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Land cover dynamics and urbanization in peri-urban areas: Assessing the socio-economic and environmental consequences of rapid urban expansion

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Abstract
Rapid population growth has accelerated urbanization, significantly altering land use and land cover in peri-urban areas. This study examines the urban expansion of Wolaita Sodo Town in South Ethiopia over the past two decades (2003–2023) and its socio-economic and environmental implications. A longitudinal research design was employed, combining remote sensing and GIS-based analysis of Landsat satellite imagery from 2003, 2013, and 2023 with qualitative insights from key informant interviews to assess land cover dynamics and community-level impacts. The results show that the built-up area expanded from 4,654 ha (10.8%) in 2003 to 7,914.9 ha (18.4%) in 2013 and further to 11,681.5 ha (27.2%) in 2023, while agricultural land declined from 35,891.9 ha (83.5%) in 2003 to 28,389.8 ha (66%) in 2023. Over the study period, the average annual rate of urban expansion increased from 326.09 ha/year (2003–2013) to 376.66 ha/year (2013–2023), with an overall rate of 702.75 ha/year across the 20 years. This rapid urban growth has led to large-scale land expropriations, disproportionately affecting peri-urban farmers whose agricultural lands were converted into residential, industrial, and infrastructure zones. As a result, agricultural productivity has declined, forcing many affected households to transition into low-paying informal sector jobs, contributing to economic instability and increased vulnerability. The study highlights the urgent need for integrated urban planning and sustainable land management strategies to mitigate these adverse impacts. In particular, improving compensation mechanisms for displaced communities, ensuring equitable land policies, and enhancing access to essential services are crucial for promoting resilience. The findings emphasize the importance of adopting a holistic approach to urban development that balances the needs of expanding cities with environmental conservation efforts.\

Keywords: Land cover change, Environmental consequences, Peri-urban areas, Rapid urban expansion

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1. Introduction

Urbanization, a global phenomenon driven by population growth and economic development, has significantly altered land use patterns and socioeconomic structures in both developed and developing countries (Borku et al., 2024a). The rapid expansion of urban areas is particularly pronounced in sub-Saharan Africa, where cities are growing at unprecedented rates due to rural-to-urban migration, natural population increases, and policy-driven urban development. Ethiopia, one of Africa's most rapidly urbanizing nations, exemplifies this trend, with its towns and cities expanding rapidly to accommodate increasing populations. While urbanization is often associated with economic growth and improved access to services, it also presents critical challenges, particularly in peri-urban communities, where land use transformations disrupt traditional livelihoods, threaten food security, and contribute to socio-economic inequalities. The physical extension of urban areas into rural and agricultural zones marks one of the most visible indicators of this process. As urban populations increase, the demand for land in cities rises, often leading to encroachment upon agricultural land and natural ecosystems (Congalton & Green 2019; Navruz & Mücahit 2022; Abdulai 2022). This phenomenon is not isolated to the global North but is increasingly being witnessed in developing economies, particularly in regions of Africa and Asia, where urbanization is rapidly reshaping landscapes and socio-economic structures (Phiri & Morgenroth, 2017; Deribew; 2020; Henderson et al., 2020).

The increasing populations and economic development in emerging economies are driving rapid urban growth, which creates significant challenges for maintaining sustainability and protecting biodiversity. To accommodate this growth, natural landscapes are being converted into urban areas, leading to land use changes (Li et al., 2022). This conversion, spurred by governmental policies aimed at facilitating urban development, results in the loss of agricultural land and natural habitats, impacting food security and local economies (Putra et al., 2020). Many developing countries are struggling to keep pace with the speed of urbanization, leading to negative consequences for both urban and rural communities (Chen et al., 2018).

The rapid urban expansion seen in Africa, and specifically in East Africa, illustrates the global trend of fast-paced urbanization. In 1975, only a quarter of the African population lived in cities, but by 2000, this number had risen to 38%, and projections indicate that over 50% of Africa's population will be urbanized by 2050 (Ramiaramanana et al., 2021). Ethiopia, despite its relatively low overall urbanization rate, has been experiencing one of the highest rates of urban growth in the world, which has put immense pressure on its agricultural land (Wassie, 2020). This rapid urbanization is not without consequences, as it often results in the displacement of rural populations, changes to land use practices, and increased environmental degradation (Borku et al., 2024c).

In Ethiopia, the urban development policy has heavily relied on the expropriation of urban farmland, often displacing local farmers in favor of urban expansion (Mohammed et al., 2020). This process has led to various socio-economic challenges, including increased migration, overpopulation in cities, and the degradation of natural resources. Moreover, the expansion of cities has been largely unplanned, contributing to air, noise, and visual pollution, as well as environmental degradation from industrialization and unsustainable resource use (Voumik & Sultana, 2022). This urban sprawl not only impacts urban areas themselves but also exerts significant pressure on peri-urban regions, where land use changes dramatically as rural areas are converted to urban land (Huang & Grimmond, 2019). The peri-urban interface is particularly vulnerable to these changes, as it is often a site of both agricultural production and urban expansion, making it a critical zone for managing land use and ecological impacts (Zhou et al. 2018; Afriyie et al., 2020).

