

Research Article

Urban induced land use land cover changes in upper Deme watershed, Southwest Ethiopia

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Abstract

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The study was aimed to assess urban induced land use land cover changes in the upper Deme watershed. Three satellite images of 1986, 2002, and 2019 were analyzed by ArcGIS and processed by supervised classification. Land use land cover change in the watershed increased for settlement, bare land, and croplands in the period 1986-2019 by 56.6%, 53%, and 0.25%, respectively. However, the land use land cover change in the watershed decreased for a water body, forest, and grassland by 65%, 57.7%, and 7%, respectively. These enforced to change the work habit and social bases. Out of converted lands, during 1986-2002, 34.9%, 53%, 18%, 40.9%, and 10.6% of bare land, cropland, forest land, grassland, and water bodies, respectively, in the upper Deme watershed were changed into settlement areas. During 2002-2019, 30.7%, 36.8%, 26.9%, 66%, and 33.3% of bare land, cropland, forest land, grassland, and water bodies, respectively, were changed into settlement areas. This shows urbanization results in a different change in economic, social, land use land cover, and watershed management activities in the upper Deme watershed.

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Introduction

Urbanization is a process of distribution of populations from rural to urban settlements over time through industrialization and economic development. It has various criteria to define urbanization which vary from country to country (Peng et al., 2008). It is a demographic process that is increasing in population that resulted in a share of the national population that lives in an urban settlement and the residents derive the majority of their livelihood from non-farm occupations (Mohamed et al., 2014).

Urbanization is a process of relative growth in a country's urban population which is not for a single country phenomenon that accompanied by an even faster increase in the economic, political, and cultural importance of cities relative to rural areas linked with increased per capita energy and resource consumption

and extensive landscape modification (McDonnell and Pickett, 1990).

Urbanization is also the proportion increment of the national population that resides in urban areas. This increment rate of population change in urban areas is higher than the overall national rate of population change, the combination of rural to urban migration, natural increases, boundary changes, or reclassification of rural villages into urban areas. When urban and rural populations are growing at the same rate, there is no increase in urbanization (UN, 2016).

Land use land cover change is the most prominent form of global natural resource and environmental change phenomenon occurring at spatial and temporal scales. Land use change is one of the results of urbanization and development-related activities in the urbanized area which is mostly faced

with natural and environmental degradation (Verburg et al., 2011; Weldegebriel et al., 2016).

Africa is still largely rural and the fastest urbanizing region around the world. Its projected urban population is expected to more than triple from 395 million in 2010 to 1.339 billion in 2050 which constituted 21% of the world population (Güneralp et al., 2018). Ethiopia is the second populous country in Africa. About 15 million residents are living in urban centers in the country (EPHC, 2007). Ethiopia has one of the highest rates of urbanization by the standard of developing countries that was estimated at 4.1%. It was also higher than the average growth rate of the total population which was estimated at 3% per annum. This fast-growing rate resulted in a lack of good urban landscapes that combined to produce attractive buildings, public amenities, and a satisfactory urban lifestyle (MoUDHC, 2014).

Watershed has been affected by urbanization in changing the natural systems of the watershed by altering the land use and land cover by agriculture, buildings, roads, and other urban infrastructures (NAS, 2009). Urbanization has different types of impacts on natural drainage patterns and flows in the receiving catchment as a result of urban development. Uncontrolled or past development of urbanization in the flood plain that did not consider the impacts on hydrology, flood plain encroachment, morphology, and ecology of the receiving water body system had detrimental effects on the receiving catchment, flood plain development, and downstream uses of the watershed (Novotny et al., 2001).

The urbanized watershed is mostly affected by anthropogenic activities that could potentially impact the overall situation of the watershed by freshwater muscels. In most cases, urbanization leads to bank erosion and bed scouring. Urbanization could also cause negative impacts on sediment production supplied from the surrounding watershed, channel instability, decreasing infiltration rates, increase in the frequency and magnitude of flooding, and increase in runoff volume for a single rain event (Gillies et al., 2003).

Frew (2010) reported that urbanization of watershed has adversely affected the financial, social, natural, physical, and human capitals of sub-urban watershed agricultural activities. An increase in population pressure, change of land use and land cover due to settlement changing the working habit of the communities, and migration from rural to urban were observed and are the main problems affecting the watershed. In the study sites, few research findings were carried out regarding the impacts of urbanization on watershed management practices to take measures and reverse the situation. Thus, this problem was initiated to identify the effects of urbanization and land use land cover change in the upper Deme watershed. This research was aimed to assess the spatial land use land cover change in the upper Deme watershed and

investigate the trend of urbanization in the upper Deme watershed. Thus, the study responds to the research questions: how is the spatial land use land cover change in the upper Deme watershed? and what is the trend of urbanization in the upper Deme watershed?

