

CARBON SEQUESTRATION POTENTIAL OF ECOSYSTEMS IN UTTARA KANNADA DISTRICT, WESTERN GHATS OF KARNATAKA, INDIA.

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Abstract:

Carbon sequestration is the process of removing carbon from the atmosphere and depositing it in a reservoir. It is a controlled disposal or storage of carbon compounds to prevent their release into the environment. Carbon dioxide is one of the major factors for global warming these days and sequestration has drawn the global attention in recent times. Forests, waterbodies and soil are the major sinks accumulating carbon. The study demonstrates the carbon sequestration potential of ecosystems in UttaraKannada district, Western Ghats Karnataka. Linear and logarithmic regression equations using basal area (BA), height (H), diameter at breast height (DBH), volume (V), and density (D) of individual tree species in a forest are followed to calculate the biomass. LANDSAT-TM and ETM⁺ data for consecutive years and IRS- P6 LISS III 2004 high resolution data is used to spatially estimate biomass in the evergreen, deciduous, teak plantations, savannas, scrubs forests in the Western Ghats of Karnataka using ground data as reference. Furthermore the calculation of various vegetation indices gives us a clear picture about the vegetation status of a region. The classification is based on the species present in each forest type that enables us to identify the type of species and thus helps in the management of the biodiversity and estimation of biomass. UttaraKannada is the only district in Karnataka, which has a forested area of about 80% and falls in the region of the Western Ghats. Uttara Kannada (north canara) district lies between 13.92220°N to 15.5252°N latitude and 74.0852°E to 75.0999°E longitude and covers an area of 10,291 km². It comprises of 40.466% of evergreen forests, 7.92% of deciduous forest, teak plantations of 12.07% and exotic plantation of 7.0% and Areca, coconut cashew plantation of 7.58% and grasslands savannas, scrubs of 5.45%.

Keywords: Carbon, Sequestration, Western Ghats, UttaraKannada, Biomass

Introduction:

Carbon sequestration is the process of removing carbon from the atmosphere and depositing it in a reservoir. Trees play an important role as carbon sink, during the process of photosynthesis, the atmospheric CO₂ is taken by the leaves for the manufacture of food in the form of glucose, later on it gets converted to other forms of food materials i.e.; starch, lignin, hemicellulose, amino acids, proteins etc, and is diverted to other tree components for storage. Biomass is calculated using density of stems, height of the trees and basal area of the trees in a given location.

Therefore, accurate biomass estimation is necessary for better understanding deforestation impacts on carbon release, global warming and environmental degradation. Forests sequester and store more carbon than any other terrestrial ecosystem.

Remote sensing data applications have evolved as very useful tool in the characterization of the state of the biosphere at regional and global scales. The understanding of the effects of varying spectral responses is useful in the quantification and retrieval of bio-geographical parameters such as reflectance, vegetation indices, LAI, forest density, above-ground biomass, etc. Land Use and land Cover change is the most important source of green house gases and also has a potential for carbon sequestration, so the present study would deal with the application of geospatial tools with regard to Land Use and Land Cover change detection. Remotely sensed data is considered to be the most reliable means for spatial biomass estimation in the tropical region over large areas (Roy and Ravan, 1996). Several studies (Franklin and Hiernaux, 1991; Nelson et al., 2000; Steininger, 2000) have estimated the biophysical parameters using the coarse resolution sensors and thus were not able to account for the local variabilities and also suffer from uncertainties.

The study is carried out to analyze the carbon sequestration potential of ecosystems in Uttara Kannada district, Western Ghats Karnataka using Remote Sensing and GIS.

Review of literature:

