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Research Article

Carbon Sequestration of Sacred Groves in Ambegaon taluka of Pune districts through student activity

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Abstract

The increasing carbon emission is of major concerns for entire world as well addressed in Kyoto protocol . Carbon sequestration in growing forests is known to be a cost-effective option for mitigation of global warming and global climatic change. That's why there is the need for knowing the carbon sequestration potential of sacred groves. In the present study seven M.Sc. students from Department of Environment Science, Savitribai Phule Pune University visited sacred groves and they trained for data collection of vegetation from Sacred groves and calculation of carbon sequestration of individual species based on standard method. There are 6 species including 20 individuals have been recorded in Aghane sacred grove, Tirpad Sacred grove, there are 4 species and 8 individuals. The total Organic Carbon is 258.08 tons, for Aghane Sacred grove. *Caryota urens* L. species are dominant in sacred grove; we took sequestration for only 3 individuals. The total Organic Carbon is 433.93 tons, for Tirpad Sacred grove. *Syzigium cumini* Skeels. species are dominant in Tirpad Sacred grove. There are 14 species including 35 individuals have been recorded in *Asane* sacred grove. Above table demonstrates total number of trees present in sacred grove. The above ground organic carbon (AGC) per tree (t/tree); below ground organic carbon (BGC) per tree (t/tree); the total organic carbon of each tree in tones and the total organic carbon sequestrated in 54 trees have been summarized. *Atlantia racemosa* Wt.. species are dominant followed by *Mangifera indica* L. and *Syzygium cuminii* Skeels. in Asane sacred grove. The total amount of carbon sequestered by 35 trees is 341.1125 tones**.** This clearly indicates that the carbon sequestration is more in Tirpad Sacred grove than Aghane. The individuals tree species in Asane sacred groves are 35 and carbon sequestration is less. The organic carbon sequestrated in per species is shown for comparison purpose. The estimated organic carbon (biomass) has been compared with allometric model.

INTRODUCTION

Conservation of Nature by way of sacred grove is a ancient practice in India as well as in other countries. Sacred groves are important elements of ecosystem. These ecosystems need to under by Pune based educated people having interest of nature. These groups gathered to understand wealth of Sacred Groves preserve by local people and tribal people reside in villages. Maharashtra Vrikash Sanvardhini, Pune based NGO need to communicate conservation message through field visits along with M.Sc. students for their relation with sacred groves and to know present status.

Sacred grove mission reached to the students of Department of Environmental Science, S.P. Pune University by giving different projects related to Devrai/sacred grove concept and its conservation issue.

Seven students focus their attention towards ecology and ecosystem studies and create awareness of conservation. All these efforts are necessary for community sensitization either rural or urban to understand nature conservation (Phatak *et al*., 2017)

Carbon Sequestration of Sacred Groves :

The study of carbon sequestration is an important aspect from the environmental point of view. All living and non-living organic matter contains approximately 50% carbon. Carbon exists in various forms and is cycled between several biotic and abiotic pools including oceans, terrestrial biota and atmosphere (Skole *et al.,* 1995). Plants are important sinks for atmospheric carbon since 50% of their standing biomass is carbon itself (Ravindranath *et al.,* 1997). In the modern world, because of industrial revolution and increased rate of urbanization the concentration of greenhouse gases (GHG_S) such as methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) in the atmosphere are increasing constantly. Among GHG_s, CO_2 is the dominant, accounting for nearly 77% of the global total CO_2 equivalent greenhouse gas emissions (IPCC 2007c). In terms of radiation forces by GHG_s emitted as a result of human activities CO_2 accounts for 56% of the total global warming potential of GHG_s (IPCC 2007a). The concentration of CO_2 in the atmosphere increased from a pre-industrial level of 279 parts per million by volume (PPMV) to 379 PPMV in 2005. An unprecedented increase of 36% in CO_2 concentration was observed between 1750 and 2005.

