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Analysis of Urban Green Spaces using Geospatial Techniques: A case study of Chandannagar Municipal Corporation, Hugli, West Bengal, India

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Abstract

Urbanization is a global phenomenon that is a natural outgrowth of human social progress which has both positive and negative effects. Urban green space is seen as a crucial component of preserving the wellbeing of urban ecosystems, ensuring a healthy coexistence between humans and other species and eventually achieving urban sustainability by enhancing air and water quality and reducing urban heat island. Urban green spaces serve as a link between the city and nature. Green areas have a positive impact on the environment by promoting biodiversity, reducing air pollution, attenuating the effects of heat islands, and reducing noise pollution. They are particularly essential in urban areas because they have positive social effects, the abundance of recreational activities, encourage social interaction and integration, and help to promote both physical and mental health. It is currently required for city design and planning initiatives to maintain a substantial section of the urban area covered by vegetation. However, rapid and unplanned development, particularly in India, is causing an alarming rate of loss of urban green space. The ecological balance of the urban centers has been seriously threatened. Through this paper the present work is carried out to identify some factors that contribute to the growing urban population, the rate of residential development, and how these factors affect the urban environment. Finally, we are intending to determine the best method for managing the urban environment through the use of advanced technologies.

Keywords: Urban Green Space; NDVI; Landuse/cover; Supervised Classification; Urbanization; Biodiversity; Green Belt

1. Introduction

Urbanization is the most powerful socio-economic component of modernity. In India urbanization has come to occupy an important place in economic development of different regions. Urban development is a direct and immediate concern to 26 percent of population who live in towns and cities (Mandal, 2000). Nowadays, a large portion of the population resides in urban areas. In addition, the city's natural habitats are ruined and degraded by urban expansion. However, in high-stress urban areas, exposure to environment is essential for human health and wellbeing. Exposure to green spaces and the observation of nature provided well-being and psychological relief from urban stress. Urban nature offers important opportunities for nature education, providing outdoor labs and play areas. Nature provides an important place in the cultural landscapes through its scarcity, ranging across all strata of Indian society (Dr. Atreya Paul, 2021).

Urban green spaces are the public open spaces interspersed primarily by green plants in urban areas used for multi-functional benefits directly or indirectly received by the city dwellers and commuters (Manlun, 2003). These are the

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most important environmental premises and sometimes eco-heritage of any city (Eveline van Leeuwen, 2009).They are diverse in nature, variable in size, scale, function, and location (Gill S. , Handley, Ennos, Pauleit, Theuray, & Lindley, 2018).The proportion of green open space in numerous capital cities across Southeast Asia displays significant variation compared to cities that are widely recognized for their abundant green areas. In certain cities, approximately 20 to 30 percent of the city's total geographical area is covered by green open spaces, equivalent to around 15 to 25 square meters of urban green space per person, taking into account the pressures posed by population density. Public Green Spaces are the Urban Green spaces that possessed Social Efficiency. They are social green components including bench, light, drinking water, laboratory and passages. This space is called Park (Maleki & Hatami, 2016). On the other hand, Private Green Space includes green roofs, corporate gardens, orchards, common gardens of apartment buildings, and corporate complexes that boost the ecological efficiency of the city but do not have the same social efficiency as internal green space. People depend on fresh air, natural ecosystems and landscape which indicate public natural perception and social behavior (L. Wuqiang, 2012). Today, the world's natural ecosystems and landscapes are rapidly changing as a result of urbanization and population increase. Human activities are driving these changes and threatening many of the ecological services that are essential to society (F.S. Chapin III, 2011). On the other hand, sustainable development is a key idea to solve a series of environmental, economic and social problems (Mehdi Rakhshandehroo M. Y., 2016).Species extinction, habitat loss, landslides, floods, urban heat islands, air pollution, noise pollution, contaminants etc. are just a few instances of the environmental issues connected to Urban Green Space. The massive scale of urbanization in India will pose undoubted challenges for the country's environment, ecology, society and sustainability (Dr. Atreya Paul, 2021). The current emphasis on smart cities as a response to urban sustainability issues in India is influenced by a management of technology for the effective management of economic growth, thus it is important to take into consideration how we govern land use and shape of our cities.

2. Literature review

Urban green areas are becoming more widely acknowledged as essential components in the promotion of environmental sustainability and urban quality of life. Preservation of a substantial proportion of the city's space under green cover has now become a qualification for city planning and design. But, the urban green spaces are vanishing out at an alarming rate caused by rapid and unplanned urbanization especially in India (Giyasuddin Siddique, 2020).These paper mainly discuss about the gradual loss of green space in the city Asansol has a clear impact on the physical landscape of the city, especially the central area where the population density is higher due to the more dynamic urban functions compared to its periphery zones.

India is rapidly becoming more urbanized. Urban greenery/forestry is one of the ways to bridge this gap between people and nature. Most of the Indian cities are far behind in quality as well as quantity of urban forests than their counterpart in Europe and America (Pradeep Chaudhry, 2011). This paper discusses the state of urban greenery in certain Indian Cities where it is stated that the educational attainment and environmental consciousness of urban dwellers play a significant role in determining the species diversity, management, and total demand for urban forests. The growth of urban greenery depends not just on technology, resources, and investments but also in significant part on the attitudes and participation of urban dwellers.

Urban green spaces are urban areas which were occurred that natural and partially natural ecosystems were transformed urban spaces by anthropogenic influences. The health and wellness of urban dwellers are thought to be improved by Urban Green Space(Dr. Atreya Paul, 2021). These research article aims to comprehensively investigate the significance of urban green spaces in enhancing the quality of life for urban dwellers. By conducting this research, the author seeks to identify effective approaches to managing urban environments through the integration of advanced geospatial techniques and technologies.

Nowadays, due to the population growth and urbanization, ecosystems and natural landscape are changing drastically (Anthony D. Barnosky, 2012). Most of the scientific papers on urban planning and sustainable development begin by emphasizing the multiple benefits of urban open green space. When it comes to the benefits of urban green and open space, one should concern on the facilities provided to promote human or societal wellbeing, either directly or indirectly (Mehdi Rakhshandehroo M. J., 2017). In order to create livable and sustainable cities, urban open green spaces are important. This paper discusses its contribution to enhancing of understanding of urban open green spaces and their environmental consequences to humans.

Urbanization is the process of rendering a place more urbanized. Currently, more than half of the world's population resides in urban centers, and this number is projected to rise in future days*(Kondo et al., 2018).*Although there have been multiple evaluations of empirical investigations regarding the correlation between the environment and human well-being, minimal attention has been given to the urban setting. Furthermore, the majority of these studies have

primarily concentrated on cross-sectional research, with limited emphasis on other methodologies. In this academic publication, an in-depth analysis is presented regarding the connection between exposure to urban green spaces and its influence on overall well-being, body weight, mood disorders, and stress levels. Specifically, it investigates the intricate interplay between nature and urban well-being. Furthermore, the article highlights the collaborative endeavors undertaken by communities, organizations, and urban planners to establish additional green spaces, while simultaneously emphasizing the importance of safeguarding the existing ones.

The urban environment changes along with the growing urban populations. As urban landscapes are increasingly large, they can be an important component of regional or global biodiversity (Doanld Dearborn, 2010). The importance of identifying the motivations behind the conservation of urban biodiversity is highlighted in this paper.

The worth of green spaces has been attempted to be measure during the past few years by the economist using a variety of methods. The importance of urban green-spaces were known for decades; however, the relationship between urban livability and green-spaces as incorporated in overall urban green structures has become the focus of international studies especially during the last 10 to 15 years (Cilliers, 2015).This paper highlights that it is important to first identify the value of green spaces in terms of their direct and indirect advantages, and secondly the advantages they provide to priority communities and the sustainable development approach.

Planning of green space problem is one of the urban implications because it provides not only non-substituted environmental values such as sir purification, modifying temperature but it influences on aesthetic, citizen's relaxation and freshness directly. Urban Green Space means a kind of applied ground surface with a vegetable covers where constructed by mean that possessed "ecological efficiency"(Saeed Malekii, 2016). The main topic covered in these papers are the effects of growing in urbanization and pollution on the environment, as well as the vital role that green spaces play in preserving ecological equilibrium.

