URBAN SPRAWL MAPPING OF AJMER CITY (2020-2024) USING SATELLITE IMAGERY

Gaurav Kumar[1] Saurav Kumar[2]

[1]Assistant Professor, Dept. of Geography, Sophia Girls College (Autonomous), Ajmer

[2]JRF, Punjab Remote Sensing Center Ludhiana, Punjab.

ARTICLE INFO

ABSTRACT

The rate of urbanization in Indian cities, like several other developing cities around the world is increasing at an alarming rate. This unprecedented and uncontrolled urbanization may result in urban sprawl or suburban sprawl, the rapid expansion of the geographic extent of cities and towns, often characterized by low-density residential housing, single-use zoning, and increased reliance on the private automobile for transportation. Urban sprawl is caused in part by the need to accommodate a rising urban population; however, in many metropolitan areas, it results from a desire for increased living space and other residential amenities. Urbanization is the process in which the population shifts from rural to cities or urban centres for an improved standard of living due to economic growth and development. As the migration rate increases, urban cities undergo major changes in land use and land cover which trigger several negative effects such as overcrowding, water scarcity, air pollution, loss of productive agricultural lands and forest cover. Remote sensing and Geographical Information System (GIS) are used for monitoring the emerging urbanization of the cities using satellite images. The ill effects of urban sprawl in developing countries are a bit complicated compared to those of developed countries because of uncontrolled population growth and haphazard urbanization.An overview of the enormous potential of remote sensing and GIS techniques in mapping and monitoring the Spatio-temporal patterns urban sprawl is dealt with here. The spatial pattern and dynamics of the urban sprawl of Ajmer City (Rajasthan, India) during the period from 2020 to 2024 using the integrated approach of remote sensing and GIS are attempted here. Supervised classification is used for the rapid and automated extraction of built-up features from the time series satellite imageries. The extracted built-up areas of each year are then used for the quantification of urban sprawl and its associated area (in km). The results and analysis highlight the fact that there was an alarming increase in the built-up area extent from 2020 to 2024.

Corresponding author

Email: : kumargaurav4770@gmail.com (Gaurav Kumar)

Introduction-

As the Earth's population increases and national economies move away from agriculture-based systems, cities will grow and spread. The urban sprawl often infringes upon viable agricultural or productive forest land, neither of which can resist nor deflect the overwhelming momentum of urbanization. City growth is an indicator of industrialization (development) and generally hurts the environmental health of a region.

Measuring urban sprawl is a controversial topic among scholars who investigate the urban landscape. This study attempts to measure sprawl from a landscape perspective. The measures and indices used are derived from various research disciplines (Frenkel et.al 2008).

2.1 Importance of urban sprawl mapping

The change in land use from rural to urban is monitored to estimate populations, predict and plan direction of urban sprawl for developers, and monitor adjacent environmentally sensitive areas or hazards. Temporary refugee settlements and tent cities can be monitored, and population amount and densities estimated.

Analyzing agricultural vs. urban land use is important for ensuring that development does not encroach on valuable agricultural land, and to likewise ensure that agriculture is occurring on the most appropriate land and will not degrade due to improper adjacent development or infrastructure. (M.K. Jata et.al 2008).

Rapid and haphazard urban growth has triggered urban sprawl and induced irreversible land cover conversions (Chettry et.al 2023).

Urban sprawl is one of the main dynamic forces of global environmental change, especially in small cities (Singh et.al 2020).

Objectives

The urban planning authorities can make use of these techniques of built-up area extraction and urban sprawl analysis for effective city planning and sprawl control. The results showed that the urban built-up area in the city has increased by almost 4303% or you can say four times from previous year. The following are the objectives identified as a part of this project:

1. Identification and mapping of extent of urbanization taking place in the study area.
2. Classification using MLC Classifier.
3. To find the area of expansion by using satellite imagery.

