

Landscape Pattern and Dynamics in Greater Kuru Urban Area of Nasarawa State, Nigeria, using GIS and Remote Sensing Technology

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Abstract

Population development, speedy growth of events and natural processes set changes landuse/landcover (LULC). The effects of these transformations on natural resources and environment all around the world attract researchers globally. The LULC changes impacts on buildup Area. Open space, bare surface, Agricultural Land, water, Vegetation, Shrubs, Plantation In this investigation, Remote Sensing (RS) and Geographical Information System (GIS) technology were utilized rather than traditional methods. A Supervised classification (Maximum likelihood) algorithm was applied on three Landsat TM images of 1991, 2002, and 2017 of Greater Karu Urban Area of Nasarawa State Nigeria. Change Analysis technique in Idrisi in Terrset was adopted to analyze the changes that have taking place over the years (1991, 2002, and 2017) According to the IPCC, Africa is one of the most vulnerable continents to climate change so climate drivers are likely to exacerbate this situation. In spite of this knowledge, Africa is the least covered by climate change research; these studies incorporated the effect of urbanization and its impact on the ecosystem looking at how urbanization impact on the global climate system

Keywords: Urban Growth, Land use, land cover, Climate change, Remote sensing and GIS

Introduction

A rise in the worldwide human population has been a significant focus for policymakers, planners, and scholars for an extended period.

The United Nations reports that (United Nations, 2017), the world's population numbered nearly 7.6 billion as of mid-2017 implying an addition of approximately one billion inhabitants over the last twelve years.

According to the results of the 2017 Revision, the world's population numbered nearly 7.6 billion as of mid-2017, implying that the world has added approximately one billion inhabitants over the last twelve years. Sixty per cent of the world's people live in Asia (4.5 billion), 17 per cent in Africa (1.3 billion), 10 per cent in Europe (742 million), 9 per cent in Latin America and the Caribbean (646 million), and the remaining 6 per cent in Northern America (361 million) and Oceania (41 million). China (1.4 billion) and India (1.3 billion) remain the two most populous countries of the world, comprising 19 and 18 per cent of the global total, respectively(United Nations - Department of Economic and Social Affairs -Population Division, 2017) .

By the year 2050, it is estimated that populations will hit 300 million in six of the ten most populous countries: China, India, Indonesia, Nigeria, Pakistan, and the United States. (Dicker et al., 2018) It is predicted that by 2050 the proportion of global urban population will exceed 84 per cent. This pattern would be markedly different between developed regions and less developed ones (United Nations, 2014).

Studies have further confirmed that a minimal fraction of the Earth's landscape remains untouched. Human activities have profoundly changed the land surface. This transformation impacts land use, subsequently influencing the

natural environment, leading to noticeable changes in land use and land cover over time and across different areas. In order to understand how LU/LC change affects and interacts with the processes of the global Earth system, it is essential to use data on what has changed, how the change occurs, how quickly it occurs, and the role of social and anthropogenic forces that drive it. LU/LC changes have become a key component of modern techniques for managing ecological resources and tracking environmental change. (Soydan, Duzgun, & Ozdemir, 2015).

The LU/LC Pattern is also a result of natural processes combined with socioeconomic elements and how humans have used them over time and space. Due to demand from agriculture and population growth, land availability has been declining. In order to choose, develop, and integrate land use strategies to satisfy the expanding needs of humanity, information on land use and land cover is therefore essential. The major socioeconomic driver of both local and global environmental changes is the spatial shift of land use and land cover.. (Giri & Shrestha, 2000)

Keeping an eye on land use dynamics is essential to comprehending the causes of land cover conversion and population demand rises. LU/LC exchange has shown to be an important component of modern methods for monitoring environmental changes and managing natural resources. (T. Liu & Yang, 2015)

Professionals now need to see the world from orbit in order to understand human activity on the surface and how it has affected the planet's resource base over time. Seeing the planet from space gives vital information about human activities on the earth's surface because of the continuous and unrecorded rate of land use change. Satellite data from remote sensing has become increasingly important throughout time for observing the Earth and tracking environmental changes.. (Hegazy & Kaloop, 2015)

The development of remote sensing and Geographic Information Systems (GIS) has greatly benefited environmental systems, climate change, and earth observation. Synoptic analyses of changes in the Earth's surface, its characteristics, and its nature

over time at both global and local scales can be conducted with ease thanks to remotely sensed data that comes in series. These facts also provide a crucial link for ecological studies, biodiversity conservation, and management. (Welde & Gebremariam, 2017)

The most fashionable and easy change detection technique detected in urban sprawl is the post classification contrast method (Al-Awadhi, Ramadan, & Charabi, 2017). For instance, in the United States of America, Ji, Ma, Twibell, & Underhill, (2006) used multistage Landsat satellite information to screen the urban growth within the Kansas City metropolitan location. Knowledge of LU/LC will certainly contribute to the ongoing and rising challenges of our global earth system, such as land degradation (Mallick, Al-Wadi, Rahman, & Ahmed, 2014), agricultural disuse, deforestation, air and water pollution, soil carbon emission(Al-Bilbisi, 2019)

In order to evaluate, analyze, characterize, monitor, and map city growth and expansion, urban growth analysis has recently placed greater reliance on remote sensing as a useful data source. With positive outcomes, it has been used to identify and monitor city growth and decline on a variety of scales. (Al-Bilbisi, 2019). urban growth analysis has thus rely on remote as an important source of data, primarily because of its accuracy, consistency and most of all spatial and temporal nature (Furberg, Ban, & Nascetti, 2019). The significance of remote sensing data lies in its synoptic perspective, repetitive coverage, and real-time data acquisition. Using satellite images makes it possible to distinguish between classes and track changes in land use and cover while still preserving spatial infrastructure, which is crucial for monitoring urban growth. (C. P. Giri, 2016).

This study aim to analyze Remote Sensing data from 1991, 2002, and 2017 and to identify the, types, and trends of land cover change in Greater Karu urban Area of Nasarawa.

Urbanization in Africa is centered in the growth of its megacities, and to a larger extends its smaller towns. (Holly Reed, 2018).

The world population living in urban areas rose from about 30% in 1950 to 54% in 2015 and is said to rise to 66% by 2050 (UNDESA, 2018).

When the seat of government was moved from Lagos to Abuja in 1991, the population suddenly skyrocketed within the Federal Capital Territory with a population of 371, 6747. However, in 2006, it was increased to 1.4 million, which represent an average annual growth rate of 9.3 percent for that 15-year period. (National Population Commission, 2009) Specifically, in 1991, the population of Karu was approximately 10, 0009, which increased at an astounding growth rate of 22.7 percent annually, which took it to 216,230 by 2006 (N.P.C, 2006). This growth was driven fundamentally by the inability of Abuja to fully absorb the migrant who went to search for employment (UN-HABITAT, 2015). Consequently, lack of affordable accommodation for average income earners, massive influx of people to settle in Greater Karu Urban Area (Yari et al, 2002; Vilo, 2012; Rikko and Laka, 2013) primarily due to its proximity to FCT and low land prices has resulted in massive population growth.

The introduction of satellite data of high-resolution (0.6–2.5m; QuickBird, IKONOS, SPOT,) and medium resolution (15–30m; ASTER, IRS, SPOT, and Land sat) have provided additional details for urban area analysis (Guindon, Zhang, & Dillabaugh, 2004; Megahed, Cabral, Silva, & Caetano, 2015; Thapa & Murayama, 2012). New opportunity to analyze urban structures was made possible with the availability of high-resolution images, in both spatially and thematic form. A number of LULC studies have investigated the use of high-resolution data in urban studies (Lefebvre, Sannier, & Corpetti, 2016). However, because of the higher level of data capacity, the expense of acquisition, and the limited availability of data, the majority of these research are still constrained. (Fonji & Taff, 2014). Research on urban studies most often deployed medium resolution satellite images in urban applications (Bajwa et al., 2015). Landsat imagery remains the satellite of choice for land-use/cover mapping particularly in urban studies and in other applications. (Schneider, 2012) (Bagan & Yamagata, 2014), (T. Liu & Yang, 2015) Landsat is capable of providing

regularly updated, and high-quality, data on land environments. This satellite images have been regularly available since 1972 and have led to historical changes and the characterization of the urban areas from local to global levels (Sleeter et al., 2013).

The historical viewpoint of an urban development must be incorporated into the current study setting in order to analyze it. As a result, remotely sensed time-series data can be used to evaluate the temporal and dynamic nature of urban processes or characteristics that can help understand natural processes in urban settings. (Huang et al., 2015).

This paper fills these knowledge gaps by addressing the following questions:

- (i) Which land use is most vulnerable to conversion due to future urban expansion?
- (ii) What is the magnitude of loss, of other land use, due to future urban expansion?
- (iii) What are the impacts of urbanization on ecosystems and the services they provide?