In Maharashtra, there are approximately 1600 Sacred groves are recorded (Deshmukh et al. 1999). Sacred groves from Pune district were surveyed for multi-disciplinary aspects. Earlier documentation of sacred groves from Maharashtra state by Gadgil and Vartak (1981), Kulkarni and Kumbhojkar (1999) recorded submerged sacred groves from Varasgaon dam site. Kanhere (2006) made quantitative and comparative plant diversity of two monotypic sacred groves in Pune district, Maharashtra state (Kulkarni et al 2013). Kulkarni et.al.(2007) reported wild bamboo diversity in sacred groves of Pune district, Maharashtra state. In recent years due to developmental activities threat to medicinal plants in Pune district was reported by Upadhye *et al.,* (2004). Kulkarni and Sindikar (2005) made plant diversity evaluation of Shirkai sacred grove situated at village Shirkoli. Nipunage and Kulkarni reported regeneration study of 19 sacred groves from Ambegaon taluka of Pune districts. Hangarge (2013) carried out research on carbon sequestration of sacred groves from Bhor region of Pune district for their Ph.D. degree. In recent years sacred groves are focused on carbon sequestration like Kalamvihira from Jawhar region of Palghar district, Somjaichi rai from Bhor region of Pune district. (Kulkarni and Kulkrni 2012, Hangarge et al.2013). In the present study carbon sequestration from sacred groves in Ambegaon region has been carried out. The results of Agane , Asane Tirpad sacred grove are presented.

MATERIAL AND METHODS :

Study Area :

Ambegaon taluka of Pune district has 34 Sacred groves recorded in 20 villages. Field studies were selected two Sacred groves viz. Aghane, Asane and Tirpad. The hilly region from the North Western Ghats moist deciduous forest and located in (19°2′5″N 73°50′11″E) . The detail geographical location and other details are as below:

1)Aghane Sacred grove :

<u>Geographic co-ordinates **:**</u>
Latitude **:** 19°10′53.9520″ N to 19°10′53.7240″ N
Longitude **:** 73°37′0.6599″ E to 73°37′0.780″ E
Altitude **:** 1023.3 to 1023.9 m
<u>Total area **:**</u> 358.52 hectares
<u>Deity of grove **:**</u> Vandev

2)Tirpad Sacred grove :

<u>Geographic co-ordinates **:**</u>
Latitude **:** 19°9′58.46.40″ N to 19°9′56.7780″ N
Longitude **:** 73°38′49.7459″ E to 73°38′49.2660″ E
Altitude **:** 961.9 to 1003.2 m
<u>Total area **:**</u> 699.55 hectares
<u>Deity of grove **:**</u> Vandev / Shankar

3) Asane sacred groves

Latitude: 19°09' and 73°40' E longitude.

An average rainfall is 2200 to 2500 mm from June to September.

Female diety Varsubhai,.

Methods : Three major components (or sets of processes) together constitute net sequestration of carbon in forest trees :

a) Carbon uptake and assimilation, including immediate respiratory losses which detract from previously 'fixed' carbon in photosynthetic plant cells.

b. Carbon transport, allocation and partitioning of carbon for storage, structural and metabolic use in above-ground and below-ground parts of the tree.
c. Return of forest carbon to the atmosphere via oxidative pathways, notably via the food chain, biological decay and combustion of forest biomass and forest products.

- **Sampling Strategy :**

– The random sampling method was used for sampling the above ground vegetation. Individuals of tree species are selected randomly in the field.
– For this, Plot method is used, all plots of 25x25 m size were laid randomly.
– This method is one of the most commonly used for all kind of vegetation sampling. The method is versatile, cost-effective and applicable to baseline as well as project scenario.
– Plot method is also among the methodologies approved by the Clean Development Mechanism for afforestation and reforestation projects under the Kyoto Protocol, measuring the indicator parameters (e.g. tree DBH, or height), using different approaches such as allometric functions, for calculating the biomass and extrapolating the value to per hectare and for the total project area.
The following parameters were measured for estimating the above-ground biomass pool.

1) Tree Height and Diameter at Breast Height (DBH) :

– To estimate biomass of different trees, non-destructive method was used.
– The biomass of tree was estimated on the basis of DBH and tree height.
– DBH can be determined by measuring tree Girth at Breast Height (GBH), approximately 1.3 meter from the ground.
– The GBHs of trees having diameter greater than 10 cm were measured directly by measuring tape.
– The tree height was measured by stick/pen method.

