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Research Article

Impacts of Urban Sprawl and Land Use/Land Cover Change on Socio-economic and Environmental Dynamics in Bole, Yeka, and Lemi-Kura Sub-cities, Addis Ababa, Ethiopia

Melaku Bayu[1], Kenate Worku[2, *], Teshome Tamirat[3], Bizuayehu Alemu[4]

[1]Small Scale and Agroforestry Development and Management Department, Ethiopian Forestry Development, Addis Ababa, Ethiopia

[2]Geography and Environmental Studies Department, Jimma University, Jimma, Ethiopia

[3]Bamboo Development and Technology Desk, Ethiopian Forestry Development, Addis Ababa, Ethiopia

[4]GIS and Remote Sensing Expert, Ethiopian Forestry Development, Addis Ababa, Ethiopia

Abstract

Expansion urban sprawl and land use/cover change has profoundly impacts socio-economic and environmental dynamics. This study investigates the impact of urban sprawl and land use/cover transformation on socio-economic and environmental impacts on sub-cities of Bole, Yeka, and Lemi-Kura in Addis Ababa from 1991 to 2022. Descriptive and explanatory research design was applied using a survey data of 138 residents across six districts within the three sub-cities. The result reveal significant land use and cover transformations occurred over the period, with built-up areas increasing from 2,382.12 hectares (10.96%) to 11,291.31 hectares (51.95%), while non-built-up areas decreased from 19,349.19 hectares (89.04%) to 10,441.89 hectares (48.05%). Notably, Bole, Yeka, and Lemi-Kura experienced substantial urban expansion, reflecting broader urbanization trends in Ethiopia. The study reveals that urban sprawl in Bole, Yeka, and Lemi-Kura imposes substantial economic burdens, with a majority of respondents reporting high congestion costs for businesses (75%) and high costs for extending urban infrastructure (71%). Administratively, (29%) of respondents perceive the management of urban-rural relations as poor, highlighting governance gaps. While these negative impacts are evident, the findings also underscores emerging efforts toward sustainability, (50%) rating the implementation of long-term integrated strategies as high, and (62%) noting strong measures to protect greenfield land, indicating an acknowledged need for better planning despite the ongoing challenges of unplanned expansion. Respondents' perceptions indicate that urban sprawl exacerbates social and economic divisions, with 37.68% and 25.36% reporting high or very high levels of social stratification. Economic repercussions are evident, with 45.65% of respondents noting increased commuting costs due to urban sprawl, driven by longer distances between residences and workplaces. Additionally, perceptions of high congestion and infrastructure costs (42.03% each) emphasize the mounting strain on municipal budgets. Effective management of urban-rural relationships is deemed crucial, with mixed views on the implementation of collaborative strategies for sustainable urban development. These findings underscore the intricate interplay between urban sprawl and socio-economic variables in Addis Ababa. The challenges and present experience posed by unplanned urbanization and weak governance necessitate targeted policy interventions, emphasizing the need for strategic urban planning and enhanced community engagement to promote sustainable growth and mitigate adverse impacts on livelihoods, social cohesion, and economic stability in rapidly urbanizing settings.

*Correspondence: Kenate Worku (kenate.worku@ju.edu.et)

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1. Introduction

Global demographic data indicate a profound and persistent trend of urbanization which projects by 2020, approximately 4.4 billion individuals (56% of the global population) reside in urban areas [1]. This trajectory is projected to intensify, with the urban population anticipated to nearly double by 2050, resulting in approximately 70% of the world's inhabitants occupying urban environments [2] While urbanization serves as a potent engine for sustainable economic expansion given that cities collectively account for over 80% of global Gross Domestic Product (GDP) its rapid pace introduces complex socio-economic and environmental challenges [3].

Critical demands include the provision of affordable housing, the development of sustainable infrastructure, and robust job creation, particularly for the nearly 1 billion urban poor residing in informal settlements [4]. Furthermore, the concentration of over half of the world's internally displaced persons within urban centers exacerbates existing pressures on urban services and resources [2]. City's physical layout and land use patterns become entrenched for generations, often resulting in unsustainable sprawl [5]. This urbanization trend, primarily driven by the migration from rural to urban settings, could see an increase of 2.5 billion people in urban regions by 2050, with 90% of this growth occurring in developing countries in Africa and Asia [6].