Study Area and data set

Greater Karu Urban Area is a Planning Area established in 2001 by the Nasarawa State Government as a development corridor to the FCT due to its proximity. The area lies between latitudes 8° 5"N and 9° 25"E and longitudes 7° 54"E and 10° 42"N east of the Greenwich Meridian. Located within the administrative area of Karu Local Government Area, it shares common boundaries with Old Nyanya and Old Karu in FCT, Abuja to the South west, Keffi Local Government Area of Nasarawa State to the south, and Jaba Local Government Area of Kaduna state to the north, (see, figures 1 and 2). It occupies an area of about 800sqkm (KAPDA Report, 2001). It covers approximately 20 kilometres from north to south and approximately 40 kilometers from the FCT boundary in Old Nyanya to Angwan Zakara along Abuja-Keffi high way. The major urban settlements in the planning area comprise of Mararaba, New Karu, New Nyanya, Masaka and Uke, while the rural areas that have also been overtaken by new urban development and engulfed by the larger ones include: Koroduma, One Man Village, Ado, Ado Kasa, Zhenwu, Luvu, Gurku, Kuchikau and Auta ba Laifi (Kodepe) among others and has an elevation of 850m and the lowest 250 meters (figure 1and 2).

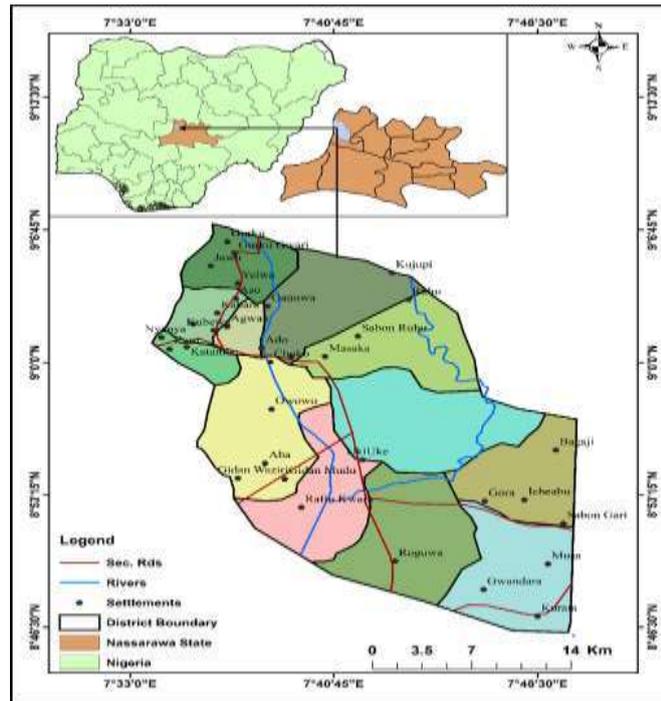


Figure: 1. Location of study Area

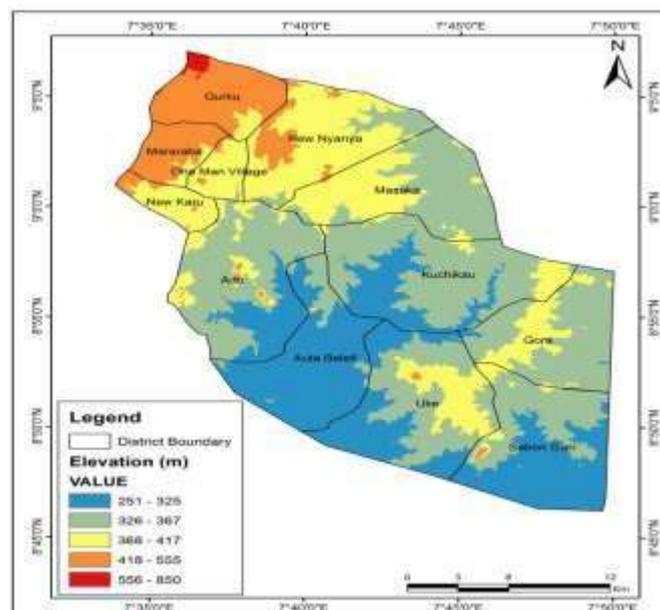


Figure: 2. Digital elevation model map of Greater Karu urban Area

Data set

Landsat images have been extensively and the most deployed satellite remote sensing data and their temporal resolution, spectral, and spatial characteristics made them useful input for planning, executing and mapping remote sensing projects (Mishra, Rai, & Mohan, 2014) Landsat TM 1991, Landsat ETM 2002, and

Landsat 8 (OLI/TIRS) 2017 were chosen for this research (Table 1). These images were obtained freely from the United States Geological Survey (USGS) portal. According to the meta data information made available by USGS Earth Resources Observation and Science (EROS) Center, data acquired had gone through processing

at the Level 1T Product Generation System (LPGS), which provides systematic, radiometric and geometric accuracy by including ground control points; and every single one of the bands are free of any striping. Moreover, the images are projected to WGS_1984_UTM_Zone_31N Coordinate System.

During field work data were collected, of significance is the high-resolution imageries which were obtained from the National Centre for Remote Sensing Jos Plateau State Nigeria (NCRS JOS) some of the

imageries are QuickBird, of 5m meter spatial resolution acquired in March 14, 2019. Moreover, Google Earth was also utilized for preliminary interpretation and familiarize with the historical imageries of the study area. This is possible with the help of the time slider icon in Google Earth, while moving it between the acquisition dates of various images in the KML file of the Greater Karu Urban Area. These ancillary data was employed during sample collection for image classification and accuracy assessment.

Methodology

Data pre-processing The images deployed for this research are level-1 Terrain corrected (L1 T) which implies that geometric and radiometric corrections have already been carried out at the source (Freitas, Silva, Almeida, & Silva, 2018) as the analysis involve images of different time periods, there is need to geometrically correct or co-registered to each other for differences between satellite calibrations and environmentally introduced radiometric effects

$$L = \left(\frac{L_{max} - L_{min}}{255} \right) DN + L_{min} \quad (\text{Equation 1})$$

Where L is the radiance expressed in $W m^{-2} sr^{-1}$

$$\rho_{\lambda} = \left(\frac{\pi L_{\lambda} d^2}{E_{Sun} \lambda \cos \theta} \right) \quad (\text{Equation 2})$$

Whereas in this study the technique were carried out using inbuilt function of Terrset software. The COST model (Cosine of the Sun Zenith Angle) which is an improved version of Dark Object Subtraction (DOS) algorithm developed by Chavez (1991) was deployed for the atmospheric correction. Other image pre-processing operations such as contrast, stretching and digital filtering (3x3) were also undertaking.

Anderson classification system level I (Table 2) was employed for developing the land cover classification (Yim & Hardwicke, 2018) which gave birth to eight land cover classes (Build-up area, vegetation, Agricultural land, water body, Shrubs, Open space, Bare-surface and Plantation) was adopted in this research. Built-

(Marujo, Fonseca, Körting, & Bendini, 2020). To correct for possible haze, noise, and other impurities that might likely affects the quality of a satellite image (Q. Liu, Gao, He, & Lu, 2017). Image digital number were thus converted to At Sensor Radiance and then to Top Atmospheric reflectance (TOA). These operations are traditionally carried out using Equation (1) and (2) respectively (Eastman, 2015)

Where;

ρ = Reflectance

λ = spectral band

L = radiance

d = Earth-Sun distance

E_{sun} = the solar atmospheric irradiance and

θ = Solar zenith angle in degree

up land category is characterized by exhaustive land use where human activities have altered the landscape the landscape. Furthermore, vegetation was categorized as land use for food production and some activities associated with this production. In addition to the agricultural land, vegetation. Though the system was originally developed for the USA, it is the most commonly used land cover system across the world (Yuan et al., 2005).

Prior to classification, spectral and spatial profiles were utilized to analyze the satellite data and determine the digital numbers (DNs) of various land use and land cover change categories. After evaluating the class statistics,

statistical, and histogram parameters, training samples were selected from the reference information and supplementary data. They were then refined, renamed, merged, and removed. If every class has a Gaussian distribution, a supervised maximum likelihood classification (MLC) technique has been shown to get the best results from remotely sensed data. (Bolstad & Lillesand, 1991), was subsequently applied to every image. Lastly, the MLC was run with original bands and the texture image as inputs, producing three final land cover maps of 1991, 2002, and 2017 were compared. (Eastman, 2015).

Post-classification The method used in this study is change detection; the photos from 1991, 2002, and 2017 were categorized independently. Nonetheless, the categorization criteria created for the individual photos were

identical, as were the samples gathered. Since there should be less inconsistency, the post-classification accuracy level remains constant, similar to that of the classified photos.

Accuracy assessment

According to Congalton (1991), classification accuracy generally refers to the degree of correlation between the remotely sensed data and reference information. A total of 300 stratified random pixels were created for the years 1991, 2002, and 2017 in order to evaluate the accuracy of land cover maps that were taken from Landsat data.

