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Urban Frontiers: Rethinking Market Gardening Resilience in the Face of Rapid City Expansion in Limbe, Cameroon

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ABSTRACT

This study addresses a pressing knowledge gap concerning how rapid, unchecked urban expansion is undermining the resilience of market gardening in Limbe, Cameroon—a sector vital for local food security and inclusive livelihoods. Unlike prior assessments limited to mapping land use change or basic socio-economic profiling, this research uniquely integrates spatial analysis, household surveys, and stakeholder interviews to examine the adaptive strategies and vulnerabilities of smallholder market gardeners. The results provide new evidence that built-up areas in Limbe have expanded nearly eightfold since 1995, shrinking cropland below 6% of total land by 2025 and sharply intensifying spatial and socio-economic pressure on predominantly female growers. These findings are significant because only 21.8% of gardeners benefit from secure tenure, average plot size and income have declined by over one-third since 2015, and more than half now report precarious livelihoods. This study demonstrates that while gardeners actively pursue land-sharing, crop diversification, and group action, persistent tenure insecurity and policy fragmentation sharply limit their capacity for sustainable adaptation. Implications for urban policy include the urgent need for participatory land use planning, formalized tenure, and more robust institutional support for peri-urban growers. The findings advance current understanding of urban agriculture's vulnerability amid African urbanization and provide actionable evidence to inform resilient urban food system development locally and in similarly dynamic cities.

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KEYWORDS: market gardening, urban expansion, resilience, Limbe, land tenure, urban policy, food security, Cameroon, adaptation strategies, peri-urban agriculture.

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1. INTRODUCTION

Limbe, a coastal city in the Southwest Region of Cameroon, has long been recognized for its vibrant market gardening sector, which contributes significantly to local food security, employment, and urban sustainability (Ekane, 2025). Over the past decade, however, Limbe has experienced rapid urbanization, characterized by accelerated population growth and infrastructural development, which has fundamentally transformed its peri-urban landscape (Neba & Fonyuy, 2021; Ojong et al., 2023). This urban expansion, defined as the outward growth of built-up areas into previously rural or agricultural zones, is a trend observed across many African cities, often resulting in the reduction of arable land and increased competition for space (Akinyemi et al., 2022; Tchamabe et al., 2024).The encroachment of urban development on agricultural land in Limbe poses a critical threat to the livelihoods and resilience of market gardeners—small-scale farmers who supply fresh vegetables to urban populations (Ekane, 2025; Njie & Ndip, 2022). As the city expands, market gardeners face shrinking access to fertile land, insecure tenure, and mounting resource competition, all of which undermine their capacity to sustain production and adapt to changing conditions (Akinyemi et al., 2022; Tchamabe et al., 2024). These challenges are compounded by policy gaps and limited institutional support, making it increasingly difficult for market gardeners to maintain their role in the urban food system (Njie & Ndip, 2022; Ojong et al., 2023).

This paper aims to critically examine how market gardeners in Limbe are adapting or struggling to adapt to the pressures of rapid urbanization. By analyzing land use and land cover (LULC) changes, socio-economic data, and stakeholder perspectives, the

study seeks to identify both the vulnerabilities and adaptive strategies present in Limbe's market gardening sector. Furthermore, the paper proposes innovative pathways for strengthening resilience, drawing on recent research and local experience.The significance of this study lies in the crucial role that urban agriculture (UA) plays in ensuring food security, generating employment, and promoting sustainable urban development in Sub-Saharan Africa (SSA) (Akinyemi et al., 2022; Tchamabe et al., 2024). As cities like Limbe continue to grow, safeguarding the resilience of market gardening is essential not only for the well-being of local communities but also for the broader goals of urban sustainability and inclusive development (Njie & Ndip, 2022; Ojong et al., 2023).This paper argues that the resilience of market gardening in Limbe is under significant threat from unchecked urban expansion, but that targeted interventions and adaptive strategies can help secure its future as a cornerstone of urban food systems in Cameroon and beyond.

2. LITERATURE REVIEW

2.1. Urban Expansion and Peri-Urban Agriculture

Urban expansion, the process by which cities grow spatially into surrounding rural or agricultural areas, has accelerated across Africa and the globe in recent years. In Sub-Saharan Africa (SSA), this expansion is largely driven by population growth, rural-to-urban migration, and economic transformation (Neba & Fonyuy, 2021; Akinyemi et al., 2022). Studies have documented that the conversion of peri-urban agricultural land to residential, commercial, and infrastructural uses is a common feature of urbanization in countries such as Nigeria, Ghana, and Cameroon (Akinyemi et al., 2022; Ojong et al., 2023). This trend has led to a marked decline in the availability of arable land for smallholder farmers and market gardeners, resulting in heightened competition for space and resources (Njie & Ndip, 2022; Tchamabe et al., 2024).

Globally, peri-urban agriculture (PUA) plays a vital role in food provisioning for urban populations, especially in rapidly growing cities where formal food systems may not keep pace with demand (Akinyemi et al., 2022). However, the sustainability of PUA is increasingly threatened by land tenure insecurity, environmental degradation, and policy neglect (Ojong et al., 2023). In SSA, these challenges are compounded by weak urban planning frameworks and limited institutional support for urban and peri-urban farmers (Tchamabe et al., 2024).

2.2. Resilience in Urban Agriculture

Resilience in urban agriculture (UA) refers to the capacity of farming systems and communities to absorb, adapt, and transform in response to shocks and stresses, including those associated with urban expansion (Akinyemi et al., 2022). The Sustainable Livelihoods Framework (SLF), originally developed by Chambers and Conway (1992), has been widely applied to analyze how urban and peri-urban farmers mobilize assets natural, social, human, physical, and financial capital to sustain their livelihoods in the face of change (Njie & Ndip, 2022). Recent studies have also employed urban resilience theory, emphasizing the need for adaptive governance, social learning, and diversification of livelihood strategies to enhance the robustness and flexibility of UA systems (Ojong et al., 2023).

In the context of SSA, resilience-building strategies among market gardeners include crop diversification, adoption of water-saving technologies, collective action through farmer associations, and negotiation of informal land tenure arrangements (Akinyemi et al., 2022; Tchamabe et al., 2024). Nevertheless, the effectiveness of these strategies is often limited by structural barriers such as inadequate access to credit, lack of extension services, and exclusion from urban policy processes (Njie & Ndip, 2022).

