Impacts of Urban Expansion on the Livelihood of Farming Community in Peri-Urban Areas of Dessie Town Using GIS and Remote Sensing Techniques

Jemal Tefera[a]

a Department of Geography and Environmental Study, Bonga University

Abstract

The high rate of urbanization coupled with population growth and migration has caused changes in land use and land cover in Ethiopia. Therefore, understanding and quantifying the spatio- temporal dynamics of urban land use and land cover changes and its driving factors requires lu/lc map integrated with socio economic data. Therefore, the objective of this study was to assess the impact of urban sprawl on farming Communities over the last 30 years of Dessie town. This study used Remote Sensing and Geographic Information system for quantifying urban land use and land cover change dynamics. Socio economic data was used to analyze the impacts and factors of urban sprawl on prei urban farming communities. Three dates of Landsat image data of the 1988, 2006 and 2018 were used to produce land cover map in general and urban expansion map in particular .Digitization, image differencing and post-classification comparison change detection methods were employed. In addition to this, socioeconomic data were used in explaining the drivers of urban expansion in the study area. The results showed that during the last 30 years, built up area increased from 1088.19ha in 1988 to 3826.5hain 2003 and 6091.12 ha in the year 2018. The annual rate of built up area cover change between 1988 and 2003 was 182.52ha/year. The socioeconomic factors like population growth, rural-urban migration, and reclassification of land is the major driving forces for the observed built up area increment. Therefore, in order to reduce the problem national and regional government policies in terms of urban expansion and other responsible body should get considerable attention for urban planning to reduce the rate of those factors. Like that of improving vertical expansion rather than horizontal.

Keywords: Urban sprawl, Impacts, Livelihoods, Farming community.

1. Introduction

In developing countries, where urbanization rates are high, urban sprawl is a significant contributor of the land use change and sprawl generally infers to 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). Urban expansion is a common phenomenon in both developed and developing countries. However, in developing countries urban expansions are known with its negative effect. The major factors contributing for rapid urban expansion in Ethiopia are higher natural population growth, rural to urban migration and spatial urban development (Fekadu, 2014).

According to Redman and Jones (2004), basically urban growth is a combination of three basic Processes. First is rural-urban migration: it is a key source of urban growth since the origin of cities. Rural-Urban migration is driven from perceived economic opportunities, insecurity in rural areas, climate or economic problems, etc. Second is natural increase: this is a combination of increased fertility and decreased mortality rate. The rate of natural increase is slightly lower in urban than in rural areas .Third is re-classification of land from rural to urban categories: Many cities are rapidly growing into their fringe, engulfing former villages and farm lands and transforming them into urban development. However, the principal reasons for raising the level of urbanization and city growth are rural-urban migration, geographical expansion of urban areas through annexation and transformation and re-classification of rural village in to small urban settlements (Cohen, 2006).

Selection and peer-review under responsibility of JoHESSM 2020.
Available at: https://www.joherd.co/journals/index.php

The nature and consequences of urbanization have significant impact on the lives of the citizens both in the developed and developing countries. Therefore, the horizontal expansion of urban centers can result in the loss of prime agricultural farmlands and natural beauties (Minwuyelet, 2004). Unchecked urbanization is often referred as sprawl which poses serious problems in infrastructure planning and implementation that leads to unforeseen consequences. Although both developing countries and developed countries have common urbanization processes, formerly the problem of urban sprawl is restricted to developed countries. The reason for urban sprawl for developed countries is mainly a result of higher incomes that make people preferring to live in the outskirts of the city, with open spaces at reasonable distances from cities. For developing countries sprawl is largely a result of necessity- people move to the city in search of better employment opportunity which leads to an increase in size well beyond the limits of the city (Haregewoin, 2005).

Dessie town is, one of the towns of Amhara region, the economic bases of the people in the district are rain fed farming practices and free range livestock rearing. Mixed agriculture remains to be the main livelihood activity of the community. Urban expansion has been its own impact on the livelihood of the surrounding farm households. The general objective of this study is to examine the extent, rate and pattern of LU/LC change in general and assessing the impact of urban expansion on the livelihood of farming communities in prei urban area in particular of dese town. The Specific objectives including detecting the rate of urban expansion and their spatial distribution by using GIS and remote sensing for the years 1988, 2003 and 2018, to identify the main cause of urban expansion ,to investigate the impact of urban expansion on the livelihood of prei urban area farming communities .