Carbon dioxide (CO₂) is one of the abundant greenhouse gas which causes global warming. Studies say that both Species wise and volumetric equations have been used by the authors to compute biomass. JanaKr Bipal, Biswas Soumyajit, Majumdar Mrinmoy, Roy Kr Pankaj, MazumdarAsis (2009) in their study carried out their estimation of biomass using species wise equations. Murthy I.K., Hedge G.T., sudha P., Ravindranath N.H.(2006) used volumetric equations to compute biomass. In India, especially in Southern Western Ghats having very high biodiversity, very few biomass studies have been carried out, e.g.,biomass estimation using destructive method (Rai,1984) and using non-destructive method (Tiwari, 1992).The total above ground carbon stocks was carried out by Ravindranath *etal*, 2005; Swamy, Puri and Singh, 2003. A non-destructive method is mainly based on regression equations which are derived from measurable tree parameters like diameter at breast height (DBH), basal area, and tree height (Brown et al., 1991; Murali et al., 2005). . Nowadays we can see deforestation and degradation of forests which lead to Global Warming. Trees not only help as to combat climate change but also they serve as with ecological value. Biomass is also a prime substitute for quantifying forest resources, including timber, fuel and fodder, and represents a key indicator of biodiversity and forest structure.They give shelter not only to human beings but also to many species which are endemic in nature as *Slender loris* in Western Ghats .Trees that are good in carbon sequestration can go a long way in mitigating effects of climate change. These studies highlight the need for focusing on conservation of forested areas and its ecological value in so an attempt has been made to review the current potential of carbon sequestration potential for forests of Uttara Kannada district in Western Ghats and in this regard a study has been initiated.

Study area:

Uttara Kannada (North Canara) district lies between 13.92220°N to 15.5252°N latitude and 74.0852°E to 75.0999°E longitude and covers an area of 10,291 km². Uttara Kannada district is one of the northernmost districts in Karnataka State. The district comprises of 11 Taluks namely, Supa, Haliyal, Mundgod, Yellapur, Karwar, Ankola, Sirsi, Siddapur, Honnavar, Kumta and Bhatkal. Climate of Uttara Kannada is typically tropical. Southwest monsoon winds bring down rains during the months June September. Average annual rainfall is about 250 cm, followed by 7 months of more or less no rain. The month of July experiences the heaviest rains. Rainfall is very heavy in the coast, averaging more than 300 cm annually. Uttara Kannada is the only district in Karnataka, which has a forested area of about 80% and falls in the region of the Western Ghats. It is considered to be a very resourceful in terms of abundant natural resources and constitutes an important district in Karnataka. Vegetation analysis. The classification is based on the species present in each forest type that enables us to identify the type of species and thus helps in the management of the biodiversity and its conservation. It comprises of 40.466% of evergreen forests, 7.92% of deciduous forest, teak plantations of 12.07% and exotic plantation of 7.0% and Areca, coconut cashew plantation of 7.58% and grasslands, savannas, scrubs of 5.45%.

