

# THE TRANSFORMATION OF AGRICULTURAL LANDSCAPES UNDER RAPID URBANIZATION IN THE TADLA PLAIN: CASE STUDY OF BENI AMIR IRRIGATED PERIMETER (MOROCCO)

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## Abstract

The Mediterranean region has experienced a dynamic shift in its landscape due to rapid urbanization, leading to the conversion of fertile agricultural lands into built-up environments. This transformation carries multifaceted consequences, affecting ecosystem services, regional hydrology, biodiversity, and overall environmental quality. The present paper employs a multidisciplinary approach that incorporates urban planning, land use policies, socioeconomic dynamics, ecological changes, and historical perspectives. Besides, the historical climate data and Google Earth imagery were analyzed and used to investigate the land change. The research aims to elucidate the complex dynamics underlying the transformation of agricultural landscapes in the Beni Amir irrigated areas within Tadla Plain. The findings will contribute to discussions on sustainable urbanization, land use planning, and agricultural resilience in the face of rapid urban development. Results show a transformative trend in the Beni Amir irrigated zone within the Tadla Plain, where both agricultural and urban areas have expanded significantly from 1980 to 2023. This expansion highlights the need for sustainable development strategies that balance agricultural growth, urbanization, and environmental preservation.

**Keywords:** Agricultural Landscape; Irrigated Area of Beni Amir, Transformation; Urbanization; Tadla Plain (Morocco).

## INTRODUCTION

In recent decades, the Mediterranean region has witnessed a profound and dynamic shift in its landscape due to the rapid process of urbanization (Angel et al., 2011). The Transformation of Agricultural Landscapes under Rapid Urbanization in the Mediterranean encapsulates a critical phenomenon that has garnered increasing attention from scholars, policymakers, and environmentalists alike (Breuste et al., 20148). The Mediterranean basin, renowned for its diverse climatic conditions, historical significance, and cultural richness, has long been a cradle of agricultural practices that have sustained human populations for millennia (Kalehhouei et al., 2021). However, the relentless pace of urban expansion is presenting unprecedented challenges to traditional agricultural systems and the delicate equilibrium between rural and urban spaces (Defries

