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Anthropogenic Pressure on Forest Resources in Chitradurga Taluk of Karnataka State, India using Geospatial Technology

Manjunatha M.C[1], Basavarajappa H.T[2], Siddaraju M.S[2] and Maruthi N.E[3]

Department of Civil Engineering, Maharaja Institute of Technology, Thandavapura, Mysuru, India[1]

Department of Studies in Earth Science, CAS in Precambrian Geology, University of Mysore, Mysuru, India[2]

Department of Geology, Yuvaraja's College, University of Mysore, Mysuru, India[3]

Abstract: Forests are predominantly made of thick vegetation, medicinal plants and huge number of vegetation types and other forest economic products. These products boost the economy by providing food, fibre, timber and maintain a healthy environment by sequestering the carbon through regulation of gaseous and nutrient cycling. Geological landforms, climatic conditions, water regime, soil erosion are widely controlled by forest resources. Each forest type has its own uniqueness and together supports various socio-economic, ecological, cultural and spiritual functions. Forest cover is associated with other land surface features which need immediate monitoring for its sustainability. Forests management, conservation and developmental strategies are an utmost important to meet demand and supply of environmental needs for upcoming generations. The study area holds 7.8% spread of forest cover which includes open deciduous; dense/closed deciduous; forest plantations and scrub forest according to 1999 assessment of the Karnataka Forest Department. The present study aims to map forest types and it's Change Detection Analysis (CDA) from 1978 to 2019 through geospatial technology. Thematic maps are prepared using Survey of India (SoI) topomap of 1:50,000 scale; geo-rectified multi-spectral & multi-temporal satellite images of IRS-1C/1D PAN+LISS-III of 5.8m resolution and Sentinel-2A of 10m resolution. The present study reveals the change detection in forest cover of over 4 decades using geospatial techniques for sustainable management of forest goods and services.

Keywords: Forest resources; CDA; Chitradurga taluk; Geospatial Technology.

I. INTRODUCTION

Forestsare mostly outlined as a plant community predominantly made up of trees and various woody vegetation with tree canopy cover of over 10% and land of more than 0.5 ha [9, 29]. Forests act as major resource and play an important role in maintaining the ecological balance and environmental setup [26]. Forests and its products support the basic demand and supply for human survival in larger scale [8]. Forests not only provide multiple benefits to mankind but also help in conserving the environment has created global concern for their protection and conservation. But these resources are slowly degrading in their area due to anthropogenic pressure such as illegal mining, agricultural encroachment, grazing animals and demand for economic deposits [17, 31].

The forest consists mostly of shrub growth which is being exploited for fuel and agricultural implements due to human forces [1] resulted in substantial denudation and also affect the soil and vegetation conditions. Deforestation increases atmospheric CO^2 and other trace gases, possibly affecting climate, due to absorption of carbon is higher in forests than in the agricultural lands which replace them [10]. Thesoil fertility attracts more farmers for agricultural activities within the boundaries of reserved forest covers are noticed. Low rainfall conditions during extreme summers and increase in mining activities on reserved forest cover leads to deforestation [14]. Moreover, people tend to be more inclined towards the utilization of natural resources rather than conservation. An accurate forest cover-type is essential for effective management of natural resources [27].

Geospatial technologies, such as remote sensing, Geographic Information System (GIS), and Global Positioning System (GPS) provide vital role in collection, analysis and storing all sort of geospatial information particularly important for forest assessment [26]. Vegetation mapping through remotely sensed satellite dataserve as primary demand for numerous management and planning activities at the landscape level [28]. Geospatial technologies reveal tremendous application in quick spatial and temporal observing of tropical forest resources that acts as support system for decision makers [22].

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II. MATERIAL AND METHODS

A. Study Area

It lies in between $14^0$03'7" to $14^0$27'10" N latitude and $76^0$06'22" to $76^0$34'53" E longitude with an aerial extent of 1383 km^2 (Fig.1a). Physiographically, it is a dry and thirsty land with broken hills ranges and huge undulating plains with general elevation of 732 m[18]. The study area undergoes a hot, seasonally dry, tropical savannah climate that receives low to moderate rain. The quality of vegetation is poor because of poor rains. However, small grooves of the trees are to be seen in rural villages. The average annual rainfall in the district is 574 mm (1980-2010) recorded from last three decades. The average annual rain is 355.6 mm (2011). The maximum temperature recorded is 37^0 c, whereas minimum is 15^0 c; could falls up to 12^0 c throughout winter season (Nov-Jan). SW monsoon (June-Sep) contributes major portion of rainfall about 194.56 mm [6].

