International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Assessing Land-Use/Land-Cover Changes and Spatio-Temporal Expansion Process of Assela Town, Arsi Zone, Ethiopia

Gezahegn Weldu[1], Anteneh Derribew[2]

[1]Haramaya University, School of Geography and Environmental Studies, Department of Geo-Information Science, Ethiopia

[2]Haramaya University, School of Geography and Environmental Studies, Ethiopia

Abstract: ***Urbanization has a pivotal role for land-use and land-cover changes and ecological degradation in return with some socio-economic benefits. Hence, it is very important to have frequent urban information to secure urban land use sustainability so as to minimize its impacts on urban ecology. This study was aimed at to map and quantify Land-use/Land-cover change and spatio-temporal expansion process of Assela Town between 1985 and 2013. Integrated Remote Sensing (RS) and Geographical Information System (GIS) techniques were applied. The Land-use/Land-cover and urban expansion dynamics of the town was the result of remotely sensed multi-temporal satellite imageries interpretation traced back to 1985, 1993, 2001 and 2013 respectively. Land-use/Land-cover area changes detection and conversion to urban landscape comparison between each study period was computed. The supervised image classification method with maximum likelihood probability algorithm has been employed for the land -cover classification in ERDAS IMAGINE 10 software. Finally, urban (Built-up) area expansion of the town over1985-2013 was analyzed using map overlay techniques with consecutive population growth. The results of the study reveals that urbanization of the town between 1985 and 2013 is expanded by 995.31 ha (291.64%) from 341.28 ha to 1336.59 respectively, while farmland, plantation and bare land was increased by 502.65ha (43.67%), 118.17ha (33.49%), 69.57ha (32.58%) respectively. Land-use/Land-cover change detection of the study periods also indicates that the area of shrub, grazing land and water have been decreased 1537.56 ha (87.62 %), 148.14 ha (22.63%), 0.45 ha (8.19 %) in the study period lasted between 1985- 2013 respectively.***

Keywords: GIS, Remote Sensing, Land-use/Land-cover, Landsat, Spatio-temporal expansion

1. Introduction

Human beings were passed through lots of remarkable achievements such as the emergence of urban development and multi-purpose industries. These viable drives were followed by irreversible rural-urban migration of people in large scale and increased urban settlements with enormous demands for dwelling places. Hereafter, the spatial expansion process of urban landscape was occurred alarmingly and became cause of concern in different parts of the world (Desai *et al*., 2009). Urban expansion is commonly quantified by growth of the built-up area in side urban cities and towns (Epstein *et al*., 2002).

There are varies factors behind urban expansion out of which urban population and economic progress were potentially the two most influential elements (Lin *et al*., 2003). Chiefly in developing countries rapid urban population growth particularly due to rural urban resettlements were leading to spatial-temporal expansion of urban landscape and worsen the local authorities even to arrange the provision of basic infrastructures (Jitendrudu, 2005). Hence, understanding the aggravating factors of unchecked spatial and temporal urban expansion empowers us to identify the present and future needs of the towns and cities (Sundra *et al*., 2003).

The investigation on the growth of urban settlements on the other hand is also essential for proper urban planning to achieve sustainable land use development. However, it is not as such easy task due to lack of accurate urban land information of the past. But, the advancement in Geographic information System(GIS) and Remote Sensing (RS) technology absolutely serve as efficient tool in monitoring urban landscape using satellite data archive of the past (Tran and Yasuoka, 2000).

As far as the application of GIS and RS in urban study is taken into account there were efforts made by lots of scholars and institutions in different parts of the world. Definitely, initiations has made by Wenli *et al*., (2007) to monitor urban expansion of Beijing city of china. Moreover, Soffianian *et al*., (2010) have also analyzed urban expansion of Isfahan city of Iran using remotely sensed imageries and aerial photos.

Urban dynamics is accelerated in developing countries as compared to developed nations (Shlomo *et al*., 2005; Xiao *et al*., 2006). The case in Ethiopia also proved this situation as per recent research studies conducted at different cities and towns. Thus, mapping and quantifying urban expansion by interpreting multi-temporal datasets of the past has a paramount importance to analyze urban expansion trend of the past. It also plays a great role in monitoring further expansion so as to introduce some possible remedial intervention to avert or minimize the socio-economic and environmental impacts of unstructured urban expansion process (Barredo *et al*., 2003). Therefore, as in many other towns of Ethiopia rapid urban population growth and spatio-temporal expansion conditions over the last three decades have created considerable economic, social and environmental problems in Assela town. Consequently, the municipal authorities and other decision makers faced challenges in course of managing urban expansion of the town with timely update information supported by GIS and RS techniques. Thus, the application of GIS and RS to study Land-use/Land-cover change and spatio-temporal expansion process of Assela town is the right and timely decision to avert the negative consequences of uncontrolled urbanization and associated problems.