Urbanization is transforming both developing and developed countries, leading to the conversion of non-urban spaces into urban areas [7]. In developing nations, urban development is characterized by dynamism, diversity, and complexity. Pre-urban zones require careful management and expertise in land use to address challenges such as overpopulation, rapid social change, poverty, and resource depletion [8]. Currently, Africa's average urbanization level is around 40%, while Sub-Saharan Africa is about 30% urbanized [9], and Ethiopia stands at 23%.

This rapid growth positions Ethiopia among the 23 countries experiencing significant urbanization as the second most populous country in Africa, Ethiopia has an annual population growth rate of 2.3%, with urban population growth reaching 4.2%, surpassing the average rate of 2.2% for developing nations [10]. This growth is largely attributed to unplanned urban expansion that various studies have examined land use and land cover (LULC) changes in the Ethiopian highlands, revealing diverse patterns and magnitudes of urbanization [11].

Despite existing literature on urbanization, significant gaps remain regarding the specific effects of land use changes on community well-being and ecological balance in Addis Ababa sub-cities. Notably, there is a lack of comprehensive data connecting socio-economic indicators with land use patterns, as well as insufficient exploration of adaptive strategies employed by local populations in response to these changes. This study aims to investigate the impact of urban sprawl and land use cover change on the socio-economic and environmental dynamics in on sub-cities of Bole, Yeka, and Lemi-Kura in Addis Ababa. Specifically, it will analyze how the rapid expansion of urban areas influences local economic activities, social infrastructure, and environmental sustainability.

2. Methodology of the Study

Addis Ababa contributes nearly half of the national GDP, with significant economic activity in non-agricultural sectors. Approximately 65.1% of the population aged 15 and older is economically active, with a literacy rate of 85.35%. The total population of Addis Ababa is approximately 3,435,028, with Bole, Yeka, and Lemi-Kura sub-cities accounting for 24% (821,954) of this total. The population density in these sub-cities is about 4,241.9 persons/km^2, with a higher proportion of females (53.53%) compared to males (46.47%). The religious affiliations predominantly include Orthodox Christians (84.4%) and Muslims (6.8%), while the major ethnic groups are Amhara and Oromo.

Geographically, Bole is located in the southeast, Yeka in the north, and Lemi-Kura in the northeast, with respective coordinates of 8°53'40"N, 9°05'40"N, and 9°01'00"N latitude, and 38°47'20"E, 38°54'12"E, and 38°52'19"E longitude. The land areas of these sub-cities are approximately 58 km^2, 65 km^2, and 89 km^2, respectively. Bole Sub-city borders Yeka to the north, Kirkos and Nifas Silk Lafto to the west, Akaki Kaliti to the south, and Lemi-Kura to the northeast. Yeka shares boundaries with Oromiya to the north and Lemi-Kura to the northeast, while Lemi-Kura borders Oromiya to the north, Yeka to the northwest, and Bole to the southwest. Each sub-city contains 10 to 12 woredas/ districts.

A descriptive research design was adopted, utilizing both quantitative and qualitative methods to provide a comprehensive understanding of the research problem. A mixed-methods approach was employed, combining quantitative surveys and qualitative interviews. Data were collected through field surveys, questionnaires, focus group discussions, and satellite

imagery analysis. The study utilized both primary and secondary data. Primary data included interviews and field surveys, while secondary data were derived from literature reviews, legal documents, and published reports. A questionnaire survey was conducted among 138 residents from six districts within the three sub-cities. A mix of purposive and random sampling techniques was used to select participants, including long-term residents and officials from land management sectors. Data collection involved satellite imagery analysis for land use transformation, utilizing Landsat imagery and Google Earth. Complementary methods included field point sampling and GIS analysis.

Spatial data analysis involved change detection and classification of land use using ArcGIS. Remote sensing data were sourced from USGS archives, utilizing Landsat imagery for various years. Pre-processing and classification were conducted using ArcGIS software. Urban sprawl was measured using Shannon's entropy values calculated from land use maps across different years, allowing evaluation of spatial concentration and dispersion Data analysis combined qualitative and quantitative approaches. Qualitative data were analyzed through thematic interpretation, while quantitative data were processed using statistical software.

