost forest includes primary dense forests. There is a concerted effort by the state government officials to educate, incentivize and train *jhum* dependent families to horticulture and other high value crops, along with an offer of food supply security[37,38].

*Effects of tribal population growth on forest flora*

Tribal population growth in forest/tribal areas is so fast, naturally available forest resources (NTFP) in a sustainable manner are becoming inadequate for their basic livelihood. Tribals are giving up their traditional livelihood and taking up farming in the forest areas causing irreparable damage to forests. Forests are slowly turning into the bane of forests. The government should devise schemes to avert this process and save the dwindling forest area

and its flora. Tribal people have extraordinary understanding of forest flora, which can be productively utilized. Tribal peoples shall be employed by the government in the expansion and protection of forests, till their descendants get educated and diversify into industrial and service sectors [39].

India, its land area includes regions with some of the world's highest rainfall to very dry deserts, coast line to alpine regions, river deltas to tropical islands. India is a large and diverse country endowed with the distribution of variety and forest vegetation, there are 600 species of hardwoods, including sal (*Shorea robusta*). India is one of the 17 mega biodiverse regions of the world, with diverse forest types having different areas and percentage of forest[40]. Indian forests types include tropical evergreens, tropical deciduous, swamps, mangroves, sub-tropical, montane, scrub, sub-alpine and alpine forests. These forests support a variety of ecosystems with diverse flora and fauna (Table 1) [40].

**Table 1.** Forest types, area and percentage of forest, in India.

| Type of forest * | Area (in square kilometres) | Percentage of total forest |
|---|---|---|
| Tropical Wet Evergreen Forests | 51,249 | 8.0 |
| Tropical Semi Evergreen Forests | 26,424 | 4.1 |
| Tropical Moist Deciduous Forests | 2,36,794 | 37.0 |
| Littoral & Swamp Forests | 4,046 | 0.6 |
| Tropical Dry Deciduous Forests | 1,86,620 | 28.6 |
| Tropical Thorn Forests | 16,491 | 2.6 |
| Tropical Dry Evergreen Forests | 1,404 | 0.2 |
| Subtropical Broadleaved Hill Forests | 2,781 | 0.4 |
| Subtropical Pine Forests | 42,377 | 6.6 |
| Subtropical Dry evergreen Forests | 12,538 | 2.5 |
| Montane Wet Temperate Forests | 23,365 | 3.6 |
| Himalayan Moist Temperate Forests | 12,012 | 3.4 |
| Himalayan Dry Temperate Forests | 312 | 0.0 |
| Sub Alpine Forests | 18,628 | 2.9 |
| Total (Forest Cover + Scrub) | 7,54,252 | 98.26 |
| Grass land in different forest type groups (without forest cover) | 13,329 | 1.74 |
| **Grand Total** | **7,67,581** | **100.00** |

*Source: "India's Forests" (PDF). Ministry of Environment and Forests, Government of India. 2019. p. 24.

Density and biomass contributed by shrubs and herbs species in forest stand I and II, carbon stock and rate of carbon sequestration in *Dipterocarpus* forests of Manipur among the forests of Manipur State, has got variation in the same forest areas of Stand I and II [26]. The shrub layer biomass in stand I was recorded to be of 6.35 t ha-1 contributed by seven shrub species and in stand II, it was 1.432 t ha-1 contributed by three shrub species (Table 2). Of these,

*Elaeocarpus chinensis* and *Actiphella exelsa* exhibited the maximum biomass in stand I and stand II, respectively. *Albizia saman* and Gynocardia odorata exhibited the minimum biomass in stand I and II, respectively. In herbaceous layer in stand I, nine herb species contributed a total biomass of 0.552 t ha-1 , whereas a total biomass of 0.999 t ha-1 was contributed in stand II. Among the herbs, *Arundinella setosa* and *Kyllinga triceps* contributed the maximum biomass in stand I and *Imperata cylindrica* in stand II (Table 2) [26].