2. Methods

The study was conducted in Dese town, south wollo zone , Amhara regional state and in north central part of Ethiopia. Geographically, the study area lies within 11° 5′ 00” to 11° 15′ 00” E longitude and 39°35′ 00” to 39°400′ 00”N latitude at a distance of 401km km Northwest of Addis Ababa the capital of Ethiopia and 417km from the capital of Amhara regional state , Bahir dar. The altitude of the district ranges from 1919-3035 m.a.s.l. (Fig.1).

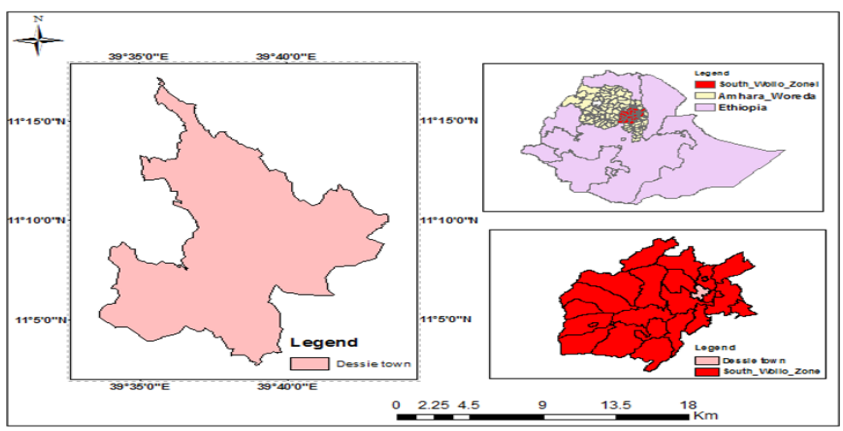

Figure 1. Location of the study area

In order to address the stated objectives the study was used descriptive and cross sectional research design. However, GIS and Remote sensing data were used to assess the expansion of urban area by considering land use land cover change. Purposive and systematic sampling techniques were used. Purposive sampling for selection of town and for selection of kebeles, systematic sampling for selection of households. The reason for the purposive selection of the town is because of most of the town in south wollo zone characterizes similar problems in urban expansion and the researcher are knowhow about the area. Dessie town has 26 Kebeles and it is surrounded by six peripheral neighboring kebeles. From this, the town rapid urban expansion is highly prevalent in the peri-urban

area part of the town. In this regard, the study purposively selects three kebeles from those kebeles. Therefore, representative sample of these households have been calculated based on formula for sample size determination and for finite population. According to (Kothari,2004). The formula is given as:

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

Where n= required sample size=148

N= total population=11508

Z= Confidence interval at 95% which is 1.96

e=8%

P= 0.5 q= 0.5

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

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

To achieve the intended objectives, both primary and secondary data have been used in this research. Primary data used in the study were: orthophoto data image acquisition date of 1988 with three bands , spot 5 data image acquisition date of 2003 having three bands, google earth image acquisition date of 20018 and SRTM (Shuttle Radar Topographic Mission) DEM data 90m resolution. In order to assess the causes and impact that brought about urban expansion on the livelihood of prei urban area farming community; questionnaires, FGD and interviews have been designed. The survey instruments used for collecting data were structured and semi-structured questionnaires. The research findings from the primary data have been supplemented by secondary data sources such as published and unpublished materials. Garmin GPS was used for collecting ground control points for image classification. Field observation sheet was prepared for storing all land use /land cover information types. Totally 120 ground truth points were collected. Images (Ortho photo 1988, spot 5 image 2003 and google earth image 2018) were projected to similar projection and datum, UTM projection and WGS datum. Geometric correction, radiometric correction, resolution merge, removal of stripes, Sub setting of Study area images and layer stacking were performed. By doing this accordingly, the spatial resolution of all images become 3m by 3m. Furthermore, supervised image classification techniques were applied. The supervised image classification training areas were established based on the ground truth taken during field work. Among different algorithms in the supervised classification maximum likelihood was utilized. Having applied the techniques of image classification methods, land use / land cover types were identified in order to detect land use land cover change in genera and built up area change in particular. With the help of visual interpretation and the different reflectance characteristics of the features in the satellite images of 1988, 2003 and 2018 six Land use/Land cover classes, namely; Dense forest, Grazing land, Farm land, built up area, Bare land and water bodies, have been identified with the support of GIS software. All the existing images were classified in to five Land use/Land cover types, to detect the changes of each land use land cover over time in to built up area. Change detection involves the use of multi-temporal data sets to differentiate areas of land cover change between dates of imaging. This kind of change detection method identifies where and how much change has occurred. In the meantime, four conditions of each land use land cover change detection characteristics such as, detecting the changes that have occurred, identifying the nature of the change, measuring the areal extent of the change, and assessing the spatial pattern of the change are explored. Besides, change detection matrix has been produced to explore the trends and patterns of land use/land cover change in general and built up area change in particular.

