MAPPING OF URBAN GREEN SPACES USING REMOTE SENSING TECHNIQUE: A STUDY OF CITIES OF PUNJAB

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In

Geography

BY

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DECLARATION

I declare that the dissertation/thesis entitled " MAPPING OF URBAN GREEN SPACE USING REMOTE SENSING TECHNIQUE: A STUDY OF CITIES OF PUNJAB " has been prepared by me under the guidance of Dr. Kiran K. Singh, Assistant Professor, Department of Geography and Geology, School of Environment and Earth Sciences, Central University of Punjab, Bathinda. No part of this dissertation/thesis has formed the basis for the award of any degree or fellowship previously.

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ABSTRACT

Mapping of Urban Green Spaces Using Remote Sensing Techniques: A Study of Cities of Punjab

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Key words: Urban green spaces, NDVI, Sentinel, Landsat and Change detection.

Urban green spaces are important part of urban areas for good/fresh environment. These spaces are helpful in controlling and reducing the pollution and the temperature. These urban spaces provide a variety of services like biodiversity conservation, noise reduction, mitigation of urban heat island effect, prevention of soil erosion and carbon sequestration. Due to increasing urbanization, the quantity and quality of urban green spaces are degraded. So urban authorities are concerned about the management of green areas in the cities. Mapping of vegetation and green spaces play an important role to conserve the environment and sustainable environment in urban areas for authorities. In the study, the remote sensing is used for the mapping the urban green areas. This study probes the vegetation change detection in the four cities of Punjab over the period of 17 years from 2000 to 2017 based on NDVI (Normalized Difference Vegetation Index) by using remote sensing images of Landsat 7 and Sentinel 2 data.

Mandeep Kaur	Dr. Kiran K. Singh (Assistant Professor)
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Mandeep Kaur

(Signature)

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CHAPTER 1:INTRODUCTION

In present time the world is gradually become more urbanized. With this gain momentum process arise a host of challenges. According to Global Health Observatory (GHO) data (WHO) in 2014 urban areas now contain nearly 54 percent of the world's population and use 75 percent of natural resources, however, they are concentrated only in 2.8 percent of the world's land area. Because of intensive concentration of people on small proportion of land area creates several environmental problems. As a result, of this quantity and quality of Urban Green spaces is prime concern for planners and city administrators. They have significant role in physical, social and mental development. The importance of Urban greenery is very well known for maintain the environmental quality and sustainability so; these are an essential part of any urban area. Greenery provide abundant benefits to urban dwellers by acting as urban lungs – absorbing pollutants and releasing oxygen supply the clean air, water and soil, and balances city's natural urban environment These areas perform role as a visual screen and act as noise barrier and evade too much spatial uniformity. It has been proved in many studies that green areas helps peoples to convalesce from physical and mental stress. In now day's urban green paces and urban forests are vulnerable due to competition for space in the urban region and encroachments by the growth of the city (Li, 2016)

Assessing and monitoring the state of the earth surface is a key requirement for global change research (Committee on Global Change Research, National Research Council, 1999). Classifying and mapping of vegetation is an vital technical task for managing natural resources as vegetation provide a base for all living beings and plays an essential role in affecting global climate change, such as influencing terrestrial CO2. Vegetation mapping also presents valuable information for understanding the natural and man-made environments through quantifying vegetation cover from local to global scales at a given time point or over a continuous period (Xie, 2008). Areas such as parks, green ways, Residential landscaping and unutilized fields serve as urban green spaces.

Urban Green Spaces includes parks, gardens and recreation areas, informal green spaces such as rivers fronts, green spaces nearby historical sites, railway corridors and native vegetation types. Urban habitats for example abandoned industrial sites and overgrown gardens have also been encompassed in Urban Green Spaces (Venn and Niemelä, 2004). Urban planners depend on detailed and updated knowledge of their nature and distribution for the management of vegetated areas.

Because of vegetation a versatile resource for effectively managing and moderating a variety of problems associated with urbanization so it gains particular interest. The spatial distribution and abundance of urban vegetation are recognized as a key factor influence many biophysical processes of the urban environment. From while the understanding of ecosystem services is developing, researchers are becoming more and more aware from the importance of urban vegetation. In recent years, remote sensing technology provides a deal of convenience for urban vegetation information acquisition and mapping (Tooke, 2009).

Traditional methods for example map interpretation, literature reviews and secondary data analysis, however, are not very helpful to acquire vegetation covers because they are time consuming and frequently too expensive. Mapping with the help of Ground survey give outputs with high accuracy and detail but it is very time taking and in some cases such detailed information is not necessary. The use of remote sensing images in recent times has been very helpful in monitoring the changing pattern of vegetation. New technology like remote sensing offers a practical and economical means to study vegetation cover changes, especially over large areas. Because of the potential capacity for organized observations at various scales, remote sensing technology make possibilities of data archives from present time to over several decades back. Vegetation condition can be monitored by using remote sensing and image processing techniques at a variety of scales from site specific to regional or even larger, depending on one's goals. For this advantage, a huge no. of efforts have been made by researchers and application specialists to demarcate vegetation cover from local scale to global scale by applying remote sensing imagery (Xie, 2008) 'Change detection' in remote sensing image analysis is a special method which observes the differences of an object or phenomenon at different times and quantifies the change through analysis of difference in spectral response of vegetation or other cover type which occurs at a given location (Haque, 2017), With the capacity to distinguish land cover types at a large scale, remote sensing has been widely used for vegetation mapping in different environments. Satellite data has been adopted for the monitoring the vegetation both in urban and rural areas (Li, 2016)

Remote sensing technologies which are very advance, such as high spatial resolution sensors and laser scanning devices, are useful tools for examining urban environments since they can acquire detailed information about the material and structural composition of the urban areas. Remote sensing technologies make new possibilities to quantify the contributions of urban vegetation for a wealth of active processes in urban areas by provide a full coverage of urban environments.

The spatial structure of impervious-vegetated is mixed at much finer scale in urban landscape than elsewhere. As a result, for a long time, conventional method of urban vegetation mapping is depend on a visual interpretation of aerial images and fieldwork. More recently, developed very high resolution (VHR) satellite remote sensing systems (IKONOS, QuickBird, GeoEye, RapidEye, WorldView, Pleiades) are able to providing imagery with similar detail to aerial photography, and they offer opportunities to overcome the lack of dependable and reproducible information on urban vegetation across large areas. However, the difficulty with VHR satellites is their narrow swath and consequently limited coverage of the Earth's surface. Moreover, the VHR satellites are commercial services, and the data cost is relatively high.

One of the latest sources of information for surface cover, including urban green space, is Sentinel-2A (S2A), a high-resolution optical Earth observation mission. Although the VHR satellites has fine resolution and Sentinel-2A has coarser spatial resolution, but it offers higher spectral resolution and it is freelyavailable. Sentinel missions are the part of the Copernicus program (earlier called GMES), a joint initiative of the European Commission and European Space Agency to found a European capacity for the provisioning and use of information for environmental monitoring and security applications. (Rosina, 2017)

NDVI is also one of the methods for urban vegetation mapping. Normalized Difference Vegetation Index derived from remote sensing Data has been used in various studies for mapping and for make a distinction between vegetated and non-vegetated area.

1.1Background of using remote sensing & GIS in the study of urban green spaces

The global research agenda has been concerned about land cover change, its long term impact on environmental change and the influence of the regional as well as local climate. In the last decades, it was recognized that high modifications of land surfaces found in urban areas through intensive use of land have negative effects on the ecosystems of Earth. Urban environment which serves as sources of carbon sink and control surface temperatures and the water cycle, is highly affected by surface features as a high density of settlement, and infrastructure which results in long and short term degradation of natural land cover

From the 1970s, satellite data have been acquired and widely used to study land surfaces and Remote Sensing (RS) has been well recognized as effective means for depicting and mapping land cover surface such as natural resources and social economic resources. Remote sensed data with multispectral capabilities have been used to track and record long term changes in the characteristics of these resources, through the production of land surface maps indicating land surface processes and patterns. The information resulting from the analysis has also been used to understand the changes in ecosystem functions as well as in their spatial distribution and impact of changes on the ecosystem.

However, long term analysis of changes is challenged by temporal as well as geographic and spatial coverage of the remotely sensed data. Despite these drawbacks, successful long term analyses of landscape processes have provided promising results for monitoring a greater range of earth surface modifications around the world. Other studies have emerged to use RS and Geographical Information Systems (GIS) techniques to understand the impact of land surface changes on the spatial arrangement and distribution of ecosystems.

Green areas haven’t always been a main concern in urban development. Now, green spaces are an important element of urban areas to build healthy, habitable cities, and urban planners have jumped onboard. They have startedconcatenate green infrastructure, green spaces (parks and recreational spaces), tree canopies, erect green walls, and green roofs into urban environments. They are doing it through the support of maps.

Geographic Information System (GIS) and geospatial equipment are extremely useful to plan, build, and monitor green areas. Urban green spaces are not only important in building a fun and energetic city, but also essential for supporting the resilient population across an environment. Increased use of green spaces is related with improvement of psychological well-being, physical activity and general public health of urban peoples. As green spaces become necessary part in city planning, it is important to be able to visualize them.In the United States some cities green areasalready have chiefconcern in their agenda. Here are three groupswhich are already using maps to improve the green spaces in their cities: 1. Casey Trees 2. Green Roofs for Healthy Cities 3. New York Restoration Project (NYRP) (Adler, 2015)

High urbanization and the high pace of social and economic development in Asia resulting from the increase of population in cities, lack of infrastructure, congested traffic, environmental degradation and a housing shortage are major issues faced by cities in Asia in their sustainable development. According to population experts, 62 percent of the world' population will live in urban areas by the year 2020, while the Asia-Pacific Region will contain about 49 per cent of that urban population and will have contained a level of urbanization of 55 per cent. But it is also need to mention that growth of population has been slowed down in Asia-Pacific region. The great threat to health and safety in cities comes from water and air pollution. Especially those who are poor and do not have adequate ventilation systems, air pollution is hazardous for them women and children because they expose regularly and waterborne diseases are found most commonly in low-income groups because of inadequate sanitation, drainage and solid waste collection services. Another most important challenge facing in Asia region due to over urbanization is the conversion of agricultural land and forest for urban uses and the development of infrastructure in urban areas. As a result, widespread removal of vegetation to support urban ecosystem, ground water overdraft and put additional pressure on nearby areas may be even more ecologically sensitive and may even increase the higher frequency of flooding in urban areas (Haq, 2011)

According to Poushesh, 2007, land surveying of urban green space have enormous costs and also are very time consuming. Therefore, urban green space mapping using satellite images to have a time series and to be careful with high speed and cost is less (Mehdi Saati, 2010)

It has been confirmed that geographical methods can be used to effectively characterize ecosystem health and localize potentially endangered habitat based on different greenness and stress related measurements.From the beginning of 1980s, terrestrial vegetation condition has been monitored from advance satellite sensors such as the Advanced Very High Resolution Radiometer (AVHRR) and Moderate-Resolution Imaging Spector radiometer (MODIS) and vegetation indices for example Normalized Difference Vegetation Index (NDVI) was relatively established.

1.2 Benefits of urban green spaces

Urban green-spaces are necessary part of the urban environment, they known as a source of provide the aesthetic pleasure and recreational for city residents that are otherwise unavailable in an environment dominated by buildings and privately owned land.

The benefits of urban green-space include both on site and off site benefits in addition to passive benefits including the aesthetic benefits of viewing green-spaces, reductions in air and noise pollution and the provision of habitats for biodiversity They also include cultural benefits including the preservation of history and memorials and they bring aesthetic value to the landscape, providing visual diversity and made positive perception about cities. (Andrews, 2014)

Within the urban habitat the term 'green-space' can refer to various urban land use types including natural and semi-natural places (e.g. woodlands, SSSIs and grasslands) areas with street trees and roadside verges, public parks and other formal green spaces, domestic gardens and cemeteries and church yards. (Andrews, 2014).

