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Natural Light and Sensory Experience in Museums: A Sustainable Approach to the Cultural Valorization of Dellys

Final Year Project: Bridging Land and Sea: A Phenomenological and Cultural Museum in Dellys.

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Dedication

To my dearest family,

Your unwavering love, constant encouragement, and boundless patience have been the foundation upon which this journey was built. I am forever indebted to your presence in my life a presence that carried me through every moment and every step toward growth.

And to the resilient souls of Gaza,

To the students whose dreams persevered amidst the ashes of war, whose determination endured the horror of loss, and who, in the face of devastation, held on to their dreams and graduated with pride your courage humbled me. You redefined for me the meaning of strength, of dignity, and of what it means to pursue your dreams under the heaviest skies.

This modest work is dedicated to you, though it will never be enough.

You deserve more than words, more than acknowledgment, more than our distant sorrow. Yet, in this world that feels so helpless, I offer this page as a testament to your light.

May Allah forgive our silence, elevate our efforts, and guide us toward impactful ways to support your resistance.

May He hasten your liberation, from the river to the sea, Palestine will be free.

Acknowledgment

الحمد لله الذي بنعمته تتم الصالحات

بسم الله و الصلاة و السلام على محمد رسول الله صلى الله عليه و سلّم

First and foremost, I offer my deepest gratitude to Allah, the Most Merciful, whose divine guidance, wisdom, and will have allowed me to reach this point. Without His blessings and permission, none of this would have been possible.

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Abstract

In order to explore innovative and sustainable architectural solutions that celebrate the cultural identity and environmental specificities of Dellys, a Mediterranean coastal city in Algeria, a comprehensive research has been carried out. This study investigates the role of natural lighting and sensory experience in museum design, with the aim of developing a contemporary cultural institution that aligns with both local heritage and climate-responsive strategies.

The research adopts a multi-layered approach combining theoretical analysis, typomorphological and sensorial studies, and environmental simulations. Tools such as Meteonorm, Climate Consultant, Ecotect, and Radiance were used to evaluate daylighting performance and inform passive strategies tailored to Dellys' context. A diachronic urban analysis, supported by a SWOT evaluation, led to the definition of a thematic project: a cultural museum that acts as a bridge between land and sea, past and future.

The proposed museum reinterprets traditional Dellysian features, such as courtyards, qbous, and filtered openings, within a phenomenological and bioclimatic framework. The goal is to create a sensorial and emotional journey for visitors while enhancing visual comfort, reducing energy consumption, and promoting sustainable tourism. The spatial experience integrates local craftsmanship, educational workshops, and external artisan pavilions, all designed to revive the unique urban and architectural identity of Dellys in a resilient, environmentally responsive environment.

Keywords: natural lighting, phenomenology, sensory experience, sustainability, Dellys, cultural museum, bioclimatic strategies, passive design, heritage.

ملخص

من اجل استكشاف حلول معمارية مبتكرة و مستدامة تعزز الهوية الثقافية و الخصوصيات البيئية لمدية دلس, و هي مدينة ساحلية متوسطية تقع شمال الجزائر, أنجز بحث علمي شامل, يتناول هذا البحث دورالاضاءة الطبيعية و التجربة الحسية في تصميم المتاحف, و ذلك بهدف تصميم مؤسسة ثقافية معاصرة تنسجم مع التراث المحلي و تتبنى استراتيجيات معمارية متجاوبة مع المناخ.

يعتمد هذا البحث على مقاربة متعددة المستويات, تجمع بين التحليل النظري, و الدراسات التيبومورفولوجية و الحسية, بالإضافة الى الحاكاة ابيئية, و قد تم توظيف أدوات علمية متخصصة, لتقديم أداء الإضاءة الطبيعية و توجيه الإستراتيجيات الملائمة لسياق مدينة دلس.

يُعيد المتحف المقترح قراءة العناصر المعمارية التقليدية للدلس، على غرار الفناءات، القبّو، والمشربيات، ضمن مقاربة فينومينولوجية. ويهدف هذا التصور إلى توفير تجربة حسية وعاطفية للزائر، ترتكز على تحسين الراحة البصرية، وتقليل استهلاك الطاقة، وتعزيز السياحة المستدامة. كما تنخرط التجربة الفضائية في دعم الحرف التقليدية المحلية، من خلال ورشات تثقيفية وأجنحة خارجية للحرفيين، وذلك في إطار إحياء الهوية الحضرية والمعمارية المتميزة لمدينة دلس، في بيئة متجاوبة مع الخصائص المناخية.

الكلمات المفتاحية: الإضاءة الطبيعية، الفينومينولوجيا، التجربة الحسية، الاستدامة، دلس، المتحف الثقافي، الاستراتيجيات.

