

# Palm groves in oasis cities: a sustainable and multifunctional green infrastructure - the case of Biskra, Algeria

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**Abstract.** This paper provides a comprehensive exploration of the multifaceted and sustainable characteristics of palm groves within oasis cities, with a specific focus on the city of Biskra, located in Algeria. The palm groves in Biskra serve as a compelling exemplar of green infrastructure in oasis cities, as they fulfill numerous roles that contribute significantly to both the ecological and socio-economic well-being of the region. The research delves into the intricate web of connections that exist between palm groves and several essential elements. These elements encompass efficient water management systems, the urban layout intricacies, the rich biodiversity that thrives within the groves, the social cohesion they foster, and the creation of a stable ecological environment. Furthermore, the study highlights the pivotal role played by these palm groves in promoting sustainability, preserving the natural environment, and elevating the overall quality of life for the local community. Biskra's palm groves exemplify how green infrastructure can serve as a driving force for sustainable practices in arid regions, presenting a valuable model that can be emulated by other oasis cities grappling with similar challenges.

**Key words:** green infrastructure, oasis cities, palm grove, ecosystem, multifunctionality, sustainability.

## 1. Green infrastructure

Green infrastructure is a concept that can be approached in various ways, giving it a versatile definition. It can be viewed as a vast, preserved natural park where nature takes center stage, or as a network of interconnected green spaces within a city, collaborating to provide a comprehensive and functional landscape experience. This approach highlights the complementarity and synergy among the green elements of an urban region<sup>1</sup>. However, this approach goes beyond the mere aggregation of green spaces under a single designation. Green infrastructure is also envisioned as a global concept encompassing a variety of green spaces, giving them a unified identity. It acts as a catalyst by establishing connections between these spaces, assigning them a shared purpose and collective utility. This expanded perspective stems from the desire to integrate nature into the heart of urban environments, promoting a more holistic approach to urban planning<sup>2</sup>. The ecological aspect of green infrastructure is crucial, as it emphasizes the preservation and promotion of natural ecosystems in urban environments. The term "green infrastructure" underscores the significance of nature in contemporary urban planning. These spaces are not isolated but are an integral part of a balanced and sustainable urban ecosystem<sup>3</sup>. In summary, green infrastructure is a network consisting of natural, semi-natural, and green spaces designed to

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<sup>1</sup> Popescu and Petrișor 2021

<sup>2</sup> Kleiber *et al* 2002

<sup>3</sup> Wallasey 2006

provide a multitude of ecosystem services that are essential for human well-being and quality of life. It also addresses economic, social, and environmental challenges<sup>4</sup>.

## 2. Oasis

An oasis is a place where land is intensely irrigated to cultivate plants in arid regions where agriculture without water is impossible. Trees, especially date palms, play a crucial role in the sustainability of the oasis. In arid areas, oases are primarily established through the use of external water sources or deep groundwater<sup>5</sup>.

An oasis is defined as a thriving green environment despite extreme conditions, housing a variety of species and possessing a complex ecosystem that has evolved over millennia. Water management plays a crucial role within this system, being supported by traditional institutions that ensure equitable distribution of resources<sup>6</sup>. Water has played a crucial role in human settlement in the desert. However, the mere presence of water does not guarantee human survival in the Sahara. Other factors such as climate, heat, winds, soil quality, and accessibility are also essential elements to be taken into consideration<sup>7</sup>. The oasis ecosystem is characterized by its complexity, shaped by various essential elements such as water, palm trees, humans, and habitats. These habitats come in various forms, influenced by the natural factors of the region and the culture of the human group. Thus, humans become an integral component of this specific ecosystem<sup>8</sup>.

According to Kilani *"When we talk about an oasis, we refer to an enclosed space within a vast desert. There is no shortage of metaphors to illustrate this fundamental enclosure. An oasis is (a haven of peace or prosperity in a inhospitable world), (a patch of greenery in a hostile environment), (a harbor in the desert), (a perfect place)"*<sup>9</sup>.

An oasis can be described as a geographical location characterized by the presence of human settlements and cultivated lands, which often include palm groves, typically found in arid or semi-arid environments. What makes an oasis distinctive is its ability to seamlessly blend into its surroundings, thanks to its unique and specialized ecosystem structure<sup>10</sup>.

