Application of Remote sensing and GIS Techniques in Urban Planning, Development and Management.

(A case study of Allahabad District, India)

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Abstract— Management and planning of urban space requires spatially accurate and timely information on land use and changing pattern. Evaluation provides the planners and decision-makers with required information about the current state of development and the nature of changes that have occurred. Remote sensing and Geographical Information system (GIS) provides vital tools which can be applied in the analysis at the district and as well, as the city level. This study evaluates the proposed future land use plan (2021) in context to the existing land use (2015) in Allahabad district. Land use /land cover map was prepared using supervised classification of landsat 8 (OLI) and LISS IV satellite data The results obtained from classified image were compared with the land use information obtained from National Remote Sensing Centre (NRSC, Govt. of India) for the Allahabad district. Though the land use information obtained from NRSC is for the period 2011-12, however in the absence of a more recent data, the one available from NRSC was used for assessing/ verifying the overall pattern and distribution of the land use. Evaluation of the proposed plan (2021) was done by assessing the various types of land use and their respective areas existing under each proposed land use class. It was found that agriculture will be the most affected land use followed by bare land accounting 97.4 km2 and 32 km2 respectively. The least affected class is the water encompasses approximately 2.5 km2.

Keywords: Remote sensing, GIS, Urban Planning, Proposed land use plan, Landsat 8 (OLI),

1.0 Introduction

While the change in climate is a hot topic these days, the rapid transformation of a world's cities is equally dramatic. As the population explodes and global resources wane, a new set of urban obstacles demands visionary thinking from architects, planners and policy makers. There is an unequal urban growth, which is taking place all over the world, but the rate of urbanization is very fast in the developing countries, especially in Asia (Fazal, S. 2013). In 1800 A.D., only 3% of the world's population lived in urban centre, but this figure reached to 14% in 1900 and in 2000, about 47% (2.8 billion) people were living in urban areas (Demers, M. N. 2014). To support this increase in population and physical growth rate observed, constant monitoring of the urban growth is required to be sustained by anthropogenic activities. (Ade, M.A. and Afolabi Y.D. 2013).

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In India for example, people no longer lives in villages. A figure shows that 79 million people live in urban areas as of 1961, but it went up to 285 million in 2001(Census of India 2001). In India and China alone, there are more than170 urban areas with populations of over 750,000 inhabitants (United Nations Population Division, 2001). Statistics show that India's urban population is the second largest in the world after China, and is higher than the total urban population of all countries put together barring China, USA and Russia. In 1991, there were 23 metropolitan cities in India, which increased to 35 in 2001 (Census of India, 1991 and 2001).

Urban planning (urban, merged urban regions, regional, city, and town planning) is a technical and political process concerned with the use of land and design of the urban environment,

including air and water and infrastructure passing into and out of urban areas such as transportation and distribution network (Wikipedia 2014). Urban planning guides and ensures orderly development of settlements and satellite communities which commute into and out of urban areas or share resources with it. It concerns itself with research and analysis, strategic thinking, architecture, urban design, public consultation, policy recommendations, implementation and management (Omojola, M. F. 2014). It is possible to create a cadastral layer or parcel boundary layer because of very high spatial resolution data (M. Raghunath,2006). A plan can take a variety of forms including strategic plans, comprehensive plans, neighborhood plans, regulatory and incentive strategies, or historic preservation plans. Planners are often also responsible for enforcing the chosen policies. The modern origins of urban planning lie in the movement for urban reform that arose as a reaction against the disorder of the industrial city in the mid-19th century. Urban planning can include urban renewal, by adapting urban planning methods to existing cities suffering from decline. Alternatively, it can concern the massive challenges associated with urban growth. Therefore, this paper evaluates the proposed future plan (2021) in context to the existing land use (2015) in Allahabad district.