To validate and crosscheck the result of the satellite image classification with known ground truth data, accuracy assessment was done for the year 1988,2003 and 2018 using ERDAS 2015 and GIS 10.3 software. Accuracy assessment evaluation includes an error matrix which is a report of the overall proportion of correctly classified pixels.

Finally, Kappa Statistics was calculated for the different areas that were classified.

3. Results and Discussions

3.1. Land Use and Land Cover Results

The land use/land cover units of the study area were classified in to classes of dense forest, grazing land, farmland, built up area, bare land and water bodies. The statistics of land use /land cover change in general and built up area change in particular were computed and summarized to detect the nature of the changes based on the years 1988 ,2003 and 2018.

The dominant land use, farm land and forest land takes(7825.95ha) and (6831.3ha) of the total area in the first study period(1988) , grass land covers(2786.94ha), bare land covers (1319.14ha), built up-area covers (1088.19)ha and water bodies covers (49.14ha). The land cover classes for 2018 takes the highest share for built up-area and forest land covering 6091.12ha and 5724.08ha respectively followed by farm land 5338.8, grass land 1614.84ha,Bare land 1119.09ha, and water bodies 13ha of land from the total area of the town.

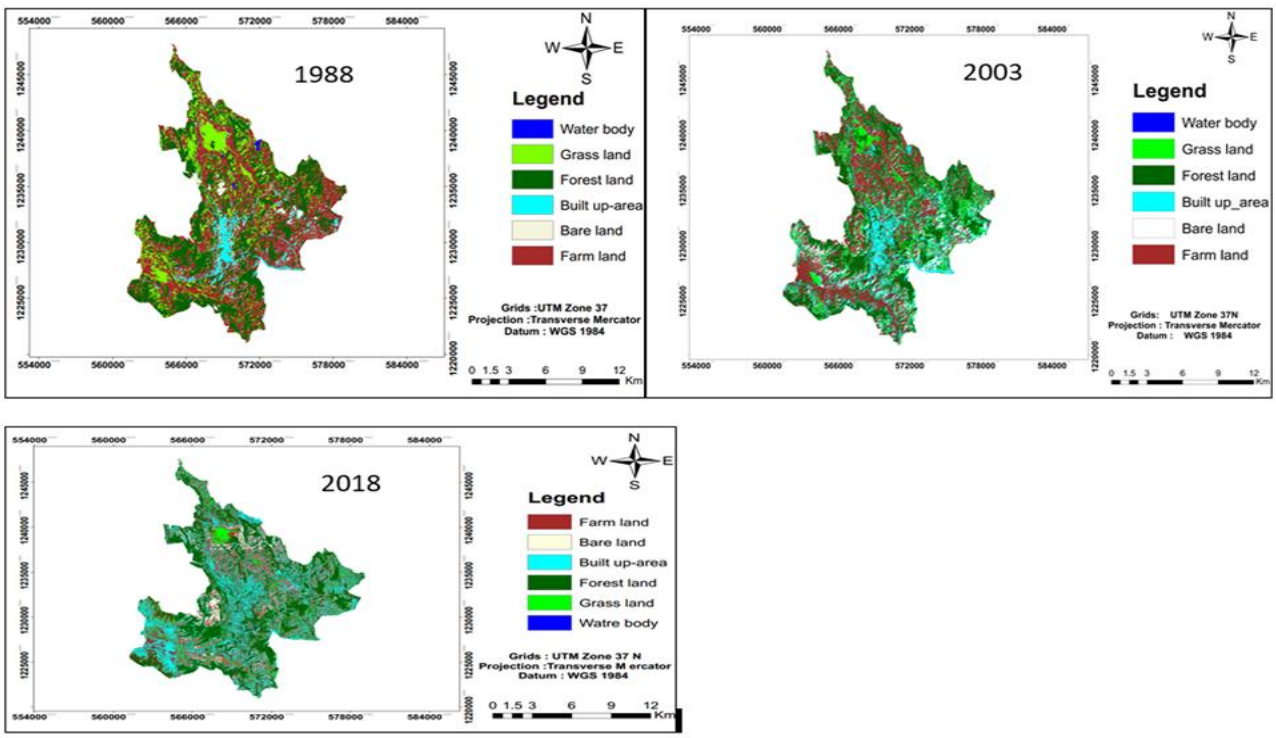

Figure 2. Land use/Land Cover map for 1988, 2003 and 2018

3.2. Change Detection

The land use/land cover change scenario was developed for the change detection analysis to understand and quantify the trend of the land use land cover change in general and built up area change in particular for each three periods of the studies. In addition, the built up area cover change in the form of maps and statistics has been assembled to examine the specific nature and extent of the built up area cover changes between the stated dates of imageries in the study area. The rate of land use/ land cover is presented in (table 1).

The area covered by built up area has the only shown a maximum rate of increment in the three consecutive study periods. Built up area covered (5.5 %) in 1988 has increased to 19.2% in the 2003 and increased to 30.6% in 2018. The temporal urban expansion is observed between 1988 and 2018.

The area under forestland declined from 34.33% in 1988 to 29.95% in 2003 and finally remained at 28.8% in 2018. The garss land covered 14% in 1988 and being declined to 12% in 2003 then to 8.1% in 2018. The farmland covered 39% in 1988and getting declined to 32% in 2003 and finally remained 26.8% in 2018. Similarly for bar land and water bodies in which it shows continuous decline from 1988 to 2018.