2.3. Market Gardening in Cameroon

Market gardening, the intensive production of vegetables and other high-value crops for urban markets, is a longstanding livelihood activity in Cameroon's urban and peri-urban areas (Ekane, 2025). In cities like Limbe, market gardening not only contributes to household income and employment but also enhances urban food security by providing affordable, fresh produce (Njie & Ndip, 2022; Ojong et al., 2023). However, the sector faces unique challenges, including rapid land conversion due to urban expansion, insecure land tenure, limited access to irrigation, and fluctuating market conditions (Neba & Fonyuy, 2021; Ekane, 2025).Recent research highlights that market gardeners in Limbe and other Cameroonian cities are increasingly marginalized as urban land values rise and formal planning processes prioritize residential and commercial development over agriculture (Akinyemi et al., 2022; Tchamabe et al., 2024). These pressures have forced many gardeners to adopt short-term coping strategies, such as renting land or shifting to less secure, marginal plots, which undermines long-term resilience and investment in sustainable practices (Ekane, 2025).

2.4. Gap in the Literature

While there is a growing body of research on urban expansion and its impact on agriculture in SSA, most studies tend to focus either on the spatial dynamics of urban growth or on the socio-economic characteristics of urban farmers (Akinyemi et al., 2022; Njie & Ndip, 2022). Few studies explicitly integrate resilience thinking to examine how market gardeners adapt to and are

affected by rapid urbanization, particularly in secondary cities like Limbe (Ojong et al., 2023; Tchamabe et al., 2024). This gap limits the development of holistic policy responses that address both the drivers of urban expansion and the adaptive capacities of peri-urban agricultural communities. Addressing this gap is critical for fostering sustainable urban food systems and resilient livelihoods in the face of ongoing urban transformation.

3. METHODOLOGY

3.1. Study Area

This study was conducted in Limbe (Figure 1), a coastal city in the Southwest Region of Cameroon, historically known for its dynamic market gardening sector. Limbe has experienced rapid urban expansion over the past three decades, making it an ideal case for examining the intersection of urban growth and peri-urban agriculture (Ekane, 2025).

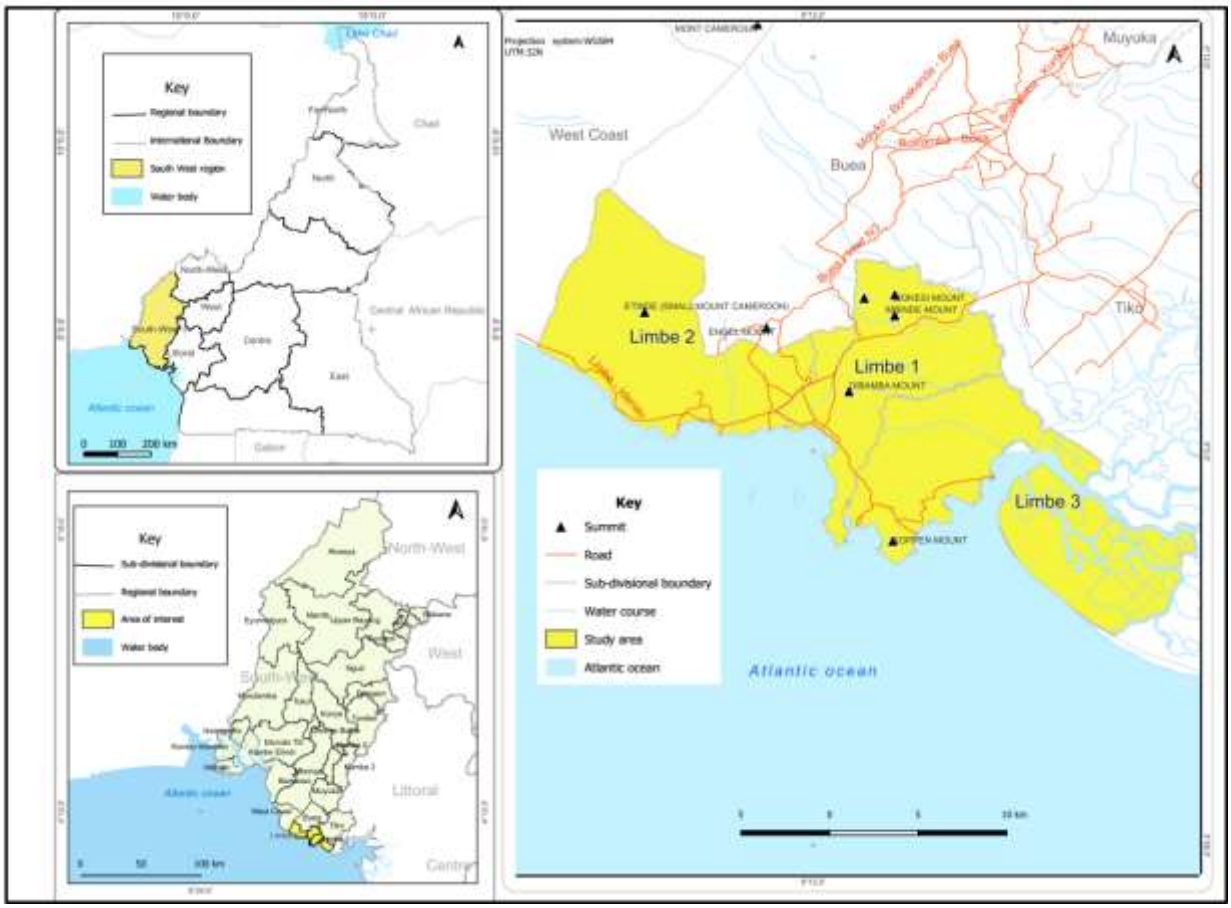

Figure 1 : Study area

3.2. Research Design

A mixed-methods approach (Figure 2) was adopted, combining quantitative and qualitative data to provide a comprehensive understanding of how urban expansion affects market gardening resilience. This design facilitated triangulation of findings and enriched the analysis of adaptation strategies.

3.3. Target Population and Sampling

The target population comprised market gardeners operating within Limbe's urban and peri-urban zones. Additional participants included representatives from relevant government ministries, non-governmental organizations (NGOs), and local authorities involved in land management and urban planning.

A multi-stage sampling technique was used:

First, major market gardening sites were identified based on land use/land cover (LULC) maps and local knowledge.

Second, a simple random sampling method was employed to select 202 market gardeners for questionnaire administration, ensuring representation across Limbe's key neighborhoods.

Purposive sampling was used for key informant interviews with officials from the Limbe City Council (LCC), Ministry of Agriculture and Rural Development (MINADER), and local NGOs.

3.4. Data Sources

3.4.1. Primary Data

Structured Questionnaires: Administered to 202 market gardeners to collect quantitative data on demographics, land access, production practices, adaptation strategies, and livelihood outcomes.

Key Informant Interviews: Conducted with officials from LCC, MINADER, and NGOs to gain insights into policy, institutional support, and challenges facing market gardeners.

Field Observations: Used to validate questionnaire and interview responses and to document land use changes on the ground.

3.4.2. Secondary Data

Land Use/Land Cover (LULC) Maps: Historical (1995, 2015) and projected (2025) maps obtained from municipal archives and previous research (Ekane, 2025).

