RS Global Journals

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw, Poland 00-773
Tel: +48 226 0 227 03
Email: editorial_office@rsglobal.pl

JOURNAL	International Journal of Innovative Technologies in Social Science
p-ISSN	2544-9338
e-ISSN	2544-9435
PUBLISHER	RS Global Sp. z O.O., Poland

ARTICLE TITLE	NATURAL CHARACTERISTICS' IMPACT ON URBAN ENVIRONMENTAL QUALITY: A CASE STUDY OF AIN BEIDA CITY, ALGERIA
AUTHOR(S)	Nassira Guemini, Foued Benghadbane
ARTICLE INFO	Nassira Guemini, Foued Benghadbane. (2024) Natural Characteristics' Impact on Urban Environmental Quality: a Case Study of Ain Beida City, Algeria. *International Journal of Innovative Technologies in Social Science*. 3(43). doi: 10.31435/rsglobal_ijitss/30092024/8251
DOI	https://doi.org/10.31435/rsglobal_ijitss/30092024/8251
RECEIVED	05 August 2024
ACCEPTED	27 September 2024
PUBLISHED	29 September 2024
LICENSE	This work is licensed under a **Creative Commons Attribution 4.0 International License.**

NATURAL CHARACTERISTICS' IMPACT ON URBAN ENVIRONMENTAL QUALITY: A CASE STUDY OF AIN BEIDA CITY, ALGERIA

Nassira Guemini
Institute of Management of the Urban Techniques,
Laboratory Evaluation of Quality of Use in Architecture and the Built Environment (LEQUAEB)
University of Oum El Bouaghi, Oum El Bouaghi (Algeria)

Foued Benghadbane
Institute of Management of the Urban Techniques,
Laboratory Evaluation of Quality of Use in Architecture and the Built Environment (LEQUAEB)
University of Oum El Bouaghi, Oum El Bouaghi (Algeria)

DOI: https://doi.org/10.31435/rsglobal_ijitss/30092024/8251

ARTICLE INFO

Received 05 August 2024
Accepted 27 September 2024
Published 29 September 2024

KEYWORDS

Urban Matural and Technical Features-Opportunities and Challenges-Urban Development-Environmental Quality- Ain Beida City (Algeria).

ABSTRACT

The city of Ain Beida struggles with a complex interplay of natural and technical characteristics that significantly influence its urban development, environmental quality, and overall sustainability. The city's natural components present both opportunities and challenges for urban planning and development. This paper explores the impacts of these factors on urban development and environmental quality. Additionally, it delves into the consequences of natural characteristics on urban development policies, addressing the dilemma between preserving green spaces and the imperative for urban expansion. Artificial obstacles pose challenges to urban expansion and impact security, as well as overall environmental health. Furthermore, the paper discusses the risks associated with natural and technological elements emphasising the importance of safety measures and emergency response protocols. The urban development policies of Ain Beida have undergone a shift primarily driven by limited land availability. Urban densification, aimed at optimizing land use, has been adopted, but it comes with environmental trade-offs. Considering the challenges and opportunities identified, the paper concludes with a set of recommendations.

Citation: Nassira Guemini, Foued Benghadbane. (2024) Natural Characteristics' Impact on Urban Environmental Quality: a Case Study of Ain Beida City, Algeria. *International Journal of Innovative Technologies in Social Science*. 3(43). doi: 10.31435/rsglobal_ijitss/30092024/8251

Introduction.

The concept of urban environmental quality refers to the assessment and exploration of different elements of the environment in urban areas. It is used as an indicator to describe the overall natural, urban, environmental, and socio-economic condition of an urban area (Gamba, 2018). Conceptual models and theoretical approaches identify six different research. They range from human ecology to quality-of-life studies, urban planning, the social indicator movement, satisfaction research and the transactional approach between people and their environment. These studies relate to different aspects and focus on different elements as components of urban environmental quality: interaction between the physical, social, cultural, economic aspects, health, amenities, and other features of environmental quality (van Kamp et al., 2003).

Natural elements are one component of urban environmental quality (Habibi et al., 2020). Exploring and assessing the natural elements of a city serves several objectives, contributing to a deeper understanding of the urban environment. The impact of the surrounding environment, urban topography, hydrography, climate, geology, and pedology on environmental quality is multifaceted, as these factors collectively influence various aspects of the natural and built environment(Metzler et al., 2023). Urban natural components have a great impact on urban planning and design (Spirn, 1980) and the land use pattern, and the planning and development of essential infrastructure. The natural elements allow for an assessment of the ecological impact of urbanization (Theodorou, 2022).

The topography of an urban area affects water drainage patterns. Slope and elevation are the two primary topographic factors that contribute to floods(Agonafir et al., 2023). Poorly planned topography can lead to waterlogging, increased runoff, and erosion, impacting soil quality and potentially causing flooding. Land surface topography significantly affects the processes of runoff and erosion (Zevenbergen and Thorne, 1987). The layout of hills, valleys, and buildings can influence air circulation within urban areas. This, in turn, affects the dispersion of air pollutants(Miao et al., 2015), which can impact air quality. Hilly or mountainous terrain can make transportation more challenging affecting mobility and accessibility(Aghabayk et al., 2021).The hydrographic characteristics, including its topography and drainage patterns, can exacerbate the risk of flooding. The sudden surge of water into urban rivers can cause them to swell rapidly, subsequently increasing the likelihood of downstream flood risks (Sohn et al., 2020). Climatic conditions impact urban environmental quality in various ways. Higher temperatures can lead to increased energy consumption for cooling, exacerbate air pollution, and contribute to heat-related health issues (Scoccimarro et al., 2023). Changes in precipitation patterns can lead to flooding (Tabari, 2020) and waterlogging, affecting infrastructure and overall environmental quality. Extreme weather events can result in widespread damage to urban infrastructure, disrupting normal life and compromising environmental quality. Climatic conditions can influence air quality and the prevalence of vector-borne diseases (Rocklöv and Dubrow, 2020). Drought conditions can lead to water scarcity in urban areas, negatively impacting overall environmental quality. Climatic conditions also present challenges for the resilience of urban infrastructure (Salimi and Al-Ghamdi, 2020), requiring adaptive measures to maintain environmental quality. Geology and pedology are crucial factors in urban planning and development, playing significant roles in shaping and influencing the quality of the urban environment. They influence land use suitability for development (Wiggering, 2014), foundation design, stormwater management (Alsharhan and Rizk, 2020), transportation planning (Zhu et al., 2022), environmental sustainability, and disaster risk reduction. Understanding the natural landscape and soil characteristics can guide sustainable development and minimize risks to infrastructure and residents. Natural elements contribute to the overall aesthetic quality and visual appeal of a city impacting the well-being of residents.

Urban natural environmental quality is a complex concept that encompasses the relationship between the urban landscape and its natural elements(Sopina and Šćitaroci, 2024). It reflects the health of ecosystems(MacKinnon et al., 2019) and the impact these elements have on residents' health(van den Bosch and Ode Sang, 2017) and well-being, serving as a barometer for the vitality and sustainability of a city. This interplay is critical in assessing the ecological equilibrium, sustainability practices, and overall livability of an urban space. The urban environment is intricately incorporated into the natural fabric of the region. The city exists within a broader context of diverse ecosystems and natural features (Laganier and Roussel, 2000), and every element contributes to the unique character and ecological equilibrium of the city. Acknowledging and addressing the complex interplay of these factors is crucial for achieving environmental quality in urban areas. A comprehensive and integrated approach to urban planning, considering natural elements can contribute to the creation of resilient, sustainable, and environmentally friendly cities that enhance the overall quality of life for their residents (Datola, 2023). Exploring Ain Beida's natural urban environmental quality uncovers not only the challenges but also the opportunities. This exploration serves as a critical lens informing urban planning and development strategies, fostering a city that thrives economically, sustains resilience, and promotes the well-being of its residents.

Problematic.

Ain-Beida, a city with a high population density of 1223,47 inhabitants per square kilometer in 2022, is renowned for its rich socio-cultural history. Nevertheless, it encounters persistent obstacles that impede the achievement of harmonious socio-economic growth and urbanisation that comply with sustainable standards. Consequently, it is challenging to establish a comfortable environment within the city (Bendada, 2022). The urban environment in Ain Beida, Algeria, faces a complex myriad of challenges arising from the interplay of natural characteristics and artificial obstacles (Urban Master development Plan, 2006), collectively influencing urban development, and subsequently impacting urban environmental quality. The lack of a viable plan for sustainable development is posing a significant risk to the equilibrium of the environment. This is leading to a depletion of biodiversity due to the conversion of natural areas into man-made ones. This trend has been increasing in the past decade, primarily at the cost of agricultural land (Mazouz, 2018).

The city's arid climate, distinctive topography, and limited green spaces pose significant hurdles for air and water quality, drainage patterns, and biodiversity, influencing the overall environmental quality. The arid climate prevalent in many Algerian regions can lead to challenges in air and water quality, with limited natural processes to aid in purification. Additionally, the topography of the city may impact water drainage patterns, affect air dispersion, and create microclimatic variations, further complicating efforts to maintain a pristine urban environment. The scarcity of green spaces in arid climate also poses challenges for biodiversity, limiting essential ecosystem services like air purification and pollution reduction. Simultaneously, artificial obstacles, particularly in the built-up environment, contribute significantly to the challenges faced by Ain Beida. The quality of urban infrastructure, such as energy network, industrial and commercial activities, and public transportation, has direct implications for accessibility, security, air, and noise pollution levels. Inadequate planning and zoning arrangements, including the distribution of residential, commercial, industrial, and recreational zones, can concentrate pollution sources, leading to potential environmental quality issues. Socioeconomic factors further exacerbate the situation. High population density in urban areas may result in increased pollution and resource pressure. Income disparities can lead to unequal exposure to environmental risks and unequal access to environmental amenities, affecting the overall well-being of the population. Furthermore, the level of environmental awareness and education within the population is crucial, as it influences the adoption of sustainable practices and environmental protection.