To clearly understand the major land cover change source and destination of cover classes change conversion matrix is analyzed. Change matrix has been produced on the basis of between 1988 and 2018, satellite images classification presented in (Tables 2). The Confusion Matrix table show that the areal distribution of land cover/ land use classes that have undergone transformation from one type to another or being lost their areal extents or remained intact. For instance, built up area expanded at the expense of grass land (936.5ha), forest land (497.52ha),bare land (700.84ha) and farm land (2868.34ha) classes. Whereas the bolded diagonal values stand for the unchanged land use / land cover that maintained its original land cover / land use unit in (Table 2).

From this we can understand that agricultural area was decreasing significantly, whereas built up area is increasing by an alarming rate. As discussed in the literature review which mentioned by different studies like (Basudeb Bhatta, et al. 2011) urbanization has mainly exerted strong pressure on existing land use and the most affected one is agricultural lands which is transformed to build up areas in a very high rate.

Table 1. Rate of land covers change

LULC class	Rate land use /land cover change					
	1988-2003		2003-2018		1988-2018	
	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 1988 and 2018

Class name		LU/ LC UNIT IN 2018(ha)						
		Farm land	Built-up area	Water body	Grass land	Forest land	Bare Land	Total
LULC UNIT IN(ha)1988	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 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

From 1988 to 2018 within 30 years. 2880.2, 763.6, 1077.06, 4198.1, 786.06 and 2.81 that classified as farmland land, grazing land, built up area, forest land, bare land and water bodies respectively remained unchanged. On the other hand, the conversion of land takes place from one types of land use in to other land use types. 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 3. Trends and Rates of built up area expansion

built up area in hectare for in the stud years			Rate of Change					
			Area change	(ha) (ha/yr)	Area change	(ha) (ha/yr)	Area change	(ha) (ha/yr)
1988	2003	2018	1988-2003	1988-2003	2002-2018	2003-2018	1988-2018	1988-2018
1088.2	3826.5	6091.12	+2738.31	+182.56	+2264.62	+151	+5002.93	+166.8

