Scientific Papers. Series B, Horticulture. Vol. LXVIII, No. 1, 2024
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

FROM AGRICULTURAL OASIS TO URBANIZATION: PATH OF OASIS GREEN INFRASTRUCTURES IN BISKRA, ALGERIA

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Abstract

This article explores the dynamic of oasis green infrastructure in Biskra, Algeria, highlighting the crucial role of palm groves in urban sustainability. By revisiting its traditional past and assessing its current impact on urban sustainability, the study highlights the importance of the oasis of Biskra as an essential connector between cultural heritage and contemporary challenges. Analytical methods encompass historical, geographical and environmental assessment approaches to trace the evolution of green infrastructure in the pre-colonial, colonial and post-independence periods. Indicators of surface area and types of green infrastructure were used to quantify changes. The results highlight the capacity of the palm grove to adapt while preserving its crucial role in providing social, economic and environmental services, underlining the environmental issues associated with its degradation. In conclusion, the Biskra palm grove emerges as an essential element of urban sustainability, illustrating the need to preserve this traditional ecosystem. Integrating sustainable practices into palm grove management can strengthen urban resilience and promote a harmonious balance between urbanization and ecological conservation.

Key words*: oases, green infrastructure, palm groves, urban sustainability, biodiversity, cultural heritage, environmental assessment, environmental management.*

INTRODUCTION

Urban green infrastructure refers to the network of natural and semi-natural areas, such as parks, green roofs, street trees, rain gardens, and wetlands, designed and managed to provide ecological, social, and economic benefits in urban areas (Taylor Lovell and Taylor, 2013; Mell, 2008). It is a planning and design approach that recognizes the importance of incorporating nature into the built environment to enhance the quality of life for people and the environment (Cameron et al., 2012; Cilliers et al., 2013). Effective urban green infrastructure planning involves considering the needs and preferences of diverse stakeholders, as well as assessing the ecological and social value of green spaces, and integrating green infrastructure into urban design and development (Petrişor et al., 2021; 2022). The green infrastructure includes a variety of semi-natural areas along with green spaces intentionally created to provide diverse ecosystem services essential for human welfare and improving overall life quality (Gavrilidis et al., 2023). Additionally, green infrastructure answers to different economic, social, and environmental challenges (Tzoulas et al., 2007). More exactly, the urban green infrastructure plays a crucial role in mitigating the adverse impacts of urbanization, such as air and water pollution, heat island effect, and reduced biodiversity (McMahon, 2000; Gill et al., 2007). It can also provide numerous benefits, such as improving air and water quality, reducing energy use, enhancing mental and physical health, supporting local food

production, and increasing property values (Taylor Lovell and Taylor, 2013).

The ecological side of green infrastructure is crucial, as it emphasizes the need to preserve and promote natural ecosystems in urban areas. The term "green infrastructure" highlights the crucial role of nature in modern urban planning. These spaces are not isolated but are an integral part of any balanced and sustainable urban ecosystem (Walmsley, 2006).

The continuous growth of urban areas, at the expense of natural areas, poses an imminent threat to urban ecosystems. Several studies have highlighted the negative consequences of habitat fragmentation on biodiversity, leading to a concerning decrease in biological diversity and a significant reduction in the quality and amount of essential ecosystem services due to urban sprawl (Petrişor et al., 2021; 2022).

The benefits of ecosystem services highlight their importance even more in arid environments (Hadagha et al., 2018). In Biskra, and especially after the independence of Algeria in 1962, the loss of palm grove due to urban sprawl has particularly affected the palm groves which play an essential role as reservoirs of biodiversity, drivers of agricultural economy, and climate regulators for the oasis city. Urban sprawl was a consequence of derogatory planning, more intense after the independence (Hamma and Petrişor, 2018). Although palm trees are an important natural resource, they have suffered the negative consequences of rapid urban sprawl. Uncontrolled urbanization endangers the palm groves, and results into significant environmental challenges (Dechaicha, 2020).

While significant progress has been made in understanding the benefits of urban green infrastructure, there are still several knowledge gaps that need to be addressed to optimize its implementation and management. Some of these gaps include its long-term effectiveness, scale and context, relation to equity and social justice, management and maintenance issues, metrics and evaluation. While urban green infrastructure is generally viewed as a positive and necessary part of urban planning and design, there are some controversies and challenges associated with its implementation. Some of these include its costs, maintenance, equity issues, effectiveness, and trade-offs.