Urbanization is a global phenomenon with both positive and negative effects that is a natural outgrowth of the accelerating pace of human social progress. To take better advantage of benefits and minimize negative impact of urbanization, urban green space is recognized as an essential means of maintaining urban ecosystem health, nurturing a harmonious human nature relationship and ultimately achieving urban sustainability by improving air, water quality and cooling urban heat island. In order to develop sustainable communities, these paper emphasizes the need for greater open space and less ground covered i.e., to increase urban resilience and human wellbeing, it encourages multifunctional landscapes.

Urban green spaces are put under high pressure due to increasing population density in cities (Lundh, 2017). Where a city continues to become denser, this problem could become worse. This paper discusses the relevant parameters for ecosystem services at a green space and also it explains how to use ecosystem services to enhance the management of an urban green space.

The rapid urbanization of India cities poses a multitude of challenges, including inadequate urban green space quality and quantity. With the rapid urbanization occurring in our cities, the need for sustainable development is more than ever. Urban Planners play a significant role in the provision of UGS in our cities (Sangwan, Saraswat, Kumar, Pipralia, & Kumar, 2022). This Paper addresses how it is important for urban planning to deal with the difficulties posed by urban green spaces and provides a multitude of possibilities for approaches and actions to improve the quality of urban green spaces.

Urban green space offers a broad spectrum of ecological services that could help to fight with many urban problems and enhance the quality of life of city people', particularly their health. Urban green space, such as parks, forests, green roofs, steams, and community gardens, provides critical ecosystem services. Green space also promotes physical activity, psychological well-being, and the general public health of urban residents (Jennifer R. Wolch, 2014).Therefore, in order to protect both physical and ecological sustainability; this research has emphasized the significance of urban green space for public health.

Research objectives

The following are the main objectives of the current research:

- To evaluate the current level of green cover/spaces of Chandannagar Municipal Corporation between 2011 and 2022;

- To analysis land use and land cover of Chandannagar Municipal Corporation with a focus on the green cover; and
- To assess the spatio-temporal changes in the land use and land cover composition of and green cover areas of Chandannagar Municipal Corporation between 2011 and 2022;

The present study is organized as follows: an informative and detailed introduction, a brief review of the literature, the study area, a description of the materials and methods used, a discussion of the findings, and finally a conclusion.

2.1. Research questions

The following questions have been chosen for this study:

- To what extent on cities increase the green spaces levels of natural ecosystem?
- How significant is green infrastructure in urban settings?
- How can urban green spaces be planned and managed to preserve biodiversity and the well-being of city dwellers?

2.2. The study area: location and geo-environmental setup of chandannagar municipal corporation (CMC)

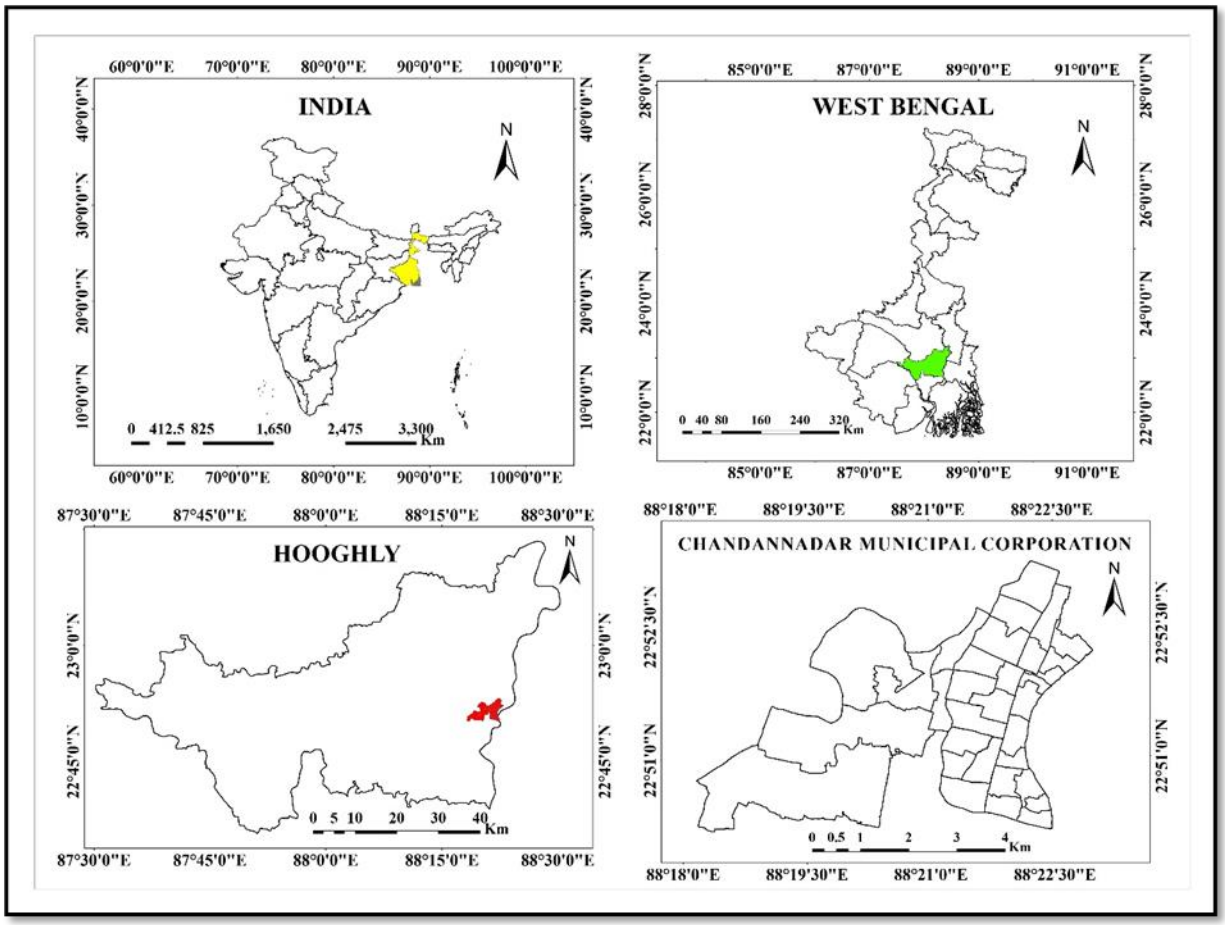

Figure 1 The Study Area

The Chandannagar City under Chandannagar Sub-Division of Hooghly district has been selected as the area under study. The city of Chandannagar is the oldest Municipal Corporation of West Bengal. As a former French colony in eastern India, the city, characterized by glorious colonial legacy and culture enjoys an esteemed position amongst the major urban units of the state. Geographically the area extends from 88º18'24" east to 88º24'26" east and from 22º50'54" north to 22º57'17" north. Total area of Chandannagar Municipal Corporations is 22.03 km^2. Established in 1955, now the Chandannagar Municipal Corporation (CMC) comprises 33 wards and accommodates nearly 1666867 population of which male and female are 84,009 and 82,858 respectively. Although the urban/metropolitan population of Chandannagar City is 14,035,959 of which 7,251,098 are males and 6,784,051 are females(Census of India, 2011). It

should be emphasized that Ward No. 27 is not included in the study due to its remote position, which is surrounded by the municipalities of Bhadeswar and Champdani, making it an administratively disabled spatial entity.

The Chandannagar is well connected to Kolkata, the capital of West Bengal, which is only 35 km away. The daily commuter flow has been impacted by location suitability, good rail-road connectivity, and easy accessibility, which has accelerated urbanization over the past few decades, The city is bordered by the Hugli-Chinsurah Municipality to the north-east, the Chinsurah-Magra Block to the north, the Polba-Dadpur Block to the north-west, the Singur Block to the west, the Bhadreswar Municipality to the south, the River Hugli to the east, and the River Saraswati to the north and nort-west. The Bhadreswar Khal i.e., the stream runs through the west. The eastern half of the city is traversed by the G.T. Road, the middle by the Eastern Railway, and the western edge by the Delhi Road.