Materials and Methods

Description of the study area

Gamo highland is situated in southwestern Ethiopia, along the Northwestern escarpment of the Great East African Rift Valley System, in the South region of Gamo Zone administration. Under this administration, Dita woreda is one of 14 rural and 4 town administrative woredas of the Zone with the geographic The upper Deme watershed is 562 km southwest from Addis Ababa and 58km north of Arbaminch geographically located in 6°16'10" - 6°23'40" North and 37°27'15" - 37°33'0" East in Dita woreda (Figure 1). It is situated in the Omo basin which is the initial point of Deme River in Lanta/Mayilo Mountain on the mountain path of Mt. Gugie (DWFEDO, 2020). Gamo high land is the source of rivers in the Sub basins of Abaya and Chamo lakes with the rivers like Hare, Kulfo, Shafe (Kassa, 2009; Teshome, 2015) and in the Omo Gibe basin, the rivers named at the Gamo high lands like Maze, Zage, Domba, and Deme. These rivers joined in the low lands and were named Zage and Deme (Shiferaw et al., 2016).

Zada town

Zada town is the only administered municipality structure in the Upper Deme watershed. The town was re-established to serve as a government center for the district in the 1980s. It was served as a government center in different parts of the localities of the district as well as in the surrounding districts of the Gamo zone (DWFEDO, 2020). The national government structure was established around the 1960s in the area. From the starting time to recent time, the town structure was shifting 12 times its setting of the government center.

The beginning was in Lanta Mountain (Gana Kare kebele) in 1960/61 and next Gorka Abessa (Wugula kebele), Gulta (Chencha district), Woyza (Woyza Daycha kebele), Hoya Dagaza (Daramalo district), Wulo Kode (Ganakare Kebele), Zada (Giyasa Kebele, the present place), Chencha (Chencha district), Zada (Giyasa Kebele, the present place), Wacha (Daramalo district) and at last starting from 2000/2001 the Zada town was served as the administrative center of Dita woreda. The town was transformed to the town Administration in 2008 with an area of 200 hectares (DWFEDO, 2020). Now a day, the area of the town was increasing its area and revised its previous plan to 700 hectares (Zada Town municipality in 2020).

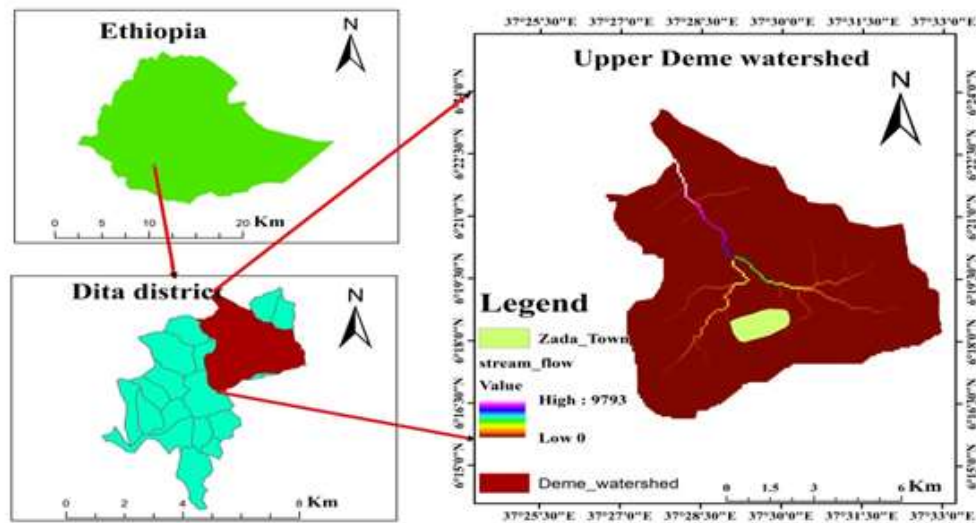


Figure 1. Map of upper Deme watershed.

Demography

The upper Deme watershed has 7 rural, 2 semi-urban 1 urban administrative sites (kebele) with a total population of 55,791. From these 27,279 were male and 28,512 were female with 6628 household heads. From the household heads, 2092 was urban household, 1329 semi-urban, and 3207 was rural household (DWFEDO, 2020).