The specific objectives are:

1. To prepare a land use/land cover map of the study area using supervised classification
2. To calculate the area covered by the individual land use in the proposed plan (2021)
3. Examine the level at which the current development (2015) comply with the proposed future plan (2021) in the study area

Material and Method

Study Area:

Allahabad is located at 25.45°N 81.84°E in the southern part of the Uttar Pradesh at an elevation of 98 meters (322 ft.) and stands at the confluence of two, the Ganges and Yamuna (Figure 3.1). The region was known in antiquity as the Vats country. To its south and southeast is the Bagelkhand region, to its east is middle Ganges valley of North India, or Purvanchal, to its southwest is the Bundelkhand region, to its north and northeast is the Awadh region and to its west along with Kaushambi it forms the part of Doab i.e. the Lower Doab region. In the North district Pratapgarh, in the south Rewa (M.P.), in the east Sant Ravi Das Nagar and in the west kaushambhi districts are located. It has an average area of 5482km^2.
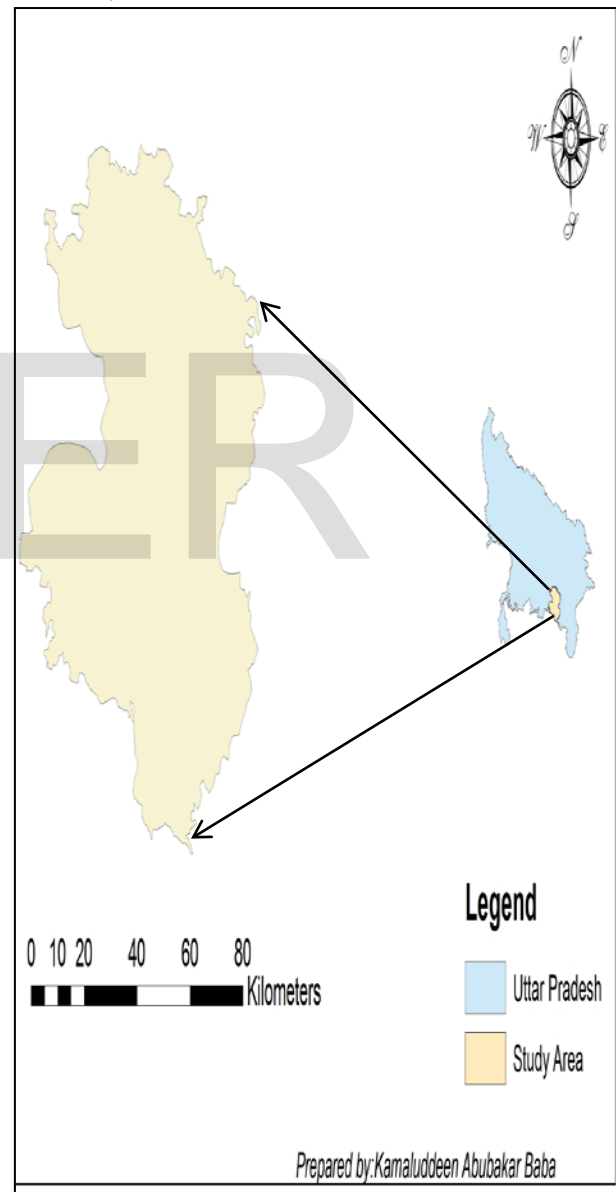

Figure 1: Study Area

Data used

Satellite data: Two satellite data are used in conducting the analysis in this study; the landsat 8 (OLI) and LISS IV data:

S/N	Satellite	Sensor	Date	Spatial Resolution	Band	Path/Row
1	Landsat 8	OLI	May-15	30	9	143/42 & 143/43
2	IRS-P6	L4fx	Dec-13	5.8	3	101/54

