URBAN SPRAWL IMPACT ASSESSMENT ON SOIL DEGRADATION OF SOLAPUR MUNICIPAL CORPORATION USING REMOTE SENSING AND DIGITAL SOIL DATABASE

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Abstract

Urban Sprawl is one of the main problem that threaten the limited highly fertile land in the Solapur city , In this research , satellite images Land sat TM 1992, ETM+ 2005 and Sentinel 2017 has been used to study the urban sprawl and its impact on agriculture land in Solapur . Land use land cover and change detection techniques were applied to map land cover changes in the study area collected ground truth, during several field trips conducted between 1992 and 2005, and 2017 topographic map in were used to access the accuracy of the classification result using ancillary data, visual interpretation and expert knowledge of the area through GIS further refined the classification results. Post combining the soil and land capability map in one hand , and the urban thematic layers , in another hand , using GIS made it possible to point out the risk of urban expansions on the expense of the highly capability soil class during the study period .

Human activities have often led to degradation of 15% of the world's land resources. These influences regularly lead to reduction in yields. Land conservation and rehabilitation are essential parts of sustainable agricultural development. While severely degraded soil is found in most regions of the world, the negative economic impact of degraded soil may be most severe in the country's most dependent on agriculture for their incomes.

The high capable soils decreased 63.99 km^{2}in 2017 the moderate capable soils decreased 49.94 km^2 in 2005 while the marginally capable soils decreased 31.47 km^2 in 1992 during the period. It is noticed that urban encroachment over the non-capable soils are very limited, as their coverage was found stable during 1992 -2017.

Keywords: Urban sprawl, Solapur city, Arc GIS, Soil Degradation, LULC, Geo database

Introduction

Land cover dynamics is one of the main interests of environmental monitoring. Land cover undergoes changes caused as natural so mankind factors. Nowadays, anthropogenic factors, e.g. urbanization, agricultural intensification, etc. become more significant sources altering earth's surface, while natural factors also play important role. Up-to-date land cover information is required by a great number of users.

Food scarcity and continuous loss of agricultural lands are issues of global concern .The Municipal Corporation of Solapur adopted policies aimed at self –sufficiency in food production e.g. extension of cultivated area and maximization of production of existing agricultural land. The principal purpose was and still is to overcome Solapur population to agricultural land ratio.

Agriculture, natural vegetation and unoccupied lands represent near about 75 % of the total area of Solapur. However, the majority of the population is concentrated around the Siddheshwar temple Solapur. This unbalanced distribution causes serious social and economical problems. Since, the Solapur municipal plans to adjust this situation by re-distributing the population through applying an effective horizontal urban expansion along the areas This policy aims at reducing the pressure on the old and highly productive agricultural land, decrease population density in the inhabited areas and decrease pollution sources by establishing industrial areas outside the Solapur city. Therefore, determining the trend and the rate of land cover conversion are necessary for the development planner in order to establish rational land use policy. For this purpose, the temporal dynamics of remote sensing data can play an important role in monitoring and analyzing land cover changes.

Digital change detection is the process of determining and/or describing changes in land-cover and land-use properties based on co-registered multi-temporal remote sensing data. The basic premise in using remote sensing data for change detection is that the process can identify change between two or more dates that is uncharacteristic of variation. Numerous researchers have addressed the problem of exactly monitoring land-cover and land-use change in a wide variety of environments.

There are many techniques available to detect and record differences (e.g. image differencing, ratios or correlation) and theses might be attributable to changes in land cover However, the simple detection of change is rarely sufficient in itself: information is generally required about the initial and final land cover or types or land uses, the "from-to" analysis Furthermore, the detection of image differences may be confused with problems in phenology and cropping, and such problems may be exacerbated by limited image availability and poor quality in temperate zones, and difficulties in calibrating poor images

The objectives of this study are to investigate the urban sprawl and its impact on agricultural land through integrating remote sensing and GIS and to examine the capabilities of integrating remote sensing and GIS in studying the spatial distribution of land cover changes.