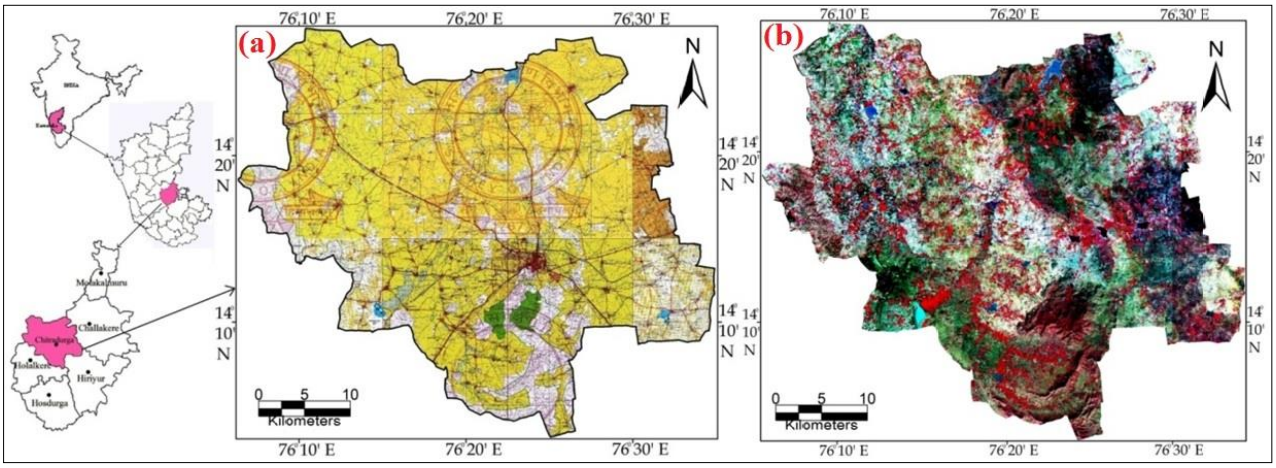

Fig.1. (a) Topomap Location and (b) IRS LISS-III Satellite Image of Chitradurga taluk

B. Materials

a. Topomaps: 57B/3, 4, 7, 8, 11, 12 of 1978 and updated edition of the year 2009/10 (SoI), (Fig.1a).
Source: Survey of India (SoI) of 1:50,000 scale, Bengaluru.
b. Satellite Data: IRS-1C/D, PAN+LISS-III of 5.8m Resolution (D43K03; 04; 07; 08; 11; 12) [Year of Pass: 2000-01 & 2005-06] (Fig.1b); Sentinel-2A Image of 10m Resolution [23th Nov 2019](Fig.5a).
Source: Bhuvan-portal, ISRO-NRSA, Hyderabad.
c. Software's: Erdas Imagine v2013 and Arc GIS v10.
d. GPS: Garmin eTrex-10 of 3m error handheld GPS is used to check the conditions of land use/land cover patterns during limited field survey.

C. Methodology

Satellite images are geo-rectified by considering permanent features such as major roads, power-lines, settlements, co-ordinates, forests and village boundaries derived from SoItopomap on 1:50,000 scale. Forest cover map was first derived from Survey of India (SoI) topomap of 1:50,000 scale during 1975-78 and 2009-10 [4] (Fig.2; 3; 4; 5). The forest cover and its patterns were digitized based on the standard schemes developed by National Remote Sensing Agency [19, 20]. Supervised classification analyses were carried out on multispectral, multi-temporal IRS-1C & 1D, PAN+LISS-III FCC [Year of Pass: 2000-01 (Nov-Jan) & 2005-06 (Nov-Jan)] image and 10m Resolution data of Sentinel-2A through ArcGIS v10[15](Fig.1b; 5a). A field survey was conducted for ground verification of doubtful areas with the help of GPS and local guides in different parts of remote villages and hilly terrains covering all the Forest types.Rough terrain and steep slopes and few areas were not accessible due to mountainous topography.