Table 1: Satellite Data Used in the Study

The Landsat 8 OLI/TIRS Pre-WRS-2 data set contains nearly 10,000 scenes acquired by the Operational Land Imager (OLI) and/or Thermal Infrared Sensor (TIRS) sensors after launch (February 11, 2013) through April 10, 2013, when the satellite achieved operational orbit (WRS-2). The sensor provides improved signal-to-noise (SNR) radiometric performance quantized over a 12-bit dynamic range. (This translates into 4096 potential grey levels in an image compared with only 256 grey levels in previous 8-bit instruments.) Improved signal to noise performance enable better characterization of land cover state and condition. Products are delivered as 16-bit images (scaled to 55,000 grey levels) and have a large file size, at approximately 1 GB compressed. The data is used in this study for classification and obtaining the pixels count of land uses as proposed in the future plan (2021) of the Allahabad district. The table below provides the spectral band, spatial resolution and wavelength of the data.

Table 2: Spatial resolution and wavelength of landsat 8 (OLI)

Landsat 8 (OLI) Bands	Wavelength (um)	Spatial resolution(m)
Band 1 - Coastal aerosol	0.43-0.45	30
Band 2 - Blue	0.45-0.51	30
Band 3 - Green	0.53-0.59	30
Band 4 - Red	0.64-0.67	30
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Band 6 – SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15
Band 9 - Cirrus	1.36 - 1.38	30

Another satellite data used in the present analysis is LISS-IV data which is the advanced high resolution camera operating in three spectral bands, in the visible 0.52-0.59 microns (Green Band 2) and 0.62-0.68 microns (Red Band 3); and in the NIR: 0.76-0.86 microns (Band 4) with spatial resolution of 5.8 m and a swath of 70 km. It is used in this study to identify land use /land cover in the study area

Table 3: Spatial resolution and wavelength of LISS IV Data

IRS P-6 LISS IV Bands	Wavelength (um)	Spatial resolution (m)
Band 2-Green	0.52-0.59	5.8
Band 3-Red	0.62-0.68	5.8
Band 4-NIR	0.77-0.86	5.8

Other data used

Other data used includes topographic map of Allahabad district (2014), proposed future land use plan for Allahabad (2021) and Global positioning system (GPS) data.

Software used

The software used in carrying out the analysis includes the following**:**

ArcGIS software (ArcGIS 10.2)

ArcGIS is vector- based software that is used in inputting, storing, manipulating and analyzing the spatial data. It is designed by (ESRI)

Erdas software (Erdas imagery 9.2 & Erdas imagine 2014)

ERDAS Imagine is a raster-based software package designed by leica Geosystems specifically to extract information from imagery. It provides a variety of tools such as image orthorectification, mosaicking, reprojection, classification and interpretation.

Microsoft office

Microsoft office is an office suite of applications, servers and services. It was first announced by Bill Gates of Microsoft on 1 August 1988 at COMDEX in Las Vegas. It contained Microsoft Word, Microsoft Excel and Microsoft PowerPoint

Methodology

The methodology applied to find solutions for the research problems and objectives is given below:

