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Carbon loss estimation: a case study of Little Andaman development plan

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Abstract: In 'Sustainable Development of Little Andaman - Vision Document' NITI Aayog proposed a development plan for Little Andaman of Andaman and Nicobar Island group to build a greenfield coastal megacity as a free trade zone to compete with Hong Kong and Singapore. The plan needs 240 sq km from the east and west coast of the island that is 30% of the total area out of 680 sq km of the island comprises of 95% forest area most of that is evergreen forest [1][2]. Due to the closeness of the island to the Malacca Strait, an important world shipping route, also having 53683.10 Sq km Exclusive Economic Zone (EEZ) and potentiality for medical and natural tourism the vision is very much significant for blue wealth of the nation [3]. Among the different environmental impact one of them will be carbon stock losses as more than 2 million trees will be uprooted from the pristine forest. This study aims to forecast the carbon stock losses that will be helpful for environment impact assessment, NITIAayog yet not published. For the study area land use and land cover (LU/LC) data set was created from Bhuvan thematic satellite data. LU/LC multi-temporal satellite data from Resourcesat-2, LISS-III sensor of 2015-16 with a scale of 1:50,000 have been used in this study. Another data set for carbon stock of four forest type groups viz. Tropical Wet Evergreen, Tropical Semi Evergreen, Tropical Moist Deciduous and Littoral & Swamp forests in Andaman and Nicobar Island was prepared from India State of Forest Report (ISFR) 2019. From this two data set total carbon stock loss for the study area was calculated. QGIS a open source s/w was used for various data operations.

Keywords: Carbon Stock, Little Andaman, Land use and Land Cover, Bhuvan -Indian Geo-platform

1. INTRODUCTION

Carbon is found on earth in various forms within living organisms and in non-living things like- oil, natural gas, coal, rocks and air. Different terrestrial systems store carbon in rocks, sediments, swamps, wetlands, forest, forest soil, grassland and agriculture etc. Two third of the terrestrial carbon are found in forest and forest soil [1].

Carbon play an important role in climate change [2]. Green house effect that is occurred due to increasing CO2, one of the most harmful greenhouse gases (GHG)[2] and created for different anthropogenic activities, is the most significant reason for climate change[3]. The rapid climate changes is attributed to two human actions- burning fossil fuels and clearing or degrading natural ecosystems [4][5]. More than 7 trillion tons of carbon dioxide stored in forest and other terrestrial ecosystems.

Growing trees and forest sequestered carbon from the atmosphere and act as a largest carbon sink [6]. The main carbon pools in the forest are above ground living biomass(AGB), below ground biomass(BGB), under story vegetation, dead mass of litter, woody debris and soil organic matter(SOC)[7][8][9].Forest Survey of India(FSI) under Ministry of Environment and Forests release periodically forest carbon stock of country in the India State of Forest Report[10]. However, due to unscientific management or deforestation this forest can be act as a carbon sources [11].

The Andaman and Nicobar Islands, a Union Territory, of India is a chain of 556 Islands are the most isolated parts of Indian Union situated in the South-Eastern part of Bay of Bengal and lying between 6^{o} and 14^{o}N latitude and 92^{0} and 94^{0}E longitude. The average distance is about 1200 km from main land mass. The area break-up of the Islands is as under total geographical area 829,300 ha, forest area 746,400 ha Effective forest are is 642,000 ha. (Excluding tidal swamps, steep hills and mangrove belts). Little Andaman island is situated at the southern extreme of Andaman District.The geographical area of the Island is 734.39 Sq km. About 90% of the geographical area of this Island is

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covered by valuable forests. A separate forest division has been established for this Island in 1975. The Little Andaman abounds with an excellent stand of Gurjan, but Padauk is absent. This type of unique tropical forests of precious rare species is not found anywhere in the whole of south and South-East Asia. The following types of forest are commonly seen (Champion & Seth's classification code in bracket) : (1) Giant evergreen forest (1 Ac_1), (2) Andaman tropical evergreen forest (1 Ac_2), (3) Andaman moist deciduous forest ,(4) Andaman semi-Evergreen :forest (2 Ac_1), (5) Littoral forest (4B/TS_2)[12].