**Table 2.** Density and biomass contributed by shrubs and herbs species in forest stand I and II Species Stand I Stand II, Carbon stock and rate of carbon sequestration in *Dipterocarpus* forests of Manipur.*

| **Species** | **Stand I** | | **Stand II** | |
|---|---|---|---|---|
| | **Density (stems ha-1)** | **Biomass (t ha-1)** | **Density (stems ha-1)** | **Biomass (t ha-1)** |
| *Shrubs*<br>*Elaeocarpus chinenis* | 200 | 1.8000 | - | - |
| *Albizia samman* | 1400 | 0.0161 | - | - |
| *Machilus puthii* | 220 | 0.7480 | - | - |
| *Quercus incana* | 380 | 0.5580 | 660 | 0.082 |
| *Desmodium pulchellum* | 80 | 0.3440 | - | - |
| *Gynocardia odorata* | 220 | 0.6820 | 60 | 0.010 |
| *Magnolia species* | 220 | 0.6380 | - | - |
| *Actephila excelsa* | - | - | 1260 | 1.200 |
| Others | 340 | 1.5640 | 760 | 0.130 |
| Total | 3060 | 6.3500 | 2740 | 1.432 |
| Herbs<br>*Carex spinosa* | 61,000 | 0.0183 | - | - |
| *Fimbristylis dichotoma* | 8000 | 0.0648 | - | - |
| *Cardamine species* | 5500 | 0.0501 | - | - |
| *Arundinella setose* | 97,000 | 0.0770 | - | - |
| *Leucas aspera* | 9000 | 0.0400 | - | - |
| *Imperata cylindrica* | 59,500 | 0.0464 | 11,850 | 0.340 |
| *Kyllinga triceps* | 11,500 | 0.0770 | - | - |
| *Sclereria alata* | 11,000 | 0.0737 | - | - |
| *Eulalia fastigiata* | 1500 | 0.0144 | - | - |
| *Axonopus compressus* | - | - | 7000 | 0.021 |
| *Andropogon species* | - | - | 5000 | 0.014 |
| *Heteropogon contortus* | - | - | 69,000 | 0.160 |
| *Eragrostis nigra* | - | - | 108,000 | 0.240 |
| *Justicia simplex* | - | - | 99,500 | 0.200 |
| Others | 9000 | 0.0936 | 17,500 | 0.020 |
| Total | 218,100 | 0.5520 | 424,500 | 0.999 |

*Source: Devi, L. S., Yadava, P. S. Carbon stock and rate of carbon sequestration in *Dipterocarpus* forests of Manipur, Northeast India. Journal of Forestry Research, 2015, 26(2): 315-322.

## Conclusion

TOF assume a critical part in the financial existences of individuals both in rustic and metropolitan region of the nation by improving individuals and society in general monetarily

as well as biologically. The administration of TOF accepts high importance in the country for acknowledging a lot higher potential which it offers in creating wood-based economy and environment administrations including carbon sequestration. Occasional evaluation of TOF assets including its spatial circulation is essential for its logical administration in the country. FSI is ordered with this undertaking anyway there is need for ceaseless improvement in the philosophy and consideration of more number of factors in the appraisal. The association should be additionally fortified especially as far as labour supply, to address the arising data needs on TOF. There has been normal refinement in philosophies over the most recent 30 years to measure TOF assets utilizing different factual plans and gauges with better accuracy. There is additionally a requirement for a different strategy on TOF to guarantee its extensions and supportable administration for a long-time benefit, lumber creation, carbon sequestration and for deterring strain from the normal timberlands.

