URBAN SPRAWL ANALYSIS:
A CASE OF LAGATAFO LAGADADI TOWN, ETHIOPIA

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Thesis Submitted to the department of Geomatics Engineering

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DECLARATION

I hereby declare that this research thesis entitled "URBAN SPRAWL ANALYSIS: A CASE OF LAGATAFO LAGADADI TOWN, ETHIOPIA" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Degu Bekele Gashe	______________________	_______________
Name of student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "URBAN SPRAWL ANALYSIS: A CASE OF LAGATAFO LAGADADI TOWN, ETHIOPIA" prepared under my guidance by Degu Bekele Gashe submitted in partial fulfillment of the requirements for the degree of Master's in **Geoinformatics Engineering**. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Roba Gemechu (PhD)	__________________	__________________
Name of Major Advisor	Signature	Date

APPROVAL SHEET

I, the advisor of the thesis entitled "URBAN SPRAWL ANALYSIS: A CASE OF LAGATAFO LAGADADI TOWN, ETHIOPIA" and developed by Degu Bekele Gashe hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Degu Bekele Gashe have read and evaluated the thesis entitled "URBAN SPRAWL ANALYSIS: A CASE OF LAGATAFO LAGADADI TOWN, ETHIOPIA" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Geoinformatics Engineering**.

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Degu Bekele

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List of Acronyms

CSA	Central Statistics Agency
ERDAS	Earth Resources Data Analysis System
ESRI	Environmental Systems Research Institute
G.C	Gregorian calendar
GDP	Gross Domestic Product
GIS	Geographic Information System
IGT	Integrated Geospatial Technology
LULC	Land Use Land Cover
OUPI	Oromia Urban Planning Institute
RS	Remote Sensing
SDG	Sustainable Development Goals
TM	Thematic Mapper
UN DESA	United Nations, Department of Economic and Social Affairs
UN	United Nations
USGS	United States Geological Survey
WPP	World Population Prospects

ABSTRACT

The continued formation of urban sprawl is a worldwide concern associated with the rapid growth of urban population, particularly in developing countries like Ethiopia. Like the problems of many cities in the country, Urban sprawl around the periphery and within the Laga tafo laga dadi town is the critical problem which has a great impact in provision of urban amenities in to those places. For this reason, there is a need for employing geospatial information for measuring spatial indicators to determine the spatio-temporal characteristics of urban sprawl in order to support cities to contain urban sprawl. In this research, Landsat Images, Spot Images, AutoCAD and Google Earth Maps are integrated with Remote Sensing and Geographic Information System technology software for Land Use Land Cover changes and urban sprawl analysis in the concentric rings of 0 to 3km, 3 to 6km and 6 to 9km. The result demonstrate that, during the period of 2000 up to 2022 urbanization increased generally, bare land areas and agricultural land were converted in to built-up lands. Concentration of built-up area increased from 3.4 km2 to 34.91 km2 during the study period, and dominance of dispersed growth than compact settlement development and the result of Shannon entropy values shows that, high level of urban sprawl examined in 2010 in the proximity of 6 to 9 km. Dominant urban sprawl pattern in LagaTafo LagaDadhi town was outward extension and infill development. This research provides a better understanding about measurement of urban sprawl pattern, intensity and development trend around Laga-Tafo Laga-Dadhi Town. It also, important guideline and a resource for urban planner and policy makers to design appropriate plans and policy for sustainable city development. Implementation of building bylaws and land use plans is highly recommended. Furthermore, is high time for planner and policy makers to develop urbanization not only in horizontal dimension but in vertical dimension as well.

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Keywords: *Urban Sprawl, GIS, Remote sensing, Shannon entropy, Urbanization*

1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

The rising trend of Urbanization nowadays is seen in an alarming rate all over the world especially in developing countries. As a result, this makes cities to grow both in number and in physical size. In quite a lot of instances, the population percentage increase is accompanied by more than proportional percentage increase of an urbanized area. This indicates that both growth rates differ and urban area grows in greater rapid pace. Because of the different activities and processes that take place every day in the urban ecosystem, the subject of urbanization and urban sprawl has drawn attention from ecologists, urban planners, civil engineers, sociologists, administrators, policy makers, and finally to common urban or rural resident (Haregewoin B. 2005).

Today, the world’s population numbered approximately 7.6 billion, indicating that the world has added roughly one billion peoples over the last one dozen years (WPP, 2017). According to WPP (2017), Sixty percent of the world’s population live in Asia, 17 percent in Africa, 10 percent in Europe, 9 percent in Latin America and the Caribbean, and the remaining 6 percent in Northern America and Oceania where China and India comprise 19 and 18 percent of the world total population, respectively. Globally, more than half of the world’s population live in urban area and it is predicted that in 2030 and 2050 the world’s population would reach 8.6 and 9.8 billion, respectively, more than two-third of whom will live in cities (WPP, 2017).

Apparently, cities are places of both enormous opportunities and unprecedented challenges. On the one hand, cities are a place of potential challenge, which makes cities more and more vulnerable to natural disasters, pollution, and the effect of climate change. On the other hand, cities are the place of immense opportunities that makes cities a vehicle to tackle these major urban challenges. For example, cities are the major contributors to the global economy and the driving forces of sustainable development (Parnell, 2016). Indeed, cities occupy about 2% of the total land, yet account for 70% economy (GDP), over 60% global energy consumption, 70% greenhouse gas emission and 70% global waste (UN-Habitat III, 2017).

Recognizing the critical role of cities as a crosscutting issue of almost every sustainable development concern, Sustainable Cities and Communities known as Goal-11 became one of 17 Sustainable Development Goals (SDGs) of the 2030 Agenda (UN, 2015). The aspiration of SDG-11 is to “make cities and human settlements inclusive, safe, resilient, and sustainable” (UN, 2015). It includes targets such as slum upgrading, participatory planning, sustainable transport, improved waste management and air quality, cultural and natural heritage protection, and climate resiliency and natural disaster risk reduction (UN Habitat, 2016).

Understandably, urbanization is inevitable and irreversible. Moreover, urbanization by itself is not a problem. It is a powerful driver for social development and economic growth. However, the inability of cities, to cope up with the pace of urbanization and rate of population growth in pursuit of sustainable development is an issue as a worldwide. Obviously, the current growth pattern of human settlements will have a profound and long-lasting impact on sustainability development (UN-Habitat III, 2017).

Many African developing countries have recently begun rapidly urbanizing, with the urban population is projected to triple by 2030 (Güneralp, B., et al. 2020),. Furthermore, the continent is projected to be most rapidly urbanizing between 2020 and 2050 Güneralp, B., et al. 2020), (WPP, 2017). Ethiopia, for example, with about more than 100 million people is the second largest populated nation in Africa next to Nigeria. Similarly, Ethiopia has more than 900 urban centers where Lagaafo Lagadadhi is experiencing the most noticeable rapid urban expansion in the country like other emerging cities. Furthermore, Ethiopia has attained notable economic development over the last decade, yet the country still faces urban challenges such as urban sprawl that can be attributed to partly rapid population growth and uncontrolled and unplanned urbanization process.

Given the current population growth and rapid urbanization trends, and the central role of cities in economy development and mitigation of climate change, reconsidering the way the urban space is being planned and managed in Ethiopia is not a choice but an imperative to foster sustainable development while protecting the environment (UN-Habitat III, 2017). This is because; the uncontrolled urban expansion alters a city’s agricultural land, natural vegetation and resources. As a result, land use planning and proactive urban management has become one of the most important urban challenges in developing countries including Ethiopia (WPP, 2017). However, several local urban authorities lack evidence-based decision making to contain urban sprawl, particularly in developing countries such as in Ethiopia even though many efforts have been done. Accordingly, rapid urban expansion is proceeding in an uncontrolled manner, resulting in informal settlements and urban sprawl (UN-habitat, 2015).

To this effect, urban growth both in the forms of extension or infill, has been consuming land in various ways, paces and rates across the world including Ethiopia. For example, it was projected that 95% of urban expansion in the next few decades will be experienced in the Global South, with Africa and Asia alone contributing more than 86% (UN DESA, 2014). These emerging trends exacerbate the formation of informal settlements and urban sprawl, the pressure on periurban environments and loss of prime agricultural lands and other associated urban challenges, particularly in rapidly urbanizing cities unless otherwise contained through evidence-based decision process (Güneralp et al., 2020). At the center of these is the need for spatial analysis of the trends of urban sprawl and its implications using reliable and timely geospatial information for informed urban land policies and strategies.

Urban Sprawl can be defined as rapid extension of urban areas, development of built-up fringes in suburbs and rural areas (Galster et al., 2001). Urban sprawl refers to transfer of urban population, from zero point areas or towns to low density rural fringe or rural areas.

There are many reasons why urbanization processes have been a hot research area for several decades. One of the most important reasons for such an interest is that, the size and spatial configuration of an urban area directly impacts energy and material flows such as carbon emissions and infrastructure demands, Although urban sprawl is an inescapable process, efforts can be made to protect natural resources, reduce natural hazards such as flooding and improve the livelihoods of urban dwellers through proper way of urban planning and management (Soffianian, 2010). To do so city planners, policy makers and resource managers need more advanced and quick techniques to acquire quantitative information on urban growth processes and patterns. It can facilitate the urgent establishment of management mechanisms and relevant policy interventions for proper allocation of resources and urban infrastructures based on empirical evidences. However, the available information on the city growth and evolution is insufficient and out- dated. This makes decision making process complex and less transparent. Therefore, quantifying urban growth processes and patterns is crucial to monitor urbanization and its impact on environment over time. However, they give insufficient information about spatial patterns of urbanization processes that characterize urban areas.

LULC change analysis is the one way to identify urban sprawl process and can be effective tool to determine urbanization in the future prospect. GIS and RS is effective tool for monitoring and modeling LULC change. RS technique provides cost effective method and acts as primary data for urban sprawl analysis. In order to study characteristics of urban sprawl like pattern, extent and level of urban sprawl appropriate statistical technique alongside with GIS technique is necessary (Jat et al., 2008). Despite such chaotic urbanization change, urban sprawl growth and population growth, there have been very few urban sprawl studies in Lgatafo-Lagadadi Town.

Remote sensing data can provide time series land-cover maps explicitly exhibiting the dynamics of urban growth; yet some underlying patterns and characteristics could not be visualized clearly. Spatial metrics, in the form of a succession of indices, can reliably quantify and represent the spatial-temporal patterns and processes of urban growth. They provide an improved description and understanding of the structure and morphology of heterogeneous urban areas. Moreover, spatial metrics provides a linkage to structure, pattern, processes and functionality in urban studies (Luck & Wu, 2002). Thus, remote sensing and spatial metrics are valuable tools to analyze urbanization processes and patterns empirically.

This research title is selected from the point of view of the above reasons and motivated the researcher to do the research on this topic by practical observation of the current real problem in the study area.

1.2. STATEMENT OF THE PROBLEM

The pace and rate of urban growth in developing countries like Ethiopia needs to comprehend to attain sustainable forms of urban expansion as well as its effects such as urban sprawl, particularly in emerging cities and towns like Lagatafo Lagadadi tgown. However, there is little systematic analysis of the trends of urban sprawl change, particularly in most of rapidly urbanizing emerging cities of Ethiopia such as Lagatafo Lagadadhi. As a result, the dynamics of unsustainable urban change resulting in complete land transformation including loss of periurban agricultural lands and proliferation of informal settlements and urban sprawl, among other things (d'Amour et al., 2017). As long as these emerging cities will continue to experience rapid urban growth without adequate infrastructure and proactive urban planning, the prospect of urban sprawl seems to continue. Consequently, the expansion of urban land areas has outpaced the growth of urban populations across the world (Seto et al, 2014). This is particularly the case in rapidly growing emerging urban centers of Ethiopia creating huge institutional and financial challenges.

In general, uncontrolled and unplanned urbanization trends are closely associated with lack of commitment in land management of the urban authorities, and lack of institutional capacity and analytical capability to accommodate high rate of population growth and address demand for basic services and adequate infrastructure ahead of development, resulting in urban sprawl. Thus, hinders progress towards the three pillars of sustainable development: economic, environmental and social in the long-term.

On the other hand, lack of reliable, available, and timely geospatial data added to inadequate urban planning, limited institutional capacity, and analytical capability in urban development in general leads to poor decision and inadequate urban planning, mainly in rapidly growing cities of Ethiopia. This prevalence of data scarcity and lack of institutional capacity and practical methodological gaps coupled with the need to address the many urban challenges including urban sprawl, and as well as the need for measuring and analyzing the trends of urban land use land cover change has been a concern.

Overall, the massive urban transition, the continued urban population growth, the growing matching demand for basic infrastructure, services and opportunities, added to the continued formation urban sprawl in Lagatafo Lagadadhi motivated this study to embark.

Given these compelling facts and contemporary urban challenges in Ethiopia, there is a need for action in the integration of geospatial information with socio-economic datasets for measuring and assessing urban sprawl. There is a need for employing geospatial information for measuring spatial indicators such as urban sprawl for building methodological framework so as to support cities to contain urban sprawl and other undesirable urbanization process. Accordingly, reliable and timely geospatial information and analysis are a prerequisite for evidence based decision making to better address various urban challenges including the issues associated with urban sprawl. This is mainly evident given its ability to integrate both qualitative and quantitative data from different sources. Hence, this study attempts to quantify urban sprawl in the context of rapidly urbanizing emerging cities of Ethiopia where reliable and timely geospatial data and institutional capacity and analytical capability at the local level are typically not available. Lagatafo Lagadadhi town is being selected as a case study in order to provide simple but reliable methodological and analytical framework.

Like the problems of many cities in the country, in Lagatafo Lagadadhi town, the critical problems is Urban sprawl around the periphery of the town which have a great impact in provision of urban infrastructural facilities in to those places (Selamawit,2017). The town is under the influence of population spillover from the Addis Ababa city which caused fast land use/land cover dynamics within the past few years. Hence, due to competition over the land for various developments, the town is sprawling to the surrounding rural areas where in many circumstances the land use is not efficiently utilized.

The development of built up areas in the peripheral area of the town, and even along the river banks are so placed in scattered manner, and leaving vacant lands in between the built up areas. The town administration has no information about the extent, level and pattern for proper planning. Therefore, such spontaneous developments require identification of the extent, level and patterns of sprawling of the town for guiding and monitoring its urban development. Given such rapid development characteristics and land use/land cover dynamics of the town, there is no study conducted on analyzing the level and pattern/Type of urban sprawl of Lagatafo Lagadadhi town.

Selamawit (2019) conducted a research on spatio temporal analysis of Land Use/Land Cover Change of Lagatafo Lagadadhi town using GIS and Remote sensing. The research only quantifies the amount of land use change in hectare and percent from 1996-2016. However to Understand the dynamic phenomenon of urban sprawl requires the identification of urban sprawl patterns, level and the computation of landscape criteria.

The rapid urbanization and urban sprawl in particular in the developing world require a scientific understanding of complex urban growth patterns and processes. This knowledge is highly crucial to sustainable land management and urban development planning. Progress in modern remote sensing, Landscape matrix and GIS techniques has opened up great opportunities for monitoring and managing fast urban growth/Sprawl.

Basically, planning and management of urban spaces requires a comprehensive knowledge of the development process and physical dimension of cities (Klosterman, 1999). most literature‘s on the analysis of the spatial characteristics of cites growths highlight the value of spatial metrics in the study of urban landscapes. However, Seto and Fragkias (2005) argue that, most of these studies focus on western cities. However, less is studied in relatively fast growing cities of Africa using spatial metrics for quantifying urban growth patterns. Combined with remote sensing, spatial metrics can give better result than using either of them gives separately (Herold et al., 2003). Thus, it is worthwhile to expand the application of spatial metrics to fast growing African countries. This is particularly true for less developed Sub Saharan cities/towns like Lagatafo Lagadadi, where the availability of spatial data is very limited.

This research attempted to investigate the spatio-temporal patterns of lagatafo lagadadi urban sprawl and quantify the underlying spatial pattern of the urban landscape. Remote sensing and spatial metrics tools will be utilized to accomplish this task. The combined use of these tools is believed to lead to new levels of understanding of urban development process which can assist city planners and policy makers to make informed decision (Herold et al., 2005).

This study attempted to show the pattern, type and concentration of Urban sprawl using integrated geospatial technology and spatial metrics to fill the gap identified on the previous study to furnish the research of lagatafo lagadadi town urban sprawl.

1.3. OBJECTIVES OF THE STUDY

1.3.1. General Objective

Within this context, the general objective of this study is to determine the spatio-temporal characteristics of urban sprawl in Lagatafo Lagadadhi from 2000 to 2022 using geospatial information.

1.3.2. SPECIFIC OBJECTIVE

1. To quantify or analyze the spatial land use pattern change of Lagatafo Lagadadi town since 2000.

2. To measure the distribution, extent and level of urban sprawl of Lagatafo Lagadadhi town between 2000 and 2022 using Shannon entropy and land scape metrics.
3. To determine the type of spatio-temporal pattern of urban sprawl of Lagatafo Lagadadhi town between 2000 and 2022.

1.4. RESEARCH QUESTIONS

The following research questions has devised in the study based on the stated specific objectives.

1. What land use land cover change is happened in Lagatafo Lagadadhi town between 2000 and 2022?
2. What are the distribution, extent and level of urban sprawl in Lagatafo Lagadadhi town between 2000 and 2022?
3. What is the type of urban sprawl in Lagatafo Lagadadhi town between 2000 and 2022?

1.5. SIGNIFICANCE OF THE STUDY

The outcome of the study will contribute to the knowledge and understanding of patterns of urban sprawl and its characteristics. The findings of the study will also contribute to a knowledge-based policy and decision making in key aspects of informal settlements and uncontrolled urban sprawl, as well as to inform better ways for a sustainable urban expansion with due consideration to human and natural environments.

Likewise, the outcome of the study could help to enable urban policy makers and planners to pro-actively plan and monitor, and shape future urban land development towards the aspired sustainable urban transformation. Similarly, the methodological framework will provide a basis for analyzing urban sprawl dynamics in other cities having similar socio-economic conditions to explore, gain insights into, and develop and evaluate alternative pro-active plans in order to getting ahead of demand for land and services.

Furthermore, the outcome of the study could help to raise awareness and understanding about the contribution of geospatial technologies and information in addressing the contemporary urban growth challenges and directing future urban expansion in rapidly urbanizing Ethiopia cities where up-to-date and accurate data, as well as institutional capacity and analytical capability at the local level are typically not available.

1.6. Scope of The Study

1.6.1. Spatial Scope

Geographically the study focused particularly on Lagatafo Lagadadhi town of the Oromia Regional State, which is located at North East Parts of our Capital city Addis Ababa. This study area selection is for the two reasons: one, the researcher's close observation of the existing sprawl problem, and second the proximity for the researcher to conduct the research work.

1.6.2. Thematic scope

Contextually, the paper reveals the magnitude, extent, level and type of urban sprawl in Lagatafo Lagadadhi town by using the spot and Landsat images, in the year between 2000 and 2022.

1.7. Structure of the Thesis

As it has been described in the preceding sections, chapter one introduces and explains the background of the study to place the research in context. It also describes the importance of the research problem leading to the identification of the research objectives. Likewise, this chapter states scope and significance of the study.

Chapter two will discuss the theoretical background information about the cause and consequences of urban sprawl and other associated concepts such as its type and pattern. The chapter will also review the spatio-temporal growth of urban, application of GIS and RS as well as land use land cover classification scheme. Furthermore, this chapter reviews the theory and concepts of Shannon entropy to measure urban sprawl.

Chapter three will provide background information about the case study area. The chapter will describe the urbanization and population growth trend and illustrates the methodological workflow of the methods. It will describe the data: sources, acquisition and analysis methods similarly, it will give the general analysis of spatial pattern-process analysis of the built-up change, landscape metrics and growth type.

Chapter four will present the most relevant results of the land use land cover classification of the case study area starting from 2000. This chapter will also describe the meaning of the results with respect to the level, rate and types of urban sprawl. Furthermore, this chapter will illustrate the results in the form of maps, graphs and tables along with the corresponding discussions.

The last chapter, chapter five, will provide the general conclusions observed from empirical investigation and analysis. The chapter will also highlight possible recommendations to improve the limitations and finally proposes possible future research areas and directions.

2. LITERATURE REVIEW

In this thesis report is the beginning for understanding the concept of urban sprawl, causes, drivers, consequences, methods of measuring, and modeling future growth. Literature review was useful in gathering significant study reports from different scholars. Comprehensive knowledge of the literature of the field is essential to every research papers. Thus literature review in this context was very crucial in preparation of overall thesis report.

2.1. URBAN SPRAWL

Urban Sprawl is a term that is often used to describe perceived inefficiencies of development, including disproportionate growth of urban areas and excessive leapfrog development. Sprawl is a cumulative result of many individual decisions and it requires not only an understanding of the factors that motivate an individual landowner to convert land, but also an understanding of how these factors and individual land use decisions aggregate over space. Population dynamics are often cited as a driving force behind urban sprawl. Population increases and the consequences of unplanned urbanization are directly related to recent growth management practices that seek to influence the way in which built-up land can proliferate. (Maier et al., 2006)

In the present context there has been several definition of urban sprawl (US), still agreement on common definition has not been determined. Urban sprawl defined as unaesthetic and uneconomic settlement form. According to Oxford Dictionary, urban sprawl is been defined as the disorganized and unattractive expansion of an urban or industrial area into the adjoining countryside‖ this statement is significant as disoriented and haphazard urbanization and industrialization resulted in series of problems in developing countries (Tiwari et al., 2012).

Urban Sprawl can be defined as low density development of residential area, commercial areas, business areas that are segregated, with lack of thriving activity center and limited choice of travel route (Jiang et al., 2007), author described four important factors which can be used to measure sprawl as residential density, neighborhood mix homes, occupation and services, strength of service centers and accessibility network. Al-Dosary and Khan, (2010) stated different forms of urban sprawl, from low density residential development or edge cities‖, or the form of planned communities or downtown‖ or individual houses that pop up in formal rural areas. Burchell et al. (1998) conceptualized in order to define characteristics of urban sprawl, spatial pattern, root causes and main consequences of sprawl needs to be determined. He further lists the spatial pattern of sprawl as low density, unlimited outward expansion; land uses spatially segregated, leapfrog‖ development, and widespread commercial strip development.

Many authors defined urban sprawl in several ways, but Franz et al. (2006) summarized the several definition of urban sprawl based on various concept: in the form of density attributes, de-concentration process, structure and form of attributes, socially relevant effect, and normative planning and other prospective. Firstly, urban sprawl was defined in terms of density attributes considering low density settlement form, decrease in density and breakdown of cities or core areas in the form of sprawl (Glaeser & Kahn, 2003; Fulton, 2001). Secondly urban sprawl was defined in the form of de-concentration process, which exhibits the urban function defined with combination of spatial expansion of urban areas into rural areas (Glaeser and Kahn 2003; Pumain, 2010).

Thirdly Urban Sprawl was characterized in the form of attributes of settlement system considering urban form building process disrupting mono-centric structure to discontinuous and dispersed settlement (Galster et al., 2001). Fourthly, urban sprawl was defined in terms of social effect on land use changes: traffic congestion, loss of water sources and soil fertility, transformation of agriculture area to non-agriculture purpose etc. (Ewing, 1997). And finally Urban Sprawl has been defined in terms of normative planning and order perceptions: Which can be summarized as unplanned development of urban areas which opposes the goal of sustainable development (Angel et al., 2007).

However, sprawl must be considered in a space-time context as not simply the increase of urban lands in a given area, but the rate of increase relative to population grows. United States Environmental Protection Agency defined sprawl in 2001 as at a metropolitan scale, sprawl may be said to occur when the rate at which land is converted to non-agricultural or non-natural uses exceeds the rate of population growth (Angel et al., 2007).

Sudhira and Ramachandra (2007, July) have stated Urban sprawl refers to the outgrowth of urban areas caused by uncontrolled, uncoordinated and unplanned growth. This outgrowth seen along the periphery of cities, along highways, and along roads connecting a city, lacks basic amenities like sanitation, treated water supply, primary health center, etc. as planners were unable to visualize such growth during planning, policy and decision-making. Although accurate definition of urban sprawl is debated, a general consensus is that urban sprawl is characterized by unplanned and uneven pattern of growth, driven by multitude of processes and leading to inefficient resource utilization. The direct implication of such sprawl is change in land-use and land-cover of the region as sprawl induces the increase in built-up and paved area (Sudhira and Ramachandra 2007, July).

2.2. CAUSE AND CONSEQUENCES OF URBAN SPRAWL

The causes that force growth in urban areas and the causes that are responsible for undesirable pattern or process of urban growth are also essentially important for the analysis of urban growth. The consequences or the impacts of urban growth, whether ill or good, are also necessary to be understood and evaluated towards achieving a sustainable urban growth. Galster et al. (2001) argue that sprawl as a pattern or a process is to be distinguished from the causes that bring such a pattern about, or from the consequences of such patterns. This statement clearly says that analysis of pattern and process should be differentiated from the analysis of causes and consequences.