Considering strategic location, blue economic benefits and truism potential in the 'Sustainable Development of Little Andaman Island- Vision Document' NITI Aayog propose a port let development plan for taking 210 Sq Km from east and west cost of Little Andaman Island[13][14]. Having the great blue economic significance the question is how much biomass and carbon stock will be loss due to deforestation that is unavoidable in this development plan. The specific objective of this study are a) to find the area of different forest types in the study area using Bhuvan thematic satellite data (210 sq km east and west cost of Little Andaman) and b) to estimate total carbon stock loss using national carbon stock inventory.

2.EXPERIMENTAL METHODS OR METHODOLOGY

2.1 Study Area

Little Andaman island is lying between 92^0-22` to 92^0-57' - East longitude and 10°-30' to 10^0-55'North Latitude. The development area has been limited to a 240 sq.km area along the east and west coastlines.

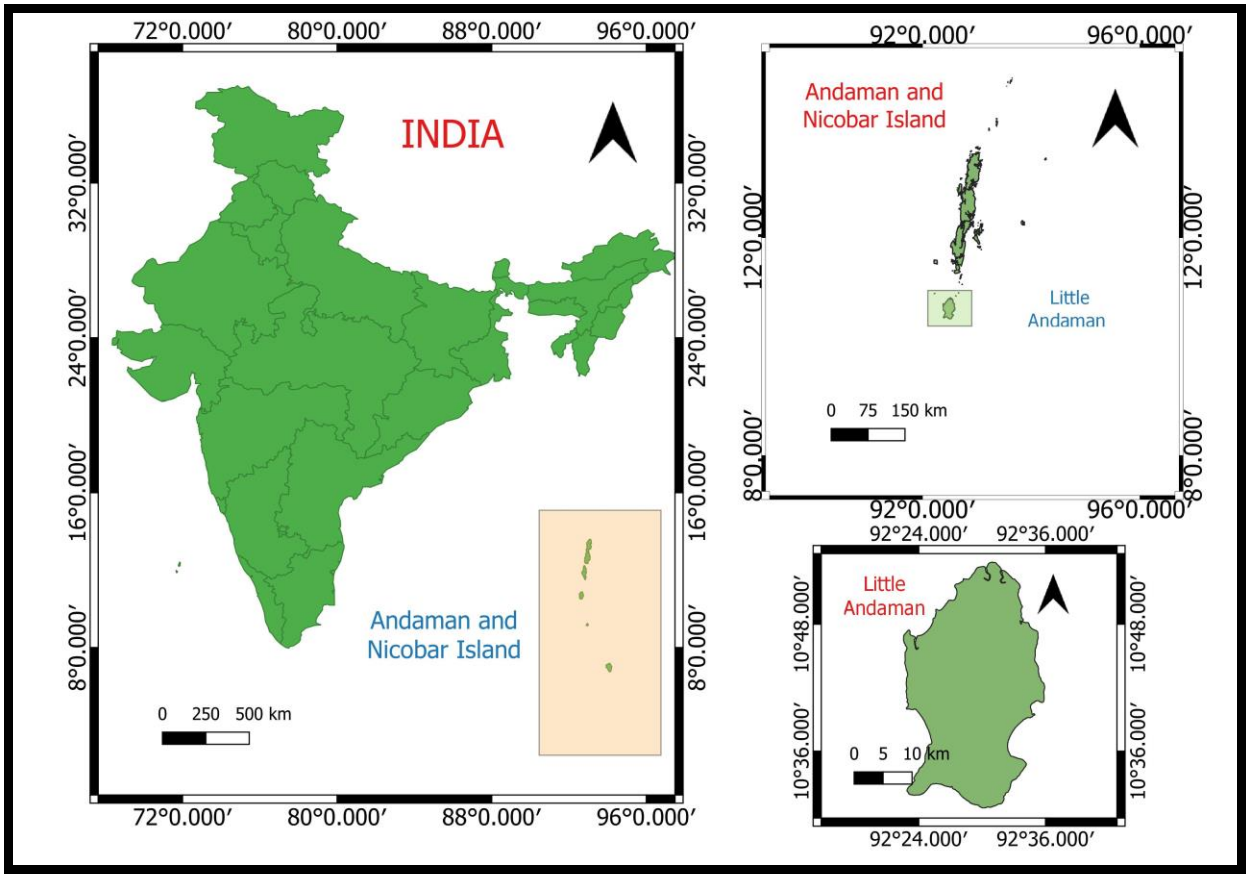

Fig 1. Study Area Little Andaman

2.2 Sample collection

The development area has been limited to a 240 sq.km area along the east and west coastlines of Little Andaman island. For the study area land use and land cover (LU/LC) data set was created from Bhuvan -Indian Geo-platform of ISRO

(https://bhuvan- app1.nrsc.gov.in/thematic/thematic/index.php) thematic satellite data [15]. Using the Bhuvan thematic service platform we selected four area of interest(AOI) as the sample data set in Fig.2. Among the different 11 LU/LC

