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Biosequestration potential of trees outside forest in the plains of District Samba, J&K, India

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Abstract

There is a growing awareness all over the world about the various adverse impacts of green house gas emission and the consequent climate change. Trees absorb CO_2 from the atmosphere and store the carbon in their trunk, branches and roots. Generally, extensive tree wealth exists outside continuous forested areas in every country termed as 'Trees Outside Forests' (TOF) which also serve as the world's most important carbon sink. The present study was conducted in the plains of district Samba, J&K. On the basis of classification, the classes of TOF selected for the study in the area were agriculture fields, strips along the link roads, distributaries/canals, defence ditches as well as sample plots in sacred groves. Out of the total growing stock, biomass and carbon sequestered in the study area, sacred groves accounted for the highest values for growing stock (497.95 m^3/ha), biomass (257.13 t/ha) and carbon (123.43 t/ha) followed by agricultural fields *i.e.* growing stock (17.61 m^3/ha) biomass (9.19 t/ha) and carbon (4.5 t/ha) whereas least in case, along defence ditches *i.e.* growing stock (0.73 m^3/ha) biomass (0.41 t/ha) and carbon (0.19 t/ha). Among all the tree species in the study area *Ficus benghalensis* showed highest value of average growing stock, biomass and carbon followed by *Ficus religiosa.*

Keywords: Climate, Carbon, Biomass, Agriculture fields, Defence ditches

Introduction

Contrary to popular perception, trees and forests are not synonymous; trees alone do not make up forests, and trees are not found only in forests (Long and Nair, 1999). All the trees have high potential of tapping atmospheric carbon through the process of photosynthesis. As trees are the largest component of aboveground biomass in terrestrial ecosystems, a number of studies have paid attention to the role of forests in mitigating climate change, carbon (C) sequestration and biodiversity conservation (*e.g.*, IPCC, 2007; Pan *et al.*, 2011; Dolman *et al.*, 2012). In recent decades, trees outside forests (TOF) have begun to attract more and more attention with growing acknowledgements of their potential economic importance and political interest in their environmental services (de Foresta*et al.*, 2013). United Nations Framework Convention on Climate Change (UNFCCC) has also recognized the importance of plantation forestry as a greenhouse gas mitigation option, as well as their need to preserve, monitor and enhance terrestrial carbon stocks (Updegraff *et al.*, 2004). According to Bijalwan *et al.* (2016) Agroforestry trees (Agroforests) play an important role in global carbon cycle and also help in regulating the biospheric climate. Agroforestry systems are known to have higher potential to sequester carbon than pastures or field crops (Sanchez, 2000; Kirby and Potvin, 2007). For centuries, farmers in India have maintained a traditional land-use system known as sacred groves in which a separate area with trees was set aside. The concept of sacred groves is related to religious faith of people which contribute to conservation of biodiversity. Sacred groves are tracts of virgin forests with rich diversity, which have been protected by local people for centuries for their cultural and religious beliefs and taboos that the deities reside in them and protect the villagers from different calamities (Khan *et al.,* 2008). Remote sensing technology is useful for verifying land use/land cover change monitoring, growing stock, biomass and carbon pool estimation in forest ecosystems (Sharma, 2005). As the area selected for study is away from the natural forests, so people are mostly depended on trees outside forest in order to fulfill their daily needs. The study area being irrigated has the potential for agro-forestry system. The agriculture

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lands are having scarce trees which prompted us to conduct study in the villages. Moreover, people of the area are unaware about the importance of trees outside forest as these trees are more socially linked to our society.

Material and Methods

Study Area

The Headquarter of Samba district is situated in range of Shivalik hills alongside the National Highway 1-A/ on the bank of river Basantar at a distance of 40 km. from Jammu city. Samba is bounded by District Udhampur in the North, District Kathua in the East, Tehsils Jammu and Bishnah of District Jammu in the west, while on the southern side it has International Border with Pakistan. The study area lies between $74^0$50’0”E to $75^0$2’0”E and $32^0$27’0” N to $32^0$35’0”N. The district is separated from the Jammu district by "Purmandal Bridge". About two third of the area of the district Samba is *Kandi* and rain fed. The southern area downside of the national highway is irrigated through Ravi Tawi Irrigation Canal Network, which contributes towards cultivation of major cereals crops and vegetables cultivation. Special focus has been assigned to these activities by the Government of India, Ministry of Water Resources through Command Area Development department. The climate of the district is sub-tropical being hot and dry in summer and cold in winter. The temperature ranges between 6^0C in winter and 45^0C in summer.