Urban green spaces, such as open parks, forests, and grasslands and other formal vegetation, have been increasingly known as key elements of urban planning. Urban green areas have been shown to form cool islands and improve outdoor thermal comfort during warm seasons, as well as reduce environmental stress produced by heat island. They can also supply important ecosystem services that could improve residents' health and wellbeing. By the two major processes: shading and by providing higher evapotranspiration urban green spaces can cool the climate effectively (Chaobin Yang, 2017). The life of urban population has a large influence of urban green spaces because of the supply of goods which are provided by these areas. Urban green areas also reduce the stress so, particularly beneficial to urban residents for whom stress is a part of daily life. Formal recreation green-space and parks give the benefit of unique activities and experiences not possible in the rest of the urban environment. They also provide other valuable services in terms of the reduction of air and noise pollution and the prevention of flooding. One study showed that one acre of trees has the ability to remove 13 tons of particles and gases annually. (Projectevergreen, 2013) Indeed simply the presence of natural features (i.e. trees and vegetation) in the urban environment may have beneficial effects as studies have shown that simply viewing natural scenes reduce stress in comparison to viewing urban scenes. Kuo, 1998 showed that the presence of trees and grass in common spaces promoted the development of social ties and some studies have even shown that "greener" surroundings result in lower reports of fear and less aggressive and violent behavior. Other many epidemiological studies have also proved various optimistic health effects of urban green spaces, such as reduced depression and improved mental health, reduced heart morbidity and mortality, improved the pregnancy outcomes and reduced rates of corpulence and diabetes (reviewed by WHO Regional Office for Europe 2016).So, urban green spaceprovide nature-based solution with a no. of known health and well-being benefits. In general greener infrastructure within a city's boundaries can improve the urban environment.

1.3Significance of the study

Land use changes are increasingly transforming land cover at a very high speed mainly in tropical countries. Around 50% of global population is urban, and the most of expected population growth will be in developing counties. My study area Ludhiana, Amritsar Chandigarh and Bathinda are the most urban areas in the Punjab. Population wise these cities includes in the top six cities of Punjab. So fulfill the needs of the population of these cities needs related with space, the urban green areas are using. In the other words the needs of growing urban population are fulfill at the cost of green areas.

So, in this research study done for address complex issues related with urban green spaces in these four cities and also address the necessity to account for these problems in urban planning. The research further contributes to scientific knowledge related to extracting information from remotely sensed data and provides understanding of the techniques to fully use of this data for better urban green areas monitoring. This study also contributes in providing the knowledge how the freely available remote sensing data is use full in Urban Green Space Mapping. It is expected that the results of this study will be of great use for policy makers and urban planner in the study area and the other researchers for further study in this field.

By contrast, a reduced amount of public space impacts negatively on life in a city. The private sector generally has little incentive to provide public space and wider urban connectivity, so the role of local governments in defending the commons is critical. However, many local governments are relinquishing this role. As a result, much rapid urbanization is proceeding in an uncontrolled manner, yielding settlement patterns with dangerously low proportions of public space. Even the planned areas of new cities have sizably reduced allocations of land for public space, with an average of 15% of land allocated to streets. In unplanned areas the situation is considerably worse, with an average of only 2% (Nematinasab, 2017)

1.4Statement of the problem:

At present, in general areas under green spaces in cities are decreasing in developing countries due to various reasons that varies from city to city. Urban green spaces decreasing due to compelling demand forconstruction of buildings and uses of urban land for other commercial purposes. Generally, in central parts of old cities, areas under green spaces are negligible and tend to decrease in the future. For the sustainable development there is need for management of the vegetation and to have the knowledge of how much change is appearing inthe green space areas. The present study is an initiative to study the change in last 17 years with the help of vegetation mapping by using remote sensing data.

1.5Objective:

1. Mapping of Urban green space in major four cities of Punjab; Ludhiana, Amritsar,Chandigarh,Bathinda
2. Compute change detection in urban green space areas in four cities over the period frame 2000 to 2017.

1.6What is NDVI?

Researchers are required to observe the different colors (Radiations) of visible and near-infrared sunrays reflected by the plants to find out the density of green on land. When can be seen in a prism, many wavelengths produce the spectrum of sunlight. Some wavelengths are absorbed and other wavelengths are reflected, when sunlight strikes with objects. Plant leaves have pigment in, chlorophyll so they mostly absorbs the visible light (390 to 700 nanometers) for use in photosynthesis. On the other hand, the cell composition of the leaves strongly reflects near-infrared light (700 nanometers (nm) to 1 millimeter (mm).which plant have more leaves that affected the more wavelengths of light, respectively. Commonly, if there is reflected light in near-infrared wavelengths is more than in visible wavelengths, it means the vegetation in that pixel is expected to be dense and it may contain some type of forest. If there is very little variation in the amount of visible wavelengths and near-infrared wavelengths reflected, then the vegetation in that area is most likely sparse and may consist of grassland, tundra, or desert. (Weier, 2000)

NDVI is anarithmetical indicator which uses the red and near-infrared bands. And it is used to analyze the remote sensing measurements and also to recognize whether the target being observed contains live green vegetation or not. NDVI has found a no. of applications in vegetative mapping studies for example it used for the estimation of crop yields, pasture performance, and rangeland carrying capacities among others.Percent of ground cover, photosynthetic activity of the plants, surface water, leaf area index and the amount of biomassother ground parameters for which NDVI using. NDVI was firstly used by the Rouse from the Remote Sensing Centre of Texas A&M Universityin 1973. In general, healthy vegetation absorbs most part of the visible light that hits with it, and reflects a large part of the near-infrared radiation. Reflectance from the Unhealthy or sparse vegetation is much more in visible radiation and less in near-infrared radiation. Reflectance of the bare soils is moderate in both the red and infrared radiations of the electromagnetic spectrum. (Holm, 1987)

As we recognize the behavior of vegetation in the electromagnetic spectrum, we can calculate the NDVI information by directing the satellite bands which are most sensitive to vegetation information (near-infrared and red). The NDVI algorithm minus the red color reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands. Mathematical formula is:

$$NDVI = (NIR - VIS) / (NIR + VIS)$$

By this formulation we become able to handle the fact that two identical patches of vegetative area could have different values if one were. Theoretically, ratios of NDVI values ranging from -1 to 1 .In this practice extreme negative values shows water, bare soil represent by the values around zero and values over the 0.6 represent dense green vegetation. (Fahmi, 2016)

NDVI data in time sequence acquired by satellite sensors can reflect terrestrial vegetation growth status, seasonal aspect, and internal variation precisely. It has been commonly used for monitoring global and regional ecological environment variables and simulation, dynamic changes of vegetation cover research, vegetation phenology feature recognition and information extraction, and many other fields (Feng, 2016).

1.7Landsat 7 ETM +

The US (NASA and USGS) satellite remote sensing program was the first civil Earth-observing satellite program. It started by the first launch of Land sat satellites in 1972 and is continuing with Landsat 7, 8, still operational. The Landsat program has continuously collected spectral information from Earth's surface approximately from 40 years; this unparalleled data archive gives scientist the ability to assess changes in Earth surfaces. Since June 2009, the entire Land sat image archive are online freely available. Presently there are three series of Landsat.

Landsat 7 was successfully launched from the Western Test Range of Vandenberg Air Force Base, California, on a Delta-II expendable launch vehicle, on April 1, 1999, The Enhanced Thematic Mapper Plus (ETM+), Earth observing device on Landsat 7, replicates the capabilities of the highly successful Thematic Mapper instruments on Landsat 4 and 5.

LANDSAT 7 (15/04/1999 – still operational)

Altitude: 705 km Inclination: 98.2 degrees

Orbit: sun-synchronous polar Orbit period: 98.9 minutes

Revisit time: 16 days Scene size: 170 km x 183 km

Table 1.1 Bands of Landsat 7

Band	Spectral band	Resolution	Use
1	0,441 - 0,514 Âµm (Blue	30 m x 30 m	Ground/plant differentiation coastal zones
2	0,519 - 0,601 (Green	30 m x 30 m	Vegetation
3	0,631 - 0,692 Âµm (Red)	30 m x 30 m	Differentiate plant species
4	0,772 - 0,898 Âµm (NIR	30 m x 30 m	Biomass
5	1,547 - 1,749 Âµm (SWIR-1)	30 m x 30 m	Snow/cloud differentiation
6	10,31 - 12,36 Âµm (TIR)	60m x 60 m	Thermal
7	2,064 - 2,345 Âµm (SWIR-2)	30m x 30 m	Lithology
8	0,515 - 0,896 Âµm	15m x 15 m	

As its name indicates, this scanner is an enhanced version of the earlier TMs. It has a panchromatic wide band with high-resolution.[1]

[1]https://landsat.usgs.gov/what-are-band-designations-landsat-satellites

1.8 Sentinel-2A

The Sentinel-2A mission is a land monitoring asterism of two satellites that supply high resolution imagery and provide continuity for the current SPOT and Landsat missions. The mission provide a global coverage of the Earth landscapes in every 10 days with one satellite and 5 days with 2 satellites, making the data of great use in on-going studies. The satellites are outfitted with the state-of-the-art MSI (Multispectral Imager) device, which offers high-resolution optical imagery. The Sentinels are a raft of satellites designed specifically to distribute the wealth of data and imagery that are central to the European Commission's Copernicus program. Copernicus has been specially designed to meet user requirements.

Copernicus services deliver near-real-time data on a global level based on satellite and in situ observations, which can also be used for local and regional needs, to provide us a better understanding of our planet and sustainably manage the environment we live in. Copernicus data served by a group of dedicated satellites (the Sentinel families) The Sentinel satellites are specially planned to meet the requirements of the Copernicus services and their users. Sentinel-4 and -5 are instruments onboard EUMETSAT's weather satellites and Sentinel-1, -2, -3, -5P and -6 are dedicated satellites, while; Since the launch of Sentinel-1A in 2014, the European Union set in motion a process to place a constellation of almost 20 more satellites in orbit before 2030.

A partnership which is established between the European Space Agency (ESA) and the United States Geological Survey (USGS) allows for USGS storage and redistribution of data captured by the multispectral instrument (MSI) on the European Union's Sentinel-2A satellite launched in June 2015. The MSI sensor captured data in 13 spectral bands that are highly complementary to data captured by the USGS Landsat 8 Operational Land Imager (OLI) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+). Partnership between ESA and USGS provides public access and redistribution of global acquisitions of Sentinel-2A data freely, allowing users to download the MSI imagery from USGS access systems such as Earth Explorer in addition to the ESA Sentinels Scientific Data center. Present USGS Sentinel-2A archive is just a partial representation of all available acquisitions from ESA.

Resolution of Sentinel – 2A

Temporal resolution

The temporal resolution of any satellite is the repeat frequency of the satellite in orbit to a particular location. The revisit frequency of each single satellite of sentinel – 2A is 10 days and the combined constellation revisit is 5 days.

Spatial resolution

The spatial resolution of an instrument in any satellite is the at-ground representation of an individual detector. The spatial resolution of sentinel – 2A is dependent on the particular spectral band. 13 spectral bands in Sentinel-2, extend from the VNIR to the SWIR.

Featuring:

1. 10 m. of four bands blue (490 nm), green (560 nm), red (665 nm) and near-infrared (842 nm);
2. 20 m of six bands four narrow bands in the vegetation red-edge spectral domain (705 nm, 740 nm, 783 nm and 865 nm) and two large SWIR bands (1610 nm and 2190 nm).
3. 60 m of three bands at which are mainly dedicated to atmospheric corrections and cloud screening (443 nm for aerosol retrieval, 945 nm for water vapor retrieval and 1375 nm for cirrus cloud detection)[2].

