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SOCIAL FUNCTIONL MAPPING OF URBAN GREEN SPACE USING GEOSPATIAL TECHNIQUES FOR BHIWANI CITY, HARYANA

Ms. Nisha Rani , Mr. Aman Deep Lamba*, Mr. Vikram*, Mr. Sunil Chahal*
*Project Fellow, Haryana Space Application Centre (HARSAC), Hisar

ABSTRACT

Green-space are an enormous benefit to our environment. The green-space are natural or semi-natural areas partially or completely covered by vegetation that occurs in or near urban areas. Urban green space (UGS) is a critical factor of city environmental systems and plays vital to urban residents. Therefore, social functional mapping of urban green space is important to facilitate the urban planning sustainably. This study has been taken up to map the Social functional mapping of UGS in the Bhiwani Municipal Corporation (BMC) area of Haryana State constituting an area of 24.77 ha using high resolution Super View data of April 2018 using geo-spatial techniques and find out the best method for extraction of green space. Different methods were used: (a) MXL classification (b) NDVI and other subsidiary information (c) Support Vector Machine (d) Layer Extraction have been tested to extract the green space. Due to the limitations of remote sensing in identifying social features; social sensing, which can reflect socioeconomic characteristics, is needed. As a result, a methodological framework for integrating the different data set from varied sources to conduct the social functional mapping of UGS is required. Consequently, first extracted vegetation patches from an area in Bhiwani, via the Hyperplanes for Plant Extraction Methodology (HPEM) and considered the parcels segmented by the Open Street Map (OSM) road networks as the basic analytical units.The study provides an improved understanding of UGS and can assist government departments in urban planning.

Keywords: Urban green space, Social Functional Mapping, Open Street Map Hyperplane for Plant Extraction Methodology (Near-convex-hull analysis, Accuracy Assessment)

1.1 Introduction- The green spaces are naturally occurred or semi-natural occurred areas covered by vegetation that occurs inside or near about urban areas. Urban green space is a critical factor for city ecological systems and plays vital role for urban settlements. Physical feature and social function are important aspect in UGS (Urban green space) mapping. Physical features like trees, shrubs, bushes. Social functions like community parks, public parks, green buffer outside the roads and parks (Chen et al., 2018). UGS together with public parks, community parks, forest, streams, and provide a large variety of environmental services (city heat reduction, storm water filtration, meals safety, bodily exercise, and health properly of human being. Urban vegetation is appreciably distinctive from natural vegetation because of the intense human effect.

WHO 2016 has suggested that urban green space as the location that includes herbal surfaces or usual settings and it includes specific kinds of urban green space consisting of roadside tree and it could additionally encompass the water factors ranging from ponds to coastal zones, the water area like river , a lake, a sea shore or a sea cliff. Those have helped the significance of city green area in promoting the healthful living inside the city area.

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1.2 Urban Green Spaces and its Type

➢ <u>Urban forest</u>– It represents the patches having area more than 50% woody vegetation without cultivation and paved roads.

➢ <u>Public Park-</u> It represents Municipal Parks, Theme Parks and Community Parks characterized by lawns, shrubs, and scattered trees. These parks are open for public and appropriate for outdoor activities.

➢ <u>Stream bank/lake shore vegetation</u>– Represents the patches having green areas nearby to ponds, lakes and rivers.

➢<u>Greenery in apartment accommodation areas</u> – Represents the patches having area public greenery in residential zones like private horticultural garden and commercial buildings parks.

➢ <u>Greenery in public services</u>–It represents the patches having area greenery in compact areas with particular public facilities, like hospitals within that area, university, school campuses, colleges etc.

➢ <u>Greenery in sports services</u>– It represents the patches having area used for games and leisure covered by pasture, such as stadium, golf course, playground, etc.

➢ <u>Cropland</u>— It represents the patches having agricultural areas with signs of crop growing. Cropland contains both cropped areas and grass in rotation, as well as orchards and vineyards.

➢ Railway and roadside greenery– It represents the patches having edge with pasture or other plants accompanying a railway and road.

➢ Greenery in industrial areas – It represents the patches having areas covered by greenery in factories with industrial manufacture, storage services, logistic centers, etc. (Rosina et al, .2016)

1.3 Geospatial technology for urban green space mapping

➢ Energy used with Geographical information System, that find out the best locations for harnessing alternative energy and that alternative energy mapping, such as wind speed and solar energy can supports government departments and developers who were invest in various energy sources.

➢ Green Spaces Carbon sequestering is a very important element of maintaining the green neighborhood. The GIS permits you to visually interpret existing green spaces and examine carbon emissions and sequestration, and make decisions about the selection of site where to plant more trees and grasses. ➢ For green government initiatives the use of Web GIS, it displays maps that show the actual development of green practices and resources.