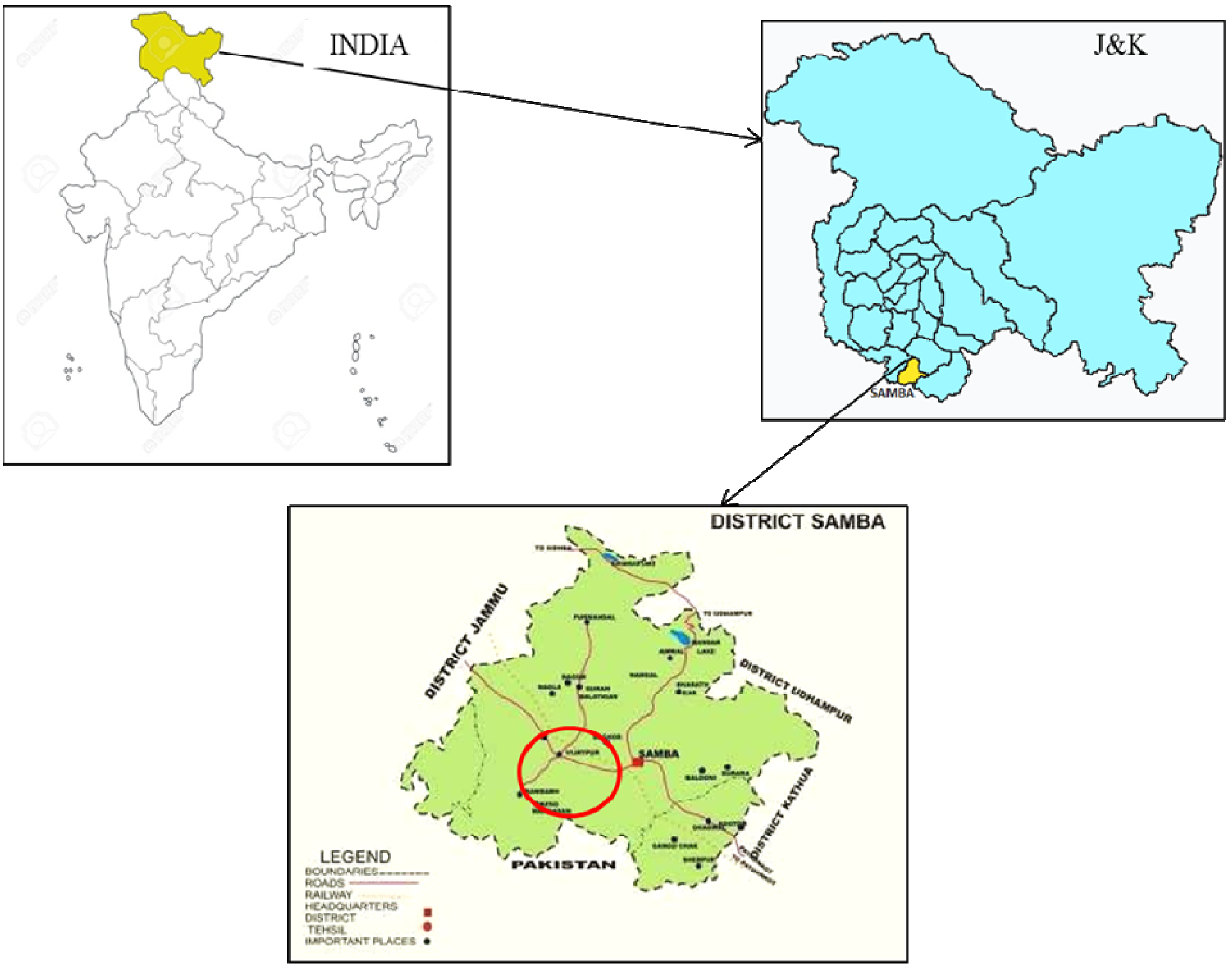


Fig 1: Location map of the study area

Data Collection and Analysis

The materials used for reconnaissance of the study area were the topo-maps at a scale of 1:50,000 and the Google image of the study area. The methodology of Forest Survey of India (FSI, 2006), Dehradun, was followed for the assessment of Trees Outside Forest (Rural) (TOF-R), in the Vijaypur block of Samba district. On the basis of classification, the classes of TOF selected for the study in the area were agriculture fields, strips along the link roads, distributaries/canals, defence ditches as well as sample plots in sacred groves. A total of thirty sample plots of 100x100m size were randomly selected in agriculture fields in the study area. Similarly thirty belt transects each of 1000x10m were laid randomly along the link roads and distributories/canals and twenty belt transect were laid along the defence ditches (100×10 m) in the study area. For studying trees in the sacred groves a total of thirty sample plots of 10x10m were selected. For the estimation of Growing stock of the trees outside forests the data such as girth of trees collected from the sample plots in each class was used. The volume for each tree was calculated by using the allometric equations developed by FSI (2006) for various tree species of Indian Himalaya. A general volume equation was used for tree species for which the volume equations were not available. The data arrived after calculation of volume for each tree was arranged plot wise and species wise and the average volume was also calculated. Volume obtained by using volume equation was multiplied with species specific gravity to obtain biomass. The carbon content in the trees was calculated by multiplying the total biomass by a conversion factor 0.475 (Singh and Chand, 2013).