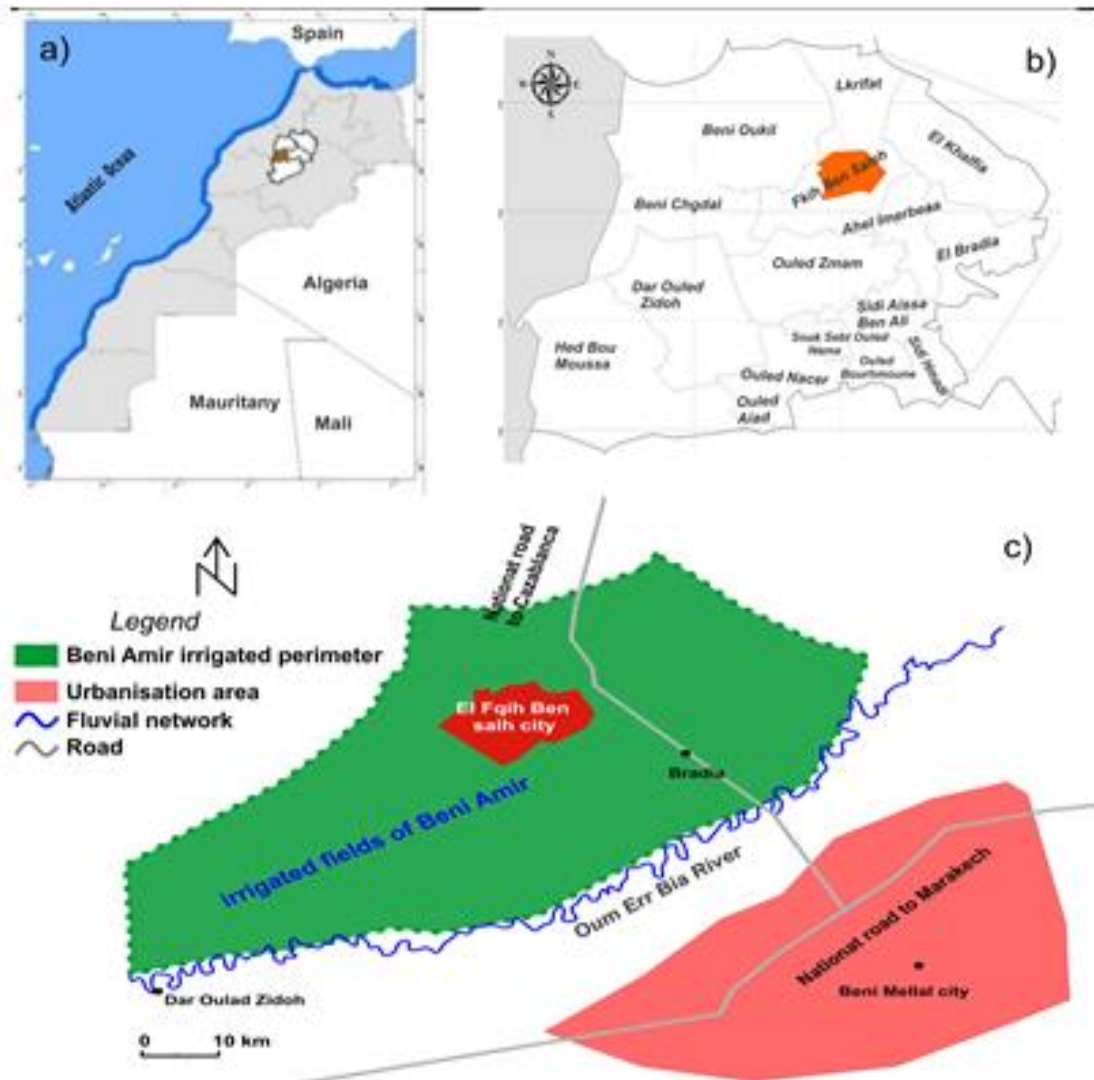
et al., 2004). As urban centers expand and populations burgeon, the conversion of once fertile agricultural lands into built-up environments is becoming more pronounced (Seto et al., 2012). This transformation is accompanied by multifaceted consequences, ranging from the loss of crucial ecosystem services provided by agricultural landscapes to alterations in regional hydrology, biodiversity, and overall environmental quality (United Nations, 2018). Scholars have observed that the complex interplay between urbanization and agriculture necessitates a comprehensive understanding of the social, economic, and environmental factors influencing land use decisions and the subsequent impacts on local communities and ecosystems (Verburg et al., 2011).

To comprehend the nuances of this transformation, a multidisciplinary approach is imperative. Studies have delved into urban planning, land use policies, socioeconomic dynamics, and ecological changes to unravel the intricacies of agricultural landscape shifts in the Mediterranean under the pressure of urbanization (Zhang et al., 2015). Additionally, historical perspectives contribute to tracing the roots of this evolution and provide valuable insights into the adaptive strategies that communities have employed in the face of changing landscapes (Zhou et al., 2020). Against this backdrop, this paper embarks on a journey to explore the transformation of agricultural landscapes in the Mediterranean region amidst rapid urbanization (Su et al., 2011). By drawing upon a spectrum of scholarly works, this study aims to dissect the intricate relationship between urban expansion and agricultural resilience, shedding light on the challenges and opportunities that arise in the wake of such a profound shift (Spalevic et al., 2022). Furthermore, an analysis of policy interventions and best practices from various Mediterranean countries will contribute to the formulation of strategies that reconcile the burgeoning urban footprint with the preservation of vital agricultural resources and heritage. In the subsequent sections, we will navigate through the historical context of Mediterranean agriculture, examine the drivers of urbanization, dissect the impacts of landscape changes on ecosystems and communities, and conclude with a contemplation of potential pathways for sustainable coexistence between urban and rural realms (Ennaji et al., 2022). This exploration underscores the urgency of addressing the transformation of agricultural landscapes under rapid urbanization, not merely as an academic endeavor, but as a vital step towards fostering resilience, conserving heritage, and shaping a sustainable future for the Mediterranean and its diverse inhabitants. The intricate interplay between urbanization and agricultural landscapes has become a crucial focal point in contemporary geographical research. As urban centers expand at an unprecedented pace, the adjacent agricultural territories undergo substantial transformations to accommodate the evolving urban needs. This phenomenon is particularly evident in regions like the Tadla Plain, Morocco, where the rapid urbanization of cities such as El Fqih Ben Saleh has brought forth significant changes to the agricultural fabric. This case study delves into the intricate dynamics of the transformation of agricultural landscapes under the influence of rapid urbanization, with a specific focus on El Fqih Ben Saleh City. By examining the interrelated factors, mechanisms, and consequences of this transformation, this study aims to offer insights into the broader implications of urbanization on agricultural sustainability and land use management.

