published by

EQA - International Journal of Environmental Quality
ISSN 2281-4485 - Vol. 70 (2025): 87 - 95
Journal homepage: https://eqa.unibo.it/

The implications of urbanization on urban agriculture dynamics: A case of Beira City, Mozambique

Matias Siueia Júnior[1*], António Machava Júnior[2], Elton Amadeus Francisco[3], Elcídio Eugénio Sambo[3], José Mateus Nampunda Júnior[4], Obadias Ricardo Maguaza Nzucule[5]

[1] College of Agricultural Sciences, Aquila University, Maputo City, Mozambique
[2] Graduate School of Science and Technology, Niigata University, Niigata City, Japan
[3] Graduate School of Animal and Veterinary Sciences and Agriculture, Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan
[4] United Graduate School of Agricultural Sciences, Kagoshima University, Kagoshima City, Japan
[5] Graduate School of Medicine, Engineering and Agriculture, Department of Life and Environmental Sciences University of Yamanashi, Yamanashi-ken, Japan

* Corresponding author E.mail: siueia.junior@gmail.com

Article info
Received 28/2/2025; received in revised form 10/6/2025; accepted 30/7/2025
DOI: 10.6092/issn.2281-4485/21434

Abstract
Urban agriculture is increasingly recognized as a critical component of sustainable urban development, particularly in rapidly growing African cities. Beira City in Mozambique, exemplifies the tensions between urban expansion and agricultural land use, as population growth and climate change exert pressure on available land resources. This study examines the spatial and temporal dynamics of urban cropping areas in Beira City from 2017 to 2023, assessing their correlation with land use/land cover (LULC) changes and population growth. Using high-resolution satellite imagery and regression analysis, we identify key factors influencing the expansion or reduction of urban cropping areas. The findings reveal that the variation LULC was class and year-dependent. However, the built-up areas and water bodies generally increased over the years, whereas bare land decreased. Overall, urban cropping areas remained dependent on natural resources such as water, while built-up areas and bare ground significantly impacted cropping area dynamics. These results underscore the need for developing integrated urban planning policies that incorporate sustainable agricultural land use while balancing urban development and food security.

Keywords: *Urban cropping area, Land Use/Land Cover, Beira City, urban agriculture*
.

Introduction

Urbanization in Africa is accelerating, with projections indicating that the urban population will gow from 400 million to 1.2 billion by 2050 (UN-Habitat, 2014). Mozambique has an estimated population of 30 million and is expected to reach 46 million by 2040 (INE, 2020), while about 50 to 60% of the population will be in urban areas by 2050 (World Bank, 2023). This rapid change puts significant pressure on land resources, infrastructure, and food security systems. One of the maint challenges is balancing urban growth with the need to maintain agricultural activities that support populations by supplementing food production and enhancing accessibility. Food production inurban or nearby areas is a crucial part of the urban life strategy isurrounding areas is an integral part of the vital in developing countries. Traditionally linked to rural regions, food insecurity has become “urbanized”. Around 25 percent of the world's hungry are estimated to live in urban areas. In contrast, it is estimated that more than 800 million people are involved in urban agriculture, contributing to around 10% of global food production, thus representing significant potential to reduce global food insecurity (O’Sullivan et al., 2019;