[2]https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/resolutions/spatial

Table 1.2 Bands of Sentinel 2A

Band	Wavelength	Resolution
Band 2 – Blue	490nm	10
Band 3 – Green	560nm	10
Band 4 – Red	665nm	10
Band 8 – NIR	842nm	10
Band 5 – Vegetation Red Edge	705nm	20
Band 6 – Vegetation Red Edge	740nm	20
Band 7 – Vegetation Red Edge	783nm	20
Band 8A- Narrow NIR	865nm	20
Band 11 – SWIR	1610nm	20
Band 12 – SWIR	2190nm	20
Band1 Coastal aerosol	443nm	60
Band 9 – Water Vapor	940nm	60
Band 10 – SWIR – Cirrus	1375nm	60

Radiometric resolution: The radiometric resolution of an instrument tin any satellite is a determination of the gradual level of intensity or reflectance that can be showed or distinguished by the system. If radiometric resolution is greater, than sensed image will be more accurate. Radiometric resolution is routinely represented as a bit number, typically in the range of 8 to 16 bits. The radiometric resolution of Sentinel – 2A is 12-bit. This allows a potential range of brightness levels from 0 - 4 095.

CHAPTER 2: LITERATURE REVIEW

Urban green spaces have the important role in our life. It provide several types of benefits to the living ones.Green spaces in urban system supply a no. of ecosystem services including biodiversity conservation, removal of atmospheric pollutants, release of oxygen, noise reduction, mitigation of urban heat island effect, microclimate regulation, stabilization of soil, groundwater recharge, prevention of soil erosion and carbon sequestration(Sinha, 2013).

(Andrews, 12th September 2014)The authorin his Ph.D. thesis also address on the several benefits of urban green spaces with the help of different approaches urban green space also provide other type benefits like overall temperature of cities is lowered at an amount which is perceptible to humans; third, open green spaces usually function as corridors for fresh air supply and air circulation in general.The loss of urban green not only threatens urban climate and ecosystems, but may also affect a city's image and the residential satisfaction in general. Quantifiable information about green structures and the amount and distribution of green spaces is essential for sustainable planning (Lang, 2005).

(Yang, et al., 2017)Inthe author's article, shows that how urban green spaces can mitigate the effects urban heat island so that environmental problems may be resolved. In this study, landscape metrics and NDVI were used to characterize the structure features of urban green spaces. The outcome of this study suggested that the process of cooling effects of urban green spaces differed among different seasons and green types, and it may provide insights for city planners and decision makers to make sustainable urban strategies by considering the composition and configuration features of urban green spaces at the same time. In the first chapter of "Mapping and Quantitative Assessment of Vegetation of Jiribam Sub-Division, Imphal East District, Manipur, India using Remote Sensing and GIS"writer talks about the use of remote sensing and GIS technology in the vegetation mapping. According to this chapter remote sensing primarily has been used to stratify habitats, vegetation types, land use and other association. In Indiathe first ever forest cover mapping was carried out using Land sat imageries pertaining to period 1981-83 at 1:1 million scales.

(Lang, 2005)In their literature, they have stressed on the use of remote sensing in the vegetation mapping.

(Sharma & Jalan, 2013)They shows the change in the urban green spaces during the period of 2004 to 2009. In this study they were used the remote sensing techniques like LULC mapping and NDVI on the IRS P6 (LISS-IV) datasets. The results shows that in this five year period a significant decline has occurred in the extent of urban green spaces in Dehradun city with concomitant fragmentation resulting in considerable degradation of urban environment especially in southern parts of the city.

(Tiwari & Awasthi, 2018) The author's in their article, shows the change detection in urban area of Delhi over the period of four years from 2011 to 2015. For this study they have used Landsat 7ETM+ images as remote sensing data. In this study they calculate the NDVI and analyze the change detection in urban vegetation. The result shows that, the vegetation greenness (NDVI) has been reduced by 5% over the period of time while various fluctuations have been seen in different areas of Delhi.

(Saati, 2010)Shows that the study how to develop green areas in the Jiroft city in Kerman province, Iran. They have used remote sensing data of Landsat 7 ETM+ and GIS to identify the most appropriate sites and areas cultivated for ornamental species in the city. By this study they identified the potential for growth of ornamental species and for recreational development and tourism. They also use the NDVI in their study.

(Li,et al. 2016) In their article,talks about, the study of urban green spaces with the use of remotely sensed data. They use green area of City, Jiangsu Province is the new HJ NDVI selected as the case study area. They also conducted a field survey to better understand the vegetation in the study area and collect some pure vegetation samples for the evaluation of filters. The purpose of this study is providing a reference for NDVI time series renovation in fine spatial scale application.

In a another dissertation report, namely "Using GIS and Remote Sensing to Study Urban Green Structure Health And Dynamics", a student also used the remote sensing and GIS techniques to study the health of urban green structure in the city of

Kigali. For this study he used the data sources of Landsat 7.MODIS and SPOT. He used the pixel based and object based classification. For known the vegetation health index he used NDVI AND VCI. For the study of change detection he used change statics and landscape matrix. Highly stressed vegetation found in urban areas.

(Hu,et al. 2016)‘Use the Landsat Images and Open Social Data for mapping of urban land use. The study showsLarge-scale urbanization has had a dramatic impact on the environment and the wellbeing of seven hundred million urban residents’ Satellite-based remote sensing holds certain advantages in monitoring the dynamics of urban land use because of the large spatial coverage, high time resolution, and wide availability.

(Vorovencii, 2014) Determine the NDVI for different land covers before and after atmospheric corrections. For this study he used Land sat 5 Thematic Mapper (TM) satellite images. In this study the mean and standard deviation to show the variation in the NDVI values of before atmospheric corrections and after atmospheric corrections.

(P & B, 2014)Theyuse NDVI in the study of urban land covers. Landsat datahas been used for this study. In their study area they make many types of the vegetation index like water bodies, barren areas and rock surface, Shrub and Grass land, Moderate Green Areas, Very green areas, dense forests, Temperature and tropical forests by the use of USGS NDVI values.

CHAPTER 3:MATERIAL & METHODS

In this Section, the NDVI technique is used for recognize the various types of features presented in the Satellite Image of four major cities of Punjab. The detailed methodology has been illustrated as flowchart.

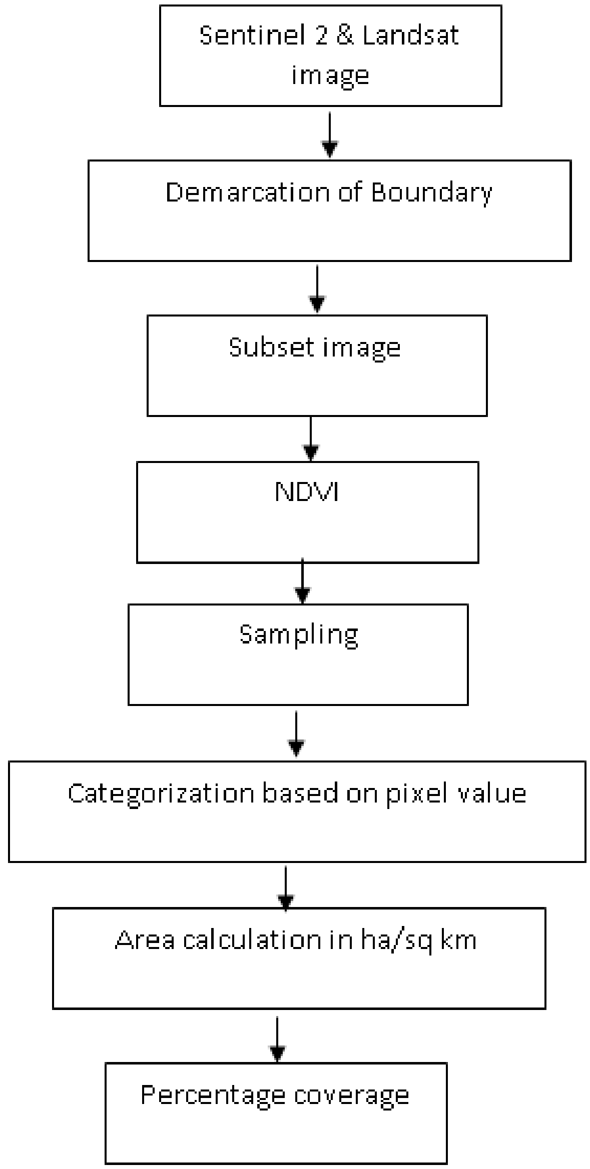


Fig: 3.1 Detail of Methodology

Data use

First step of my methodology was data collection.

Satellite data

For the both objectives the satellite images of the European Union's Sentinel-2 satellite with multispectral instrument (MSI) was used. Sentinel-2A satellite is a high resolution multi-spectral camera operating in 13 spectral bands (Green, Red, NIR,Narrow NIR Vegetation Red Edge, SWIR, Water vapor, Coastal aerosol).

Table 3.1 Information of Sentinel 2A Data

Sr. No	Data	Resolution	City	Year
1	Sentinal_2	10 meter	Ludihana	Feb 2017
2	Sentinal_2	10 meter	Amritsar	May 2017
3	Sentinal_2	10 meter	Chandigarh	Feb 2017
4	Sentinal_2	10 meter	Bathinda	Nov 2017

For second objective thesatellite data of LANDSAT 7 ETM+ Satellite Sensor was used. The Landsat 7 satellite is a medium resolution with enhanced thematic mappersensor operating in 8 spectral bands (Green, Red, NIR, SWIR-1, TIR, and PAN).

Table 3.2 Information of Landsat 7 Data

Sr.No	Data	Resolution	City	Year
1	LANDSAT 7	30 meter	Ludihana	Jan.2000
2	LANDSAT 7	30 meter	Amritsar	Mar-2000
3	LANDSAT 7	30 meter	Chandigarh	Feb.2000
4	LANDSAT 7	30 meter	Bathinda	Jan.2000

Data of Land use

For the data of land use under the municipal area taken from the Master plans of cities from the website PUDA and the city development plans (CDP) of the cities.

Boundary demarcation

The study deals with the municipal area of the city. For demarcation the boundary of municipal area of cities, two sources were used.

First source is Bhuvan and second is open series topo sheet on 1: 50, 000 scale. To demarcate theboundary of Ludhiana city and Bathinda city the Administrativeboundary which is provided by Bhuvan was used. For demarcation of the boundary of Chandigarh and Amritsar city open series map were used.

Table 3.3 Information of Topo sheet Data

City	Toposheet No.	Scale
Chandigarh	H43K9	1:50,000
Chandigarh	H43K10	1:50,000
Chandigarh	H43K13	1:50,000
Chandigarh	H43K14	1:50,000
Amritsar	H43C14	1:50,000

For made of vector layers of boundaries QGIS 2.18.1was used.

Subset the images

The satellite images which were downloaded have very large area but for my study area only the municipal area of cities were selected. So, for the area of different municipalities subset image is generated. For subset the images ERDAS IMAGINE 9.1 software is used.

NDVI

For Urban Green space mapping NDVI (Normalized Difference Vegetation Index) was used. NDVI is calculated from the red and near-infrared radiation reflected by vegetation. Healthy vegetation reflects the near-infrared rays, and absorbs most part of the visible light. For calculate the NDVI near-infrared light minus visible light divided by near-infrared light plus visible light. The outcome of this formula is called the Normalized Difference Vegetation Index.For NDVI calculation Arc GIS 2016 software are used Formula is:

$$NDVI = (NIR - VIS)/ (NIR + VIS)$$

For sentinal-2 images NDVI calculated by using of 8 and 4 bands .so, the formula is

$$NDVI = \frac{(Band\ 8 - band\ 4)}{(Band\ 8 + band\ 4)}$$

For Landsat-7 images NDVI calculated by using of 4 and 3bands.so, the formula is

NDVI= (BAND4-BAND3)

(BAND4+BAND3)

Sampling

For the Classification of images the sampling method was used. Sampling was done in ERDAS IMAGINE 2016.The sample size taken is 30. For theaccuracy of results the data is also verified by usingGoogle Earth.

