Algerian Journal of Environmental Science and Technology
December edition. Vol.3. Nº3-B. (2017)
ISSN : 2437-1114
www.aljest.webs.com

Costing of Total Biomass, C-Stock and CO_2 Sequestered by the Trees out of Forest (TOF) at Telineelapuram Bird Protected Area, an IBA Site; IN 229 India

H. Ramamohan[1]

[1]Associate Professor of Environmental Studies, Aditya Institute of Technology and Management, Tekkali, Srikakulam district, A.P., India

*Corresponding author: drhrmdora@gmail.com: Phone: +91 7093484788.

ARTICLE INFO

Article History:

Received ***: 25/12/2016***
Accepted ***: 10/12/2017***

***Key Words*:**

C-Stock, Above Ground Biomass (AGB), Below Ground Biomass (BGB), Bird Protected Area, Non-destructive allometric method, Carbon Sequestration.

ABSTRACT/RESUME

Abstract: *Changing climatic conditions, loss of agricultural production and biodiversity are the brain storming and much debated fields in recent past. The major root causes for the above issues are growing carbon levels at an upsetting rate in the atmosphere and on the other hand qualitative and quantitative loss of vegetation every year. To combat apart from other carbon sources, evaluation of standing biomass (AGB and BGB) of Trees out of Forest (TOF) area and C-stock will give a feasible solution for our present and future obstacles. The current study intended to bring out the total biomass and C-stock of nesting trees both Above Ground Biomass (AGB) and Below Ground Biomass (BGB) with the help of non-destructive allometric method. Since it is a bird protected area and recording total biomass and C-stock change over time is vital for the protection. This study is aimed to estimate the total CO_2 sequestered by the nesting trees at Telineelapuram. Since, the two important Near-threatened category migratory bird species (Pelicanus philippensis and Mycteria leucephala) are using different tree species for their nesting, breeding and roosting purposes.*

I. Introduction

Forests are one of the important inseparable parts of earth and are significant in stabilizing atmospheric carbon levels through sequestration. Biomass estimates are useful for the computation of carbon storage and biomass energy values. The Intergovernmental Panel on Climate Change identified five carbon pools of the terrestrial ecosystem involving biomass, namely the aboveground biomass, below-ground biomass, litter, woody debris and soil organic matter. Among all the carbon pools, the above-ground biomass constitutes the major portion of the carbon pool. The current all C-stock estimates and CO_2 sequestered are concentrated and based on forests. But, hardly any attempts have been made to study the potential role in carbon sequestration of Trees out of Forest (Rural and Urban) areas. In recent past larger forest areas are removing for other land use purposes and undergoing sever degradation. As per the existing statistics a study by NASA's GISS has discovered that the global warming is increasing and global temperatures are escalating at a rate of 0.15 to 0.2°C decade^{-1} [1]. Hence currently Trees out of Forests (TOF) are prioritizing for their critical role but even ignoring in momentous situations. As per the forests report status [2], India is supporting 78.37 M ha (23.84%) of both forest and tree cover. Though, defined information on trees outside forests at root level is missing and this has become major obstacle in estimating TOF potential in carbon sequestration. According to the recent forest status report the total forest cover in India is 21.34% and trees outside forests (TOF) is 2.82% [3], more over TOF is playing enormous role for the removal of atmospheric carbon levels.

As like forests TOF in concert a key role in boosting the environmental quality and economy of a nation, address the idea of effective resources management and sustainable development, hence planned and systematic management is required [4, 5]. The present study site is occupied by good number of vegetation of different kind (mixed), that too it is satisfying the needs of migratory birds as nesting and breeding spot. The quantity of carbon removed and stored is influenced by different parameters and one of them is over all composition of tree species [6]. TOF assumed great potential in sequestering the carbon levels of atmosphere [7]. Trees outside forests potentially remove the atmospheric CO_2 levels, they are the immediate stabilizers under the existing development is concern. Sequestration and deposition of carbon as biomass is obvious and possible by vegetation in the urban areas are as well [8]. Yet, the CO_2 levels of earth are being increasing constantly is also monitoring and recording continuously since 1957 [9].