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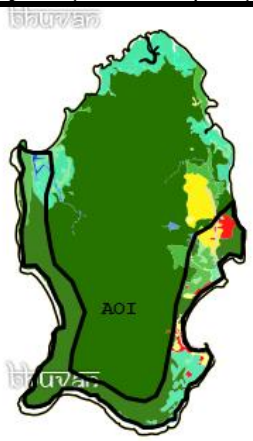
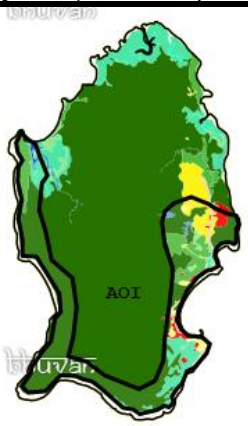
classes we selected only four classes Deciduous, Evergreen / Semi Evergreen, Plantation, Swamp / Mangrove. From this sample data set using the formula mentioned in point 2.3 we find the area of the four forest class in the study area that is shown in the Fig.3 in sq km.

Sample-I (167.481 Sq.Km)



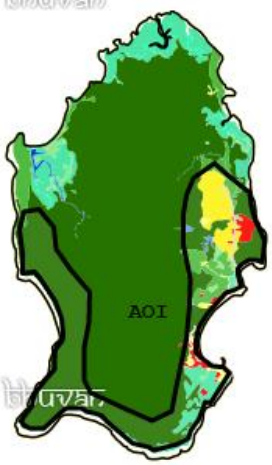
LULC Class	Area (Sq. Km.)
Coastal wetland	0.33
Crop land	4.9
Deciduous	15.89
Evergreen / Semi Evergreen	103.74
Plantation	4.96
River / Stream / Canals	1.07
Scrub Forest	3.93
Scrub land	0.02
Swamp / Mangrove	23.6

Sample-II (180.135 Sq.Km)



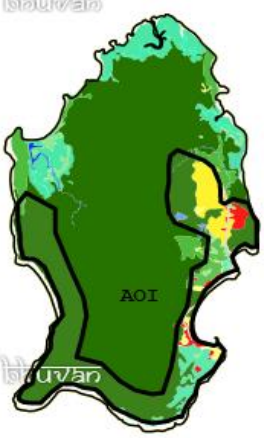
LULC Class	Area (Sq. Km.)
Coastal wetland	0.35
Crop land	5.37
Deciduous	21.2
Evergreen / Semi Evergreen	108.31
Plantation	8.1
River / Stream / Canals	0.76
Scrub Forest	3.16
Scrub land	0.02
Swamp / Mangrove	22.48

Sample-III (203.840 Sq.Km)



LULC Class	Area (Sq. Km.)
Deciduous	16.07
Evergreen / Semi Evergreen	134.51
Plantation	18.85

Sample-IV (199.753 Sq.Km)



LULC Class	Area (Sq. Km.)
Deciduous	8.69
Evergreen / Semi Evergreen	138.62
Plantation	16.99

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	Swamp / Mangrove	15.48		Swamp / Mangrove	16.36

Fig 2. Little Andaman- Area of Interest (AOI) LU/LC classes in the selected area. The approximate area distribution of each class (clipped area) is shown above from Bhuvan-Thematic Services[15].