Categorization based on pixel value

After sampling three categories were made on the basis of pixel value. Then by the use of Microsoft Excel Word 2010 area was calculated in ha/sq. km. and then calculate the percentage of area.

3.1 Study Area

Fig. 3.1 Base map of India.

Fig. 3.2 Base map of Punjab

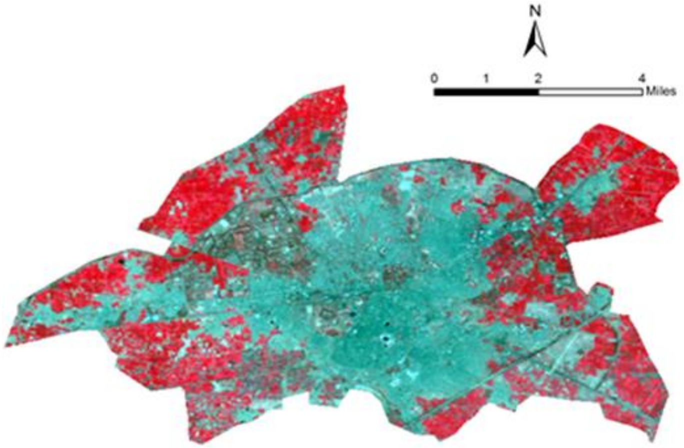


Fig.3.3: Map of Amritsar City

Fig.3.4 Map of Bathinda City

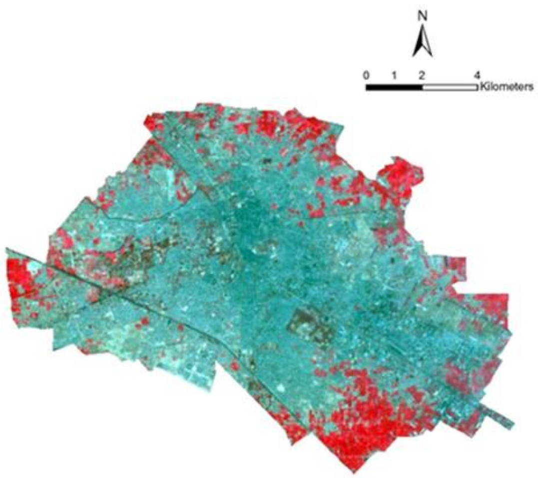


Fig.3.5: Map of Ludhiana City

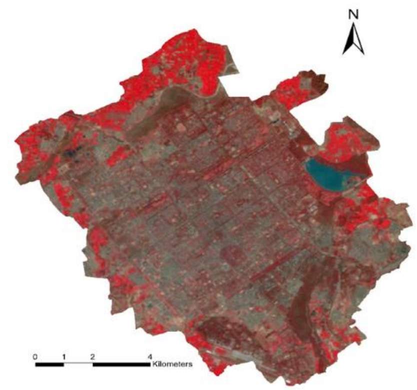


Fig.3.6. Map of Chandigarh City

Introduction to Chandigarh city

Chandigarh is planned city in India with a population of 961,587 in the year 2011. Chandigarh City is the joint capital of both the states of Punjab and Haryana. This City was declared as a Union Territory in the year 1966. Chandigarh is also the regional center of three adjoining States of Punjab, Haryana and Himachal Pradesh. It is the political and administrative hub of these adjoining States. The city is located near the foothills of the Sivalik range of the Himalayas in northwest India which form a part of the fragile Himalayan ecosystem. It is occupied by Kandi (Bhabhar) in the north east and Sirowal (Tarai) and alluvial plains in the remaining part. Area of Chandigarh is approximately 114 sq. km. The City shares its borders with the states of Haryana and Punjab. The Geographical Location of Chandigarh lies between 30.74°N and 76.79°E.the average elevation of Chandigarh is 321 meters (1053 ft). The city Chandigarh because of its unique concept is known as 'City beautiful'. It is one of the greenest cities of India with its 1400 green belts / parks/ gardens. The city Chandigarh is located in western side of river Gagger and Shimla National highway.

Climate, Temperature, Rainfall

The climate of Chandigarh is humid subtropical characterized by a seasonal variations: very hot summers, mild winters, unpredictable rainfall and great variation in temperature (−1°C to 46°C). The average annual rainfall of Chandigarh is 1,110 mm. winter season stars from November to January and temperature ranges between 4 degree Celsius to 14 degree Celsius. Te summers starts from April and ends in July, the temperature ranges between 37 degree Celsius to44 degree Celsius.Summerseasons starts from July run continuously to September. Annual rainfall of Chandigarh is 111.4 cm.

Vegetation: There are wide variety of trees, shrubs, herbs, grasses and climbers. The prominent among them are : Acacia catechu (Khair), Acacia modesta (Phulai), Acacia Arabica (Kikar), Acacia leucophloea (Raeru), Dalbergia sisoo (Shisham), Anogeissus latifolia (Chhal), Azadirachta indica (Neem), Bombax ceiba (Semal), Butea frondosa (Dhak), Bauhinia racemosa (Kachnar), Emblica officinalis (Amla), Morus alba (Tut), Lannea grandis (Jhingan), Diospyros montana (Kendu), Murraya koenigii (Kari patta), Prosopis etc (chandigarh Administration, 2016)Dense banyan and eucalyptus plantation is the Most common plantation of Chandigarh. The city has forests surrounding with total area is 3245.30 hectares. They have high ecological values with many animal and plant species. Parks keep an important role in planning and protecting environment. Leisure Valley, Rajendra Park, Bougainvillea Park, Zakir Rose Garden, Shanti Kunj, Hibiscus Garden, Garden of Fragrance, Botanical Garden, SmritiUpavan, Topiary garden and Terraced Garden are some of the famous parks in Chandigarh.

Introduction to Ludhiana City

Ludhiana is the biggest city of Punjab, from the terms of area and population. The expansion of the city over an area of 158 sq. km and accommodates approximately 1,693,653 population (2011 Census). This City is one of the major industrial and educational centers of northern India, and is the intersection of many different cultures. Now, Ludhiana city is commonly known as the "Manchester of India", the "hub of the Indian Hosiery Industry". Ludhiana is also well as Industrial Capital of small scale Industry in the country. The city is situated in district Ludhiana, which is the most centrally located district amongst the 22 districts of Punjab State. The area of the city falls under the Malwa region of the State of Punjab. The Geographical location of the city lies between north latitude 300 34' and 310 01' and east longitude 75o 18' and 76o 20'.

Topography: the Ludhiana city and its surrounding areas owes origin to aggravation work of river Satluj so the topography of Ludhiana city and its surrounding areas is a typical representative of an alluvial plain. Location of The city is centrally in the plain region which is marked for its flatness and featurelessness. The gradient of slope from east to west is gentle because the elevation of the city and its surrounding areas ranges from about 248.5 meters in the East to 244.0 meters in the west.

Climatic and seasons and their duration: The season of cold is starts almost from the middle of November to the early part of March. The later period up to June is the hot season. Monsoon season starts almost from June and run continuously in July, August and the first half of September. Mid-September to about the middle of November may be termed as the post monsoon or transitional period.

Temperature: the hottest month generally is June with the mean daily maximum temperature at 44.0 C and the mean daily minimum at 27.20 C. The coldest month is January. The mean daily Maximum temperature in January is 19.50 C and the mean daily minimum temperature is 6.4 0 C.

Rainfall: About 70 percent of the annual rainfall in the city is received during period from July to September. 16 percent of the rainfall is received during the period of December to March.

Vegetation: Dhraik or Bakain (Melia azadirachta) Kikar (Acacia nilotica) Neem (Azadirachta indica) Ber (Zizyphus mauritiana) Mango (Mangifera indica) Phalai (Acacia modesta) Shisham or Tahli (Dalbergia sissoo)are the trees and. Ak (Calotropis procera) Malah are shrubs and Chirian da dana (Eragrostis pislora) Madhana (Eleusine aegytiacum) Makra (Eleusine indic) Kutta ghass (Cenchsus catharticus) Takri ghass (Digitaria ischaemum) Swank (Paricum asusg) are the Grasses and broad leaf weeds are the types of vegetation found here. Parks and gardens are also keep an important role in planning and protecting environment. Ludhiana leisure Valley Park, Rakh Park, Nehru Rose Garden Park, Atam Park, are the major parks of Ludhiana city.

Introduction to Bathinda City

Bathinda is one of the oldest towns in the state of Punjab and has many historical associations. Bathinda is the 5th largest city of Punjab with population of 285,788 persons in 2011. It is located in Punjab and the administrative headquarter of Bathinda District. It is 225 km away from the state capital Chandigarh and is situated in the north-western region of India and is a part of the Indo-Gangetic alluvial plains. Bathinda is located in Malwa Region of Southern Punjab. The geographical location of Bathinda lies between 30˚-4'-30" N to 30˚-21'-20" N Latitude and 74˚-47'-50" E to 75˚-10'-00" E longitude .Its hinterland is fertile and rich in agriculture.

The soil of Local Planning Area, Bathinda is mostly sandy. But the topography in this area experienced a vast change with the various schemes connected with green revolution. No river flows through the Local Planning Area however Bathinda Branch of Sirhind Canal crosses in the middle providing a very good irrigation network. It is believed that earlier river Sutlej flew adjoining Bathinda Fort which later turned its course towards west.

Climate, Temperature, Rainfall: The climate of the Bathinda city is mainly characterized by a very hot summer, a short rainy season and a cold winter. Summer season in Bathinda starts from March and till extends June. It experiences extreme summer season because of its location is close to the Thar Desert of Rajasthan and the temperature during this season become extremely hot. In the month of June, temperature increases to even 47 degree Celsius and at some times, the dust storms are a regular feature in this season. In the Bathinda city rainfall is mainly the result of south-west monsoon. It receives scanty rainfall in the peak monsoon season; the average rainfall in the area is about 410 mm. The winter season in Bathinda starts in November and continues till February. The coldest month of the Bathinda is January, with the mean daily maximum temperature of about 21 degree Celsius and the mean daily minimum of about 4 degree Celsius. Nights are extremely frigid in and around the city. Bathinda is affected by cold waves in this season in the rear of passing western disturbances.

Vegetation: The types of plants found here are Pipal, Kikar, Shisham, Siris, Neem, Khair etc. Some exotic species of plants found in Bathinda are Sagwan, Mysore Gum, etc. Ground flora of Bathinda primarily consists of herbs and grasses. Parks keep an important role in planning and protecting environment. In Bathinda city green areas mainly in Rose garden, phases parks of model town, Rajindra hockey stadium, sports stadium, etc. parks and outside the roads and in the house.

Introduction to Amritsar city

Amritsar is one of the largest citiesin Punjab, and the home of Golden Temple (Harmandir Sahib. This is the most important city of the Majha region of Punjab, on the east bank of the Beas River, is a repository of spiritual and national heritage. It is administrative headquarter of Amritsar district. The location coordinates of Amritsar district lies between 31° 29' and 32° 03' North latitudes and between 74° 29' and 75° 23' East longitudes It has semi-arid climate and facing four seasons primarily winter (November to March), summer (April to June), monsoon (July to September) and post-monsoon season (September to November).Annual rainfall is about 681 millimeters.

Topography: As Punjab Plain is a part of Indo-Gangetic system, Amritsar also has alluvial deposits brought by Beas and Ravi Rivers. The soil in Amritsar is a light reddish-yellow loam (colloquially called maira) that becomes somewhat stiffer at the Doab, finally deteriorating into sandy and slightly uneven soil (colloquially called tibba. Amritsar has a levelled plain area situated at an elevation of about 200 meters.