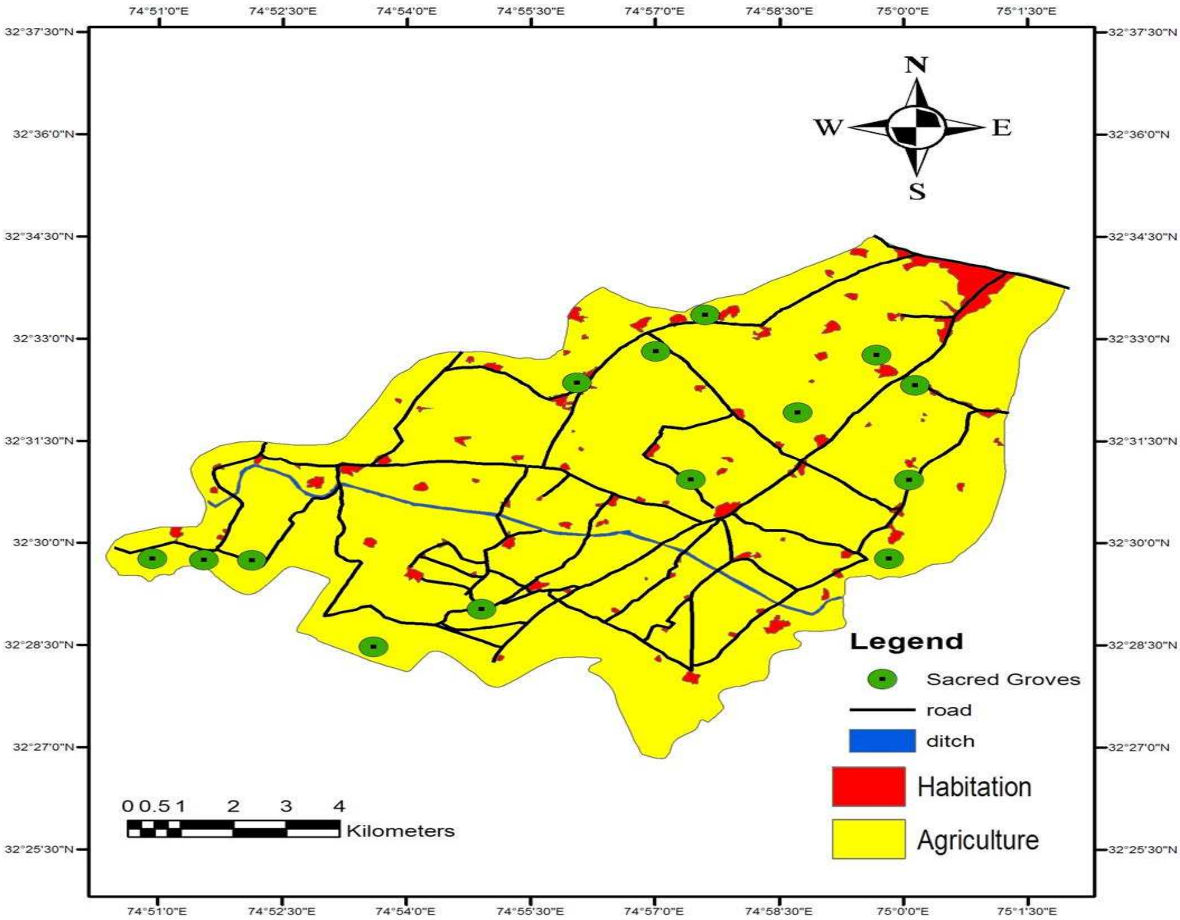


Fig 2. Different feature class of the study area

Results and Discussion

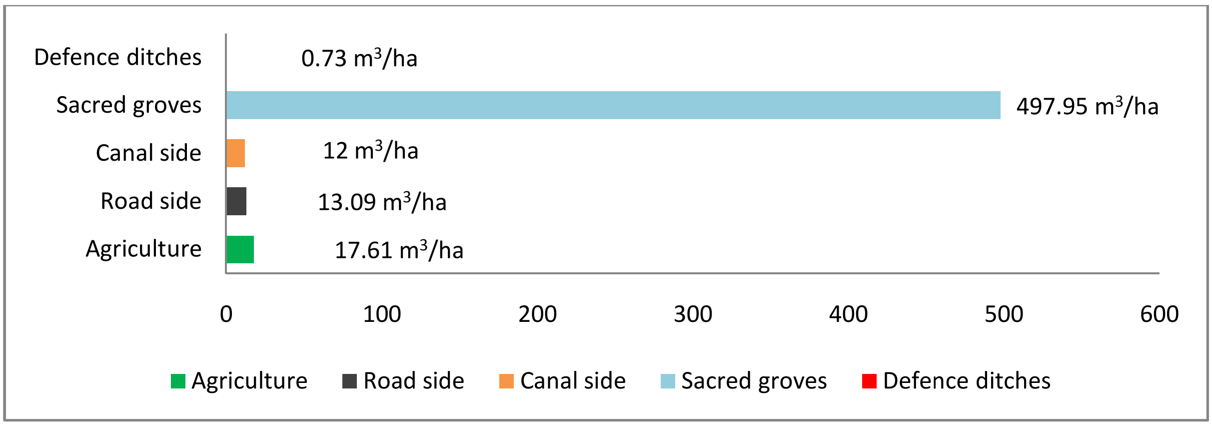
The land use/land cover map of study area (Fig. 2) obtained showed that majority of the area is under agriculture class (96%), whereas, rest of the area accounted for link roads, canals/distributories, defence ditches and sacred groves. Land use/ Land cover information is essential for a number of planning and management activities. In order to provide basic amenities and to develop proper infrastructure to fulfill the demand of the growing population, land use/land cover change detection is now generating interest among the researchers and planners as it has serious implications for urban planning (Taubenböck *et al.*, 2009; Suzanchia and Kaur, 2011). Application of remote sensing technology is suitable for verifying land use/ land cover change, growing stock, biomass and carbon pool estimates in forest as well as other ecosystems. Since the last decade, remote sensing has become an important data gathering tool for analysing these changes (Taubenböck *et al.*, 2009; Punia *et al.*, 2011 and Schneider, 2012).

In the study area 17 tree species were encountered in agricultural fields with *Ziziphus mauritiana, Mangifera indica, Melia azedarach, Dalbergia sissoo,etc*. the dominant tree species shown in table 3. Similarly, Kharal *et al.