Socioeconomic description

The upper Deme watershed has 8585 hectares of land. The maximum landholding size of the upper Deme watershed was less than 1 hectares and the average landholding size per household was 0.63 hectares (Melkamu and Mesfin, 2016). The area was characterized by a mixed farming system (that means, crop and livestock production). Barely, wheat, potato, enset, bean, pea were the dominant crops grown in the area which covers around 85% of the cultivated area of the watershed, and livestock production is an integral part of the production system of the area that animals reared in the

watershed were cattle, sheep, horse, mule, and chicken (DWFEDO, 2020).

Research technique

Data source

Three satellite images Landsat_5TM, Landsat_7TM, and Landsat_8OLI were downloaded from the USGS Earth Explore portal (<https://earthexplorer.usgs.gov/>) to prepare land use land cover change map of upper Deme watershed for the years 1986, 2002, and 2019 (Table 1).

Data processing

In preprocessing and image classification was carried out by the supervised classification method. In the supervised classification method, the maximum likelihood algorithm technique was used to classify the images based on provided signatures. Six lands use types, namely settlement, cropland, forest land, grassland, bare land, and water bodies, were identified to analyze the land use land cover change (Table 2).

Table 1. Characteristics of the Landsat images used for the study.

Sensor	Date of acquisition	Path/ Row	Spatial resolution (m)	Source
Landsat_5 TM	25-04-1986	168/55	30 X 30	USGS
Landsat_7 TM	13-02-2002	169/55	30 X 30	USGS
Landsat_8 OLI	03-01-2019	169/55	30 X 30	USGS

Data analysis

Accuracy assessment

The accuracy assessment for supervised land use classification was used only for the recent year 2019. From the classified image of 2019, 100 points were

randomly sampled for basic information and information gathered from the interview from the study area and ground truth data from satellite imageries of Google earth pro 2020. The accuracy assessments were then calculated using equation 1 (Amit, 2018).

Table 2. Descriptions of identified land cover type in the upper Deme watershed.

Land cover type	Description*
Settlement	Land used for built-up compounds and other constructed infrastructures to serve the community
Cropland	Land used for different types of perennial and annual crop cultivation
Bare land	The land compound used for open grazing for communal use and lands used for different types of cultural ceremonies in the community like yearly cultural festival and sorrow ceremony low in grass cover.
Grassland	The land used for growing grass used to cut and carry for forage usage in private or in common.
Forest	Land covered by trees with forests, small trees, bushes
Water body	Area of land covered with water bodies like wetlands, springs, and rivers.

*Own description of land use land cover.

$$\text{User accuracy} = \frac{\text{number of correctly classified pixel in each category}}{\text{egory total number of classified pixel in that category(row total)}} * 100 \text{ ---- (1)}$$

$$\text{Producer accuracy} = \frac{\text{number of correctly classified pixel in each category}}{\text{egory total number of classified pixel in that category(column)}} * 100 \text{ ---- (2)}$$

$$\text{Overall accuracy} = \frac{\text{Total number of correctly classified pixel(Diagonal)}}{\text{Total number of reference pixel}} * 100 \text{ ---- (3)}$$

$$\text{Kappa coefficient (T)} = \frac{(\text{TS} \times \text{TCS}) - \sum(\text{column total} \times \text{row total})}{\text{TS}^2 - \sum(\text{column total} \times \text{row total})} \text{ ---- (4)}$$

The Kappa coefficient close to 1 means it reaches a perfect agreement whereas a value close to zero means the agreement is not better (Table 3) which was computed using equation 4 (Rwanga and Ndambuki, 2017).

Land use land covers change detection

Land use land cover changes of the study years were calculated from processed images following equations 5 and 6 (Islam et al., 2018).

$$\text{Change Magnitude} = \text{Magnitude of the New Year} - \text{Magnitude of the previous year} \text{ --- (5)}$$

$$\text{Percent of change} = \frac{\text{The magnitude of change}}{\text{base year}} * 100 \text{ ---- (6)}$$

Results

Accuracy assessment

The accuracy assessment was done only for the year 2019 (Landsat 8 OLI). The reference points were accessed from the google earth map. Accuracy assessment was not performed for 1986 and 2002 images due to the unavailability of ground validation data in the form of Google earth images. From the Google image, 100 reference points were taken from

Table 3. Rating of the Kappa coefficient.