➢ With GIS and Remote Sensing Planning for Community Land use, zoning, and development are the factors that consider when creating a green neighborhood. GIS, analyze data related to numerous planning factors and conclude the excellent way to establish commercial, environmental susceptible practices.

1.4 Guidelines Urban Green Space requirement

The coverage of the total geographical region and the percentage of green area requirement in keeping with per capita requirement may also range differently from one to another. There also exist number of guidelines for defining the urban green space, which is as curtained in keeping with the requirement and the improvement of the worldwide class city.

1.4.1 International Norms for Urban Green Space

The World Health Organization (WHO) acclaims that the minimum standard of urban green and open space must be nine square meters per city dweller (Singh, et al., 2010; MoUD, 2014).

A study conducted in 389 European metropolises marked a varied presence of green space. The average presence of urban forest estimated to be 18.6 percent ranging from 1.9 to 46 percent (Singh et.al, 2010).

1.4.2 Indian Norms for Urban Green Space

Based on the master plan the surrounding area under recreation and the open space analyzed for exceptional towns and it famous that the existing availability of per person open area considerably varies from 0.81sqm in Chennai to 278 sq m in Greater noida. Cities like Varanasi, Bhopal, Jaipur, and Allahabad have green space extra than Bangalore. Ludhiana, and Amritsar both cities had much less than the usual range one percent to five percent (MoUD, 2014). According to the action Plan 2009-10, Chandigarh city is a planned town of India and has more than 35% of its overall geographical are beneath the tree and woodland cover i.e. approximately 55 square meter green space per person (Singh et al., 2010).

1.5.1 Bhiwani City

Bhiwani District is in the Southwest division of the Haryana, which covers an area of 5140 sq km. There is no permanent river passing throughout the Bhiwani district. Physical structure of this district consists of even and level plain intermittent from one place to another place by clusters of sand dunes, hillocks, and stony ridges. A few inaccessible rocky ridges elevated sharply from the plain occur in the central south part of the district. Dohan tributary is the only transient stream in the area, which flows, in through reaction to precipitation. Bhiwani municipal council is located in Bhiwani district. Bhiwani is located 28.78°N 76.13°E. The average elevation of Bhiwani is 225 m (738 ft). Bhiwani lies at the distance of 285 km from the Chandigarh (State Capital) and at the distance 124 km from the Delhi (National Capital). Figure 1.1 representing the study area showing Municipal Corporation boundary of Bhiwani.