3. Result and Discussion

3.1. Impact of Urban Sprawl and Transformation on Land Use and Cover Changes

Result in Table 1 shows the land use and land cover (LULC) transformations observed in the study area, characterized by a significant increase in built-up areas and a corresponding decrease in non-built-up areas between 1991 and 2022, reflect broader urbanization trends in Addis Ababa and other Ethiopian cities. Result in Table 1 shows the built-up area increased from 2,382.12 ha (10.96%) in 1991 to 11,291.31 ha (51.95%) in 2022, while non-built-up areas decreased from 19,349.19 ha (89.04%) to 10,441.89 ha (48.05%) during the same period. These changes are further highlighted at the sub-city level, with Bole, Yeka, and particularly Lemi-Kura experiencing substantial increases in built-up areas.

These findings align with numerous Ethiopian research studies documenting similar patterns of rapid urban expansion and land-use change. For instance, studies confirm the rapid expansion of Addis Ababa's built-up area at the expense of green spaces and agricultural land (found a 224.7% increase in built-up areas in Addis Ababa from 1993 to 2023, with a corresponding decrease in green areas and croplands [6].

The conversion of agricultural land to built-up areas is a significant concern in Ethiopia, threatening food security and livelihoods. Research indicates substantial agricultural land losses in peri-urban areas due to unplanned urban expansion in many Ethiopian cities [12]. A study in Hawassa City found a 56.81% decrease in agricultural land between 1984 and 2021, with a significant portion converted to built-up areas [13]. This trend is not unique to Ethiopia; across Africa, urbanization has led to the conversion of agricultural land, impacting local food production and livelihoods [14].

Studies show that the expansion of built-up areas is characterized by horizontal growth, leaving the peri-urban environment and livelihoods at risk. This horizontal expansion often results in the displacement of communities and the loss of traditional farming practices [15]. Furthermore, the increase in built-up areas often leads to deforestation and land degradation, exacerbating environmental problems [16]. Ethiopia's forest coverage has declined drastically, and land degradation is a significant issue impacting the country's economy and agricultural production [17].

Several factors contribute to these LULC transformations. Rapid population growth, driven by natural increase and rural-urban migration, increases the demand for housing and infrastructure, leading to urban expansion [18]. Economic growth and development drive urbanization, with more land being converted for built-up purposes [19]. Urban development policies and governance structures play a significant role in shaping LULC patterns [20]. In adequate planning and weak institutional frameworks can exacerbate urban sprawl and its associated problems that the conversion of agricultural land through extensive expropriation in the city's expansion areas is a major driver of LULC change in Addis Ababa.

Table 1. *Depicts the Periodic Land Use Cover Change in Bole, Yeka and Lemi-kura Sub-Cities.*

Land cover class	Total Area in Ha / 21,733.20			
	LULC Detection 1991	LULC Detection 2001	LULC Detection 2011	LULC Detection 2022
Built-up Area in Ha	2382.12	3,339.81	6,175.53	11,291.31
Percentage (%) Built-up Area	10.96	15.37	28.41	51.95
Non-built-up Area in Ha	19,349.19	18,392.04	15,557.94	10,441.89
Percentage (%) Non-built-up Area in Ha	89.04	74.63	71.59	48.05

Land cover class		Total Area in Ha / 21,733.20			
		LULC Detection 1991	LULC Detection 2001	LULC Detection 2011	LULC Detection 2022
Bole Sub-city	Non-built-up	5661.45	4991.04	4521.69	2985.21
	Built-up	1023.75	1694.52	2163.87	3699.81
Yeka Sub-city	Non-built-up	4708.08	4626.72	3904.38	2959.47
	Built-up	1237.14	1316.07	2040.93	2985.57
Lemi-kura Sub-city	Non-built-up	8981.64	8774.28	7132.14	4497.39
	Built-up	121.77	329.22	1971.36	4606.02

3.2. Impact of Urban Sprawl and Land Use on Socio-economic Variables

Result in Table 2 shows the perceived impacts of urban sprawl on social and economic dynamics within the study area. The responses, measured on a scale from "Very Low" to "Very High," offer insights into community perceptions of increased social divisions, residential segregation, reduced social interaction, inner-city concentration of low-quality neighborhoods, and social/cultural conflict. The survey responses reveal significant community perceptions regarding the impacts of urban sprawl on social and economic dynamics within the study area. The data, measured on a scale from "Very Low" to "Very High," highlights concerns about increased social divisions, residential segregation, reduced social interaction, inner-city concentration of low-quality neighborhoods, and social/cultural conflict.

