

Monitoring Urban Growth: The Case of Burayu Town, Oromia Regional State of Ethiopia

By:

Birhanu Girma Abebe^{1*)}, Bedane Shata Gameda²⁾, Agemasie Gebeyehu Amare³⁾

¹⁾Ethiopian Institute of Architecture, Building Construction, and City Development, Addis Ababa University, Ethiopia

²⁾Addis Ababa City Land Development and Administration Bureau, Ethiopia

³⁾Geospatial Researcher at Ethiopian Geospatial Information Institute, Ethiopia

^{*)}Corresponding author: mesi.bire@gmail.com

Submission: January 26, 2024; Accepted: May 13, 2024

ABSTRACT: Due to the presence of a low level of urbanization in developing countries, the horizontal expansion of cities/towns is obvious and results in a rapid rate of urbanization. To monitor the horizontal expansion/growth of the Burayu town from 1986 to 2020 and forecasting by 2030, a time series and high-resolution aerial and satellite images were used. Besides, GIS tools and techniques were applied to organize and analyze the data. Results indicate that the town of Burayu horizontally expanded by 6,331 Ha from year 1986 to 2020; and will expand doubly by 2030. To monitor the growth/expansion of towns and cities of the urban extent, the town administration and decision-makers should promote; the compact city and mixed-use principles, as well as the regional planning approaches.

Keywords: GIS, Horizontal Expansion, Urban Growth, Urbanization, Ethiopia

ABSTRAK: Disebabkan rendahnya tingkat urbanisasi di negara-negara berkembang, perluasan kota cenderung semakin meluas secara horizontal dan di sisi lain juga telah mengakibatkan laju urbanisasi yang pesat. Penelitian ini memantau perluasan atau pertumbuhan secara horizontal dari Kota Burayu dari tahun 1986 hingga 2020 dan estimasi perkiraannya untuk tahun 2030 dengan menggunakan serangkaian gambar udara dan satelit beresolusi tinggi. Selain itu, alat dan teknik GIS diterapkan untuk mengatur dan menganalisis data. Hasil penelitian menunjukkan bahwa Kota Burayu secara horizontal telah mengalami perluasan 6.331 Ha dari tahun 1986 hingga 2020 dan diestimasi akan berkembang dua kali lipat pada tahun 2030. Untuk memantau pertumbuhan atau perluasan kota-kota di wilayah perkotaan, pemerintah kota dan para pengambil kebijakan perlu untuk menerapkan prinsip tata kota secara kompak dan melakukan serta pendekatan perencanaan wilayah yang baik.

Kata Kunci: GIS, Perluasan Kota, Pertumbuhan Kota, Urbanisasi, Ethiopia

INTRODUCTION

Urbanization is a dominant phenomenon in the world; it increases the number of people globally who live in urban areas (Hannah & Max, 2019). While the rate of urbanization is rapid in developing countries that leads to unorganized expansion (Ibrahim & Mosbeh, 2015). On the other hand, cities have always attracted people with their vibrancies, energy, and most great opportunities that has tremendous pressure on the city's resources which forced cities to expand horizontally or vertically (Sunny, 2016). Moreover, the population density and socio-economic issues are highly affecting horizontal and vertical urban growth (Weixing, et al, 2017). As indicated in the UN estimation in 2017, the level of urbanization in Ethiopia is 20.31%; the UN-Habitat study (2014) indicated that 73.9% population of Ethiopia live within slum areas and low standard of living.

The term urbanization is changing through time: as it is the process of urban growth, it can be a process or instrument of social change and development. It reflects a change in thinking about development. Therefore, it includes the improvement of human and social conditions as a catalyst for balanced and sufficiently rapid economic growth (Nijhoff, 1968). According to Mark (2014), urbanization is the formation process of cities and their growth and expansion due to the growth of rural communities. The increment of the urbanization process in developing countries is the result of the growing proportion of the population in cities due to rural to urban migration (J-P Ancot, 1983).

According to Bhatta, the major causes of urban growth are population growth, independence of decision, economic growth, and industrialization, expectations of land appreciation, land hunger attitude, legal disputes, physical geography, development and property tax. Besides, population growth due to migration and natural birth is the first and most notable reason for urban growth (Bhatta, 2010). Lack of appropriately managing growing urban land area aggravates urban inequality, greater economic stresses, and environmental risk for the city as a whole. Further lower-income groups are highly affected while the city expands to the outer ward; the land prices and cost of rent push them to the periphery. Associated with the city's explanation, it demands and requires infrastructures, public services, and facilities. Therefore, it costs the municipality unnecessary additional costs and burdens. The rapid increment of the population also creates congestion, *slumization*, and pollution in the core area leading to the city expanding and/or sprawl to the periphery (Jillian & Anjali, 2019).