Land-use Class	1991			2002			2017	
	Accuracy	Kappa index		Accuracy	Kappa Index	Accuracy	Kappa index	
Build up Area	88.6		0.8382	95.0	100.0	96.0	90.6	
Open Space	93.6		0.8303	92.5	92.5	88.0	89.1	
Agricultural Land	100.0		0.8058	97.5	90.7	92.0	90.2	
Vegetation	73.9		0.8518	96.7	100.0	92.0	97.8	
Water	100.0		0.8012	90.0	90.0	94.0	94.0	
Bare Surface	88.0		0.8412	91.0	92.0	92.0	92.0	
Shrup	73.6		0.8413	90.0	91.0	90.0	91.0	
Overall Accuracy	90.7			95.0		92.4		
Kappa Coefficient	87.7			93.5		90.5		

Table 1. Satellite images with their acquisition dates and resolution.

Date	Sensor	Path/Row
25 August	Landsat- TM (1991)	142/51
9 May	Landsat-7ETM+(2002)	142/51
4 July	Landsat 8 (OLITIRS) (2017)	142/51

Table 2. Land use and land cover (LULC) nomenclatur

S/N	Land cover class	Description
1	Buildup Area	Roads, airports, and build-up areas,
2	Open Space	bare lands, rock-strewn, and other soil surfaces that remain devoid of vegetation throughout the year
3	Agriculture	Agricultural Land and green areas
4	Vegetation	such as deciduous forest, mixed forest lands, palms, conifer, scrub and others
5	Water	River, permanent open water, lagoons, lakes, ponds and reservoirs
6	Bare Surface	Dry land, non-irrigated land and real estate plots
7	Shrub	Mix of trees (<5 m tall) and other natural covers
8	Plantation	cherry almond Walnut, orchards and social forestry such as poplar, willow, and other deciduous trees

Source: Anderson et al., 1976.

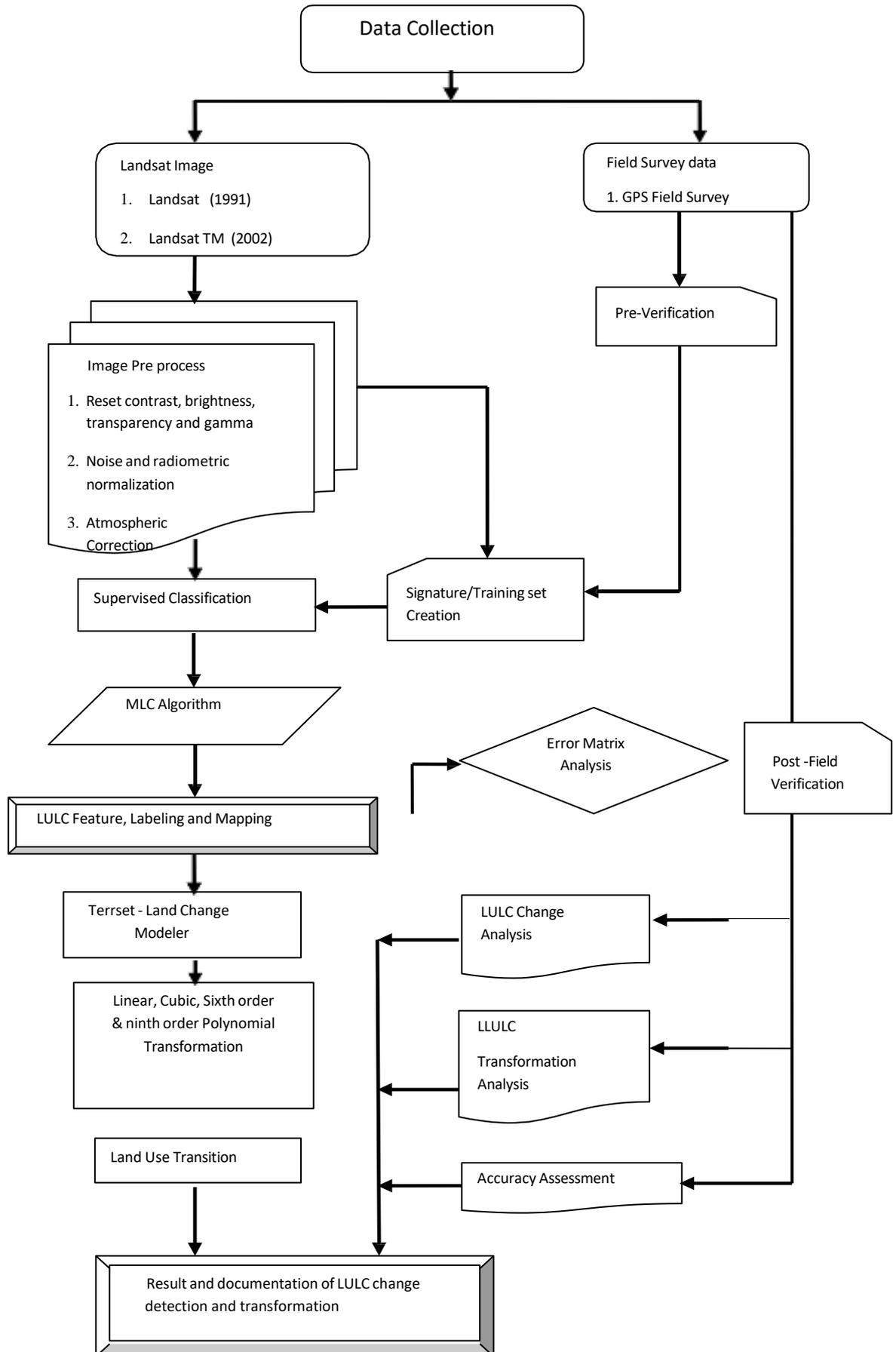


Fig: 3 Research Flow-chart**Change detection**

The change detection method, which has been effectively implemented by researchers in urban environments, employed the post-classification technique, which has shown effective in identifying the rate, location, and nature of changes. (Butt, Shabbir, Ahmad, & Aziz, 2015). A GIS overlay procedure was used to determine the LULC spatial changes for the three years 1991, 2002, and 2017. The application of this technique resulted in a two-way cross-matrix that illustrated the main categories of change within the field of study. The willpower of the magnitude of conversions from a particular land cover class to other land use types and their equivalent area throughout the period assessed was made easier by cross tabulation analysis on a pixel-by-pixel basis. For each land use, a new theme layer with different combinations of "from-to" transition classes was subsequently developed.

LULC Change Quantification and analysis

In order to properly quantify changes in land use and land cover In order to show the spatial pattern and composition of land cover in a dynamic symbol, geospatial technologies

Spatial Trend of Land use land cover

A polynomial trend of three orders was used to ascertain the Greater Karu Urban Area's spreading trend. The cubic spatial trend of change result was reached by using the third order, which is the most appropriate polynomial order for linear functions. According to Eastman (2015), this interpolation result is adequate; using the lowest-order function yields a suitable result. A linear function chosen to best fit the interpolated trend result with the input image is called a third order polynomial function. The degree of the polynomial surface (in this case, 3 for a cubic polynomial) and the absence of the data frame with no data (the background) are the parameters for the trend surface modeling function..

were used to quantify land use and land cover from remote sensing data in both space and time. The focus of urban change detection has recently shifted from detection to measurement of change, pattern dimension, and analysis of the urban expansion and sprawl process. (Bhatta, 2010).

LULC analysis with Land Change Modeler

By streamlining and improving the supports required for planning and policymaking, the implementation of Land Change Modeler in LULC analysis has reduced the number of people who do not understand how land use systems work. Under a variety of scenarios, these models may forecast how the land cover will likely change and be used in the future. (IDRISI focus paper, 2009). Land Change Modeler of IDRISI *Andes* is used out of so many models. Land Change Modeler (LCM), is a suite of tool for land cover change analysis, it is a tool design for mapping changes in urban land cover changes. Change Analysis with LCM has a set of tools, for the quick measurement of change, allowing one to evaluations gains and losses, net change, persistence and specific transitions both in map, statistical and graphical form (Eastman, 2015).