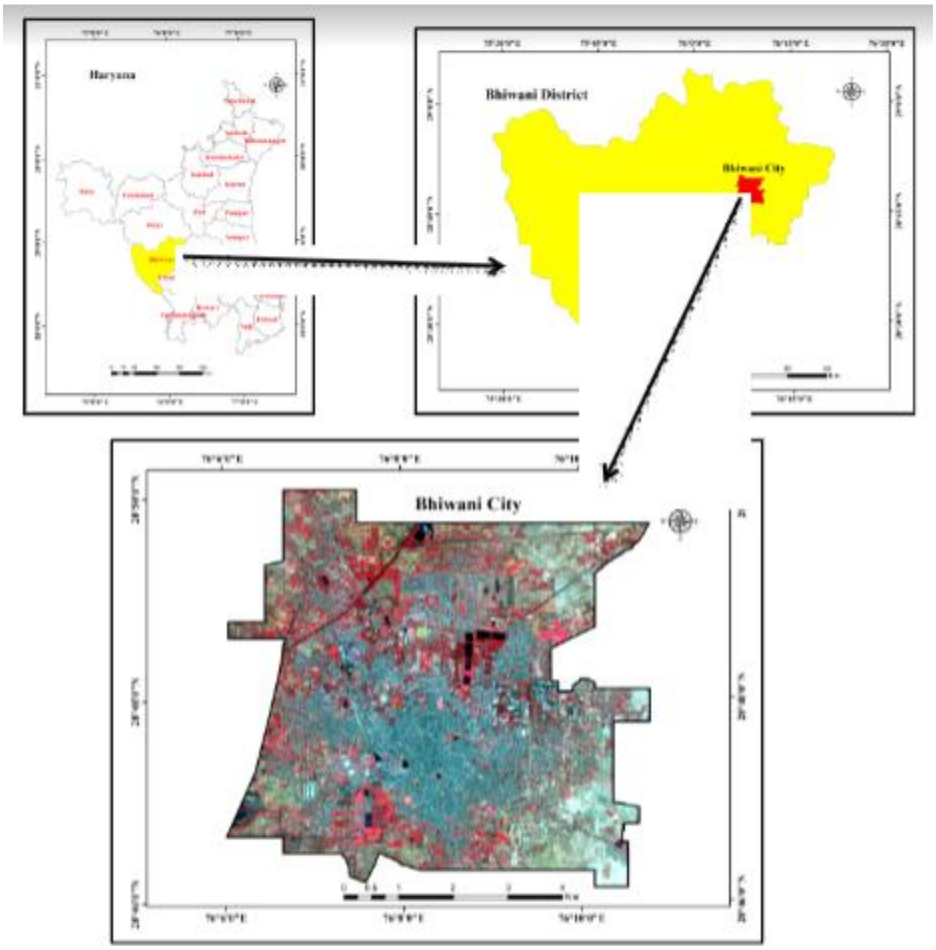


Figure 1.1 Study Area showing Municipal Corporation boundary

1.5.2 Climate

The Climate of Bhiwani district have classified as tropical steppe, semi-arid and warm which is generally dry through very warm summer and cold in winter without the monsoon season when humid air of oceanic origin goes through into the Bhiwani district area. In four seasons hot weather conditions season starts from middle of March to last week of June month, which followed by the southwest monsoon, which last ahead September. The transition period from September to October, form the. September to October time is the post-monsoon season. The winter season start on late in November month and up to the first week of March month.

1.5.3 Transportation

Bhiwani city well connected to other districts and cities through the Road and railway network.

1.5.3.1 Railways

Bathinda-Rewari line lies in Bhiwani railway Junction. Three railway lines begin from Bhiwani; 1st is towards the Rewari region and the 2nd railway line towards Hisar region. The 3rd division line goes towards Rohtak region and it connects to Delhi.

1.5.3.2 Road Network

The Bhiwani city well connected with road networks. All the state roadways are well connected with all the major towns. Bhiwani located in the western division of Haryana state. Therefore, that it shares its boundary, which connected with Jhunjhunu district of Rajasthan State. Bus service is the major resources of public transport in the Bhiwani.

1.5.4 Rainfall

The regular rainfall of the Bhiwani is 420 mm, which is not uniformly distributed over the area. The southwest monsoon starts from of June last week and withdraws in the September end. It contributes in 85% of annual rainfall in Bhiwani. July and August are the wettest months of the season. Generally, rainfall in the district rise from southwest to northeast.

1.5.5 Population

The initial provisional data according to census India 2011 shows that density of Bhiwani district for 2011 is 342 people per sq. km. In 2001, Bhiwani district density was at 298 people per sq. km. Bhiwani district administers 4,778 square kilometers of areas.

1.6 Significance of the Study

Due to the population, expansion and extreme density in cities can adversely affect natural and ecological resources. Conservation of vegetated or green spaces improves the quality of urban life by given that settlements with natural settings for relaxation, recreation and by conservation the basic resources such as air and water. In fact, adequate tree cover is an essential link in the bio-diversity chain. This entails us to go for assessment of urban green space in a city like Bhiwani. It is also significant to classify the key stages in preparation and expansion where urban green space incorporated with the built-up area. This is will help planners in framing suitable guidelines for enhancement and upkeep of green space

1.7 Objectives

Following objectives where defined to achieve the Social functional mapping of urban green space in Bhiwani:

1. Comparison of different geospatial techniques for mapping of UGS.
2. Urban Green Space (UGS) mapping over Bhiwani city using R S techniques at the scale of 1:4000.
3. Social Functional mapping of UGS using social sensing.

Materials and methodology

The idea of the work was to evaluate the green space in the Bhiwani City and the mapping of social functions in the city area. Methodology represents both quantitative and qualitative analysis of available UGS in Bhiwani city (Haryana). LULC was prepared and analyzed using data of SuperView satellite for the year 2018. Different methods suggested in various literature for LULC classification were again judged for their accuracy and decision was taken on best method for urban green space mapping. Social function mapping was done utilizing crowd sourcing, field visits.

3.1. Data Sources

3.1.1 Satellite Images

The single date (11.04.2018) satellite image of SuperView-1 was taken for the study from HARSAC data repository purchased from NRSC, Hyderabad, and the nodal agency for foreign satellite data in India. It is a Chinese remote sensing satellite operated by Beijing Space View Technology. The available spatial resolution of the satellite data is of 2 m for multispectral bands and 0.5 m for panchromatic band. In this study, only multispectral dataset having spatial resolution of 2 m was used.

3.1.2 Software

Both the image processing and GIS software were used to achieve the objectives defined for the research work along with the MS office package. The list is given below:

- ENVI 5.1: Used for image processing and analysis (Support Vector Machine)
- ERDAS Imagine 11: Used for image information Extraction, Analysis, Classification and Mapping
- Arc GIS 1.0: Used for Data creation, Analysis, and Map Composition
- Microsoft Office : Used for Report writing and Data analysis

3.1.3 Data collection

The SuperView satellite image of 2 m spatial resolution and municipal boundary of the Bhiwani city used in the study was collected from satellite data repository of Haryana Space Applications Center, Hisar. Social Sensing data was obtained from the Google Earth, Google maps and field visit.