Remote sensing data are more widely used for the analysis of pattern and process rather than causes or consequences. However, some of the researchers argue that impacts of development present a specific development patterns as undesirable, not the patterns themselves. Therefore, whether a pattern is good or bad should be analyzed from the perspective of its consequences. Causes are also similarly important to know the factors that are responsible to bring such pattern. The causes of urban growth are quite similar with those of sprawl. In most of the instances they cannot be discriminated since urban growth and sprawl are highly interlinked. However, it is important to realize that urban growth may be observed without the occurrence of sprawl, but sprawl must induce growth in urban area. Some of the causes, for example population growth, may result in coordinated com-pact growth or uncoordinated sprawled growth. Whether the growth is good or bad depends on its pattern, process, and consequences. There are also some of the causes that are especially responsible for sprawl; they cannot result in a compact neighborhood (Bhatta, 2010).

Urban Sprawl growth is dependent on variety of factors. Causes of sprawl are Population growth, Independence of decision, Economic growth, Industrialization, Speculation, Expectations of land appreciation, Land hunger attitude, Legal disputes, Physical geography, Development and property tax, Living and property cost, Lack of affordable housing, Demand of more living space, Public regulation, Transportation, Road width, Single-family home, Nucleus family, Credit and capital market, Government developmental policies, Lack of proper planning policies, Failure to enforce planning policies, Country-living desire, Housing investment, Large lot size (Bhatta, 2010).

Political Driver: Christiansen and Loftsgarden (2011). Consider political factors as one of the crucial driver for urban sprawl development. Political decision related to planning system subsidies, taxation system, legislative norms can limit or prevent urban sprawl. Politics plays major role in establishing legislative norms that can helps in promoting sustainable development and on the other hand control urban sprawl.

Technological drivers: Christiansen and Loftsgarden (2011) consider technological driver as one of the major cause of urban sprawl, with advent to 20th century, there was tremendous development in technologies. With advancement of transportation network and automobile accessibility, restriction to live within the proximity of factory was diminished. Also, Living expenses in the core area amplified with development in infrastructure in core area increased. Thus high living expenses in core area was one of the drivers for more dispersed settlement along the fringe. Thus need of commuting can be reduced in remarkable amount, with advancement in technology, resulting in dwelling pattern in more dispersed location, like wisely increases urban sprawl as well.

2.3. CONSEQUENCES OF URBAN SPRAWL

Urban sprawl is generally considered as adverse effect as compared to densely developed city, lacking diversity and economic activities and social infrastructure (Batty et al., 2003). Authors further discussed urban sprawl as haphazard operation of land market, and outcome of uncompetitive process of urbanization. The problem with urban sprawl causes failure in land market strategy accounting for long term economic misbalance in the society. Urban sprawl effect cannot be isolated within single entity, but their effects are accumulated in multiple entities. Mostly consequences of urban sprawl are related to land fragmentation (EEA & FOEN, 2011). Effect due to urban sprawl can be realized in gradual perception. Although single house construction can be visible easily and may be considered in significant in overall effect in urban sprawl, but the long term effect on larger period of time cannot be easily determined (Christiansen and Loftsgarden, 2011).

Another, consequences of urban sprawl can be characterized in terms of efficiency of infrastructure, utilities and related services. Urban Sprawl directly effects on livelihood of people, property values, commutation, and several other aspects of urban environment (Lynch, 1981), he further suggested urban sprawl in cities can be evaluated in the basis of five dimensions viability, sense, fit, access and control. With urban sprawl consumption of resource per capita will increase (Batty et al., 2003).Structure of society is the third consequences of urban sprawl. Urban sprawl causes exclusion of population, limiting better accommodation and quality life to wealthy individual or family (Batty et al., 2003). Thus urban sprawl distorts the social wellbeing of the citizen and creation of inequity in the community.

Urban sprawl has negative impact in landscape through process of transformation, degradation and fragmentation. Agricultural area is mostly transformed into concrete built-up area resulting in loss of agricultural productivity and biodiversity. On the other hand, energy consumption for commuting in low density sprawl area is greater in comparison to core areas. There will be need of production of larger amount of energy for maintaining energy balance in up skirts also results in unsustainable land use practices in sprawl area. There will also be increased competition of land (Christiansen and Loftsgarden, 2011).

Although urban sprawl is considered as negative impact in society, still there are some of benefits of sprawl. Batty et al. (2003) specified with increase in urban sprawl, there will be increase in residential, commercial area and industrial area creating more job opportunity and freedom of job selection to individual. Secondly, with increase in spatial extent of urbanization, there will be spread of metropolitan area, thus public service can be provided to rural population as well. Urbanization also decreases cost of buying houses or apartment, thus relieving pressure of accommodation of people in cities. People are encouraged to live further away from cities, where living expenses, commuting cost will be comparatively low than living in cities. With development of urban sprawl in leapfrog‖ pattern, developers are attracted to develop markets, apartments and housing in relative lower cost than that of cities (Holcombe et al., 1999).

Consequences of urban growth may have both positive and negative impacts; how- ever, negative impacts are generally more highlighted because this growth is often uncontrolled or uncoordinated and therefore the negative impacts override the positive sides. Positive implications of urban growth include higher economic production, opportunities for the underemployed and unemployed, better life because of better opportunities and better services, and better lifestyles. Urban growth can extend better basic services (such as transportation, sewer, and water) as well as other specialist services (such as better educational facilities, health care facilities) to more peoples. However, in many instances, urban growth is uncontrolled and uncoordinated resulting in sprawl. As a result, the upside impacts vanish inviting the downsides (Ishtiaque et al., 2017).

2.4. TYPES OF URBAN SPRAWL

It is necessary to identify type of sprawl to determine characteristics of urban sprawl. Urban sprawl type varies amongst countries and their context (Christiansen and Loftsgarden, 2011). Batty et al. (2003) has described the type of sprawl as compact development, scattered development, linear strip development, poly nucleated development and finally leapfrog‖ development. Scattered development and leapfrog‖ development is the form of urban sprawl which is result of car ownership. Scattered development is directly related to good accessibility to cars and road. Due to availability to car population can settle in any location, with subsequent travel time and travel distance.

Urban Sprawl of these forms may have fewer incentives to intense housing in settlement center, thus resulting in more dispersed land development. Linear urban sprawl strip is developed along the rail/road transportation route. The scattered sprawl development consists of haphazard and uncoordinated development away from core city. Residential cluster comprise open areas between newly created built-up areas. Leapfrog‖ development is a type of development with leap frog pattern over existing boundaries (Batty et al., 2003).

Sprawl is urbanization that takes place in either a radial direction around a well-established city or linearly along the highways over a given period of time (Sudhira et al., 2004). Clearly, radial and linear are just two types of map patterns that sprawl can take. Sudhira et al., (2004) state that to understand the complexity of urban sprawl, land use change analyses and urban growth pattern recognition must be determined. The linear pattern of sprawl is classified as high and medium density built-up areas of development located along the highways.

Wilson et al., (2003) have identified three categories of urban growth: infill, expansion, and outlying, with outlying urban growth further separated into isolated, linear branch, and clustered branch growth. The relation (or distance) to existing developed areas is important when determining what kind of urban growth has occurred. An infill growth is characterized by a non-developed pixel being converted to urban use and surrounded by at least 40% existing developed pixels. It can be defined as the development of a small tract of land mostly surrounded by urban land-cover (Wilson et al. 2003). He defines infill policies as the encouragement to develop vacant land in already built-up areas. Infill development usually occurs where public facilities such as sewer, water, and roads already exist (Wilson et al. 2003). Forman (1995) describes infill attrition as the disappearance of objects such as patches and corridors. An expansion growth is characterized by a non-developed pixel being converted to developed and surrounded by no more than 40% existing developed pixels. This conversion represents an expansion of the existing urban patch. Expansion-type development has been called metropolitan fringe development or urban fringe development (Wilson et al., 2003). Forman (1995) discusses it as edge development, defined as a land type spreading unidirectional in more or less parallel strips from an edge. The analogous land transformation is shrinkage, defined as the decrease in size of objects, such as patches (Forman, 1995).

Outlying growth is characterized by a change from non-developed to developed land-cover occurring beyond existing developed areas. This type of growth has been called development beyond the urban fringe (Wilson et al., 2003). The outlying growth designation is broken down into the following three classes: isolated, linear branch, and clustered branch (Wilson et al., 2003). Isolated growth is characterized by one or several non-developed pixels some distance from an existing developed area being developed. This class of growth is characteristic of a new house or similar construction surrounded by little or no developed land (Wilson et al., 2003).

2.5. URBAN GROWTH PATTERNS AS SPRAWL

Urban growth is an increase in the absolute size of an urban population. This could be at the level of an individual settlement or a collection of settlements (e.g. at the national level). Urban growth and urbanization often occur together, but not always. A nation's urban population can grow in absolute terms without increasing in relative terms (Fox & Goodfellow, 2016: 6). Other authors also define Urban Growth as it means growth that makes intensive use of land for the location of buildings, structures, and impermeable surfaces to such a degree as to be incompatible with the primary use of such land for the production of food, other agricultural products, or fiber, or the extraction of mineral resources. The distinction between growth and sprawl as urban growth occurs, that growth is often confused with urban sprawl. However, there is a distinction between urban growth and urban sprawl. Cities often experience growth physically or by population, or by a combination of both. Urban sprawl is much more complicated because it may or may not qualify as urban growth. How a city grows can create the appearance of sprawl. Such urban growth may appear as a low-density leapfrog pattern, a linear or strip development pattern along highways, or a tightly condensed pattern of new development around pre-existing built-up landscapes (Al-Dosary and Khan, 2010). Without urban growth there would be no appearance of urban sprawl.

In fact, some types of urban growth (e.g., 'infill' growth) are generally considered as remedies to urban sprawl. Therefore, sprawl cannot be characterized by the simple quantification of the amount of land that has changed to urban uses. Sprawl phenomenon should be treated separately than the general urban growth. Harvey and Clark (1965) have identified three major forms of urban sprawl. First, low-density continuous development sprawl, second is ribbon development sprawl, and third is leap-frog development sprawl. These are basically expansion growth, linear branch growth, and clustered (as well as isolated) branch growth accordingly as defined by Wilson et al. (2003). Angel et al. (2007) also identified three basic forms of urban growth as sprawl: (a) a secondary urban center, (b) ribbon development, and (c) scattered development.

An important type of urban growth infill, generally not considered as sprawl. Most of the proponents encourage infill to encounter the sprawl. However, infill should not be considered as simple as it defines. Rather it should be judged and justified with multi-criteria circumstances, for example the growth rate of population in consideration or the actual need of infill by sacrificing what. Furthermore, 100% built-up saturation or urban congestion will also have negative impacts on urban ecosystem (Wilson et al., 2003).

In a similar way, the line between leapfrog development and economically efficient 'discontinuous development' is not always clear. Leapfrog development may occur naturally due to variations in terrain; some portions of the land may not be suitable for urban development (Harvey and Clark, 1965). New communities nearly always start up just beyond the urban fringe, where large tracts of land are available at moderate cost (Ewing, 1997). Some sites are necessarily bypassed in the course of development, awaiting commercial or higher-density residential uses that will become viable after the surrounding area matures (Harvey and Clark, 1965).

Galster et al. (2001) described compactness as the degree to which development is clustered and minimizes the amount of land developed in each square unit of area. This clearly indicates that there is no consensus regarding the compactness. One common theme is the vague concept that compactness involves the concentration of development; however, the degree of compactness is not well understood. The difference between strip development and other linear patterns is also a matter of degree. Likewise, the difference between low-density urban development, exurban development and rural residential development is also a matter of degree. Where to draw the line between sprawl and related forms of efficient development will be subject to challenge unless the analysis is based on impacts. It is the impacts of development that present development patterns as undesirable, not the patterns themselves (Ewing, 1997).

2.6. TEMPORAL PROCESS OF URBAN GROWTH AND SPRAWL

Urban sprawl should be considered both as a pattern of urban land-use that is, a spatial configuration of a metropolitan area in a temporal instant and as a process, namely as the change in the spatial structure of cities over time. If the sprawl is considered as a pattern it is a static phenomenon and as a process it is a dynamic phenomenon. Some of the researchers have considered sprawl as a static phenomenon, whereas some have analyzed it as a dynamic phenomenon; however, most of the researchers shout for both. Sprawl, as a pattern, although help us to understand the spatial distribution but as a static phenomenon; in fact areas described as sprawled are typically part of a dynamic urban scene (Harvey and Clark, 1965; Ewing, 1997). The dynamics of sprawl process can be understood from the theoretical framework of urban growth process. According to Ewing, (1997), urban area expansion starts with a historical seed or core that grows and disperses to new individual development centers. This process of diffusion continues along a trajectory of organic growth and outward expansion. Therefore, sprawl as a process without considering the pattern cannot be characterized. Rather, it should be considered as a pattern in the light of multiple temporal process snapshots. ‘In any event, measuring the respective dimensions of development patterns for an urban area at different times will reveal the process (or progress) of sprawl’ (Galster et al. 2001).

2.7. URBAN GROWTH ANALYSIS WITH APPLICATION OF GIS AND REMOTE SENSING

Urban growth is a spatially-conditioned process, and the outcome at one location is partially affected by the events of its neighboring locations. Several spatial processes relevant to urban growth analysis can be identified in the existing literature of spatial data analysis. Determining the rate of urban growth and the spatial configuration from remote sensing data, is not only a prevalent approach, rather has a long history. GIS also has a wide spectrum of applications in urban analysis, because the discipline embraces space in analysis and modeling (Batty, 2000).

Morphological measurement of urban development is important for land-use planning and the study of urban development. Urban planners and researchers are often concerned with the change in size, shape, and configuration of built-up area. The measurement of urban form can provide a more systematic analysis of the relationships between urban form and process. Urban economics, transport, and social structure are predicted in spatial terms, and thus, the effects of such a theory are often articulated through geometric notions involving the shape of urban land-use and the manner in which it found that there are significant relationships between energy use in transport and physical characteristics of a city, such as density, size, and amount of open space (Angel et al., 2007).

Analysis of urban growth, as a pattern and process, helps us to understand how an urban landscape is changing with time. This understanding includes (1) the rate of urban growth, (2) the spatial configuration of growth, (3) whether there is any discrepancy in the observed and expected growth, (4) whether there is any spatial or temporal disparity in growth, and (5) whether the growth is sprawling or not (Bhatta, 2010). As mentioned earlier, the analysis of urban growth can be per- formed for the past, present, and the future as well. However, the case of past and present is different than the future; because the former is based on empirical evidences whereas the latter is based on simulations. However, simulation is obviously dependent on the past and present evidences. In the recent years, remote sensing data and GIS techniques are widely being used for mapping (to understand the pattern), monitoring (to understand the process), measuring (to analyze), and modeling (to simulate) the urban growth, land-use/land-cover, and sprawl. The physical expressions and patterns of urban growth and sprawl on landscapes can be detected, mapped, and analyzed by using remote sensing data and GIS techniques (Angel et al., 2007). The decision support systems within the GIS can evaluate remote sensing and other geospatial datasets by using multi-agent evaluation, which can also predict the possibilities in the subsequent years using the current and historical data. In the last few decades, these techniques have successfully been implemented to detect, analyses, and model the urban growth dynamics (Angel et al., 2007).

Remote Sensing is advanced technique of collection of data from space borne technique or airborne technique without having any physical contact in the earth surface. RS provides flexibility of multispectral, multi temporal, multi resolution data, which are valuable assets for urban analysis, urban modeling and urban sprawl modeling as well. Due to its nature of timely, cost effectiveness, high temporal frequency, this technique was widely used for urban modeling, land use land cover change detection and variety of other urban study related field. Urban growth/urban sprawl growth can be monitored properly with the application of GIS and RS (Araya & Cabral, 2010).

2.8. LAND USE LAND COVER

Classification is systematic approach of distinguishing classes and adding in appropriate clusters and assigning relationship between associated classes. Gregorio and Jansen (2005) stated that classification requires definition of classes boundary must be clear, precise quantitative and based on objective criteria. One concept that has much merit is that land use refers to, "man's activities on land which are directly related to the land". Land cover, on the other hand, describes, "Vegetation and artificial constructions covering the land surface". Concepts concerning land cover and land use activity are closely related and in many cases have been used interchangeably. The purposes for which lands are being used commonly have associated types of cover, whether they are forest, agricultural, residential, or industrial. Remote sensing image-forming devices do not record activity directly. The remote sensor acquires a response which is based on many characteristics of the land surface, including natural or artificial cover (Burley, 1961).

LULC mapping can be best achieved with the application of classification technique in RS, classification can be defined as process of applying pixel based continuous data to land cover classes (Araya & Cabral, 2010). Quality of image interpretation is dependent upon the remote sensing data quality, algorithm used, and classification technique. There are two types of classification techniques, object based and pixel based classification technique. Overall quality of the output is related upon the quality of data and classification technique, thus it is very important to use suitable classification technique (Araya & Cabral, 2010). Object based classification approach uses segmentation technique in image data, and assigns multiple levels. Objects are created and class are assigned with application of training sets, fuzzy classification and nearest neighbor algorithm, whereas in pixel based approach, there are two standard classification technique, unsupervised and supervised classification technique, supervised classification takes training data and appropriate classification algorithm. It is obligatory to access accuracy of classified data for quality assurance (Araya & Cabral, 2010).

Land use land cover change analysis is very information need for local, regional and state level planner. Authors further stated application of GIS and RS integrated with spatial data processing technique has value added for cost efficient, competitive, accurate and timely LULC monitoring. Michalak (1993) stated the application of GIS provides conceptual framework for land use land cover change analysis, GIS platform provides most comprehensive conceptual approach for spatial data analysis, essential for planning and policy making. Application of spatial analysis is not sufficient for urban growth analysis; there is need of temporal datasets as well.RS technology with the advent of different platform and different sensors provides historical and recent satellite image which is valuable assets for urban growth analysis. Fichera et al. (2011) used integrated technique of GIS and RS for land cover classification and land cover change analysis for determining urban sprawl growth phenomena. Author highlighted the process of integration of GIS and RS created LULC maps, used it for change detection and identify urban sprawl pattern in rural and urban fringe. Commonly used indices with application of GIS and statistical analysis for determination of urban sprawl can be summarized as growth rate of population or built-up area growth rate, density of population or built-up area, determination of spatial configuration consisting of proximity, fragmentation and accessibility (Jiang et al., 2007). Analyzing time series of archive and recent satellite image data can generate LULC change and also predict future urban growth. RS technique can be used for measuring variety of morphological structure of cities development, urban sprawl extent, density and shape (Jiang et al., 2007). Implication of conversion matrix is frequently used for generation of land use conversion or change detection. Conversion matrix subsequently shows the encroachment on different land use types for formulation of built-up areas (Yeh & Li, 2001).

2.9. MAPPING AND MONITORING URBAN GROWTH/SPRAWL

Mapping of urban growth is different than the mapping of urban area. Urban area can be detected and mapped using a single temporal image, that is, image from a specific date. However, mapping of urban growth/sprawl necessitates minimum of two temporal imageries; since it actually means the mapping of changes between two different dates. This process is often called change detection the process of identifying differences in the state of an object or phenomenon by observing it at different dates (Singh, 1989). Mapping of urban growth can lead to motoring of urban area and its growth through time. In general, urban change detection involves the application of multi-temporal datasets to quantitatively (or visually) analyze the temporal effects of the phenomenon (Lu et al., 2004). Various techniques have been developed to improve change-detection accuracy, including image differencing, image rationing, post- classification comparison, the masking method, principal component analysis, etc.

2.9.1. IMAGE OVERLAY

Image overlay is one of the simplest methods of visually identifying the location and extent of change or urban growth (Jensen, 2005). It is generally done by passing single bands of imagery from different dates through the red, green, and blue (RGB) bands. This is a simple approach and may be used for quick identification of changes in urban landscape, particularly when monitoring urban fringe areas where conversion.

2.9.2. IMAGE SUBTRACTION

Image subtraction (also called image differencing) uses software algorithm to identify and quantify the changes between two temporal images. Typically, two images which have been geometrically registered are used with the pixel values in one image being subtracted from the pixel values in the other. In such a change image (or difference image), areas where there has been little or no-change between the original images contain resultant brightness values around 0, while those areas where significant change has occurred contain values higher or lower than 0, e.g., brighter or darker depending on the 'direction' (positive or negative) of change in reflectance between the two images. This is one type of image transform that can be useful for mapping changes in urban development around cities and for identifying areas where deforestation is occurring (Bhatta, 2000).

2.9.3. SPECTRAL-TEMPORAL CLASSIFICATION

Spectral-temporal classification is another method for change detection (Schneider et al., 2005). Images are created by layer staking the bands from multiple dates of imagery together to form a single image. If two four-band images are stacked, the output is a composite image of eight bands. Despite of being an effective method of change detection it has several limitations. The classified image results in many classes that are often difficult to interpret and not effective for cartographic representation. Signature collection procedure for supervised classification is also difficult. Image overlay technique may be used for the collection of signatures, but, image overlay technique itself suffers from identification of what has changed and changed to what. As a result, unsupervised approach is most preferred which requires image to be classified in large number of classes and to be identified accordingly. Since the composite image has many bands from different dates, there will be a high spectral confusion as well, resulting in difficulties in classification. Further, temporal images should have same spatial resolution and similar spectral characteristics that are often difficult to obtain; especially if the analysis is based on long temporal span. Important to realize, the image to be classified has many bands, some of which may be redundant in information content (Schneider et al., 2005). Principal component transformation is used to overcome the problem of redundancy on the original data set. The first few components containing significant amounts of variance from the two dates can be used in the classification.

2.9.4. MEASUREMENT OF URBAN SPRAWL

Urban sprawl can be measured by correlating sprawl pattern and land cover matrices. Landscape metrics provide statistical insights for configuration of urban sprawl and the relationship between spatial concentration of land cover distribution and land fragmentation. (Christiansen, 2011) Galster et al. (2001) used eight parameters for measuring urban sprawl (density, continuity, concentration, clustering, centrality, nuclearity, mixed uses and proximity).

Christiansen and Loftsgarden (2011) stated for determining prime component depends upon landscape indices used for statistical analysis. Factors used for statistical analysis differs between different input indices, making it impossible to directly compare the integrative measures of these indices. Third measure for urban sprawl measurement is based on one or few variables. Yue et al. (2013) used population measures for determining urban sprawl. Authors used high and low population growth area and their relationship with total population of area to determine urban sprawl. Arribas-Bel et al. (2011) integrated indices of connectivity, decentralization, density, scattering, and open space availability into self- organizing map algorithm and urban sprawl was determined. On the other hand Ewing et al. (2003) used residential area density, parcel size, mixed land use, degree of centering and accessibility to road network and Rutgers-Cornell sprawl indicators to measure sprawl.

Patch level, differentiate individual patches as area, provides detailed information about spatial metric information for individual patches. The primary input data for computation of landscape metrics are patch metrics. For computation of patch level each patch can be represented as core area each patch, total Class Area, mean patch of Class Area. Configuration and sample representative metrics are described as McGarigal et al., (2012).

Patch Shape Complexity: It can be defined as geometry of patch that tends to form irregular or convoluted structure, simple or complex structure. The most efficient measure of shape complexity is based upon the perimeter to area ratio, fractal dimension or Euclidean shape. Higher the value of mean denotes greater shape complexity or farther departure from Euclidean geometry (McGarigal et al., 2012).

Patch area and edge: Patch area and edge is simplest measure to configure patch size, which represents an important attributes based on spatial characteristics of patch. The distribution of Patch size can be summarized in the form of mean, median, max, variance, etc. Most landscape metrics directly incorporate patch size information. Patch size can be computed in the form of area of patch and spatial characteristics. Patch size can be regarded as spatial extent in the form of patch radius of gyration. As the literatures indicate, radius of gyration is the measures of the average distance an organism can move within patch boundary from random point of start. When using the sum for the class using weighted area mean, the matrices so obtained is correlation length matrices and measures traverse length from particular patch from random point of start and in random direction (Keitt et al, 1997). Therefore edge length can be summarized as landscape levels and patch parameter as total edge length including focal class.

Class Area: It refers to the interior patch area, after removing of edge buffer from the patch. The edge buffer is area of the core or interior patch that is unaffected by edge (McGarigal et al., 2012). Class Area is integrated form of patch size, shape, and edge effect. Similar patches with small patch size but greater complexity have less Class Area. Matrices like mean patch size and variability patch size are associated with Class Area.

Contrast: It can be define the Contrast as the differences amongst patch type. Contrast can be computed with the use of contrast weight density, where different edge type area assigned with definite contrast weight. Contrast can be also defined as attribute properties associated with the edge (McGarigal et al., 2012).

Aggregation: Aggregation is defined as the degree of attachment of patch types. Aggregation is associated with landscape texture. Aggregation is diversified phenomena which can be closely related to interspersion, dispersion, isolation and subdivision. Where dispersion refers how much dispersed or spread out patch type is without reference to other patch type? Whereas interspersion refers to spatial intermixing of different explicit patch type. Most of the matrices of aggregation type are cell adjacency matrix, where different frequency of patch type appears alongside (McGarigal et al., 2012).