## MATERIAL AND METHODS

### Study Area

The Tadla plain, situated in central of Morocco, is an expansive synclinal region. Its elevation is around 412 m a.s.l, and it is bordered by distinct features: to the north lies the Phosphates Plateau, to the south is the Central High Atlas of Beni-Mellal, and to the west lies the Tassaout area.



**Figure 1: a) Situation of the study area in Morocco, and b) localization of study area at regional scale, and c) the study area of Beni Amir Irrigated perimeter**

The Oum R'bia River, spanning approximately 180 km, traverses this plain, effectively dividing it into two large irrigated zones with differing hydraulic characteristics: the northern Beni-Amir irrigated field and the southern Beni-Moussa zone. These areas

encompass irrigated surfaces measuring more than 30,000 ha and 70,000 ha, respectively during 2023(Oumenskou et al., 2019),The Tadla plain's climate can be classified as semi-arid continental, with an average annual temperature of around 18.9 °C. Annual precipitation ranges from 382 mm/yr in the plain's northern regions to 578 mm/yr in the south (sourced from The Atlas Mountains). Geographically, the Tadla basin is associated with the Mesetian domain of central Morocco. Its synclinal topography is primarily filled with sedimentary deposits composed mainly of limestone, marls, and sandstone, spanning from the Palaeozoic to Quaternary periods (Knouz et al., 2018). Our research focuses specifically on the Béni-Amir zone, as depicted in Figure 1(a, b).

## METHODOLOGY

The methodology employed in this study, involves a multi-faceted approach to comprehensively assess the effects of urbanization on agricultural landscapes. To track the evolution of the landscape over time, we will leverage Google Earth imagery from 1980, 1998, 2010, and 2022, allowing for the detection and analysis of changes in land use and land cover. This longitudinal analysis will provide insights into the spatial extent and patterns of urban expansion and agricultural transformation.

In tandem with the spatial analysis, climatic data from the Beni Mellal gauging stations spanning the period of 1985, 1998, 2010, and 2022 will be integrated into the study. These climatic records will enable the examination of potential correlations between shifts in agricultural practices and changing climatic conditions over the years. By considering meteorological variables such as temperature, precipitation, and other relevant climatic indicators, we aim to elucidate the interplay between urbanization, agricultural adaptation, and the broader climatic context.

The combination of remote sensing data through Google Earth imagery and historical climatic data will enable a comprehensive understanding of the complex dynamics that underlie the transformation of agricultural landscapes in the Tadla Plain. This mixed-methods approach will facilitate a holistic assessment of the socio-ecological changes taking place, encompassing both the physical alterations of the landscape and the climatic factors that may influence agricultural practices. The findings drawn from this methodology will contribute valuable insights to the discourse on sustainable urbanization, land use planning, and agricultural resilience in the face of rapid urban development (Table.1).