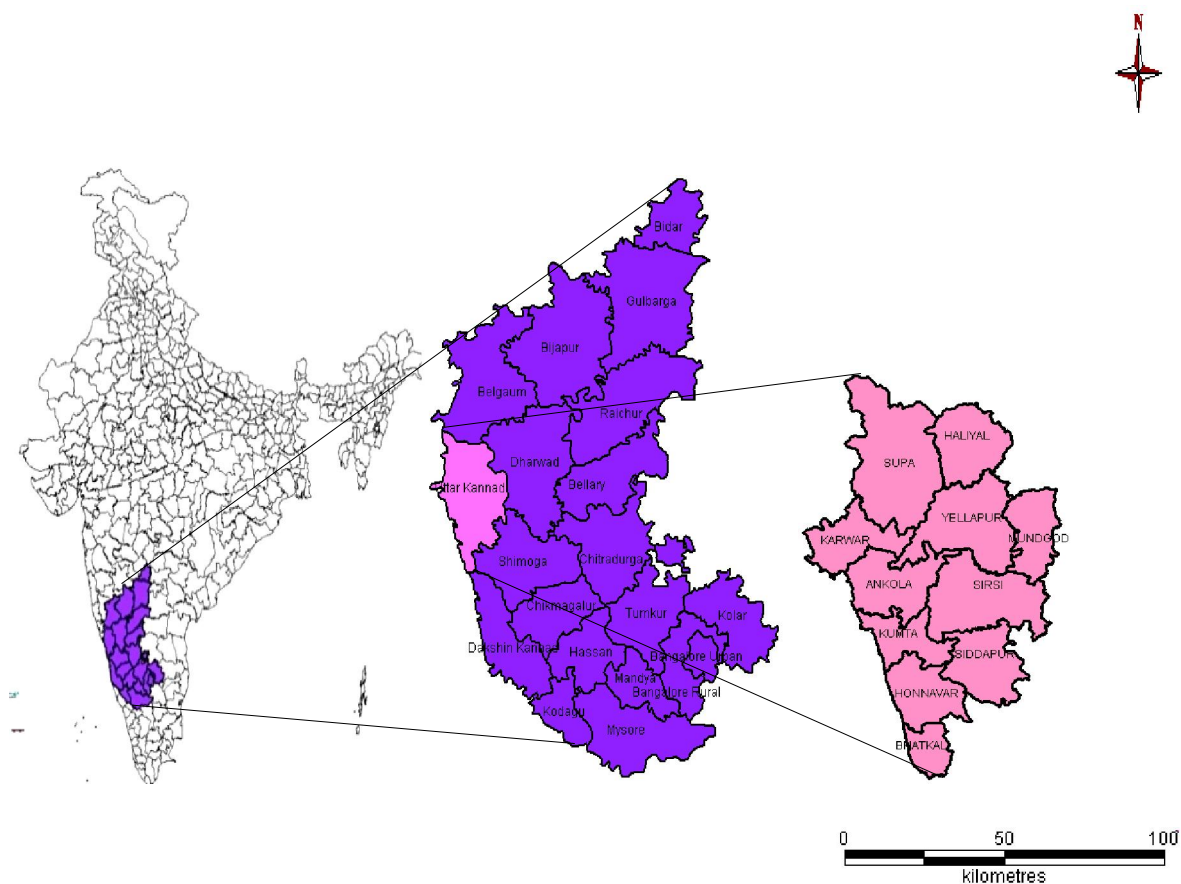


Figure 1: location of Uttara Kannada District in India

The central part of Uttara Kannada is of the evergreen type as shown in. They are composed of very tall trees, forming a very dense canopy and are many storied and impenetrable. The rainfall in this forest is as high as 4000-5000 mm. The semi evergreen forests are seen in pockets and often merge with the evergreen and the moist deciduous type. These forests have semi evergreen species in the upper canopy and evergreen in the lower storey. In these forests, some moist places have predominance of bamboo and on red soil Xylia is present. They have a rainfall of about 1000-2000 mm. Few of the species found in Uttara Kannada are listed below.

Evergreen species: *Dipterocarpus indicus*, *Diospyros candolleana*, *Artocarpus hirsutum*, *Vateria indica*, *Hoppea intergrifolia*, *Memecylon umbellatum*, *Mangifera indica*, *Actinodaphne agustifolia*, *Holigarna grahmie*, *Calamus rotang*.

Semi evergreen species: *Cinnamomum malabaricum*, *Holigarna arnottiana*, *Dalbergia latifolia*, *Ficus spp.*, *Pterocarpus marsupium*, *Aglaia roxbhurgiana*.

Moist deciduous species: *Terminalia paniculata*, *Terminalia tomentosa*, *Xylia xylocarpa* *Careya arborea*, *Spondias spp.*, *Tectona grandis*, *Lagerstroemia parviflora*, *Dillenia pentagyna*, *Strychnos nuxvomica*, *Bambusa arundinaceae*.

Dry deciduous species: *Acacia catechu*, *Sepium insigne*, *Anoegissus spp.*, *Bauhinia racemosa*, *Bombax ceiba*..

Plantations: *Tectona grandis*, *Areca catechu*, *Cocos nucifera*, *Casuarina equisetifolia*, *Acacia auriculiformis*, *Acacia nilotica*, *Eucalyptus spp.*

Materials and Methods:

Satellite data and Survey of India (SOI) topographic maps of Shimoga and Belgaum at 1:250,000 scale were used for carrying out the research work. The detail of the satellite data used is given in table 1:

SATELITE	SENSOR	MONTH AND YEAR	SPATIAL	SOURCE (SPATIAL)
LANDSAT	TM	NOVEMBER 1989,2000	30m	http://glcfapp.umiacs.umd.edu

Table 1: Details of satellite data

The False Color Composite (FCC) of the images of band 2 (Green), 3 (Red) and 4 (IR) were created in order to differentiate the different features on the image based on their reflectance in each band. Using acquired Toposheets as training sets the image was classified using supervised classification method into a land use/land cover image. The classes are as follows: (1) moist deciduous forest as major component and (2) Evergreen forest, (3) Deciduous scrubs,(4)Evergreen scrubs,(5)Plantations,(6) Evergreen thickets,(7)built up areas,(8)Waterbodies,(9)Agricultural lands,(10) prawn culture,(11) barren lands.