3. Database and methodology

3.1. Database

The analysis is based on a variety of secondary data that was gathered from various governmental and non-governmental sources. The office of the Chandannagar Municipal Corporation has provided secondary data, whereas numerous filed visits to the study area have provided primary data. Ward Map of Chandannagar Municipal Corporation (CMC) that were gathered from CMC's office have proven very helpful. To comprehend the central idea relevant journals, articles and reports have been studied. The USGS Earth Explorer Was used to download the Landsat imageries of the two years2011 & 2022 and these were then processed to achieve the goals. The nature and properties of data are discussed in the following table:

Table 1 Details of Landsat data collected from USGS Earth Explorer

No.	Satellite Sensor	WRS-Path/Row	Date Acquired	Coordinate System	Purpose
1	LANDSAT 7/ETM+	138/44	2011/02/03	UGS 84/UTM	NDVI/LULC
2	LANDSAT OLI TIRS	138/44	2011/02/08	UGS 84/UTM	NDVI/LULC

The relevant data on the spatio-temporal changes of vegetation cover, land use/cover classes are extracted using LANDSAT 7/ETM+ of February 2011 and LANDSAT 8 OLI TIRS of February 2022 (Datum: WGS-84; Projection: UTM Zone 45 N; Path/Row: 138/044).With the help of fundamental quantitative techniques, all of the data thus collected, arranges, tabulated and examined. Finally, the outcome has been analyzed and mapped out using the appropriate cartographic methods

4. Methodology

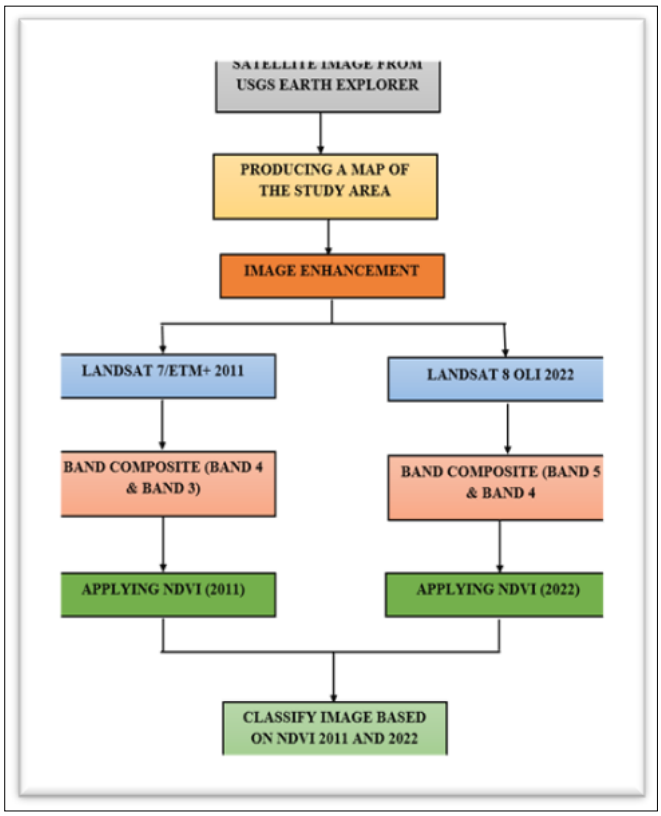

Figure 2 NDVI Methodology of the study

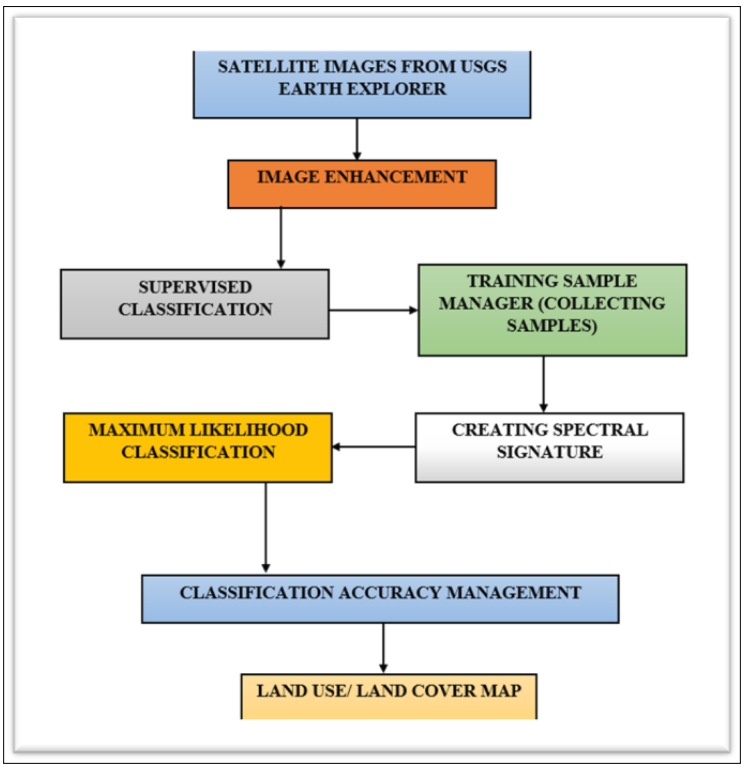

Figure 3 Procedures for Land Use Land Cover Classification

5. Operational definition

5.1. Urban Green Spaces

Urban green spaces are areas within urban environments that have retained their natural ecosystems. These spaces play a crucial role in bridging the gap between urbanization and nature. Additionally, urban green areas offer numerous ecological advantages specifically tailored to meet the needs of urban residents. In order to meet social and psychological needs of citizens satisfactorily, green spaces in the city should be easily accessible and in adequately optimal in quality and quantity. Green spaces need to be uniformly distributed throughout the city(Dr. Atreya Paul, 2021). The city area needs to be evenly distributed with green spaces. The livability of our towns and cities is significantly enhanced by urban green spaces. Contiguous vegetated regions and spaces are referred to as "green spaces" and examples include naturally occurring vegetation and land areas like botanical gardens as well as man-made urban parks, schoolyards and sports fields. A system of green places that provide essentials support for life such as food, water and air to breathe. The goal of the green infrastructure strategy is to protect natural areas through the application of planning or regulatory policies.

5.2. Supervised Classification

Supervised Classification is a method which examines a large number of pixels and divides into a number of classed based on natural groupings present in the image values (Dr. Atreya Paul, 2021). Using the Supervised (Maximum Likelihood) Image Classification technique, the land use/land cover classification of the study's landscape was prepared in Arc-GIS software (version 10.8).

5.3. Normalized Difference Vegetation Index (NDVI)

The normalized difference vegetation index (NDVI) is one of the most suitable, proficient and widely used techniques for mapping chronological changes in the vegetation health over a wide area (Newnham, Verbesselt,, Grant, & S. A. J., 2011). The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands. Theoretically, NDVI values are represented as a ratio ranging in value from -1 to +1 but in practice extreme negative values represent water, values around zero represent bare soil and values over 6 represents dense green vegetation (Dr. Atreya Paul, 2021)i.e. negative NDVI values are typically associated to bare soil, snow, clouds, or non-vegetated surfaces, whereas high positive NDVI values correspond to dense plant cover that is growing at a rapid pace.

6. Results and discussion

6.1. An Analysis of Urban Green Space: Some Global Data

Globally available information suggests that the cities in developed countries have more trees compared to cities in developing countries which often fall below the minimum standard of WHO (9 m2 green space/city dweller) (Kabisch, Strohbach, Haase, & Kronenberg, 2016).An inclusive study across 386 European Cities reports that average proportion of green space is 18.6%, which witnesses' variation from 1.9% (Reggio di Calabria, Italy) to 46% (Ferrol, Spain) (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). A study of 439 cities in China noted that the overall green space was 20.1% of the urban areas on 1991. Almost 40% of the Chinese cities had more than 30% green cover in 1991 (Ming & Profous, 1993). Urban tree cover in the United States ranges from 0.4% (Lancaster, California) to 55% (Baston Rouge, Louisiana). occupying an average canopy cover of 27% (Nowak & Greenfeld, 2002).The green cover and per capita green space was 23% and 6.52 m2 respectively in 2000 (Wang, Jiang, Zhou, Liu, Ji, & Wang, 2007). By the end of 2006, green cover in the cities with vascular plant diversity (276 species) including 207 species of conservation concern such as endemic, threatened and protected species (Wang, Jiang, Zhou, Liu, Ji, & Wang, 2007).Cities of developing countries have lower green cover and less per capita availability of urban green space compared to that of the developed countries (Singh,, Pandey, & Chaudhary, 2010). Despite wide variation in coverage as well as per capita availability, cities global renowned for their urban greeneries have 20 m2 per capita share of urban green space. Most of the Indian cities lag behind such share in comparison to the cities of Europe, Australia, USA and China with few exceptions like Chandigarh, Gandhinagar and Bangalore (Giyasuddin Siddique, 2020).