Result in Table 2 shows a significant majority of respondents perceive urban sprawl as contributing to high or very high levels of social and economic division (37.68% and 25.36%, respectively). This aligns with existing research on urban expansion in Ethiopia. For example, a study in Hawassa City found that most respondents scored the exacerbation of social and economic divisions as very high due to urban sprawl [21]. Our result indicates that as urban areas expand; inequalities are amplified, potentially leading to social fragmentation. This is further supported by studies indicating that urban expansion in Ethiopia often leads to the concentration of poor-quality neighborhoods in peripheral communities. This phenomenon is not unique to Ethiopia; across Africa, rapid urbanization has been linked to increased social and economic disparities [22].

Result in Table 2 shows similar to the perception of social and economic division, a substantial portion of respondents believe that residential zone segregation is high or very high (25.36% and 29%, respectively). Residential segregation can exacerbate existing social and economic divisions. Research indicates that spatial inequality is an enduring issue in Ethiopian cities, with vulnerable populations concentrated in informal settlements while wealthier residents are segregated into formal neighborhoods [23]. This spatial separation can limit social interaction and reinforce disparities. This trend is consistent with findings from other African cities, where residential segregation often reflects underlying socio-economic inequalities [24].

Result in Table 2 shows the data indicates a strong perception that urban sprawl leads to reduced social interaction, with the majority of respondents indicating "Very High" (66.67%). This aligns with research suggesting that rapid urbanization and changing lifestyles can weaken social cohesion [25]. A study in Jajura, Ethiopia, found that a significant percentage of respondents agreed that urban expansion caused segregation in neighborhood relationships [26]. The expansion of urban areas can disrupt existing social networks and community bonds, leading to social isolation. This decline in social interaction has been observed in various urban settings globally, as highlighted by studies on the impact of suburbanization on community life [27].

Result in Table 2 shows the responses suggest a notable concern about the concentration of low-quality neighborhoods in inner-city areas, with a high percentage of respondents indicating "High" (45.65%). This finding reflects the challenges of urban development in Ethiopia, where a large proportion of the urban population lives in slums with inadequate access to basic services [28]. Inner-city areas often face issues of overcrowding, poor housing conditions, and limited infrastructure, contributing to the concentration of low-quality neighborhoods [29]. This concentration of poverty and inadequate housing is a common feature of many African cities, as documented in studies on urban poverty and inequality [25].

Result in Table 2 shows a considerable number of respondents perceive social or cultural conflict between new and old residents as high (42.03%) or very high (24.64%). Urban expansion can lead to conflicts between long-term residents and newcomers due to competition for resources, differing values, and changes in community dynamics [30]. As urban areas expand, the influx of new residents can strain existing social

structures and create tensions between different groups. This type of social conflict has been observed in various urban contexts, particularly in rapidly growing cities [31].

Result in Table 2 shows findings collectively point to the complex social and economic consequences of urban sprawl in the study area. Several Ethiopian studies corroborate these perceptions. Urban expansion often involves the conversion of agricultural land, leading to conflicts between farmers and urban developers [32]. This can result in displacement, loss of livelihoods, and social unrest [15]. Unplanned urban expansion, driven by factors like population growth and rural migration, contributes to sprawl and its associated problems [33]. Weak institutional frameworks and ineffective land management exacerbate these challenges [34]. Urbanization can amplify existing inequalities, leading to the concentration of poverty in certain areas and the segregation of different socioeconomic groups [35]. This can undermine social cohesion and create social divisions.