Study Area-

The study area is located between 268 200 N to 268 350 N latitude and 748 330 E to 748450 E longitude. Municipal limit of Ajmer spreads over an area of 250 Sq. km.
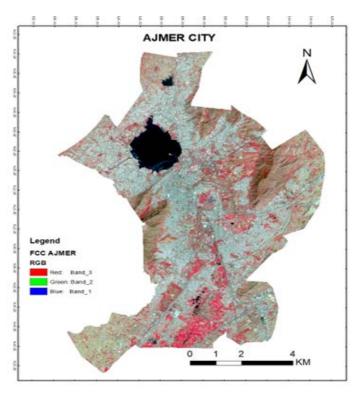

Figure 1.1: Base map of Ajmer city

Data and Methodology

Sentinel-2

Sentinel-2 multi-spectral Level-2A (L2A) dataset was obtained from USGS (UNITED STATE GEOLOGICAL SURVEY). The experiment was carried out using multi-temporal data. Sentinel-2 L2A images with a cloud cover percentage of less than 20% between January and March in 2020-2022 were selected. For each selected year, there are 13 multi-band images covering the entire study area. In this experiment, 4 spectral bands of Sentinel-2 imagery are selected and processed as the classification features, including Blue, Green, Red, near infrared (NIR).

Maximum Likelihood classification

➢   It is a supervised technique based on layer signature statistics extracted directly from satellite images or training samples representing different

types of land cover selected based on data collected from the field.

➢ MLC is a pixel-based classifier that assumes that the statistics for each class in each band are normally distributed and computes the probability that a given pixel belongs to a particular class.

➢ Most machine learning algorithms are mathematical model mapping methods used to learn or discover underlying patterns embedded in data.

➢ Machine learning includes a group of computational algorithms that can perform pattern recognition, classification, and prediction on data by learning from existing data.
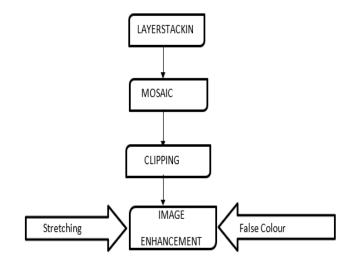

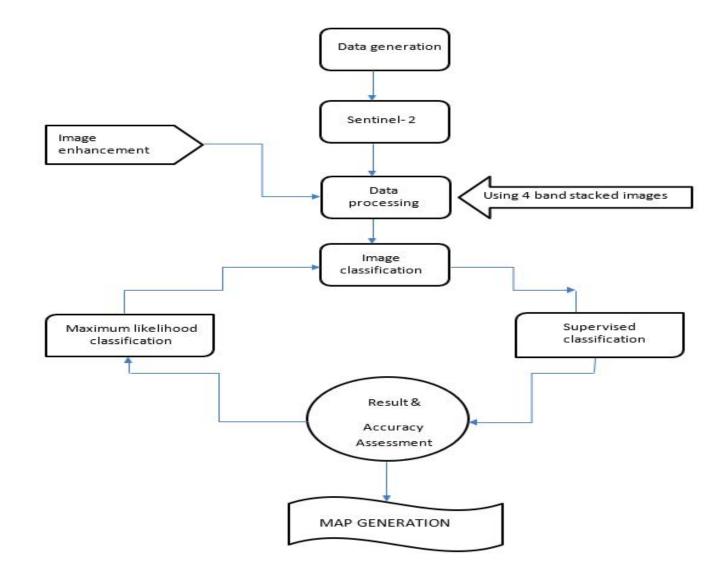Figure 1.2: Methodology-Phase-I

Figure 1.3: Methodology-Phase-II

RESULT AND DISCUSSION

Urban growth is a critical cause of Sprawl - as cities get bigger, they expand around their Peripheries. But sprawl is more specific in nature, it is defined as 'uncoordinated growth': the expansion of a community without a real concern for consequences of poor environmental conditions or environmental impact.

Urban sprawl is also known as 'horizontal spreading' or 'dispersed urbanization'. The uncontrolled and disproportionate expansion of an urban area into the surrounding countryside, forming low-density, poorly planned patterns of development is described as urban sprawl. Appearing both in high-income and low-income countries, urban sprawl is often characterized by a scattered population who live in separate residential areas, with long blocks of houses and poor access, often population is over dependent on motorized transport and the place is missing well defined hubs of commercial activity (UNICEF, 2012). Sprawl is also a highly political word, framing debate over the loss of agricultural land and wildlife habitat, the costs of automobile use, and appropriate design and policy solutions (Duany, Plater-Zyberk and Speck, 2000).

