RE-CORKING THE MAÂMORA

Designing a Regional Landscape Framework for Spatial Development and Forest Conservation



Msc thesis by Jesper Groothoff

Re-corking the Maâmora

Designing a Regional Landscape Framework for Spatial Development and Forest Conservation

Master Thesis Report

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All figures are made by author unless stated otherwise

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Abstract

The long-term conservation of the Maâmora forest requires looking beyond the forest boundaries. Human pressures, including urban expansion, agricultural intensification, and forest resource exploitation, have contributed to the decline of cork oak cover. Although previous research has extensively documented these drivers, less attention has been given to how these challenges can be addressed through spatial planning and design. This thesis therefore explores how a landscape-based design approach can provide a framework that guides spatial development in the Rabat–Salé–Kénitra region while supporting the protection and restoration of the Maâmora forest.

The research combines landscape analysis, precedent studies, and design experiments across three spatial scales. It analyses the environmental and anthropogenic pressures contributing to forest decline to identify the main challenges and opportunities of the region. It then translates lessons from three precedents into adaptable design principles and uses these to develop a large-scale strategic vision, a regional landscape park framework, and a detailed design of a productive green belt. The designs focus on strengthening ecological and social connectivity, protecting productive landscapes, and accommodating competing land uses through transitional landscapes.

The thesis demonstrates how landscape-based regional design can provide a spatial structure that guides future development while supporting ecological conservation. In this way, the surrounding peri-urban landscape can become part of the strategy for the long-term protection and restoration of the Maâmora forest, rather than continuing to contribute to its decline.

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01 INTRODUCTION

1.1 Research context

Urban expansion and ecological decline

Urbanization, the process by which an increasing number of people move to cities, is one of the most rapid transformations shaping the modern world. It is often a beneficial process, contributing to economic development, technological innovation, and improved standards of living (Mukherjee & Bairwa, 2025). However, when urban growth occurs without sufficient planning or regulation, it can lead to severe and irreversible environmental consequences. Urban development usually generates high levels of pollution, including greenhouse gas emissions, untreated sewage water, and solid waste, which degrade air and water quality and threaten biodiversity (Mukherjee & Bairwa, 2025). Moreover, as cities grow outward, they consume agricultural land and natural habitats that provide essential ecosystem services that support urban life. In addition to providing food and water, these ecosystems regulate temperature, maintain air quality, and manage stormwater runoff. However, these regulatory functions are increasingly compromised by uncontrolled urbanization (Elmqvist et al., 2015). Figure 1 illustrates this twofold relationship between urban expansion and increased vulnerability to climate threats.

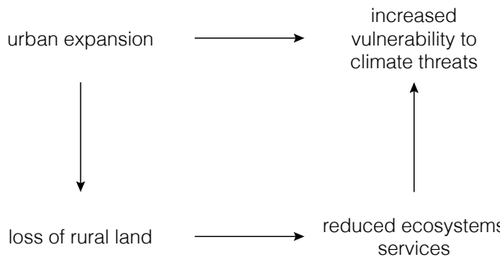


Figure 1. The twofold relationship between urban expansion and vulnerabilty to climate-related threats

Environmental degradation resulting from urbanization poses serious risks not only to natural systems but also to human health and livability. The high concentration of population and infrastructure in cities increases the impact of climate-related threats. Events as flooding and storms can damage urban infrastructure, deteriorate water quality, and increase the spread of diseases. At the same time, dense urban environments intensify the urban heat island effect, increasing heat-related illnesses and mortality among vulnerable populations (Das et al., 2024). The interconnectedness of urbanization and climate-related challenges highlights the need for an integrated approach that prioritizes sustainable urban planning, green infrastructure development, and climate adaptation strategies to safeguard both environmental systems and human well-being (Das et al., 2024).

Urbanization in Morocco

As a developing country, Morocco has experienced rapid urbanization over recent decades. Cities have expanded considerably due to large-scale rural-to-urban migration. This process is driven by a combination of population growth, economic development, government policies, and infrastructure improvements (Zahra et al., 2025). The Rabat–Salé–Kénitra (RSK) region in northwestern Morocco is one of the country's fastest urbanizing regions (fig. 2 & 3). Its strategic position along the Atlantic coast and the presence of the capital city Rabat, make the region an important economic and administrative center (Loulad et al., 2023). The region covers an area of 18,194 km² and has a population of over five million inhabitants, resulting in a relatively high population density. A study by Loulad et al. (2023) shows that urban expansion in the RSK region has been rapid and unevenly distributed, with large impact on surrounding agricultural and natural landscapes. On top of that, urban sprawl has led to the emergence of new urban agglomerations at the expense of rural communes. So far, policies for regulating urban growth and promoting sustainable development have been insufficient. As a result, ongoing urbanization has contributed to landscape fragmentation and environmental degradation in the region.

To address this, this thesis explores the potential of a regional strategy that combines urban development and ecological conservation. Such an integrated approach supports sustainable development, while limiting further land degradation. A landscape-based approach provides a framework based on existing landscape structures, while leaving space for flexibility. Ultimately, this approach could contribute to a more sustainable and multifunctional landscape. Applying a regional landscape-based approach in the RSK region can protect vulnerable landscapes that provide essential ecosystem services necessary for sustainable urban growth.



Figure 2. The location of the RSK region in Morocco.
Map created using Google Satellite imagery.

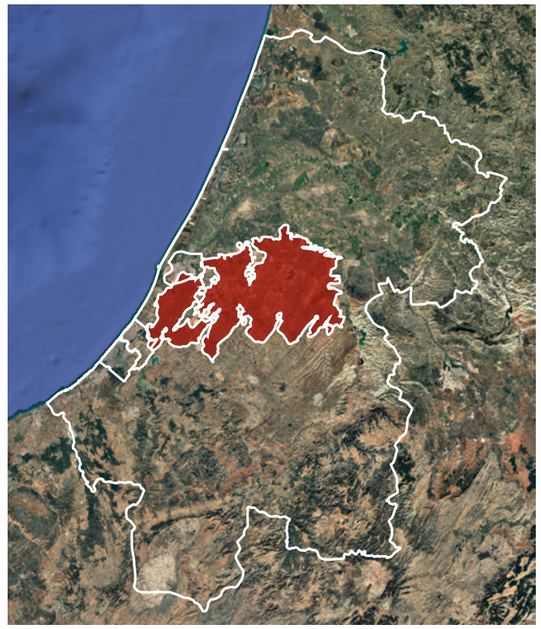


Figure 3. The Maâmora forest in the RSK region.
Map created using Google Satellite imagery.

Problem Statement

The Maâmora forest, once the world's largest contiguous cork oak forest, has been in decline since the early 20th century. From a potential extent of 300,000 hectares, only about 60,000 hectares of cork oak remain today, with the climax stage almost absent (Noumonvi et al., 2017; Malki et al., 2022; Ghouldan et al., 2024).

The forest plays an important ecological, economic, and social role for the Rabat–Salé–Kenitra region and for Morocco as a whole, providing resources such as timber, acorns, cork, pasture, and opportunities for recreation. However, overexploitation of forest products and intensive grazing have exceeded the forest's regenerative capacity, making natural regeneration nearly impossible (Laaribya & Alaoui, 2014). In addition, previous regeneration failures have led to the replacement of cork oak with pine, acacia, and eucalyptus plantations, altering the ecosystem and reducing biodiversity (Noumonvi et al., 2017).

At the same time, ongoing urban expansion and agricultural land conversion along the forest edge continue to reduce and fragment the remaining cork oak cover. These developments are accompanied by a growing water demand from nearby cities and farms, resulting in increased groundwater extraction and reduced water availability for vegetation. The forest also serves as a recreational area for the surrounding population, but the lack of appropriate infrastructure and management leads to additional ecological disturbance (Fennane & Rejdali, 2015).

On top of that, because the Maâmora forest is located at the southern limit of the cork oak's natural range, it is particularly vulnerable to climate change. Rising temperatures, more frequent droughts, and subsequent soil erosion threaten the long-term stability of the sandy landscape (Mitique et al., 2025). Without effective intervention, future climate scenarios predict further decline and a potential collapse of the Maâmora ecosystem (Noumonvi et al., 2017).

1.2 Research framework

Relevance

Previous research has extensively documented the decline of the Maâmora forest and identified the factors contributing to its degradation. These studies provide important knowledge about the ecological condition of the forest and the pressures affecting its regeneration. However, much of this research focuses on individual aspects of forest decline. Less attention is given to how these challenges can be addressed together through spatial planning and design.

This research approaches the problem from a landscape architectural perspective. It considers the decline of the Maâmora forest in relation to the development of the surrounding areas. The research adds a design-oriented perspective to the existing knowledge on the Maâmora forest, shifting the focus from identifying problems to exploring ways to address them. It also contributes to the broader field by providing insights into the use of a landscape-based approach in peri-urban regions facing similar challenges.

Research aim

The peri-urban interface between the cities of Rabat, Salé and Kénitra, and the Maâmora forest is a key zone where urban growth, agricultural intensification, and ecological degradation coincide. Here, competing land uses challenge the balance between urban development and ecological conservation, indicating the need for an integrated strategy. This research aims to develop a landscape-based spatial strategy that can guide the development of the area and support the protection, restoration, and long-term resilience of the Maâmora forest within the wider regional landscape.

Research objective

To achieve the research aim, the thesis uses a landscape-based approach to develop a strategy that works across different scales. The objective is to combine ecological, agricultural and urban systems in one coherent spatial framework. Within this framework, the concept of a regional landscape park is used to guide land use transitions, support ecological restoration, and strengthen the spatial relationship between the Maâmora forest and the surrounding territory.

Research questions

The main research question of this thesis is:

How can a landscape-based approach guide the spatial development of the Rabat–Salé–Kénitra region while supporting the protection and restoration of the Maâmora forest?

To answer the main research question, the research is divided into four sub-questions. The first question aims to understand the landscape and its processes in order to discover the main challenges and opportunities. The second question looks into existing design strategies that can address the defined challenges. The third question focuses on the spatial translation of the identified strategies. The final question considers how the findings contribute to the field of study and how they may be applied in a broader context.

Sub-questions:

- *What environmental and anthropogenic factors drive the decline of the Maâmora forest, and how do they relate to regional urbanization and land-use dynamics?*
- *What landscape-based planning and design strategies address landscape conservation in relation to spatial development, and how can these strategies be translated into design principles?*
- *How can these design principles be translated into a spatial framework that structures land use and strengthens ecological and social connectivity around the Maâmora forest?*
- *What lessons can be learned from using a landscape-based strategy to mediate between urban development and ecological conservation?*





Figure 4. Cork oak trees in the Maâmora forest.

1.3 Reading guide

The report is structured into several chapters. The first chapters introduce the topic of the thesis and explain the research approach. The following three design chapters then cover three different spatial scales, starting with the largest scale and gradually zooming in. These chapters follow the same structure. First, the site is analyzed to identify the main challenges and opportunities. A relevant precedent is then carefully selected and studied to understand how similar challenges have been addressed in practice. The analysis of the precedent is included as a separate booklet within the respective chapter. The findings from both the site analysis and precedent study are translated into a set of six design principles, which guide the design at each of the three scales.

1. Introduction

The introduction first discusses urbanization and its environmental consequences. It then relates these processes to Morocco and more specifically to the Maâmora forest. The decline of the forest is introduced as the main problem of the thesis. This is followed by the research relevance, aim, and objective, followed by the main research question and four sub-questions that structure the research.

2. Research approach

This chapter explains the theoretical and methodological framework of the thesis. First, the theory of landscape-based urbanism is introduced, including how it operates and how it is applied in the thesis. The concept of a regional landscape park is then discussed as a possible spatial application of this approach. The methodology explains the relationship between research and design and introduces the methods used throughout the thesis. The research is divided into three spatial scales, with the same research and design cycle applied at each scale.

3. The Maâmora Forest

This chapter studies the Maâmora forest at the largest scale. It first describes the main landscape conditions, including climate, vegetation, soils, hydrology, and land use, as well as the role of the forest within the wider region. The decline of the cork oak forest is then studied in more detail and the main environmental and anthropogenic drivers are identified. The findings are brought together in a spatial synthesis. Together with insights from studying the Serra de Collserola Natural Park, the spatial synthesis forms the basis for the design principles and the large-scale vision for the forest. The resulting vision proposes a spatial structure for the Maâmora forest and its surroundings and identifies the western forest edge as the location for a regional landscape park.

4. West-Maâmora Landscape Park

This chapter zooms in on the western edge of the Maâmora forest, where the regional landscape park is developed. Existing land uses and ongoing urban expansion are analyzed to identify the main challenges and opportunities within the area. A structural analysis then examines the existing network of open spaces and identifies three spatial structures that can form the basis of the park. Additionally, a detailed study of the Parc Agrari del Baix Llobregat informs the design principles for this scale. These principles guide the development of a regional framework consisting of three complementary layers, which are then applied to the landscape.

5. Productive Green Belt

The final design chapter covers the smallest scale. One of the productive green belts directly north of Salé is selected to test how the regional framework can be translated into a more detailed landscape design. The site analysis examines the existing land uses, landscape structures, and important stakeholders in the area. The Agdal of Marrakech is studied as a precedent for the organization of productive landscapes and irrigation systems. The resulting design principles guide the design of the green belt, in which the water system becomes the main structuring element. Two locations within the green belt are then designed in more detail to show how the principles can be applied at a smaller scale.

6. Discussion and Conclusion

The final chapter discusses the main findings of the research, its limitations, and transferability to other contexts. It also reflects on the research and design process, including the challenges encountered and lessons learned. Finally, the conclusion answers the research questions and considers the potential of a landscape-based approach to mediate between forest conservation and spatial development.

RESEARCH APPROACH

02

2.1 Landscape-based urbanism

This thesis uses landscape-based urbanism as the main theoretical approach. Landscape-based urbanism is an approach in which the landscape serves as the foundation for sustainable urban development. Urban structures are not developed independently, but respond to the existing conditions of the landscape. Physical landscape structures and natural processes therefore play a central role in guiding spatial transformations (Nijhuis, 2022). The approach brings together nature, people, and history. Understanding these relationships requires knowledge from different disciplines, including landscape architecture, urban planning, hydrology, ecology, and the social sciences (Nijhuis, 2024). Based on this understanding, landscape-based urbanism guides development towards suitable locations and organizes different functions and relationships within the landscape. This is achieved through robust landscape structures that provide a long-term spatial framework for the region. At the same time, these structures remain flexible enough to accommodate local interventions and changing conditions. The approach therefore operates across different scales, from regional strategies to more specific local measures (Nijhuis, 2024).

Four perspectives of landscape-based urbanism

Nijhuis (2024) distinguishes four perspectives that together explain how landscape-based urbanism approaches design:

Designing with nature

Natural processes such as erosion, sedimentation, and vegetation succession continuously shape the landscape. Designing with nature means understanding these processes and using them as part of the design. Instead of working against existing ecological conditions, the design responds to how the landscape functions and creates conditions in which natural systems can develop. Restoration, management, and ecological succession can then be used to strengthen these systems over time.

Designing for people

Designing for people means creating public spaces that contribute to healthy and livable urban environments. These include parks, natural areas, water, and other forms of open space. Rather than functioning as separate elements, these spaces can form connected networks that structure the city and link it to the surrounding landscape. Such networks provide space for recreation and social interaction while also supporting biodiversity and climate adaptation. To function well for people, public spaces should be accessible, respond to local conditions, and be designed at a human scale.

Designing with history

Designing with history starts by understanding how the landscape has developed over time. The landscape can be understood as a palimpsest, where traces from the past remain visible. Together, these historical layers contribute to the identity of a place and should be considered when designing. Historical land-use practices can also provide useful knowledge about agriculture, water management, and the relationship between people and natural systems.

Architecture of space

The architecture of space focuses on how the landscape is perceived and experienced while moving through it. Characteristics such as scale, proportion, rhythm, and contrast can be used to create recognizable and varied landscapes. Routes are especially important because they guide movement and determine how the landscape is experienced over time. As people move through the landscape, different spaces and views are revealed in sequence, creating a continuous spatial experience rather than a single static image.

Layered approach

Landscape-based urbanism starts by looking at how the landscape functions as a system. It is about understanding the dynamic relationship between natural and human processes. One way to study this is through a layered approach. Nijhuis (2022) distinguishes three main layers that together explain how the landscape has developed and how it functions. These layers are not separate or fixed, as they continuously influence one another.

- The first layer is the natural context, which includes relief, water, soil, geology, climate, and the corresponding ecosystems. These conditions change slowly and form the physical basis of the landscape.
- The second layer consists of human modifications and interventions. Human activity changes the landscape through the construction of settlements and infrastructure, altering the water system and cultivation of the land. Successive occupation patterns have changed the natural landscape over time.
- The third layer concerns culture, organization, and politics. This layer includes sociocultural values, technology, planning systems, and design ideas that influence how the landscape is understood and used.

Landscape-based regional design

Landscape-based regional design applies the analysis of landscape systems at the regional scale. Natural and urban systems are studied together to understand the structure and functioning of the region. This regional perspective makes it possible to coordinate urban development while protecting important natural resources. Landscape can be used to guide urban development at different levels. Natural conditions such as soil and water directly determine where development can take place. Networks of natural areas or historical structures can also influence development by providing a spatial framework around which urban development can be organized. At a local level, landscape can serve as a source of inspiration. Existing landscape characteristics can, for instance, inform the layout of housing areas or green structures (Nijhuis, 2024).

The aim of regional design is to develop a long-term vision that addresses the main challenges and opportunities of the region. Rather than prescribing a fixed end result, the vision should be a spatial framework that responds to changing conditions and uncertainty over time (Nijhuis, 2022). The regional vision should also be able to be translated into small-scale projects. Adaptive design principles link the regional strategy with local interventions. These principles express general spatial ideas that can be adjusted to different conditions while maintaining the overall objectives of the regional vision. Local projects can test how the design principles work in practice. In this way, regional design connects large-scale strategies with local actions. Nijhuis (2024) summarizes this principle as “thinking globally, planning regionally, and then acting locally.”

Regional landscape parks

Regional landscape parks are one way to implement landscape-based urbanism. They can be used to protect and develop the spatial, ecological, and cultural qualities of metropolitan areas. As a planning concept, regional landscape parks use local and site-specific qualities as the basis for regional projects (Nijhuis, 2007). The regional park concept functions as a multi-layered strategy for urban development, sustainable agriculture, and biodiversity protection. Regional parks connect public open spaces into a spatial framework that links cities, landscapes, and users, while preserving the differences between urban, rural, and natural areas. In this way, they function both as connective and protective structures (Nijhuis, 2007). Overall, their aim is to integrate ecological conservation with sustainable land use and socio-economic development (EUROPARC Federation,

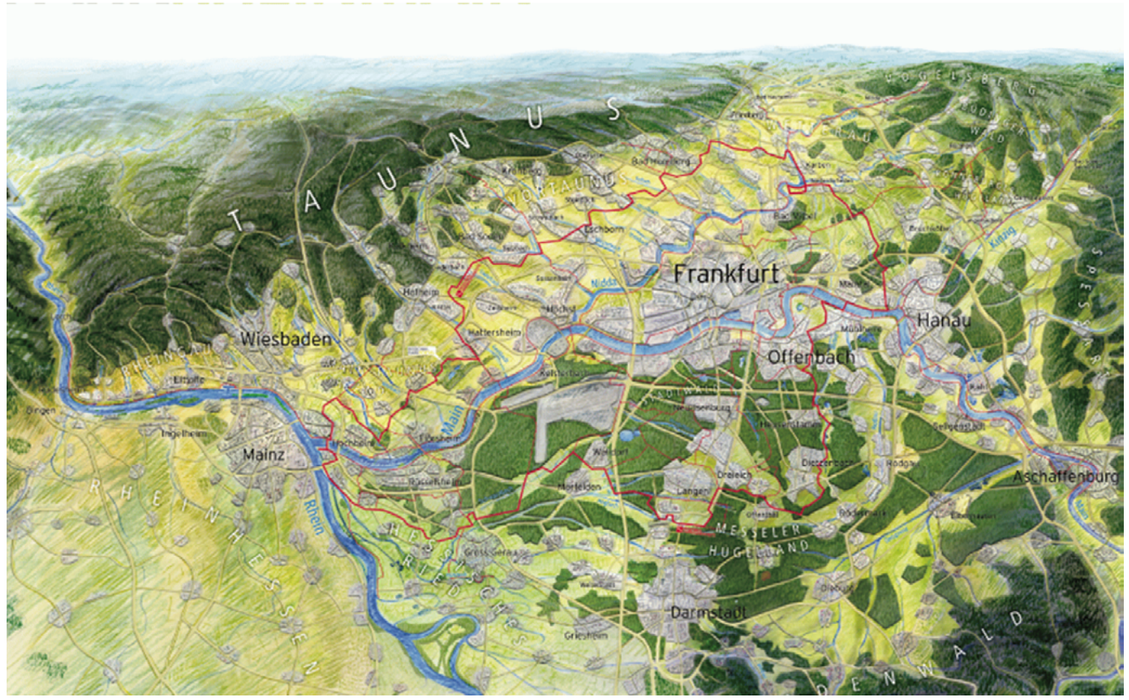


Figure 5. Panorama map of the Rhein-Main Regional Park (Unit-design, n.d.).

2020), resulting in multifunctional landscapes that address both environmental challenges and societal needs.

An example of a regional landscape park is the Rhein-Main Regional Park in Germany. The park combines agriculture, forestry, environmental protection, and recreation within one regional framework (fig. 5). It is organized as a network of open spaces connected by walking and cycling routes. Local interventions strengthen this network by completing missing links and creating new destinations. These destinations highlight the cultural, historical, and recreational qualities of the landscape and include historical sites, vineyards, public artworks, gardens, industrial heritage, and restaurants (Nijhuis, 2007). The Rhein-Main Regional Park shows how the concept of a regional landscape park can be translated into practice through a network of open spaces, routes, and local projects.

Application

As described in the problem statement, the decline of the Maâmora forest is caused by a combination of ecological and anthropogenic pressures. These pressures are interconnected and therefore require an integrated spatial approach. Landscape-based urbanism provides such an approach by bringing ecological conservation, agricultural production, and urban development together within one regional strategy. Its ability to work across different spatial scales also makes it suitable for addressing both regional and local challenges. By responding to the specific conditions and dynamics of the landscape, this approach can support a more resilient and context-specific development of the Maâmora region.

2.2 Research methodology

Iterative design approach

The research follows a research through design approach based on the iterative design process described by Nijhuis & De Vries (2019). The process consists of three interconnected phases: analysis, synthesis, and evaluation. The overall research process and the relationships between these phases are shown in figure 6.

During the analysis phase, information is collected and interpreted to better understand the study area and the design context. The main challenges and opportunities are identified to determine where and how the design should be applied.

The synthesis phase translates the findings of the analysis into design ideas. Different possibilities are explored, combined, and developed through an iterative process that results in a coherent context-specific design.

The evaluation phase assesses the design proposal in relation to the objectives of the project. The outcomes of this assessment can lead to further adjustments of the design.

These phases form an iterative process in which analysis, design ideas, and objectives can be refined throughout the research. Nijhuis & De Vries (2019), describe this as a continuous dialogue between the problem and possible solutions.

Relationship between research and design

Within the process, different relationships between research and design are applied. Research for design provides knowledge that directly informs the design. In this thesis, this mainly consists of literature research, site analysis, mapping, and field observations used to identify the existing conditions, challenges, and opportunities.

Research on design focuses on studying existing projects that can inform the design process. These precedent projects are analyzed to identify relevant spatial concepts, strategies, and design principles.