III. RESULTS AND ANALYSIS

A. Mapping of Forest Cover

Vegetation mapping is a primary requirement tosustain biodiversity at the regional and global level [28].Satellite imagery with high spatial resolution gives forests a new set of mapping and monitoring options satisfactorily. Satellite data has become useful tool in mapping the different forest types and density classes with reliable accuracy through Visual Image Interpretation Techniques (VIIT) [13, 25, 30]. The linear plantation having width of 7-8 m and cluster of 3-4 trees were easily identifiable [26]. The use of multi-date imaging provides data regarding phenological conditions of the forests, i.e., evergreen or deciduous. The multispectral satellite image in digital types are analysed through digital

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image processing software and categorized into different forest categories[26]. Reserved forest covers within the study area were distributed in fragmented blocks and embrace each natural forests and artificial forests (plantations) [5]. The study area includes 4 State Reserved Forest namely, Bevinahalli, Guheshwaragudda, Niruthadi and Jogimatti State forests (Fig.2a) with an approximately area of 109.85 km^2 (1978) which were being degraded by several major and minor factors (Fig.3;4;5; Table.1 & 2).

B. Forest Classification

The forests were classified into open deciduous; dense/closed deciduous; forest plantations and scrub forest based on the crown density/ cover/ closure and location for two periods of time. The larger imagery scale or higher sensor resolution helps in differentiating forest types more accurately [26]. Limited ground truthsare employed for training the computer and therefore the images are classified based on training area statistics. Generally, supervised classification techniques using maximum likelihood algorithm are considered adequate [26]. However, it has been found that a combination of supervised and unsupervised technique, i.e., hybrid methods yield best results [12]. Selecting a time of the year when maximum differences occur due to phonological changes such as leaf fall, flowering improves the capability of satellite data in forest type delineation.

1. Deciduous Forest: It is described as a forest which predominantly comprises of deciduous species and where the trees shed their leaves once in a year [2]. Type, crown density and composition of forest vegetation along with degradation stage help to analyse the deciduous forest vegetation under acceptable limits of accuracy [21]. Multi-temporal data, particularly of October and March/April seasons help in their discrimination from other forest types [2]. It represents dark red to red tone, mainly rich in timber trees like teak wood, rose wood, honne, bamboo on standard False Color Composite (FCC) (Fig.2b). Dense/ closed deciduous forest are noticed all along the medium relief of hill slopes occupy the major parts of Jogimatti State Forest (S.F)and Niruthadi S.F [5]. Open deciduous forests are noticed in Eastern parts of Jogimatti S.F and Guheshwaragudda S.F.

2. Forest Plantation: These are forest areas artificially planted with trees economic importance of forest resources [2]. The common endemic and exotic trees of forest plantations are deodar, sal, teak, and others [1]. Fully grown adult plantations are unremarkably tough to differentiate from natural forests; however, new and young plantations will be promptly separated from the contiguous wooded areas. It depicts light red to red tone on standard False Color Composite [7] (Fig.2b). A huge mass of forest plantations were noticed on foot hills in Southern parts ofNiruthadi S.F.

3. Scrub Forest: Scrub forest is associated with barren rocky/stony waste and scrub formed due to inadequate and erratic rainfall [2]. The condition is drought and extreme heat in summer season precludes hardly any profitable forest [16]. On Standard False Color Composite, it represents light red to brown tone depending upon the canopy cover [7] (Fig.2b). These were encountered in majorly in Southern parts of Niruthadi S.F and Northern parts of Jogimatti S.F.

