GIS and remote Sensing based impacts of urban sprawl on the Livelihood of Farming community in Peri-urban areas of Dessie town

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Research Article

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Abstract

The high rate of urbanization coupled with population growth and migration has brought about adjustments in land use and land cover in Ethiopia. consequently, understanding and quantifying the spatio- temporal dynamics of urban land use and land cover changes and its using elements requires lu/lc map integrated with socio economic records. consequently, the objective of this study turned into to assess the effect of urban sprawl on farming communities over the ultimate 30 years of Dessie town. This examines used remote Sensing and Geographic information system for quantifying urban land use and land cover change dynamics. Socio-economic information changed into used to analyze the influences and elements of urban sprawl on prei- urban farming communities. Three dates of Land sat image information of the 1989, 2005 and 2019 had been used to supply land cover map in general and concrete enlargement map particularly. Digitization, image differencing and post-class assessment exchange detection techniques had been employed. Similarly to this, socio-economic facts had been used in explaining the drivers of urban expansion inside the examine location. The consequences showed that over the last 30 years, built-up area increased from 1088.19ha in 1989 to 3826.5hain 2005 and 6091.12 ha inside the yr 2019.the annual rate of built-up area cover exchange among 1988 and 2005 turned into 182.52ha/yr. The socio-economic factors like population growth, rural-urban migration, and reclassification of land is the main using forces for the determined built-up area increment. consequently, with a view to reduce the problem national and regional government policies in terms of urban growth and different responsible body need to get vast interest for city making plans to reduce the charge of the ones factors. Like that of improving vertical expansion in preference to horizontal.

Introduction

Urban sprawl is a significant contributor of land use change in developing countries where urbanization rates are high, and sprawl generally denotes some type of uncoordinated development with impacts such as loss of agricultural land, open space, and ecologically sensitive habitats in and around urban areas (Sudhira et al., 2007).In both developed and developing countries, urbanization is a widespread occurrence. However, in poor countries, urban growth is associated with negative consequences. Higher natural population increase, rural to urban migration and spatial urban development are the key factors leading to Ethiopia's rapid urbanization (Fekadu, 2014).

According to Redman and Jones (2004), urban expansion is essentially the result of the interaction of three key processes. The first is rural-urban migration, which has been a major source of urban growth since cities' inception. Rural-urban migration is fueled by perceived economic prospects, rural insecurity, climate or economic concerns, and so on. The second type of rise is natural, which is a combination of increasing fertility and lower mortality rates. The rate of natural increase in urban regions is slightly lower than in rural settings. Reclassification of land from rural to urban categories is the third step: Many cities are rapidly expanding their outskirts, swallowing up previous towns and farmlands. Rural-urban migration, geographical extension of urban regions through annexation and transformation, and re-classification of

rural villages into minor urban settlements are the main drivers for increasing urbanization and city growth (Cohen, 2006).

Urbanization's nature and results have a profound impact on individuals' lives in both developed and developing countries. As a result, urban center horizontal growth may result in the loss of prime agricultural farmland and natural beauty (Minwuyelet, 2004).Unchecked urbanization is known as sprawl, and it causes major issues in infrastructure design and implementation, as well as unanticipated effects. Despite the fact that both emerging and developed countries have similar urbanization processes, the problem of urban sprawl was formerly limited to developed countries.

The main cause of urban sprawl in industrialized countries is increasing wages, which lead to people preferring to live on the outskirts of cities, where there are more open spaces and are located at a fair distance from cities. For developing countries, sprawl is generally a product of necessity: people migrate to cities in pursuit of better job opportunities, resulting in a growth in population far beyond the city's boundaries (Haregewoin, 2005).

Dessie town is one of the towns in the Amhara region, and the district's economic foundations include rain-fed agricultural and free-range animal rearing. The community's major source of income continues to be mixed agriculture. The impact of urbanization on the livelihood of nearby agricultural households has been significant. The overall goal of this research is to determine the magnitude, rate, and pattern of LU/LC change in general, as well as the influence of urban growth on the livelihood of farming communities in the prei- urban area, specifically in Dese town. The specific objectives include determining the rate of urban expansion and its spatial distribution using GIS and remote sensing for the years 1989, 2005, and 2019, determining the main cause of urban expansion, and investigating the impact of urban expansion on the livelihood of farming communities in the prei urban area.