2. Description of the Study Area

The study was conducted at Assela town; the administrative headquarter of East Arsi Zone of Oromia Regional State, Ethiopia. The town situated at about 166 kilometers away from Addis Ababa capital City. Astronomically, it is located between $7^0$54'55''N-$8^0$00'05''N latitude and $39^0$06'10''E - $39^0$10'00'E longitudes (Bahiru, 1991, ATMD, 2013).

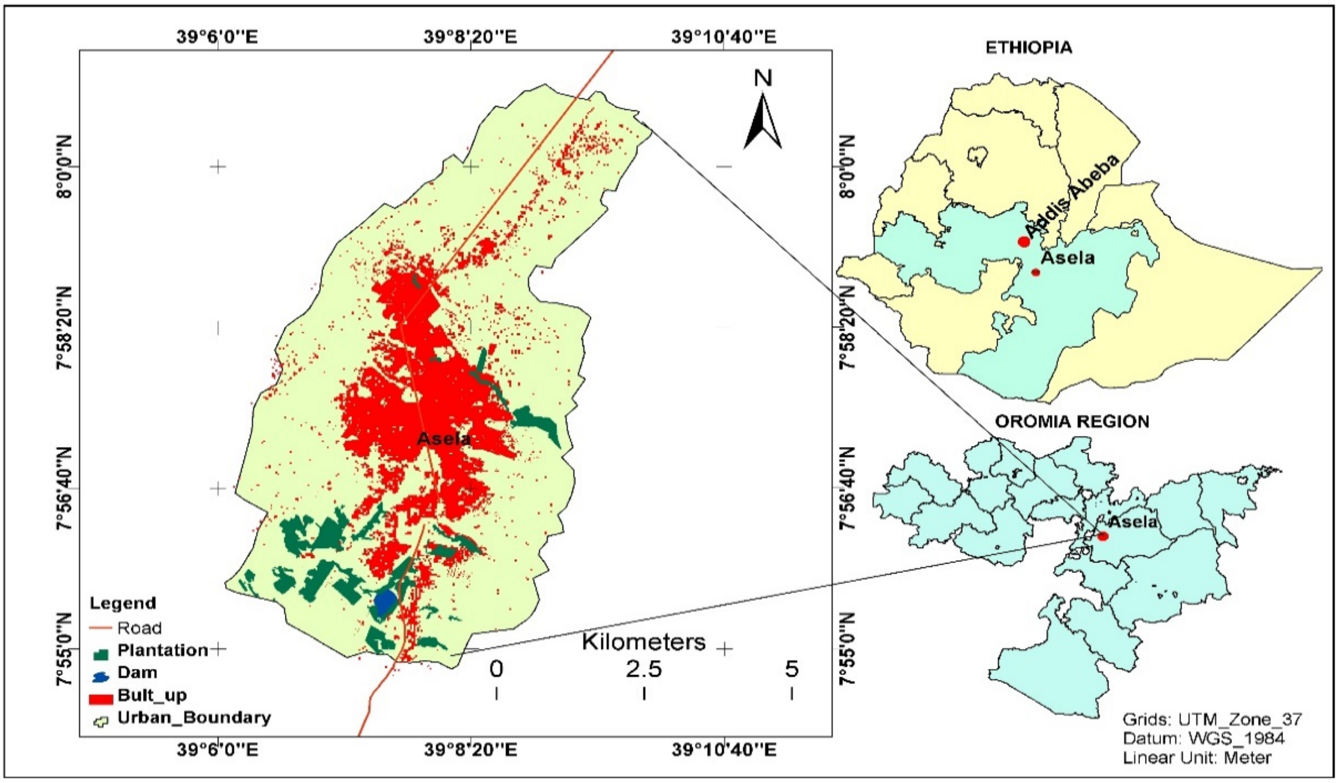

Figure 1: location of the study area

3. Materials and Methods

3.1 Input Data Sets

The study supported by various primary and secondary data sets collected from different sources. The main geospatial data sets used to analyze Land-use/Land-cover of the town includes four pairs of clouds free Landsat4/5 (TM) and L8 OLI/TIRS (ETM$^+$) imageries with 30 meter resolution of path 186 and row 54 obtained on 25, February 1985, 25, February 1993, 05, December, 2001 and 25, December, 2013 by freely downloading from United States geological survey (USGS) website (*http://www.earthexplorer.usgs.gov*). Moreover, topographic map (1.50, 000 scale) and spot 5 image were obtained from Ethiopian Mapping Agency (EMA). Other vector data sets like the town administrative boundary were obtained from Assela town municipality.

Table 1: Data sets and Sources

Data type				**Data source**		
Different documents				Internet		
Population data				Central Statistical Agency (CSA)		
Key informant Interview				Assela town municipality officials		
Satellite images	Years	Path	Row	Resolution	Sources	Application
Landsat5	1985	168	54	30m	USGS website	Land-use/Land-Cover Mapping
Landsat 4	1993	168	54	30m		
Landsat 5	2001	168	54	30m		
Landsat 8	2013	168	54	30m	EMA	
Spot 5 image	2007	168	54	5m		
Master plan	2007				Municipality	Town boundary

3.2 Methods

The imageries were projected to a World Geodetic System (WGS) 1984, Universal Transverse Mercator (UTM) Zone_37 North coordinate system. Since the collected multi-temporal satellite imageries cover a large area with a sensor spatial resolution of 30 meter the town boundary shape file has been used to subset spatial extent covering the town. The scène for all the spectral bands were combined using layer stack tool using ERDAS IMAGINE 10 software (Jensen, 2004). In order to get accurate Land-use/Land-cover class with better accuracy Global Position System (GPS) and digital camera were used to collect sample ground control point indicating each Land-use/Land-cover Class (Jensen, 1996).