2.3Methodology of finding LULC types instudy area

$x_i = (\sum D_i / \sum Si) * TSA$, for i=1 to 4

Where, TSA = Total Study Area(210 Sq.Km)

D_i = Deciduous type in sample i in Sq.Km.
E_i = Evergreen / Semi Evergreen type in sample i in Sq.Km.
S_i = Swamp / Mangrove type in sample i in Sq.Km.
P_i = Plantationtype in sample i in Sq.Km

x_1= Deciduous type in study area in Sq.Km.
x_2= Evergreen / Semi Evergreen type in study area in Sq.Km.
x_3= Swamp / Mangrove type in study area in Sq.Km.
x_4= Plantationtype in study area in Sq.Km.

Si= Area in sample i in Sq.Km.

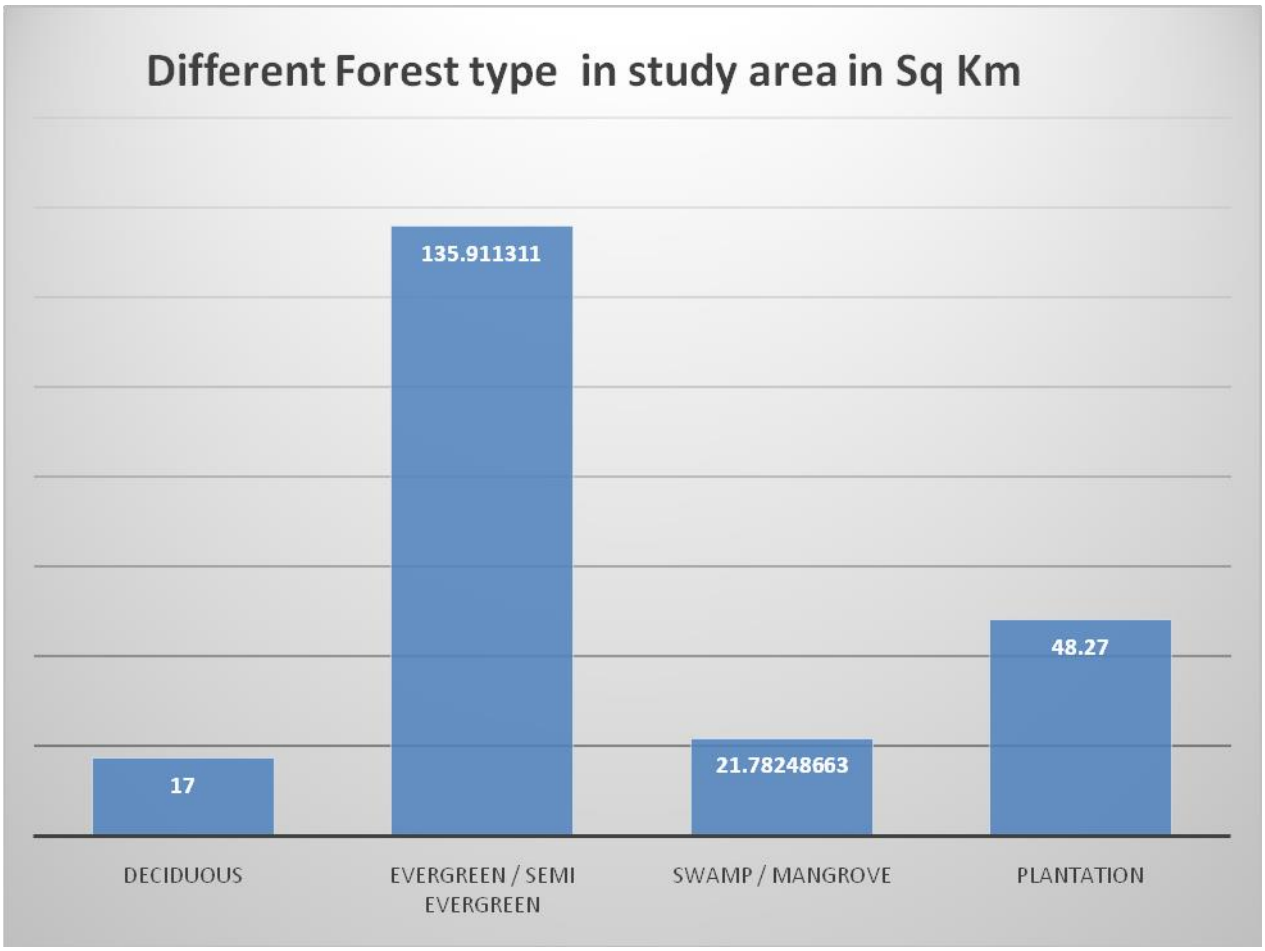

Fig 3. Different LU/LC classesin study area in Sq Km

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2.4Methodology of finding carbon stock under different carbon pools in A&N UT

Forest type and density wise carbon stock under different carbon pools in A&N UT									
('000 Tonnes)									
Forest Type Stratum	Density	Area in Km'	AGB	BGB	Dead wood	Litter	SOC	Total	C Stock/ ha (tonnes)
Tropical Wet Evergreen Forests Western Ghats	VDF	2,039.7	14,432.2	4,992.3	835.9	1,437.2	19,258.1	40,955.7	200.80
Tropical Wet Evergreen Forests Western Ghats	MDF	1,075.2	5,198.5	1,798.2	37.7	410.3	8,916.4	16,361.2	152.17
Tropical Wet Evergreen Forests Western Ghats	OF	122.9	140.4	48.6	3.3	31.3	949.0	1,172.5	95.44