Official Reports and Policy Documents: Reviewed to contextualize findings and understand the regulatory environment.

3.5. Data Collection Procedures

Data collection was carried out between January and April 2025. Enumerators fluent in local languages were trained to administer questionnaires and conduct interviews. All participants provided informed consent, and ethical guidelines were strictly observed.

3.6. Data Analysis

Quantitative Data: Analyzed using descriptive statistics (frequencies, percentages, means) and inferential statistics, notably the Chi-square test, to examine relationships between urban expansion and market gardening outcomes. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 26.

Qualitative Data: Thematic analysis was applied to interview transcripts and field notes, allowing for the identification of key themes related to adaptation and resilience.

Spatial Analysis: LULC data were analyzed using Geographic Information Systems (GIS) to map and quantify changes in built-up and agricultural areas over time.

3.7. Limitations

While the study employed robust methods, limitations include potential recall bias in self-reported data and the challenges of projecting future land use with absolute certainty. Nonetheless, triangulation of multiple data sources and methods helped to enhance the validity and reliability of findings.

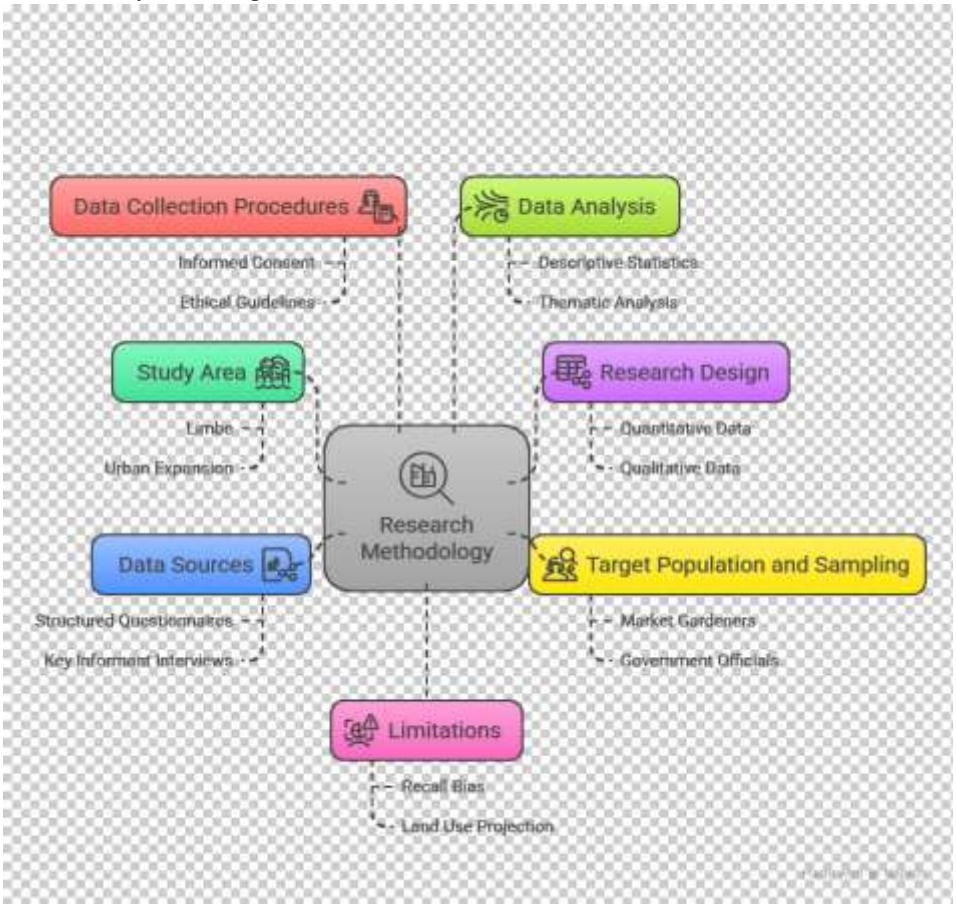

Figure 2 : Research methodology for urban expansion and market gardening resilience

4. RESULTS

This section presents the empirical findings on urban expansion and its effects on market gardeners in Limbe, integrating spatial, socio-economic, and comparative perspectives. The results are structured to first establish land use trends, then profile the affected population, analyze livelihood impacts, and finally assess adaptation strategies.

4.1. Urban Expansion Trends in Limbe: Evidence from Land Use Land Cover Maps (1995, 2015, 2025)

To understand the scale and pace of urban expansion in Limbe, Table 1 provides a quantitative summary of land use changes over three decades. The table shows a dramatic increase in built-up areas and a corresponding decline in cropland, reflecting the intense spatial competition between urban development and agriculture a trend widely documented in sub-Saharan Africa (Akinyemi et al., 2022; Tchamabe et al., 2024).

Table 1 : Quantitative Changes in Land Use Categories in Limbe, 1995–2025: Evidence of Urban Encroachment on Cropland

Land Use Category	1995 (%)	2015 (%)	2025 (%)
Built-up Area	1.87	8.54	14.71
Cropland	33.09	13.52	5.62
Other (Forest, etc.)	65.04	77.94	79.67

Table 1 quantifies the dramatic shift in land cover composition over three decades. Built-up areas expand from a negligible 1.87% in 1995 to 14.71% by 2025 an almost eightfold increase while cropland contracts precipitously from 33.09% to just 5.62%. The residual "Other" category (primarily forest and non-cultivated land) correspondingly grows, reflecting both urban encroachment and the diminishing footprint of agricultural zones. This tabular summary underscores the scale of spatial reorganization occurring in Limbe and sets the stage for analyzing its socio-economic impacts. To further illustrate these dynamics, Figure 3 visualizes the spatial and temporal progression of land use change. The area chart highlights the steady encroachment of built-up land, the dramatic thinning of cropland, and the expansion of "Other" land categories. The steepest decline in cropland occurs between 1995 and 2015, coinciding with rapid urbanization, while built-up area accelerates most sharply after 2015.

