IMPACT OF GROUND WATER ON FOREST PRODUCTIVITY IN HALIYAL TALUKA USING RS AND GIS TECHNIQUES

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Abstract: *The study was conducted in Haliyal taluka to assess the impact of ground water on forest productivity and carbon sequestration. The watershed delineation and drainage assessment was done using cartosat dem downloaded from the Bhuvan website; data was processed in ArcGIS software. The field data for assessing forest productivity was done through transact survey in catchment and command area of Tattiyal dam. There are 4 plots each in catchment and command area were laid out each plot with 20x20 mts. The growth parameters such as tree height and diameter were recorded in all the 8 plots. The results indicated that the forest productivity in catchment area was 301.25m^3/Ha whereas in command area the volume was 710.56 m^3/ha. The carbon sequestration was 147.61 and 348.17 t/ha in catchment and command area respectively. Soil organic Carbon was also estimated and the results indicated that the organic carbon of soil in catchment and command area was 1.77 and 2.04% respectively. The LULC, watershed mapping, slope, contour, NDVI, soil moisture and stream order mapping was done in ArcGIS software. Based on this study is concluded that the water resource helps in command area to maintain the water table and provides the moisture to the tree growth as indicated by highest biomass in command area.*

***Keywords*: catchment, command area, water resource, Forest productivity, LULC and drainage map.**

I. INTRODUCTION

Forests provide a wide range of economic and social benefits, such as employment, forest products and protection of sites of cultural value (FAO, 2006). Forests provide a wide range of goods and services. Goods include timber, fuel-wood, as well as food products and fodder. With respect to services is concerned forests and trees play a important role in conservation of eco- systems, in maintaining quality of water, and in preventing or reducing the severity of floods, erosion, and drought.

Forest play an important role in water balancing, by holding the rain water, reducing the runoff, helps in infiltration and increases the ground water table. The natural forest as such maintains the ecological balance in terms of soil, water and vegetation. Anthropogenic pressure on forest leads to degradation and deforestation, which in-turn accelerates the erosion, loss of natural resources and final affects on climate change.

Water is most important source for plant or tree growth, the tree species adopt itself for the moisture and behaves as deciduous tree or evergreen tree. Most of the places where rainfall is low, less than 800 mm the some of the tree species would be of deciduous in nature if the same species is grown in such climatic situation where rainfall is more it behave like semi or evergreen in nature.

The water storage play an important role in maintaining the water table which in-turn help tree species in the forest for better growth and productivity. In the present scenario of climate change higher growth and productivity of forest is very much needed in order to maintain the ecological balance. The higher productivity of tree species sequesters the atmospheric carbon and thereby reduces the CO_2 concentration in the atmosphere.

The Soil Organic Carbon (SOC) stock acts as a major part of the terrestrial carbon reservoir as soils contain more organic carbon than the atmosphere with a storage of about 1500 Pg to 2000 Pg C (1 Pg =1 billion tonnes) in the top 100 cm depth layer in the world soils (Batjes, 1996). The carbon pool in soils is twice the amount present in the atmosphere; any changes in soil carbon pool can affect the composition of the atmosphere significantly. The carbon sequestration in the soil is also depends on the forest tree growth and its productivity. Carbon sequestration in tree species is higher in high productivity lands. (Roger and Brent, 2012, Watson *et al.*,2000) Keeping these points in view the experiment was planned in catchment and command area of Tattihalla dam to assess the following objectives

1. To assess the impact of ground water source on productivity of forest.
2. To study the impact of water source on carbon sequestration in forests.

II. MATERIALS AND METHOD.

Study area:

The study was conducted in Haliyal taluk, one of the water resource dams called Tattihalla dam where in catchment and command area of the dam was considered for taking the observations on forest tree species. The map of Haliyal taluka is given in fig. 1.

