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Land Use and Land Cover Mapping of Davangere using Google Earth Engine

Geetha M, Ashagowda Karegowda, H S Sudhira

***Abstract:** Ever since the advent of modern geo information systems, tracking environmental changes due to natural and/or manmade causes with the aid of remote sensing applications has been an indispensable tool in numerous fields of geography, most of the earth science disciplines, defence, intelligence, commerce, economics and administrative planning. One among these applications is the construction of land use and land cover maps through image classification process. Land Use / Land Cover (LULC) information is a crucial input in designing efficient strategies for managing natural resources and monitoring environmental changes from time to time. The present study aims to know the extent of land cover and its usage in Davangere region of Karnataka, India. In this study, satellite image of Davangere during October-November 2018 was used for LULC supervised classification with the help of remote sensing tools like QGIS and Google Earth Engine. Six LULC classes were decided to locate on the map and the accuracy assessment was done using theoretical error matrix and Kappa coefficient. The key findings include LULC under Water bodies (8%), Built up Area (15.1%), Vegetation (9%), Horticulture (20.8%), Agriculture (39.3%) and Others (7%) with overall accuracy of 94.8% and Kappa coefficient of 0.866 indicating almost accurate goodness of classification.*

***Keywords:** Remote Sensing, Land Use, Land Cover, QGIS, Classification, Accuracy Assessment*

I. INTRODUCTION

Land cover refers to the coverage of earth's surface by its natural physical features of existence like water, plain land, vegetation, deserts, mountains and valleys; land use is the extent of earth's surface being used by human beings and their habitations for survival. Usually land cover is a depleting and land use is raising phenomenon over generations of human existence due to increased population, industrialization, urbanization and expanding human needs. This has resulted in ill effects of over exploiting earth's surface in the form of greenhouse effect and global warming due to continuous replacement of natural and fertile landscapes into buildings, concrete structures and inorganic chemical / industrial waste yards.

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* Correspondence Author
Geetha M, Asst.Professor,Dept.of MCA,BIET,Davangere,India
Dr.Asha Gowda, Karegowda, Associate Prof. Dept.of MCA,SIT,Tumkur,India
Dr.H.S.Sudhira, ,Director, Gubbi Labs,Gubbi,India

Thus nations across the world are seriously involved in assessing land cover and land use statistics from time to time within their geographical boundaries in order to better manage land resources through improved administration and policies. As a matter of fact, these tools of satellite image processing have become indispensable not just to know land use and land cover changes but also to precisely locate remote objects, water bodies, identifying soil types on earth's surface and so on. In this paper, attempt has been made to map land use and land cover in Davangere during October - November 2018.

II. STUDY AREA

The area of interest for this study was Davangere taluk of Davangere district, Karnataka, India. Davangere is geographically located at the centre of the Karnataka state between latitude parallels 14°28' - 14.1096" North and longitude parallels 75° 54' - 50.9544" East at an altitude of 602.5m above sea level.

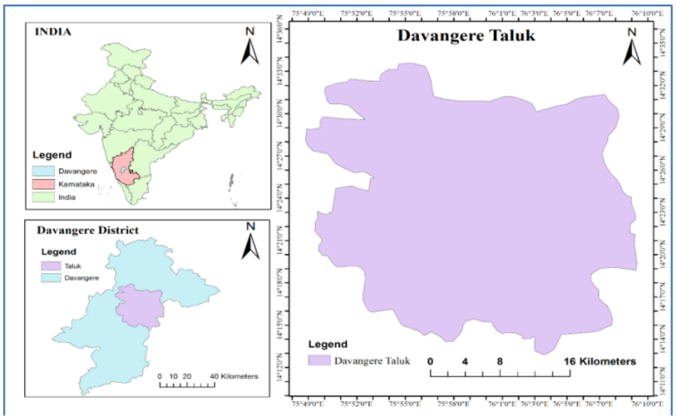

Figure 1: Geographical identification of the study area

Across the world there have been many studies using remote sensing techniques for land use/land cover mapping using different sources of getting satellite image and processing software. Studies in India used IRS-P6, LISS (Linear Imaging Self Scanning Sensor) or Landsat-8 to obtain satellite image and ERDAS Imagine [1]-[2]. Studies reported from Romania, Egypt, South Africa used Landsat-8 and USGS earth Explorer along with ERDAS Imagine [3]-[6]). These satellite image sources used image resolution of 23 to 30 meters and needed huge memory space. Now since Google Earth Engine is available, which is open source software with better features of high resolution (10m) and image frequency (5 days revisit cycle), the intent of this research work is to use Google Earth Engine images and QGIS (Quantum Geospatial Information System) to ascertain and map land use and land cover in Davangere.