According to Gemechu (2018), the rapid expansion of squatter settlements in the town of Burayu was due to the uncooperative procedures and very poor performance of management and implementation system. The problem also aggravated due to the presence of 'networked government bureaucrats and brokers' (Gemechu, 2018). The main cause of illegal settlement and expansion was unfair compensation paid for expropriated farmland and a high rate of the lease price (Dinsa, 2016).

The government of Ethiopia has developed and implemented urban planning policies and strategies to provide a framework for sustainable development. The guidelines developed are based on the approaches that cities should have an accelerating and promising role in local and national growth. It has a significant role in job opportunities, housing provision, and investment in large and small urban centers (Kassahun & Tiwari, 2012). However, due to the presence of a traditional land management system, informal land acquisition, corruption, land speculations are the main challenges of land management in the town. That is the effect of the weekly institutional framework and the top-down planning approach (Dube, 2013).

According to Dinsa (2016), there is an imbalance between land compensation values and lease price. It exposes the land speculation and informal land market and informal settlement. Thus, he argues that the existing land rules and regulation of the land lease, property compensation, and expropriation law should be revised and amended (Dinsa, 2016). The horizontal growth of the towns highly consumes the agricultural land. It undesirably affects the livelihood of the community. Thus, lack of urban good governance and absence of the right regulations on land expropriation and compensation results in the informal market and illegal settlement (Bekele, 2010). According to Mekonnen (2012), due to lack of skilled professionals, commitment, political and personal interest, institutional and financial limitation are the major challenges of urban planning implementation. Besides, those problems exposed for the incompatible land use implementation and informal settlement (Mekonnen, 2012).

The integrated master plan of Addis Ababa and Oromia special zone towns was the momentous approach and the first planning of the cities to consider the surrounding outskirts of the city. However, the planning was not implemented due to criticism raised from the Oromia region, which results in an uprising and diverting the planning issues. Nevertheless, the planning process and the implementation shall be executed collaboration and participatory approach with both parties to successfully implement the master plan (Merhatsidk, 2014).

In managing the horizontal expansion of urbanization, China has the best experience. They adopt a 'vertical planning system' that capacitates sustainability to realize the development of the cities and resource utilization. Even though there was a high rate of urbanization, the planning system helps them to achieve remarkable economic growth and fast reduction of poverty (Wennersten, 2018).

In the perspective, Burayu Town was founded in 1946 and it is located in Oromia Special Zone. The town has an integrated development plan in 2006 and a structured plan in 2014 (Burayu Town Administration, 2018). It is one of the highly expanding neighborhoods and interconnected towns with the city of Addis Ababa, which is the base for many countries' embassies, international companies, and the capital city of the country. Hence, for managing the expansion of towns and cities, GIS tools and techniques play a vital role (Karen & Jarlath, 2018). Accordingly, high spatial and temporal resolution images for several years are required. The resolution increases the assessment of urban growth in the past, present, and future (Coffey, 2013). Therefore, to manage the rapid expansion, monitoring of urban growth over time is critical for the urban planners and decision-makers.

Lastly this study attempts to assess the expansion of the town from 1986 to 2020 and estimate the urban growth trends of the town by 2030 and suggest potential points for the town administrations and policymakers.

METHODS

Study area

According to the town administration (2018), Burayu Town was founded in 1946. Nowadays the town is found in the Oromia special zone, Oromia Regional State of Ethiopia. It is located in the northwestern fringe, and 15km far from the center of Addis Ababa. As figure-1 shows, spatially the town extends between 90 02' 00" to 90 02' 30" N Latitudes and 380 03' 30" to 380 41'30" E longitudes.