Results**Analysis of change detection**

In 1991, which is the base year, the land use land cover distribution shows that Build-up area had 3283.56 hectares (4.72%) while Open space had 10930.32 hectares (15.71%) followed by agricultural land which had 15389.82 hectares (22.12) Vegetation had 3955.14 hectares (5.69%) water had 1256.85 hectares (1.81%), bare surface had 4780.8 hectares (6.87%) Shrubs had 29970.45 hectares (43.08%) and Plantation had 0. The result demonstrated the dominance of Agricultural land and shrub. This circumstance might be because of the way that a large portion of the city's populace was occupied with farming as a way of living this implies that the area is a fertile for agricultural

production. Subsequently, build-up area and open space shows that more land was been

cleared for building construction and agricultural activities. (Figure 4 & 5)

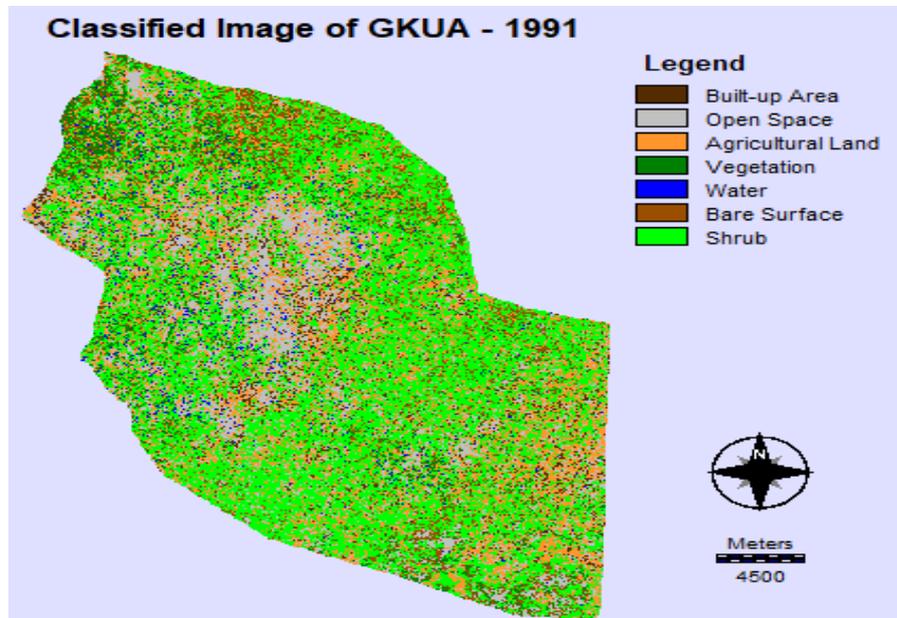


Figure: 4 Land use Land cover map 1991

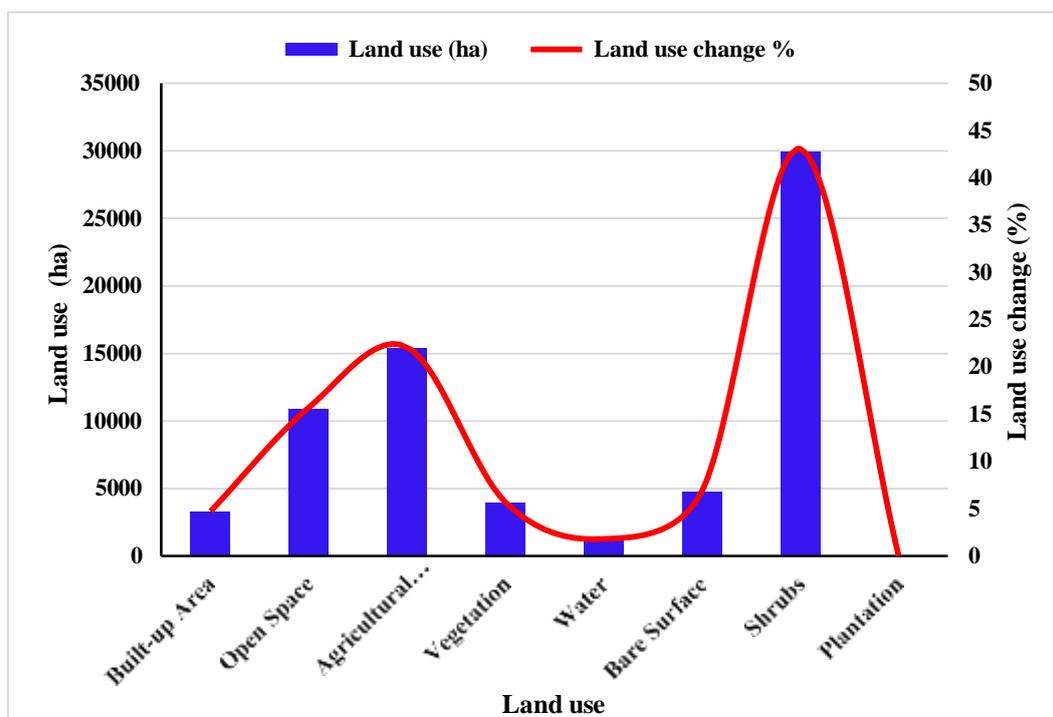


Figure: 5 Land Use and Land Cover Distribution (ha) (1991)

Figure 6 and 7 indicated that, between 1991 and 2002 the distributional pattern of change shows that there is conspicuous increase in

Build-up area, Agricultural land, and Water, the Build-up area increased by 1657.26 hectares, Agricultural land increased by 16838.37 hectares, while Water increased by 1579.68 hectares. Conversely, Open space decreased by -7184.34 hectares, Vegetation

decreased by -621 hectares, Bare Surface decreased by -3447.36 hectares, and Shrubs decreased by -8822.61 hectares respectively This is an indication that more land is been cleared for agricultural purpose as more people migrate to the city.

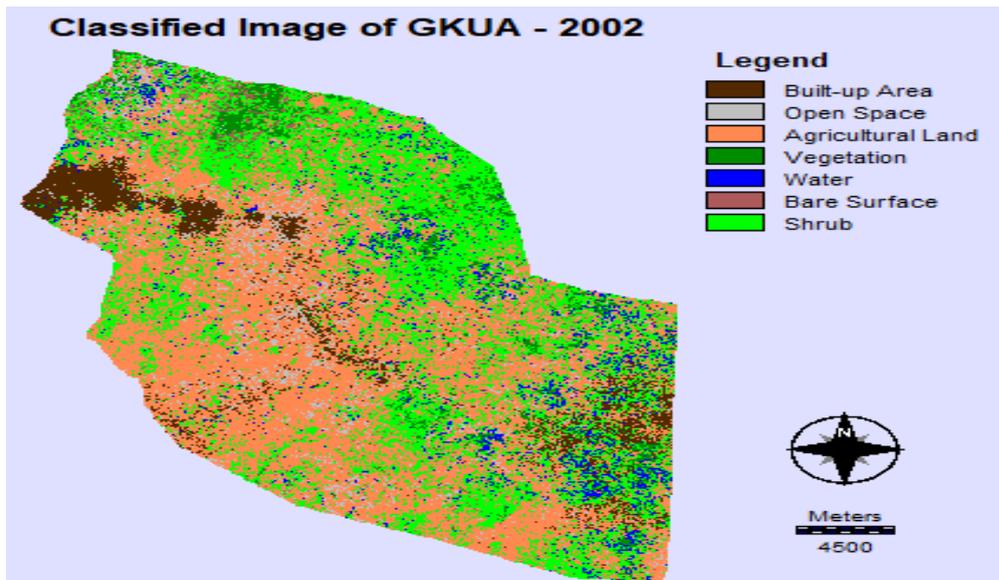


Figure: 6 Land use Land cover map 2002

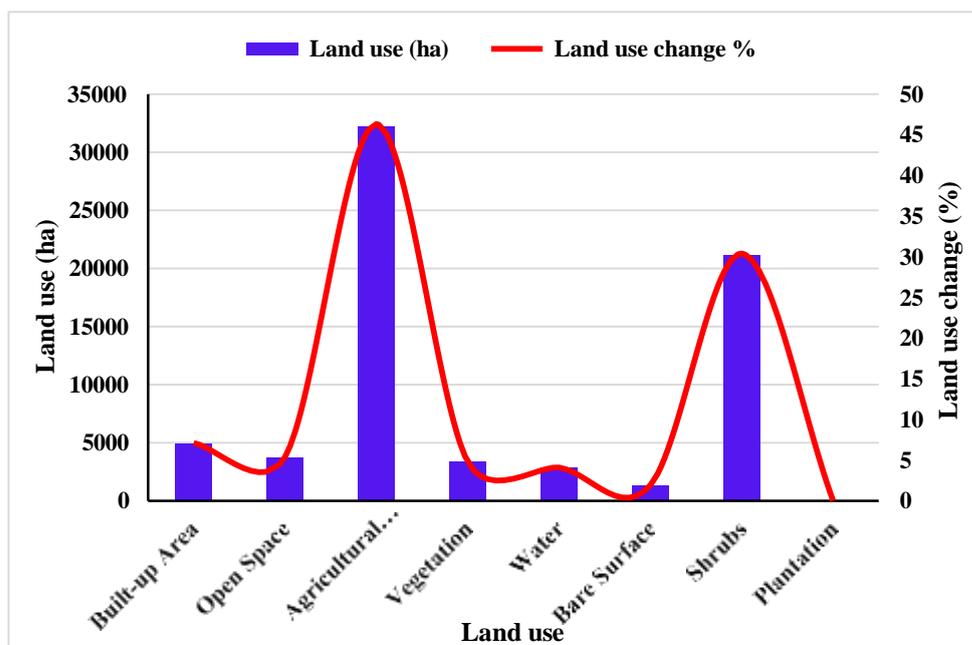


Figure: 7 Land Use and Land Cover Distribution (ha) (2002)

The build-up area is mostly located in the southwest of the city and is growing towards the southeast, as seen in Figures 8 and 9. The build-up area has increased by 3221.82 hectares from 4940.82 hectares in 2002 to 8162.64 hectares in 2017 (Figure 9). This change may be related to the shifting economic foundation, which means that more individuals are building homes as they move into the city. In 2017, 39088.26

hectares were used for agriculture, up to 32228.19 hectares in 2002. In addition to showing that there is an underutilization of productive land that can be used for agricultural production with low to moderate capital investment, this shows that the city's expanding population is relying on commercial agriculture as a source of income.

