Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Conflict and Coexistence between Urban Agriculture and Urban Expansion: The Case of N'Gaous City, Northeast Algeria (1966–2024)

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ARTICLE INFO

Received: 02 Mar 2026

Revised: 18 Apr 2026

Accepted : 28 Apr 2026

ABSTRACT

Urban Agriculture (UA) has recently attracted growing attention from researchers and policymakers as a strategic component of sustainable urban planning and food systems [1, 2]. This research explores the complex dynamics of coexistence and conflict between urban expansion and agricultural practices in the city of N'Gaous (northeast Algeria)—a small city characterized by urban agricultural pockets deeply interwoven with the urban fabric, which has experienced significant spatial growth and demographic pressure between 1966 and 2024 [3, 4]. Using a mixed methodology combining quantitative spatial analysis (Land Use/Land Cover classification—LULC, and AHP-GIS multi-criteria decision-making model) with qualitative field verification (interviews and participatory mapping), the study aimed to identify and assess areas prone to conflict or coexistence between these two land uses. Findings reveal that N'Gaous lost approximately 239.4 hectares of agricultural land (37%) between 1966 and 2024, driven primarily by demographic growth and urban expansion. The AHP-GIS model (weights: building density 25%, population density 20%) identified three main zones: high-conflict zones (23%), moderate coexistence zones (41%), and high-compatibility zones (36%). Field verification confirmed the model's accuracy. The study also reveals that the continuity of urban agriculture in N'Gaous is linked to the resilience of adaptive farming practices and a shift towards high-value crops. These findings offer a robust methodological framework for decision-makers in small and medium-sized Algerian cities facing similar challenges, emphasizing the importance of recognizing urban agriculture as an essential component of urban resilience and food security [8, 9]. The study contributes to current literature on peri-urban transitions in North Africa and offers methodologically applicable insights for similar contexts.

Keywords: Urban Agriculture, Urban Sprawl, Conflict and Coexistence, AHP-GIS, N'Gaous, Algeria.

1. Introduction

Urban Agriculture (UA) is increasingly recognized as a multifunctional element of urban systems, providing not only food production but also employment opportunities, environmental services, climate change adaptation mechanisms, and social cohesion [5, 6]. Globally, the relationship between cities and agricultural land has historically been marked by deep tension and competition for space, especially in developing countries where urban expansion accelerates without coherent land-use planning policies or effective governance mechanisms [7].

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Peri-urban areas and urban agricultural pockets—the transitional zone between consolidated urban areas and the prevailing rural landscape—have become a critical arena for land-use conflicts, where agricultural, residential, industrial, and environmental functions compete for limited space.

Researchers such as McClintock [10] and Cohen & Reynolds [11] have emphasized the metabolic and socio-political dimensions of urban agriculture, arguing for the need to reconceptualize cities as complex agri-ecological systems rather than mere built environments. This perspective challenges the traditional rural-urban dichotomy that has long dominated planning discourse and calls for integrated approaches that recognize the interdependence of urban and agricultural systems [12].

The city of N'Gaous, located in northeast Algeria, presents a unique case of urban-agricultural overlap, where expansion is not limited to city outskirts but takes the form of internal infiltration within pre-existing urban agricultural pockets inside the urban fabric. These pockets, of which the historic apricot orchards form a significant part, are subject to sustained pressure from urban expansion, creating complex scenarios of conflict and coexistence.

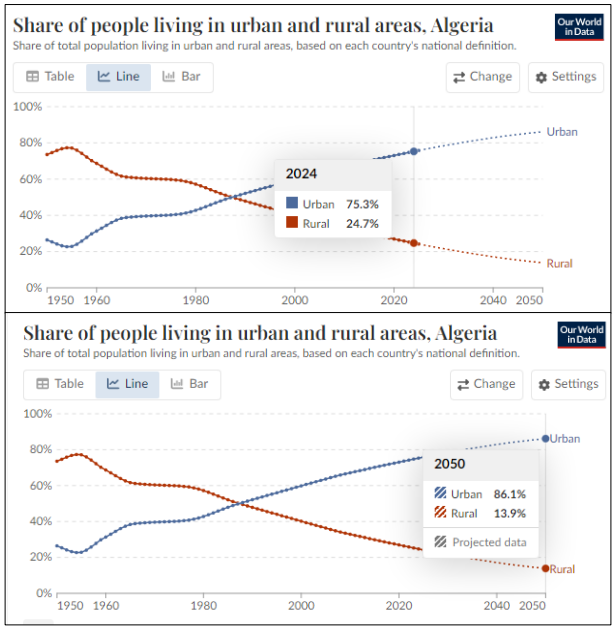

Figure 1: Evolution of the proportion of urban and rural population in Algeria (1950–2050). Source [13]: Our World in Data (2024). Share of people living in urban and rural areas, Algeria (1950–2050)

1.2 Research Problem and Objectives

The central question guiding this research is: How can urban agriculture and urban expansion coexist—or manage their inherent conflicts—within the same spatial framework in small and medium-sized Algerian cities? This question encompasses several sub-questions:

• What are the spatial patterns and rates of agricultural land loss due to urban expansion in N'Gaous?