Methods

The research was carried out in Dese town, south wollo zone, Amhara regional state, and Ethiopia's north central area. Geographically, the research area is located between 11° 5' 00” and 11° 15' 00” E longitude and 39°35' 00” and 39°400' 00”N latitude, 401 kilometers northwest of Ethiopia's capital Addis Ababa and 417 kilometers northwest of Bahir Dar, the capital of the Amhara regional state. The district's elevation ranges from 1919 to 3035 meters above sea level Fig.1).

The study employed a descriptive and cross-sectional research approach in order to meet the stated aims. GIS and remote sensing data, on the other hand, were utilized to analyze the extension of the urban area by taking into account changes in land use and land cover. Techniques of systematic and purposeful sampling were applied. Sample with a purposive for selecting town and kebeles, and systematic sampling for selecting households. The rationale for the purposive selection of the town is that most of the towns in the south wollo zone have similar urban expansion concerns, and the researcher is familiar with the area. Dessie town has 26 kebeles and is flanked by six kebeles on the outside. As a result, the town's rapid urban expansion is particularly noticeable in the peri-urban area. In this regard, the study selects three

kebeles from among those kebeles on purposively. As a result, a representative sample of these households was created using a method for determining sample size and for a finite population. According to them (Kothari,2004). The formula is as follows:

$$N = \frac{z^2.p.q.N}{e^2(N-1)+z^2.p.q} = \frac{1.96^2*0.5*0.5*11508}{0.08^{2*}(11508-1)+1.96^{2*0.5*0.5}} = \frac{3.8416*0.25*11508}{0.0064*(11507)+3.8416*0.25}$$

Where **n** denotes the required sample size of 148 and N is the entire population of 11508.

Z represents the 95 percent confidence interval, which is 1.96

e=8%.

P and **q** are estimates of the proportion of the population to be sampled.

The following sample responders from each kebele, which is calculated using the above formula as the total population of the kebele or portion/total population*total calculated sample: Gerado (kebele 015) has a value of 2870/11508*148=37, Tita (kebele 011) has a value of 4002/11508*148=51, and Borumeda (kebele 13) has a value of 4336/11508*148=60.

Total = 37 + 60 + 51 = 148

Both primary and secondary data were employed in this study to attain the desired results. Orthophoto data image acquisition date of 1989 with three bands, spot 5 data image acquisition date of 2005 with three bands, google earth image acquisition date of 2019, and SRTM (Shuttle Radar Topographic Mission) DEM data 90m resolution were the primary data used in the study.

Questionnaires, focus groups, and interviews have been constructed to analyze the causes and effects of urban expansion on the livelihood of the farming population in the prei urban region. Structured and semi-structured questionnaires were the survey instruments utilized to collect data. Secondary data sources, such as published and unpublished information, have been used to supplement the primary data findings. Ground control points for image categorization were collected using a Garmin GPS. For storing various forms of land use/land cover information, a field observation sheet was created. A total of 120 ground truth points were gathered. Images (Ortho photo 1989, spot 5 image 2005, and Google Earth image 2019) were projected to the same projection and datum, UTM projection and WGS datum, respectively. Geometric correction, radiometric correction, resolution merge, stripe removal, Study area picture sub setting, and layer stacking were all done. As a result of this, the spatial resolution of all images is increased to 3m by 3m. In addition, approaches for supervised image categorization were used. The ground truth acquired during field operations was used to create the supervised image classification training zones. In the supervised classification, maximum likelihood was chosen from among various algorithms. Land use / land cover categories were determined using image classification techniques in order to detect changes in land use and land cover in general, as well as changes in built-up area in

particular. With the help of GIS software, six Land use/Land cover classes, namely dense forest, grazing land, farm land, built up area, bare land, and water bodies, have been identified using visual interpretation and different reflectance characteristics of the features in satellite images from 1988, 2005, and 2019. To detect changes in each land use/land cover type over time in a built-up area, all existing images were categorized into five land use/land cover kinds. The use of multi-temporal data sets to discern areas of land cover change between imaging dates is known as change detection. This type of change detection approach determines how much and where change has happened. Meanwhile, four requirements of each land use land cover change detection characteristic are investigated, including detecting the changes that have occurred, defining the type of the change, measuring the change's areal extent, and assessing the change's spatial pattern. In addition, a change detection matrix was created to investigate the trends and patterns of land use/land cover change in general, as well as built-up area change in particular. Accuracy assessment was performed for the years 1989, 2005, and 2019 utilizing ERDAS 2015 and GIS 10.8 software to test and crosscheck the results of the satellite image categorization with known ground truth data. An error matrix, which is a report of the overall fraction of correctly categorized pixels, is included in the accuracy assessment evaluation.