In Ain Beida, understanding and addressing the intricate relationships between natural characteristics and artificial obstacles is crucial for devising sustainable urban planning strategies that can effectively enhance urban development and environmental quality in Ain Beida. This will be crucial for fostering a healthier and more resilient urban environment in the long term.

The purpose of this paper is to evaluate the impact of urban natural and technical components on urban development and the quality of the environment in Ain Beida city (Algeria).

Objectives.

The main objective of the paper is assessing the impact of natural features on the environmental quality of Ain Beida city using natural parameters. The specific objectives of the paper are:

- to recognise the natural factors leading to such impacts. The goal is to establish a comprehensive understanding of the natural elements influencing the environmental quality of the city.
- to evaluate the extent of the impact of technical features on the environmental quality of Ain Beida city, and
- to assess the consequences of natural characteristics on urban development policy and environmental quality and to propose sustainable measures or strategies for mitigating or managing the identified impacts.

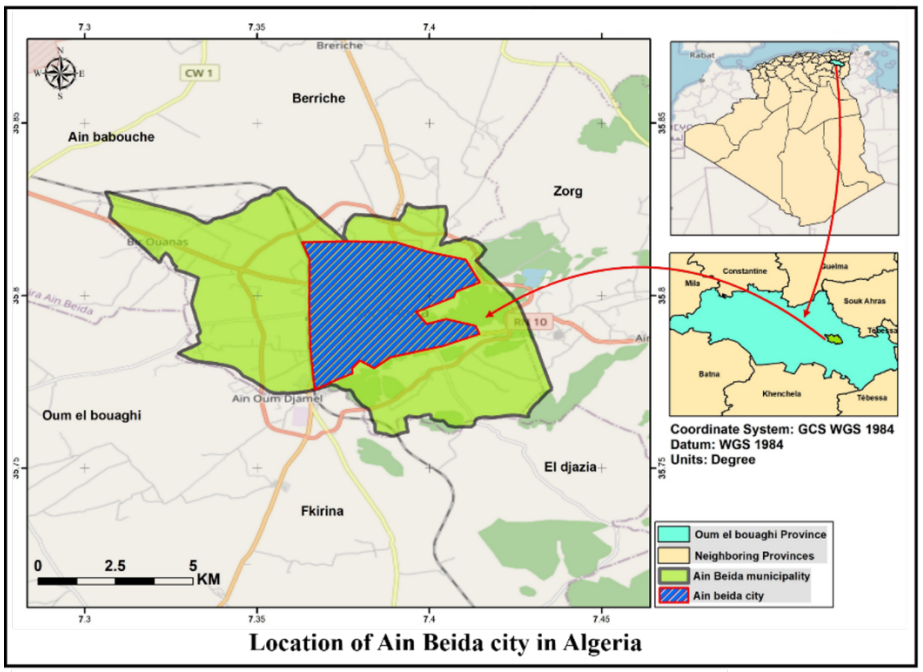
Methodology.

Developing a systematic approach for analyzing the relationship between natural components, artificial obstacles, and environmental quality in the city of Ain Beida requires a comprehensive methodology. This involves collecting and analyzing data through field surveys, interviews, and

observations, as well as acquiring secondary data from various sources. The use of GIS data is also helpful in analysing topographical and geographical features. The collected data is integrated and analysed to identify correlations and patterns. Based on the results, conclusions are drawn regarding the relationship between natural and technical components and urban environmental quality. Finally, recommendations for sustainable urban development based on the study's results should be provided.

Study area.

Aïn Beïda is a medium city and municipality (commune) located in the Oum El Bouaghi Province (Wilaya). Ain Beida is located on the eastern high plateaus of the salt flats (sebkhas) in Algeria (Map N^0 01). It is at the intersection of two important national roads: NR 10, which connects the cities of Tébessa to the east and Constantine to the west, and NR 80, which links the city of Guelma to the north and Khenchela to the south. In addition to the railway line connecting Ain M'lila and Tébessa, which demonstrates its strategic importance due to its location, the latter allows it to be a central point among a significant group of cities in the eastern Algerian region, including Constantine, Tébessa, Oum El Bouaghi, Khenchela, and Guelma. Aïn Beïda is the most populous municipality in the Oum El Bouaghi province, while being the smallest in terms of area. It is the largest city in the province with a population of 171537inhabitants in 2022 (GCPH, 2022) and covers an area of 1402,05 hectares (140,205 km²). The rapid urban growth in Aïn Beïda, coupled with insufficient planning and management, has given rise to various environmental challenges. However, despite these issues, Aïn Beïda remains a dynamic city with a significant population, highlighting its urban roots (Bouchemal, 2009) and its enduring historical and cultural significance in the region.



Location of Ain Beida city in Algeria

source: Administrative division + Processing with ArcGIS Map N^{0}01

Analysis of natural environmental components.

Immediate surrounding: environmental potentials and challenges.

The city of Ain Beida is located amidst natural elements, with forests situated to its east and southeast, and agricultural lands to its north, west, and south (Map N^{0}02). This immediate environment can significantly influence the urban environmental quality, both positively and negatively.

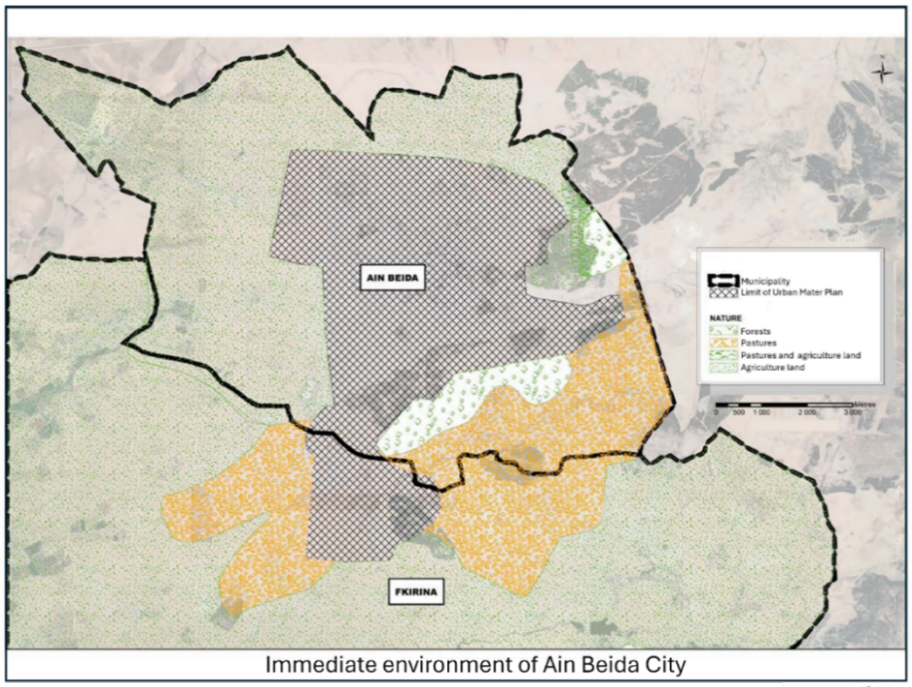
Forests act as carbon sinks, absorbing carbon dioxide and releasing oxygen through the process of photosynthesis. This can lead to improved air quality in the city. Additionally, forests provide shade and help regulate temperatures by reducing the urban heat island effect, thereby enhancing the overall comfort levels for the residents, especially during hot seasons. Moreover, forests support diverse

ecosystems, providing habitats for various plant and animal species, which can enhance the overall environmental health of the area. Furthermore, forests act as natural water filters, improving water quality by trapping sediments and filtering pollutants, thus positively impacting local water sources. They also serve as recreational spaces for residents, contributing to their overall well-being. Additionally, the natural beauty of forests and agricultural landscapes can enhance the aesthetic appeal of the city.

Agriculture, on the other hand, can contribute to the local economy by providing employment opportunities and food resources. Moreover, forests may offer opportunities for eco-tourism and sustainable resource management.

However, the surroundings can also have negative impacts. Agricultural activities may involve the use of pesticides and fertilizers, which can lead to air pollution if not managed properly. Agricultural runoff, containing fertilizers and pesticides, can degrade water quality if not properly managed, affecting both surface and groundwater.

Furthermore, the presence of agricultural land and forests may limit urban sprawl, preserving green spaces and preventing excessive development. However, these ecosystems constitute natural obstacles to urban development. Unplanned urbanization and encroachment into natural areas can lead to habitat destruction, loss of biodiversity, and other environmental issues.