* (2008) has also found *Dalbergia sissoo* and *Mangifera indica* as the most abundant tree species in Nawalparasi District of Nepal. Along the road and canal/ distributories a total of 16 and 12 species of trees were observed belonging to 9 families. Similarly, 36 tree species belonging to 17 families were recorded in roadside plantation in Southwestern Bangladesh (Rahman *et. al.*, 2015).Trees not only play important role in ecological balance but also help in defending along the border ditches, as the study area has an International Border with Pakistan on the southern side. The most common species along the defence ditches was found to be *Acacia modesta* which camouflaged the defence bunkers. These are maintained by our defence forces. During the field study along the defence ditches a total of 10 species of trees were observed belonging to 7 families.The sacred groves are considered the repositories of phytodiversity which have upto some extent a religious protection. The sacred groves were also found in the study area. The data collected from the sacred groves showed a total of 28 trees species prevalent in these sites belonging to temples, peer baba, burial ground, family deity, *etc.* which is closer to the 31 tree species as reported by Hangarge *et al.* (2012) in Somjaichi Rai(Sacred grove) at Nandghur village, in Bhor region of Pune District, Maharashtra State, India. The analysis conducted by Sharma and Kour (2014) in the sacred grooves of rural areas of block Vijaypur, revealed that out of total of six tree species, *Dalbergia sissoo* was the most dominant followed by *Eugenia jambolana.*