Human activities are one of the major motives for this rise in atmospheric carbon, the current CO_2 concentration of atmosphere is around 390 ppm, where as this was 280 ppm during pre-industrial period [10]. Carbon cycle attains a good deal why because, CO_2 has much residence time and is being the principal component among all the greenhouse gases in the global warming [11]. IPCC revealed that for mitigating green house gasses of earth the developing countries are in concert a key role [12]. The forests resources of the world are facing sever and constant pressure, slowly going deforestation and degradation because of land use land cover changes. The carbon stocks of Indian forests are also degrading continuously since, 2003 [13]. On contrast the total global CO_2 emissions are almost two thirds (61%) accounting by China, United States, EU-28 and India alone. The top 4 emitting countries/regions, which together account for of China (30%), the United States (15%), the European Union (EU-28) (10%) and India (6.5%) [14]. Vegetation provides us a range of services which includes carbon sequestration, whether they are categorized as inside or outside of the forests. Increasingly important given the continued degradation they face and the urgent need to design and implement appropriate policies and measures for their sustainable management. This study was intended to know the total biomass (AGB and BGB), carbon stock and CO_2 sequestered by all nesting trees utilizing by the migratory birds at Telineelapuram bird protected area.

II. Materials and methods

Accurate data on carbon stocks and carbon stock change over time are of particular interest for countries like India. With the growing danger of environmental pollution, energy crisis, loss of biological diversity and mismanagement of natural resources due to economic development needs of human civilization, the role of natural as well as planted forests is being increasingly felt for diverse intangible ecosystems services than the tangible economic goods. Consequently the dimensions of forest-based trades and international politics are shifting from timber-oriented focus toward the regional and global services like conservation of biological diversity, watershed values, ecotourism and mitigating climate changes. Hence periodic estimation, monitoring and reporting on area under forest and plantation types and Afforestation rates are critical to forest and biodiversity conservation, sustainable forest management and for meeting international commitments.

II. 1. Study Area

The study area, Telineelapuram village is situated in Tekkali mandal of Srikakulam district, A.P., India (180 30' to 180 35' of North latitudes and 840 15' to 840 20.5' of East longitudes). The village is about 5 km northwest from Naupada railway station on the Chennai-Howrah track; and is 7 km south east from Tekkali on NH-5 (16), the National Highway from Chennai to Kolkata and thus, is well connected by road and railways. The village is about 65 km north of Srikakulam town, which is the district head quarter is shown in Figure 1.

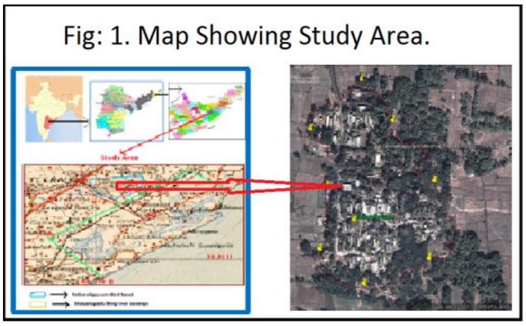

Figure 1. *Study Area*

The village is bounded by Naupada salt pans and flooded fields on the east, Talagam and Ijjavaram villages on the north and northeast, Vemulavada village on the north-west, Srirangam, Ravivalasa and Yemalapeta villages on the west, Yemalapeta and Kasipuram villages on the south-west and south. Bhavanapadu Mangrove swamps are located at a distance of 10 km southeast from the village. The terrain is plain with an altitude of < 27 m, and with a gentle slope towards southeast. Based on the satellite images and topo maps, four types of land uses were identified in the study area and include Agricultural lands; Wetlands; Wastelands and Habitations.