Research through design uses designing itself to explore possible solutions. Different spatial concepts and configurations are tested through design experiments. These experiments help to translate the findings from the analysis and precedent studies into context-specific spatial solutions.

Together, these research modes support the three phases of analysis, synthesis, and evaluation. Research for design and research on design mainly provide input for the analysis and synthesis phases, while research through design is used to develop, test and refine possible solutions. The resulting designs are subsequently evaluated in relation to the research questions and objectives of the thesis.

Application at three spatial scales

The iterative research process is applied at three spatial scales. At each scale, site analysis and precedent research are combined to identify challenges and opportunities and to develop a set of design principles. These principles are then tested and translated into a spatial design through design experiments. The outcome of one scale forms the starting point for the next, allowing the research to move progressively from a regional strategy to a detailed landscape design.

The first scale involves the Maâmora forest region. The site analysis examines the topography, geology, soils, climate, hydrology, vegetation, and land use of the region. Literature research is used to understand the environmental and anthropogenic drivers behind the decline of the forest, as well as regional urbanization and land-use dynamics. Spatial information from these sources is interpreted through GIS mapping. The results are brought together in a site synthesis that identifies the main challenges and opportunities of the region. The Serra de Collserola Natural Park is then studied as a precedent for the relationship between ecological protection and urban development. The findings of the analysis and precedent study are translated into design principles and tested through design experiments. This results in a strategic vision for the Maâmora forest and its surroundings.

The second scale focuses on the western Maâmora landscape between Rabat–Salé, Kénitra. Here, the site analysis examines existing land-use patterns, as well as infrastructure, open spaces, ecological connections, and other landscape elements. A site visit provides additional observations of the Maâmora forest edge and its relationship with adjacent urban areas. These findings are synthesized to identify the structures that could form the basis of the regional landscape park. The MultiPark proposal for Parc Agrari del Baix Llobregat is studied as a precedent for organizing productivity, connectivity, and biodiversity goals within a regional park. The resulting design principles are tested through design experiments and translated into the spatial framework of the West-Maâmora Regional Landscape Park.

The third scale focuses on a the peri-urban landscape north of Salé. The analysis examines the existing land use, plot structure, infrastructure, water system, and other landscape elements of the site. The Agdal of Marrakech is studied as a precedent for the organization of productive landscapes through water infrastructure. The findings are translated into design principles for the productive green belt. These principles are then adapted to the local conditions through design experiments, resulting in a detailed landscape design.

Finally, the outcomes of the three design scales are evaluated in relation to the main research question and the design objectives of the thesis. The evaluation reflects on how a landscape-based approach can mediate between ecological conservation, agricultural production, and urban development. It also considers the limitations of the proposed strategy and the extent to which its principles could be applied to similar peri-urban landscapes.

Pre study
Site analysis of the RSK-region;
Climate issues in the RSK-region;
Urban development in the RSK-region

Problem statement
The Maâmora forest is declining due to increasing anthropogenic and environmental pressures

MRQ How can a landscape-based approach guide the spatial development of the Rabat–Salé–Kénitra region while supporting the protection and restoration of the Maâmora forest?

Theoretical framework
Landscape-based urbanism

Research for design

SQ 1 What environmental and anthropogenic factors drive the decline of the Maâmora forest, and how do they relate to regional urbanization and land-use dynamics?

Research on design

SQ2 What landscape-based planning and design strategies address landscape conservation in relation to urban development, and how can these strategies be translated into design principles?

Research through design

SQ3 How can these design principles be translated into a spatial framework that structures land use and strengthens ecological and social connectivity around the Maâmora forest?

SQ4 What lessons can be learned from using a landscape-based strategy to mediate between urban development and ecological conservation?

Scale 1
Maâmora forest region

Literature review
Causes of the decline of the Maâmora forest; Urbanization trends in the RSK-region; Land use dynamics

Site analysis
Topography, Geology, Soils, Climate, Hydrology, Vegetation, Land use

Precedent study
Serra de Collserola Natural Park

Design experiments

Strategic vision for the Maâmora forest

Scale 2
West-Maâmora Landscape Park

Site analysis
Urban development patterns, Land use, Landscape structures

Site visit
Maâmora forest border

Precedent study
Parc Agrari del Baix Llobregat

Design experiments

Spatial framework for the West-Maâmora Landscape Park

Scale 3
Productive green belt

Site analysis
Topography, Land use, Landscape structures

Precedent study
The Agdal of Marrakesh

Design experiments

Detail design of a productive green belt north of Salé

Site synthesis

Design principles

Spatial design

Design evaluation

Figure 6. Methodology diagram showing the research and design process.

THE MAÂMORA FOREST

03

3.1 Site analysis

The Maâmora is located in the northwestern part of Morocco along the coast of the Atlantic Ocean between the cities Rabat-Salé and Kenitra (see fig. 3). It covers approximately 132,000 hectares, making it the largest contiguous cork oak forest in the world (El Boukhari et al., 2015; Fennane & Re¬jdali, 2015). From west to east, the forest spans about 60 km, and from north to south it measures around 30 km. The forest can be divided into five cantons that are separated from each other by waterways. They are designated from west to east by the letters A, B, C, D and E. (Aafi, 2007) (fig. 8).

Topography and geology

The topography of the Maâmora forest is predominantly flat. Altitudes range from 8 m in the west to 300 m in the east. In the western part, the forest consists of ridges and depressions. They run southwest to northeast, parallel to the coastline. These undulations gradually attenuate toward the east, transitioning into a plateau with a relatively even, gently sloping surface (Ghouldan et al., 2025).

To the west, red continental sands have fossilized ancient Maghrebian dunes, forming large limestone-like ridges. To the east, these sands mix with pebbles and align with marine Pliocene deposits. In the north, the red formations are thick. They thin toward the south.

The forest sits on a large sandy formation. In the west, this sand forms dune ridges. Some of these dunes have a rugged, eroded surface, similar to limestone. Further east, the sand becomes mixed with pebbles. (Aafi, 2007).

Soils

The soils of the Maâmora forest are relatively homogeneous and are predominantly composed of sand over clay. Two type of sands can be distinguished (Aafi, 2007). Beige sands with little to no clay and silt particles and therefore poor water retention. And red sands, that contain iron oxide and comparatively more clay and silt and retain more water. All sands are siliceous and acidic. The thickness of the sandy surface layer ranges from 50 cm to 4 m. Thicker sand layers generally mean lower water availability for vegetation. Beneath this layer sits a compact red clay layer whose thickness varies from about 1 m in the southwest to more than 10 m in the center. Beneath this clay layer lies an impermeable marly-clay layer that retains the water table (Bernoussi, 1982).

Based on these criteria, Aafi (2007) distinguishes four main soil types:

- Thin beige sands over clay that retain moisture in winter but drain quickly on slopes. They are common in the southern parts of cantons C, D, and E.
- Thick beige sands over clay that have much thicker sand layers (up to 6–7 m). These soils become extremely dry in summer.
- Beige and red sands over clay with a surface layer of beige sand over red sands on top of red clay. These soils have a better water balance, because of the red sand.
- Hydromorphic soils in flat areas with poor drainage. These soils can become waterlogged in the wet season (see fig 9.).

Organic matter in the soil depends heavily on the presence of forest cover (Aafi, 2007). In areas with dense forest cover organic matter content is higher than in open areas where humus layer is entirely absent.

Climate

The study area has a Mediterranean climate, strongly influenced by the Atlantic ocean. Average maximum temperatures range from 11 °C in January to 34 °C in August. Rather than four distinct seasons, the area has two main periods: a wet period lasting 6 to 9 months, and a dry period lasting 3 to 5 months. The dry season generally begins in late April or early May and ends in October. Most rain falls in November and December (Aafi et al., 2005). Besides rainfall, fog and dew are important extra water sources for the cork oak forest (Fennane & Rejdali, 2015).

Climatic differences exist between the western and eastern parts of the forest. Rainfall amounts decrease from the coast toward the interior, but altitude appears more decisive for some stations. The annual rainfall in the west is about 600 mm, compared to 450 mm in the east. In the western part atmospheric humidity is high, because of the influence of the ocean, whereas in the east this influence is negligible. Drought conditions



Figure 7. Typical red sand of the Maâmora forest.

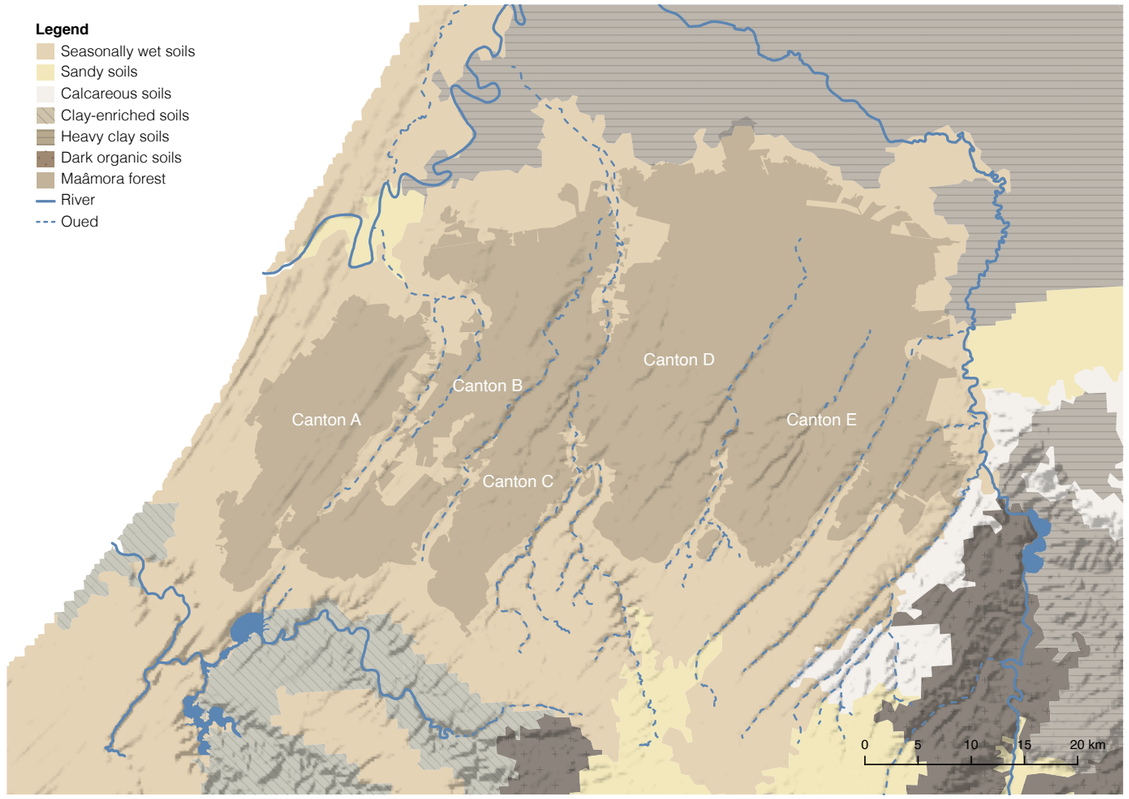


Figure 8. Regional analysis map of the Maâmora landscape showing soil types and surface water network.

are more severe in the eastern part compared to the western part as well. Overall, The western part of the forest belongs to a subhumid, while the central and eastern parts fall within a semi-arid bioclimate. (Aafi, 2007).

Hydrology

The Maâmora's hydrological network is limited. This results from the high permeability of the soil and low annual rainfall, which favor intermittent streams and temporary oueds. Five oueds flow from south-southwest to north-northeast. They separate the five forest cantons and drain surface water toward the Gharb plain. These are Oued Fouarat, Oued Foui, Oued Smento, Oued Tiflet, and Oued Touirza. Only Oued Tiflet is perennial. The other oueds play only a local role, during the rainy season. Their limited flow is explained by the small size of their catchment areas and the low surface runoff on sandy soils covered with vegetation. In addition, there are numerous dayas, which are temporary ponds formed by the accumulation of rainwater in depressions in the landscape (Lepoutre & Combes, 1967).

The Maâmora aquifer lies underneath the forest and is contained within the sandy soil and rests on the impermeable clay layers. It is relatively shallow and of limited thickness, which restricts its storage capacity. Groundwater recharge is low, due to low rainfall and high evapotranspiration. The aquifer is used for irrigation, domestic supply, and for the preservation of the forest ecosystem (Jbilou et al., 2025. In addition to the main water table, small aquifers may form on top of clay layers that slow infiltration. They form close to the surface and tend to dry up during the summer (Lepoutre & Combes, 1967).

Vegetation

Covering approximately 132,000 hectares, this forest includes around 60,000 hectares of native cork oak (Quercus suber L.) (Noumonvi et al., 2017; Malki et al., 2022; Ghouldan et al., 2024). Cork Oak currently dominates the majority of the western section of the Maâmora forest, with the highest density observed in cantons A & B. The more humid atmosphere and the sandy nature of the soil made here the ecosystem resilience the ecosystem is more resilient due to an influence from the Atlantic Ocean and the sandy nature of soil. The eastern section experiences a drier climate and is characterized by harder substrates, where cork oak has almost completely disappeared more important than in the eastern part (drier and hard substrates) where the cork oak has completely disappeared (Fennane & Rejdali, 2015).



Figure 9. Waterlogged soil after heavy rainfall.



Figure 10. Cork oak trees with stripped barks after cork harvesting. Source: Hespress Français.

Eucalyptus plantations are predominantly concentrated in the eastern part of the forest, characterized by a relatively high planting density. On the other hand, the resinous plantations, which encompass reforestation efforts involving pines, acacia formations, as well as bare land, are dispersed across the entire forest territory, appearing as scattered patches throughout the landscape. (Malki et al., 2022; Ghouldan et al, 2024.).

The vegetation of the Maâmora is dominated by cork oak (Quercus suber), which forms the characteristic *subéraie* that is unique to the sandy soils of the region (Métro & Sauvage, 1955). The only other tree that can be found is the endemic Maâmora pear (Pyrus mamorensis), which grows alone or in small groups. The understory differs across the forest. In the western part, it is mainly composed of Mediterranean broom (Genista linifolia), while the eastern part is dominated by spotted yellow sun rose (Cistus halimifolius). In more open areas, species such as sage-leaved rock rose (Cistus salviifolius), Spanish lavender (Lavandula stoechas), and dwarf palm (Chamaerops humilis) become more common. These species can be seen in figure 11.

The composition of the understory provides an important indication of forest condition. A diverse shrub layer supports the natural regeneration of cork oak, whereas the loss of understory vegetation or the dominance of a single shrub species is associated with declining regeneration and forest degradation (Métro & Sauvage, 1955).

In areas where the sandy soil becomes shallow or disappears, the cork oak forest is replaced by scrubland dominated by lentisk (Pistacia lentiscus) and wild olive (Olea oleaster). This vegetation is mainly found on exposed red soils and becomes more common toward the eastern part of the Maâmora.

Ecosystem services and regional significance

Moroccan forests provide a wide range of ecosystem services that are important for both society and the environment. Besides supplying raw materials, energy resources, and grazing land, they support local livelihoods and contribute to the national economy. Ecologically, forests regulate water, reduce soil erosion, prevent reservoir sedimentation, and store carbon, making them an important component of Morocco's environmental resilience (Aafi et al., 2002; Aafi, 2007).

Within this national context, the Maâmora forest is one of Morocco's most valuable forest landscapes. It provides a wide range of provisioning services, including cork (fig. 10), timber, honey, mushrooms, medicinal plants, and grazing land, while also supporting local livelihoods (Maghnia et al., 2019; Ghouldan et al., 2024). In addition, the forest delivers important regulating services. The cork oak ecosystem stabilizes the sandy soils of the region, reduces wind erosion, maintains soil moisture, and helps protect the surrounding landscape from desertification (Aronson et al., 2009; Serrasolses et al., 2009; Mitique et al., 2025).

The Maâmora also provides important cultural and ecological services. As one of the largest continuous cork oak forests in the world, it supports a high level of biodiversity and serves as a major recreational landscape for the surrounding metropolitan region, attracting visitors from Rabat, Salé, Kénitra, and Khémisset (M.A.T.E.U.H., 2002; Ghouldan et al., 2024).



Photograph by Author



Photograph by A. Homrani Bakali. Source: Teline



Source: Whitehorse City Council



Photograph by A. Homrani Bakali. Source: Teline



Photograph by Tom Christian. Source: Trees and Shrubs Online



Photograph by René Baud. Source: Teline



Photograph by Fouad Msanda. Source: Teline



Photograph by Fouad Msanda. Source: Teline



Photograph by Filipe Cera. Source: Wikimedia Commons

Figure 11. Vegetation of the Maâmora forest. From left to right: Quercus suber, Pyrus mamorensis, Genista linifolia, Cistus halimifolius, Cistus salviifolius, Lavandula stoechas, Chamaerops humilis, Pistacia lentiscus, Olea oleaster.

3.2 Decline of the cork oak cover

Despite its ecological and socioeconomic importance, the Maâmora forest has undergone a substantial decline over the past century. Historically, the forest covered an estimated 300,000 hectares (Natividade, 1956), but today only around 133,000 hectares remain (Noumonvi et al., 2017). Of this remaining area, less than half consists of cork oak (approximately 60,000 ha), while the rest is largely occupied by eucalyptus, pine, and acacia plantations.

Recent remote sensing studies provide a more detailed picture of how the forest has changed over time. Malki et al. (2022) analysed land-cover dynamics between 1984 and 2019 and found that cork oak cover declined sharply during the first decade, decreasing from approximately 76,100 ha to 61,100 ha. After 1994, this trend partially reversed, with cork oak recovering to around 67,600 ha by 2019. During the same period, eucalyptus plantations expanded rapidly, while pine plantations showed a temporary increase followed by a gradual decline. Acacia plantations generally decreased throughout the study period.

Ghouldan et al. (2024) reported a comparable overall trend, although the extent and timing of the changes differ from those identified by Malki et al (2022). Their analysis shows an initial expansion of cork oak between 1989 and 1999, followed by a strong decline to approximately 58,900 ha by 2022. Over the same period, eucalyptus plantations more than doubled in extent, becoming an increasingly dominant component of the forest landscape. Pine plantations fluctuated over time but showed an overall decline, while acacia plantations remained relatively limited in extent and gradually decreased throughout the study period.

Although the two studies differ in their estimates, both indicate that changes in forest cover have not followed a simple linear decline. Instead, the Maâmora forest has experienced alternating periods of regeneration and regression. Nevertheless, both studies point to the same long-term trend: a substantial reduction in cork oak cover accompanied by the continued expansion of eucalyptus plantations. The differences between the reported values are likely related to variations in image classification methods, reference data, and land-cover definitions (Ghouldan et al., 2024).

These long-term changes in forest composition are illustrated in the land-cover maps produced by Ghouldan et al. (2024), which compare the distribution of vegetation types between 1989 and 2022 (fig. 12).

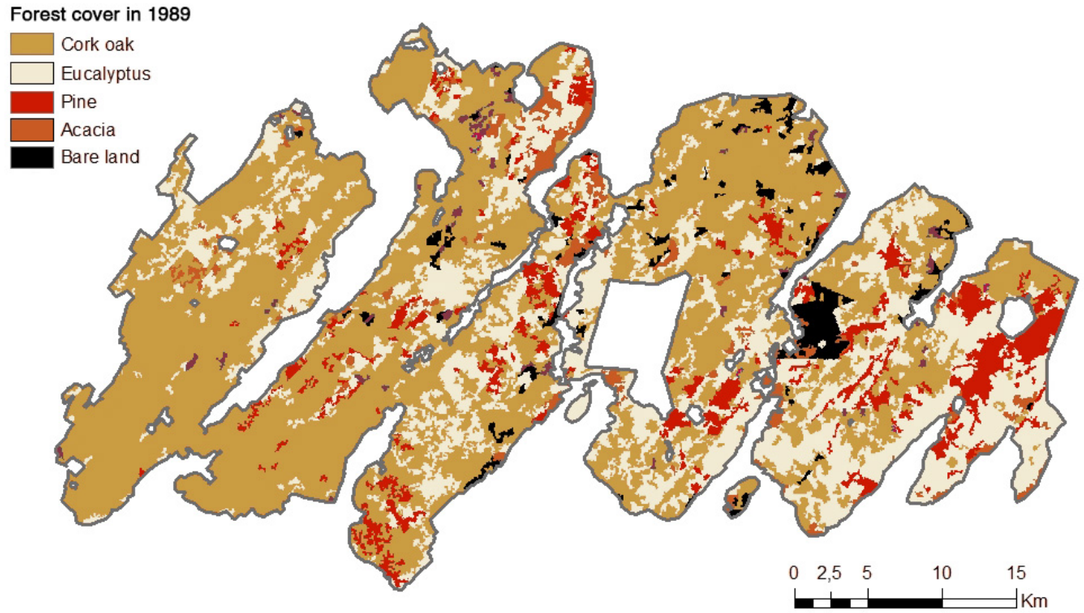


Figure 12. Changes in the Maâmora forest cover between 1989 and 2022. Maps adapted from Ghouldan et al. (2024).

3.3 Drivers of the decline

Climate change

As described in the site analysis, the Maâmora forest has a Mediterranean climate with warm, dry summers and mild, wet winters. Rainfall decreases from the subhumid Atlantic coast to the semi-arid forest interior, resulting in increasingly dry conditions from west to east. Climate projections for Morocco predict increased temperatures, reduced rainfall, and more frequent heat waves and droughts (Zine El Abidine et al., 2020). Together, these changes are expected to further reduce water availability by lowering groundwater levels and reducing the storage capacity of reservoirs (Van Dijck et al., 2006). Reduced water availability limits tree growth and cork production, while also reducing the success of natural regeneration. At the same time, high temperatures and droughts increase the susceptibility of trees to pests, diseases, and forest fires, further weakening the resilience of cork oak forests (Mechergui et al., 2023). The sandy soils of the Maâmora forest further intensify these impacts. These soils have a limited capacity to hold moisture, which increases drought stress and reduces the survival of young seedlings. As a result, both natural regeneration and artificial reforestation become increasingly difficult (Zine El Abidine et al., 2020).

Human pressures

Although climate change represents an important driver of forest decline, it does not fully explain the degradation of the Maâmora ecosystem. In addition to the environmental challenges, human activities have placed increasing pressure on the forest and have accelerated its degradation over recent decades. Population growth, urban expansion, agricultural development, and unsustainable resource extraction have all contributed to the fragmentation and decline of the forest (Mitique et al., 2025).

Since the end of the twentieth century, the Rabat–Salé–Kénitra region has experienced rapid urban growth, driven by population growth, economic development, and housing policies. Figure 13 illustrates this development by showing the expansion of built-up areas in Rabat, Salé, and Kénitra. As a result of this growth, major towns have expanded into the surrounding rural landscape, creating rural-urban interfaces where formerly rural areas are gradually transformed by urban development (Loulad et al., 2023). These transitional areas place increasing pressure on adjacent natural and productive landscapes, including the Maâmora forest.

The western part of the forest experiences the greatest human pressure due to its proximity to Rabat, Salé, and Kénitra. Population growth and expanding settlements along the forest edge have intensified the demand for land, firewood, construction materials, and grazing areas. According to Mitique et al. (2025), the highest levels of forest degradation coincide with areas of high population density, indicating a strong relationship between human activity and the decline of the cork oak ecosystem. The following sections discuss the main anthropogenic drivers contributing to the decline of the Maâmora forest.