Population

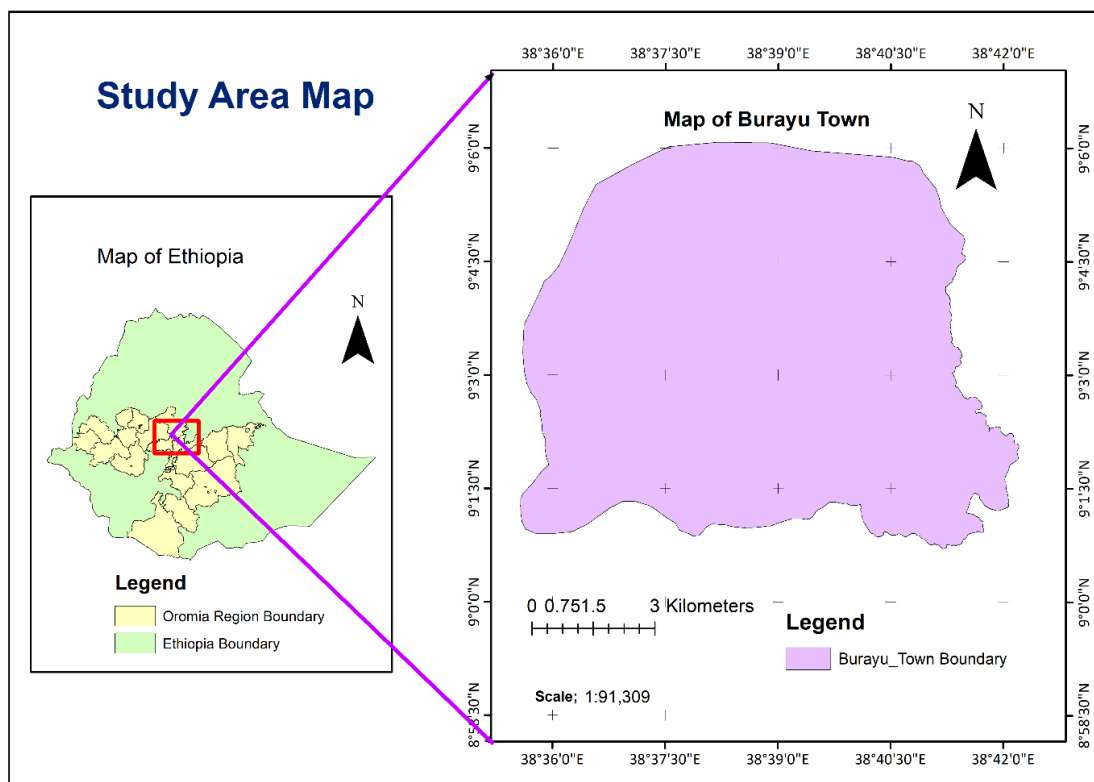
According to the CSA census reports, the total population of Burayu Town in 1986 was 4,934. In 1996 and 2006, the population of the town was 11,766 and 58,503 respectively. Based on the 2007 census, the CSA population projection shows that the population of Burayu Town in the years 2014 and 2017 was estimated at 86,343 and 97,997 respectively (CSA, 2013).

Data sources

In this study, both primary and secondary data sources are used. Primary data was collected through interviews of the federal urban planning preparation, implementation, and follow-up Bureau and Burayu Town administration higher officials and experts, and field and personal observation. Whereas secondary sources; 15cm (2014) and 25cm (2017) resolution aerial image, 5m (2006) resolution SPOT-5 images, and additionally 30m Landsat-5 (1986 & 1996) and Landsat-8 (2020) spatial and temporal resolution historical images are used to show the trends in a meaningful manner. Moreover, different books, journals, websites, and documents were used to compare and prove the findings.

Methods of data extraction and analysis

To extract, organize, and analyze information's from the aerial, satellite imagery was mainly used. Moreover, GIS software of Arc Map, Microsoft office (Word, Excel, etc.) and software were programs used. As Lingli, et al., (2008) and Jason & Anne (2013) stated spatial, radiometric, and spectral enhancements were practical for multi-temporal and spatial resolution aerial and satellite images.



Source: Computed using the town administration boundary shape file overlay with Ethio- GIS data, 2020

Figure 1: Locational Map of the study area

Further, to maintain the data consistency, the spatial resolutions of the image were re-sampled into 5m resolution and used visible spectral bands. On the other hand, according to (Schneider, et al., 2010 & Yao, et al., 2018) urban areas are defined as the areas dominated (more than 50%) by the built-up area with a minimum mapping unit of 1 km by 1 km, which contains all features built-ups, agricultural areas, and open spaces. Thus, the growth of the town extent digitized/extracted based on the satellite and aerial images using Arc Map software for the years 1986 to 2020 and analyzed by calculating the corresponding areas. Similarly, the annual growth rate (Eq-2) of the urban area expansion calculated the proportion of annual growth of the town with the administrative boundary (9,219 Ha) extent.

$$\text{Annual Growth} = \frac{\text{Urban Extent Coverage (Year 2 - Year 1)}}{\text{Time Fame (Year 2 - Year 1)}} \quad \dots\dots\dots (1)$$

$$\text{Annual Growth Rate} = \frac{\text{Annual Growth Coverage}}{\text{Total Own Administrative Area}} \times 100 \quad \dots\dots\dots (2)$$

Further the projection of the urban area expansion of the Burayu Town; the previous urban expansion statistics (table-2) are used. Thus, the exponential growth function (Eq-3) is used to project the urban extent expansion coverage by 2030 (Donna, 2012, Yhdego, 2007 & BYJU'S, n.d.). The projected urban area extent denotes (y), (a) represents the initial urban extent value, (r) denotes growth rate, and (t) is the time intervals between the initial and projected year.

$$y = a (1 + r)^t \quad \dots\dots\dots (3)$$

Tools of analysis and techniques of data presentation

The researchers used descriptive methods (sum, minimum/maximum, and range, percentage) to organize the data. The quantitative data is presented through statistical tools like a chart, table, figure,

and map. On the other hand, qualitative data arising from field observation and interviews are analyzed in a narrative approach.