The supervised image classification technique was applied to classify each raster imageries on the bases of training samples. The maximum likelihood probability has been used based on assumption that each land-use pixels under the classification will fall under one of the class. These probabilities are the same for all classes as well as input data sets in all bands which result the normal distribution function (Lillesan and Kiefer, 2004). Furthermore, the supervised image classification was conducted based up on the prior knowledge of the study area. The Land-use/Land-cover class of the town were categorized into seven class namely water, farmland, urban (built-up), plantation, Grass and pasture, bare land and Shrub (see Table, 2).

According to Araya (2009), accuracy assessment is mandatory in LULC study to proceed into any change analysis in advance. Thus, accuracy assessment has been computed for LULC map of each study periods. Furthermore, demographic data collected from CSA and the responses drown from key informant interview of five municipality authorities has been used in urban expansion analysis part.

Table 2: Landuse/Landcover class and their description

LULC Class	*Description*
Water body	Include lakes and rivers
Farmland	Composed of arable land used for agriculture purpose
Urban or built-up	Includes urban settlements, Industries, Asphalt and gravel roads and Social services and administration buildings.
Plantation	Green areas such as economic tress used for construction and fire wood such as eucalyptus trees and other natural forests are included under this class.
Grass and Pasture	Pasture area and Grass lands found in and at the periphery of the town boundary used as food for animals.
Bare land	Includes sandy and bare rock area
Shrub	Scattered , short heighted trees and bushes

4. Results and Discussions

4.1 Land-use/Land-cover Change Detection (1985-2013)

The table below shows that the absolute Land-use/Land-cover pattern of Assela town between 1985 –2013 categorized into Water, Farmland, Built-up, Plantation, Pasture and Grass, Bare land and Open Shrub Land.

Table 3: Absolute Land-use/Land-cover of Assela Town (1985-2013)

LULC Class	**1985**		**1993**		**2001**		**2013**	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Water	5.49	0.1	5.94	0.1	6.3	0.1	5.49	0.12
Farmland	1151.0	4.7	1613.9	36.	1260.2	28.	1653.6	36.9
Built-up	341.28	7.6	399.24	8.9	796.14	17.	1336.5	29.8
Plantation	352.8	7.8	332.64	7.4	424.26	9.4	470.97	10.5
Pasture & Grass	654.57	14.	539.19	12.	1569.0	35.	506.43	11.3
Bare land	213.48	25.	630.18	14.	92.61	2.0	283.05	6.33
Shrub	1754.7	39.	952.2	21.	324.72	7.2	217.17	4.85

Four sets of Landsat thematic imageries of 1985, 1993, 2001 and 2013 were employed to analyze LULC of the town using and each map were prepared using Arc GIS 10 software. From the total land coverage of 1985, the majority of LULC were categorized under shrub land and accounts for about 1757.73 hectare (39.22%), while built up was contributes 341.28 hectare (7.63%). Meanwhile, from Land-use/Land-cover class interpreted from Landsat 4 (TM) of 1993, the lion share of the town LULC class was covered by Farmland which contributes 1613.97 ha (36.08 %) and rapid decline in open shrub class was observed in this period and became 952.2 ha (21.29%), while water, plantation, Grass and Pasture, and Bare land accounts for 5.94 ha (0.13 %), 332.64 ha (7.44 %), 539.19 ha (12.05 %), 630.18ha (14.09 %) out of the total LULC class respectively. The built up of the town in this period was resulted an in increase in area and constitute 399.24 ha (8.92 %).