DOI: 10.6092/issn.2281-4485/21434

Clinton et al., 2018). Although urban agriculture, though historically been marginalized in policy frameworks, it serves as an essential strategy for food security, economic resilience, and environmental sustainability (Mougeot, 2005). Urban agriculture not only provides food and income for many households in cities but also plays a vital role in managing the urban environment. It aids to climate regulation, promotes biodiversity, recycles and reuses waste, and helps reduce the ecological footprint of urban areas. However, the development of urban agriculture faces challenges. Essential resources like land and water are often scarce in cities and highly sought after in cities. This situation is significantly impacted by urban policies and the rapid changes in land uses occurring urban settlements (Mougeot, 2006). Land Use/Land Cover (LULC) pertains to the biophysical cover of the Earth's terrestrial surface, identifying vegetation, inland water, bare soil, or human infrastructure (Goméz et al., 2016). LULC changes can be associated to natural processes (e.g. flooding, wildfire) and anthropogenic activities (e.g. urbanization, agriculture). The rate of change and the nature of land cover transitions can vary over time and across different areas. Some regions are relatively stable (e.g. permanent forest); while, other areas are subject to rapid and persistent transformation (e.g. urban expansion of previously vegetated areas). Increased human population and technological advances have been shown to accelerate land cover change (Goldewijk, 2001; Ramankutty and Foley, 1999). Beira is ranked the second largest and fourth most populated City in Mozambique, with approximately 0.5 million residents, expeceted to reach 1.6 million by 2040 (INE, 2020). Its economy mostly relies on port trading, commercial, and transport sectors. Yet, agricul- ture has a great contribution to the economy and food security of about of the population (Silvestri et al., 2020). Like many African cities , Beira has experienced notable urban expansion. From 2001 to 2013, the city's urban area expanded to 12,153 hectares, growing annually at a of rate of 12.6% (Atlas for Urban Expansion, 2016). The rapid urban growth has led to widespread land use changes, transfomorming arable land into residential zones. Climatic events like Cyclone Idai in 2019 have further disrupted land use patterns, affecting the viability of agricultural land (Ministry of Land and Environment of Mozambique, 2021). Understanding land cover changes is essential for assessing the impacts of urbanization on agricultural areas. Global land cover datasets offer valuable insights into the dynamics of land use change, capturing both natural and human-induced transfor- mations (Chaves et al., 2020; Phiri et al., 2020; Liu et al., 2021). Changes in land cover can be driven by factors such as urban expansion, infraestucture deve- lopment, and environmental influences, necessitating a comprehensive analysis to identify patterns and drivers of change (Goméz et al., 2016). Urban agriculture in Beira City faces unique challenges, as it competes for space and resources while contributing to local food security and economic development (FAO, 2007). This study aims to analyze LULC changes in Beira City from 2017 to 2023, identify the main factors, and clarify how those changes affect the urban crop- ping areas. By addressing these questions, this research provides evidence-based insights that can inform urban planning policies, ensuring that urban agriculture is integrated into sustainable land-use strategies.

.

<u>Materials and Methods</u>

General description of the study site

The study focused on the City of Beira, which is the capital of the Sofala Province located in the central region of Mozambique (Fig. 1). Beira spans an area of 658 km² and has an average elevation of 14 meters above sea level, with geographic coordinates of

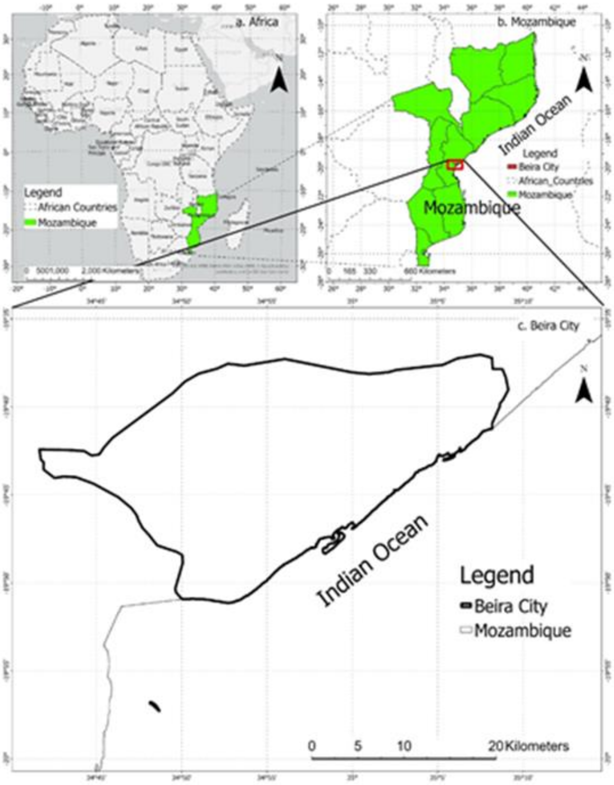

Figure 1. *Map showing the geographic boundary of (a) Africa, (b) Mozambique, and (c) Beira city*

DOI: 10.6092/issn.2281-4485/21434

19°50'36"S and 34°50'20"E. It is bordered to the north and west by the Dondo district, to the east by the Indian Ocean, and to the south by the Búzi district (Fig. 1). The City is situated in a marshy area near the mouth of the Púnguè River, extending over sandy coastal regions along the Indian Ocean. The natural landscape features lowlands and a coastline with mangrove forests (Batista et al., 2018). It is the fourth-largest city by population, projected to be about 767,787 in 2024 (INE, 2020; Santos et al., 2021). Beira experiences a humid tropical savanna climate, with high temperatures and humidity during the summer, particularly in the monsoon season, which lasts from October to February in the southern hemisphere (Batista et al., 2018). The rain season is typically from December to March, with average precipitation ranging from 191 to 236 mm. Additionally, the annual average temperature is 25°C, with a minimum of 20°C in July and a maximum of 27°C in January (Mavume et al., 2021). The annual evapotranspiration is approximately 1,175 mm (Thornthwaite, 1948). Due to its geographic location, the city is vulnerable to extreme climatic events such as cyclones, floods, and seawater intrusion with significant economic implications. Cyclone Idai in 2019 was a major event for Beira City and the surrounding areas. It caused extensive damage to infrastructure and hindered humanitarian efforts from Beira into the northern hinterland, as several primary roads and many secondary roads were cut off. In the agriculture sector, vast areas of crops and livestock production were destroyed, disrupting food security.