RESULTS AND DISCUSSIONS

The horizontal growth of the Burayu town

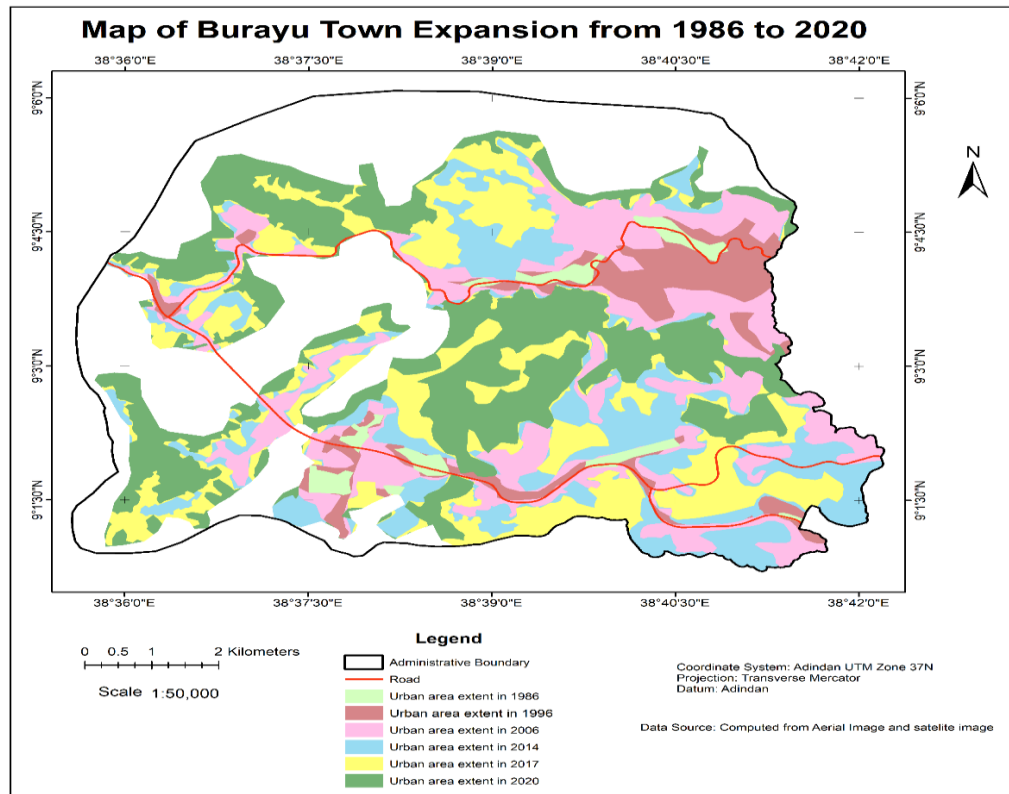
Result obtained from the satellite and aerial images of 1986, 1996, 2006, 2014, 2017, and 2020 indicates that the horizontal expansion of the town is increased from 1986 (185ha) to 2020 (6,516ha), and it more expanded in recent years than in the early years (see Table 1).

Table 1: The coverage of urban area of Burayu town from 1986 to 2020

Year	1986	1996	2006	2014	2017	2020
Area Coverage	185 ha	680 ha	2,033 ha	3,195 ha	4,599 ha	6,516 ha
Population	4,934	11,766	58,503	86,343	97,997	111,222

Source: Area computed from aerial and satellite images, 1986 to 2020, and population CSA, 2013