2) Above ground biomass (AGB) of trees :

– The above ground biomass of tree includes the whole shoot, branches, leaves, flowers, and fruits. It is obtained by using the following formula:
–

$$AGB\ (kg) = volume\ of\ tree\ (m^3) * wood\ density\ (kg/m^3)$$

$$V = \pi r^2 H$$

$V = volume\ of\ the\ cylindrical\ shaped\ tree\ in\ m^3$

$r = radius\ of\ the\ tree\ in\ m$

$H = Height\ of\ the\ tree\ in\ m$

– Radius of the tree is calculated from GBH of tree.
– The wood densities of Asian tree species are considered as 0.63

3) Belowground biomass (BGB) of tree :

– The below ground biomass (BGB) includes all biomass of live roots excluding fine roots having less than 2 mm diameter.
The belowground biomass has been calculated by multiplying the above ground biomass (AGB) by 0.26 factors as the root**:** shoot ratio.

$$BGB\ (kg/tree) or\ (ton/tree) = AGB\ (kg/tree) * 0.26$$

RESULTS AND DISCUSSIONS

Global warming is amongst the most dreaded problems of the new millennium. Carbon emission is supposed to be the strongest causal factor for global warming. In recent years increasing carbon emission is one of the major concerns, which is addressed in Kyoto Protocol. Trees are significant elements of landscape in relation to biomass and diversity. The anthropogenic activities have known to affect the bio-sphere through changes in land use pattern and forest management activities, naturally which alter the balance of greenhouse gases in the atmosphere. Over the last three centuries forests have decreased by 1.2 billion hectares i.e. 19 % and grass lands by 560 million hectares. This has resulted due to an increase in cropland and growth of urban areas. The rate of agricultural expansion during the period of 1950-1980 was greater than the entire span of 150 years between 1700 and 1850. During the decade 1981-1990, land use changes in the tropics accounted for CO_2 emissons of about 1.6 giga tonnes per year. On the other hand terrestrial vegetation assimilated approximately 1.8 giga tonnes of carbon per year during the same period. This indicates that carbon balance shows that in the 1980 the terrestrial vegetation in the tropics acted as a net sink of carbon (Bhadwal and Singh, 2002). Forest ecosystems capture and store more than 80% of all terrestrial above-ground carbon and more than 70% of all soil organic carbon. The annual CO_2 exchange between forests and the atmosphere via photosynthesis and respiration is 7 times the anthropogenic carbon emission. Green plants and trees uptake CO_2 from the atmosphere and combines it with H_2O through photosynthesis and produce simple sugars and more stable carbohydrates. Thus, trees capture and store atmospheric CO_2 in vegetation, soils and biomass products through photosynthesis. Carbohydrates become the building blocks and energy supply for almost all o flife on Earth.

Table 1: Aghane Sacred grove

Sr. No.	Name of Plant Species	Height (m)	Width (m)	Radius (m)	Volume (cubic m)	AGB	BGB	Total
1	*Caryota urens L.*	6.75	1.2	0.6	7.63	5.26	1.37	6.63
2	*Caryota urens L.*	6	1.1	0.55	5.70	3.93	1.02	4.95
3	*Caryota urens L.*	5.25	0.5	0.25	1.03	0.71	0.18	0.90
4	*Diospyrous montana* Roxb	8.25	1.65	0.825	17.63	12.16	3.16	15.33
5	*Diospyrous Montana* Roxb.	8.25	2.1	1.05	28.56	19.71	5.12	24.83
7	*Mangifera indica L.*	6	0.95	0.475	4.25	2.93	0.76	3.69
8	*Mangifera indica L.*	6	0.75	0.375	2.65	1.83	0.48	2.30
9	*Mangifera indica L.*	8.25	1.7	0.85	18.72	12.92	3.36	16.28
10	*Mangifera indica L.*	7.5	2.1	1.05	25.96	17.91	4.66	22.57
11	*Memecylon umbellatum* Burm.f.	7.5	1.45	0.725	12.38	8.54	2.22	10.76
12	*Memecylon umbellatum* Burm.f.	6	1.3	0.65	7.96	5.49	1.43	6.92
13	*Memecylon umbellatum* Burm.f.	6.75	1.9	0.95	19.13	13.20	3.43	16.63
14	*Syzygium cumini* Skeels	7.5	2.2	1.1	28.50	19.67	5.11	24.78
15	*Syzygium cumini* Skeels	6.75	1.7	0.85	15.31	10.56	2.75	13.31
16	*Syzygium cumini* Skeels	7.5	2.2	1.1	28.50	19.67	5.11	24.78
17	*Xantolis tomentosa* Raf	5.25	1.55	0.775	9.90	6.83	1.78	8.61
18	*Xantolis tomentosa* Raf	6.75	1.6	0.8	13.56	9.36	2.43	11.79
19	*Xantolis tomentosa* Raf	8.25	1.8	0.9	20.98	14.48	3.76	18.24
20	*Xantolis tomentosa* Raf	7.5	2.2	1.1	28.50	19.67	5.11	24.78
		132	**29.95**	**14.98**	**296.85**	**204.83**	**53.26**	**258.08**

