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**POTENTIAL ROLE OF SIDDHKHO SACRED GROVE OF GWALIOR FOR CLIMATE  
CHANGE MITIGATION BY USING TERRESTRIAL CARBON SEQUESTRATION AS  
AN INDICATOR**

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**ABSTRACT**

Siddhkho sacred grove possesses rich diversity due to the protection offered by the priest and local people on the basis of religious beliefs and therefore still conserved for many years. These are the natural remnant of forest patches with functional ecosystem and which provides valuable ecosystem services. The present study aims to evaluate and compare the trees carbon stock of Siddhkho sacred grove and non sacred grove in Gwalior district of Madhya Pradesh, India. The aboveground biomass (AGB), belowground biomass (BGB) and carbon content sequestered in trees were estimated by allometric equations and conversion factors. The total biomass of tree vegetation in sacred grove was found to be 144.4 t/ha in 2015 and 153.51 t/ha in 2017, respectively. The aboveground carbon, belowground carbon and total carbon for 2015 and 2017 was 57.31 t/ha and 60.92 t/ha; 14.90 t/ha and 15.84 t/ha; 72.21 t/ha and 76.76 t/ha, respectively. The carbon increment during the two years (2015 – 2017) was found to be 4.55 t/ha/2yr. It can be concluded that the terrestrial carbon sequestration by trees can be an effective pathway for regional/local climate stabilization by reducing carbon dioxide from the atmosphere, and thus have a significant contribution towards mitigation of global climate change, at local level.

**Keywords: Sacred Grove, Terrestrial carbon sequestration, Carbon Increment**

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## INTRODUCTION

Presently, the atmospheric carbon dioxide concentration has risen to 412 ppm and may exceed upto 550 ppm by the end of the century [1]. The anthropogenic carbon dioxide emissions from the use of fossil fuels for energy, land use conversion, deforestation and an expansion in agriculture are the basic reasons for more amount of carbon in the atmosphere. The impact has been seen in the disturbances of terrestrial and marine ecosystems as global carbon cycling involves the exchange of carbon between the four main reservoirs of environment i.e. terrestrial biosphere, atmosphere, oceans and sediments. In terrestrial ecosystems, trees and soil together capture carbon dioxide thereby offsetting global heating by a small amount. Hence, terrestrial carbon sequestration process has been involved by which the atmospheric carbon dioxide through photosynthesis is taken up by the plants and is stored as carbon in the biomass and soil [2]. However, the efficiency with which flora fix the carbon depends on many factors such as climatic conditions, temperature, precipitation, edaphic conditions, etc. Siddhkho sacred grove, an undamaged fragment of natural forest conserved on the basis of traditional and religious beliefs, can capture atmospheric carbon dioxide and may

provide valuable regulatory ecosystem service. Therefore, the study was undertaken at Siddhkho sacred grove located in Gwalior district to study the role of trees for terrestrial carbon sequestration. The present work attempts to give a comparative account of carbon sequestration rate of sacred grove and the surrounding vegetation. Although, all biotic components trees, shrubs, herbs, litter and soil sequestered carbon dioxide, but in the current study major carbon pool i.e., trees vegetation were taken into consideration for two years.

## MATERIALS & METHODS

### 1) Study Area:

Siddhkho sacred grove (site – SKI) located at the geographical coordinate 26°04' 24.6" N and 078°17'57.6" E; is around 35 km from Gwalior city, Madhya Pradesh, conserved and enriched with flora and fauna was chosen for the present study. The outside adjacent area of Siddkhkho sacred grove (site – SKO) was considered as non sacred unconserved area with less biodiversity. The divine deity that resides over here is Lord Shiva and Goddess Parvati. The average altitude of Siddhkho sacred grove is about 269 meters above msl. The vegetation in this region is of tropical dry deciduous forests type. The climate is hot and dry with three distinct

seasons viz. summer, monsoon and winter. Maximum temperature ranges from 40°C - 48°C during April to June and minimum temperature ranges from 5°C – 0°C. The average rainfall is 80 mm.

