Insaniyat, n° 108, avril-juin 2025, p. 69-93

Is Green Space Integrated into Urban Expansion? Biophilic Urban Design in Tiaret, Algeria: An Assessment

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Abstract

Urban green spaces play a vital role in promoting public health, enhancing sustainability, and strengthening environmental resilience. However, numerous studies have identified persistent shortcomings in urban green space planning, particularly in the context of rapid urban population growth. This study investigates the integration of green spaces within the processes of urban expansion by developing an evaluative framework grounded in Algerian environmental protection legislation and the principles of biophilic urbanism. Employing a hybrid descriptive-quantitative methodology, the study underscores the dual imperative of preserving natural landscapes and systematically integrating green spaces into urban planning. Five planned residential neighbourhoods in the city of Tiaret, characterized by surrounding cropland and forest, serve as case studies. The findings indicate a failure to adequately protect natural land and mitigate environmental hazards. Green space integration is weak, with green area ratios ranging between 5% and 10% in four of the five neighbourhoods. Furthermore, a lack of diversity in green space typologies and the absence of key biophilic urbanism strategies reflect the consequences of a uniform and rigid design approach adopted by urban planners.

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Keywords: Urban expansion - Environmental Algerian laws - Biophilic urbanism - Indicators - Neighbourhood.

ملخص

تلعب المساحات الخضراء الحضرية دورًا أساسيًا في تعزيز الصّحة العامّة ودعم الاستدامة وتقوية القدرة على الصمود البيئي. ومع ذلك، فقد أبرزت العديد من الدّراسات وجود نقائص مستمرة في تخطيط المساحات الخضراء الحضرية، خاصّة في سياق النمو السّريع للسّكان في المدن. تبحث هذه الدّراسة في إدماج المساحات الخضراء ضمن عمليات التّوسع العمراني من خلال تطوير إطار تقييمي يستند إلى التّشريعات الجزائرية لحماية البيئة وإلى مبادئ التخطيط العمراني البيوفيلي. وباعتماد منهجية هجينة وصفية-كمية، تُبْرِزُ الدّراسة الحاجة المزدوجة إلى الحفاظ على المناظر الطّبيعية وإدماج المساحات الخضراء بشكل منهجي في التّخطيط العمراني. قد تمّ اعتماد خمسة أحياء سكنية مبرمجة في مدينة تيارت، محاطة بأراضٍ زراعية وغابات، كحالات دراسية. تُظْهِرُ النّتائج قصورًا في حماية الأراضي الطّبيعية والحدّ من المخاطر البيئية. كما أن إدماج المساحات الخضراء ضعيف، حيث تتراوح نسبتها بين 5% و10% في أربعة من الأحياء الخمسة. إضافة إلى ذلك، فإنّ غياب التّنوع في أنماط المساحات الخضراء وغياب استراتيجيات رئيسية للتّخطيط العمراني البيوفيلي يعكس نتائج اعتماد مقاربة تصميمية موحدة وصلبة من طرف المخطّطين العمرانيين.

الكلمات المفتاحية: التّوسع العمراني - القوانين البيئية الجزائرية - العمران البيوفيلي - المؤشّرات - الحيّ.

Résumé

Les espaces verts urbains jouent un rôle essentiel dans la promotion de la santé publique, le renforcement de la durabilité et le soutien de la résilience environnementale. Cependant, de nombreuses études ont mis en évidence des insuffisances persistantes dans la planification de ces espaces, en particulier dans le contexte d'une croissance rapide de la population urbaine. Cette étude examine l'intégration des espaces verts dans les processus d'expansion urbaine à travers le développement d'un cadre d'évaluation fondé sur la législation algérienne en matière de protection de l'environnement et sur les principes de l'urbanisme biophilique. En adoptant une méthodologie hybride, descriptive et quantitative, l'étude met en évidence le double impératif de préserver les paysages naturels et d'intégrer systématiquement les espaces verts

dans la planification urbaine. Cinq quartiers résidentiels planifiés de la ville de Tiaret, entourés de terres agricoles et de forêts, servent de cas d'étude. Les résultats révèlent une incapacité à protéger de manière adéquate les terres naturelles et à atténuer les risques environnementaux. L'intégration des espaces verts demeure faible, avec des ratios variant entre 5% et 10% dans quatre des cinq quartiers analysés. De plus, le manque de diversité dans les typologies d'espaces verts et l'absence de stratégies clés de l'urbanisme biophilique reflètent les conséquences d'une approche de conception uniforme et rigide adoptée par les urbanistes.

Mots-clés : Expansion urbaine - Lois environnementales algériennes - Urbanisme biophilique - Indicateurs - Voisinage.

A virtuous relationship between urban areas and green spaces necessitates not only protection but also intentional integration (Cavin et al., 2010). Protection entails the rational use of natural resources to improve the quality of life for current and future urban populations, thereby fostering long-term sustainability (Ostárek, 2021). For instance, the compact city model aims to reduce spatial dispersion and increase urban density to conserve surrounding natural environments (Bibri et al., 2020). This protective approach establishes a reciprocal dynamic in which urban inhabitants benefit from enhanced environmental quality and reduced exposure to natural hazards (Degg, 1998; November, 1994). It is reinforced by legal and regulatory frameworks that uphold environmental standards.