Finally, Kappa Statistics were determined for each of the identified locations.

Results And Discussions

3.1. Land Use and Land Cover Results

The study region's land use/land cover units were divided into five categories: dense forest, grazing land, agriculture, built up area, bare land, and water bodies. Based on the years 1989, 2005, and 2019, statistics of land use/land cover change in general and built up area change in particular were computed and summarized to discover the nature of the changes.

In the first study period (1989), the dominating land use, farm land, and forest land, respectively, took up (7825.95ha) and (6831.3ha) of the total area, followed by grass land covers (2786.94ha), bare land covers (1319.14ha), built-up-area covers (1088.19)ha, and water bodies covers (49.14ha). Built-up-area and forest land cover the most land in 2019, accounting for 6091.12ha and 5724.08ha, respectively, followed by farm land 5338.8, grass land 1614.84ha, barren land 1119.09ha, and water bodies 13ha of land from the total area of the town.

3.2. Change Detection

The land use/land cover change scenario was created for the change detection analysis in order to comprehend and quantify the trend of land use/land cover change in general and built-up area change in particular for each of the three study periods. In addition, the built-up area cover change has been compiled in the form of maps and data to evaluate the precise character and extent of the built-up area cover changes in the study region between the given dates of imageries. The rate of land use/coverage is seen in (table 1). In the three studied periods, the area covered by built-up area has only showed a

maximum rate of increase. In 1989, the built-up area covered (5.5%) climbed to 19.2 percent in 2005, and then to 30.6 percent in 2019. Between 1989 and 2019, there was a temporal urban expansion. The percentage of land covered by forestland decreased from 34.33 percent in 1989 to 29.95 percent in 2005, and then remained at 28.8 percent in 2019. Garss land covered 14 percent of the area in 1989, fell to 12 percent in 2005, and finally to 8.1 percent in 2019. In 1989, farming covered 39 percent of the total area, fell to 32 percent in 2003, and finally remained at 26.8% in 2019. Similarly, there has been a steady drop in bar land and water bodies from 1989 to 2019.

The major land cover change source and destination of cover classes change conversion matrix is investigated to better understand the major land cover change. Between 1989 and 2019, a change matrix was created based on the classification of satellite pictures shown in (Tables 2). The areal distribution of land cover/ land use classes that have undergone transformation from one type to another or have lost their areal extents or stayed intact is shown in the Confusion Matrix table. For example, the built-up area increased at the expense of grass land (936.5 ha), forest land (497.52 ha), bare ground (700.84 ha), and farm land (2868.34 ha). The bolded diagonal values represent the unchanging land use / land cover that kept its initial land cover / land use unit throughout the year (Table 2).

We can deduce from this agricultural land has been shrinking, while urban land has been growing at an alarming rate. As discussed in the literature review cited by several studies such as (Basudeb Bhatta, et al. 2011), urbanization has primarily imposed tremendous pressure on existing land use, the most affected of which is agricultural lands, which are being converted to build up areas at an alarming rate.

Table 1. Rate of land covers change

LULC class	**Rate land use /land cover change**					
	1989-2005		**2005-2019**		**1989-2019**	
	Hectare	**rate of change(ha/ye)**	**Hectare**	**rate of change(ha/ye)**	**Hectare**	**rate of change(ha/ye)**
Farm Land	-1413.31	-94.22	-1073.84	-72	2487.15	-83
Grass land	-398.1	-26.54	-774	-52	-1172.1	-39.07
Forest land	-870.62	-58.04	-236.6	-15.8	-1107.22	-37
Bare land	-24.37	-1.62	-175.68	-11.8	-200.05	-6.7
Water bodes	-31.91	-2.1	- 4.5	0.3	-36.41	-1.2
Built up area	+2738.31	+182.56	+2264.62	+151	+5002.93	+166.8