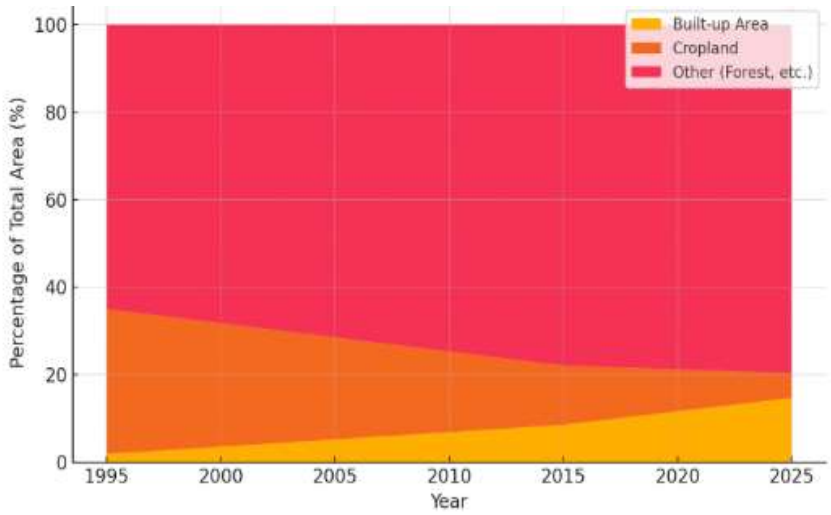

Figure 3 : Spatial Progression of Urban Expansion and Cropland Loss in Limbe, 1995–2025

The area chart vividly portrays these dynamics over time: the rising yellow band of built-up land encroaches steadily upward, the orange band of cropland thins dramatically, and the red band of "Other" land expands to fill the gap. By visually integrating all three categories, Figure 3 makes clear how urban growth has systematically displaced agricultural land, fragmenting and reducing the area available for market gardening. This is a trend widely reported in the literature on urban land transitions in SSA (Akinyemi et al., 2022; Tchamabe et al., 2024).

Mapping Recent Land Use/Land Cover Changes: 2015–2025

To provide a detailed, spatially explicit perspective on recent land dynamics, land use land cover (LULC) maps for Limbe for 2015 and 2025 are presented in Figures 9 and 10. These maps visually demonstrate the scale and nature of conversion from vegetation and cropland to built-up and bare soil areas in the past decade.

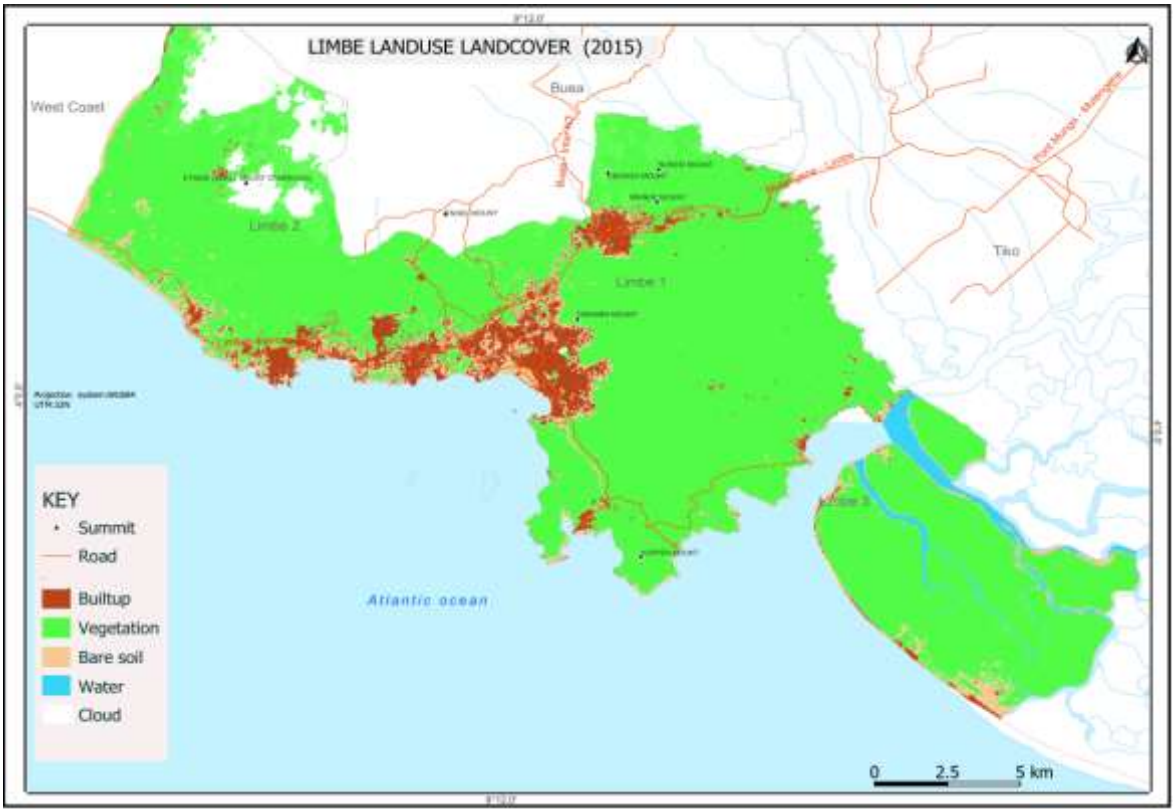

Figure 9: Limbe Land Use Land Cover, 2015

Figure 9 *(Limbe Land Use Land Cover, 2015) depicts the spatial distribution of built-up areas, vegetation, bare soil, water, and cloud cover in Limbe at the start of the last decade. The figure shows that, in 2015, vegetation dominates the landscape, while built-up and bare soil areas are relatively limited.*