Land conversion

A clear consequence of increasing human pressure is the conversion of cork oak forest to other land uses. As a result of urbanization, natural forest areas have been cleared and replaced by residential areas, infrastructure, agricultural land, and plantations (Fennane & Rejdali, 2015; Ghouldan et al., 2025). These changes are reflected in recent land-cover analyses of the Maâmora forest by Ghouldan et al. (2025). Between 1989 and 2022 cork oak cover declined by more than 21,000 hectares, while plantations and bare land grew considerably. The increase in plantations is largely the result of reforestation policies that replaced degraded cork oak stands with fast-growing species such as eucalyptus, pine, and acacia. Although intended to maintain forest productivity and meet the high demand for timber, these interventions changed the composition of the Maâmora forest and reduced the extent of the cork oak (Ghouldan et al., 2025). Together, these forms of land conversion have changed the structure and composition of the Maâmora forest significantly. This impact becomes clear when comparing historical and recent Google Earth imagery from 1984 and 2020, as shown in figure 14.

Forest resource exploitation

The Maâmora forest provides a variety of goods and services that support both local communities and the surrounding urban population. These include timber, cork, acorns, honey, truffles, tannins, and fodder (El Mokaddem, 2016). A growing population has increased the demand for these resources, leading to unsustainable extraction that exceeds the forest's capacity to regenerate naturally (Fennane & Rejdali, 2015) (fig 16).

Overgrazing is one of the most pressing forms of exploitation in the Maâmora. As grazing land outside the forest has declined and livestock numbers have increased, local communities now depend on forest pastures. The result is a reported grazing pressure of 6.4 livestock units per hectare, which is more than four times the ecological carrying capacity of 1.5 livestock

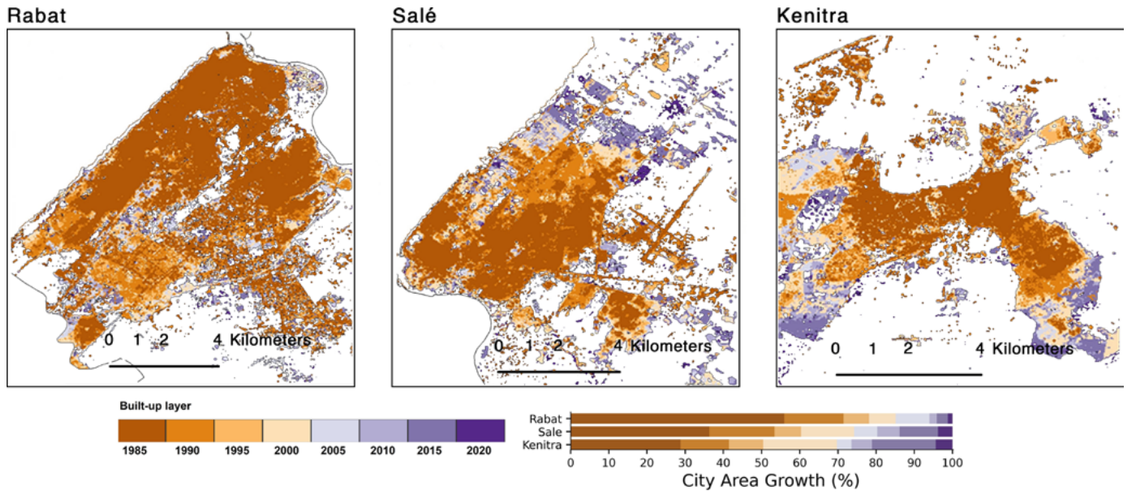


Figure 13. Spatial evolution of the built-up area for Rabat, Salé, and Kenitra from 1985 to 2020. Adapted from Loulad et al. (2023).

units per hectare (Laaribya et al., 2014).

The continuous presence of livestock prevents the growth of new cork oak trees. Grazing compacts the soil, while livestock consume acorns and young seedlings before they can establish (fig. 17). At the same time, local communities reduce the availability of seeds by collecting acorns for consumption (Mechergui et al., 2023). During periods of fodder scarcity, tree branches are cut to provide additional feed, causing damage to the trees. Additionally, improper cork harvesting by untrained workers can also wound trees. These wounds increase the susceptibility of cork oak trees to pests and diseases, further weakening them (Laaribya, 2006).

Groundwater extraction

The Maâmora aquifer is an important water source for domestic use, agriculture, and industry. At the same time, it is essential for the survival of the cork oak forest. Because rainfall is its only source of recharge, it is vulnerable to increasing water demand and prolonged drought (Ben Kabbour et al., 2005).

Concerns about groundwater depletion are not new. Already in the 1960s, researchers reported declining groundwater levels and recommended limiting withdrawals from the aquifer (Lepoutre & Combes, 1967). Since then, population growth, urban expansion, agricultural intensification, and industrial development have substantially increased groundwater extraction. At the same time, climate change has reduced groundwater recharge through declining rainfall and more frequent droughts (Van Dijck et al., 2006). As a result, groundwater extraction now exceeds natural replenishment, leaving the Maâmora aquifer in deficit (Moumane et al., 2025). In addition to declining groundwater availability, expanding agriculture and





Figure 14. Comparison of forest cover in the southern parts of Maâmora Cantons B and C in December 1984 (top) and December 2020 (bottom). Google Satellite imagery.

urbanization increasingly threaten groundwater quality through the infiltration of fertilizers, pesticides, and other pollutants (Ben Kabbour et al., 2005; Nafaa, 2002).

Cork oak woodlands are groundwater-dependent ecosystems. During prolonged summer droughts, cork oak trees rely on their deep root systems to access groundwater. This allows them to maintain growth despite limited rainfall (Mendes et al., 2016). As groundwater levels continue to decline, water becomes harder to access, reducing tree growth, cork production, and the long-term survival of cork oak stands. The depletion of the Maâmora aquifer therefore poses a direct threat to the resilience of the cork oak ecosystem.

Recreational pressure

The Maâmora forest is an important recreational destination for residents of the surrounding cities (Fennane & Rejdali, 2015). As urban populations have grown, the forest has become increasingly popular for picnics, barbecues, walking, and other outdoor activities (Said et al., 2011). While recreation is an important service of the forest, the lack of infrastructure and visitor management has turned it into an additional source of disturbance.

Visitors often enter the forest by car, but the absence of roads and parking areas results in vehicles driving and parking throughout the forest. This causes soil compaction and damages the vegetation (Said et al., 2011). Due to the lack of trash cans, litter is scattered throughout the forest. In addition, the forest is sometimes used as a dumping site for domestic waste. These conditions were also observed during the field visit, which can be seen in figure 33. Together, these forms of unregulated recreational use degrade both the ecological and landscape quality of the Maâmora forest.

Previous management practices

Since the beginning of the twentieth century, the Maâmora forest has been subject to different management practices. To address the declining state of the forest, three major management plans were implemented between 1951 and 2012, aiming to regenerate and restore the cork oak forest (El Boukhari et al., 2015; Nafaa, 2002).

The first two management plans primarily approached the Maâmora as a productive forest. Their main objective was to maintain cork oak stands where economically profitable, while replacing low-density or degraded stands with fast-growing introduced species such as eucalyptus, pine, and acacia. These interventions aimed to maintain cork production, supply the timber and cellulose industries, and support the recreational function of the forest (HCEFLCD, 2014; Malki et al., 2022). The plans also marked the first formal recognition of existing user rights and access to forest resources within the management framework (El Boukhari et al., 2015). However, efforts at natural regeneration were insufficient, and the cork oak cover continued to decline. At the same time, the composition of the forest was permanently altered by the introduced plantation species (Nafaa, 2002).



Figure 15. Sheep grazing in the Mâamora forest.

The third management plan considered the factors contributing to the degradation of the cork oak forest and adopted a broader approach. Consequently, it integrated ecological, social, and pastoral considerations into forest management. Unlike the previous two plans, it focused on artificial regeneration through direct seeding and planting while also promoting community involvement, improving grazing management, and encouraging the sustainable use of forest resources (El Boukhari et al., 2015). However, the regeneration program was soon affected by fungal diseases and insect infestations, resulting in widespread mortality among newly planted cork oak trees (El Boukhari et al., 2015).

Nafaa (2002) argues that the limited success of previous management plans reflects the complexity of the Maâmora forest. She states that the Maâmora should not be treated as a single unit that can be managed through one uniform strategy. Instead, she proposes understanding it as a region composed of different zones. These zones differ in their environmental conditions, land use, human pressures, and constraints. Therefore, each zone requires a different management approach.

Conclusion

This perspective corresponds with the findings of the analysis of this chapter. The drivers of forest decline vary across the Maâmora and extend beyond the boundary of the forest. Although past management plans gradually broadened their scope, they remained focused on the forest itself. Fennane and Rejdali (2015) similarly argue that long-term recovery depends on reducing the external pressures affecting the forest, rather than relying solely on restoration efforts within the forest itself. Therefore, this thesis argues that addressing the long-term decline of the Maâmora forest requires an approach that considers the forest within its wider landscape context and responds to the different conditions across the region. As Nafaa (2002) also suggests, long-term conservation cannot rely on ecological restoration alone. Instead, it requires a multidisciplinary approach that considers the ecological, social, and economic factors affecting the forest.



Figure 16. Chopped trees and remaining stumps in a degraded forest area.



Figure 17. Eroded soil on a hill where sheep graze and the forest cover is absent.

3.4 Spatial synthesis

The analysis identified several environmental and anthropogenic factors contributing to the decline of the Maâmora forest. However, not all of these factors can be addressed through planning and design. Some mainly require changes in management or policies. Therefore, a spatial synthesis is made to identify the main spatial challenges and opportunities that can be addressed with a landscape-based design approach. Figure 18 shows these findings on a map and highlights where spatial interventions could contribute to the protection and restoration of the Maâmora forest.

The western part of the Maâmora forest, closest to the major cities and highlighted in light green on the map, experiences the highest human pressure, despite being one of the best-preserved parts of the forest. This pressure comes from recreational use, resource exploitation, and the conversion of forest land for urban development. The forest areas directly adjacent to the cities are marked with red dots. These locations offer opportunities for developing urban forests that can accommodate recreational activities. Concentrating visitors in these areas could relieve recreational pressure on the rest of the forest.

The main challenge in the central and eastern parts of the Maâmora forest is the fragmented cork oak cover. Many forest patches are isolated due to missing ecological connections. The arrows on the map indicate where these connections are missing and should be restored. Consequently, the green dots identify areas that offer starting points for forest restoration. These locations are situated close to existing forest cores and have relatively favorable conditions for restoration (see fig. 23).

Closely related to the degradation of the forest is the increasing pressure from urban expansion on the peri-urban landscape between Rabat, Salé, and Kénitra. The rural landscape is gradually being converted into urban areas, while smaller settlements are also expanding. Without intervention, this could eventually result in the merging of urban areas. Protecting the remaining open landscape is important to prevent agriculture from being pushed into the forest, and to maintain a buffer between the city and the Maâmora forest.

The findings of the spatial synthesis form the starting point for the development of the strategic vision in the next chapter. The vision integrates the spatial challenges and opportunities into one regional strategy.

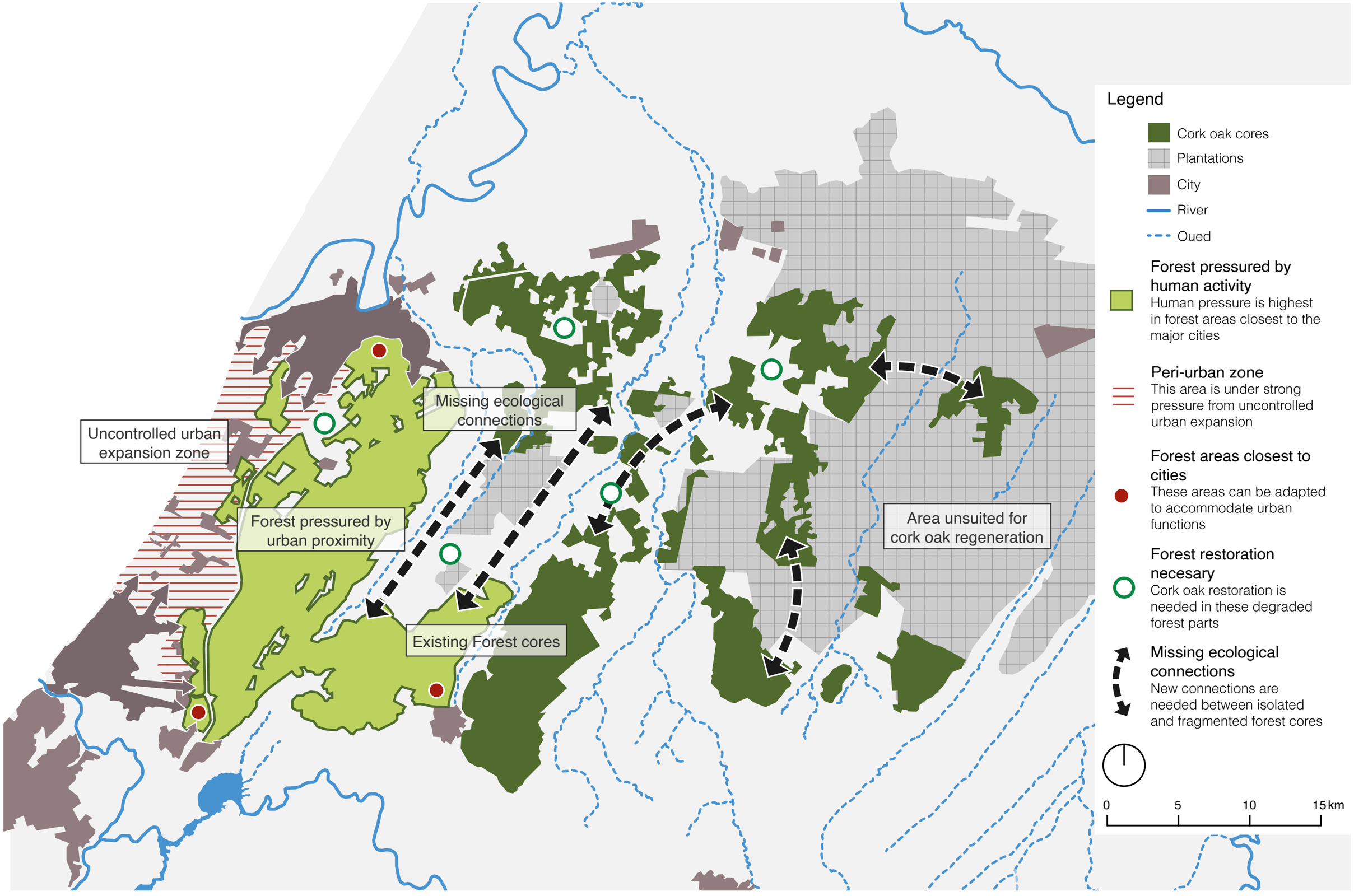


Figure 18. Spatial synthesis map showing the conclusions from the analysis.

Precedent 1. Serra de Collserola Natural Park

3.5 Serra de Collserola Natural Park

Introduction

The Serra de Collserola Natural Park is a mountainous nature reserve of over 8,000 ha located northwest of Barcelona (fig. 19). The park consists of a mosaic of forests and agricultural land that plays an important role in the ecological network of the metropolitan area. Its steep topography has largely protected it from urban sprawl. However, its location within a densely urbanized region has also limited its connectivity to surrounding natural areas. As a result, the ecological values and biodiversity of the park remain vulnerable without legal protection (Vidal-Casanovas & Farrero Compte, 2020a; Vidal-Casanovas, 2024).

This is why the Pla Especial de Protecció del Medi Natural i el Paisatge (PEPNat) was formally approved in 2021. The plan provides the legal and spatial planning framework for the protection and management of the Collserola Natural Park. Its objective is to preserve biodiversity and enhance ecosystem services through a dynamic and adaptive management approach. Rather than focusing exclusively on the protected area itself, PEPNat positions the park within the wider metropolitan green infrastructure. An important component of the plan is the designation of approximately 3,676 ha of Functional Space. This area includes land that lies outside the Natural Park but is considered essential for protecting and strengthening the park's ecological values and biodiversity (Vidal-Casanovas, 2024).

According to Vidal-Casanovas (2024), the biggest innovation of the PEPNat is the paradigm shift it introduces. Previous planning approaches primarily focused on preserving the landscape types that existed when the plan was drafted. In contrast, PEPNat recognizes the dynamic character of the landscape and focuses on the ecological processes and functions within and beyond the park boundary. This process-based perspective is combined with a comprehensive and systemic planning approach that integrates ecological, social, and spatial considerations. In doing so, the plan acknowledges that environmental challenges in a metropolitan context cannot be addressed by a single discipline, but require collaboration between different knowledge fields and stakeholders.

Strategy

The ecological strategy forms the foundation of the PEPNat. Ecological objectives are integrated into all aspects of the plan and guide all planning and management decisions. To achieve these objectives, the plan regulates land use and recreational activity within the park and provides guidelines and recommendations for the development of strategic projects and interventions (Vidal-Casanovas & Farrero Compte, 2020a).

The strategy is organized around four complementary objectives: improving ecological connectivity, conserving areas of high ecological value, controlling disturbances, and promoting a green economy. The spatial implementation of the strategy is shown in figure 20. Ecological connectivity is strengthened through a

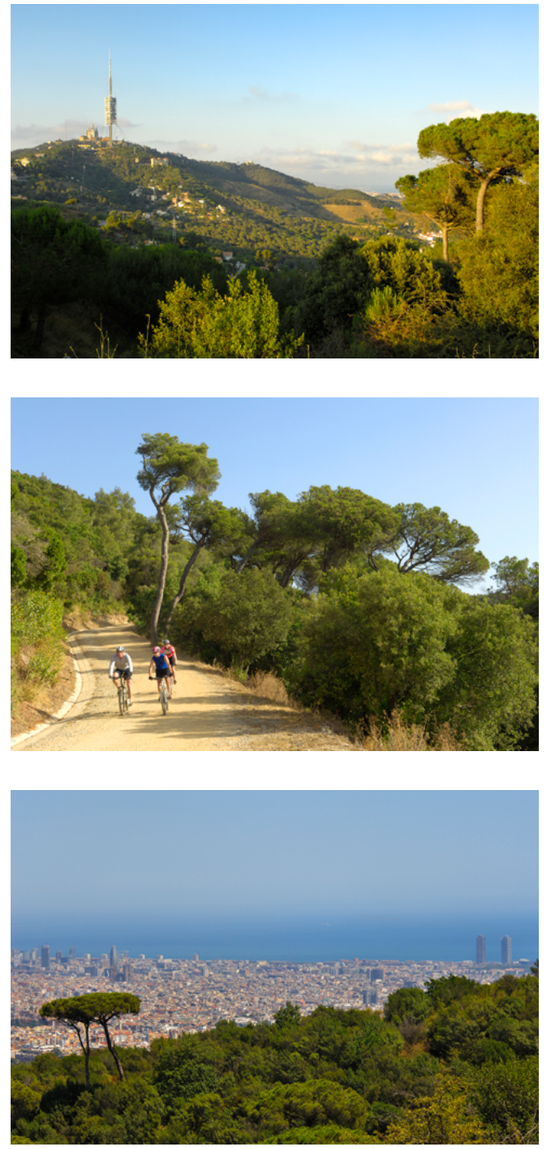


Figure 19. Impressions of Serra de Collserola Natural Park. Photographs by Robert Peña. Source: Parc Natural de la Serra de Collserola.

network of ecological corridors and watercourses. To protect vulnerable habitats, areas with high ecological value are managed more strictly. Recreational pressure is concentrated in designated areas, while islands of tranquility restrict access and mobility to provide favorable conditions for flora and fauna. PEPNat promotes a green economy by stimulating local consumption, implementing a low-carbon strategy, monitoring climate change, and raising environmental awareness (Vidal-Casanovas & Farrero Compte, 2020a).

The ecological strategy guides the remaining themes within the PEPNat. These include the valorization of natural resources, public use, built heritage, infrastructure and technical services, and the functional space surrounding the Park (Vidal-Casanovas, 2024).

The valorization of natural resources promotes sustainable forestry, agriculture, and livestock farming while protecting vulnerable areas. Agricultural land is restored to maintain the agroforestry mosaic and preserve the cultural landscape. Public use is organized through a network of paths, recreational areas, and educational facilities. Recreational activities are concentrated to reduce pressure on ecologically sensitive habitats, and non-motorized access is encouraged. Built heritage is preserved and restored, while new construction is limited to protect the landscape character. Additionally, infrastructure and technical services are managed to reduce habitat fragmentation and improve ecological flows.

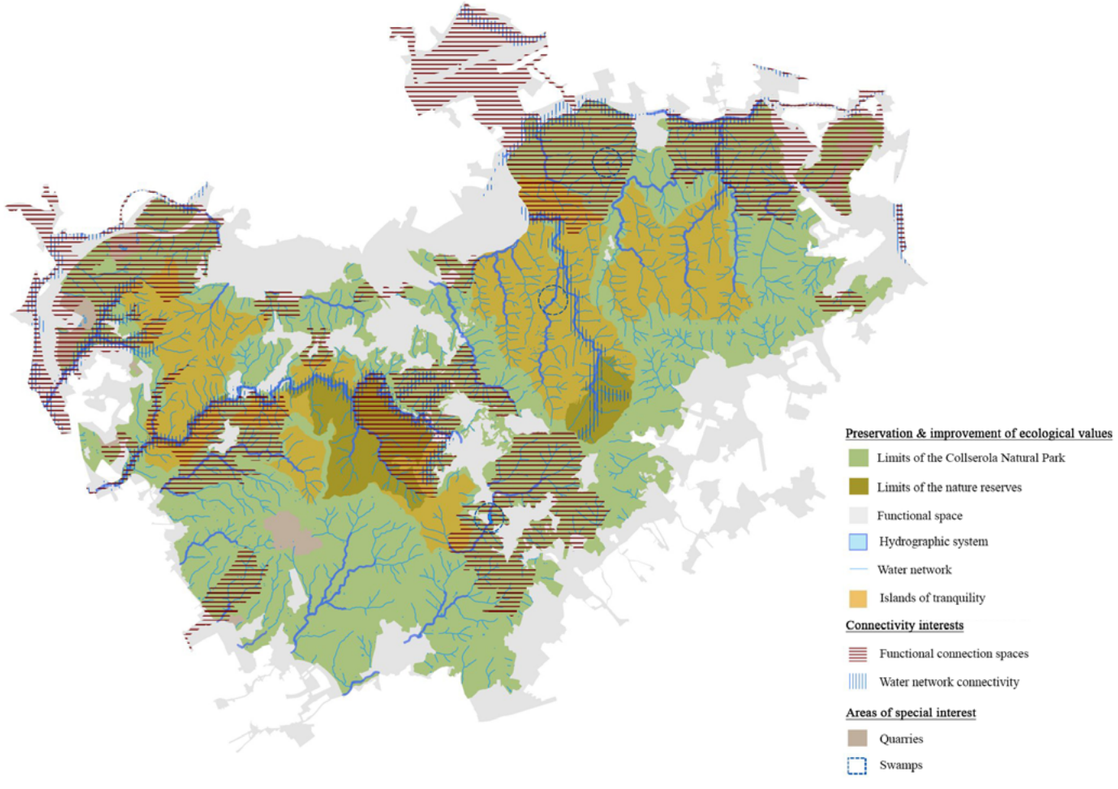


Figure 20. Spatial implementation of the ecological strategy for Serra de Collserola Natural Park (Parc Natural de la Serra de Collserola, 2018).

Functional space

Among the themes included in the PEPNat, the functional space is especially relevant to this study. The functional space includes areas outside the natural park whose characteristics or functions contribute to the conservation of the park's ecological values and the ecological processes taking place within it. The PEPNat provides guidelines, recommendations, and a catalogue of interventions for these areas. These frameworks focus on the transition between the park and the surrounding metropolitan landscape. The guidelines address ecological connectivity, edge conditions, and public accessibility (Vidal-Casanovas & Farrero Compte, 2020a; Vidal-Casanovas, 2024).