Objectives:

- To investigate the urban sprawl and its impact on agricultural and waste land.
- To generate land use land cover classes of major categories at Level-I for the periods 1992, 2005 and 2017.
- To determine the trend, nature, rate, location and magnitude of land use land cover change.
- To generate land use land cover change statistics for the years -1992, 2005 and 2017

Location :-

Solapur is a city located in the south-eastern region of the Indian state of Maharashtra. Solapur is located on major road and rail routes between Mumbai and Hyderabad, with a branch line to the cities of Bijapur and Gadag in the neighboring state of Karnataka. It is well known for textile production such as bed sheet, blanket, towels etc. It is 49th-most-populous city in India and 43rd-largest urban agglomeration. Solapur city lies between 17^{0} 36'0" N to 17^{0} 44' 0"N latitude and 75^{0}48'0" E to 76^{0}4'0" E longitude.

Solapur municipal corporation:-

The Solapur Municipal Council established in the year 1852 and was given the status of corporation on 1st may 1964. It is governed under "Maharashtra Municipalities Act -1965''.

Secondly, the Solapur Municipal Council was the first Municipal Council of India to hoist the national flag on the national flag on Municipal Council building (Now Municipal Corporation) Solapur in 1930. The brief history of the same runs like this: Talking the spirit of Dandi March from Mahatma Gandhi, the freedom fighters of Solapur decided the hoist the national flag on the Solapur Municipal Council building.

Materials and Methods

Data Used:

Data is soul of any information system. Any kind of analysis or results mainly depends upon reliability and accuracy of data. The efficiency and performance of any information system highly depends on nature, quality and availability of data.

Table no1: Data Used

Sr. No.	Data Used	Spatial Resolution	Data Source
01.	Landsat TM, 1992 WRS-2 Path 145 Row 48	30m	www.glcf.com
02.	Landsat ETM+ 200 WRS-2 Path 145 Row 48	30m	www.glcf.com
03.	Sentinel (USGS)	10m	Earth Explorer
04.	Carto DEM	30m	Bhuvan
05.	SOI Toposheet	1:50000	S.O.I. Dehradun
06.	Soil Data	-	N.B.S.S.

Software Used:

-- ArcGIS 10.0

-- MS office

Methodology:

The methodology is divided into following modules.

-- Geo-database Generation

-- Image Processing

The detail description about every module is as below:

Accurate per-pixel registration of multi-temporal remote sensing data is essential for change detection since registration errors could be interpreted as land-cover and land-use changes, leading to an overestimation of actual change.Geometric correction was carried out using from topographic maps to then, this image was used to register all the other images.

Geo-database Generation:

The Geodatabase is the common data storage and management framework for ArcGIS. It combines "geo" (spatial data) with "database" (data repository) to create a central data repository for spatial data storage and management. It is the primary mechanism used to organize and use geographic information in ArcGIS. The Geodatabase contains three primary dataset types:

-- Feature classes

-- Raster datasets

-- Tables

Creating a collection of these dataset types is the first step in designing and building a Geodatabase. Geo-database storage includes both the schema and rule base for each geographic dataset plus simple, tabular storage of the spatial and attribute data. All three primary datasets in the Geodatabase (feature classes, attribute tables, and raster datasets) as well as other Geodatabase elements are stored using tables. The spatial representations in geographic datasets are stored as either vector features or as raster's. These geometries are stored and managed in attribute columns along with traditional tabular attribute fields.

A feature class is stored as a table. Each row represents one feature. Feature classes are homogeneous collections of common features, each having the same spatial representation, such as points, lines, or polygons, and a common set of attribute columns, for example, a line feature class for representing road centerlines. The four most commonly used feature classes in the Geo-database are points, lines, polygons, and annotation (the Geo-database name for map text).