Tropical Semi Evergreen-Western Ghats	VDF	856.9	4,480.5	921.5	351.2	536.0	7,983.3	14,272.5	166.57
Tropical Semi Evergreen-Western Ghats	MDF	947.5	3,115.2	640.7	33.3	324.7	6,162.5	10,276.3	108.46
Tropical Semi Evergreen-Western Ghats	OF	185.2	239.3	49.2	4.9	47.8	1,047.9	1,389.0	75.01
Evergreen / Semi Evergreen	**Total**	**5227.4**	**27606.1**	**8450.5**	**1266.3**	**2787.3**	**44,317.2**	**84,427.2**	
Tropical Moist Deciduous Forest	VDF	194.8	975.8	200.7	22.8	58.4	1,248.0	2,505.8	128.63
Tropical Moist Deciduous Forest	MDF	347.6	971.8	199.9	28.6	111.4	2,176.9	3,488.7	100.37
Tropical Moist Deciduous Forest	OF	51.6	63.3	13.0	2.1	10.2	320.3	408.9	79.23
Deciduous	**Total**	**594.0**	**2010.9**	**413.6**	**53.5**	**180.0**	**3745.2**	**6403.4**	
Littoral & Swamp Forest	VDF	267.7	2,024.2	700.2	0.6	33.9	1,871.2	4,630.0	172.98
Littoral & Swamp Forest	MDF	275.8	1,077.7	372.8	0.6	19.0	1,734.6	3,204.7	116.21
Littoral & Swamp Forest	OF	121.8	142.0	49.1	0.3	5.0	402.3	598.7	49.15
Swamp / Mangrove	**Total**	**665.3**	**3243.9**	**1122.1**	**1.5**	**57.9**	**4008.1**	**8433.4**	
Plantation/TOF	VDF	0.0							
Plantation/TOF	MDF	0.0							
Plantation/TOF	OF	142.6	169.8	34.9	0.0	18.4	777.6	1,000.6	70.19
Plantation/TOF	**Total**	**142.6**	**169.8**	**34.9**	**0.0**	**18.4**	**777.6**	**1,000.6**	**70.19**