Data acquisition

The Beira shapefile was extracted from data supplied by DIVA-GIS. Based on multiple combinations, the annual land cover of 10m resolution was generated through Sentinel-2 as true imagery, available from 2017 to 2023. The 10m global resolution map of land use/land cover (LULC) is derived from ESA Sentinel-2 imagery for each year with Impact Observatory. The data was generated from deep learning models trained on the same reference dataset, detailed by Tsendbazar et al., 2021. The Global dataset 10m resolution Land Cover classification comprises 9 classes, however, the study area is only covered by 7 classes (Table 1). The details about Sentinel 2 accuracy are also found in Tsendbazar et al. (2021). Overall accuracy at the continental level is mostly above 70%, with the highest accuracy of 80.7% for Asia and the lowest accuracy of 67.5% for Oceania.

Table 1. *Land Cover description in the study area.*

Class ID	LULC Type	Description
1	Water	Areas where water was predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built-up features like docks; examples: rivers, ponds, lakes, oceans, flooded salt plains.
2	Trees	Any significant clustering of tall (~4.6 m or higher) dense vegetation, typically with a closed or dense canopy; examples: wooded vegetation, clusters of dense tall vegetation within savannas, plantations, swamp or mangroves (dense/tall vegetation with ephemeral water or canopy too thick to detect water underneath).
4	Flooded vegetation	Areas of any type of vegetation with obvious intermixing of water throughout a majority of the year; seasonally flooded area that is a mix of grass/shrub/trees/bare ground; examples: flooded mangroves, emergent vegetation, rice paddies, and other heavily irrigated and inundated agriculture.
5	Crops	Humans planted/plotted cereals, grasses, and crops not at tree height; examples: corn, wheat, soy, fallow plots of structured land.
7	Built area	Human-made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings, and residential housing; examples: houses, dense villages / towns / cities, paved roads, asphalt.
8	Bare ground	Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and sand dunes, dry salt flats/pans, dried lake beds, mines.
10	Cloud*	No land cover information due to persistent cloud cover
11	Rangeland	Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals and grasses with no obvious human plotting

Adapted from: https://www.impactobservatory.com/monitor/maps-for-good-classes/. *Areas covered by clouds are declared as having no information

DOI: 10.6092/issn.2281-4485/21434

LULC Analysis

The analysis involved various LULC classes obtained from the Sentinel-2, to generate the correlation matrix. First, the relationships between the various LULC classes and the population growth were examined. Alig et al. (2004) tested the land rent theory in urban land and other built-up land, as well as economic and demographic variables, through a regression model. To answer one of the research questions about how changes in relevant land cover classes and population growth influence the expansion or reduction of urban agricultural areas in Beira City, we adapted as the second step the regression model in Equation [1] proposed by Alig et al. (2004):

$$\text{Urban Agriculture} = a_0 + a_1(\text{Built-up Area}) + a_2(\text{Water}) + a_3(\text{Bare Ground}) \quad [1]$$

where: Urban Agriculture is the dependent variable (represented by the cropping area), $a0$ is the intersection, $a1$, $a2$, $a3$ are the coefficients of build-up area, water, and bare ground areas, respectively. After- ward, the land use/land cover (LULC) classes were randomly grouped into 7 combinations considered in the cropping area multiple regression analyses as follows: combination 1 – population and built-up area, combination 2 – water and tree area, combination 3 – water, tree and build-up area, combination 4 – population, water and trees area, combination 5 – population, build up and rangeland area, combination 6 - population, build up and bare ground area and combination 7 – built-up
:
area, water, and bare ground. Overall, the combination 6 used in Equation [1], resulted in the most statistically significant variables for *p*-values. The respective percentages were calculated by dividing the class contribution value by the total area, and multiplying by 100: :

$$\text{Percentage} = \left(\frac{Class\ Value}{Total\ area}\right) x\ 100 \quad [2]$$

Results

Land use and land cover changes in Beira City

The results of different land use and land cover (LULC) classes, including population, water, trees, flooded vegetation, crops, built-up area, exposed soil, and pasture changes from 2017 to 2023 are shown in Table 2. The total area covered by the 7 classes evaluated in this study was 658.12 km2. The influence of clouds was found in 4 out of 7 years assessed in this study. However, the estimated areas were negligible (0.0001 to 0.0007 Km^2 (Table 1). The contribution of the area covered by clouds to the total area was about 0.00%, indicating reliable data for the 7 LULC classes. Overall, the variation of LULC was class and year-dependent. In the scope of this research, the yearly contribution of cropping areas to the total area decreased continuously from 2017 to 2019. Accordingly, the areas changed from 1.25% (2017), 0.87% (2018), and 0.41% (2019), with an abrupt decrease in 2019 at a low value of 2.70 Km^2.