III. DATA

Satellite image is acquired from Sentinel-2, an Earth Observation Mission developed by European Union's Copernicus programme using Google Earth Engine code editor. Sentinel-2 images are characterized by 10m resolution, 5-day revisit cycle and open access policy. Ground truth information about 168 sites covering all categories of classification were collected using GPS Essentials and used as an input for training sites in making LULC classifications.

Table-1 gives details of acquired satellite data with four spectral bands which correspond to Red (R), Green (G), Blue (B) and Near Infrared (NIR) at 10m resolution. In the present study, False Colour Composite (FCC) was constituted by three bands R, G and B.

Table I: Characteristics of acquired satellite data

Sensor	Provider	Resolution	Image Collection ID	Date of Acquisition
Sentinel-2 MSI	European Union/ Copernicus	10 meters	COPERNICUS/S2	30/11/2018

IV. METHODOLOGY

High resolution (10m) satellite image of Davangere taluk drawn from Google Earth Engine during October-November 2018 was used for land use/cover classification. This image was used for classification of identified LULC classes namely Water bodies, Built up Area, Vegetation, Horticulture, Agriculture and Others as described in table-2.

Table II: Description of land use classes under study

Land cover classes	Description
Water Bodies	River, Lakes & water collected due to rain
Built-up	Residential, Commercial and industrial set ups
Vegetation	Green pastures, trees, grazing land
Horticulture	Areca nut, Coconut trees
Agriculture	Lands covered with crops followed by harvesting
Others	Barren, Non-agriculture and fallow lands

The detailed methodology and stages of image processing for acquired sentinel-2 image is depicted in figure 2.

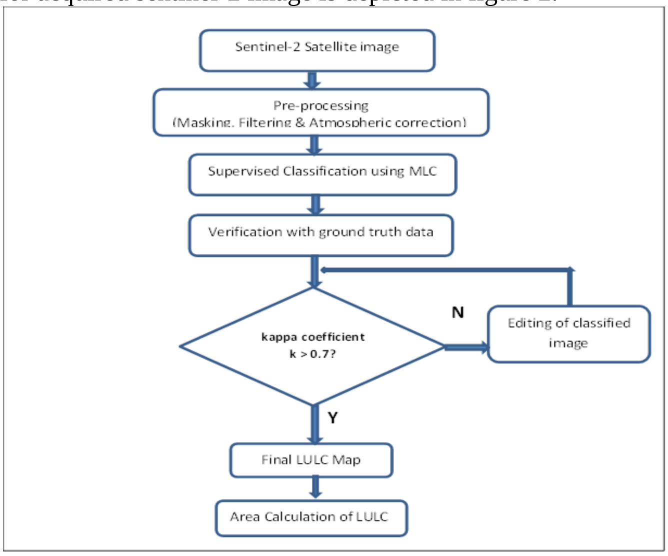

Figure 2: LULC image processing stages of study area

A. *Pre-processing*

It involves masking, that identifies dense and cirrus clouds in the obtained satellite image; filtering that ensures of images being more than 80% cloud free for further analyses using QA-60, a built-in function in Google Earth Engine followed by atmospheric correction by enabling the atmospheric correction filter, which is a runtime optimized Sen2Cor processor.(Source: https://sentinel.esa.int)

B. *Land Use and Land Cover detection using MLC*

The pre-processed sentinel-2 satellite data was classified using Maximum Likelihood (MLC) supervised classification algorithm as this is known to be one of the most widely used estimate for its simplicity and appropriateness as acknowledged by many satellite related research studies [1]-[6].

LULC Classification of six categories, namely Water bodies, Built up Area, Vegetation, Horticulture, Agriculture and Others was made for Davangere taluk region using 168 training sites. These sites were located by demarcating them by polygons representing area of interest. Once supervised classification is done, obtained initial LULC map was edited for those areas which are not clear on the basis of ground trothing which resulted in final LULC map.