• Which urban areas exhibit the highest levels of conflict or coexistence potential between urban and agricultural functions?

• How can spatial planning tools better integrate urban agriculture into urban development frameworks?

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Research Objectives:

This research aims to analyze these complex dynamics in N'Gaous through:

• Identifying and spatially analyzing land-use changes in N'Gaous between 1985 and 2024 using remote sensing and GIS techniques.

• Developing and applying an AHP-GIS multi-criteria evaluation model to identify conflict and coexistence zones.

• Validating the spatial analysis results through field investigations and participatory mapping with local stakeholders.

• Formulating evidence-based policy recommendations for integrating urban agriculture into urban planning frameworks.

This study contributes to the scientific literature by offering a methodological framework combining quantitative and qualitative analysis to understand land dynamics in overlapping urban-agricultural contexts, and by providing practical insights for decision-makers.

1.3 Urban and Agricultural Context in Algeria

1.3.1 The Algerian Urban Context

Algeria, since its independence in 1962, has undergone rapid urban transformations. The urbanization rate, which stood at only 26.4% in 1950, rose to 75.3% in 2024, with projections indicating it will reach 86.1% by 2050 [13]. This rapid demographic and urban growth has led to the swelling and expansion of cities at the expense of fertile agricultural land, particularly in coastal areas and interior plains.

According to Law No. 06-06 of 20 February 2006 on the Urban Orientation Law [14], Algerian cities are classified according to their population size. Cities with a population between 20,000 and 50,000 inhabitants are considered small cities. N'Gaous falls within this classification, having experienced notable demographic and spatial growth, making it an ideal model for studying the challenges of urban expansion and urban agriculture in this category of cities.

1.3.2 Urban Agriculture in Algeria

Historically, agriculture was an integral part of the urban fabric in many Algerian cities, especially in oases and old medinas. With modern urban expansion, these practices declined but did not disappear entirely. In many cities, urban agricultural pockets still exist and contribute to local food security and employment [15, 16].

Urban agriculture in Algeria, particularly in areas such as N'Gaous, features unique characteristics reflecting adaptation to urban pressures:

• Location: found on the outskirts of old city centers, backyards or house courtyards, vacant lots, riverbanks, and agricultural areas interwoven with the urban fabric.

• Scale: ranges from small individual family gardens to broader commercial farming operations.

• Production systems: include traditional soil-based systems, as well as the adoption of modern techniques in farming, livestock, and irrigation.

• Organizational forms: vary between individual and family practices, community gardens, and agricultural cooperatives.

• Products: encompass a wide range of vegetables, fruits (especially apricots in N'Gaous), herbs, and livestock.

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These practices remain resilient through agricultural adaptation, informal land governance arrangements, and local community efforts [8] [9].

2. Theoretical Framework and Literature Review

2.1 The Concept of Urban Agriculture

Urban agriculture has been defined in various ways across disciplines and urban-geographical contexts, reflecting its multifunctional and context-dependent nature [15, 16]. Mougeot's widely cited definition [16] describes urban agriculture as:

"An industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city, or a metropolis, which grows or raises, processes, and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products, and services found in and around that urban area, and in turn supplying human and material resources, products, and services largely to that urban area."

This comprehensive definition encompasses agricultural and horticultural practices within and around urban areas, contributing to local food production, environmental regulation, and social inclusion [17, 18]. Urban agriculture thus sits at the critical intersection of spatial planning, food systems, and the urban environment—linking global sustainability goals to local practices [19].

2.2 Models of Urban-Agricultural Coexistence

Theoretically, two prevailing models shape the academic discourse on urban agriculture and spatial coexistence:

2.2.1 The Conflict Model

The conflict model holds that urban expansion and agriculture are fundamentally incompatible land uses, with urban expansion leading to the systematic erosion of fertile land and the dismantling of rural livelihoods [7] [20]. This perspective focuses on:

• Land competition: urban development typically occupies the most accessible and fertile land, which is also the most productive for agriculture.

• Economic pressure: rising land values in peri-urban areas create strong financial incentives to convert agricultural land.