Table 2. *Land Cover change from 2017 to 2023 and average land cover change*

	Year													
	2017		2018		2019		2020		2021		2022		2023	
	Area (km²)	%	Area (km²)	%	Area (km²)	%	Area (km²)	%	Area (km²)	%	Area (km²)	%	Area (km²)	%
Water	25.37	3.86	25.57	3.88	25.3	3.84	26.94	4.09	27.17	4.13	27.9	4.24	27.38	4.16
Trees	42.05	6.39	44.08	6.70	22.76	3.46	36.97	5.62	35.75	5.43	34.22	5.20	34.88	5.30
Flooded Vegetation	23.21	3.53	23.33	3.55	24.02	3.65	22.37	3.40	31.41	4.77	24.39	3.71	17.09	2.60
Crops	8.25	1.25	5.72	0.87	2.70	0.41	5.23	0.79	6.8	1.03	9.54	1.45	7.06	1.07
Built Area	103.81	15.8	109.03	16.6	106.45	16.2	118.46	18.0	122.72	18.7	130.08	19.8	124.96	19.0
Bare Ground	5.39	0.82	4.22	0.64	4.04	0.61	3.73	0.57	3.58	0.54	3.49	0.53	3.23	0.49
Rangeland	450.03	68.4	446.17	67.8	472.86	71.9	444.42	67.5	430.69	65.4	428.51	65.1	443.54	67.4
Cloud		0.00	0.0001	0.00		0.00	0.0007	0.00		0.00	0.0002	0.00	0.0002	0.00
Total area	658.12	0.00	658.12	0.00	658.12	0.00	658.12	0.00	658.12	0.00	658.12	0.00	658.12	0.00

DOI: 10.6092/issn.2281-4485/21434

Conversely, in the subsequent years 2020 to 2023, the cropland shows an increase from 0.79% (2020), 1.03% (2021), 1.45% (2022), and 1.07% (2023) even though this last year has demonstrated a slight reduction (Table 2, Fig. 2). Based on these results, the bare ground area generally decreased over the years. However, it was found that the built area contrasts with bare ground, which continuously increased from 2017 to 2022 by 15.8%, 16.6%, 18.0%, 18.7%, and 19.8%, except in 2023, where a slight reduction was verified (19.0%). It should also be noted that between 2017 and 2023, water class tends to increase by 3.85% (2017), 3.88% (2018), 3.84% (2019), 4.09% (2020), 4.13% (2021), 4.24% (2022), and decreased to 4.16% (2023). These results indicate that flooded vegetation showed a consistent increasing trend 2022, followed by its greatest annual decrease of 2.60% in 2023. On the other hand, rangeland and tree areas have shown constant variation, especially in 2019, where the range - land increased by as much reaching 71.85%, while the trees decreased by 3.46%. In 2019, the built-up, bare ground, crops, and water areas reduced drastically; meanwhile, flooded vegetation increased (Table 2, Fig. 2). This abrupt decline of land use may be attributed to cyclone IDAI, which affected this City, resulting in LULCbig change in area for all 7 classes. When analyzing the LULC differences between two consecutive years (Yearn+1 -Yearn) and the average LULC it was found that the cropland experienced its most significant decline between 2019 and 2020, likely due to climatic events, such as cyclone Idai occurred in 2019, while its largest expansion occurred from 2021 to 2022, possibly driven by government policies, including post-cyclone recovery programs (Table 3). The average LULC trends indicate how each class has changed over the period analysis, with built-up areas and water bodies exhibiting growth, whereas bare land shows a decreasing trend (Table 3)