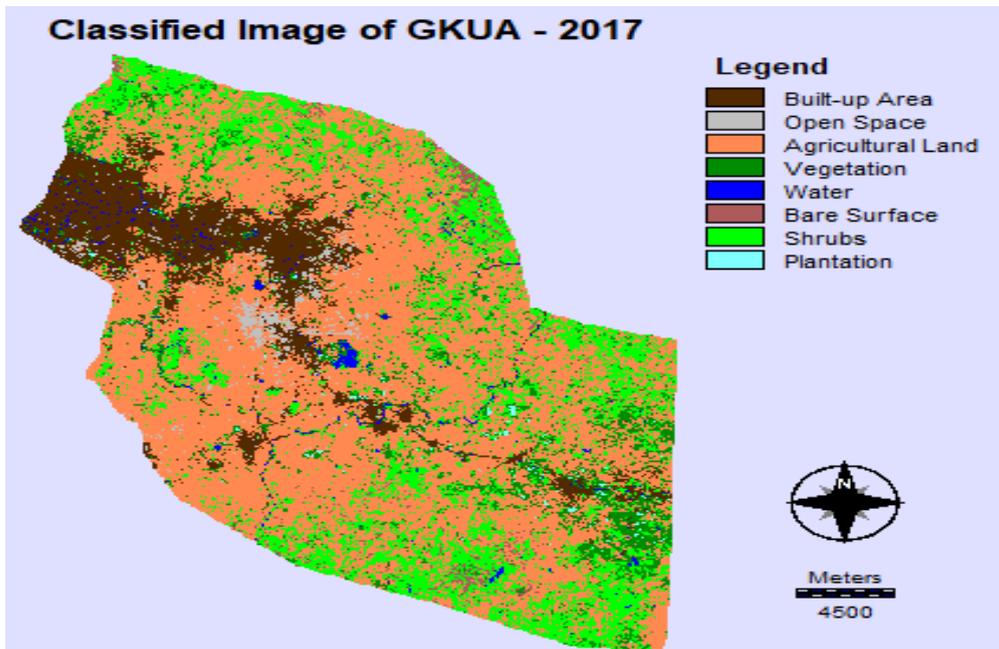


Figure 8: Land use Land cover map 2017

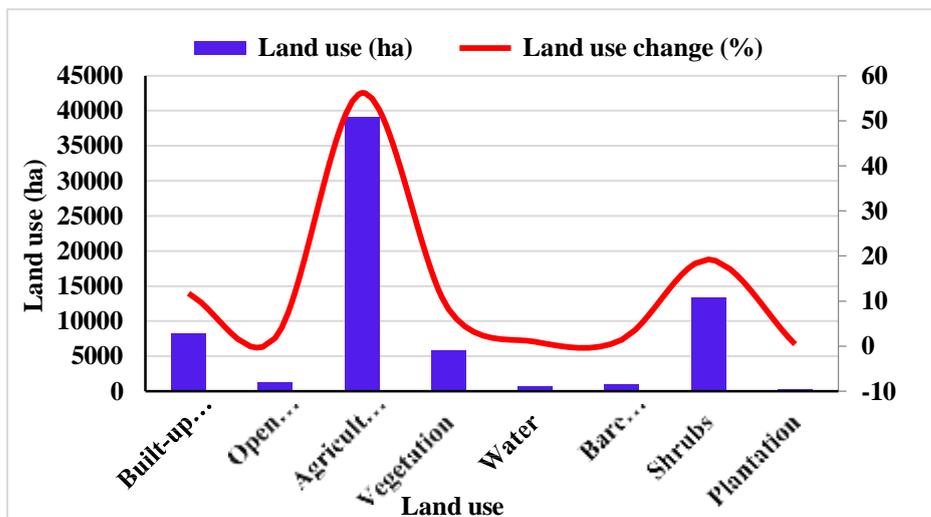


Figure 9 Land Use and Land Cover Distribution (ha) (2017)

Land use land cover change analysis (1991-2002)

Classified LU/LC maps from the two years were utilized to analyze the change detection analysis in Terrset software in order to evaluate the LU/LC alternate from 1991 to 2002. The consequences of land use changes are shown in Figures 10 and 11, which indicate the locations of all land transformations. A change that reduces a certain type of land use to another type has been referred to as a loss, as seen in both tables and figures, while any change that enhances a specific land use category from distinct classes has been referred to as a gain. The change between the various LU/LC between the two distinct time periods is depicted in Figure 6.. The end result suggests that there had been considerable transformation in all LU/LC classes between 1991 and 2002 with the exception of water for which little transformation was recorded. The major transformation was recorded in Build-up Area, Agricultural land, and water, which had 4940.82 hectares, 32228.19 hectares, and 2836.53 respectively. Figure 11 indicates positive aspects and losses in the transformation from 1991 to 2002. Both shrubs, open space, vegetation, and bare surface diminished, Shrubs had -8822.61

hectares, Open space, -7184.34 hectares, vegetation -621 hectares, and bare surface - 3447.36 hectares throughout the 11 year.

The development of impermeable surfaces will raise the land surface temperature, which affects the microclimate. This rise in built-up area occurred in areas of shrub, vegetation, bare surface, and open space. (Bowler et al. 2010) green infrastructure (trees, forest, parks and green roofs) have a elevated height of thermal comfort than urban spaces and the Urban Heat Island reduction effects of Urban Green Space is unswervingly linked with its vegetation cover and three shade area. Figure 10 shows the contribution of unique LU/LC classes to the net change in the built-up areas.

Determining what is obviously changing—that is, whatever LU/LC class is changing to the other—is a crucial aspect of change detection. This analysis will reveal the classes that are particularly stable throughout time, as well as the transition that is both acceptable and undesirable. It will also be a crucial instrument for examining microclimate change and deciding how best to manage the environment. The type of land modification that took place between 1991 and 2002 is depicted in Figure10.