Wolaita Sodo Town, a rapidly growing urban center in southern Ethiopia, serves as a prime example of the profound impacts of urbanization on peri-urban communities. The town has experienced significant spatial expansion over the past two decades, driven by infrastructural development, industrialization, and increasing demand for residential and commercial spaces

(Badesso, 2020). This expansion has led to widespread land cover transformations, primarily the conversion of agricultural land into urban infrastructure, housing, and industrial zones. Such changes have far-reaching consequences for peri-urban farmers and local communities, as they often face land expropriation, displacement, and economic instability due to the loss of their primary livelihood sources (Admasie & Debebe, 2016).

One of the major consequences of rapid urban expansion is the decline of agricultural land in peri-urban areas (Fitawok et al., 2020). Agriculture has historically been the backbone of Ethiopia's economy, providing employment and food security for a large portion of the population (Bekelcha et al., 2019). However, as cities expand, farmland is increasingly converted into urban developments, reducing the land available for cultivation and disrupting traditional farming practices. In Wolaita Sodo Town, the encroachment of urban areas into agricultural zones has led to declining agricultural productivity, forcing many peri-urban farmers to seek alternative income sources, often in the informal sector (Foody 2002). This transition is not always smooth, as many displaced farmers lack the necessary skills and capital to establish stable non-agricultural livelihoods, resulting in economic vulnerability and increased poverty levels (Fragkias et al. 2013; Belay et al., 2022).

Furthermore, the socio-economic impact of urbanization extends beyond land loss. The displacement of peri-urban communities often leads to inadequate compensation and insufficient access to essential services such as education, healthcare, and transportation (Talebi Khiavi et al., 2022; Alaei et al., 2024). Many affected households struggle to adapt to the rapidly changing urban landscape, facing difficulties in securing stable employment and affordable housing (Borku et al., 2024a). This growing economic insecurity exacerbates social inequalities and contributes to urban poverty, making it crucial to assess the broader implications of land use transformations on peri-urban residents' well-being. While urban expansion is inevitable, how it is managed determines its long-term sustainability. Sustainable urban planning and land use management are essential to mitigate the negative consequences of rapid urbanization. Policymakers must implement comprehensive land policies that balance urban growth with environmental conservation and social equity. Strategies such as equitable land acquisition policies, fair compensation for displaced communities, and investments in alternative livelihood programs can help create a more inclusive and sustainable urbanization process. Additionally, integrating green infrastructure and environmental protection measures into urban development plans can mitigate the adverse ecological impacts of land cover changes, ensuring that urban expansion does not come at the cost of long-term environmental degradation (Belay 2014; Ayenachew & Abebe, 2024).

This study aims to analyze the effects of urbanization and land cover transformations on peri-urban areas in Sodo Town over 20 years (2003–2023). The significance of this study lies in its contribution to the growing body of research on urbanization and its impacts on peri-urban communities in Ethiopia. While numerous studies have examined urban expansion in major Ethiopian cities (Kasa et al., 2011; Mohammed, 2020; Weldearegay et al., 2021), there is limited research on the effects of urban growth in secondary cities like Wolaita Sodo. Understanding the dynamics of land use transformation in such emerging urban centers is crucial for formulating informed urban policies and development strategies that prioritize both economic growth and social equity. In addition to contributing to academic literature, the findings of this study hold practical implications for urban planners, policymakers, and local authorities. By identifying key trends in urban expansion and their consequences, the research provides valuable insights for designing land use policies that protect peri-urban livelihoods while accommodating urban growth. It also emphasizes the need for participatory urban planning approaches that involve affected communities in decision-making processes, ensuring that urban development initiatives align with local needs and aspirations.

2. Materials and Methods

2.1. Study area setting

The Wolaita zone is one of the 12 newly established zones within the South Ethiopia Regional State. The region was created as the 12th Regional State in Ethiopia, with its formation occurring on August 19, 2023, following a successful referendum. Wolaita Sodo, the administrative center of the Wolaita zone, is situated approximately 329 km from Addis Ababa, the capital of Ethiopia. According to the Wolaita Zone Finance and Economic Development office, the zone is bordered to the north by the Hadya, Kembata, and Tembaro zones, to the east by the Sidama zone, and to the south by the Qucha and Boreda zones of the Gamo region. The Wolaita zone encompasses a total area of 451,170 hectares and is administratively divided into 16 districts, 7 town administrations, and 362 Kebeles, with 289 being rural and 73 urban. Sodo serves as both the political center of the Wolaita zone and one of the capitals of the SERS, holding significance in both political and administrative capacities (Borku et al., 2024a). Wolaita Sodo is a rapidly growing city located in the Wolaita zone of the Southern Nations Nationalities and Peoples Regional State of Ethiopia. The town is situated between 6º 44' 30" and 7º 9'49" latitude, and 37º 34' 47" and 37º 98' 58" longitude. It serves as the administrative hub for the Wolaita Zone and South Ethiopia, situated approximately 320 kilometers southwest of the national capital, Addis Ababa. Sodo is characterized by a diverse topography, ranging from 1,600 to 2,222 meters above sea level, with a predominantly flat terrain and fertile soils.