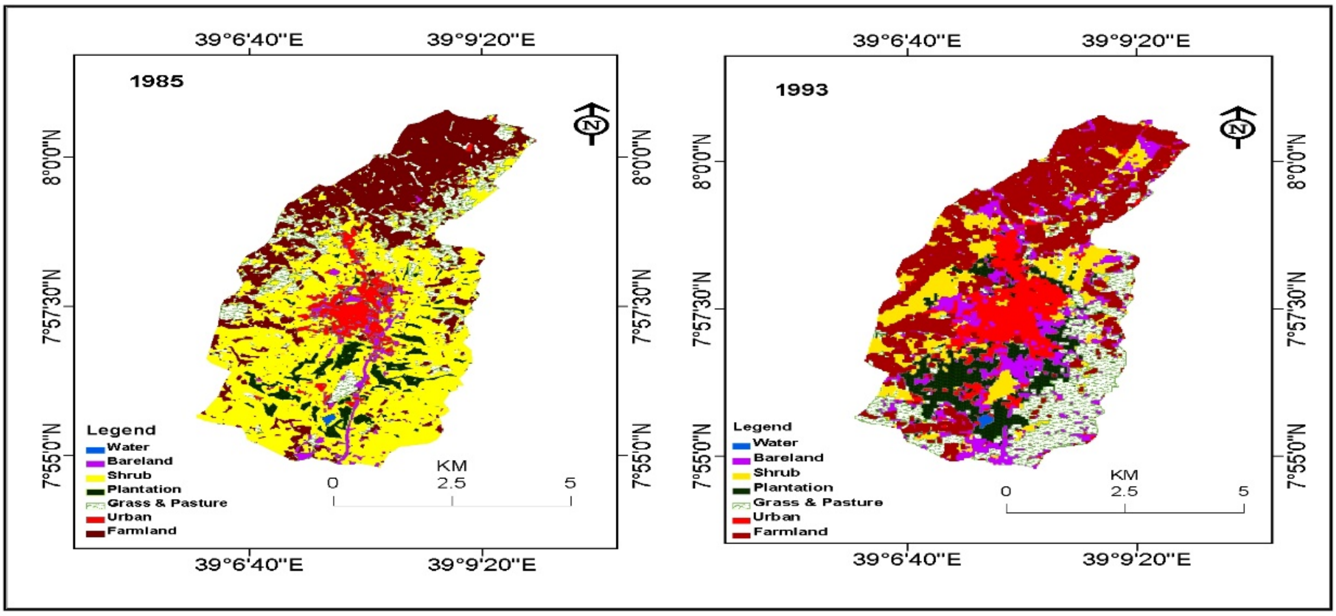

Figure 2: Land –use/Land -cover map of 1985(left) and 1993(right)

In 2001, the dominant class was pasture and grassland covered about 1569.06 ha (35.06 %), whereas Water, Farmland, Built-up, Plantation, Bare land and Shrub Land contributes 6.3 ha (0.14%), 1260.27 ha (28.17 %), 496.14 ha (17.79 %), 92.61 ha (2.07%), 324.72 ha (7.25%) respectively. In the LULC classification map result of Assela town in 2013, farmland was the dominant class covering 1653.66 ha (36.96 %), followed by built-up (Urban) and grassland covering 1336.59 ha (29.87%), 506.43 ha (11.32 %) respectively, while plantation contributes 470.97 ha (10.52 %).