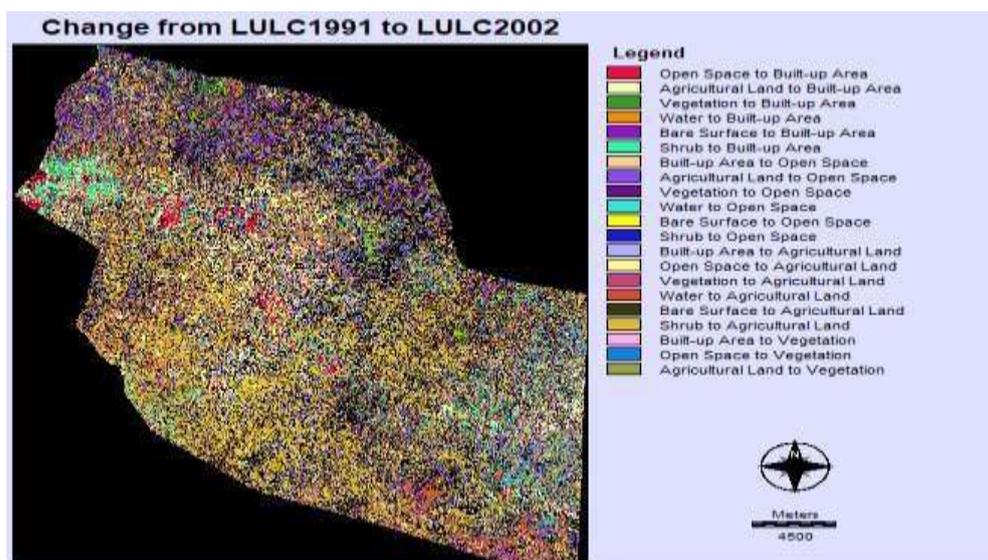


Figure10: Category of land transformation between 1991 and 2002

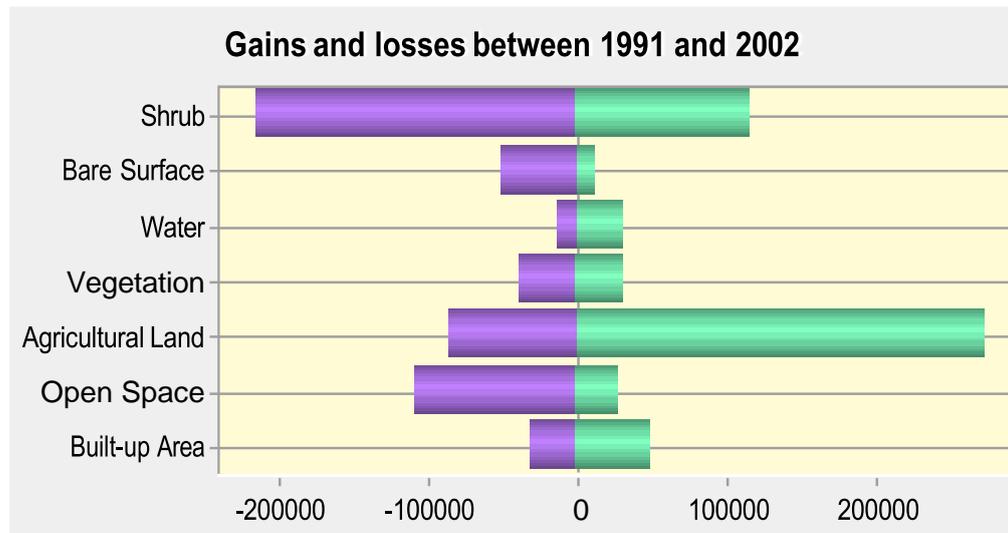


Figure 11: Gains and Losses between LULC 1991 and LULC 2002

Land use Landover changes (2002-2017)

Analysis of gain and losses

Agricultural land had the largest growth rate, followed by build-up area and water, according to the 2002 gain and loss report. Build-up area grew by 1657.26 hectares, water by 1579.68 hectares, and agricultural land by 16838.37 hectares. This trend of growth shows that as the region's population grew due to migration, more individuals bought property to construct homes and then turned to agriculture as a source of income.. (N.P.C 1991).

Conversion from Open Space to Farmland and from Farm land to Build-up area as indicated during this period can be attributed an increase in the population of people as the Greater Karu Urban Area serves as the corridor to the Federal Capital Territory. (UN. HABITAT, 2015).

Between 1991 and 2017, there was a high change in land use land cover change of the area. (Figure 13). The Build-up area increased considerably by 3221.82 hectares while Agricultural land expanded by 6860.07 hectares, this further confirms the assertion that agriculture is the main stay of the people of Greater Karu Urban Area (Macualay, 2014). However, there is a negative trend which is of a great concern in the study area which is the loss of Open Space, water body

and shrubs land to Agriculture and to Build-up Area. From 1991 to 2002 the loses are - 7184.34 hectares -3447.36 hectares, and - 8822.61 hectares respectively, (figure 12). However Vegetation showed a slide decrease in 2002 and increased subsequently in 2017, in other words there was no contribution in net change by Vegetation in 2017, this can be attributed to general growth in other plant species that have wider canopies within the span of 15years that became obvious to the satellite while orbiting the earth (Pradhan, Using, & Data, 2017)

Figures 8 show the conversion patterns between the land cover categories. Although water contributed the least to net change, it was found that shrub was the main factor (growing) in built-up areas, followed by open space, bare surface, and water. These factors include water (-575.91 hectares), bare surface (3802.86 hectares), open space (4887.42 hectares), and shrub (16587.09 hectares)..

If the trend continues, other land use such as agriculture and vegetation will eventually be taking over by Build-up area, this is line with the findings of (Aburas, Abdullah, Ramli, Ash'Aari, & Ahamad, 2018) and this could impact on self-reliance and food security. similarly, unrestrained housing expansion has resulted in subjecting the communities to a variety of natural hazards (e.g., Alam et al., 2018; Bhat et al., 2019).

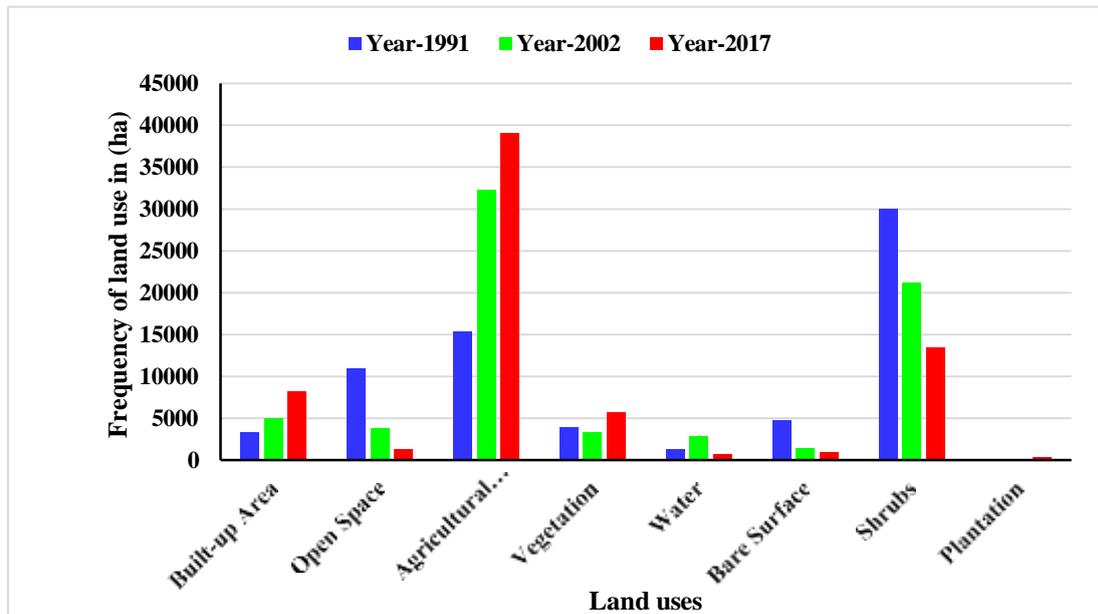


Figure 12: land uses changes from 1991-2017

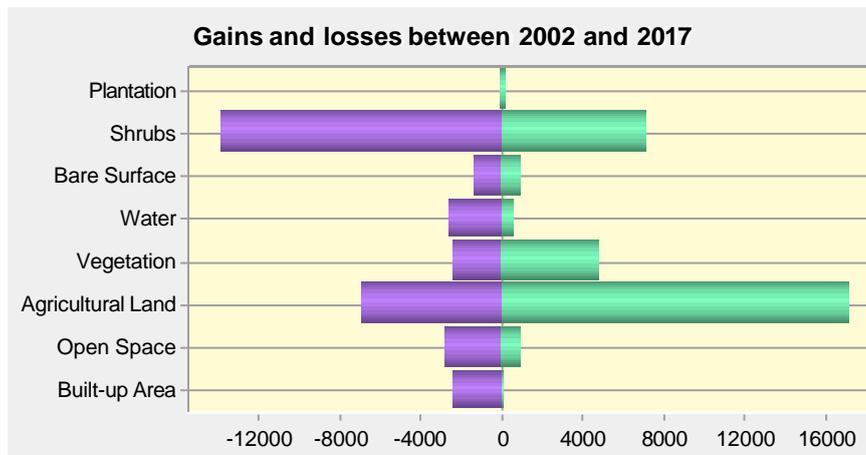


Figure 13: Gains and Losses between LULC 1991 and LULC 2002

Spatial Trend of Change

The result of the spatial trend was based on the change of open space to buildup area, Open space to Agriculture, shrubs to agriculture, and all to buildup area. The result

of Open space to build up area showed that the transformation was mainly in the western part of Greater Karu Urban Area (Figure 14).