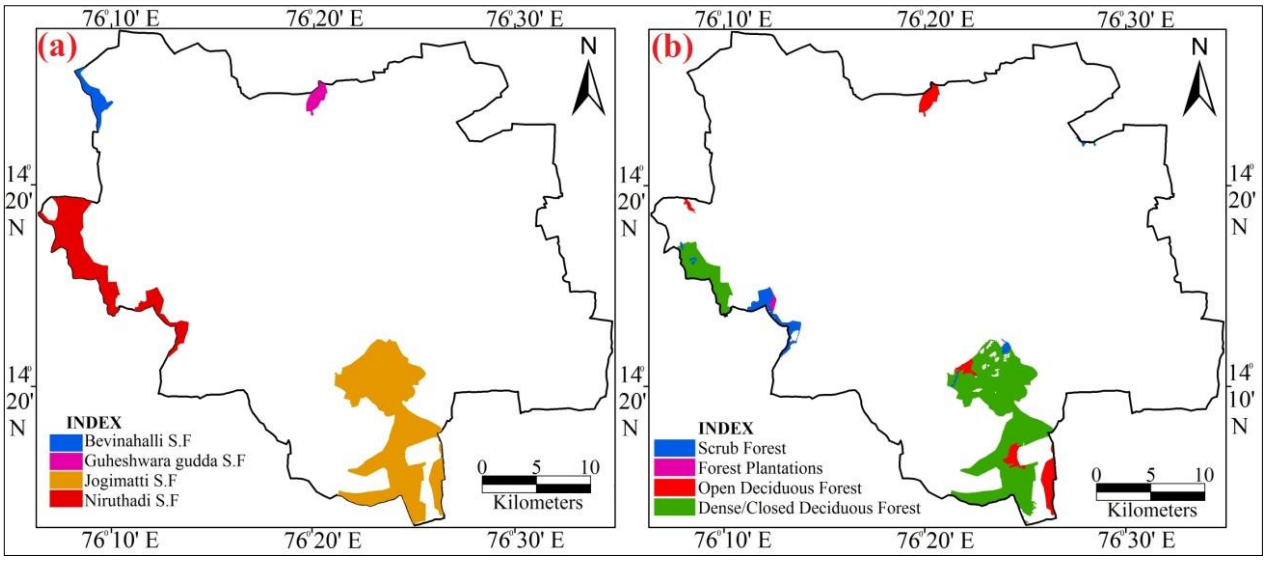

Fig.2. (a) Reserved Forest and (b) Forest Classification map of Chitradurga taluk

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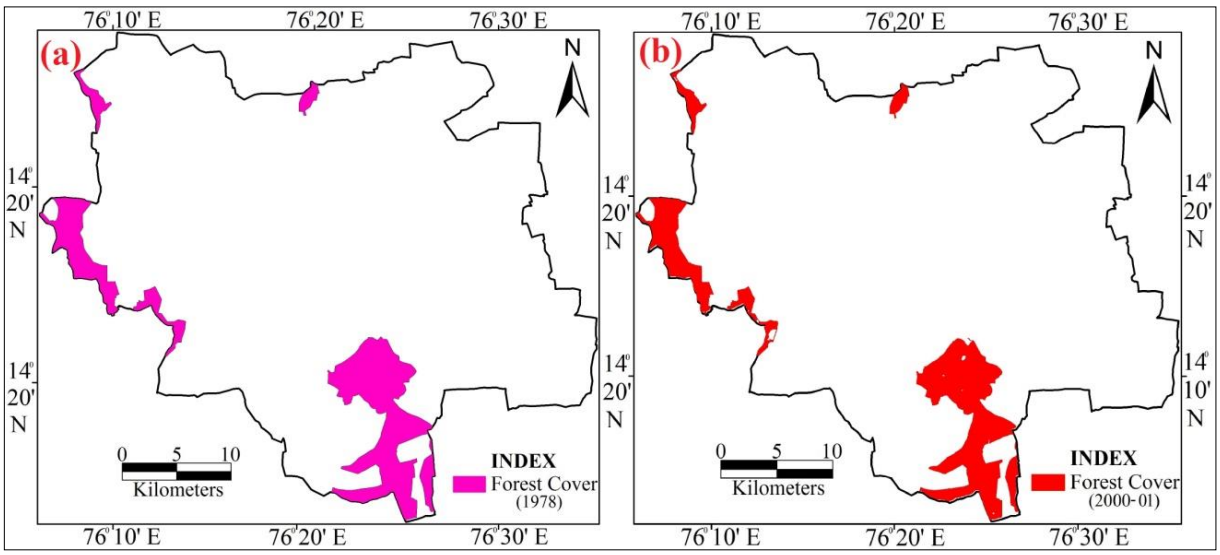

Fig.3. Temporal Mapping of Forest Covers during 1978 (a) and 2000-01 (b)