Although Ajmer sprawl is often associated with a lack of planning or a failing planning apparatus, government policies and public agencies, influencing decisions about road construction, housing financing and zoning, have shaped the rise of sprawling cities over a past decade. Ajmer urban sprawl development is majorly of ribbon development along corridors, and leapfrog development at one of its end.

Reason for Urban Sprawl in Ajmer City-

➤   Lower Land Rates: Lower cost land and houses in the outer suburbs of the cities, because the centers of urban development have really made people want to stop settling in these areas and want to venture further out. Like near Parbatpura bypass area, MDS university Area, Makopura village.

➤   Improved Infrastructure: There is increased spending on certain types of infrastructures, including roads and electricity. This is something that hasn't always been available.
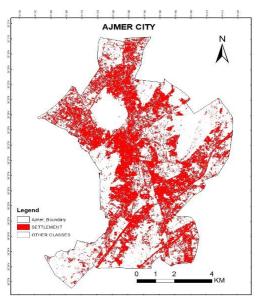
➤   Rise in Standard of Living: There are also increases in standards of living and average family incomes, which means that people have the ability to pay more to travel and commute longer distances to work and back home.

➤   Lack of Urban planning: People love to find areas that are less trafficked and more calm, which leads them to sprawl out to other sections of the town. Unprecedented development, cutting of trees, loss of green cover, long traffic jams, poor infrastructure force people to move out to new areas.

➤   Lower house tax rates: Cities will usually have high property taxes, and you can usually avoid these taxes by living in the outer suburbs because the taxes are usually lower than they would be in other situations.
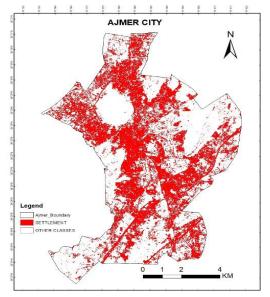
➤   Rise in Population Growth: Another factor that contributes towards urban sprawl is rise in population growth. As number of people in a city grows beyond capacity, the local communities continue to spread farther and farther from city centers.
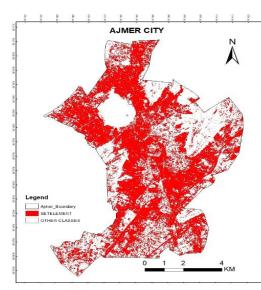
AJMER EXPANSION, 2020-24

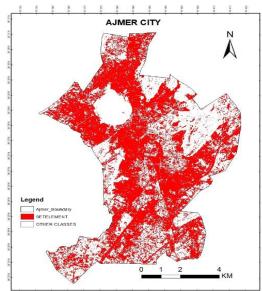The results obtained as the area of built-up in the year 2020 is **26.09 sq. km**

2020

2021

2023

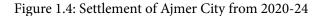Figure 1.4: Settlement of Ajmer City from 2020-24

Study findings based on the study objectives; including satellite imagery of the years 2020 to 2024, existing land use patterns map, ward wise population density map and impacts of urbanization on land use/ land cover. Dramatic transformation of a primarily rural population became increasingly centered in cities over the course of 2020-24. Ajmer city witnessed the accelerated growth of suburbs. Due to urbanization the increasing demand for land, coupled with a limitation in its supplies, is a major cause for more conflicts over land use throughout the natural vegetation.

We have been able to create this map using ArcMap software where we use supervised maximum likely hood classifier after which we only prepared the map highlighting the urban settlement making off other symbology followed by the Areal calculation.

Study of maps shows the aerial expansion of Ajmer urban

sprawl from 2020-24 i.e.-

➢ The results obtained as the area of built-up in the year 2020 is 26.09 sq. km

➢ The results obtained as the area of built-up in the year 2021 is 32.40 sq. km

➢ The results obtained as the area of built-up in the year 2023 is 37.67 sq. km

➢ The results obtained as the area of built-up in the year 2024 is 44.03 sq. km

Major impacts of urban sprawl in Ajmer city is due to the large chunks of productive agricultural land with very good amount of ground water, are now converting into a concrete jungle. The fertile land which was once under agricultural activities, has now become a market place.