SuperView covers the surface of the earth between 81° north and south latitude every 16 days and the spacecraft covers 14 orbits per day. The SuperView sensor provides the image information with four spectral bands of Red (630-690nm), Green (520-590nm), and Blue (450-520nm) in the visible range, NIR range (770-890nm) as shown in table 3.1.

Table 3.1 Technical Specifications of satellite data used

Name	Specification	Range (λ)
Sensor Bands	Panchromatic	450-890 nm
	Blue	450-520 nm
	Green	520-590 nm
	Red	630-690 nm
	NIR	770-890 nm
Spatial Resolution	PAN	0.5 m
	Multispectral	2 m

3.2 Method

3.2.1 The workflow of the method used to accomplish the 1st and 2nd objectives

The first objective was to establish the best geospatial method for Urban Green Space (UGS) mapping among available algorithms like MXL (Supervised), SVM (Supervised), NDVI thresholding (Index based) and onscreen image interpretation for layer extraction. Once the best method was established it was used for urban green space is urban green space (UGS) mapping over Bhiwani city. The methodology is separated into four stages: (a) Vector data preparation (b) Classification based on the digitization of social functions and road map (OSM) (c) Area Estimation Based on classification (d) Accuracy assessment of results based on Ground Truth and Google Earth and Google Map data.

3.2.1.1. UGS mapping using Maximum likelihood (MXL) algorithm

It is classification process used in RS. It involves clustering of pixel of satellite image to a set of classes which consist the pixel in the same class are having the similar properties. Supervised classification required exact knowledge of the land cover in the area. The classification transforms remote sensing data into useful thematic information that can be useful as input to geographical information systems. Supervised classification is preferred for a high accuracy. This requires of manual delineated per-classified training sets to instruct the automatic classifier. Per-pixel classification is performed by MXL classification. Some signature sets defined by visual interpretation and assigned to the algorithm and then classifier checks the entire image and groups all the pixels with similar spectral properties of a specific spectral signature. The single date imagery of SuperView satellite for Bhiwani city was subjected to MXL classification algorithm and accuracy was checked to establish the best method for UGS mapping.

3.2.1.3. UGS mapping using Support Vector Machine (SVM)

The SVM supervised classification technique was followed to classify LULC using ENVI software. The SVM works as a tool was implemented to automatically take out the LULC features as per the instruction sites given by the user. A training set of samples is assigned to determine the LULC comprising of several classes like Green space, built up, Fallow land, and Water body defined for the study. The classes of Built-up, Fallow Land and Water body were merged together to form the non-green space class. The SVM algorithm separates the object in various classes into the field of the hyperplane. It classifies the class related with each pixel and separates the class pixels with a decision plane that maximizes the boundary between the classes. These surfaces were known as hyperplane and all the data point those are close to the hyperplane are known as support vectors. These support vectors were used as the elements of the training set. It is a non-parametric statistical learning algorithm. This algorithm worked with an objective that builds a binary classification for each possible pair of class. The SVM classification is performed using various types of kernels. These kernels turn nonlinear boundaries into linear boundary in the high dimensional space to define best possible hyperplane. SVM is implemented in ENVI's based on a pair-wise multiple classes' classification approach. Resultant values classification for every pixel received are used for probability assessment, those are saved in software as rule images, and characterize the true probability that ranges involving zero to one or the calculation of values of each pixel is equal to one. Classification achieved by choosing the maximum probability. An optional threshold permits reporting the pixel with probability values less than the threshold marked as unclassified pixels. The SVM classifier facilitates kernels: linear kernel, polynomial kernel, radial basis function kernel (RBF) and sigmoid kernel. In the study, the classification results were obtained using the linear basis kernel. The scientific representation of linear kernel is as follows:

3.2.1.4 UGS mapping using Normalized Difference Vegetation Index (NDVI)

NDVI often used around the world to examine drought, predict agricultural production, and assist in forecasting fire zones and desert offensive maps. NDVI is preferable for global vegetation monitoring since it helps to compensate for changes in lighting conditions, surface slope, exposure, and other external factors. NDVI the common approach used to describe an optimal threshold to take out green patches. (Chen et al,.2018)

NIR representing the Reflection in the NR spectrum

RED representing the Reflection in the red range of the spectrum

NDVI is use to determine of the condition of plant health. Based on absorption and reflection of light wave how the plants reflect light energy at certain frequencies). NDVI range from -1 to +1. +1 NDVI values of Green vegetation close to (0.8-0.9) for the maximum possible vegetation density. This index was used to calculate the green cover (UGS) in the study area. Further, accuracy was also established for the results thus obtained.