In contrast, integration represents a more advanced paradigm wherein ecological systems are considered intrinsic to urban form and design. Historical figures in urban planning; such as Frank Lloyd Wright, with his concepts of *The Living City* and *Broadacre City* (Wise, 2013), Charles Fourier's *Phalanstery*, and Ebenezer Howard's *Garden City* model (Batchelor, 1969), were pioneers of this integrative vision. International conventions and policy frameworks have significantly shaped the evolution of these principles. The 1992 United Nations Conference on Environment and Development (Earth Summit) marked a pivotal moment, laying the groundwork for global initiatives in sustainability, biodiversity conservation, and climate action. Subsequent agreements, including the Kyoto Protocol (1997), the Earth Charter (2000), the Sustainable Development Goals (2015), and the New Urban Agenda (2016) further institutionalized sustainability norms (Klopp & Petretta, 2017).

Since the early 2000s, Algeria has enacted major legal instruments to support sustainable development, notably Law 01-20 on spatial planning and Law 03-10 on environmental protection (Gherbi, 2012). In parallel, global sustainability paradigms such as New Urbanism, Ecological Urbanism, and Biophilic Urbanism have influenced urban planning discourse. E.O. Wilson's *Biophilia* theory posits that human well-being is positively affected by contact with nature (Beatley & Newman, 2013; Totaforti, 2020). This idea catalyzed the Green Building Movement in the 1990s (Korkmaz et al., 2009), which incorporated biophilic design principles. Consequently, Biophilic Urbanism emphasizes embedding natural elements within the urban fabric.

Urban expansion in Algerian cities is confronted by a range of challenges. Several studies underscore the widespread prevalence of unsustainable land use practices that contribute to the degradation of ecological assets, particularly through the urbanization of croplands and forests (Bounoua et al., 2023; Kalbaza et al., 2022; Laiche & Sadoudi, 2011), inadequacies in urban planning documentation that negatively influence expansion processes (Benkada, 2001; Nemouchi, 2023), and a policy landscape overly focused on addressing housing deficits (Nait Saada, 1999; Riyadh & Mohamed Osman, 2021). Despite these concerns, the issue of green space provision in urban expansion zones remains underexplored, even as Algerian cities increasingly resemble "concrete jungles" (Mili et al., 2019; Ouzir et al., 2021). Urban green spaces contribute significantly to urban livability, offering benefits such as improved air quality, enhanced mental and physical health, increased social cohesion, biodiversity support, and climate resilience (Andreucci et al., 2021; Bourdeau-Lepage, 2019; Keniger et al., 2013). Nonetheless, access to these spaces remains limited in many Algerian urban contexts.

In response to this gap, our study aims to evaluate the degree to which green space considerations have been incorporated into the planning of urban expansion areas. Drawing on Algerian environmental legislation and the principles of Biophilic Urbanism, we developed an evaluative framework to assess the greening strategies of five residential neighborhoods located within the expansion zones of Tiaret, Algeria. Our objectives are to identify the extent to which nature-human connection strategies have been employed and to evaluate whether these initiatives originate from

institutional planning authorities, community-level interventions, or individual actions.