The climate is more or less characterized as humid throughout the year. The southwest monsoons, which follow the summer season yields a major quantum of rain from June and lasts up to September. Immediately northeast monsoons or retreating monsoons start, often triggering low pressure depressions or by forming cyclones during October - November. The period from December to February, generally have a fine weather of winter. Seasons in this region can be observed as:

Summer season: March to May
Southwest monsoon season: June to September
Northeast monsoon season: October to November
Winter season: December to February

In general the mean annual maximum temperature is 31.40C and minimum temperature is 23.20C. The maximum temperature normally occurs in the month of May and minimum temperature in the month of January. The annual rainfall is 937.6 mm during the year 2004-05 as against normal rainfall 1274 mm. During study period (2008-13) the mean annual maximum temperature is 32.70C recorded in the year 2010 and minimum temperature is 21.80C recorded in the year 2008. The annual maximum rainfall is 1653.4 mm recorded in the year 2010 as against normal rainfall 1274 mm at the study site.

The entire village is under plains and is in agricultural activity, and looks lush green during monsoons period. The major crop is paddy raised during south-west monsoon period (June-September). Telineelapuram village has a total area of 692.64 acres as per the revenue records, and belong to both government and private owners. Four dominant land use types are recognized, which include Agricultural lands (509 Acres); Wastelands (92 Acres); Wetlands (54 Acres) and Habitations (28 Acres) Other categories (9.6 Acres).

All the flowering plant species of the study area, in its all land use types, were recorded systematically and 108 species of angiosperms belonging to 48 families were recorded from the different land use types of Telineelapuram village and the surrounding (15 km radius) region. Of these, 50 were herbs, 23 were shrubs and 35 were tree species. There were no endemic or endangered or threatened plant species in the region. The fauna of the study area were identified and recorded; the vertebrate species of amphibious and terrestrial were also recorded. The faunal inventory shows that in the entire Telineelapuram area has only two species of birds protected under Schedule-I of the Wildlife (Protection) Act, 1972. All other species are mostly common species, which are widely distributed in India.

II. 2. Sampling Design

The total study area was considered as one segment and within this sub segments have been identified based on requirement. Since the study area is smaller and supporting good number of trees using as nesting, breeding and roosting purpose by the near-threatened migratory birds. The data from all the sub segments later used to estimate the biomass, carbon deposited and CO2 sequestered.

II. 3. Data Collection

All the trees at study site are naturally grown and some are planted, but trees using by the migratory birds are larger and age old and at different age groups. Moreover the dbh of trees are ≥ 20 cm, hence all the nesting trees were considered for the estimation and measurements like dbh, height etc taken and recorded accordingly. In each sub segment all the individual trees was identified and recorded to species level.

II. 4. Data Analysis

The techniques currently applying for calculation of biomass to get accurate results require felling of many trees. Such methods are not well suited to the natural environment, especially if the environment is subject to anthropic degradation and if the wood supply to local populations is at stake. Moreover these can be more applicable during harvesting of trees to yield wood when they reach to maturity levels. Once trees attains their full adulthood stage generally carbon sequestration from such trees are less or zero. The biomass was estimated from allometric relations between the tree diameter at DBH and tree height [15]. Tree biomass and carbon estimation is difficult and tedious while considering species specific and site specific methods. Hence common allometric non-destructive models that have been developed in tropical and sub-tropical areas are the easier and best way for the estimation.

Taking this point in to consideration the non-destructive allometric equations developed for the above ground biomass and carbon estimation [16] was employed, as it covers wide geographical range of vegetation of all types. Below ground biomass was estimated using [17] since it is the most applicable method and cost effective. The wood density data base of trees obtained from the world Agro forestry data base [18] and the global wood density data base [19, 20]. The total biomass, both above and below ground, is calculated and the total carbon stock estimated finally by means of [21] as it is most consistent method. Specific method has been applied to estimate the biomass of *Melia azadirachta* and *Bambusa arundinacea* by following [22].