There are a number of vegetation indices that have been developed to help in monitoring vegetation. They are based on the interaction between vegetation and electromagnetic energy in the red (R) and infra red (IR) wavelengths.

A very simple vegetation index can thus be achieved by dividing the measure of infrared reflectance by that of the red reflectance. Areas of strong vegetation will thus result in a very high index value. The most commonly used vegetation index is the Normalised Difference Vegetation Index (NDVI), which is calculated in the following manner:

$$NDVI = (NIR - R) / (NIR + R)$$

Where NIR = Near infra red, R = Red band

Biomass estimation:

Biomass computed by basal area, height,DBH and density gives us an accurate measurement.So this is the equation being taken by me to calculate biomass of evergreen and moist deciduous trees in the region using the ground data of tree density,and GBH of the individual trees. (Murali K.S., Bhat D.M., Ravindranath N.H.,(2005)

Evergreen trees	$Y = C + m \cdot \text{basal area}$ $-2.81 + 6.78 (r^2 = 0.53)$
Moist Deciduous trees	$Y = C + m \cdot \text{basal area}$ $73.55 + (10.73 \text{ Basal area}) (r^2 = 0.82)$

Table 2: Biomass equations

Basal area = $GBH/4\pi$, For finding the basal area we need trees/ha and also the GBH of a tree

The amount of carbon sequestered may be inferred from the biomass change since 50% of the dry biomass can be inferred as carbon (Westlake, 1996, Brown & Lugo, 1982, Schroeder, 1992, Dixon, 1994, Cannel *etal*, 1995, Richter *etal*, 1995, Ravindranath *etal*, 1997, Montagnini and Porras, 1998, Losi *etal*, 2003, Montagu *etal*, 2005).

Results and Discussions:

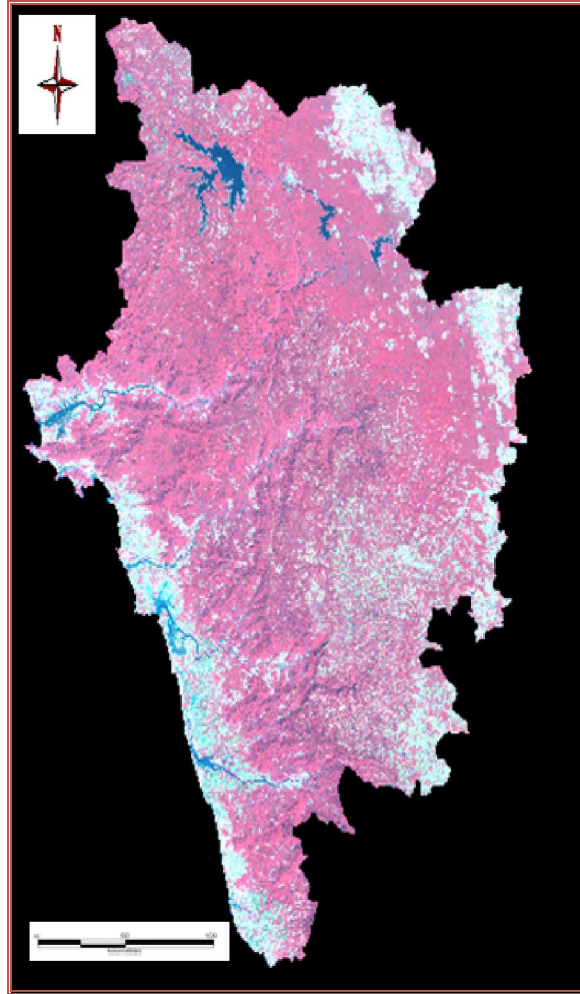
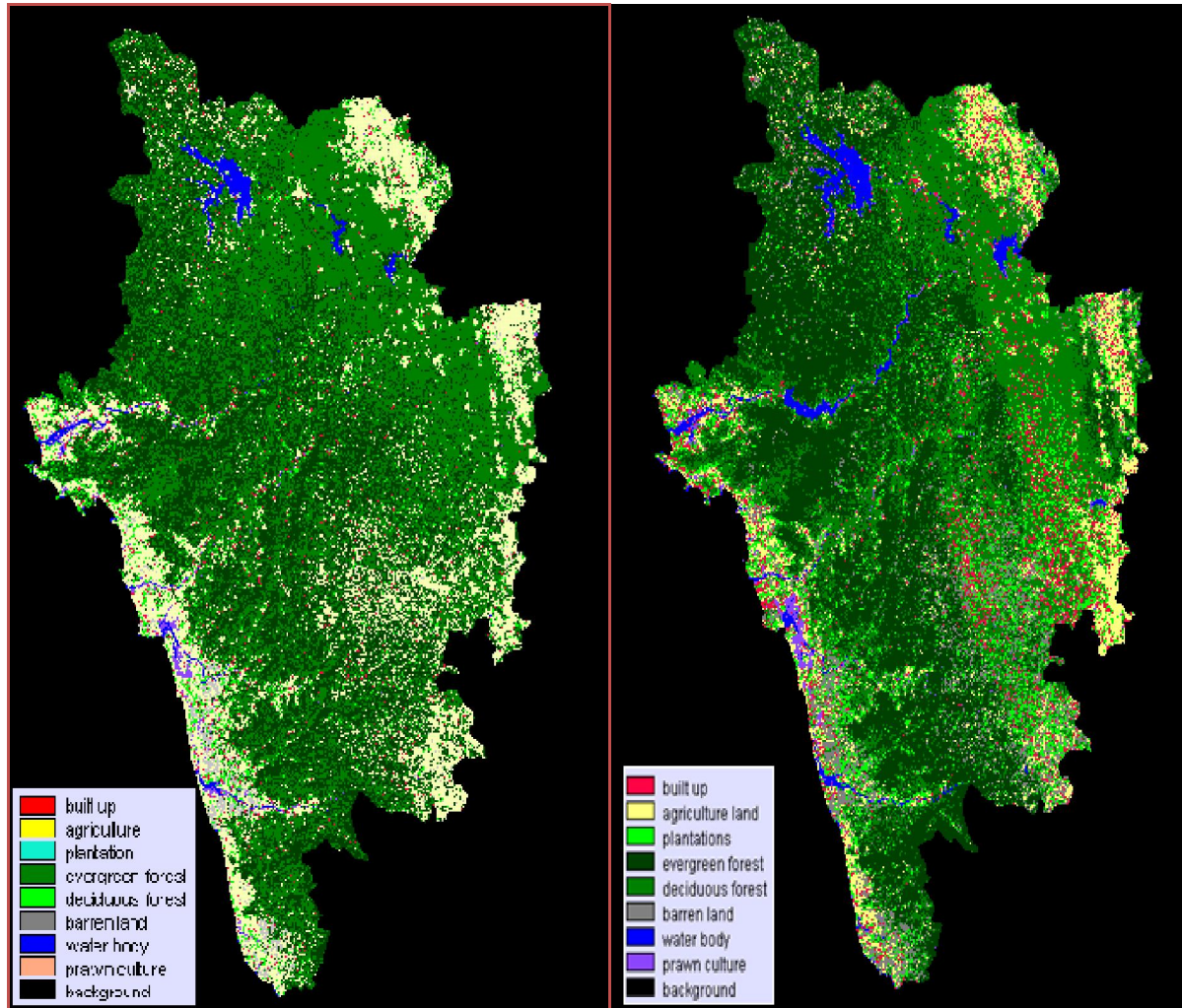


Figure 2: FCC of Uttara Kannada

It depicts merged and cropped false color composite (FCC) image of Uttara Kannada for the year 1989. This figure clearly distinguishes the different features associated with the image. The features that are at a high altitude such as the ghat section, and hilly areas could be identified easily from this image.

Land-use classification for Uttara Kannada was done by maximum likelihood hard supervised classifiers respectively. The area is classified into 8 land-use classes namely, urban agricultural land, forest, water bodies, etc.