It is well known fact that, with the assessment of TOF in India as well as in Manipur State, it can be mentioned that, there is need to conserve of indigenous trees, which are depleting day by day, in all the states of our country. For instance, the most depleted indigenous trees of Manipur should be given more emphasis for conservation in near future. Some of the TOFs are: *Grevillea robusta* A.Cunn. ex R.Br. (*Koubilia*), *Dillenia indica* L. (*Heigri*), *Diospyros cordifolia* Roxb. Syn. *D. Montana* Roxb. (*Tomal*), *Sapindus trifoliatus* L. (*Kekru*), *Nephalium lingana (Nongang-hei), Mitragyna parviflora* (Roxb.) Kuntze (*Kadam*), *Michelia fuscata* Blume Syn. *Magnolia fuscata* Andr.(*U-thambal*), *Michelia doltsopa* Buch.-Ham.ex DC. (*Leihao-leishang*), *Michelia champaca* L. (*Leihao*), *Mahonia napaulensis* DC. *Syn. Mahonia manipurensis* Takeda *(U-napu), Magnolia hodgsonii* (Hook. f. & Thomson) Keng.(*U-thum*), etc. The above trees are not found abundantly in urban as well as in rural areas of the valley districts of Manipur. It is high time to protect these indigenous trees as we are working on TOF of Manipur. Even though there are introductions of new plant varieties by various agents like Forest Department, GOM, which are exotic in our Manipur state time to time makes our flora a combination of many plant species. Ultimately, change our vegetation.

## References

1. Boffa, J.M. West African agroforestry parklands: keys to conservation and sustainable management. *Unasylva,* 2000,No. 200. Trees outside forest.
2. Kleinn, C., Morales, D. Obtaining resource information on trees outside the forests: experiences with inventory approaches in Central America. In Tewari, V.P. and Srivastava, R.L. (eds.) *Multipurpose Trees in the Tropics: Management & Improvement Strategies,* 2005, Scientific Publishers, Jodhpur, India. pp. 612-618.
3. Waltert, M.,*et al.,* From Forest to farmland - habitat effects on afrotropical forest bird ecology. *Ecological Applications,* 2005, 15:1351-1366.
4. FSI. *State of forest report,* 1997. Forest Survey of India, Dehra Dun, India.
5. Guevara, S. *et al.,* Are isolated remnant trees in pastures a fragmented canopy? *Selbyana,* 1998,19(1): 34-43.
6. Harvey, C., Harber, W. Remnant trees and the conservation of biodiversity in Costa Rica Pastures. *Agroforestry Systems,* 1999, 44: 37-68.
7. FAO Évaluation des ressources forestières mondiales 2000. Rapport principal.
8. FAO FRA Global forest resources assessment 2001a. Main report. FAO Forestry Paper 140.