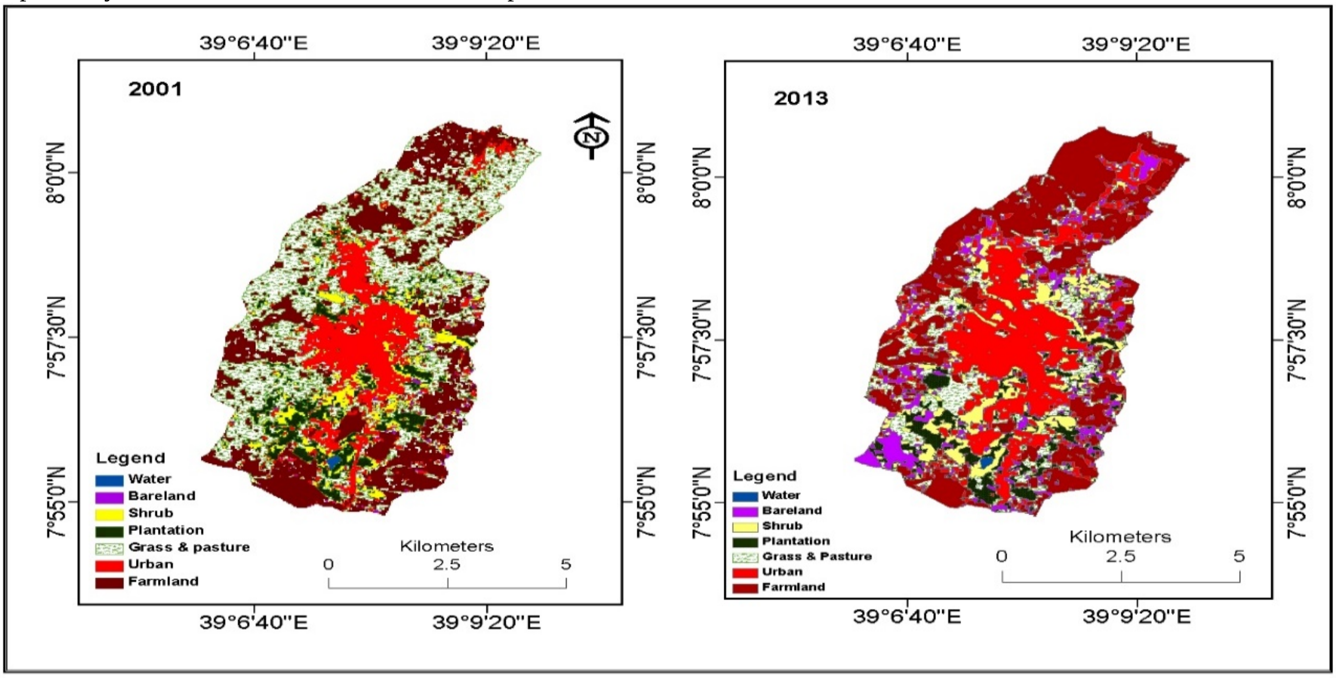

Figure 3: Land-use/Land-cover Map of 2001(left) and 2013(Right**)**

The analysis on LULC map of the town between 1985-1993 reveals that much of area increase was observed in Farmland, Bare land and Built-up class and have shown area increase of 462.96 ha, 416.7 ha, 57.96 ha respectively, while dramatic decrease was observed in Shrub land (-1215.54 ha) followed by Pasture and Grass as well as Plantation which accounts for -115.38, -20.16 ha respectively. In the LULC transformation map ranges between 1993 – 2001, the major positive transformation was took place in Pasture and grass, Built-up, plantation and water body and accounts for 1029.87 ha, 396.9 ha, 91.62 ha, 0.36 ha respectively. In the last phase lasted between 2001 – 2013, built-up was increased by 540.45 hectare, followed by farmland (393.39 ha), Bare land (190.44 ha) and Plantation (46.71 ha) respectively.

4.2. Land-use/Land-cover Classification Accuracy Assessment

Land-use/Land-cover maps interpreted from remotely sensed imagery may prone to certain types of errors related to several factors such as classification technique to method of satellite data acquisition. In order to wisely use the land cover maps which are derived from remote sensing and the accompanying land resource statistics, the errors must be quantitatively explained in terms of classification accuracy. Whether the output meets expected accuracy or not is therefore an integral part of any Land-use/Land-cover studies (Zewudu, 2011).

Table 4: Producers and Users Accuracy Result of Land-use/Land-cover map (1985 – 2013)

LULC Class	1985 Accuracy %		1993 Accuracy %		2001 Accuracy %		2013 Accuracy %	
	Producers	Users	Producers	Users	Produce	Users	Producers	Users
Water	83.33	100.00	84.21	100.00	100.00	100.00	93.33	100.00
Farmland	100.00	87.50	85.71	100.00	100.00	72.73	93.75	83.33
Built-up	90.00	100.00	100.00	80.00	78.64	80.33	96.43	81.82
Plantation	100.00	80.00	90.00	90.00	86.67	86.67	81.82	90.00
Grass land	86.96	86.96	86.67	81.25	81.00	90.00	95.65	81.48
Bare land	85.71	100.00	84.62	91.67	100.00	90.00	73.08	81.00
Shrub	91.67	91.67	84.62	78.57	100.00	83.33	89.47	93.00

Table 5: Overall accuracy and Kappa (K^) statistics for Land-use/Land-cover map (1985 – 2013)

Accuracy Statistics	1985	1993	2001	2013
Overall classification accuracy	89.19%	87.64%	86.27%	89.13%
Overall Kappa (K) statistics	0.8722%	0.8543%	0.8392%	0.8712%

Based on the accuracy assessment made for testing the accuracy of the classification from 150 samples taken randomly from each LULC class for each study years (1985, 1993, 2001 and 2013), an overall classification accuracy of 89.19%, 87.64%, 86.27% and 89.13% and overall Kappa (κ^) statistics of 0.8722 %, 0.8543%, 0.8392% and 0.8712% were achieved respectively (Table 4 and 5). In general, the higher users and producers accuracy achieved for water body.

4.3. Relative Land-use/Land-cover changes Matrix (1985 – 2013)

Post classification cover detection such as change matrix computation is very important to determine the independent change in classified Land-use/Land-cover class (Pontius *et al.*, 2004).

Table 6: Relative Land-use/Land-cover changes Matrix of Assela Town (1985-1993)

LU/LC Class	Water	Farm	Built-up	Plantatio	Grass & Pasture	Bare land	Shrub	Raw
Water	5.13	0.00	0.27	0.00	0.00	0.00	0.09	5.49
Farmland	0.00	796.68	29.79	0.36	128.25	120.06	75.87	1151.01
Built-up	0.00	45.9	204.66	3.33	19.71	48.42	19.26	341.28
Plantation	0.81	2.43	11.97	184.05	0.99	39.6	112.95	352.8
Pasture & Grass	0.00	302.31	9.9	0.81	227.16	43.47	70.92	654.57
Bare land	0.00	23.94	40.23	6.21	12.33	99.72	31.05	213.48
Shrub	0.00	442.71	102.42	137.88	150.75	278.91	642.06	1754.7
Class Total	5.49	1151.0	341.28	352.8	654.57	213.48	1754.7	0.00
Class Changes	0.36	354.33	136.62	168.75	427.41	113.76	1112.7	0.00
Image difference	00	462.96	57.96	-20.16	-115.38	416.7	-1215.5	0.00

Table 7: Relative Land-use/Land-cover changes Matrix of Assela Town (1993 – 2001)