Preparation of Existing Land Cover/Land Use Map using supervised Classification

Supervised Classification is the type of classification in which the image analyst supervises the pixel categorization process by specifying, to the computer algorithm, numerical descriptors of the various land cover types present in a scene (Nnam, V.C. 2013). Representative sample sites of known cover type, called training areas, are used to compile a numerical interpretation key that describes the spectral attributes for each feature type of interest. Each pixel in the dataset is then compared numerically to each category in the interpretation key and labeled with the name of the category it looks most like (Addink, E.A, et' al 2010). Land cover/land use map is prepared using image classification of landsat 8. Layer stacking of the image is performed before mosaicking of the two scenes covering the study area. Seventy-five sample site points were collected representing the study area (Allahabad (District) using Global positioning system
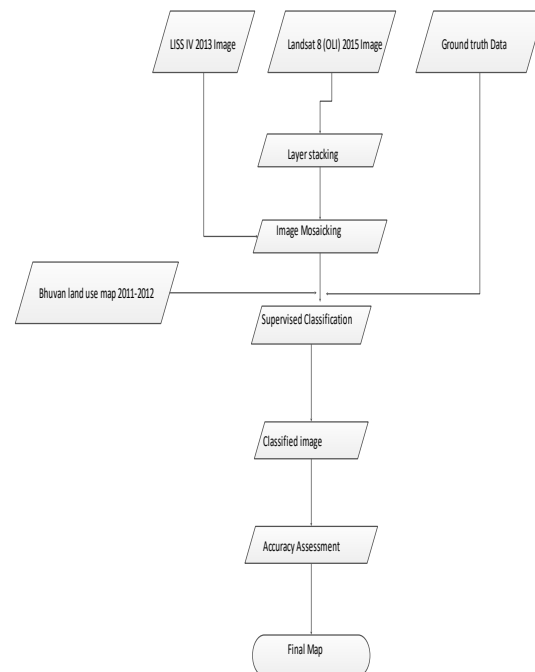

Figure 2: Flow chart of the classification procedure

The colonies selected for purpose of obtaining the ground control points includes Civil lines, Naya katra, Lukarganj, Malviya nagar, George Town, Allahpur, Katra, Police lines, Tagore nagar, Mumford ganj, Gongotri nagar, Bahrana, Rambagh, Dariyabad, Daraganj, Arail, Mahewa, Central jail, Chak nounian, Jhusi, High court line, Ashok nagar, Mutti ganj, Dandi, and classification was carried out in which five classes were classified (Built up area, Agriculture, Forest, Water body and Barrel land. Maximum likelihood algorithm is used because it has an advantage over the other types. Maximum likelihood classification method applies the probability theory to the classification task. From the training set classes, the method determines the class centers and the variability in raster values in each input band for each class (Lillesand, T.M, 2001). This information allows the process to determine the probability that a given cell in the in the input raster set belongs to a particular training set class. The probability depends upon the distance from the cell to the class centre, and the size and shape of the class in spectral space. The maximum likelihood method computes all of the class probabilities for each raster cell and assigns the cell to the class with the highest probability value

Comparing the Future Land Use Plan (2021) with the Classified Images (2015)

The proposed future plan of the study area was compared with the classified images in order to examined the level at which the plan comply with the current development in the study area. The hard copy of the plan design of the study area (Allahabad district) was obtained from the municipal corporation of Allahabad district; it was scanned into a picture format (tiff.), and georeferenced to the same coordinate system (UTM Zone 44 N) as the satellite imagery using the observed coordinates of some ground control points. After georeferencing, shape files were created for different land uses and the design was vectorised. After the vectorisation of the design, the proposed land use was evaluated with reference to 2015 classified image. The image segmentation was carried out on the image using user defined constraints which controls the segmentation of different image objects into independent objects. Segmentation is the division of an image into spatially continuous, disjoint and homogeneous regions, i.e. the objects (Jensen, J.R., 2014). After the segmentation the image objects are given meaning or identification by carrying out training which is based on information obtained during field survey pertaining to the Land use.