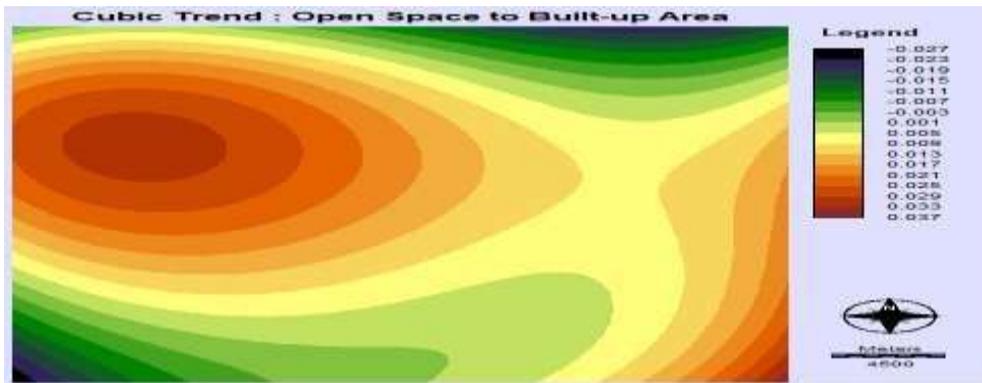


Figure 14: Trend of LULC conversion from Open space to Built-up area between 1991 and 2002

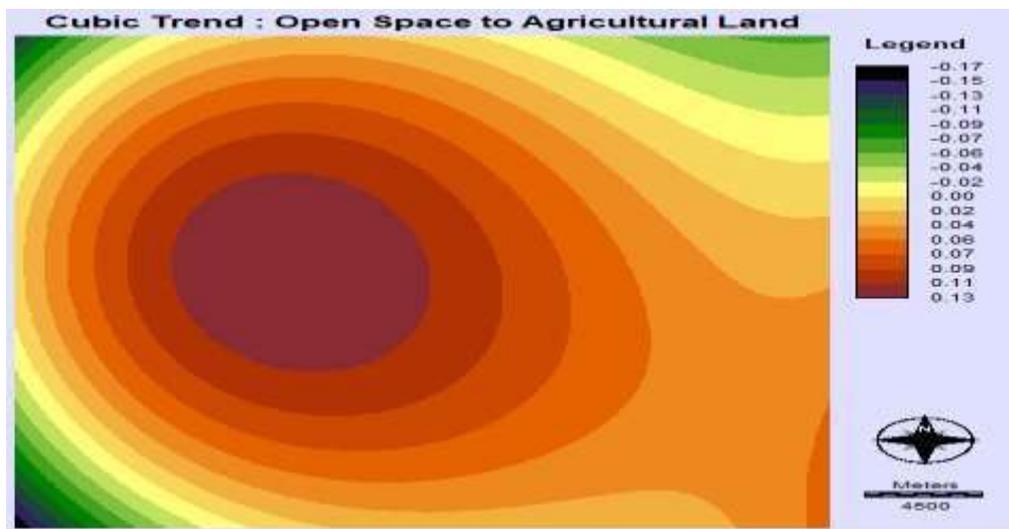


Figure 15: Trend of LULC conversion from Open space to Agricultural land between 1991 and 2002

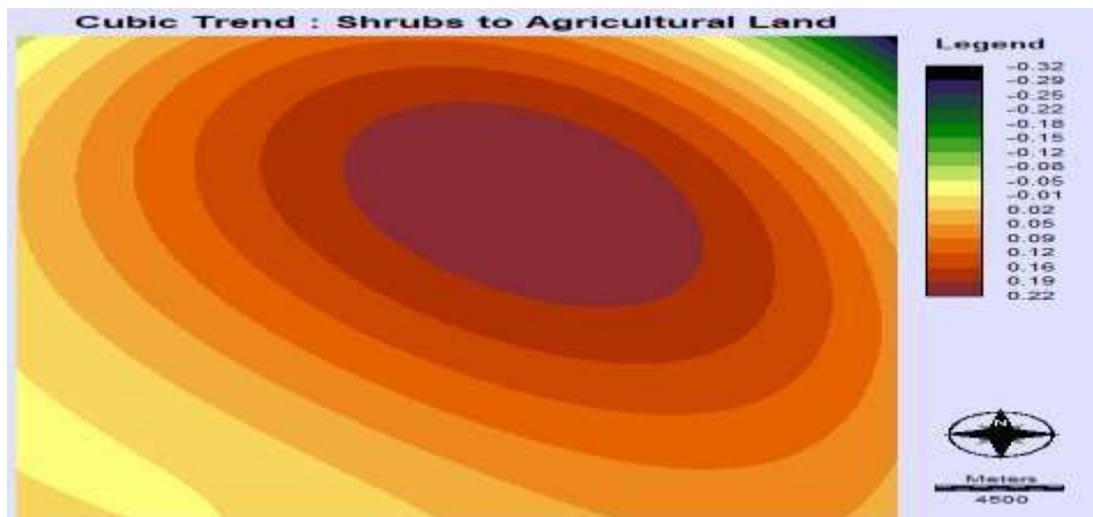


Figure 16: Trend of LULC conversion from Shrubs to Agricultural land between 2002 and 2017

Meanwhile, the transformation from open space to Agriculture could be seen to be more on the western part of the study area. (Figure

15) While the transformation from Shrubs to Agriculture was concentrated at the Northern part of the study area.(Figure 16). However, the transformation from all to buildup area is concentrated in North Eastern part of the study area (Figure 17)

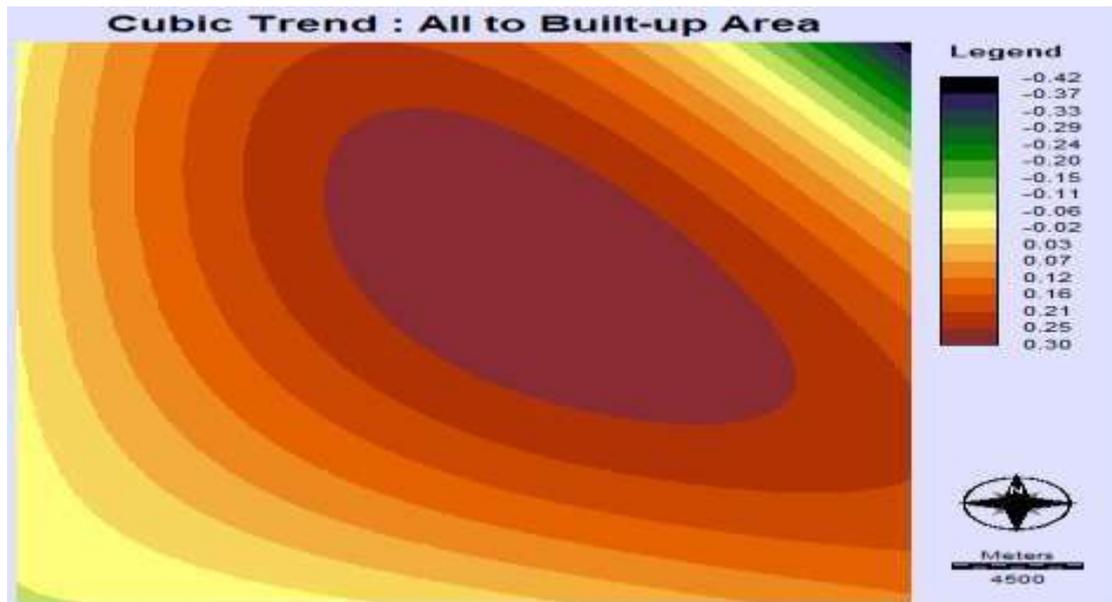


Figure 17: Trend of LULC conversion from all LULC to Built-up Area between 2002 and 2017

Implication of urbanization on the ecosystems and the services they provide.

The alteration of Earth's land surface to urban uses is one of the most irreparable human impacts on the global biosphere. It fastens the degradation of highly productive farmland, affects energy demand, alters the climate, alters hydrologic and biogeochemical cycles, fragments habitats, and reduces biodiversity (Seto, Golden, Alberti, & Turner, 2017) Future urban expansion will, pose direct threats to high-value ecosystems: the highest rates of land transformation over the next few decades will likely take place in biodiversity regions that were relatively undisturbed by urban development in 2000 (Seto et al., 2012). In cities, the nature of urban growth is also an important determinant of urban dwellers'

vulnerability to environmental stress (Güneralp & Seto, 2012).

The environmental impacts of Urban expansion are far beyond urban areas themselves. In fast urbanizing areas, agriculture intensifies on left behind undeveloped land and is likely to expand to fresh areas, putting strain on land resources(Jiang, Deng, & Seto, 2013) . Moreover, urban areas changes precipitation patterns at scales of hundreds of square kilometers (Kaufmann et al., 2007) Urban expansion will affect global climate as well. Direct loss in vegetation biomass from areas with high probability of urban expansion is predicted to contribute about 5% of total emissions from tropical deforestation and land-use change (Seto & Christensen, 2013). The scope and scale of these impacts is yet to be fully researched. Although many studies have described how urbanization affects CO2 emissions and heat budgets, effects on the

circulation of water, aerosols, and nitrogen in the climate system are only beginning to be understood (Carter, 2018).

The intergovernmental panel on climate change (2001) states that the atmosphere, embossed with the fossil fuel CO₂ signal, is nearly 100 ppmv greater than the preceding -hard stopl of 280–300 ppmv. The existing CH₄ value is further (percentage-wise) from its earlier inter- glacial high standards. In other words, carbon has been taking from a moderately stationary pool (in fossil fuel reserves) in the dawdling carbon cycle to the relatively movable pool (the atmosphere) in the rapid carbon cycle, as well as the ocean, terrestrial plants and soils are yet to equilibrate through this

-rapidly shifting concentration of carbon dioxide in the atmosphere.

The most important human actions contributing to the existing change in the universal carbon cycle are fossil fuel combustion and transformation of global vegetation during land-use (e.g., biomass burning and modification to agriculture). During the 1990s, an average of about 6 Gt C per year as CO₂ was released into the atmosphere from the smoldering of fossil fuels, and it is estimated that an average of about 0.5–1.5 Gt C per year was emitted owing to deforestation and land-use change for the duration of the same interval (IPCC 2001).