From a climatic standpoint, it can be observed that an oasis is a region that starkly sets itself apart from its surroundings. Alterations in surface characteristics lead to significant repercussions on the properties of the lower atmosphere adjacent to the oasis. Consequently, the local climate undergoes distinct modifications and in contrast, just outside the oasis, temperatures frequently soar to exceedingly high levels, creating a dry climate characterized by substantial temperature fluctuations, primarily driven by intense solar radiation and the infrequency of rainfall. The wind speed often elevates considerably due to the desert's minimal surface roughness. This unique interplay of climatic factors within and

<sup>4</sup> Agence européenne pour l'environnement 2015

<sup>5</sup> Kassah 2009

<sup>6</sup> Koohafkan and Altieri 2011

<sup>7</sup> Hadagha, 2022

<sup>8</sup> Hadagha 2022 ; Bouzaher 2015 ; Kouzmine 2007

<sup>9</sup> Kilani 1992

<sup>10</sup> Battesti 1999

outside the oasis boundary underscores the oasis's role in creating a distinct microclimate and its significant impact on the surrounding environment. From a geographical perspective, the oasis embodies a striking contrast between the harshness of the surrounding desert and the abundance of life within its boundaries, making it a place of natural beauty and vital resource in otherwise inhospitable areas. Considering the socio-economic aspect, oases serve as focal points for local populations, where sedentarization, agriculture, craftsmanship, and culture are vital components of these communities' social and economic fabric. They thus demonstrate humanity's ability to establish prosperous and culturally rich societies even in arid environments<sup>11</sup>.

Based on all the definitions and concepts, it can be concluded that oases represent humanity's ability to ingeniously harness natural resources, create verdant environments amidst aridity, and establish thriving communities in the heart of these inhospitable areas. They showcase human adaptability and resilience in the face of significant environmental challenges (Fig. 1).

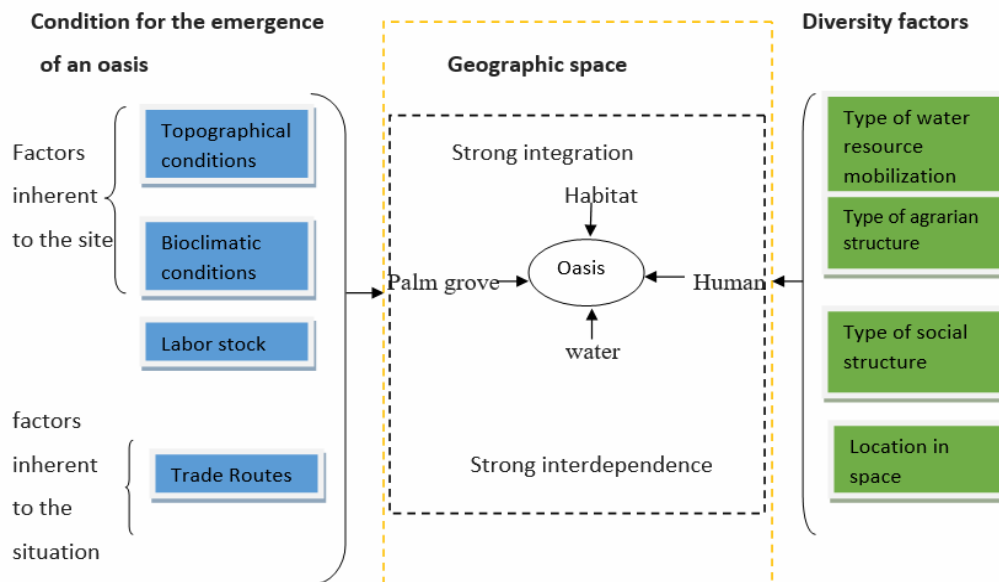


Fig. 1. Configuration of the oasis system<sup>12</sup>.

### 3. The oasis green infrastructure of Biskra and ecosystem services

The oasis ecosystem of Biskra thrives due to the close interdependence between water, palm trees, and the human environment. This symbiotic relationship brings numerous benefits to the community of Biskra<sup>13</sup>.