3.3. Areal Extent and Rate of built up area expansion

Three satellite images of 1988, 2003 and 2018 were used to monitor the areal extent and rate of urban expansion within time series. Throughout the analysis stage, digital image interpretation of built up area expansion for each year was performed and total area of the built up area in hectare and its percentage from each date of satellite interpretations were calculated and summarized. Urban expansion map and total built up area coverage of 1988, 2003 and 2018 is presented in Table 3. From this result (table, 3) about 1888.2 ha (5.5%) of the study area was covered with built up area in the year 1988. Meanwhile, the built up area of the town was accounted for 3826.5ha (19.23%) and 6091.12 ha (30.6%) in the year 2003 and 2018 respectively. From 1988 up to 2002 13.8% of built up area were increased from total area of the land .whereas from year (2003-2018) about 11.38% of built up area were increased from the total area of land and currently 25.1% of the area covered by built up area. The rate of urban expansion from year 1988 to 2003 is +182.56ha per year (-3826.5 - 1088.2 /15years) and from year 2003 to 2018, it was +151ha annually (6091.12-3826.5ha/ 15years). Besides, considering the annual rate of urban expansion between1988 and 2018, the computed result is +166.8ha per year (6091.12-1088.2/30).

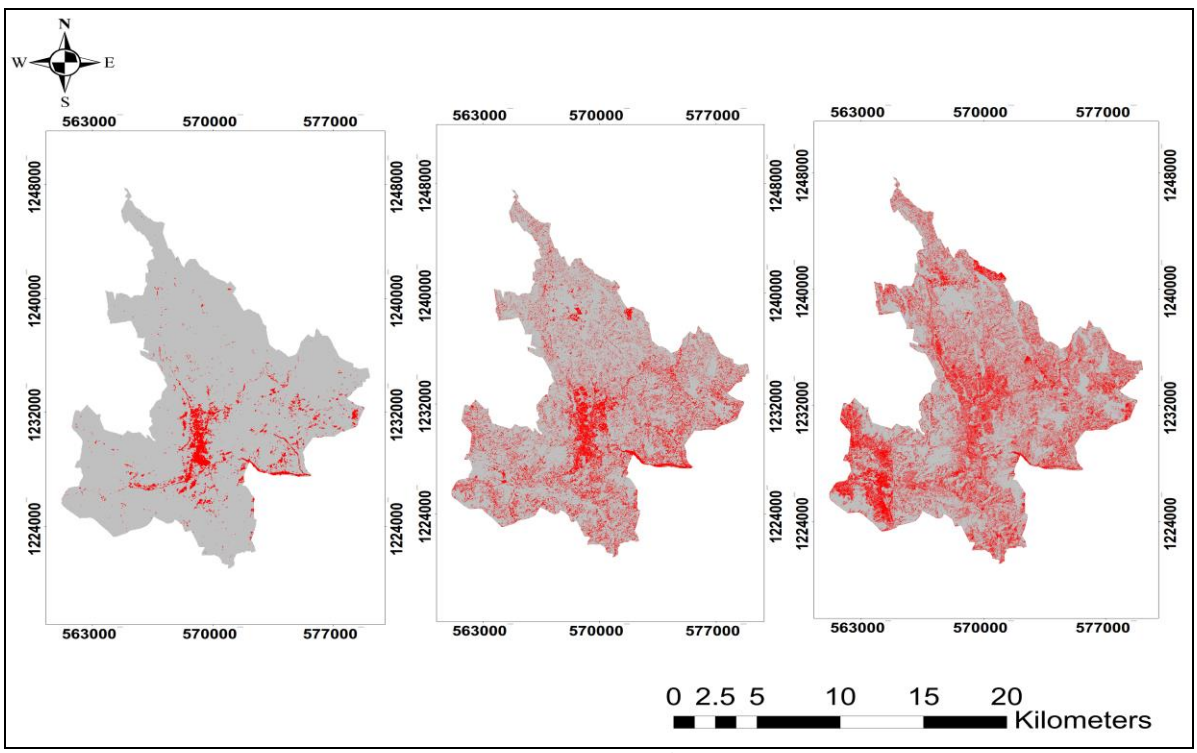

Figure. 3 urban expansion map of 1988, 2002 and 2018

3.4. Patterns of urban expansion

The result shows the areal share of other land use land cover units and also gives information about the amount of other land cover and land use units that was converted into built up area in three periods. The pattern of other land use/ land cover units converted in to build up area between in the year 1988 and 2018 is presented in (figure 4).

As shown in (figure 4), 5003ha of other land cover land use units changed into built up area between1988 and 2018. Specifically, 57.3% of farmland is changed into built up area followed by grass land , bare land and forest land transformed in to (18.7%) , (14%) and (10%) respectively .

