



Biophilic assessment of urban planning in the El Kala world biosphere reserve (eastern Algeria) Evaluación biofílica de la planificación urbana en la reserva de la biosfera mundial de El Kala (este de Argelia)

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ABSTRACT This study focuses on the El Kala World Biosphere Reserve, valued for its ecological and landscape importance, and intersected by the presence of the city of El Kala, which has been guided by an urban development master plan since 1990. The objective is to analyze the relationship between urban growth and natural spaces, highlighting the urgent issue of forest fires as a central challenge for sustainable planning. The method relies on a biophilic approach, which emphasizes the innate human connection to nature and uses documentary, landscape, and behavioral analyses to understand how architect-urbanists perceive and manage this environment. The results reveal three scenarios that show the standardized nature of the master plan, its adaptability to the surrounding ecosystems, and the persistent gap between projected strategies and actual implementation. In conclusion, the research underlines the need to integrate biophilic principles more deeply into urban planning, while stressing that effective responses to forest fires are essential to balance development with the ecological preservation.

RESUMEN Este estudio se centra en la Reserva Mundial de la Biosfera de El Kala, valorada por su importancia ecológica y paisajística, y atravesada por la ciudad de El Kala, que desde 1990 se rige por un plan maestro de desarrollo urbano. El objetivo es analizar la relación entre el crecimiento urbano y los espacios naturales, destacando la urgencia de los incendios forestales como un desafío central para la planificación sostenible. El método se basa en un enfoque biofílico, que subraya la conexión innata del ser humano con la naturaleza y utiliza análisis documentales, paisajísticos y conductuales para comprender cómo los arquitectos-urbanistas perciben y gestionan este entorno. Los resultados revelan tres escenarios que muestran el carácter estandarizado del plan maestro, su capacidad de adaptación a los ecosistemas circundantes y la persistente brecha entre las estrategias proyectadas y su aplicación real. En conclusión, la investigación subraya la necesidad de integrar más profundamente los principios biofílicos en la planificación urbana, al tiempo que enfatiza que las respuestas eficaces a los incendios forestales son esenciales para equilibrar el desarrollo con la preservación ecológica.

KEYWORDS nature, urban planning, biophilic behavior, urban practice, Argelia

PALABRAS CLAVE naturaleza, planificación urbana, comportamiento biofílico, práctica urbana, Argelia

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1. Introduction

In the early centuries, natural spaces served as the primary habitat for humans, providing them with shelter, food, and security. Over time, this bond weakened as urban expansion encroached upon these environments, gradually replacing their organic vibrancy with the artificial tones of the built landscape (Dagno et al., 2025). Driven by the pursuit of spatial and technological progress, human expansion led to the systematic takeover of natural environments, including forests (Hook et al., 2026). Thus, the interplay between urban and natural spaces manifests as the transformation of natural environments into urbanized landscapes, while urban spaces undergo a process of ruralization and natural integration (Pietrobon, 2025). The downside of this interaction manifests as a natural hazard: forest fires that have evolved into a recurring threat, severely affecting urban environments (Wei et al., 2026). Various disciplines study and manage natural spaces, yet urban planning stands out for its focus on areas with urban characteristics, shaping the city's structure and boundaries (Gonzalez-Mathiesen, 2024). The urban-natural dynamic is approached through biophilia, which seeks to integrate nature's presence and functions into the core of urban planning. By strengthening ecological connectivity and reducing habitat fragmentation, this approach enhances cities' resilience to climate risks, particularly forest fires (Lefosse et al., 2025).

In northeastern Algeria, where densely forested, mountainous wilayas face high population pressure and limited land for urban expansion (Meddour-Sahar and Bouisset, 2013), urban development inevitably extends into wooded areas. This dynamic results in a dual phenomenon: the urbanization of forested landscapes and the ruralization of urban spaces (Pickett et al., 2026). Located in northeastern Algeria, at the heart of a biosphere reserve designated by UNESCO in 1990, the city of El Kala continues to expand spatially, confronting its natural environment, particularly its forested areas, which form an integral part of the reserve and the El Kala National Park (EKNP), established in 1983. In 2022, this environment was severely affected by large-scale forest fires that even reached urban areas, causing not only ecological and material damage but also human losses. Several scientific studies conducted by ecological and forestry experts have highlighted this issue by mapping risk zones and proposing tailored solutions for the El Kala region (Arfa et al., 2019). This reality has led us to investigate the role of this environment in urban planning and its implementation, to clarify whether this specific situation is considered in the city's spatial development, with the aim of preventing and minimizing damage from forest fires. This study hypothesizes that a gap exists between urban planning and its implementation, particularly

regarding the natural environment. The latter is often relegated to the background. At the same time, emphasis is placed on the spatial aspect, directed by urban space specialists (institutions or individuals), to the detriment of environmental, ecological, and forestry dimensions advocated by experts in the natural world, especially the management of the El Kala National Park.

This study underscores the imperative of integrating the natural environment of El Kala into both the planning and implementation phases of urban space production. The research scrutinizes the flexibility of the Master Plan for Development and Urban Planning (PDAU) under local governance, evaluating its responsiveness to constraints imposed by natural environments. It further examines the vision held by urban planners and architects, highlighting a dominant artificial approach that often marginalizes ecological considerations. As a response, the study formulates targeted recommendations to guide future urban planning toward a more harmonious interaction between built and natural environments. Ultimately, it emphasizes that the increased risk of forest fires in urban settings stems from an unstructured and poorly planned relationship between urban space and forest ecosystems.

2. Spatial development of the city: between urbanization and environmental protection

The traditional definition of urban planning is a process of implementing territorial strategies to address issues of social cohesion and sustainable development through the formalization of a spatial project. In the contemporary era, urban planning incorporates digital tools (GIS, BIM...) (Aidaoui et al., 2024) as well as spatial data, in order to address climate and socioeconomic challenges by promoting adaptive and equitable governance (Lafioune et al., 2025). As a contemporary approach, biophilic planning seeks to rebuild the relationship between humans and nature by systematically integrating natural elements into policies, infrastructure, and urban spaces to ensure the well-being, resilience, and sustainability of both urban and natural environments (Mohammedani et al., 2026). The relationship humans maintain with their natural environment was theorized by American biologist Edward O. Wilson in his 1984 book *Biophilia*. As formulated, it stems from a genetic basis for human attachment to nature and natural processes (Wilson, 1993). Thus, the producers of urban space, whether institutional, private, community-based, or individual, are those who have planned and implemented their planning by mobilizing urban planning tools and instruments (Murer et al., 2024).