• Institutional bias: planning systems often view agricultural land as a 'land reserve' for future urban development rather than as permanently productive space.

• Environmental degradation: urban expansion brings pollution, fragmentation of agricultural landscapes, and disruption of ecological corridors.

• Cultural dimension: the absorption of agricultural areas into the urban fabric erodes traditional knowledge, leads to the disappearance of inherited farming practices, and causes the loss of rural identity tied to the land.

• Security dimension: urban expansion creates conditions favorable to rising rates of theft of agricultural produce and equipment, due to the proximity of farms to residential settlements and weak surveillance.

Empirical studies supporting this model have documented severe agricultural land losses in rapidly urbanizing regions worldwide.

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2.2.2 The Coexistence/Integration Model

In contrast, the coexistence model holds that urban agriculture is not merely a transient economic activity, but a strategic solution to contemporary urban challenges, and advocates for its systematic integration into urban planning frameworks [21, 22]. This perspective highlights the multifunctionality of urban agriculture, which provides:

• Environmental services: stormwater management, carbon sequestration, biodiversity conservation, and urban cooling.

• Social benefits: community building, educational opportunities, improved public health, enhanced food security for low-income households, and strengthening family bonds through shared agricultural activities.

• Economic benefits: local food supply, job creation, and reduced transportation and storage costs.

This model advocates shifting from a purely competitive perspective to a synergistic and integrative perspective based on Urban Metabolism, where urban waste (grey water, organic matter, household waste) is recycled back into agricultural production, transforming the city from a consumptive entity into a circular productive system [12].

2.3 International Experiences and Regional Context

2.3.1 European and Mediterranean Examples

In European and Mediterranean contexts, researchers have confirmed that urban agriculture can serve as a 'buffer zone' or 'green belt' that mitigates environmental degradation and supports ecosystem services [17]. These experiences also show that political will and appropriate regulatory tools are key to the success of any integration strategy between agriculture and urban expansion. Prominent examples include:

• The Agricultural Park in Barcelona: protecting 3,000 hectares of fertile agricultural land through special zoning classification.

• Agro Romano in Rome: preserving approximately 40,000 hectares of agricultural land through historic land tenure arrangements.

• The Agricultural Protection Zone in Montpellier: using regulatory tools to preserve 8,000 hectares of peri-urban agricultural land.

These examples illustrate that with appropriate governance frameworks, urban agriculture and urban development can coexist in densely populated areas.

2.3.2 African Urban Agriculture

In sub-Saharan Africa, urban agriculture has become an integral part of urban livelihood strategies, with estimates suggesting that 30–40% of urban households participate in some form of food production [23]. Key characteristics include:

• Livelihood importance: urban agriculture provides significant income and food security for poor urban households.

• Institutional challenges: lack of formal recognition, insecure land tenure, and limited access to extension services.

• Policy evolution: cities such as Kampala (Uganda) and Accra (Ghana) have begun developing specific urban agriculture policies.

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2.3.3 Specificities of North Africa

In North Africa, rapid urban expansions have deeply reshaped traditional agricultural landscapes. In this context, agriculture in peri-urban areas around Algerian cities has undergone profound changes since the 1960s [4]. Case studies from similar urban areas, such as Sétif and N'Gaous in Algeria, have demonstrated both intensive fragmentation of agricultural land and the emergence of adaptive practices—including precision irrigation systems, intensive greenhouse production [25]:

• Historical context: a strong legacy of state-led agricultural policies and post-independence land nationalization.

• Semi-arid climate: heavy reliance on irrigation and exposure to climate change, making the preservation of fertile land critically important.

• Urban expansion : often characterized by informal or unplanned expansion onto high-value agricultural land.

2.4 Conceptual Framework of this Study

This study adopts a conceptual framework that views the urban-rural shared zone as a continuum between conflict and coexistence. The spatial outcome in N'Gaous is not a simple binary of loss or preservation, but a complex mosaic resulting from the interaction between:

• Urban pressure: demographic growth, housing demand, and land speculation.

• Agricultural resilience: adaptive farming practices, local governance, and the inherent productivity of the land.

• Planning interventions: the presence or absence of effective land-use regulations.

The AHP-GIS model was designed to map this continuum, moving beyond simple detection of land-use change to identify the latent suitability and vulnerability of agricultural areas to urban development.

3. Research Methodology

This study employs a mixed-methods approach combining quantitative spatial analysis with qualitative field verification, in order to provide a comprehensive understanding of the conflict and coexistence dynamics between urban agriculture and urban expansion in N'Gaous.