Subdivision: It is the degree of which landscape was segregated into separate patch or fragments irrespective of shape, size, location and spatial arrangement of patch. Subdivision is derived from suite of metrics from cumulative distribution of patch size and gives better measure of subdivision. These metrics can be used to measure fragmentation degree from focal patch (McGarigal et al., 2012).

Class distribution statistics: Class distribution metrics measures the relationship between patch belonging to same type or class. Class is representation of aggregated patch belonging to same class; hence class can be characterized with summarized class metrics belonging to same class. Fragstats compute both first and second order statistics for patch distribution summary in the form of mean, area weighted mean, median, range, standard deviation and coefficient of variation (McGarigal et al., 2012).

Class Level: The data of the similar land use type is used for Class level metrics. Class indices measures spatial configuration and amount of patch associated with each type of patch separately, thus providing the measures of extent and fragmentation of each patch type (McGarigal et al., 2012). Class metrics can be computed for every patch type and every class of landscape. Class level uses indices denoting class size and spatial configuration, while second type sets distribution of first order, second order statistical summaries of patch metrics for each class in focus. These metrics are used for summarizing mean, median, standard deviation, variation, range, coefficient of variation in the patch attribute properties across all patches in focal class (McGarigal et al., 2012).

Landscape level: The measurement of landscape level is another method for measuring urban sprawl. Landscape level measures entire landscape in the form of mosaic of landscape, distribution of landscape patches and spatial characteristics. Landscape metrics are associated with entire patch mosaic. Landscape metrics consists of two metrics at landscape level first is statistical distribution of first and second order statistical summaries of entire landscape patch metrics and second is landscape composition and spatial configuration (McGarigal et al., 2012).

Landscape distribution statistics: It can be described that, landscape metrics is measure of aggregate properties of patch mosaic. Fragstats computes are mean, area weighted mean, median, range, standard deviation, and coefficient of variance. Best way for analyzing patch distribution is to summarize all the patches metrics present over landscape. All these statistics are computed at landscape level (McGarigal et al., 2012).

2.9.5. SHANNON'S ENTROPY APPROACH TO MEASURING URBAN SPRAWL

Several urban growth studies use Shannon's entropy to measure urban sprawl over time (Bhatta, 2010; Dadras et al., 2014). Bhatta (2010) notes that one of the most popular methods used to measure urban sprawl using remote sensing and GIS methods is Shannon's Entropy, due to its decreased sensitivity to issues relating to the modifiable areal unit problem, where results may change drastically with the size, shape, extent, and number of regions involved (Bhatta, 2010). Thomas (1981) states that unlike other, more traditional methods of measuring spatial dispersal, the value of relative Shannon's Entropy is “invariant” with the number of regions, n. The metric is still sensitive to the size and shape of the zones within the regions.

The aggregation effect of coarser scale combined with few numbers of zones can have a considerable effect on the metric, as the entropy value would be very low if only one zone were used across an entire metro area. This is significant because Masoumi and Roque (2015) are successful in comparing the different sprawl studies, whereas very few studies comparing the Shannon’s Entropy metric exists. The different studies Masoumi and Roque (2015) investigate use different land cover classifications, number of buffer zones, and satellite sensors for land cover data, but can be 22 compared, because the authors apply a standardization equation to convert the entropy to relative entropy. Relative entropy scales the value of entropy from the range of 0 to log(n) to a range of 0 to 1. By converting entropy to relative entropy, Masoumi and Roque (2015) argue that the degree of dispersion can be compared between with different sizes and numbers of buffer zones.

Relative entropy can be calculated by dividing the entropy by log (n). The authors caution that the study is limited to developed or industrial countries, and reliable studies in South America and much of Africa are unavailable for comparison. The current study finds that differing sizes and number of buffer zones can have a slight effect on the entropy value, so Masoumi and Roque’s study is used primarily as a reference for the magnitude of change between entropy values over time, with differing numbers and sizes of buffers, and across different geographical regions around the world.

Entropy with integration of GIS and RS can be used for modeling urban sprawl (Yeh & Li, 2001). Shannon‘s entropy (h) is used to calculate dispersion or concentration of spatial variable (xi) among zones (Thomas, 1981). Use of Entropy after integration of GIS and RS technique has been most effective tool for measuring urban sprawl. Implication of Shannon‘s Entropy with application of GIS and RS can calculate degree of spatial concentration or dispersion of urban sprawl (Yeh & Li, 2001). Urban system is associated with urban sprawl.

2.10 Empirical Literature Review

Currently, the use of Remote Sensing and Geographic Information Systems techniques has become important for quantifying the degree of urban sprawl, mapping, monitoring, and managing urban land-use/land cover changes. Mapping urban sprawl provides a picture of where this type of growth is occurring, and helps to identify the environmental and natural resources threatened by such sprawls, and it also suggests the likely future directions and patterns of sprawling growth. There are limited number of studies conducted on quantifying the extent and detecting the pattern of urban sprawl in Ethiopia using GIS and Remote Sensing. Contrary to this, more number of studies conducted in the other countries. Here under related research is reviewed to learn and identify gaps from the previous literature.

Yang and Lo (2002) used multi-temporal/multi-resolution satellite imageries to successfully extracted land use/cover data in the Atlanta, Georgia metropolitan area for the past 25 years. The result revealed that the loss of forest and urban sprawl have the major consequences of Atlanta‘s accelerated urban development. Deka et al. (2012) showed that the integration of remote sensing (RS) and Geographical Information System (GIS) technique to successfully distinguish urban growth. These studies also pointed out the value of medium resolution Landsat images for analysis of urban growth at metropolitan scale, compared to the more resent VRH images.

Pham and Yamaguchi (2011) showed how spatial metrics is used for supporting remotely sensed data to characterize urban growth patterns of Hanoi, Vietnam. This study used the percentage of like adjacency (PLADJ) metric on the urban growth maps to illustrate the changes in the urban structure in the study area. In addition ,Six class-level landscape metrics, i.e. class area, number of patch, edge density, largest patch index, mean nearest neighbor distance and area weighted mean patch fractal dimension, were selected to characterize the urban composition parameters.

Kuffer and Barrosb (2011) used spatial metrics in a classified remotely sensed image to analyze the morphology of unplanned urban settlements in Dar es Salaam and New Delhi. In this study, the authors selected a set of four metrics, i.e. is mean area, patch density, aggregation index and Shannon‘s diversity index for Dar es Salaam and a set of six metrics, i.e. effective mesh size, landscape division index, patch density, contagion, aggregation and Simpson‘s evenness index for Delhi. Both sets of metrics measure size, pattern and density. The research also shows how a set of spatial metrics were combined using spatial multi- criteria evaluation to produce a composite index indicating areas of high likelihood of unplanned-ness in the study area.

Similarly, Sandeep S. et al 2018 conducted a research to analyze the urban growth of Debre Berhan town by Remote Sensing and GIS technique. In this research the urban growth was calculated by delineating town boundary of different years in ArcGIS software and the trend was estimated with regression technique. However to Understand the dynamic phenomenon of urban sprawl requires the identification of urban sprawl patterns, the computation of landscape criteria, and the analysis of built-up area change.

Kiros Tsegay Deribew, uses an integrated GIS tool, remote sensing technique, and Shannon entropy method to quantifying and analyzing the trends of the urban growth and its impacts on agricultural land in Sebeta Town. In this research, Object-based image classification technique was carried out to generate the LULC and to measure the changes in the urban land-use class within the town. The research shows general urban sprawl level and direction, the type of urban sprawl and fragmentation pattern was not shown.

Selamawit et al.2019 conducted a research on Spatio-Temporal Analysis of Land Use/Land Cover Change and Urban Sprawl Using GIS and Remote Sensing Technologies of Lagatafo Lagadadhi. In this study a two decades time series data (Landsat TM 1996, SPOT-5 image of 2006, and Landsat ETM+ 2016) was used and analyzed quantitatively using GIS and remote sensing data processing software's. Maximum likelihood supervised classification of satellite imageries was applied for Image classification. In this study the urban expansion extent and growth direction were identified by overlaying the three periods land use/cover classes of the study area. The built-up area has been expanding in all directions during the study period consuming land from the other land uses in and around the town. The research only identifies the urban growth extent and direction not the urban sprawl. However the concentration of urban sprawl, the form of urban sprawl not conducted in this research.

In the above literatures, different approaches are presented to study the urban sprawl in different study area and lessons are obtained and also the literature gaps are drawn. In this research the drawn gaps are filled in such a way that, the urban sprawl pattern, computation of landscape criteria, and the analysis of built-up area are identified to understand the urban sprawl dynamics phenomenon using landscape metrics and Shannon's relative entropy analysis. The type and concentration of urban sprawl or hot spot analysis of Lagatafo Lagadadhi town is also identified to fill the gap of the previous research.

3. MATERIALS AND METHODS

3.1. DESCRIPTION OF THE STUDY AREA

3.1.1. DESCRIPTION OF THE STUDY AREA

Lagatafo Lagadadhi town was administered as one of farmer's association kebeles under Berek woreda before the establishment as the town administration. In the former Laga-Tafo village under Berek Woreda, different investment activities have started from 1998 E.C (2006 G.C), which finally gave it a great attention and attraction for further investment activities. In July, 2006 G.C the town was decided by Oromia Regional State Government to be a town administration and incorporated under Oromia Special Zone Surrounding Finfine by taking in to consideration the public questions (OUPI, 2017).

3.1.2. LOCATION OF THE STUDY AREA

Lagatafo Lagadadhi town is located in Oromia Special Zone Surrounding Finfine in Oromia Regional State of Ethiopia. It is located at 18 km in the North East side of Addis Ababa. Astronomically the town is located between 38^0 53' 42''and 38^0 55' 30'' East Longitudes and between 9^0 01' 29" and 9^0 6^{0}' 0" North Latitudes. Currently the town has four Kebeles namely Lagatafo, Eka Dale, Dambal and Lagadadhi with a total area of 10,056.45 hectare (OUPI, 2017).

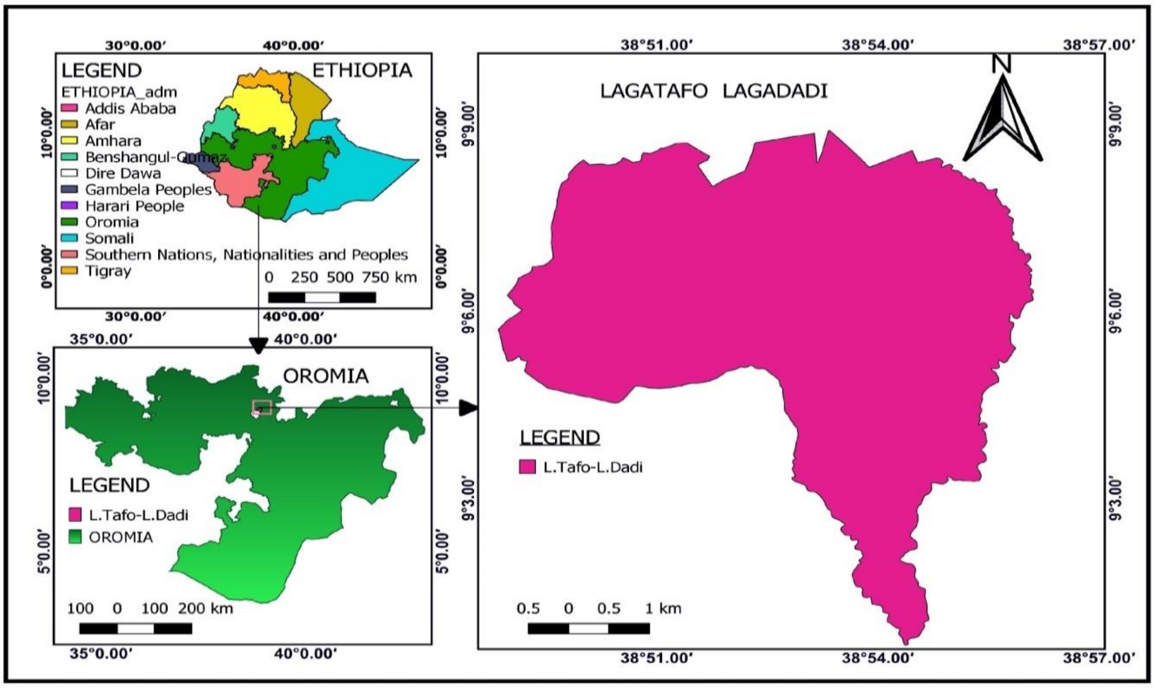


Figure 3-1: Location of Lagatafo-Lagadadi Town

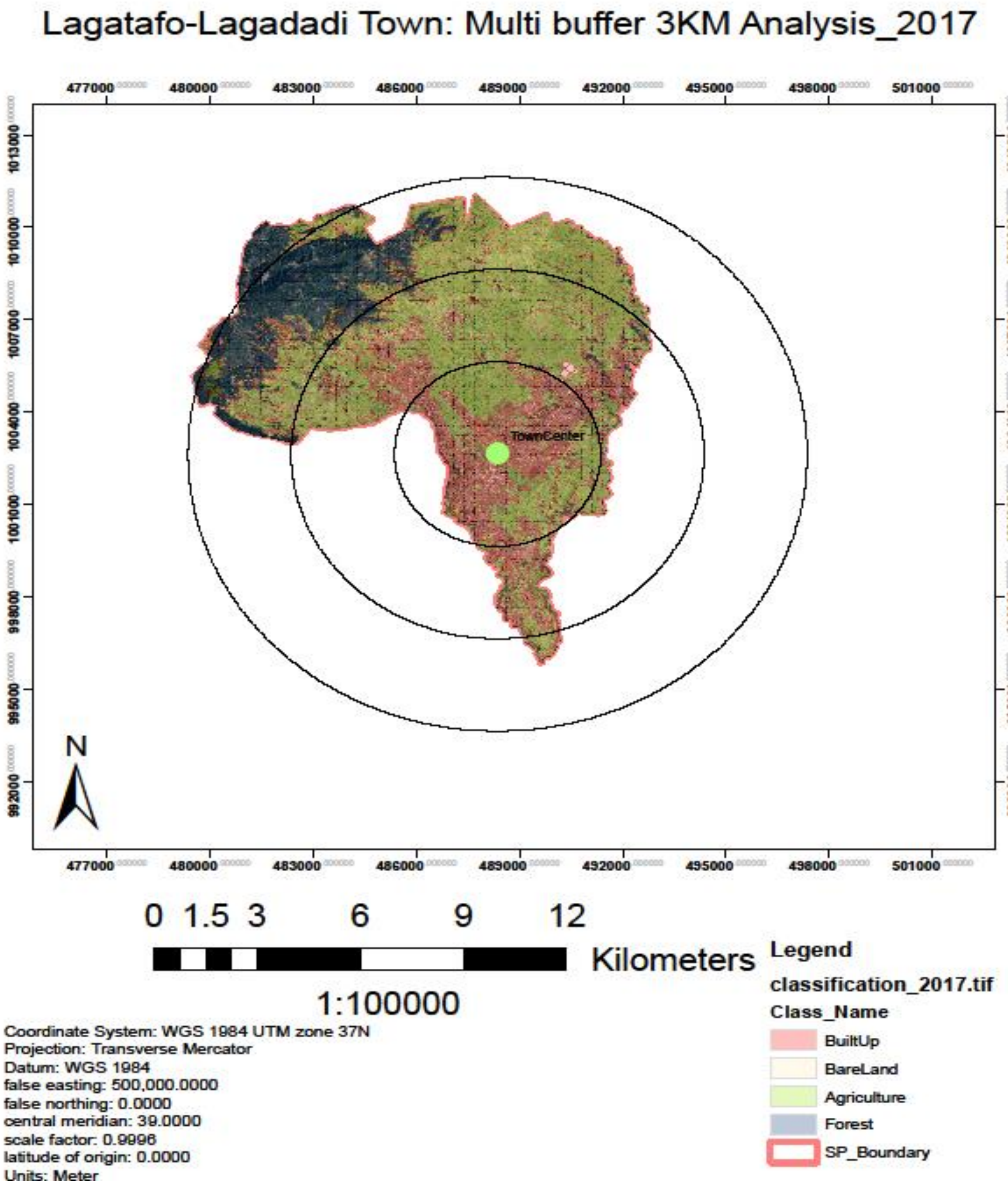


Figure 3-2: Lagatafo Lagadadhi Town: Satellite View, 2017

3.2. METHODOLOGY

The methodology of Urban Sprawl Analysis in Lagatafo Lagadadhi town was based on spatial and temporal remote sensing data of 2000, 2005, 2010, 2017 and 2022. This research conducted using satellite images since 6 years before the establishment of the town, and at least 22 years' time difference images are used. So that, sufficient land use land cover change information was investigated.

3.3. DESIGN OF METHODOLOGY

To facilitate the smooth navigating of various research operations, research design is very important. It makes research as efficient as possible producing maximum information with minimum money, time, effort and expenditure.

This research paper used a quantitative research approach to analyze distribution, extent and level of urban sprawl in Lagatafo Lagadadhi town and in order to furnish the research work with descriptive data through supervised classification of multi temporal satellite images. The research used downloaded Landsat Images with less than 10 % cloud cover and spatial resolution of 30m of Lagatafo Lagadadhi town from USGS website in GeoTIFF format from the period of 2000 up to 2022 years. Spot image of 2005 and 2017 obtained from Ethiopian Geospatial Technology Institute, town boundary of Lagatafo Lagadadhi town and Google earth data also used for this research.

This is accomplished with an integrated application of geographic information systems (GIS) and remote sensing (RS) techniques that helped us for pre-processing the images and supervised classification using ERDAS Imagine 2015. After classification, urban sprawl measurement analysis has been done using spatial metrics and Shannon's Entropy.

3.4. DATA USED

The geospatial data are used to analyze and measure Urban sprawl of Lagatafo Lagadadhi town collected from different sources. Geospatial datasets such as Landsat image 30m spatial resolution, administrative boundary of the city; spot image and Google earth pro were used. All collected satellite data were projected to WGS84 spheroid, Universal Transverse Mercator (UTM) Zone 37 North hemisphere, false Easting is 500.000, false northing 0.0000, latitude of origin of 0.0000, central meridian 39.000, Scale factor of 0.9998 and meter unit.

Table 3-1: Sources of data for analysis

Landsat image Acquisition Date: 15, September 2022						
No	Data Type	year	Specification	source	purpose	Description
1	Landsat Image	2000, 2005, 2010, 2017, 2022	30m Spatial resolution	USGS, Earth Explorer (Landsat)	For image classification	Secondary data
2	Spot Image	2005, 2017	15m Spatial resolution	Ethiopian Geospatial Institute	For Accuracy assessment	Secondary data
3	Auto CAD maps		1:50,000 Scale	L/Tafo L/Dadi urban land management office	To extract Administrative boundary	Secondary data
4	Google Earth	-		Google Earth pro	For Accuracy assessment	Secondary data
5	Arc GIS software	-	Arc GIS 10.5	-	For image extraction and analysis	
6	ERDAS IAGINE Software	-	ERDAS IAGINE 2015	-	For image extraction and analysis	

3.5. WORKFLOW

Overall methodology for Analyzing Urban Sprawl of Lagatafo Lagadadhi town with the application of GIS and Remote Sensing and spatial metrics composed of following procedures portrayed in Figure 3.3.

First Landsat Image of Lagatafo Lagadadhi town of 2000,2005,2010,2017, and 2022 were downloaded from USGS website in GeoTIFF format, next the Downloaded Landsat images were extracted using extract by mask tool in ArcGIS 10.5 using boundary of Lagatafo Lagadadhi town. Followed by, image Classification and generation of LULC of the year 2000, 2005, 2010 2017 and 2022. Then LULC change analysis of 2000 - 2005, 2005 - 2010, 2010 - 2017 and 2017 - 2022 were done. After that, Delineation of 3km multi ring buffer from zero point (city center) was generated in ArcGIS. The city center (zero point) was selected by the information obtained from the history that, this zero point is the towns' early origin of development center, and the 3km multi buffer zoning is preferred by the researcher to obtain sufficient data and to easily manage the number of clipped classified images used for analyses. Extent of Urban Sprawl was measured in each ring of multi ring buffer by analyzing landscape metrics (Number of patch, Class area, Largest Patch Index and Fractal Index) in FRAGSTATS version 4.2, because in our research the spatial indices are more appropriate for measuring urban sprawl. Subsequently, Level of Urban Sprawl was determined in each ring of multi ring buffer was done using Shannon's Entropy. In this research we used Shannon entropy to better measure the pattern of urban growth, by measuring degree of spatial concentration and dispersion of built-up area. Finally Types of urban sprawl in Lagatafo Lagadadhi town was analyzed in ARCGIS 10.5.

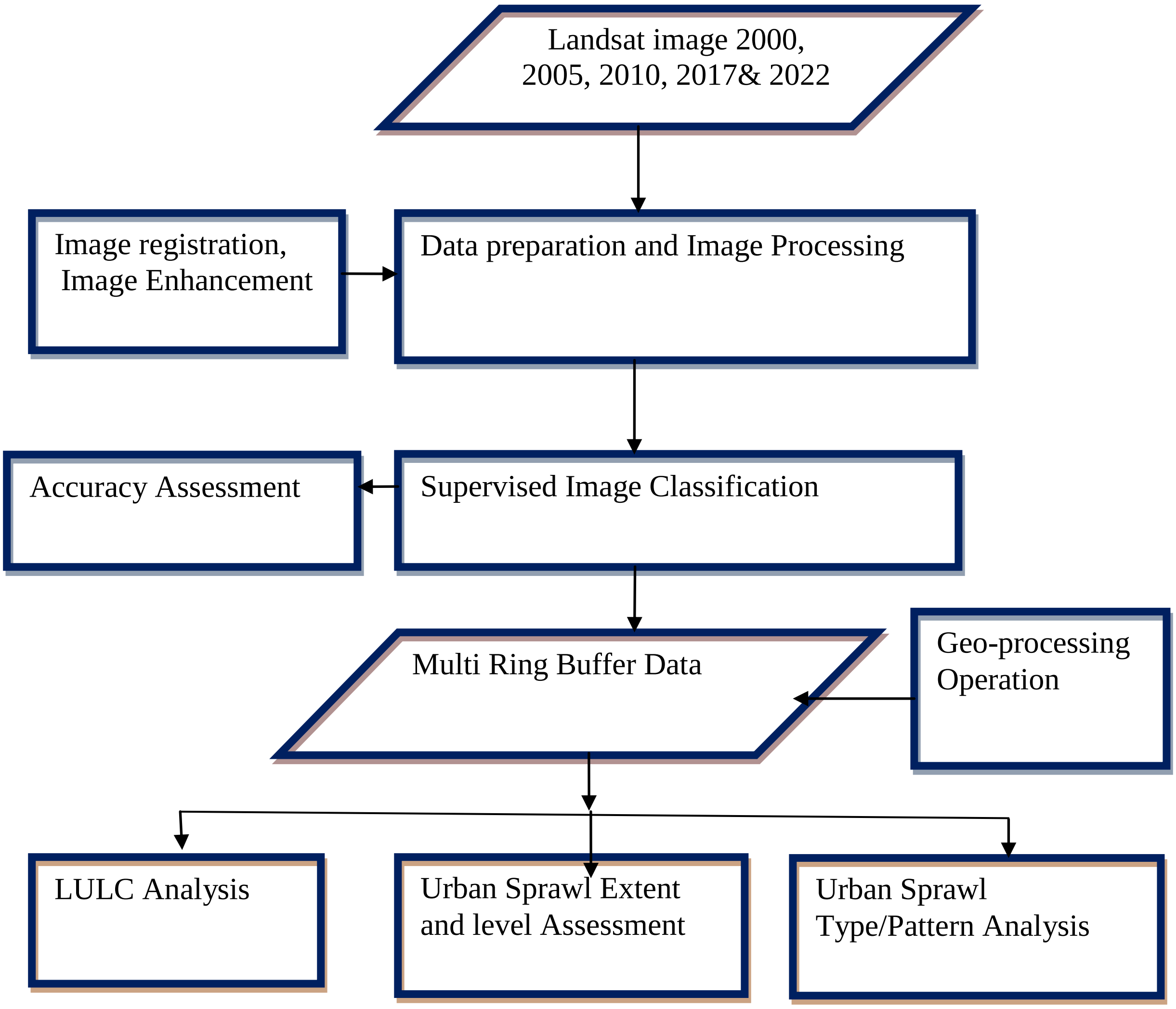


Figure 3-3: Workflow of Urban Sprawl Analysis

3.6. DATA PROCESSING AND LULC CLASSIFICATION

Urban dynamics in the study area were analyzed using multi-spectral satellite images covering almost two decades at five points in time, i.e., 2000, 2005, 2010, 2017 and 2022. The images were obtained from Landsat 5 (TM) and 8 (OLI/TIRS) satellites provided by USGS (United States Geological Survey) (http://earthexplorer.usgs.gov/) at a spatial resolution of 30 m.