Growing Stock

In the agricultural fields and sacred groves maximum average growing stock was found for *Ficus religiosa* (7.51$\pm$5.97m^3/ha) followed by *Ziziphus mauritiana* (1.71$\pm$1.24m^3/ha) and *Ficus benghalensis* (181.57$\pm$130.11m^3/ha) followed by *Ficus religiosa* (69.56$\pm$46.18m^3/ha), respectively

Fig. 3: Graphical representation of average total growing stock (m^3/ha) of different land use/land cover



whereas, least in case of *Eucalyptus citridora* (0.006±0.003 m^3/ha) and *Anthocephalus cadmba* (-0.02±0.00m^3/ha) respectively. Along the roadside, canalside, and defence ditches the maximum growing stock was found for *Bombax ceiba* (4.25 m^3/ha), *Ficus religiosa* (5.55 m^3/ha) and *Mangifera indica* (0.17±0.05 m^3/ha) and least for *Eucalyptus citridora* (0.004±0.003 m^3/ha), *Eucalyptus citridora* (0.003±0.01 m^3/ha) *Acacia nilotica* (0.0004±0.00 m^3/ha) respectively.

Biomass and Carbon

Out of the total biomass and carbon stock in the study area, sacred groves accounted for the highest values for biomass (257.13 t/ha) and carbon (123.43 t/ha) followed by agricultural fields *i.e.* biomass (9.19 t/ha) and carbon (4.5 t/ha) whereas least in case of along defence ditches *i.e.* biomass (0.41 t/ha) and carbon (0.19 t/ha). Ahmed and Sharma (2016), in the agricultural fields of Ponda Watershed of Rajouri district, reported biomass (5.49 t/ha) and carbon stock (2.47 t/ha) which is lower in comparison to present study. The high biomass in the sacred groves of the study area was due to maximum number of old or mature tree species and undisturbed vegetation due to their religious importance. Sacred groves are prominent sequester of carbon emitted in atmosphere in large quantities (Kulkarni and Kulkarni, 2013).Values of biomass and carbon varied among various tree species in the study area. In the agricultural fields maximum average biomass and carbon was found in case of *Ficus religiosa* (3.33±2.64 t/ha) and (1.60±1.27 t/ha), respectively, whereas in sacred groves, *Ficus benghalensis* has maximum biomass (89.69±64.28t/ha) and carbon (43.05±30.85 t/ha) followed by *Ficus religiosa* i.e. biomass (30.82±20.46 t/ha) and carbon (14.79±9.82 t/ha). The other major carbon sequestrating species in sacred groves were *Mangifera indica* (13.77±16.79 t/ha) and *Morus alba* (8.83±10.98 t/ha). Along the roadside, canalside and defence ditches, maximum average biomass and carbon was in case of *Bombax ceiba* (1.49 t/ha and 0.71 t/ha), *Ficus religiosa* (2.46 t/ha and 1.18 t/ha) and *Mangifera indica* (0.09± 0.03 t/ha and 0.05±0.01) respectively. However among the total potential of biomass and carbon sequestration, it is found to be highest in case agricultural fields followed by sacred groves and least along defence ditches ditches followed by canal/distributories **(Table 8).**

Table 1: Species wise average growing stock volume density, biomass and carbon in agriculture fields