3.1. Study Area: The City of N'Gaous

The city of N'Gaous is located in northeast Algeria, in the Wilaya of Batna. It is historically renowned for its high-quality apricot orchards, which form an important part of its cultural and economic identity. Unlike the common pattern of urban agriculture on city outskirts, N'Gaous follows a unique pattern of urban infiltration within urban agricultural pockets, making it an ideal case study for understanding challenges and opportunities in these overlapping environments. The city's agricultural land is simultaneously consumed by expansions and sustained by traditional family farming systems that have persisted for generations [4].

The city's population grew from 13,378 inhabitants in 1985 to an estimated 29,257 in 2008 (according to the ONS), and current projections for 2024 indicate 34,717 inhabitants, with a high annual growth rate of approximately 2.47% between 1985 and 2024 [26, 27]. This demographic pressure, combined with housing policies prioritizing urban expansion over agricultural land protection, has created a critical situation for urban agriculture.

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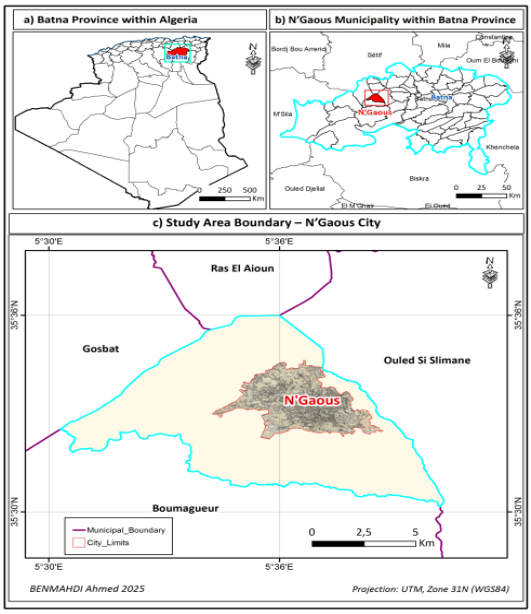

Figure 2: Location map of the city of N'Gaous. Source: Prepared by the author

3.2. Data Sources

The study relied on a diverse set of data sources, including:

• Satellite imagery: Landsat images (TM, ETM+, OLI) for the years 1985, 2000, and 2024, used for land-use change analysis and vegetation index (NDVI).

• Topographic maps and urban documents: Master Plan for Urban Development and Planning (PDAU) maps and historical land-use maps.

• Statistical data: data from the Directorate of Agricultural Services, the National Office of Statistics (ONS), and census reports for the years 1966, 1977, 1987, 1998, 2008, and 2024.

• Spatial data (GIS): digital layers of the road network (classified into primary, secondary, and municipal), locations of irrigation sources (springs and wells), and the statistical district layer (containing data on population density, building density, and agricultural holding density).

• Field interviews: interviews with farmers, urban planners, and local officials to collect qualitative insights on conflict and coexistence dynamics.

Table 1: Summary of Data Sources

Data Type	Source	Use
Satellite imagery	Landsat (1985, 2000, 2024)	Land use/land cover change analysis (LULC)
Topographic data	National Survey	Digital Elevation Model (DEM), slope, elevation
Infrastructure data	Various Technical Departments	Road network, existing urban areas, waterways
Statistical data	Directorate of Agricultural Services	Agricultural land use
Qualitative data	Expert & farmer interviews	AHP weights, field validation, adaptive strategies

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3.3. Spatial Analysis Methodology

A combination of Geographic Information Systems (GIS) techniques and Multi-Criteria Analysis (MCA) was used to identify zones of conflict and coexistence.

3.3.1. Land Use/Land Cover Change Analysis (LULC)

LULC analysis was carried out for the periods 1966, 1977, 1987, 1998, 2008, and 2024 using satellite imagery and historical maps. Land was classified into main categories (e.g., built-up area, orchards, open agricultural land, vacant land) to determine the magnitude and direction of urban expansion and the decline of agricultural areas.

3.3.2. AHP-GIS Model for Identifying Conflict and Coexistence Zones

To assess conflict and coexistence zones, an AHP-GIS model was applied, combining the power of the Analytic Hierarchy Process (AHP) in determining the relative weights of criteria with GIS spatial analysis capabilities. Six main criteria were identified, classified into urban pressure factors and agricultural suitability factors, based on the scientific literature and the characteristics of the study area.

a. Criteria Selection and AHP Weighting:

The factors influencing conflict/coexistence and their relative weights (on a scale of 1 to 9) were selected based on literature review and inputs from local experts (urban planners, agricultural engineers, and farmer representatives), taking into account the availability of local data. The factors were grouped into two main categories: agricultural suitability and urban pressure [28].