The Geo database is created for storing, processing and retrieval of spatial data. The Feature Dataset is created with WGS 1984projection system which will applicable to all Feature Classes to be created in this Feature Dataset. The Line Feature Classes is generated here. The detail process is depicted as below:

Remote Sensing Data Interpretation:

Remote sensing is the small or large-scale acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing device(s) that is not in physical or intimate contact with the object. (Such as by way of aircraft, spacecraft, satellite, buoy, or ship)

In remote sensing, sensor pixels are observed in different portion if the electromagnetic spectrum. They also vary in spatial resolution. Because many bands imply a large volume of data storage, the multispectral senor does, usually, have a lower-spatial resolution in order to keep an adequate image size, currently there are many environmental application (for example, classification, image interpretation, etc.) that require good spectral information with an adequate spatial information. Land sat TM, ETM+ and Sentinal (USGS) Images having spatial resolution 30m, 10 m respectively were available for depicting change detection of the study area.

Image enhancement and visual interpretation:-

The goal of image enhancement is to improve the visual interpretability of an image by increasing the apparent distinction between the features. The process of visually interpreting digitally enhanced imagery attempts to optimize the complementary abilities of the human mind and the computer. The mind is excellent at interpreting spatial attributes on an image and is capable of identifying obscure or subtle features. Contrast stretching was applied on all images and four False Colour Composites (FCC) were produced. These FCC are visually interpreted using on screen digitizing in order to delineate land cover classes that could be easily interpreted such as urban and water.

Image classification

Land cover classes are typically mapped from digital remotely sensed data through the process of a vector based supervised digital image classification with help of Arc GIS. Unknown pixel so that it is considered to be one of the most accurate classifier since it is based on statistical parameters.

Supervised classification was done using ground checkpoints and digital topographic maps of the study area. Then accuracy assessment was carried out using 200 points from field data and existing land cover maps. In order to increase the accuracy of land cover mapping of the two images, ancillary data and the result of visual interpretation was integrated with the classification result using GIS.

Land cover / use change Detection

Regardless of the technique used, the success of change detection from imagery will depend on both the nature of the change involved and the success of the image pre-processing and classification procedures. If the nature of change within a particular scene is either abrupt or at a scale appropriate to the imagery collected then change should be relatively easy to detect; problems occur only if spatial change is subtly distributed and hence not obvious within any image pixel. In the case of the study area chosen, field observation and measurements have showed that the change in land cover between the three dates was both marked and abrupt.

In this study post-classification change detection technique was applied. Post-classification is the most obvious method of change detection, which requires the comparison of independently produced classified images. Post-classification comparison proved to be the most effective technique, because data from two dates are separately classified, thereby minimizing the problem of normalizing for atmospheric and sensor differences between different dates. Cross-tabulation analysis was carried out to study the spatial distribution and areas of urban sprawl on different soil types.

Digital soil map

The transformation of paper soil map into digital soil map was done following the next steps:

Spatial adjustment on basis of Land Sat images and topographic maps

Well registered topographic maps and accurately geo-referenced toposheet or satellite images have been used to perform the transformation process. The transformation tools of ArcGIS system were found to be very effective in performing the spatial adjustment of the thematic maps.

Extracting areas of interest

After having one digital soil map for the studied regions, the soil data analysis have been incorporated into the GIS attribute tables. For the detailed studies, a modified soil map have tobe produced using the GIS techniques as well as the basis of the N.B.S.S. Cutting the area of interest from the previously integrated soil map of the SMC using the Extraction function of ArcGIS system, has been used to extract the modified soil map on basis of administrative boundaries of the Maharashtra.

Digital Elevation Model

Digital elevation model (DEM) of the studied areas has been generated from the elevation points, Carto DEM images and the vector contour lines; ArcGIS10.0 software was used for this function. Digital elevation model (DEM) was used by ArcGIS10.0 software to produce the physiographic maps of the investigated areas.

Results and Discussion

The False Color Composites (FCC) generated from Landsat 7 bands 4, 3 and 2 and for Sentinel data bands are 3,2,&1were visually interpreted through on screen digitizing.