Climate, Temperature, Rainfall: Amritsar has semi-arid climate and facing four seasons. During the summers and winters climate remains very extreme. In Amritsar winters starts almost from November to the March. Monsoon starts from July to onwards till September which is then followed by Post Monsoon which goes on till the begging of November month. Summers starts from April and go on till the June. In these months the city faces very hot air which also leads to a lot of humidity in the city. The district has a continental climate typical of North-West Indian region. It comprises of theIn winter season temperatures ranges from 16 °C (61 °F) to about 4 °C (39 °F), the hot season when temperatures can reach 45 °C (113 °F), monsoon season and post-monsoon (September to November). The annual rainfall is about 790 millimeters (31.1 in). The lowest recorded temperature since 1970 is −2.6 °C (27 °F) recorded on 21 Jan 2005. The highest temperature recorded was 47.7 °C (117.9 °F) on 21 May 1978.

Vegetation: The types of plants found here are Pipal, Kikar, Shisham, Siris, Neem, Khair etc there are found some medicinal value vegetation like Arjuna(Terminalia arjuna) Aragvadh(Cassia fistula) Amra(Mangifera indica) are trees Ashvagandha (Withania somnifera) Atibala(Abutilon indicum) are the shrubs Arka (Calatropis procera) Bhringraj (Eclipta alba) are the herbs. Amrit Anand Park, Kaiser Bagh, Amritsar Company Bagh, Jallianwala Bagh, Rambagh Gardens are the major parks in Amritsar.

CHAPTER 4:RESULTS & DISCUSSION

By the use of red and NIR bands which are sensitive for the vegetation NDVI is calculated of the four cities of Punjab as Ludhiana, Bathinda, Chandigarh, and Amritsar for 17 years. The reflectance of the vegetation is vary in these all cities. Because the data of different seasons has been used.

According to the results of this study urban green spaces vary From city to city. In the four cities of Punjabland under different categories is also vary. Changes in the Area under green spaces from 2000 year to 2017 year also vary in these cities. The results of Bathinda and Chandigarh city shows positive changes in the land under green spaces and in the Amritsar and Ludhiana city results shown negative changes in the area under urban green spaces.

NDVI Map of Chandigarh City

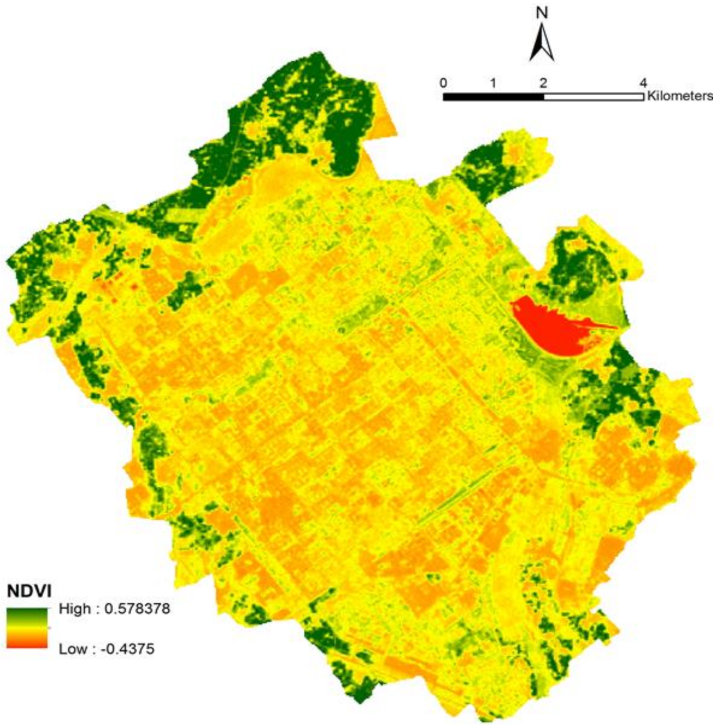


Fig. 4.1: NDVI of Landsat 7 data

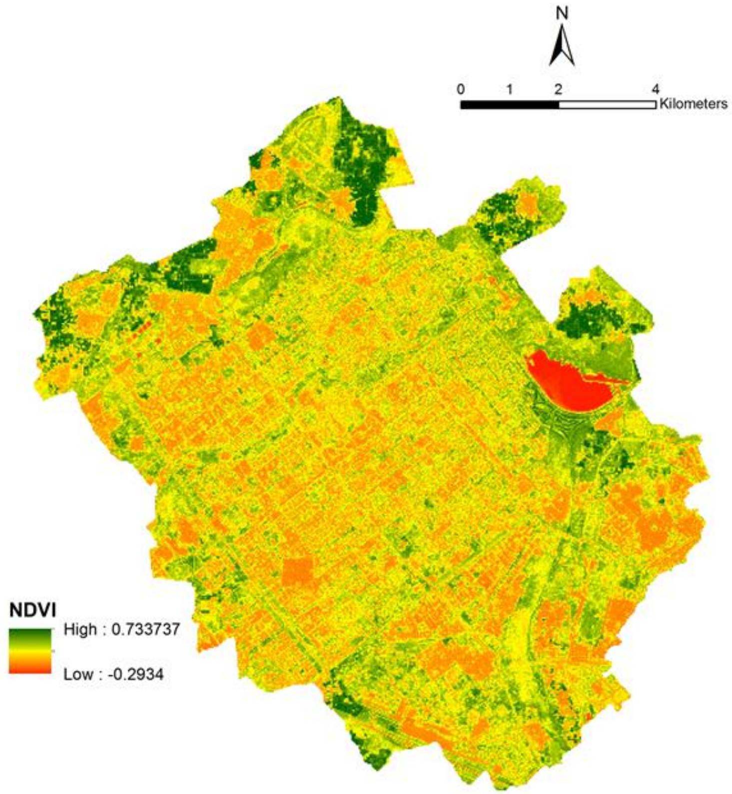
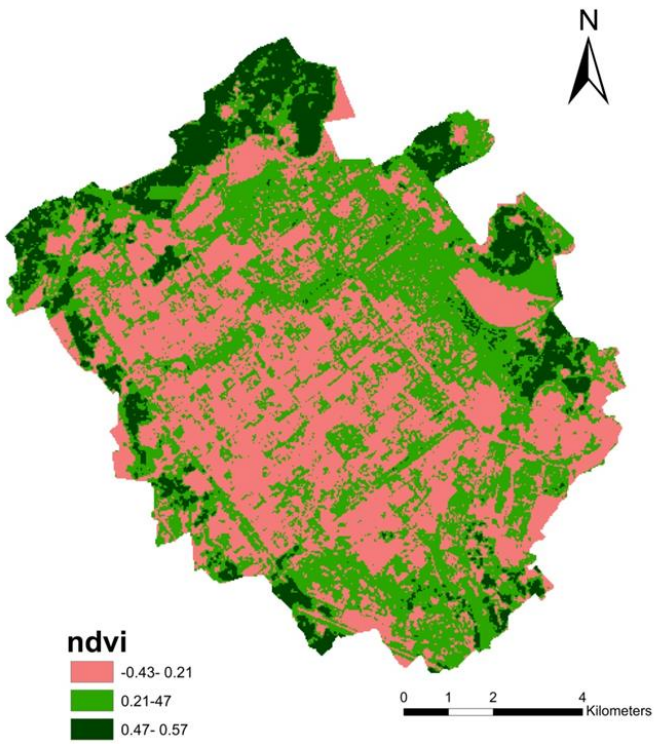


Fig. 4.2: NDVI of Sentinel 2Adata

Fig.4.1 and Fig.4.2 show the NDVI of the Chandigarh City in two different years. First map shows the value of NDVI in the year of 2000.This map is made by use of Landsat 7 ETM+ data with 30m spatial resolution. The value of NDVI is range from -0.4375 to 0.578378. It means highest NDVI value for Landsat 7 ETM+ data map is 0.578378 for vegetated areasand the lowest NDVI value is-0.4375 for no vegetated areas. In this map dark green color shows the high NDVI value and yellow color shows medium value of NDVI and orange color shows lowest NDVI.

Second map shows the value of NDVI in the year of 2017.this map is made by use of sentinel -2 Data with 10m spatial resolution. The value of NDVI is range from -0.4375 to 0.578378. It means highest NDVI valuefor Landsat data map is 0.733737 and the lowest NDVI value is-0.2934.   In this map dark green color shows the high NDVI value and yellow color shows medium value of NDVI and orange color shows lowest NDVI.

Categorizedd Map of NDVI Chandigarh City



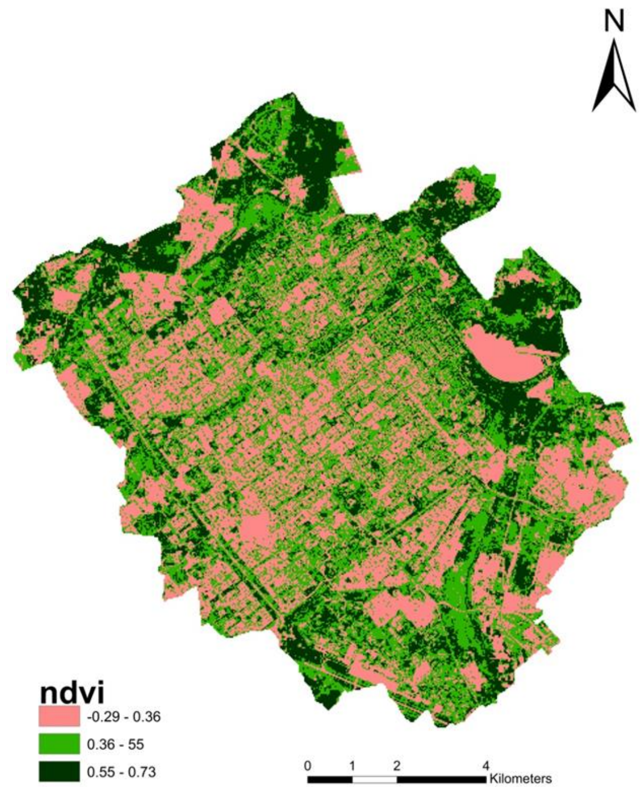


Fig.4.3:Catogorized Map of NDVI Landsat 7

Fig.4.4:Catogorized Map of NDVI sentinel 2A

Fig.4.3 and Fig.4.4 are the catogorized map of NDVI Candigah City of two different years. Both the maps show three catories of NDVI values, these categories shows by three different colours. First map shows the categorized NDVI map of the year 2000. In this map there are three catogories of NDVI values assigned, first category is -0.43-0.21 which is shows by pink colour and this category is used for other landuses in the Chandigarh city. Other landuses included built-uparea, roads,and other open and fallow lands. Second catogoy is 0.21-0.47 which is shows the light green colour and this catogory is used to show green spaces other than agriculture in the Chandigarh city. The third category is 0.47-0.57 which shows the dark green color and this category is used for highlighting the agriculture lands of the Chandigarh city.

The second map shows the categorized map of 2017 year NDVI. In this map there are three categories of NDVI values assigned. First category is -0.29-0.36 which is shows the pink colour and this category is used for otherland uses in the Chandigarh city. Other land uses included built-up area, roads, and other open and fallow land uses. Second category is 0.36-0.55 which shows the light green colour and this categoryis used for shows green spaces other than agriculture in the Chandigarh city. Third category is 0.55-0.73 which shows the dark green colour and this categoryis used forhighlighting of agriculture in the Chandigarh city.