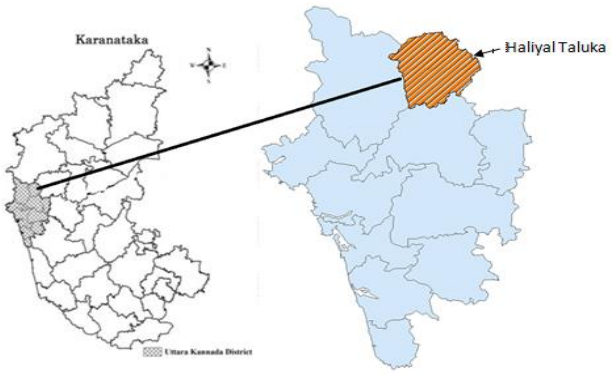

Fig.1 Map showing the study area (Haliyal Taluka)

Collection of Data:

The watershed delineation and drainage assessment was done using Cartosat dem downloaded from the Bhuvan website; data was processed in ArcGIS software.

Field data collection: In the catchment area of Tattihalla dam of Haliyal taluka, transact was laid out, there were four plots with size 20 X 20m was laid out randomly over the catchment area and observation on growth parameters i.e girth at breast height (GBH) at 1.37m above the ground level and tree height was recorded with diameter tape and Ravi altimeter respectively in all the plots. The plot latitude and longitude and elevation were recorded with GPS. Similarly four plots were selected in command area from just below the dam and away from the dam at downstream side and recorded all the parameters as did in catchment area.

The basal area was determined by the formuia (Chaturvedi and Khanna,1984).

Basal area= $\pi d^2/4$ or $g2/4\pi$. The total wood volume was determined by using formula

Volume = Total height x Basal area x Form factor. (Chaturvedi and Khanna, 1984)

Biomass:

Above and below ground biomass was calculated separately by using standard formulae's and expressed in tonnes per hectare.

Above ground biomass (tonnes /ha) = Volume of tree X Density of wood (Mac dicken ,1997)

Below ground biomass (tonnes/ha)=Above ground biomass X0.26 (Ravindranath *et al* ,2008)

Density of wood:

Wood sample of square shaped was cut from each species and weighed in weighing balance and also volume of that square shaped wood sample was calculated by using formulae volume of cube

$$\text{Density of wood (g/cc)} = \frac{\text{Mass of wood sample}}{\text{Volume of that wood sample}}$$

Carbon Sequestration (tonnes/ha)

The above ground biomass of standing trees was estimated to work out the amount of carbon sequestration by reducing the total biomass yield to its 50% or converting biomass by multiplying 0.5 (Mac Dicken., 1997).

Carbon sequestration=Total biomass(AGB+BGB) x0.5

Soil parameters`

Soil samples was collected from representative sample plots from 0-30 cm depth after scraping away the litter.The soil samples were air dried, powdered and allowed to pass through 2mm sieve and analyzed for chemical properties. The soil properties such as Electrical Conductivity whci was analysd by Conducto metric method.

Bulk-density by Core Sampler method, pH by using Potentiometric method (Jakson,1973) and soil Organic carbon (%) was estimated by Wet oxidation method (Walkely and Black, 1934)

III. RESULT AND DISCUSSION:

The field data recorded on tree species both at catchment (Upstream) and command (Down stream) area is given in table 1 and 2.

On upstream area i. e in the catchment area of Tattihall dam there are seven tree species with different numbers in each species, majority of the trees were teak, *Terminelia* and *Lagestromia species*. The average volume of wood was 301.25 m^3/ha. The plot to plot wood volume variation was from m^3/plot. The elevation of the plots was from 484 m to 501 m in the catchment area.

On downstream side i.e in command area of Tattihalla dam there is more number of species present as compared to catchment area. The total volume in transact plot was varied from 17.813 to 47.840 m^3/plot. The average wood volume in catchment area was 710 m^3/ha. The results indicated that more than double volume of wood was recorded in command area as compared to catchment area; this variation in wood volume was due to the influence of water source stored in the dam. The study clearly indicated that water storage in forest is very much essential for the growth of tree and higher wood volume.