Many forest services, such as timber and fuel wood production, but also climate change mitigation through the forestry sector for example, require accurate estimations of carbon stocks. Allometric Equations (AEs) are of great importance in this regard, because they are the most used tool for predicting forest volume or biomass from easy-to-measure tree characteristics (tree diameter, height or wood density for example) and statistically determined parameters. The same can be applied to measure the volume of biomass and carbon deposited by vegetation at the Trees out of Forests (TOF). Further improvement of allometric equation development would be in a technical capacity, in order to better consider the variability of wood density within a tree – as an important explanatory variable of tree biomass. More generally, integrating approaches to tree allometry for biomass estimates (height-diameter relations, biomass expansion factors, etc.) would lead to a great improvement of forest carbon stock and carbon stock change assessment.

II. 5. Estimation of biomass carbon (above and below ground)

Estimates of carbon stock are generally produced by first measuring the total biomass of the population using one of the two approaches. The first is to estimate wood volume for each tree using a volume equation, convert wood volume to mass using an estimate of timber density, and then convert wood mass to total tree biomass using biomass expansion factors. The second approach is to apply a regression equation that directly converts external measurements, such as stem diameter and sometimes height, to total tree biomass. Individual tree biomass values produced using either of the approach are summed to produce the biomass of the entire population, which is then multiplied by a standard value of carbon concentration to produce an estimate of carbon stock. The current study adopted the second method following non-destructive sampling approach to estimate the above ground and below ground tree and bamboo biomass, Tree biomass was estimated by multiplying volume with specific gravity.

III. Results and discussion

A total of 108 species of angiosperms belonging to 48 families were recorded from all segments, different land use types of Telineelapuram village and the surrounding (15 km radius) region are presented in ***Table: 1***. Of these, 50 were herbs, 23 were shrubs and 35 were tree species. Out of 35 tree species only 14 species were present in the 28 acres (11.33 hectares) of the Habitation area. Of these, *Tamarindus indica*, *Prosopis juliflora*, *Melia azadirachta*, *Sapindus emarginatus* and 1 species of shrub *Bambusa arundinacea* were the most important and utilizing by the birds as roosting and nesting purposes are only considered for the estimation of biomass and C-stock.

A total of 49 trees and 5 shrubs (54) were studied in the area and Fabaceae was the most dominant family accounting 53.7% of the studied species and deposited 54% of total estimated biomass carbon is represented in ***Figure 2***.

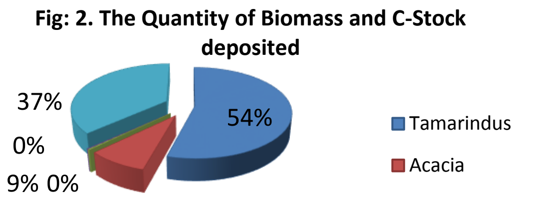

Figure 2. *Quantity of Biomass and C-Stock Deposited*

The amount of biomass and carbon stock deposited by Tmarindus, Acacia, Sapindus, Azadirachta and Bamboo are 153.19 and 84.25 tons, 24.26 and 13.34 tons, 0.56 and 0.31 tons, 0.62 and 0.34 tons and 104.09 and 57.25 tons respectively from the study area were shown in Table: 2. The quantity of Above Ground Biomass (AGB) and Below Ground Biomass (BGB) is set down by Tmarindus, Acacia, Sapindus, Azadirachta and Bamboo are 127.66 and 25.53 tons, 20.22 and 4.04 tons, 0.47 and 0.09 tons, 0.52 and 0.10 tons and 86.75 and 17.34 tons correspondingly.