S. No	Name of the species	Basal area (m^2/ha)	Growing stock (m^3/ha)	Biomass (t/ha)	Carbon (t/ha)
1	*Ficus religiosa* Linn.	0.60 ±0.45	7.51±5.97	3.33±2.64	1.60±1.27
2	*Dalbergia sissoo*Roxb.	0.06±0.02	0.30±021	0.25±0.10	0.12±0.05
3	*Eucalyptus citridora*Linn.	0.04±0.03	0.00±0.00	0.00±0.00	0.00±0.00
4	*Mangifera indica* L.	0.14±0.14	1.31±1.86	0.75±1.02	0.35±0.49
5	*Acacia nilotica* L.	0.07±0.06	0.84±1.73	0.63±1.30	0.31±0.62
6	*Meliaazedarach* L.	0.04±0.02	0.32±0.15	0.18±0.08	0.09±0.04
7	*Tectonagrandis* L.F.	0.08±0.02	0.89±0.25	0.38±0.11	0.18±0.05
8	*Psidium guajava* L.	0.03±0.01	1.26±0.97	0.74±0.57	0.36±0.28
9	*Emblica officinalis* Gaertn	0.00±0.00	0.24±0.00	0.17±0.00	0.08±0.00
10	*Butea monosperma* (Lam.) Taub.	0.05±0.02	0.32±0.13	0.14±0.06	0.07±0.03
11	*Ziziphus mauritiana* Lam.	0.18±0.12	1.71±1.24	1.11±0.81	0.54±0.39
12	*Populus cilliata* Wall.exRoyle	0.00±0.00	0.23±0.15	0.11±0.07	0.05±0.03
13	*Salix acmophylla*Boiss	0.05±0.03	0.33±0.20	0.15±0.09	0.07±0.04
14	*Morus alba* Linn.	0.06±0.04	0.41±0.28	0.25±0.17	0.12±0.08
15	*Sizygium cumini* (L.) Skeels	0.13±0.11	0.98±0.82	0.63±0.53	0.30±0.25
16	*Albizzia lebbeck* (L.) Benth	0.05±0.03	0.36±0.15	0.20±0.08	0.10±0.04
17	*Bauhinia purpurea* (L.) Benth	0.08±0.08	0.60±0.60	0.34±0.34	0.16±0.16

It is because of the reason that the study area being irrigated has the potential for agro-forestry system. Kirby and Potvin (2007) suggested that agroforestry systems have higher potential to sequester carbon than pastures or field crops. Agroforestry, therefore play an important role in producing more timber and revenue for the local community as livelihood – and more importantly sequester carbon – compared to other natural and restored ecosystems in plains of district Samba. Agroforestry as a land use system is accepting a wider attention not only in terms of agricultural sustainability but also in terms of issues related to climate change (Albrecht and Kandji, 2003). There is a positive correlation between the biomass and carbon storage across different land-use. The linear correlation between basal area *vs* volume, total biomass *vs* carbon among different land use was found to be significant with the values of R^2 is 1 in each case. Sundarapandian *et al.* (2014) and Kour and Sharma (2016) also showed similar trend of significant positive correlation of basal area with biomass and total carbon in the campuses of educational institution.

Table 2: Species wise average growing stock volume density, biomass and carbon along road side

S. No	Name of the species	Basal area (m^2/ha)	Growing stock (m^3/ha)	Biomass (t/ha)	Carbon (t/ha)
1	*Zizyphus mauritiana* Lam.	0.01±0.01	0.66±0.50	0.43±0.32	0.21±0.15
2	*Melia azedarach* L.	0.07±0.03	0.53±0.24	0.29±0.13	0.14±0.06
3	*Albizzia lebbeck (L.)* Benth	0.08±0.09	0.54±0.52	0.30±0.29	0.15±0.14
4	*Acacia nilotica* L.	0.07±0.06	0.26±0.29	0.19±0.22	0.09±0.10
5	*Mangifera indica* L.	0.03±0.02	3.82±3.78	2.10±2.08	1.01±1.00
6	*Morus alba* Linn.	0.05±0.02	0.31±0.15	0.19±0.09	0.09±0.04
7	*Sizygium cumini* (L.) Skeels	0.04±0.02	0.24±0.19	0.15±0.13	0.07±0.06
8	*Ficus religiosa* Linn.	0.05±0.03	0.41±0.26	0.18±0.11	0.09±0.05
9	*Delbergia sissoo* Roxb.	0.10±0.13	0.50±0.65	0.42±0.55	0.20±0.26
10	*Bombax ceiba* Linn.	0.51	4.25	1.49	0.71
11	*Laeuceanealeuco cephala* (Lam.) de Wit	0.01±0.00	0.42±0.12	0.25±0.07	0.12±0.03
12	*Salix acmophylla* Boiss	0.005±0.002	0.29±0.16	0.13±0.07	0.06±0.04
13	*Eucalyptus citridora* Linn.	0.16±0.14	0.004±0.003	0.003±0.002	0.002±0.001
14	*Populus cilliata* Wall.exRoyle	0.04±0.02	0.28±0.15	0.13±0.07	0.06±0.03
15	*Acacia modesta* Wall &Roxb	0.06±0.01	0.18±0.03	0.17±0.03	0.08±0.01
16	*Psidium guajava* L.	0.06	0.4	0.23	0.11