Table 2. Matrix of land cover/land use changes between 1989 and 2019

Class name		LU/ LC UNIT IN 2019(ha)						
		Farm land	Built-up area	Water body	Grass land	Forest land	Bare Land	Total
LULC UNIT IN(ha)1989	Farm land	2880.2 (36.8 %)	2868.34	8.6	652.81	101.2	1314.8	7825.95
	Built-up area	0.3	1077.06 (98.9 %)	1.96	8.05	0.82	0	1088.19
	Water body	8.5	10.86	2.81 (5.7 %)	8.4	3.25	15.61	49.41
	Grass land	820.25	936.5	0	763.6 (27.4)	166.7	99.89	2786.94
	Forest land	597.05	497.52	0	68.27	4198.1 (61.5%)	116.3 (8.8%)	6831.3
	Bare Land	892.5	700.84	0	113.71	40.82	786.06 (59.6%)	1319.14
	Total	5338.8	6091.12	13	1614.84	5724.08	1119.09	19900.93

Within 30 years, from 1989 to 2019, Farmland land, grazing land, built up area, forest land, bare land, and water bodies were all classified as 2880.2, 763.6, 1077.06, 4198.1, 786.06, and 2.81, respectively. Land conversion, on the other hand, occurs when one type of land use is changed to another. For Instance, farm land to built up area was (2868.34ha), grazing to built up area (936.5ha) and forest land to built up area (497.52ha) (Table 2) (Table 2)

Table 3. Trends and Rates of built up area expansion

For the stud years, the built-up area in hectare			Rate of Change					
			Area change	(ha/yr	Area change	(ha/yr	Area change	(ha/yr
1989	2005	2019	1989-2005	1989-2005	2005-2019	2005-2019	1989-2019	1989-2019
1088.2	3826.5	6091.12	+2738.31	+182.56	+2264.62	+151	+5002.93	+166.8

3.3. Areal Extent and Rate of Expansion of Built-Up Area

Within a time series, three satellite images from 1989, 2005, and 2019 were utilized to track the amount and rate of urbanization. During the analysis stage, a digital image interpretation of built-up area expansion was performed for each year, and the total area of the built-up area in hectares and its percentage from each date of satellite interpretations were calculated and summarized. Table 3 shows a map of urban expansion and total built-up area coverage for the years 1988, 2005, and 2019. In 1989, 1888.2 ha (5.5%) of the study area was covered with built-up area, according to this finding (table 3). In the meantime, the town's built-up area was 3826.5 hectares (19.23%) in 2005 and 6091.12 ha (30.6%) in 2019. Between 1989 and 2005, the built-up area of the land expanded by 13.8 percent. While built-up area expanded by 11.38 percent from 2005 to 2019, accounting for 25.1 percent of total land area. From 1989 to 2005, the annual pace of urban expansion was +182.56ha (-3826.5 - 1088.2/15years), and from 2005 to 2019, it was +151ha (6091.12-3826.5ha/15years). Furthermore, the computed figure is +166.8ha per year (6091.12-1088.2/30) when the yearly rate of urban expansion is taken into account between 1989 and 2019.

3.4. Patterns of urban expansion

The result displays the area share of other land use land cover units as well as the amount of other land cover and land use units transformed into built-up area during three periods. Between 1988 and 2018, the pattern of various land use/ land cover units changed to build up area is depicted (figure 4).Between 1988 and 2018, 5003 hectares of alternative land cover land use units were converted to built-up areas, as illustrated in (figure 4). Specifically, 57.3 percent of farmland is converted to built-up area, with grassland, bare ground, and forest land being converted to 18.7%, 14%, and 10%, respectively.

3.5. The Socio-Economic Results

Peri-urban development that is well-planned and sustainable creates a variety of options that help to alleviate poverty. Infrastructure such as power, roads, telephone lines, new schools, and health centers are easily accessible by locals as a result of the rise of commercial and market centers (Mandere et al., 2010). As a result, urbanization has a disproportionately negative impact on impoverished people's livelihoods by reducing the natural resources available to them. The increasing conversion of land to non-agricultural uses is jeopardizing the dominating agricultural operations, which are the primary source of income for people living in peri-urban areas (Ampong et al., 2005).

However, it was discovered in a land use/land cover change analysis that urbanization is expanding at the expense of other land uses, with agricultural land being the most impacted. When compared to the situation prior to 1988, 98 percent of those polled said there had been an increase in urbanization. Agriculture is a major source of income for rural households. The physical form of the environment, as well as the economic and social characteristics of the peri-urban interface, is affected by changes in land use from rural to urban activity (DFID 1999). As a result of the town's expansion, 77 percent of the sample homes in the research region lost their own land, according to the present survey. The rise of commercial and market centers, as well as infrastructure such as power, roads, and telephone

services, as well as new schools and health centers, are all contributing to urban expansion in the studied region.