Prior to generating LULC maps, the images were processed and enhanced in ArcGIS 10.5 software. To classify the images, a supervised classification technique was applied using the maximum likelihood classifier (MLC), which is based on the similarity of spectral signatures. However, owing to the high spatial heterogeneity that is inherent to urban areas, the spatial resolution of Landsat Images are not sufficient for all processes of spatial analysis, meaning that spectral signatures may be misclassified. For this reason, Google Earth images and spot images of 2005 and 2017 were used additionally to complement the training sample generation. Each satellite image was classified into four LULC classes, i.e., built-up, Agriculture, forest, Bare land.

3.7. LAND USE LAND COVER CLASSIFICATION

Satellite Image classification technique was implied for LULC map generation. Image Classification was used to create LULC maps in temporal dimension (Dadras et al., 2014).LULC patterns for five different years (2000, 2005, 2010, 2017 and 2022) were generated. Landsat 5, spot image and Landsat 8 was used for land use land cover map. Landsat images were visually enhanced to improve the image visual quality using haze correction and histogram equalization in ERDAS Imagine 2015. Supervised Classification technique was used for classifying the Landsat Image. Reference training sites for each LULC classes were taken to generate training signatures. Landsat image was displayed in image viewer in false color composite. Image classification tool was used for creating signature polygons and for classification in ArcGIS 10.5. Features resembling similar characteristic of LULC types, Area of Interest (AOI) were drawn in polygon and Signature was created from these AOI representing different LULC type. Several training areas for each LULC types with different characteristics were drawn before merging them into single signature class. Supervised classification was performed, checking separa-bility of each signature classes. Maximum likelihood technique was used for supervised classification. In the process of classification landscape type and cover were detected.

LULC were classified; categories of LULC were 1) Built-up, 2) Bare, 3) Agriculture and 4) Forest. Table 4.1 lists four different LULC and definition of each category.

Table 3-2: Land use land cover classified classes

SN	Classes	Definitions
1	Built-up	Areas consisting buildings, roads.
2	Bare	Area consisting bare Land and no vegetation area.
3	Forest	Area consisting forest area, Shrub and bushes
4	Agricultural	Area consisting cultivation area

Supervised classification technique was used for preparing LULC map of Lagatafo Lagadadhi during 2000, 2005, 2010, 2017 and 2022. Overall land use land cover distribution is presented in this section.

3.8. ACCURACY ASSESSMENT

The accuracy assessment was carried out using accuracy assessment of each classified images done by ERDAS Imagine 2015 with Spot image of 2005, 2017 and Google Earth Pro Version 7.3 for 2022 and the image itself for 2000 and 2010 as the source of data. Simple stratified random sampling technique is used to determine the location or the “X” and “Y” co-ordinate of the training points to be cross referenced with its corresponding points on the original image.

3.8.1. REFERENCE DATA FOR ACCURACY ASSESSMENT

One of the most important sources of data required for Accuracy assessment is Google earth image. In this research, it is used to assess the accuracy of classified land cover map of 2022. For this purpose 43 sample points are extracted to assess the accuracy of classified images of 2022 (see figure 4.12).

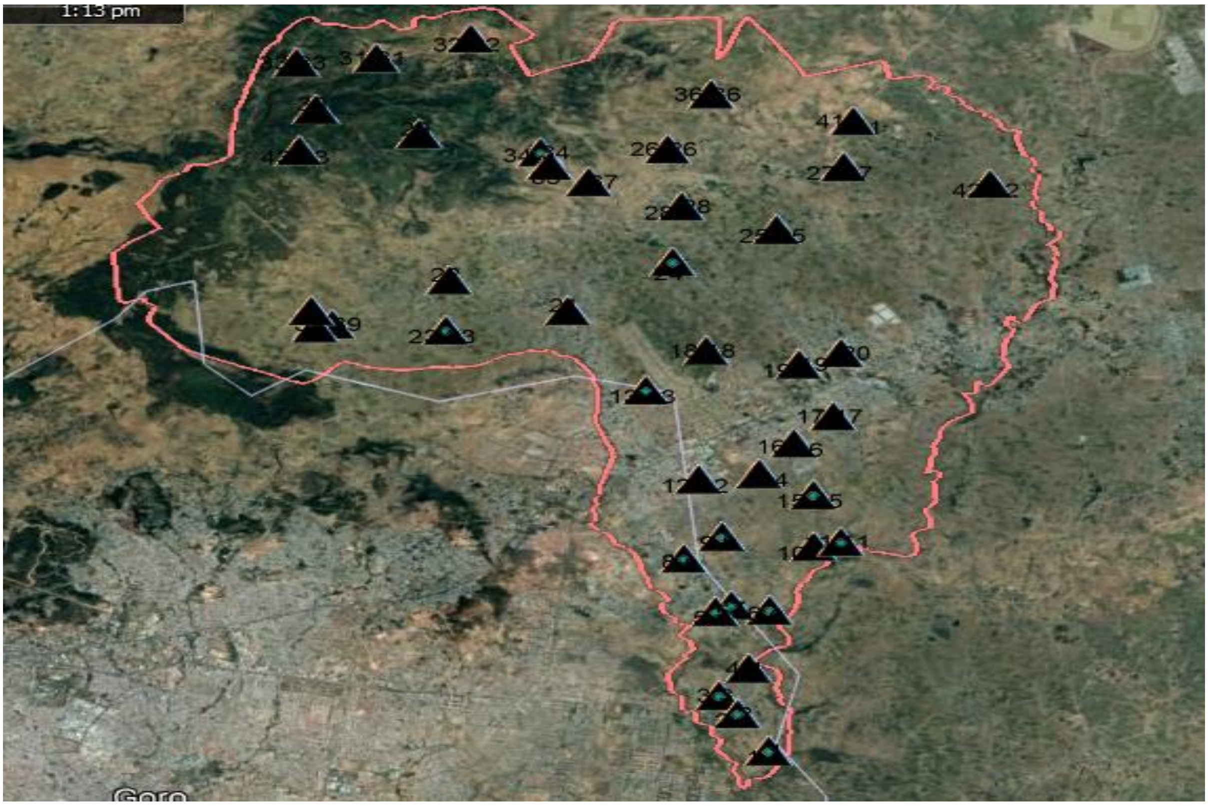


Figure 3-4: Location of reference data

Likewise for 2017 and 2005 we used spot image for verifying the classified image. However due to lack of higher resolution image for the year 2000 and 2010 we used the image itself for Accuracy assessment. But the accuracy assessment of the 2022 image is done using Google earth data for its new to obtain better result.

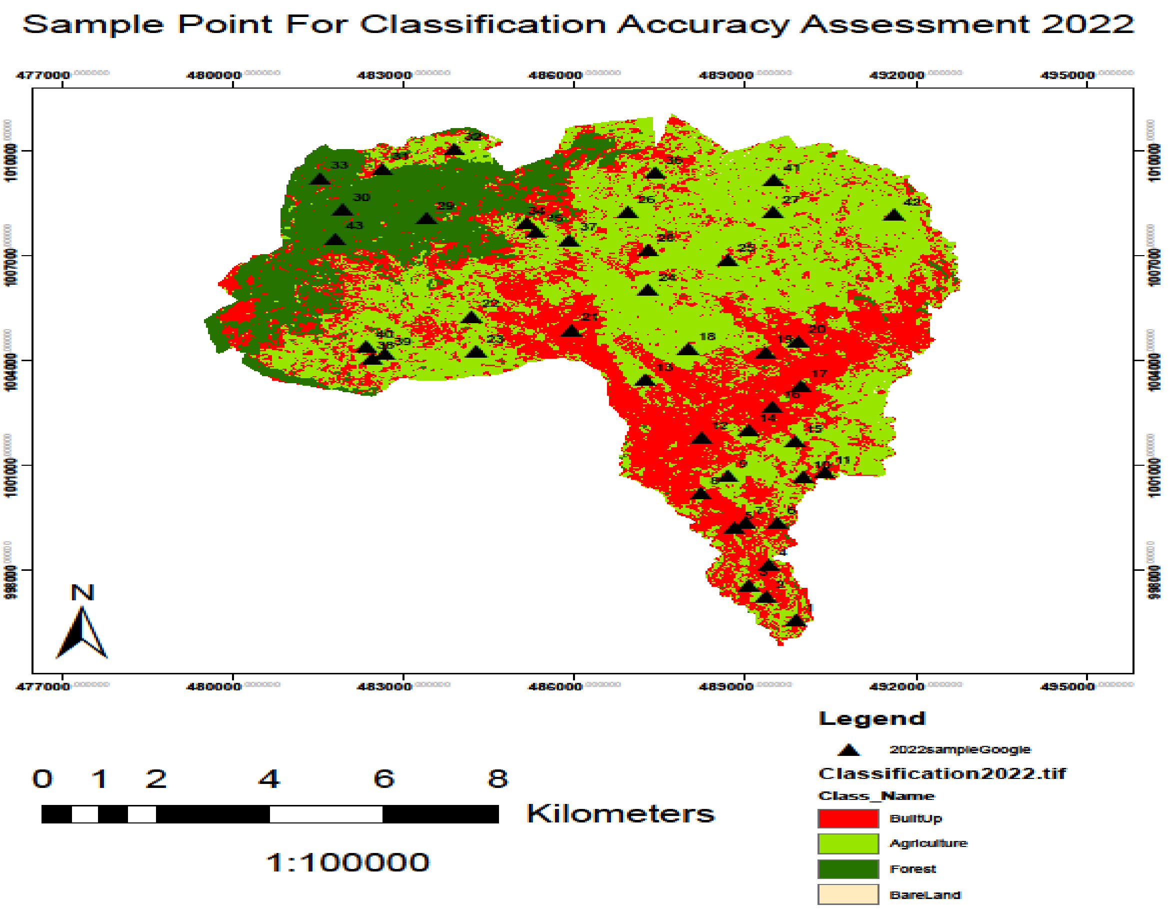


Figure 3-5: sample point for accuracy assessment

3.8.2. RESULTS OF ACCURACY ASSESSMENT

The accuracy assessment of this research was conducted in such a way that, sample was taken considering the required error margin. So, that the required number of minimum sample points necessary per the land use class for estimated classification accuracy of greater than 85% error margin is 20. Hence, we selected 43 number of sample for each class and, the overall accuracy of all images was found to be greater than 85%, which is considered as a good result for remote sensing image based analysis (Herold et al., 2005). The following table presents the accuracy of classified images for the different time periods.

Table 3-3: Accuracy Assessment result

Classified Image	Overall Accuracy	Kappa Statistics
2000	85%	0.7
2005	85%	0.7
2010	86%	0.72
2017	88%	0.78
2022	90%	0.82

3.9. Spatial Pattern-Process Analysis

To understand the complex relationship between landscape patterns and co-existing change processes driven by the patterns themselves, the research followed three paths of spatial analysis: built-up change analysis, landscape metrics analysis, and growth pattern analysis.

3.9.1. Built-up change analysis

In this part, spatial extent, percentage and rates of Built-up expansions were analyzed. First the classified image of 2000,2005,2010,2017,2022 were clipped with multi buffer ring of 0-3km, 3-6km and 6-9km, then the clipped classified raster's were converted to vector and the areas were calculated for each land use land cover type. To quantify the magnitude of urban expansion and understand spatial dynamics, three key indices, change in spatial extent, the urban expansion rate (r) and urban expansion percentage (p), are computed. (AE) quantifies change in the built-up areas in specific time interval T (Equation (1)). (p) Quantifies change in the built-up areas as a percentage of total urban growth in the given interval (Equation (2)). (r) Quantifies the change in built-up categories between different given points in time as a percentage of the total area in the selected land unit (Equation (3)).

$$AE = \frac{A2-A1}{T} \tag{1}$$

$$P = \frac{A2-A1}{A1} * 100 \tag{2}$$

$$r = (100/\Delta t) * ln(A2/A1) \tag{3}$$

3.9.2. Landscape metrics analysis

In the landscape metrics analysis, different landscape metrics are computed at differential proximity from the city center 0-3, 3-6 and 6-9km for the years 2000,2005,2010, 2017 and 2022.In order to determine the composition and configuration of the built-up area. As landscape metrics are known to be spatially dependent and to change across spatial resolutions, the researcher calculated all the values at a spatial resolution of 30 m. With respect to this resolution, the selected cell sizes captured variation in the geometric values of the landscape metrics and allowed a determination of scale which captures the heterogeneity in the study area. To capture the spatial heterogeneity and derive the inner construct of feature characteristics, five spatial metrics were selected based on the objectives of the study and literature review. The researcher chooses a core set of five class-level metrics, namely, Class Area, Number of Patches, Fractal Index Distribution (FRAC_AM) (NP) largest patch index (LPI), Relative entropy value. Refer the fragstat manual for detail statistical explanation of the indices

3.9.3. GROWTH TYPE ANALYSIS

Analysis of urban growth types, wherein each new urban patch is categorized into one of the recognized growth types, provides a deeper understanding of the landscape transformation processes. Forman (1995) classified three distinct growth types: infilling, outlying and edge-expansion. These spatial patterns of growth are based on the urban expansion of the newer patch with respect to the older one. To extract this relation and to identify the pattern ArcGIS geo-processing and Cluster Analysis tools were used. First, the researcher performed a change detection analysis to identify old and new patches among the study years. The classes identified thus were recorded to form three new classes: old, new and non-built up.

Generally this integrated methodology helped in capturing the structural changes in built-up patterns and enables to utilize an innovative way of visualizing localized information in different parts of the city. By focusing on more than one parameter of built-up area change, this methodology makes it possible to carry out a comprehensive analysis of urban dynamics, which is a key indicator for urban planners. Detailed analysis of spatial variation in landscape metrics and growth type is an essential step towards visualizing urban dynamics at the local level.

4. RESULTS AND DISCUSSIONS

4.1. LULC CLASSIFICATION RESULTS

The process and result of LULC classification is discussed in this chapter using Landsat images, urban sprawl extent, LULC change using landscape analysis in FRAGSTATS 4.2, /QGIS Lecos plugin, types of urban sprawl using urban landscape analysis tool.

4.1.1. LAGATAFO LAGADADI: LULC, 2000

Figure 4.1 depicts the spatial distribution of LULC of 2000 agricultural land is most dominant LULC class in 2000. Out of 100.56 km2 land, agricultural land occupies 64.97 km2 of total land, which was 64 percentage of total LULC of Lagatafo Lagadadhi town. Likewise, Forest area was second dominating LULC class in 2000. Forest area covers 23.82 km2 of total land, which covers 23 percentage of total LULC. Bare land was third dominant LULC class in 2000. Bare land covers 8.34 km2 of total land, which was 9 percent of total LULC. Finally built-up area is least dominant class. In 2000, built-up area was very low in comparison to other LULC. Out of total area it occupies only 3.4km2 of total area, which was 4 percent of total LULC of Lagatafo Lagadadhi Town. In 2000, built-up area was significantly less and mostly agricultural land was prominent in Lagatafo Lagadadhi Town. Figure 4.2 depicts the LULC composition in Lagatafo Lagadadhi Town.

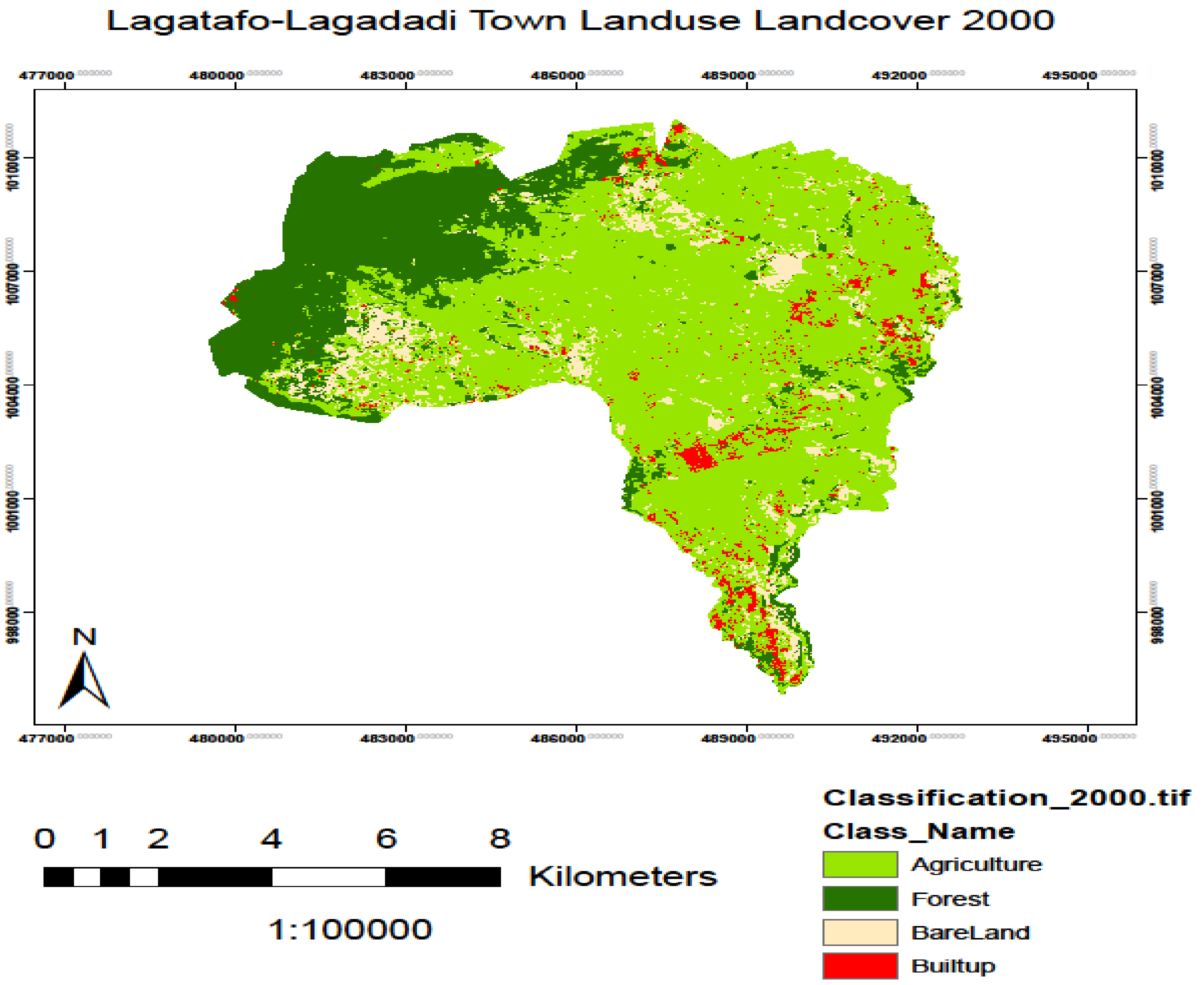


Figure 4-1: Lagatafo Lagadadi Town: Land Use Land Cover - 2000

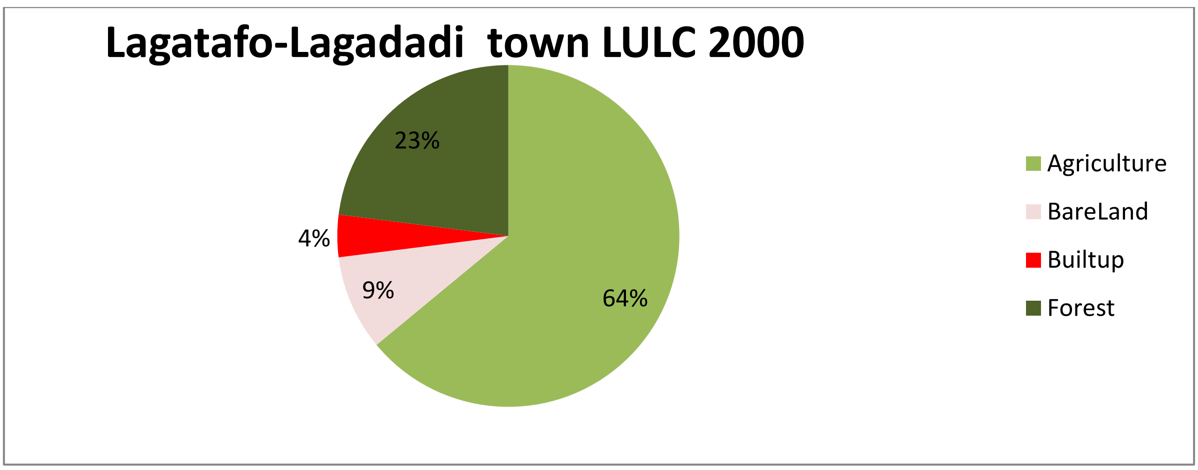


Figure 4-2: Lagatafo Lagadadi Town: LULC - 2000.

4.1.2. LAGATAFO LAGADAI TOWN: LULC, 2005

Figure 4.3 depicts the spatial distribution of LULC of 2005 agricultural land was most dominant LULC class in 2005. Out of 100.56 km^2 land, agricultural occupies 57.93 km^2 of total land, which was 58 percent of total LULC of Lagatafo Lagadadhi Town. Bare land covers 22.4 km^2 of total land, which was 22 percent of total LULC. Forest covers 14.22km^2 of total land, which was 14 percent of total LULC. Finally Built-up land area was least dominant class. In 2005, Built-up area was very low in comparison to other LULC. Out of total area it occupies only 6.1km^2 of total area, which was 6 percent of total LULC of Lagatafo Lagadadhi Town. Figure 4.4 depicts the LULC distribution of Lagatafo Lagadadhi town. Overall scenario of LULC of Lagatafo Lagadadhi town in 2005 depicts that, there was trivial development of built-up area on the expense of Forest and agricultural area. During 2000 built-up area contributes 4 percent of total LULC distribution in Lagatafo Lagadadhi, while in 2005, built-up area increased to 6 percent.

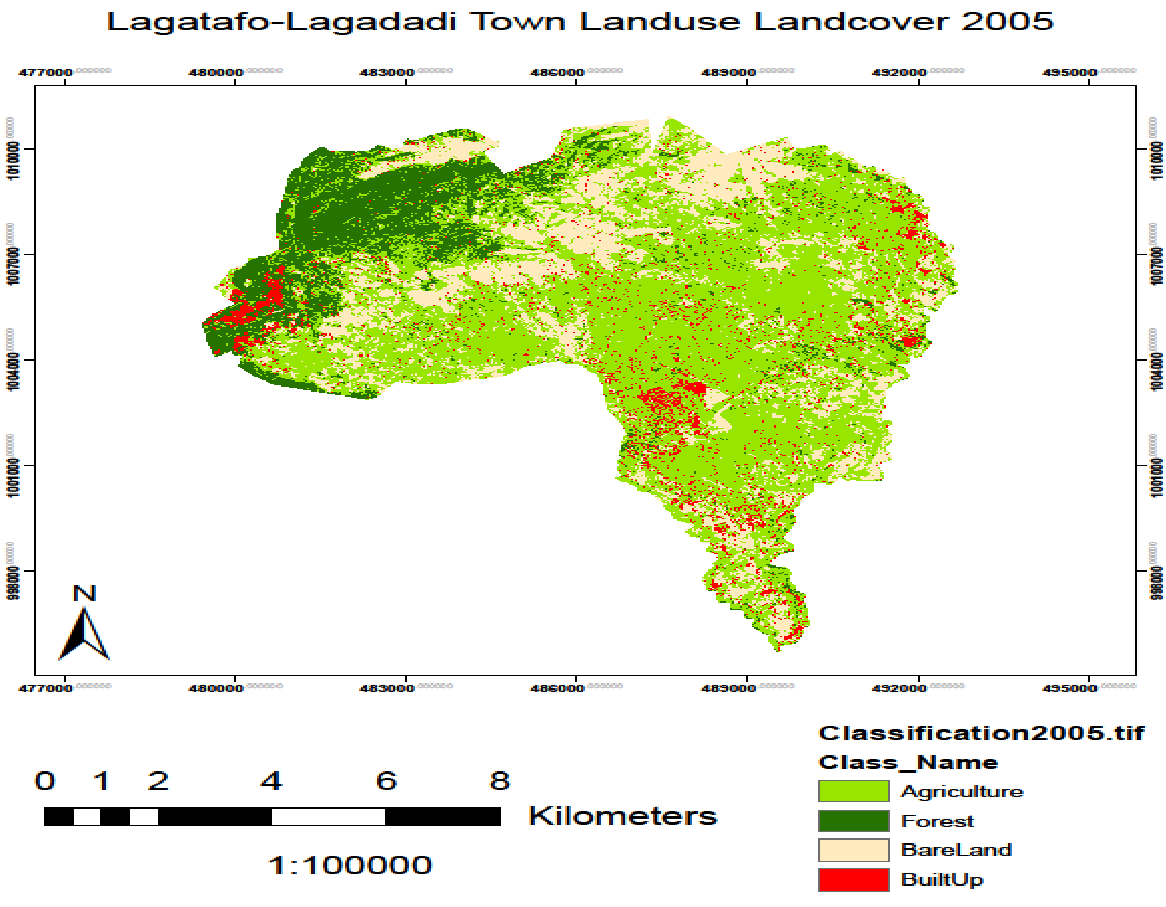


Figure 4-3: Lagatafo Lagadadhi Town: Land Use Land Cover – 2005

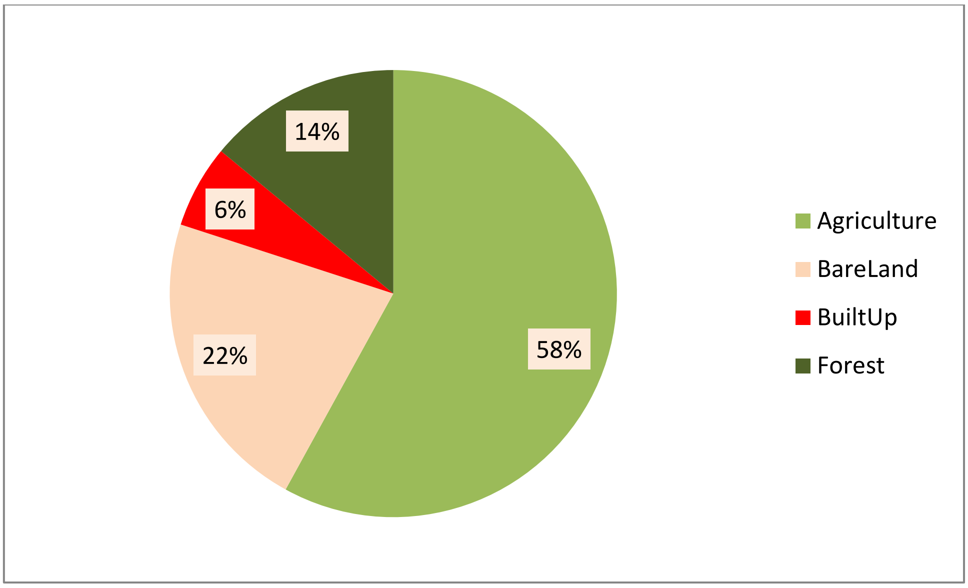


Figure 4-4: Lagatafo Lagadadhi Town: LULC - 2005.