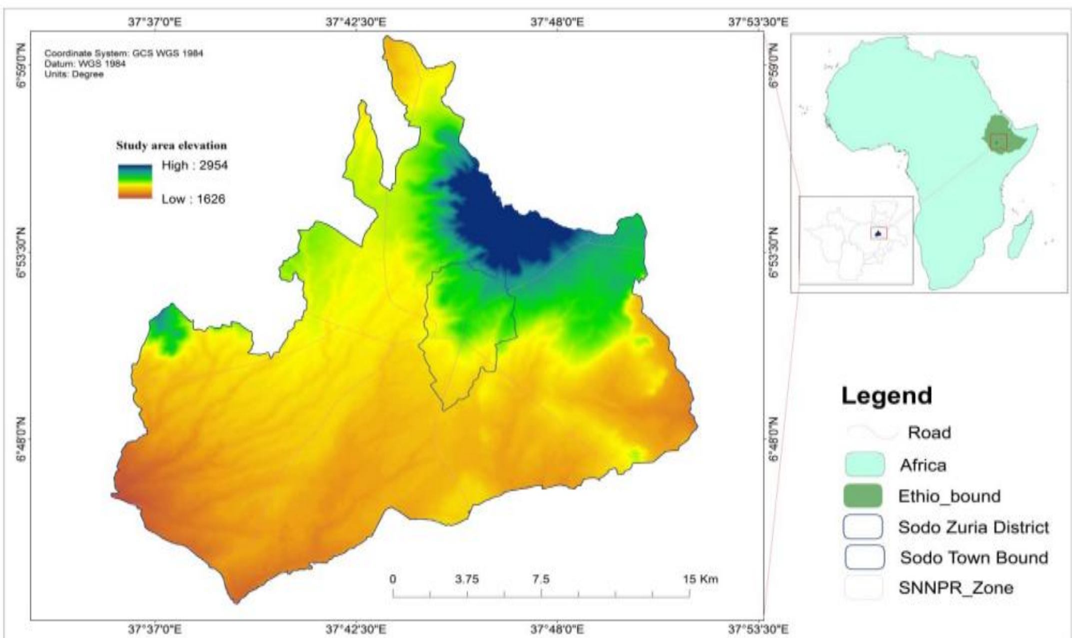

Figure 1. Location of the study area in Gesha District, Kaffa Zone, Southwest Ethiopia

2.2. Procedures for soil data

A longitudinal research design was implemented to analyze the spatiotemporal dynamics of land cover change and urban ecosystem transformation in the study area. This approach was chosen due to its ability to track changes over extended periods using data collected from the same geographical region at different time intervals. By adopting a longitudinal framework, the study effectively captures patterns of land cover modification, providing a comprehensive understanding of urbanization's progression. Additionally, this design facilitates the identification of sequential developments, enables an in-depth examination of shifting land use trends, and offers valuable insights into causal relationships between urban expansion and ecological transformations. This methodological choice enhances the reliability of findings by reducing temporal inconsistencies, allowing for a more precise assessment of urban growth impacts on local ecosystems and community livelihoods (Borku et al., 2024a). We selected two experts from the agricultural and rural development office, two political leaders, two municipal office experts, and two natural resource management office experts for personal interviews. This selection was based on their experience and knowledge regarding land cover change dynamics and urban expansion in the region.

2.3. Classification of LU/LC Data

Landsat satellite imagery is widely utilized for remote sensing applications in land use and land cover (LULC) mapping, planning, and change detection due to its high spectral, spatial, and temporal resolution (Onačillová et al., 2022). In this study, Landsat images served as the primary data source for LULC classification, change analysis, and spatial mapping. The required satellite images and processed datasets were accessed from the United States Geological Survey (USGS) Earth Explorer platform, ensuring reliability and consistency in data acquisition. To examine the spatiotemporal changes in LULC over two decades, the study selected three key years: 2003, 2013, and 2023 based on significant historical events that influenced land use patterns. The year 2003 was chosen as the baseline, as Ethiopia's economy at the time was predominantly agrarian, and the nation's development policies had direct implications for land use transformation. Furthermore, while the Ethiopian government introduced the Millennium Development Goals (MDGs) in 1999/2000, aiming for an annual economic growth rate of 5.7% until 2015 to reduce poverty, its impact on LULC changes became more evident over time. Consequently, the 2013 Landsat image was selected to capture the mid-term effects of these developmental initiatives on land use patterns (Phiri & Morgenroth, 2017; Ramiaramanana, Nantenaina & Jacques, 2021; Navruz & Mücahit, 2022).

The most recent image, from 2023, was incorporated to assess the contemporary LULC conditions, particularly in response to the Ethiopian Prime Minister's Green Legacy Initiative launched in 2020. This large-scale afforestation program aimed to mitigate deforestation, enhance environmental sustainability, and potentially reshape land cover dynamics across urban and rural areas. By integrating these three datasets, the study provides a comprehensive evaluation of urban expansion, agricultural land conversion, and the broader ecological implications of policy-driven land use changes. The selected Landsat images, corresponding to Path 170 and Row 056, were freely available from USGS, ensuring data accessibility for analysis. This methodological approach enhances the study's capacity to detect trends, assess the long-term consequences of urbanization, and offer insights for sustainable land use planning in the region (Mohamed & Worku, 2019).

Table 1: Landsat image information

Satellite sensor	Sensor	Date	Path and row	Spatial resolution (m)
Landsat 7	ETM+	07,02,2003	170/056	30*30
Landsat 7	ETM+	07,02,2013	170/056	30*30
Landsat 8	OLI	07,02,2023	170/156	30*30

The dry season was chosen for analysis as it provided clearer satellite imagery, free from cloud cover, which allowed for a more accurate distinction between cultivated areas and grasslands. Once the satellite images were obtained, they were processed and categorized using ERDAS Imagine 2015 and ArcGIS 10.4 software. This approach ensured better image clarity and enhanced the reliability of land cover classification, making it easier to monitor agricultural changes over time. Using these advanced software tools also facilitated precise analysis of land use patterns and environmental shifts (Yuan et al. 2005; Ayele et al., 2023). Moreover, the satellite images were then classified into five categories: (see Table 2). The aim of generating classification maps for three different periods was to assess how human activities, both past and present, have influenced changes in the landscape. These thematic maps were subsequently used as inputs for change detection analysis, which aimed to identify transitions between various land cover and land use classes. This approach provided insights into the dynamics of land use change and its implications for environmental planning and management.