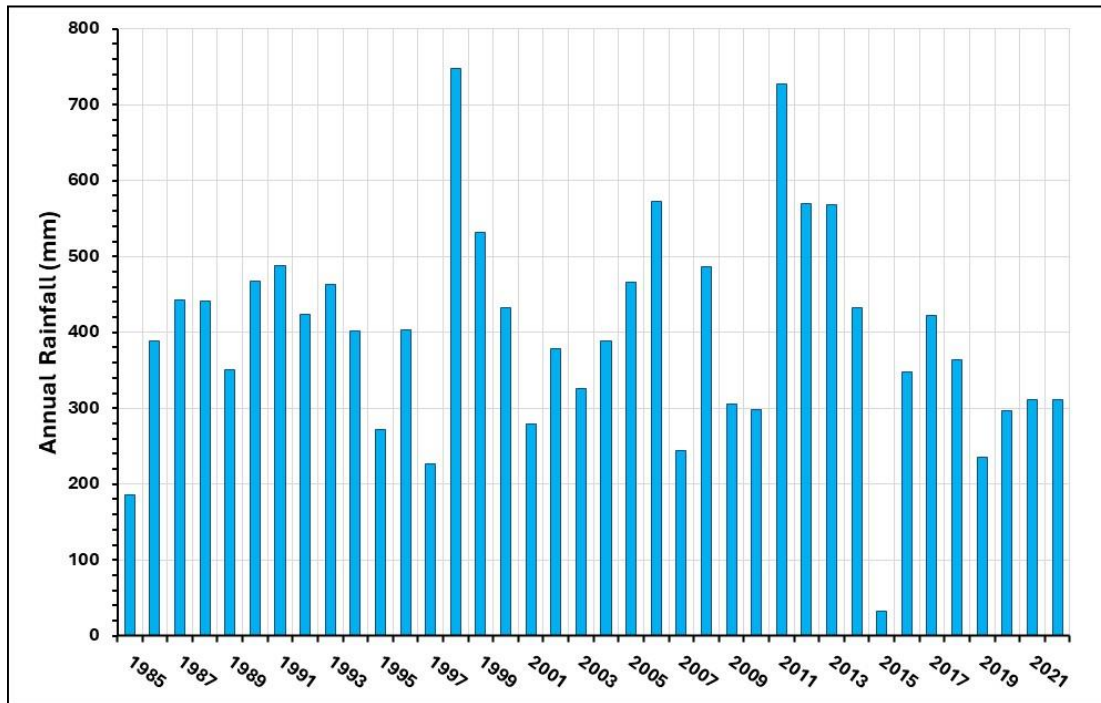
**Table 1 : The Source of Used Data**

Data	Source	Period
Climatic data	Hydraulic Agency of Oum Err Bia ( <a href="http://www.equipement.gov.ma/Actualites/Pages/Actualites.aspx?IdNews=3210">http://www.equipement.gov.ma/Actualites/Pages/Actualites.aspx?IdNews=3210</a> )	1985/2022
Agricultural data	The Chamber of Agriculture of the Beni Mellal Khenifra Region.	2010/2023
Images	Google Earth Imagery	1980/2023

## RESULTS AND DISCUSSION

### The Influence of Climate on the Transformation of Agricultural Landscapes

The provided climatic data of Beni Mellal gauging station represents the total annual rainfall (in mm) for a series of years, started from 1985 to 2022. Analyzing this data in the context of a Mediterranean climate with arid influences, we can observe certain trends and patterns that shed light on the climatic conditions in the region and their impact on the transformation of plains and the development of agriculture.



**Figure 2: Climatic Context of the Study Area during 1985/2022**

The Mediterranean climate is characterized by hot, dry summers and mild, wet winters. However, the presence of arid influences can lead to significant rainfall variability (Ouakhir et al, 2023). Looking at the annual rainfall values in figure 2, we can see notable fluctuations from year to year. Some years, like 1998 with 748 mm and 2011 with 727 mm, experienced relatively high rainfall, indicating periods of increased precipitation (Ouakhir et al., 2022). On the other hand, there are years like 2015 with only 32 mm of rainfall, indicating severe drought conditions. This variability is indicative of the influence of both Mediterranean and arid climatic factors.