In this context, the present study explores the dynamics of oasis green infrastructure in Biskra, Algeria, from pre-colonial times to the contemporary period. These infrastructures have their origins in palm groves, which fulfill economic, environmental, and social functions. The analysis aims at highlighting the crucial role of palm groves in urban sustainability, addressing also some of the gaps identified in the literature review.

MATERIALS AND METHODS

The study employs an approach involving the use of different types of data including detailed historical records, precise geographic information and environmental assessments. This method allows for an examination of the development of infrastructures throughout important historical periods like pre-colonial times the colonial era and the post-independence period.

By focusing on measures such as the size and variety of infrastructures, researchers can accurately measure the changes that have taken place over time.

Moreover, a classification of infrastructures was carried out to understand the environmental advancements during each historical era. This classification differentiates between the purposes and uses of infrastructures across time, offering a detailed insight into their progression and significance within specific historical and geographical contexts.

This analysis is carried out from a perspective on how individuals engage with their environment, emphasizing the importance of reflecting on the past to guide future decisions concerning sustainable development and natural resource management.

RESULTS AND DISCUSSIONS

Before the arrival of the Turks in 1541, Biskra was primarily characterized by an agricultural oasis, where 90% of the land was occupied by a vast palm grove. However, the arrival of the Turks prompted an acceleration of urbanization, leading to the creation of seven villages within the palm grove. This phase of development, marking the beginnings of

ancient Biskra, resulted in a reduction of the palm grove area to approximately 80% of its initial size (Benmechiche et al., 2021). The seven oasis villages are ingeniously arranged around the mosque and Seguias (irrigation canals) that wind along the streets to water the palm grove gardens. The palm grove and Seguias played a central role in the formation of small human settlements in Biskra, while water was the driving force that shaped the structure of the city and its urban configuration in Biskra (Alkama, 2005).

During this pre-colonial period (before 1541-1844), the oasis green infrastructure in Biskra originates from the lush vegetation of the palm grove. It assumes a crucial role as habitat cover, thereby forming a bioclimatic envelope. This zone extends beyond providing thermal comfort. It also holds significant economic importance, as the palm grove serves as the foundation and life source of the region due to the versatility of ecosystems (Addad and Zerouala, 2002; Badache, 2014).

The thriving oasis ecosystem of Biskra owes its success to the interconnectedness of water, palm trees, and the human environment. This symbiotic relationship yields myriad benefits for the community of Biskra (Bouzaher and Alkama, 2017).

At the urban level, Biskra was characterized by a unique urban configuration, with houses integrated at the heart of the palm grove. Each village has its own characteristics, such as an exclusive watercourse, a central mosque, and a lively public square. Gardens also adorn some residences, adding a touch of beauty to the environment. This spatial organization shaped the morphological aspect of the city, in harmony with the climatic conditions (Hadagha, 2022). The streets and alleys of the Biskra offer a variety of landscapes and unique features. However, they all share a calm and serene atmosphere, enhanced by the presence of vegetation providing constant and soothing shade along these pathways (Figure 1). This atmosphere, in turn, fosters social interactions among the residents of the area (Farhi and Hadahga, 2018).

Agriculture and date palm cultivation play a fundamental role in local development. These activities help shape the environment and significantly improve the quality of life for residents.

Figure 1. The streets and alleys of the old city of Biskra (Source: Authors, 2024)

Additionally, they foster a harmonious connection between agriculture, date palm cultivation, and commerce, generating a social and economic fabric that contributes to the well-being of the local population. Biskra has leveraged its strategic geographical location by specializing in trade, adding an additional layer of prosperity to local life. Date palms, cereal crops, horticulture, and medicinal plants have played a key role in local development, creating a positive economic and social dynamic (Bouzaher and Alkama, 2017).

The traditional city of Biskra had a rich biodiversity due to the overlapping of three layers of vegetation creating an oasis effect. The palm grove provides for an ecosystem with a high biodiversity, serving as a refuge for numerous plant and animal species. This biological diversity plays a vital role in the ecological balance of the oasis, while also ensuring the livelihoods of the residents (Hadagha et al., 2018).

The inhabitants of Biskra, known as the Bsakra, had a variety of agricultural resources that allowed them to meet their economic needs (Figure 2). They had a palm grove, an olive grove, fields of wheat or barley, vegetable crops, a poultry yard, a sheepfold, and even a stable for donkeys (Zerdoum, 2003).