Table 2. *Depicts the Periodic Land Use Cover Change on Socio-Economic Variables.*

Item	Response	Frequency	Percent	Item	Response	Frequency	Percent
1. Increased Social and Economic Division	Very low	11	7.97%,	2. Residential Zone Segregation	Very low	6	4.34%,
	Low	11	7.97%		Low	11	7.97%
	Medium	29	21.02%		Medium	46	33.33%
	High	52	37.68%		High	35	25.36%
	Very high	35	25.36%		Very high	40	29%
	Total	138	100		Total	138	100
3. Reduced Social Interaction	Very low	0	0	4. Inner-city concentration of low-quality neighborhoods	Very low	29	21.02%
	Low	6	4.34%		Low	11	7.97%
	Medium	6	4.34%		Medium	29	21.02%
	High	34	24.65%		High	63	45.65%
	Very high	92	66.67%		Very high	6	4.34%
	Total	138	100		Total	138	100
5. Social or cultural conflict between the new and the old residents					Very low	17	12.32%
					Low	6	4.34%
					Medium	23	16.67%
					High	58	42.03%
					Very high	34	24.64%
					Total	138	100

3.3. Impact of Urban Sprawl and Land Use on Economic Variables

Result in Table 3 presents the perceived economic impacts of urban sprawl in three sub-cities. The responses, ranging from "Very Low" to "Very High," reveal community perceptions regarding increased commuting costs, congestion costs, infrastructure extension costs, and the effectiveness of various management and planning strategies. Result in Table 3 shows a significant majority of respondents perceive high or very high increases in household spending on commuting due to urban sprawl (45.65% each). This aligns with the understanding that urban sprawl increases distances between residential areas and workplaces, leading to higher transportation costs. A study on urban expansion in Hawassa, Ethiopia, found that increased household expenditure on commuting was scored as high by 62% of respondents [36]. The limited availability and high cost of public transport in many Ethiopian cities exacerbate this issue, reflecting broader trends across Africa where urban sprawl often leads to increased commuting burdens [37].

Results in Table 3 shows a large percentage of respondents believe that congestion costs for businesses are high or very high (42.03% and 33.33%, respectively). Urban sprawl often

results in increased traffic congestion due to inadequate transportation infrastructure. This congestion leads to delays, increased fuel consumption, and reduced productivity for businesses. Research in Addis Ababa has similarly indicated that traffic congestion significantly hampers economic productivity, costing businesses millions in lost revenue [38].

Results in Table 3 shows Most respondents indicated that the additional costs of extending urban infrastructure are high (42.03%) or very high (28.99%). As cities expand, the costs of providing essential services like transport, water, waste management, and utilities increase significantly. Studies show that sprawled development increases per capita land consumption and the distance between homes, businesses, services, and jobs, which raises the cost of providing public infrastructure and services. This phenomenon is observed not only in Ethiopia but also in many African cities where the rapid growth of informal settlements places additional strain on existing infrastructure [39].

Result in Table 3 shows A significant number of respondents perceive the management of urban-rural relations as very low (12.32%) or low (16.67%). Effective management of urban-rural linkages is crucial for sustainable development. The lack of collaboration and coordination between urban, rural, and regional authorities can hinder economic development and exacerbate inequalities. A study in Ethiopia emphasized the need to develop stronger and more functional linkages between rural and urban areas through intermediary cities and small urban centers [40]. Similar observations have been made across Africa, highlighting the importance of integrated urban-rural planning to address disparities [41].

Result in Table 3 shows Half of the respondents (50%) rated the implementation of long-term integrated strategies for fostering sustainable development and limiting urban sprawl as high, while a smaller percentage rated it as very low (7.97%) or low (16.67%). The mixed responses suggest varying degrees of awareness and implementation of sustainable development strategies. A study on urban expansion planning in Ethiopia highlighted the need for cities to estimate their future growth, identify land for growth, create grids of arterial roads, and protect environmentally sensitive areas [42].

Result in Table 3 shows A considerable number of respondents believe that measures to avoid the utilization of Greenfield land are high (45.65%) or very high (16.67%). Protecting Greenfield land is essential for preserving natural resources and preventing environmental degradation. The high percentage indicates that some measures are being taken, but the existence of urban sprawl indicates that they may not be fully effective. Research in Ethiopia has shown that unplanned urban expansion often results in the loss of valuable agricultural land, underscoring the need for better land use policies [43].