4.1.3. LAGATAFO LAGADAI TOWN: LULC, 2010

Figure 4.5 depicts the spatial distribution of LULC of 2010 agriculture was most dominant LULC class in 2010. Out of 100.56 km^2 land, agriculture occupies 48.72 km^2 of total land, which was 48 percent of total LULC of Lagatafo Lagadadhi Town, which is slightly decreased from 2005. Likewise Built-up was second dominant LULC class in 2010. Built Up covers 22.73 km^2 of total land, which covers 23 percent of total LULC. Forest was third dominating LULC class in 2010. Forest covered 19.07 km^2 of total land, which was 19 percent of total LULC. Finally bare land was least dominant class. In 2010, bare land area was very low in comparison to other LULC. Out of total area it occupied only 10.01 km^2 of total area, which was 10 percent of total LULC of Lagatafo Lagadadhi Town.

Overall scenario of LULC of Lagatafo Lagadadhi town in 2010 depicts that, there was development of built-up area on the expense of bare land area and agricultural area. During 2005 built-up area contributes 6 percent of total LULC distribution in Lagatafo Lagadadhi while in 2010, built-up area increased to 23 percent as shown on Fig. 4.6.

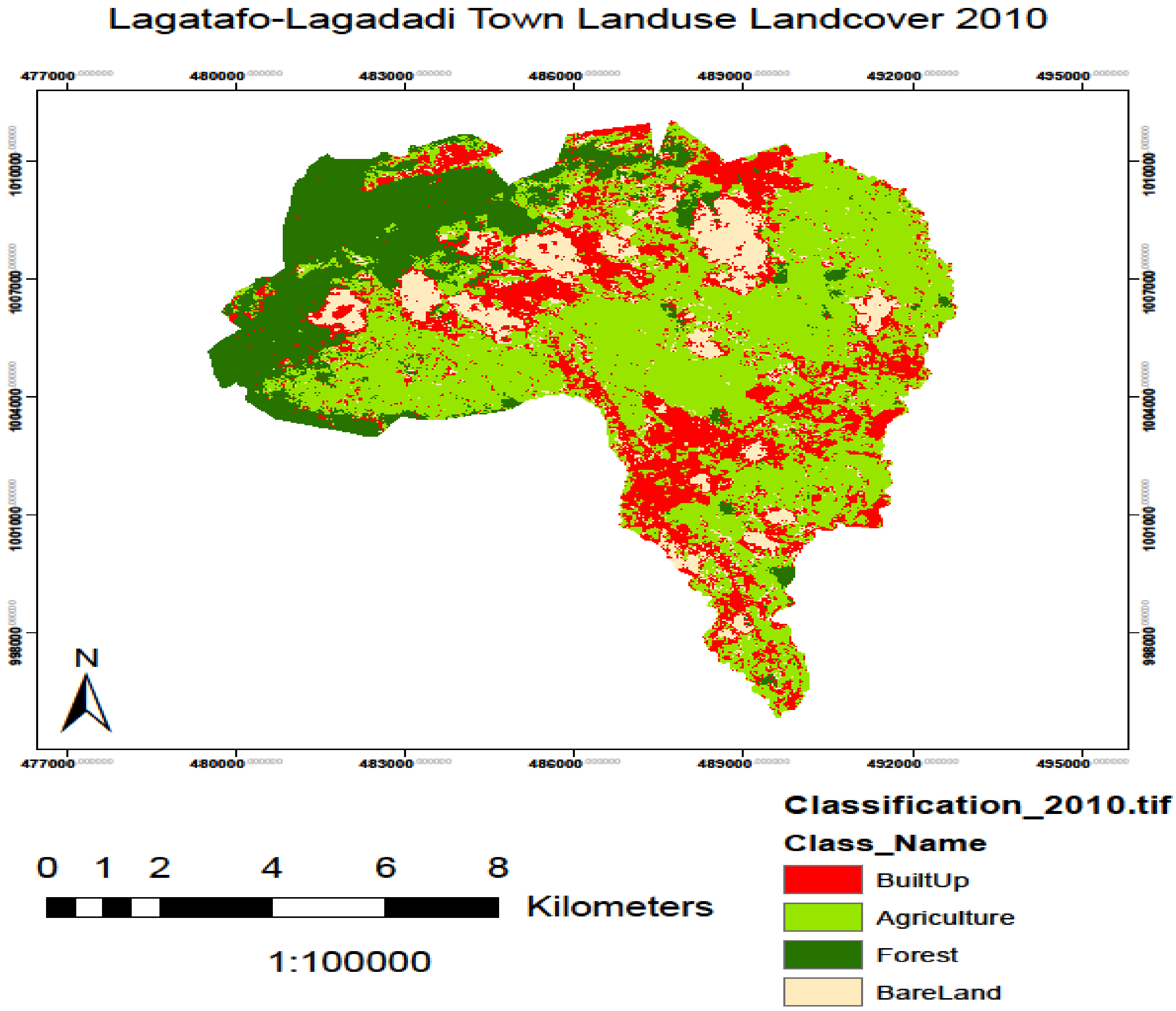


Figure 4-5: Lagatafo Lagadadhi Town : Land Use Land Cover – 2010

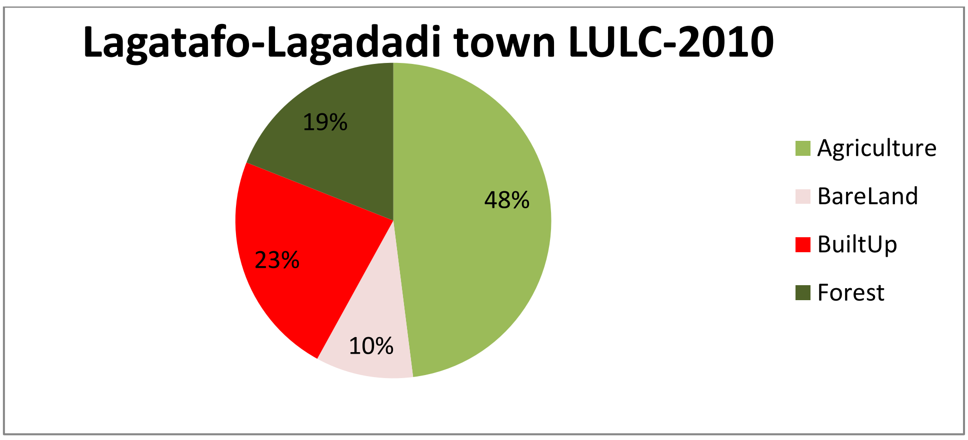


Figure 4-6: Lagatafo Lagadadhi Town: LULC - 2010.

4.1.4. Lagafafo Lagadadhi Town: LULC, 2017

Figure 4.7 depicts the spatial distribution of LULC of 2017 agriculture land is most dominant LULC class in 2017. Out of 100.56 km^2 land, agricultural land occupies 48.90 km^2 of total land, which was 48 percent of total LULC of Lagatafo Lagadadhi Town. Likewise built-up area was second dominant LULC class in 2017. Built-up area covers 30.78 km^2 of total land, which covers 31 percent of total LULC. Forest land was third dominant LULC class in 2017. Forest land covered 17.69 km^2 of total land, which was 18 percent of total LULC. Finally Bare land area was least dominant class. In 2017, Bare Land area was very low in comparison to other LULC. Out of total area it occupied only 3.16 km^2 of total area, which was 3 percent of total LULC of Lagatafo Lagadadhi Town. Figure 4.8 depicts the LULC distribution of Lagatafo Lagadadhi Town. LULC of Lagatafo Lagadadhi Town in 2017 is shown in figure 4.7. There has been increase in built-up area from 2000 to 2017 in dramatic manner. Mostly, bare areas contributed for development of new built-up areas. Forest area remained unchanged in larger extent during the study period.

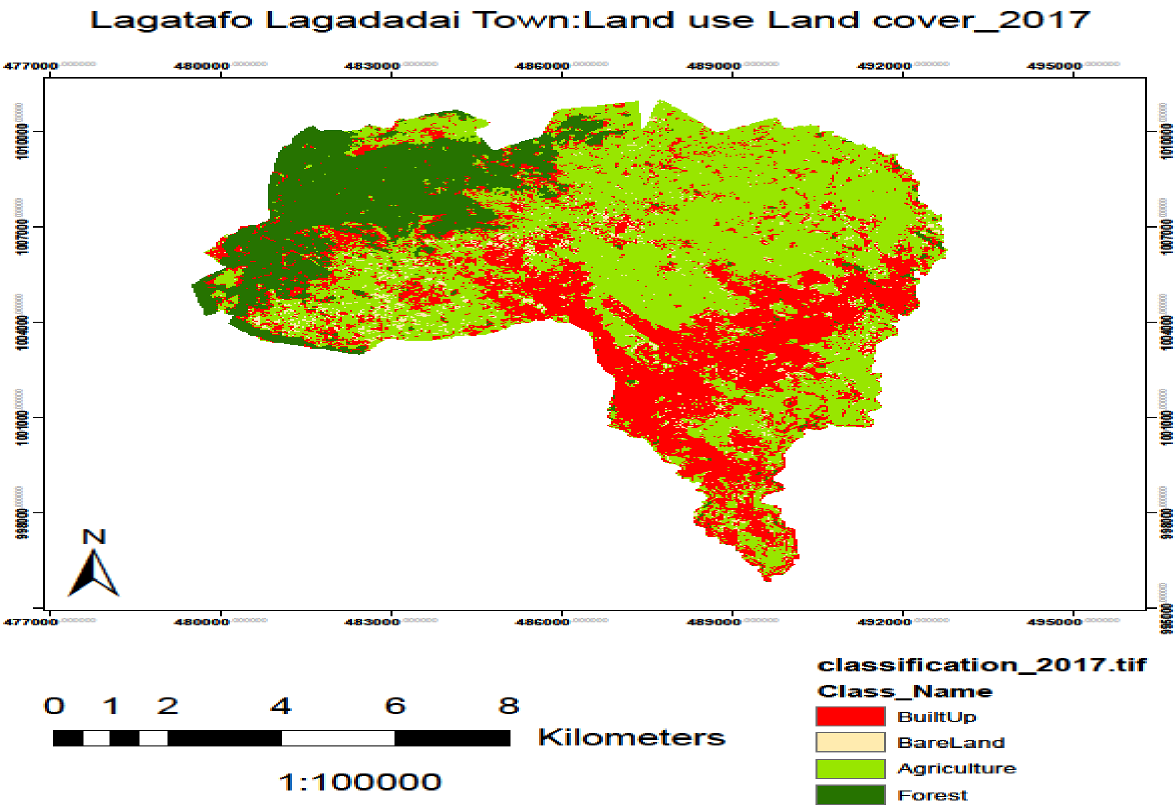


Figure 4-7: Lagatafo Lagadadhi Town: Land Use Land Cover – 2017

Overall scenario of LULC of Lagatafo Lagadadhi in 2017, depicts there was gradual increase of built-up area as compared to decade of 2010 to 2017. During 2010 built-up area contributed 23 percentage of total LULC distribution in Lagatafo Lagadadhi Town, while in 2017, built-up area increased to 31 percentages.

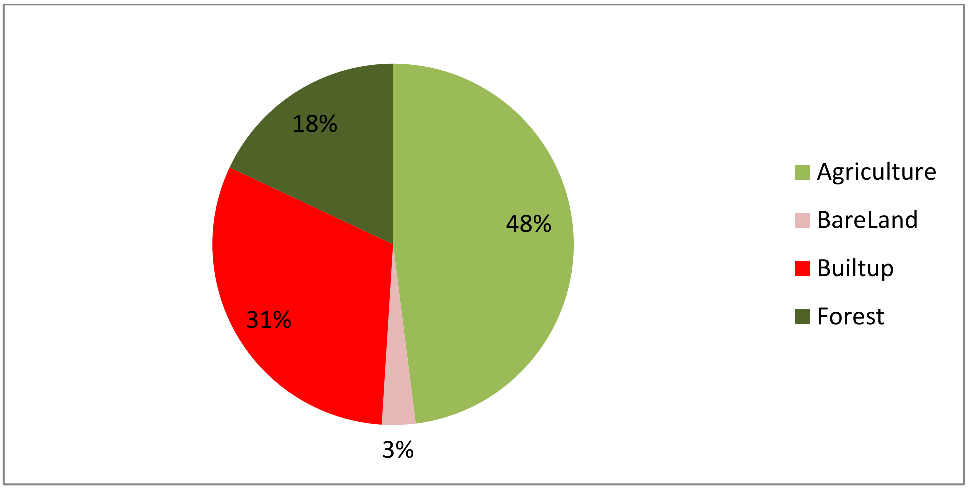


Figure 4-8: Lagatafo Lagadadhi Town: Land Use Land Cover - 2017

4.1.5. Lagatafo Lagadadi Town: LULC, 2022

Figure 4.9 depicts the spatial distribution of LULC of 2022. Agriculture land is most dominant LULC class in 2022. Out of 100.56 km^2 land, Agricultural land occupies 48.97 km^2 of total land, which was 48 percent of total LULC of Lagatafo Lagadadhi Town. Likewise built-up area was second dominant LULC class in 2022. Built-up area covers 34.91 km^2 of total land, which covers 35 percent of total LULC. Forest land was third dominating LULC class in 2022. Forest land covered 16.56 km^2 of total land, which was 16 percent of total LULC. Finally Bare land area was least dominant class. In 2022, Bare Land area was very low in comparison to other LULC. Out of total area it occupied only 0.1 km^2 of total area, which was 1 percent of total LULC of Lagatafo Lagadadhi Town. Figure 4.10 depicts the LULC distribution of Laga- Lagatafo Lagadadhi Town. LULC of Lagatafo Lagadadhi Town in 2022 is shown in figure 4.9. There has been little increase in built-up area from 2017 to 2022. Mostly, bare areas and forest contributed for development of new built-up areas. Agricultural area remained unchanged in larger extent during the study period.

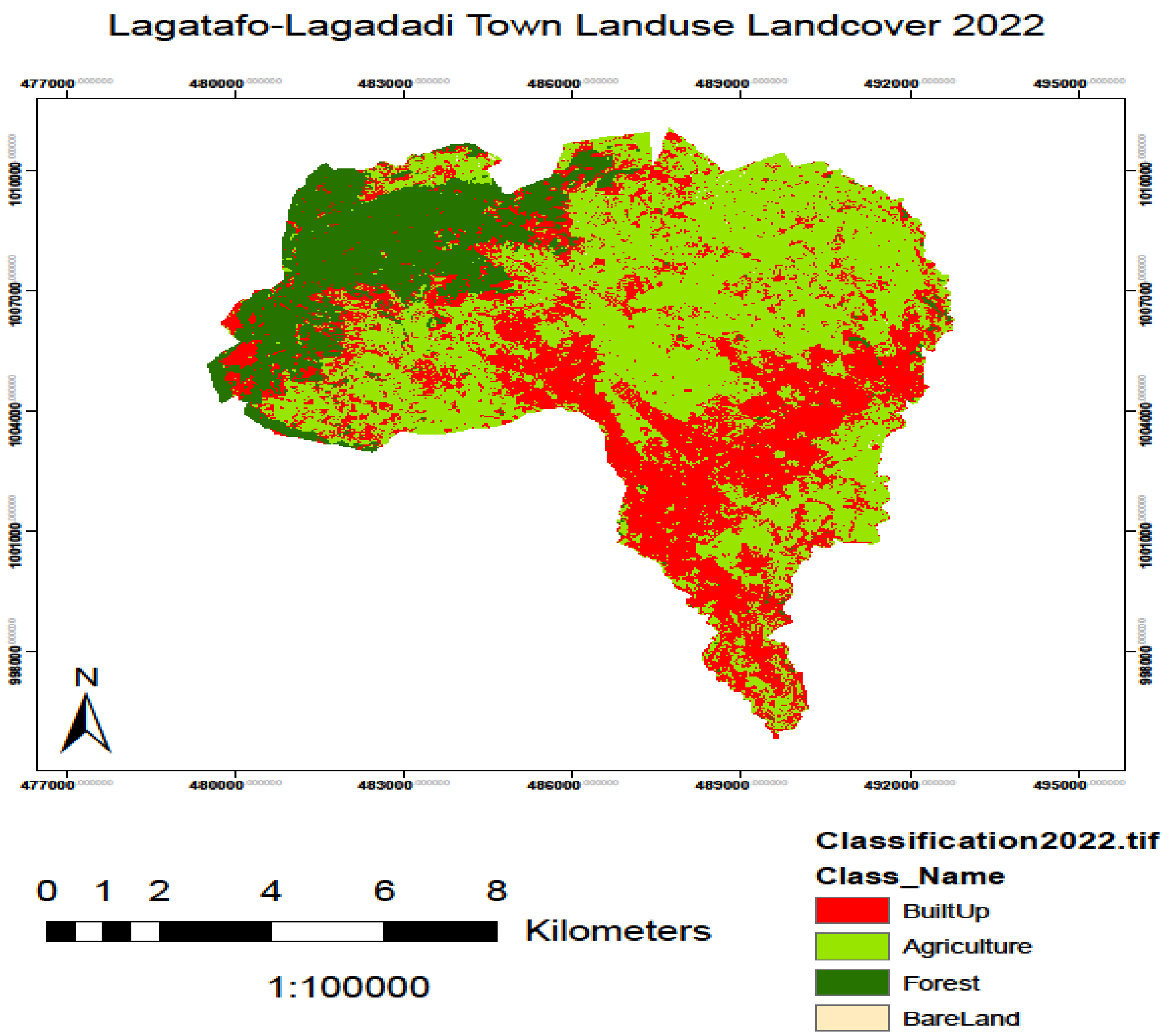


Figure 4-9: Lagatafo Lagadadhi Town: Land Use Land Cover – 2022

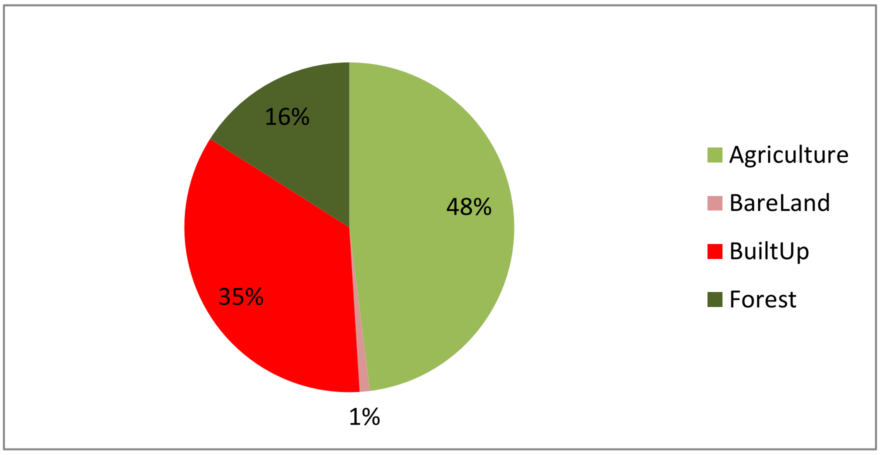


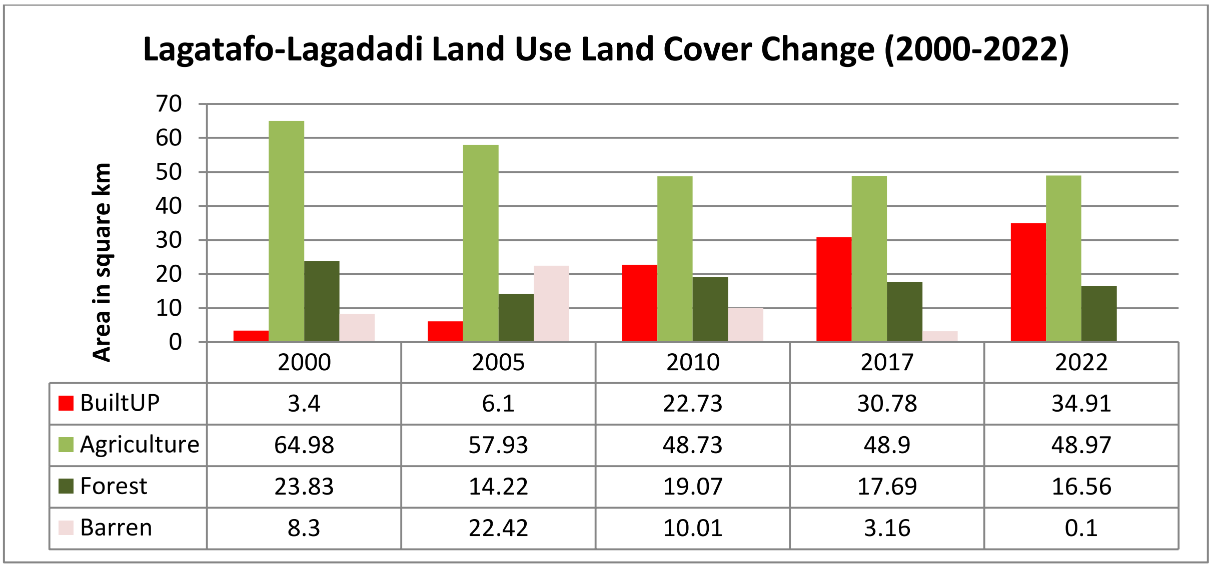
Figure 4-10: Lagatafo Lagadadhi Town: Land Use Land Cover – 2022

4.2. Spatial Extent (SE), Percentage Increased (P) and Expansion Rate (R)

AE is mostly used to absolutely quantify the yearly changes of urban regions and compare the urban growth of the same study area over different times. While AER applied to avoid the extent effect of cities and make it more suitable for spatio-temporal analysis of urban growth among different times.

In this research three indicators were used: spatial extent, Percentage Increased and expansion rate. The results of these indices are explained in the following paragraph:

Significant increase in built-up area were distinguished; this expansion of built- up area was detected during the period of 2000, 2005, 2010, 2017 to 2022. In 2000, total built-up area in Lagatafo Lagadadhi Town was 3.4 km^2. During the period of 2000 to 2005, the built-up area increased up to 6.1 km^2, which is increased 79% within five years, with 5% growth rate. Likewise, during the period of 2005 to 2010 built-up area stretched up to 22.73 km^2 that is increased 270% within five years, with 11% growth rate. Whereas during the period of 2010 to 2017 built-up area extended up to 30.78 km^2, which is increased 35% within in five years, with 1.8% growth rate. Correspondingly, in the period of 2017 to 2022 built-up area expanded up to 34.91 km^2, which is increased 13% within in five years, with 1% growth rate. With the increase in built-up area, there was little effect in forest and agricultural area. Bare land area compensates most for the changed built-up area.