Materials and Methods

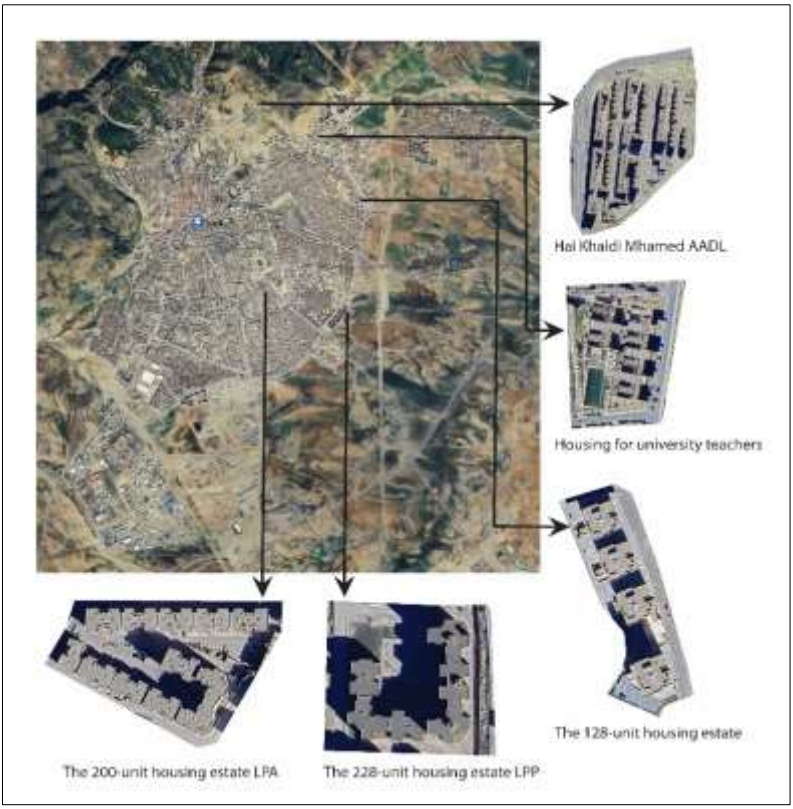
Case Study

Tiaret's urban expansion is bounded by the extensive agricultural plains of Sersou to the east, south, and west, and by the forested massif of Djbel Guezoul to the north. Within these expansion zones, five residential sites were selected for analysis, four of which are located in proximity to either croplands or forested areas, reflecting planned residential developments initiated by governmental programs or real estate agencies. The five sites, illustrated in Figure 1, include: *Hai Khaldi Mhamed AADL* in Zmala and *Housing for University Teachers* in Hai Kharoubi El Miloud, both situated adjacent to forested areas; *The 128-unit Housing Estate* in Hai Ettefah and *The 218-unit Housing Estate LPP* in Kerjou, both located near farmland; and *The 200-unit Housing Estate LPA* in Hai Houari Abed, surrounded predominantly by urban fabric.

Specifically, *Hai Khaldi Mhamed AADL* in Zmala is located in the northeastern sector of the city, directly adjacent to forested land on all sides, and was constructed after 2010 by the Algerian Housing Development Agency (AADL). Similarly, the *Housing for University Teachers* in Hai Kharoubi El Miloud, also developed post-2010, is located in the northeast, bordered by pine forests to the north and connected to the urban core on other sides. The *128-unit Housing Estate* in Hai Ettefah, developed by a private Algerian entity after 2010, is situated in the northeastern sector, near agricultural land. The *218-unit Housing Estate LPP* in Kerjou, likewise constructed after 2010, borders farmland to the south while being surrounded by urban areas on the remaining sides. In contrast, the *200-unit Housing Estate LPA* in Hai Houari Abed, developed post-2000, is located in the southern part of Tiaret and is entirely encompassed by urban neighborhoods.

Figure 1: Geographical Location of the Five Selected Neighborhoods in Tiaret, Algeria

***Source*:** Adapted by Amina Kalbaza from satellite imagery available via Google Earth Pro, 2024.



Methodology

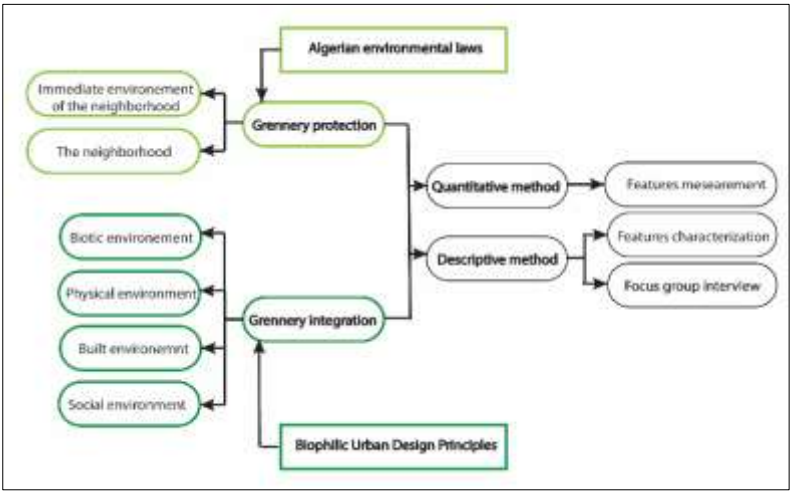
Overall Workflow

Figure 2 illustrates the overall methodological workflow, structured around a two-tier evaluative framework. The first tier, referred to as the *conservation level*, assesses whether urban expansion respects the natural surroundings by evaluating compliance with national conservation legislation at both the neighborhood scale and its immediate environment. The second tier, the *integration level*, examines the degree to which green space has been integrated into urban expansion areas and identifies

the primary agents responsible for these initiatives. This evaluation employs biophilic urban design indicators; addressing the biotic, physical, built, and social environments, based on frameworks proposed by Alaskary and Alrobaee (2022), Cheshmehzangi et al., (2021), Dizdaroğlu (2020), and Pedersen Zari (2023).

Figure 2: Overall Workflow Chart of the Methodological Framework

Source: Amina Kalbaza, 2024.



Reading Grid

We developed a reading grid, presented in Table 1, comprising twenty-six indicators designed to assess a wide range of factors, from ecological preservation to the integration of green spaces within public, transit, and built environments. Some indicators extend beyond the immediate neighborhood scale to evaluate broader city-level dynamics that influence local quality of life. The indicators are assessed using a hybrid descriptive-quantitative methodology, which involves the measurement of spatial features through Google Earth Pro, the characterization of features by identifying the presence of specific elements within neighborhoods, and the collection of qualitative insights through focus group interviews.