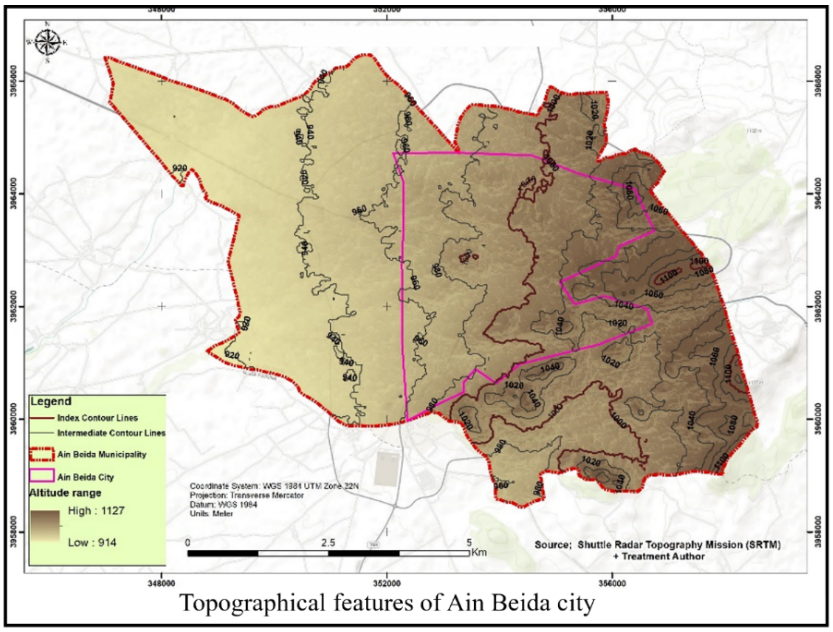
Immediate environment of Ain Beida City

source: Directorate of forests 2020, URBACO 2022+ Authors treatment

Map N^{0}02

Varied topography and challenging environment

Ain Beida city is situated in a mostly flat area with an average elevation of 900 meters (Map N^{0}03). However, in the past two decades, the city has expanded onto the slopes of Mount Oum El Jemal (1022m), Koudiat Al-Qalaa (1105m), and Mount Bouakouz). The city's location is characterized by the presence of elevations and hard or rocky hills within the urban fabric, such as Koudiat Al-Hamlawia, Askari Al-Sharif, and Koudiat Bouakouz. The city's elevation noticeably increases towards the outskirts, particularly in the eastern and southern directions, consisting of wooded areas. The prevalence and dominance of flat terrain renders it favorable for development initiatives. However, the forested areas, in the eastern and southern outskirts, present a substantial challenge to urban development.

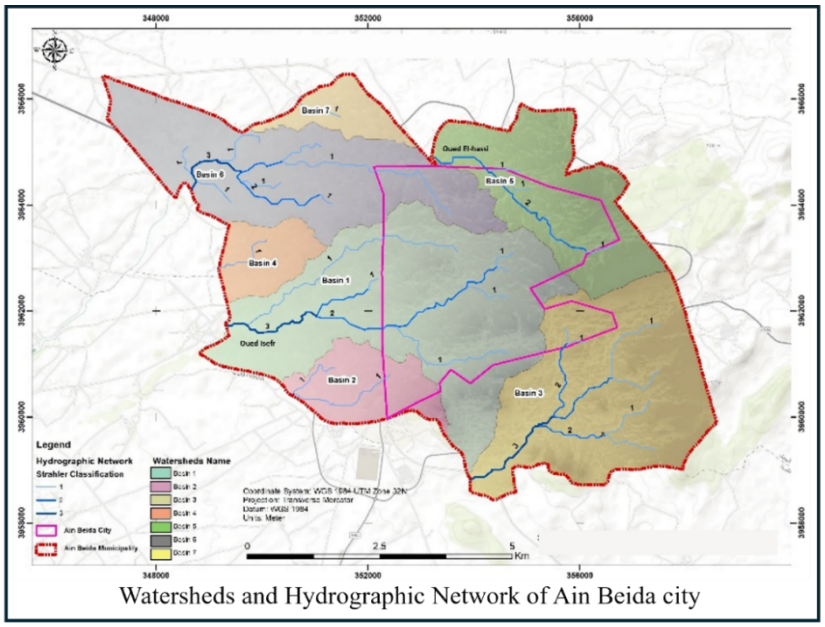


Topographical features of Ain Beida city

Source: Shuttle Radar Topography Mission (SRTM) + Authors Treatment Map N^{0}03

Hydrographic constraints and environmental issue.

Studying the hydrographic network of a city is important for understanding the management of rainwater, flood prevention, and the preservation of water quality. The hydrological system (Map N^0 04) of Ain Beida is characterized by Oued Al-Hassi to the north and Oued Isefr to the south. The city is intersected in its northern part by Oued Al-Hassi, which separates the neighborhoods of Beida Sghira and Essalem to the northeast. It also runs along the northern part of the city, which is planned for future urbanization. Oued Isefr also cuts through Al-Aurass Al-Kabir neighborhood. These two watercourses cause environmental issues.



Watersheds and Hydrographic Network of Ain Beida city

Source: Shuttle Radar Topography Mission (SRTM) + Authors Treatment Map N^{0}04

Slope suitability for balancing urban growth and preserving environmental health.

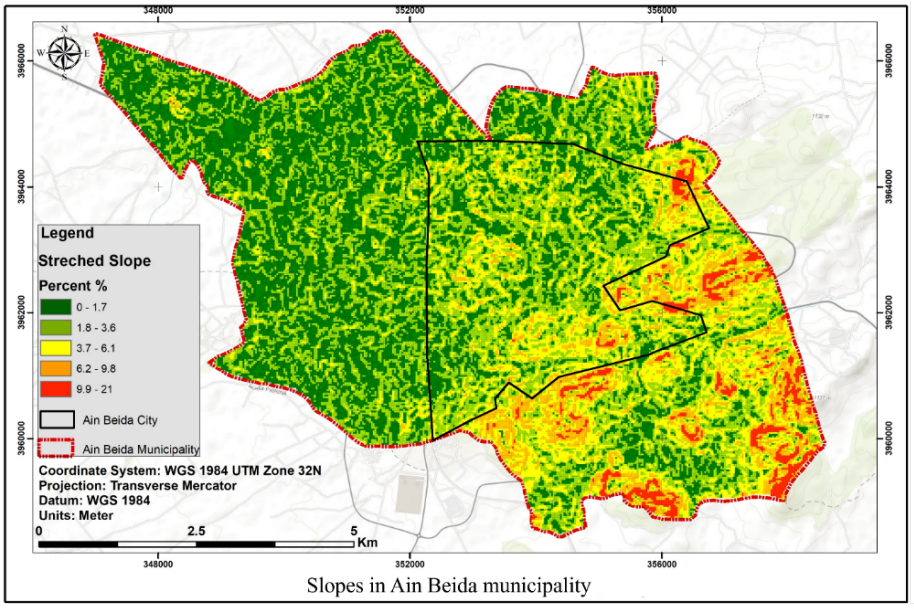
According to (Shuttle Radar Topography Mission (SRTM)), the majority of urban land gradients range between 0.1% to 1.7% and 1.8% to 3.6%. These variations represent relatively gentle to moderate slopes. Urban development on such slopes is generally more convenient compared to steeper terrains. Construction is typically easier, drainage is more manageable, and accessibility is better. The cost of

development is generally lower, and there are fewer engineering challenges. However, it's important to note that this range of slopes may be prone to flooding, emphasizing the need for proper drainage planning.

Slopes ranging between 3.7% to 6.1% are considered relatively steep and are characterized by elevations and hills within the urban fabric. These areas may present some challenges, but they are still manageable for development.

The steepest slopes, ranging from 6.2% to 9.8% and 9.9% to 21%, are in the eastern, northeastern, and southeastern parts of the city and are primarily associated with forested areas. These areas, marked in red on the map, may pose more significant challenges for construction and development due to their steepness. Special considerations and careful planning are essential for these regions to address issues such as erosion and stability.

In essence, the topography is favorable for urbanization. While gentler slopes provide a favorable environment for urban development, steeper terrains require more meticulous planning and engineering expertise to mitigate potential environmental challenges.



Slopes in Ain Beida municipality

Source: Shuttle Radar Topography Mission (SRTM) + Authors Treatment Map N°05

Impacts of topography and hydrography characteristics on the environmental quality.

The topographic and geographical features of Ain Beida have the potential to significantly affect urban environmental quality. Several implications, both beneficial and detrimental, arise from these features. This includes the impacts on urban fragmentation and accessibility, flooding risks, terrain gradient and land use planning, obstacles to development.