They interpret a relationship with the natural environment, more specifically a spatial behavior, defined as the set of actions and reactions expressed by an individual or a group in response to their internal or external environment (Wronkowski, 2025). Biophilic behavior refers to the innate human attraction to life forms, promoting psychological well-being through positive interactions with natural elements, particularly within artificial environments (Ramdane et al., 2025). This inclination manifests in various ways, as identified by Kellert (1993) through a typology of nine biophilic experiences that illustrate the relationship between humans and nature. This typology was later reduced to eight categories when Kellert merged the naturalistic and aesthetic experiences, as Djouad (2021) highlighted. These human interactions with the natural environment are now described in terms of dimensions such as affection, attraction, aversion, control, exploitation, intellect/reason, symbolism, and spirituality, reflecting a more nuanced and in-depth understanding of the human–nature relationship (Kellert, 1993; Faircloth et al., 2025).

Recent research conducted worldwide on biophilic cities, particularly in Mediterranean and semi-arid contexts comparable to El Kala, shows that the integration of green infrastructure and urban forests into urban planning constitutes a key lever to strengthen resilience to climate change and wildfires; thus, a study carried out in Sfax, Tunisia by Bouaziz et al. (2025), demonstrated that “smart biophilic cities” improve quality of life by combining digital technologies with ecological management of green spaces, while in Barcelona, street greening policies and the creation of “superblocks” have reduced heat islands and increased urban biodiversity (Nieuwenhuijsen et al. 2024), and in Italy, participatory urban forestry projects in Palermo and Naples highlighted the importance of inclusive governance to preserve parks and ecological corridors (Buonanno and Macaluso, 2024). These results, derived from similar climatic contexts, provide transferable pathways for El Kala, where biophilia could be mobilized to reconcile urbanization, protection of nearby forests, and adaptation to climate risks.

The natural environment refers to all elements of the biosphere that have not been directly altered by human activity, in other words, the more authentic components of nature (Goeldner-Gianella et al., 2024). In certain cases, this environment displays remarkable ecological and landscape qualities, earning it UNESCO recognition as a biosphere reserve under the “Man and the Biosphere” program (Kock, 2026). This natural heritage is exposed to natural threats, notably forest fires, which can devastate valuable ecosystems. This vulnerability calls for implementing protection strategies, including integrated planning and rational land-use management (Bossé y Bergeron, 2024). Fire risk is understood as a conditional probability of ignition, spread, and the generation of significant damage to the environment, infrastructure, and human populations (Sapountzaki y Dermosinoglou, 2026). Despite the rise of sustainable development, urban sprawl continues to encroach on forested areas that are crucial to long-term resilience. The French case, with Forest Fire Risk Prevention Plans (PPRIF) integrated into Local Urban Plans (PLU), illustrates efforts to slow development in risk-prone zones (Ardisson, 2005). Prados and Key (2025) highlight the Spanish model’s “action laws”, rooted in strong environmental obligations and public involvement. Tezcan and Eren (2025) stress the need for a holistic strategy that combines land-use planning, environmental management, climate planning, and stakeholder engagement. Sapountzaki and Dermosinoglou (2026) suggest buffer zones around cities to reduce these risks, introducing the “forest city” concept where nature becomes integral to urban form (Zheng et al., 2025). Zhang et al. (2024) note temperature and wind as critical fire factors near urban areas. Simončič et al. (2024) emphasize the distinct ecological value of urban forests and the need for intentional, sustainable planning. This paradox, balancing urban growth with forest conservation, leads scholars like Gonzalez-Mathiesm (2024) to consider urban planning as a key mediator in this dynamic.

The expansion of peri-urban zones, especially in Mediterranean regions, has heightened fire risks in Wildland-Urban Interfaces (WUI). Identifying WUI zones is crucial, though methodologies vary: local mapping in Australia; buffer zones in Chile, Italy, Portugal, and South Africa; four risk zones in France; and multiple buffer zones in the United States (Gonzalez and Ghermandi, 2024). In Algeria, the protection of green spaces and forests against the threats of climate change and wildfires relies on a legislative framework that has been strengthened in recent years: Law No. 84-12 on the general forest regime remains the foundation for management and reforestation, complemented

by Law No. 03-10 on the environment, which establishes principles of prevention and preservation of natural resources, while more recent texts, such as the 2024 law on the protection of forest heritage and Decree 24/245, have introduced stricter sanctions against forest damage and created a National Protection Commission to improve inter-institutional coordination; these measures are part of the National Climate Plan (PNC) and the National Adaptation Plan (PNA), reflecting a political will to reinforce ecological resilience and to reconcile urban development, preservation of green infrastructure, and the fight against recurrent wildfires. In summary, legislation provides the structural framework for conservation, while biophilic principles offer a complementary vision that humanizes and enriches the relationship between urbanization and nature. For El Kala, the articulation of both is essential to transforming regulatory ambitions into sustainable, lived urban practices.

This section provides a comprehensive overview of global strategies aimed at balancing urbanization, conserving natural environments, and reducing wildfire risks, highlighting effective examples such as Spain's action laws, buffer zones, and the concepts of "forest cities" and Wildland-Urban Interfaces. However, to strengthen the argument, it is crucial to establish a more direct link between these international practices and the policy tools applicable to El Kala's specific context. For instance, zoning could draw inspiration from Mediterranean buffer zones to limit urban expansion in the most vulnerable areas of the national park. Building codes should incorporate fire-resistance standards, following the model of Spanish regulations, to reduce the vulnerability of housing. Likewise, community wildfire protection plans and Wildland-Urban Interface strategies could be developed by engaging El Kala's residents, building on participatory experiences implemented in other regions.

3. Methods

Biophilia, viewed as a sociological, psychological, and environmental theory (Djouad et al., 2025), serves as a framework for evaluating the role of natural spaces in urban development through the lens of human-nature interaction (Ghanem et al., 2025). The theory of biophilia can be adopted as an urban approach by studying the relationship between urban spaces and various natural elements through its dimensions of biophilic design, based on technical indicators (surface, materials, etc.), psychological and physical aspects (landscape, green space, etc.), and decisional factors (protection, urbanization, etc.) (Bechlem et al., 2025).