Lack of access to planed space for the urban poor, has resulted in encroachment on the hill slopes especially on Taragarh hill, Nagfani area, data nagar area and water bodies. The encroachment on hills

especially along the course of natural drains lead to pollution and chocking of the drains and lead to change in the course of drain which affects the inflow into the lakes.

These sprawl leads to loss of an important limited resource that is land. Over the years, sprawl has directly contributed to and resulted in the degradation and decline of natural habitats such as wetlands, woodlands and wildlife. It has also reduced farmland and open spaces. Water use and energy consumption has increased. Sprawl leads to land-use patterns which are unfavorable to the development of sustainable transport modes and hence, increase the use of private car that in turn result in increased trip lengths, congestion, increase in fuel consumption and air pollution. It is in general a threat to ecology. Even though automobile and truck engines have become far cleaner in recent decades, motor vehicle emissions are still the leading sources of air pollution. As homes and businesses spread further and further apart, local governments are forced to provide for widely spaced services and infrastructure leading to higher costs and increased tax burden.

Computation of urban sprawl-

The percentage change in the area of built-up in Ajmer city is as follows-

$$\% \ change \ in \ area = \frac{Area \ in \ final \ year - Area \ in \ inital \ year}{Area \ in \ initial \ year} * 100$$

(i) From 2020-21

% Change in Built-up = 32.40-26.09÷26.09

$= 31.40 \times 100$

$= 3140\%$

(ii) From 2021-23

% Change in Built-up = 37.67-32.40÷32.40

$= 36.67 \times 100$

$= 3667\%$

(iii) From 2023-24

% Change in Built-up = 44.03-37.67÷37.67

$= 43.03 \times 100$

$= 4303\%$

Conclusion

The areas affected by sprawl and the locations of sprawl are different. A city's adjacent cities or other areas within its administrative boundaries may be directly or indirectly impacted when sprawl occurs on its outskirts. There are typically two opposing viewpoints regarding the repercussions or impacts of sprawl. While some authors support and promote it, others contend that it is detrimental and that drastic efforts should be made to combat it. Although there may be both beneficial and negative effects of urban sprawl, the latter are frequently more prominent because of the unchecked or disorganised growth, eventually overshadowing the former. Urban sprawl has several beneficial effects, such as increased economic output, more job opportunities and improved chances and services that lead to better living circumstances and lifestyles. Better infrastructure and social capital, including water, sewer, and transportation, as well as improved educational and medical facilities, can be made available to a greater number of people through urban expansion. However, because of the unplanned and uncontrolled growth that leads to sprawl, the benefits are obscured, allowing attention to be drawn solely to the drawbacks. According to the findings, the city's urban built-up area has grown by over 4303%, or four times annually. The expansion in the area is mainly illegal encroachment and colonization which is due to the lack of supervision on time. Earlier in developed countries, urbanization was created from and it also led to industrialization. Surplus population from the villages were motivated to make a mass movement towards cities because of new job opportunities created there. For the cities too, these migrants provided cheap labour for the newly established factories. Due to the present globalized scenario and opening up of economies, the circumstances are similar in developing countries. The huge concentration of investments in cities attracts a large number of migrants from villages who are looking for employment. This creates a large surplus labor force, and because of which the wages remain low. Developed and developing countries of the world differ not only in the number of people living in cities, but also in the way in which urbanization is occurring. Urban sprawl is a common problem and a substantial amount of city dwellers live in slums within the city or in the urban periphery in poverty and degraded environment. Evidence of the environmental impacts of sprawl continues to mount. Kirtland et al. (1994) report that the impact of urban land on environmental quality is much larger than its spatial extent would imply. The consequences and significance of sprawl, good or ill, are evaluated based on its socioeconomic and environmental impacts. Often these are overlapping or one may have several indirect impacts.

ECOLOGICAL IMPACTS: -

LAND CONSUMPTION:

The amount of open space used by each inhabitant has increased in the last 20 years by two or three times.

ENERGY CONSUMPTION:

The level of gas consumption can be used as a parameter of the level of car use. The United Nations and the European Union have moved in favour of the compact city embracing the position, supported by research (that denser cities consume the least amount of energy for transport.