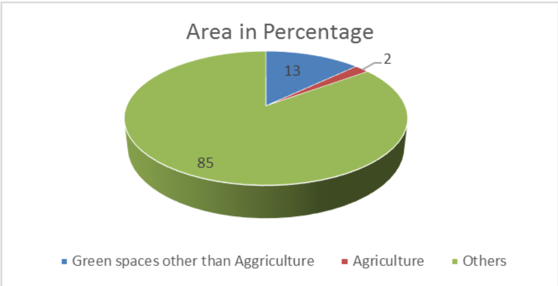


Fig.4.5:Area Percentage of Chandigarh city (2000)

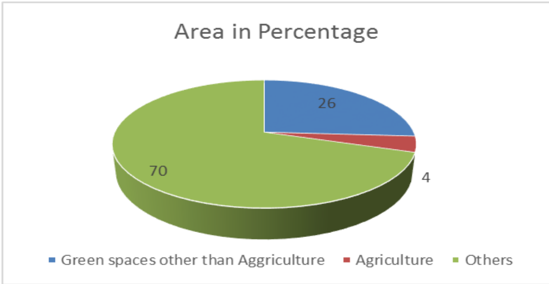
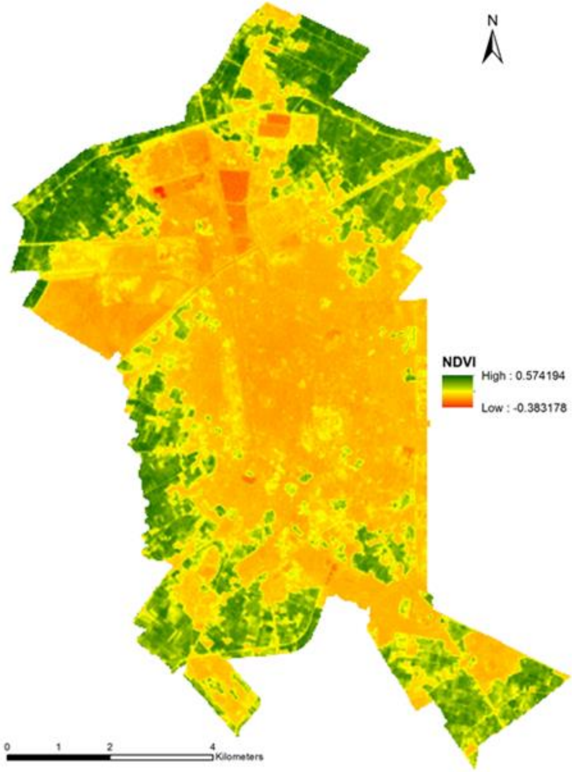


Fig.4.6:Area Percentage of Chandigarh city (2017)

Results: the results shows with the help of pie diagram, red colour in this pie diagram shows agriculturalarea, blue colour shows green spaces other than agricultureandgreen colour is used to shows other land use categories. There is a number of changesappear in the NDVIvalue and area under different land uses between two different years.Total area of Chandigarh is approximate 114 sq.km.from the analysis of maps the results shows is there is gradual negative change in the area under other land use category. In the year 2000the area under other land use category is approximate 97.4km (85 percent). But in the 2017 the area under other land use is decrease. In the 2017 area under other land use category is 79.8(70 percent).the results show the positive change in the area under green spaces other than agriculture. In the year 2000 the area under green spaces other than agriculture is approximate 14.88km (13percent). But in the 2017 the area under green spaces other than agriculture increases. In the 2017 area under other green spaces other than agriculture is 29.56km (26percent).The results show the positive change in the area agriculture. In the year 2000 the area under agriculture is approximate 2.30km (2 m percent) But in the 2017 the area under agriculture increase. In the 2017 area under agriculture is 4.64km (4percent).

NDVI Map Of Bathinda City



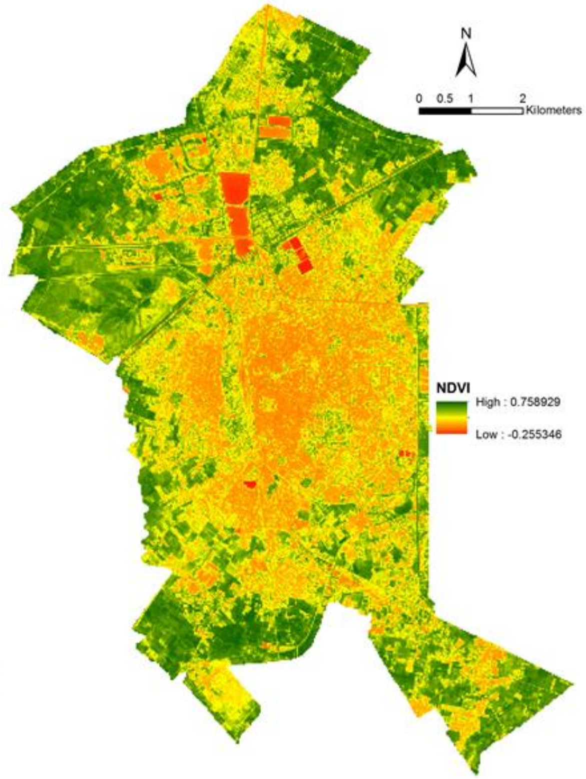


Fig. 4.7: NDVI of Landsat 7 data

Fig.4.8: NDVI of Sentinel 2A data

Fig.4.7 and fig.4.8 show the NDVI of the Bathinda City in two different years. First map is shows the value of NDVI in the year of 2000.this map is made by use of Landsat 7 ETM+ data with 30m spatial resolution. The value of NDVI is range from -0.383178 to 0.574194. It means that the highest NDVI value for land sat data map is 0.574194 forvegetated areasand the lowest NDVI value is-0.383178 for no vegetated areas. In this map dark green colour shows the high NDVI value and yellow colour shows medium value of NDVI and orange colour shows lowest NDVI.

Second map shows the value of NDVI in the year of 2017. This map is made by use of sentinel – 2A data with 10m spatial resolution. The value of NDVI is ranging from -255346 to 0.758929. It means that the highest NDVI value for landsat data map is 0.758929 and the lowest NDVI value is-255346. In this map dark green colour shows the high NDVI value and yellow colour shows medium value of NDVI and orange color shows lowest NDVI.

Categorized Map of NDVI Bathinda City

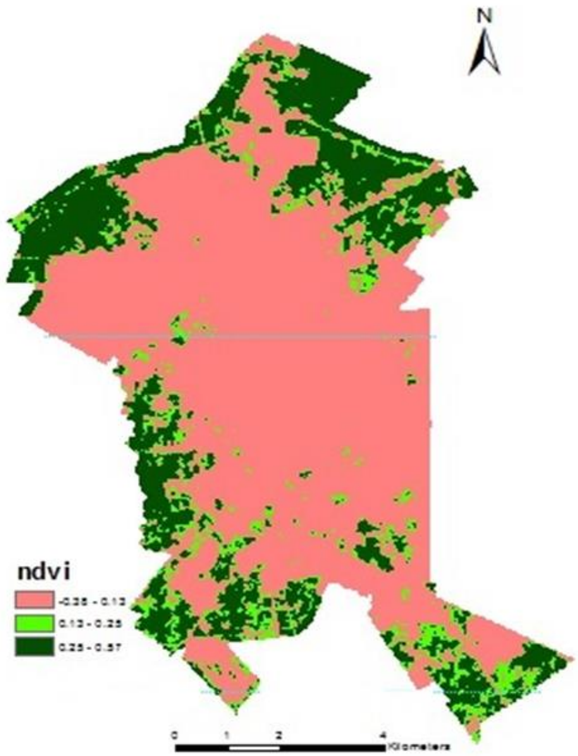


Fig.4.9: Categorized Map of NDVI Landsat 7

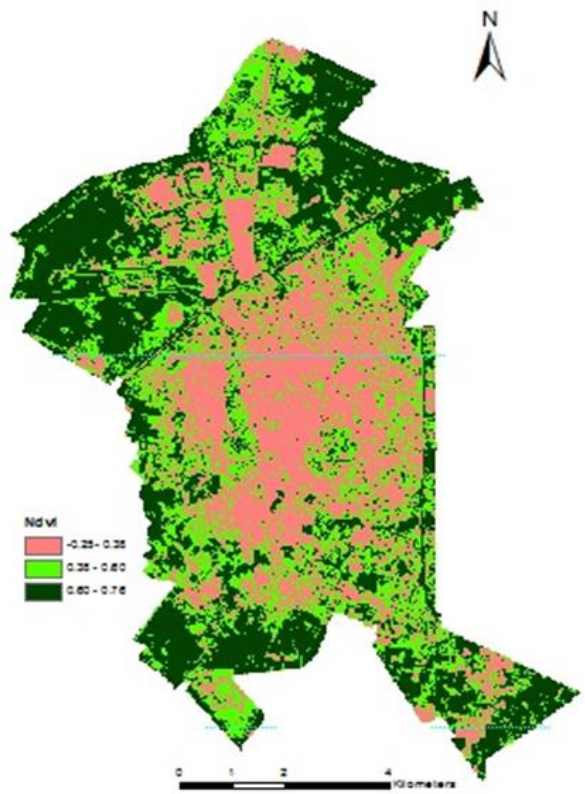


Fig.4.10: Categorized Map of NDVI sentinel 2A

Fig.4.9 and Fig 4.10 are the categorized map of NDVI Bathinda City of two different years .in these maps show three categories of NDVI value. These categories show by three different colours. First map shows the categorized NDVI map of the year 2000. In this map there are three categories of NDVI value assigned. First category is -0.28-0.12 which is shows by pink colour and this category is used for other land uses in the Bathinda city. Other land uses included built-up area, roads, and other open and fallow land. Second category is 0.12-0.25 which shows the light green color and this category is used to show green spaces other than agriculture in the Bathinda city. Third category is 0.25-0.57 which shows the dark green colour and this category is used for shows agriculture in the Bathinda city.

Second map shows the categorized map of 2017 year NDVI .in this map there are three categories of NDVI value. First category is -0.25-0.28 which is shows by pink color and this category is used for other landuses in the Bathinda city. Other land uses included Built-up area, Roads, and other open and fellow land. Second category is 0.28-0.40 which shows the light green color and this category is used to show the green spaces other than agriculture in the Bathinda city. Third category is 0.40-0.75 which shows the dark green color and this category is used for highlighting of agriculture in the Bathinda city.

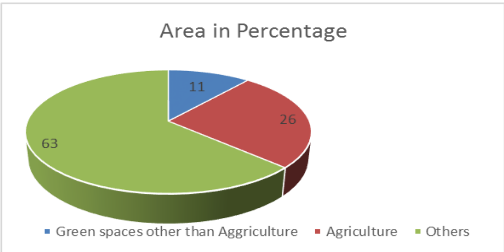


Fig.4.11 Area Percentage of Chandigarh city (2000)

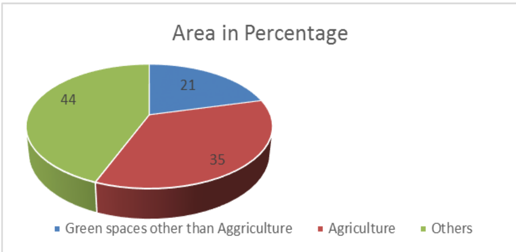
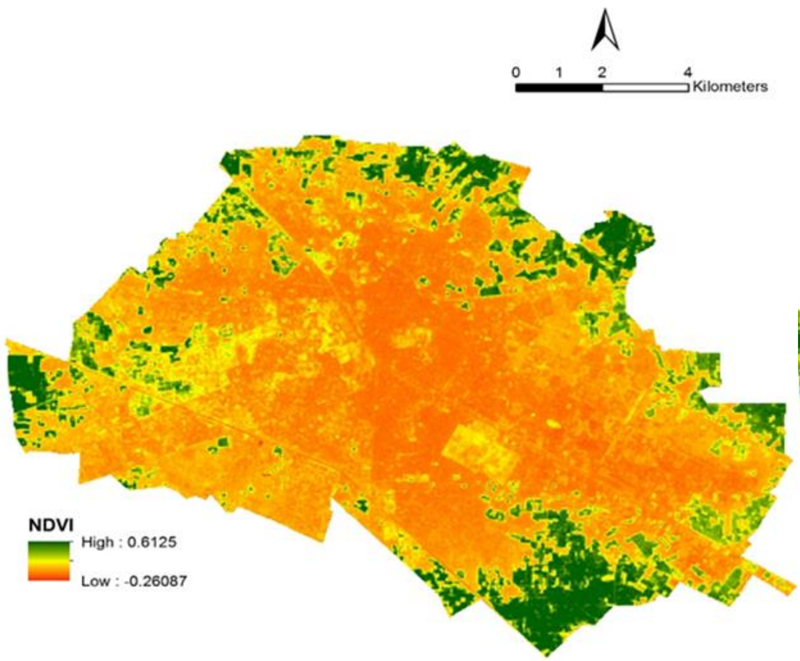


Fig.4.12 Area Percentage of Chandigarh city (2017)

Results: the results shows with the help of pie diagram, red color in this pie diagram shows agricultural area, blue color shows green spaces other than agriculture and green color is used to show other land use categories. There is a number of changes appear in the NDVI value and area under different land uses between two different years. Total area of Bathinda city is approximate 68 km.from the analysis of maps the results show that there is a gradual negative change in the area under other land use category. In the 2000year the area under other land use category is approximate 43.00km (63 percent). But in the 2017 the area under other land use is decreasing. In the 2017 area under other land use category is 29.98(44 percent).the results show the positive change in the area under green spaces other than agriculture. In the year 2000 the area under green spaces other than agriculture is approximate 7.5 km (11 percent) But in the 2017 the area under green spaces other than agriculture increase. In the 2017 area under other green spaces other than agriculture is 23.80km (35percent). The results show the positive change in the area agriculture. In the year 2000 the area under agriculture is approximate 17.70 km. (26 percent), but in the 2017 the area under agriculture increases. In 2017, the area under agriculture is approximate 14.3km (21percent).