Experience	Description	Indicators
Utilitarian	The exploitation of nature's vast resources, including food, clothing, tools, medicine and shelter.	– Natural materials (reeds, cactus, bamboo...) – Development of vegetable gardens, vertical farms... – Agriculture
Naturalist and aesthetic	A contact characterised by fascination, wonder and admiration for the beauty and complexity of nature and its diversity.	– Development of urban green spaces – Development of landscaped trails – Development of panoramic views – Protection
Ecological science	Motivation to study biophysics systematically model, structures and functions of the natural world.	– Flora census – Development of urban forests – Relationship between urban green spaces and heat islands – Experimental gardens – Green nature management plan – Scientific and academic projects
Symbolic	Refers to the use of nature's symbols to communicate.	– Unexpected development of the Metaphor – Development of educational trails – Incorporating local legends
Humanist	A deep emotional connection with the sensitive aspects of nature and its individual elements.	– Integration of biodiversity into urban spaces -Biophilic urbanism and architecture
Moralist	A strong sense of affinity and a sense of ethical responsibility for the natural world.	– Attitudes - Commitments -Decisions – Projects -Proposals
Dominionistic	The desire to master and control the natural world, often associated with destructive tendencies.	– Urbanization, extension, construction, artificialization, mineralization.
Negativistic	The negative affect associated with nature including fear, aversion, marginalization and disgust.	– No protection. – No maintenance.

Table 1: Typology of human-nature relationships. (2021, 2025)

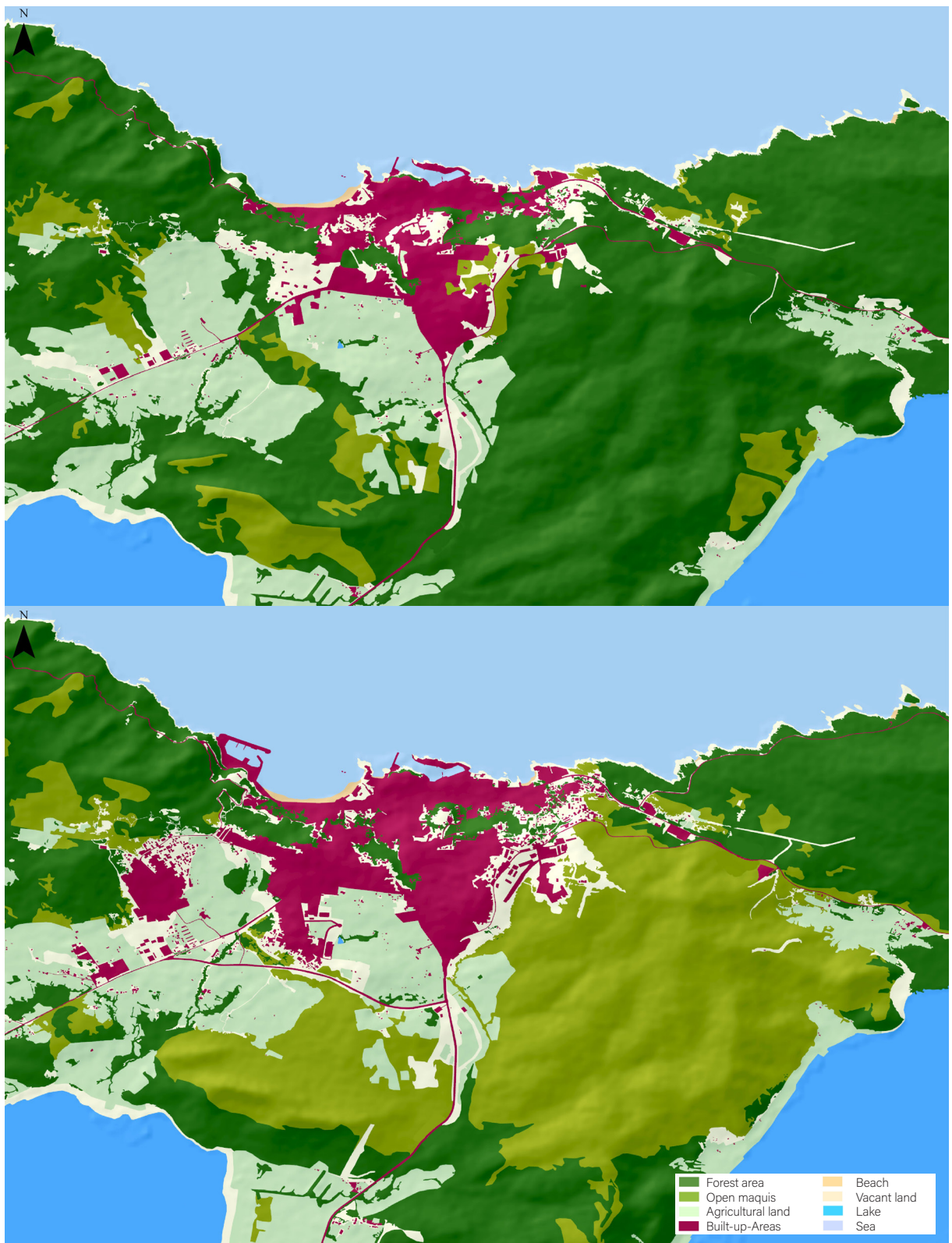


Figure 1: Landscape units of the natural environment of El Kala between 1994 and 2024. Google Earth Pro photo dated 03.04.2024, satellite image from 23.11.1994 (SPOT 3, with a panchromatic band resolution of 10 meters). (2025)