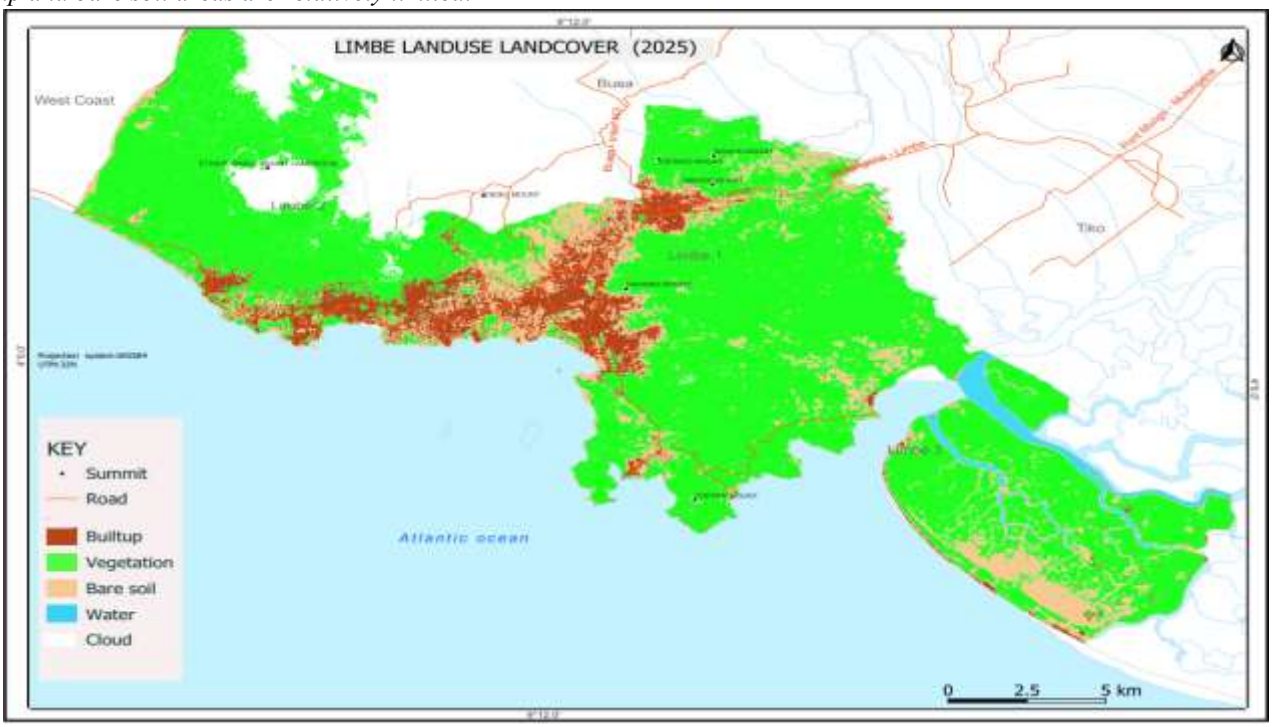

Figure 10: Limbe Land Use Land Cover, 2025

Figure 10 (Limbe Land Use Land Cover, 2025) illustrates the same categories as in Figure 9 but reveals a striking change: built-up and bare soil areas have expanded considerably, while vegetation cover has shrunk. This pronounced shift reflects accelerated urbanization and land conversion over the decade.

A comparative analysis of these maps reveals pronounced expansion of urban/built-up surfaces between 2015 and 2025, coupled with marked reduction in vegetation cover. These spatial patterns are consistent with the tabulated land use changes over the same period, and further corroborate the intense spatial pressure on market gardening and agricultural zones.

Supporting these visual representations, the quantitative changes between 2015 and 2025 are summarized in Table 5:

Table 5: Limbe LULC Change (in hectares) Between 2015 and 2025

Category	2015	2025	Change (2015-2025)
Built-up	2,236.89	2,717.33	+480.45
Vegetation	25,625.98	22,842.59	−2,783.39
Bare soil	1,658.42	4,051.09	+2,392.67
Water	578.23	1,508.49	+930.26
Clouds	1,614.85	1,508.49	−106.36

Table 5 quantifies the changes underlying the mapped LULC transitions. The built-up area increased by 480.45 hectares, while vegetation decreased by 2,783.39 hectares and bare soil surged by 2,392.67 hectares. Water surfaces and cloud cover also shifted likely reflecting changes in surface hydrology and seasonal atmospheric conditions. These results further substantiate the narrative of accelerating spatial competition and encroachment on farmland.

Thus, Figures 9 and 10, together with Table 5, provide both visual and quantitative evidence of the magnitude and pattern of land use change in Limbe over the last decade, clearly highlighting the spatial context and empirical basis for subsequent analyses of social and livelihood impacts.

4.2. Socio-Economic Profile of Market Gardeners in Limbe

Understanding who is affected by land use change is crucial for interpreting its impacts. Table 2 summarizes the demographic and socio-economic characteristics of market gardeners in Limbe. The majority are women, with most in their prime working years and possessing only primary or secondary education. Nearly four out of five respondents rely on gardening as their main income source.

Table 2: Demographic and Socio-Economic Profile of Market Gardeners in Limbe (n=202)

Characteristic	Category	Percentage (%)
Gender	Female	62
	Male	38
Age (mean)	Years	38
Education	Primary	42
	Secondary	47
	Tertiary	11
Main Income Source	Gardening	79

The predominance of women and the reliance on gardening for income reflect broader regional patterns in urban agriculture, where female labor predominates and vulnerability is heightened by land scarcity and limited alternative livelihoods (Njie & Ndip, 2022; Ojong et al., 2023).

4.3. Implications of Increased Built-Up Areas for Market Gardeners' Livelihoods

4.3.1. Land Access and Tenure Security

Urban encroachment has led to increased land fragmentation and tenure insecurity among market gardeners. Figure 4 presents the distribution of land tenure arrangements, highlighting the predominance of insecure and informal access.

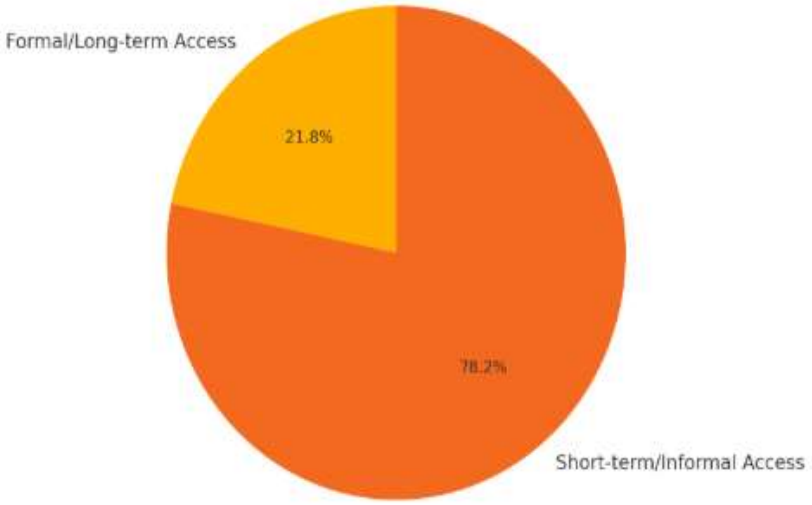

Figure 4: Distribution of Land Tenure Arrangements Among Market Gardeners in Limbe: Prevalence of Insecure and Informal Access

Figure 4 shows that only 21.8% of respondents report having formal or long-term access to land, while the majority rely on short-term rental or informal arrangements. This insecurity discourages investment in sustainable practices and long-term planning, echoing findings from other urbanizing regions in SSA (Akinyemi et al., 2022; Tchamabe et al., 2024).

4.3.2. Production and Livelihood Outcomes

The contraction of cropland has forced many gardeners to intensify production on smaller plots or relocate to less suitable areas, resulting in lower yields and declining incomes. Table 3 presents key indicators of livelihood decline, including average income, plot size, and the percentage reporting livelihood precarity.

Table 3: Declining Livelihood Indicators Among Market Gardeners in Limbe, 2015–2025

Indicator	2015	2025	% Change
Average Income (FCFA/year)	420,000	306,600	−27%
Plot Size (m²)	520	340	−34.6%
% Reporting Precarity	32.1	54.5	+22.4%

By presenting income, plot size, and precarity side by side, Table 3 encapsulates the multifaceted nature of gardeners' vulnerability. The simultaneous contraction of land and income coupled with rising precarity signals a compounding crisis: diminished resources to cope with shocks just as exposure to them intensifies, as also observed in other SSA cities (Tchamabe et al., 2024).

To further illustrate these trends, Figures 5, 6, and 7 provide visual representations of the decline in average annual income, average plot size, and the percentage of market gardeners reporting livelihood precarity, respectively.