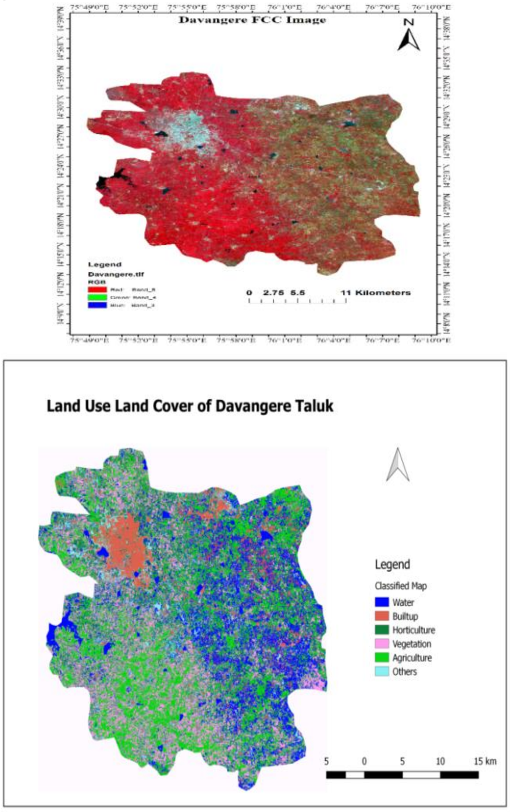

Figure 3: Sentinel-2 image before and after LULC classification

C. Accuracy assessment of LULC detection

To assess the reliability of the obtained LULC map, accuracy assessment is carried out to prove the completeness of image classification. Hence to ascertain the accuracy of classification, a sample of pixels was selected on the classified image and their class identity is compared with the ground reference data. This process of evaluating quality of classification result is an integral part of remote sensing as it gives evidence of how best the classifier is able to extract the desired objects from the image.

Generally confusion (/error) matrix is used as widely accepted measure of overall accuracy. The confirmatory technique used for accuracy assessment is the KAPPA analysis [7]. Unlike overall accuracy, kappa provide error bounds on accuracy by weighing cells in the error matrix according to the severity of misclassification. It is also known as kappa coefficient (KHAT Statistic, denoted by k).

i.e., Overall Accuracy = $\frac{Correctly\ classified\ pixels}{Total\ Number\ of\ pixels}$ --------- (i)

and **k** = $\frac{Observed\ Accuracy - Chance\ agreement}{1 - chance\ agreement}$ ---------- (ii)

Further to ascertain the sensitivity and specificity of classification, users accuracy and producer's accuracy in % is calculated and tabulated in the confusion matrix.

Following table presents confusion matrix followed by user's accuracy, producer's accuracy, overall accuracy and kappa coefficient.

Table III: Accuracy assessment (Confusion) matrix

Substituting in relations (i) and (ii) discussed above we get Overall accuracy = 94.8% and k=0.866.

		Reference Data							User's
	Classes	Water	Buitup	Horticulture	Vegetation	Agriculture	Others	Total	Accuracy
Classification Data	Water	35693	0	1	0	42	0	35736	99.9
	Buitup	60	727	10	0	71	34	902	80.6
	Horticulture	4	1	374	20	22	92	513	72.9
	Vegetation	33	2	10	510	86	20	661	77.2
	Agriculture	67	159	105	100	3888	624	4943	78.7
	Others	30	25	8	40	712	2713	3528	76.9
	Total	35887	914	508	670	4821	3483	**46283**	
Producer's Accuracy		99.5	79.5	73.6	76.1	80.6	17.9		

V. RESULTS AND DISCUSSION

As evident from accuracy assessment, it can be noted from table-3 that the overall accuracy is about 94.8% with kappa coefficient of 0.866. Since the overall accuracy does not provide information about misclassification of individual class, there is a need to compute users and producers accuracy for each class.