The visual interpretation gave a general idea about the forms of land cover changes over the period. Many urban areas were erected recently, especially solapur on the expense of the fertile soils.

Supervised classification using all reflective bands of the Landsat TM 1992, ETM+ 2005 and Sentinel 2017 images, was carried out using vector based classification. In order to increase the accuracy of land cover mapping of the classified images, ancillary data and the result of visual interpretation was integrated with the classification results using GIS. This overlying of the visual interpretation on the result of the classification led to the increase in the overall accuracies. The urban areas is overlaid on top of the soil capability map to show the extend of urban on the expense of agricultural land

Accuracy Assessment:

Once a classification has been directed, an accuracy assessment must be made to determine how correct the classified image is. An accuracy assessment involves the determination of the overall accuracy of the classification, errors of omission, errors of commission, producer's accuracy, and consumer's accuracy. All measures give an indication of how well the classification of the image was conducted.

Analysis and Interpretation

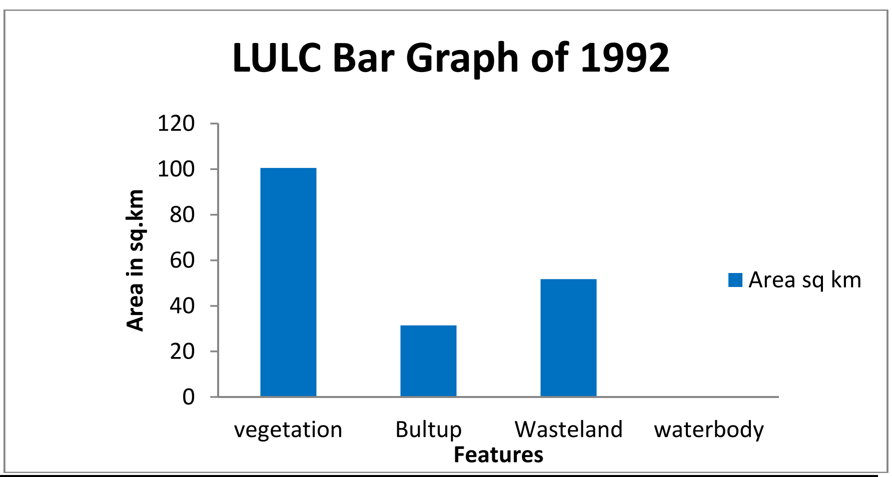
It is common practice to make two or more iterations of a classification process, to improve the accuracy of the result. With each iteration, the test sites are edited to better reflect the representation of their class and to remove or reduce any class overlap.

Land sat TM 1992 Image:

The classified image of Thematic Mapper (TM) is ofyear 1992. As per the Fig. 1 and Table 1)184.16 SqKm.of total study area. Vegetation which is maximum among the classified area is 100.51SqKm, Built-Up area is31.47 SqKm,and Wasteland is 51.74 SqKm of the total study area is classified as Water Body which is minimum among the classified area. The agriculture area is distributed throughout the study area whereas settlement mostly concentrated in South direction. The Wasteland also distributed throughout the study area. The water body covers minimum area and is in the form of streams and dams i.e. Hipparga Talao, Siddeshwar Talao, Sambhaji Talao.

Table no2: Area of Features of 1992 image

Feature	Area in sq. km.	Area in %
Vegetation	100.51	54.58%
Built Up	31.47	17.09%
Wasteland	51.74	28.09%
Water-body	0.44	0.24%
Total	**184.16**	**100%**