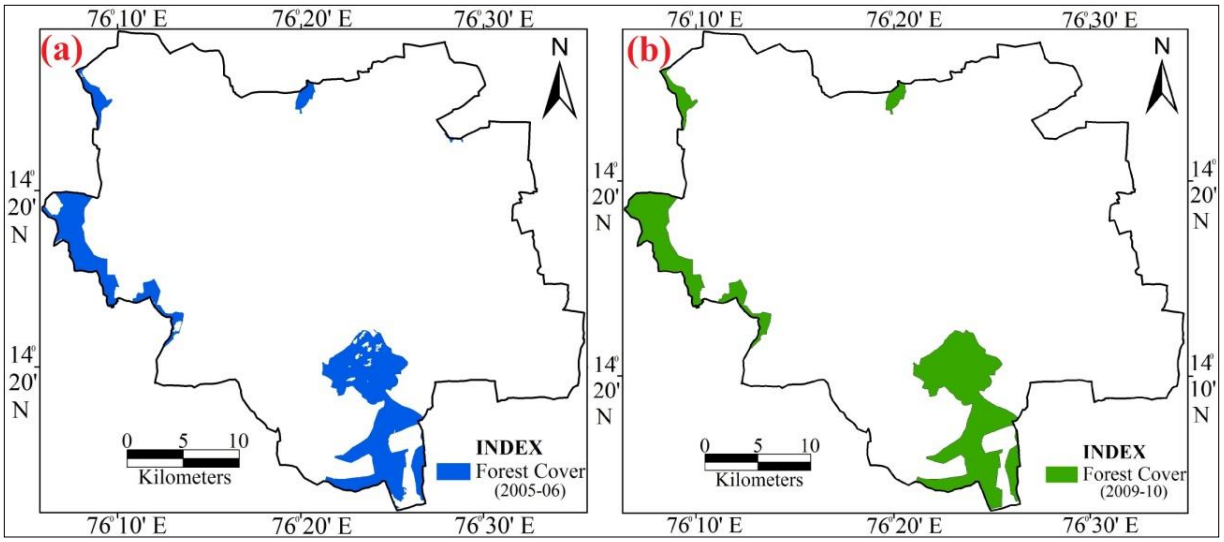

Fig.4. Temporal Mapping of Forest Covers during 2005-06 (a) and 2009-10 (b)

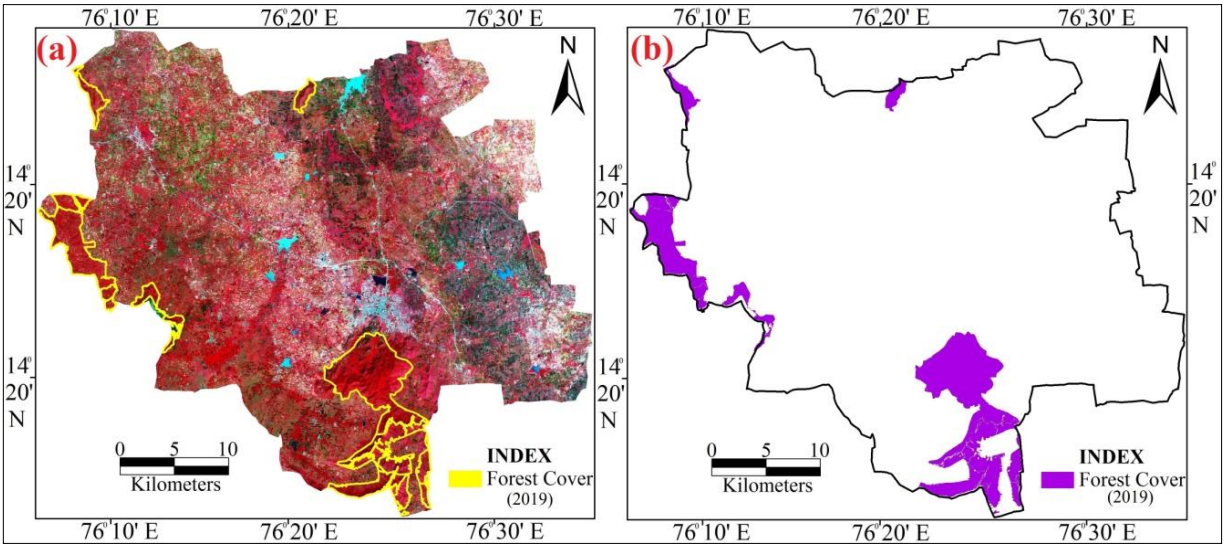

Fig.5. (a) Sentinel-2A image and (b) Forest Cover map of 2019

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Table.1. Temporal Mapping of Forest covers in Chitradurga taluk