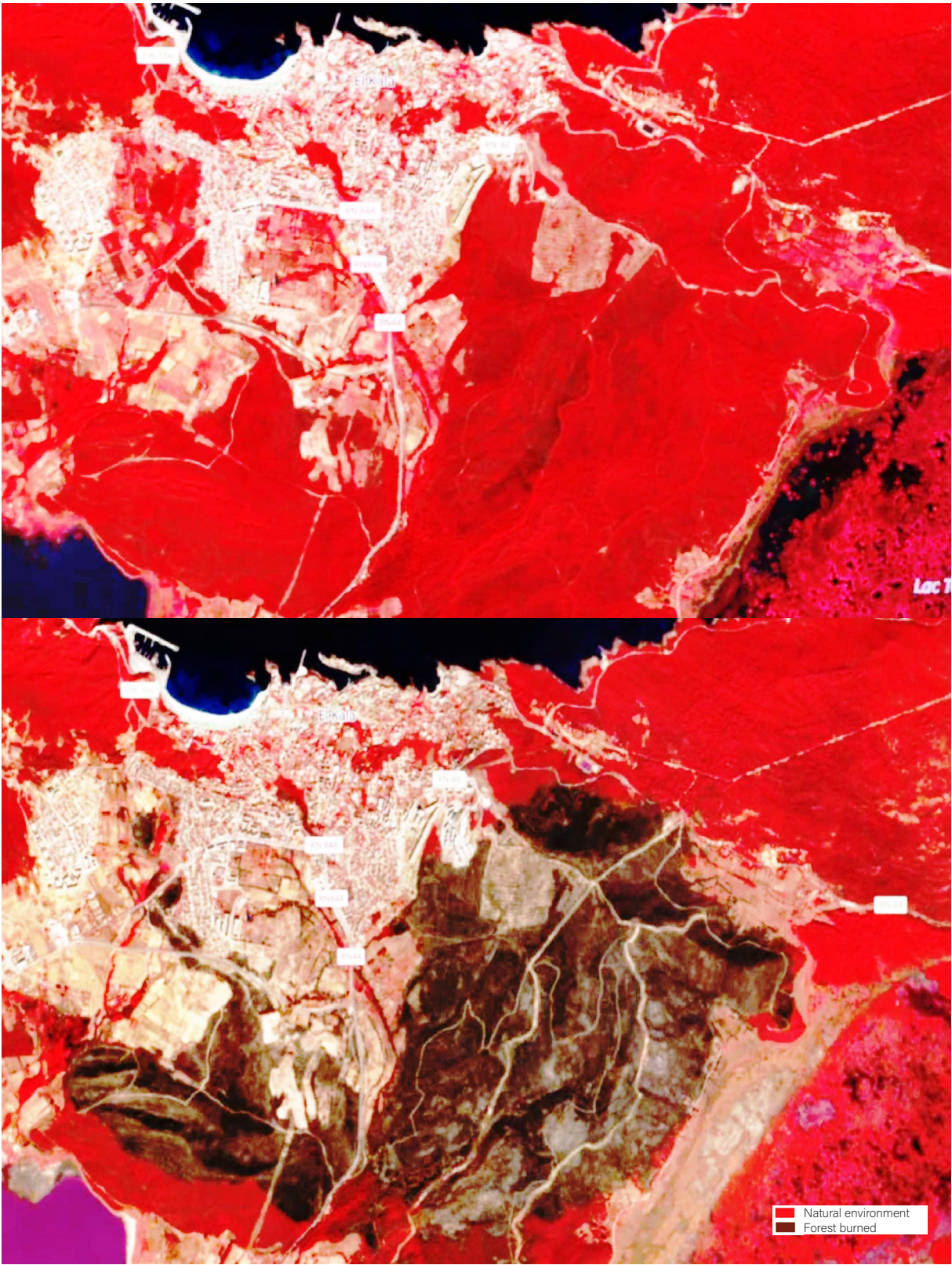


Figure 2: Transformation of the natural environment by forest fires of 2022. European Space Agency, Sentinel-2 image of El Kala. (2023). (2025)

In El Kala, this is rooted in the urban master plan and observed urban realities. The approach seeks to integrate nature into urban design via direct contact with landscapes and vegetation. Landscape analysis through photo-interpretation divides the city into distinct landscape units and explores their interaction with urban space (Djouad, 2022). Satellite images from Google Earth Pro (2024), SPOT 3 (1993), and Sentinel-2 (2023) are the primary tools used to illustrate the spatial development of the city at the expense of its natural environment over three decades, as well as the impacts of forest fires. The satellite data employed were selected primarily based on the availability and clarity of the satellite imagery, followed by the duration of El Kala's coverage under its PDAU over 30 years.

3.1. Evaluation of the natural environment by the PDAU

A biophilic analysis of the PDAU, spanning its written report, regulations, and graphic documents, identifies strategies shaping nature conservation, urban expansion (Peralta Arias and Higuera García, 2016), and forest fire risk mitigation (Wood, 2025). Spatial assessment is based on photo-interpretation, the result of superimposing the photo-interpretation of landscape units taken from the 23.11.1994 satellite image (SPOT 3, with a panchromatic band resolution of 10 meters) and the graphic documentation of the PDAU.

3.2. Evaluation of the natural environment through urban practices

This phase enabled the identification of transformations affecting landscape entities over three decades (1994–2024) within the PDAU framework (Newman-Thacker et al., 2025). The goal was to assess the alignment between the PDAU's urban planning directives and real-world developments, highlighting discrepancies between projected strategies and actual implementation. The analysis first relies on photo interpretation to track the various changes that have affected the landscape units of El Kala's natural environment over 30 years. The reference images include a Google Earth Pro photo dated 03.04.2024, and a SPOT 3 satellite image dated 23.11.1994 (panchromatic resolution: 10 meters), illustrating transformations in natural landscapes. Additionally, graphs were generated based on estimated surface areas derived from photo-interpretation, comparing detected changes in El Kala's natural environment with projections from the PDAU verified by environmental, forestry, and urban planning departments with 8–10% uncertainty.

The analysis of the PDAU, encompassing its written report, regulations, and graphical documents, aims to identify the visions and strategies adopted regarding nature protection, urban expansion, and forest fire risk mitigation.

3.3. The analysis of biophilic behavior among urban space producers

The qualitative analysis draws on Kellert's (1993, 2014) typology of biophilic behaviors, which distinguishes different forms of human interaction with nature. This framework was adapted to the context of the studied cities through a preliminary phase of non-participant direct observation, a recognized and reliable method for assessing the actual use of nature spaces. A structured grid was employed to systematically record the biophilic behaviors of urban space producers, focusing on direct or indirect interactions with nature as defined by Kellert's typology (Ramdane et al., 2025). This process validated the relevance of Kellert's nine types of biophilic behaviors in the local context and refined the indicators presented in Table 1. This analysis is reinforced by interviews with stakeholders from various institutions: urban planning, environment, forestry, national parks, associations, municipalities, and civil protection.