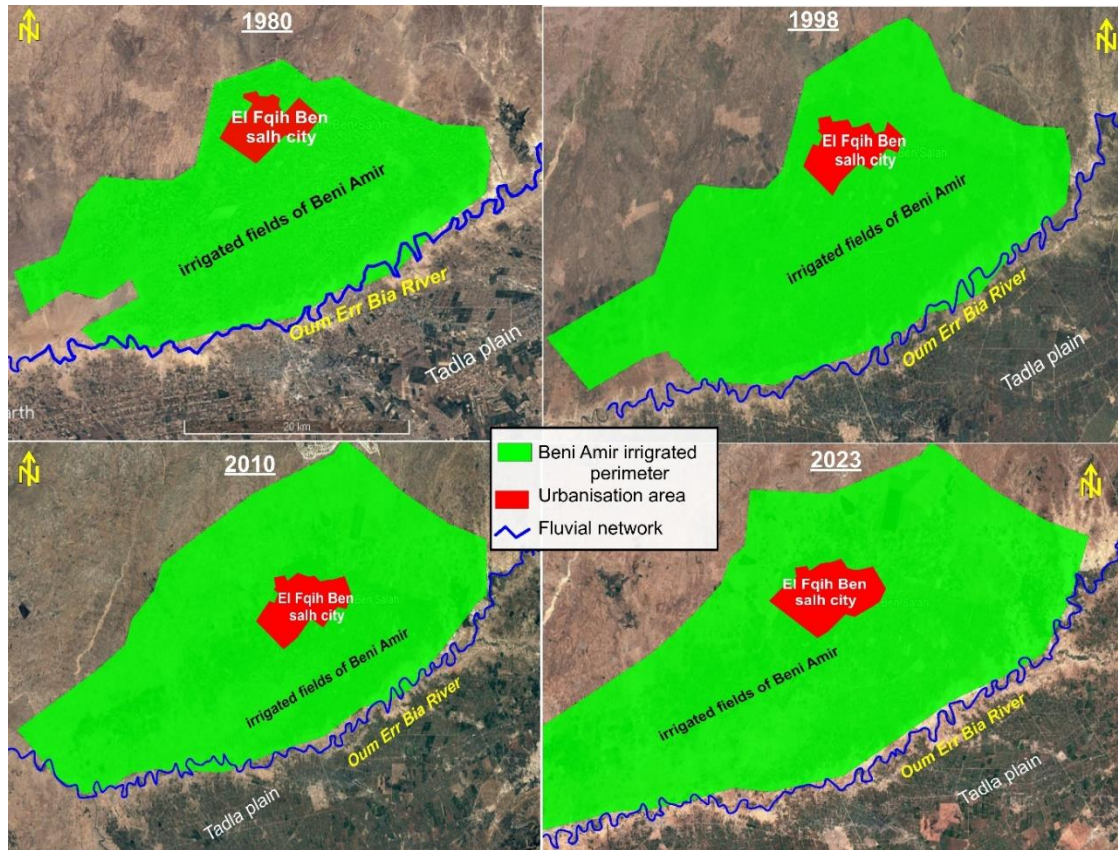
The data showcases periods of higher and lower rainfall. For instance, there appears to be a drier period from around 1995 to 2001, where annual rainfall is consistently below 500 mm. This could have implications for agriculture and water availability. Conversely, there are wetter years, such as 2006 with 572 mm and 2012 with 570 mm, suggesting more favorable conditions for vegetation growth and farming.

The transformation of plains and the development of agriculture are closely tied to the availability of water resources. In a Mediterranean climate with arid influences, water scarcity during dry periods can limit agricultural activities. Insufficient rainfall can lead to drought stress on crops, reduced soil moisture, and even crop failures. On the other hand, periods of higher rainfall can support more productive agricultural practices and contribute to the development of the plains. The variability in annual rainfall highlights the importance of effective water management strategies. This could involve techniques such as rainwater harvesting, efficient irrigation systems, and water storage facilities. These measures are crucial for optimizing agricultural production in regions prone to climatic variability. While the data captures annual fluctuations, it's also important to assess long-term trends. By analyzing data over several decades, researchers and policymakers can identify shifts in precipitation patterns and assess whether there are significant changes in the climate that could impact agriculture and land use planning in the region.

Consequently, the provided climatic data, when considered within the context of a Mediterranean climate with arid influences, demonstrates the variability in annual rainfall over the years. This variability has direct implications for the transformation of plains and the development of agriculture, as it influences water availability and impacts the overall productivity of the region. Effective water management and adaptation strategies are essential for mitigating the challenges posed by the climatic variability in such regions.