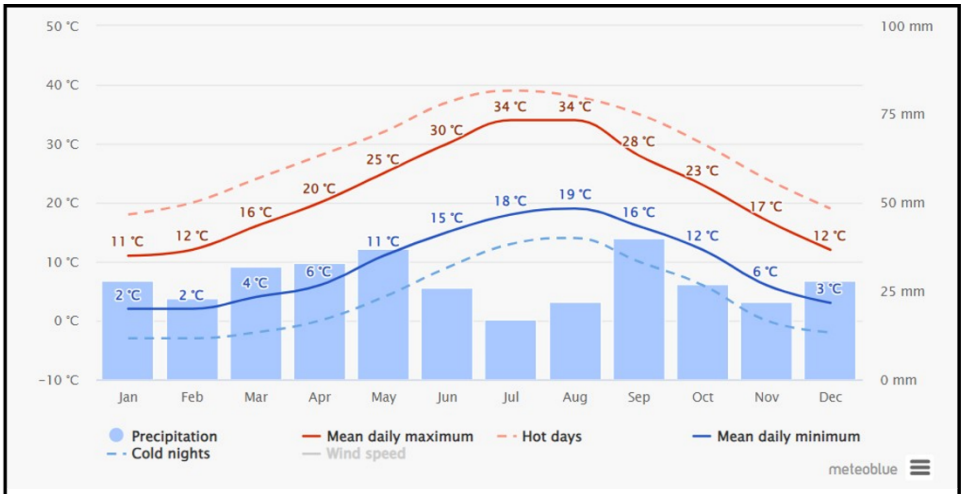
The presence of elevations, hills, and rivers within urban areas poses a significant challenge, leading to the fragmentation of the urban fabric. This topographical variety results in disrupted neighborhoods, increased distances, and the emergence of numerous pathways to shorten travel distances. Consequently, the overall connectivity and accessibility within the city are impacted, potentially hindering efficient transportation and the flow of urban life. The varied topography also gives rise to microclimates, introducing differences in temperature, humidity, and wind patterns. This diversity supports the formation of an urban ecosystem that fosters a variety of plant and animal species, contributing to the overall environmental health of the area. Another concern is the flooding risk posed by Oued Al-Hassi and Oued Isefr cutting through the city during heavy rainfall leading to property damage, transportation network disruptions, risks to public safety, and possible implications soil erosion. While most of Ain Beida's topography is favorable for urbanization, different slope categories determine the suitability of land for various purposes. However, attention must be given to areas with steeper slopes, particularly those in the eastern, northeastern, and southeastern regions, where forested areas are present. The development on slopes may lead to increased surface runoff, posing risks of downstream flooding and altering the natural flow of water.

A comprehensive and adaptable approach to urban planning is crucial to ensure sustainable development across the diverse topography of the city. The wooded regions, which constitute an obstacle to development, demand environmental consideration and necessitate sustainable practices to achieve a balance between urban expansion and the preservation of vital ecosystems.

Climate and environmental challenges.

Climate and weather play crucial roles in shaping the urban environment and can have significant impacts on its quality. The interaction between climate, weather patterns, and urban development can affect various aspects of the environment, including air quality, water resources, energy consumption, infrastructure resilience, biodiversity, public health, and overall livability.

Ain Beida belongs to the High Plains with a continental climate primarily semi-arid climate with a cold and rainy winter and a hot and dry summer. Rainfall varies from year to year, with a precipitation range between 300 to 500 mm. According to meteoblue climatic data from 1940 to 2020 ("Simulated historical climate & weather data for Aïn Beïda - meteoblue," n.d.), the average annual precipitation reaches 419 mm spread over a period of 81 days. The city also experiences periodic thunderstorms that can lead to flooding. Temperatures also vary from month to month, with an annual average reaching 20 degrees. For the months of extreme heat (July-August), the annual average ranges from 30 to 35 degrees. Maximum winter temperatures reach 10 degrees, while minimum temperatures drop to 02°. Winters are cold due to the altitude that characterises the region. In summer, maximum temperatures reach 35°, with minimum temperatures at 25° (Figure N^0 01). As for snowy periods, the average snowy days reach 12.1 days per year. Additionally, icy periods can extend to 49 days per year, significantly impacting agriculture and farming in general. However, it is observed that winds do not significantly affect the city. The region is characterized by Sirocco winds, reaching up to 38.3 days per year. The Sirocco is a hot and dry wind originating from the Sahara Desert, blowing across the Mediterranean Sea into southern Europe.



Average temperatures and precipitation

Source: ("Simulated historical climate & weather data for Aïn Beïda - meteoblue," n.d.) Figure N^{0}01

The Impact of climate attributes on the quality of the environment.

The semi-arid climate of Ain Beida, characterized by cold and rainy winters, hot and dry summers, variable rainfall, temperature fluctuations, occasional thunderstorms, and wind patterns, has significant effects on the quality of the environment in the region.

Water availability and agriculture are two areas that are particularly affected by the climate. The variable rainfall, which ranges from 300 to 500 mm, poses challenges for water availability, impacting agriculture and farming. The scarcity of water resources can have detrimental effects on crop yields and sustainability. Additionally, periodic thunderstorms may lead to flooding, impacting soil quality and crop growth.

The wide range of temperatures in the region, from cold winters to hot summers, can also have implications for the types of flora and fauna that can thrive in the area. The temperature fluctuations and extreme temperature ranges may limit the range of crops that can be cultivated and affect the overall biodiversity in the region.

Snowfall and icy periods can have significant consequences for agriculture. Extended periods of snow and ice can damage crops, disrupt farming activities, and pose challenges to infrastructure and transportation. Additionally, the Sirocco winds cause a notable rise in temperatures in affected regions and carry dust and sand particles, resulting in reduced air quality and visibility. The presence of dust and sand particles poses significant health risks, contributing to respiratory issues and adversely impacting outdoor activities while compromising environmental cleanliness. Furthermore, prolonged exposure to the Sirocco wind may have detrimental effects on vegetation.

The climate features, especially extreme temperatures, variable precipitation, and icy periods can have direct impacts on the jobs of the local population involved in agriculture. Unpredictable weather patterns may lead to economic uncertainties.

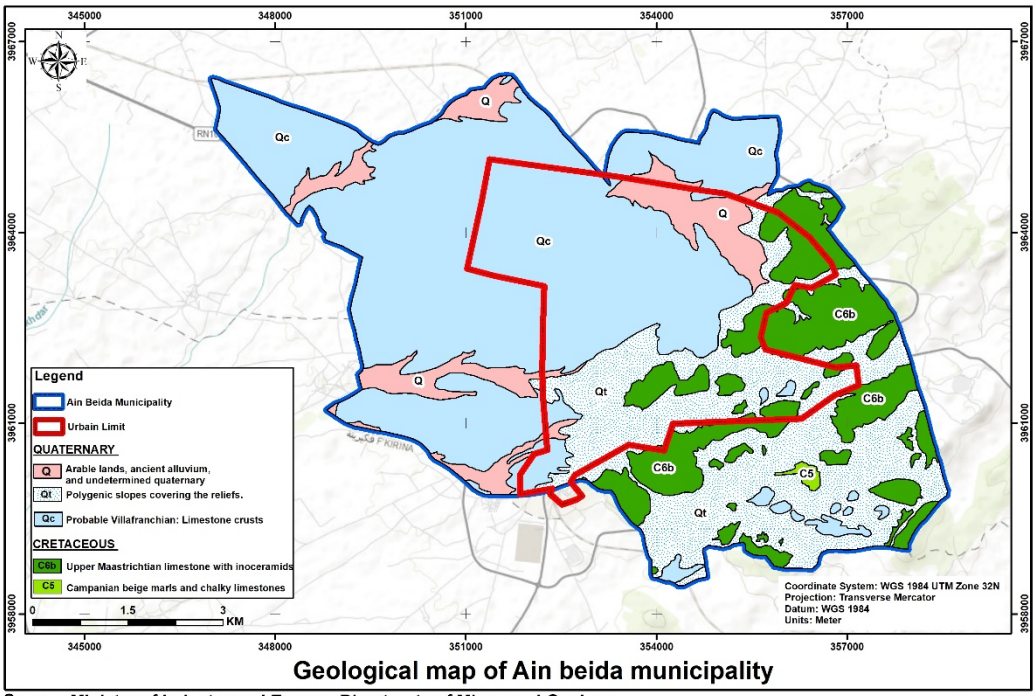
In conclusion, the climate features of Ain Beida have significant implications for the quality of the environment, affecting water availability, agriculture, biodiversity, and overall livelihoods. Adapting to these climatic conditions is crucial for sustaining the well-being of the local population and maintaining a balanced and healthy environment.

Geological diversity and environmental sustainability.

The Ain El Beida region experienced mild tectonic movements towards the east, south, and northwest at the end of the Cretaceous period. The geological composition of the region is distinguished based on the type of rocks and their load-bearing capacity. The region's geological structure consists of the following formations (Urban Master Development Plan, 2006):

- Second Time Formations: These formations belong to the Upper Cretaceous period and can be found in the highlands adjacent to Ain El Beida. They include the Campanian and Maastrichtian formations. The Campanian Formation is characterized by brown limestone and marl layers concentrated at the base, gradually transitioning to a mix of marl and limestone with a thickness of 60 meters. The Maastrichtian Formation is situated in the highlands of Mount Um Al Qamal and is composed of brown marl and limestone.

- Fourth Time Formations: These ancient formations cover most of the area and are distributed in the northern and eastern regions. They have a flat morphology with overlays of ashy soils.



Geological map of Ain beida municipality

Source: Ministry of Industry and Energy; Directorate of Mines and Geology; Geological Map Service of Algeria.(1973)

Map N°06

Favorable soil properties for durable built up environment.

There are various types of grounds that can be found in the city (URBA.CO, 2022):

The first type is Favorable Grounds. They are located towards the East and South of the city and have soils that are highly load-bearing and compact, perfect for any type of construction.

The second type is Moderately Favorable Grounds. These grounds are located towards the West and North of the city, where future expansions will take place. They are composed of different materials such as limestone crusts, dune-shaped sand, scree, gravel, and clay, which make them moderately favorable for construction.

Low seismic hazard for enhanced environmental Safety.