During the process of survey, ground coordinates of image points of the different themes (classes) were recorded as well as the different land uses, this information enabled us to check the accuracy of the image classification process that was carried out. The shape file of the individual land use of the proposed plan was overlaid on the classified image of the study area in order to assess the level of development. Finally, Area of the individual classes was obtained by multiplying the number of count with the resolution.
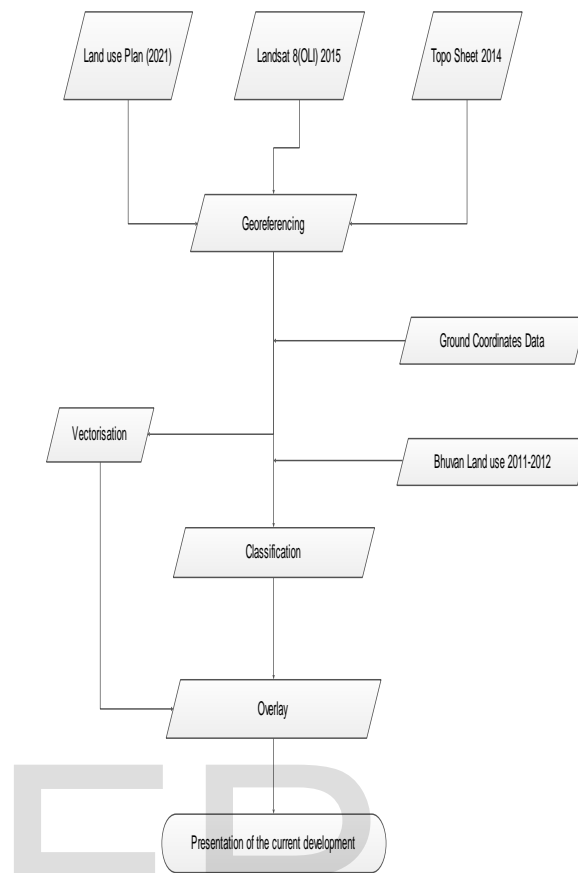

Figure 3: General evaluation flow chart

Result and Discussion

Future Development Plan, Allahabad District, 2021

The 2021 plan map for Allahabad district was obtained as a hard copy map which was georeferenced with the topo sheet of Allahabad district and imported into a GIS environment. Each land use from the map was digitized and converted into vector format. The various land use classes present in the map are provided in table 4.1 and the map is presented in figure 4.1

Table 4: Various Land use under the proposed plan

S.NO	Land use	Area(km2)	% Area covered
1	Residential	123	53
2	Commercial	5	2
3	Industrial	17	7
4	Colleges	9	4
5	Offices	37	16
6	Proposed road	1	0

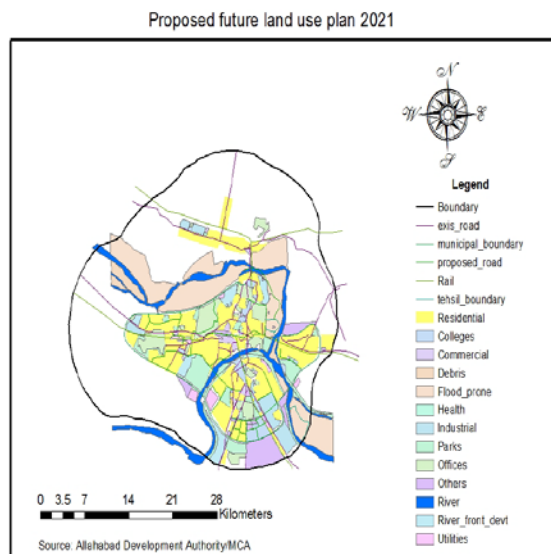| 7 | Pasture and dairy farm | 15 | 7 |
| 8 | Parks | 24 | 11 |
| Total | | 231 | 100 |

Figure 4: Land use /land cover, Allahabad District, 2015

In the absence of most recent Land use /land cover information of the study area, a land use map was prepared for the study area using Landsat 8 image acquired on May 2015. The entire study area was classified into five classes that included Built up area, Agriculture, Forest, Water, and Barren land (Table &Figure 4.2).