Table 2: Description of land use and land covers

Value	Name	Description
1	Forest (FL)	A significant aggregation of tall, densely packed vegetation, typically around 15 feet or taller, exhibiting a continuous or thick canopy. This includes forested areas, dense clusters of tall plants within savannas, plantations, wetlands, or mangrove ecosystems, where the vegetation density may coincide with transient water bodies or where the canopy is sufficiently thick to obscure any underlying water.
2	Shrub land (SL)	Regions dominated by vegetation intermingled with water for a substantial part of the year; these seasonally inundated areas comprise a mosaic of grasses, shrubs, trees, and exposed soil. Examples include flooded mangroves, emergent vegetation zones, rice paddies, and other extensively irrigated or waterlogged agricultural landscapes.
3	Agricultural land (AL)	areas planted with cereals, grasses, and other crops that remain below tree height, including maize, wheat, soybeans, and fallow plots within managed agricultural land.
4	Built Area (BUA)	Anthropogenic structures encompass major road and rail networks, as well as extensive, uniform impervious surfaces such as parking areas, commercial buildings, and residential complexes. Examples include individual houses, densely populated villages, towns, and cities, in addition to paved roads and asphalted surfaces.
5	Open land	Areas dominated by bare rock or soil with little to no vegetation year-round; these include extensive sandy expanses and regions largely devoid of plant cover. Examples comprise exposed bedrock or soil, deserts and dunes, dry salt flats or pans, desiccated lakebeds, and mining sites.

Source: Author's survey 2023

Following the identification of land cover types, the subsequent step involved detecting changes in land cover. Land cover change detection entails identifying spatial and temporal variations in land use/land cover within the study area. Changes were analyzed sequentially using Landsat-derived remote sensing datasets from 2003, 2013, and 2023, with attention to specific land cover classes. This process was carried out by overlaying the classified satellite images and assessing differences through image differencing (Figure 2). Among various techniques for detecting land use/cover changes, the post-classification comparative method is one of the most widely employed. This approach entails independently classifying images from different time periods and then comparing them either on a map-to-map or image-to-image basis (Wang et al., 2020). By classifying and labeling images from multiple years, the post-classification method allows for a clear assessment of temporal changes. Beyond detecting changes, the classified images also supported mapping exercises and layout preparation. Furthermore, the accuracy of the image classification was verified through ground-truthing, ensuring the reliability and validity of the results.

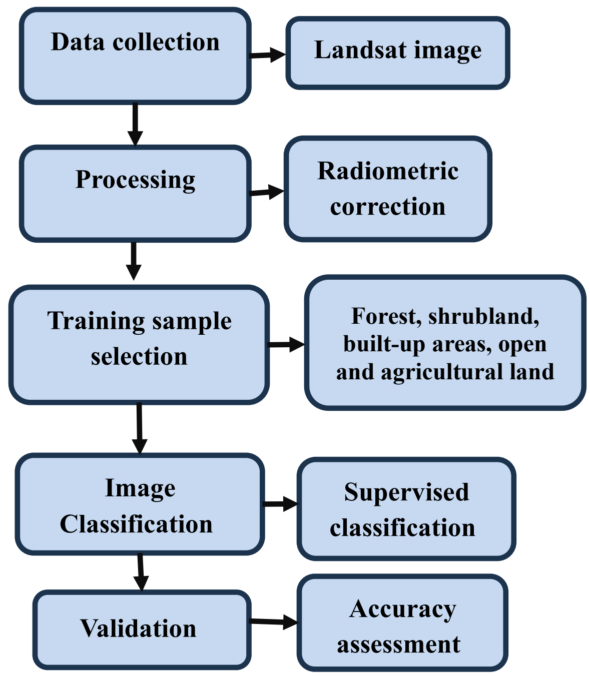

Figure 2. Methodological workflow of the study area

3. Results

3.1. Land use/cover change (2003)

Table 4 shows the major land use/cover types of the study area in both quantitative and thematic formats. In the current year, agricultural land dominated, covering 35,891.9 ha, which represents 83.5% of the total study area. The next largest category was built-up areas, occupying 4,654 ha (10.8%). Open land constituted the smallest portion, accounting for only 1.6 ha (0.004%) of the total area.