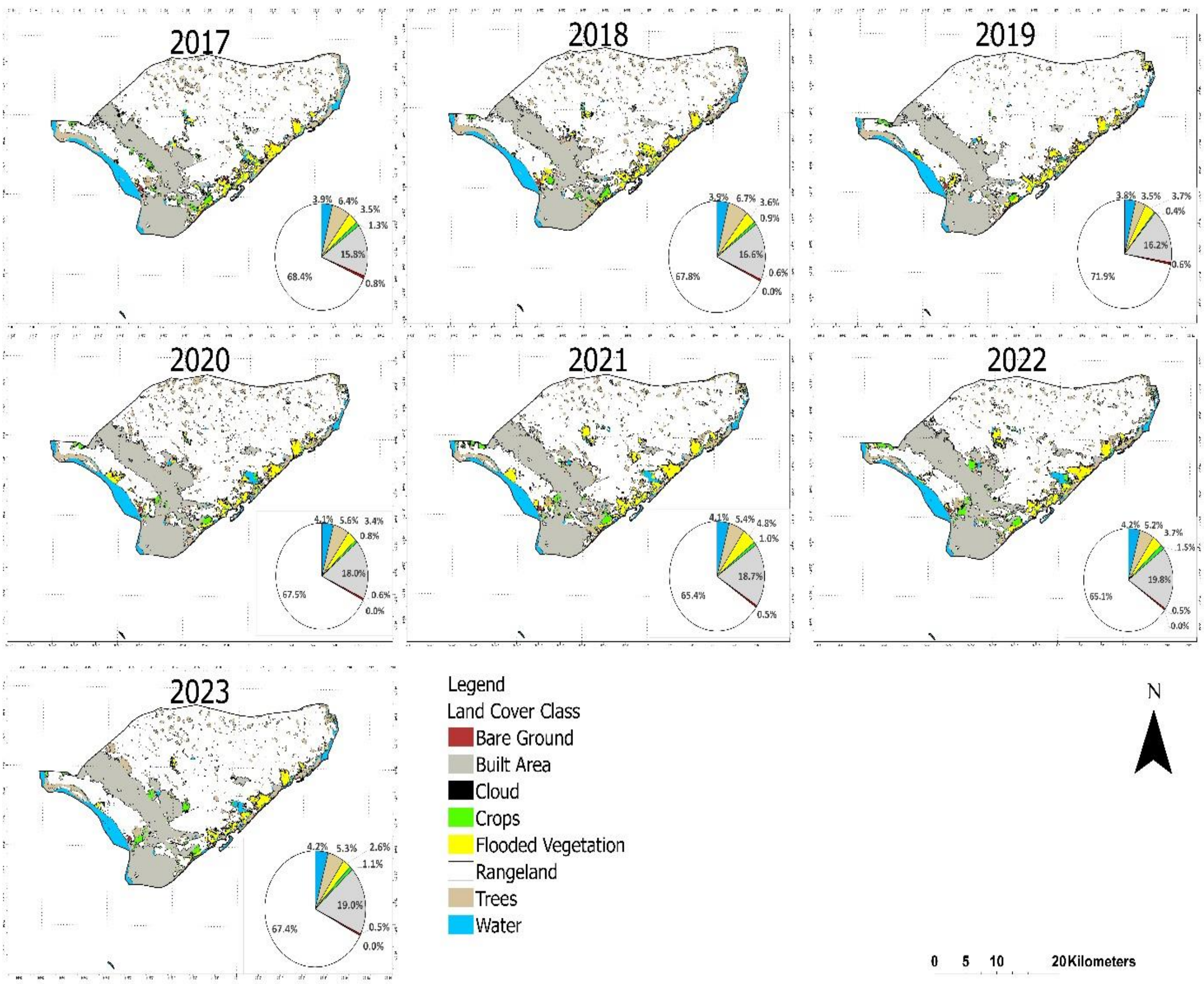

Figure 2. *Beira city time series Land Cover maps from 2017 to 2023*

DOI: 10.6092/issn.2281-4485/21434

Table 3. *Variations of the LULC in the study site.*

	Area (Km²)						
Year	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	Average LULC
Water	0.20	-0.27	1.64	0.22	0.74	-0.53	0.33
Trees	2.03	-21.3	14.2	-1.22	-1.53	0.66	-1.20
Flooded Vegetation	0.12	0.69	-1.65	9.04	-7.02	-7.30	-1.02
Crops	-2.53	-3.03	2.53	1.57	2.73	-2.48	-0.20
Built Area	5.22	-2.58	12.01	4.26	7.35	-5.12	3.53
Bare Ground	-1.17	-0.18	-0.32	-0.14	-0.10	-0.26	-0.36
Rangeland	-3.86	26.7	-28.4	-13.7	-2.18	15.03	-1.08

Land Use/Land Cover correlation

Our result indicated an interaction between land cover classes and population growth, build-up area, and water classes (Table 4). Built-up areas and water bodies (Water class) showed a strong positive correlation with population growth, suggesting that this these land cover types increases as the the population grows. Cropping areas had a moderate positive correlation with water, trees, and built-up areas, meaning agricultural land is often found near these features. Cropping areas and rangelands had a strong inverse relationship, indicating an eventual shifting of land use from grazing to cultivation areas. On the other hand, rangelands showed a moderate negative correlation with population and a strong correlation with built area, indicating a decrease in the open lands as the population and urbanization grow.