Map of NDVI Ludhiana City



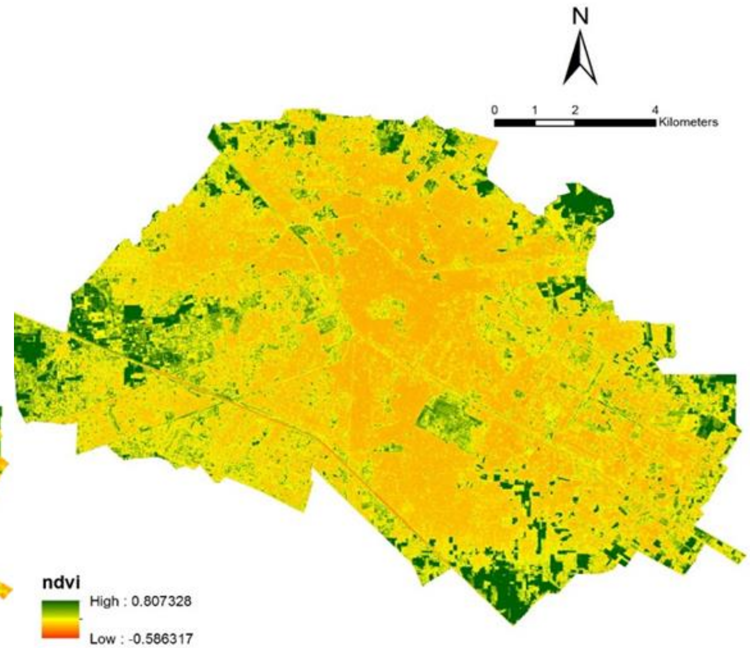


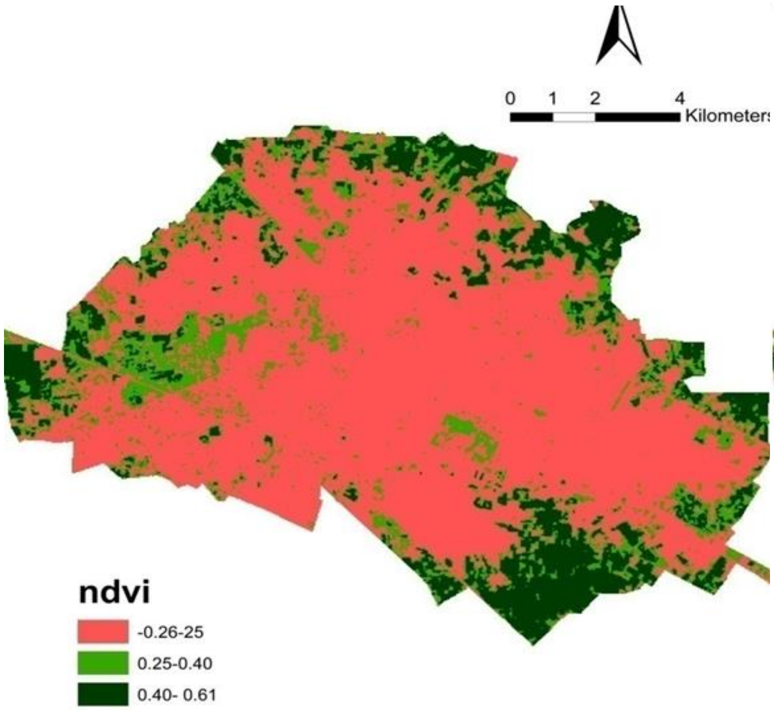
Fig. 4.13: NDVI of Landsat 7 data

Fig.4.14: NDVI of Sentinel 2A data

Fig.4.13 and fig 4.14 show the NDVI of the Ludhiana City in two different years. First map is shows the value of NDVI in the year of 2000. This map is made by use of Land sat 7 data with 30m spatial resolution. The value of NDVI is range from 0.6125 to -0.26087. It means that the highest NDVI value for Landsat 7 ETM+ data map is0.6125 forvegetated areas and the lowest NDVI value is -0.26087 for no vegetated areas. In this map dark green color shows the high NDVI value and yellow color shows medium value of NDVI and orange color shows lowest NDVI.

Second map shows the value of NDVI in the year of 2017. This map is made by use of sentinel – 2A data with 10m spatial resolution. The value of NDVI is range from -0.586317 to 0.807328. It means highest NDVI value for land sat data map is 0.807328 and the lowest NDVI value is-0.586317. In this map dark green color shows the high NDVI value and yellow color shows medium value of NDVI and orange color shows lowest NDVI.

Categorized Map of Ludhiana city



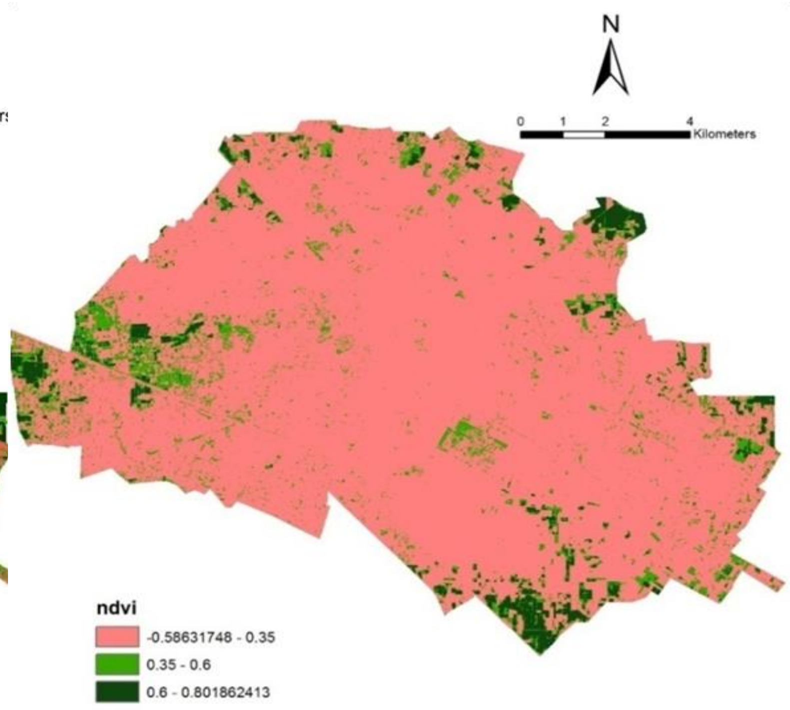


Fig.4.15: Categorized Map of NDVI Landsat 7

Fig.4.16: Categorized Map of NDVI sentinel 2A

Fig.4.15 and Fig.4.16 are the categorized map of NDVI Ludhiana city of two different years. The maps show three categories of NDVI value. These categories show by three different colours. First map shows the categorized map of 2000 year NDVI. In this map there are three categories of NDVI value. First category is -0.26-0.25 which is shows by pink color and this category is used for other land uses in the Ludhiana city. Other land uses included built-up area, roads, and other open and fallow land. Second category is 0.25-0.40 which is shows by light green color and this category is used to show the green spaces other than agriculture in the Ludhiana city. Third category is 0.40-0.61 which is shows by dark green color and this category is used to show agriculture in the Ludhiana city.

Second map shows the categorized map of 2017 year NDVI. In this map there are three categories of NDVI value. First category is -0.58-0.35 which is shows by pink color and this category is used for other land uses in the Ludhiana city. Other land uses included built-up area, roads, and other open and fallow land. The second category is 0.35-0.60 which shows the light green color and this category is used to show the green spaces other than agriculture in the Ludhiana city. Third category is 0.60-0.80 which shows the dark green color and this category is used to show the agriculture in the Ludhiana city.

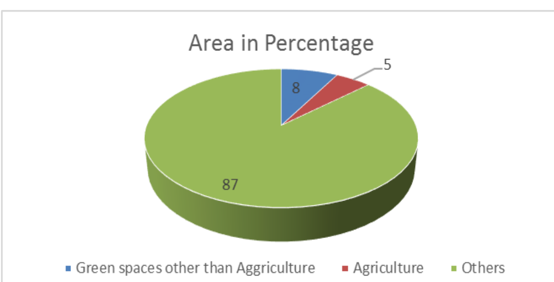


Fig.4.17 Area Percentage of Chandigarh city (2000)

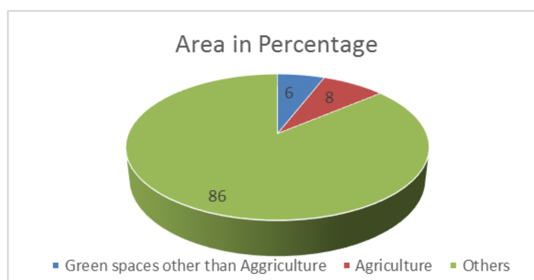
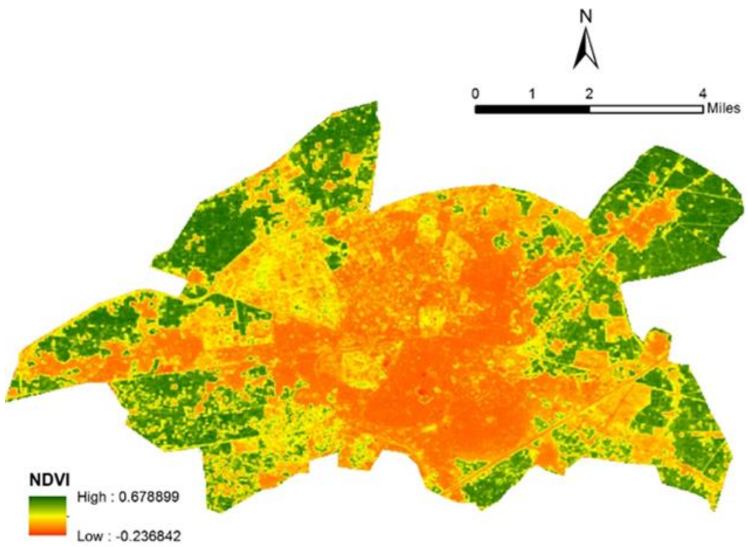


Fig.4.18 Area Percentage of Chandigarh city (2017)