Result in Table 3 shows A significant proportion of respondents view the identification of key partners as high (45.65%), while a notable percentage rated it as very low (12.32%) or low (8.69%). Collaboration among the commercial sector, community, and government is crucial for effective urban planning and implementation. The mixed responses suggest that while some partnerships exist, there may be gaps in engaging all relevant stakeholders. This is consistent with findings from other African nations, where effective collaboration has been shown to enhance urban development outcomes [44].

These findings highlight the economic challenges associated with urban sprawl in the study area. Several Ethiopian studies corroborate these perceptions. Urban sprawl increases the costs of providing infrastructure and services, straining municipal budgets [45]. Increased commuting distances and traffic congestion lead to higher transportation costs for households and businesses, as evidenced by similar studies in other urban centers [46]. Additionally, the inefficient land use resulting from sprawl contributes to environmental degradation and loss of agricultural land, posing significant long-term risks to food security and sustainability [47].

Table 3. *Depicts the Periodic Land Use Cover Change on Social Infrastructure.*

Item	Response	Frequency	Percent	Item	Response	Frequency	Percent
1. Increased household spending on commuting from home to work across increasing distances	Very low	0	0	2. Congestion costs businesses in sprawling urban regions with ineffective transportation infrastructure.	Very low	0	0
	Low	0	0		Low	5	3.62%
	Medium	12	8.7%		Medium	29	21.02%
	High	63	45.65%		High	58	42.03%
	Very high	63	45.65%		Very high	46	33.33%
	Total	138	100		Total	138	100
3. Additional costs of extending urban infrastructures (transport, trash, waste water, etc.) across	Very low	6	4.34%	4. Management of urban-rural relations through collaboration and coordi-	Very low	17	12.32%
	Low	0	0		Low	23	16.67%
	Medium	34	24.64%,		Medium	35	25.35%

Item	Response	Frequency	Percent	Item	Response	Frequency	Percent
the urban region, including utilities and related services	High	58	42.03%	nation between urban, rural, and regional authorities in order to promote sustainable development	High	40	28.99%
	Very high	40	28.99%		Very high	23	16.67%
	Total	138	100		Total	138	100
5. Long-term integrated strategies for fostering sustainable development and limiting urban sprawl	Very low	11	7.97%	6. Measures to avoid the utilization of greenfield land/ undeveloped land in an urban or rural/, as well as measures to supplement urban containment	Very low	17	12.32%
	Low	23	16.67%		Low	6	4.34%
	Medium	23	16.67%		Medium	29	21.02%
	High	69	50%		High	63	45.65%
	Very high	12	8.69%		Very high	23	16.67%
	Total	138	100		Total	138	100
7. Identification of key partners, including the commercial sector and community, as well as local, regional, and national government, and mobilization of these partners in planning, implementation, and evaluation.					Very low	17	12.32%
					Low	12	8.69%
					Medium	40	29%
					High	63	45.65%
					Very high	6	4.34%
					Total	138	100

3.4. Impact of Urban Sprawl and Land Use on Environmental and Livelihood

Result in Table 4 highlight community perceptions regarding the impacts of urban sprawl, revealing significant concerns across various dimensions, including land and soil depletion, natural habitat loss, agricultural land loss, increased air pollution, respiratory problems, traffic congestion, lack of public transportation, vulnerability to geo-hazards, impacts of informal settlements, and effects on urban ecosystems. Result in Table 4 highlight A significant majority perceive land and soil depletion as very high (58.69%) or high (29%). This aligns with findings a study that rapid urbanization leads to land degradation through the conversion of agricultural and forest lands, soil erosion, and unsustainable land use practices [48]. The loss of productive land poses a serious threat to food security and agricultural sustainability in Ethiopia.

Result in Table 4 highlight Most respondents perceive natural habitat loss as high (41.3%) or very high (58.7%). This aligns with findings a study Urban sprawl often encroaches on natural habitats, leading to biodiversity loss and ecosystem disruption [49]. This trend is echoed in studies across Africa, where urban expansion frequently threatens wildlife habitats and diminishes ecological integrity [50].

Result in Table 4 highlight A large majority perceive agricultural land loss as very high (66.67%) or high (25.36%). This is consistent with studies showing the conversion of agricultural land for urban development, threatening food security and livelihoods [51]. A study in the upper Awash basin of central Ethiopia found that cultivated lands around Addis Ababa declined as a result of urban sprawl [52].