Table 2 Account of urban green space: International Level

Region/Country/City	**Estimated area of urban green space and Per capita green space**	**Source**
Urban areas in USA	Average green space: 27% (i.e. 32 m2 /inhabitant)	(Singh,, Pandey, & Chaudhary, 2010)&*Invalid source specified.*
Washington, D.C. (USA)	Average green space: 28.6% (about 1928000 trees)	*Invalid source specified*
San Francisco, USA	13.81 sq.km(16.92 m.sq/city dwellers)	*Invalid source specified.*
Europe (26 large cities)	Average green cover: 18.5% (i.e. 104 m.sq/inhabitant)	*Invalid source specified.*
Paris, France	Average per capita green space: 80 m.sq./inhabitant	(Singh,, Pandey, & Chaudhary, 2010).
Great Britain	Average green cover: 14% of urban areas (120000 ha. Of park/garden space)	(Singh,, Pandey, & Chaudhary, 2010)*&Invalid source specified.*
Netherlands (22 large cities)	Average green space: 19% (i.e. 228 m.sq./inhabitant)	(Singh,, Pandey, & Chaudhary, 2010)&*Invalid source specified.*
Copenhagen, Denmark	Total green space: 22.61 sq.km (i.e. 42.44m.sq./city dwellers)	*Invalid source specified.*
Canberra, Australia	About 2400 ha (about 80 m.sq./inhabitants) contains 400000 trees belonging to some 200 species	*Invalid source specified.*
Melborne, Australia	Green space cover: 40% (i.e. 16.3 m.sq./inhabitant) in 1997	*Invalid source specified.*
Wellington, New Zealand	Average per capita green space: 200 m.sq./person	*Invalid source specified*
China	Average urban green space: 32.54%	*Invalid source specified.&Invalid source specified.*
Hong Kong	Average green space: 1.81% (i.e. 3 m.sq,/inhabitant)	(Singh,, Pandey, & Chaudhary, 2010)*&*
Seoul, South Korea	Green space cover: 25.2% (i.e. 14.57 m.sq./inhabitant) in 1996	*Invalid source specified.*
Kuwafa Lupmpur, Malayasia	Average Green Cover: 5% (i.e. 2.25 m.sq./inhabitant) in 1998	*Invalid source specified*
Singapore	Average urban green space: 17.8% (I.e. 7.5 m.sq./inhabitant)	*Invalid source specified*
Colombo, Sri Lanka	Green space cover: 4.4%	*Invalid source specified*
Japan	Average urban green space: 26.74%	*Invalid source specified.*

Tokyo, Japan	Average per capita green space ranges from 6.1 m.sq./person to 8.5m.sq/person	*Invalid source specified.*
Hannou, Japan	Average Green Space: 84% in 1990	*Invalid source specified.*
Curitiba, Brazil	Average per capita green space: 51.5 m.sq/person in 2003	*Invalid source specified.*

Source: (Siddique, Ghosh, & RoY, 2020). Table No. 2 Account of urban green space: international level

6.2. Spatial growth of urban space in chandannagar

The spatial detail and accuracy of the present urban expansion forecasting need to be enhanced in order to assist policy-makers in preparing for future socio-economic, environmental and health changes related to urban growth and expansion. For a variety of reasons, Chandannagar develop more rapidly than other cities. Cities have complex spatial and temporal dynamics that are influenced by a variety of factors, including the regional economy, population dynamics, the political culture, and socio-cultural processes. The first is that urban population expansion is significant from an economical perspective. Chandannagar is inhabited by a variety of built-up areas including academic institutions, hospitals and shopping centres. Additionally, the settlement pattern's spatial dispersion reveals important information. More settlements are located i.e., new urban extension with modern building structure is visible briskly in the areas of Bagbazar, Borobazar, Fatokgora, Hatkhola, Lichutala, Jyoti, Mankundu, Sitalatala, Khalisani (Siddique, Ghosh, & RoY, 2020).

6.3. Temporal changes of green space in Chandannagar

6.3.1. Analysis of NDVI (Normalized Difference Vegetation Index) 2011

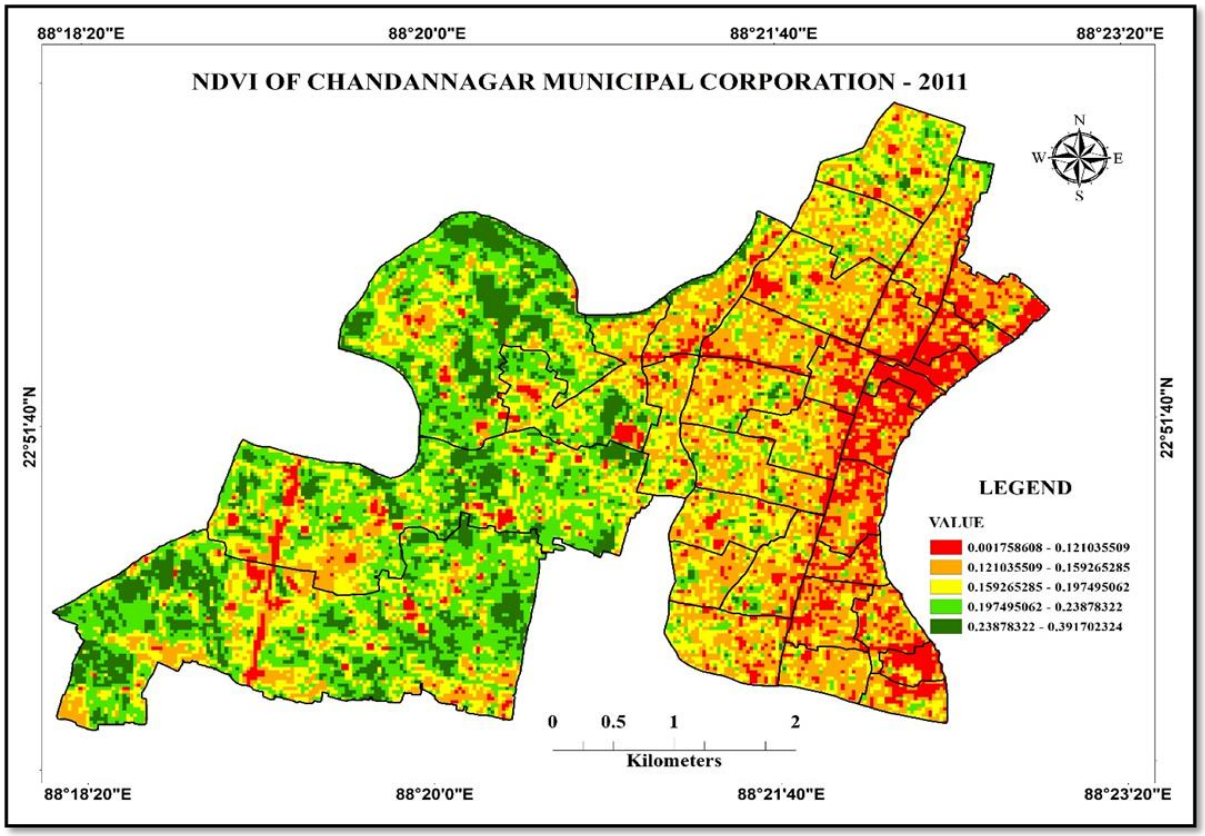

Figure 4 NDVI of Chandannagar Municipal Coropration-2011 - prepared by researcher

Here, we use a Landsat 8 image with a resolution of 30 meters of February 8, 2011. The highest value of the NDVI for Chandannagar in 2022 is 0.39702324, and the lowest value is 0.001758608 in Fig No. According to Fig No. i.e., the NDVI of Chandannagar 2011, we can conclude that South-Western part of Chandannagar has more vegetation than the South-Eastern part. Southern part of the city has healthy vegetation with pixel values ranges from 0.2387 to 0.3917 and there were no negative values of NDVI, which means no dead plants were present in Chandannagar in 2011. North-Western part of Chandannagar was dominated by pixel values of 0.1974 to 0.2387 represented by unhealthy vegetation to moderately healthy vegetation. On the other hand, Eastern part of the city have sparse vegetation where South-Western corner of the city has denser vegetation in compare to other parts of the city, Chandannagar. In the centre of the city, orange colour pixels which are basically lesser dense vegetation dominates here. 06 to 0.9 pixel values represent the healthy dense vegetation and in Fig No. anywhere of the city pixel value are in between 0.6 to 0.9 could not be seen, therefore, the city has no highly dense healthy vegetation condition.