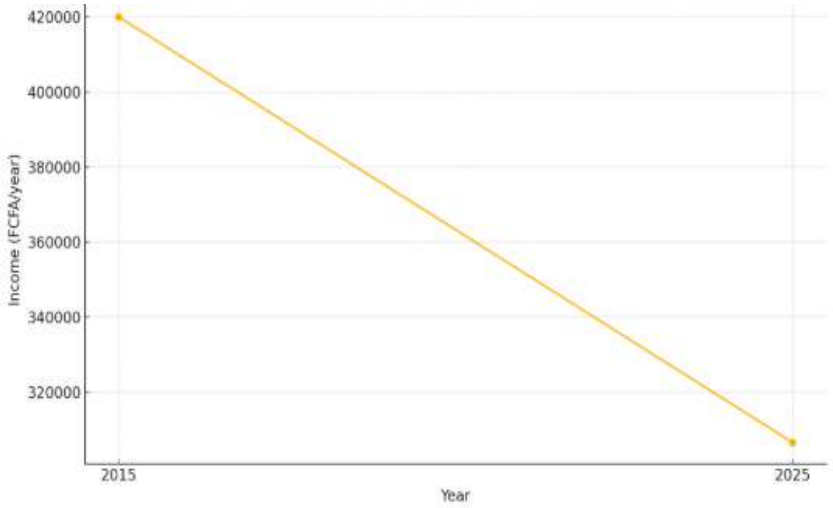

Figure 5: Average Annual Income of Market Gardeners (2015 vs 2025)

This line chart starkly illustrates the 27% erosion in gardeners' earnings over the decade. The drop from 420,000 FCFA in 2015 to 306,600 FCFA in 2025 signals not only reduced revenues but also diminished capacity to invest in inputs, labor, or risk-mitigation measures factors that can further undermine productivity and household food security.

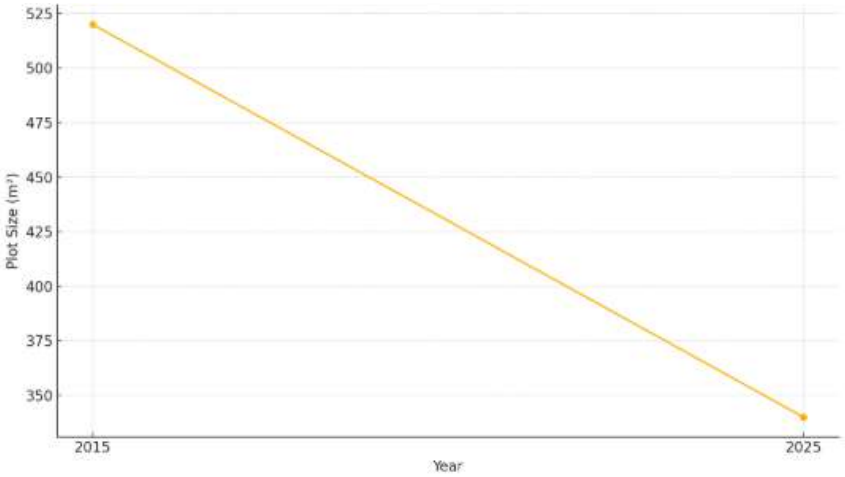

Figure 6 : AveragePlot Size Cultivated by Market Gardeners (2015 vs 2025)

The downward trend in plot size from an average of 520 m² to 340 m² highlights the tangible impact of urban encroachment and land subdivision. Smaller, fragmented parcels constrain economies of scale, limit mechanization potential, and heighten the transaction costs of managing multiple plots, all of which impede gardeners' efficiency and incomes.

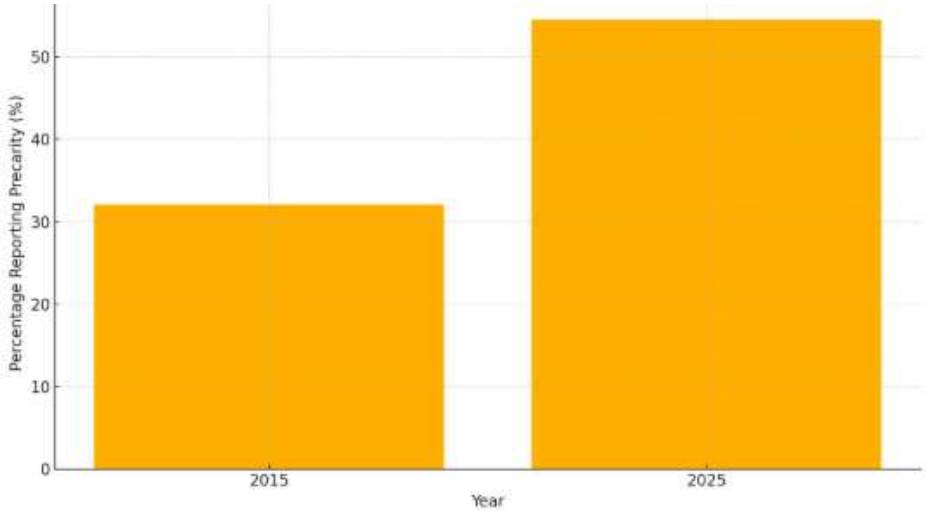

Figure 7 : Percentageof Market Gardeners Reporting Livelihood Precarity (2015 vs 2025)

The rise in self-reported precarity from 32.1% to 54.5% reflects a shift in gardeners' risk perceptions and stress levels. This majority share in 2025 underscores growing anxiety over tenure security, input affordability, and income stability, which may prompt migration, diversification into non-farm activities, or even exit from gardening altogether.

4.4. Adaptation Strategies and Resilience Among Market Gardeners

Despite these challenges, market gardeners are adopting various adaptive strategies. Figure 8 summarizes the prevalence of key adaptation and resilience strategies, including land rental/sharing, crop diversification, basic irrigation, and collective action.