<sup>11</sup> Kabiri 2014

<sup>12</sup> Kouzmine 2007

<sup>13</sup> Bouzaher and Alkama, 2017

### 3.1. Unique urban configuration

The planning of the traditional core of the city of Biskra emphasizes the compactness of dwellings in response to climatic needs. However, this compactness is not necessary in the context of Biskra because houses are integrated in the heart of the palm grove, where sunlight is moderate. The structural elements extending between the *segua* (irrigation canal) and the palm grove, combined with the climatic conditions, have given rise to an urban configuration and a housing typology unique to Biskra. This has influenced both its morphological appearance and spatial organization<sup>14</sup>. Each of the villages at the heart of this specific urban area has its own unique features, including its exclusive watercourse, a central mosque serving as a religious gathering place, a lively public square that fosters social life, and gardens that adorn certain residences<sup>15</sup>.

The influence of water played a crucial role in shaping the urban configuration in Biskra<sup>16</sup>. This urban structure promoted synergy between agricultural activities such as date palm cultivation, fruit trees, and vegetable farming, along with the use of *Toub* (earth brick) construction for housing. This type of housing served a dual function by acting as both a residence and a storage or production space. The palm grove and the irrigation system were closely intertwined, forming a harmonious and inseparable system<sup>17</sup>.

The streets and alleys within the city of Biskra offer a variety of unique landscapes and features. Nevertheless, they all share a calm and serene ambiance, enhanced by the presence of vegetation providing constant and soothing shade along these pathways (Fig. 2). This atmosphere, in turn, promotes social interactions among the residents of the region<sup>18</sup>.



Fig. 2. The streets and alleys of the old city of Biskra<sup>19</sup>.

<sup>14</sup> Addad and Zerouala 2002

<sup>15</sup> Hadagha 2022

<sup>16</sup> Alkama 1995

<sup>17</sup> Zkiri 2015

<sup>18</sup> Farhi and Hadahga 2018

<sup>19</sup> Hadagha *et al* 2018

### 3.2. Rich biodiversity for the local economy

The palm grove is a defining feature of the oasis, playing a dual essential role for its residents. It serves both as a source of income and as a creator of a favorable bioclimatic environment. This is why oasis dwellers attach great importance to agricultural production, considering it a fundamental pillar of their way of life<sup>20</sup>.

Agriculture and date palm cultivation, practiced within the community in Biskra, hold fundamental and versatile significance in local development. These activities serve as essential pillars not only in reshaping the environment but also in significantly enhancing the residents' quality of life. Furthermore, they create a smooth and harmonious connection among various sectors such as agriculture, date palm cultivation, and trade. This synergy generates a social and economic fabric that contributes to the well-being of the local population. It is worth noting that the oasis in Biskra, owing to its strategic geographical location, has specialized in trade and commerce, adding an additional layer of prosperity and enrichment to local life. In the Ziban region, date palm cultivation and agriculture were regarded as fundamental choices for the society, resulting in significant economic diversification. Date palm trees, cereal crops, horticulture, and medicinal plants have played a pivotal role in local development, creating a positive economic and social dynamic<sup>21</sup>.



Fig. 3. Plant hierarchy in an oasis through a stratified structure<sup>22</sup>.

The enclosed garden at the heart of the palm grove is truly a green treasure within traditional economic communities. Its biodiversity makes it an essential component of local life thanks to the superposition of three plant floors creating the effect of an oasis (Fig. 3). Firstly, it plays a crucial role as a source of sustenance for the residents of the region, offering a variety of fresh products, from vegetables to fruits, thereby significantly contributing to the food security of the community. Furthermore, this garden has a substantial economic impact as a reserve of food products intended for sale in local markets. It serves as a cornerstone of the local economy, generating income for the inhabitants. This

<sup>20</sup> Hadagha 2022

<sup>21</sup> Bouzaher and Alkama 2017

<sup>22</sup> Bengouga 2019

green space also serves as a showcase of sustainable lifestyles and economic practices deeply rooted in these communities. It epitomizes these societies' ability to make balanced use of their natural environment, preserving resources while meeting their food and economic needs<sup>23</sup>.

The inhabitants of Biskra, known as the Bsakra, sustained their livelihood through a variety of economic resources, including a date palm grove, an olive orchard, cereal fields like wheat and barley, vegetable cultivation, a poultry farm, a flock of sheep, and a stable for donkeys<sup>24</sup>.