3.2.1.5 Layer Extraction

Available bands of the satellite image were layer stacked to create an FCC. FCC image was transformed into projected coordinate system, which was finally clipped by the municipal boundary in ArcGIS. The municipal boundary was overlaid on the FCC image, and cut polygon tool was used to extract the green space, create a database, and generate a vector map of green spaces in Bhiwani Municipal area. Moreover, the layer extraction method was followed by on a scale of 1:4000. On screen visual interpretation, technique was used to extract and evaluate land features. In addition to this attribution was done to the interpreted data to describe the areas forming the part of urban green spaces. The urban green classes includes the Roadside tree, Residential green Space, Public Park, Municipal Park, Shrub land, Agriculture land and tree.

3.2.1.6 Field Survey

Ground truth survey points are an important input for assessing the accuracy and uncertainty of the classification. It was tried to physically observe and identify the features whose class could not be decided using on screen interpretation or any image classification algorithm followed for the study. Moreover, the field visit for ground truth collection was planned after image classification was done and it was undertaken during 22 May 2019 to 24 May 2019. Field observations were undertaken using handheld Garmin-H72 GPS.

4.2.1.7 Accuracy Assessment

Accuracy assessment of classified image is another most important step in remote sensing-based analysis, without which the output-classified image may not be valuable for further research work and planning. Ground truth data is necessary for this process. Accuracy assessment provides complete information on the categorical accuracy. In this study, the Accuracy Assessment tool of ERDAS imagines software was used to find the accuracy of the classified image (2018). Accuracy assessment was performed by comparing the LULC map created and ground truth information (125) collected as reference data obtained from different information sources such as Google earth and handheld GPS (H-72). An interpretation was then made as to how closely the map produced by remotely sensed data coordinated with the reference data (Source Map). In order to summarize the classification accuracy results, the most commonly used measures for accuracy assessment such as user accuracy; producer accuracy, overall accuracy, and Kappa coefficient were calculated.

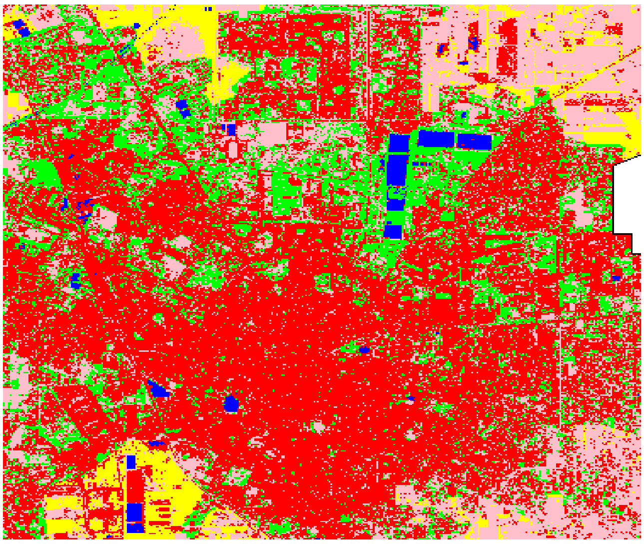
PA: Producer Accuracy

UA: User Accuracy

Kappa coefficient (K): The Kappa coefficient value lies between 0 and 1, where 0 represents agreement due to chance only. One represents the complete agreement between the two data sets.

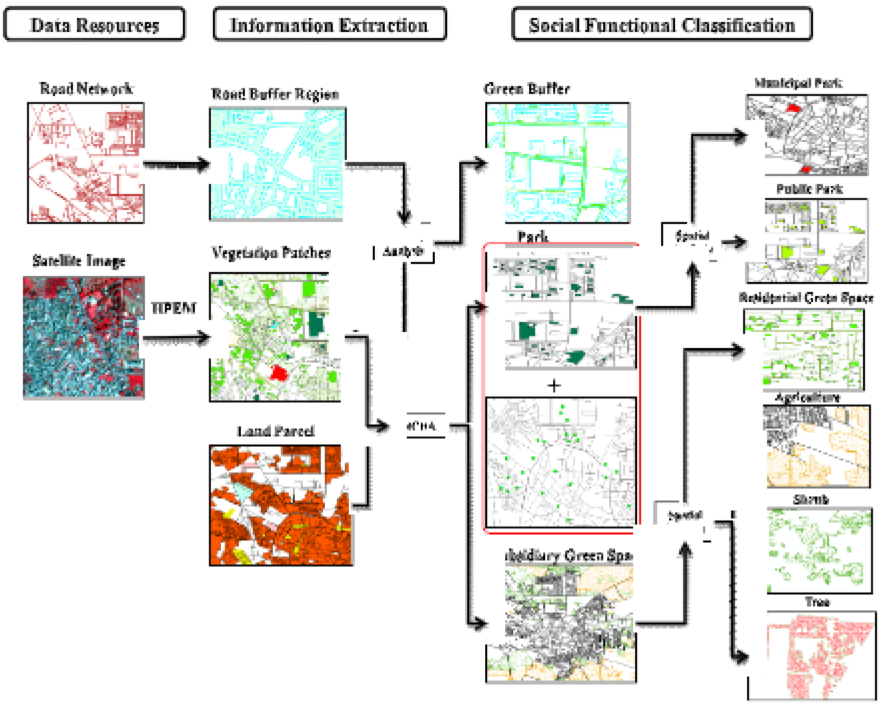
Figure 3.3 is showing GPS points location in the study area for ground truth collection overlaid on the Bhiwani City FCC image.