The quantum of CO2 sequestered by the tree species of Tmarindus is 309.21 tons, Acacia is 48.96 tons, Sapindus is 1.14 tons, Azadirachta is 1.26 tons and Bamboo is 210.13 tons as well. The total AGB, BGB and the total biomass is put down from all the studied species of trees at Telineelapuram are 235.62 tons, 47.1 tons and 282.72 tons respectively. Moreover the amount of C-Stock deposited is 155.49 tones and the CO2 sequestered by all the trees species and one shrub at the study area is 570.69 tones were represented in Fig: 3.

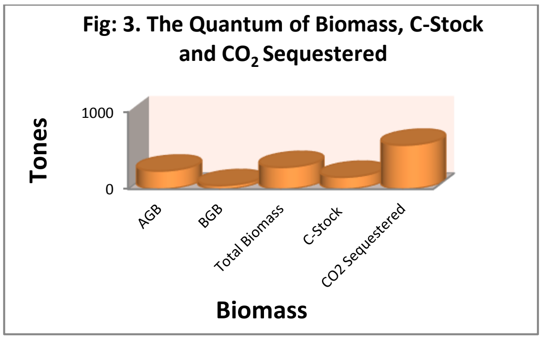

Figure 3. *Quantum of Biomass and C-Stock Deposited*

Algerian Journal of Environmental Science and Technology
December edition. Vol.3. Nº3-B. (2017)
ISSN : 2437-1114
www.aljest.webs.com

Table 1. Flora of the Telineelapuram Village and its Surroundings.

No.	Family	Scientific Name (Table: 1.)	Habit
1	Anacardiaceae	*Anacardium occidentale*L.	T*
2	Anacardiaceae	*Mangifera indica*Linn.	T
3	Annonaceae	*Annona reticulate* L.	T
4	Annonaceae	*A. squamosa*L.	T
5	Annonaceae	*Polyalthia suberosa*(Roxb.) Hook.f. &Thoms	T
6	Apocynanaceae	*Alstonia venenata R.Br*	T
7	Arecaceae	*Borassus flabellifer L.*	T*
8	Arecaceae	*Cocos nusifera L.*	T*
9	Arecaceae	*Phoenix sylvestris (L.) Roxb.*	T*
10	Burseraceae	*Garuga pinnata Roxb.*	T
11	Burseraceae	*Protium serratum*	T
12	Elaeocarpaceae	*Elaeocarpus tectorius (Lour.)*	T
13	Fabaceae	*Pithecolobium daulense* Spruce ex Benth.	T
14	Fabaceae	*Tamarindus indica* L.	T
15	Meliaceae	*Aglaiaelaea gnoidea (A. Juss).*	T
16	Meliaceae	*Cipadessa baccifera (Roth.)*	T
17	Meliaceae	*Melia azadirachta L.*	T*
18	Mimosaceae	*Prosopis juliflora* (Sw.) DC.	T*
19	Moraceae	*Ficus benghalensis* L.	T
20	Moraceae	*Ficus religiosa* L.	T
21	Myrtaceae	*Eucalyptus L, Herit*	T
22	Myrtaceae	*Syzygium cumini*	T
23	Rutaceae	*Atlantia monophylla (L.)*	T
24	Rutaceae	*Citrus medica L.*	T
25	Rutaceae	*Glycomisma uritiana (Lam.)*	T
26	Rutaceae	*Glycosmis pentaphylla*	T
27	Rutaceae	*Limonia acidissima L.*	T
28	Rutaceae	*Murraya koengii (L.)*	T
29	Sapindaceae	*Sapindus emarginatus* Vahl.	T
30	Simaroubaceae	*Ailanthus excels Roxb.*	T
31	Sonneratiaceae	*Sonneratia apetala Buch.-Ham*	T
32	Sterculiaceae	*Helicteres isora L.*	T
33	Sterculiaceae	*Sterculia urens Roxb.*	T
34	Tiliaceae	*Grewia tiliifolia Vahl.*	T
35	Violaceae	*Homalium nepalense (Wall.)*	T