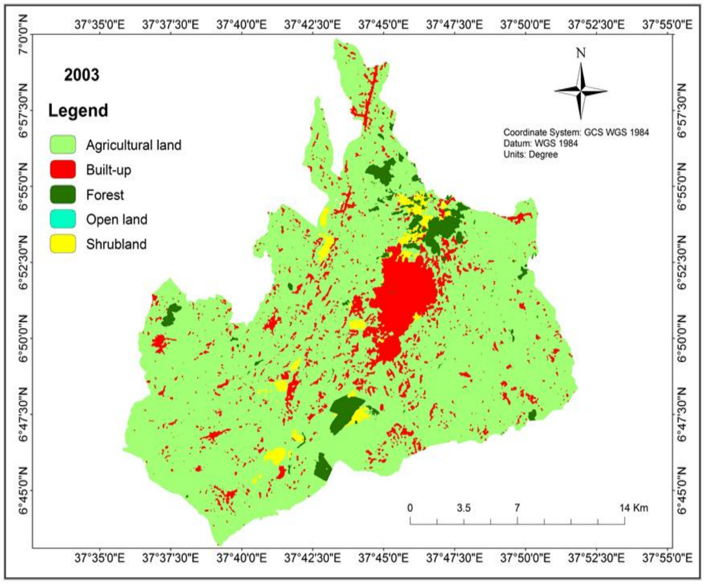

Figure 3: LULC map of 2003

In 2003, agricultural land represented the largest land use category in the study area, covering 35,891.9 ha (83.5% of the total area). Built-up areas were the second largest, occupying 4,654 ha (10.8%), while open land accounted for the smallest fraction, at 1.6 ha (0.004%). These conditions served as a baseline for assessing land use/land cover (LULC) changes over the study period. The analysis focused on three primary LULC types, as these classifications encompass other minor land uses within the region. This pattern aligns with the findings of Badesso (2020), who reported that agriculture was the dominant land-use type around Wolaita Sodo town between 1985 and 2016, with cropland expanding particularly in the northern and northeastern parts of the area, often replacing marginal and pasture lands. Throughout the study period, however, cropland area exhibited a gradual decline. Badesso (2020) noted a reduction of approximately 3.7% (2.9 ha yr^{-1}) between 1985 and 2000, and 24% (17.3 ha yr^{-1}) between 2000 and 2016, a trend attributed to population growth, urban expansion, and land degradation. Similarly, Teshome (2019) observed that in 1999, agricultural land covered 4,986.5 ha (54.3%) of the study area, while open spaces and grazing fields accounted for 1,656 ha (18%). Across Sub-Saharan Africa, including Ethiopia, rapid population growth, resettlement programs, climate change, and other anthropogenic and natural drivers have been identified as major factors influencing LULC dynamics.

3.2. Land use/Land cover in 2013

As shown in Table 4, by 2013, agricultural land and built-up areas remained the dominant land use categories, covering 31,796.2 ha (74%) and 7,914.9 ha (18.4%) of the total study area, respectively. Open land represented the smallest portion, at 71.7 ha (0.2%). Compared to 2003, the study area experienced notable changes in land use/land cover, primarily due to reductions and modifications in forested and agricultural areas. Overall, built-up areas expanded over the decade, reflecting a significant increase relative to the 2003 LULC configuration.

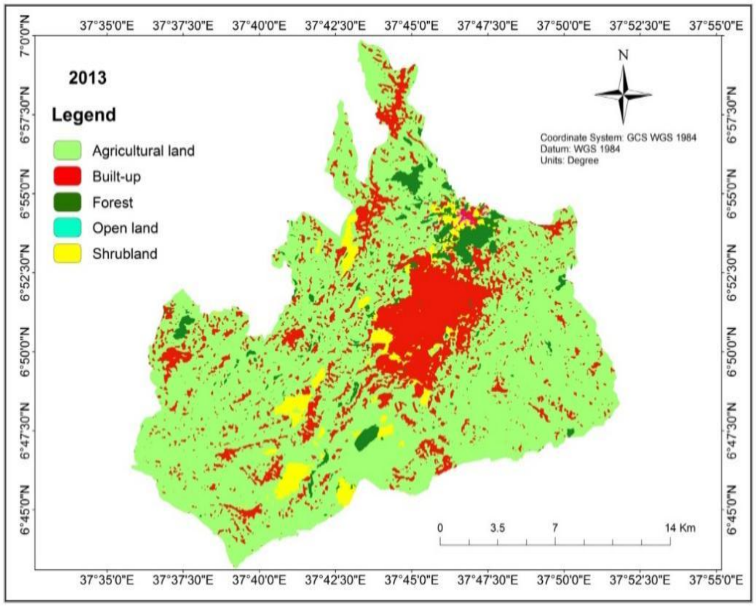

Figure 4: LULC map of 2013

3.3. Land use/Land cover in 2023

As presented in Table 4, the land use/land cover (LULC) of the study area has undergone substantial changes over the past 20 years. Built-up areas have emerged and expanded threefold since 2003, largely due to government allocation of land to public employees for housing, which necessitated the provision of basic infrastructure and considerable land resources. By this period, built-up land accounted for 27.2% of the town's total area. In contrast, agricultural and forest lands experienced notable declines, decreasing from 35,891.9 ha (83.5%) to 28,389.8 ha (66%) and from 1,540.3 ha (3.6%) to 1,377.8 ha (3.2%), respectively (Figure 7). Built-up areas exhibited the highest rate of change, increasing from 4,654 ha (10.8%) to 11,681.5 ha (27.2%). This rapid urban expansion is attributed to the high population growth driven by natural increase, as well as rural–urban and urban–urban migration within the study region.