6.4. Analysis of NDVI (Normalized Difference Vegetation Index) 2022

Here, we take the image of Landsat 8 which have the resolution of 10 meters of the date 8th February, 2022 which was cloud-free winter day. Fig No. represents the NDVI of Chandannagar of the year 2022 which has the highest value of 0.317841 and the lowest value is 0.428537. As we know that NDVI values varies between +1.0 to +1.0 where negative values are associated with inanimate object or dead plants and positive values are associated with moderately to healthy vegetation. Therefore, in the eastern part to south eastern part of Chandannagar is dominated by the moderately vegetation representing in red to orange shade colour.

Central and eastern part is dominated by the Pixel values -0.15000 (red colour) represents the unhealthy vegetation where vermilion colour represents the area with inanimate object or have dead plants in there.

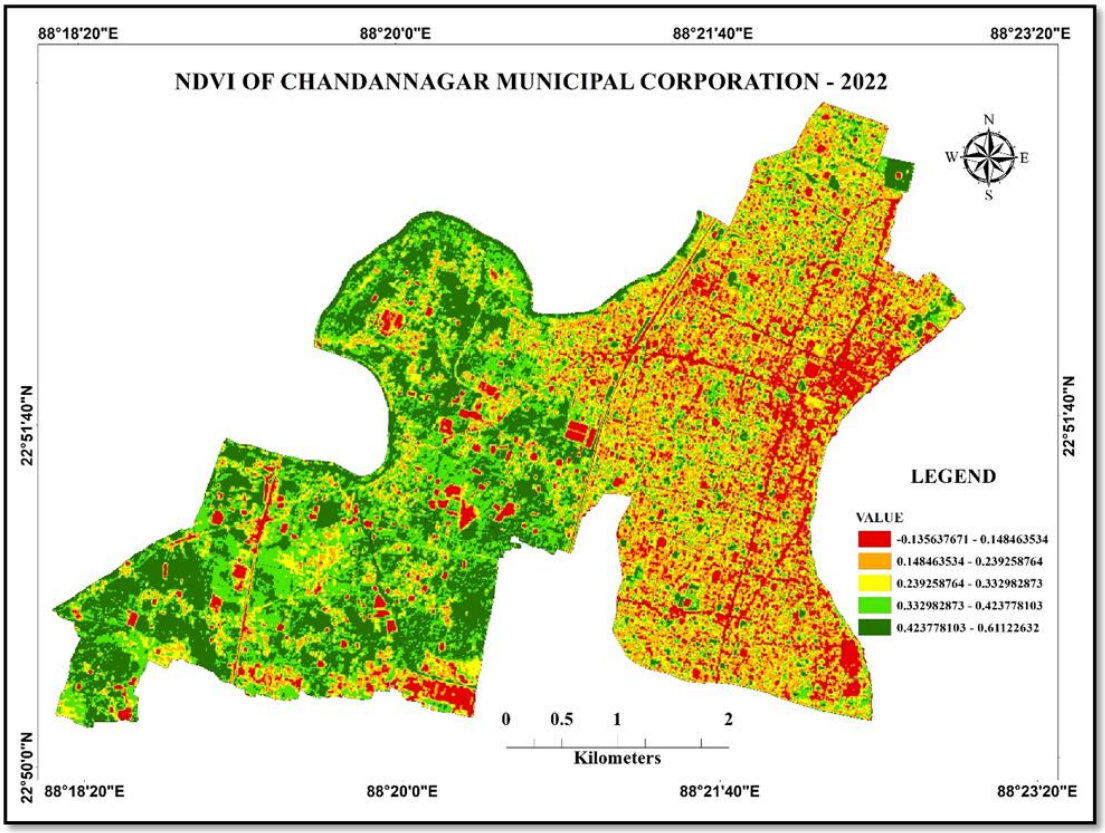

Figure 5 NDVI of Chandannagar Municipal Coropration-2022(prepared by researcher)

Pixel values 0 to 0.33 represents the unhealthy vegetation, therefore all the orange and yellow shade pixel demined over all area of Chandannagar which is basically covered with unhealthy vegetation mostly seen in the eastern and south part of Chandannagar. South western part of Chandannagar covered with healthy vegetation and water bodies. The moderately healthy vegetation having pixel values varies between 0.33 to 0.66 which in Fig. represented by the shade of green variation. Very healthy vegetation pixel value varies from in between 0.66 to 1 which is not present in Chandannagar. In the southern mostly southern-western part, we can see vegetation density is more than southern-

eastern corner of Chandannagar. South-Eastern Chandannagar has comparatively sparse vegetation and central part of Chandannagar mostly have bare soil and build up areas.

If we compare 2011 and 2022, NDVI values of Chandannagar have healthy and dense vegetation and it has increased with time. In 2011, comparatively healthy vegetation dominated in the Western and Southern part of the city and also in the Northern and Central part also, where in 2022, vegetation slightly decreased in the South-Eastern and Northern part of the city and even in Central part particularly in Ward No. 13, 14, 15, 19 comparatives to 2011. Although even in this ten years of gap vegetation density has also increased.

6.5. Over viewing analysis of the Chandannagar municipal corporation (CMC)

The study area, which has a total area of 22.08 Sq. Km was analyzed using remote sensing techniques, which allowed the authors to map and identify a total of 5 land use/land cover groups (2011 & 2022). These categories include Vegetation, Built-Up Land, Agricultural Land, Water Body and Barren Land (Fig. 6).

The statistics of the Land use/land cover classes of 2011 and 2022 are provided in Table No.3 and Table No.4 displays changes by class of 2011 to 2022.

6.5.1. Vegetation

Almost 37.089 % (8.192 Sq. Km) of the total CMC area was covered by patches of vegetation in 2011, those patches had grown to 40.603 % (8.968 Sq. Km). The vegetation patches were primarily composed of big trees. The area covered by various vegetation patches decreased steadily during the year 2020 as because of Amphan Super Cyclone in West Bengal. Due to cyclonic activity many trees have been destroyed in various places and the city faces vegetation loss in 2020. Although compared to the other regions of the research area, the western part of Chandannagar and a few isolated portions of Northern Chandannagar's vegetation patches slightly increased between 2011 and 2022, with an increase of 3.513% (i.e., from 8.192 Sq. Km to 8.968 Sq. Km). Conversely, the area covered by barren lands decreased from 0.937 Sq. Km to 0.334 Sq. Km.

6.5.2. Built-Up Land

Built up is an area of human habitation which has a cover of buildings and network of transport and other civic amenities(Chaudhari, 2008).In the present study, the Built-Up class also comprises of settlement, commercial zones, educational, governmental, highways, hospitals and religious institutions. The five main land use classes – (1) Vegetation Patches, (2) Built-Up Areas, (3) Agricultural Land, (4) Water Body, and (5) Barren Land – were mapped for the Chandannagar Municipal Corporation between the years of 2011 and 2022.These major land use classes of spatial patterns throughout this demonstrate notable changes: In 2011 the urban settlements covered 41.095% of the total CMC area while compared to 2022 it almost captured the CMC area covering 42.6341467 % (9.41709 Sq. Km). Between 2011 and 2022, the area of urban settlements under CMC (Chandannagar Municipal Corporation) changed from 9.077 Sq. Km to 9.41 Sq. Km. Over the course of study, the area covered by wetlands (barren lands) decreased from 4.245 % to 0.334 %. Dispersed and small settlements have been encompassed in the rapid urban sprawl of the study area (Gardner, Biswas, & Majeed, 2016).This suggest that barren lands were desiccated and overgrown by vegetation rather than being converted directly to urbanized area.