Figure 3.3 Ground truth points overlaid on FCC image of Bhiwani City



3.2.2 The workflow of the method used to accomplish the 3rd objective

The third objective was to map the Social Functions of UGS using social sensing. The detailed methodology has been explained through the methodology flow chart.



RESULTS AND DISCUSSION

In the present research work different techniques for image classification was identified and chosen for the mapping of Urban Green Space (UGS). Different authors suggested merit and de-merit of the different automatic/semiautomatic approaches for UGS extraction from remotely sensed data. For this study Maximum Likelihood, a parametric supervised classifier, ISODATA an iterative unsupervised classification technique, NDVI with subsidiary information and SVM-based supervised classification technique was used to extract UGS in Bhiwani Municipal area. Social Functional mapping of urban green space was extracted and estimated through the process using visual interpretation and onscreen digitization for layer extraction. The as follows results are-

4.1 LULC Based on Maximum Likelihood Classification (MXL)

Figure4.1 illustrates the green space cover and other land cover classes of Bhiwani city. The green space map was obtained by collecting a set of signatures for different land cover classes and passing the remote sensing SuperView image through MXL algorithm. Based upon the interpretation Technique following land use and land cover classes such as water body, Fallow land, Green Space and Built-up were identified and mapped.

Accuracy assessment report suggests that the overall accuracy of the image was found 87.20% with a Kappa coefficient of 0.78. The Producer Accuracy (PA) and User Accuracies (UA) of individual classes were high, ranging in 68.42% (PA) and 86.67% (UA) for Water body, 91.67% (PA) and 90.41% (UA) for Fallow land, 89.29% (PA) and 83.33% (UA) for Green Space and 83.33% (PA) and 71.43% (UA)

for Built-up Area respectively.

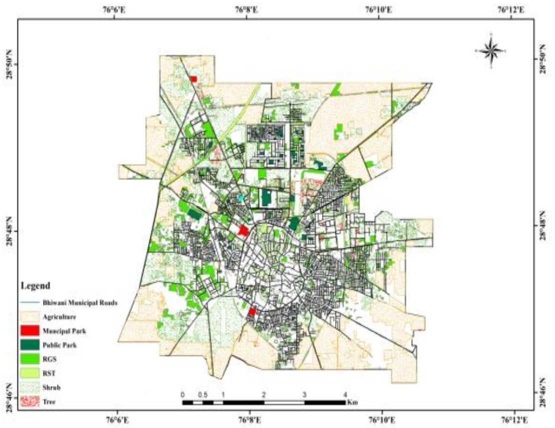


Figure 4.1 Green Space of Bhiwani City using MXL classification

Classification using NDVI and Subsidiary Information Technique

NDVI threshold was determined using GPS points taken during field visit. The threshold value of NDVI >= 0.33 was used to extract the urban green space and cropped agriculture area in the study area. Agriculture mask was used to discriminate between the UGS, and vegetation cover due to agriculture activities. Figure 4.5 illustrates the distribution and spread of green space and agriculture land in Bhiwani city.

Table 4.5 represents different parameters of accuracy assessment such as Producer accuracy (PA), User Accuracy (UA), Overall accuracy and kappa coefficient as obtained using NDVI technique. The overall accuracy of the classified Bhiwani image was found 93.33% with a Kappa coefficient 0.81. The PA and UA of individual classes were very much high, which are ranging in 98.28% (PA) and 94.21% (UA)for Non-green space, 58.82% (PA) and 83.33% (UA) for Agriculture and the highest for Green Space ranging in 94.12 (PA) and 94.12% (UA) respectively.