Table 3: Species wise average growing stock volume density, biomass and carbon along canal side

S. No	Name of the species	Basal area (m^2/ha)	Growing stock (m^3/ha)	Biomass (t/ha)	Carbon (t/ha)
1	*Acacia nilotica* L.	0.08±0.08	0.31±0.41	0.23±0.31	0.11±0.15
2	*Melia azedarach* L.	0.05±0.02	0.38±0.13	0.22±0.07	0.10±0.04
3	*Eucalyptus citridora* Linn.	0.02±0.01	0.003±0.01	0.003±0.004	0.001±0.002
4	*Albizzia labbeck* (L.) Benth	0.05±0.02	0.38±0.10	0.21±0.06	0.10±0.03
5	*Dalbergia sissoo* Roxb.	0.13±0.11	0.64±0.57	0.55±0.49	0.26±0.23
6	*Ziziphus mauritiana* Lam.	0.06±0.04	0.43±0.29	0.28±0.19	0.13±0.09
7	*Salix acmophylla* Boiss	0.005±0.002	0.30±0.14	0.14±0.06	0.07±0.03
8	*Laeuceanealuco cephalla* (Lam.) de Wit	0.04±0.02	0.26±0.14	0.16±0.08	0.08±0.04
9	*Crateva nurvala* Buch. Ham.	0.02	0.11	0.04	0.02
10	*Acacia modesta*Wall &Roxb	0.05	0.16	0.15	0.07
11	*Mangifera indica* L.	0.33±0.10	3.48±1.39	1.92±0.76	0.92±0.37
12	*Populus cilliata* Wall.exRoyle	0.47	5.55	2.46	1.18

Table 4: Species wise average growing stock volume density, biomass and carbon in Sacred grooves

S. No	Name of the species	Basal area (m^2/ha)	Growing stock (m^3/ha)	Biomass (t/ha)	Carbon (t/ha)
1	*Ficus elastic* Roxb	0.72±0.29	8.96±4.07	4.39±1.99	2.11±0.96
2	*Melia azedarach* L.	0.87±0.95	5.96±6.46	3.34±3.61	1.6±1.74
3	*Mangifera indica* L.	1.86± 1.61	52.16±63.61	28.69±34.98	13.77±16.79
4	*Tectona grandis* L.F.	1±.90	17.2±17.34	7.29±7.35	3.5±3.53
5	*Morus alba* Linn.	1.3±1.20	30.5±37.95	18.39±22.88	8.83±10.98
6	*Syzygium cumini* (L.) Skeels	1.58±1.22	0.11±7.82	0.07±5.06	0.03±2.43
7	*Eucalyptus citridora* Linn.	1.05±0.88	0.07±0.10	0.06±0.08	0.03±0.04
8	*Salix acmophylla* Boiss	0.26±0.07	2.46±1.05	1.13±0.48	0.54±0.23
9	*Ficus religiosa* Linn.	4.6±2.85	69.56±46.18	30.82±20.46	14.79±9.82
10	*Anthocephalus cadmba* Roxb.	0.9±0.03	-0.02±0.00	-0.01±0.00	-0.003±0.00
11	*Acacia nilotica* L.	1.69±1.39	10.33±9.55	7.74±7.16	3.72±3.44
12	*Ficus benghalensis* L.	11.36±7.67	181.57±130.11	89.69±64.28	43.05±30.85
13	*Leauceanealeuco cephlla* (Lam.) de Wit	0.68±0.15	9.71±3.09	5.84±1.86	2.8±0.89
14	*Dalbergia sissoo* Roxb.	0.93±0.70	4.65±3.54	1.81±1.38	0.87±0.66
15	*Psidium guajava* L.	0.54	6.79	4	1.92
16	*Albizzia lebeeck* (L.) Benth	1.81±1.15	10.38±6.55	5.81±3.67	2.79±1.76
17	*Ziziphus mauritiana* Lam.	0.5±0.25	6.54±4.16	4.25±2.70	2.04±1.30
18	*Toona ciliate* M. Roemer	0.65±0.29	8.52±4.27	3.61±1.81	1.73±0.87
19	*Aegel marmelos* (L.) Correa	0.45±0.15	5.4±2.61	4.56±2.21	2.19±1.06
20	*Acacia modesta*Wall &Roxb	0.75±0.21	4.1±1.31	3.94±1.25	1.89±0.60
21	*Crateva nurvala* Buch. Ham.	0.43±0.14	5.14±2.19	1.75±0.75	0.84±0.36
22	*Diospyros cordifolia* Roxb.	0.71±0.18	10.4±3.55	7.28±2.48	3.5±1.19
23	*Bombax ceiba* Linn.	0.9	7.65	2.68	1.29
24	*Alistonia scholaris* L.R.Br.	0.54	6.79	2.58	1.24
25	*Emblica officinalis* Gaertn	1.8±0.79	11.22±4.90	7.85±3.43	3.77±1.65
26	*Cordia dichotoma* G. Forst.	0.58±0.20	16.54±9.75	7.29±4.30	3.5±2.06
27	*Butea monosperma* (Lam.)Taub.	0.44±0.18	5.26±2.88	2.28±1.25	1.09±0.60