This section clarifies what respondents saw as effects of urbanization on their livelihood. The influence of urbanization on people's livelihoods was asked of all responders. As a result, the majority of respondents (36%) agreed that the primary impacts of urban expansion are loss of agricultural land, loss of grassland for cattle, loss of clean environment, and loss of shelter (Table 4). About 57 percent of respondents proposed vertical expansion as a way to restrict urban expansion when asked about remedies. Developing a new technology for tracking developer activity. According to 43 percent of respondents, this will aid in minimizing uncontrolled urban expansion and the resulting loss of agricultural areas.

Table 4. Impact urban expansion on the livelihood of the community

Impacts of urban expansion	Frequency	Percent (%)
loss of agricultural land	47	36
loss of shelter	8	10
loss of clean environment	10	26
loss of grass land	35	28
Total	108	100

Conclusion

According to the findings, between 1988 and 2018, the extent of land use and land cover change in general, as well as built-up area cover change in particular, changed dramatically. In particular, there was an increase in built-up land and a decrease in both land use and land cover units. Between 1989 and 2005, 2005 and 2019, and 1989 and 2019, respectively, the town's built-up area rose by 2738.31ha, 2264.62ha, and 5003ha. The town's urban expansion was primarily caused by increased population growth, land classification, and rural urban migration. Between 1989 and 2019, a total of 5003ha of other land use units were converted to built-up area. Furthermore, the built-up area's covering is periodically increased. In 1988, around 1088 acres of land out of the total area of the town had been developed. However, in the year 2018, this figure was raised to 6091.12ha. Anthropogenic elements have been identified as main reasons of urban expansion in the municipality, according to the socio-economic data analysis. Rural urban migration and land classification have resulted in urban expansion in town, due to the alarming rate of population rise. This situation has much more negative consequences for the rural communities in the adjacent urban areas.

As a result, agricultural and grassland resources have been depleted, resulting in a significant reduction in household income in the prior urban area. According to the literature review, financial capital refers to the

financial resource that allows people to adopt various livelihood strategies and includes income, credit, and saving facilities. According to the information gathered through household surveys, the majority of the informants lost their farmland, which provided food and income for their families. However, as a result of the rapid tow expansion, households found themselves in more difficult financial circumstances, unable to meet basic demands such as food security, the need to support their families, and the expense of social services such as child care, health care, and so on. As a result, the town municipality and the land resource conservation office must establish an efficient and strong urban management and usage strategy to limit rapid urban expansion. For monitoring the actions of urban developers, GIS and remote sensing-based urban land management and urban sprawl control technology will be implemented. Finally, municipalities and town administration offices should provide training to pre-urban area farmers prior to implementing urban expansion to raise awareness about the composition, property valuation, and legal procedure for land acquisition in accordance with land expropriation proclamation and regulations.

Declarations

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Nomenclature

There are no competing interests reported by the author’s acronyms.
AOI: Area of Interest
CSA: Central Statistical Authority
RUL Rural Urban linkage
UN United Nation
GPS Global Positioning System