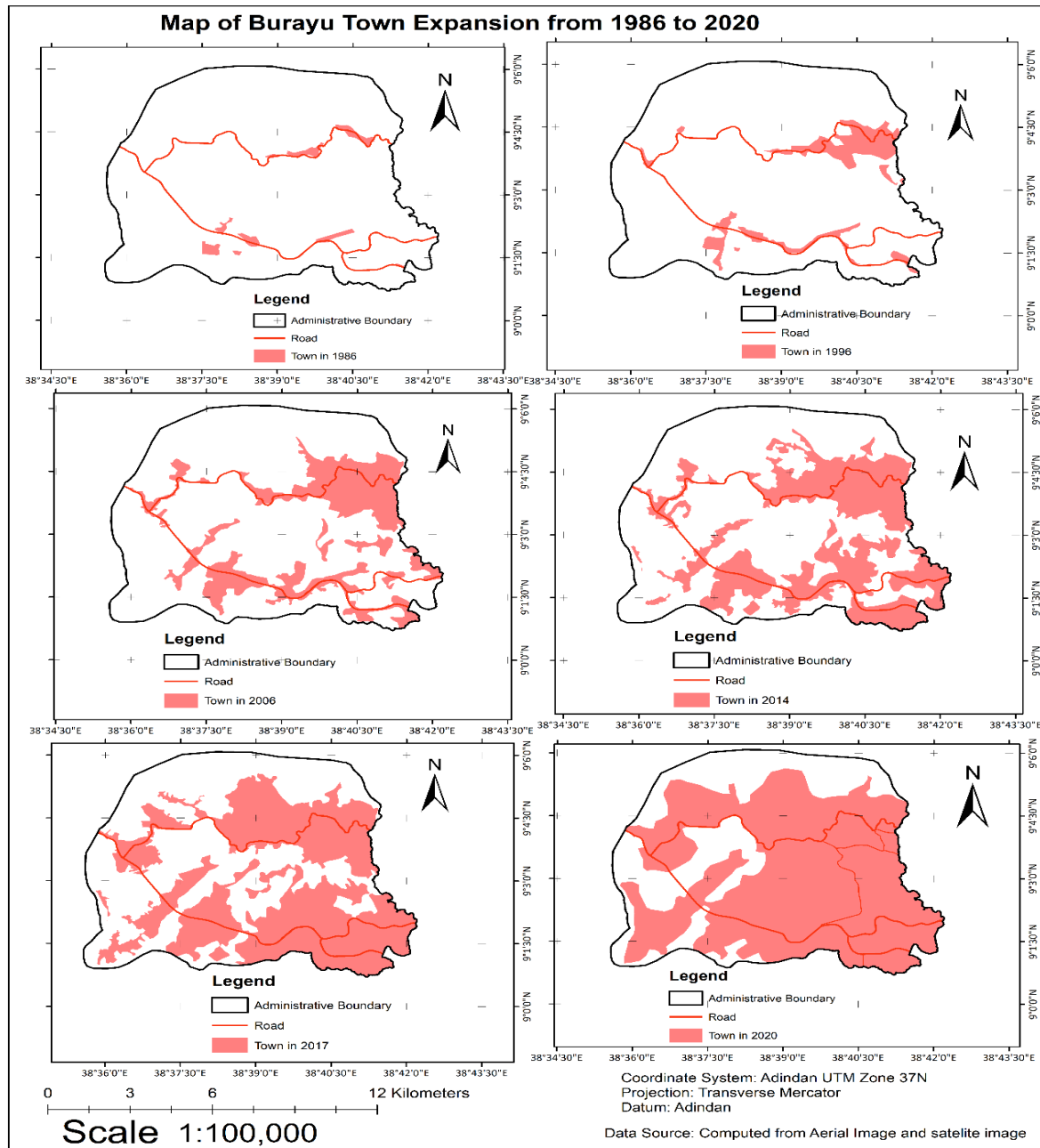
Besides, as illustrated in Figure-1 the urban expansion of Burayu Town from 1986 to 2020 is mapped by overlaying the recent year's (2020) urban extent at lower, and early year's (1986) extent at the top layer sequence. It describes how the urban area extent of the town expanded from 1986 to now.



Source: Computed from aerial and satellite images, 1986 to 2020

Figure 1: The overlay urban area Map of Burayu town from 1986 to 2020

Further, figure-3 indicates, in the early years the expansion of the town mainly along the main roads of the town, whereas in recent years, it becomes expanded to every corner of the town. Hence, the expansion trend shows that the town expands from the eastern part to the North West and Southwest part of the town.



Source: Computed from aerial and satellite images, 1986 to 2020

Figure 2: Burayu town expansion Map from 1986 to 2020

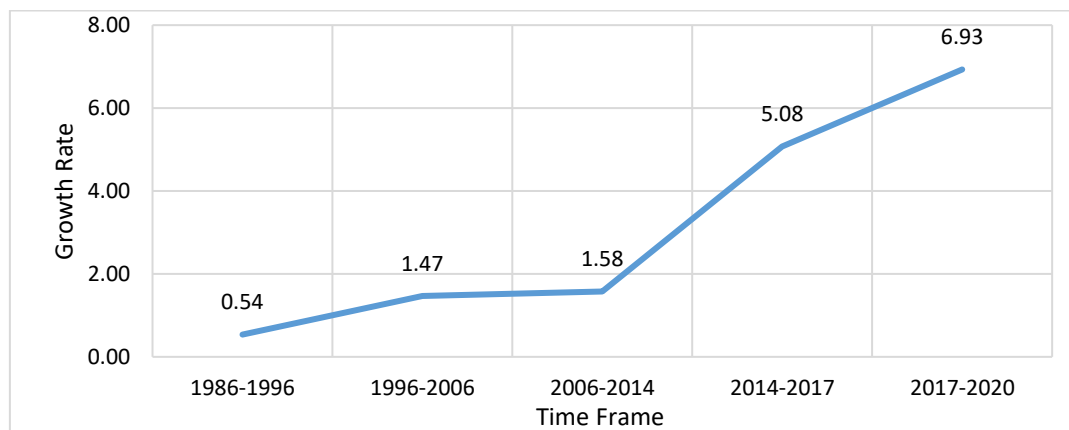
The annual growth (Eq-1) of the town was examined by computing the urban area coverage within a given year per the given time-span of recent (year 2) and early (year 1) years.

