Accuracy Assessment of Land Use/Land Cover Classification using multi temporal images and Geo-spatial techniques for Varanasi city

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Abstract – *Land Use Land Cover (LULC) change detection study helps to understand the environmental change dynamics to ensure sustainable development. Land cover is what covers the surface of the earth and land use describes how the land is used. This study mainly focuses on the usage of the geographic information system (GIS) and land usage to identify the changes in Varanasi city, which is located in Uttar Pradesh, India. GIS technique provides reliable accurate information for land use mapping through Landsat satellite imagery because it provides a synoptic view. The present study is focused on defining boundaries of different land use / land cover on a landsat satellite Imagery using Erdas Imagine 14 software. The work is done by visual image interpretation. This study mainly focuses on the classification and identification of the changes in Land use/Land cover in the years 2000, 2010 & 2020 based on a multi temporal images gathered from the satellite. The experimental results indicate that over the specified period of study, the rate of increment and decrement in the built-up area, water bodies, crop land, vegetation, fallow land and sandbars that may exhibit a significant impact on the environmental ecosystem and sustainable development.*

Key Words: **Land use Land cover, Change detection, Landsat.**

1. INTRODUCTION

Land use/land cover (LULC) changes play an significant role in monitoring the changes at local, regional, and national level (Gupta & Munshi, 1985; Mas, 1999). Land cover is what covers the surface of the earth and land use describes how the land is used. Since the past 100 years, the human population and its influence have increased exponentially on land. Human migrations on the Earth's surface result in changes in the land cover. These changes considerably affect key features of Earth system functioning. Moreover, population is growing rapidly, far out spacing the ability of our planet to support it , it continues to be a major underlying force of environmental degradation and a threat to sustainable use of natural resources , which is caused by an increase in population, impact the land use/land cover changes (Islam et al., 2018).

The main purpose of LULC classification and change detection in GIS include discriminating the geographical features and sort of changes, admeasure the changes and estimate the accuracy assessment results by using kappa statistics(Coppin *et al.,* 2004; Im & Jensen, 2005).

Landsat data sets has been downloaded from the online poartal of United States Geological Survey (USGS) Earth Explorer free of cost (http://earthexplorer.usgs.gov) .

2. STUDY AREA

This study is done on Varanasi which is located in the north Indian state of Uttar Pradesh. It is also called Kashi. According to Hindu and Buddhist mythologies, it is one of the sacred places of pilgrimage for Hindus and Buddhists. It is believed that Lord Shiva along with Parvathi as Vishwanatha and Vishalaakshi reside there to bless devotees. It is surrounded by Mirzapur district, Jaunpur district, Ghazipur district, Chandauli district, and Bhadohi district. The Ganga (Ganges) river flows through the district. It is considered by Hindus to be a sacred and pure river, having the ability to wash away sins when people take a dip in it. Location map of the study area is shown in the Fig. 1.
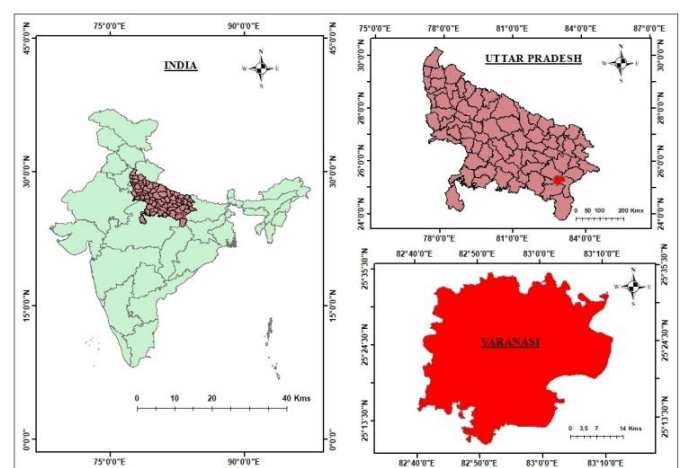

Fig-1: Location map of Study Area

3. DATA USED AND METHODOLOGY:

Landsat satellite imageries datasets have been used in the study. In this study, LULC were prepared from Landsat data at decadal interval in ERDAS IMAGINE 14. Landsat-7 ETM+ (2000), Landsat-5 TM (2010) and Landsat-OLI (2020) were downloaded from the U.S. Geological Survey (www.usgs.gov.in). Then, all bands of datasets were stacked as a single image for each scene. Thereafter, imageries were projected in UTM projection system (datum WGS 1984, 44 N zone). Before the supervised classification, the dataset were masked for the study area. Details of Landsat images used in the study are given in the Table 1.