The Ain Beida area does not have any known seismic activity. Though, an analysis of the seismic activity of the whole region (High Plains-Saharan Atlas) suggests that the area has a moderate risk for seismic hazard. The seismic zoning of the Algerian territory, developed by the CRAAG (Algerian Research Center in Astronomy, Astrophysics, and Geophysics), reveals that the Ain Beida region falls under seismicity zone level 1 low seismic hazard zone (Guizani et al., 2015). Being in a low seismic hazard zone suggests a lower probability of experiencing strong earthquakes. This designation implies a safer environment in terms of seismic risk. Even though the seismic activity in Ain Beida is not as high as in the Northern part of the country where it is constant, it is still essential to comply with the seismic construction norms and rules and take preventive and crisis management measures for natural disasters.

Geology, pedology composition and environmental impact.

The geological composition of the Ain Beida region significantly impacts the urban environmental quality, particularly in terms of construction and land use. Considering some key points when evaluating the region's geological features is imperative.

The stability of buildings and infrastructure is determined by the type of geological formations(Ghorbani et al., 2012), especially the Second Time Formations such as the Campanian and Maastrichtian, with their brown limestone (Hay et al., 2021), marl layers, and ashy soils.

Highly load-bearing and compact soils in the East and South are ideal for construction since they provide a stable foundation for buildings, contributing to the overall safety and longevity of structures in these areas.

However, in the West and North, the region has Moderately Favorable Grounds with a diverse composition of limestone crusts, sand(Westgate et al., 2023), scree, gravel, and clay(Alnmr and Ray, 2023), which may pose challenges for construction. Different materials may have varying load-bearing capacities, requiring careful engineering considerations to ensure the stability of buildings.

The distribution of geological formations across the region influences land use planning and urban development. Areas with more stable grounds may be preferred for residential, commercial, and industrial developments, while areas with less favorable grounds may require more thoughtful planning to address potential construction challenges.

In conclusion, the Ain Beida region's geological composition is a critical factor that significantly influences the urban environmental quality, construction practices, and overall sustainability of the city. The presence of stable formations, such as the Second Time Formations with brown limestone, marl layers, and ashy soils in the East and South, provides a solid foundation for construction, ensuring the safety and longevity of structures.

Exploring the interplay of natural parameters and their influence on land availability for urban development.

Geotechnical considerations play a crucial role in ensuring the stability and sustainability of structures in an urban environment. Based on the topography of the urban site, terrain inclination, hydrography, geological composition, pedology, agricultural productivity, and geomorphological characteristics of the land, we were able to identify areas suitable for urban development. The identified

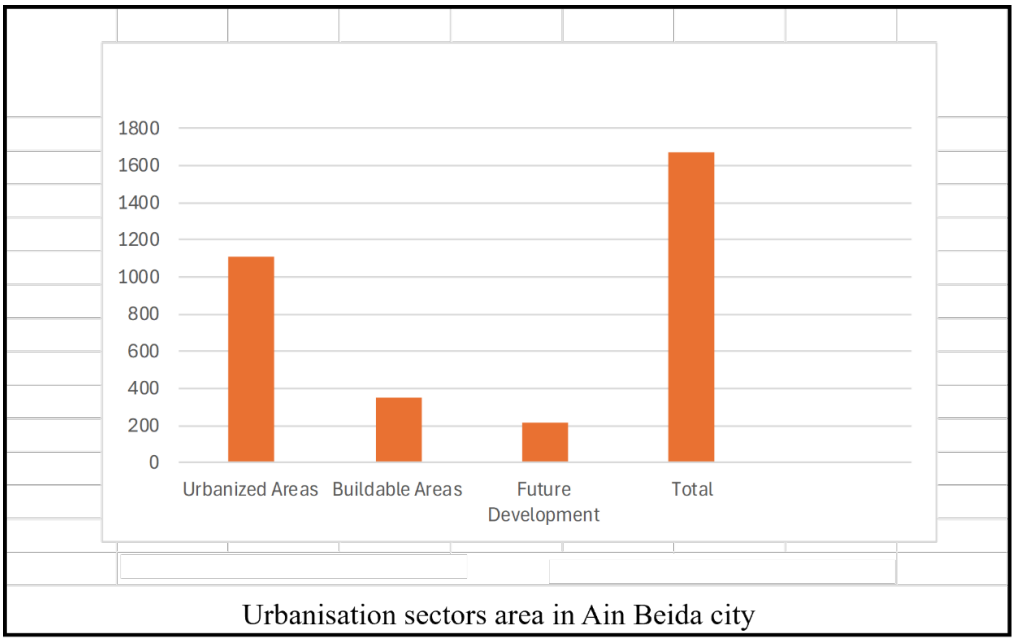
areas have been classified into three categories: urbanized areas, buildable areas, and future development sectors (Urban Master Development Plan,2006). (Figure N^0 02).

Urbanized Areas: The old urban center and some new developments have been identified as suitable for urbanization. The circular layout of the urban center and its accessibility through existing roads make it an ideal location for further development. However, it is crucial to consider the geotechnical factors in these areas to ensure the stability and sustainability of structures.

Buildable Areas: The buildable areas are strategically located along existing roads, such as National Road 80 leading to Khenchela, National Road 10 leading to Tébessa, and the road leading to Guelma. These areas offer expansion possibilities along the main axes.

Future Development Sectors: The northern part of the urban center includes future development sectors. These areas, totaling 213.02 hectares, present opportunities for planned and sustainable urban growth.

In summary, geotechnical analysis is essential for identifying suitable areas for urban development. It also provides critical information to design structures that can withstand the geological and topographical challenges of the region. Therefore, it is imperative for urban planners, engineers, and developers to integrate geotechnical considerations into their plans to ensure the long-term stability and sustainability of the proposed urban developments.



Source: Urban Master Plan of Ain Beida city,2006 + Authors treatment Figure N^{0}02

Vegetation: Overcoming Challenges for a Healthy Environment.

Vegetation plays a multifaceted role in maintaining and enhancing environmental quality. It contributes to air and water purification, climate regulation, biodiversity conservation, and overall human well-being.

Green spaces in Ain Beida, such as forests and gardens, are often associated with public spaces. However, a large percentage of the city's green spaces can be found in private areas such as gardens and squares. Apart from the 1st of November garden, the municipality has created other green spaces which are not well-maintained. Another green space is the "Black Tiger" garden located in the Murienne sector. This privately-owned garden contains a wide variety of plant species and serves as both a nursery and a showcase for the exhibition and sale of plant species and seeds. The El Amir Khaled Garden features different types of trees such as olive trees, willows, and cypresses. However, it faces maintenance issues due to municipal negligence. It is crucial for the authorities to take appropriate measures to ensure that

green spaces, both public and private, are well-designed and maintained, as they play a vital role in the overall well-being of urban residents.

The bulk of Ain Beida's wooded area is in the immediate vicinity of the city in the form of several urban and peri-urban Aleppo pine forests. Within the city, the forest network is quite limited **(**Table N^{0}01) (Image N^{0}01). These natural ecosystems are a home to a diverse array of plant life and wildlife, including hares, jackals, foxes, and wild boars. Despite this fact, the rate of reforestation has remained consistently low. The underlying causes for this inadequacy are multifaceted, ranging from a lack of volunteer campaigns to insufficient budget allocations. Additionally, bioclimatic conditions exacerbate the degradation of these sensitive areas. The lack of a comprehensive management and protection policy has contributed to various human activities that degrade the forests and accelerate deforestation, including tree cutting and improper disposal of solid waste.

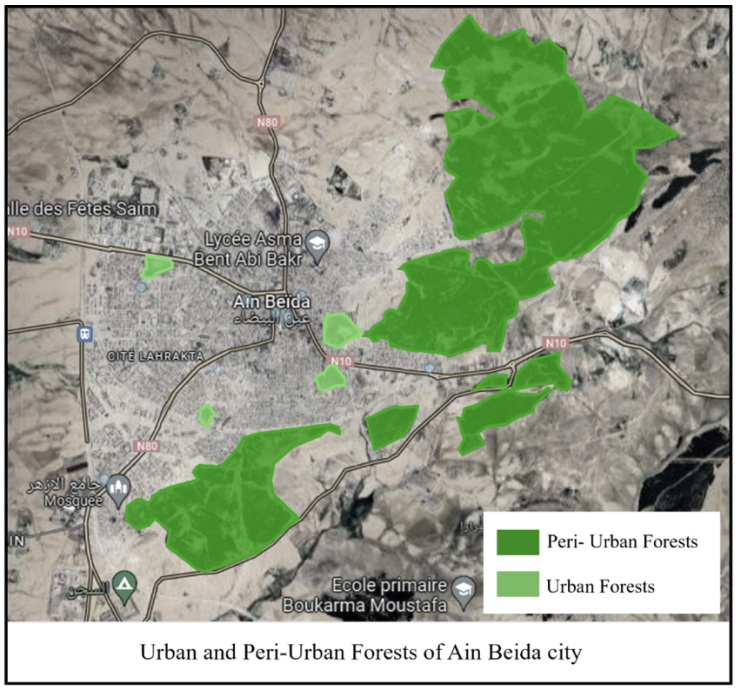
The city of Ain Beida is a densely urbanised area, which leaves little space for vegetation. This shortage of greenery has resulted in numerous issues, including an increase in runoff volumes, leading directly to flood risks, low water infiltration, and a rise in the dispersion and concentration of pollutant particles. These areas are typically composed of impermeable surfaces with low albedos and dark colors. The ratio of reflected light to incident light is low, meaning that these surfaces retain energy during the day and release it as heat at night, leading to an increase in surface and air temperatures. This phenomenon, commonly referred to as "heat islands," results in elevated temperatures at night, which slows down the city's cooling process. As a result, significant temperature differences arise between the city center and its outskirts, inconveniencing all inhabitants and other organisms.