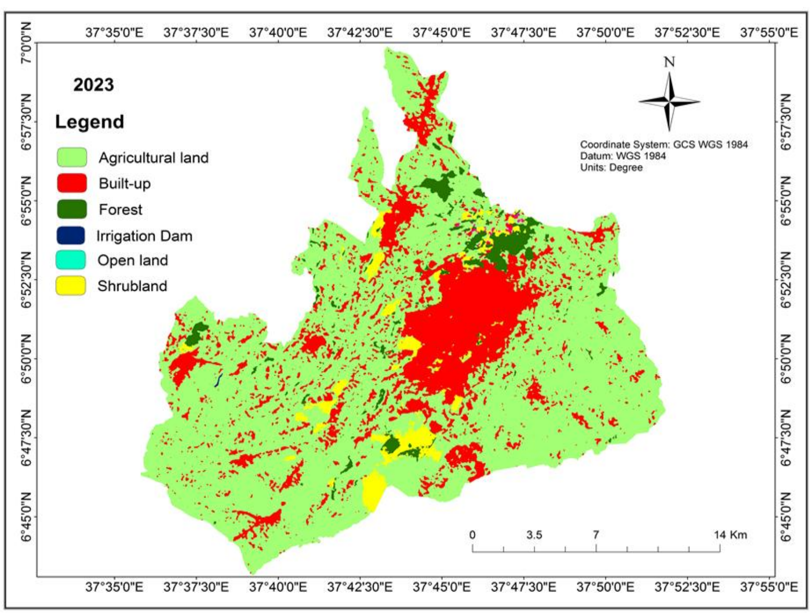

Figure 5: LU/LC map (2023)

Table 4: Area Coverages of the study area

Classes	2003		2013		2023	
	Hectare	%	Hectare	%	Hectare	%
AL	35891.9	83.4870	31796.20	74	28389.8	66
BUA	4654	10.825	7914.9	18.4	11681.50	27.2
FL	1540.30	3.5830	1579.70	3.70	1377.80	3.2
OA	1.61	0.004	71.70	0.20	60.90	0.10
SL	903.40	2.1010	1633.5	3.80	1486.1	3.50
Total	42991.3	100	42996	100	42996.1	100.0