Table 1. Tree species volume (m^3) on upstream side of the water source

SL NO	TREE SPECIES / Location (lat and long) / Elevation m	Volume of tree species (m^3) N15 08 30.4, E74 46 42.9 490	N15 08 45.5, E 74 46 39.6 484	N15 08 43.8, E 74 46 36.4 493	N15 08 46.4, E 74 46 36.1 501
1.	*Tectona grandis*	0.043	1.875	1.552	0.612
2.	*Tectona grandis*	0.096		1.886	0.019
3.	*Tectona grandis*	0.082		3.406	0.078
4.	*Tectona grandis*	0.048		2.441	1.321
5.	*Tectona grandis*	0.015	0.118		0.597
6.	*Tectona grandis*	0.032	1.648		2.483
7.	*Tectona grandis*	0.078	0.330		0.126
8.	*Tectona grandis*	0.060	0.432		
9.	*Tectona grandis*	0.115			
10.	*Tectona grandis*	0.060			
11.	*Tectona grandis*	0.100			
12.	*Tectona grandis*	0.012			
13.	*Terminelia panic ulata*	0.008	1.321		0.465
14.	*Terminelia panic ulata*	0.002	0.946		0.007
15.	*Terminelia panic ulata*	0.005			0.012
16.	*Terminelia panic ulata*	0.232	0.107		0.050
17.	*Terminelia panic ulata*	0.060			
18.	*Terminelia tomentosa*	7.545	1.296	1.652	
19.	*Terminelia tomentosa*		1.166		
20.	*Lagestromia lanc iolata*	0.061	0.383	1.438	0.118
21.	*Lagestromia lanc iolata*	0.023	0.524	0.180	0.730
22.	*Lagestromia lanc iolata*			2.827	0.014
23.	*Lagestromia lanc iolata*				0.091
24.	*Lagestromia lanc iolata*				0.070
25.	*Lagestromia lanc iolata*				0.140
26.	*Melia dubia*	0.094			
27.	*Xylia xyloc arpa*				0.033
28.	*Xylia xyloc arpa*				0.060
29.	Unknown	6.048			
	Total	**14.819**	**10.992**	**15.383**	**7.025**
	Average volume m^3/plot	**12.05m3 / plot**			
	Volume m^3 /ha	**301.25**			

Table 2. Tree species volume (m^3) on downstream side of the water source

SL NO	TREE SPECIES / Location (lat and long) / Elevation m	Volume of tree species (m^3)			
		N 15 07 0.09,E 74 46 9.31	N 15 07 03..4, E 074 46 7.69	N15 07 041, E 074 46 7.23	N15 07 0.51, E074 46 6.37
		443	460	455	440
1.	*Tectona grandis*	1.389	0.205	1.738	0.097
2.	*Tectona grandis*	1.534	0.056	1.862	0.700
3.	*Tectona grandis*	1.273	0.168		1.669
4.	*Tectona grandis*	1.234	0.107		1.456
5.	*Tectona grandis*	1.370	3.006		0.027
6.	*Tectona grandis*	0.349			6.008
7.	*Tectona grandis*	1.048			1.885
8.	*Tectona grandis*	1.210			
9.	*Tectona grandis*	1.188			
10.	*Terminelia panic ulata*		1.484	0.066	0.465
11.	*Terminelia panic ulata*		0.524		0.168
12.	*Terminelia panic ulata*		5.655		0.060
13.	*Terminelia panic ulata*		0.066		0.026
14.	*Terminelia panic ulata*				0.042
15.	*Terminelia tomentosa*		4.970	2.679	7.435
16.	*Terminelia tomentosa*		0.436	4.777	
17.	*Terminelia tomentosa*		6.168		
18.	*Lagestromia lanc iolata*		0.405	1.630	1.162
19.	*Lagestromia lanc iolata*		0.893		
20.	*Xylia xyloc arpa*		1.048	1.852	0.021
21.	*Xylia xyloc arpa*			0.417	0.028
22.	*Xylia xyloc arpa*			1.372	0.067
23.	*Bahunia species*	0.491		3.183	
24.	*Bahunia species*	1.016			
25.	*Bahunia species*	0.368			
26.	*Dalbergialatifolia*	0.436			
27.	*Dalbergialatifolia*	0.896			
28.	*Ficus glomaruta*	3.542			
29.	*Adina cardifolia*	1.520			
30.	*Vateria indic a*		0.103	0.129	
31.	*Vateria indic a*		0.762	1.317	
32.	*Adina cardifolia*		21.714		
33.	*Syzizium cumini*		0.070		
34.	*Veteria indica*			0.463	
35.	*Veteria indica*			0.062	
36.	*Veteria indica*			0.143	
37.	*Veteria indica*			0.659	
38.	Unknown			1.190	3.185
	Total	**17.813**	**47.840**	**23.538**	**24.512**
	Average volume m^3/plot	**28.43**			
	Volume m^3 /ha	**710**			