Figure 2. Variety of agriculture in an oasis of Biskra (Source: Authors, 2024)

Social cohesion is present where the palm grove acts as a central gathering place for all oasis residents. It serves as a hub for planning, recruiting, exchanging agricultural goods, and discussing the future of the oasis and their children. This area is where social bonds are forged, reinforced, and sustained over time, fostering a community life grounded in fairness and marked by diverse forms of solidarity (Farhi and Hadahga, 2018). A concrete example of solidarity within the palm grove is illustrated by the tradition of building oasis houses, called "Twisa". When one of the families in the oasis needs a new house or renovation, all residents come together to offer their support. This solidarity is demonstrated by collective mobilization to gather the necessary construction materials and actively participate in all stages of the construction process. Each member of the community contributes, whether by providing materials, offering labor, or assisting in coordinating efforts. This practice demonstrates a beautiful display of cooperation and mutual assistance within the community life of the oasis, strengthening social ties and enhancing the sense of belonging to the community (Farhi and Hadahga, 2018).

Ecologically, every part of the palm tree is utilized in a sustainable manner, thereby contributing to the balance of local ecosystems. Its wood is carefully employed in house construction, a traditional practice that has passed the test of time in sustainability terms (Figure 3). Additionally, the leaves of the palm tree hold considerable ecological importance. They are utilized in crafting fences, offering an eco-friendly alternative to synthetic materials or products sourced from deforestation (Bouzaher and Alkama, 2012; 2013).

Figure 3. Different applications of palm trees include their use: lintels, beams, fences and false ceilings (Source: Authors, 2018)

The palm grove plays a truly remarkable role in regulating the local climate. Acting as a natural shield against the sun, it provides protection against the region's high temperatures. This vegetative canopy also serves as an effective barrier against the hot winds from the south and the cold winds from the north, thereby creating a stable and comfortable atmosphere within the inhabited area. The presence of Seguia is also essential; it supplies water for crop irrigation, and also plays a crucial role in humidifying the dry air and regulating ambient humidity. Overall, these combined factors contribute to making the urban environment cooler and more pleasant, thereby enhancing the quality of life for the region's residents. The palm grove, with its irrigation system and dense vegetation cover, thus constitutes a fundamental element of Biskra's natural architecture, offering not only ecological benefits but also tangible advantages for the health and well-being of its inhabitants (Bencheikh, 2001).

The oasis ecosystem in Biskra demonstrates a remarkable ability to recycle and reuse waste highly efficient. This practice not only contributes to environmental preservation, but also improves soil quality and boosts agricultural productivity. The residents of Biskra have truly developed an ingenious approach to maximizing the use of available resources. It serves as an inspiring example of sustainability and nature conservation, underscoring the importance of harmony between humans and their environment (Hadagha, 2022).

During the French colonial period between 1844 and 1962, the city of Biskra underwent an interesting evolution in its development, including the change of vernacular architecture into a modern one, along with urban plans that cut off right streets and planted them alongside, creating other green space, in the nucleus of the new colonial city near the old one (Abdou and Alkama, 2022). Although the spirit of the oasis remains present with water, vegetation, and traditional architecture, it has evolved in a unique way. The oasis green infrastructure that once surrounded the city is now integrated into plots (Badache, 2014). By then, urbanization intensified, reducing the area of palm grove to 70% (Benmechiche et al., 2021). New types of green infrastructure, such as public gardens and the Dufourg square, were introduced. Biskra became a picturesque and tourist destination for

European vacationers. These gardens, such as the Landon garden and the public garden, were laid out, crossed by Seguias, and benefited from a traditional irrigation system that recalls the atmosphere of a real oasis (Naceur, 2004).
These gardens played a crucial role in regulating the temperature of the city of Biskra. Their balanced arrangement throughout the city favored the creation of a favorable microclimate, providing appreciable thermal comfort, which is particularly important in a hot and arid region like Biskra (Badache, 2014). Moreover, they were meeting places for various people and played an essential role in social life (Benmechiche et al., 2021).
Since the independence of Algeria in 1962, the city has experienced exponential urban growth (Figure 4), with a remarkable rate estimated at 63.6% (Kouzmine and Fontaine, 2018).