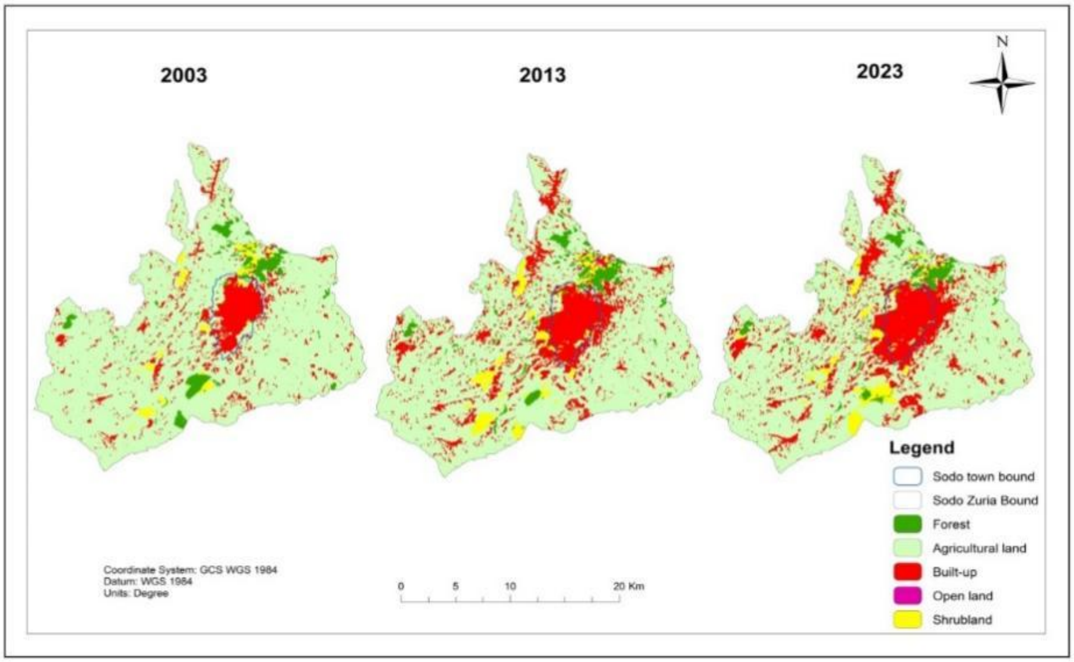

Figure 6. Three periods in one map of the LULC classification study area

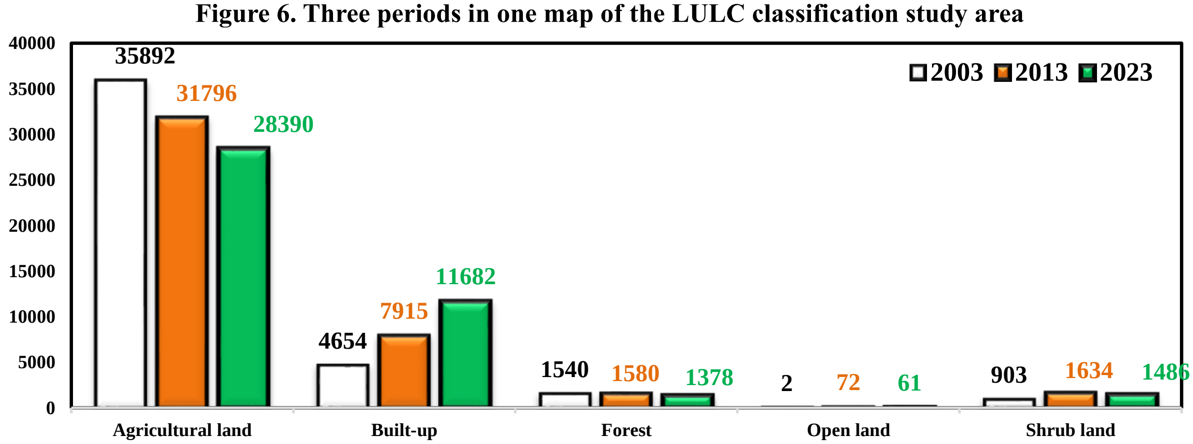

Figure 7. Area coverage of 2003, 2013, and 2023 in the study area

3.4 Accuracy Assessment

The three categorized maps achieved overall accuracies of 95%, 96.5%, and 97% in 2003, 2013, and 2023, respectively, meeting the criterion of USGS's classification (85%) in identifying land use and land cover classes from remote sensing information. Reference data for accuracy assessment were collected using aerial photographs, high-resolution imagery, and field observations. The researcher evaluated sample plots and assigned class values accordingly. Error matrices were subsequently used to calculate overall accuracy, user's accuracy, producer's accuracy, and the Kappa statistic. A brief explanation of each accuracy metric, along with the Kappa statistic, is provided in Table 5.

Table 5. Assessments of accuracy and error matrix of LULC maps

Class	AL	BUA	FL	OL	SL	TP	UA	PA	
2003									
AL	50	0	0	0	1	51	98.0	92.6	OAA
BUA	1	59	0	0	0	60	98.3	96.7	95%
FL	1	0	38	1	0	40	95.0	97.4	
OL	0	2	0	17	1	20	85.0	94.4	OAK
SL	2	0	1	0	26	29	89.7	92.9	94.6%
TP	54	61	39	18	28	200			
2013									
AL	53	0	0	0	1	54	98.1	94.6	OAA
BUA	1	60	0	1	0	62	96.8	98.4	96.5%
FL	1	0	38	0	0	39	97.4	97.4	
OL	0	1	0	13	0	14	92.9	92.9	OAK
SL	1	0	1	0	29	31	93.5	96.7	95.1%
TP	56	61	39	14	30	200			
2023									
AL	49	0	0	0	1	50	98	96.1	OAA
BUA	1	50	0	0	0	51	98.0	98.0	97%
FL	0	1	44	0	0	45	97.8	97.8	
OL	1	0	0	21	1	23	91.3	100.0	OAK
SL	0	0	1	0	30	31	96.8	93.8	96.1%
TP	51	51	45	21	32	200			

AL=Agricultural Land, BUA= Built-Up Area, FL= Forest Land=, OL=Open Land, SL=Shrub land, TP=Total Producer, OAA=Overall Accuracy, OAK=Overall Khat

4. Discussion

4.1. Socio-Economic Impacts on Peri-Urban Communities

The rapid urbanization has had profound socio-economic consequences for peri-urban communities, particularly farmers and low-income households. These communities have faced significant land expropriations for urban development projects. The loss of agricultural land has severely affected food security in peri-urban areas, as agricultural production declined due to land expropriation. The shift from agriculture to other forms of employment, such as low-wage labor in the informal economy, has left many individuals struggling with income instability. Furthermore, many peri-urban communities have encountered challenges in adapting to urban lifestyles and accessing necessary services such as education, healthcare, and transportation. According to discussions with key informants in the city, 44.6% of agricultural land has been vacated, followed by 14.38% of residential land and 12.94% of grassland. This indicates the substantial impact of urban expansion on agricultural land. As the city grows, agricultural land in its peri-urban areas is increasingly converted for residential, commercial, and industrial use. This expansion threatens the viability of traditional agriculture, which is central to the livelihoods of many peri-urban residents. Urban expansion leads to the loss of agricultural land, directly impacting crop production, types of crops grown, and farmers' incomes. Qualitative results from informants reveal that as Wolaita Sodo expands, agricultural lands are being converted to accommodate the growing population and infrastructure needs, such as housing, roads, and factories (Mohamed & Worku 2019).

Urban sprawl results in the fragmentation of farmlands, reducing the overall area available for farming. According to the discussion points, the conversion of agricultural land to urban uses forces farmers to adjust their crop types. In this regard, traditional crops such as teff, maize, and barley may give way to cash crops like vegetables and fruits, which offer quicker returns. However, the loss of irrigation infrastructure and soil fertility from urban expansion hampers the potential for diverse agricultural production. As available land decreases, farmers are unable to cultivate staple crops as extensively, leading to a decline in local food production. This increased reliance on external markets for staple foods could affect local food security, driving up prices and making food less affordable for the peri-urban population. Many local farmers are forced to abandon their land, disrupting the local agricultural economy and causing livelihood challenges for rural communities. During the town's expansion, despite the community's awareness of urban expansion through public orientation and government meeting training, not all members of the peripheral community were involved in decision-making about the amount and types of benefits and compensation for the displaced community. In most developing countries like Ethiopia, landowners have not been adequately compensated for urban expansion. In this case, the peripheral landowners and local government have not reached an agreement because the town government administration did not provide satisfactory monetary and other compensation.