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Figures

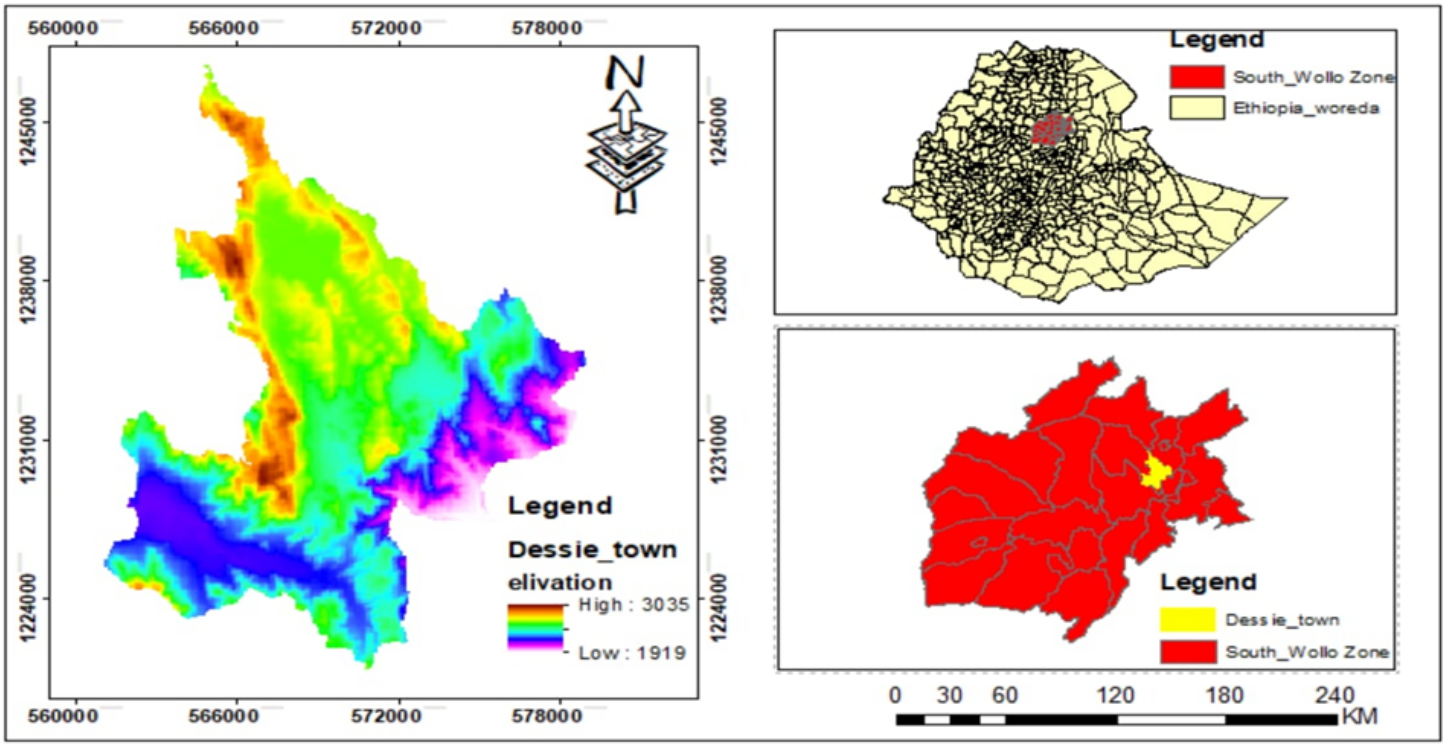

Figure 1

map of the study area