Table 1: Reading Grid Integrating Algerian Environmental Legislation and Biophilic Urban Design Principles

Indicators	Indicator's elements	Measurement method
Level 01: Conservation of the Green Space		
Scale 01: The Immediate Environment		
1-Protection of Environmentally Sensitive Areas: Law 90-25 on land use, Law 01-20 on regional planning and sustainable development and Law 03-10 on environmental protection and sustainable development.	**-Protection:** The natural surroundings are bordered by elements such as trees, hedges, and fences… **-Damage:** The natural surroundings are affected by waste from urban households, construction, commercial, and industrial source.	D: Note whether the natural surrounding is protected or damaged.
2-Project Location: Law 90-25 on land use and Law 06-06 on the city for the rational use of natural resources.	**-Densification** **-Expansion**	D: Indicate whether the project has been developed within a densification framework or as part of urban expansion.
Scale 02: The neighborhood		
3-Efficient Land Utilization: Law 06-06 on the city for the rational use of land.	Wasted outdoor areas (without predefined functions and equipment).	Q: Calculation of the percentage of wasted outdoor areas.
4-Prevention From Major Risks: Law 06-06 on the city.	Natural hazards like heat waves, extreme cold, storms, floods, forest fires, landslides, earthquakes…	D-FGI: About the major risks.

Level 02: Green Space Integration		
Scale 01: Biotic Environment		
5-Climate-responsive Urban Design	Climate-responsive urban design elements such as habitat conservation, urban agriculture, mixed-use development, water-sensitive urban design, adaptive reuse and regeneration…	D: Note the presence of climate-responsive urban design elements.
6- Land Heritage Preservation	Design elements that relate to the natural history of the site, such as native plants and landscaping, historic signage and interpretive displays…	D: Note the presence of design elements that relate to the natural history of the site.
7-Biophilic Art and Design	The integration of artistic and aesthetic elements from nature into urban design such as sculptures, murals and artwork inspired by nature…	D: Note the presence of artwork inspired by nature.

Scale 02: Physical Environment		
8-Biodiversity conservation	Preserving natural habitats, incorporating native plant species, and creating wildlife corridors…	Q: Count all kinds of living things in the area.
9-Healthy Water Systems and Natural Water Management	-Permanent clean water for urban use. - Natural water management like permeable pavement, and rain gardens…	D-FGI: About clean water for urban use. D: Note the presence of water management.
10-Improved Air Quality	Green space and vegetation, compact urban form, mixed-use…	D: Note the presence of elements to improve air quality.
11-Soundscape Quality	Sound levels, sound sources and temporal patterns…	D-FGI: About the soundscape quality.
12-Soil Quality	Greening of land	D: Note the presence of greened open spaces.

Scale 03: Built Environment		
13-Biophilic Architecture	Building with human connection to nature, natural ventilation systems and daylighting strategies…	D: Note the presence of biophilic architectural elements.
14-Suitable building height	Taking into account zoning regulations, shadows and sunlight and visual impact.	Q: Calculate building heights using meters as the unit of measurement.
15-Promotion and Preservation of Green Public Spaces: law 06-06 on the city.	Existing green public spaces accessible to all residents.	D: Note the presence of green public space.
16-Vegetation Coverage Ratio	Percentage of area covered by vegetation: trees, plants, hedges…	Q: Calculate the area planted with trees or other plants to the total area.
17-Diversity in Green Spaces	Community gardens, green spaces, greenways, botanical gardens, nature reserves and wildlife sanctuaries, promenades...	Q: Count the types of green spaces in the area.
18-Urban Agriculture	Community gardens, rooftop gardens, urban farms, edible landscaping…	Q: The ratio of the number of produced green spaces to the total number of green spaces.
19-Accessible Nature	Ensure that nature is accessible to all urban dwellers, natural areas within walking distance of residential areas.	Q: Calculate the distance between the neighborhood and the nearest public green space in the city, a maximum of 400 meters is required.
20-Diversity in Land Uses	Relaxation areas, entertainment, gardening, play areas for children…	Q: Quantify the number of variant outdoor spaces.

21-Green Transportation	Cycling infrastructure, walking infrastructure…	D: Note the presence of green transport infrastructures.
22-Correct Handling of Waste	Recycling bins for different types of waste (recyclable, organic, non-recyclable).	D: Note the presence of recycling bins.
Scale 4: Social environment		
23-Opportunities for Physical Activities	Opportunities to promote physical activity like outdoor fitness equipment, playgrounds and walking infrastructure…	D: Note the presence of equipment for physical activity.
24-Comfortable, Safe Mobility	Enhancing public safety through measures such as improved lighting, security cameras, and police patrols…	D-FGI: About sense of security when moving between the spaces.
25-Socially Inclusive Community	Efforts to create a socially inclusive community by mixed-income housing, accessible public transport, gardens and playgrounds accessible to all residents…	D: Note the available facilities for social inclusion.
26-Community Engagement and Education	Involve local communities in the design process, provide educational opportunities to raise awareness of the benefits of nature, youth engagement programs…	D-FGI: About the efforts for community engagement and education.