Table 2: Annual growth and expansion rate of Burayu town from 1986 to 2020

	Time frame				
	1986-1996	1996-2006	2006-2014	2014-2017	2017-2020
Expansion/ha	495ha	1,353 ha	1,162 ha	1,404 ha	1,917 ha
Time extent	10years	10 years	8 years	3 years	3 years
Annual growth	49.5 ha	135.3 ha	145.25 ha	468 ha	639 ha
Annual growth rate	0.54%	1.47%	1.58%	5.08%	6.93%

Source: Computed from aerial and satellite images, 1986 to 2020

As table-2 illustrated, the annual growth (expansion) of the town increased from 1986 to 2020. The higher annual growth was noted from 2017 to 2020 (639ha), and 2014 to 2017 (468ha). While the lower annual growth rate was noted from 1986 to 1996 (49.5ha), and 1996 to 2006 (135.3ha).



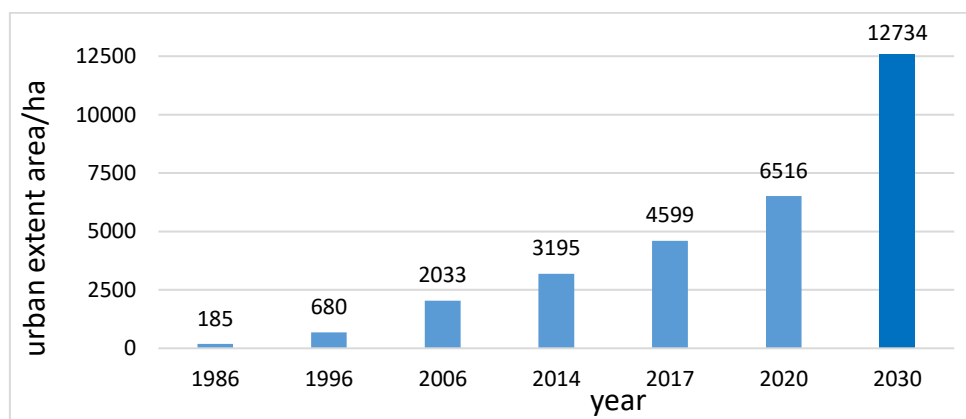
Source: Computed from aerial and satellite images, 1986 to 2020

Figure 3: Annual urban growth rate of Burayu town from 1986 to 2020

Correspondingly as figure-4 indicated that the annual growth rate of the town was higher from 2017 to 2020 (6.93%), and 2014 to 2017 (5.08%). While the lowest growth rate was from 1986 to 1996 (0.54%).

The growth trends of the town

As Figure-5 shows, the urban area extent of Burayu Town by 2030 will cover 12,734 hectares and the population projection also shows, the town will have 169,616 populations by 2030 (CSA, projection). This implies that by 2030 due to the increment of the population the urban area of the town will expand doubly and the urban extent expansion will be out of the current administrative boundary of the town (9219 ha).



Source: Computed from aerial and satellite images, 1986 to 2020

Figure 4: The urban expansion trend and projection of Burayu town by 2030

Managing the rapid expansion of Burayu town

According to the town administration and the federal urban planning bureau managements and experts, the major causes of the horizontal expansion of town were primarily associated with the rapid growth of population and the improper implementation of the urban plan of the town. Professionals also argued that even though the rapid horizontal expansion of towns and cities are expected in developing countries, the problem aggravated due to its physical linkage, social, economic, and political relation, and interconnectedness with the primate city of Addis Ababa. As officials and planning experts agreed the town of Burayu could not be free from the influence of Addis Ababa.