## 2) Experimental lay out:

Permanent quadrants of 20m X 20m were laid randomly at both the sites - SKI and SKO. All the individual trees with GBH  $\geq$  10cm were enumerated and their girth was measured at 1.37m from the ground level. The non - destructive method was used to estimate tree biomass. Aboveground biomass was calculated by using allometric equation of [3] and below ground biomass by [4]. Carbon was considered as 50% of biomass as given by [5].

## RESULTS & DISCUSSION

### 1. Percentage distribution of trees in different girth classes of both sites - SKI and SKO

The site SKI and site SKO showed the maximum percentage 66.85% and 51.24% of trees in the girth class - Bole (32cm – 66 cm). The site SKI and site SKO showed lowest percentage (2.76%) in girth class - Sapling (10cm – 31cm) and (0.83%) in girth class – Mature tree (102cm – 171cm), respectively (**Figure 1 & Figure 2**). The mature trees were found more at site SKI due to the restrictions imposed on illegal cutting of

trees and conservation because of sacred grove. Similar type of girth class studies has been reported by [6].

### 2. Biomass estimation in tree vegetation of both sites - SKI and SKO

At site SKI, *Anogeissus latifolia* species showed the maximum biomass 113.66 t/ha and 121.45 in the year 2015 and 2017, respectively while minimum biomass was observed in *Bauhinia racemosa* 0.05 t/ha in both the years with no increment during the study period (**Table 1 and 2**). *Anogeissus latifolia* was the dominant species in site SKI that sequestered 56.83 t/ha and 60.73 t/ha of carbon in years 2015 and 2017, respectively, followed by other carbon sequestering tree species *Diospyros melanoxylon* (9.41 t/ha), *Alangium salviifolium* (2.42 t/ha), *Butea monosperma* (1.38 t/ha), *Acacia nilotica* (1.35 t/ha) and *Holoptelea integrifolia* (0.79 t/ha). The lowest carbon sequestration potential of 0.027 t/ha was found in *Bauhinia racemosa* species (**Table 1 and 2**).

The tree vegetation of site SKI showed the highest aboveground biomass (AGB) (114.60 t/ha), belowground biomass (BGB) (29.80 t/ha) and total biomass (TB) (144.40 t/ha) as compared to site SKO with AGB (28.93 t/ha), BGB (7.52 t/ha) and TB (36.45 t/ha), respectively, in the year 2015. Similarly,

highest AGB (121.84 t/ha), BGB (31.67 t/ha), TB (153.51 t/ha) was recorded in year 2017 at site SKI while site SKO showed AGB, BGB and TB to be 29.49 t/ha, 7.67 t/ha and 37.16 t/ha, respectively (**Table 3**). The large variation in biomass among sacred grove and non sacred groves may be attributed to differences in species composition, less vegetation, other edaphic factors and the type of anthropogenic disturbance. Similar reasons has also been stated by several workers [7-13]. The higher biomass may be also be attributed to trees of large diameter classes as depicted in fig.1 which is in coincides with the report of [14], as they observed that the various larger diameter size class trees, though lesser in number harbors more biomass and contribute to higher aboveground biomass.

An increment in biomass of trees was observed more at site SKI (9.11 t/ha/2yr) as compared to SKO (0.71 t/ha/2yr) of two years 2015-2017 (**Table 1**). Several workers recently have been working only on the total biomass and its related factors in Madhya Pradesh but they have not estimated the biomass increment for two years successively. Some earlier studies by [15] reported less biomass increment than the present study.

### **3. Carbon stock estimation in tree vegetation of both sites - SKI and SKO**

The aboveground carbon (AGC) and belowground carbon (BGC) of site SKI during the year 2015 and 2017 was found to be 57.31 t/ha and 60.92 t/ha; 14.90 t/ha and 15.84 t/ha, respectively (**Figure 3**). The site SKO showed very less AGC (14.46 t/ha and 14.75 t/ha) and BGC (3.76 t/ha and 3.83 t/ha), respectively during the year 2015 and 2017 (**Figure 4**). The total carbon stock (TC) of site SKI and SKO during the year 2015 and 2017 was found to be 72.21 t/ha and 76.76 t/ha; 18.23 t/ha and 18.58 t/ha, respectively (**Figure 3 & 4**). The total carbon stock result of sacred grove are comparable with the findings of [16] who reported the total carbon stock of various districts of Madhya Pradesh in the range of 4.7 t/ha to 68.7 t/ha. But the current results are less than the reported carbon stock for tropical deciduous forests of India found in the range of 15.6 t/ha to 151 t/ha [17].