Table 2: AHP Criteria and Weight Distribution

Category	Criterion	Normalized Weight (AHP)	Source
Urban Pressure	Building density in statistical district	25%	ONS / RGPH
Urban Pressure	Population density in statistical district	20%	ONS / RGPH
Agricultural Suitability	Agricultural holding density	20%	Directorate of Agriculture / RGA
Agricultural Suitability	Vegetation Index (NDVI)	15%	Satellite imagery analysis
Urban Pressure	Distance to primary road network (Major Arterial)	10%	Road network / PDAU
Agricultural Suitability	Distance to main irrigation sources	10%	Directorate of Water Resources
Total		100%	

Source: Authors elaboration based on ONS and Landsat, 2024.

b. Input Layer Preparation (Raster Preparation):

All criteria were converted into standardized raster layers, and the values of each layer were reclassified on a scale of 1 to 9, where 9 represents the highest compatibility with urban agriculture (or lowest conflict with urban expansion), and 1 represents the lowest compatibility (or highest conflict):

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• Building density, population density, and agricultural holding density: extracted from the statistical district layer; density fields were converted to raster and reclassified. For urban pressure factors, high values were assigned low scores (high conflict); for agricultural suitability, high holding density was assigned high scores (high compatibility).

• Vegetation Index (NDVI): the NDVI map for 2024 was used. High NDVI values (indicating dense vegetation cover, likely orchards and agricultural areas) were assigned high scores (9), and low values (bare or built land) were assigned low scores (1).

• Distance to primary road network: the primary road layer was filtered (major arterial). Euclidean distance from these roads was calculated. Areas close to main roads (high urban pressure) were assigned low scores (1), and areas far from them were assigned high scores (9).

• Distance to main irrigation sources: the wells layer was used to represent main irrigation sources. Euclidean distance from these wells was calculated. Areas close to irrigation sources (high agricultural suitability) were assigned high scores (9), and distant areas were assigned low scores (1).

c. Weighted Overlay:

After preparing all classified raster layers, the Weighted Overlay tool in ArcMap was applied. This tool combines the input layers based on their relative weights (determined by AHP) and their classified values (1–9) to produce a final map expressing the degree of conflict or coexistence in each pixel. Higher values in the resulting map represent zones of high compatibility (sustainable agriculture), while lower values represent zones of high conflict (urban pressure).

d. Final Map Classification:

The resulting Weighted Overlay map was reclassified into three main categories to represent conflict and coexistence zones:

• High Conflict Zones: where urban pressure is high and agricultural suitability is low.

• Moderate Coexistence Zones: where a balance exists between urban pressure and agricultural suitability.

• High Compatibility Zones: where agricultural suitability is high and urban pressure is low.

4. Results and Discussion

4.1. Urban Expansion and the Decline of Agricultural Areas

LULC analysis and statistical data revealed a radical transformation in the natural landscape of N'Gaous over past decades. Since 1966, the city has witnessed accelerating urban expansion at the expense of fertile agricultural land, particularly apricot orchards that form an essential part of its identity.

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Table 3: Temporal Changes in Agricultural Areas, Urban Areas, and Population in N'Gaous (1966–2024)

Year	Built-up Area (ha)	Orchards (ha)	Agricultural Land (ha)	No. of Trees	Population	Pop. Density (inh./ha)
1966	33.7	455.3	646.3	640,000	4,887	60
1977	47.6	445.3	642.4	630,000	9,284	115
1987	141.6	426.4	567.3	605,000	15,132	187
1998	216.5	422.6	496.2	600,000	25,766	318
2008	287.0	384.0	464.3	545,000	29,300	362
2024	379.7	348.7	406.9	495,000	34,717	429

Source: Directorate of Agricultural Services, National Office of Statistics (ONS), Master Plan for Urban Development and Planning (PDAU).

Table 3: shows that the built-up area multiplied more than tenfold between 1966 and 2024, rising from 33.7 ha to 379.7 ha. Conversely, orchard area declined from 455.3 ha to 348.7 ha, and total agricultural land from 646.3 ha to 406.9 ha. This means the city lost approximately 239.4 hectares of agricultural land, equivalent to 37% of its total agricultural area in 1966. This significant decline coincides with rapid population growth, with the population rising from 4,887 in 1966 to 34,717 in 2024.