Results: The results shown is with the help of pie diagram, red colour in this pie diagram shows agricultural area, blue colour shows green spaces other than agriculture and green color is used to shows other land use categories. There is a number of changes appear in the NDVI value and area under different land uses between two different years. Total area of Ludhiana city is approximate 158sq.km. From the analysis of maps the results show that there is gradual positive change in the area under other land use category. In the year 2000the area under other land use category is approximate km 136.00(86percent). But in the 2017 the area under other land use is increase. In the 2017 area under other land use category is 137.5(87 percent). The results show the positive change in the area under green spaces other than agriculture. In the year 2000 the area under green spaces other than agriculture is approximate 9.5 (6 percent). But in the 2017 the area under green spaces other than agriculture increases. In the 2017 area under other green spaces other than agriculture is km12.69 km (8 percent).The results show the negative change in the area agriculture. In the year 2000 the area under agriculture is approximate 12.7(8 percent)But in the 2017 the area under agriculture decrease. In the 2017 area under agriculture is approximate7.9 km. (5 percent)

Map of NDVI Amritsar City



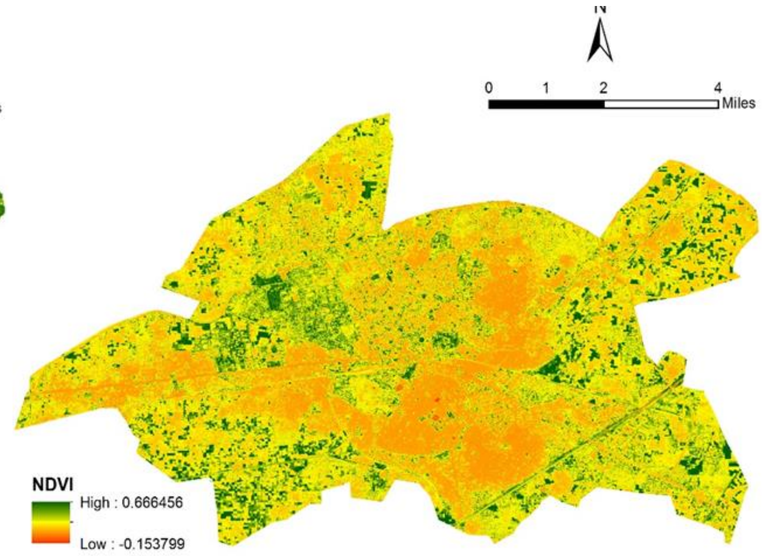


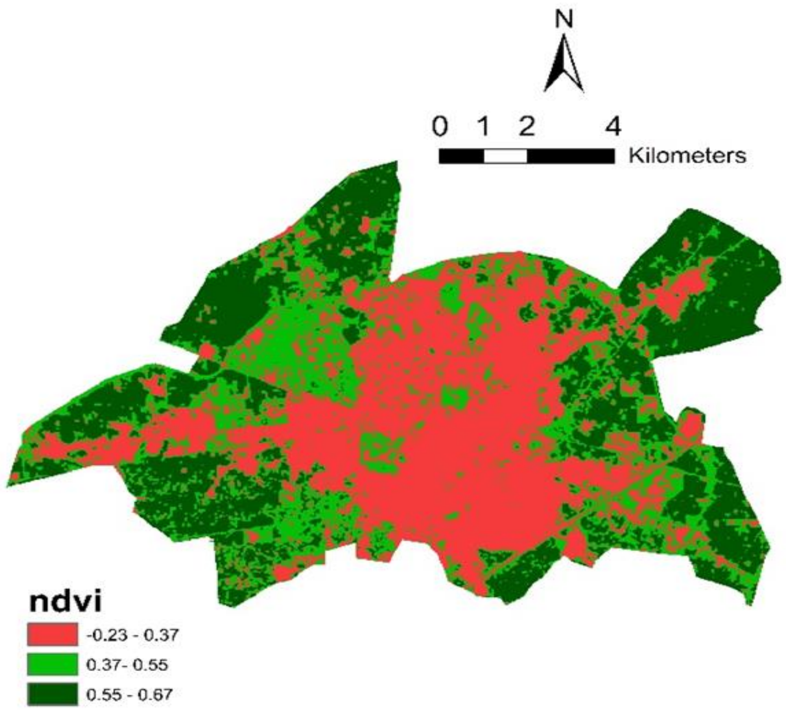
Fig. 4.19: NDVI of Landsat 7 data

Fig.4.20: NDVI of Sentinel 2A data

Fig.4.19 and Fig.4.20 show the NDVI of the Amritsar city in two different years. First map is shows the value of NDVI in the year of 2000. This map is made by use of Land sat 7 ETM+ data with 30m spatial resolution. The value of NDVI is range from -0.153799 to 0.666456. It means that the highest NDVI value for land sat data map is 0.666456 forvegetated areas and the lowest NDVI value is -0.153799 for no vegetated areas. In this map dark green colour shows the high NDVI value and yellow colour shows medium value of NDVI and orange colour shows lowest NDVI.

Second map shows the value of NDVI in the year of 2017.this map is made by use of sentinel – 2A data with 10m spatial resolution. The value of NDVI is range from -0.236842 to 0.678899. It means that the highest NDVI value for land sat data map is 0.678899 and the lowest NDVI value is-0.236842. In this map dark green colour shows the high NDVI value and yellow color shows medium value of NDVI and orange color shows lowest NDVI.

Categorized Map of Amrisar City



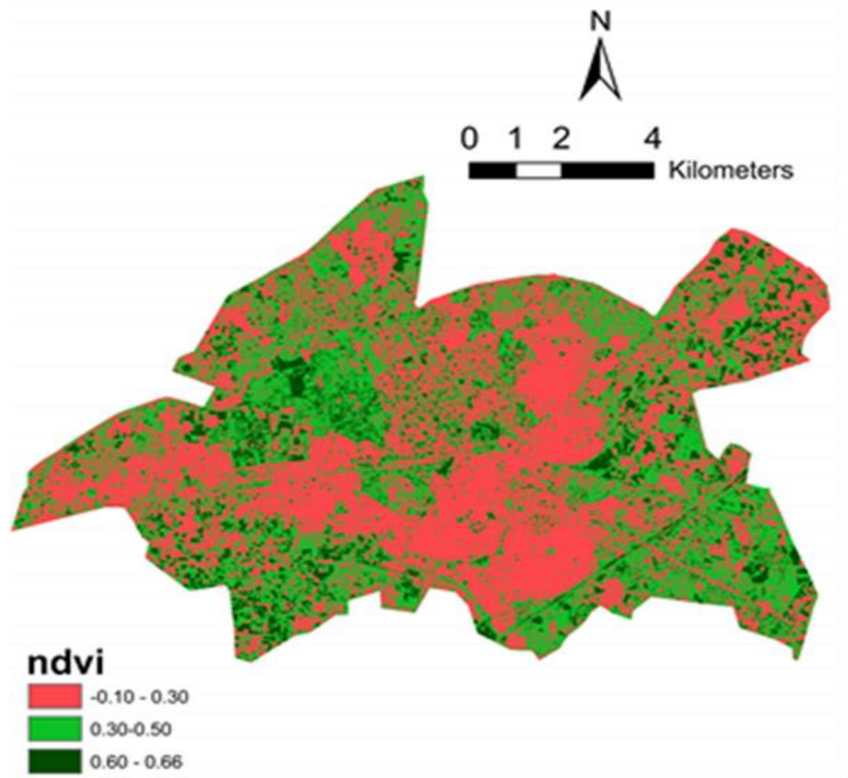


Fig.4.21: Categorized Map of NDVI Landsat 7

Fig.4.22: Categorized Map of NDVI sentinel 2A

Fig.4.21 and Fig.4.22 are the categorized map of NDVI Amritsar city of two different years .in these maps show three categories of NDVI values. These categories show by three different colours. First map shows the categorized map of 2000 year NDVI .In this map there are three categories of NDVI values. First category is -0.23-0.37which is shows by pink colour and this category is used for other land uses in the Amritsar city. Other land uses included built-up area, roads, and other open and fallow land. Second category is 0.37-0.55 which is shows by light green color and this category is used to show green spaces which areshown by dark green color and this category is used to show the agriculture in the Amritsar city.

Second map shows the categorized map of 2017 year NDVI. In this map there are three categories of NDVI value. First category is -0.10-0.30 which shows the pink colour and this category is used for other land uses in the Amritsar city. Other land uses included built-up area, roads, and other open and fallow land. Second category is 0.30-0.50 which shows the light green colour and this category is used to show the green spaces other than agriculture in the Amritsar city. Third category is 0.60-0.66 which shows the dark green colour and this category is used to show the agriculture in the Amritsar city.

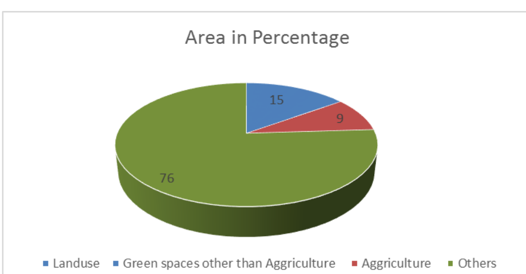


Fig.4.23: Area Percentage of Chandigarh city (2000)

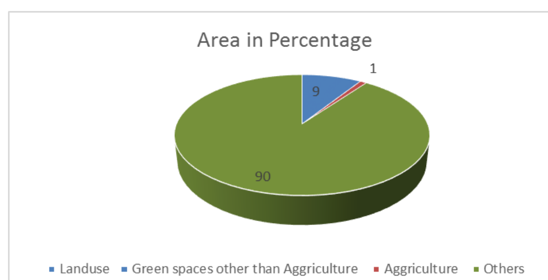


Fig.4.24: Area Percentage of Chandigarh city (2017)

Results: The results shows with the help of pie diagram, red colour in these pie diagrams shows agricultural area, blue colour shows green spaces other than agriculture and green colour is used to shows other land use categories. There is a number of changes appear in the NDVI value and area under different land uses between two different years. Total area of Amritsar city is approximate 142 sq.km. From the analysis of maps the results shows is there is gradual positive change in the area under other land use category. In the year 2000, the area under other land use category is approximate km 108(76percent). But in the 2017 the area under other land use is increase. In the 2017 area under other land use category is 127.9(90 percent).the results show the positive change in the area under green spaces other than agriculture. In the year 2000 the area under green spaces other than agriculture is approximate 21.34 (15 percent). But in the 2017 the area under green spaces other than agriculture decreases. In the 2017 area under other green spaces other than agriculture is 12.9 km (9 percent). The results show the negative change in the area agriculture. In the year 2000 the area under agriculture is approximate 13.00(9 percent) But in the 2017 the area under agriculture decrease. In the 2017 area under agriculture is approximate 1.5km. (1 percent)

CONCLUSION

On the basis of mapping of Chandigarh, Bathinda, Ludhiana and Amritsar cities it can be concluded that changes has been recorded in the urban green spaces. The Land Sat 7 and Sentinel 2 data has been used for present study and on the basis of mapping it is observed that In Chandigarh city during the period of 2000 the total green space was 13 percent that has changed, in present scenario the areas has increase up to 26 percent showing 100 percent increase. Secondly, in the concern of Bathinda city the total area under green space was 11 percent during 2000 and in 2017 it was 21 percent showing 90 percent increase in green spaces. Ludhiana city showing decline in green cover that was 8 percent in 2000 and during 2017 it was 6 percent showing 25 percent decline. Apart from these Amritsar city recorded decrease in green cover that was 15 percent in 2000 and now it is 9 percent. So, the study concluded that Positive changes appears in the urban green spaces of the Chandigarh and Bathinda city and negative changes appears in the green spaces of Ludhiana and Amritsar city.

Limitation

The data that has been used for research has certain shortcoming such as:

1. The resolution of Landsat 7 is 30 meter and Sentinel 2 is 10 meter showing that is major drawback of data. Landsat 7 resolution is 30 meter and on the other Sentinel 2 resolution is 10 meter that is capable of showing clear and detailed information of different features on ground surface.
2. The data which has been used for present study varies from season to season that are the reason showing changes in the results. In the case of Bathinda city whereas November, 2017 data has been used instead of February.
3. In general, reflectance of mature trees matches with reflectance of crops that are the reason it is difficult to separate from each other.
4. For the study purpose agriculture land is not considered as green cover because agriculture land is private land and not use for public purpose.

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