Ain Beida is facing challenges in managing its urban vegetation and forested areas. The city's forested areas are under threat due to low reforestation rates and human activities. Conflicts between urban development and green spaces, illegal occupations, and insufficient conservation measures contribute to this problem. Urgent attention is needed to ensure the long-term sustainability of Ain Beida's natural resources.

Table 1. Urban and peri-urban forests.

Vegetation	Designation	Area (ha)
1-Oum El Gemel	Peri-urban Forest	150
2-Reb Chentli	Peri-urban Forest	106
3-Bouakouz	Peri-urban Forest	160
4-Zaarir Smalil	Peri-urban Forest	509
5-Koudiet Zaarir	Peri-urban Forest	176
6-Hamlaouia	Urban Forest	25
7-Faliti	Urban Forest	4,5
7-Bosquet	Peri-Urban Forest	4,9

Source: Directorate of Forests+ Authors treatment.

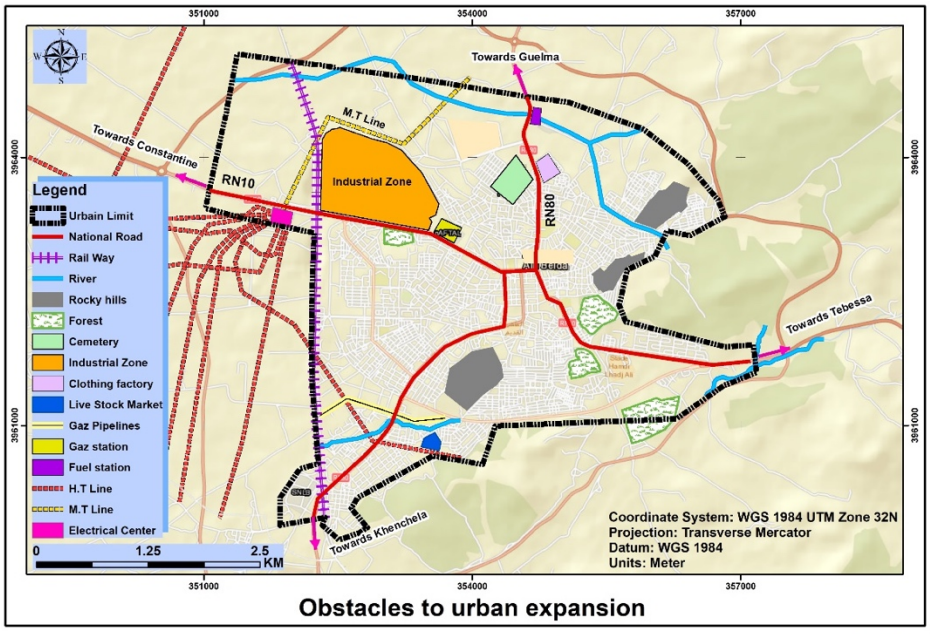


Urban and Peri-Urban Forests of Ain Beida city

Source: Google Earth + Authors treatment Image N⁰01

Technical obstacles to urban expansion.

In addition to natural barriers, Ain Beida faces technical obstacles to urban development, such as the Industrial Zone in the northwest. A railway line that passes through the western side of the city and crosses the craft activities zone affiliated with Fekirina, Ain Oum El Jemal, creates another obstacle to urban expansion. The natural gas pipeline penetrating Al-Aurass Al-Kabir and Aurès 01 neighborhoods poses a danger to residents due to non-compliance with the pipeline easement. Similarly, high voltage power lines located in the western and southern parts of the city, meeting at the power generation station, create health and security problems when their easement is not respected. The cemetery located north of the city, and the military clothing factory situated north of the city, are other artificial obstacles. Land ownership is also a significant concern, with significant areas belonging to private owners. Although a portion of privately-owned land has been integrated into municipal ownership, a significant portion remains challenging for expansion.



Obstacles to urban expansion

Source: The authors **Map N° 07**

Natural and technical risks and environmental issues.

The impediments to urban development in Ain Beida, whether natural or man-made, can have profound risks and environmental issues and far-reaching impacts on the area's environmental quality.

Natural risks and environmental issues.

The urban area is crossed by Oued El Hassi and Oued Isefr, and due to the absence of adequate flood barriers and levees, which protect riverbanks from overflowing, these two watercourses often cause floods. These floods pose a significant threat to the security of nearby neighborhoods during the period of flooding. The topography of the city, particularly the elevated land located in the northeast, east, and southeast, amplifies the impact of heavy rainfall on the local drainage system, resulting in flooding. The runoff from the elevated areas exacerbates the situation, which can cause significant damage to the surrounding communities. These two watercourses have become a source of environmental contamination due to the discharge of both solid and liquid wastes (Photo N° 01-N° 02). The slopes of the elevations in the outskirts, particularly Koudiat Bouakouz in the northeast of the city, are irregularly occupied by precarious and spontaneous housing (Photo N°03). This has led to environmental concerns. The limited opportunities for urban expansion have led to increased population density and intensified land use. This concentration can exacerbate environmental stressors and impact the quality of life for residents.

Forest fires are a common risk in arid climates. These areas are particularly vulnerable to wildfires because of a lack of resources and infrastructure to control and manage them. Some of the challenges faced include poor reforestation programs, insufficient firefighting equipment and human resources, damaged forest pathways that make access difficult, lack of lookout posts and forest houses, and an inadequate number of fire brigades. All these factors make it challenging to prevent and manage wildfires in forested areas.

Photo N° 01: Draining used water into the valley stream.

Source: Authors, February 2024.

Photo N° 02: Accumulation of solid urban waste in the valley stream

Source: Authors, February 2024.

Photo N^0 03: The spread of spontaneous housing
Source: Authors, February 2024.

Technological risks and environmental concerns.

The Industrial Zone and the railway line, both of which can contribute to air and noise pollution, thereby affecting the air quality and overall environmental health of the area. Industrial activities often release pollutants into the air and water, while railway operations can produce noise and vibrations that impact the surrounding environment.

The presence of a cemetery and a military clothing factory can also contribute to localized environmental issues. The factory may release pollutants associated with manufacturing processes, while the cemetery may pose challenges in terms of land use planning and potential impacts on groundwater quality. Furthermore, the issue of land ownership and the inability to acquire private lands for development can lead to inefficient land use and unplanned urban development.

The presence of natural gas pipelines in the Grand Aurès neighborhood and Aurès 01, has raised concerns over the non-compliance with the pipeline clearzone or the servitude corridor, potentially posing a significant risk to the residents. The pipeline may be prone to accidents or leaks, which can lead to environmental contamination.

High-voltage power lines are widely distributed in the western and southern parts of the city (Photo N^{0}04), ultimately converging at the power generation station. However, the lack of compliance with the clearzone has resulted in serious safety and health concerns for the residents. The proposed new power station project affiliated with Fkirina in the southern part of the city has only added to these concerns. Power lines may have electromagnetic field effects that can impact human health and the surrounding ecosystem.

Photo N^0 04: High-voltage power lines are widely distributed in the western and southern parts of the city.

Source: Authors, February 2024.

The railway line near the western edge of the city lacks proper infrastructure and security measures, posing significant risks to nearby residents (Photo N^{0}05). The absence of adequate fencing increases the likelihood of unauthorized entry, which could result in accidents or other perilous activities. It's crucial to implement appropriate security measures and ensure proper infrastructure to minimize risks.

Photo N^0 05: Crossing the railway line on the western side of the city.

Source: Authors, February 2024.

The presence of a gasoline station situated within an urban area (N^0 06) raises concerns about the potential risks of fire and gas explosions. These hazards can pose a serious security threat to the

surrounding neighborhoods, particularly in the absence of a green buffer zone. The absence of such a buffer zone can further amplify the risk of these hazards.

Photo N^0 06: The presence of a gasoline station situated within an urban area.

Source: Authors, February 2024.

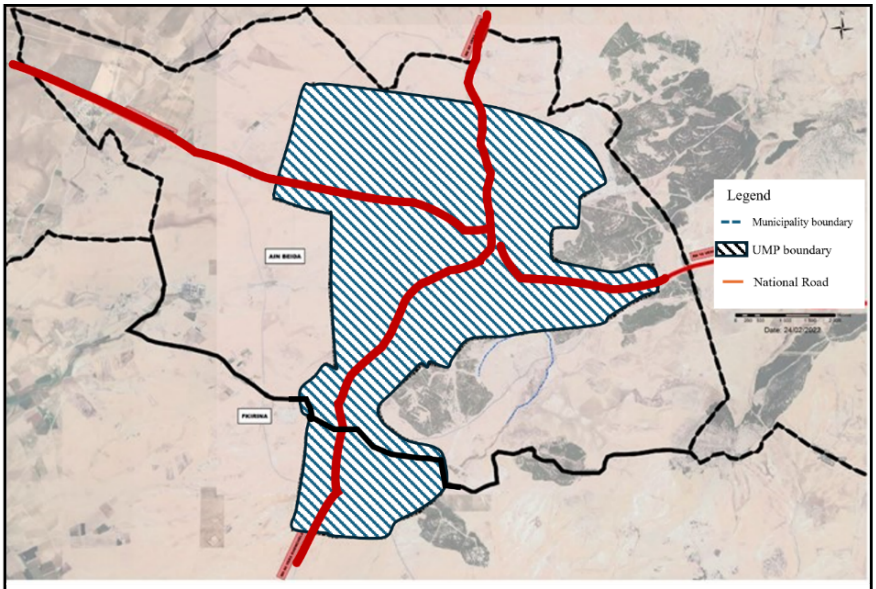
The weekly open-air livestock market near Al-Aurass Al-Kabir neighborhood has several environmental impacts. The movement of people and livestock causes air pollution by creating dust and particulate matter. Additionally, the bustling activity within the market generates noise pollution that can disturb the peace of the nearby residential zone. Furthermore, the market produces significant waste that could harm the environment. The increased vehicular traffic associated with the market also leads to congestion and worsens air pollution, affecting the environment and the quality of life for residents in the area.