	2000	2005	2010	2017	2022
BuiltUP	3.4	6.1	22.73	30.78	34.91
Agriculture	64.98	57.93	48.73	48.9	48.97
Forest	23.83	14.22	19.07	17.69	16.56
Barren	8.3	22.42	10.01	3.16	0.1

Figure 4-11: Laga-tafo-Laga-dadi Town: Land Use Land Cover Change (2000- 2022)

Figure 4.11 represents land use land cover change in graphical form, we can observe, there was slightly built up growth in the year between 2000 to 2005 and rapid growth of built-up areas between 2005 to 2010. Within twenty two years interval the built-up area increased from 3.4 to 34.91 km square with an average percentage of 42%. Whereas, agriculture decreased from 64.98 - 48.97 km square with an average percentage of 1.12%.

While forest decreased from 23.83 to 16.56 km square with an average percentage of 1.38%. Similarly, Barren land decreased from 8.3 to 0.1 km square with an average percentage of 4%.

4.3. LAGATAFO- LAGADADI TOWN: EXTENT OF URBAN SPRAWL (2000-2022)

During the urban expansion or growth process, change in phase (expansion or shrinkage) of different landscape metrics under influence of human activities can be summarized as urban sprawl change (Niemela et al., 2011). Landscape metrics used for analysis of heterogeneity of land use land cover pattern or landscape diversity in ecological investigation (Katayama et al., 2014).

Calculation of landscape metrics for determination of urban sprawl extent was computed using the clipped classified image of the years 2000, 2005, 2010, 2017 and 2022 Calculation of landscape metrics helped in explaining land scape configuration in relation to urban sprawl computation. Implication of built-up area patch indices and density indices can be used for evaluation of landscape pattern distribution for a particular land use land cover in regional or global scale (Bagan & Yamagata, 2012; Jat et al., 2008; Ji et al., 2006). Fragstats Version 4.2 developed by McGarigal and Marks (1995) was used for landscape metrics analysis. For urban sprawl analysis landscape metrics were implied shown in Table 4.3 with description. Five landscape metrics were used for quantification of urban sprawl of Lagatafo Lagadadhi Town from 2000 to 2022. These landscape metrics used three levels a) Class Area level and b) landscape level for quantification and determining pattern of land use land cover change in project area.

Table 4-1: Land scape metrics used in the research

S.N.	Landscape Metrics	Description	Range
1	Class Area Metrics (CA)	Aggregation of class area in the landscape	CA > 0, without limit
2	Number of Patches (NP)	Number of patches of landscape classes	NP ≥ 1, without limit
3	Largest patch Index (LPI)	Percentage of the landscape included by the largest patch	0 < LPI ≤100
4	Fractal Index Distribution (FRAC_AM)	To measure area weighted mea patch fractal dimension	1 ≤ FRAC_AM ≤ 2
5	Relative entropy value	To measure the level of urban	0≤ RE_ Value ≤ 1

Class Area Metrics (CA) measures the landscape composition i.e. how much the land scape metrics composed the particular land use land cover patch. For the study of urban sprawl extent CA metrics was used to determine increase in urban class (Padmanaban et al., 2017). Number of Patches (NP) measures the homogeneity of the landscape, whereas patch can be better understood as landscape with its independent structure irrespective to its surroundings (Bhatta et al., 2010). NP was used to evaluate evenness in landscape distribution and diversity (Harrison, 1999). Having higher NP value indicates dispersed distribution of patches whereas lower value of NP indicates compact distribution of patches. In this case Built-up area was considered.

Largest patch index (LPI) quantifies the total landscape area in project area which is comprised by largest patch. LPI can simply be understood as measure of dominance of patch in overall landscape. Having LPI value close to zero indicates corresponding patch size increasingly small, whereas larger patch size indicates entire land scape is dominated by particular patch type (McGarigal, K., 2015).

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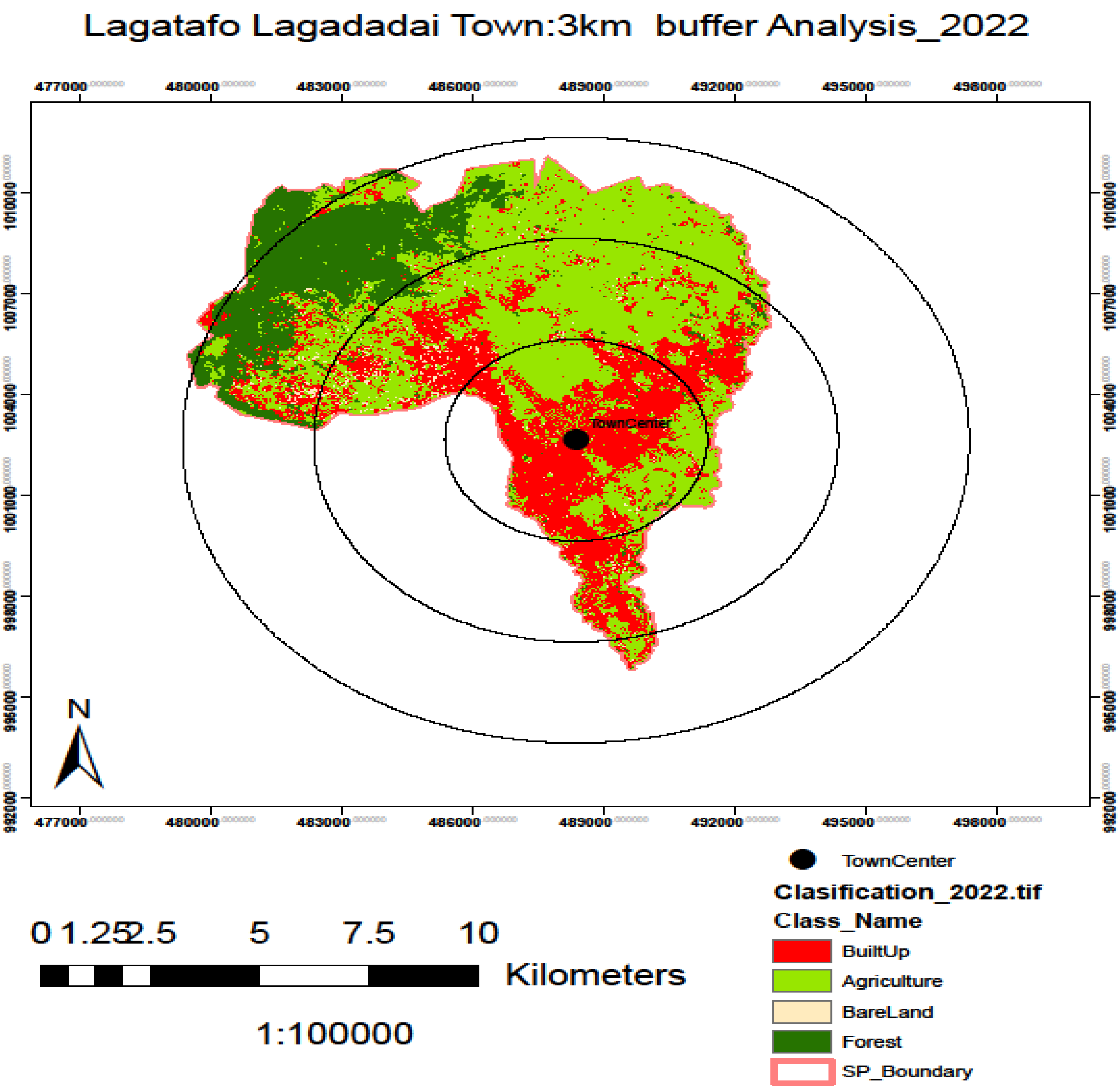


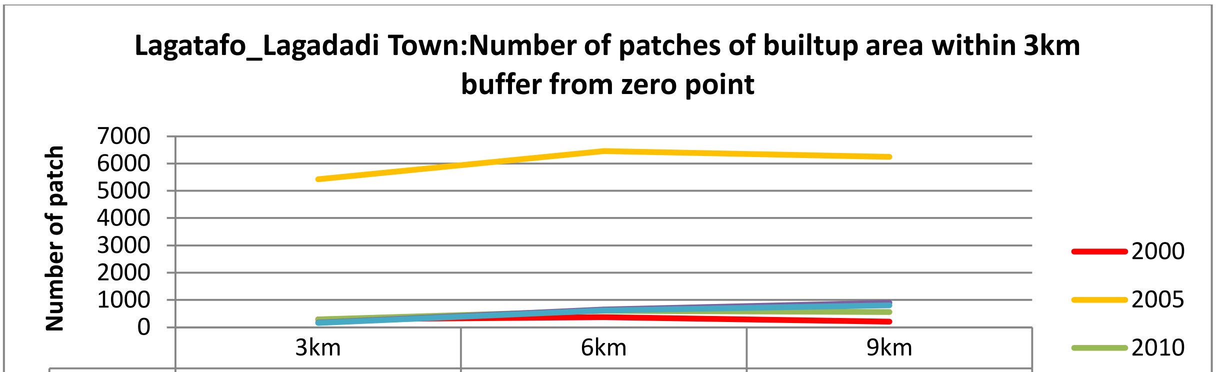
Figure 4-122: Lagatafo Lagadadhi Town: Multibuffer 3km Analysis, 2022

Area Weighted Mean Fractal Dimension Index (FRAC_AM) is specialized landscape metrics for landscape pattern analysis. Calculation of FRAC_AM of landscape metrics was done in Fragstats 4.2. FRAC_AM value ranges from 1 to 2. FRAC_AM determines overall shape and edge of landscapes. Aggregated shapes better establishes connection amongst various patches (McGarigal, K., 2015).

Landscape metrics was computed for the period from 2000 to 2022. Lagatafo Lagadadhi Town was divided into buffer of 3 km, and landscape metrics for each buffer region was computed and urban sprawl for each buffer ring was computed.

4.4. NUMBER OF PATCHES

The clipped classified images from 2000 to 2022 along 3 km incremental buffer were used for Number of patches (NP) analysis, and result is portrayed in figure 4.15. Number of patch in different proximity for five different years was represented. NP values in proximity of 0 to 3 km, 3 to 6km, 6 to 9 km during 2000 was relatively low; however NP value in proximity of 0 to 3 km, 3 to 6km, 6 to 9km during 2005 was very high, this was due to highly scattered settlement in Lagatafo Lagadadhi Town. During 2005, segregated settlement area with open spaces between those areas existed, resulting in higher amount of dispersed distribution of built-up patches, resulting in heterogonous distribution of built-up area. Within 0 to 3-6-9 km. NP values decreased from 2005 up to 2022. Bare lands and agricultural area between the built- up areas was populated with new built-up area. From 2000 to 2010 the NP values increased from 0 to 3km to 3 to 6km and the NP values decreased slightly from 6 to 9km. From 2017 to 2022, the NP values decreased slightly, however from 2017 to 2022 the NP values increased from 3 to 9km buffer area. Generally the figures show that, the built-up growth homogeneity from 2000-2020 in different proximity analysis from the origin point. In 2005, highly fragmented built up distribution exist in the area.



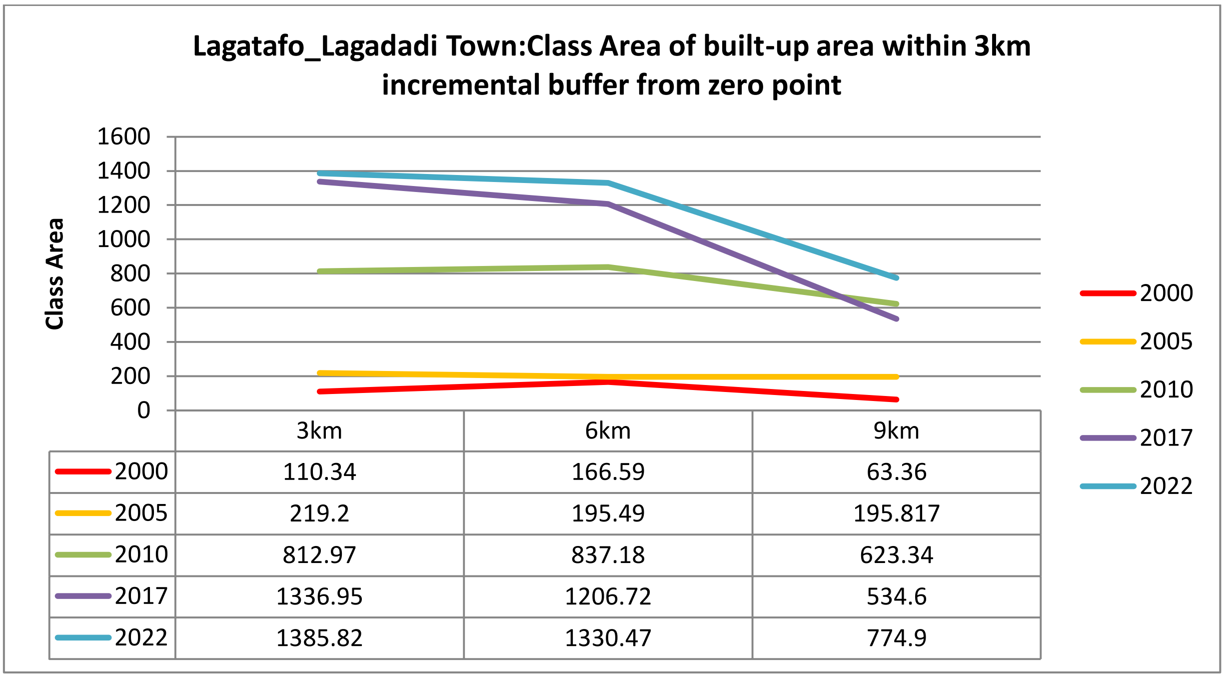
	3km	6km	9km
2000	286	367	206
2005	5427	6455	6247
2010	288	604	555
2017	170	655	894
2022	161	620	801

Figure 4-133: Number of patches for built-up area within 3 Km incremental

4.5. CLASS AREA METRICS

The clipped classified images from 2000 to 2022 along 3 km incremental buffer were used for Class Area Metrics (CA) analysis, and result is portrayed in figure 4.16. CA in first proximity of 0 to 3 km during 2000 was 110.34 this is due to highly scattered settlement in. During 2000, Lagatafo Lagadadhi Town scattered settlement area with bare land between those areas existed, resulting in higher amount of dispersed distribution of built-up patches, resulting in heterogonous distribution of built-up area within 3 km.
The above figure shows, the built up area increased temporally from 2000 to 2020. Spatially, from 2000 to 2010 the built-up area increased in the proximity of 0 to 3km to 3 to 6km and then decreased in 6 to 9km buffer. However in 2017 and 2022 the built up area decreased linearly from origin point to 9km.

Generally the figure shows, little change is exhibited spatially from 3 to 6km buffer and from 6 to 9km. However there is significant increase temporally, especially from 2005 to 2010 and from 2010 to 2017.



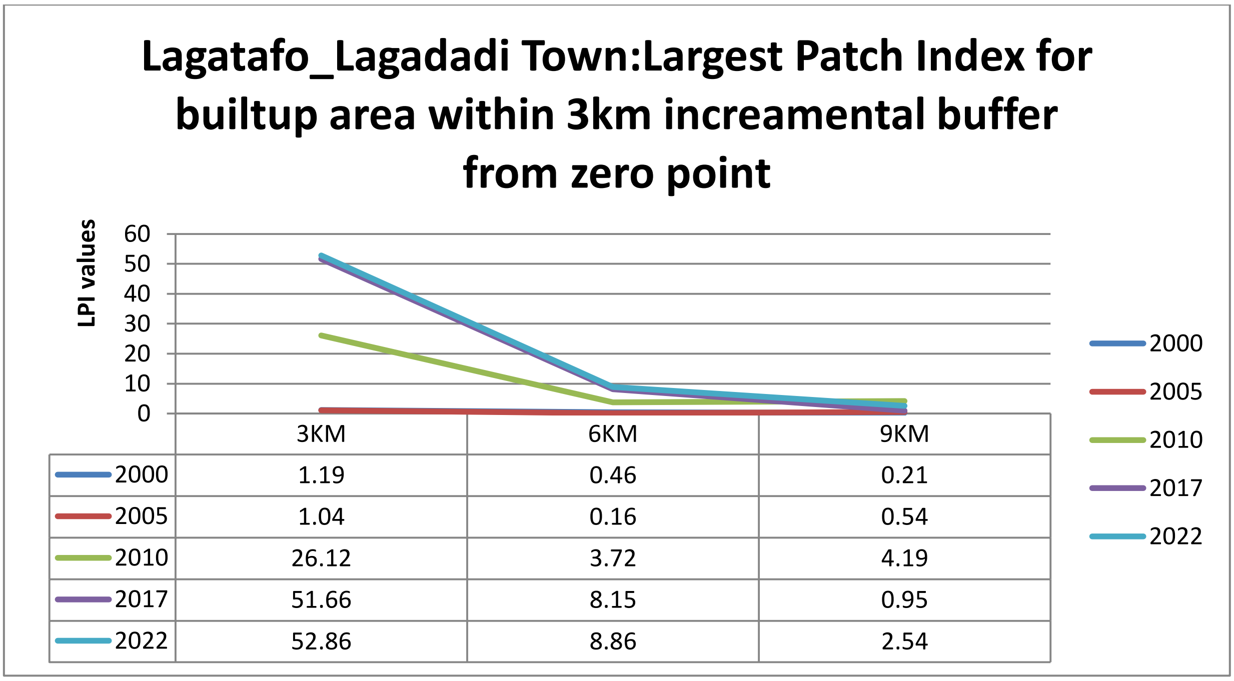
	3km	6km	9km
2000	110.34	166.59	63.36
2005	219.2	195.49	195.817
2010	812.97	837.18	623.34
2017	1336.95	1206.72	534.6
2022	1385.82	1330.47	774.9

Figure 4-14: Lagatafo Lagadadhi Town: Class Area for built-up area within 3 Km incremental buffer from zero point.

4.6. Largest Patch Index

LPI equals the area (m) of the largest patch in the landscape divided by total landscape area (m), multiplied by 100 (to convert to a percentage); in other words, LPI equals the percent of the landscape that the largest patch comprises. LPI ranges from 0 to 100, LPI approaches 0 when the largest patch in the landscape is increasingly small. LPI = 100 when the entire landscape consists of a single patch; that is, when the largest patch comprises 100% of the landscape. Largest patch index quantifies the percentage of total landscape area comprised by the largest patch. As such, it is a simple measure of dominance.

The clipped classified images from 2000 to 2022 along 3 km incremental buffer were used for Largest Patch Index (LPI) analysis. Figure 4.17 represent LPI values in three different proximities and in five different time period. Generally the figure shows that, LPI values were very low Except the year from 2010 to 2022 in the first proximity of 0 to 3km. in the first proximity of 2017 and 2022, the LPI values approaches 50, that shows almost half of the area was dominated by built-up patches, due to Bare Land and agricultural area between the built-up areas were converted to compact built-up area. In addition, LPI values decreased, when it is far from the origin. These values strongly suggest development of urban sprawl.



	3KM	6KM	9KM
2000	1.19	0.46	0.21
2005	1.04	0.16	0.54
2010	26.12	3.72	4.19
2017	51.66	8.15	0.95
2022	52.86	8.86	2.54

Figure 4-15: Lagatafo Lagadadhi Town: Largest Patch Index for built-up area within 3 Km incremental buffer from zero point

4.7. FRACTAL INDEX DISTRIBUTION

The interaction of patch shape and size can influence a number of important morphological processes. Shape is a difficult parameter to quantify concisely in a metric. Generally speaking, the shape of a geometric object, such as a patch, is a function of its morphology. Thus, one might expect shape metrics to discriminate among patch morphologies. While it is possible to quantitatively distinguish morphological patterns, as is done in the field of computer visions (e.g., face recognition).Perimeter-area ratio is a simple measure of shape complexity, but without standardization to a simple Euclidean shape (e.g., square). A problem with this metric as a shape index is that it varies with the size of the patch. For example, holding shape constant, an increase in patch size will cause a decrease in the perimeter-area ratio. Shape index corrects for the size problem of the perimeter-area ratio index, by adjusting for a square standard and, as a result, is the simplest and perhaps most straightforward measure of shape complexity.

A fractal dimension ranges between 1 and 2; a fractal dimension greater than 1 for a 2-dimensional patch indicates a departure from Euclidean geometry (i.e., an increase in shape complexity). FRAC approaches 1 for shapes with very simple perimeters such as squares, and approaches 2 for shapes with highly convoluted, plane-filling perimeters Fractal dimension index is appealing because it reflects shape complexity across a range of spatial scales (patch sizes). Thus, like the shape index (SHAPE), it overcomes one of the major limitations of the straight perimeter-area ratio as a measure of shape complexity.

The clipped classified images from 2000 to 2022 along 3 km incremental buffer were used for Fractal Index (FRAC_AM) analysis, and result is portrayed in figure 4.18. Within first proximity of 0 to 3 km during 2000 FRAC_AM was 1.03. During decade of 2000 to 2005, FRAC_AM increased from 1.03 to 1.07. FRAC_AM decreased from 1.07 in 2005 to 1.04 in 2010 and to 1.03 in 2017 and 2022. Similarly Within the second proximity of 3 to 6 km during 2000 FRAC_AM was 1.03. During decade of 2000 to 2005, FRAC_AM increased from 1.03 to 1.07. FRAC_AM decreased from 1.07 in 2005 to 1.04 in 2010, 2017 and 2022.On the other hand, within the third proximity of 6 to 9 km during 2000 FRAC_AM was 1.02. During 2005 and 2010 FRAC_AM increased to 1.04. FRAC_AM decreased from 1.05 to 1.02 from 2017 to 2022.

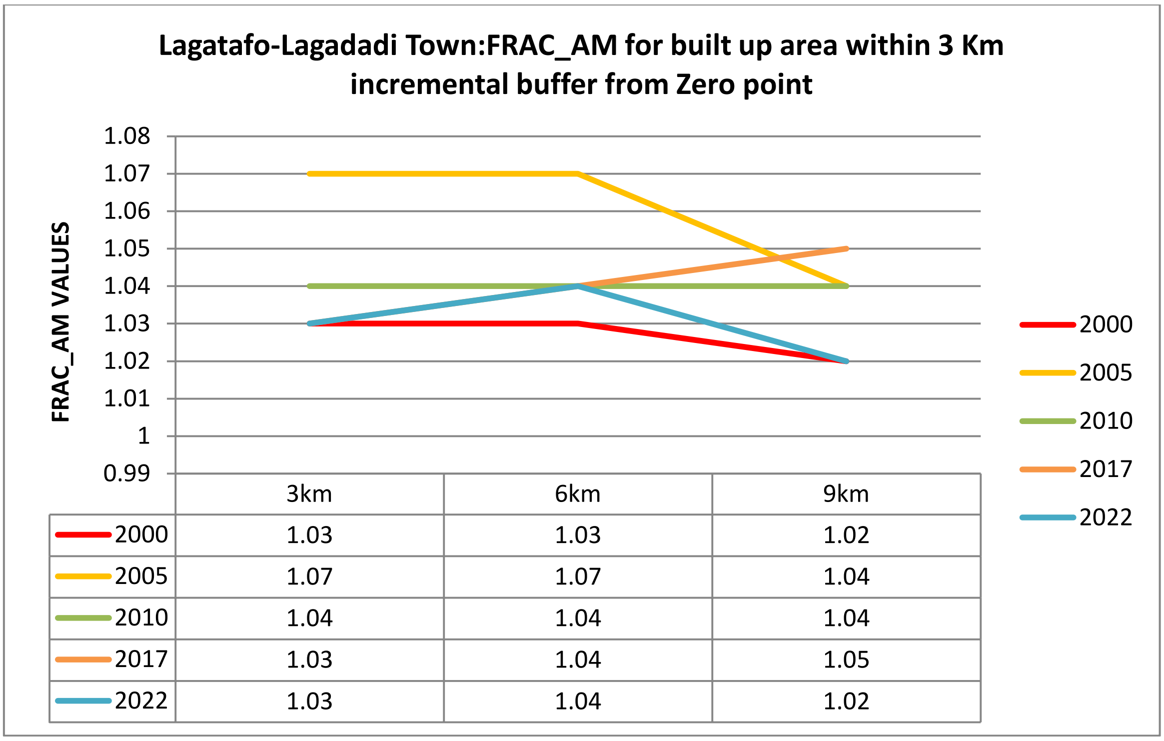


Figure 4-146 Lagatafo Lagadadhi Town: FRAC_AM for built-up area within 3 Km incremental buffer from -zero point

4.8. Level of Urban Sprawl

Shannon‘s Entropy was used to calculate the level of urban sprawl of Lagatafo Lagadadhi Town from 2000 to 2022. Determining change detection of urban sprawl relationship of landscape pattern and process needs to be considered as well, Urban Sprawl can be measured with application of entropy (Yeh & Xia, 2001). Shannon‘s entropy is technique of information communication, which measures uncertainty of random variable. Entropy is one of the frequently used measures in developing countries for determining urban sprawl decades (Bhatta et al., 2010; Sudhira et al., 2004). Shannon‘s entropy measures the degree of spatial compactness or dispersed nature of geographic variable (Jat et al., 2008; Yeh & Xia, 2001). Shannon‘s entropy was used in this research to determining degree of concentration or dispersion of built-up area, and also used for determining compactness or dispersed urban growth. Shannon‘s entropy analysis was used for determination of degree of urban sprawl in Lagatafo Lagadadhi Town. Shannon‘s entropy for urban sprawl analysis in this analysis is understood considering n number of characteristics of urban sprawl, for determining sprawl, n*log(n) value Overall Lagatafo Lagadadhi Town was divided by buffer ring with radius of 3 km.