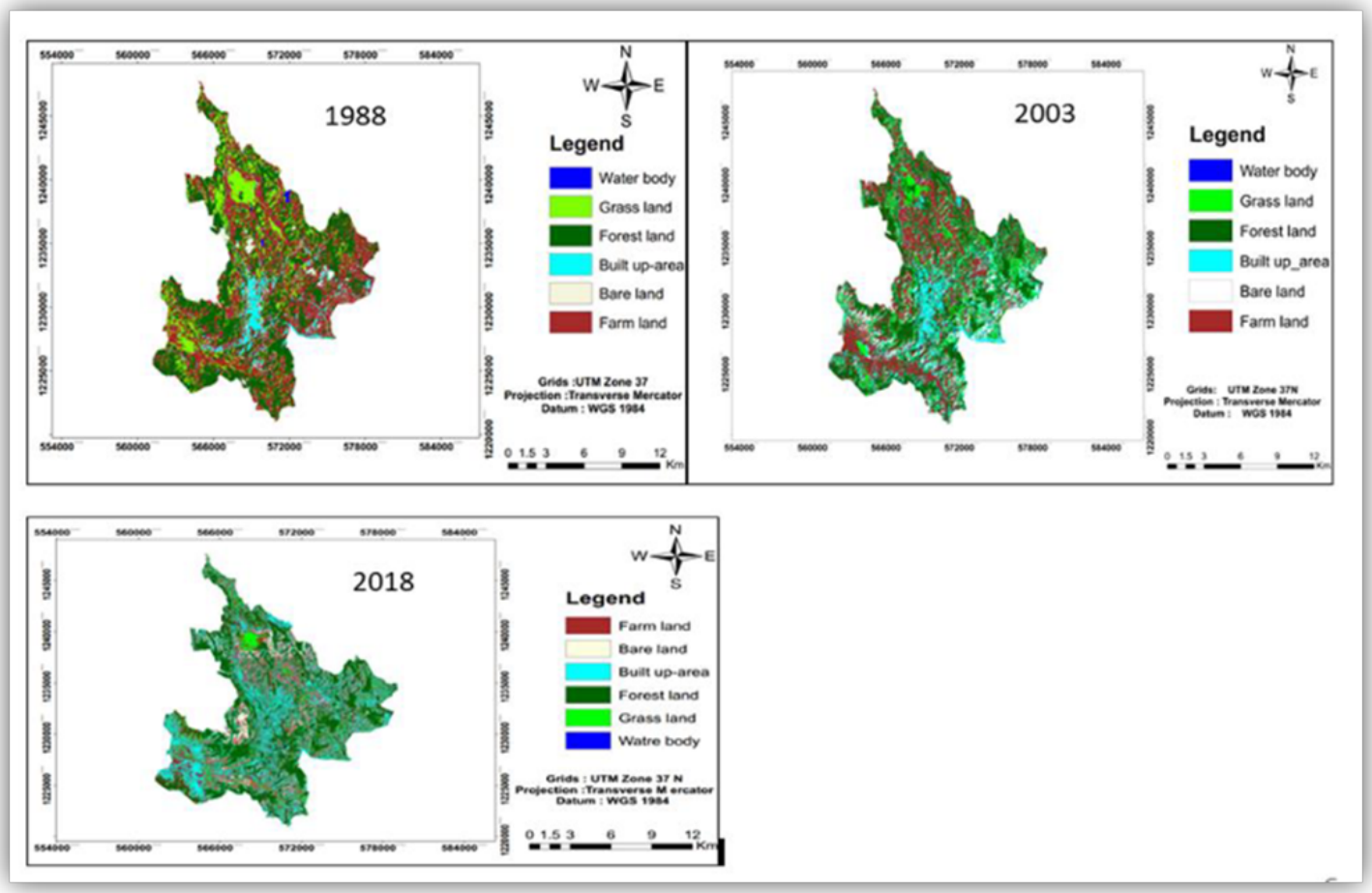

Figure 2

Land use/Land Cover map for 1989, 2005 and 2019

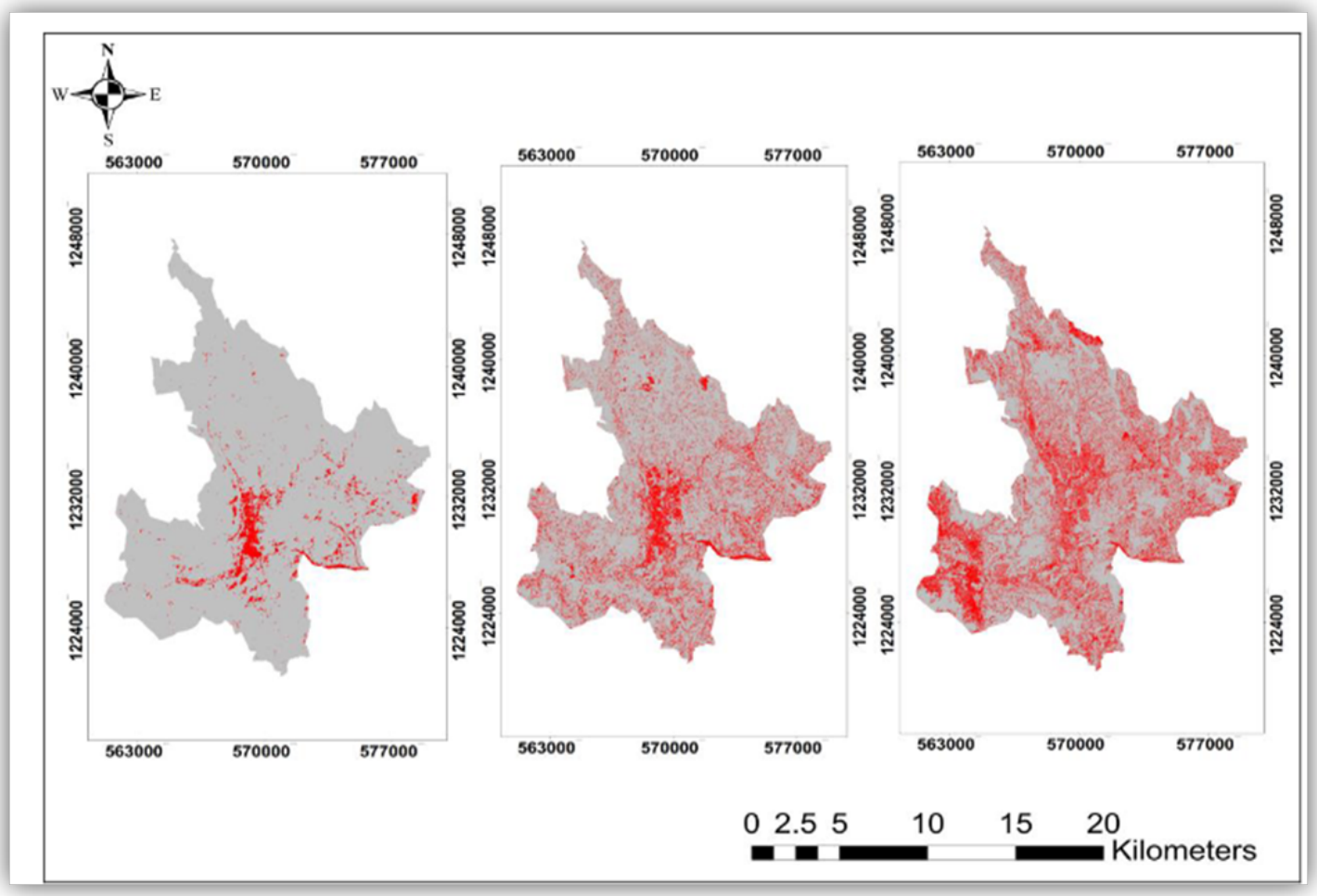