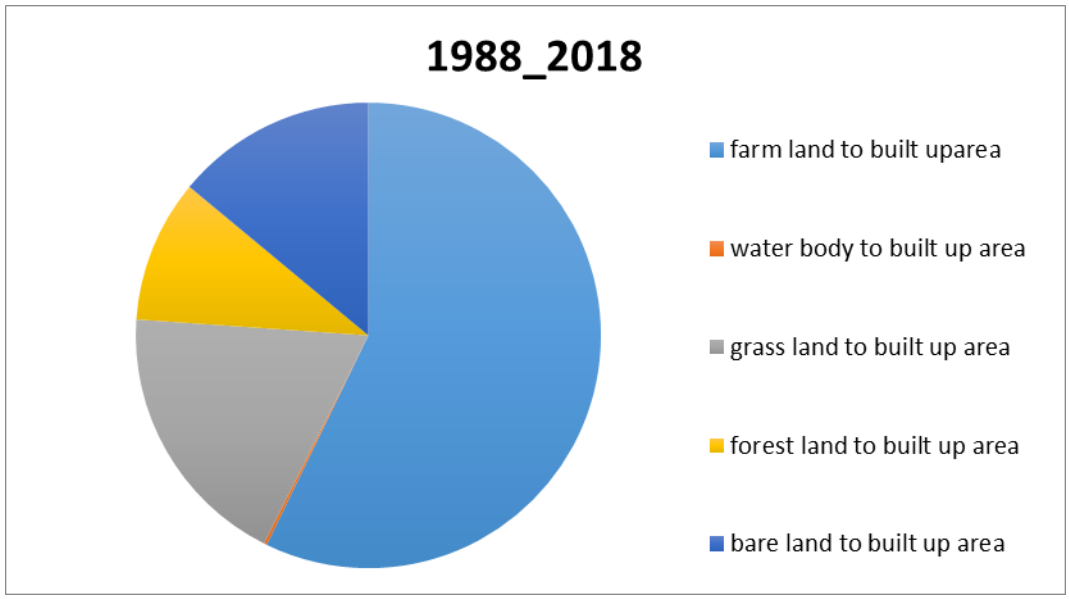

Figure 4. Built up area expansion

3.5. The Socio-Economic Results

Planned and sustainable peri-urban development comes up with various opportunities, which enhance to reduce poverty. Due to expansion of the business and market centers, infrastructure such as electricity, roads, telephone services, new schools and health centers are easily access by local people (Mandere et al., 2010). Hence, urbanization disproportionately affects the livelihood of poor people by diminishing the natural resources available to them. The rapid conversion of land for non-agricultural purpose is threatening the dominant agricultural activities that are the main source of livelihood for people who reside in the peri-urban areas (Ampong et al., 2005).

In land use/land cover change analysis however, it was observed that urban expansion is increasing at the expense of other land use especially agricultural land is the main impacted one. Out of the total sampled 98% of the respondents reported that there was an increasing of urban expansion compared the status with before 1988. Rural households are very dependent on agricultural activities. Changes in land use from rural to urban activities affects the physical form of environment as well as economic and social features of peri-urban interface (DFID 1999). For instance, as indicated in the current survey 77% of the sample households in the study area lost their own land due to the expansion of the town.

Urban expansion in the study area is happening as a result expansion of the business and market centers, infrastructure such as electricity, roads, telephone services, new schools and health centers. This section helps to understand respondents' observed about the impacts of urban expansion on their livelihood. All the respondents were asked the impact of urban expansion on their livelihood. Accordingly, the majority of the respondents (36%) agreed with loss of agricultural land as the main impacts of urban expansion , (28 %)of respondents said loss of grass land for raising cattle , (26%) of respondents said loss of clean environment and (10%)of the respondents said loss of shelter (Table 4).

Regarding the solutions for urban expansion, about 57% of the respondents suggested vertical expansion as a solution to control urban expansion. Providing a new technology for monitoring the activities of developers. This will help in reducing unplanned urban expansion and the associated loss of agricultural lands was indicated by 43% of the respondent.