LU/LC Class	Water	Farmland	Built-up	Plantation	Grass & Pasture	Bare land	Shrub	Raw Total
Water	5.58	0.00	0.09	0.18	0.00	0.00	0.09	5.94
Farmland	0.00	669.06	138.24	48.06	720	12.06	26.55	1613.97
Built-up	0.27	14.22	286.74	15.84	49.41	4.86	27.9	399.24
Plantation	0.27	5.49	25.02	149.67	55.44	10.26	86.49	332.64
Pasture& Grass	0.00	202.5	50.4	41.76	220.05	4.5	19.98	539.19
Bare land	0.00	108.72	187.29	49.32	193.95	20.61	70.29	630.18
Shrub	0.18	260.28	108.36	119.43	330.21	40.32	93.42	952.2
Class Total	5.94	1613.97	399.24	332.64	539.19	630.18	952.2	0.00
Class Changes	-0.09	944.91	112.5	-58.05	182.97	609.57	445.77	0.00
Image difference	0.36	-353.7	396.9	91.62	1029.87	-537.57	-627.28	0.00

Table 8: Relative Land-use/Land-cover changes Matrix of Assela Town (2001 – 2013)

LU/LC Class	Water	Farmland	Built-up	Plantatio	Grass & Pasture	Bare	Shrub	Raw
Water	5.31	0.00	0.00	0.99	0.00	0.00	0.00	6.3
Farmland	0.00	0.99	152.64	9.27	115.47	58.77	4.68	341.82
Built-up	83.07	546.3	59.22	59.22	40.95	48.33	18.27	855.36
Plantation	0.09	14.67	88.11	172.71	58.86	14.31	75.51	424.26
Pasture& Grass	0.00	605.34	411.93	111.69	252.36	137.07	50.67	1569.06

Bare land	0.00	9.9	34.11	18.18	12.51	10.71	7.2	92.61
Shrub	0.09	21.24	103.5	98.91	26.28	13.86	60.84	324.72
Class Total	6.3	1260.27	796.14	424.26	1569.06	92.61	324.7	0.00
Class Changes	0.99	1259.28	736.92	251.55	1316.7	81.9	263.8	0.00
Image difference	-0.81	393.39	540.45	46.71	-1062.6	190.44	-	0.00

The thematic LULC Changes from one land-use/land-cover class to another class was computed using ERDAS IMAGINE software. The diagonal values colored in greening change matrix tabulation (table 6, 7 and 8) indicate land-use/land-covers that were unchanged over the study periods. This relative change in LULC was conducted by subtracting the area of each land cover class of 1985 from 1993, 1993 from 2001 and 2001 from 2013. The class total indicates the overall area of each land-use/land-cover for the initial years and the row total depicts the total area of the later years. Image difference shows the difference of the total area in each class between the study years. Moreover, the class change describes the total change for each land-use/ land-cover for initial and the later years.

4.4. Spatio-temporal Expansion of Assela Town

In order to assess the spatial expansion of the town from the classified multi temporal datasets of Landsat imageries built-up area of 1985, 1993, 2001 and 2013 were extracted to show the consecutive changes observed in urban landscape so far. In the first phase lasted between 1985 - 1993, the town has exhibited the built-up expansion of 57.96 ha at 2.1 % annual growth rate. In the second phase ranges between 1993 and 2001 the town has begun to take a note of large scale urban expansion process and responsible for 396.9 hectare expansion at 12.4 % annual growth rate, whereas population of the town was increased by 59,081 with 3.6 % annual growth rate. Moreover, 540.45 hectare built-up expansion at 5.7 % annual growth rate and the town population growth of 27139 at 3.8 % growth rate was exhibited between 2001 and 2013.

In reference to urban expansion history of Assela town in the past 28 years, the town was significantly experienced the spatial expansion to different parts. To this effect, further expansion in the coming future is thought to be inevitable. According to Hofstee and Brussel (1991), arithmetic urban growth can be calculated by using exponential formula. Hence, the built-up expansion of the town after five years (2018), ten years (2023) has been computed.

$$Af = Ab * (1+\%/100)^{(f-b)}$$

Where: *A:* is built up area, *f:* is the future year, *b:* is the base year and *%* is the average growth rate per year.

Thus, 274 hectare increase of built-up area at 4.1percent annual growth rate has been observed between 2013 and 2018, while urban population was increased by 17,675 at 4.1 percent annual growth rate. The estimation is conducted by applying linear growth rate per year and thus the aforementioned projection will took place if there is no any rules and regulations interfere at the national level or unless urban municipality try to monitor unplanned and irregular urban expansion. Moreover, the projection was conducted assuming that the horizontal built-up area expansion will continuing to increase at an average expansion rate of the past 28 years and if other things remain constant.