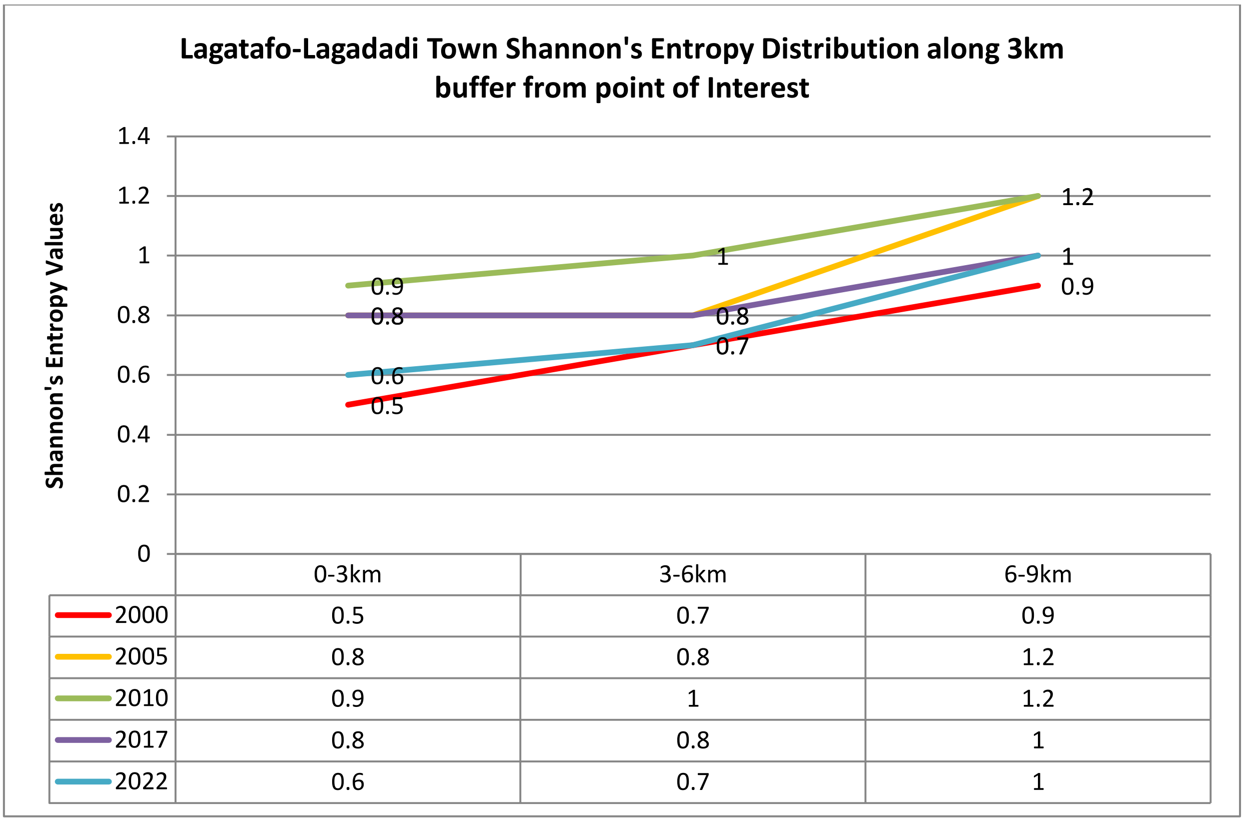


Figure 4-157 Lagatafo Lagadadhi Town: Shannon’s Entropy for built-up area within 3Km incremental buffer from zero point

The clipped classified images from 2000 to 2022 along 3 km incremental buffer were used for Shannon‘s entropy analysis, and result is portrayed in figure 4.19. Having four LULC classes for analysis, upper range of entropy value for this analysis is 1.2 and the lower value is 0.5.Value close to 0 represents compact growth of built-up areas, whereas value close to upper limit refers, more dispersed built-up area, or higher degree of urban sprawl. In this study, in 2000 Shannon‘s entropy value in 0 to 3 km proximity was 0.5, while in 2005 entropy value was 0.8 and that of 2010 was 0.9. Whereas the entropy value decreased in 2017 to 0.8 and then in 2022 it was 0.6.similarly,Within the proximity of 3 to 6 kilometer in the year 2000 Shannon‘s entropy value was 0.7, while in 2005 entropy value was 0.8 and that of 2010 was 1.0. Whereas in 2017 it was 0.8 And that of 2022 was 0.7.Likewise,Within the proximity of 6 to 9 kilometer in the year 2000 Shannon‘s entropy value was 0.9, while in 2005 entropy value was 1.2 and that of 2010 was 1.2, where as in 2017 entropy value was 1 .0 and that of 2010 was 1.0

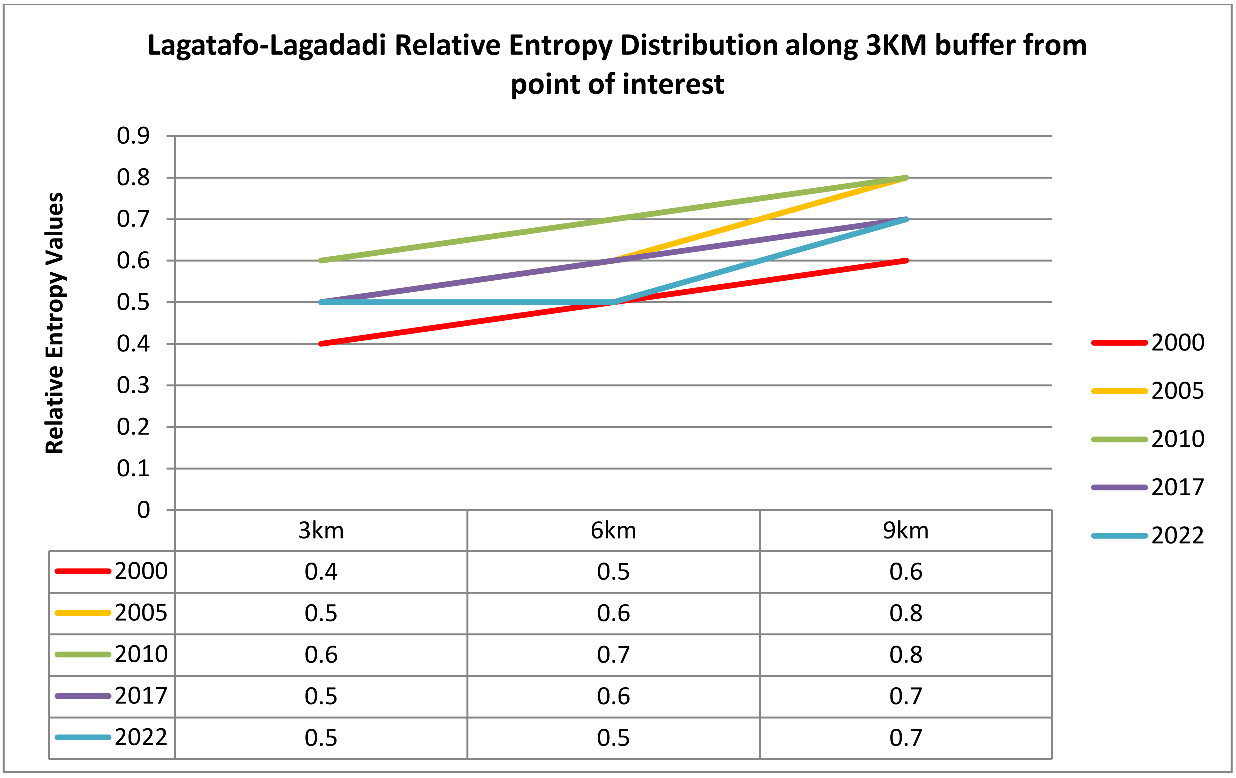
These values of entropy clearly shows, urban sprawl increased spatially when it was far from the origin, due to conversion of other LULC to built-up area, and dispersed settlement development. Generally the figure shows that, the entropy values increased from 2000 to 2010 in all Zones .and then decreased from 2010 to 2022.This shows initially the urban growth was not compact, whereas after 2010 the growth was relatively compact due to infill type of development, where the bare land and agriculture were converted in to urban built-up.

4.9. RELATIVE ENTROPY

Relative entropy scales the value of entropy from the range of 0 to log (n) to a range of 0 to 1. By converting entropy to relative entropy, the degree of dispersion can be compared between with different sizes and numbers of buffer zones. Relative entropy can be calculated by dividing the entropy by log (n). The temporal component of the study involves calculating the change in entropy over time. A decrease in entropy over time indicates that the city is developing in a compact, concentrated manner, while an increase in entropy indicates that the city is developing in a dispersed manner. (Masoumi ,2015)

The clipped classified images from 2000 to 2022 along 3 km incremental buffer were used for Relative entropy analysis, and result is portrayed in figure 4.20. In the proximity of 0 to 3km the relative entropy value increased by 0.1 from 2000 to 2005, similarly the relative entropy value increased by 0.1 from 2005 to 2010, this shows that similar level of urban sprawl existed between 2000 to 2005 and 2005 to 2010.

From 2010 to 2017 the relative entropy value decreased from 0.6 to 0.5 which was 0.1, this shows relative compact development occurred in 2017. Likewise the relative entropy value was similar in 2017 and 2022, which was 0.5; this sows similar level of relative compact development. More over the relative entropy value was used to examine the level of urban sprawl spatially.



	3km	6km	9km
2000	0.4	0.5	0.6
2005	0.5	0.6	0.8
2010	0.6	0.7	0.8
2017	0.5	0.6	0.7
2022	0.5	0.5	0.7

Figure 4-18: Lagatafo Lagadadhi Town: Relative Entropy for built-up area within 3Km incremental buffer from zero point

In 2005 the relative entropy value from 0 to 3km was 0.5 and from 3 to 6km was 0.6, which was increased by 0.1 and the relative entropy value from 6 to 9km was 0.8, which was increased by 0.2 from 3 to 6km, this shows the level of urban sprawl was double in the proximity of 6 to 9km. A decrease in entropy over time indicates that the city is developing in a compact, concentrated manner, while an increase in entropy indicates that the city is developing in a dispersed manner

Generally Figure 4.20 shows that, the relative entropy values increased, that means level of urban sprawl increased spatially when it was far from the origin, due to conversion of other LULC to built-up area, and dispersed settlement development. When the level of urban sprawl examined temporally, the relative entropy value increased up to 2010, which indicates that the city is developing in a dispersed manner and then the relative entropy value decreased up to 2022, this shows that the city was developing in a relative compact, concentrated manner.

4.10. TYPES OF URBAN SPRAWL

Urban sprawl can be differentiated in three type based on extent of sprawl. Three form of urban sprawl are: leapfrog‖, infill‖ and expansion (Angel et al., 2007, Battyet al., 2003; Besussi et al., 2010).

Leapfrog development occurs when developers skip over land to obtain cheaper land further away from cities, thus, leaving huge areas empty between the city and the new development. It can be seen when it comes to the development or urbanization of more rural areas. The term infill development refers to building within unused and underutilized lands within existing development patterns, typically but not exclusively in urban areas. Infill development is critical to accommodating growth and redesigning our cities to be environmentally and socially sustainable. This area refers to new development in open area lying within existing urbanized area, newly developed pixels that are in the urbanized open land of the previous time period. Expansion refers to non-infill new development built-up area which is overlapped with existing urban footprint, newly developed pixels that are in the fringe open land of the previous time period (Angel et al., 2007).

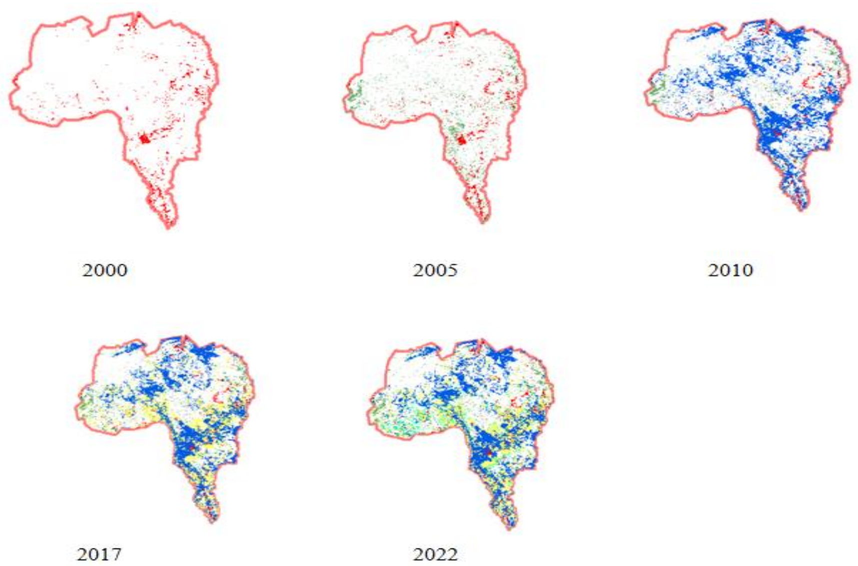


Figure 4-19: Lagatafo Lagadadhi Town: Trend of Built-up Growth

Figure 4.21 shows that the form of built up growth of Lagatafo Lagadadhi town from 2000 to 2022. In 2000, the built up area was very scattered throughout the town. In 2005 and 2010 the form of the built-up area were infill and extension type of development. After 2010 the form of the built up area was examined as infill type of development.

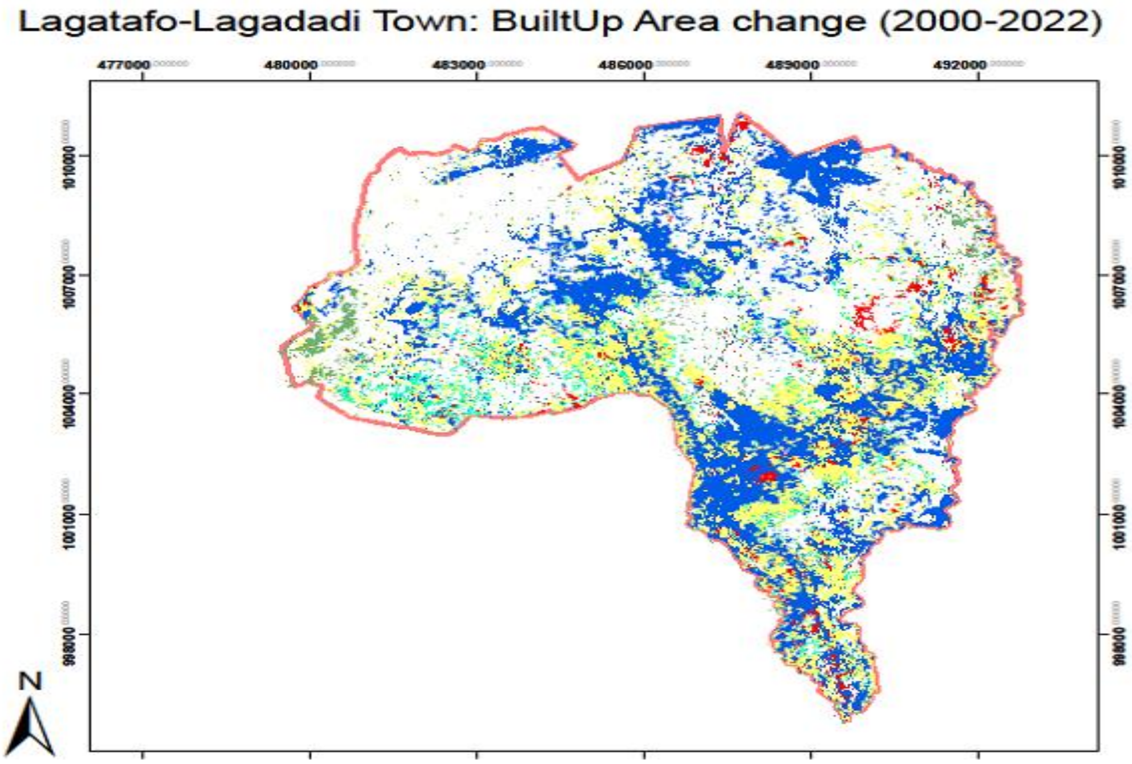


Figure 4-20: Lagatafo Lagadadhi Town: Built up area map from 2000-2022

The red, cyan, blue, yellow and green colors in Figure 4.22 shows the distribution and pattern of built up growth in 2000, 2005,2010,2017,2022 respectively. Initially in 2000 the growth pattern was very scattered leapfrog and then extension type was dominant type of development, afterwards infill type of development pattern was dominant type in the study area.

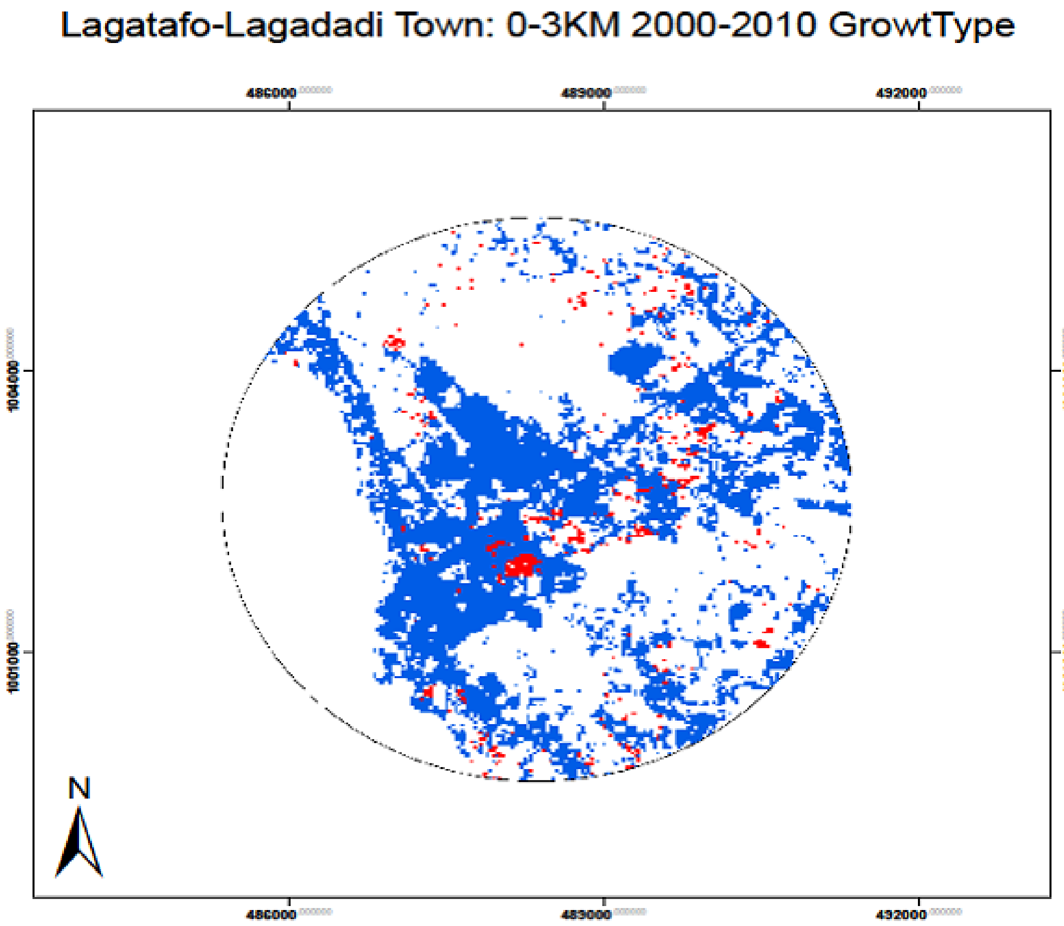


Figure 4-162: Lagatafo Lagadadhi Town: Built up Growth Type map from 2000-2010

The red color and the blue color in Figure 4.23 show the built up distribution in 2000 and 2010 respectively. In 2005, the built-up distribution was very scattered and in 2010, it was somehow compact. The type of urban growth is extension type, new development built-up area is overlapped with existing urban footprint.

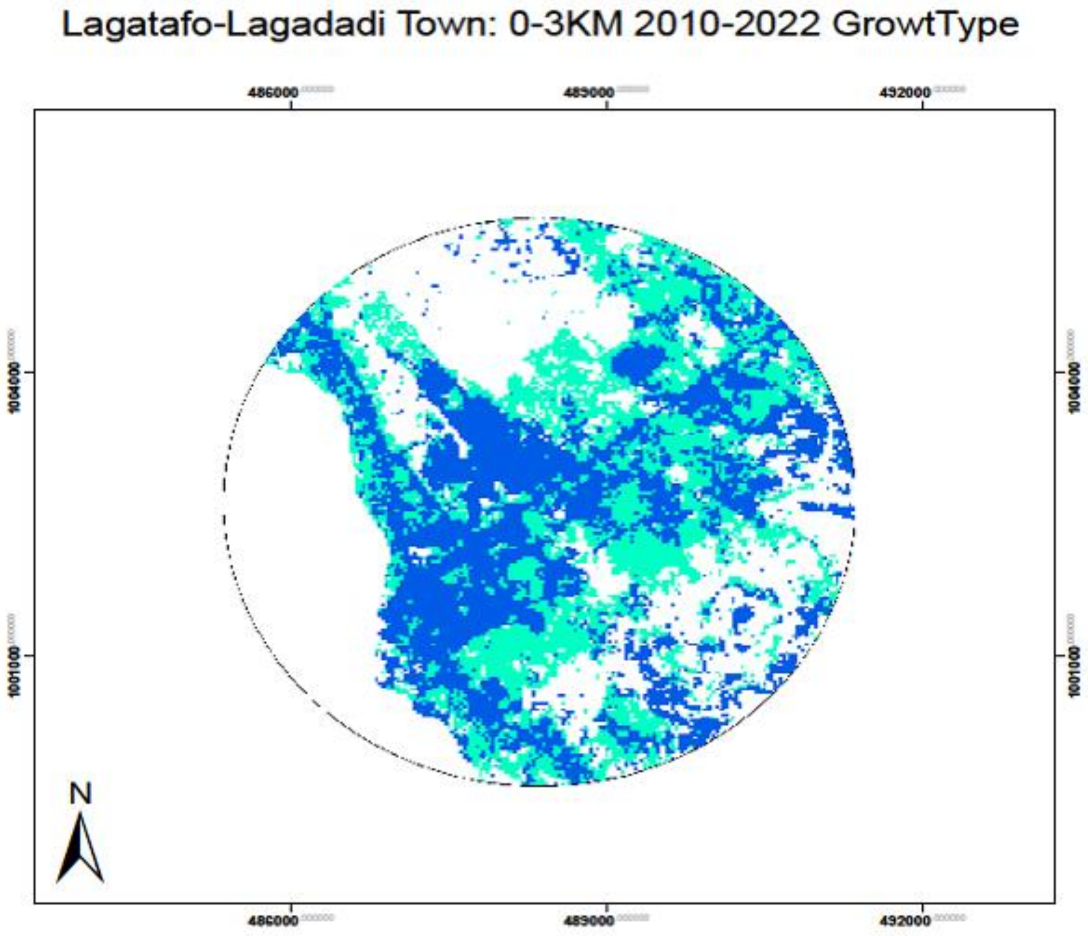


Figure 4-173: Lagatafo Lagadadhi Town: Built up Growth Type map from 2010-2022

The Blue color and the Green color in Figure 4.24 show the built up distribution in 2010 and 2022 respectively. The type of urban growth is extension type, new development built-up area is overlapped with existing urban footprint and infill type, which is new development in open area lying within existing urbanized area.