4. Results

4.1. A city in the center of a World Biosphere Nature Reserve

The El Kala region is part of the El Kala National Park (EKNP), established by Decree No. 83-462 on July 23, 1983. On November 4, 1983, two of its numerous wetlands, Lake Tonga and Lake Oubeira, were listed under the Ramsar Convention as wetlands of international importance. Later, on December 17, 1990, the EKNP was designated a biosphere reserve, granting it World Heritage status over an area of 76,438 hectares. The forest area is the largest component of this world biosphere reserve, covering 20,184 hectares, which represents 69% of the municipal surface. It is distinguished by its diverse vegetation, including Zeen oak, maritime pine forests, Aleppo pine, and open and dense maquis. The city of El Kala is a product of the colonial period, evolving to shape its current urban landscape, primarily composed of individual dwellings. Relict vegetation refers to plant communities that survive as remnants of formerly widespread ecosystems, now restricted to small areas due to climatic, ecological, or human-induced changes. (Djouad, 2021) (Figure 1).

El Kala Biosphere Reserve, known for its summer forest fires, loses significant numbers of flora and fauna each year. This situation has led researchers to conduct scientific studies, mapping the fire risk of forested massifs in the El Kala region and proposing solutions to better manage this natural hazard (Arfa et al., 2019). The summer of 2022 was the most catastrophic for the El Kala region. The fires reached the urban area, encircling it from the southeast and transforming the city of El Kala and its surrounding landscape (Figure 2).

Repeated wildfires in El Kala have deeply affected the urban population, beyond the ecological damage they cause. Socially, they caused human losses, trauma, displacement, insecurity, and pressure on public services. Economically, they devastated forests and resources, weakening agriculture, beekeeping, and tourism, leading to declining incomes, unemployment, and costly reconstruction. These impacts reveal a deterioration in quality of life and highlight the urgency of integrating social and economic concerns into wildfire policies. Conservation efforts, such as surveillance, awareness, and reforestation, show partial effectiveness but are constrained by scarce resources, weak institutional coordination, and an overly ecological focus, underscoring the need for integrated, inclusive strategies.

4.2. The PDAU, an instrument for planning the duality between natural and urban space

Urban planning in Algeria, historically shaped by French colonial models, has evolved into a distinct national strategy centered on the development of planning instruments (Djouad and Spiga, 2018). The Master Plan for Development and Urban Planning (PDAU), established under Law No. 90-29 of December 1, 1990, serves as a long-term (20 years) framework for communal organization.

Its objectives include balancing urban expansion with agricultural and economic activities, protecting forests, landscapes, and natural sites, and ensuring a coherent spatial organization. The PDAU integrates state programs, local authorities, institutions, and public services to determine land allocation and infrastructure placement. Drafting involves multiple stakeholders, coordinated by study bureaus, with final approval requiring input from civil protection and forestry services.

The written report delivers a detailed diagnosis of the municipality, assessing the current situation, identifying needs, and projecting economic, sociological, and spatial trends. Its primary objective is to establish fundamental orientations and define the selected planning strategy to guide future development. According to the PDAU, all natural spaces within the urban area are considered part of the urbanized sector and should be developed into green spaces, open-air theaters, or amusement parks. The PDAU forecasts suggest urbanizing nature and forested areas within urbanized areas, and future urbanization sectors, even if they are part of a world natural reserve, as in the case of the city of El Kala. The PDAU's written report mandates the preservation of nature in non-urbanizable zones through various operations such as afforestation and reforestation of degraded areas, the establishment

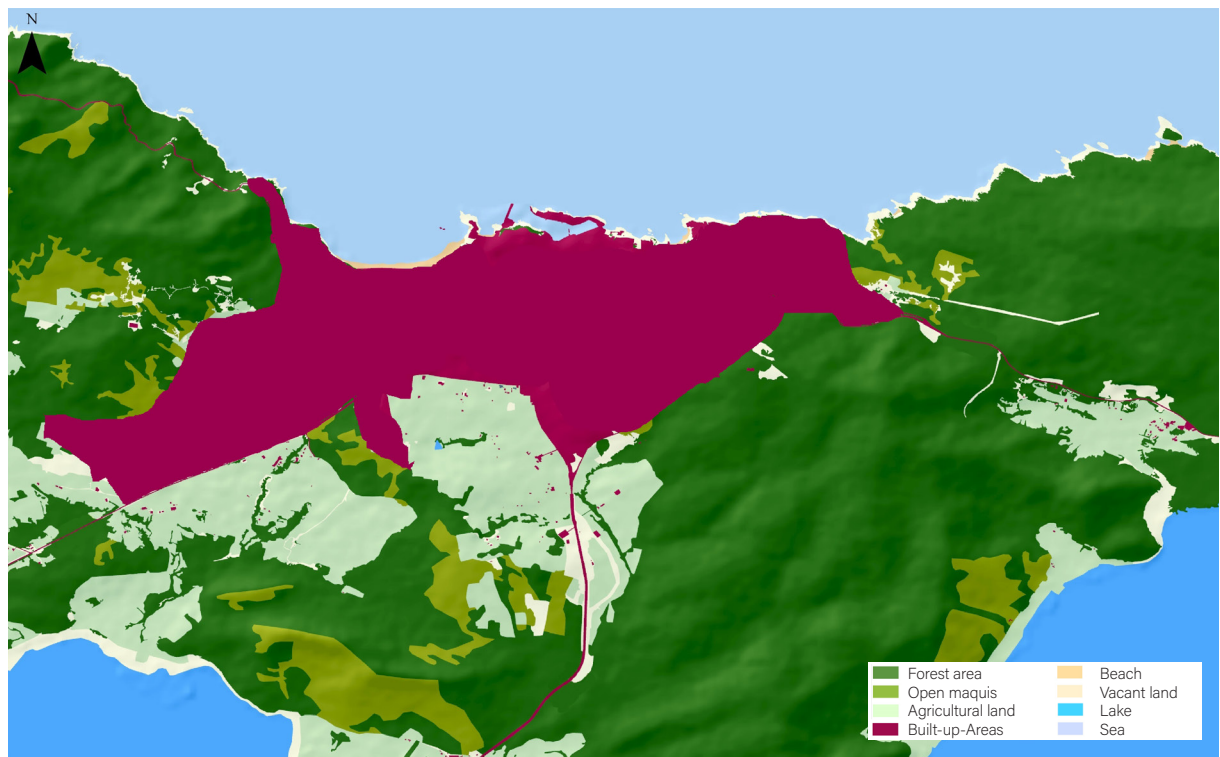


Figure 3: Landscape units of the natural environment of El Kala as proposed by the PDAU. Centre National d'Etudes Spatiales. Photo dated november 23, 1994 (SPOT 3, with a panchromatic band resolution of 10 meters) and graphic document of the PDAU. (2025).