Table 9: Comparison of Built-up Expansion and population growth of Assela (1985-2013)

Years	Built-up	Δ hectare	Population	Δ Population	Annual Growth rate (%) of Built-up and Population		
1985	341.28	-	35,365	-	Intervals	Built-up	Population
1993	399.24	57.96	45,875	10510	1985- 1993	2.1	3.7
2001	796.14	396.9	59,081	13206	1993 -2001	12.4	3.6
2013	1336.59	540.45	86,220	27139	2001 -2013	5.7	3.8
2018	1610.59	274	103,895	17675	2013 -2018	4.1	4.1
2023	1968.97	358.38	127,013	23118	2018 -2023	4.5	4.5

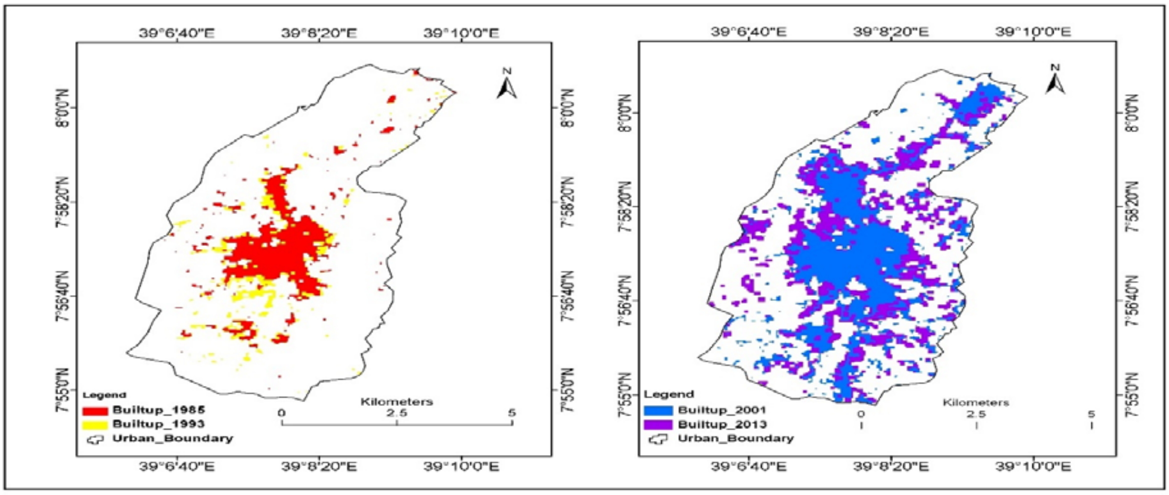

Figure 4: the linkage between population growth and urban expansion

4.5 Factors for Urban expansion of Assela Town

Urban expansion process of Assela town has been influenced by multitude of driving forces like geographical location, urban population growth, and increased accessibility to public infrastructures and several economic opportunities. The Land-use/Land-cover interpreted from spatial and temporal data sets in the past 28 years indicate that the town was marked spatial-temporal expansion triggered by varies factors.

According to the response of senior experts and authorities from the town municipality and other town dwellers the second launched master plan of 1980/81 has played a great role for one step expansion of the town following the land lease system. Accordingly, new organizations and additional manufacturing industries as well as hotels have been constructed in different parts of the town. Moreover, based on response of the key informants, the extension of urban infrastructures like roads and other public facilities has significantly necessitated urban expansion to all direction of the town.

In addition to what has been mentioned, government-driven reform in 2007 is also other factor for large scale built-up expansion of the town. The reform has been started with the development of new structural plan which allowed the inclusion of additional lands in all direction of the town aimed at to boost the municipality's annual revenue. Hence, this situation consequently opened the door for the growing demand of land for investment, commercial, housing and other activities from time to time which were further enhanced urban expansion of the town. Moreover, urban expansion is largely associated with demand derived by physical, environmental and socio-economic activities inside urban areas (He C.*et al*., 2006; Soffianian, 2010).

Even though urban areas are covering small share of the earth's total landscape, nearly half of the world population resides in urban centers (UN, 2001). Therefore, population growth of Assela town can be thought of as a factor associated with urban expansion of the town following the influx of population from neighboring woreda and peripheral rural villages. This is true for Assela town in which urban population raised from 35,365 to 86,220 in 1985 and 2013 respectively (CSA, 2013).Urban expansion aroused by fast population growth on the other hand is a great concern for local authorities as it was a dominant factor for immense environmental problems (Mandal, 2000). Furthermore, the effort of the town municipality in terms of arranging attractive environments for trade expansion and investment promotion is also necessitated further urban expansion of the town.

5. Conclusion

This research has potentially demonstrated the effectiveness of Geographic Information system (GIS) and Remote Sensing (RS) as best tools in the study conducted on urban environments and Land-use/Land-cover change detection in particular. Moreover, the emphasis was also given to assess urban expansion process of Assela town in the last 28 years. In this regard, the research has intended to meet the pre-stated objectives by applying different spatial analysis techniques using four years multi-temporal Landsat imageries of 1985, 1993, 2011 and 2013 in combination with other vector datasets. The result of analysis from satellite imageries indicates that urban expansion in the study area has encroached fertile farm land, open space and green lots. Hence, an aggregate built-up expansion of 995.31hectares was observed and attributes for 291.64 % urban expansion between 1985 and 2031. The driving factors for urban expansion of the town were highly related to the socio-economic importance of the town. One of the main cause associated to spatial expansion process of the town is thought to be related with the population growth because of natural increase and influx from nearby rural areas during different time which increased demands of land for the investment and residential housing. Furthermore, the launched master plans of the town in 1980/81 and 2007,infrastructural development supplemented with the efforts of the town municipality in arranging conducive environment for trade and investment were factors initiated further urban expansion of Assela town.