Table 1. Data collected from ISFR-2019 [12] for **A&N UT**

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Forest Type Stratum	Total Area in Sq Km	AGB		BGB	Dead wood	Litter	SOC(Tonnes)
	Xi	Ai,j	A1	A2	A3	A4	A5
Evergreen / Semi Evergreen	5227.40(X_1)	A1	27606.10	8450.50	1266.30	2787.30	44317.20
Deciduous	594.00(X_2)	A2	2010.90	413.60	53.50	180.00	3745.20
Swamp / Mangrove	665.30(X_3)	A3	3243.90	1122.10	1.50	57.90	4008.10
Plantation/TOF	142.60(X_4)	A4	169.80	34.90	0.00	18.40	777.60

Table 2. Forest type and density wise carbon stock under different carbon pools in A&N UT

2.5Methodology of findingtotal carbon stock under different carbon pools in study area

Table.2 shows the total carbon pool for four different forest types in the study area by summing the carbon pools of different densities derived from Table.1. Then using the following formula we found the different carbon pools for the four forest types in the study area and finally calculated the total carbon stock in the study area(TSA) as TC(Total carbon) in Table.3.

T_{AGB}= ∑(Ai,1/Xi)*xi,for i=1 to 4

T BGB== **∑(Ai,2/Xi)*xi,for i=1 to 4**

T Dead wood= **∑(Ai,3/Xi)*xi ,for i=1 to 4**

T Litter= **∑(Ai,4/Xi)*xi ,for i=1 to 4**

TSOC =**∑(Ai,5/Xi)*xi,for i=1 to 4**

TC= T_{AGB} + T BGB+ **T** Dead wood + **T** Litter+ **T** SOC.

LU/LC Class	Study Area (Sq Km)	AGB	BGB	Dead wood	Litter	SOC	Total (Tonnes)
	xi						
Evergreen / Semi Evergreen	135.911311**(x1)**	717.7528488	219.711239	32.92353619	72.46922	1152.238	2195.095
Deciduous	17**(x2)**	58.53	12.0390523	1.555727586 7	5.239433	109.0151	186.3841
Swamp / Mangrove	21.78248663**(x3)**	106.21	36.738506 3	0.00010350 6	1.895695	131.2286	276.0709
Plantation	48.27**(x4)**	57.48	11.813625 5	0	6.228387	263.2171	338.7362
TotalCorbon(TC)	210.00(TSA)	**T_{AGB}**=939.97	**T** BGB= 280.302424	**T** Dead wood= 34.48091556	**T** Litter = 85.83273	**T** SOC = 1655.699	TC=2996.286

Table 3. Forest type and density wise carbon stock under different carbon pools in study area

3. RESULTS AND DISCUSSION

3.1Different carbon pools in study area

Total 2996.286 tonnes carbon stock loss was estimated from this study. In Fig.4 it shows the amount of carbon stock in different pools and in Fig.5 it shows in percentage wise.

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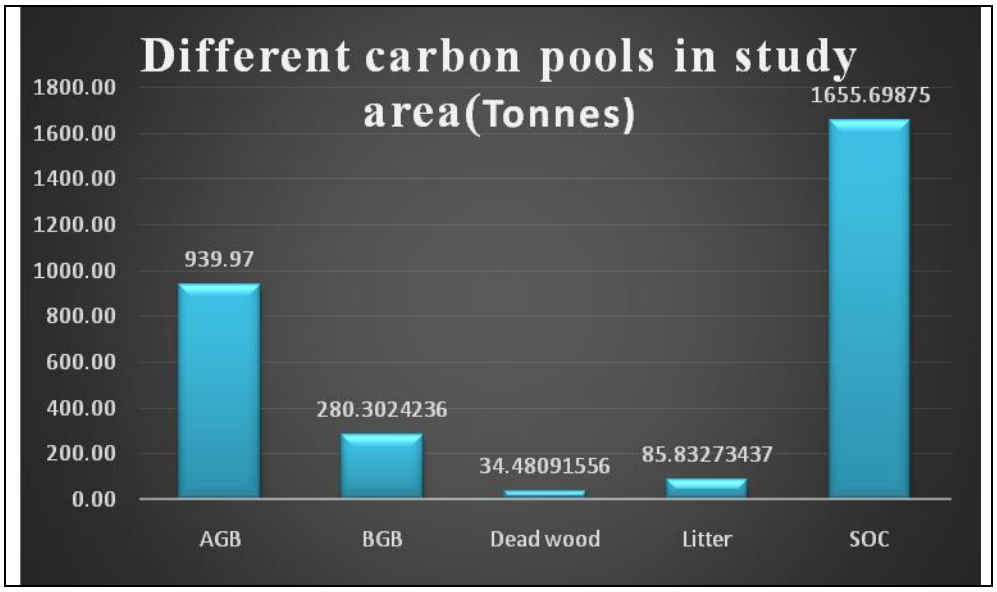