Sl. No	Name of the State Forests (S.F)	Area in Km^2	Area in Km^2	Area in Km^2	Area in Km^2	Area in Km^2
		1978	2000 - 01	2005 - 06	2010	2019
		SoITopomap	IRS-LISS-III	IRS-LISS-III	SoITopomap	Sentinel-2A
1.	Bevinahalli	4.4874	4.5547	4.5520	4.6970	4.4746
2.	Guheshwaragudda	2.8641	2.9001	2.8716	2.9143	2.9900
3.	Jogimatti	72.7643	69.8924	68.5106	72.9745	68.2549
4.	Niruthadi	29.7373	28.9727	28.6703	32.3805	29.3780
	Total	**109.8531**	**106.3199**	**104.6045**	**112.9663**	**105.0975**

C. Change Detection Analysis

The forest cover and its patterns are digitized based on the standard schemes developed by National Remote Sensing Agency to extract the change occurred over a period of 4 decades [19, 20]. Forest cover maps aredigitized from Survey of India (SoI) topomapand geo-rectified satellite images through the selection of GCP (Ground Control Points) and locating the training sets [7, 23]. Forest covers an area of 109.85 km^2 in 1978 has been degraded to 104.60 km^2 (2005) due to human intrusions at each forest boundaries by agricultural sprawl, grazing animals, illegal cut of trees and illegal quarrying activities [17] (Fig.7). Approximately 5 km^2 of the forest cover has been degraded 1978 to 2005 observed through Change Detection Analysis (CDA) (Table.2). Iron and manganese mining activities were observed in Southern parts of Niruthadi S.F and granitic-gneiss quarrieswere observed along the southern parts of Jogimatti S.F and Guheshwaragudda S.F. Wind turbines spread over 24.83 hectares dominating the crowns of the hills around JogimattiS.F and some environmentalists consider them a hazard to wild animals,birds,medicinal plantsand other biodiversity.Gradual increase in population increased the agricultural activities noticed in Southern parts of Jogimatti S.F and Eastern parts of Niruthadi S.F [16]. Metalled and Unmetalled roads were identified to be passing through northern parts of Niruthadi S.F; while numerous unmetalled roads were observed southern parts of Jogimatti S.F which later may lead into more illegal granite/ gneiss quarrying activities, illegal cut of trees, agricultural sprawl, grazing domestic animals and other impacts [17].

Table.2. Change Detection Analysis (CDA) of Forest Covers in Chitradurga taluk

Sl. No	Forest Covers	1978 to 2001	2001 to 2005	2005 to 2009	2009 to 2019
1.	BevinahalliS.F	+0.0673	-0.0027	+0.1450	-0.2224
2.	GuheshwaraguddaS.F	+0.0360	-0.0285	+0.0427	+0.0757
3.	JogimattiS.F	-2.8719	-1.3818	+4.4639	-4.7196
4.	NiruthadiS.F	-0.7646	-0.3024	+3.7102	+3.0025

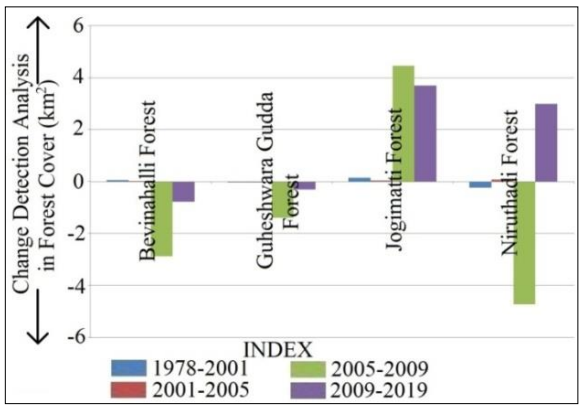

Fig.6. Line graph depicting the Change Detection Analysis (CDA) of Forest covers

D. Economic Mineral Deposits

Geologically, the study area confirms Archaean and Dharwar as basement complex [24]. The study area is endowed with major proportions of iron, manganese, quartzite deposits and abounds of many other metals & minerals which being illegally mined at the verge of forest vicinities [16]. Discontinuous bands of ferruginous, manganeseand quartzite'sdeposits occur all along SSE-NNW directions on parallel chains of hills [5].