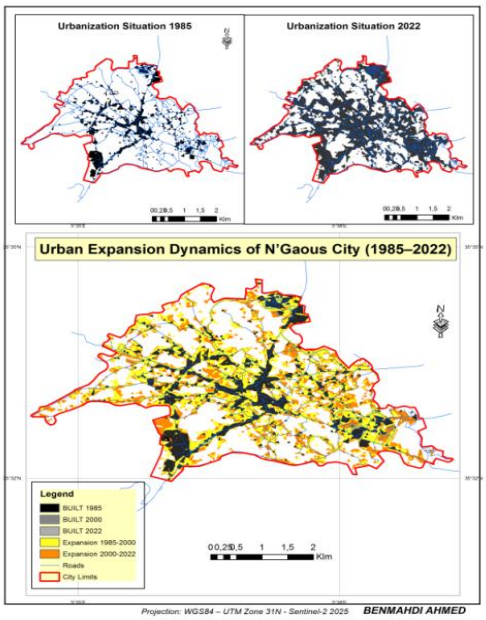

Figure 3: Spatio-temporal Evolution of the Built-up Area of N'Gaous City: Expansion Phases 1985–2000 and 2000–2022

Source: Author's elaboration based on Landsat satellite imagery (TM 1985, ETM+ 2000, OLI 2022), processed using ArcMap 10.8 (USGS Earth Explorer).

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4.2. Analysis of Urban Expansion in N'Gaous: Development Phases and Influencing Factors

N'Gaous, a city with a rich history as an agricultural centre, has experienced significant urban and demographic transformations, particularly since the mid-twentieth century. Urban expansion can be divided into key phases reflecting political, social, and economic changes:

• Pre-colonial and colonial phase (until 1962): characterized by slow organic growth, with the city centred on its historic core and close interlocking of the urban fabric with surrounding urban agricultural pockets.

• Post-independence phase (1962–1970): significant population growth put initial pressure on agricultural land surrounding the historic centre; new residential clusters appeared but expansion remained relatively limited.

• Rapid expansion phase (1970–2000): the most dynamic phase in N'Gaous's urban history, coinciding with national development policies (agrarian and industrial revolutions) that triggered rural-to-urban migration and intensive urban encroachment on agricultural land.

• Urban infiltration phase (2000–2015): the city began expanding not only on its outskirts, but also by infiltrating pre-existing internal urban agricultural pockets, fragmenting agricultural space as enclosed agricultural lands became targets for development.

• Contemporary expansion phase (2015–2024): continued expansion filling gaps within the existing urban fabric and along main axes, with sharper pressures on urban agricultural pockets as more orchards converted to residential or service areas.

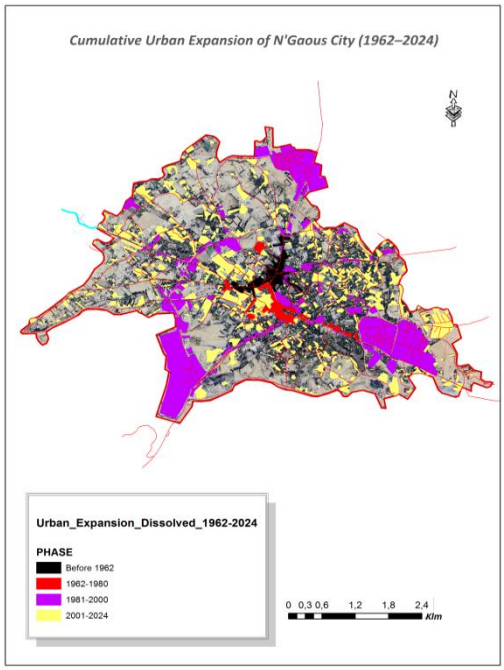

Figure 4: Cumulative Urban Expansion of N'Gaous City (1962–2024) Source: Author's elaboration based on aerial photography (IGN, 1962) and Landsat imagery (USGS, 1985–2024), processed using ArcMap 10.8.

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Key Factors Driving Urban Expansion:

• Demographic growth: population multiplied several times since 1966 (from 4,887 to 34,717 in 2024), creating massive demand for housing and infrastructure.

• Urban policies: planning policies focused on housing provision without adequate protection of agricultural land.

• Land ownership structure: dominance of private ownership over agricultural land inside and around the city, making it vulnerable to urban conversion.

• Infrastructure: development of the internal road network—particularly National Road No. 78 and Wilaya Road No. 40—that channelled urban expansion along its sides.

Constraints on Expansion:

N'Gaous's urban expansion faced several natural constraints (wadis, mountainous areas) and artificial ones (gas pipelines, industrial activity zones), compounded by scarce public land reserves and high private property prices. These constraints directed expansion towards infiltration of urban agricultural pockets rather than outward growth on open land.