Table1:- Details of Landsat images used in the study.

S.NO.	Satellite data	DATE	PATH/ROW
1.	Landsat-8	02/04/2020	142/42 142/43
2.	Landsat-5	25/05/2010	142/42 142/43
3.	Landsat-7	03/04/2000	142/42 142/43

Accuracy assessment is used to assess the quality of the information of LU/LC maps generated from the google earth pro data. The confusion matrices has been plotted as cross-tabulations of information obtained from classified maps versus the google earth pro data. Hence, overall accuracy, user's and producer's accuracies and the kappa statistic were estimated from the confusion matrices(Liu & Mason, 2009).

The overall accuracy is estimated by taking the ratio between sum of the major diagonal elements and the total number of pixels (N). The following equation used for determination of user's accuracy, producer's accuracy and kappa coefficient (k):

User's accuracy = C_{ii}/Nr_i

Producer's accuracy = C_{ii}/Nc_j

$$Kappa\ coefficient\ (k) = \frac{N\sum_{i=1}^{m} C_{ii} - \sum_{i=1}^{m} Nr_i.Nc_j}{N^2 - \sum_{i=1}^{m} Nr_i.Nc_j}.$$

where,Nr_i is sum of any row i and Nc_j is sum of any column j in the confusion matrix.

2.3. Methodology adopted for this analysis

Flowchart for the Land use/ land cover changes and change detection methodology have been shown in **figure 2**.
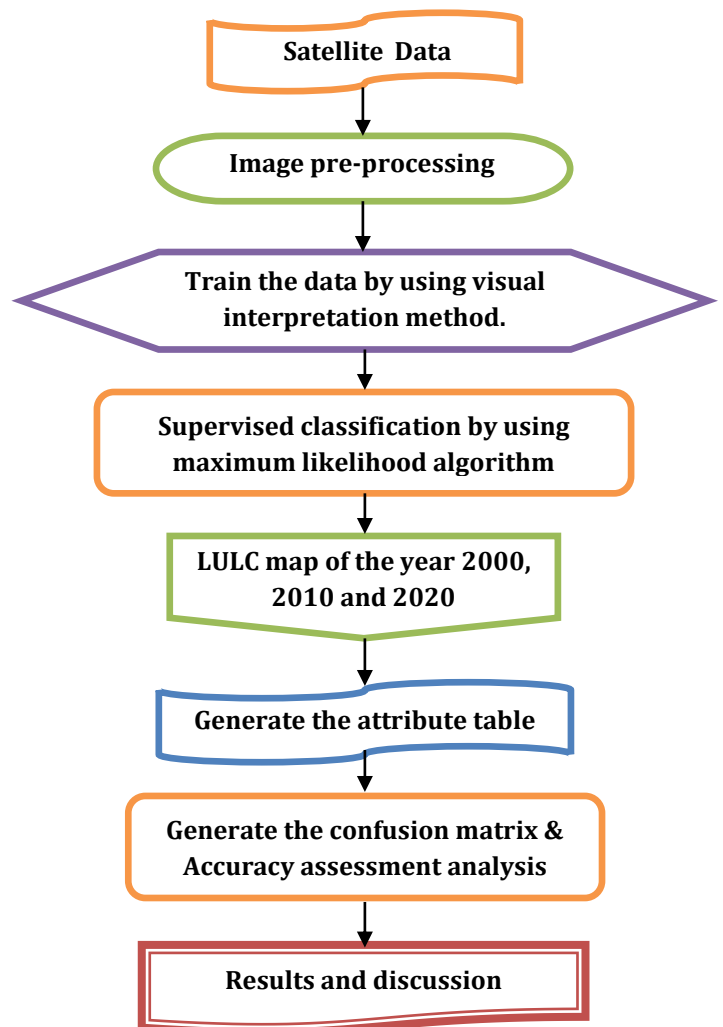

Fig-2:Flowchart of the methodology.

4. RESULTS AND DISCUSSIONS:

The whole study area has been classified into six classes. Land use land cover (LULC) maps prepared at decadal interval and there has been a positive and negative variation in each category at each decadal interval. The area falling under each category for different five years (2000, 2010, 2020) has been given in table 1.