4.2. Impacts of Urbanization on land cover changes

Urbanization in Wolaita Sodo town has led to significant environmental changes, particularly in its peri-urban areas, where the expansion of the city has resulted in the clearing of forests and natural vegetation for construction and infrastructure development. This transformation disrupts local ecosystems, causing habitat loss for wildlife and a decrease in regional biodiversity. The construction of roads, buildings, and other infrastructure also alters the natural topography, leading to soil erosion that further degrades land fertility and threatens local agriculture, contributing to food insecurity. Key informant discussions highlight several ecological challenges, including the loss of biodiversity, water management issues, and the disruption of ecosystems. The conversion of natural habitats and agricultural land not only reduces the available space for wildlife and farming but also fragments ecosystems, endangering local species. Additionally, the rise in impervious surfaces, such as roads and buildings, exacerbates stormwater runoff, increasing the risk of flooding and deteriorating water quality in nearby rivers and lakes. To address these issues, effective urban planning that incorporates environmental sustainability is essential. While urban growth offers economic benefits and infrastructure development, it is crucial to balance these advantages with efforts to protect the environment and ensure the long-term sustainability of the region's natural resources.

5. Conclusion

This research scrutinizes the effects of urbanization and land cover transformation on peri-urban communities in Wolaita Sodo City, Southern Ethiopia, over 2003–2023. The result shows that increasing trend of built-up areas: 4654 ha (10.82%) between 2003 and 2013, 7914.9 ha (18.4%) from 2013 to 2023, and a cumulative 11681.5 ha (27.2%) over the 20 years. The urban expansion rates were 326.09 ha/year in the first decade, 376.66 ha/year in the second decade, and 702.75 ha/year overall. This rapid urban growth has led to extensive land expropriations, particularly affecting peri-urban farmers, whose lands were appropriated for residential, industrial, and infrastructure development. The study highlights that this urban expansion, driven by population growth and migration, has profoundly altered the peri-urban landscape. The transformation of agricultural and forest lands into built-up areas has created significant socio-economic challenges, including the loss of livelihoods, food insecurity, and increased vulnerability for the peri-urban communities due to land expropriation.

While urban growth is often seen as a sign of economic growth, the study emphasizes that it also brings about environmental degradation, shifts in land ownership patterns, and increased strain on resources in the surrounding communities. In particular, urbanization in Wolaita Sodo town has led to horizontal expansion, which, after utilizing flat land areas and developing infrastructure, has extended into nearby villages, converting agricultural lands into urbanized zones. The study also reveals a marked decrease in agricultural and forest lands, highlighting the environmental consequences of urban sprawl. The conversion of land for settlement areas disrupts ecosystems, leading to the loss of plant and animal species. Furthermore, the construction of infrastructure, such as roads and buildings, alters the natural topography, causing soil erosion. Inadequate urban planning, including poor drainage systems and insufficient soil conservation measures, exacerbates the issue. The resulting soil erosion reduces land fertility, further threatening local agriculture and contributing to food insecurity. The absence of comprehensive land use planning has allowed for rapid, often uncoordinated urban expansion, which has intensified the negative effects on peri-urban communities. Peri-urban residents have expressed dissatisfaction with the lack of consultation in urban development decisions, as well as inadequate compensation policies. Overall, this study provides valuable insights and offers clear recommendations for sustainably managing urban expansion. It serves as an important guide for stakeholders to balance urban growth with environmental conservation and the well-being of peri-urban communities.

5.1. Limitation

This study has some limitations that should be considered when interpreting its findings. First, the research relied on Landsat satellite imagery with a spatial resolution of 30m × 30m, which, while effective for broad-scale analysis, may not accurately capture smallholder farmlands, fragmented plots, or subtle vegetation changes. Future studies could overcome this by integrating higher-resolution imagery, such as Sentinel-2 or drone-based data, to provide more precise mapping of land cover transformations. Second, the temporal scope of the study was restricted to three reference years (2003, 2013, and 2023), which provides a general decadal trend but does not account for short-term fluctuations, seasonal variations, or the immediate impacts of policy shifts. More frequent temporal data would allow for a continuous and dynamic assessment of urban expansion. Third, although qualitative insights were gathered from key informants, the study did not include large-scale household surveys or quantitative socio-economic indicators. This limits the ability to generalize livelihood impacts and compensation issues across the wider peri-urban population. Future research should therefore adopt mixed-method approaches, incorporating household-level surveys and longitudinal socio-economic data, to provide a more comprehensive understanding of urbanization impacts on communities.

5.2. Recommendation

To ensure sustainable urban growth, it is crucial to implement smart urban planning practices that prioritize the inclusion of peri-urban areas in policymaking procedures. Policymakers and urban planners should adopt zoning regulations that promote sustainable land use while protecting vital agricultural land, biodiversity, and water resources. Using geospatial tools can help identify appropriate expansion areas and guide land use planning effectively. Additionally, engaging peri-urban communities in urban planning through participatory approaches is essential for aligning urban expansion with local needs. This can be achieved by utilizing geospatial data to create visual tools that foster community ownership of sustainability initiatives. Environmental protection policies should be strengthened to conserve natural habitats and address water management concerns, with solutions such as sustainable drainage systems to mitigate the negative impacts of urban sprawl. Equally important is the need for enhanced compensation policies for displaced communities, ensuring fair compensation and support for relocation. Strengthening access to essential services such as education, healthcare, and transportation is critical for maintaining the well-being and resilience of peri-urban residents. Together, these strategies will ensure a balance between urban development, environmental conservation, and the socio-economic stability of peri-urban communities.

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Declaration of competing interest
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