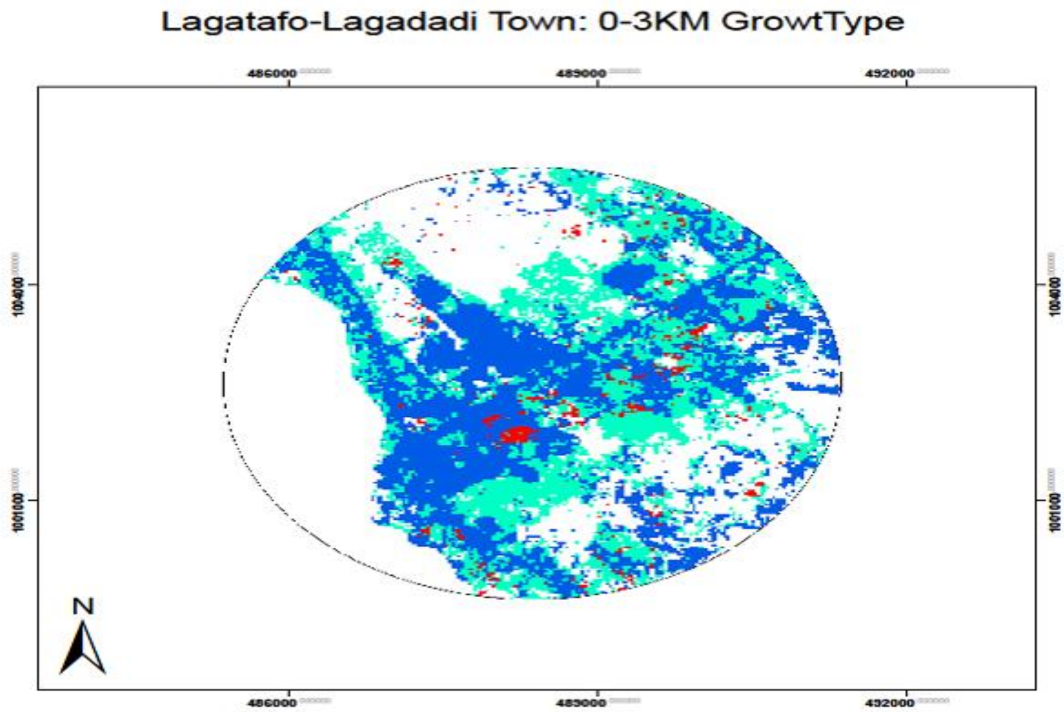


Figure 4-184: Lagatafo Lagadadhi Town: Built up Growth Type map from 2000-2022

Figure 4.25 show the built up distribution from 2000 up to 2022 in the proximity of 0-3km. clearly shown the type of urban growth was extension and infill.

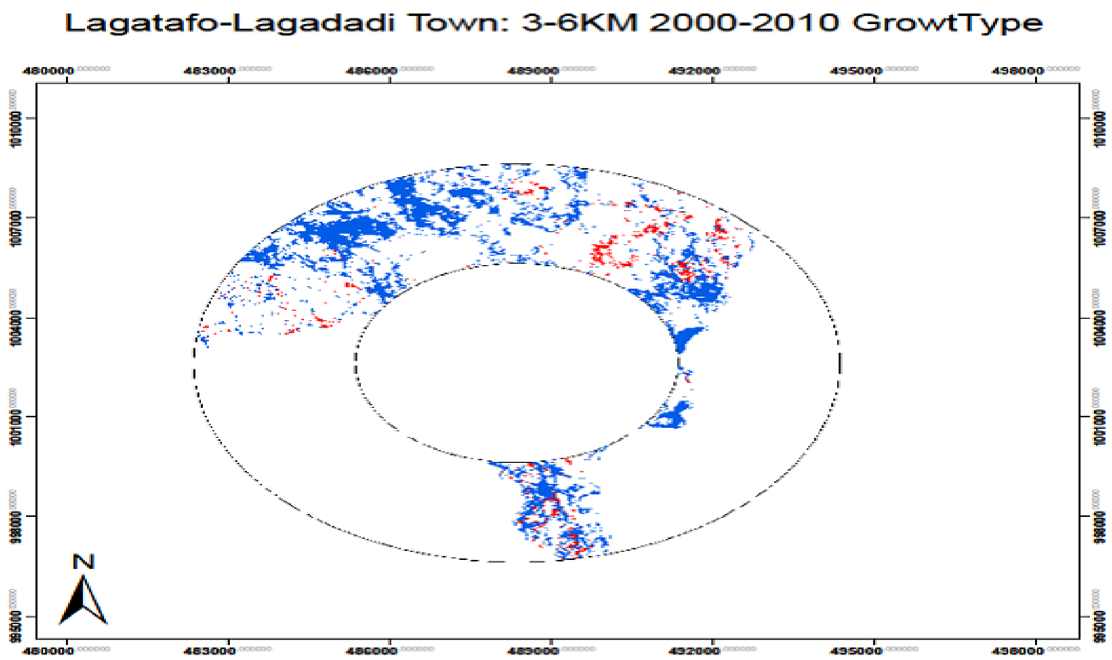


Figure 4-25: Lagatafo Lagadadhi Town: Built up Growth Type map from 2000-2010

Figure 4.26 show the built up distribution from 2000 up to 2010 in the proximity of 3-6km. clearly shown the type of urban growth was extension and infill.

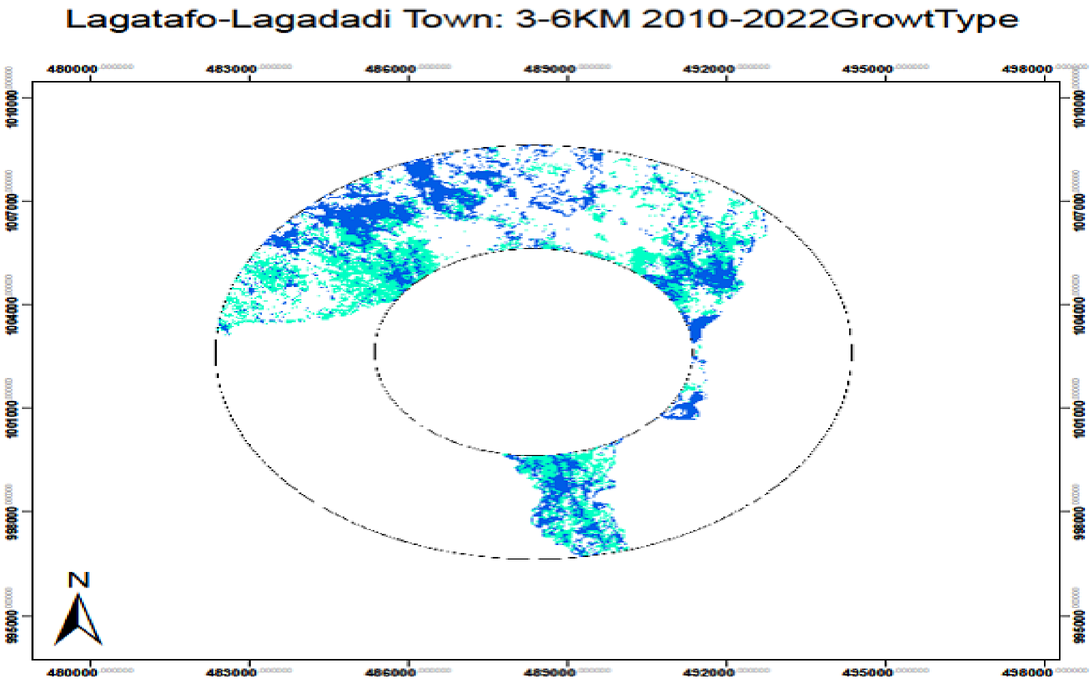


Figure 4-19: Lagatafo Lagadadhi Town: Built up Growth Type map from 2010-2022

Figure 4.27 show the built up distribution from 2010 up to 2022 in the proximity of 3-6km, visibly shown the type of urban growth was extension and infill.

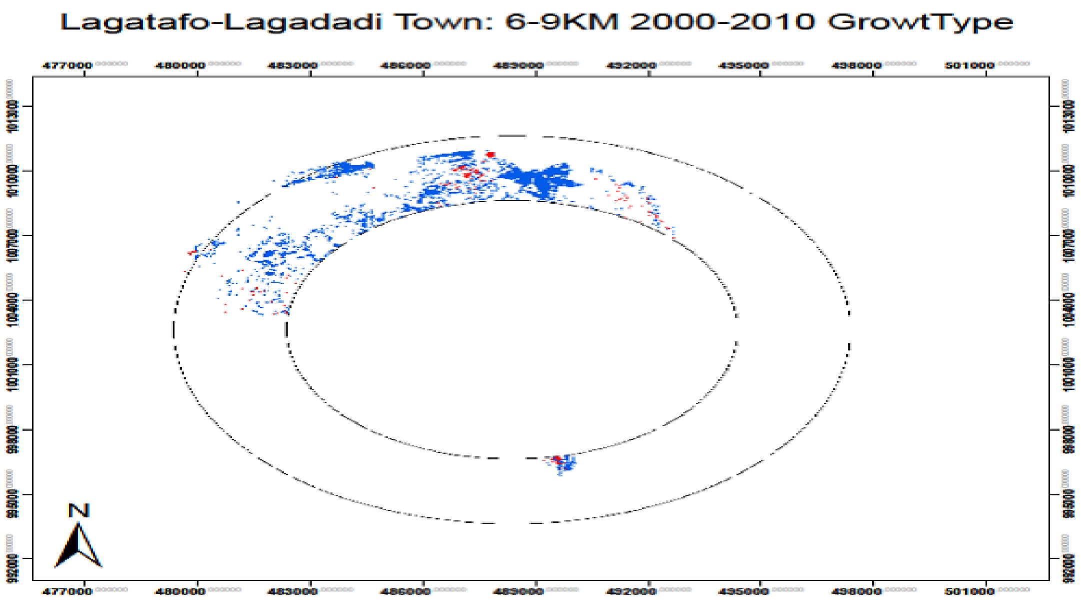


Figure 4-20: Lagatafo Lagadadhi Town: Built up Growth Type map from 2000-2010

Figure 4.26 show the built up distribution from 2000 up to 2010 in the proximity of 6-9km. noticeably shown the type of urban growth was extension and infill.

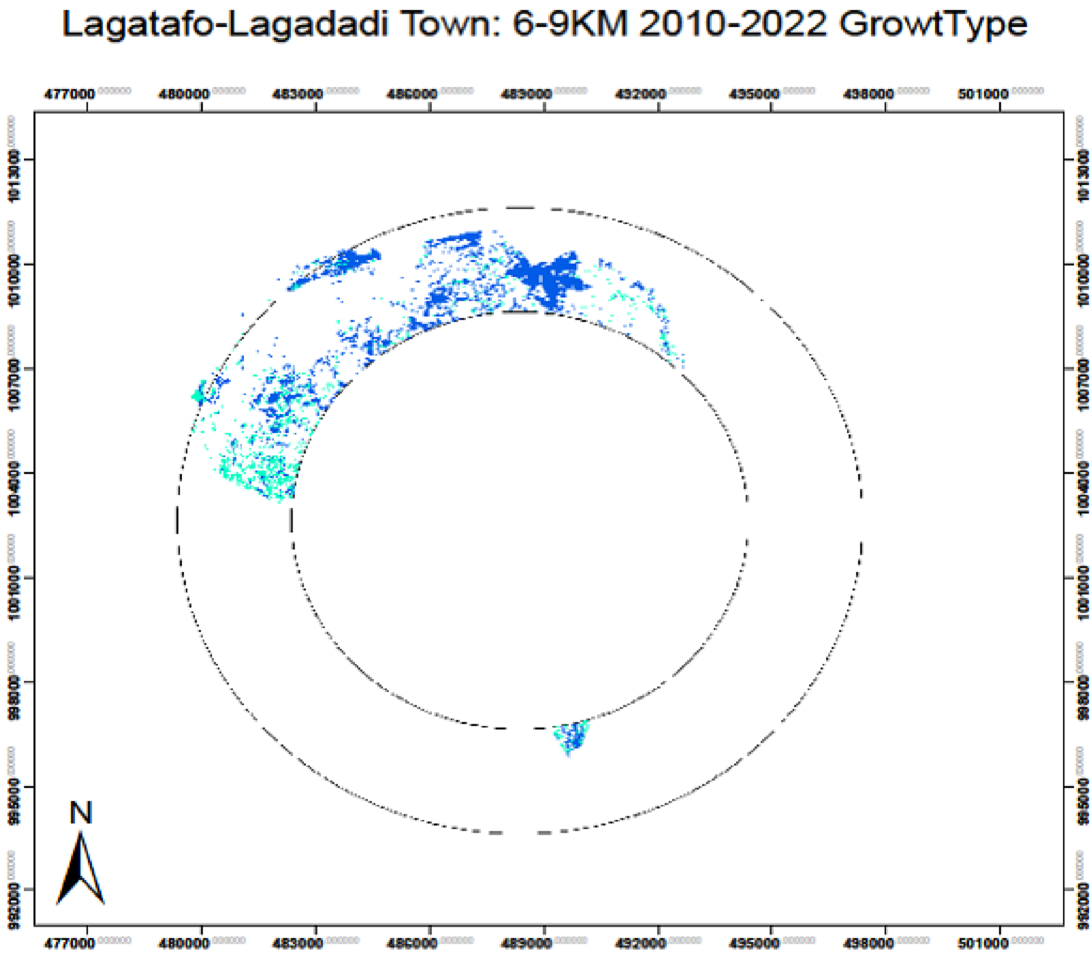


Figure 4-217: Lagatafo Lagadadhi Town: Built up Growth Type map from 2010-2022

Figure 4.29 show the built up distribution from 2010 up to 2022 in the proximity of 6-9km. noticeably shown the type of urban growth was extension and infill.

4.11. HOT SPOT ANALYSIS

Hotspot analysis is a spatial analysis and mapping technique interested in the identification of clustering of spatial phenomena. These spatial phenomena are depicted as points in a map and refer to locations of events or objects. A hotspot can be defined as an area that has higher concentration of events compared to the expected number given a random distribution of events. Hotspot detection evolved from the study of point distributions or spatial arrangements of points in a space (Chakravorty, 1995). When examining point patterns, the density of points within a defined area is compared against a complete spatial randomness model, which describes a process in which point events occur completely at random (i.e., homogeneous spatial Poisson process). Beyond assessing the density of points in a given area, hotspot techniques also measure the extent of point event interaction to understand spatial patterns (Baddeley, 2010).

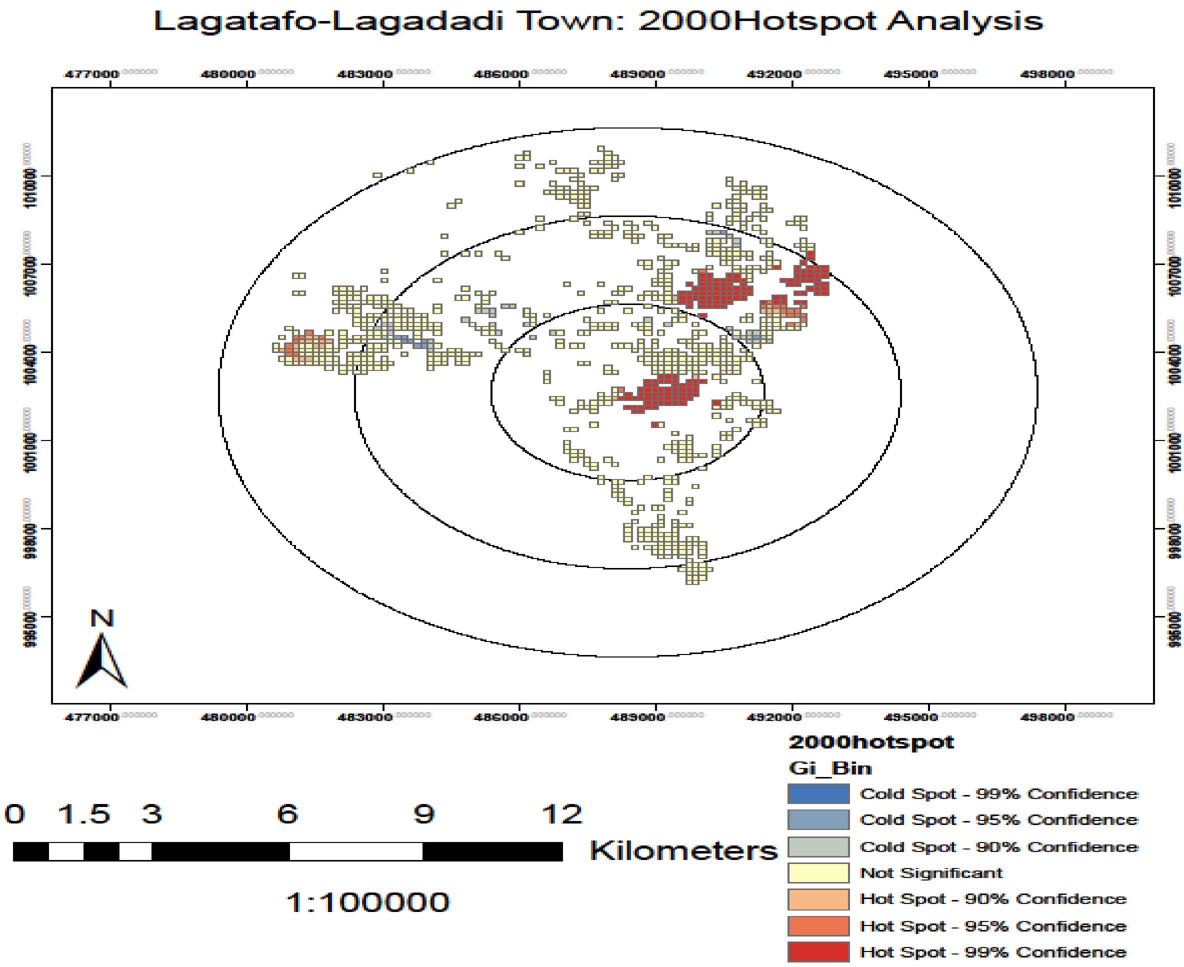


Figure 4-28: Lagatafo Lagadadhi Town: Built up hotspot analysis, 2000

Figure 4.30 shows the built up hot spot analysis result for the year 2000 conducted with the optimized hot spot analysis-tool in Esri's ArcGIS software. The software identifies statistically significant hot and cold spots. Hot spots are essentially locations or small areas within a boundary showing a concentration of built-up. The red color shows existence of high concentration of built-up in that specific area.

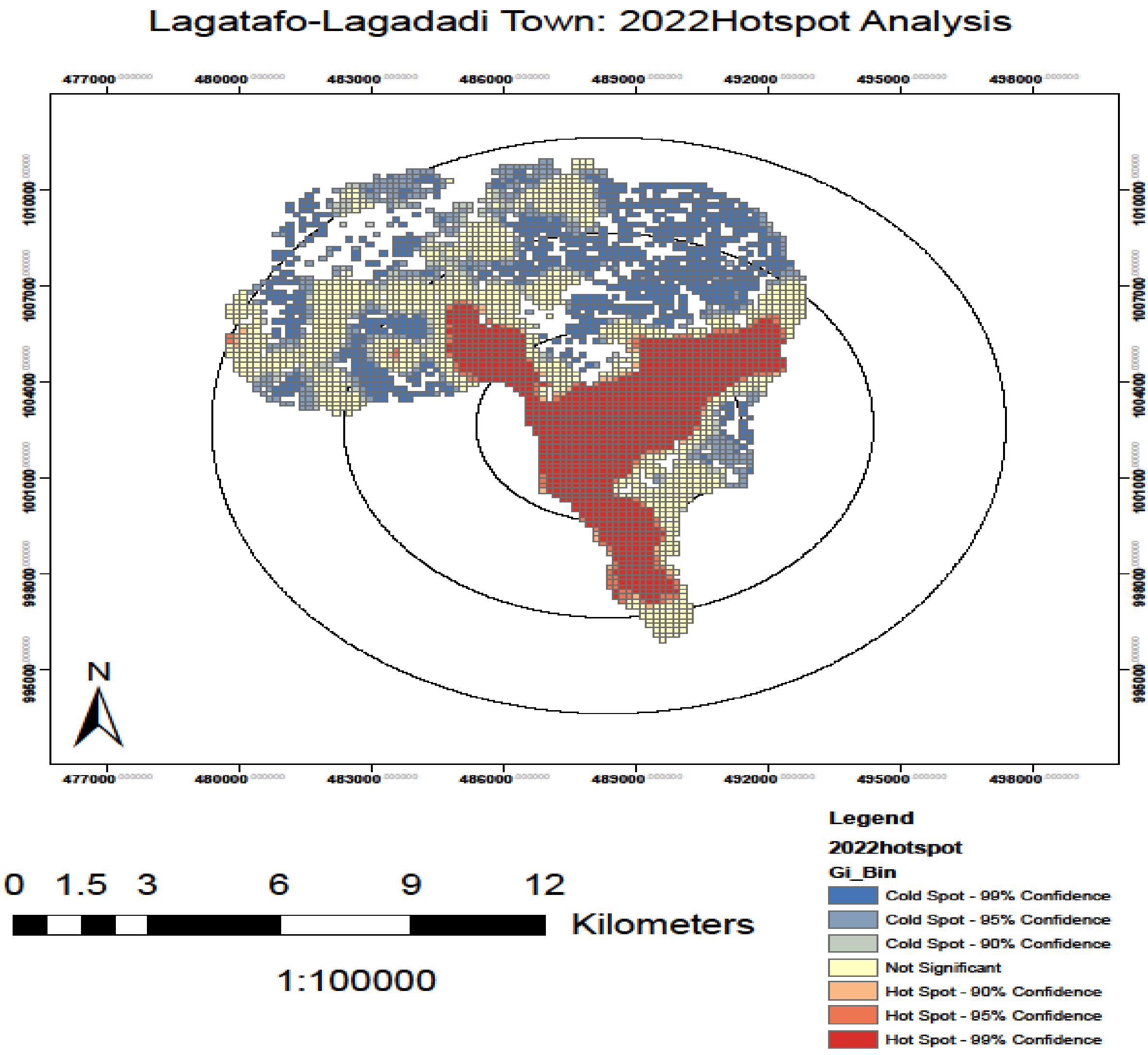


Figure 4-29: Lagatafo Lagadadhi Town: Built up Hotspot analysis, 2022

The red color in figure 4.31 shows higher Z-score value, the more statistically significant and thus the more intense clustering of built-up. Likewise, the opposite holds true with the lower the Z-score, represented with blue color the less clustered are the built-up for the area.

5. CONCLUSIONS AND RECOMMENDATION

5.1. CONCLUSION

Urban sprawl analysis revealed built-up area rapidly increased in Lagatafo Lagadadhi town. Spatial distribution of built-up area demonstrated fast grown, disoriented, low efficiency and scattered spatial distribution characteristics, which clearly suggests typical urban sprawl tendency. Uncontrolled urbanization resulted degradation of bare land and agricultural areas. It can be concluded from the LULC change analyses result that, the built-up area is developed as an expense of the bare land more than the agricultural area in Legetafo Legedadi town. This can be practically observed that, in the study area the land selected earlier for the construction of real estate buildings which are left for a long time without construction are considered as a bare-land on the satellite images. As a result of 2018 Ethiopian government political change, the town Administration decided to let these abandoned areas for the government workers for the construction of residential home and currently these areas are converted to the built-up areas.

.Newly developed built-up area expanded in multi direction from the core cities. Infill expansion of built-up area from inner city was observed during the study period.

Shannon‘s entropy value was increased when it is far from the town center, this suggest built-up area were much dispersed in. Intensity of urban sprawl was determined with relation to entropy value. The entropy values clearly shows, urban sprawl increased spatially when it was far from the origin, due to conversion of other LULC to built-up area, and dispersed settlement development. The entropy values increased from 2000 to 2010 in all Zones and then decreased from 2010 to 2022. This value shows initially the urban growth was not compact, whereas after 2010 the growth was relatively compact due to infill type of development, where the bare land and agriculture were converted in to urban built-up.

Urban sprawl analysis in different radius from core cities, showed within radius of 3 km from zero point gradually increased; this is due to densification of built-up area within existing open spaces between settlement areas. There was homogenized distribution of settlement area within this proximity. Within the proximity of 3 to 6 km there was higher development of urban sprawl. Mostly suburbs were abruptly converted to residential clusters within this proximity. Built-up areas continuously developed around existing settlement areas, as a result small patches of built-up area merged into larger patches and in homogenized direction. Outside the buffer of 6 km new settlement areas were developed, which were more haphazard and dispersed. Mostly infill and extension form of urban sprawl were observed within Lagatafo Lagadadhi town.

5.2. RECOMMENDATION

Study was conducted based on medium resolution Landsat image, due to 30 meters spatial resolution image classification was greatly affected. In some case multiple land use land cover class were prevalent in single pixels. Not all the features could be aggregated in the LULC maps. This research concentrated on urban expansion in two dimensional spaces. This study analyzed expansion of built-up areas in inwards and outwards direction. It is essential to understand the vertical expansion of built-up area for properly determining urban sprawl and its associated problems and risk. But, lack of building data /cadastral map and mono satellite image, three dimensional change analyses was not possible during this research.

This research was based on geographic prospective of land use land cover change. Aspects of population growth and population change were not incorporated to relate the growth of built-up area. Urban sprawl was analyzed based on methodological approach derived from literature review and expert consultation. Urban Sprawl analysis without social, economic, environmental, development trends, land value and standard of living of population cannot give actual result for decision makers and planners.

On the basis of this research following future prospects and recommendation can be made:

- From the research, urbanization of Lgatafo-Lagadadi town is expected to rise, causing severe impact on socio economic and environmental aspects. It is high time for planner and policy makers to develop urbanization not only in horizontal dimension but in vertical dimension as well. Furthermore, implementation of building bylaws and land use plans is highly recommended.
- Urban sprawl development should be integrated with environmental factors, socio-economic prospective, land values for development of proper plans and bi laws for city planning and development.

- In future research, researchers could incorporate factors such as land value, education, quality of life, and economic activities to better understand causes and consequences of urban sprawl.

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