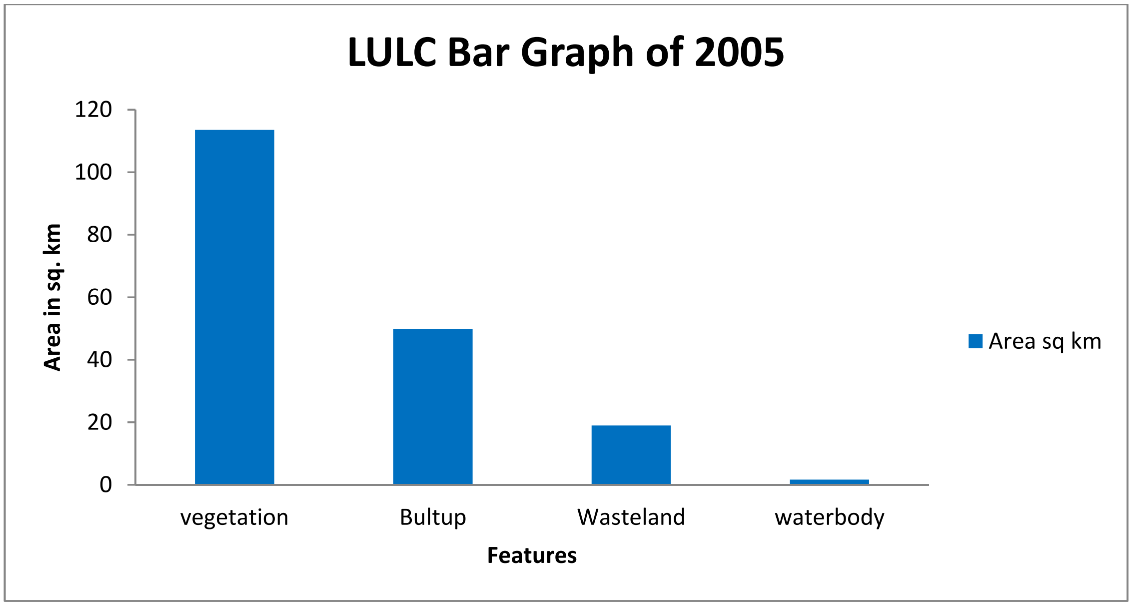
Land sat ETM+ 2005 Image:

The classified image of Enhanced Thematic Mapper plus (ETM+) is of 2005. The Spatial distribution of features in this image is also same like TM image of 1992. Area statistics for the image is given as below.

Table no3: Area of Features of 2005LULC Image

Feature	Area in sq. km.	Area in %
Vegetation	113.54	61.65%
Built Up	49.94	27.12%
Wasteland	19.00	10.32
Water-body	1.68	0.91
Total	**184.16**	**100%**

As per the Fig. and Table 3) the Built-up has occupied 49.94 Sqkm. of area and located at Solapur, South East direction and mostly concentrated in East part of study area. Vegetation land has occupied 435 Sqkm. of total area and located at throughout the study area. The Wasteland also dispersed central part of the study area. . The water body covers minimum area and is in the form of streams and dams i.e. Hipparga Lake, Siddeshwar Lake Sambhaji Lake