### **4. Carbon increment and carbon dioxide uptake of both sites**

The results of site SKI showed the highest increment in aboveground carbon (AGC) (3.61 t/ha/2yr), below ground carbon (BGC) (0.94 t/ha/2yr) and total carbon (TC) (4.55 t/ha/2yr) as compared to site SKO with an

increment in AGC (0.28 t/ha), BGC (0.07 t/ha) and TC (0.35 t/ha), respectively, during the year 2015-2017 (Figure 5). Similar studies on annual carbon sequestration rates of selected trees species of forests and plantations were studied by [18]. They reported that the moderate growing teak forests and slow growing long rotation Sal

forests sequestered 2MgC/ha/yr and 1MgC/ha/yr, respectively. The carbon dioxide uptake (MgCO<sub>2</sub>/ha/2yr) taken by the tree biomass of sites - SKI and SKO was 16.68 and 1.28, respectively. Similar work on carbon storage and CO<sub>2</sub> has been done by [19] (Figure 5).

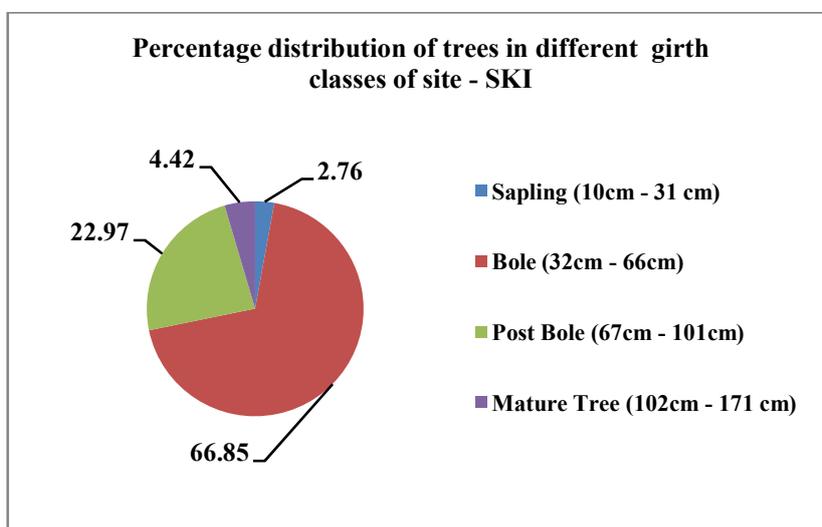


Figure 1: Percentage distribution of trees in different girth classes of site - SKI

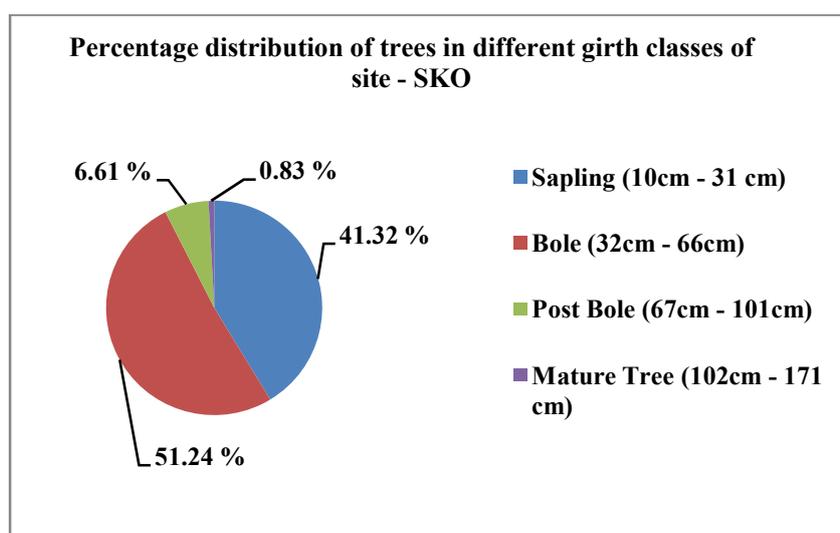


Figure 2: Percentage distribution of trees in different girth classes of site - SKO