The delineation of the functional space is particularly important because the surrounding metropolitan landscape strongly influences the ecological and social functioning of the natural park. With the introduction of the functional space, the park edge is no longer treated as an administrative boundary but as a strategic landscape (Vidal-Casanovas, 2024).

The PEPNat includes a catalogue of general design interventions for the functional space. The catalogue includes a common design language for graphic identity and signage, and provides general design solutions that can be adapted to local conditions. As a result, the park edge becomes a coherent transition space to the urban environment. The interventions are organized around four principles: global identity, local identity, connectivity, and biodiversity (see fig. 21). These principles are discussed in more detail below. Together, they transform the park edge into a refuge for flora and fauna while allowing biodiversity to expand into the metropolitan landscape (Vidal-Casanovas & Farrero Compte, 2020b).

Global identity

The global identity principle ensures the natural park is clearly recognizable the metropolitan scale. It defines the boundaries of the functional space to create a consistent and identifiable park edge.

Local identity

The local identity principle adapts the park edge to the urban fabric and infrastructure surrounding the park. Design solutions respond to the specific characteristics of each location while maintaining the overall identity of the natural park.

Connectivity

The connectivity principle strengthens ecological and social connections between Collserola Natural Park and the surrounding metropolitan landscape. It improves connectivity by linking the park's recreational path network to the surrounding neighborhoods. At the same time, it identifies opportunities for the park to extend into the urban fabric by renaturalizing existing public spaces and streets, and removing ecological barriers.

Biodiversity

The biodiversity principle focuses on increasing biodiversity along the park edge. It restores degraded edge environments to create habitats for flora and fauna. For example, improved water retention and infiltration measures create new wet habitats while simultaneously reducing pressure on urban drainage systems. Together, these interventions allow biodiversity to increase both inside and outside the natural park (Vidal-Casanovas & Farrero Compte, 2020b).

Relevance for the Project

Collserola Natural Park shows how a large natural area can be managed within a densely populated metropolitan region. The management plan (PEPNat) is structured around ecological objectives that inform decisions on land use, recreation, heritage, and infrastructure. By applying an overarching ecological strategy, PEPNat ensures that the park's other functions do not compromise its biodiversity objectives.

PEPNat also shows how public access can be managed through a structured recreation network. Paths and recreational facilities concentrate public use in suitable areas, while islands of tranquillity limit access to ecologically sensitive areas. This offers a transferable model for balancing recreational use with ecological protection in the Maâmora forest.

Finally, Collserola Park demonstrates how the park edge can function as a transition zone rather than an administrative boundary. Functional spaces bordering the park are structured to strengthen ecological connectivity, manage edge conditions, and regulate public access. The concept of functional space is relevant to the Maâmora forest, where urban pressures also need to be managed beyond the forest boundary. Overall, Collserola shows that protecting a natural area also requires managing its surrounding territory as well.

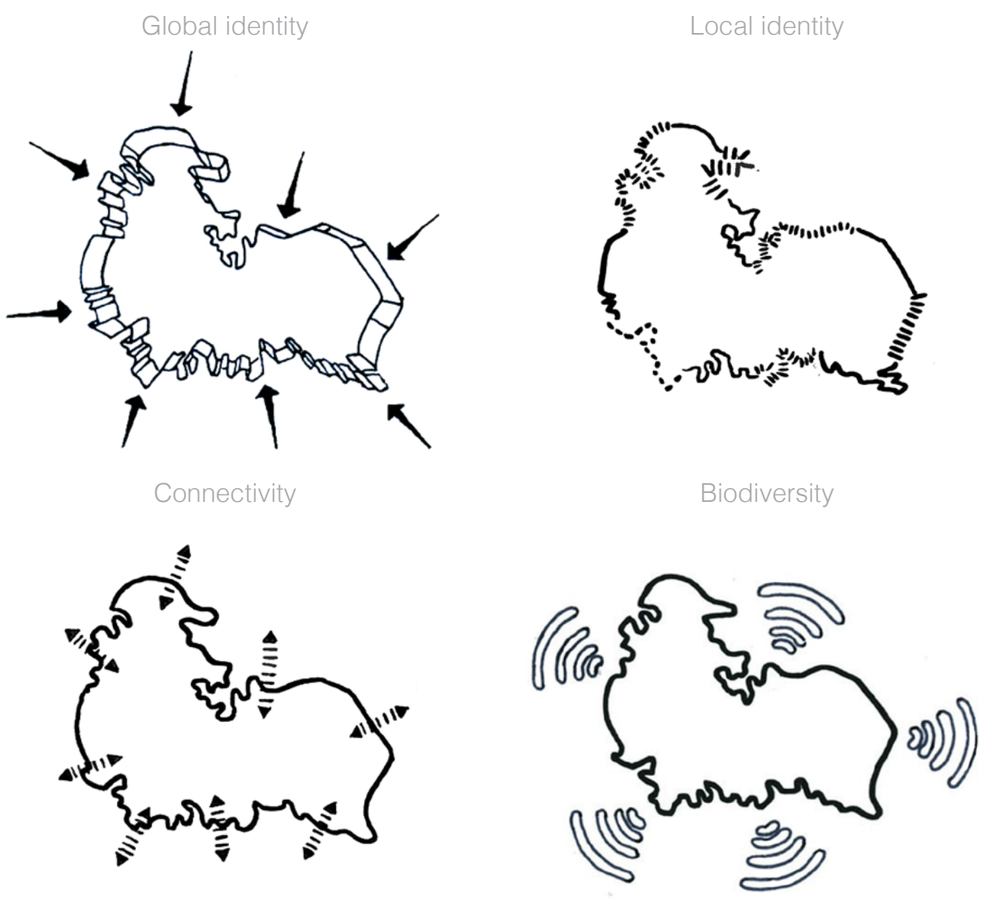


Figure 21. Design principles for the functional space around Serra de Collserola Natural Park. Adapted from (Vidal-Casanovas & Farrero Compte, 2020b).

3.6 Strategic vision

Design principles

Based on the site analysis of the Maâmora forest and the strategy of the Serra de Collserola Natural Park, a set of design principles was developed for the strategic vision of the forest. The design principles are shown in figure 22. The spatial application of these principles is shown in the strategic vision map (fig. 26). The vision focuses on supporting the regeneration of the cork oak cover while reducing pressures from agriculture, grazing, recreation, and urban development.

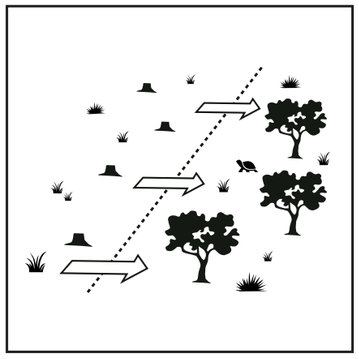
The design principles are:

- Regenerate suitable cork oak areas
- Reconnect ecological cores
- Implement zoned accessibility
- Create silvopastoral buffers
- Concentrate agriculture around oueds
- Design the forest edge as functional space

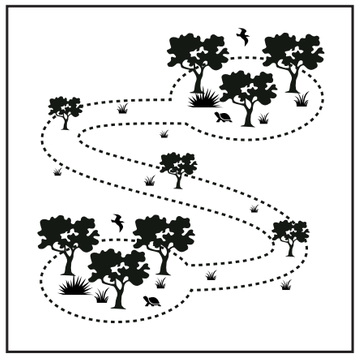
Elaboration of the vision

The vision starts from the existing conditions of the forest, combined with the suitability of different areas for cork oak regeneration based on a study by Bagaram et al. (2016). The study assesses regeneration suitability by combining the main environmental factors that influence cork oak regeneration in the Maâmora forest. Based on these factors, the forest is classified into areas with good, medium, low, and very low regeneration potential. These findings are shown in figure 23.

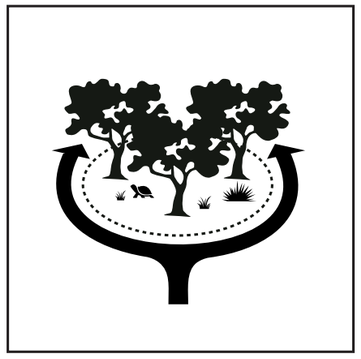
Areas with a strong existing cork oak cover form the ecological cores of the forest. Within these areas, biodiversity conservation is the main priority. Access for recreation and grazing is therefore limited, following a similar principle to the islands of tranquility in the ecological strategy for Collserola Park. Cork oak regeneration efforts are concentrated in areas with suitable environmental conditions. Around the existing cores, regeneration increases the extent of the cork oak cover and strengthens these areas. Between fragmented cores, regeneration areas can restore connections and improve the continuity of the forest.



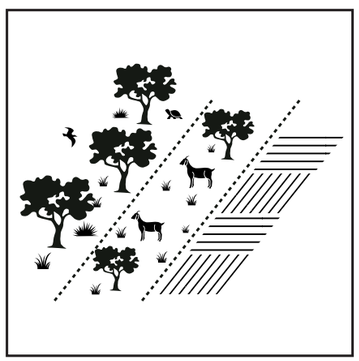
Regenerate suitable cork oak areas



Reconnect ecological cores



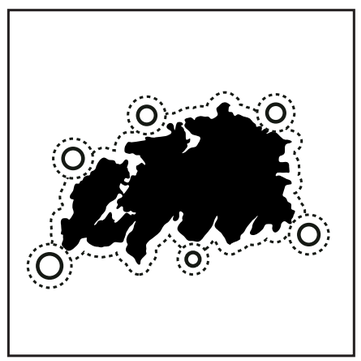
Implement zoned accessibility



Create a silvopastoral forest buffer



Concentrate agriculture around oueds



Design the forest edges as functional space

Figure 22. Design principles for the strategic vision for the Maâmora forest.

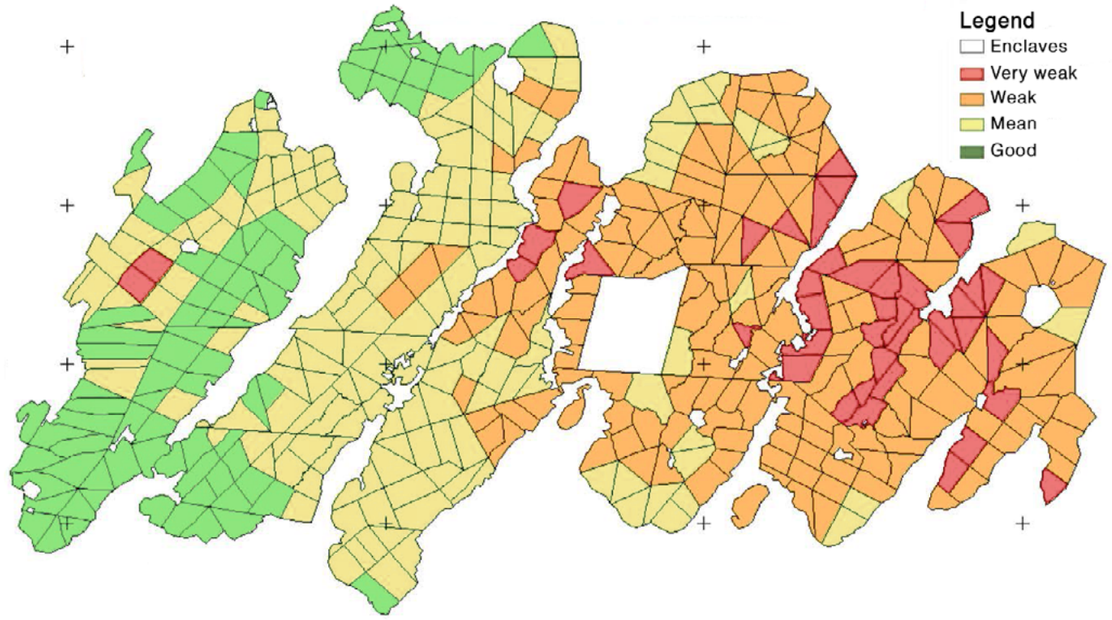


Figure 23. Map of the average regeneration suitability of cork oak by parcel in the Maâmora forest. Adapted from Bagaram et al. (2016).

Silvopastoral buffer zones are introduced around the forest cores to create a gradual transition towards the surrounding landscape. These buffers are inspired by the dehesa and montado landscapes of Spain and Portugal respectively, where open cork oak woodlands are combined with animal grazing (fig. 24 & 25). The buffers reduce direct pressure from surrounding agricultural and urban land on the forest cores. They also contribute to the ecological connectivity between forest areas and support the movement of species across the landscape. At the same time, the buffer zones function as transhumance corridors by providing grazing areas for livestock. This allows shepherds to move their herds between grazing areas without damaging the ecological cores or regeneration areas (see fig. 27 & 29). The distribution of ecological cores, regeneration areas, and silvopastoral buffers can be seen on the vision map (fig. 26).



Figure 24. Pig Dehesa in Spain. Source: Origen.



Figure 25. Cow Montado in Portugal. Source: Carne Mertolenga.

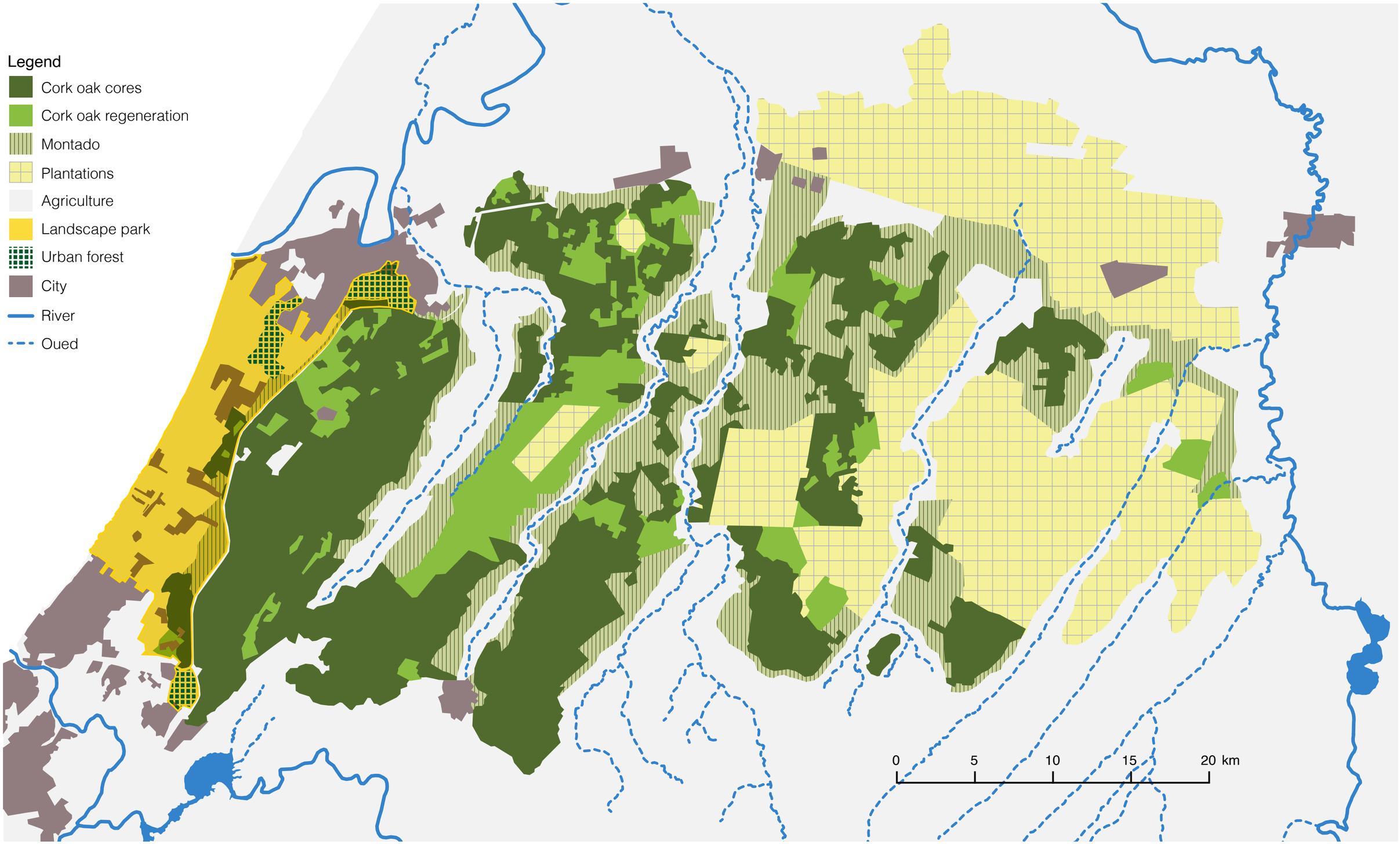


Figure 26. Strategic vision map for the Maâmora forest and the surrounding territory.



Figure 27. A sheperd and his sheep in a dehesa. Source: Verdehesa.

In the vision, agriculture is concentrated around the seasonal oueds. This allows farms to use surface water for irrigation during the wet season. Excess water should also be retained and stored within the landscape for use during the dry season. This reduces dependence on groundwater extraction for farming and reduces water competition between agriculture and the forest.

Together, these elements create a landscape sequence from the oueds towards the forest: oued → agricultural fields → silvopastoral buffer → forest edge → forest core (fig. 28). The exact sequence and width of these zones depend on local landscape conditions.

As with Collserola Park, the forest edge forms a fundamental part of the vision. Rather than treating it as an administrative boundary, the edge is designed as functional space. Access and recreational activities are concentrated at selected locations along the edge, reducing pressure on the ecological cores. Along the western forest edge between Rabat–Salé and Kénitra, where urban pressure is highest, this principle is developed into a regional landscape park. Its role is to guide future urban development while accommodating land uses that would otherwise increase pressure on the forest. The followin chapter will explain this regional landscape park in more detail.



Figure 28. Landscape section showing the sequence from oued to cork oak forest.

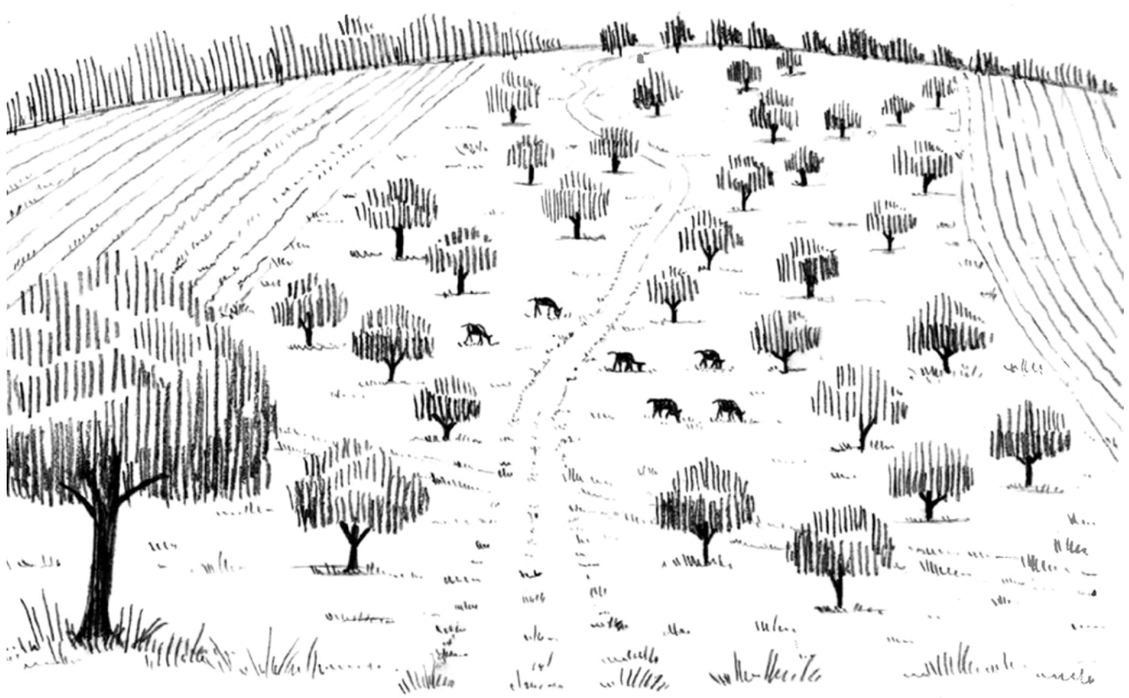


Figure 29. A dehesa/montado landscape as transhumance corridor between agricultural fields.



04

THE WEST-MAÂMORA LANDSCAPE PARK

4.1 Site analysis

The large-scale vision identified the western edge of the Maâmora forest between Rabat–Salé and Kénitra as the focus area for the development of the regional landscape park (see fig. 30). This area forms the transition between the Maâmora forest and the Atlantic coast. It is the most urbanized part of the RSK region and therefore experiences the most pressure from urban development. As discussed in the introduction, the RSK region has experienced rapid and unregulated urban expansion over recent decades. Rabat, Salé, Kénitra, and their surrounding agglomerations have all expanded considerably, which has led to the loss of agricultural land and natural areas (Loulad et al., 2023). Figure 31 illustrates how urban development encroaches on the surrounding landscape. This process of urbanization has created a peri-urban landscape zone between the cities, consisting of a mosaic of urban areas, agricultural fields, orchards, forest patches, and coastal dunes.

To understand the existing conditions of this landscape and its potential for the development of a regional landscape park, the study area is analyzed in more detail. The analysis focuses on the current land uses and identifies the main spatial structures of the landscape.

Land use analysis

Figure 32 shows the current land uses within the study area. Despite considerable urban expansion into the rural landscape, agriculture remains an important land use. Agricultural production mainly consists of vegetables and cereals, including potatoes, tomatoes, and wheat. Orchards and fodder crops occupy a smaller proportion of the land, while livestock farming happens only on a small scale (Hakimi & Brech, 2021). The land-use map shows that orchards are mainly located along the urban edges, while agricultural fields are generally located further inland.

Most major infrastructure follows a north–south direction and connects Rabat–Salé with Kénitra. The cities are connected by two highways and a railway, with stations at Sidi Bouknadel and Sidi Taibi within the peri-urban landscape. Additionally, the Rabat–Salé Airport forms a major infrastructural element in the south of the site. These infrastructural hubs provide good accessibility between the main urban areas. At the same time, they create barriers across the landscape, particularly in the east–west direction.

These barriers also affect the natural areas within the study area, which are generally isolated or highly fragmented. Along the western edge of the Maâmora forest, the Rabat–Tangier highway separates the main

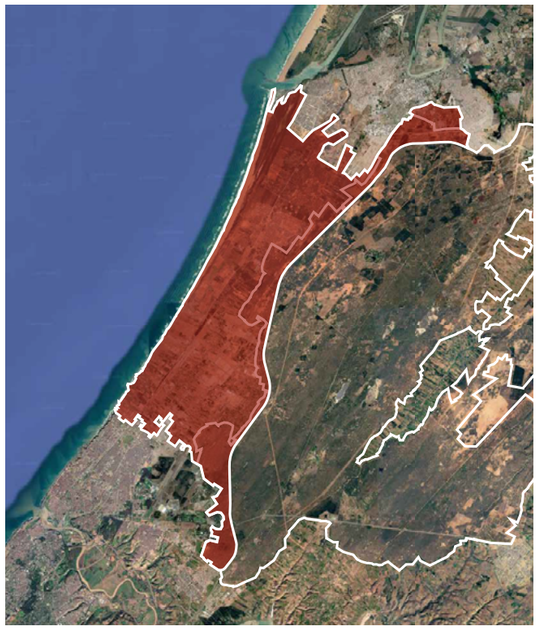


Figure 30. Landscape zone along the western Maâmora fringe between Rabat-Salé and Kénitra. Map created using Google Satellite imagery.