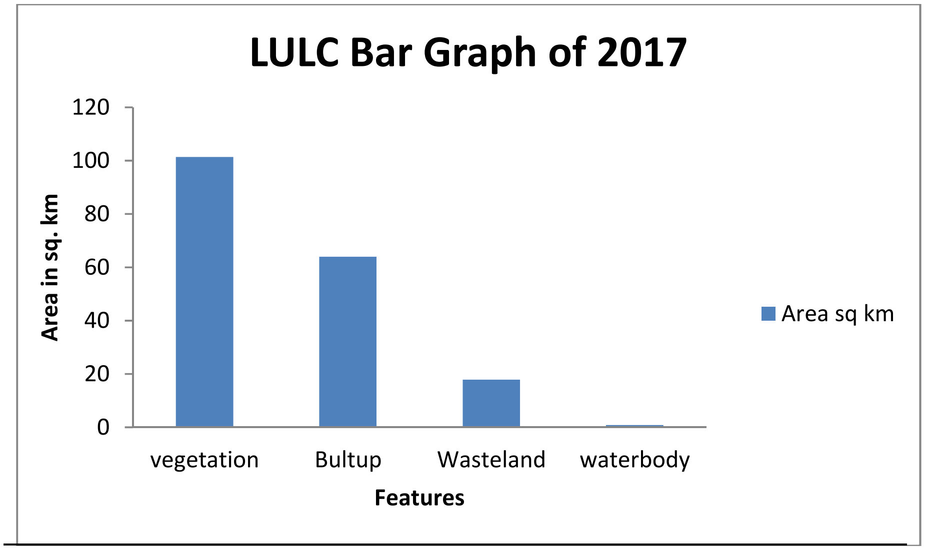


Sentinel 2 (USGS) 2017 Image:

The classified image of Sentinel 2017 sensor is of Year. 2017. In this thematic map Vegetation area has engaged maximum area i.e. 101.39 Sq.km. and water body has the minimum area of 0.86 Sq.km. of the total area. Here Built Up is found in South-East direction and also East at the center of image. Mostly, urban area is adjacent to roads and Vegetation area and lakes. Westland is distributed throughout the study area.

Table no4: Area of Features of 2017 LULC Image

Feature	Area in sq. km.	Area in %
Vegetation	101.39	55.05
Built Up	63.99	34.75%
Wasteland	17.92	9.73%
Water-body	0.86	0.47%
Total	184.16	100%



Digital Soil Mapping

The analysis of soil discovered 3 different soil texture in whole study area, these soil texture consist of clayey soil, Fine soil and Loamy soil. The classified image of N. B. S. S. In this thematic map clayey type of soil area has engaged maximum area i.e. 67.87 Km^2, fine type of soil covered 62.2 $km^2$and loamy type of soil has the minimum area of 52.58Km^2. of the total area. Here clayey soil is mostly found in North-West direction and also North –East, South-West direction of the study area. Then Fine and Loamy type of soil mostly originate in center part of the study area and also East and South- East direction of the study area.

Change Detection:

In the comparison of image of 1992 and of 2005 it can be seen that, vegetation, built-up area is increased, wasteland area is decreased. Water body remains nearly constant i.e. around 1.24 Sq.kms in the study area.

Vegetation is increased i.e. 13.03 sq.km, built-up area increased by 18.47sqkm respectively whereas Wasteland area is decreased by 32.74sqkm.

Table no5: Area wise Comparison Matrix for Year 1992 and 2005.

Class Name	Area in Sq Km.		+Difference in Sq. Km
	1992	2005	
Vegetation	100.51	113.54	13.03
Built Up	31.47	49.94	18.47
Wasteland	51.74	19.00	-32.74
Water	0.44	1.68	1.24

In the following comparison of thematic map of yr.2005and 2017, vegetation area is decreased by 12.15sq.km and built-up is increased 14.05sq.km respectively where as wasteland area is decreased significantly as compare to image of 1992. Water body remains nearly constant in the study area.

Table no6: Area wise Comparison Matrix for 2005 and 2017.

Class Name	Area in Sq Km.		+Difference in Sq Km
	2005	2017	
Vegetation	113.54	101.39	-12.15
Built Up	49.94	63.99	14.05
Wasteland	19.00	17.92	-1.08
Water	1.68	0.86	-0.82

The comparison of all three images in areas as well as in percentages is given below for detail analysis.