Source: Amina Kalbaza, D is for descriptive methods, D-FGI is for descriptive method using focus group interview and Q is for quantitative method.

Focus Group Interview

As part of our qualitative approach, we employed focus group interviews following the methodology outlined by Szymańska (2020). A total of 25 individuals were interviewed, with each session involving five residents per neighborhood and a maximum of two women per group. Participants were selected through

convenience sampling based on their availability. The interviews, lasting between 15 and 25 minutes, were structured around six guiding questions, presented in Table 2. Sessions were moderated to direct discussions toward topics related to green space and urbanity, deliberately minimizing the inclusion of personal anecdotes. Data collection was conducted through written notes, and the analysis focused on synthesizing general group responses to achieve a comprehensive understanding of shared perspectives.

Table 2: Focus Group Interview Questions for Data Collection

Indicator	Question	Type of question
Natural Hazards	-Is your neighborhood protected against major risks associated with its natural surroundings?	Y/N
	-If not, what risks or harm are you exposed to?	O
Soundscape Quality	-How would you evaluate the quality of the soundscape in your neighborhood? o Very good o Good o Average o Bad o Very bad	S
	-What are the main sources of noise?	S. S
	-Do you notice any specific time patterns for the noise?	O
Clean Water for Urban Use	-Is clean water readily accessible for urban use?	Y/N
Safe Mobility	-Do you feel secure when moving between spaces?	Y/N
	-If no specify the reasons	O
Community Engagement and Education	-Are there any initiatives in place that promote community engagement and provide educational opportunities related to green space management?	Y/N
	-If yes, specify?	S. S

Source: Amina Kalbaza, Y/N is for yes or no questions, O is for opened questions, S is for structured questions and S.S is for semi structured questions.

Results and Discussions

The Preservation of the Natural Surroundings

The findings reveal a weak preservation of the natural surroundings, characterized by the absence of protective boundaries across all studied cases, which has allowed urban and commercial waste to encroach upon adjacent cropland and forest areas. All analyzed neighborhoods exhibit a radial urban expansion pattern, with the exception of Hai Khaldi Mhamed AADL in Zmala, which demonstrates a leapfrog development pattern (Yasin et al., 2021). In terms of risk prevention, no measures have been implemented to protect residents from natural hazards, apart from adherence to the Algerian Earthquake-Resistant Regulations (AERR). Despite the proximity of four out of the five neighborhoods to cropland or forested areas, no protections have been established against major climatic or ecological risks, such as extreme cold during winter, heatwaves during summer, or wildlife incursions. This has led to frequent complaints, notably regarding wild boar intrusions into Hai Khaldi Mhamed AADL in Zmala. Comparable findings were reported in Bejaia, where the absence of hazard mitigation strategies in urban planning was similarly highlighted (Hamma, 2018). Overall, the results underscore significant deficiencies in both the protection of natural environments and the implementation of hazard mitigation measures.

Current Strategies for Green Space Integration

The analysis of the five neighborhoods reveals the presence of several strategies for environmental integration; however, these initiatives remain limited and sporadic, as illustrated in Figure 03. These strategies are evident at multiple scales, including building design, transitional spaces and outdoor areas. They have a positive impact on the social environment within each neighbourhood. Notable examples include mixed-use developments, the incorporation of natural ventilation systems, and daylighting strategies, particularly within transitional spaces. In terms of greening, the use of native plant species in private gardens, the integration of vegetation in neighborhoods lacking dedicated green spaces, and the establishment of pedestrian paths and greenways were observed. Artistic expressions inspired by nature are modest, confined mainly to murals featuring natural themes. Social

dimensions are reflected through the creation of community gardens, which facilitate recreational and social interactions; however, further research is necessary to fully understand Algerian residents' engagement with communal gardening initiatives. Accessibility to public transport and the implementation of safety measures, such as regular police patrols, were generally found to be satisfactory. Furthermore, community-driven educational initiatives, organized by neighborhood committees and youth programs, seek to enhance public awareness of the benefits of integrating nature within urban environments.

Figure 3: Photograph Depicting Current Biophilic Urban Design Strategies



Source: Amina Kalbaza, 2024; A, B and C: Slopping tree-lined promenade, Planted areas and garden in The Housing for University Teachers in Hai Kharoubi El Miloud, D: Green Containment walls in Hai Khaldi Mhamed AADL in Zmala.