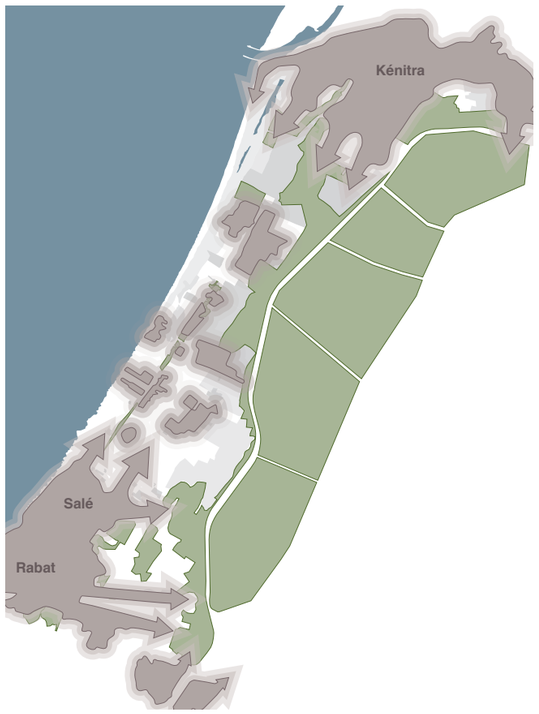


Figure 31. Urban sprawl encroaching on the remaining open landscape between Rabat-Salé and Kénitra.



Figure 32. Land use analysis map of the study area between Rabat-Salé and Kénitra.

forest from smaller forest patches to the west. Along the Atlantic coast, Sidi Boughaba National Park forms an important natural area but has few ecological connections to other natural spaces. The lack of east–west connections leaves these natural areas largely disconnected from one another in particular. Strengthening these connections therefore provides an important opportunity for the regional landscape park.

The condition of the Maâmora forest also changes along its western edge. Near Salé, the cork oak cover remains relatively dense and continuous. Towards Kénitra, the forest becomes increasingly open and fragmented, while plantations occupy a larger proportion of the forest. These different conditions require different approaches to forest restoration. Near Salé, the existing cork oak cover should primarily be conserved. Near Kénitra, there is more need for the regeneration of degraded forest areas.

Urban development is still contributing to the fragmentation of the open landscape. As shown in figure 31, Salé and Kénitra have expanded through arm-like extensions into the surrounding agricultural landscape. This development has consumed agricultural land and divided larger open areas into smaller fragments. The remaining open spaces along the urban edges therefore become particularly important for limiting further sprawl.

The relationship between urban areas and the forest is particularly important where they meet directly. Salé Al Jadida, located southeast of Salé, borders the Maâmora forest and provides access to a frequently used recreational forest area. During the field visit, recreational pressure was clearly visible in this area (fig. 33). Visitors drive and park within the forest, while litter and domestic waste is scattered throughout the site. Despite the intensity of recreational use, the transition between the neighborhood and the forest is poorly defined. The forest edge lacks both a clear spatial structure and facilities to accommodate visitors (see fig. 34 & 35). A similar condition can be observed around the urban forest of Kénitra, where roads separate the forest from surrounding neighborhoods. These locations provide opportunities to develop the forest edge as a transition between urban areas and the forest.

Access to the Atlantic coast is relatively limited within the peri-urban landscape. Only the western expansion of Kénitra provides direct access to the beach, as well as a large holiday resort and golf course further south. Overall, only a small number of roads connect the inland landscape with the coast. Improving connections to the coast provides an opportunity to expand the recreational network of the regional landscape park.

Another noticeable element is the regional water infrastructure. The Sidi Mohamed Ben Abdellah dam, southeast of Rabat–Salé, provides drinking water to the region. The cities are supplied through an underground pipeline that crosses the Maâmora forest from south to north. The presence of this regional water infrastructure provides an opportunity to explore its potential in supporting the productive areas of the regional park.

Overall, the study area consists of a complex and fragmented peri-urban landscape. Strong north–south infrastructure connects the main cities but also creates barriers. Natural areas are therefore fragmented and lack strong ecological connections. At the same time, urban expansion continues to put pressure on agricultural land and the Maâmora forest. Therefore, the main challenge is to protect and better connect the remaining open spaces while finding alternative spaces for urban development. The remaining open spaces could be the starting point for this. Together, they have the potential to form the basis for the regional landscape park.

As described in the methodology, a regional landscape park uses existing landscape characteristics as the





Figure 33. Scattered waste and parked cars in the Maâmora forest near Salé al Jadida.



Figure 34. The Maâmora forest edge at Salé al Jadida. There is little integration between the forest and the city.

basis for a regional spatial framework. Within this framework, the rural landscape is considered as public open space. According to Nijhuis (2007), this open space has a dual spatial function. It separates urban areas from the surrounding countryside and prevents them from merging into one continuous urban landscape. At the same time, it connects different parts of the region through an open-space network. This network includes functions such as recreation, agriculture, nature, and living and working. Additionally, cultural-historical locations can function as important destinations within this network and contribute to the identity of the region. In this way, the open-space network guides urban development, while protecting and strengthening the spatial qualities of the open space (Nijhuis, 2007).

Within the study area, this strategy can be applied to the landscape between Rabat–Salé and Kénitra. Here, a regional landscape park can help protect the Maâmora forest and remaining open spaces, while providing structure for future urban development. An open-space network can provide boundaries for this urban development while connecting existing natural and productive landscapes. Recreational routes can improve access between urban areas and the surrounding open landscape. The structural analysis identifies which existing landscape structures can form the basis of the regional framework in the study area.



Figure 35. A children's playground is the only recreational facility in the forest near Salé al Jadida.

4.2 Preparing the framework

Structural analysis

Figure 36 shows the network of open spaces identified within the study area. In the south, near Salé, the open landscape consists mainly of agricultural fields, which transition into the Maâmora forest towards the east. Along the eastern edge of the study area, patches of cork oak forest form an almost continuous north–south structure. Towards Kénitra in the north, forest patches become more dominant alongside larger orchards. As identified in the land-use analysis, orchards are mainly located near the urban edges and form the transitions between the urban and rural landscape. Although these orchards do not currently form a continuous structure, they provide the basis for productive east–west connections. Scattered plots of undeveloped land and abandoned agricultural fields provide additional spaces that could become part of these connections. Collectively, the open spaces reveal a potential network with two main directions. Additionally, a third axis can be derived from looking at the main infrastructure system. This third layer can become the connectivity layer that connects the open space network.

North–south forest connection

The forest patches along the western edge of the Maâmora have the potential to form a continuous north–south ecological structure.

East–west productive corridors

The patchwork of orchards, agricultural areas, and undeveloped land provides opportunities for transverse productive corridors connecting the Maâmora forest with the Atlantic coast. At the same time, these corridors can become clear transitions between the urban and rural landscape.

Recreational axis

The existing infrastructure provides the basis for a recreational axis that connects the landscape structures. From the main axis, smaller connections extend into the surrounding landscape, providing access to the main cultural, natural, and recreational destinations identified in the land-use analysis (see fig. 32).

Together, these three elements form the spatial framework for the regional landscape park.

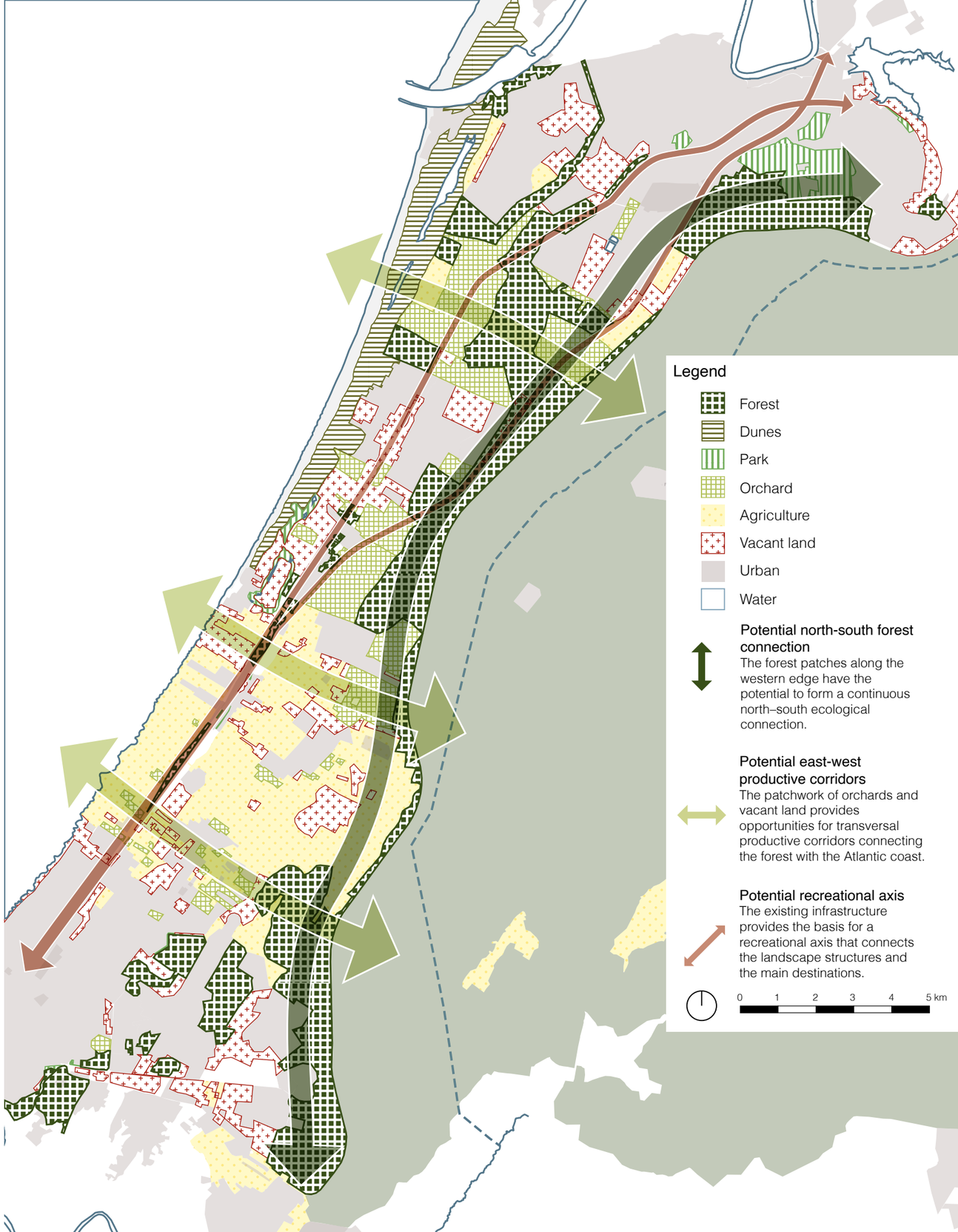


Figure 36. Structural analysis map showing the spatial structure of the combined open spaces.

Precedent 2. Parc Agrari del Baix Llobregat

4.3 Parc Agrari del Baix Llobregat

Introduction

The Parc Agrari del Baix Llobregat is a peri-urban agricultural park of approximately 3316 ha located near Barcelona (Müller et al., 2024). Just like Collserola Natural Park, it is part of the larger green structure surrounding the Barcelona metropolitan region. Located in the lower valley of the Llobregat river, the park occupies one of Catalonia's most productive agricultural landscapes (fig. 37). The park is characterized by highly fertile soils, a temperate climate, and an extensive irrigation network that supports intensive vegetable and fruit production. Agricultural production primarily supplies the regional food system through local markets and Barcelona's Mercabarna. Artichokes are the park's most characteristic crop (Àrea Metropolitana de Barcelona, 2014).

In addition, the agricultural park functions as a green lung within one of the most densely urbanized regions of Spain, providing important ecological and social benefits (Àrea Metropolitana de Barcelona, 2014). It forms a transition zone between the protected natural areas of the Llobregat Delta and the surrounding urban landscape. In doing so, it buffers sensitive ecological areas from urban pressures and reinforces ecological connectivity. The park also provides important social value by accommodating educational and recreational activities. However, Àrea Metropolitana de Barcelona (2014) emphasizes that these complementary functions must remain compatible with the primary agricultural use of the land.

Despite its importance, the agricultural area has been under continuous pressure from the development of the Barcelona metropolitan area. Urban expansion and the construction of new infrastructure have fragmented the agricultural landscape and degraded its environmental quality. At the same time, the loss of agricultural heritage has weakened the cultural identity of the landscape.

In response to these pressures, Parc Agrari del Baix Llobregat was consolidated in 1998. The subsequent Pla Especial de Protecció i Millora (Special Protection and Improvement Plan), approved in 2003, provides the legal and spatial planning framework for the protection and management of the park (Àrea Metropolitana de Barcelona, 2014). Rather than only focusing on preserving agricultural land, the plan integrates agricultural production with environmental protection and public use regulation. As a result of this integrated approach, the park functions as a multifunctional territorial model within the metropolitan landscape (Tucci & Müller, 2026).

Strategy

The planning framework of the Parc Agrari del Baix Llobregat consists of three complementary instruments: the Special Protection and Improvement Plan, the Management and Development Plan, and the Agricultural Park Consortium (Montasell i Dorda & Callau i Berenguer, 2008). Together, these instruments provide the legal framework, strategic direction and governance of the park.

The Special Protection and Improvement Plan is based



Photograph by Patxi Uriz. Source: Diputació de Barcelona.



Photograph by Moreno Ramal. Source: Next Llobregat.



Photograph by Patxi Uriz. Source: Banc de Terres.

Figure 37. Impressions of Parc Agrari del Baix Llobregat

on three interests: the productive interest of agricultural activity, the ecological and environmental interest of the natural systems, and the social interest in preserving the cultural landscape while supporting educational and recreational activities. Accordingly, the plan establishes three complementary objectives. At a productive and economic level, it organizes the agricultural area to guarantee the necessary conditions for competitive and high-quality agricultural production. At an ecological level, it ensures the long-term conservation of the natural areas and their biodiversity. At a social level, it preserves the cultural landscape and its heritage while accommodating public use for recreation and environmental education (Àrea Metropolitana de Barcelona, 2014).

The three objectives are implemented through five strategies, defined in the Management and Development Plan. The strategies are: improve the efficiency of agricultural infrastructure and services; promote agricultural production and marketing; encourage the modernization of agricultural enterprises; create a high-quality landscape that is integrated into the surrounding territory and in harmony with the natural environment; and preserve the natural and cultural heritage of the park while remaining compatible with agricultural activity (Àrea Metropolitana de Barcelona, 2014).

The implementation of both plans is coordinated by the Agricultural Park Consortium. This is a multi-level governance body containing regional and local governments together with the Farmers' Union. Ultimately, the consortium is responsible for the management of the Parc Agrari del Baix Llobregat (Consorci del Parc Agrari del Baix Llobregat, n.d.).

MultiPark proposal

While the previous section described the planning framework of the existing Parc Agrari del Baix Llobregat, Gausa and Canessa (2018) propose the concept of a MultiPark as a strategic vision for the park's spatial organization (see fig. 38). Building upon the existing agricultural park, the proposal seeks to restructure the landscape into a multifunctional territorial system. Rather than viewing the city and countryside as separate entities, the proposal reflects a broader shift towards an integrated peri-urban landscape in which agricultural production forms the structural framework for ecological, recreational and cultural functions (Gausa & Canessa, 2018). Agriculture remains the dominant land use, but is strengthened through complementary activities that reinforce its economic, environmental, and social value.

The proposal builds upon a territorial analysis that analyzes the Agricultural Park through multiple themes and scales to understand its position within the metropolitan region. The resulting diagnosis identifies the park's relationships, potentials and opportunities as the basis for the proposed spatial framework (Gausa & Canessa, 2018; Tucci & Müller, 2026).

Gausa and Canessa (2018) synthesize the multi-layer analysis into four conceptual diagrams. These integrate the identified infrastructural, functional, heritage, environmental, productive and landscape potentials into a coherent planning framework. The diagrams organize these potentials into spatial strategies that operate at both the metropolitan and local scale (Tucci & Müller, 2026).

Together, the four conceptual diagrams form the MultiPark. The proposal structures the Agricultural Park as one large landscape composed of four distinct but interconnected sub-parks. Each sub-park has its own character and program while remaining part of a coherent landscape network. This structure combines different forms of use within a single agricultural landscape and provides a model that can be adapted to other peri-urban contexts (Gausa & Canessa, 2018; Tucci & Müller, 2026). Figure 39 presents the four conceptual diagrams that structure the MultiPark.

The Central Network

The Central Network forms an internal system of scenic routes based on the existing roads, waterways and historical buildings. The strategy strengthens the central axis between the river and the beach and opens the park to walking, cycling and other recreational activities. Greenways and forest areas are added to the network, while existing farms are repurposed for educational and eco-tourism uses, restaurants and other recreational functions. Community gardens and information points along the routes further connect public use with the agricultural identity of the park.

The Cross Bands

The Cross Bands create a series of transverse connections through the park. They follow the existing field structure and main routes, linking the park interior with the surrounding urban areas. New peri-urban parks along the edge serve as entrances and connect residential and productive areas to the agricultural landscape. Existing roads are redeveloped as green routes that extend into the park. Along the cross bands, agricultural land is reorganized for experimental cultivation, while unproductive areas are reused for recreation.



Figure 38. MultiPark proposal concept diagram (Gausa et al., 2018).

The Perimeter Ring

The Perimeter Ring forms an active band around the park. It concentrates productive and recreational uses along the boundary. These include gateway parks, research centers, distribution points for local products and spaces for recreation. Along the coast, the ring accommodates eco-tourism and agro-tourism facilities, while former industrial sites along the perimeter are adapted to agricultural uses.

The Green Spine

The Green Spine extends the river landscape by adding a green corridor running parallel to the highway. It acts as a buffer between the airport and the agricultural land. The green spine expands river habitats, forest areas, and recreational spaces. It also includes community gardens that support educational activities. Additionally, it integrates eco-tourism and wellness facilities into the natural environment, combining public use with landscape conservation and ecological improvement of the park.

Relevance for the project

The Parc Agrari del Baix Llobregat demonstrates how an agricultural landscape park can be managed to include environmental protection and public accessibility without compromising its primary productive role. Agriculture remains the structural foundation of the park, while recreational, educational, and ecological functions strengthen its environmental and social value. This is relevant to the Maâmora context, where productive landscapes could be designed to support ecological restoration and public use instead of pressuring them.

Another relevant aspect for the design project is the MultiPark concept proposed by Gausa and Canessa (2018). It uses a multi-layer territorial analysis to identify spatial relationships, challenges, and opportunities within the Agricultural Park. These findings are translated into four complementary spatial design strategies that operate at different scales. Rather than proposing a fixed design, the MultiPark provides a flexible spatial framework that can be adapted to different conditions.

This approach is transferable to the Maâmora forest, where multiple stakeholders and land uses compete. The site analysis in the previous chapter shows that the decline of the forest results from interacting environmental and anthropogenic pressures across the region. The MultiPark demonstrates how these challenges can be addressed within one regional framework. It organizes urban, productive, and natural landscapes as complementary parts of one connected landscape. This spatial concept could therefore provide a basis for the design of the Maâmora regional landscape park.

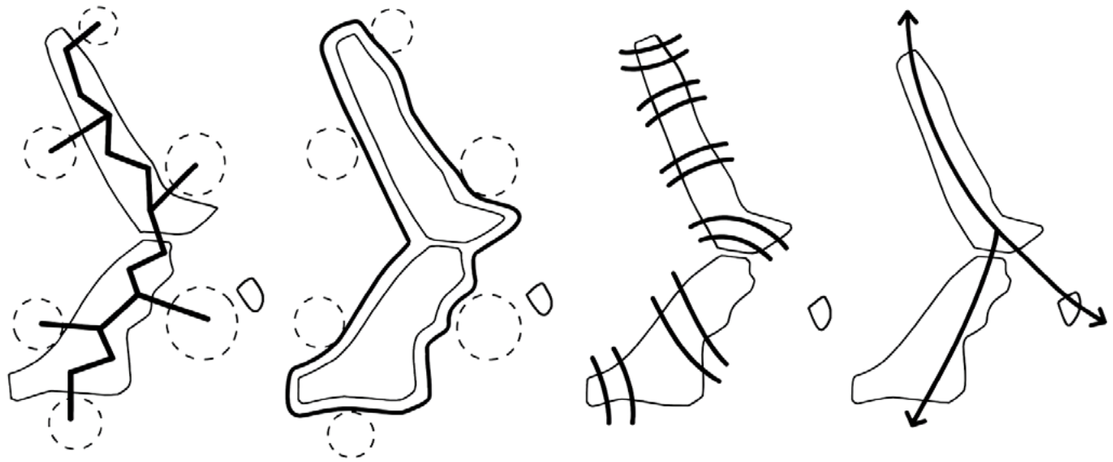


Figure 39. Design principles for the Multipark proposal of Parc Agrari del Baix Llobregat. Adapted from Gausa et al. (2018).

4.4 Designing the spatial framework

Design principles

Based on the findings of the land-use and structural analysis, together with the analysis of the MultiPark proposal for Parc Agrari del Baix Llobregat, a set of six design principles was developed. The principles are shown in figure 40. They are used as starting points for the design, as they translate the main findings of the analysis into spatial guidelines for the framework of the West-Maâmora Regional Park. The six principles can be divided into three pairs, each related to one of the three main structures of the park: the recreational axis, the north–south forest connection, and the east–west productive corridors.

The design principles are:

- Improve public access within and to the rural landscape
- Activate strategic locations as recreational destinations
- Create a continuous forest structure along the Maâmora edge
- Integrate urban functions into the forest edge
- Strengthen east-west connections through productive corridors
- Structure urban growth with clear urban-rural transitions

Concept development

The concept consists of three layers, following the three spatial structures identified in the structural analysis. Using the design principles as guidelines, these structures are developed into the main elements of the regional landscape park. The layers have different functions but are not hierarchically ordered. Together, they form one spatial framework. The conceptual framework is shown in figure 41. The three layers will be explained in detail on the following pages.