Table 4.5Accuracy Assessment of classification using NDVI & Subsidiary Information Technique

Class Name	Reference Totals	Classified Totals	No. Correct	Producers Accuracy	Users Accuracy
Non-Green Space	116	121	114	98.28%	94.21%
Agriculture	17	12	10	58.82%	83.33%
Green Space	17	17	16	94.12%	94.12%
Overall Classification Accuracy = 93%			Overall Kappa Statistics = 0.81		

Table 4.6 shows the distribution of coverage area of Green space, Agriculture and Non-vegetation in Bhiwani City. Green space occupies the 359.45 ha, agriculture occupies 325.82 ha and non-vegetation occupies 1791.73 ha. Green space in Bhiwani Municipal area occupies 14.52% of total area under study.

Table 4.6 Area of classes as obtained using NDVI and Subsidiary Information

LULC Class	Area	
Category	**Ha**	**%**
Non-vegetation	**1791.73**	**72.34**
Agriculture	**325.82**	**13.15**
Green Space	**359.45**	**14.52**

Class Name	Reference Totals	Classified Totals	No. Correct	Producers Accuracy	Users Accuracy
Water	21	21	18	85.71%	85.71%
Fallow land	43	44	40	93.02%	90.91%
Green Space	17	15	14	82.35%	93.33%
Built-Up	42	44	40	95.24%	90.91%
Overall Classification Accuracy 90.40%			Overall Kappa Statistics = 0.85		

Figure 4.5 Area of classes as obtained using NDVI and other subsidiary information

LULC Based on Support Vector Machine (SVM)

The supervised classification algorithm SVM was applied on the SuperView image of the study area in ENVI software. The signature of green space was assigned to prepare a sample of training sets to extract green space using the assigned machine learning approach. Thus, the region of interest as green space was extracted partially automatically. Figure 4.6 illustrates the green space cover of Bhiwani city as obtained using SVM. The green space map obtained through a Support Vector Machine approach shows that the green space increases as one moves away from center of the city area. However, the green space is available throughout the city.

Table 4.7 represents different parameters of accuracy assessment such as PA, UA, Overall Accuracy and Kappa Coefficient. The overall accuracy of the classified image was found 90.40% with a Kappa coefficient of 0.85. The PA and UA accuracies SVM ofeach classes were very high, which ranging from 85.71% (PA) and 85.71% (UA) for Water, 93.02% (PA) and 90.91% (UA) for Fallow land,82.35% (PA) and 90.91% (UA) for Green Space and 95.24% (PA) and 90.91% (UA) for Built up area respectively. The accuracy of the classification results out to be better than expected. Location information from Google Earth, ground truth (GPS Point) information covering different LULC classes were used together to assess the accuracy of classification results reliably.

Table4.7 Accuracy Assessment of Classification obtained using SVM

Class Name	Reference Totals	Classified Totals	No. Correct	Producers Accuracy	Users Accuracy
Water	21	21	18	85.71%	85.71%
Fallow land	43	44	40	93.02%	90.91%
Green Space	17	15	14	82.35%	93.33%
Built-Up	42	44	40	95.24%	90.91%
Overall Classification Accuracy 90.40%			Overall Kappa Statistics = 0.85		

Out of the total geographical area, water body occupies 39.83 ha, agricultural area occupies 255.93 ha, Fallow land occupies 963.11 ha of area, built up occupies 941.13 ha, and green space occupies277.00 ha as shown in table 4.8.

Table4.8 Area of LULC classes obtained using SVM

LULC Class	Area	
Category	**Ha**	**%**
Water	39.83	1.61%
Agriculture	255.93	10.33%
Fallow land	963.11	38.88%
Built-Up	941.13	37.99%
Green Space	277.00	11.18%

Thus, it illustrates that the fallow land together with agriculture land occupies almost 50% of the total geographical area of the study region, which is the highest percentage as shown in figure 4.7. Built up area covers around 37.99% and Green space occupies approximately 11.18% of total area. Water body occupying around 1.61% covers least area.