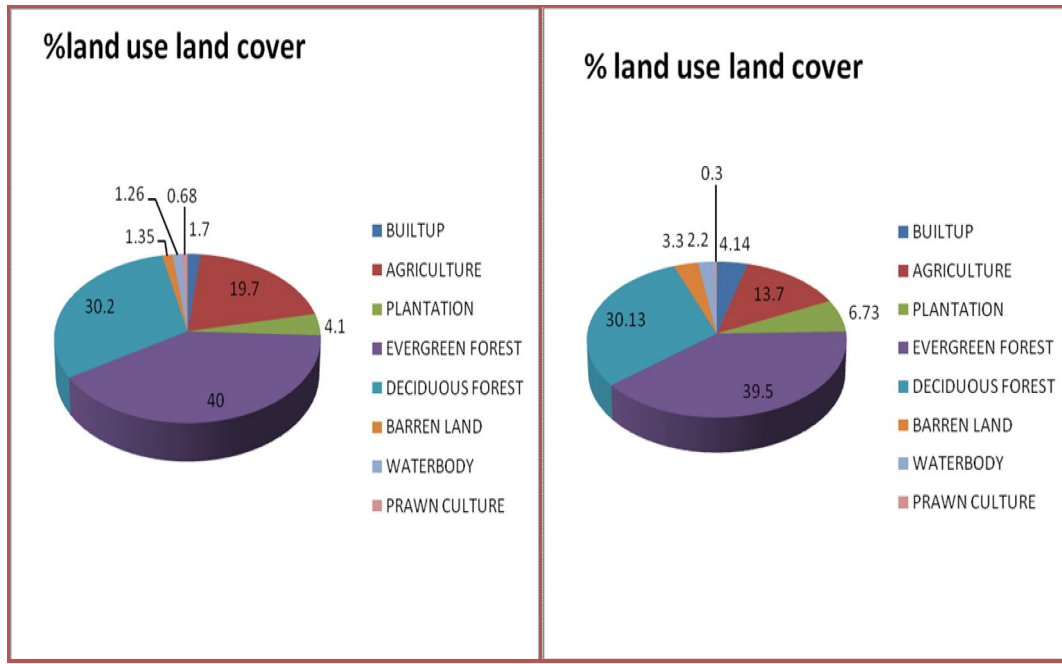


3(a) 1989

3(b) 2000

0 50 100
kilometres

Figure 3: Land Use Land Cover Analysis of 1989 and 2000



4(a)1989

4(b)2000

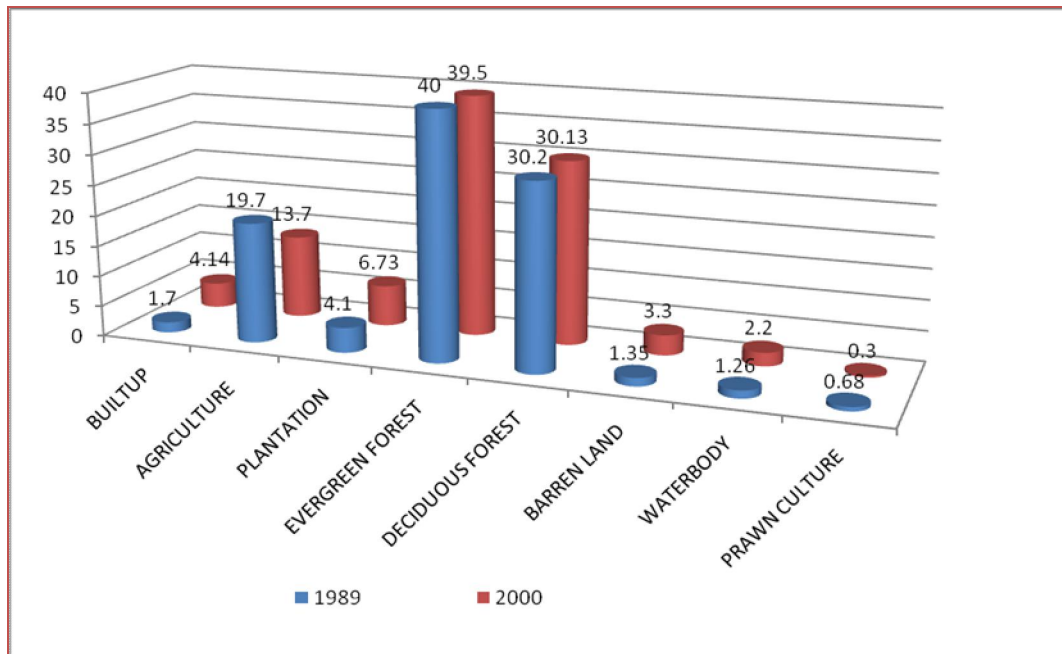


Figure 4 The land use land cover analysis

The land use land cover analysis showed that Evergreen and Moist Deciduous trees are in huge abundance in Uttara Kannada District. These trees have the maximum potential to sequester carbon. There is no change in land cover in Evergreen trees from 1989 to 2000 but a little increase of 1% in Moist deciduous trees from 30% to 31%. If we see these Moist Deciduous trees have started dominating the Evergreen trees in the region. Water