### 3.3. Social cohesion

The date palm tree truly holds a central place in the social life of the oasis inhabitants. It plays a fundamental role in the social stability of the Ziban oasis communities. This is due to its capacity to preserve traditional knowledge and skills, which promotes the wise and sustainable use of natural resources, particularly in terms of water management, irrigation techniques, and the selection of suitable date palm varieties. It is fascinating to observe how the date palm tree contributes to the preservation of both local culture and the environment within the Ziban oases. The diversity of date palm varieties carries invaluable significance because of the historical, technical, and agricultural connections among various groups and individuals, not to mention its cultural and social importance. It is a wealth that strengthens community bonds and contributes to the overall well-being of the residents<sup>25</sup>.

The palm grove serves as a focal point for all the inhabitants of the oasis. It is where they come together to plan, recruit, exchange agricultural products, and discuss the future of the oasis and their children. This is the space where social solidarities are born, strengthened, and enduring over time, creating a social life based on equity and characterized by various forms of solidarity. A concrete example of this solidarity is the participation in the construction of oasis houses, locally known as "Twisa." During social events, all oasis residents gather to support the families involved. They collect the necessary products and actively participate in various tasks. The residents mobilize to assist those in need, coordinating their efforts and sharing responsibilities with the aim of providing needy families with decent housing in line with rural standards. This solidarity within the palm grove embodies the values of cooperation and mutual support that underpin community life in the oases<sup>26</sup>.

To address the issue of irrigation in Biskra, a solution was implemented with the construction of the fort known as Borj\_Tork in the northern part of the oasis, at Ras El Ma. This fort played a crucial role in organizing irrigation in Biskra. It ensured that each neighborhood within the oasis received an adequate amount of water for their agricultural needs. This equitable approach contributed to maintaining harmony within the community by avoiding conflicts related to water distribution, thereby strengthening social cohesion. It also demonstrated how water resource management can be carried out systematically and

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<sup>23</sup> Farhi and Hadahga 2018

<sup>24</sup> Zerdoum 2003

<sup>25</sup> Bouzaher and Alkama 2012 ; 2013

<sup>26</sup> Farhi and Hadahga 2018

fairly at the local level, taking into account the specific needs of each neighborhood within the oasis<sup>27</sup>.

### 3.4. An ecologically stable environment conducive to bioclimatic conditions

The ecological importance of the palm tree is undeniable. Every part of this tree is utilized sustainably, contributing to the balance of the local ecosystem. Its wood is thoughtfully used in the construction of homes. The use of palm wood for house structures is a traditional practice that has proven to be sustainable over time (Fig. 4). Furthermore, the palm tree's leaves also hold significant ecological value. They are used to create fences, providing an environmentally friendly alternative to synthetic materials or products derived from deforestation. This showcases a clever and environmentally responsible utilization of natural resources<sup>28</sup>.



Fig. 4. Various uses of palm trees: beams, gutters, fences, and false ceilings<sup>29</sup>.

The palm grove plays an essential role in regulating the local climate. It provides protection against solar radiation, acting as a natural shield that mitigates the impact of high temperatures. Additionally, it serves as a barrier against the hot winds from the South and the cold winds from the North, creating a natural boundary that helps maintain a more stable temperature within the inhabited area. The presence of the *sagua*, the irrigation canal at the heart of the palm grove, is of paramount importance. It allows for the humidification of the dry air coming from the outside, acting as a natural humidity regulator. As a result, the temperature inside residential spaces is naturally reduced, creating a cooler and more pleasant climate within urban environments (Fig. 5). The breezes that form in this setup contribute to making the environment more comfortable for its residents. All of these climatic features demonstrate how the Biskra palm grove works in favor of the well-being of its inhabitants by creating a beneficial microclimate and mitigating extreme weather conditions, thus contributing to a higher quality of life in the region<sup>30</sup>.