Considerable float ore of manganese of low grade has been observed on eastern boundary of Niruthadi S.F. Hematite quartzite and limonitic ore are found in association with manganiferous deposits in fairly large quantities in Megalahalli and BedaraBommanahalli villages [11]. Iron and manganese ore mining activities are noticed over an area of 109.17

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hectares near the villages of Bedara Bommanahalli, Meghalahalli and Dindadahalli in Niruthadi forest area[3]. This area contains mainly iron ore fines and a small fraction of lumpy ore producing low-grade iron ore analysing approximately 50% Fe content.

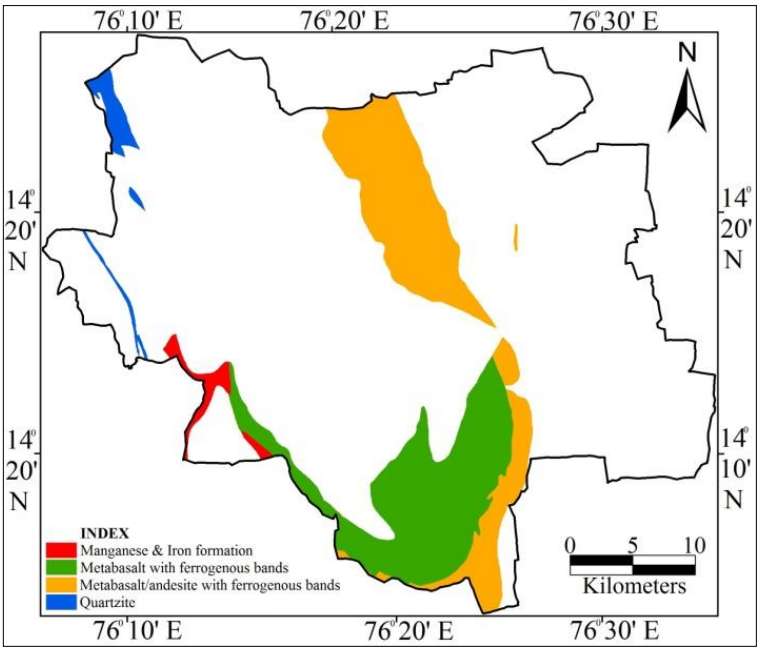

Fig.7. Economic mineral deposits map of Chitradurga taluk

IV. DISCUSSION

Forests vary from dry mixed deciduous type occur in patches in certain blocks with primarily scrub forests tending to thorny bushes in the driest localities [11]. Deforestation was noticed recently due to the intensity of over-grazing, forest fires and other anthropogenic factors [16]. Several huge rocky hills of irretrievable stage can be noticed in Jogimatti S. F covering large portion of forest barrenness [11]. Extreme edaphic condition is one of the types of degraded forests occurs in poor and shallow soil associated with vast area of bare and rocky localities [11].

Illicit cutting of trees were commonly observed by the vicinity of village peoples to fulfill their needs of fuel, small timbers for huts & houses and agricultural implementations [5]. Over-grazing was observed by the large population of cattle, goats&sheeps especially in Niruthadi and Jogimatti forest premises which affecting the natural regeneration status causing deterioration of wild life habitat [5]. Rotational grazing, controlling fire hazards combined with rigid protection avoiding soil erosion and enriching moisture regime were practiced periodically by the Forest Department Authorities [5]. Artificial mode of sowing seeds in the bushes helps in regeneration [5].

Plantations in large areal extent of encroachments of agricultural activities, grazing lands and in mining area should be implemented. The use of geospatial technology by forest managers has steadily increased, promoted in large part which suits the information require for forest regeneration practices [32].

V. CONCLUSION

Forest covers an area of 109.85km^2 in 1978 has been degraded to 106.31 km^2(2000-01); later degraded to 104.60 km^2(2005-06) due to anthropogenic pressure at each forest boundaries; agricultural sprawl, grazing animals and mining activities. Gradual increase inhuman population raised the agricultural activities, mining of economic minerals and waste dumping were major factors caused the forest degradation. SoI topomap& IRS LISS-III and Sentinel-2A satellite images were effectively utilized to bring out temporal changes of Forest covers for over a period of 41 years through geospatial tools.

Forest Department Authority had recovered the forest area of waste mining storage, dumping yard, mining pit and other areas that are noticed under taluk forest boundary. More than 8.36 km^2 area of forest cover has been restored and reclaimed through periodic implementation programs by Forest Authorities and sufficient amount of rainfall received

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by the taluk (2009-10) that increased the vegetation cover. An accurate mapping of forest cover is essential information that adds immense value to planning & development analysis for forest regeneration to achieve sustainable goals.