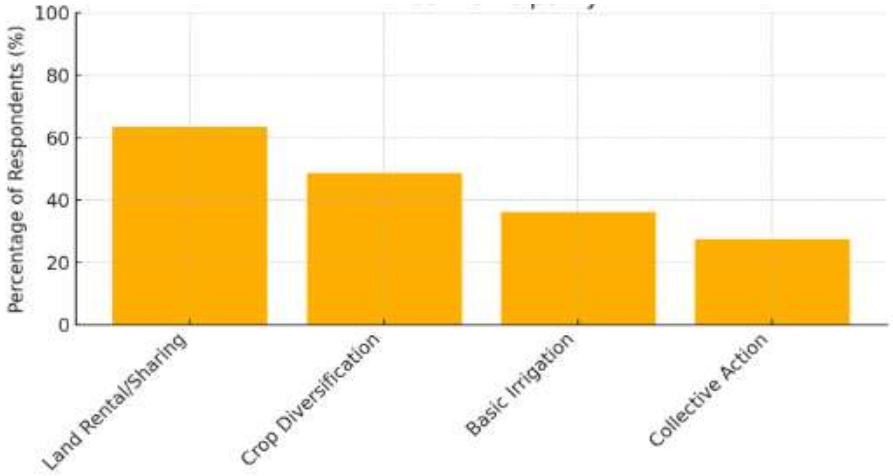

Figure 8: Prevalenceof Adaptive Strategies Among Market Gardeners in Limbe: Responses to Urban Encroachment

Figure 8 Analysis: Land rental/sharing (63.4%) is the most common strategy, reflecting a proactive response to tenure insecurity. Crop diversification (48.7%) helps buffer against price volatility and environmental stressors. Basic irrigation (36.1%) addresses unreliable rainfall, though its rudimentary nature limits efficiency. Collective action (28.9%) through informal groups strengthens bargaining power and resource sharing, but their informal status may limit access to formal support. Overall, Figure 3 highlights a spectrum of both individual and collective strategies, revealing where interventions such as secure tenure mechanisms, training in diversified cropping systems, improved irrigation infrastructure, and formalization of producer groups could most effectively bolster gardener resilience in Limbe (Akinyemi et al., 2022; Ojong et al., 2023).

4.5. Comparative and Analytical Perspectives

The trajectory of urban growth in Limbe aligns with similar studies in sub-Saharan Africa, where rapid urbanization leads to cropland loss, tenure insecurity, and declining agricultural livelihoods (Akinyemi et al., 2022; Njie & Ndip, 2022). However, Limbe's case is notable for the speed and scale of land conversion, with built-up areas increasing nearly eightfold between 1995 and 2025. This underscores the urgent need for context-specific interventions and policy reforms.To illustrate the pace of urban expansion, Figure 9 and Table 4 present the growth of built-up area in Limbe.

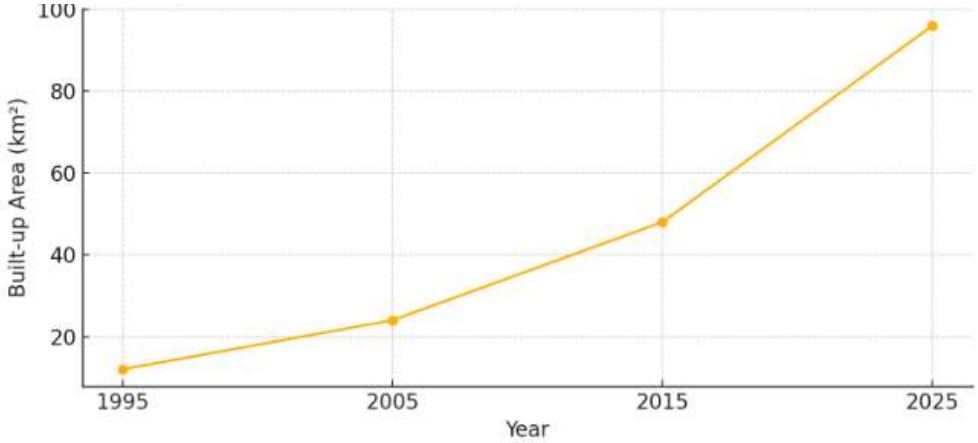

Figure 9: Growth of Built-up Area in Limbe, 1995–2025

The line graph in Figure 7 visually conveys the accelerating pace of land conversion. After modest growth from 12 km² in 1995 to 24 km² in 2005, urban expansion accelerates jumping to 48 km² by 2015 and then surging to 96 km² by 2025. This steep curve highlights a critical inflection point where policy intervention is most urgently needed to protect remaining cropland and secure tenure for gardeners.

Table 4 : Expansion of Built-up Areas in Limbe (1995–2025): Nearly Eightfold Increase in Urban Footprint

Year	Built-up Area (km²)
1995	12
2005	24
2015	48
2025	96

Table 4 quantifies a dramatic urban footprint escalation: built-up land doubles between each decade snapshot and culminates in an eightfold increase over 30 years. This numeric summary underscores how rapidly agricultural and peri-urban zones have been absorbed by construction, signaling the magnitude of spatial competition faced by market gardeners.

Connecting land cover changes with socio-economic impacts is crucial for comprehensive urban planning. It enables policymakers to design interventions such as zoning, land tenure reform, and targeted support for market gardeners that balance urban growth with sustainable livelihoods and inclusive development (Tchamabe et al., 2024; Ojong et al., 2023).

5. DISCUSSION

This research has demonstrated the multidimensional impacts of rapid urban expansion on market gardening in Limbe, Cameroon. The spatial, quantitative, and socio-economic evidence presented in the Results section collectively reveals a dramatic reshaping of the urban-peri-urban landscape and a compounding of vulnerabilities for small-scale horticultural producers.

5.1. Spatial Dynamics: Intensifying Urban Encroachment and LULC Change

The marked increase in built-up areas and the sharp decline in cropland and vegetation between 2015 and 2025 (Table 5; Figures 9 and 10) mirrors the pattern observed over three decades (Table 1, Figure 3), confirming the acceleration of urban land conversion at the expense of agriculture. Limbe's built-up area expanded nearly eightfold between 1995 and 2025—a rate significantly higher than many other secondary cities in sub-Saharan Africa (Akinyemi et al., 2022; Tchamabe et al., 2024).

These changes are not simply a story of demographic growth but are mediated by planning decisions and market forces that prioritize housing and infrastructure over food system resilience. The reduction of vegetated and cultivated land (−2,783 ha over just a decade; Table 5) has immediate implications for urban food supply, microclimate, and landscape connectivity (Lin et al., 2017; Liu et al., 2019).

5.2. Socio-Economic Strain: Livelihoods Under Pressure

The results underline how spatial reorganization impacts the livelihoods of market gardeners. Land fragmentation, tenure insecurity, and the loss of productive land have led to a 27% drop in average annual income and a 34.6% contraction in cultivated plot size between 2015 and 2025 (Table 3; Figures 5–7). The growing proportion of gardeners reporting livelihood precarity (from 32.1% to 54.5%) signals heightened vulnerability not only to land shocks but also to market, climate, and institutional risks.

The demographic profile—dominated by women with limited formal education—underscores the equity and gender dimensions of this transformation. As previous studies in Cameroon and SSA have found, female-headed households often have less access to formal land rights, credit, and extension services (Mbome, 2020; Njie & Ndip, 2022).

5.3. Land Tenure, Risk, and Adaptation Strategies

Only 21.8% of market gardeners report long-term or formal tenure, with most operating under insecure, temporary, or informal arrangements (Figure 4). Such insecurity discourages capital investment and sustainable soil management, and limits the adoption of climate-smart technologies (Kumar et al., 2022). This finding reinforces calls in the literature for tenure reform as a prerequisite for sustainable urban agriculture (Nelson, 2013; Fongang, 2017).