Table 5: Various land use obtained from classified landsat 8 image

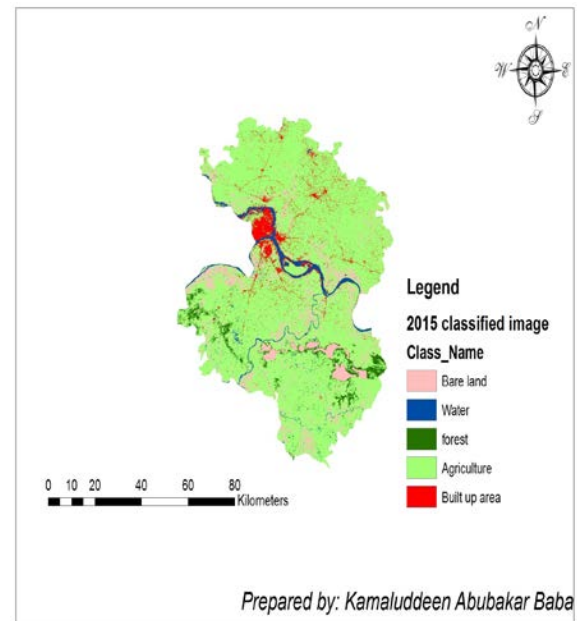| S.No.	Land use	Area (km2)	% Area Covered
1	Bare Land	575	11
2	Water	156	3
3	Agriculture	4069	78
4	Built up	251	5
5	Forest	163	3
Total		5214	100

Figure 5: Distributions of land use/land cover in the study area

NRSC Land use (2011-12), Allahabad District

The results obtained from classified image were compared with the land use information obtained from National Remote Sensing Centre (NRSC, Govt. of India) for the Allahabad district. Though the land use information obtained from NRSC is for the period 2011-12, however in the absence of a more recent data, the one available from NRSC was used for assessing/ verifying the overall pattern and distribution of the land use. The land use information and its comparison to the land use obtained from the classified Landsat 8 image is summarized in table 4.3

Table 6: Comparison between NRSC classification and 2015 classified image

S.No.	Land use	NRSC Area (km2)	Classified Image Area (km2)	% Difference
1	Bare Land	524	575	10
2	Water	317	156	-51
3	Agriculture	3970	4069	2
4	Built up	146	251	72

5	Forest	154	163	6
Total		**5111**	**5214**	**2**

Considering the above table, five types of land use was compared (Bare land, water, Agriculture, built up and forest) The total area of NRSC and classified image are 5111km2 and 5214km2 respectively, whereas the percentage difference is 10% for bare land, -51% for water, 2% for agriculture, 6% for forest and 72% for built up area.

Table 7: Existing Land Use Areas

S.No.	Proposed Land Use Classes (2021)	Existing land use Area (km2) 2015				
		Bare land	Water	Agriculture	Built up	Total
1	Residential	15	1	49	58	123
2	Commercial	0.4	0.05	1	4	5
3	Industrial	2	0.1	10	5	17
4	Offices	3	0.5	13	20	37
5	Colleges	0.5	0.05	4	4	9
6	Proposed road	0.1	0.005	0.4	0.4	1
7	Pasture and Dairy Farm	3	0.3	7	5	15
8	Parks	8	0.4	13	3	24
Total		**32**	**2.405**	**97.4**	**99.4**	**231**

Evaluation of Proposed Land Use Plan (2021) with Current Land Use (2015), Allahabad District

The future land use plan (2021) for Allahabad district proposed by the Allahabad Development Authority was evaluated with the existing scenario of land use in the district obtained from the classified 2015 Landsat 8 image. The evaluation was done by assessing the various types of land use and their respective areas existing under each proposed land use class. The results are summarized in the figure below

Summary and Conclusion

The paper is aimed to evaluate the proposed future land use plan (2021) designed by Allahabad development Authority/Municipal corporation Allahabad, with reference to existing land use which was obtained by classifying a Landsat 8 satellite image acquired on May 2015. The results of the classified image were compared with the land use information available from Bhuvan (2011-2012). Conclusively, eight proposed land use classes were evaluated which includes residential, commercial, industrial, offices, colleges, proposed road, pasture and dairy farm and parks. The total area of the proposed land use classes under the existing 2015 classified image is 231 km2. Agriculture class will be the most affected class followed by bare land accounting 97.4 km2 and 32 km2 respectively. The least affected class is the water encompasses approximately 2.5 km2.

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