Influence of individual variables on the cropping area

The multiple regression analysis of the cropping area with the proposed independent variables (population, built-up areas, and bare ground) showed an R-value of 0.96. This indicates a strong positive correlation among all independent variables. Furthermore, the F-value obtained was 12.1, which is greater than the significance level of F (0.035). This means that the multiple regression model based on population, built-up areas, and bare ground is statistically significant (F < 0.05), confirming the validity of the regression analysis. It was also found that the population growth alone does not directly impact cropping areas in Beira City because it was not statistically significant (p-value = 0.67). This suggests that while urban areas in Beira City are expanding, the growth of the population is not the primary factor contributing to the decrease in agricultural land. Instead, the expansion of built-up areas has a direct impact on cropping land (p-value = 0.03), indicating that agricultural land is being converted into residential areas. This supports the idea that urbanization expansion takes over agricultural land use rather than population growth. Likewise, similar results were

Table 4
Correlation Matrix

	Population	Water	Trees	Flooded vegetation	Crops	Built Area	Bare Ground
Water	0.90						
Trees	-0.31	-0.04					
Flooded Vegetation	-0.17	0.01	-0.04				
Crops	0.29	0.54	0.52	0.01			
Built Area	0.93	0.99	-0.09	0.02	0.50		
Bare Ground	-0.90	-0.78	0.38	0.06	0.03	-0.84	
Rangeland	-0.51	-0.79	-0.49	-0.29	-0.79	-0.76	0.39

EQA 70 (2025): 87-95

DOI: 10.6092/issn.2281-4485/21434

found in the Bare Ground (*p*-value = 0.67). This suggests that while urban areas in Beira City are expanding, the growth of the population is not the primary factor contributing to the decrease in agricultural land. Instead, the expansion of built-up areas has a direct impact on cropping land (*p*-value = 0.03), indicating that agricultural land is being converted into residential areas. This supports the idea that urbanization expansion takes over agricultural land use rather than population growth. Likewise, some results were found in the Bare Ground (p-value = 0.02), contributing to the reduction of the cropping area.

Discussion

The global land cover is undergoing various changes worldwide due to human activities such as agriculture, urbanization, and natural processes such as flooding (Hansen et al., 2000, Phiri et al., 2019). The changes we observe significantly affect hu-man life, highlighting the necessity for proper manage-ment and utilization of natural resources to establish effective sustainability mechanisms. Our findings indi-cate that the reduction of agricultural land in Beira City is closely linked to the expansion of urban areas. This is consistent with the research conducted by Beckers et al. (2020), which reported similar changes in agricultural land due to urbanization in Belgium. On the other hand, one of the greatest constraints to the widespread adoption of urban agriculture is the limited access to land for those who would like to grow food, and the lack of security tenure on that land, particularly where the production functions are competing with other uses (such as commercial development) that provide greater profit for the landowner (Redwood, 2009). For example, studies have revealed that many urban farms are established on vacant lots or other underutilized spaces but without the direct permission or long-term commitment of the landowner or manager. Marginalized groups and minority populations are particularly vulnerable to the problem of land access and security since they often do not have the means to purchase land (Redwood, 2009; Poor and Brule, 2007). The correlation analysis revealed significant relationships between land cover classes and urban expansion variables, providing insights into the spatial dynamics of urban agriculture in Beira City. Notably, built-up areas and water bodies exhibited a strong positive correlation with population growth (r = 0.93 and r = 0.89, respectively), suggesting that urban expansion is driven primarily by infrastructure development rather than direct agricultural land use. Conversely, cropping areas demonstrated a moderate positive correlation with water bodies (r = 0.54) and trees (r = 0.52), implying that urban agriculture is predominantly concentrated near natural water sources and vegetation cover. However, the inverse correlation between rangelands and cropping areas (r = -0.79) suggests that the conversion of rangelands into cultivated land is a prominent land-use transition, possibly influenced by agricultural intensification. The multiple regression analysis further substantiates these findings. The model achieved a strong predictive capability ($R^2 = 0.96$, $p < 0.05$), indicating that built-up area expansion and bare ground reduction significantly impact urban agriculture dynamics. The multiple regression analysis further substantiates these findings. The model achieved a strong predictive capability ($R^2 = 0.96$, $p < 0.05$), indicating that built-up area expansion and bare ground reduction significantly impact urban agriculture dynamics. The regression coefficients suggest that Built-up areas (p = 0.03) exert a statistically significant negative effect on cropping areas, confirming that urbanization encroaches upon agricultural land. Bare ground (p = 0.02) is also a critical determinant, with its reduction corresponding to declines in available cropping areas, possibly due to land degradation or conversion to non-agricultural uses. Population growth (p = 0.67), however, did not exhibit statistical significance, suggesting that demographic growth alone cannot directly drive changes in urban agricultural land use, which contradicts findings reported in other urban contexts, such as North Ethiopia (e.g., Urgesa et al., 2016). This contradictory finding could be explained by a relatively small covered area and the population growth rate in our study. These results highlight that while urban expansion is a primary driver of land-use change, agricultural land dynamics are more closely linked to environmental factors and land availability than to direct population pressure. Future urban planning policies should incorporate land-use zoning strategies that balance agricultural sustainability with urban growth demands. Government programs aimed at food production can help facilitate agricultural recovery and expansion. However, urban agriculture faces several challenges, including competition for land, climate events, and inconsistencies in planning. To promote sustainability, urban planning policies should incorporate urban agriculture into land-use frameworks, effectively balancing food security, environmental sustainability, and urban growth. Collaboration among policymakers, local farmers, and stakeholders is