Absent Strategies for Green Space Integration

The findings highlight notable deficiencies in the incorporation of biophilic urban design principles throughout all analyzed sites. Despite the natural history inherent to each site, there is a conspicuous absence of heritage integration, such as interpretive signage or habitat restoration efforts. The artistic incorporation of nature is minimal, with no sculptures or design elements that evoke

natural ecosystems. Gardens lack biodiversity-enhancing features, such as wildlife corridors, and there is a notable absence of green roofs or urban agriculture initiatives. Furthermore, water-sensitive urban design elements, including permeable pavements and rain gardens, are missing, as are adaptive reuse strategies and waste sorting systems. The absence of sustainable infrastructure is particularly striking, with no provisions for low-carbon transport options or cycling paths.

Roles of Key Actors in Green Space Strategy Integration

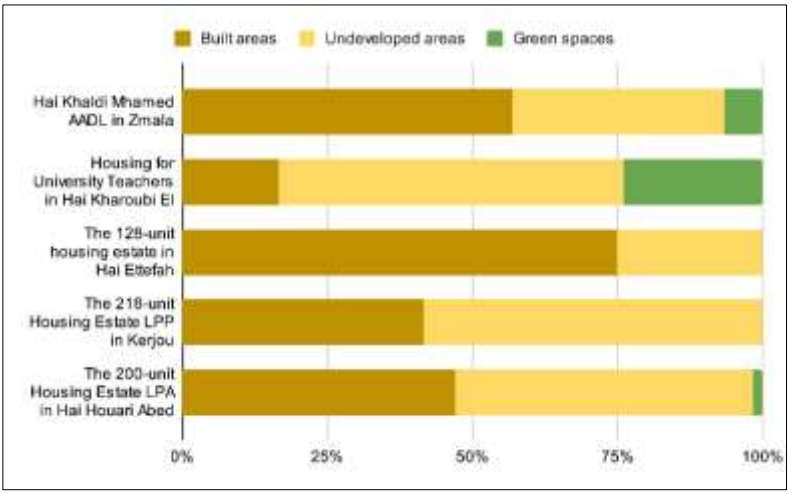
The analysis of residential urban expansions reveals a significant neglect of green space integration across all sites. Uniform design approaches prevail, with minimal attention given to the inclusion of green spaces. Notably, only the Housing for University Teachers in Hai Kharoubi El Miloud incorporates a range of landscaped, greened outdoor areas. In contrast, other neighborhoods such as the 128-Unit Estate in Hai Ettefah, the 218-Unit LPP Estate in Kerjou, and the 200-Unit LPA Estate in Hai Houari Abed demonstrate no deliberate efforts by planners to integrate green spaces. Neighborhood committees exhibit limited involvement in green space initiatives, primarily focusing on vegetation planting and cleanliness. However, the situation differs in Hai Khaldi Mhamed AADL in Zmala, where maintenance is managed by a dedicated organization. In the 200-Unit LPA Estate in Hai Houari Abed, green space-related activities are driven exclusively by individual efforts.

Spatial Evaluation of Urban Green Space

We conducted an analysis of the proportion of green areas in relation to unbuilt spaces and the share of productive green areas relative to existing vegetation across the neighborhoods, measured in hectares, as illustrated in Figure 04. The highest recorded vegetation coverage was 22% in the Housing for University Teachers in Hai Kharoubi El Miloud. In contrast, all other sites exhibited minimal vegetation, with less than 10% in Hai Khaldi Mhamed AADL in Zmala, and less than 5% in the 200-unit Housing Estate LPA in Hai Houari Abed. The 128-unit Housing Estate in Hai Ettefah and the 218-unit Housing Estate LPP in Kerjou recorded no vegetative coverage, highlighting severe deficiencies in green space integration. Notably, the 218-unit Housing Estate LPP in Kerjou exhibited 18% of unmanaged areas

designated for future vegetation, yet these spaces remain undeveloped. The productive green spaces across all neighborhoods were either non-existent or negligible. Although small patches of productive green areas were observed, primarily in the form of fruit trees, their surface area was minimal.

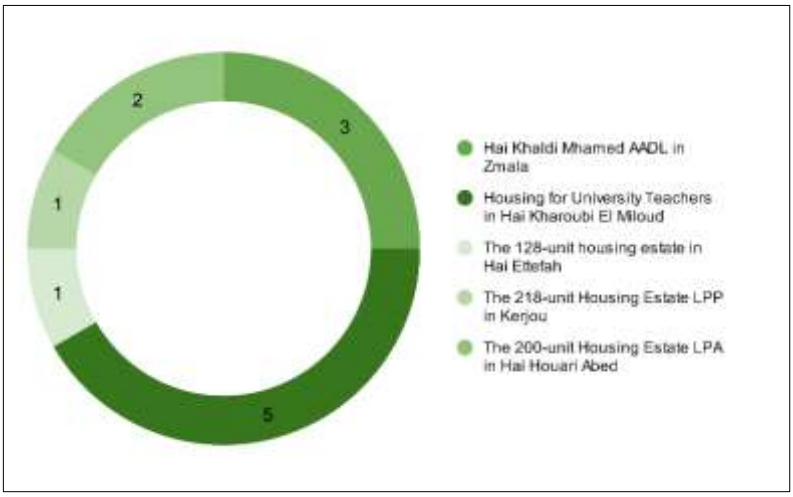
Figure 4: Spatial Analysis of Green Spaces Across the Selected Neighborhoods



Source: Amina Kalbaza.