Result in Table 4 highlight Most respondents perceive an increase in air pollution as very high (45.65%) or high (42.03%). This aligns with findings a study Urban sprawl contributes to air pollution through increased traffic, industrial activities, and waste burning [53]. A systematic review of air pollution in Ethiopia identifies traffic and industrial emissions as major sources of outdoor air pollution [30].

Result in Table 4 highlight A significant number of respondents perceive an increase in respiratory problems as medium (42.03%) or high (33.33%). Air pollution is a major contributor to respiratory illnesses, particularly in urban areas with high levels of traffic and industrial emissions. Studies in Addis Ababa have linked air pollution to increased rates of respiratory problems, highlighting public health concerns [54].

Result in Table 4 highlight A large proportion of respondents perceive traffic congestion as high (45.65%) or very high (33.33%). Urban sprawl increases commuting distances and reliance on private vehicles, leading to traffic congestion and related economic and social costs. This aligns with findings a study that his issue is widespread in urban centers across Africa, where inadequate infrastructure struggles to keep pace with rapid population growth [48].

Result in Table 4 highlight Most respondents perceive a lack of public transportation as high (45.65%) or very high (37.68%). Inadequate public transportation infrastructure exacerbates the negative impacts of urban sprawl, making it difficult for residents to access jobs, services, and amenities [43].

Result in Table 4 highlight A significant number of respondents perceive vulnerability to minor geo-hazards as medium (37.68%) or high (42.03%). Unplanned urban development can increase vulnerability to landslides and flooding, particularly in areas with steep slopes or poor drainage [42]. This vulnerability is a critical concern in many rapidly urbanizing areas in Ethiopia and beyond.

Result in Table 4 highlight Most respondents perceive the impacts of informal settlements on environmental degradation as high (41.3%) or very high (42.03%). Informal settlements often lack basic services and infrastructure, leading to pollution, sanitation problems, and environmental degradation [39].

Result in Table 4 highlight A large majority perceive the impact of urban sprawl on urban ecosystems and forest areas related to climate change as high (66.67%). This aligns with findings study Urban sprawl contributes to climate change through increased greenhouse gas emissions, deforestation, and loss of carbon sequestration capacity [55].

These findings collectively highlight the significant environmental challenges associated with urban sprawl in the study area. Several Ethiopian studies corroborate these perceptions. Urban expansion leads to deforestation, soil erosion, water pollution, and air pollution [56]. The conversion of green spaces for built-up areas reduces ecosystem services and increases vulnerability to climate change impacts [57].

Increased pollution from traffic congestion, industrial activities, and waste burning affects public health and environmental quality, exacerbating existing health disparities in urban populations [58]. This aligns with findings a study [39]. Additionally, the proliferation of informal settlements exacerbates environmental problems due to a lack of infrastructure and services, highlighting the urgent need for integrated urban planning and effective governance to address these challenges.

Table 4. *Depicts the Periodic Land Use Cover Change on Environmental and Livelihood.*

Item	Response	Frequency	Percent	Item	Response	Frequency	Percent
1. Land and soil depletion	Very low	5	3.62%	2. Natural Habitat Loss	Very low	0	0
	Low	0	0		Low	0	0
	Medium	12	8.69%		Medium	0	0
	High	40	29%		High	57	41.3%
	Very high	81	58.69%		Very high	81	58.7%
	Total	138	100		Total	138	100
3. Agricultural Land Loss	Very low	5	3.62%	4. Increase in Air Pollution	Very low	5	3.62%
	Low	0	0		Low	6	4.35%
	Medium	6	4.35%,		Medium	6	4.35%
	High	35	25.36%		High	58	42.03%
	Very high	92	66.67%		Very high	63	45.65%
	Total	138	100		Total	138	100
5. Increase in Respiratory problems	Very low	5	3.62%	6. Traffic congestion	Very low	12	8.7%
	Low	6	4.34%		Low	0	0
	Medium	58	42.03%,		Medium	17	12.32%
	High	46	33.33%		High	63	45.65%
	Very high	23	16.67%		Very high	46	33.33%
	Total	138	100		Total	138	100
7. Lack of public transportation due to growing urban areas	Very low	0	0	8. Vulnerability of sub-urban's to minor Geo-hazards	Very low	5	3.62%
	Low	6	4.35%		Low	11	7.97%
	Medium	17	12.32%,		Medium	52	37.68%
	High	63	45.65%		High	58	42.03%
	Very high	52	37.68%		Very high	12	8.7%
	Total	138	100		Total	138	100