DOI: 10.6092/issn.2281-4485/21434

crucial for developing resilient agricultural strategies that support both livelihoods and ecological stability. Our research indicates that during events with a magnitude similar to IDAI, there is a significant decline in the area used for cropping, Build-up, and tree coverage, while rangeland increases. These insights may assist policymakers in addressing urban agriculture planning, food security, and climate resilience, particularly in regions susceptible to extreme climatic events, such as Beira City.

Conclusions

The findings of this study indicate that population growth does not directly influence changes in cropping areas in Beira City. Instead, urbanization and land degradation are leading to a decline in agricultural land use. The study reveals that the dynamics of built-up areas and bare ground significantly affect cropping areas, with urban expansion resulting in the reduction of agricultural land. Furthermore, there is a correlation between cropping areas, water bodies, and trees, suggesting that urban agriculture relies on natural resources. These results highlight the need for different strategies regarding urban agricultural land use, which is constrained by urban development policies, to alleviate pressure on cropping areas. Additionally, the study recommends promoting sustainable land-use planning, managing urban expansion, conserving soil, and improving agricultural productivity. Local decision-makers in Beira City should consider these actions in collaboration with various stakeholders to address food security and support sustainable urban growth.

References

ALIG R.J., KLINE J.D., LICHTENSTEIN M. (2004) Urbanization on the US land scape: looking ahead in the 21st century. Landscape and urban planning, 69(2-3):219-234. https://doi.org/10.1016/j.landurbplan.2003.07.004

BATISTA M.J., QUENTAL L., DIAS R., RAMALHO E., FERNANDES J., MILISSE D., MANHIÇA V., USSENE U., CUNE G.R., DAUDI E.X., OLIVEIRA J.T. (2018) Geochemical characterisation of soil of Beira city, Mozambique: geogenic origin and relation with land cover. Journal of Geochemical Exploration, 187:184-200. https://doi.org/10.1016/j.gexplo.2017.10.014

BECKERS V., POELMANS L., VAN ROMPAEY A., DENDONCKER N. (2020) The impact of urbanization on agricultural dynamics: a case study in Belgium. Journal of Land Use Science, *15*(5), 626–643. https://doi.org/10.1080/1747423X.2020.1769211

CHAVES M.E.D., PICOLI M.C.A., SANCHES I.D. (2020) Recent Applications of Landsat 8/OLI and Sentinel-2/MSI for Land Use and Land Cover Mapping: A Systematic Review. Remote Sensing, 12:3062. https://doi.org/10.3390/rs12183062

CLINTON N., STUHLMACHER M., MILES A., ULUDERE ARAGON N., WAGNER M., GEORGESCU M., HERWIG C., GONG P. (2018) A global geospatial ecosystem services estimate of urban agriculture. Earth's Future, 6(1):40-60. https://doi.org/0.1002/2017EF000536

GOLDEWIJK K.K., (2001) Estimating global land use change over the past 300 years: the HYDE database. Global biogeochemical cycles, 15(2):417-433. https://doi.org/10.1029/1999GB001232

GÓMEZ C., WHITEJ C., WULDERM. A. (2016) Optical remotely sensed time series data for land cover classification: A review. ISPRS Journal of photogrammetry and Remote Sensing, 116:55-72. https://doi.org/10.1016/j.isprsjprs.2016.03.008

GUMMA M.K., MOHAMMAD I., NEDUMARAN S., WHITBREAD A., LAGERKVIST C.J. (2017) Urban Sprawl and Adverse Impacts on Agricultural Land: A Case Study on Hyderabad, India. Remote Sensong, 9:1136. https://doi.org/10.3390/rs9111136

HANSEN M.C., DEFRIES R.S., TOWNSHEND J.R.G., SOHLBERG R. (2000) Global land cover classification at 1 km spatial resolution using a classification tree approach. Int. J. Remote Sens. 21, 1331–1364

INE. (2020) População Projectada por Distritos, Maputo Cidade 2007-2040: Projected Population by Districts, Maputo City. Maputo. http://www.ine.gov.mz/estatisticas/estatisticas-demograficas-e-indicadores-cassociais/projecco es-da-populacao/populacao-projectada-por-distritos-mapu to-cidade-2007_2040.xls/view