***Table: 2.** Biomass and Carbon deposited and Sequestered by the Nesting Trees at Telineelapuram*

S. No.	Tree Species	AGB (Tons)	BGB (Tons)	Total B (Tons)	C-Stock (Tons)	CO_2 Sequestered (Tons)
1	**Tamarindus**	127.66	25.53	153.19	84.25	309.21
2	**Acacia**	20.22	4.04	24.26	13.34	48.96
3	**Sapindus**	0.47	0.09	0.56	0.31	1.14
4	**Azadirachta**	0.52	0.10	0.62	0.34	1.26
5	***Bamboo**	86.75	17.34	104.09	57.25	210.13
	Grand Total:	**235.62**	**47.1**	**282.72**	**155.49**	**570.69**
AGB: Above Ground Biomass, BGB: Below Ground Biomass, Total B: Total Biomass, *Shrub						

It is estimated that the AGB, BGB and Total biomass of Tamarind at the study site is 11.27 tons/ha, 2.25 tons/ha and 13.52 tons/ha correspondingly. This is 1.78 tons/ha, 0.36 tons/ha and 2.14 tons/ha in Acacia, where as in Sapindus the AGB, BGB and Total biomass is 0.041 tons/ha, 0.008 tons/ha and 0.049 tons/ha respectively. In Azadirachta this is 0.046 tons/ha, 0.009 tons/ha and 0.055 tons/ha, however in Bamboo it is predicted that 7.66 tons/ha, 1.53 tons/ha and 9.19 tons/ha respectively is represented in ***Fig: 4***.

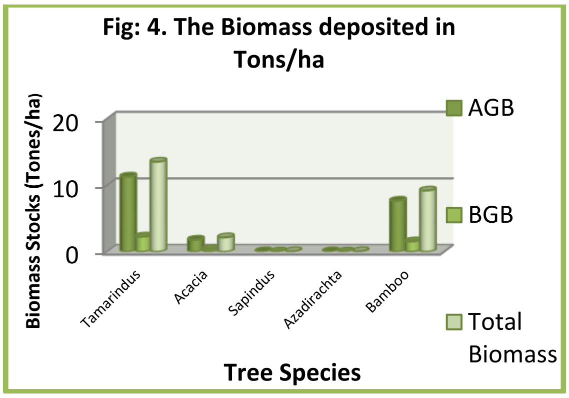

Figure 4. *The Biomass deposited in Tons/ha*

However the total biomass, C-Stock and CO_2 sequestered by each species of Tmarindus, Acacia, Sapindus, Azadirachta and Bamboo are 13.52, 7.44, 27.29 tons/ha; 2.14, 1.18, 4.32 tons/ha; 0.05, 0.03, 0.1 tons/ha; 0.055, 0.03, 0.11 tons/ha and 9.19, 5.05, 18.55 tons/ha respectively is represented in ***Fig: 5.*** The present study revealed that the total AGB at Telineelapuram is 20.79 tons/ha, BGB is 4.16 tons/ha and total biomass is 24.95 tons/ha. Whereas the total carbon stock is 13.73 tons/ha and the total CO_2 sequestered is 50.37 tons/ha.