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

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

4. Conclusion

From the examined results, the extent of land use and land cover in general and built up area cover change in particular was radically changed between 1988 and 2018. Particularly, expansion of built up area land and decline of both land use land cover units were observed. In the town, built up area increased by 2738.31ha, 2264.62ha and 5003ha between 1988and 2003, 2003 and 2018, and 1988 and 2018 respectively. An increasing population growth, classification of land, rural urban migration was the main cause urban expansion in the town. Totally, 5003ha of other land use units were converted into built up area between 1988 and 2018.

In addition, the areal coverage of built up area is increased from time to time. From the total area of the town about 1088 ha of land was covered with built up area in 1988. However, this figure is increased to 6091.12ha in the year 2018.The socio-economic data analysis; anthropogenic factors were identified as major causes for urban expansion in town. To the alarming rate of population growth, rural urban migration and classification of land resulted in urban expansion in town. This conditions leads to further impacts on the livelihood of the pri urban area farming communities. Consequently, the depletion of agricultural and grassland which highly contributed to the decrement of the pri urban area household income. As indicated in the literature review, financial capital refers to the financial resource that enables to adopt different livelihood strategies and comprise income, credit and saving facilities, as the information collected through the household surveys most of the informants lost their farmland, which were providing food and generating income for their family. However, due to the rapid tow expansion, the households were affected in more serious situation economically and they could not meet some basic needs including food security, necessarily sustain their family as well as cost of social services including fees for children ,health etc . Hence, to minimize the rapid urban expansion, effective and strong urban management and utilization policy have to be implemented by town municipality and land resource conservation office. The use of GIS and remote sensing based urban land management and urban sprawl controlling technology to be introduced for monitoring the activities of urban developers. Finally, before implementing urban expansion the municipalities and town administration office should give training for the pre urban area farmers to create awareness about composition, property valuation and legal procedure of land acquisition in accordance with land expropriation proclamation and regulations.

Acknowledgements

This study would never be completed without the contribution of many people to whom we would like to express our gratitude. The administrative Kebele's, development agents, town municipality's officials, local guiders, committee leaders and respondent households in each sample kebeles were indispensable for the successful

completion of the fieldwork. We would like also to acknowledge people who contribute their knowledge and time in data collection and entry processes.

Nomenclature

Authors declared that they have no competing interest acronyms

AOI: Area of Interest
CSA: Central Statistical Authority
RUL Rural Urban linkage
UN United Nation
GPS Global Positioning System

References

Adomako, Janet Afua Abrafi. Urbanisation of the Rural Landscape: Assessing the Effects and Coping Mechanisms in Peri-Urban Kumas. Diss. 2013.

Agunbiade, Muyiwa Elijah, Abbas Rajabifard, and Rohan Bennett. "The dynamics of city growth and the impact on urban land policies in developing countries." International journal of urban sustainable development 4.2 (2012): 146-165.

Basudeb Bhatta,(2011).Remote Sensing and GIS 2ndedition textbook, from (peg 361_378)

Cohen, Barney. "Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability." Technology in society 28.1-2 (2006): 63-80.

Haregewoin, Bekele. "Urbanization and urban sprawl." Department of infrastructure Section of Building and Real Estate Economics Kungliga Tekniska Högskolan. Master of Science Thesis 294 (2005): 59.

Kassa, Fekadu. "The rates and effects of urban sprawl in developing countries: the case of Addis Ababa, Ethiopia." International Journal of Area Studies 9.2 (2014): 135-151.

Kothari, C. R. "Sample size determination. Research Methodology." New Age International Publications 1 (2004): 74-1.

Melese, Minwuyelet. "City expansion, squatter settlements and policy implications in Addis Ababa: The case of Kolfe Keranio sub-city." Ethiopian Journal of the Social Sciences and Humanities 2.2 (2004): 50-79.

Nicodemus, M., and Barry Ness. "Peri-urban development, livelihood change and household income: A case study of peri-urban Nyahururu, Kenya." Journal of Agricultural Extension and Rural Development 2.5 (2010): 73-83.

Sudhira, H. S., and T. V. Ramachandra. "Characterising urban sprawl from remote sensing data and using landscape metrics." Proceedings of the 10th International Conference on Computers in Urban Planning and Urban Management, Iguassu Falls, Brazil. 2007.

Tacoli, Cecilia. "Understanding the opportunities and constraints for low-income groups in the peri-urban interface: the contribution of livelihood frameworks." (1999).