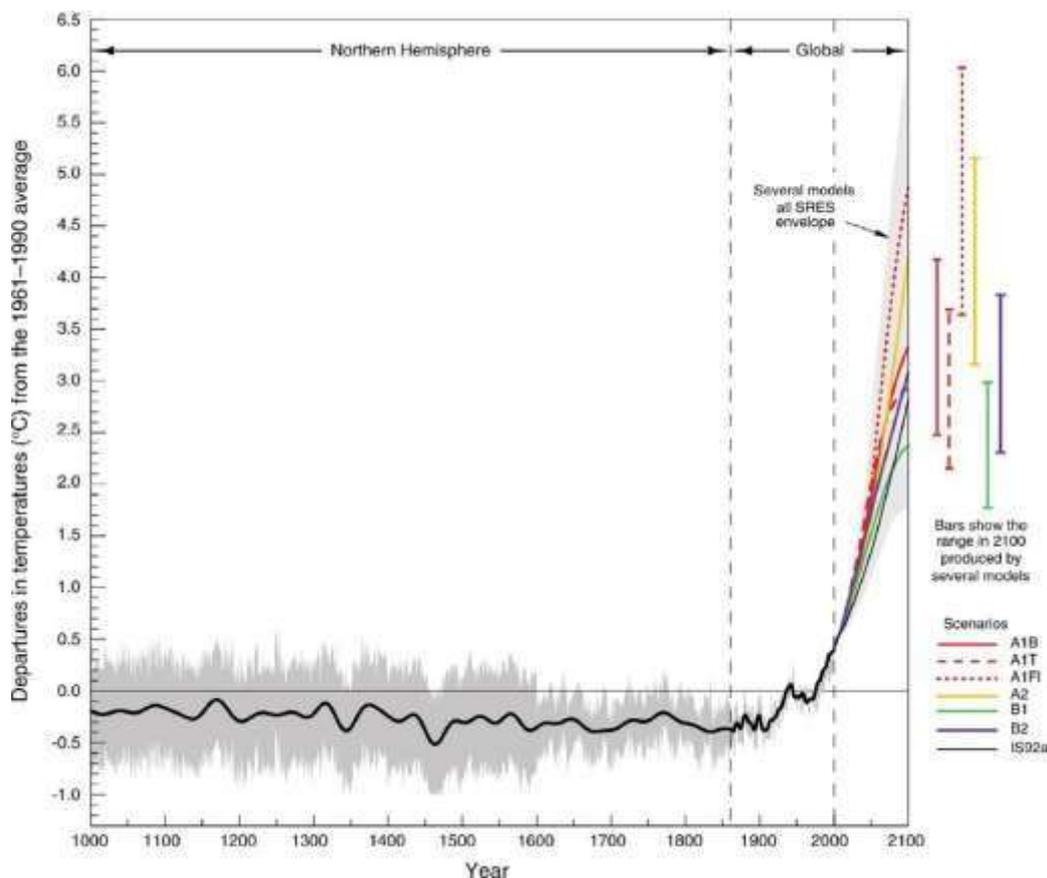


Figure 18. Models indicate that global temperature will rise by 1.4–5.8 °C over this century unless greenhouse gas emissions are greatly reduced (adapted with permission from Cubasch et al. 2001, © IPCC 2001)

The rise in the atmospheric CO₂ concentration (as well as other radioactively active trace gases) as result of human activity has generated serious anxiety regarding the heat equilibrium of the global atmosphere. Distinctively, the growing concentrations of these gases will

lead to an escalation of the Earth's natural green- house effect. (Figure 18) Changing the heat balance will compel the global

atmosphere system in ways which are not well under- stood, particular the multifaceted interactions and feedbacks involved, but there is a universal consensus that worldwide patterns of temperature and rainfall will change, however the magnitude, distribution and timing of these changes are far from certain. (Edenhofer & Seyboth, 2013)(IPCC, 2001).

There is, however, an emerging consensus that is reflected in the scientific literature that global mean surface temperature has doubled more than 0.5 °C since the commencement of the 20th century, by this warming likely being the major during any century over the past 1000 years for the Northern hemisphere a rising body of clarification of climatic and other changes in physical and ecological systems gives a combined picture of a warming world; global temperature will rise from 1.4–5.8 °C over this century unless greenhouse gas emissions are greatly reduced; and There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities. (IPCC 2001; Figure 18)

Many studies, a good number of which have been undertaken in the previous five to ten years, point obviously towards the important role that land surface and biospheric processes could play in weather with climate on local, regional with global scales. The position of the land surface ranges from entirely physical influences, for instance, the aerodynamic drag on the atmosphere or the role of soil distinctiveness(Steffen, Jäger, Carson, & Bradshaw, 2002)

This confirmation comes from a broad range of spatial scales, from tip and local measurements up to global scale multi-century modeling. From hypothetical considerations about the Earth's climate system, large-scale regional land-cover changes, particularly in the tropics, is

likely to have remote climatic effects(Richardson et al., 2009)

Hotter environment in cities will also raise demand for air conditioning. More air conditioners produce more heat and have important effects on the local-scale external climate, with implications for human comfort and the demand for cooling. At a larger scale, greater use of air conditioning results in more greenhouse gases through increased electricity generation. Significant growth in the use of air conditioning in North America, Europe and Asia has been documented and recent simulations indicate the resultant increase in energy demand will more than offset reductions in energy demand for heating under cold conditions (Lu, Vecchi, & Reichler, 2007).

Likewise, metropolitan areas are dynamic, therefore urban heat patterns modify over longer periods. Some cities expand in the course of time through a processes of very premeditated planning, others in a more *ad hoc* way. The type of urban growth also varies. For instance, in China, where urban growth is rapid due to urban populations, new structure tends to be of high buildings(Grimmond, 2007)

The highest increment in the 20-year return estimations of day by day greatest temperature (Figure 19) is found in central and southeast North America, central and south-east Asia and tropical Africa, where there is a decline in soil dampness content. Enormous temperature increments are observed over the dry surface of North Africa. Conversely, the west bank of North America is influenced by expanded rainfall there by generating moister soil and increasingly moderate increase in outrageous temperature. There are little territories of reduction in the Labrador Sea and Southern Ocean that are related with changes in sea temperature. The adjustments in the arrival estimations of every day least temperature (Figure 19) are bigger than those of day by day most extreme temperature over land territories and high latitude ocean where snow and ice retreat. To some degree extreme changes are found over land masses and the Arctic while littler increments in extreme least temperatures happen at the edges of the polar seas. Consequently, there is some asymmetry

between the adjustment in the boundaries of least and greatest temperature (with a greater increment for minima than maxima). This has to do with the adjustment in the idea of the contact among air and the surface (e.g., minima increment pointedly where ice and snow spread have withdrawn uncovering either sea or land, maxima increment more where the land surface has dried).

Conclusions

Using RS data and a geographic information system, this study evaluated LULC changes and the dynamics of urban expansion in Nasarawa State's Greater Karu Urban Area. Using the post-classification comparison technique, urban expansion was evaluated. LULC in the Greater Karu Urban Area was found to have changed quickly, especially in agricultural land and built-up regions. A significant decrease in the amount of water bodies, vegetation, and open space was the outcome of the analysis, which showed that the areas that increased were build-up area, agricultural land, and water, with 4940.82 hectares, 32228.19 hectares, and 2836.53 hectares, respectively. The expansion of the urban areas of Greater Karu Urban Area exhibited clear spatio-temporal differences. The conversion of water bodies, vegetation and low-lying areas to Agricultural land and urban areas have caused extensive and varied environmental degradation in the study area, and the vulnerability to flooding and the growth of slums have been the main negative outcomes associated with the rapid urban development.

Integrated use of GIS, RS and socio-economic data could thus be effectively used to understand the spatial and temporal dynamics of LULC changes. The interpretation and classification of RS data were useful for estimating the rate and spatial dimension of LULC change.

Furthermore, there is no doubt that urban warming has minimal direct effects on the global atmosphere. Only a small portion of the Earth's surface is made up of urban areas, and the wetness, warmth, and kinematic effects of these areas extend only a few kilometers downwind. In any case, the growth and activity of metropolitan areas result in

massive and growing greenhouse gas emissions, with anthropogenic sources accounting for the majority of these emissions. Additionally, the harsher weather in many metropolitan locations causes residents to use their resources and vitality more prominently to offset the effects. This further renders urban populations more vulnerable to heat waves and other extreme weather. In this sense, metropolitan regions and the forces behind urbanization are crucial to ecological studies on a global scale. The size and population of urban areas and populations will continue to grow. Existing urban areas will be repaired and redeveloped. The decisions made regarding how this will occur will have an impact on the people who reside in the buildings, communities, and cities. When combined, they will have global effects and consequences.

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