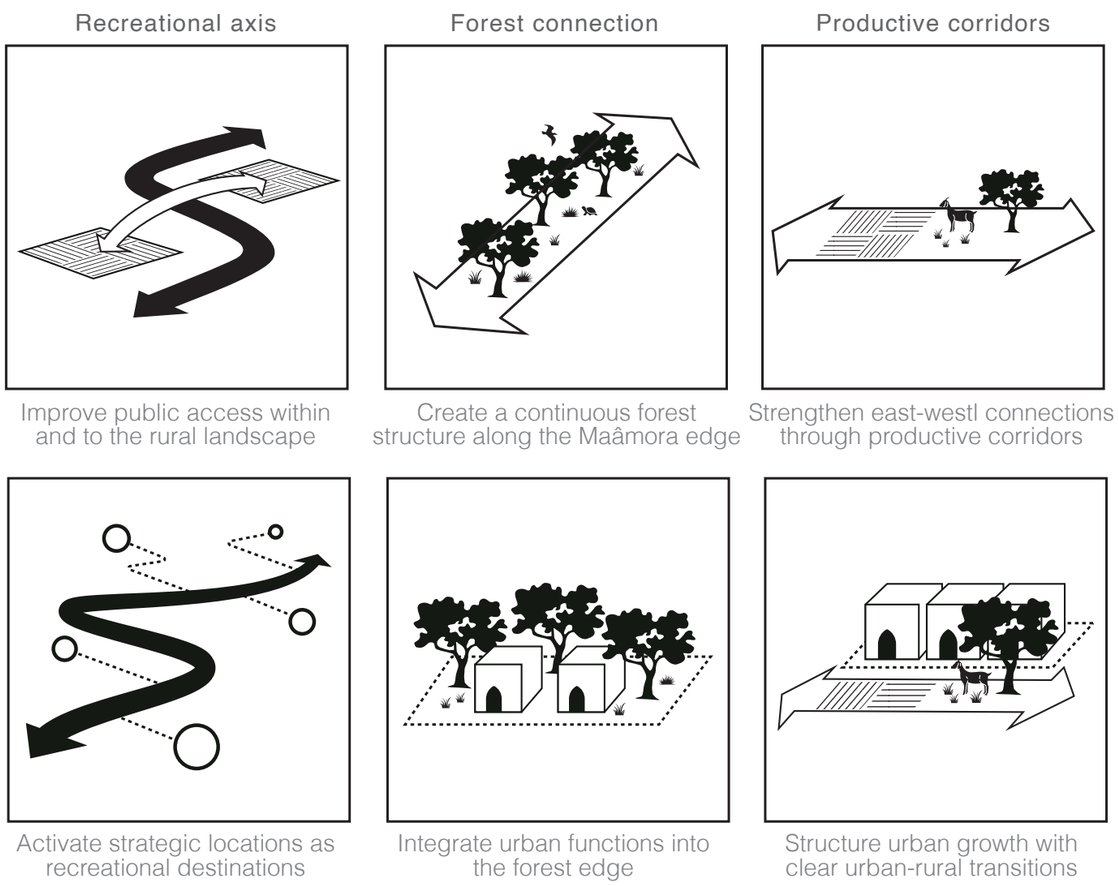


Figure 40. The six design principles used to develop the framework of the regional landscape park.

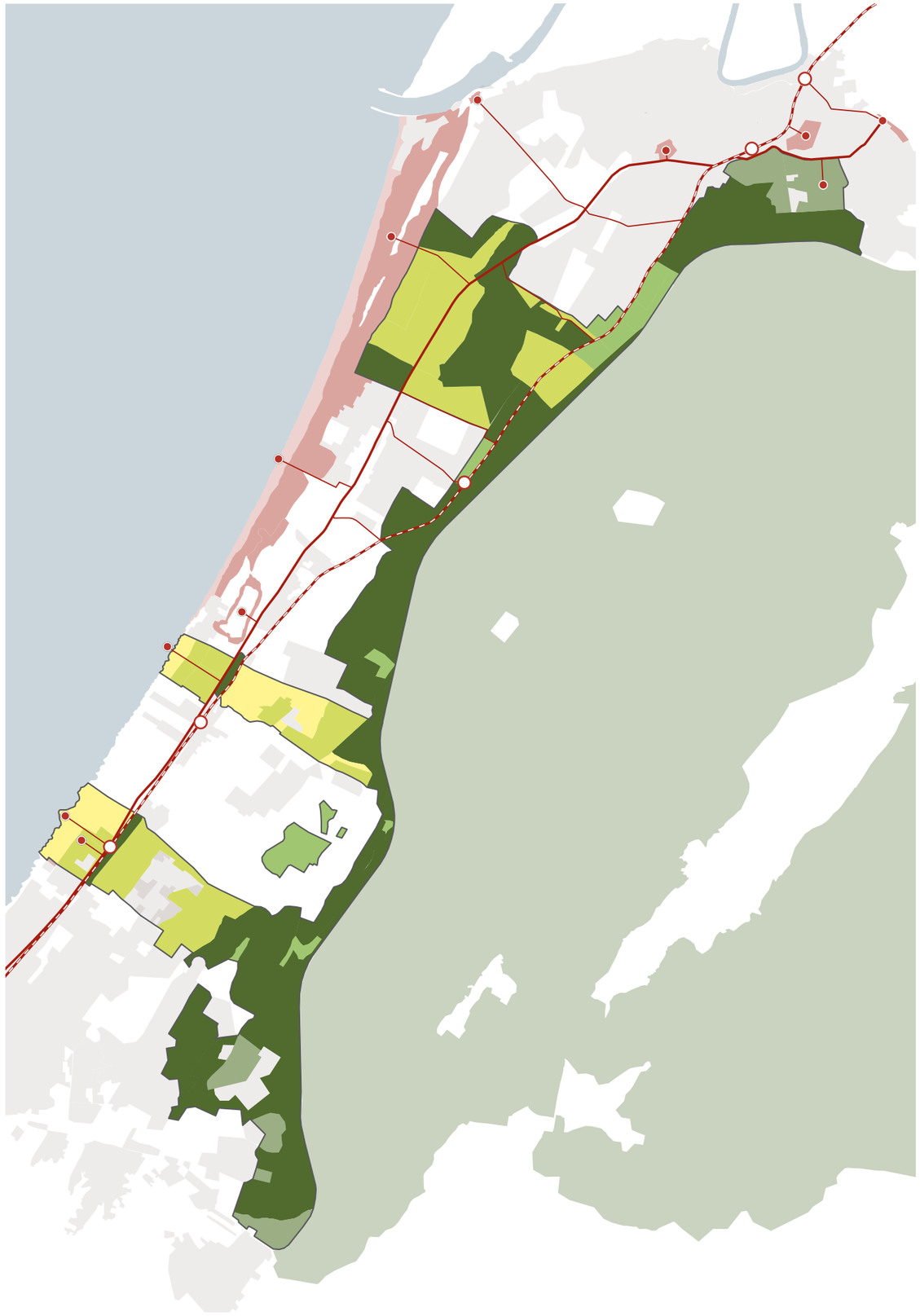


Figure 41. Concept drawing for the West-Maâmora landscape park framework.

The forest buffer zone

The first layer is the forest buffer zone along the western edge of the Maâmora forest (fig. 42). Existing forest patches provide the basis of this structure. The main purpose of this zone is to restore the missing connections between the patches to create a continuous north–south forest strip. Existing cork oak areas are conserved, while degraded areas are regenerated. As mentioned in the analysis, regeneration efforts are mostly needed near Kénitra, where cork oak cover is fragmented. The aim is to create a continuous forest structure that improves ecological connectivity and forms a transition between the peri-urban landscape and the ecological core of the Maâmora forest. The forest buffer is spatially separated from the lager Maâmora forest by the Rabat-Tangier highway, but remains connected by constructing wildlife underpasses underneath the road.

The buffer zone also includes productive landscapes. The agricultural areas adjacent to the forest edge, are transformed into new ways of agriculture that benefits the ecological function of the forest buffer. One example are Silvopastoral systems inspired by the dehesa and montado landscapes, that combine open cork oak woodland with livestock grazing. This allows productive land to remain in use while creating a more gradual transition towards the forest. These areas can also reduce grazing pressure on the ecological cores by providing alternative grazing areas outside the sensitive forest zones. Agroforestry provides another suitable land-use strategy. It offers a multifunctional land-use strategy that can help reconcile productive, ecological, and social interests in peri-urban landscapes. Torralba et al. (2025) specifically mention agroforestry as a promising approach for reconciling conflicting land use interests in the peri-urban context of the Maâmora forest.

Recreational access is differentiated within the forest buffer zone. In particular, the urban forests next to Salé and Kénitra function as the main recreational hubs. However, as identified in the analysis, these areas are currently poorly connected to surrounding neighborhoods and lack the spatial structure and facilities needed to accommodate visitors. The focus should be on strengthening their connection to the city and improve their capacity to support recreational use. By concentrating recreational access near the cities, pressure is reduced on the ecologically sensitive forest areas.

The forest buffer zone is not a single-purpose landscape, but combines ecological objectives with multifunctional agriculture and recreation. Forest conservation remains the main priority, but integrating productive

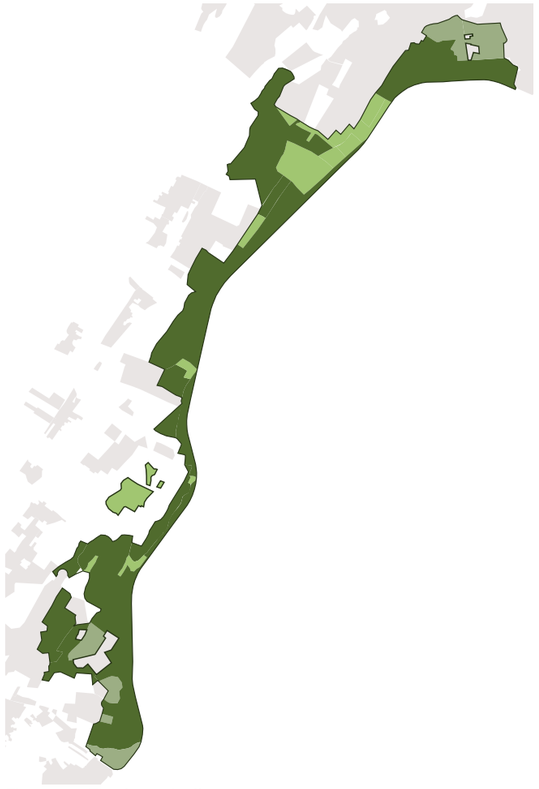


Figure 42. The forest buffer zone.

and recreational functions ensures the landscape also supports the social and economic demands of the area.

The productive green belts

The second layer consists of three productive green belts, mainly made up of cropland, orchards, and nurseries (fig. 43). Their main purpose is productive, but they also function as important east–west connections between the Maâmora forest and the Atlantic coast. Infrastructure within the belts should therefore mainly support movement in this direction. To function as connective landscapes, the productive belts should be publicly accessible and well connected to the existing infrastructure network.

Agriculture within the belts should respond to local environmental conditions. Considering soil conditions and water availability when selecting crops contributes to a more climate-resilient productive landscape. However, the green belts should not depend on production alone. Integrating ecological and recreational functions into the agricultural landscape increases their long-term value and contributes to the multifunctional character of the regional park.

The three belts share the same overall objectives, but their character differs according to the local landscape

context. The northern belt has a stronger ecological role because it connects the Maâmora forest with the coastal dunes. The southern belt includes more urban functions because it incorporates an urban extension of Salé. The spatial structure of each belt should build on existing conditions, including plot patterns, roads, and land-use types.

The belts are located directly next to urban areas. Here, they can protect the remaining open agricultural landscape by preventing urban development from gradually expanding into the countryside. Designing clear edges is important to maintain the distinction between urban and rural areas. Using physical landscape elements to define these edges creates clear transition zones that work better than relying on administrative boundaries alone. This is particularly important in the middle belt, where maintaining open space prevents Sidi Bouknadel and Sidi Taibi from merging into one.

The productive green belts strengthen the spatial framework of the regional landscape park by introducing a transverse east–west structure that complements the longitudinal structure of the forest buffer zone. Additionally, they add a productive layer to the ecological structure, integrating agriculture as an important part of the regional park.

The recreational route

The third layer is the recreational route, which connects the main cultural, natural, and recreational destinations of the region into one network (see fig. 44). At the same time, it improves general accessibility and strengthens connections between urban and rural areas. The route builds on the existing infrastructure network and supports different speeds of movement. Railways and highways provide fast regional transportation, while local roads and walking paths allow for a slower pace to experience the landscape. Together, these different types of routes create a hierarchical network through the regional park.

The main existing destinations include the Botanical Gardens of Bouknadel, Sidi Boughaba National Park, the golf course, Kasbah Moulay Ismail, Lake Park Kénitra, and the urban forests of Salé and Kénitra (see fig. 45). To add to this, strategic locations along the route can be developed as new destinations. Farms, gardens, and educational facilities can be activated to provide opportunities to experience the landscape. A variety of experience that reflect the unique characteristics of the region help to strengthen the identity of the landscape park.



Figure 43. The productive green belts.

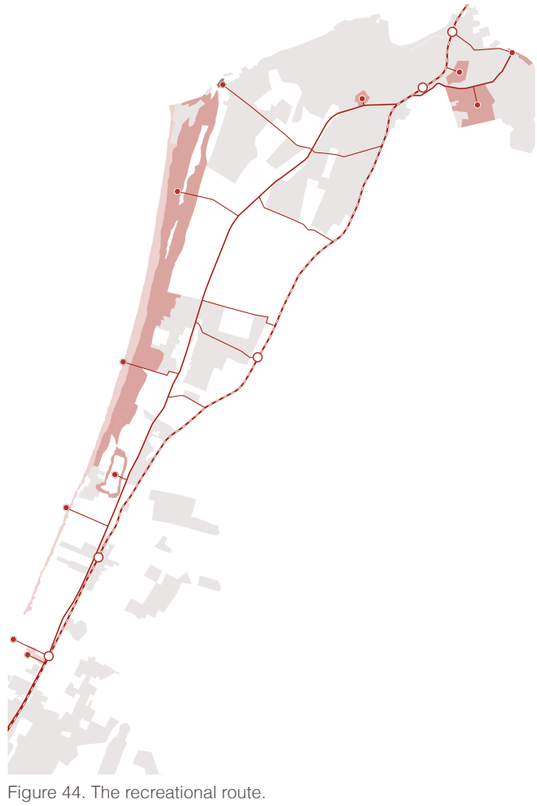


Figure 44. The recreational route.

Another important objective is improving access to the Atlantic coast. At present, access to the beach is limited in several parts of the study area, while some coastal sections are dominated by private developments. The recreational network can create new connections to make the Atlantic coastline more accessible and an integral part of the regional park.

Unlike the forest buffer zone and productive green belts, the recreational route does not form a separate functional zone. Instead, it acts as a connective layer that ties the different landscape elements and destinations of the regional park together.

Application of the spatial framework

Figure 45 shows how the proposed framework is applied to the existing landscape. The three layers are developed in more detail, showing the different land uses within each layer. As in the large-scale strategic vision, regeneration areas and montado landscapes are used to connect existing forest patches into one continuous structure. Within the productive green belts, different agricultural land uses are proposed based on the existing landscape. The map also shows the recreational destinations connected by the route, as well as train stations that improve accessibility. Ultimately, the framework establishes spatial conditions to guide urban development. It identifies areas where urban development should be restricted, while also indicating potential locations for expansion. These areas are shown in light pink on the map, mainly adjacent to existing urban centers. However, the framework does not determine exactly where or how future development should take place.

An important characteristic of the framework is the balance between spatial continuity and flexibility. The forest buffer zone and productive green belts establish long-term landscape structures that guide the development of the surrounding region. While these structures are intended to remain relatively stable, the activities and land uses within them can adapt to changing conditions and demands. In contrast, the surrounding landscape allows greater flexibility, while still responding to the boundaries established by the framework. In this way, the proposal provides a long-term spatial direction without prescribing a fixed end result.

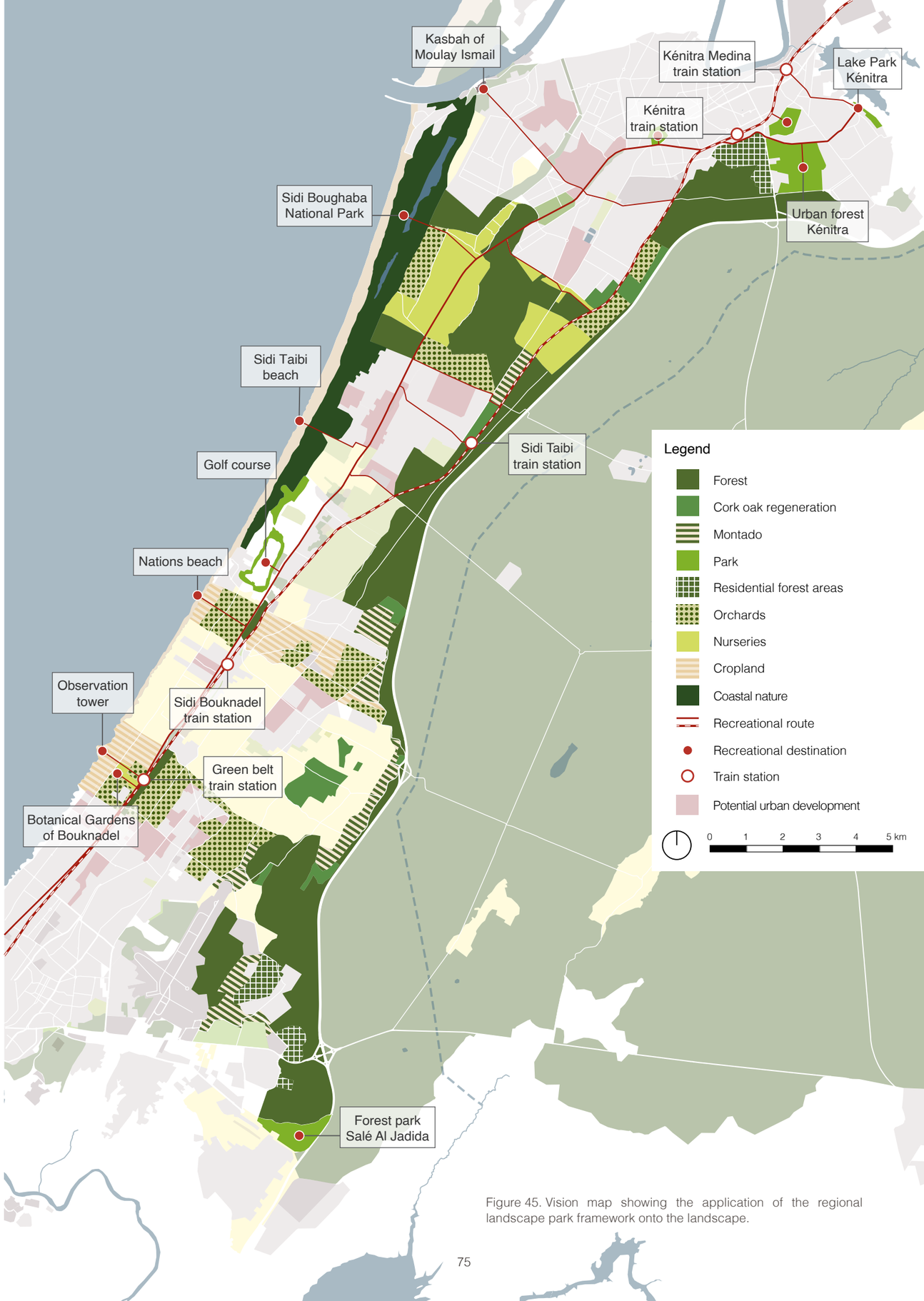


Figure 45. Vision map showing the application of the regional landscape park framework onto the landscape.

THE PRODUCTIVE GREEN BELT

05

5.1 Site analysis

Of the three productive green belts proposed within the regional landscape park, the southern belt north of Salé is selected for further elaboration (see fig. 46). This green belt is located in a peri-urban landscape affected by the northward expansion of Salé. Parts of the city have already expanded into the rural landscape, resulting in fragmented urban areas between the agricultural fields. The productive green belt could provide a counterbalance to this expansion by protecting the remaining open landscape and structuring future development.

Figure 48 depicts an analysis map of the study area, showing the existing land uses. Additionally, figure 47 illustrates a schematic section of the landscape between the Atlantic coast and the Maâmora forest. The area consists mainly of agricultural fields, with orchards scattered throughout the landscape. Notably, a considerable number of plots appear to be undeveloped or no longer in agricultural use. Due to their proximity to the city, these areas are particularly vulnerable to urban development.

In terms of spatial structure, the landscape lacks a clear layout. The highways and railroad form the main infrastructural elements and mainly run in a north–south direction. East–west connections are limited. Strengthening these connections is one of the main objectives of the productive green belts and should therefore become an important part of the design.

Along the eastern side of the study area, a substantial forest area remains west of the highway. This area is separated from the main Maâmora forest but forms an important natural area within the regional landscape park. The productive green belt could help protect this part of the forest.

The agricultural landscape currently offers few opportunities for recreation. Public access is limited, with no recreational routes and only a few destinations within the area, such as the Botanical Gardens of Bouknadel, the Atlantic coast, and the Maâmora forest. Improving connections to these locations could make the agricultural landscape more accessible for recreational use.

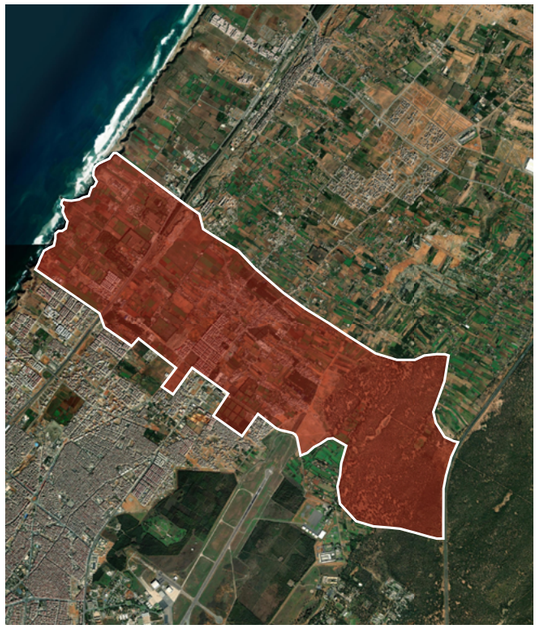


Figure 46. Location of the peri-urban strip directly north of Salé as the area for the proposed green belt. Map created using Esri satellite imagery.

Two existing institutions provide opportunities to strengthen the agricultural and recreational functions of the area. The Botanical Gardens of Bouknadel already form an important recreational and educational destination. In addition, the agricultural institute could provide agricultural knowledge and education to support the expansion of productive land. Both institutions could become important catalysts for the development of the green belt.

Water availability is another important consideration. The study area currently lacks a coherent irrigation network that could support a more productive agricultural landscape. However, an underground water channel connected to the Sidi Mohamed Ben Abdellah Dam passes through the area. Its exact use is unknown, but its location provides an opportunity for the development of a water distribution system. If water cannot be extracted directly, a separate pipeline could potentially be constructed alongside it. Such a system could also become an important structural element for the productive landscape.

Conclusion

The analysis shows that the study area has a fragmented landscape structure and lacks internal connections. Agricultural fields and orchards form a large part of the open landscape, but are threatened by urbanization. East–west connections are limited and the agricultural landscape offers few opportunities for recreation. The lack of a coherent irrigation network also limits the expansion of productive land.

Nevertheless, there are still elements that the design can build on. Sufficient open space remains to form the basis of the green belt, while the existing water infrastructure could provide a starting point for a new irrigation system. Further research is needed to determine how this water infrastructure could be used. The Botanical Gardens of Bouknadel and the agricultural institute could support the development of the green belt by providing agricultural knowledge. The goal of the design is to develop a productive landscape that protects the remaining open space and the Maâmora forest, improves accessibility, and creates new opportunities for recreation.



Figure 48. Analysis map showing the main land uses and destinations on the design site.



Figure 47. Cross-section showing the different landscape types between the Atlantic coast and the Maâmora forest.

Precedent 3.
The Agdal of Marrakech

5.2 The Agdal of Marrakech

Introduction

The Agdal (Agdāl) is a large agricultural estate located south of Marrakesh at the foot of the Atlas Mountains. Founded during the twelfth century, it consists of an enclosed landscape of orchards, gardens, reservoirs, royal residences, and service buildings that has remained largely intact to the present day (see fig. 49). The Agdal has been restored, expanded and adapted by successive dynasties. It reached almost 500 hectares at its greatest extent before urban development reduced it to its current area of approximately 340 hectares (Navarro et al., 2017; Stockstill, 2024). Although the area surrounding Marrakesh has limited arable land and no permanent water resources, the Agdal was made productive through an extensive irrigation system (Navarro et al., 2018).