Table 1: Total biomass and total carbon stock of tree species in 2015 at site SKI

S. No.	Site - SKI	Total Biomass	Total Carbon
1.	<i>Anogeissus latifolia</i>	113.66	56.83
2.	<i>Alangium salviifolium</i>	4.84	2.42
3.	<i>Diospyros melanoxylon</i>	18.82	9.41
4.	<i>Acacia nilotica</i>	2.70	1.35
5.	<i>Bauhinia racemosa</i>	0.05	0.03
6.	<i>Butea monosperma</i>	2.77	1.38
7.	<i>Holoptelea integrifolia</i>	1.57	0.79

Table 2: Total biomass and total carbon stock of tree species in 2017 at site SKI

S. No.	Site - SKI	Total Biomass	Total Carbon
1.	<i>Anogeissus latifolia</i>	121.45	60.73
2.	<i>Alangium salviifolium</i>	5.12	2.56
3.	<i>Diospyros melanoxylon</i>	19.45	9.72
4.	<i>Acacia nilotica</i>	2.89	1.46
5.	<i>Bauhinia racemosa</i>	0.05	0.03
6.	<i>Butea monosperma</i>	2.90	1.45
7.	<i>Holoptelea integrifolia</i>	1.65	0.83

Table 3: Biomass in tree vegetation of sites – SKI and SKO

Site	AGB (t/ha)		BGB (t/ha)		TB (t/ha)		Biomass Increment (t/ha/2yr)
	2015	2017	2015	2017	2015	2017	
SKI	114.60	121.84	29.80	31.67	144.40	153.51	9.11
SKO	28.93	29.49	7.52	7.67	36.45	37.16	0.71

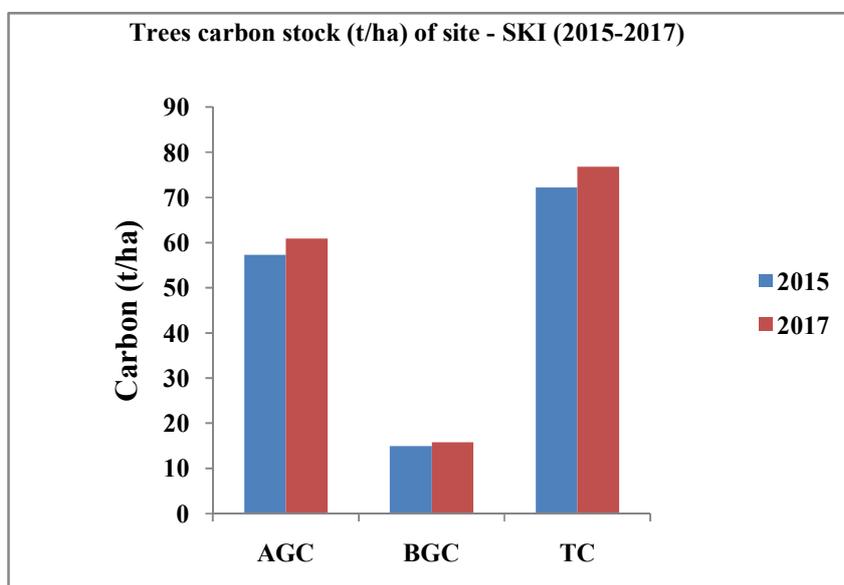


Figure 3: Trees carbon stock (t/ha) of site - SKI (2015-2017)