The soil samples collected from catchment and command area from all the transact plots were analysed. The results are given in table 3. The results indicated that PH is slightly increased in command area towards neutral from acidic. The electric conductivity was increased from 95.55 to 136.013 for µŚ/dm. The bulk density was increased slightly and organic carbon in soil was also increased from 1.87 to 2.22. The higher organic carbon returned to the soil via litter fall is an important source of nutrients for vegetation. Organic carbon content in surface soil is higher command area due to highe leaf litter and less soil erosion (Dutta and Singh,2007).

Table. 3 Soil properties in catchment and command area of Tattihalla Dam

Places	PH	EC(µŚ/dm)	Bulk density (g/cc)	Organic carbon %
Catchment area	5.69	95.55	1.13	1.87
Command area	6.43	136.01	1.33	2.22

Based on the volume of the wood, the carbon sequestration was estimated as shown in table 4. It was found that the carbon sequestration was 147.61 tonnes /ha in catchment area where as it was 348.17 tonnes /ha in command area. There was a significant increase in the carbon sequestration in tree species present in command area. This was due to the influence of storage water in the dam.

Table.4: Wood Volume and carbon sequestration as influenced by water resource

Sl.No	Place	Volume m^3/ha	Carbon sequestration t/ha
1	Catchment area	301.25	147.61
2	Command area	710.56	348.17

Based on the supervised classification the different LULC classes and their area details are shown the Table.5 and Fig.2. The results indicated that the forest covers an area of about (47.31%) dense forest and followed by Agriculture (26.15%) and other classes are shown in the Table.5.

Table.5. Land use and Land cover different classification area details in Ha

Land cover features	Area in Ha	% Area
Water bodies	2751.52	3.19
Settlement	1296.64	1.50
Agriculture	22498.2	26.15
Open land	1876.22	2.18
Horticulture	1905.48	2.21
Sparse forest	14984.6	17.42
Dense forest	40693.8	47.31
Total	**86006.46**	**100**

The NDWI map is shown in **Fig.3**. The results indicated that water content present in various land features as indicated by the NDWI which is varies from -0.561 to 0.276.