4.3. Conflict/Coexistence Mapping (AHP-GIS)

Application of the AHP-GIS model yielded clear spatial results identifying conflict and coexistence zones between urban agriculture and urban expansion in N'Gaous. The derived weights showed that building density in the district (25%) and agricultural holding density (20%) were the most influential factors in determining conflict/coexistence potential, followed by population density (20%) and the NDVI (15%). The classification of the city into three main zones resulted in:

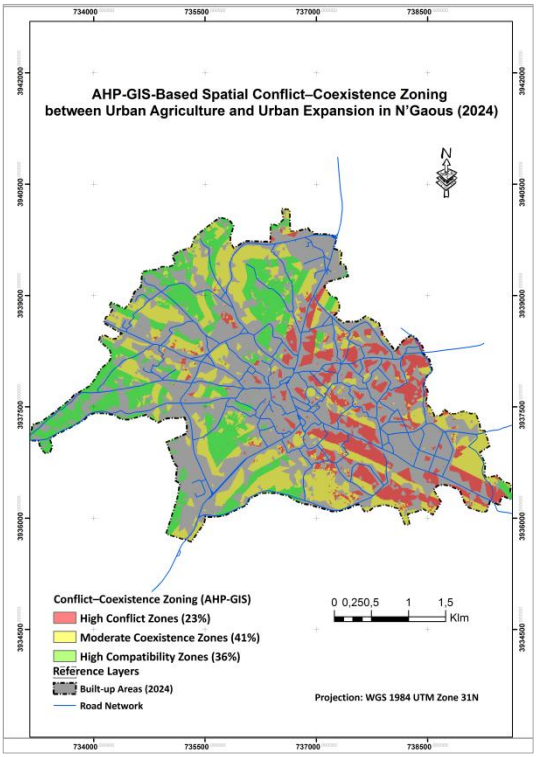

Figure 5: **AHP-GIS-Based Spatial Conflict–Coexistence Zoning between Urban Agriculture and Urban Expansion in N'Gaous (2024)**

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Source: Author's elaboration based on AHP-GIS weighted overlay model and field validation.

• High Conflict Zones (23% of study area): characterized by high urban pressure (high building and population density, proximity to main roads) and low agricultural suitability (low NDVI, low agricultural holding density). These areas are most susceptible to urban conversion and require urgent intervention to protect remaining agricultural land or to direct development towards compatible mixed uses.

• Moderate Coexistence Zones (41% of study area): characterized by a relative balance between urban pressure and agricultural suitability. They may contain still-productive agricultural pockets partially surrounded by construction, or areas of moderate population density with some agricultural activity. These zones require flexible planning policies that encourage integration of the two land uses and support sustainable agricultural practices.

• High Compatibility Zones (36% of study area): characterized by high agricultural suitability (high NDVI, high agricultural holding density, proximity to irrigation sources) and low urban pressure. These zones represent the greatest opportunity for preserving and developing urban agriculture, and should be given highest priority in agricultural protection policies.

These results confirm that land conflict is not a homogeneous phenomenon but varies spatially based on a set of interacting factors. They also highlight that the continuity of urban agriculture in N'Gaous is linked not only to the natural characteristics of the land, but also to the resilience of adaptive farming practices and the shift towards high-value crops that increase the economic viability of agricultural land in the face of urban pressures.

5. Discussion: Theoretical and Practical Implications

5.1. Theoretical Implications

This research contributes to planning theory through the empirical validation of the concept of the peri-urban interface as a conflict-coexistence continuum, moving beyond the traditional rural-urban conflict dichotomy [26]. It also reinforces the argument for recognizing urban agriculture as a permanent, multifunctional element of the urban metabolism, rather than a temporary land use awaiting conversion. As Sargolini and Pierantoni [23] pointed out, the relationship between nature, agriculture, and new urban areas develops in a "continuous tension between the processes of conflict, coexistence, or (in the best cases) integration." This new perspective challenges traditional models that view urban agriculture as a marginal or transient phenomenon, and affirms its pivotal role in achieving urban resilience and food security [17].

5.2. Practical Implications

The study's findings offer practical insights for decision-makers and urban planners in N'Gaous and other Algerian cities facing similar challenges. The spatial identification of conflict and coexistence zones provides a powerful tool for guiding land-use policies more effectively. Rather than applying uniform policies, planners can adopt a differential approach targeting each zone with the appropriate type of intervention, which aligns with recent international calls to build resilience in agrifood systems affected by climatic and urban challenges [30]. For example, agricultural protection efforts can be concentrated in high-compatibility zones, while innovative solutions for urban-agricultural integration are sought in moderate coexistence zones, and transitions in high-conflict zones are managed sustainably.