Further, it is highly influenced by the growth of Addis Ababa. Thus, they should have an integrated and holistic plan and implementation practice. While preparing and revising the planning of the town should promote compact city principles to reduce the rapid horizontal expansion of the towns, and the mixed-use approach

Discussion

Data obtained from focus group discussion and as explained by (Kassa, 2014), population growth contributes more to urban expansion in the study area. Similarly, horizontal urban growth has a greater correlation with population density (Weixing, et al, 2017). As (Bhatta, 2010) also stated population growth is the major cause of urban growth. Additionally (Wihbey, 2017) analyzed that when cities' populations increased twice, the explanation will be increased triply. Thus, the major cause of the rapid expansion of Burayu Town was the rapid growth of population from 1986 (4,934) to 2020 (111,222).

As (Sunny, 2016) stated towns and cities expand horizontally, especially the capital cities of the nations have the potential to expand horizontally to their suburbs. Burayu is also bounded by the city of Addis Ababa, which is the capital city of Ethiopia, so its horizontal expansion will be directly connected with the growth of Addis Ababa. When its compared with Addis Ababa city, the picked growth rate of Burayu Town is faster than the picked growth rate of Addis Ababa (6% from 1976 to 1985) (Kassa, 2014)

Thus, to manage the rapid horizontal expansion of the Burayu Town, the town administration should prepare and revised the urban plan of the town. As the urban extent plays an important role in assessing the process of urbanization (Yao, et al 2018). So, considering of existing situation of the expansion trend, the planning of the town should be revised and develop the right implementation strategies and capacity building program. Simultaneously, the town administration shall collaborate with the Addis Ababa city administration

CONCLUSION

The target of assessing the horizontal expansion is for managing and monitoring the improper urban expansion. Thus, monitoring the horizontal expansion of towns and cities is very essential for town administration and policymakers to manage the future growth of the town and to accomplish sustainability.

The growth of Burayu Town was assessed from 1986 to 2020 and projected for 2030. As per the study, the town of Burayu horizontally expanded from 1986 to 2020 by 6,331ha. The horizontal expansion of the town is rapid from early to now, and also the expansion rate and/or the conversion of rural areas to urban areas is higher than in the early years. Therefore, for managing the rapid horizontal expansion, the town administration and the policy and decision-makers should take a measurement and corrective action regarding population growth, planning practice, and other issues. Unless managing the expansion of the town, provision of housing and related services demand will be difficult. However, the role of high resolution and time serious aerial and satellite imagery is very cost-effective and vital for the preparation, implementation, monitoring, and controlling of urban planning practice and urban management. Future studies should research the influences of the primate cities on the surrounding cities and towns, and the socio-economic implications of rapid horizontal expansion of towns and cities.

Accordingly, the following main points are recommended:

- (1) As the study has shown, the rapid horizontal expansion of the town is highly correlated with the rapid growth of the population. Hence, there should be a demographic policy, to manage rural to urban and urban to urban migration of the population.
- (2) Besides, properly implementing the planning of the town, the town administration should monitor, and revised the planning of the town using a scientific approach of GIS tools and techniques that are cost-effective and highly recommended.
- (3) To minimize the horizontal expansion of the Burayu Town, the town administration should promote the compact city principles and vertical expansion.
- (4) The town has a strong socio-economic and physical linkage with the city of Addis Ababa. Accordingly, the town of Burayu should have a holistic integrated inter-regional planning

with the capital city of Addis Ababa. Thus, the government should promote regional planning approaches.

- (5) Moreover, the existing urban policies and regulations have a gap to accommodate the existing situation. Therefore, the policy-makers should formulate the policies, strategies, and regulations considering the existing situation. For instance, landowning and land value policy is contradicting the ground truth. Because of, the land compensation valued by the town administration is too much lower than the informal market as well as the lease price.