bodies have increased considerably from 1989 to 2000. Plantation have considerably increased from 4.1% to 6.7%. Trees provide a cost effective and feasible benefit to our environment, as well as a healthier environment to live in. They are considered to be the most effective carbon sinks which can combat climate change in recent years.

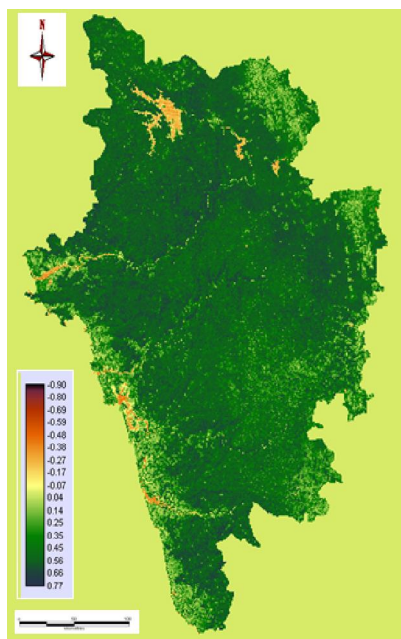


Figure 5: NDVI of Uttara Kannada.

This gives the vegetative cover of the district. The Western Ghats region of the district showed a very high vegetative index value.

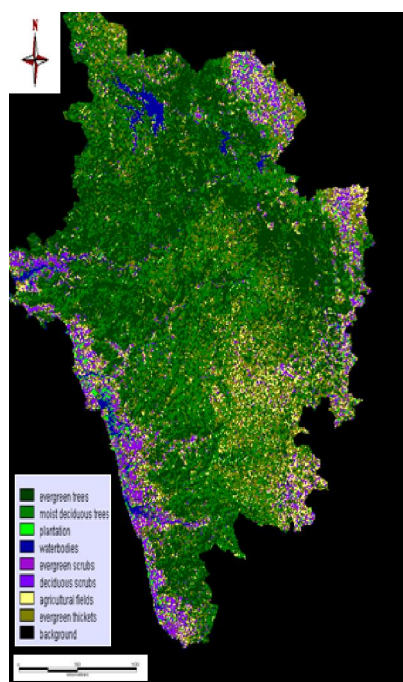


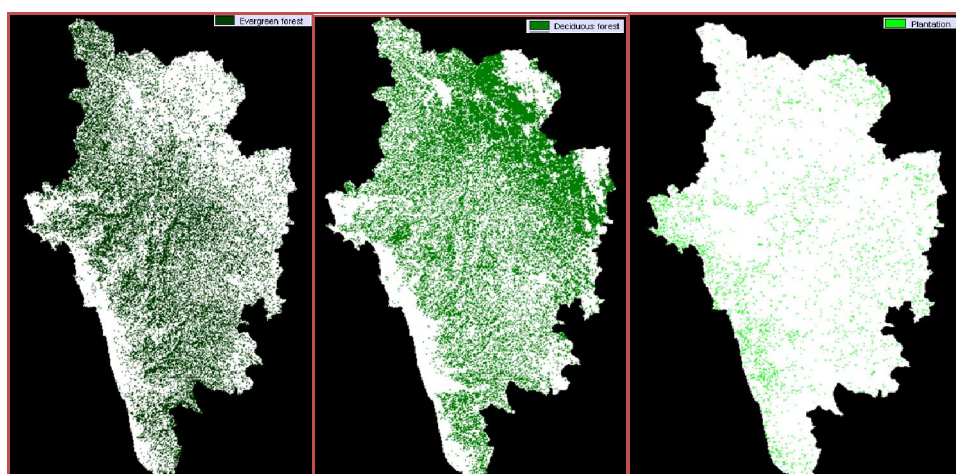
Figure 6 : Forest classification of 1989.