The water conveyed to municipalities through pumping pipelines within the intermunicipal group plays a critical role in providing a stable water supply. However, this infrastructure is not without its risks. One significant concern is the potential for contamination of public health as it can occur when contaminants enter the water supply through breaches in the pipeline or external sources. Maintaining the integrity of underground pipelines is of great importance, as the lack of proper maintenance can lead to infrastructure deterioration and increase the risk of failures. Changes in water quality standards or regulations may require pipeline system upgrades or modifications, which can pose challenges for compliance and potentially affect the continuity of water supply. It is crucial to regularly monitor and detect any potential issues to ensure public safety and an uninterrupted water supply.

Consequences of natural and technical constraints on urban development policy and environmental quality.

Natural and technical characteristics have influenced the direction and shape of urban growth, impacting urbanisation and land use patterns. The natural and technical obstacles hinder the implementation of infrastructure projects and limit accessibility, affecting the overall development and functionality of the city. The obstacles to urban expansion in Ain Beida are considerable, and the potential for future development is limited. Urban expansion can only occur towards the southwest within the administrative boundaries of the Fkirina municipality. It is important that any development proposals are collaborative between the two municipalities to serve both areas within the framework of an inter-municipal development and urban planning master plan (Map N^0 08).

However, there may be some obstacles to consider, such as the presence of high voltage lines and a power generation station.



Inter-Municipal Urban Master Plan of Ain Beida and Fkirina

Source: Urban Master Plan of Ain Beida 2006- URBACO 2022 + Authors treatement Map N^{0}08

The dilemma: the tension between the need to preserve green spaces, particularly agricultural land and forests, and the necessity for urban development and expansion. Preserving green spaces aligns with sustainable development goals, promoting a healthier and more balanced ecosystem. However, Limited land availability has resulted in challenges related to housing affordability, as the cost of land is a significant component in the overall cost of housing contributing to social and economic disparities within urban areas. Limited land availability poses challenges for developing and expanding essential infrastructure, including transportation networks, utilities, and public facilities. It has resulted in inadequate infrastructure to support the needs of a growing population. The land scarcity has resulted in increased population density, estimated at 2,045 inhabitants(Benghadbane and Fatima Zohra, 2017, 2017, 2017) per square kilometer, which is significantly higher than other cities in the province. Higher population density can lead to congestion, crowded living conditions, and pressure on existing infrastructure and public services.

The shift in urban policy from the 1990s to the present, driven by limited land availability, has led to a range of approaches aimed at addressing the challenges of urbanization. In terms of urban expansion, the city managers have opted for urban densification which refers to the process of increasing the population or building density in an already developed urban area or repurposing underutilised land for new urban developments. This can involve the construction of taller buildings, the addition of more public facilities and housing units, or the intensification of land use to accommodate a growing population within the existing urban fabric. The goal of urban densification is often to make more efficient use of limited urban space and reduce urban sprawl.

While urban densification can offer several benefits, it also comes with certain disadvantages, particularly concerning environmental quality. Densification combined with the lack of green infrastructure led to increased traffic congestion and vehicle emission resulting in poor air quality. Denser urban environments generate higher noise levels due to increased human activity, traffic, and the proximity of buildings. Noise pollution has adverse effects on health, well-being, and overall environmental quality.

The scarcity of available land for urban development poses a significant challenge to the formulation of cohesive urban planning strategies. The allocation of urban programs becomes contingent upon the limited land resources, leading to a lack of coherence in the overall planning framework. Currently, housing, social facilities and essential infrastructure are situated wherever land is available, creating a disjointed urban landscape and environmental issues. The situation involves the challenges

posed by the disparate locations of the bus station, university center, and student residences. The bus station is located on the eastern outskirts of the city, while the university center is situated on the northern outskirts, far away from the student residences in the southwest side of the city. This creates a variety of challenges related to urban traffic and transportation distances. As a result, both residents and visitors must travel further distances, which can be inconvenient and pose issues with accessibility. To address these challenges, a comprehensive approach and a long-term vision are needed to enhance urban mobility, accessibility, and convenience for passengers. The relocation of the ancient prison of Ain Beida from the city center to the extension zone in the south. The new location is within the communal zone of expansion between the municipalities of Fkirina and Ain Beida, as outlined in the intercommunal master development plan. However, the concern is that the new prison may pose an obstacle to urban development. The presence of a prison in an area may influence the zoning and land use planning of the surrounding area. It might affect property values, residential development, and the overall character of the neighborhood. The presence of a prison can affect the perception of safety and desirability in a neighborhood. This might impact real estate values and the willingness of businesses and residents to invest in the area.

To enhance land use efficiency, there has been a transition in housing provision from individual residences to collective housing. This shift aims to optimise spatial utilisation by promoting more compact and resource-efficient living arrangements. Collective housing models facilitate a more viable use of available land while fostering a sense of community, social cohesion, and shared amenities. They also have a reduced ecological impact. This evolution in housing provision not only maximises the use of limited space but also aligns with sustainable urban planning principles, promoting denser living environments. However, it is important to recognise that this change in housing may not align with local tradition, cultural values, and preferences, which often lean towards individual residences.

Recent urban development programs tend to prioritize compact urban design and mixed-use development, with a focus on housing, social facilities, and proximity services. However, these programs often overlook the importance of green infrastructure, leisure, and transport facilities. This neglect can have negative consequences on the physical and mental well-being of residents, social interactions, the quality of life, and the overall sustainability of the community.

Conclusion.

The city of Ain Beida faces a complex interplay of natural and technical characteristics that influence its urban development, environmental quality, and overall sustainability. The immediate surrounding, topography, hydrography, climate, geological composition, and pedology all play pivotal roles in shaping the urban environment. The city's location amidst forests and agricultural lands brings both environmental benefits and challenges. The topography, hydrography, and geological composition present opportunities and obstacles for urban development, while the climate features pose challenges for water availability, agriculture, and overall environmental resilience.

The identified areas for urban development, including urbanised areas, buildable areas, and future development sectors, highlight the importance of geotechnical considerations in ensuring stability and sustainability. However, artificial obstacles, such as industrial zones, railways, gas pipelines, and power lines, present challenges to urban expansion and can impact safety, air, and noise pollution, as well as overall environmental health.

The consequences of natural characteristics on urban development policies reveal a dilemma between the need to preserve green spaces and the necessity for urban expansion. Limited land availability has led to increased population density, inadequate infrastructure, and challenges in housing affordability. The shift in urban policy towards densification aims to optimize land use but comes with environmental trade-offs to balance the priorities or preferences of the decision-maker. The limited availability of land often compels authorities to initiate urban projects wherever land is accessible, without an overall strategy. This has led to severe environmental implications. Therefore, it is crucial to prioritize careful urban planning and adopt a holistic approach to ensure eco-friendly urban development and sustainable environment.

Recommendations.

In the pursuit of a comprehensive and sustainable urban future, Ain Beida should embark on a transformative process driven by integrated planning initiatives. Collaboration with neighboring

municipalities is crucial to developing a unified inter-municipal development and urban planning master plan, ensuring coordinated growth. The city's focus on infrastructure improvement must prioritise mitigating flood risks in the hydrographic network through strategic investments in flood barriers, levees, and stormwater management systems. Environmental mitigation strategies should include strict adherence to safety regulations in industrial zones, railways, and power lines, complemented by pollution control measures and thoughtful land use planning. To address climate challenges, Ain Beida should commit to developing resilient agricultural strategies, incorporating drought-resistant crops and enhanced irrigation systems. Emphasising the importance of green infrastructure is crucial, with urban development plans prioritising green spaces, recreational areas, and biodiversity preservation to enhance environmental quality and resident well-being. Public participation stands as a cornerstone, ensuring alignment with cultural values and fostering a sense of community ownership in the urban planning process. To overcome land scarcity, collaborative efforts, grants, and incentives should be explored for land acquisition to facilitate essential infrastructure development. Comprehensive risk management plans, covering natural and technological risks, should be envisioned, emphasizing infrastructure maintenance, safety protocols, and emergency response measures. Ain Beida's goal should be to create a balance between urban development and green space preservation, creating a resilient and sustainable urban environment that considers natural resources and ecosystems, technological advancements, and evolving population needs. This comprehensive, long-term vision will guide urban development policies, steering Ain Beida towards a harmonious and sustainable future for its residents.