9. Kleinn, C. On large area inventory and assessment of trees outside forests. *Unasylva*, 2000, 200 (2000/1) 51:3-10.
10. Sadio, S, *et al.*, Proceedings - Expert consultation on enhancing the contribution of trees outside forests to sustainable livelihoods. Rome 26-28 November 2001. FAO Forest Conservation, Research and Education Service, Forest Resources Division, Rome, Italy. 2002, 171p.
11. Brown, S. *et al.*, Management of forest mitigation of green house gas emissions, Chapter 24. In: Watson RT, Zinyowera MC, Moss RH (eds) Climate change 1995: impacts, adaptations and mitigation of climate change: scientific-technical analyses. Contribution of working group II to the second assessment report of the IPCC. Cambridge University Press, Cambridge, 1996, pp. 775–797.
12. Brown, S. *et al.*, Project based activities. In: Watson R, Noble I, Verardo D (eds) Land use, land use Change and forestry, 2000, vol 5. Cambridge University Press, Cambridge, pp 283–338.
13. Brown, S., Lugo, A.E. Biomass of tropical forest: a new estimates based on forest volumes. Science, 1984, 223:1290–1293.
14. Brown, S. Estimating biomass and biomass change of tropical forests. FAO Forestry Paper 134. A forest resources assessment publication, Rome, 1997, p 1
15. Burkhart, H,E,, Strud, M.R. Dry weight yield estimation for loblolly pine: a comparison of two techniques. In: IUFRO biomass studies, Univ. Maine, Crona, Maine, 1973, pp 27–40.
16. Thokchom, A., Yadava, P.S. Biomass and carbon stock assessment in the sub-tropical forests of Manipur, North East India. Int J Ecol Environ Sci, 2013, 39(2):107–113.
17. Debajit, R, Nepolion, B., Ashesh, K.D. Assessment of aboveground and soil organic carbon stocks in Dipterocarpus forests of Barak Valley, Assam, Northeast India. Int J Ecol Environ Sci, 2014,40(1):15–28.
18. Bousquet, P. *et al.*, Regional changes in carbon dioxide flfluxes of land and oceans since 1980. Science, 2000, 290:1342–1346.
19. Tipper, R. Update on carbon offsets. Trop For Update, 1998, 8(1):2–4
20. Makundi, W. *et al.*, Tropical forests in the Kyoto protocol. Trop For Update, 1998, 8(4):5–8.
21. Watson, R.T. Land use, land-use change, and forestry: A special report of the IPCC (Cambridge: Cambridge University Press),2002, pp.377.
22. Thokchom, A. Carbon Sequestration Potential of different forest ecosystems of Manipur, Northeast India, Indian Journal of Applied Research,2019, 9(7): 17-18.
23. FSI. *State of forest report* 2005. Forest Survey of India, Dehra Dun, India.
24. FRA Forest Resources Assessment (FRA) 2005-the process, Food and Agricultural Organization of the United States, p 1.
25. Kumar, R., Lakhchaura, P. Estimation of growing stock in trees outside forest of the country. *ENVIS Forestry Bulletin*, 2008, 8(2): 1-4.
26. Devi, L. S., Yadava, P. S. Carbon stock and rate of carbon sequestration in Dipterocarpus forests of Manipur, Northeast India. Journal of Forestry Research, 2015, 26(2): 315-322.
27. Newbould, P.J. Methods of estimating the primary production of forests, 1967. Black Well Scientifific Publications, Oxford and Edinburgh.
28. Anon Tree wealth of the non-forest areas of Gujarat, 2004,Vol. I. Social Forestry Wing, State Forest Department, Gandhinagar, Gujarat. p. 62.

29. Seeland, K. Trees outside forests in an Indian urban environment. In. Tewari, V.P. and Srivastava, R.L. (eds.) *Multipurpose Trees in the Tropics: Management & Improvement Strategies*. Scientific Publishers, Jodhpur, India, 2005, pp. 486-492.
30. Tewari, J.C. *et al.,* Structure and production function of traditional extensive agroforestry systems and scope of intensive agroforestry in *Thar* desert. *Indian Journal of Agroforestry*, 1999,1(1): 81-94.
31. Negi, S.S. *Urban and recreational forestry,*1998, International Book Distributors, Dehradun, India.
32. Schroeder, P. Carbon storage benefits of agroforestry system. *Agroforestry Systems*, 1994, 27:89-97.
33. Yadav, R.P. Biomass, carbon stock under different production systems in the mid hills of Indian Himalaya. Tropical Ecology, 2017, 58:15-21.
34. Narain, P., Tewari, J.C. Trees on agricultural fields: a unique basis of life support in Thar Desert. In. Tewari, V.P. and Srivastava, R.L. (eds.) *Multipurpose Trees in the Tropics: Management & Improvement Strategies*. Scientific Publishers, Jodhpur, India, 2005, pp. 516-523.
35. Christensen, C. *et al.,* Trees outside forests in West-African drylands inventories, growth measurements and management concepts. In. Tewari, V.P. and Srivastava, R.L. (eds.) *Multipurpose Trees in the Tropics: Management & Improvement Strategies*. Scientific Publishers, Jodhpur, India, 2005, pp. 447-455.
36. SFR State of Forest Report 2013, Ministry of Forests and Environment, Govt of India, 2014.
37. FCD Forest Conservation and Development of the North East Region, Planning Commission of India, 2013, page 7-10.
38. The Times of India, Area under jhum cultivation significantly reduced in Arunachal Pradesh, The Times of India, August 9, 2013.
39. Geographical area and its effective utilization". Retrieved 27 March 2013.
40. What is a megadiversity country? Archived from the original on 11 October 2019.