6.5.3. Agricultural Land

In the year 2011, 2.434 Sq. Km of land were under the agriculture in total; and this figure increased to 2.876 Sq. Km in 2022. Therefore, the amount of agricultural land increased 2 % between 2011 and 2022 in the study area. Currently, the south-western and north-western portion of the study area has agricultural land. The fertile soil in the areas adjacent to the river has also been changed into built-up areas.

6.5.4. Water Body

In the study area, the rivers and reservoirs are regarded as water bodies. The river Ganga and Saraswati are the two main rivers in the study area. In 2011, the total area included in this category was 1.446 Sq. Km, but by 2022, it has reduced to 0.492 Sq. Km. Many ponds have been dumped and it has been converted into flats i.e., built-up areas in recent decades.

6.5.5. Barren Land

The term "barren land" refers to areas of no vegetation cover, rough topography, and uncultivated agricultural areas. The area is known for its deficient soil and rapid erosion. The total area included in this class in 2011 was 0.937 Sq. Km,

but by 2022 it had reduced to 0.334283 Sq. Km. The decrease in the amount of barren land is due to human-caused factors. The lands are intentionally left fallow for a long time with the intention of converting them into built-up areas that produce significant income for the owners.

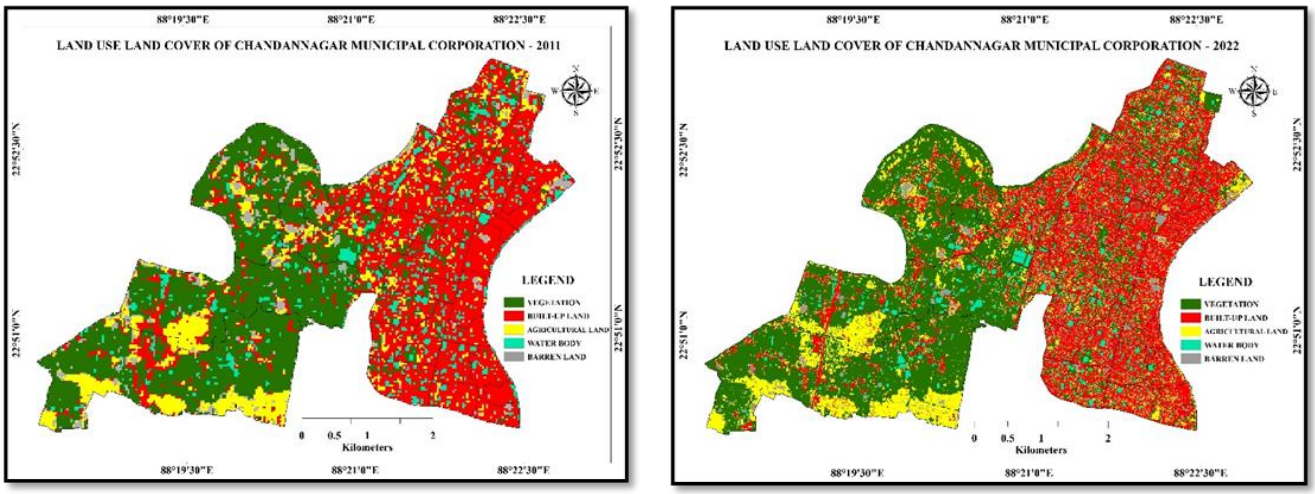

Figure 6 Land use/land cover map 2011 and 2022 (prepared by researcher)

Table 3 The area coverage and its percentage of LULC 2011

LULC 2011		
Class Name	Sum of Area	Percentage
Vegetation	8.192341	37.0893203
Built-Up Land	9.077188	41.0953027
Agricultural Land	2.434345	11.0210502
Water Body	1.446444	6.54850974
Barren Land	0.937822	4.24581699
TOTAL	22.08814	100

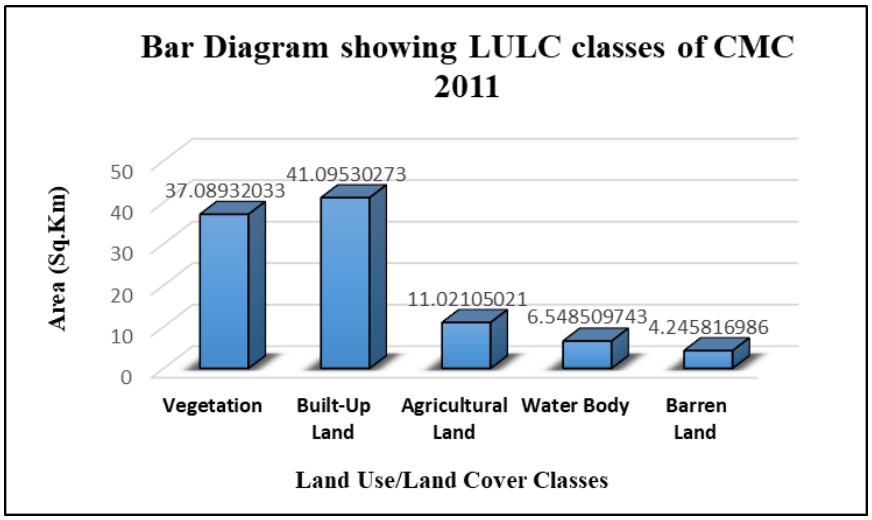

Figure 7 Bar diagram of LULC classes of 2011

Table 4 The area coverage and its percentage of LULC 2022

LULC 2022		
Class Name	Sum of Area	Percentage
Vegetation	8.968493	40.6032061
Built-Up Land	9.41709	42.6341467
Agricultural Land	2.87621	13.0215129
Water Body	0.492064	2.22772945
Barren Land	0.334283	1.51340493
TOTAL	22.08814	100

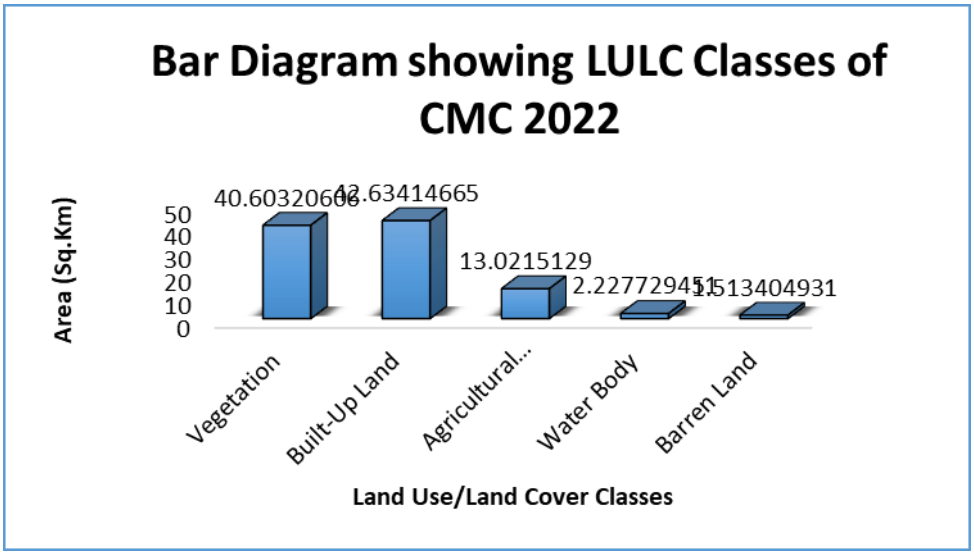

Figure 8 Bar diagram of LULC classes of 2022

Table 5 Change detection of LULC classes between 2011 and 2022

Class wise changes of various land use/land cover classes of 2011 and 2022						
Sl No.	**Land Use/Land Cover**	**Area in Sq. Km (2011)**	**Area in % (2011)**	**Area in Sq. Km (2022)**	**Area in % (2022)**	**Variation of 2022 from 2011 (Sq.Km)**
1	Vegetation	8.192341	37.08932033	8.968493	40.60320606	0.776152
2	Built-Up Land	9.077188	41.09530273	9.41709	42.63414665	0.339902
3	Agricultural Land	2.434345	11.02105021	2.87621	13.0215129	0.441865
4	Water Body	1.446444	6.548509743	0.492064	2.227729451	-0.95438
5	Barren Land	0.937822	4.245816986	0.334283	1.513404931	-0.603539