Item	Response	Frequency	Percent	Item	Response	Frequency	Percent
9. The impacts of informal settlements on the environmental degradation	Very low	0	0	10. The impact of urban sprawl on urban ecosystems and forest areas related to climate change	Very low	0	0
	Low	0	0		Low	0	0
	Medium	23	16.67%		Medium	0	0
	High	57	41.3%		High	92	66.67%
	Very high	58	42.03%		Very high	46	33.33%
	Total	138	100		Total	138	100

4. Conclusion

The findings of this study indicate a clear and consistent trend of urban sprawl in the Bole, Yeka, and Lemi-Kura sub-cities from 1991 to 2022. The analysis shows a decrease in non-built-up areas alongside increasing Shannon's entropy values, which exceed the critical threshold of 0.5, demonstrating significant urban sprawl. However, it is noteworthy that there was a reduction in the rate of sprawl from 2011 to 2022, suggesting that while urbanization continues, there may be emerging strategies or policies that are beginning to mitigate its intensity. These results underscore the urgent need for informed urban planning and present valuable insights for stakeholders involved in urban development. The primary objective of this study was to assess the risks associated with urban sprawl and its impact on land use transformations through remote sensing. The use of visual rendering techniques has proven effective in mapping urban neighborhoods accurately. The drastic land cover transformations observed in the study area are largely attributed to rapid population growth and urban sprawl, particularly affecting the fertile lands in the Lemi-Kura sub-city. This highlights the critical intersection of urban development and agricultural land preservation.

Rapid population growth, coupled with internal migration, emerges as the main driver of urban sprawl in the region. Survey results reveal significant social impacts, including the displacement of farmers, social and economic deterioration, and shifts in social values. Interestingly, perceptions of these impacts vary, with higher awareness reported among respondents with greater income and educational attainment. This disparity suggests that urban sprawl's social consequences are perceived differently across socioeconomic groups, emphasizing the need for tailored communication and engagement strategies. Urban sprawl poses considerable challenges to the socio-economic development of the city. It is identified as a contributing factor to land degradation in the Bole, Yeka, and Lemi-Kura sub-cities. To combat these issues, a policy-oriented urban development strategy is essential to protect valuable land resources. This approach should be multifaceted, addressing social and economic dimensions while raising awareness among all community members, particularly marginalized groups such as women and low-income residents.

The study also highlights the potential of remote sensing and GIS tools in examining urban sprawl and its impacts on land use transformations. By understanding current trends and predicting future developments, urban planners and environmental conservationists can make informed decisions. This research aids in identifying critical patterns in urban land use, thereby contributing to efforts aimed at sustainable development in the region. Given the emerging social, economic, and environmental threats posed by urban land use transformations, a robust policy framework is recommended to manage urban growth effectively. Strategies such as smart growth principles can enhance economic, social, and environmental outcomes by promoting high residential densities and efficient land use. Implementing these strategies could help mitigate the adverse effects of urban sprawl while supporting community resilience.

Future research should address the limitations identified in this study, particularly the need for comprehensive socio-economic data. A more nuanced understanding of factors such as land prices, income levels of developers, and local demographics will provide a clearer picture of urban dynamics. Incorporating these variables will enhance the analysis and lead to more effective urban planning interventions. In conclusion, the urban growth and expansion of cities require collaborative efforts among various governmental and non-governmental agencies. Institutional cooperation across different levels of administration is vital for sustainable development and effective environmental management. By integrating diverse stakeholders into the planning process, cities can work towards achieving a balance between development and conservation, ensuring a sustainable future for their communities.

Abbreviations

GDP	Gross Domestic Product
GIS	Geographic Information System
Ha	Hectares
Km^2	Square Kilometers
LULC	Land Use / Land Cover
USGS	United States Geological Survey

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Conflicts of Interest

The authors declare no conflicts of interest.

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