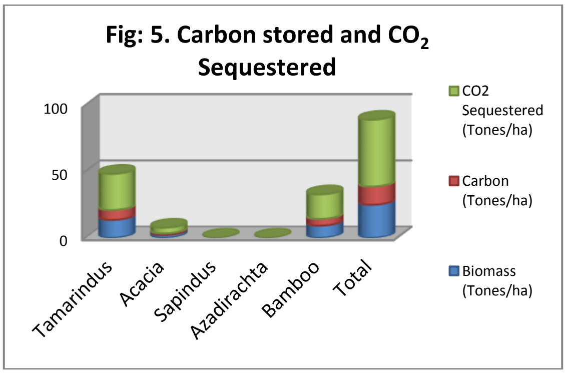

Figure 5. *Carbon Stored and CO2Sequestered*

The presented study is intended to estimate the biomass (AGB and BGB) deposited with different tree species, all the studied trees are at different age groups. But these studied tree species are using for the nesting and roosting purposes by the two important ***near threatened*** migratory birds of Spot-billed Pelicans (***Pelicanus philippensis)*** and Painted Storks (***Mycteria leucocephala)*** at Telineelapuram. It is one of the bird protected areas of A.P., India and serving as an important habitation area, inviting these migratory birds. Through costing the biomass can know the amount of C-Stock and CO_2 sequestered, since it is one of the important green house gas leading to global warming. The study area is comes under Trees out of Forests (TOF), currently we have very little and inadequate information about the carbon sequestration by vegetation at TOF. This study will help in that direction and compensate carbon present in the atmosphere and removed by vegetation.

The study area is dominated by Tamarind trees and many are age old where the birds are habituating every year. The total biomass and C-Stock deposited is much in Tamarind rather other species, Tamarind alone yielded 13.52 tons/ha of biomass and 7.44 tons/ha of C-Stock. The CO_2 sequestered by this species is 27.29 tons/ha, both the bird species are using Tamarind as nesting trees. The next dominant species in the study site is Acacia, however considering biomass and C-Stock a shrub species of Bamboo is dominating and 9.19 tons/ha of biomass, 5.05 tons/ha of C-Stock is deposited and 18.55

Algerian Journal of Environmental Science and Technology
December edition. Vol.3. Nº3-B. (2017)
ISSN : 2437-1114
www.aljest.webs.com

tons/ha CO_2 is sequestered. The shrub Bamboo is using as nesting tree by a single bird species (Painted Storks) only. It is calculated that the total C-Stock and CO_2 sequestered from the TOF of Telineelapuram is 13.73 tons/ha and 50.37 tons/ha respectively.

IV. Conclusion

However, the current study site Telineelapuram is inhabited by human settlements and the bird protected area is completely under private lands. More over these migratory birds inhabiting much closed to human settlements and sometimes these nesting trees are present at the backyards of the houses. Since the majority of land owned under private land owners, people have a habit to use these trees for agricultural implements, fire wood purposes, furniture usage etc. By this the nesting trees are disturbing and leading to loss of C-Stock. The trend of illegal harvesting of trees for charcoal and fuel wood production is unchecked the TOF of Telineelapuram bird protected area will be completely exhausted in the coming years.

Therefore, it is recommended that a decisive action is required in order to address devegitation and degradation of the reserve at TOF of Telineelapuram. No attempt has been made so far to assess the biomass and soil carbon sequestration at micro-level. Such kind of micro level study is essential for sustainable management, especially in a country like India, where heavy degradation had been caused by anthropogenic activities and different forest management prescriptions of the past warranted in different periods of time to meet the local and national needs. Therefore, a research study has been taken up to estimate the carbon stock available in a TOF of Telineelapuram of Srikakulam district, A.P., India.