REFERENCES

1. Aghabayk, K., Parishad, N., Shiwakoti, N., 2021. Investigation on the impact of walkways slope and pedestrians' physical characteristics on pedestrians normal walking and jogging speeds. Saf. Sci. 133, 105012. https://doi.org/10.1016/j.ssci.2020.105012.
2. Agonafir, C., Lakhankar, T., Khanbilvardi, R., Krakauer, N., Radell, D., Devineni, N., 2023. A review of recent advances in urban flood research. Water Secur. 19, 100141. https://doi.org/10.1016/j.wasec.2023.100141.
3. Alnmr, A., Ray, R., 2023. Investigating the Impact of Varying Sand Content on the Physical Characteristics of Expansive Clay Soils from Syria. Geotech. Geol. Eng. https://doi.org/10.1007/s10706-023-02698-w.
4. Alsharhan, A.S., Rizk, Z.E., 2020. Water Resources and Integrated Management of the United Arab Emirates. World Water Resources 3. https://doi.org/10.1007/978-3-030-31684-6.
5. Bendada, T., 2022. L'évolution urbanistique et spatiale de la ville d'Aïn-Beïda face aux enjeux, événements et défis socio-économiques du moment. Journal of Humanities, Oum El Bouaghi University, 9, 525-557.
6. Benghadbane, F., Fatima Zohra, B., 2017. Urban Projects to Prefigure the Sustainable City -- Case: The City of Ain Beida (Algeria). Civ. Eng. Archit. 5, 52–60. https://doi.org/10.13189/cea.2017.050202.
7. Bouchemal, S., 2009. Mutations sociospatiales en milieu urbain : Entre citadinité et ruralité : l'exemple d'une ancienne ville coloniale française en Algérie. Cah. Géographie Qué. 53, 261–286. https://doi.org/10.7202/038785ar.
8. Datola, G., 2023. Implementing urban resilience in urban planning: A comprehensive framework for urban resilience evaluation. Sustain. Cities Soc. 98, 104821. https://doi.org/10.1016/j.scs.2023.104821.
9. EPE.URBA.CO.SPA Constantine, 2021. Etude de typologie et d'évaluation des performances des villes en matière de développement durable. Ville de Ain Beida.
10. EPE.URBA.CO.SPA Constantine, 2022. Etude de typologie et d'évaluation des performances des villes en matière de développement durable. Ville de Ain Beida.
11. General Census of Population and Housing 2022.
12. Gamba, Q.W., Dale Quattrochi, Paolo (Ed.), 2018. Urban Remote Sensing, 2nd ed. CRC Press, Boca Raton. https://doi.org/10.1201/9781138586642.
13. Ghorbani, M., Sharifzadeh, M., Yasrobi, S., Daiyan, M., 2012. Geotechnical, structural and geodetic measurements for conventional tunnelling hazards in urban areas – The case of Niayesh road tunnel project. Tunn. Undergr. Space Technol. 31, 1–8. https://doi.org/10.1016/j.tust.2012.02.009.
14. Guizani, L., Moradiankhabiri, M., Kheireddine, B., Naimi, M., 2015. Isolation Sismique des Ponts en Algérie: Règles et Perspectives.
15. Habibi, K., Hoseini, S.M., Dehshti, M., Khanian, M., Mosavi, A., 2020. The Impact of Natural Elements on Environmental Comfort in the Iranian-Islamic Historical City of Isfahan. Int. J. Environ. Res. Public. Health 17, 5776. https://doi.org/10.3390/ijerph17165776.

16. Hay, R., Kashwani, G., Celik, K., 2021. Carbonation, strength development, and characterization of calcined limestone as a potential construction material. Cem. Concr. Res. 139, 106263. https://doi.org/10.1016/j.cemconres.2020.106263.
17. Laganier, R., Roussel, I., 2000. La gestion de l'écosystème urbain pour une ville durable (The management of urban ecosystem for a sustainable city). Bull. Assoc. Géographes Fr. 77, 137–161. https://doi.org/10.3406/bagf.2000.2159.
18. MacKinnon, K., van Ham, C., Reilly, K., Hopkins, J., 2019. Nature-Based Solutions and Protected Areas to Improve Urban Biodiversity and Health, in: Marselle, M.R., Stadler, J., Korn, H., Irvine, K.N., Bonn, A. (Eds.), Biodiversity and Health in the Face of Climate Change. Springer International Publishing, Cham, pp. 363–380. https://doi.org/10.1007/978-3-030-02318-8_16.
19. Mazouz, T., 2018. Etalement urbain et stratégies de développement durable, cas d'une ville moyenne, Ain Beida. Thèse de doctorat S. Sciences. Université Oum El Bouaghi.
20. Metzler, A.B., Nathvani, R., Sharmanska, V., Bai, W., Muller, E., Moulds, S., Agyei-Asabere, C., Adjei-Boadi, D., Kyere-Gyeabour, E., Tetteh, J.D., Owusu, G., Agyei-Mensah, S., Baumgartner, J., Robinson, B.E., Arku, R.E., Ezzati, M., 2023. Phenotyping urban built and natural environments with high-resolution satellite images and unsupervised deep learning. Sci. Total Environ. 893, 164794. https://doi.org/10.1016/j.scitotenv.2023.164794.
21. Monograph of the Oum El Bouaghi province in 2022.
22. Miao, Y., Liu, S., Zheng, Y., Wang, S., Chen, B., 2015. Numerical Study of the Effects of Topography and Urbanization on the Local Atmospheric Circulations over the Beijing-Tianjin-Hebei, China. Adv. Meteorol. 2015, 1–16. https://doi.org/10.1155/2015/397070.
23. Rocklöv, J., Dubrow, R., 2020. Climate change: an enduring challenge for vector-borne disease prevention and control. Nat. Immunol. 21, 479–483. https://doi.org/10.1038/s41590-020-0648-y.
24. Salimi, M., Al-Ghamdi, S.G., 2020. Climate change impacts on critical urban infrastructure and urban resiliency strategies for the Middle East. Sustain. Cities Soc. 54, 101948. https://doi.org/10.1016/j.scs.2019.101948.
25. Scoccimarro, E., Cattaneo, O., Gualdi, S., Mattion, F., Bizeul, A., Risquez, A.M., Quadrelli, R., 2023. Country-level energy demand for cooling has increased over the past two decades. Commun. Earth Environ. 4, 208. https://doi.org/10.1038/s43247-023-00878-3.
26. Simulated historical climate & weather data for Aïn Beïda - meteoblue [WWW Document], n.d. URL https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/a%c3%afn-be%c3%afda_algeria_2508287 (accessed 2.22.24).
27. Sohn, W., Kim, J.-H., Li, M.-H., Brown, R.D., Jaber, F.H., 2020. How does increasing impervious surfaces affect urban flooding in response to climate variability? Ecol. Indic. 118, 106774. https://doi.org/10.1016/j.ecolind.2020.106774.
28. Shuttle Radar Topography Mission (SRTM). https://www.earthdata.nasa.gov/sensors/srtm.
29. Sopina, A., Šćitaroci, B.B.O., 2024. Mapping Relations Transformation of Urban and Natural Landscape in Adriatic Cities Fostering Landscape Sustainability and Promoting Landscape Quality as Spatial Planning Objectives, in: Marucci, A., Zullo, F., Fiorini, L., Saganeiti, L. (Eds.), Innovation in Urban and Regional Planning, Lecture Notes in Civil Engineering. Springer Nature Switzerland, Cham, pp. 647–658. https://doi.org/10.1007/978-3-031-54096-7_56.
30. Spirn, A.W., 1980. The Role of Natural Processes in the Design of Cities. Ann. Am. Acad. Pol. Soc. Sci. 451, 98–105. https://doi.org/10.1177/000271628045100110.
31. Tabari, H., 2020. Climate change impact on flood and extreme precipitation increases with water availability. Sci. Rep. 10, 13768. https://doi.org/10.1038/s41598-020-70816-2.
32. Theodorou, P., 2022. The effects of urbanisation on ecological interactions. Curr. Opin. Insect Sci. 52, 100922. https://doi.org/10.1016/j.cois.2022.100922.
33. Urban Master Development Plan 2006 of the municipality of Ain Beida.
34. Van den Bosch, M., Ode Sang, Å., 2017. Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. Environ. Res. 158, 373–384. https://doi.org/10.1016/j.envres.2017.05.040.
35. Van Kamp, I., Leidelmeijer, K., Marsman, G., de Hollander, A., 2003. Urban environmental quality and human well-being: Towards a conceptual framework and demarcation of concepts; a literature study. Landsc. Urban Plan., Urban environmental quality and human wellbeing 65, 5–18. https://doi.org/10.1016/S0169-2046(02)00232-3.
36. Westgate, Z., McMullin, C., DeGroot, D., 2023. Glauconite Sand Challenges for US Offshore Wind Development. Presented at the ASME 2022 4th International Offshore Wind Technical Conference, American Society of Mechanical Engineers Digital Collection. https://doi.org/10.1115/IOWTC2022-98666.
37. Wiggering, H., 2014. The geology – land use – nexus. Environ. Earth Sci. 71, 5037–5044. https://doi.org/10.1007/s12665-013-2908-8.

38. Zevenbergen, L.W., Thorne, C.R., 1987. Quantitative analysis of land surface topography. Earth Surf. Process. Landf. 12, 47–56. https://doi.org/10.1002/esp.3290120107.
39. Zhu, G., Wang, M., Li, Q., Liu, J., Zhao, Y., Gao, J., Xu, H., 2022. Land development suitability analysis for transport planning evaluation and optimization in mountainous ecological region. J. Mt. Sci. 19, 862–873. https://doi.org/10.1007/s11629-021-6965-2.