ATMOSPHERIC POLLUTION:

The level of pollution due to motorcar dependency can more easily be connected to population densities.

IMPACTS ON WILDLIFE AND ECOSYSTEM:

In areas where sprawl is not controlled, the concentration of humans in residential and industrial areas of the sprawl may lead to an modification of ecosystems patterns and processes (Grimm et al. 2000). The reach of urban sprawl into rural natural areas such as woodlands and wetlands ranks as one of the primary forms of wildlife habitat loss. Roads, power lines, subdivisions and pipelines often cut through natural areas, thereby fragmenting wildlife habitat and altering wildlife movement patterns The fragmentation of a large forest into smaller patches disrupts ecological processes and reduces the availability of habitat for some species. Some forest fragments are too small to maintain viable breeding populations of certain wildlife species.

INCREASE IN TEMPERATURES: CREATION OF URBAN HEAT ISLANDS: -

On warm days, urban areas can be 6–8 F (3.5–4.5 C) warmer than surrounding areas, an effect known as an urban heat island (Frumkin 2002) The heat island effect is caused by two factors. First, dark surfaces such as roadways and rooftops efficiently absorb heat from sunlight and reradiate it as thermal infrared radiation; these surfaces can reach temperatures of 50–70 F (28– 39 C) higher than surrounding air. Second, urban areas are relatively devoid of vegetation, especially trees; that would provide shade and cool the air through evapotranspiration. As urban centres sprawls, the heat island effect expands, both in larger geographic extent and in intensity. This is especially true if the pattern of development features extensive tree-cutting and road construction.

A new development be it planned or unplanned could arise on vacant land or on land that was previously used for some other purpose. In most instances though, whenever the need arises, it is the outskirts of the city that provides for "unlimited" vacant land since inner cities are usually intact. Different situations are observed to cause sprawl. In almost all cases, rise in population plays a major role as a main cause. Urban sprawl has been recognized as a problematic aspect of metropolitan growth and development in the world over. The growing concern about the issue is shared among planners, policy makers, environmentalists and people in general.

REFERENCES

Joseph, G. (n.d.). *Fundamentals of remote sensing and GIS*. [Publisher not specified].

Canada Centre for Remote Sensing. (n.d.). *Fundamentals of remote sensing: A remote sensing tutorial*. [Government of Canada or relevant agency].

Cheng, J., & Masser, I. (2003). Urban growth pattern modeling: A case study of Wuhan city, PR China. *Landscape and Urban Planning, 62*(4), 199–217. https://doi.org/10.1016/S0169-2046(02)00106-1

Abbas, Z., & Jaber, H. S. (n.d.). Accuracy assessment of supervised classification methods for extraction land use maps using remote sensing and GIS techniques. *[Journal name missing]*. [Add journal info if available].

Frenkel, A., & Ashkenazi, M. (2008). Measuring urban sprawl: How can we deal with it? *Environment and Planning B: Planning and Design, 35*(1), 56–79. https://doi.org/10.1068/b32111

Chettry, V. (2023). A critical review of urban sprawl studies. *Journal of Geovisualization and Spatial Analysis, 7*, Article 28. https://doi.org/10.1007/s41651-023-00141-7

Singh, L., Singh, H., & Singh, S. (2020). Managing natural resources and environmental challenges in the face of urban sprawl in Indian Himalayan city of Jammu. *Journal of the Indian Society of Remote Sensing, 48*, 1139–1147. https://doi.org/10.1007/s12524-020-01116-3

Jat, M. K., Khare, D., Garg, P. K., & Shankar, A. (2008). Remote sensing and GIS-based assessment of urbanisation and degradation of watershed health: A case study. *Urban Water Journal, 00*(0), 1–13. [Update with real volume/issue/page if available].

Duany, A., Plater-Zyberk, E., & Speck, J. (2000). *Suburban nation: The rise of sprawl and the decline of the American dream*. North Point Press.

Chouhan, B., & Kannan, M. (2019). Impacts of urbanization on land use pattern and environment: A case study of Ajmer City, Rajasthan. *Asian Review of Social Sciences, 8*, 87–91.