Fig 4. Different carbon pools in study area

3.2 Carbon pools in study area Vs Carbon pools in A&N UT

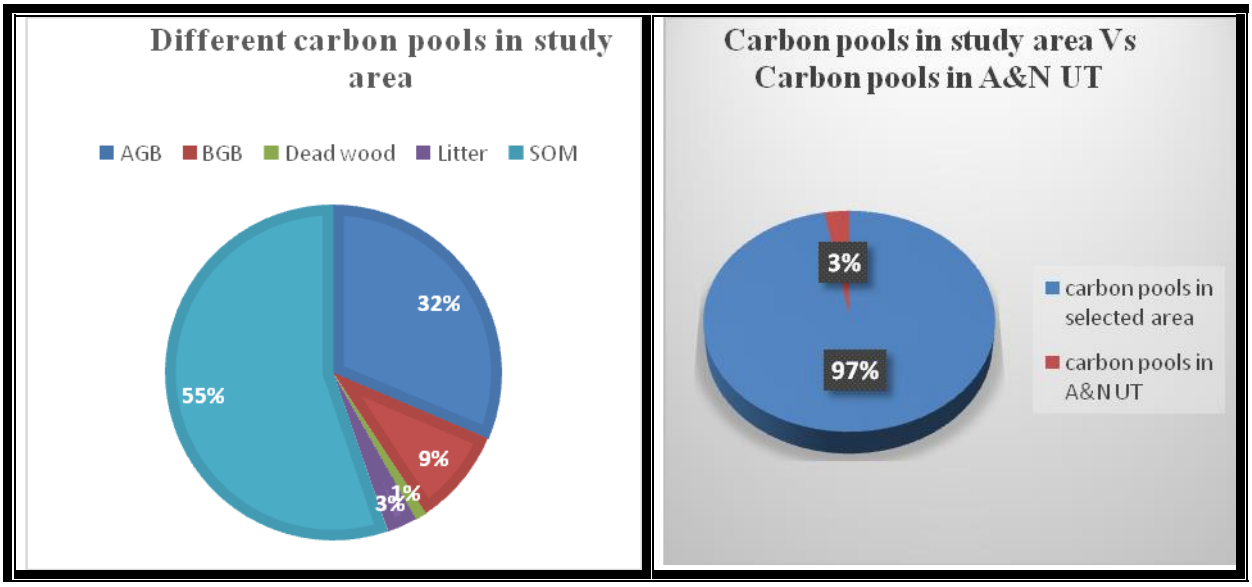

Fig 5. Carbon pools in study area Vs Carbon pools in A&N UT

CONCLUSION

The goal of the project 'Sustainable Development of Little Andaman Island in Andaman & Nicobar Islands' is for development of a new 'greenfield city' with a diverse and robust economy based on maritime services and tourism, amongst other drivers. The development of the new economic base will depend heavily on investment in catalytic infrastructure facilities, including an International Container Transshipment Terminal (ICTT), Greenfield International Airport, and Power Plants. From an environmental impact assessment perspective, deforestation is considered the primary concern . In this study we found a near estimation of carbon loss using Bhuvan thematic service and secondary data set of carbon stock from India State Forest Carbon Stock for different forest types. This study can be continued for better estimation of carbon loss of any study area by using different satellite data set and using machine learning tools in GIS s/w.

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