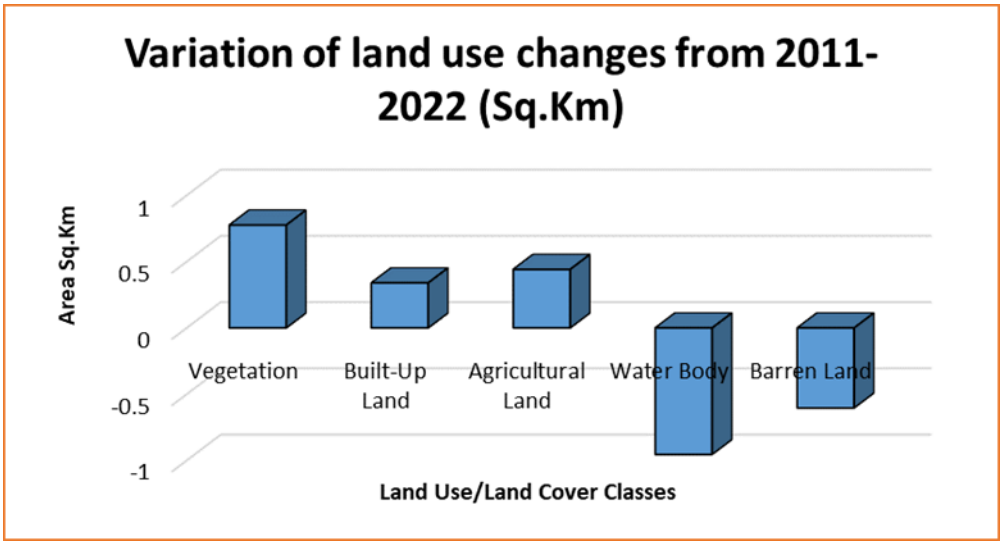

Figure 9 Bar diagram of change detection of LULC classes of 2011 and 2022

6.6. Increasing urban issues

The urban environment is a coexistence of natural elements and the built up environment. Here natural environment is altered for human dwelling and activity, including buildings, infrastructure and urban open spaces. The attribute of urban environment is effected by its geographical location; the various kind of human activities for development; the mismanagement of waste emissions and ecological ruining (Dr. Atreya Paul, 2021). The socio-cultural aspects of the native population such as their thoughts, values, behaviours, knowledge, characteristics, customs, and traditions have an impact on the urban environment as well. The assessment of urban issues that have developed in the urban, industrial landscape of the Chandannagar Municipal Corporation area is covered in the study that follows.

6.7. Air Pollution

Air pollution involves many pollutants ranging from PM to SOx and NOx also Cox and may be caused by urban warming, for example, by increasing surface ozone concentration with several negative impacts on human health (Feyisa, Dons, & Meilby, 2014). It is being associated with indirect health effects and abnormal levels of mortality and morbidity among urbanities (Su, Jerrett, de Nazelle, & Wolch, 2011).

6.8. Transport

People can travel to and through our cities because of transportation. In order for businesses to run, for commodities to commute, for children to go to school, for residents to buy goods, dine out etc., we need reliable urban mobility solutions. With traffic bottleneck and traffic congestion, almost all cities and towns of India are suffering from acute form of transport problem (Dr. Atreya Paul, 2021). As the city gets bigger, the transportation issues get worse and more complicated. With its expansion, the town executes a wide range of intricate tasks, and more people travel for work or shopping. As the city expands, even those who live in the developed region must take the bus or a car to get around, and visitors inevitably bring their own vehicles or use public transportation. Wherever, trade is important, commercial vehicles such as vans and trucks will make problem of traffic more complicated (Dr. Atreya Paul, 2021).

6.9. Urban Expansion (Urban Sprawl)

Urban problems are mostly caused by urban sprawl, or the actual extension of cities in terms of both people and geographic area. The economic structure of the majority of cities is unable to handle the issues brought on by their disproportionate size. Large-scale immigration into major cities from rural areas and small towns has occurred nearly continuously, increasing the expansion or growth of cities. During 1991 to 2001, nearly over millions of people moved to urban areas. This is due to the fact that such large cities act as magnets and attract large number of immigrants by dint of their employment opportunities and modern way of life (Dr. Atreya Paul, 2021).

6.10. Garbage Disposer

As Indian cities grow in number and size the problems of trash disposal is assuming alarming proportions. Huge quantities of garbage produced by our cities pose a serious health problem. Most cities do not have proper arrangements for garbage disposal and the existing landfills are full to the brim (Dr. Atreya Paul, 2021). The peoples living close to a polluted environment or a landfill may suffer serious health consequences as a result of improper garbage disposal. Employees at these garbage operations who deal with waste are at greater danger. Exposure to poorly dispose of garbage can result in rashes on the skin, blood infections, respiratory disorders, growth challenges, and even reproductive problems.

6.11. Slums

Slums show a level of deprivation above and beyond income poverty. They have severe overcrowding, unclean, unsanitary and dehumanising living conditions. They face unstable land tenure, a lack of access to fundamental municipal amenities like clean water, sanitation, solid waste management, internal and approach roads, street lighting, and affordable, substandard housing.

6.12. Urban Crimes

Urban regions are typically considered to be breeding grounds for criminals and more likely to experience crimes than rural areas due to their increased population density and intimate proximity of dwellings. Major contributing causes to urban crimes include the uncontrolled and unplanned growth of cities as well as a sizable floating population. It is also well known that urban industrial zones have higher criminal propensities. The migrants having with impoverished and less education sometimes experience emotional instability in urban settings. They are easily persuaded to engage in stealing, robbery, smuggling, and other unlawful crimes.

7. Challenges of urban green spaces

In order to achieve sustainable development, urban green spaces are a key component that directly influences the climate and water supplies. Several challenges are noted in the literature on developing green spaces in densely populated urban areas:

- taking into account regional perspectives
- provision of green space in developing countries
- combating social injustices
- conservation of urban biodiversity
- Institutional restrictions relating to, for instance, planning and regulations.

7.1. Urban green space solution strategies

Urban growth needs to be advantageous on all three of these fronts like environmentally, socially and economically in order to be sustainable. Urban Green Spaces are an important part of sustainable development in this environment. The following solution strategies are:

7.1.1. Provisioning and creation of Urban Green Spaces

A useful step toward reducing the impact on the climate is the growing of plants in open spaces away from concrete pavement structures and other urban areas. This is due to the fact that impermeable urban surfaces are substantially cooler than those of vegetated remote areas. According to (Bonan, 2015)*&*(Gill S. , Handley, Ennos, & Pauleit, 2007)"This less effective rainwater interception and storage generates more runoff and reduces evapo-transpiration in urban areas." Urban green spaces have the potential to collaboratively contribute to the mitigation of climate change by effectively capturing significant amounts of carbon emissions. They emphasised that an adaption approach to climate change in the urban environment is required according to their model study on surface temperature and surface runoff in the context of green infrastructure.

7.1.2. Urban Green Space water management

Green space is a highly desired amenity, even in hectic, crowded urban areas. Regular watering, nutrient supplementation, pruning, spraying, and replacement may be necessary to keep the green spaces healthy and able to support normal growth. Water is the most important and regular requirement of all of these. As it was previously stated, this limited resource is in deficit in major part because of population increase, the inefficient use of natural resources,

and overall poor management. The maintenance of biodiversity depends on a variety of natural resources, including groundwater. Due to the growing depletion of groundwater supplies, it is essential to recycle wastewater, purify it, and then utilise it again for a variety of uses, including drinking water and most critically daily irrigation and watering of urban green spaces like parks and gardens etc.

Regular irrigation is one of the methods used to keep urban green spaces healthy. Flooding of the plant regions from a pipeline affixed to trucks is the primary irrigation technique used for roadside plants in India. Urban green spaces have not yet taken into account the proper treatment of the several hundred million litres of wastewater that are produced everyday throughout the cities.