Figure 3

urban expansion maps of 1989, 2005 and 2015

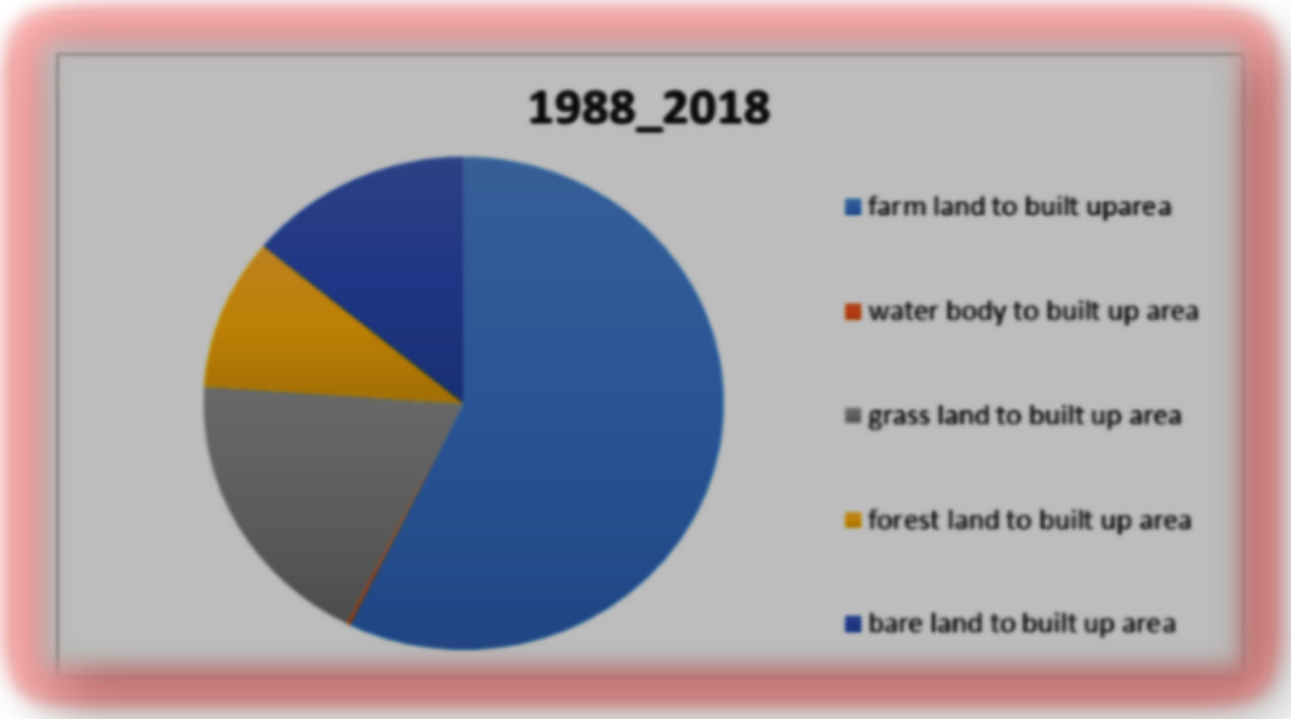

Figure 4

Built up area expansion