Forest	Area (in hectares)
Evergreen trees	405289.62
Evergreen scrubs	10598.58
Evergreen thickets	170383.41
Moist deciduous	280671.12

Deciduous scrubs	68726.70
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Table 3: Forest covers (Area in hectares)

Trees store carbon as they grow .Uttara Kannada is considered to have a forested area of about 80%. It's seen that the both Evergreen and Deciduous forests have a potential to sequester carbon to maximum. The area covered by the Moist Deciduous and Evergreen trees is approximately is 9 lac hectares in this region.



7(a)Evergreen

7(b)Moist Deciduous

7(c) Plantation

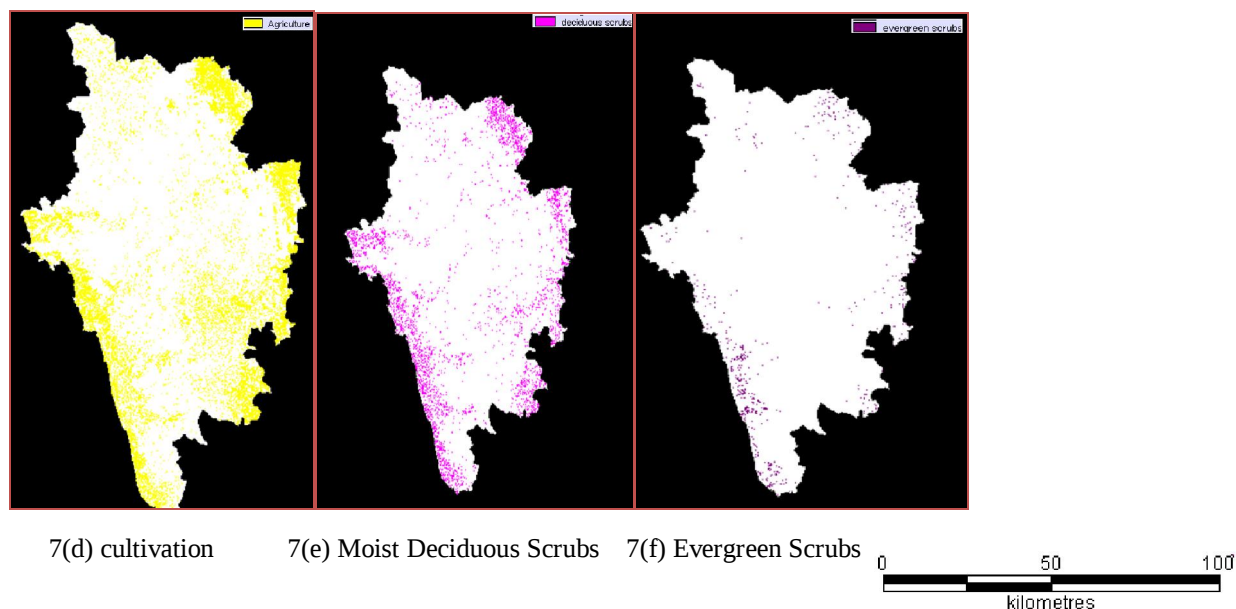


Figure 7: land cover of Uttara Kannada District, Western Ghats, India

Uttara Kannada is considered to have a forested area of about 9 lac hectares and falls in the region of the Western Ghats. The carbon pool for the Indian Forests was estimated to be 2026.72 Mt (Ravindranath et al.) for the year 1995. It is seen that both Evergreen and Deciduous forests have a potential to sequester carbon to maximum and the forests in the region have a potential to sequester carbon. Therefore, a study is being carried out at village level using Remote sensing and GIS to determine the carbon uptake by individual village trees. We are also looking into the emissions from different villages by livestock, horticulture, agriculture residue so that we can assess the ratio of carbon uptake by trees to emissions.

Conclusions:

The future research is to focus on the integration of multi-source data, which involves the effective integration using remotely sensed data. The attempt made in this study showed strong possibility of using spectral response-based models for biomass estimation. The study is carried out to demonstrate the Carbon Sequestration potential by the Ecosystems in Uttara Kannada district at village level. Forests not only provide ecosystem services but are having a potential to combat climate change.

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