The estate forms an extension of the royal kasbah, to which it is closely linked (Navarro et al., 2017). Together with the rahba, a large ceremonial esplanade located immediately south of the kasbah, the Agdal formed part of a continuous urban sequence extending beyond the city walls. The Agdal, rahba, and kasbah were organized along a continuous north–south axis, creating a spatial sequence that connected the urban center with the productive landscape (Stockstill, 2024).

The internal layout of the Agdal is organized around this main north–south axis, which follows the natural slope of the terrain. It links the kasbah with the Palace of Happiness (Dār al-Hanā), located in the south of the estate (see fig. 53). From this axis, the Agdal is divided into an orthogonal grid of rectangular plots. These are further subdivided into cultivated fields connected by paths and irrigation ditches. The relatively flat topography of the site enabled this regular layout, which facilitated the management of agricultural land (Navarro et al., 2018).

Water system

The climate around Marrakesh is characterized by low and irregular rainfall, high temperatures, low humidity, high evaporation rates, and dry summers. These conditions make irrigation and protective windbreaks essential for agriculture (Pascon, 1977). Water reached the Agdal through a combination of underground *khaṭṭāras* and aboveground irrigation channels. The working of a khaṭṭāras is shown in figure 50. The khaṭṭāras collected groundwater from the shallow aquifer and provided a relatively constant water supply throughout the year. However, this alone was insufficient to irrigate the large plantations of the Agdal during the dry season. An additional water supply was secured through the Tassoultant ditch, which diverted



Figure 49. Satellite image of the Agdal. Source: Bing

water from the Ourika River to Marrakesh (Navarro et al., 2018).

After entering the Agdal from the south, the Tassoultant ditch flowed towards the Dar al-Hana reservoir. Before reaching the reservoir, the water passed through a series of settling basins where sediment was removed. The reservoir is located on the central north–south axis of the estate and is probably the oldest surviving structure of the original Agdal. It measures 208 by 181 meters and has a storage capacity of approximately 83,000 m³. This large capacity guarantees the year-round availability of water, ensuring irrigation throughout the dry season (Navarro et al., 2018). Besides regulating irrigation, the reservoir historically supplied drinking water to Marrakesh and was used for swimming and military practice (Stockstill, 2024).

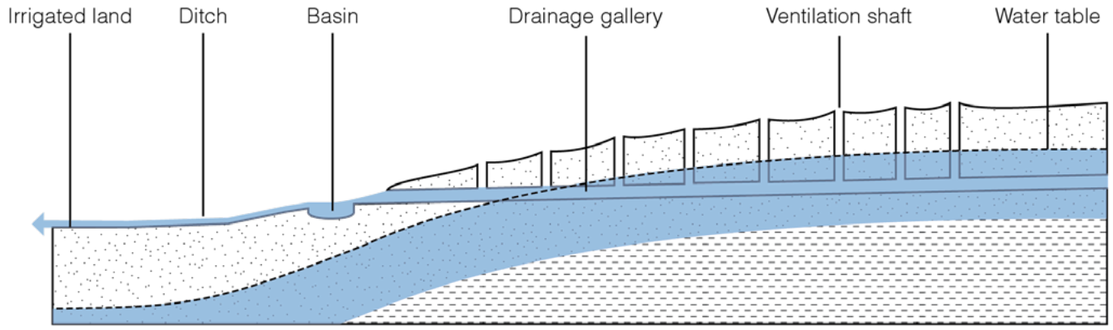


Figure 50. A sectional view showing the working of a khattara. Groundwater is collected from the water table and transported by gravity through a gently sloping underground channel to the surface, where it is collected in a basin and used to irrigate agricultural fields.

From the reservoir, water was distributed through a network of *seguias*. These aboveground irrigation channels distributed water to the cultivated plots using traditional flood irrigation. The main seguias followed the principal paths through the estate, while smaller branches carried water to the individual fields. The channels were lined with brick to reduce water loss through infiltration. Their slightly raised position along the paths gave them a clear visual presence within the landscape (Navarro et al., 2018). The entire irrigation system relies on the natural topography, allowing water to flow by gravity from the ditches and channels to the cultivated fields. The water system of the Agdal is shown in figure 52.

Agricultural production

The Agdal has remained a productive agricultural estate since its foundation. Its plots are organized according to the water requirements of different crops. Olive groves occupy the eastern and southern parts of the estate. Citrus orchards and other fruit trees are concentrated in the western section, where additional irrigation infrastructure meets their higher water demands (Navarro et al., 2018). The fruit orchards are surrounded by rows of tall olive trees that function as windbreaks and provide shade along the paths. Additionally, date palms are planted near irrigation ditches and the shafts of khaṭṭāras, where they mark elements of the water system (Navarro et al., 2018). An example of this layout can be seen in fig. 51.

Relevance for the project

The Agdal of Marrakesh demonstrates how a productive landscape can become part of the wider urban structure rather than remain separate from it. The main north–south axis connects the urban fabric with the agricultural estate and creates a strong spatial relationship between them. As a result, the Agdal becomes an extension of the city that forms a clear transition to the rural landscape. The same principle informs the proposed productive green corridors, which extend from the urban areas into the surrounding rural landscape.

The Agdal also shows how an agricultural landscape can be preserved over time. Despite its location immediately beside Marrakesh, the estate has remained largely intact since its foundation in the twelfth century. Its productive function has been retained through successive restorations and adaptations. In addition to agricultural production, the Agdal provides water management, recreation, and cultural value. This multifunctionality has strengthened its importance to the city and contributed to its preservation. The proposed green corridors follow a similar approach by combining agriculture with ecological and recreational functions. These additional functions increase the value of the corridors and help protect the landscape from urbanization.

Another relevant principle is the relationship between water management and spatial organization. In the Agdal, the irrigation system determines the spatial organization of the land. Water storage, distribution, and cultivation are arranged according to a clear spatial hierarchy. This is particularly relevant on a relatively flat terrain, where few natural landscape features provide spatial structure. The water system therefore becomes the main organizing element of the landscape. The productive green corridors apply this principle by using



Figure 51. An agricultural plot surrounded by olive trees that serve as windbreaks. Source: Navarro Palazón et al. (2013, p. 17).



Figure 52. Spatial layout of the Agdal of Marrakech. The drawing shows the underground and surface irrigation systems, as well as the plot structure and the distribution of crops.



Figure 53. Dar al-Hana enclosure. In the foreground, the central path (1) and reservoir (2). In the background a residential building (3), boathouse (4), and stables (5). Source: Navarro et al. (2018, p. 37).

the irrigation system to organize the layout of the agricultural landscape.

The distribution of crops also responds directly to water availability. Crops with higher water requirements are located closer to the main irrigation infrastructure, while less demanding crops are positioned further away. Water efficiency therefore influences the spatial organization of the Agdal. For the proposed design it is important to consider the environmental conditions of the Maâmora region. Crops should be selected according to water availability, soil conditions, and climate.

Finally, the Agdal provides a culturally grounded precedent for the design. Its spatial structure combines traditional agriculture and water management, recreation, and Moroccan architecture within one landscape. Reinterpreting these principles adds a cultural dimension to the project and connects the design to Morocco's landscape traditions.

5.3 Designing the productive green belt

Design principles

As discussed in the chapter on the concept development of the regional park, the productive green belts are intended primarily as productive landscape corridors and secondly as a way to protect open space from further urban sprawl. To translate these aims to the zoom-in site, a set of six design principles was developed. The principles combine the findings of the site analysis with lessons from the precedent study of the Agdal of Marrakesh and are shown in figure 54.

The principles guide the detail design and ensure that it responds to the existing landscape while remaining consistent with the larger goals of the regional landscape park. Although they are applied to only one of the three productive belts in this thesis, they are overarching principles that could also guide the design of the other belts.

The design principles are:

- Build on existing landscape structures
- Use the water system to structure the productive landscape
- Adapt crop selection to local water availability
- Create a multifunctional productive landscape
- Design a clear and functional edge between urban and productive landscapes
- Transform underused land into productive land

Design elaboration

The design plan for the new productive green belt can be seen in figure 55. The design translates the concept of the Agdal of Marrakech into a contemporary productive green belt north of Salé. The design principles ensure that the design aligns with the goals of the regional landscape park and responds to the local landscape. The green belt builds on existing landscape structures, including the agricultural plot structure, infrastructure, and topography. The irrigation system forms the main structure of the design. It organizes the productive landscape and facilitates new east–west connections.

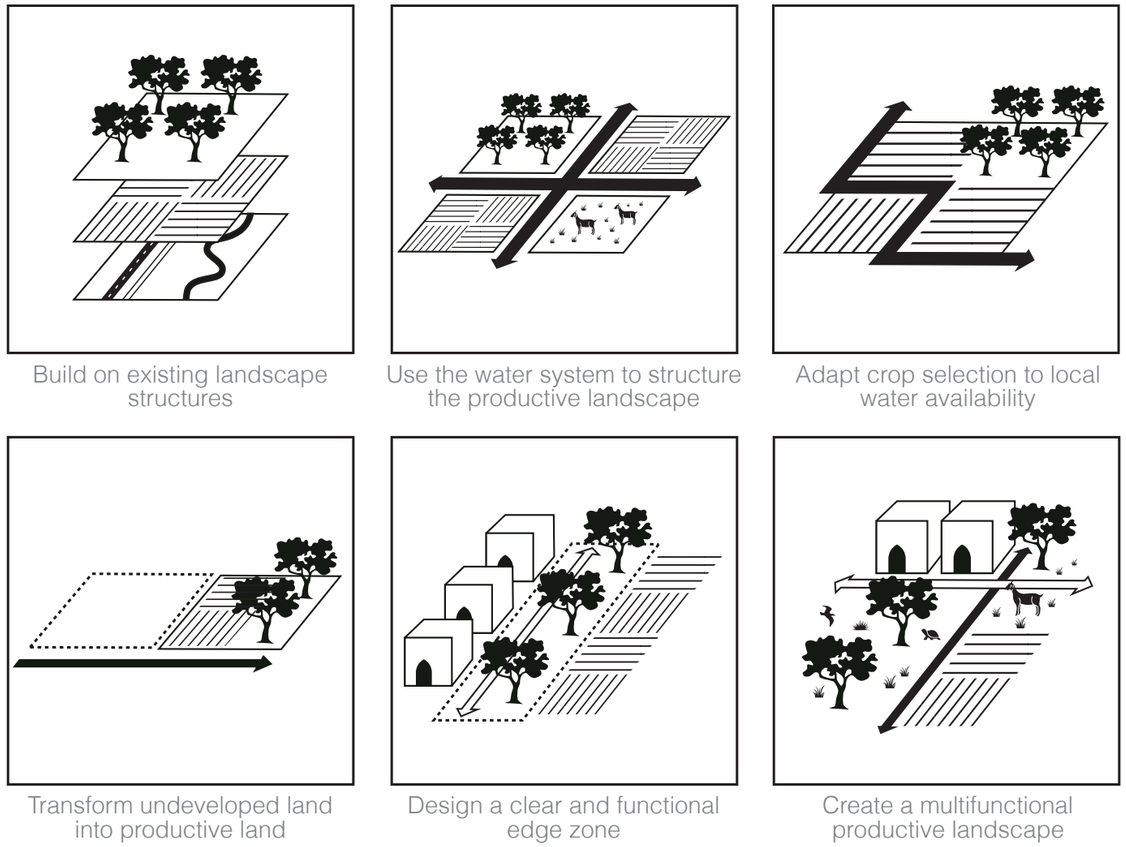


Figure 54. The six design principles used to design the productive green belts.

A schematic landscape section of the situation after the implementation of the design is shown in figure 56. This figure can be compared with figure 47 to see the difference between the existing and the new situation.

Multifuctional water system

The new water system follows a similar logic to that of the Agdal. Water is transported from the Sidi Mohamed Ben Abdellah Dam through an underground pipeline. At the western edge of the existing forest, the water emerges into an artificial lake. This forms the starting point of the irrigation system and creates a new recreational destination within the forest. Walking paths provide access around the lake. The presence of water also allows different species to grow here, such as Populus nigra and Populus alba. This gives the lake a different character from the surrounding cork oak forest.

From the lake, the water is divided between four main seguias that supply different parts of the productive green belt. The landscape gradually slopes towards the Atlantic coast, allowing the water to move through the channels by gravity. The irrigation system is explained in more detail in figure 58. The seguias form the basis for the organization of the agricultural landscape. They follow the existing plot structure as much as possible. This limits the need for new roads and reduces changes to existing property boundaries. Undeveloped plots are either transformed into productive land or used to accommodate the irrigation channels, paths, and associated landscape elements.

Agricultural land uses are organized according to water availability. The eastern part of the green belt is mainly intended for crops that require little irrigation. Here, the landscape gradually transitions from the existing cork oak forest into an open montado-inspired silvopastoral landscape and then low-irrigation orchards. The silvopastoral landscape forms a buffer around the forest and combines grazing with scattered cork oak trees. Further west, the seguias supply water to storage basins. These basins provide more reliable irrigation for crops with higher water demands. High-irrigation fruit orchards are therefore concentrated in this part of the green belt. In this way, the distribution of crops responds to differences in water availability. The high-irrigation fruit orchards are surrounded by rows of olive trees. These taller trees shield the fruit trees from strong winds, helping them grow.

Structuring urban development

The productive green belt also provides a structure for future urban development. The existing urban extension of Salé is consolidated into one urban area rather than allowing scattered development across the agricultural landscape. This creates a clearer distinction between the urban and rural landscape.

The southern seguia plays an important role in defining this boundary. Together with a recreational path and rows of trees, the channel creates a clear and functional edge between the city and the productive landscape. Agricultural land directly along this edge is adapted to uses related to the surrounding residential areas. Allotment gardens provide space for small-scale food production, while parks and other green spaces make use of currently vacant plots for recreation.

Within the urban extension, a new market square forms a central public space. Local agricultural produce can be sold here. The market square also marks an important part in the water network, as two seguias pass through the square. The water system is made visible here through designed water elements such as fountains and a reflection pool. The design of the square is elaborated further in figure 73.

Recreational connections

The irrigation system also structures the recreational network. Walking paths follow the main seguias and create continuous east–west routes. The paths provide public access to areas that are currently difficult to reach. The main destinations of the green belt are marked with numbers on the map. The routes provide access to these points. One of the main routes continues from the Maâmora forest towards the Atlantic coast. At the coast, a new observation tower marks the end of this route. From here, visitors can look across the ocean and back towards the productive landscape. Rows of trees provide shade along the recreational paths and give the routes a recognizable character. In this way, the productive landscape also becomes accessible as recreational space for surrounding residents.

To improve regional accessibility, a new train station is proposed along the existing railway, near the Botanical Gardens of Bouknadel. The station makes the green belt and its recreational destinations more accessible to visitors from surrounding cities, without having to rely on a car. At the same time, it improves mobility for residents living within the green belt.

Irrigation explained

The water system is an essential part of the productive green belt (see fig. 58). The system starts with water from the Bouregreg River, which feeds the Sidi Mohamed Ben Abdellah Dam. The dam stores water that is used for the drinking water supply of the Rabat–Salé–Kénitra region. The design proposes the

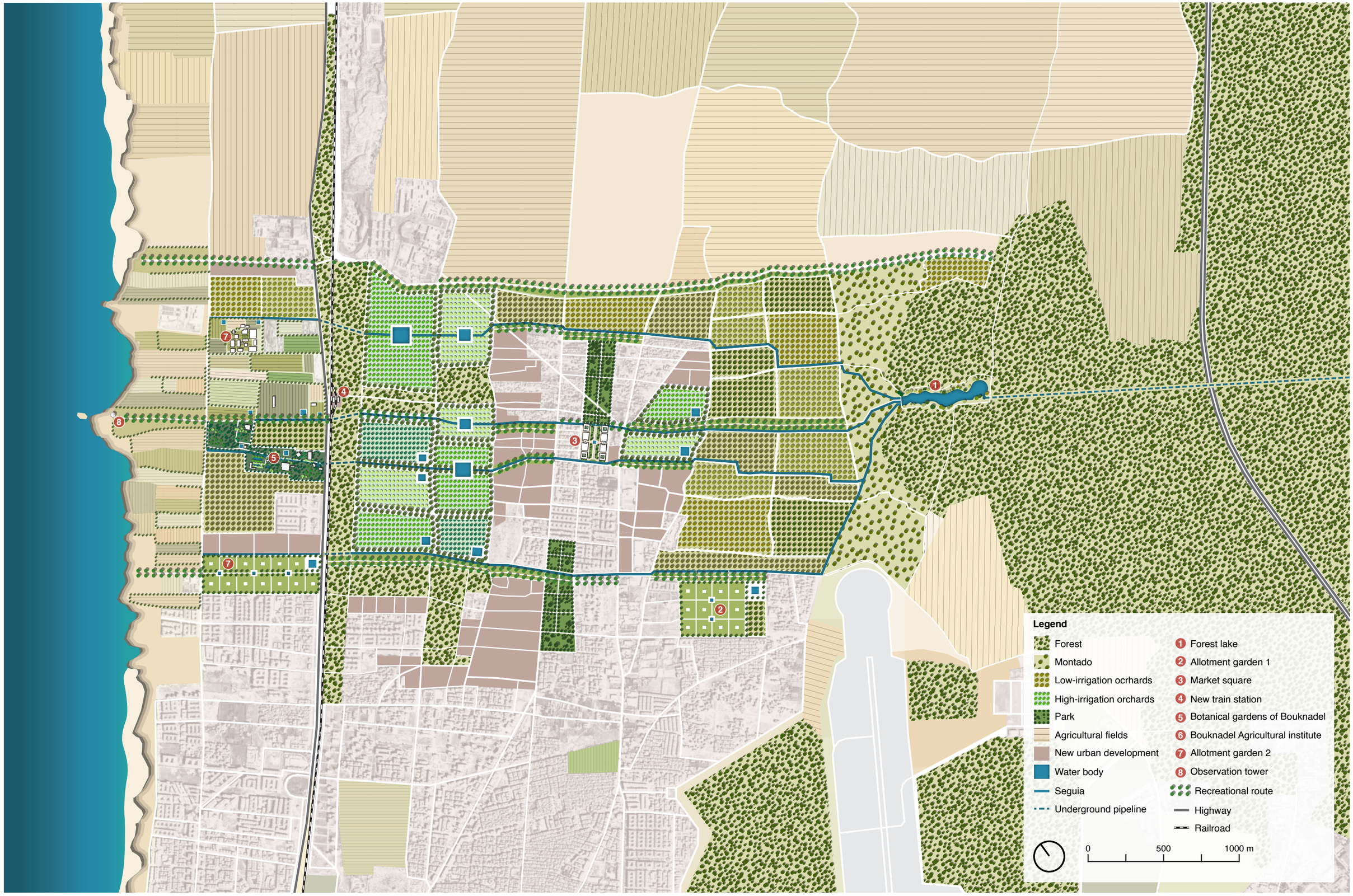


Figure 55. Design plan of the productive green belt.

construction of an underground pipeline that transports water from the dam through the Maâmora forest towards the productive green belt.

At the western edge of the existing forest, the water emerges from underground into an artificial lake. This lake forms the starting point of the visible irrigation system and divides the water between four main seguias. Each seguia follows a different route and supplies a different part of the productive landscape. The brick-lined channels distribute irrigation water to the agricultural fields and orchards.

Within the high-irrigation orchards, water is collected in larger storage basins. These basins store water for use during drier periods. From here, smaller channels distribute the water further across the agricultural plots. Two of the main seguias also pass through the urban area. Here, the water system becomes visible through designed water elements on the market square.

At the end of the system, the seguias connect to different destinations within the green belt. The Bouknadel Agricultural Institute forms one of these endpoints. Here, water can support agricultural education, experimental cultivation, and research. The Botanical Gardens of Bouknadel form another endpoint, where the water can be used to fill ponds and basins and water the exotic plants. Along the southern edge of the green belt, the irrigation system supplies the communal allotment gardens and forms part of the public space between the residential areas and agricultural fields.

Figures 59–64 give an impression of how the water system is experienced at eye level. The series of perspective drawings follows the water system, starting at the forest lake, continuing along the orchards and recreational route, and ending at the Botanical Gardens of Bouknadel.

Overall, the irrigation system consists of a hierarchical network that irrigates the agricultural plots while also organizing the landscape. It functions as a connector by structuring recreational routes and as a separator by defining the transition between urban and rural areas.

Crop selection

The Ministry of Agriculture, Maritime Fisheries, Rural Development and Water and Forests (2022) identifies several crops suitable for cultivation in the Rabat–Salé–Kénitra region. Within the productive green belt, these species are divided into two categories based on their irrigation requirements. In figure 57 some of these species are shown.

Low-irrigation orchards

Irrigation is limited within these orchards. Drought-tolerant species are therefore most suitable. Potential species include olive (Olea oleaster), almond (Prunus dulcis), fig (Ficus carica), and carob (Ceratonia siliqua).

High-irrigation orchards

These orchards have a more reliable water supply because irrigation water is stored in basins. This allows species with higher water requirements to be cultivated. Potential species include citrus trees such as orange (Citrus sinensis), lemon (Citrus limon), and mandarin (Citrus reticulata). Other suitable species are pomegranate (Punica granatum), apple (Malus domestica), plum (Prunus domestica), peach or nectarine (Prunus persica), and avocado (Persea americana).

Besides water availability, several other growing conditions should be investigated. Soil type, drainage, and salinity are important factors to consider, as well as wind exposure and seasonal temperatures . For example, some species require sufficiently cold winters for flowering and fruit production. The final crop selection should therefore respond to the local site conditions within the productive green belt.


Source: AgriMaroc


Source: AgriMaroc


Source: AgriMaroc


Source: AgriMaroc


Source: AgriMaroc


Source: AgriMaroc


Source: La Vérité


Source: AgriMaroc


Source: AgriMaroc

Figure 57. Suitable orchard species to grow in the produtive green belt. From left to right: Prunus dulcis, Ceratonia siliqua, Ficus carica, Olea oleaster, Citrus limon, Citrus reticulata, Punica granatum, Malus domestica, Prunus persica.

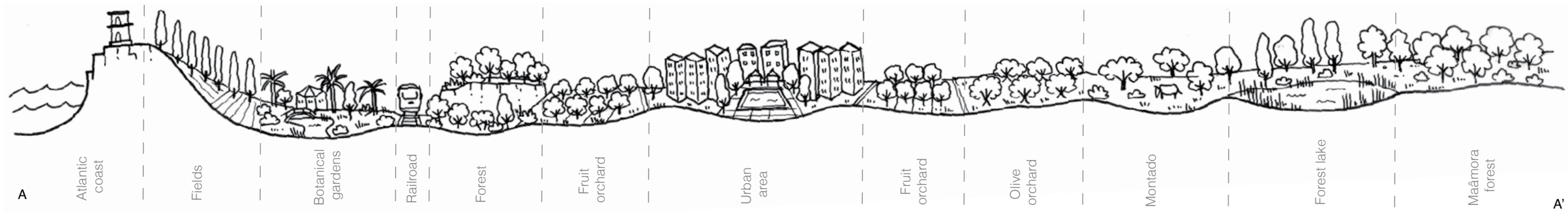


Figure 56. Schematic landscape section showing the new landscape types in the productive green belt.