Table 2: Tirpad Sacred grove :

Sr. No.	Name of Plant Species	Height (m)	Width (m)	Radius (m)	Volume (cubic m)	AGB	BGB	Total
1	*Diospyrous Montana* Roxb.	7.6	1.3	0.65	10.08	6.96	1.81	8.76
2	*Memecylon umbellatum* Burm.f.	6.1	1.9	0.95	17.29	11.93	3.10	15.03
3	*Memecylon umbellatum* Burm.f.	6.9	1.5	0.75	12.19	8.41	2.19	10.60
4	*Olea dioca* Roxb.	7.6	1.3	0.65	10.08	6.96	1.81	8.76
5	*Olea dioica* Roxb.	8.4	7.6	3.8	380.87	262.80	68.33	331.13
6	*Olea dioica* Roxb.	7.6	1.6	0.8	15.27	10.54	2.74	13.28
7	*Olea dioica* Roxb.	6.9	2.7	1.35	39.49	27.25	7.09	34.33
8	*Xantolis tomentosa* Raf.	6.1	1.7	0.85	13.84	9.55	2.48	12.03
		57.2	**19.6**	**9.8**	**499.10614**	**344.3859**	**89.544**	**433.9299**

Table 3: Asane sacred grove:

Sr. No.	Name of plant species	Height (m)	Width (m)	Radius(m)	Volume	AGB	BGB	Total Organic Carbon
1	*Sterculia guttata* Roxb	6.75	1.55	0.775	12.73	8.784	2.284	11.067
2	*Atlantia racemosa* Wt.	6.75	0.7	0.35	2.596	1.791	0.466	2.257
3	*Atlantia racemosa* Wt.	7.5	0.7	0.35	2.884	1.989	0.517	2.507
4	*Atlantia racemosa* Wt.	6.75	0.8	0.4	3.391	2.339	0.608	2.948
5	*Atlantia racemosa* Wt.	8.25	0.9	0.45	5.245	3.619	0.941	4.56
6	*Atlantia racemosa* Wt.	7.5	1	0.5	5.887	4.062	1.056	5.118
7	*Atlantia racemosa* Wt.	6	0.9	0.45	3.815	2.632	0.684	3.316
8	*Atlantia racemosa* Wt.	6	1.4	0.7	9.232	6.37	1.656	8.026
9	*Lagestroemia microcarpa* Wt.	8.15	1.2	0.6	9.213	6.356	1.653	8.009
10	*Mallotus philippensis* Muell.-Arg.	6	0.9	0.45	3.815	2.632	0.684	3.316
11	*Mallotus philippensis* Muell.-Arg.	4.5	1	0.5	3.532	2.437	0.634	3.07
12	*Bridalia retusa (L.)* Spreng	3.75	0.9	0.45	2.384	1.645	0.427	2.073
13	*Caryota urens* L.	6	1.2	0.6	6.782	4.679	1.216	5.896
14	*Caryota urens* L	6.75	1.4	0.7	10.385	7.166	1.863	9.028
15	*Ficus benghalensis* L.	9	2.6	1.3	47.759	32.954	8.568	41.522
16	*Gaurga pinnata Roxb.*	6.75	1.5	0.75	11.922	8.226	2.139	10.365
17	*Sterculia guttata* Roxb	9.75	2.1	1.05	33.753	23.289	6.055	29.345
18	*Sterculia guttata* Roxb	6.75	1	0.5	5.298	3.656	0.95	4.606
19	*Mangifera indica* L.	7.5	1.3	0.65	9.949	6.865	1.785	8.649
20	*Mangifera indica* L	3.75	0.7	0.35	1.442	0.995	0.258	1.254
21	*Mangifera indica* L	4.5	1.2	0.6	5.087	3.51	0.913	4.423
22	*Mangifera indica* L	7.5	1	0.5	5.887	4.062	1.056	5.118
23	*Mangifera indica* L	6.75	2.2	1.1	25.646	17.695	4.601	22.296
24	*Syzygium cumini* Skeels	4.5	1	0.5	3.532	2.437	0.634	3.071
25	*Syzygium cumini* Skeels	6	1	0.5	4.71	3.249	0.845	4.095
26	*Syzygium cumini* Skeels	7.5	1.2	0.6	8.478	5.849	1.521	7.371
27	*Syzygium cumini* Skeels	9	2.55	1.275	45.94	31.698	8.242	39.94
28	*Syzygium cumini* Skeels	8.25	2	1	25.905	17.874	4.647	22.522