LIU L., ZHANG X., GAO Y., CHEN X., SHUAI X., MI J. (2021) Finer-Resolution Mapping of Global Land Cover: Recent Developments, Consistency Analysis, and Pro-spects. Journal of Remote Sensing, 2021:5289697. https://doi.org/10.34133/2021/5289697

MAVUME A. F., BANZE, B. E., MACIE, O. A., & QUEFACE A. J. (2021) Analysis of Climate Change Projections for Mozambique under the Representative Concentration Pathways. Atmosphere, *12* (5), 588. https://doi.org/10.3390/atmos12050588

MOUGEOT L.J.A. (2006) Growing better cities: Urban agri-culture for sustainable development. IDRC, International Development Research Centre, Ottawa. ISBN1-55250-226-0

DOI: 10.6092/issn.2281-4485/21434

MOUGEOT L.J.A. (2005) Urban Agriculture and the Millenium Development Goals. In Agropolis –The Social, Political and Environment Dimensions of Urban Agriculture, Mougeot, A.J. (Edit.), International Development Research Centre. https://doi.org/10.4324/9781849775892

NUNBOGU A.M., KORAH P.I. (2017) Self-organisation in urban spatial planning: Evidence from the Greater Accra Metropolitan Area, Ghana. Urban Research & Practice, 10 (4):423-441.
https://doi.org/10.1080/17535069.2016.1238502.

PHIRI D., SIMWANDA M., SALEKIN S., NYIRENDA V.R., MURAYAMA Y., RANAGALAGE M. (2020) Sentinel-2 Data for Land Cover/Use Mapping: A Review. Remote Sensing., 12(14):2291.
https://doi.org/10.3390/rs12142291

POOR P.J., BRULE R. (2007) An investigation of the socio-economic aspects of open space and agricultural land preservation. Journal of sustainable agriculture, 30(3):165-176. https://doi.org/10.1300/J064v30n03_11

RAMANKUTTY N., FOLEY J.A. (1999) Estimating historical changes in global land cover: croplands from 1700 to 1992. Global biogeochemical cycles, 13(4):997-1027. https://doi.org/10.1029/1999GB900046

REDWOOD M. (2009) Urban Agriculture in urban planning: generating livelihoods and food security. London, United Kingdom: Earthscan and the International Development Research Centre (IDRC). Routledge, ISBN: 978-1-84407-668-0

SANTOS M. M., LANZINHA J. C. G. VAZ FERREIRA A. (2021) Proposal of methodology for evaluation of a vertical shanty building in Beira, Mozambique. Civil Engineering, 2:35–47.
https://doi.org/10.3390/CIVILENG2010003

SILVESTRI L., SOSA A., MC KAY F., VITORINO M.D., HILL M., ZACHARIADES C., HIGHT S., WEYL P., SMITH D., DJEDDOUR D. AND MASON P.G. (2020) Implementation of access and benefit-sharing measures has consequences for classical biological control of weeds. BioControl, 65:125-141.
https://doi.org/10.1007/s10526-019-09988-4

THORNTHWAITE C.W. (1948) An approach toward a rational classification of climate. Geographical Review 38(1): 55–94. https://doi.org/10.2307/210739

TSENDBAZAR N., LI L., KOOPMAN M., CARTER S., HEROLD M., GEORGIEVA I. AND LESIV M. (2021). Product Validation Report (D12-PVR) v 1.1.
https://pure.iiasa.ac.at/id/eprint/18981/

UN-Habitat. (2014). The state of African cities, 2014: Re-imagining sustainable urban transitions. United Nations Human Settlements Programme.

URGESA A A., ABEGAZ A., BAHIR A L., ANTILLE D. L. (2016) Population growth and other factors affecting land-use and land-cover changes in north-eastern Wollega, Ethiopia. Tropical Agriculture, 93(4):298-311.

VENTER Z.S., BARTON D.N., CHAKRABORTY T., SIMENSEN T., SINGH G. (2022) Global 10 m Land Use Land Cover Datasets: A Comparison of Dynamic World, World Cover and Esri Land Cover. Remote Sensing, 14:4101. https://doi.org/10.3390/rs14164101

WHITE S.A., HAMM M. W. (2017) A view from the south: Bringing critical planning theory to urban agriculture. In A. M. G. A. WinklerPrins (Ed.), Global urban agriculture, 12–23, CABI.
https://doi.org/10.1079/9781780647326.0012

WORLD BANK. (2009) Mozambique - Municipal Development in Mozambique: Lessons from the First Decade - Full report. World Bank.
https://openknowledge.worldbank.org/handle/10986/3102

www.agricultura.gov.mz/sofala-lanca-a-chamada-publica-do-programa-sustenta-para-a-campanha-2021-22/

www.atlasofurbanexpansion.org/cities/view/Beira