There has been gradual decrease in area of water bodies in each decadal year. The fallow land area has increased 3.27 % in the year 2010, and again increased 2.4 % in the year 2020. The crop land area has increased by 3.58% in 2010 and then decreased by 14.22% in 2020. There is not very

remarkable change in the area of sand bars. The area of vegetation has reduced by 8.05% in 2010 and increased by 4.66% in 2020. In 2000, the built up area was 3.62 % while it is 11.66 % of total area in 2020. It means that the built up land has increased in due respect of time. The maximum changes have been seen in the data depicting settlements and roads. The changes in settlements are found mainly in the area around Varanasi city and its surroundings.

The LULC classes of Varanasi district during different time periods are shown in the Fig. 3 (a-c). The area distribution and changes in LULC classes are given Table 2 and 3 .

Table 2: LandUse /Land Cover Area distribution.

LULC classes	AREA(%) 2000	AREA(%) 2010	AREA(%) 2020
WATER BODIES	1.35	1.11	1.76
SANDBARS	1.17	1.13	1.03
FALLOW LAND	7.66	10.93	13.38
BUILT UP AREA	3.62	5.1	11.66
VEGETATION	12.98	4.93	9.59
CROP LAND	73.22	76.8	62.58
TOTAL	100	100	100

Table 3: Changes in LULC during 2000–2010 and 2010-2020

CHAGES IN AREA(%)		
Period/LULC Classes	2000-2010	2010-2020
WATER BODIES	-0.24	0.65
SANDBARS	-0.04	-0.1
FALLOW LAND	3.27	2.45
BUILT UP AREA	1.48	6.56
VEGETATION	-8.05	4.66
CROP LAND	3.58	-14.22

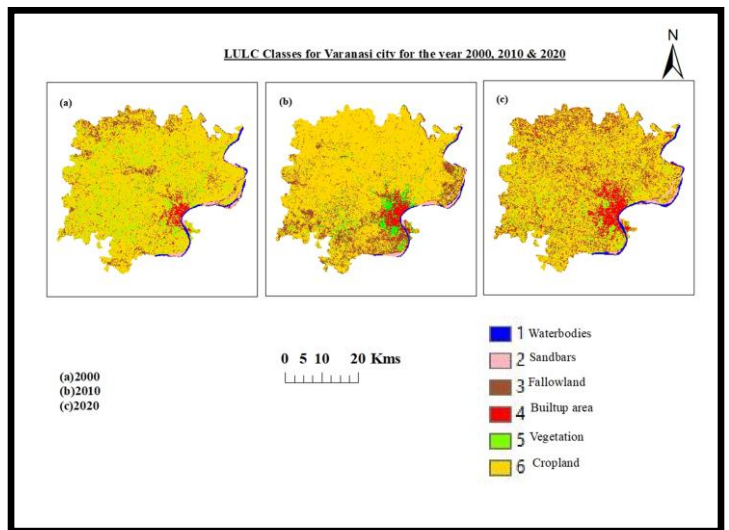Note: Positive (+) value indicate gain in the area whereas negative (-) value indicate loss in area .

Fig-3:LULC classes of Varanasi in (a)2000, (b)2010 & (c)2020

The google earth pro data is used as the reference for assessing the accuracy of classification. The accuracy and KAPPA statistics of the classified image checked with the help of accuracy assessment by confusion matrix preparation. The overall accuracy of the image is given in the Table 4.

Table 4: Overall accuracy of classified images of different years

YEAR	Overall Accuracy	KAPPA Statistics
2000	93.94%	92.66%
2010	91.66%	89.89%
2020	89.47%	86.44%

5. CONCLUSIONS

In this study , GIS is used for understanding the LULC changes in Varanasi city over 20 years from 2000 to 2020. The technique used in this study is simple and inexpensive. The extent of land-use changes was determined using multitemporal Landsat satellite imagery.

In this study, accuracy assessment analysis is done by using the confusion matrix. Significant changes in the LULC were observed in the study area between 2000 and 2020.

During these 20 years, It is apparent that urban expansion is maximum than all the other land classifications. In short,

the results have shown that there is a significant increase in urban expansion leading to a significant drop in crop land use and vegetation during the study period.

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