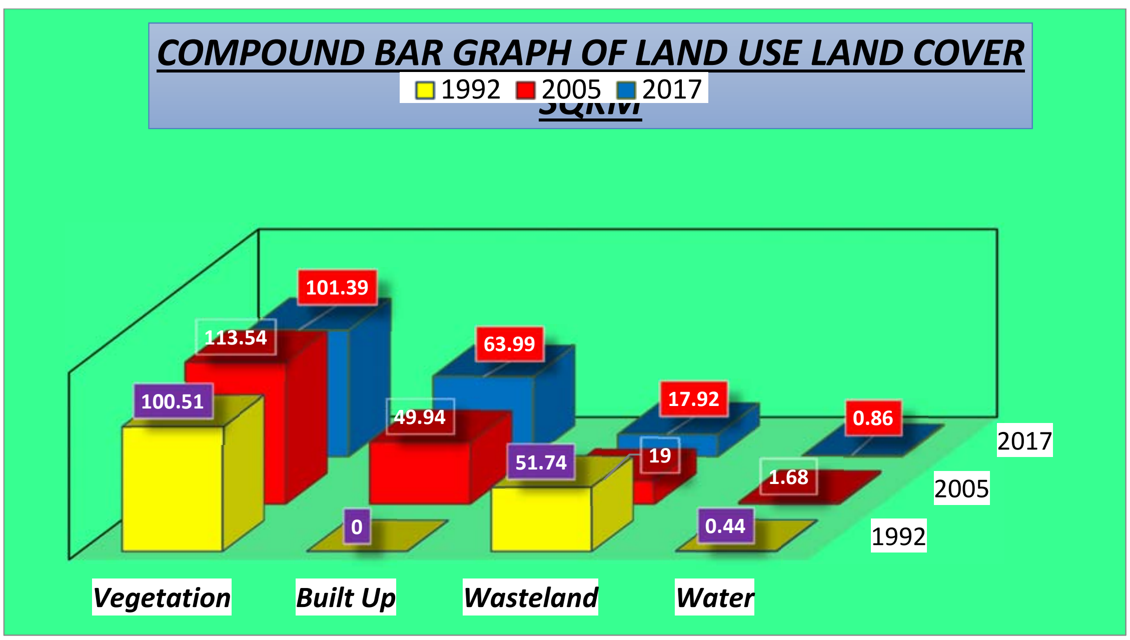
In the Table 7 comparison of thematic map of yr.1992 and 2017, vegetation area decreased up to12.15 sq.km and urban increased 14.05 sq.km whereas wasteland is decreased up to 1.08sqkm.Water body area is decreased by 0.82 sq.km. in the study area.

Table no7: Area wise Comparison between 1992, 2005 and 2017.

Class Name	Area in Sq Km.		
	1992	**2000**	**2017**
Vegetation	100.51	113.54	101.39
Built Up	31..47	49.94	63.99
Wasteland	51.74	19.00	17.92
Water	0.44	1.68	0.86

Table no8: Comparison between 1992, 2005 and 2017 in Percentage

Class Name	Area in %		
	1992	**2000**	**2017**
Vegetation	54.58%	61.65%	55.05%
Built Up	17.09%	27.12%	34.75%
Wasteland	28.09%	10.32%	9.73%
Water	0.24%	0.91%	0.47%



Conclusion:

Present research work verifies the capability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible four land use land cover classes as they change through spell. These four classes were noticeably produced for each study year. In achieving this, Land Consumption Rate and Land Fascination Coefficient were introduced into the research work.

Land use and Land cover changes can have either desired or undesired effects on any environment. Remote sensing and GIS systems are important tools for detecting the type of changes, location of the changes and quantifying the changes taking places in an environment. In the present study, the result of the work shows a rapid growth in built-up land between 1992 and 2017 while the periods between 2005 and 2017. Wasteland area is also decreased during 1992 to 2017. But vegetation is reduced during study period and Water body remains nearly constant in the study area.

It was found that integrating visual explanation with supervised classification led to increase in the overall accuracy. The study area has undergone a very severe land cover change as a result of urbanization which resulted for the rapid population. A Considerable increase in urban built-up has taken place on the expense of the most fertile land in the governorate. Integrating GIS and remote sensing provided valuable information on the nature of land cover changes expressly the area and spatial distribution of dissimilar land cover changes

The main causes of urbanization are the rapid population growth in addition to the internal. This problem needs to be seriously studied, through multi-dimensional fields including socioeconomic, in order to preserve the precious and limited agricultural land and increase food production. Water bodies' area should be increased with increasing population by artificial recharge structures to improve agriculture practice.

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