REFERENCES

- Bekele, F. (2010). *The Impact of Horizontal Urban Expansion on Sub-Urban Agricultural Community Livelihood: The Case of Tabor Sub-City, Hawassa city, SNNPRS, Ethiopia*. Addis Ababa: Addis Ababa University.
- Bhatta, B. (2010). Causes and Consequences of Urban Growth and Sprawl. In *Analysis of Urban Growth and Sprawl from Remote Sensing Data*. Springer-Verlag Berlin Heidelberg. doi:10.1007/978-3-642-05299-6_2,
- Burayu Town Administration. (2018). Retrieved December 25, 2019, from <http://www.oromiyaa.gov.et>
- Coffey, R. (2013, January 18). *Michigan State University MSU Extension*. (M. S. Extension, Producer, & Extension, Michigan State University) Retrieved from <https://extension.msu.edu>
- CSA. (2013). *Population Projection of Ethiopia for All Regions at Wereda Level from 2014 – 2017*. Addis Ababa: the Federal Democratic Republic of Ethiopia, Central Statistical Agency (CSA).
- Dinsa, M. N. (2016, May 24). *Powers of Urban Local Government on Land Administration and the Challenges of Illegal Housing: The Case of Burayu City Administration, Oromia National Regional State*. Addis Ababa: Addis Ababa University.
- Donna, R. (2012). *MathBitsNotebook*. Retrieved July 29, 2020, from Algebra 1: <http://mathbitsnotebook.com/>
- Dube, E. E. (2013, December 15). Urban Planning & Land Management Challenges In Emerging Towns Of Ethiopia: The Case Of Arbaminch. *Urban and Environmental Engineering*, 7, 340-348. doi:10.4090/juee.2013.v7n2.340348
- Gemechu, S. (2018). *The Trend and Level of Squatter Settlement in Burayu City*. Addis Ababa: Addis Ababa University.
- Hannah, R., & Max, R. (2019, November). (D. Beltekian, Editor) Retrieved from Our World in Data: <https://ourworldindata.org/urbanization>
- Ibrahim, R. H., & Mosbeh, R. K. (2015). Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. *Gulf Organisation for Research and Development*, 117-124.
- Jason, K., & Anne, A. (2013). *The Landscape Toolbox*. Retrieved December 21, 2019, from https://wiki.landscapetoolbox.org/doku.php/remote_sensing_methods:change_detection
- Jillian, D., & Anjali, M. (2019, January 31). *World Resource Institute*. Retrieved from <https://www.wri.org/blog/2019/01/too-many-cities-are-growing-out-rather-3-reasons-s-problem>
- J-P Ancot, J. H. (1983, July 27). Long-term urban trends in developing countries: some further econometric results. *Environment and Planning*, 15(1983).
- Karen, S., & Jarlath, O. D. (2018). *PennState College of Earth and Mineral Science*. (U. P. 2217 Earth and Engineering Sciences Building, Producer, & College of Earth and Mineral Sciences, The Pennsylvania State University) Retrieved from Remote Sensing Image Analysis And Applications: <https://www.e-education.psu.edu/geog883/node/496>
- Kassa, F. (2014). The Rates and Effects of Urban Sprawl in Developing Countries: The Case of Addis Ababa, Ethiopia. *International Journal of Area Studies*, 135-151. doi:10.2478/ijas-2014-0009
- Kassahun, S., & Tiwari, A. (2012). Urban Development in Ethiopia: Challenges and Policy Responses. *ResearchGate*. Retrieved from <https://www.researchgate.net/publication/256035582>

- Lingli, Z., Anna, E., Katri, K., Milka, N., Hanne, J., Nina, H., & Henrik, H. (2008, July). Georeferencing Multi-temporal and Multi-scale Imagery in Photogrammetry. *ResearchGate*. Retrieved from <https://www.researchgate.net/publication/254271705>
- Mark, J. J. (2014, April 07). Retrieved December 19, 2019, from Ancient History Encyclopedia: <https://www.ancient.eu/urbanization/>
- Merhatsidk, M. (2014, May 11). *Fortune*, 14. Retrieved September 5, 2020, from <https://addisfortune.net/columns/a-master-of-plans/>
- Nijhoff, M. (1968, December). Urbanization in Developing Countries, Report of a symposium, held in December 1967 at Noordwijk, Netherlands. *Urbanization in Developing Countries*. Noordwijk, The Hague, Netherlands in 1986., Netherlands: Springer Science.
- Sunny, K. (2016, November 21). Retrieved July 08, 2019, from <https://medium.com/@SunnyKulkarni/city-expansions-and-the-vertical-urbanization-approach-10280a05a01>
- Wang, F. (1990, March). Fuzzy Supervised Classification of Remote Sensing Images. *Transactions on Geoscience and Remote Sensing*, 28, 202. doi:10.1109/36.46698
- Weixing, Z., Weidong, L., Chuanrong, Z., & William, B. (2017, March 24). Detecting horizontal and vertical urban growth from medium resolution imagery and its relationships with major socioeconomic factors. *International Journal of Remote Sensing*, 38, 3704–3734. doi:10.1080/01431161.2017.1302113
- Wennersten, R. (2018). Development of New Sustainable Urban Areas: Horizontal or Vertical Planning Systems for ResourceEfficient Cities. *IntechOpen*. Retrieved from <http://dx.doi.org/10.5772/intechopen.79426>
- Wihbey, J. (2017, November 2). Boundary Issues: The 2016 Atlas of Urban Expansion Indicates Global Dedensification. *Cityscape: A Journal of Policy Development and Research*, 19.
- Yao, Y., Chen, D., Chen, L., Wang, H., & Gua, Q. (2018, May 24). A time series of urban extent in China using DSMP/OLS nighttime light data. (T. A. Warner, Ed.) *PLoS ONE*. Retrieved from <https://doi.org/10.1371/journal.pone.0198189>