At the green space level, we assessed the diversity of green space types across the neighborhoods by cataloging the various categories present, as depicted in Figure 5. These categories included street trees, planted areas, community gardens, greenways, tree-lined promenades on slopes, and green containment walls. The Housing for University Teachers in Hai Kharoubi El Miloud exhibited the highest diversity, incorporating five distinct types of green spaces. Hai Khaldi Mhamed AADL in Zmala followed with three types, while the 200-unit LPA Estate in Hai Houari Abed featured only two. The 128-unit Estate in Hai Ettefah and the 218-unit LPP Estate in Kerjou displayed the lowest diversity, each consisting solely of street trees.

Figure 5: Analysis of Green Space Diversity across the Selected Neighborhoods



Source: Amina Kalbaza.

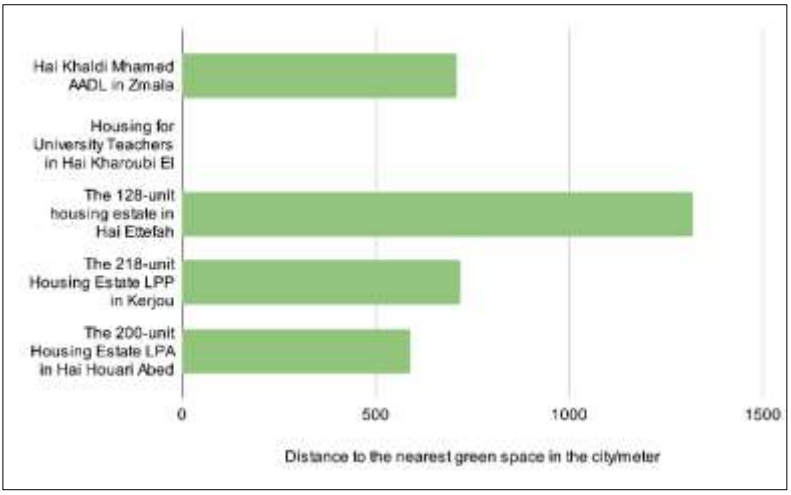
The nature accessibility indicator suggests that a neighborhood should be within a walkable distance of less than 400 meters from the nearest urban garden. For the purposes of this analysis, forests and farmland were excluded, with a focus solely on managed urban gardens accessible to all residents. Distances were calculated along pedestrian routes, rather than direct lines. As shown in Figure 6, among the neighborhoods assessed, only the Housing for University Teachers in Hai Kharoubi El Miloud met this criterion. In contrast, the 200-unit Housing Estate LPA in Hai Houari Abed is approximately 600 meters from the nearest urban garden. Hai Khaldi Mhamed AADL in Zmala and the 218-unit LPP Estate in Kerjou are each about 700 meters away, while the 128-unit Estate in Hai Ettefah is over 1 kilometer from the nearest urban green space. Overall, these results highlight a lack of prioritization for accessible green spaces in the urban planning of these neighborhoods.

The University Teachers Housing Estate in Hai Kharoubi El Miloud displayed exemplary integration of green areas, providing residents with access to both a neighborhood garden and a city garden, along with a variety of green spaces. In contrast, Hai Khaldi Mhamed AADL in Zmala and the 200-unit Housing Estate LPA in Hai Houari Abed exhibited moderate integration, with some diversity in vegetation but limited green space coverage

and proximity to an urban garden. The 128-unit Estate in Hai Ettefah and the 218-unit LPP Estate in Kerjou, however, demonstrated minimal integration, with green spaces that were largely negligible in both size and diversity.

A low ratio of green space within urban neighborhoods or cities has significant implications for public health, biodiversity, and climate resilience. Green spaces play a crucial role in city planning, contributing to climate resilience by regulating temperature, managing stormwater, and sequestering carbon. From a health perspective, insufficient green areas limit opportunities for physical activity, social interaction, and mental restoration, while exacerbating heat-related illnesses and respiratory problems caused by poor air quality and the urban heat island effect (Nguyen et al., 2021). Ecologically, the absence of continuous, well-managed green spaces leads to habitat loss and fragmentation, negatively affecting urban biodiversity and restricting species movement and survival. Additionally, the lack of green space in urban expansion increases the risk of flooding, raises energy consumption for cooling, and reduces a city's ability to adapt to climate change. Therefore, ensuring adequate green space coverage is essential for the sustainability and livability of urban environments.

Figure 6: Analysis of Proximity to the Nearest Green Space across the Selected Neighborhoods



Source: Amina Kalbaza.