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6. Policy Recommendations: Towards Integrated Agri-Urban Planning

Based on the findings and analyses, this study presents a set of policy recommendations to strengthen integrated and sustainable agri-urban planning in N'Gaous:

1. **Designation of Permanent Agricultural Protection Zones (APZs):** local authorities should identify and designate high-compatibility zones as APZs, with strict restrictions on urban expansion and encouragement of sustainable agricultural practices, including financial incentives for farmers in these areas [16].

2. **Development of Flexible Land-Use Plans:** urban development plans (e.g., PDAU) should include flexible provisions allowing the integration of urban agriculture, recognizing its environmental, economic, and social value. This could include the designation of mixed-use zones combining housing and agriculture [18].

3. **Support for Adaptive Agricultural Practices**: encouraging farmers to adopt modern and sustainable agricultural technologies (e.g., hydroponics, vertical farming) and high-value crops that increase the productivity of small plots and make them more resistant to urban pressures [31].

4. **Strengthening Participatory Governance**: involving local communities, farmers, and other stakeholders in land-use decision-making processes. Informal agreements and community initiatives can help protect agricultural land and promote coexistence [19]. As Sargolini and Pierantoni [29] pointed out, "the relationship between general strategy and actions makes it necessary to overcome the traditional dichotomy between general planning and sectoral disciplines."

5. **Application of Transfer of Development Rights (TDR)** Mechanisms: in high-conflict zones, authorities may consider TDR mechanisms, compensating owners of agricultural land for non-development and transferring development rights to other areas suitable for urban expansion [20].

6. **GIS-based Monitoring System**: establishing a permanent land use/land cover change monitoring system based on GIS to track agricultural land loss and urban expansion in real time, enabling timely intervention [21].

7. **Urban Agricultural Extension Services**: developing specialized extension services for urban agriculture, focusing on water-efficient techniques and high-value crops suited to the peri-urban environment [22].

8. **Public Awareness Campaigns and Educational Farms**: promoting the values of urban agriculture for food security and environmental quality among urban residents, and supporting the establishment of educational farms in moderate coexistence zones to reconnect urban residents with food production [23].

6.1. Implementation Strategy

Implementation should follow a phased approach, beginning with the immediate designation of Agricultural Protection Zones (Phase 1), followed by the introduction of economic incentives and institutional reforms (Phase 2), and finally the full integration of urban agriculture into the Master Plan at its next revision (Phase 3). These measures are designed to leverage the current resilience of N'Gaous's agricultural sector to achieve a more balanced and sustainable urban form.

7. Conclusion

7.1. Summary of Key Findings

This study successfully quantified the spatial dynamics of land-use change in N'Gaous, revealing the loss of 240 hectares (37%) of agricultural land between 1966 and 2024, driven primarily by urban

expansion. The application of a multi-criteria AHP-GIS model provided a precise spatial classification, identifying three distinct zones: high conflict (23%), moderate coexistence (41%), and high compatibility (36%). Most importantly, the study found that agricultural continuity is linked to the resilience of traditional family farming and adaptive shifts towards high-value crops.

7.2. Theoretical Contributions

The research contributes to planning theory through the empirical validation of the concept of the peri-urban interface as a coexistence-conflict continuum, moving beyond the traditional rural-urban conflict dichotomy. It also reinforces the argument for recognizing urban agriculture as a permanent, multifunctional component of the urban metabolism, rather than a temporary land use awaiting conversion.

7.3. Policy Implications

The policy recommendations offer a practical roadmap for integrated agri-urban planning, focusing on regulatory tools (Agricultural Protection Zones, Transfer of Development Rights), economic support, and institutional reforms. These measures are designed to leverage the current resilience of N'Gaous's agricultural sector to achieve a more balanced and sustainable urban form.

7.4. Limitations and Future Research

One limitation of this study is its reliance on expert judgement for AHP weights; future research should incorporate a broader range of stakeholder preferences (e.g., through a Delphi-AHP approach). Moreover, the study focused primarily on spatial, social, and economic factors; future work should incorporate a detailed analysis of the water-energy-food nexus in the N'Gaous context [30], particularly regarding the use of treated wastewater for irrigation.

7.5. Broader Significance

The methodological framework and findings regarding agricultural resilience in the face of moderate urban pressure are highly relevant to other medium-sized cities in North Africa and the Global South [31] that are grappling with rapid, unplanned urban expansion onto fertile land.

7.6. Closing Reflections

The future of N'Gaous—and countless other cities—depends on a fundamental shift in planning philosophy: from viewing agriculture as an obstacle to development, to recognizing it as an essential component of urban resilience, sustainability, and identity.

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