Kappa coefficient	Strength
< 0	Poor
0 - 0.2	Slight
0.21 - 0.4	Fair
0.41 - 0.6	Moderate
0.61 - 0.8	Good
0.81 - 1	Very good

the study area, and a comparison was then made with classified satellite images acquired. The accuracy assessment was determined using overall accuracy, producer's accuracy, user's accuracies, and Kappa coefficient to compare the relationship between the classified map and reference (Amit, 2018). Based on these, the result of the study's overall accuracy was 85.6%, and the Kappa value was 0.85, and this assessment was good to take the result confidentially (Table 4).

Table 4. Characteristics of the accuracy assessment Landsat_8 OLI (2019).

Class Name	Reference Total	Classified Total	Number of Correct	Producers Accuracy	User Accuracy
Settlement	28	26	24	92.9	92.39
Bare land	12	9	8	75	88.9
Cropland	32	31	31	96.9	100
Grassland	10	9	7	90	77.8
Forest	9	7	5	77.8	71.4
Water body	9	6	5	66.7	83.3
Overall accuracy	85.6%				
Kappa coefficient	0.85				

The magnitude of land use land cover in the Upper Deme watershed

Results showed that there was a high expansion of settlement and croplands at the expense of other land uses. The areas of settlement, cropland, bare land, grasslands, forest lands, and water bodies were 1780 ha, 2783 ha, 515 ha, 1519 ha, 1478 ha, 502 ha,

respectively, in 1986. The land uses were shifted in aggregate into settlement (2191ha), cropland (2889 ha), bare land (789 ha), forest lands (1553 ha), grassland (1172 ha), and water body (113 ha) in 2002. Furthermore, 2787 ha of settlement, 2790 ha cropland, 789 ha bare land, 1411 ha grassland, 625 ha of forest lands, and 175 ha water body were detected in 2019 (Table 5 and Figure 2).

Table 5. Area of the land cover unit in upper Deme watershed during 1986-2019.

Land Class	1986		2002		2019	
	ha	%	ha	%	ha	%
Settlement	1780	20.8	2191	25.5	2787	32.5
Bare land	515	6	659	7.7	789	9.2
Cropland	2783	32.5	2889	33.7	2790	32.5
Grassland	1519	17.7	1172	13.7	1411	16.5
Forest	1478	17.2	1553	18.1	625	7.3
Water body	502	5.9	113	1.3	175	2
Total	8577	100	8577	100	8577	100

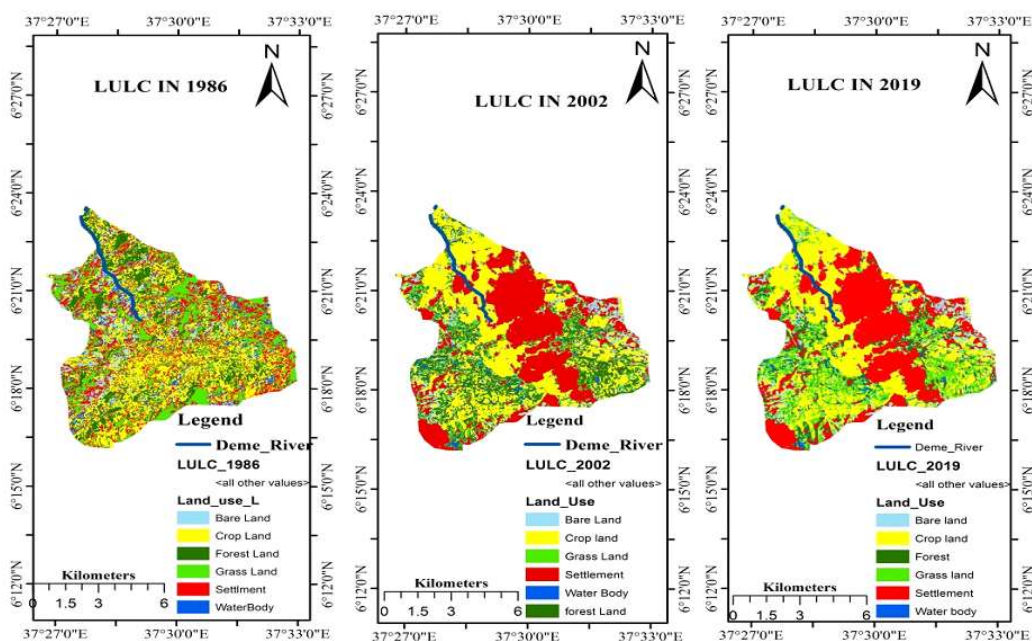


Figure 2. Land use land cover change in upper Deme watershed.