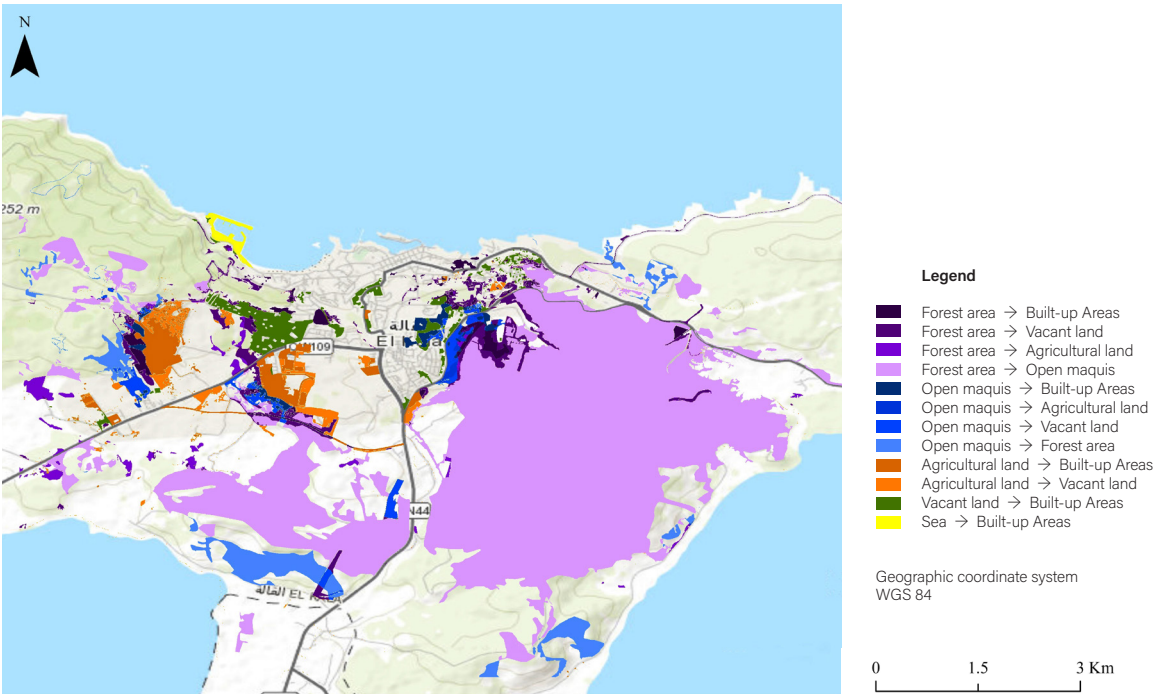


Figure 4: The various changes that have affected the landscape units of Natural Environment of El Kala Between 1994 and 2024. Google Earth Pro, Photo dated 03.04.2024 and satellite image dated 1994-11-23 (SPOT 3, with a panchromatic band resolution of 10 meters), (2025)

Land use	Area in hectares
Public green and recreational space	14,86
Agricultural land	70
Forest areaw	70
Open maquis	20
Vacant land	62.5

Table 2: The Areas Designated For Urbanization And Development Over The Past 30 Years According To The PDAU. PDAU of El Kala, (2024)

of a forest cadastre, the conservation of peri-urban woodlands, the development of recreational forests and walking trails, and authorizes only constructions necessary for forestry activities (Table 2). This sector could be urbanized, provided its development aligns with the broader economy. The forecast of forest fire risks is addressed through a request to develop a fire prevention plan to protect the forested area surrounding the city of El Kala.

Regulations governing natural spaces in El Kala include Law 03-10 on environmental protection, Law 84-12 on the forest regime, and Decree 90-78 on impact studies. These laws safeguard ecosystems by prohibiting destruction. El Kala National Park, of global importance, also benefits from UNESCO protection, reinforcing conservation efforts.

The PDAU’s graphic documents show forecasts and planning directions, emphasizing denser urban fabric and expansion into surrounding forests. This consumes large forest areas to give El Kala a compact form oriented south, east, and west (Figure 3).

Despite the detailed climate analysis included in the PDAU report, its relevance to the proposed recommendations is not specified. Projected urban expansion is consuming large areas of forest, raising concerns about environmental sustainability. Moreover, the climate analysis indicating dominant southeast summer winds was disregarded, a decision that increases fire risks by channeling flames toward the city.

Land cover	Area in hectares
Agricultural land → Built-up Areas	59.20799743
Agricultural land → Vacant land	40.41650113
Forest area → Agricultural land	28.51996858
Forest area → Built-up Areas	33.85741701
Forest area → Open maquis	1288.117743
Forest area → Vacant land	64.130579
Open maquis → Agricultural land	5.207162571
Open maquis → Built-up Areas	17.55321642
Open maquis → Forest area	94.39049373
Open maquis → Vacant land	30.0158639
Sea → Built-up Areas	8.526758834
Vacant land → Built-up Areas	53.19483812

Table 3: The various changes that have affected the landscape units of Natural Environment of El Kala between 1994 and 2024. (2026)

The urban trajectory of El Kala shows moderate demographic growth but disproportionate spatial expansion, linked to European departure after decolonization and rural migrations. The population rose from 28,760 inhabitants in 2009 to a projected 32,540 in 2024, while seasonal tourist inflows intensify pressure on infrastructure and ecosystems. Objectively, the city remains underdeveloped and largely informal, dominated by the tertiary sector ($\approx 80\%$ of employment) and marginal artisanal activities, with tourism essentially beach-oriented, seasonal, and weakly diversified; urbanization reveals a pronounced imbalance between residential needs and territorial extension, illustrated by a fivefold increase in urban surface since independence and the presence of vacant housing units often used for recreational purposes, reflecting excessive land consumption. Critically, the PDAU promotes a compact city model for densification and resource preservation, but disconnected from socioeconomic realities, it risks worsening ecological pressures and sustainability.

4.3. The interaction between urban development and the natural environment in reality

Over the past 30 years of spatial development in El Kala, natural areas have undergone two types of transformation. The first is a natural evolution where one entity transitions into another. The second is an artificial conversion where natural spaces are transformed into urban areas. Natural transformations vary by case, with forest spaces sometimes converted into agricultural land, bare terrain, or open maquis (Table 3). Among these, the open maquis has undergone the most significant changes (Figure 4).