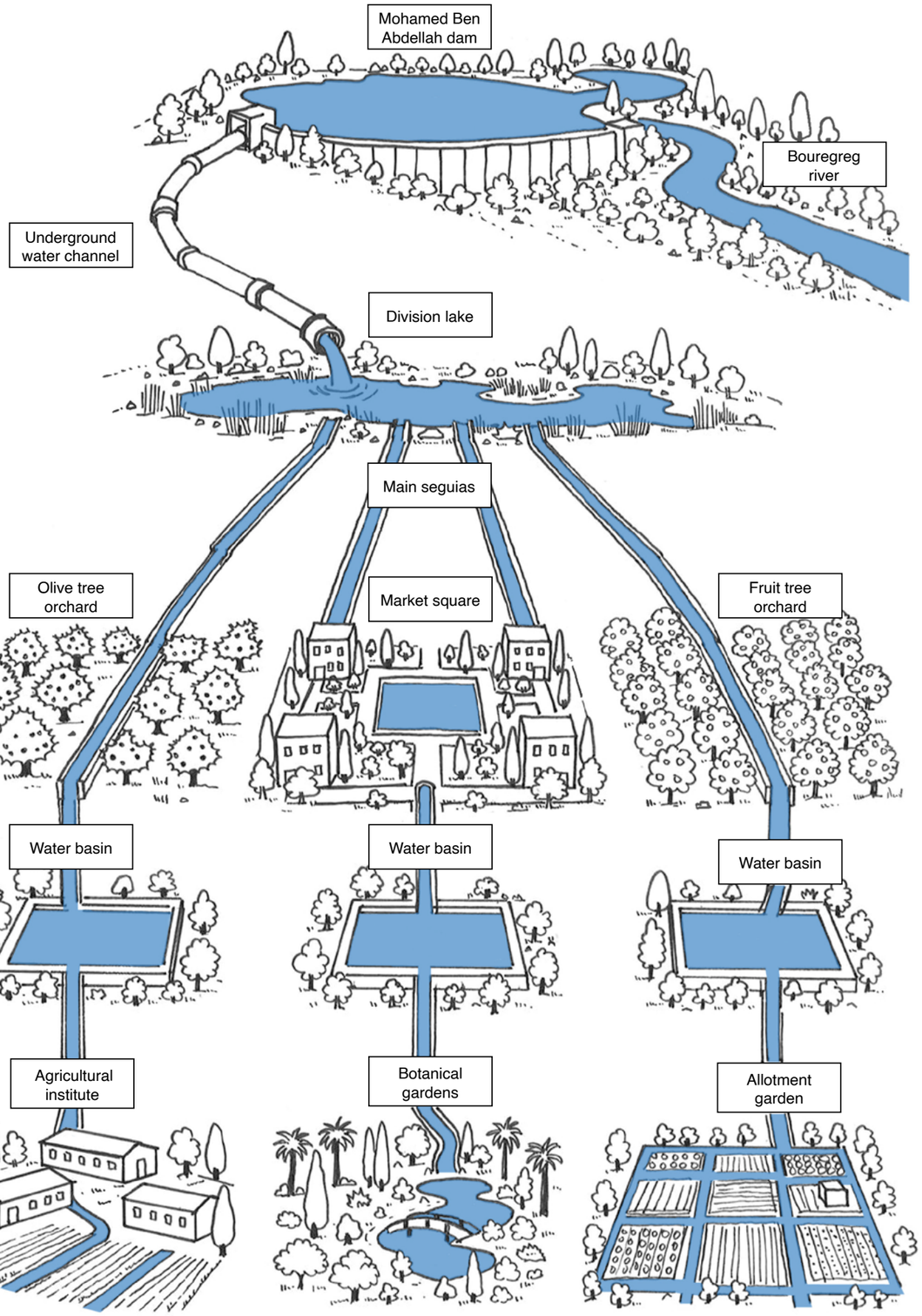


Figure 58. Schematic drawing of the water system of the green belt.



Figure 59. Eye-level perspective of the artificial forest lake.



Figure 60. Eye-level perspective of a main seguia running through the forest.

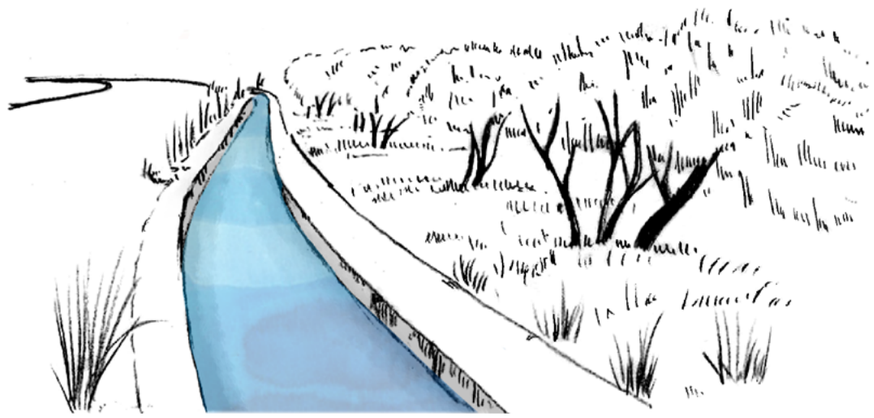


Figure 61. Eye-level perspective of a main seguia running along an orchard.



Figure 62. Eye-level perspective of a recreational path lined with cypress trees.

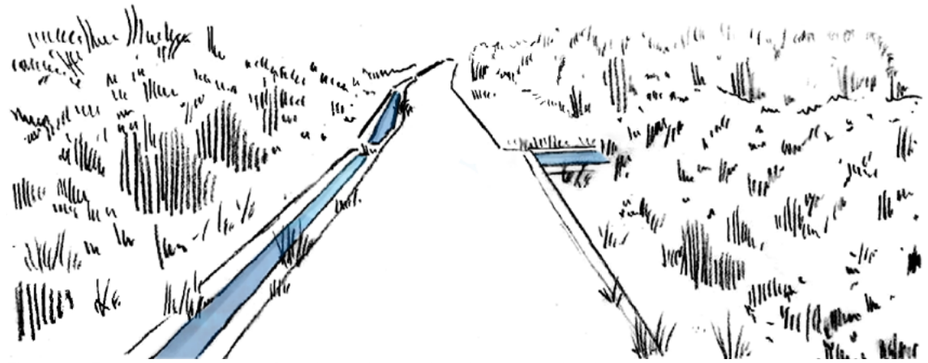


Figure 63. Eye-level perspective of small seguias running along the orchards.

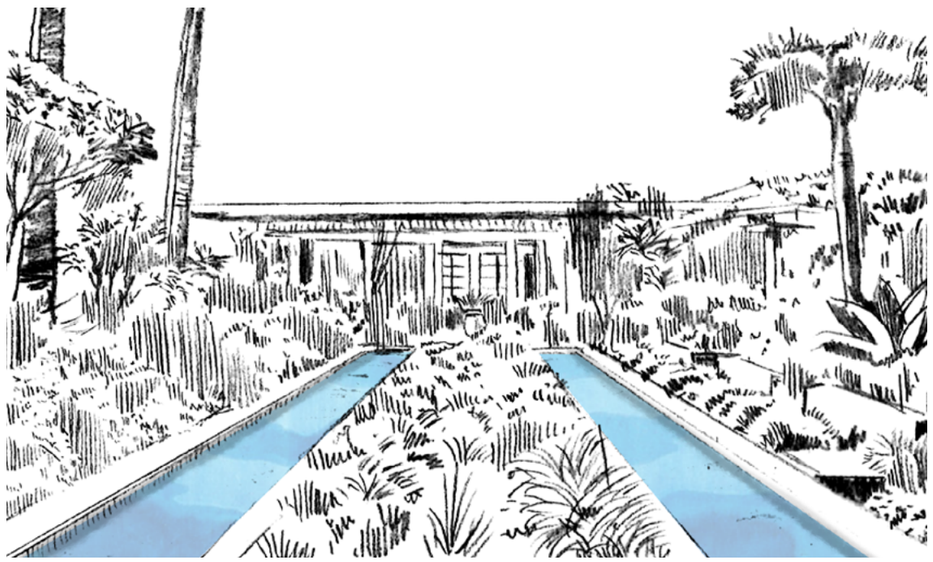


Figure 64. Eye-level perspective of a pond in the Botanical Gardens of Bouknadel.

5.4 Allotment garden detail design

The first detail design zooms in on the allotment garden on the eastern side of the green belt. Its location is indicated with number 2 on the design plan in figure 55. The allotment garden forms part of the transition between the residential area and the productive landscape. The design is shown in figure 69 and follows the same design language as the green belt, taking inspiration from the Agdal of Marrakech. It is important to note that the plan is not drawn to scale and should therefore be understood as only an illustration of the situation.

The water system applies the same hierarchical structure. Water is first collected in a large basin and then distributed through small seguias along the plots (see fig 65). From these channels, the cultivated fields can be irrigated using simple flood irrigation. Smaller basins along the central axis of the allotment gardens provide additional water that residents can use to water their gardens. Figure 66 shows an example of what this central axis could look like. Fruit trees are planted along the edges. They provide additional produce while also creating a clear boundary around the gardens.

The allotment gardens are intended for residents of the surrounding neighborhood and provide a shared space for small-scale food production (see fig. 67). By bringing residents together through gardening, these spaces can encourage social interaction and strengthen the sense of community within the neighborhood.

Alongside the allotment garden runs the recreational path that defines the edge between the city and the green belt. A section of this area is shown in Figure 68 and indicated as section A–A′ on the detail design plan. The main element is a walking path lined with tall cypress trees (Cupressus sempervirens). The path runs between the allotment gardens on one side and the orchards of the green belt on the other. The edges of the path are planted with native species adapted to the local climate. Because the transition zone is wider at this location, there is also space for a picnic area.

This detail design shows how the principles of the productive green belt can be applied at a smaller scale. The allotment gardens combine food production with recreation and shared use by local residents. The designed elements form a clear transition between the residential area and the productive landscape.



Figure 65. An earth irrigation channel running along small-scale agricultural plots. Source: El Mundo CR.



Figure 66. Irrigation channel within the Andalusian Gardens in Rabat. Source: Maroc Lovers.



Figure 67. Women at work in the YSL Beauty Ourika Community Gardens. Photograph by YSL Beauty. Source: Wallpaper

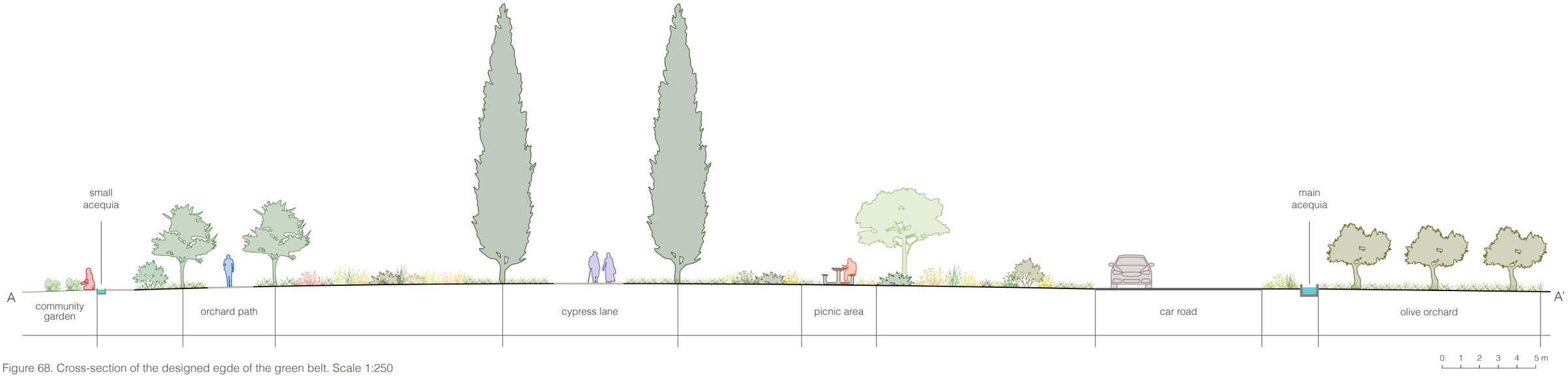


Figure 68. Cross-section of the designed egde of the green belt. Scale 1:250



Figure 69. Detail design plan of the transistion zone between the green belt and residential space. Not drawn to scale.

5.5 Market square detail design

The second detail design focuses on the market square at the center of the urban area within the productive green belt. Its location is indicated with number 3 on the design plan in figure 55. The site is currently undeveloped. The new square becomes the central public space of the residential area, providing space for meeting, selling local produce, and recreation. The design of the market square is shown in figure 73.

Water forms an important element within the design of the square. At the center is a shallow reflection pool supplied by the irrigation system of the green belt. Its shape refers to the larger water basins used within the productive landscape, but here the water merely functions as a spatial and recreational element rather than for storage. A similar example is shown in figure 70. Another water element is the fountain square, where small water jets emerge directly from the pavement. An example is shown in figure 71. This provides a place for children to play and introduces water as recreational element.

A central axis provides space for market stalls where produce from the surrounding green belt can be sold. On both sides of this axis, strips of trees provide shade across the square. New residential buildings are positioned along the edges of the square. Their arrangement creates smaller public spaces between the buildings. Each of these spaces contains a small fountain, making the irrigation water visible throughout the residential area.

A section through the center of the market square accompanies the plan and is shown in figure 72. It illustrates the sequence from the buildings and smaller squares along the edges towards the central market space. The section also shows the tree strips, market area, and reflection pool that structure the main square.

This detail design shows how the productive landscape can be integrated into the urban area. The market brings local agricultural production from the green belt directly to residents, while the irrigation system becomes a visible part of the public space.



Figure 70. Lazare-Goujon Square, Villeurbanne.Source: In Situ.



Figure 71. Granary Square fountains, London. Source: King's Cross.



Figure 73. Design plan of the market square and its water elements.

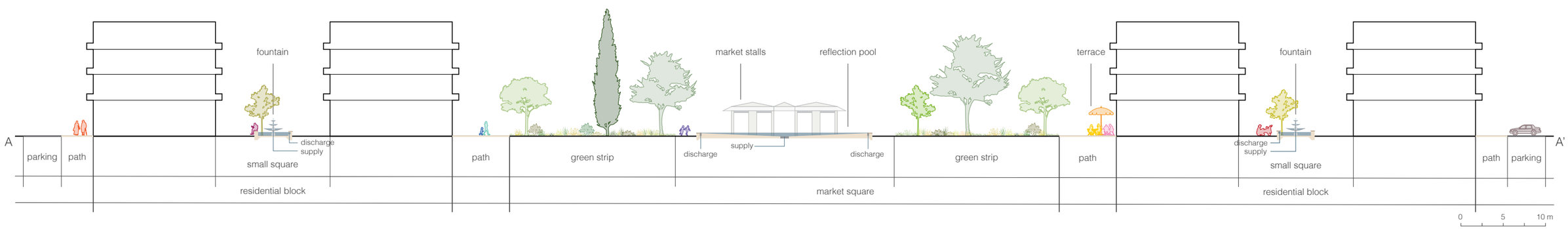


Figure 72. Section through the center of the market square showing the spaces.



DISCUSSION & CONCLUSION

06

6.1 Discussion

Findings

This thesis provides a new way of looking at the restoration of the Maâmora forest by shifting the focus from the forest itself to the spatial development of the surrounding region. Previous research has already extensively documented the degradation of the forest and identified the drivers of its decline. This research builds on that knowledge by exploring how these drivers can be addressed together through landscape-based spatial design. Rather than treating forest conservation as an isolated ecological task, the thesis considers how the surrounding landscape can be structured to contribute to the long-term conservation of the forest.

The research also demonstrates how an integrated design approach can be applied to complex problems at a large scale. A regional landscape framework allows urban development, agricultural production, and ecological restoration to be addressed simultaneously and in relation to one another. This creates opportunities to mediate between land uses that would otherwise compete. An important finding is the use of transitional landscapes to reduce these conflicts. The proposed montado landscapes, for example, combine ecological and agricultural functions, while the forest buffer zone accommodates recreation alongside ecological restoration. These transitional landscapes provide ways for competing land uses to coexist within the same space.

Another finding is that a structuring landscape framework can be developed even when pronounced landscape structures are limited. For example, the study area lacks major elevation differences or a clearly defined water system. However, careful analysis of the existing landscape revealed other elements and patterns that could form the basis of the design. By building on these existing elements, the framework can structure development without imposing an entirely new spatial organization.

The research also highlights the value of precedent studies within the design process. Studying projects that address similar challenges provided insights into possible design interventions. Translating these insights into design principles made it possible to adapt them to the specific conditions of each design site. Although the proposed interventions have not been tested in practice, the precedents provide a reference for the design decisions made.

Finally, the research shows the value of working across different spatial scales. The large-scale vision established the overall direction, the regional framework translated this into a spatial structure, and the productive green belt showed how the principles could be adapted to a local context. Moving between these scales also helped refine the design proposals, as more detailed design decisions revealed opportunities and limitations that were less visible at larger scales.

Limitations

Although the proposed regional framework establishes spatial conditions to guide urban development, it does not provide an urban development strategy. It does identify where urban development should be restricted, and indicates possible locations for urban development. However, these locations remain indicative and require further investigation. Although potential development areas were studied in more detail within the productive green belt, their integration into the design remains limited. The framework should therefore be understood only as a starting point for urban planning rather than a comprehensive development plan.

A second limitation concerns the implementation and management of the design proposals. For example, the framework identifies opportunities for cork oak restoration, but does not investigate which regeneration methods would be most suitable or how they should be implemented over time. The framework also lacks a management strategy to coordinate the different land uses within the regional landscape park. Further development of the framework should therefore address the management and phasing.

A final limitation is the lack of local knowledge and different perspectives. Regional planning is normally a collaborative process involving multiple stakeholders with different interests. This research and the resulting designs were developed from my individual perspective. Although the physical landscape was analyzed in detail, the social and cultural context received less attention. As a Dutch student without a Moroccan background, my understanding of local customs and values is limited. Visiting the region provided valuable insights, but cannot replace the knowledge of local experts and communities. Further development of the framework would therefore require close collaboration with regional experts, planning authorities, and local stakeholders.

Transferability

The methodology used in this thesis could be relevant to other large-scale landscape architecture research projects. Applying three research steps across three design scales provided a useful way to deal with the complexity of the regional scale. Moving from analysis to precedent studies to design experiments made it possible to translate research findings into spatial interventions. The methodology also improved the consistency between the design proposals at each scale, allowing for refinement throughout the process. However, this approach required considerable time and effort, reducing the level of detail at which each scale is worked out.

The design principles developed through this research could also be relevant to other regions facing similar challenges. At the largest scale, principles such as ecological connectivity, differentiated accessibility, and functional forest edges can be applied in different contexts. However, specific interventions depend on local landscape conditions and land-use practices. For example, silvopastoral buffer zones require sufficient open agricultural land, making them less suitable for densely urbanized regions.

At the regional scale, organizing the landscape park framework into overlapping layers offers a transferable approach as well. The three layers were developed in response to the main challenges identified through the regional analysis. Therefore, other regions may require different priorities and additional layers. The important takeaway is that the layers are developed in relation to one another, rather than functioning as separate structures.

At the local scale, the design becomes increasingly site-specific, drawing on the Moroccan Agdal as inspiration for the productive green belt. Nevertheless, the underlying principles remain sufficiently abstract to inform designs in similar contexts. The transferability of the design outcomes therefore lies primarily in the underlying principles, rather than the specific spatial solutions.

Personal reflection

At the beginning of this thesis, I was excited about the opportunity to work on an international project. The possibility of traveling abroad, was something I particularly looked forward to. However, I was quickly confronted with the limitations this would bring. All of the initial research depended on desktop analysis, while the availability of spatial data and documentation was very limited. This made it challenging to develop a detailed understanding of the landscape, especially considering the large scale of the study area. Adopting a landscape-based approach helped me deal with these limitations, as it allowed me to focus on broader landscape patterns and structures that I could discover using GIS analysis. Nevertheless, visiting the region was very important for adding depth to the project that could not be gained through desktop research alone.

Another challenge was the complexity of the problem at stake. Developing an appropriate research approach therefore required considerable time and effort. However, once the three-step, three-scale methodology was established, it was very effective in providing a clear structure for the research and design process. It helped me determine which steps were necessary to take and how the different scales could inform one another. At the same time, working on three different design scales meant dividing my time and attention, limiting the level of detail of each outcome.

Looking back, one of the main lessons I take from writing this thesis is that dealing with complex problems requires a clear structure, as well as a clear perspective from which to approach them. This helps to establish priorities and maintain focus on the most relevant aspects of the problem.

6.2 Conclusion

The decline of the Maâmora forest is caused by a combination of environmental and anthropogenic pressures. Rising temperatures and prolonged droughts have reduced water availability and made cork oak regeneration more difficult. At the same time, population growth and the expansion of built-up areas have increased the demand for land, groundwater, and forest resources. These pressures are particularly evident in the western part of the Maâmora, near the cities of Rabat, Salé, and Kénitra. Here, high population density coincides with high levels of forest degradation. Although previous management plans have attempted to restore cork oak cover, their focus on the forest itself has been insufficient to address the external pressures contributing to its decline. This thesis therefore used an integrated regional approach to the protection and restoration of the Maâmora forest, considering not only its ecological conditions but also the human activities and land-use dynamics affecting it.

The study of three precedents at different scales provided useful insights into landscape-based planning and design strategies that address conservation in relation to spatial development. Serra de Collserola Natural Park demonstrated how functional transition zones along the park edges help manage urban pressures and strengthen ecological connections. The MultiPark concept for Parc Agrari del Baix Llobregat showed how ecological, productive, and urban systems can be organized into overlapping layers within an adaptable regional framework. Finally, the Agdal of Marrakech illustrated how agricultural landscapes can combine productive, recreational, and cultural functions, while using water management as a structuring element of the landscape. The lessons derived from these precedents were translated into design principles that guided the development of the spatial framework. By keeping these principles relatively abstract, they could be adapted to the specific landscape conditions of each design area.

The design principles were first applied to develop a large-scale strategic vision for the Maâmora forest. This vision focuses on protecting and connecting cork oak cores through silvopastoral buffers in the form of montado landscapes. The western forest edge was also identified as an important area for intervention and became the focus area of the regional landscape park framework. This framework consists of three interconnected layers that bring together ecological, productive, and recreational functions. The forest buffer zone strengthens ecological connectivity through a continuous forest structure, while the recreational network improves social connectivity by increasing accessibility across the region. The productive green belt improves connectivity between the forest and the Atlantic coast, while simultaneously protecting the open agricultural landscape from urban expansion. Finally, to test the regional framework, a productive green belt was developed in more detail. This design demonstrates how the broader regional strategy can be adapted to local conditions.

The main lesson from this research is that ecological conservation and urban development should not be approached as separate challenges in regional strategies. By taking the landscape as starting point for regional planning, it becomes possible to first establish spatial structures that protect important ecological and productive areas before determining where urban development can happen. Additionally, a landscape-based approach provides opportunities to integrate competing land uses through transitional landscapes. However, not all land uses can coexist, and some areas still require clear boundaries. The landscape-based approach helped identify where gradual transitions could be applied and where more defined boundaries were needed. While landscape-based design responds well to the physical characteristics of the landscape, it does not automatically account for social and cultural dimensions. A comprehensive regional strategy would therefore require further research into these aspects, as well as collaboration with local stakeholders.

Overall, this thesis concludes that a landscape-based approach can guide the spatial development of the Rabat–Salé–Kénitra region by taking the existing landscape as the starting point. By identifying important ecological and productive areas, establishing connections between them, and creating opportunities for different land uses to coexist, the proposed regional landscape park provides a spatial framework that urban development can respond to. By directing recreational activities away from sensitive forest areas and establishing buffer zones along the forest edge, the framework aims to reduce the human pressures contributing to the decline of the Maâmora. In this way, the surrounding peri-urban landscape becomes part of the strategy for protecting and restoring the Maâmora forest, rather than continuing to contribute to its decline.



07

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