References

[1] Araya, H. 2009.'*Urban land use change analysis and modeling'*: MSc thesis, a case study of Setuba and Sesimbra, Portugal.

[2] ATMD. 2013. '*The Structural Plan Assela town'*. Assela, Ethiopia

[3] Barredo, J., Kasanko, M., McCormick and Lavalle, C, .2003, *Modeling dynamic spatial process':* Simulation of urban future scenarios through cellular automata. Landscape and Urban Planning, 64, 145-160.

[4] Bahiru ,Z.1991. *'A History of Modern Ethiopia 1855-1991'*.Adddis Ababa University Press. Addis Ababa, Ethiopia.

[5] CSA.2013. *'The 1994 Population and Housing Census of Ethiopia*: Results for Oromia Region. Statistical Report on Population Size & Characteristics, Volume I: Part I, Addis Ababa.

[6] Desai, C., Patil, V.,Mahale and Umrikar B,. 2009. *'Application of remote sensing and GIS to study land use/land cover changes*: a case study of Pune Metropolis Advances in Computational Research, ISSN: 0975–3273, Volume 1, Issue 2, 2009.

[7] EMA. 2013. 'Topographic Map of Assela Town'. Addis Ababa, Ethiopia.

[8] Epstein, J., Payne and Kramer, E. 2002. 'Techniques for mapping suburban Sprawl', Photogram metric Engineering and Remote Sensing, Vol. 63(9): pp. 913 – 918.

[9] He, C., Okada, N., Zhang, P.Shi, J. Zhang. 2006. *Modeling urban expansion scenarios by coupling cellular automata model and system dynamic model in Beijing*, China. Applied. Geography. pp. 323-345.

[10] Hofstee and Brussel. 1991. *'Analysis of suitability for urban expansion in Villavicencio'*, Colombia. International Institute for Geo-Information and Earth Observation (ITC), The Netherlands**.**

[11] Jensen, J.R. 1996.*'Introductory Digital Image Processing'*: A Remote Sensing Perspective, 2nd Ed.New Jersey, Prentice-Hall.

[12] Jensen, J.R. 1996.'*Introductory Digital Image Processing'*: A Remote Sensing Perspective, 2nd Ed.New Jersey, Prentice-Hall.
[13] Jensen, J. R.2004. '*Introduction digital image processing*: A remote sensing perspective. New York: Prentice Hall
[14] Lillesand, T. and R. Kiefer. 2004. '*Remote Sensing and Image Interpretation'*, Fifth Edition. John Wiley & Sons, Inc., New York.
[15] Mandal, R. 2000. '*Urban Geography: A text book,,* Concept publication Company, New Delhi.
[16] Pontius, R. G., Jr., Shusas, E., &McEachern, M. (2004). '*Detecting important categorical Land Changes while accounting for persistence*. Agriculture, Ecosystems and Environment, 101(2–3), 251–268. doi:10.1016/.agee.2003.09.008.
[17] Shlomo A., C. Sheppard, and L. Civco. 2005. '*The Dynamics of Global Urban Expansion. Transport and Urban Development Department;* The World Bank. Washington D.C.
[18] Soffianian, M, L. Yaghmaei and S. Falahatkar, 2010. '*Mapping and Analyzing UrbanExpansion Using Remotely Sensed Imagery in Isfahan*, Iran. World Applied Sciences Journal.
[19] Sudhira, T., Karthik, K. Rajand andJagadish. 2003. '*Urban Growth Analysis using Spatial and Temporal Data'*. Journal of the Indian society of Remote Sensing.
[20] Tran H. andY.Yasuoka, 2000. *'RS and GIS to Study the Sub-urbanization Dynamic'*: A Case Study in Northern Bangkok, Thailand. Proceedings of the International Chao Phraya Delta's Conference: Historical Development, Dynamics and Challenges of Thailand's Rice Bowl, Bangkok, Thailand, Vol. 1, pp. 111-123.
[21] UN, 2001. '*World urbanization prospects:* the 1999 revision'. New York: United Nations.
[22] Wenli, H., L.Huiping, L.Qingzu, B.Mu.2007. '*Monitoring urban expansion in Beijing'*, China by Multi-temporal TM and spot images. School of Geography, Beijing Normal University, Beijing, China.
[23] Xiao, J., Shen, Y., Ge, J. 2006. '*Evaluating urban expansion and land use change in Shijiazhuang, China*, by using GIS and remote sensing. Landscape and Urban Planning 75, 69–80.
[24] Zewdu, 2011. '*Analysis of Urban growth and sprawl mapping using RSand GIS (Case study of Debre Birhan town)*, M.sc.thesis,Addis Ababa University.Addis Ababa, Ethiopia.