Identified Issues in the Analyzed Sites

The focus group interviews and the results from the reading grid highlighted shared challenges across all neighborhoods. A significant issue affecting all areas is the city-wide shortage of water for urban use, which is particularly pronounced in The 200-unit Housing Estate LPA in Hai Houari Abed. Waste management continues to be a pervasive concern, with residents across all neighborhoods reporting the need to dispose of waste outside their respective areas. Additionally, the maintenance of street lighting is generally inadequate, except in The 200-unit LPA in Hai Houari Abed, where the lighting poles are well-maintained. Several other challenges, such as environmental pollution specifically air and noise pollution, insufficient vegetation, and concerns regarding building heights, are common across the neighborhoods (Lu et al., 2021; Nieuwenhuijsen, 2021). Residents largely attributed air and noise pollution to vehicle traffic. This underscores the need for further studies on Tiaret's soundscape quality to provide empirical data on noise levels and patterns, similar to the research conducted in Biskra (Bouzir & Zemmouri, 2018). While building height in most neighborhoods seems to meet general standards, concerns regarding sunlight access were reported in both Hai Khaldi Mhamed AADL in Zmala and The 200-unit LPA in Hai Houari Abed.

Overall indicators evaluation

To assess the preservation and integration of green spaces in the studied neighborhoods, we employed a binary scoring system, assigning a value of 1 for the presence of at least one element of the analyzed indicator, and 0 for its absence. This method does not account for the diversity of integrated strategies, revealing a general paucity of variation and numerous missing strategies, as previously noted. The findings indicate that The Housing for University Teachers in Hai Kharoubi El Miloud performed the best, with 20 out of the 26 indicators present. Following this, Hai Khaldi Mhamed AADL in Zmala scored 14 indicators, while both The 128-unit Housing Estate in Hai Ettefah and The 200-unit LPA Housing Estate in Hai Houari Abed each achieved 11 indicators. The 218-unit LPP Estate in Kerjou ranked the lowest, with only 7 indicators present.

Our analysis of the actors involved in the implementation of biophilic urban design strategies presents a contrasting picture when compared to the study conducted in Kala, Algeria (Djouad, 2021), despite certain similarities. We found that The Housing for University Teachers in Hai Kharoubi El Miloud incorporated biophilic design strategies as part of the planning process, suggesting active involvement of urban planners in their development. In contrast, the study in Kala revealed that biophilic strategies were largely the result of individual initiatives by self-constructors, with no input from urban planning professionals. It is crucial to note that the Kala study focused exclusively on self-constructed residential areas, which may have influenced the findings. A notable similarity between both studies is the overall low percentage of biophilic design integration. While the Kala study reported a high proportion of green areas (approaching 90%), our findings indicate that The Housing for University Teachers in Hai Kharoubi El Miloud comprises only 22% green areas. Ultimately, this study contributes valuable insights into the integration of green spaces and biophilic urban design within planned residential areas experiencing urban expansion.

Conclusion

This study investigates the preservation and integration of green spaces within the context of urban expansion, with a particular focus on five neighborhoods in the city of Tiaret, Algeria. The findings reveal limited preservation of natural environments, deficient hazard mitigation strategies, restricted diversity in green space features, and the absence of several biophilic urbanism strategies. Green space scarcity is evident both at the neighborhood scale, where green area ratios range between 5% and 10%, and at the city scale, as four of the examined sites are located beyond walking distance from the nearest urban garden. These shortcomings are largely attributed to the uniform design approaches adopted by planners, the insufficient attention devoted to green space integration, weak management practices, and the limited effectiveness of neighborhood committee activities. Although residents demonstrate awareness of the ecological and social value of green spaces, recognizing their role as essential environments for the elderly and youth as well as spaces for rest, recreation, and psychological regeneration, their involvement in

green space management remains minimal. The Housing for University Teachers in Hai Kharoubi El Miloud constitutes a noteworthy exception, exhibiting a green area ratio of 22%. In this case, both the developer and residents displayed strong commitment to green space integration and maintenance, illustrating that urban green needs can be effectively addressed through thoughtful planning, professional management, and active community engagement.

To achieve an acceptable level of green space integration in urban environments, this study recommends a multipronged strategy combining legal, strategic, and incentive-based instruments. Legal frameworks should establish minimum green space standards per inhabitant, while strategic instruments such as master plans and ecological networks can ensure long-term integration. Incentive-based programs may include the adoption of biophilic strategies by developers, educational initiatives, recognition and certification systems, and market-oriented mechanisms such as grants, tax credits, and expedited permitting processes. Capacity-building measures, including professional training programs, workshops, and design competitions, are also essential. Furthermore, public–private partnerships involving municipalities, developers, and academic institutions can foster pilot projects and model practices. The scope of this study was limited to planned residential areas developed during a period of urban expansion in a medium-sized city. Self-constructed residential zones, public services, and urban gardens were not included in the analysis. Future research on green space preservation and integration in Algeria should therefore extend to both public and residential spaces across cities of varying scales to generate a more comprehensive understanding of the challenges and opportunities in this field.

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ISSN 2830-9863

Turath n°4

Algerian Journal of Cultural Anthropology

December 2024

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Center of Research in Social and Cultural Anthropology-Algeria