In response to spatial and economic pressures, gardeners have adopted a spectrum of coping and adaptation strategies—land sharing, crop diversification, rudimentary irrigation, and informal collective action (Figure 8). While such strategies reflect resilience and flexibility, their effectiveness is constrained by structural barriers, including exclusion from planning processes, lack of formal group recognition, and unreliable access to inputs and markets. This partly echoes the broader challenge of market gardening on the continent: adaptive capacity exists, but is limited without institutional support and policy alignment (Ojong et al., 2023; Mougeot, 2000).

5.4. Limbe in Comparative Perspective

Limbe's experience echoes comparable urban expansion patterns seen in cities such as Ibadan, Kumasi, and Nairobi, where agricultural fringes are rapidly absorbed and peri-urban farming becomes marginalized (Akinyemi et al., 2022; Lin et al., 2017).

However, the pace of change in Limbe is especially striking. The near-doubling of built-up area with each passing decade (Table 4), and the contraction of cropland to below 6% by 2025, highlight acute spatial competition and urgency for context-specific solutions.

5.5. Policy and Governance Implications

The findings highlight several critical policy gaps. First, the absence of enforced agricultural zoning and participatory land use planning allows unchecked urban sprawl to threaten food security and socio-economic stability. Second, insecure land tenure perpetuates a cycle of vulnerability and limits farmers' ability to invest in long-term improvements (Fongang, 2017; Nelson, 2013). Third, the predominance of women and informal groups among market gardeners underscores the need for gender-sensitive policies and the formalization of producer organizations.

Integrated urban planning—which includes designated agricultural zones, secure tenure arrangements, and inclusive decision-making—could mitigate these trends. Extension services, subsidized access to inputs, and credit facilities would further enhance the resilience of market gardening in Limbe. Finally, regular monitoring using GIS and socio-economic surveys would provide timely evidence for adaptive management.

5.6. Limitations and Future Directions

While this study provides robust triangulated analysis, limitations include the uncertainty of future land use projections and the potential bias in self-reported survey data. Future research could integrate longitudinal household surveys, conduct participatory scenario planning with gardeners, and examine linkages between urban agriculture and urban food systems more broadly (Gertler, 2021; Gómez et al., 2013).

Limbe stands at a crossroads: unchecked urban expansion, if left unaddressed, will erode not only market gardening livelihoods but also the city's food security and ecological resilience. The adaptive strategies adopted by market gardeners illustrate both vulnerability and resourcefulness, but these alone cannot compensate for deeper structural gaps. As urbanization accelerates, there is an urgent need for multi-level, multi-sectoral interventions that safeguard urban agriculture, empower marginalized producers, and promote a balanced, inclusive model of urban growth.

6. CONCLUSION AND RECOMMENDATIONS

In light of the evidence and analysis presented, this section summarizes the major findings of the study and outlines practical steps to address the challenges identified. The following subsections first provide a concise conclusion that synthesizes core insights, and then offer targeted recommendations for policymakers, practitioners, and urban stakeholders.

6.1. Conclusion

This study has revealed that rapid urban expansion in Limbe has profoundly reshaped the physical and socio-economic landscape of market gardening. Over the past three decades—and especially between 2015 and 2025—built-up areas have expanded nearly eightfold while cropland and vegetation have shrunk dramatically. Spatial analysis via land use/land cover (LULC) mapping (Figures 9 and 10; Tables 1 and 5) demonstrates the magnitude and pattern of this transformation, and the quantitative results show a clear substitution of agriculture for urban infrastructure.

As a direct consequence, market gardeners in Limbe have faced:

Scarcity and fragmentation of arable land,

Acute tenure insecurity, with only 21.8% having formal or long-term access to land,

A significant reduction in average plot size (−34.6%) and income (−27%) over the last decade,

Increased livelihood precarity, with over half of gardeners now at risk,

Disproportionate impacts on women and those with limited education, reinforcing existing social and gendered vulnerabilities.

Despite these pressures, gardeners employ adaptation strategies—such as land sharing, crop diversification, basic irrigation, and informal collective action—but these responses are constrained by systemic barriers and inadequate institutional support.

Limbe's trajectory is emblematic of broader urban expansion challenges across sub-Saharan Africa, but the pace and scale of change here are particularly striking, signaling an urgent need for more inclusive and responsive policy interventions to safeguard livelihoods and urban food security.

6.2. Recommendations

To ensure a sustainable future for both the city and its agricultural sector, the following key recommendations are advanced:

1. Integrate Agriculture into Urban Planning

Designate Agricultural Zones: The Limbe City Council (LCC) and Ministry of Housing and Urban Development (MINDUH) should establish and enforce urban plans that allocate protected agricultural spaces within the city.

Participatory Urban Governance: Involve market gardeners—especially women and youth—in urban development and zoning decisions to ensure their voices and needs are reflected.

2. Secure Land Tenure for Market Gardeners

Formalize Land Rights: Facilitate the issuance of land titles or long-term leases for market gardeners, with an emphasis on gender equity and transparent allocation.

Promote Collective Tenure: Encourage community land trusts or group leases to reduce fragmentation and strengthen bargaining power.

3. Enhance Production and Livelihoods

Access to Inputs and Credit: Provide targeted financial support, such as microcredit and input subsidies for seeds, tools, and irrigation, to improve productivity and resilience.

Expand Extension Services: Increase training in sustainable farming techniques, integrated pest management, and efficient irrigation systems.

4. Strengthen Adaptive Capacity and Collective Action

Support Producer Associations: Formalize and empower market gardener groups for better representation, resource sharing, and integration into value chains.

Encourage Innovation: Promote crop diversification, water management solutions, and urban gardening innovations to maximize yields on shrinking land.

5. Improve Data and Monitoring

Regular Spatial Monitoring: Utilize GIS, remote sensing, and participatory mapping to track urban sprawl and protect remaining agricultural zones.

Conduct Socio-Economic Surveys: Periodically assess gardener livelihoods and adaptation needs, informing timely and evidence-based interventions.

6. Promote Sustainable Urban Expansion

Adopt Smart Growth Principles: Favor urban densification and mixed-use development over uncontrolled sprawl, protecting peri-urban livelihoods.

Establish Green Buffer Zones: Create buffer zones or green belts around agricultural areas to limit encroachment and maintain ecological functions.

In summary, the future of Limbe as a sustainable and inclusive city depends on coordinated action to protect agricultural land, secure tenure, empower market gardeners, and integrate agriculture into urban policy. By adopting these recommendations, policymakers and stakeholders can help ensure that urban expansion supports—not undermines—food security, resilient livelihoods, and social equity in Limbe and similar urban contexts.

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