29	*Terminalia bellierica* Roxb	7.5	1.7	0.85	17.015	11.74	3.052	14.793
30	*Terminalia belliercia* Roxb	7.5	1.55	0.775	14.145	9.76	2.537	12.298
31	*Terminalia chebula* Retz.	3	0.7	0.35	1.154	0.796	0.207	1.003
32	*Terminalia elliptica* Will.	6.25	2	1	19.625	13.541	3.52	17.0619
33	*Terminalia elliptica* Will	6.25	1.6	0.8	12.56	8.666	2.253	10.919
34	*Terminalia cuneata Roxb.*	7.5	0.9	0.45	4.769	3.291	0.856	4.146
35	*Terminalia cuneata Roxb.*	7.5	1	0.5	5.887	4.062	1.056	5.118
	Total					**270.724**	**70.388**	**341.1125**

The terrestrial greenery plays an important role in global carbon sequestration. It has been estimated that 1146 Gt carbon is stored within the 4.17b ha of tropical, temperate and boreal forest areas, about one-third of which is stored in forest vegetation (IPCC, 2000).

Biomass estimation is the first step to know atmospheric carbon harvest through the forest. The breast height (dbh) relationship to biomass is well formulated (Kira and Ogava, 1971). Traditionally biomass was estimated using harvest of the tree (Chaturvedi and Singh, 1987). Westlake (1963) showed that the biomass is having a direct relationship with the amount of carbon present in different parts of the tree i.e. 47% of the total dry biomass.

The expansion of forest areas and maturing of forest stands are the basis of their function as atmospheric carbon sinks (Delcourt and Harris, 1980). Estimates of net release of carbon (C) at the global level are highly uncertain, ranging from 0.4-1.6 Gt (109t or 1015g) of C/year to 1.1-3.6 Gt C/year (Houghton, 1993).

The atmospheric CO_2 concentration is currently rising by 4% per decade (Jo and Mcpherson, 2001). Increasing levels of CO_2 and other carbon containing gases will result in temperature rise by 1.4 to 5.80°C during next century (Bhadwal and Singh, 2002).. Higher temperature accelerates enzymatic processes and therefore biomass accumulation, unless other factors are limiting. Increasing temperature may also increase annual Net Primary Production (NPP) by lengthening the growing season (Hasenauer and Monserud, 1997).

The concept of carbon sequestration of trees in sacred groves is a primary role of carbon estimation and it will lead to estimate carbon credit. The benefits of carbon credit will be a major part of income to the villagers by conserving sacred groves with appropriate care. Estimation of carbon from these groves will be a unique attempt for biomass production and income from the carbon credit.

In the present study there are 6 species including 20 individuals have been recorded in Aghane sacred grove, Tirpad Sacred grove, there are 4 species including 8 individuals.