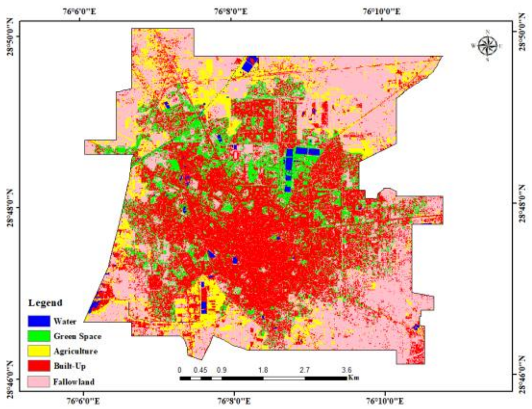


Figure 4.3 Green Space of Bhiwani City using SVM Classification

4.5 Comparison of different geospatial techniques for mapping of UGS

Table 4.9 illustrates the different accuracy level achieved using various geospatial approaches for mapping of urban green space in Bhiwani municipal area mapping. MXL classification technique was able to extract 325.11 ha of green space with 87.20% overall accuracy and 0.78 as kappa statistics. ISODATA classification approach identified 422.87 ha area with 76.80% overall accuracy and 0.66 kappa statistics. NDVI together with ancillary information approach gave 359.45 ha of green space having overall accuracy of 93.33% and kappa statistics of 0.81. Accuracy assessment for the classification using SVM approach had shown 311.09 ha of UGS with overall accuracy of 89.60% and the highest kappa statistics of 0.85, suggesting the best automatic/semi-automatic approach for UGS mapping.

Different Approaches	Green space area (ha)	Green space area (%)	Accuracy Assessment	Kappa Statistics
MXL Classification	325.11	11.72%	87.20%	0.78
NDVI	359.45	14.51%	93.33%	0.81
Support Vector Machine	277	11.18%	90.40%	0.85

4.6 Social Functional mapping of UGS using social sensing:

The land use and land cover (LULC) map was prepared as per social functions to identify the land features present in the study area. The result obtained through visual interpretation and onscreen digitization using SuperView satellite image of Bhiwani municipal area is presented in figure 4.8. The area for each class is measured in hectares and the mapping was done on a scale of 1:4000.

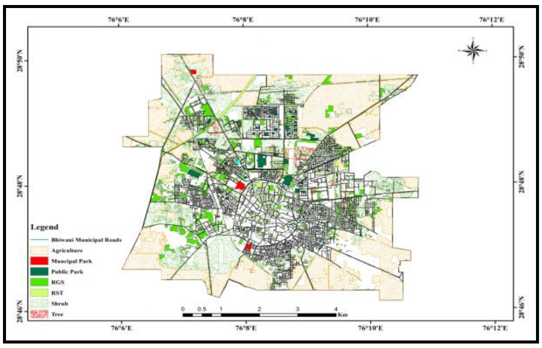


Figure 4.8 LULC Category map of Urban Green Space Bhiwani

The total area covered by Bhiwani city is 2477 ha as estimated from the municipal corporation boundary acquired from HARSAC data repository. Table 4.10 shows that out of total area the agricultural land occupies 974.65 ha (39%), Municipal Park occupies 8.70 ha (0%), Public Park occupies 26.72 ha (1%),Residential Green Space occupies 285.35ha (11%),Roadside Tree 143.34 ha (6%),Shrub Land occupies 558.26 ha (23%), Tree 40.30 ha (2%) of area, Built-up occupies 439.70 ha (18%). Thus, it is observed that the agriculture area is occupying the highest percentage of the total geographical area. Figure 4.8 illustrates that most of the green space is available on the Southwest and the northern part of the city. The central part of the city is crowded with built up and patches of green space such as Public Park, linear plantation and little vegetation can be identified at the central part of the city.

Table 4.10. LULC Category of Social Function

Name	**Area**	
Category	**Ha**	**%**
Agriculture	974.65	39%
Municipal Park	8.72	0.0036%
Public Park	26.72	1%
Residential Green Space	285.34	11%
Road-Side Tree	143.33	6%
Shrub	558.25	23%
Tree	40.29	2%
Built-up	439.69	18%

CONCLUSION

The study analyzed the extraction of green space through layer extraction, automatic feature extraction, and machine learning method. The layer extraction using onscreen digitization is a tedious and burdensome process and time-consuming too which requires many researchers to go for some appropriate method for automatic extraction of urban green spaces. Based on the study following conclusion may be driven:

1. Comparison of different geospatial techniques for mapping of UGS are performed on study area and SVM came out as the best method as it is showing highest kappa statistics and even time efficient.

2. Urban Green Space (UGS) mapping over Bhiwani city using R S techniques. It was identified that some of the features are unidentifiable though with a high zooming scale (1:4000) of layer extraction. Whereas the SVM method was able to identify and classify these pixels
3. The study of Social Functional Mapping of UGS using social sensing illustrates that Bhiwani is the pre-urban area. It is an agricultural city that has the potential to become a dynamic economic sector that quickly adapts to changing urban conditions and demands, intensifying its productivity and diversifying its functions for the city.
4. However, it can be concluded that none of the methods is highly accurate and provide exact result in comparison to manual method i.e. on screen layer extraction. On-screen interpretation is best for mapping of urban green space of smaller spaces but the semi-automatic classification technique of SVM proves to be good for larger spaces. It was seen that all the methods are important and significant in certain sectors. For example, the SVM may be good for city centers where the agriculture patches are absent in it.

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