7.1.3. Air pollution reduction

Numerous studies have supported the positive effects of urban vegetation, which helps to reduce air pollution and Carbon sequestration, on ambient air quality. Urban open green spaces play a significant role in decreasing air pollution as they intercept atmospheric particles and absorb different gaseous pollutants (Yin, Shen, Zhou, Zou, Che, & Wang, 2011). They significantly assist in the removal of particles by lowering the level of NOx and SOx, removing significant amounts of airborne pollutants, and reducing their concentration.

7.1.4. Carbon sequestration

Urban areas play a crucial role in the intricate carbon cycle that affects the entire planet. The reduction of global warming is achieved by the expulsion of carbon dioxide (CO2) from the atmosphere, which is facilitated by various biological, chemical and physical mechanisms. Additional advantages of carbon sequestration contribute in reducing the impact of greenhouse gases in the atmosphere. The sequestration of carbon by urban vegetation acts as carbon sinks and plays a significant role in the issue of climate change (Paoletti, Bardelli, Giovannini, & Pecchioli, 2011).

7.1.5. Reduction of Noise

It is widely acknowledged that the soft walls of vegetation and trees not only define spaces and establish boundaries but also significantly contribute to noise reduction. Express roads, airport express routes are all lined with green population parameters and vegetative buffers, which create not only noise buffers but also sight and air pollution buffers.

7.1.6. Removal of contaminants

Harmful pollutants may be emitted into the atmosphere in metropolitan areas and eventually end up in the soil. Metal and industrial compound contamination is a persistent issue, particularly in industrial cities. In recent decades, contaminant removal and degradation by plants has gained popularity in Europe and North America as a method of cleaning up or remediating contaminated soil, sludge, sediments, and ground water. Greenery can effectively and economically remove, degrade, or contain contaminants, while bringing the benefits of a green environment to those who reside near the past contaminated sites and provide a sense of readdressing environmental injustices (Peng, Ouyang, Wang, Chen, & Jiao, 2012).

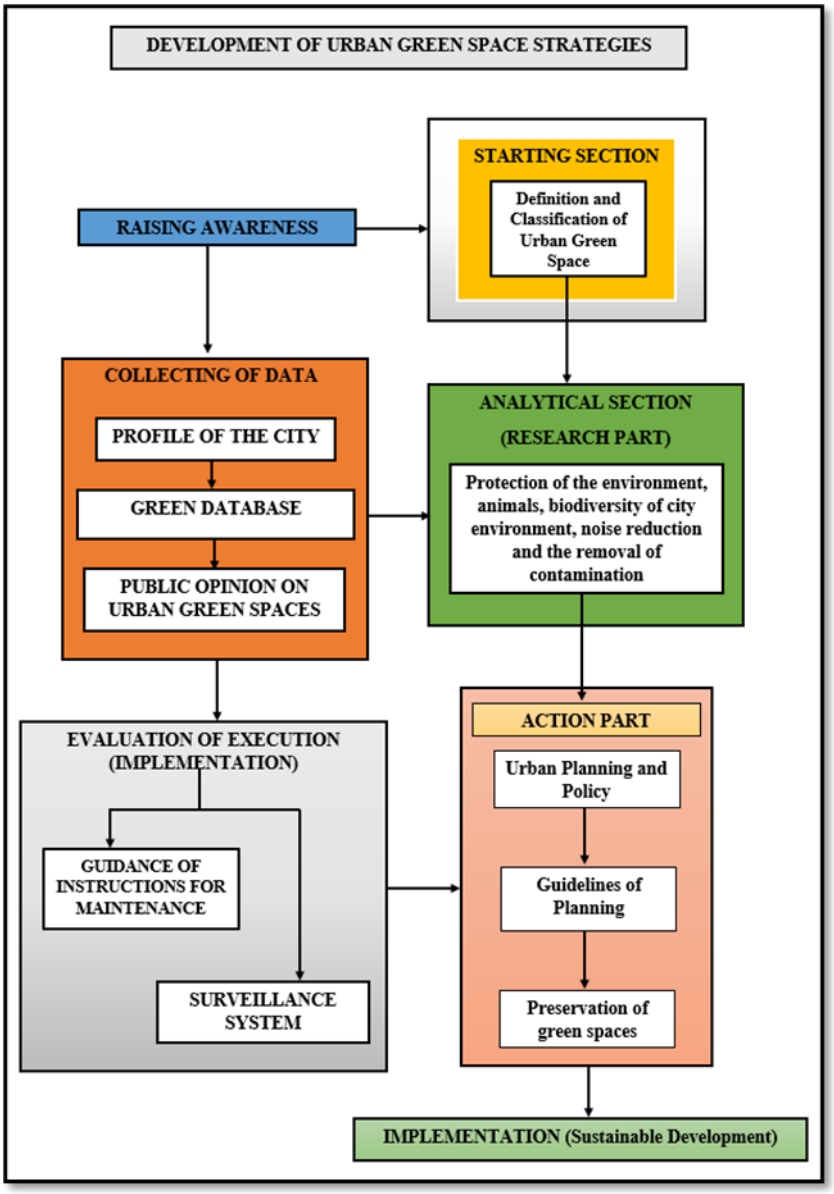

Figure 10 Model for future research and action (prepared by researcher)

8. Conclusion and recommendation

The current study's contribution which uses imagery from 2011 and 2022 helps to demonstrates the temporal variation in green space in various regions of Chandannagar. Between 2011 and 2022, there was a substantial decline of green cover, which is more pronounced in Chandannagar's central areas. The importance of urban green-spaces were known for decades; however, the relationship between urban live ability and green-spaces as incorporated in overall urban green structures has become the focus of international studies especially during the last 10 to 15 years (Caspersen,, Konijnendijk, & Olafsson, 2006). Due to excessive population growth and related cardinal problems such as pollution resulting from escalate production and accumulation of waste and mismanagement of it urgently needed maintain and expand urban green space(Dr. Atreya Paul, 2021). Although the area is mostly covered by transportation and habitation, there are small pockets of vegetative area, including open forest, dense forest and agricultural land for agriculture. It is clear that urban built-up area is occupying and increasing quantity of space. As a summary, there is general agreement that UGOS are essential for a liveable and sustainable city. There are a variety of scientific evidences, explain the many different environmental benefits of UOGS which contribute to human and social wellbeing (Rakhshandehroo,, Yusof, Ebrahim, Sharghi,, & Arabi, 2015). This can happen either directly, as in the case of air cooling, or indirectly, as in the case of their high biodiversity, enhancing possibilities for recreation and environmental experiences.

Fig. 10 illustrates the recommendations for future research and action; as the first step there is aneed to uniform definition and classification of open green spaces would allow the city municipalities to preserve adequate amount of open green spaces while enabling continuation of their housing developments and to promote themselves as green cities. Identifying important urban open green spaces and instituting an agenda for its protection prior to development can preserve productive urban farms and gardens, ensure vast recreational land and services for residents, and maintain the region's or community's natural, historic or cultural characters. Urban Open Green Space policies should be applied and implemented consistently and the rules should be based on the multiple levels of development rates that each city experiences. On the other hand, policy should be sensitive to handle the growth pressures and the propensity to convert unoccupied land or green spaces into residential, commercial or other uses in urban systems.

The residents have very clear ideas on how much urban open green space is really important in residential areas in order to provide them with a sustainable residential environment. Therefore, it should be essential for developers to include vegetation in all major developments. Adhering to the principles of conservation and spatial planning, new developments should allocate adequate Urban Open Green Spaces. For abundant aesthetic and environmental benefits, new places should have the capacity to support high quality amenity plants.

It is accepted that the value of parkland to human health and quality of life, outdoor recreation and outdoor education, and fulfils our responsibility as stewards of our natural environment and the obligation to preserve and enhance our natural environment through the maintenance, restoration and enrichment of native flora and fauna.

Provision of urban green space serves a balance between development and the environment; as such, it is the primary concern of sustainable development. Some of these spaces ought to be designated for public use in order to fulfill the goals of sustainable development. As a response, local residents, NGOs and civil society organizations should be involved in the development of urban green space areas by the federal and state governments.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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