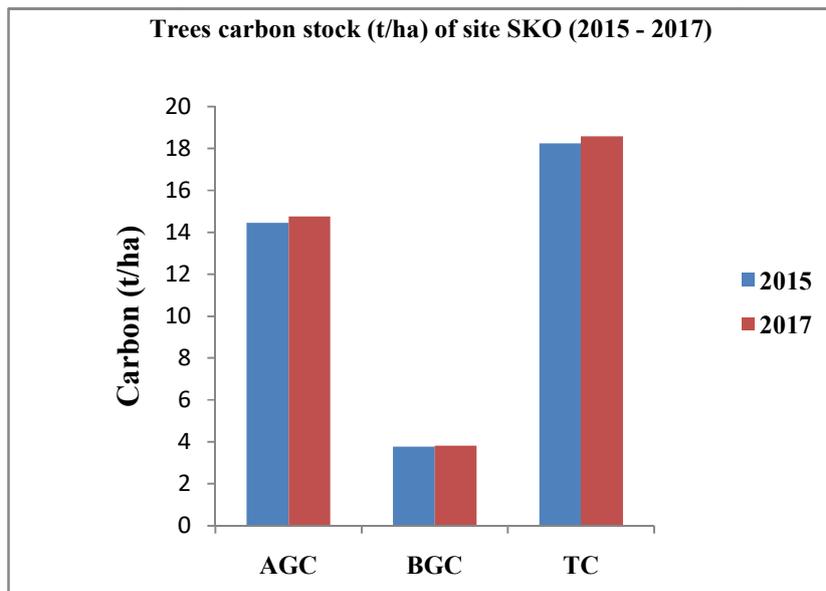


Figure 4: Trees carbon stock (t/ha) of site SKO (2015 - 2017)

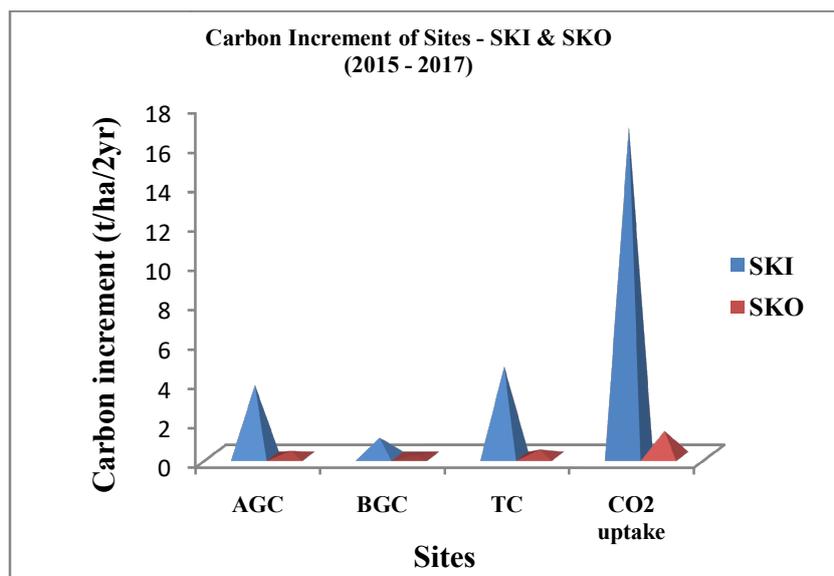


Figure 5: Carbon Increment of Sites - SKI & SKO (2015 - 2017)

**CONCLUSION**

Thus, the present work indicated that carbon dioxide emissions can be uptaken by the terrestrial biosphere i.e. trees of the conserved sacred grove and henceforth, alternate conservative strategies must also be

developed to prevent the destruction of fragile and biologically rich ecosystems. Land-based biological carbon mitigation strategies are viable pathway towards local climate stabilization and may contribute towards a better healthy environment for

living organisms, thereby supporting Gwalior for making sustainable city. Global warming and climate change are perhaps the most pressing global concern in the present scenario.

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#### REFERENCES

[1] <https://climate.nasa.gov/news>

[2] Ussiri, D. A., & Lal, R. (2017). Introduction to Terrestrial Carbon Sequestration. In *Carbon Sequestration for Climate Change Mitigation and Adaptation* (pp. 327-341). Springer, Cham.

[3] Anderson, J. M., & Ingram, J. S. I. (Eds.). (1989). *Tropical Soil Biology and Fertility* (p. 171). Wallingford: CAB International.

[4] MacDicken, K.G. 1997. A guide to monitoring carbon storage in forestry and agroforestry projects. Arlington VA (US): Winrock International Institute for Agricultural Development, Forest Carbon Monitoring Programme.