As nature takes on an urban character, public actors integrate it into city planning, making it accessible to urban society. This is less evident in El Kala, despite its extensive forest remnants covering 35.76 hectares, 11.91 hectares, 16.35 hectares, and 94.30 hectares. At the urban fringe, agricultural land is the first to be affected by city expansion, followed by forested areas and open maquis, even when they belong to protected park sectors. For further insights, you might find this study on El Kala's forest monitoring useful (Figure 5).

The forest surrounding the city fluctuates between recreational development and neglect, making it vulnerable to forest fires. These fires are difficult to control due to constraints such as weak reforestation efforts, insufficient material and human resources, including radio communication and firefighting equipment, degraded forest tracks caused by runoff, and the absence of watch posts and forest houses.

Repeated wildfires in El Kala have severely impacted communities, causing ecological loss and more. Socially, they caused deaths, trauma, displacement, insecurity, and strained public services. Economically, they destroyed forests and resources, weakening agriculture, beekeeping, and tourism, leading to unemployment, reduced incomes, and costly reconstruction. These combined effects deteriorate the quality of life and

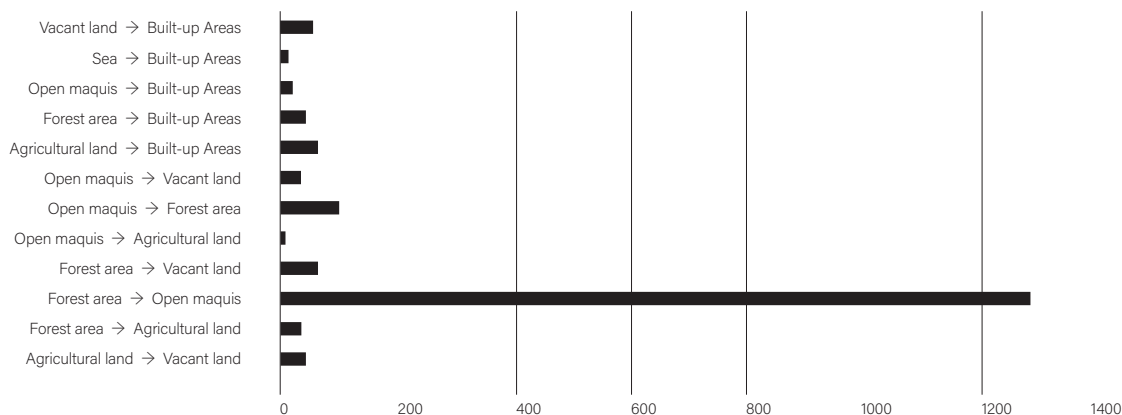


Figure 5: The urbanized nature space between 1994 and 2024. (2025)

underscore the urgency of integrating social and economic concerns into wildfire policies. Current conservation efforts, such as surveillance, awareness, and reforestation, have shown limited success due to scarce resources, weak institutional coordination, and an overly ecological focus, underscoring the need for integrated, inclusive strategies.

The strategy for wildfire control in El Kala combines prevention, governance, and restoration. Satellite monitoring and drones enhance early detection, while firebreaks and forest track maintenance limit fire spread. Integrated management plans involving authorities, civil protection, and communities foster participatory governance. Awareness campaigns reduce risky behaviors, and sustainable reforestation with fire-resistant native species, alongside ecotourism, restore ecosystems and support livelihoods. Altogether, these measures balance ecological conservation with socioeconomic resilience, aiming for sustainable and community-centered forest management.

Urban expansion in El Kala increases pressure on fragile ecosystems, leading to soil artificialization, habitat fragmentation, wetland pollution, and greater vulnerability to forest fires. While initiatives such as eco-districts and protected area regulations seek to balance development and conservation, their limited scope reveals a persistent imbalance. This highlights the urgent need for integrated, participatory governance to reduce environmental impacts and strengthen socio-environmental resilience.

4.4. Biophilic behavior between perspectives and reality

In El Kala, urban planning reflects biophilic principles through strategic frameworks and implemented projects, shaping the interaction between urban development and natural spaces, as analyzed using Kellert's typology (Djouad, 2021) (Table 4).

Urban planning in El Kala struggles with a gap between sustainability ideals and practice due to institutional, economic, and social constraints. Weak coordination, limited resources, and poor enforcement hinder regulation, while demographic growth, housing demand, and reliance on natural resources drive informal urbanization. Poverty, unemployment, and youth migration intensify conflicts between subsistence needs and conservation, leading to land appropriation and forest encroachment. Bridging these gaps requires stronger governance, sustainable economic models like ecotourism and ecological agriculture, and greater community engagement through environmental education. Biophilic tools, such as ecological corridors, multifunctional green spaces, and sustainable materials, can enhance resilience, making El Kala a model of biophilic urbanism.

5. Discussion and conclusions

5.1. Discrepancy between what is written and what is drawn in the PDAU

The biophilic interpretation of the PDAU presents a paradoxical scenario: on one hand, the written document emphasizes urban and environmental nature through recommendations and regulations that insist on its protection and development; on the other hand, the graphic documents undermine it by urbanizing large areas, favoring a compact urban form without considering its unique status as a UNESCO classified world biosphere reserve.

5.2. A gap between the PDAU's proposals and the realities

The urban reality shows that urban space producers have favored urban densification over urban expansion, reducing the consumption of the surrounding natural environment, especially forested areas (Table 5).

Urban space / Nature space	Urban planning			Urban practice	Biophilic behavior	
	Written report	Regulations	Graphic documents		Urban planning	Urban practice
Nature in urban space:						
– Forest remnants	– Development	– Protection	– Development	– No operation – No protection – No maintenance.	Naturalist and Aesthetic	Negativistic
– Public green space	– Development	– Protection	– Development	– Development	Naturalist and Aesthetic	Naturalist and Aesthetic
Nature in urban environments:						
Natural environment	Urbanization	Protection	Urbanization	Urbanization	Dominionistic	Dominionistic
	– Protection – Urbanization of public interest	– Protection	– Urbanization	– Urbanization – Protection by the PNEK administration.	– Naturalist and Aesthetic/ Dominionistic	– Dominionistic Utilitarian/ Naturalist and aesthetic/ Ecological science/ Symbolic/ Humanist/ Moralist.
– The risk of forest fires	– Forest Fire protection	– No protection measures	– No forest fire safety measures.	– No forest fire safety measures. - Protection by the PNEK administration	– Naturalist and Aesthetic/Negativistic	– Negativistic Utilitarian/ Naturalist and aesthetic/ Ecological science/ Symbolic/ Humanist/ Moralist.