V. References

1. Butler, R. A. Amazon rainforest locks up 11 years of CO2 emissions mongabay.com. (2007).
2. FSI (Forest Survey of India) Report-2009.
3. FSIISFR (Forest Survey of India-India State of Forest Report)-2015.
4. Kleinn, C. On large-scale inventory and assessment of trees outside forests, Unasylva 200 (2000) 3-10.
5. FSI (Forest Survey of India) Report-2005-06.
6. Millard P., Sommerkorn M., & Grelet G. Environmental Change and Carbon Limitation in Trees: A Biochemical, Eco-physiological and Ecosystem Appraisal. New Phytologist, 175(1) (2007) 11-28.
7. Srinivasa Rao V., Prasad K., Bheemalingappa M., Veeranjaneyulu D., Thulsi Rao K. and Ravi Prasad Rao B. Above-ground standing biomass and carbon stocks of trees outside forests in Prakasam district, Andhra Pradesh, India, Journal of Basic and Applied Biology, Vol. 6, No.3&4 (2012) pp. 83-88.
8. Chavan, B.L., and Rasal, G.B., Sequestered standing carbon stock in selective tree species grown in University campus at Aurangabad, Maharashtra, India, International Journal of Engineering Science and Technology, 2 (2010) 3003-3007.
9. Keeling CD, Bacastrow RB, Carter AF, Piper SC, Whorf TP, et al. A three-dimensional model of atmospheric carbon dioxide transport based on observed winds: 1. Analysis of observational data. In Aspects of climate variability in the Pacific and the western Americas. Washington D.C., U.S.A.: Geophysical Monographs. American Geophysical Union. (1989) pp. 165-236.
10. www.research.noaa.gov (accessed on 28th April 2012).
11. Brown S, Tropical forests and the global carbon cycle: The need for sustainable land-use patterns. Agriculture, Ecosystems and Environment 46 (1993) 31-44.
12. IPCC (Intergovernmental Panel on Climate Change) Report-2007.
13. Sheikh, M. A., M. Kumar, R. W. Bussman and, N. P. Todaria. Forest carbon stocks and fluxes in physiographic zones of India. Carbon Balance Manag. 6 (2011) 15.
14. Jos G.J. Olivier (PBL), Greet Janssens-Maenhout (IES-JRC), Marilena Muntean (IES-JRC), Jeroen A.H.W. Peters (PBL), Trends in global CO2 emissions: 2015 Report, , © PBL Netherlands Environmental Assessment Agency, The Hague, 2015, PBL publication number: 1803, JRC Technical Note number: JRC98184.
15. Zewdie M, M Olsson, and T Verwijst, Above-ground biomass production and allometric relations of Eucalyptus globulus Labill. Coppice plantations along a chronosequence in the central highlands of Ethiopia. Biomass and Bio-energy, 33 (2009) 421–428.
16. Brown Sandra, Andrew J. R. Gillespie and Ariel E. Lugo (1989) Biomass Estimation Methods for Tropical Forests with Applications to Forest Inventory Data, Forest Science, Vol. 35, No. 4, (1989) pp. 881-902.
17. Cairns MA, Brown S, Helmer EH and Baumgardner GA, Root biomass allocation in the world's upland forests 111 (1997) 1–11.
18. Carsan, S., Orwa, C., Harwood, C., Kindt, R., Stroebel, A., Neufeldt, H., Jamnadass, R., African Wood Density Database. World Agroforestry Centre, Nairobi, Kenya (2012).
19. Zanne, A.E., Lopez-Gonzalez, G., Coomes, D.A., Ilic, J., Jansen, S., Lewis, S.L., Miller, R.B., Swenson, N.G., Wiemann, M.C., Chave, J., Data from: towards a worldwide wood economics spectrum. Dryad Digital Repository. Global Wood Density Database. Retrieved from: http://dx.doi.org/10.5061/dryad.234 (2009) (accessed on December 26, 2014).

20. Chave, J., Coomes, D., Jansen, S., Lewis, S.L., Swenson, N.G., Zanne, A.E., Towards a worldwide wood economics spectrum. Ecol. Lett. 12 (4) (2009) 351–366.
21. Winrock International Institute for Agricultural Department, A guide to monitoring carbon storage in forestry projects (1997).
22. Unfccc/Ccnucc, Project Design Document Form For Afforestation And Reforestation Project Activities (Cdm-Ar-Pdd) - Version 05 (2011).

Please cite this Article as:
Ramamohan, H. Costing of Total Biomass, C-Stock and CO_2 Sequestered by the Trees out of Forest (TOF) at Telineelapuram Bird Protected Area, an IBA Site; IN 229 India, *Algerian J. Env. Sc. Technology, 3*:3-B (2017) 69-76