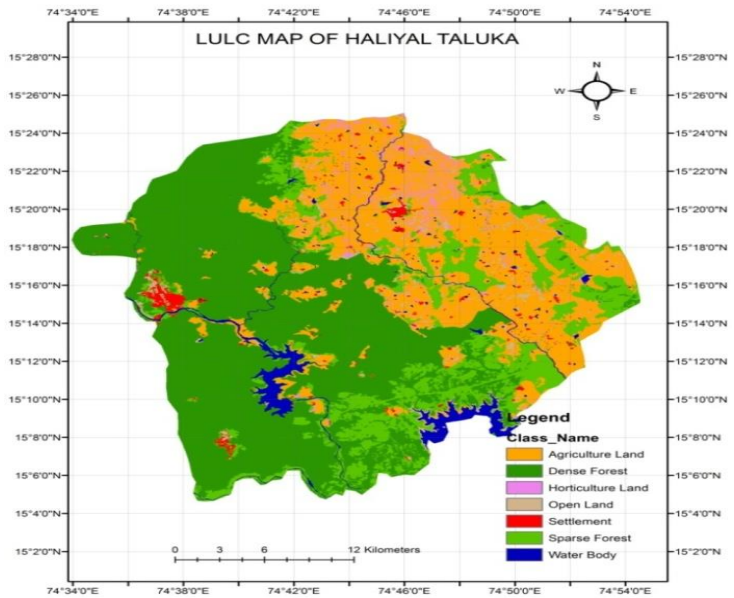

Fig.2 Land use and Land cover map of Haliyal Taluka

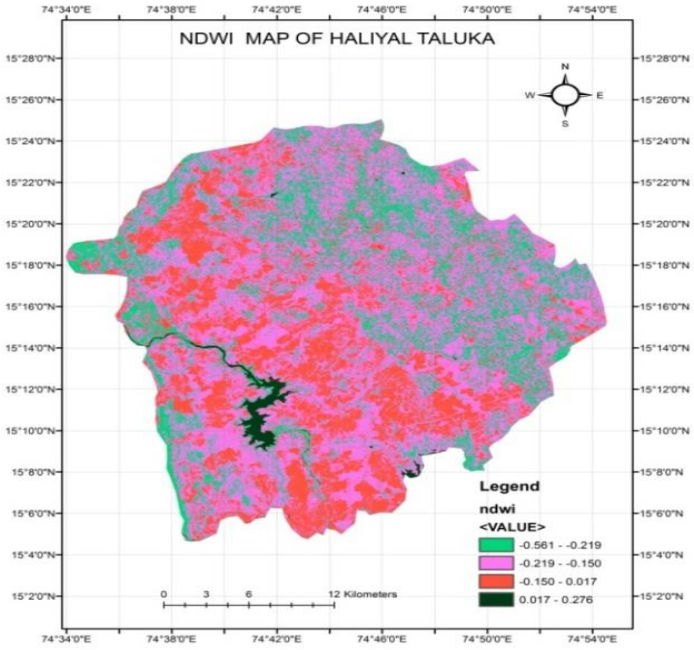

Fig.3 Normalised difference water Index map of Haliyal Taluka

The NDVI map is shown in **Fig.4** indicating the higher vegetation density with higher NDVI value towards open land and water body, the NDVI value ranges from 0.663 to -0.157

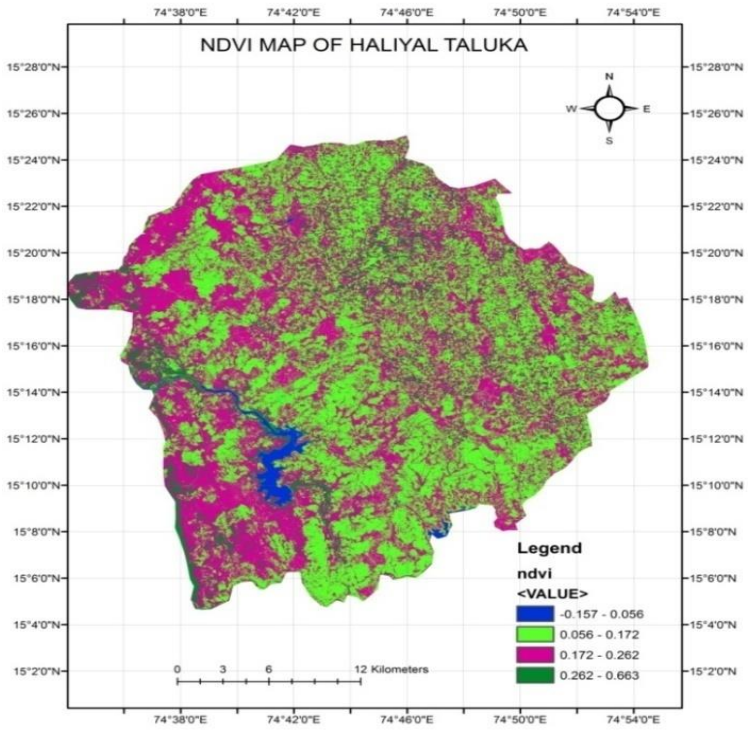

Fig.4 Normalised difference vegetation Index map of Haliyal Taluka

The watershed elevation and drainage map is shown in **Fig.5 and 6.** The elevation in the Haliyal taluka varies from -9 to 599 m. The Tattihalla dam is locate at the elevation of 450-460 m. The data regarding the forest production was estimated on upstream and downstream side of the dam as indicated in table 1 and 2. The stream flow is very important for the collection of water in the dam. The storage water in the dam is trough tout the year hence there is always provision to maintain the water table in the downstream side of the dam which has helped for the tree growth much better in command area as compared to the catchment area. The results indicated that water resource especially the dams play an important role in maintaining forest growth and productivity much higher and it helped to avoid the loss of natural resources. The watershed delineated from DEM indicated the number streams in Haliyal taluka are about 1251 in numbers in different watershed of the taluka.