Table IV: Estimate of LULC as per classification

Land cover Classes	Area in km^2	Area %
Water Body	76.9	7.8
Built-up	144.5	15.1
Horticulture	200.4	20.8
Vegetation	87.6	9.1
Agriculture	379.5	39.3
Others	67.4	7.0
Total	**956.4**	**100**

The corresponding areas used under each classification were recorded as in table-4. The land usage for agriculture and horticulture make 60.1% of the total study area, which gives an indication of major portion of the land being used for agriculture and horticulture. This classification supports district statistics[8] on share of net land sown to be 64%. In classifying horticulture, only canopy views of areca and coconut trees were identified as reference data and other prospective horticulture crops like mango, papaya, banana, sapota etc., were ignored as they were spread across the study area in tiny spots and inseparable from the adjacent vegetation. Hence they might have been included under vegetation which has a share of about 9% (district average 5%).

Built up area obtained in the study area was 15.1% which is slightly higher than 11% of district statistics (of 2011) as Davangere is the most densely populated taluk of Davngere district and the class of others amounts to 7.0% in the study, slightly higher than district statistics which is about 6%.

VI. CONCLUSION

From the results and discussion presented in paper, land use and land cover statistics obtained and processed using satellite images from Google Earth Engine and QGIS are convincing with overall accuracy of 94.8% and a kappa coefficient of 0.866 (almost accurate) and the classified area is almost comparable to that of the district with defendable reasons. Thus it is evident that user friendly geospatial information systems like Google Earth Engine and QGIS are much effective high resolution tools over other such platforms in
monitoring and controlling the land use and land cover changes from time to time in order to maintain good ecological balance amidst fast changing human needs and deforestation.

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AUTHORS PROFILE

Geetha M completed MCA from Gulbarga University in the year 2001. Since 2006 working as Assistant Professor in the Dept. of Master of Computer Applications, Bapuji Institute of Engineering and Technology(BIET), Davangere , Karnataka. She holds life membership of ISTE, New Delhi. Her areas of interest include Data Mining, Java Programming, Operations Research, Design and Analysis of Algorithms, Data Structures. Pursuing Ph.D in the area of Remote Sensing and Image processing from Visvesvaraya Technological University, Belgaum, Karnataka. Published a debut research review paper in IJARCS.

Dr. Asha Gowda Karegowda received MCA degree from Bangalore University, Karnataka, M.Phil degree from Madurai Kamraj University, Tamil Nadu, Ph.D in Computer Science from Visvesvaraya Technological University, Belgaum, Karnataka. She is currently working as Associate Professor, in the Department of Master of Computer Applications, Siddaganga Institute of Technology, Tumkur, Karnataka since 1998. She is currently guiding 3 research students under VTU, Belgaum. She is BoS and BoE member for few of the institutions. She is reviewer for few of the reputed international journals. Her area of interest includes data mining, data analytics, data science, data structures and bio-inspired computing. She has authored 3 books and published around 80 papers in international conference and journals.

H. S. Sudhira obtained his Ph.D. from the Indian Institute of Science, Bangalore for his thesis on "Studies on Urban Sprawl and Spatial Planning Support System for Bangalore, India". His primary research is studying the evolution of towns and cities using trans-disciplinary approaches. With a focus for taking theory to practice and vice-versa, he has been part of a variety of sustainable initiatives notably, Namma Cycle (the campus based public bicycle sharing system). He is also a neogeographer, using and propagating free-and-open-source mapping tools, making maps of cities and ecosystems. Sudhira is one of the lead authors of the CBO's regional assessment on India and Bangalore commissioned by the United Nation's Convention on Biological Diversity (CBD). The first part of this assessment—CBO: Scientific Analysis and Assessment – The Global Urbanization, Biodiversity, and Ecosystems – Challenges and Opportunities is published as book in 2013. He was a faculty member at the Indian Institute for Human Settlements (IIHS). Earlier, he had a stint with the Directorate of Urban Land Transport, Government of Karnataka as Land-use and Transport Specialist. He has a Bachelor of Engineering degree in Environmental Engineering and Masters in Geo-information Science and Earth Observation.

With a strong desire to carryout independent and grounded research he has established Gubbi Labs, a private research collective that works on a host of domains ranging from sustainable ecosystems to liveable settlements. Recently at Gubbi Labs, a division was carved out, called Research Media Services, with the aim of bridging the gap between research institutes and the general public. As a part of this, he has led the team that has successfully set up and is running the Science Media Center for the Indian Institute of Science (IISc).