Over the study periods, there was an increasing trend in the settlement, cropland, bare lands, and forest lands during 1986-2002 and decreasing of cropland and forest land in 17 years period (2002-2019). Grassland and water body declined in trend through the first 16 years (1986-2002) and increased in the second 17 years (2002-2019). The land use land cover condition in the upper Deme watershed shows an increase in aggregate during 33 years period (1986-2019) in the settlement, bare land, and cropland by 56.6%, 53.2%, 0.25%, respectively, and decreased in the water body, forest land, grassland, 65.1%, 57.7%, and 7.1% respectively during 1986-

2019. The trend shows increasing through the study years in settlement, and the other land use shows a fluctuating trend (Table 6 and Figure 2). Out of converted lands, during 1986-2002, 34.9%, 53%, 18%, 40.9%, and 10.6% of bare land, cropland, forest land, grassland, and water bodies, respectively, in the upper Deme watershed were changed into settlement areas (Table 7). During 2002-2019, 30.7%, 36.8%, 26.9%, 66%, and 33.3% of bare land, cropland, forest land, grassland, and water bodies, respectively, were changed into settlement areas (Table 8).

Table 6. The magnitude of land use land cover change during 1986-2019.

Type of land uses	From 1986 - 2002		2002 - 2019		1986 - 2019	
	ha	%	ha	%	ha	%
Settlement	411	23	596	27.2	1007	56.6
Bare land	144	28	130	19.7	274	53.2
Cropland	106	3.8	-99	-3.4	7	0.25
Grassland	-347	-22.8	239	20.4	-108	-7.1
Forest land	75	5	-928	-59.8	-853	-57.7
Water body	-389	-77.5	62	54.9	-327	-65.1

Table 7. Land use land cover change detection of land classes during 1986-2002.

Land use classes		Land class 2002						Total
		BL	CL	FL	GL	ST	WB	
Land class 1986	BL	208	66	98	33	107	3	515
	CL	153	1185	359	235	848	3	2783
	FL	14	752	684	28	179	14	1671
	GL	150	248	49	721	316	10	1494
	ST	51	462	213	118	688	28	1560
	WB	83	176	150	37	53	55	554
	Total	659	2889	1553	1172	2191	113	8577

BL = bare land, CL = crop land, FL = forest land, GL = Grass land, ST = settlement, WB = water body.

Table 8. Land use land cover change detection matrix for 2002-2019.

Land use classes		Land class 2019						Total
		BL	CL	GL	FL	ST	WB	
Land class 2002	BL	294	66	88	95	112	4	659
	CL	98	1240	677	166	607	101	2889
	GL	52	475	219	164	256	6	1172
	FL	86	279	96	108	957	27	1553
	ST	258	716	313	69	827	8	2191
	WB	1	14	18	23	28	29	113
	Total	789	2790	1411	625	2787	175	8577

BL = bare land, CL = crop land, FL = forest land, GL = Grass land, ST = settlement, WB = water body.

Discussion

The overall accuracy assessment for the year 2019 showed strong agreement between the classification and reference data (Haroun et al., 2013; Shiferaw et al., 2019). Kappa statistics of more than 0.80 also show better accuracy and the classification resulted from random points. The confusion matrix analysis revealed that producer accuracy for waterbody, forest, and bare land areas were relatively lower than other land use types for the year 2019. On the other hand, in the same year, accuracy for crop land and settlements were relatively higher than the rest. The reduction in user and producer accuracies for the aforementioned land use types could be due to their similar reflectance values of solar radiations that misclassified to either of the land uses. Moreover, the broad ranges of accuracies indicated severe confusions of bare lands and settlements with other land uses types and their omission errors were greater. Accuracy assessments made by Rwanga and Ndambuki (2017) in Limpopo

province of South Africa, and Tadele et al. (2017) in the case of Quashay watershed in the Northwestern Ethiopia argued similar trends with the mentioned land use types. The increase of bare lands and settlement areas during 1986-2019 in expanse of other land use types showed land degradation and built-up increase of population migration to urban areas (Ibrahim, 2020). The expansion of settlements and crop lands in 2019 could be due to population increase in the watershed that might need additional income and residence areas. The result shows urban effects in the upper Deme watershed is consistent with Miheretu and Yimer (2017); Kassahun and Tegegne (2018). Land use changes were due to urbanization results in economic, social, and environmental impacts by decreasing or increasing the area of cropland, settlement, forest, and waterbody (Izakovicova et al., 2017). Recently, the size of wetland declined and the bare land was also completely shifted into settlement areas which were similar to the results of Miheretu and Yimer (2017) in Northern Ethiopia.