Table 4: Biophilic behavior between perspectives and realities. (2025)

5.4. A discrepancy between the biophilic behavior of planners and operators of urban space

The discrepancy is also interpreted through the confrontation with reality during the production of urban space; it is no longer drawn but rather seen and practiced, which explains the contradiction between the approval of the PDAU and the deviation in its application. Another argument is the focus on written documents while marginalizing graphic documents during the approval phase, due to ignorance or a lack of specialization, even though all public actors, particularly those defending the forest environment, give their consent and approve the content of the PDAU (Figure 6).

5.3. A discrepancy between the PDAU cycle and the natural urgency of forest fires

This discrepancy was observed during the 2022 forest fires, highlighting the lack of flexibility in the current version of the city of El Kala's Master Plan for Development and Urban Planning (PDAU) in responding to natural emergencies. This underscores the need to revise the plan as soon as possible, in collaboration with all relevant stakeholders, without exclusion, to establish a constructive dialogue aimed at ensuring the city's sustainable development.

Different attitudes toward nature are reflected in how it interacts with urban spaces. In the city, planners often show a positive attitude, appreciating the beauty and richness of natural elements. But for those managing urban areas, the attitude can be negative, seeing nature as something to control. As cities expand and replace natural areas, the tendency to dominate and reshape the environment grows, sometimes in harmful ways. In forests near urban areas, two opposing views coexist: one values the forest's beauty and seeks to protect it, while the other aims to control and exploit it.

Only the direction of El Kala National Park opposes other urban space actors in preserving all natural elements, including forested areas, while respecting its status as a biosphere reserve, classified by UNESCO in 1990 (utilitarian-naturalist, aesthetic, ecological-scientific, symbolic, humanist, moralist). The issue of wildfires also highlights two contradictory attitudes: a desire for protection that is not concretely reflected in the graphic documents of the PDAU or in urban operations. From an urban perspective, forest fires are not a recent phenomenon; they result from a negative approach in urban operations in Algerian cities, where no serious measures are taken to protect both urban and forested spaces from this natural disaster.

Land cover	Area in hectares in reality	Area in hectares estimated by the PDAU
Agricultural land	59.20799743	70
Forest area	33.85741701	70
Open maquis	17.55321642	20
Vacant land	53.19483812	62.5

Table 5: The surfaces of natural areas actually urbanized and those estimated by the PDAU over a 30 year period. (2025)

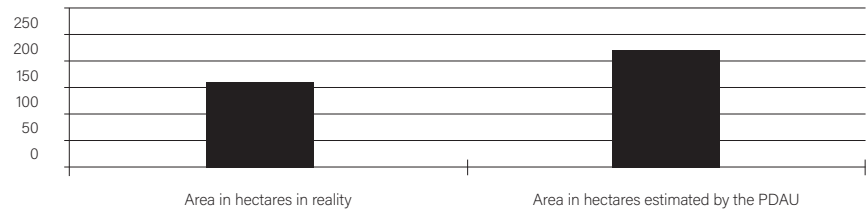


Figure 6: The actual urbanized nature space and those estimated by the PDAU between 1994 and 2024. (2025)

Biophilic planning in El Kala shows progress through the integration of vegetation and sustainable neighborhoods, strengthening residents' bond with nature. However, urbanization, wildfires, and habitat fragmentation undermine the national park's conservation role. Success requires stronger governance, reliable financing, and active community participation to transform experimental projects into genuine practices that balance development and ecological preservation.

6. Recommendations

Thinking about urban planning for the city of El Kala is necessary to control its spatial development, ensure its sustainability, and preserve its UNESCO-listed natural reserve. Departing from the strict prescriptions of the urban planning instrument (PDAU) during its implementation by adopting more flexible, context-adapted decisions appears essential to better guide the city's urban evolution while accounting for the fragility of its natural environment and the recurrence of climate emergencies. In this particular context of urban planning, it is recommended to question the traditional pairing of urban space and the natural environment, as well as the dominant compact city model. This reconsideration opens the way to other, more compatible and sustainable models, in which the natural environment becomes a full-fledged spatial, landscape, ecological, and political component. This requires a coherent articulation between theoretical knowledge and practical expertise from specialists in both the urban domain and the natural world. On a practical level, the development of environmental planning tools, coupled with natural and biophilic indicators, helps guide urban operations and foster environmental awareness among urban planning specialists. Local planning, supported by guidelines tailored to the El Kala biodiversity reserve, relies on active collaboration among the city's stakeholders and on integrating scientific research addressing urban and environmental issues. This approach aims to anticipate better urban planning aligned with the ecological challenges of the territory.

Taking forest fire risk into account in the development of urban planning instruments is strongly recommended. This involves relying on appropriate forecasting plans and promoting close collaboration among all relevant stakeholders. It is also essential to create a buffer and transitional zone between urban and forest areas to minimize damage in the event of a disaster.

Indeed, in many Algerian urban contexts, stakeholder participation remains limited, reducing the inclusion of residents and local actors in decision-making processes and widening the gap between actual needs and planned orientations. Moreover, fragmented governance, characterized by a multiplicity of institutions with overlapping

mandates and insufficient coordination, generates inconsistencies in the implementation of urban policies. The enforcement of regulations, often constrained by inadequate financial, technical, and human resources, further undermines the effectiveness of planning and deepens the divide between declared ambitions and lived realities. The case of El Kala thus exemplifies the structural tensions of Algerian urbanism, where institutional and procedural weaknesses hinder the transition toward more participatory, coherent, and environmentally and socially responsive planning.

Mediterranean cities integrate nature into urban planning through hybrid financing, specialized institutions, and participatory governance. Examples include Barcelona's public- private partnerships, Marseille's EU-funded Green corridors, and Tunis's citizen budgets. Success relies on diverse funding, coordinated institutions, and active community involvement, despite challenges of land pressure and external financial dependence.

Finally, emphasizing the construction of effective dialogue between public actors, within a perspective of sustainable urban development, helps establish a genuine environmental culture within urban practices. This approach encourages the emergence of positive biophilic behaviors toward nature, thereby achieving a form of urban and environmental justice.

Conflict of interest. The authors declare no conflicts of interest.

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