Above tables demonstrate total number of trees of each species and total number of trees present in sacred grove. It also indicates the average GBH in cm and average tree heights in meters. The mean above ground organic carbon (AGC) per tree (t/tree); mean of below ground organic carbon (BGC) per tree (t/tree); the total organic carbon of each species in tones and the total organic carbon sequestrated in 20 trees have been summarized. The organic carbon sequestrated in per species is shown for comparison purpose. The estimated organic carbon (biomass) has been compared with allometric model.

The total Organic Carbon is 258.08 tons, for Aghane Sacred grove. *Caryota urens* L. species are dominant in sacred grove; we took sequestration for only 3 individuals. The total Organic Carbon is 433.93 tons, for Tirpad Sacred grove. *Syzigium cumini* Skeels. species are dominant in Tirpad Sacred grove.

There are 14 species including 35 individuals have been recorded in *Asane* sacred grove. Above table demonstrates total number of trees present in sacred grove. The above ground organic carbon (AGC) per tree (t/tree); below ground organic carbon (BGC) per tree (t/tree); the total organic carbon of each tree in tones and the total organic carbon sequestrated in 54 trees have been summarized. *Atlantia racemosa* Wt.. species are dominant followed by *Mangifera indica* L. and *Syzygium cuminii* Skeels. in Asane sacred grove. The total amount of carbon sequestered by 35 trees is 341.1125 tones**.**

This clearly indicates that the carbon sequestration is more in Tirpad Sacred grove than Aghane. The individuals tree species in Asane sacred groves are 35 and carbon sequestration is less.

CONCLUSION

India is a unique developing country where nearly seven percent of the world's crop resources originated from forests. It has great variations due to climatic and topographic situations which make it rich in biodiversity.

The increasing carbon emission is of major concerns for entire world as well addressed in Kyoto protocol . Carbon sequestration in growing forests is known to be a cost-effective option for mitigation of global warming and global climatic change. That's why there is the need for knowing the carbon sequestration potential of sacred groves.

India is sequestrating more than 116 million tones of CO2 per year which is equal to 32 millions of carbon sequestration, contributes to reduced atmospheric carbon of the globe (Mohapatra, 2008). However, the destruction of habitats, severe land degradation and displacement of local people is posing major threats to these precious resources. This has led to the loss of traditional agro-systems, which have high crop and live stock diversity. It is observed that vegetation of the above mentioned sacred groves are conspicuously different from even well-protected vegetation of the reserved forest. These sacred groves are mainly in the high rainfall area and have tall lofty trees of optimum growth and huge giant climbers. In this respects sacred groves in dam affected areas are playing significant role in protecting various types of trees, rare plants, germplasm of economically important medicinal and wild fruit trees which are maintained by the local tribal people. Protection and preservation of these natural habitats, scientific documentation of plants and traditional knowledge of agriculture should be undertaken and a proper working plan should be formulated before planning developmental activities in these areas. Necessary efforts need to be taken to protect the sacred groves to prevent the loss of biodiversity. In addition regular monitoring is required to evaluate the loss of diversity. The protection of the groves and conservation of their valuable biodiversity and cultural diversity can be achieved through people's participation only. The stake holders of the groves may be provided substantial incentives for the same.

Considering the significance of Sacred Groves / Forests in ecological balance, culture and tradition, C.P.R. Environmental Education Centre (CPREEC) has taken efforts to identify and select endangered and near extinct Sacred Groves / Forests for restoration in Andhra Pradesh, Karnataka and Tamil Nadu. Encroachment of people's participation and contribution in selecting the sites, watering, bio-fencing, manuring, tree planting, etc. are the hallmarks of the restoration programmes. The results of restoration efforts have been remarkable and have contributed to significant environmental changes in around restored groves, such as rise in groundwater levels, restoration of sun ,soil, water, reduction of surface water runoff, prevention of soil erosion, conservation of indigenous medicinal plants, preservation of local flora and fauna, provision of food and shelter for wildlife and birds, control of air pollution and increase in scenic beauty. Many endemic flora was observed in these groves such as *Soromatum pedatum* (badad), *Acacia coincinea*(Shikakai), various types of orchids and climbers were seen such as Vanda and Ramrakhi. The plants of these sacred groves have major role in ethno-botanical point of view.

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