The idea of stacking three vegetation layers is as follows: the upper stratum (tree layer) is reserved for date palm trees, the intermediate stratum (shrub layer) is dedicated to fruit trees, while the herbaceous stratum occupies the last section, intended for both winter and

<sup>27</sup> Hadahga 2022

<sup>28</sup> Bouzaher and Alkama 2012 ; 2013

<sup>29</sup> Bouzaher 2015

<sup>30</sup> Bencheikh 2001

summer cereals as well as low-lying plants. This stacking creates a true biodiversity treasure, forming a flourishing ecosystem that provides an ideal refuge for a multitude of plants and animals. This diversity of life thriving within the palm grove plays a fundamental role in maintaining the ecological balance within the oasis. Moreover, it ensures the sustainability of the livelihoods of the local residents<sup>31</sup>.

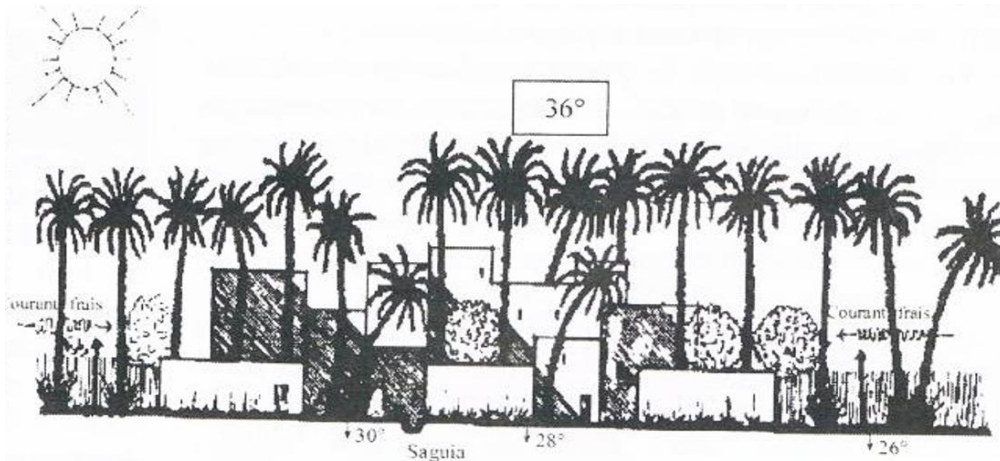


Fig. 5. Temperature variations depending on the various microclimates found in the palm grove; M'cid district (Biskra)<sup>32</sup>.

The oasis ecosystem plays a crucial role in environmental preservation by its ability to recycle and reuse waste and by-products from local agriculture and livestock. This approach significantly contributes to waste reduction and nature conservation. The residents of Biskra have effectively utilized this resource by reusing waste to produce compost, which has a positive impact on soil quality and fertility. Consequently, this results in a sustainable increase in agricultural productivity. Another striking example of this approach is how residents have repurposed household waste to feed their grazing animals, creating a circular recycling system within the oasis. This waste management model, combining agriculture and livestock, not only reduces unnecessary waste but also maximizes the utilization of available resources. Moreover, it contributes to soil health improvement and the maintenance of a natural balance<sup>33</sup>.

#### 4. Conclusion

The palm groves of Biskra stand as exemplary models of sustainable and multifunctional green infrastructure within oasis cities. These groves play a pivotal role in promoting ecological preservation, socio-economic well-being, and improved quality of life. By efficiently managing water resources, fostering rich biodiversity, enhancing urban layout, and promoting social cohesion, Biskra's palm groves offer a holistic approach to sustainability in arid regions.

The interconnectedness of these elements, from water management to the preservation of natural ecosystems, showcases how green infrastructure can serve as a catalyst for positive

<sup>31</sup> Hadagha *et al* 2018

<sup>32</sup> Bencheikh 2001

<sup>33</sup> Hadagha 2022

change. The multifunctional nature of these groves, including their contributions to agriculture, trade, and social gatherings, underscores their significance in the local community.

Biskra's palm groves provide a valuable blueprint for other oasis cities facing similar challenges. By emulating the sustainable practices and principles demonstrated by these groves, other regions can work towards a more harmonious coexistence between urban life and the natural environment. This case study not only highlights the importance of green infrastructure but also emphasizes the adaptability of human communities in the face of challenging environmental conditions.

In an era where environmental preservation and sustainability are of paramount importance, the multifunctional palm groves of Biskra represent an inspiring example of how human ingenuity can thrive in even the harshest of climates, offering hope and guidance for other arid regions seeking a sustainable future.

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