CONFLICT OF INTEREST

There is no conflict of interest between authors.

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BIOGRAPHIES

Dr. M.C. Manjunatha, is working as Assistant Professor in the Department of Civil Engineering, Maharaja Institute of Technology Thandavapura, Karnataka, India completing 3 years of Teaching Experience and 8 years of Research Experience. He has published more **61**research papers in National/International peer reviewed journals/ Proceedings. He has presented over **40** Research outcomes in National/ International Seminars and Conferences in India and abroad and participated over 29 training programmes in different states of India. Currently he is serving as **Editorial/ Review board Member** for JAERI, IJFWS, IJERT, IJCRT, IJEDR, JETIR, IJGM, IJSRCE, IJAIEM, IJSET journals. He is also serving as **Lifetime Member** in Professional bodies of MSI &DoSGAA Mysuru; ISCA, Kolkata and IAEME, Chennai. His Google Scholar Citations score has reached **247**with **8** h-index. He had nominated for several Prestigeous Awards & Professional Posts such as ***Bharath Ratna Mother Theresa Gold Medal Award, Highest Honor of Prestigeous Award, Bharath Shiksha Ratan Award, Super Honorary Doctoral Degree with Gold Medal Award and Editor-in-Chief*** Post for International Journal of Remote Sensing & Letters, Taylor & Francis, UK.

Dr. H.T. Basavarajappa, is a Professor of Geology in Department of Studies in Earth Science, Centre for Advanced Studies in Precambrian Geology, University of Mysore, Mysuru. He has received the **Young Scientist Award** from the **Karnataka Advanced Applied Science Association (KAAS)** in 1998 and **Vijayashree Award** by India International Friendship Society, New Delhi in 2005, in recognition of his merit and contribution to Earth Science. He has successfully guided **12** research students for their PhD degree, and also actively representing several scientific bodies on the Earth Science in our country. Presently serving as the **Coordinator** of the UGC-SAP CAS-I; **Chairman** of ISG-Mysore Chapter since from 2004; **Treasurer** of Mineralogical Society of India (MSI) from 2003 and **President** of DOSGAA since from 2008. He has successfully completed **6** Major Research Project under **UGC-MRP, UGC-CAS, ISRO-NRSC, DST** and **University of Mysore**. He has visited **France** (Paris) and **Germany** (Bonn University) during 1991 to participate in several international training programs on EPMA and Geochemical analysis. He has over **126** research publications to his credit. He has attended and presented about more than **106** research articles in conferences and seminars. He has also conducted successfully about **31** National and International Seminars/ Conferences/ Workshops/ Field Trainings in the department. He has edited **9** abstract Volumes/ proceedings. He has successfully adjudicated around **42** PhD thesis all over the country including the Technical Universities and has successfully guided around **45** Post Graduate Students during their dissertation work. His Google Scholar Citations score has reached **659** with **13** h-index. He has been specialized in most of the analytical instruments in Geological aspects. He has successfully developed **2** scientific laboratory using advanced high-tech tools such as Remote Sensing and GIS.

Dr. Maruthi N.E,is working as GuestLecturer in the Department of Geology, Yuvaraj's College, University of Mysore, Karnataka, India completing 2 years of TeachingExperience and 6 years of Research Experience. He has published more than 26 research papers in National/International peer reviewed journals/ Proceedings. He has presented over 30 Research outcomes in National/ International Seminars and Conferences in India and participated over 18 training programs in different states of India. He is also serving as Lifetime Member in Professional bodies of MSI &DoSGAA, Mysuru. His Google Scholar Citations score has reached 64 with 5 h-index.

Mr. Siddaraju M.S, working as a Research Scholar in Department of Earth Science, Center for Advanced Studies in Precambrian Geology, University of Mysore, Mysuru. He has 7 years Research Experience and has published more than 8 Research papers in National/ International peer reviewed journals/ Proceedings. He has presented over 20 Research outcomes in National/ International Seminars and Conferences in India. He has participated over 15 training programs in different states of India and 5 e-training courses conducted by GSI, India. He is also serving as lifetime member in Professional bodies of MSI &DoSGAA, Mysuru. His Google Scholar Citations score has reached 22 with 3 h-index.