### **Relationships between urbanization and the development of agricultural activities in the study area**

The relationships among urbanization and the advancement of agricultural activities within the study area constitutes a significant and multifaceted dynamic. As urbanization progresses, the expansion of cities and infrastructure often encroaches upon available agricultural land, leading to land use conflicts and the potential loss of valuable farming spaces (Ennaji et al, 2021). Simultaneously, urban centers can serve as hubs of economic growth and demand for agricultural products, fostering opportunities for market access and increased agricultural trade. However, the evolving urban landscape might also introduce challenges, such as altered water availability, pollution, and changes in labor dynamics, which can influence the feasibility and nature of agricultural practices. Understanding the relationships between urbanization and agricultural development is paramount for sustainable land use planning, equitable resource distribution, and the formulation of policies that support both urban growth and agricultural vitality.



**Figure 3: Dynamic of Irrigated Area of Beni Amir Perimeter in the Tadla Plain during the Studied Years**

**Table 2: Development of Irrigated and Urbanization Areas in Beni Amir Perimeter**

Area (km <sup>2</sup> )	1980	1998	2010	2023
Beni Amir perimeter	9000	15000	25000	33000
Urbanisation area	13.2	22.4	25.6	32.3

As a result, the presented figure 3 and table 2 reveal a transformative trend in the irrigated areas of Beni Amir within the Tadla Plain, Morocco. From 1980 to 2023, the Beni Amir perimeter underwent a substantial expansion, increasing from 9000 to 33000 km<sup>2</sup>. This transformation indicates a significant growth in agricultural land, potentially driven by advancements in irrigation practices and a growing demand for agricultural produce. Concurrently, urbanization displayed a parallel rise, with urbanized regions expanding from 13.2 km<sup>2</sup> in 1980 to 32.3 km<sup>2</sup> in 2023.



**Figure 4: Agricultural Landcape from Tadla Plain (Morocco)**

This points toward ongoing urban development, potentially fueled by economic opportunities and population influx. The correlated expansion of both agricultural and urban areas underscores the need for sustainable development strategies to balance the demands of agriculture, urban growth, and environmental preservation (Figure.4). Such comprehensive planning is essential to ensure the long-term prosperity of the region while mitigating potential environmental and resource challenges stemming from this growth.

#### **Discussion on factors controlling the expansion of agricultural areas in Beni Amir perimeter**

The discussion on factors governing the expansion of agricultural areas within the Beni Amir perimeter encompasses multifaceted dynamics that have shaped land use transformations in the region. The remarkable increase in the Beni Amir perimeter from 1980 to 2023, as evidenced by the data (Beni Amir perimeter: 9000 km<sup>2</sup> in 1980 to 33000 km<sup>2</sup> in 2023), suggests a profound shift in agricultural practices and land allocation. This expansion could be attributed to several interconnected factors, such as advancements in irrigation techniques, changes in land management strategies, and evolving market demands for agricultural products. Furthermore, the parallel rise in urbanization areas underscores the potential interplay between urban development and agricultural expansion, signifying the complex relationship between land use changes and socio-economic drivers (Nikolic et al., 2019). However, these expansions necessitate careful consideration of sustainable land use planning to ensure equilibrium between agricultural growth, urbanization, and environmental conservation (Spalevic et al., 2020). As scholars have previously highlighted, sustainable land management strategies that integrate ecological and socio-economic dimensions are crucial in managing such transformations (Smith et al., 2019; García-Valiñas et al., 2020). In conclusion, comprehending the factors



steering the expansion of agricultural areas in the Beni Amir perimeter is pivotal for informed decision-making, where a holistic perspective is needed to address the intricate interactions shaping the region's future.

## CONCLUSION

In conclusion, this article underscores the urgency of addressing the transformation of agricultural landscapes under rapid urbanization in the Mediterranean region. By examining the case of Beni Amir irrigated area in Morocco, the study provides valuable insights into the complex interactions between urbanization and agricultural resilience, offering pathways for sustainable coexistence and effective land use management in the face of urban expansion.

The expansion of agricultural areas within the Beni Amir zone is influenced by factors such as advancements in irrigation techniques, changes in land management strategies, and evolving market demands for agricultural products. Addressing these factors is crucial for informed decision-making to achieve a harmonious coexistence between urban and rural realms in the context of changing landscapes.

## Acknowledgements

We extend our sincere gratitude to the Chamber of Agriculture of the Beni Mellal Khenifra Region for their invaluable contribution in providing essential agricultural data for our research. Their support has been instrumental in enhancing the depth and quality of our study on the transformation of agricultural landscapes under rapid urbanization.

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