[5] Brown, S., & Lugo, A. E. (1982). The storage and production of organic matter in tropical forests and their role in the global carbon cycle. *Biotropica*, 14(3), 161-187.

[6] Jaiswal, D. G., Maheta, V. R., Patel, Y. B., & Pandya, H. A. (2014). Carbon stock estimation major tree species in Attarsumba range, Gandhinagar forest division, India. *Annals of Biological Research*, 5(9), 46-49.

[7] Hu, Y., Su, Z., Li, W., Li, J., & Ke, X. (2015). Influence of tree species composition and community structure on carbon density in a subtropical forest. *PLoS One*, 10(8), 136984.

[8] Becknell, J. M., & Powers, J. S. (2014). Stand age and soils as drivers of plant functional traits and aboveground biomass in secondary tropical dry forest. *Canadian Journal of Forest Research*, 44(6), 604-613.

- [9] Joshi, H. G., & Ghose, M. (2014). Community structure, species diversity, and aboveground biomass of the Sundarbans mangrove swamps. *Tropical Ecology*, 55(3), 283-303.
- [10] Berenguer, E., Ferreira, J., Gardner, T. A., Aragao, L. E. O. C., De Camargo, P. B., Cerri, C. E., Durigam, M., Oliveira, R. C. D., Vieira, I. C. G & Barlow, J. (2014). A large-scale field assessment of carbon stocks in human-modified tropical forests. *Global Change Biology*, 20(12), 3713-3726.
- [11] Lewis, S. L., Phillips, O. L., Sheil, D., Vinceti, B., Baker, T. R., Brown, S., Graham, A. W., Higuchi, N., Hilbert, D. W., Laurance, W. F., & Lejoly, J. (2004). Tropical forest tree mortality, recruitment and turnover rates: calculation, interpretation and comparison when census intervals vary. *Journal of Ecology*, 92(6), 929-944.
- [12] Slik, J. W. F., Aiba, S. I., Brearley, F. Q., Cannon, C. H., Forshed, O., Kitayama, K., Nagamasu, H., Nilus, R., Payne, J., Paoli, G., Poulsen, A. D., Raes, N., Sheil, D., Sidiyasa, K., Suzuki, E., & Valkenburg, J. L. C. H. V. (2010). Environmental correlates of tree biomass, basal area, wood specific gravity and stem density gradients in Borneo's tropical forests. *Global Ecology and Biogeography*, 19(1), 50-60.
- [13] Navar, J., Mendez, E., & Dale, V. (2002). Estimating stand biomass in the Tamaulipan thornscrub of northeastern Mexico. *Annals of Forest Science*, 59(8), 813-821.
- [14] Gandhi, D. S., & Sundarapandian, S. (2017). Large-scale carbon stock assessment of woody vegetation in tropical dry deciduous forest of Sathanur reserve forest, Eastern Ghats, India. *Environmental monitoring and assessment*, 189(4), 187.
- [15] Lal, M., & Singh, R. (2000). Carbon sequestration potential of Indian forests. *Environmental Monitoring and Assessment*, 60(3), 315-327.
- [16] Rahangdale, C.P., Upadhyaya, S. D., & Parte, D. (2018). Standing state biomass and carbon sequestration potential of tropical deciduous forests of Madhya Pradesh: An exploratory study. Conference: National Seminar on Climate Change at Environmental

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planning and coordination organization, Bhopal, M.P.

- [17] Chaturvedi, R. K., Raghubanshi, A. S., & Singh, J. S. (2011). Carbon density and accumulation in woody species of tropical dry forest in India. *Forest Ecology and Management*, 262(8), 1576-1588.
- [18] Kaul, M., Mohren, G. M. J., & Dadhwal, V. K. (2010). Carbon storage and sequestration potential of selected tree species in India. *Mitigation and Adaptation Strategies for Global Change*, 15(5), 489-510.
- [19] Pareta, K. (2012). LULC and climate change impact on carbon storage and sequestration: A case study of Ranthambhore Tiger Reserve, Rajasthan. In *Proceeding in 13 th ESRI India User Conference, Noida (INDIA)* (pp. 1-9). 13<sup>th</sup> ESRI India User Conference, 1-9.