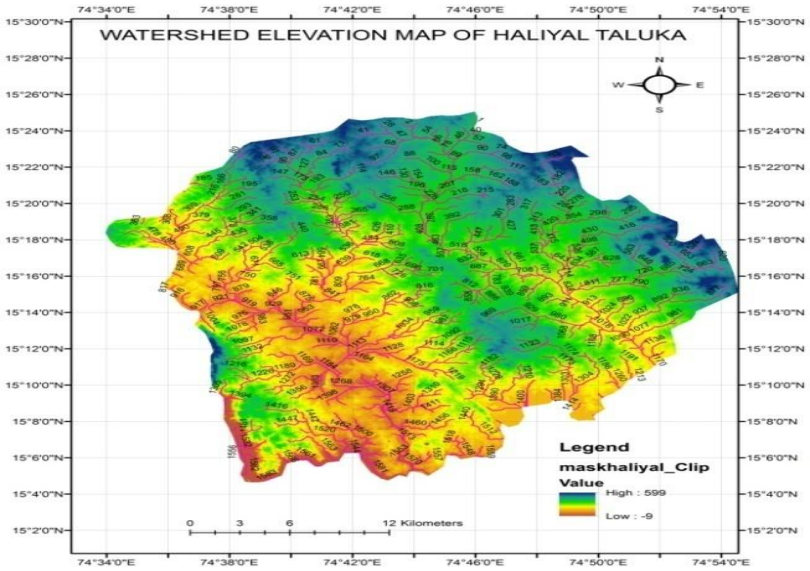

Fig.5 Watershed elevation map with drainage lines of Haliyal Taluka

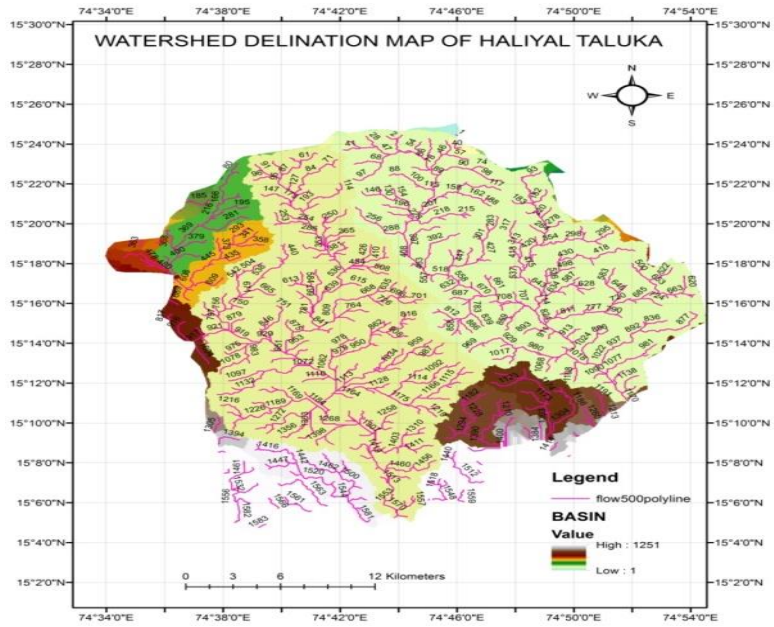

Fig.6 Watershed delineation along with drainage lines map of Haliyal Taluka

CONCLUSION

Based on the study it is concluded that the water storage dams play an important role for the forest tree growth and productivity. The Dam water helps in maintaining the water availability to the tree which in-turn helps for growth of trees in command area. The productivity of tree in command area is much higher as compared to catchment area. The spatial analyst tools are the most important for preparation of various maps related to watershed hydrology.

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