Table 5: Species wise average basal area, growing stock volume density, biomass and carbon along defence ditches

S. No	Name of the species	Basal area (m^2/ha)	Growing stock (m^3/ha)	Biomass (t/ha)	Carbon (t/ha)
1	*Acacia modesta* Wall &Roxb	0.01±0.00	0.02±0.01	0.02±0.01	0.01±0.00
2	*Eucalyptus citridora* Linn.	0.02±0.01	0.01±0.00	0.01±0.00	0.004±0.00
3	*Acacia nilotica* L.	0.02±0.00	0.0004±0.00	0.0003±0.00	0.0001±0.00
4	*Leuceanea leucocephala* (Lam.) de Wit	0.01±0.00	0.05±0.02	0.03±0.01	0.01±0.01
5	*Dalbergia sissoo* Roxb.	0.01±0.00	0.04±0.02	0.01±0.01	0.01±0.00
6	*Ficus religiosa* Linn.	0.02	0.11	0.05	0.02
7	*Albizzia lebbeck* (L.) Benth	0.01±0.00	0.14±0.02	0.08±0.01	0.04±0.01
8	*Ziziphus mauritiana* Lam.	0.02±0.00	0.1±0.02	0.07±0.01	0.03±0.01
9	*Melia azedarach* L.	0.01	0.09	0.05	0.02
10	*Mangifera indica* L.	0.03±0.01	0.17±0.05	0.09±0.03	0.05±0.01

Table 6: Total Biomass and carbon sequestration potential of the study area

Land use	Area (ha)	Biomass(t)	Carbon(t)
Agriculture fields	12588	115683.7	56646
Road side	250	1662.5	797.5
Canal side	86	546.96	261.44
Sacred groves	30	7713.9	3702.9
Defence ditches	86	35.26	16.34

Conclusion

As the area selected for study is away from the natural forests, so people are mostly depended on trees outside forest in order to fulfill their daily needs. The study area being irrigated has the potential for agro-forestry system. The study revealed that main driving force behind the disturbance and degradation of the trees occurs due to human activities. The people of that area are not aware about the importance of trees and there is lack of awareness among the local masses. Their main focus is on the agricultural crops and has less idea about the agroforestry system. They cut the trees which are planted in the agricultural fields which were actually planted by their fore-fathers. They also cut the trees which were planted along canal side as well as road side. Bijalwan *et al.* (2016) stressed on the importance of agroforestry as a sustainable land-use system and also receiving wider recognition not only in terms of agricultural sustainability but also in issues related to biodiversity, soil and water conservation and ultimately to the climate change adaptation and mitigation. There were very little block plantation of *Tectona grandis* in the agricultural fields. The increasing human interference has changed the structural and functional pattern of the landscape all over the world and has influenced the biodiversity significantly (Sinha and Sharma, 2006). Similarly, Sharma *et al.* (2008) have also reported the impacts like tree felling and lopping, grazing, fire, encroachment *etc.* responsible for forest degradation in Birhun Watershed of Udhampur district of J&K. In choosing the tree species we must consider some properties like multipurpose role, ecological improvement, companion growing *etc.* In nutshell, tree species must be culturally harmonizingwith the local society.

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