Similarly, other studies pointed out that the major pushing factors for the increase of urbanization were people migration from surrounding and increasing settlement around semi-urban, migration look for a work opportunity, better service, and loss of culture by local youth were also increased urbanization in the study area in Southern Ethiopia (Habtamu, 2015; Eshetu and Beshir, 2017). The present urban area (Zada Town) was semi-urban at all during 1986 which was the year of the reestablishment of the new Dita district and the town was within two localities (Giyasa and Dalbansa); they have more or less watershed management practices and plantation around mountainous areas like Gina mountain. However, Gina mountain has already been deforested. The highest land use changes were caused impacts on watershed management and thus on the watershed productivity which enforced the land users to shift cropland to settlement areas. The result was consistent with Mefekir (2017) impact of urban expansion on surrounding peasant land decreasing land size, production, and productivity in the urban surrounding community.

Moreover, the shifting of the administrative center to other parts of the localities or neighbor woredas changed the land use of the suburban surroundings. When the administrative center comes to the Deme watershed, the population and the built-up areas were increased, but other land uses were decreasing. The administrative center left the site, the urban dweller would be shifting their living place to search for a better work opportunity, and the surrounding farmer doing the plantation and decrease the size of forest for construction as well as firewood (DWFEDO, 2020). The shifting of land uses made the change in the watershed by shifting the work experience of the people to infrastructure made work opportunities like construction, small trading, required to different organizations. Moreover, Urbanization had several limitations, such as eradication or modification of habitats replaced by other land uses (Uttara et al., 2012). The reason for the change in work habit or settlement was the effect of the increase in population, decreasing the size of landholding and shifting of usual work type used by the community that was also in accordance with drivers and implications of land use/land cover dynamics (Dibaba et al., 2020).

Changes in land use land cover were driven by a variety of social integrations, result in land cover changes that affect biodiversity, water bodies, and other land use patterns come together to affect climate and biosphere and land cover can be altered by forces other than anthropogenic like, natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover (Zubair, 2006). Urbanization in the watershed caused to shift of the community into less resource management and thus, environmental degradations with less productivity were mainly observed. These types of misuses of resources were caused due to anthropogenic factors which contributed

to the degradation of land resources and removal of resources for a different purpose by communities in the watershed (Bahri et al., 2011).

Change detection quantifies the changes in the watershed associated with land use land cover changes in the landscape of the same geographical area between the considered 33 years periods (Munthali et al., 2019). Land cover land use detection analysis shows that the land use in the study area was highly shifting into settlement areas. These were due to scarcity of land resources that were used for agricultural production, development of urban center in the watershed resulted in increment of settlement areas. The increase in the population in the watershed also caused high usage of natural resources shifted the land use into bare land, grass, and croplands in the Deme watershed. The highest land use changes were caused impacts on watershed management and thus on the watershed productivity which enforced the land users to shift cropland to settlement areas. The result was consistent with Mefekir (2017) impact of urban expansion on surrounding peasant land decreasing land size, production, and productivity in the urban surrounding community. Urbanization induced land use land cover changes resulted from high population density in the site and increasing the settlement as well as shifting other land uses to crop lands to produce minimum food consumption for household (Shi et al., 2010).

Conclusion

The analysis revealed that land use and land cover have changed due to settlement areas in the upper Deme Watershed. The changes were significantly identified due the changes population by nature and migration around the town. This had changed income-generating work opportunities, economic activities and social structure. The main impact was of urbanization decreasing in the land size of the community. The increase of settlement and crop lands had implications in the shrinkage of other land uses such as forest, waterbody, and grazing lands. Land use land cover change analysis show that increasing of urbanization had resulted in shifting of land use land cover into settlement and crop lands.

The land use changes shift the lands services to others. These impacts result in a decrease of agricultural productivity mainly in urban and semi-urban localities and decrease work habits in agricultural sector. Urbanization affected watershed productivity by changing the land use land cover and norm of local community into new work habits, social integration, population, and land use land cover for farming communities. Urbanization had also different types of impacts on watershed management practices though it has positive effects for social and economic infrastructures in the urban area. Therefore, it should be planned and managed by a responsible body from time to time.

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