Figure 4. Current state of the oasis green infrastructure in Biskra (Source: Google Earth, 2024)

This uncontrolled urbanization has put the palm grove at risk leading to a decline of 66.56%, between 1985 and 2015, which poses significant environmental challenges. This underscores the significant impact of urban expansion on the oasis potential of the palm grove (Dechaicha, 2020). This phenomenon has caused a local climate change and an imbalance in the ecosystem of the city of Biskra; for example, in 1959, the temperature in the city center was 36°C, while around the palm grove it was 32°C. By 1999, these temperatures increased to 44°C and 32°C respectively (Adad and Zerouala, 2002). Furthermore, it has led to the emergence of the urban heat island in some areas place effect due to the presence of dense urban areas (Hamel et al., 2021).
The transition from an essentially agricultural society to an increasingly industrial one has disrupted the long-established economic balance in Biskra. Some owners are now opting to abandon palm trees, considering date farming not profitable enough (Adad and Zerouala, 2002; Hadagha, 2022).
The deterioration of the palm grove's irrigation systems, particularly the Seguias, has affected the regulatory structure of the urban fabric and the economic activity of the palm grove. These systems are essential for preserving both the ecosystem and the local economy (Berghout, 2015).
The pollution of the Seguias are a concerning issue in Biskra (Figure 5). Wastewater and household waste dumped into them can cause significant pollution. Additionally, the mixing of plant waste with urban waste complicates waste management. Over the years, the amount of urban waste in Biskra has increased, reaching around 100,044.13 tons in 2013, with approximately 80% being organic waste (Hadagha, 2022).

Figure 5. Deterioration and pollution of the Seguias (Source: Authors, 2024)

The results show that during the historical ages, due to different reasons, the urban green infrastructure of Biskra suffered from the anthropogenic pressure, reducing its total area and connectivity. In arid environments, green areas have a great importance as reservoirs of biodiversity, as indicated by other studies carried out in Algeria (Aouissi et al., 2022). At the same time, the processes contributing to the dynamics of oasis green infrastructure are also present in the European cities. Petrişor et al. (2021; 2022) found out the same in all Polish and Romanian cities during 1990-2018. A comparative study revealed that derogatory urban planning is common to Romania and Algeria (Hamma and Petrişor, 2018), and accounts for the urban sprawl and other

deviations from the provisions of urban plans, especially in conjunction with social issues (Siboukeur et al., 2023).

Apart from making a series of recommendations, in line with previous research (Petrişor et al., 2021, 2022), for planners to preserve and expand the palm grove while maintaining its spatial continuity, for city managers and policy developers to rely more on using the results of research in decision-making and develop specific policies and for scientists to draft planning manuals, there are specific approaches involving initiatives such as rehabilitating irrigation systems, promoting organic agriculture, and raising awareness about environmental protection among residents. By fostering a harmonious coexistence between urbanization and ecological conservation, these strategies can contribute to preserving the palm grove of Biskra for future generations while supporting its sustainable development.

This study brings additional evidence that the green infrastructure needs to be accounted for in the planning process in order to maintain its spatial continuity and ability to provide ecosystem services (Legutko-Kobus et al., 2023), and its value consists of bringing such evidence from an area less explored in the literature (Aouissi et al., 2022). However, the implications expand far beyond the case study area, to other arid areas. Due to this natural feature, the study is relevant under the current climate changes debates, as green areas may help mitigating the effects of climate changes, at least locally (Gopinath et al., 2023; Singh and Kikon, 2024), and brings additional evidence for the connection between land degradation and climate changes (Corcheş, 2023).

The possible methodological limitations are due to the lack of data, especially of geospatial data (Udvardy et al., 2023), confining the analyses to a qualitative approach. Future may be able to overcome this lack by using satellite imagery (Noby et al., 2023). However, satellite imagery is able to reveal only the recent dynamics. There may be possibilities to combine data from different sources, although previous studies indicated that this approach yields inconsistent results, especially at a local level (Stângă and Niacşu, 2016; Stângă et al., 2016).

CONCLUSIONS

The evolution of oasis green infrastructure in Biskra reflects the contemporary challenges faced by many cities worldwide. With increasing urbanization and rapid development, natural ecosystems such as the palm grove are often threatened. However, these ecosystems play a crucial role in regulating local climate, conserving biodiversity, and providing essential ecosystem services.

In this context, the palm grove of Biskra represents a valuable ecological and cultural heritage. Its preservation is of paramount importance to ensure urban sustainability and maintain local identity. The challenges it faces, such as degradation of irrigation systems and pollution, require effective preservation strategies.

The historical analysis of Biskra reveals that urban sprawl, which can be connected to derogatory planning, is responsible for the loss of palm grove. From this perspective, several solutions can be foreseen, not excluding each other. One is developing planning regulations that account for the green infrastructure of Biskra and its spatial continuity, including the creation of new urban greenery, and the protection and connection of existing parts. These plans should also be enforced in a strict way. The second solution is educating people, including key actors (such as planners and administrators) and involving the dwellers of the city in the planning process.

Integrating sustainable practices into palm grove management is essential to ensure its resilience in the face of growing urban pressures.

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