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Abbreviations

APRUE Agence Nationale pour la Promotion et la Rationalisation de l'Utilisation de l'Énergie (National Algerian agency for energy efficiency).

ASE Annual Sunlight Exposure.

CIBSE Chartered Institution of Building Services Engineers.

CRI Color Rendering Index.

DA Daylight Autonomy.

DF Daylight Factor.

DGI Daylight Glare Index.

DGP Daylight Glare Probability.

EUI Energy Use Intensity.

PDAU Plan Directeur d'Aménagement et d'Urbanisme (Master Plan for urban planning and land use in Algeria).

SDA Spatial Daylight Autonomy.

UDI Useful Daylight Illuminance.

UGR Unified Glare Rating.

VCP Visual Comfort Probability.

WWR Window-to-Wall Ratio.

Content

Glossary

Sustainable Architecture:
Sustainable architecture involves designing buildings that minimize environmental impacts by optimizing resource use, conserving energy, and promoting ecological conservation. It integrates aesthetic, economic, social, and ecological considerations (Mba, 2024).

Energy Efficiency
Energy efficiency refers to the effective use of energy to minimize waste and maximize output. It involves technologies and practices that reduce energy consumption without compromising performance (Li, 2021).

Bioclimatic architecture
(El-Sayed, 2023) defines bioclimatic architecture as "*A design approach that adapts buildings to the needs of occupants while optimizing energy consumption based on local climate conditions, furthermore, ensuring that the building's form is appropriate for its intended purpose. This approach considers various factors such as form configuration, orientation, internal spatial arrangement, facade design, vegetation usage, natural ventilation, and building mass usage to reduce energy passively and reduce dependence on active systems*"(p. 111). This definition emphasizes how bioclimatic architecture focuses on creating buildings that harmonize with the local climate and environment to achieve energy efficiency, comfort, and sustainability.

Bioclimatic architectural strategies
Bioclimatic architecture strategies are design approaches applied by architects to optimize the comfort and energy efficiency of buildings, especially when the local environment pushes the limits of natural comfort.

"*If we are in the comfort zone, architecture will not have to perform any corrections. If we are outside of the comfort zone, architectural strategies can be implemented to reach the comfort zone*" (Manzano-Agugliaro, 2015).

Introduction

Chapter 01

1.1. General introduction

The Industrial Revolution marked a turning point in human history, triggering profound transformations across all aspects of life. It introduced mass production, accelerated urbanization, and revolutionized global energy use. However, this progress came at a significant cost. The rapid consumption of fossil fuels, the exponential growth of cities, and the prioritization of economic efficiency over social and environmental well-being led to widespread ecological degradation. Urban environments became increasingly disconnected from their natural and cultural roots (Saidi, 2023), often resulting in uniform, alienating spaces that neglected both human experience and local identity.

In the decades following independence, Algeria experienced a rapid population growth, increasing from approximately 10 million in 1962 to over 46 million by 2024 (Review, 2024) leading to immense pressure on its urban and architectural infrastructure. The urgent need for housing and public services drove a wave of fast-paced construction, often guided by standardized, short-term solutions. This intense urban expansion frequently overlooked the value of local heritage, climatic adaptation, and social cohesion. As cities grew, many lost touch with their historical cores, and architectural practices became increasingly disconnected from the cultural and environmental specificities that once defined them (Saidi, 2023) This shift not only affected the physical character of Algerian cities but also weakened the relationship between communities and their built environment.

In response to these pressing challenges, a growing awareness is emerging about the crucial role architects can play, not just as designers of buildings, but as agents of ecological, cultural, and social transformation. Architecture today must address environmental concerns (Mba, 2024) while also contributing to the revalorization of local identity. In this context, the concept of ecovalorization becomes particularly relevant: it refers to the ecological valorization of underutilized cultural and spatial assets, especially in cities like Dellys, whose layered history and natural beauty remain insufficiently acknowledged in contemporary urban development.

This thesis aims to explore how architecture can respond to these multiple demands through the design of a museum in the coastal city of Dellys. More specifically, the research investigates how natural lighting can be used as a tool not only to enhance spatial experience within museum spaces, but also to reconnect with architectural heritage and strengthen the cultural identity of place. The project positions natural light as both a technical and symbolic element, supporting environmental performance, while also shaping emotional and sensory connections between visitors and space.

Through a bioclimatic and context-sensitive approach, the proposed museum seeks to offer more than a functional exhibition space. It seeks to act as a cultural focal point and a facilitator of sustainable transformation in Dellys, aligning with broader goals of ecological responsibility, heritage preservation, and experiential design. By integrating architecture, environment, and cultural memory, this work proposes a model for how public institutions can help restore the broken ties between past and present, human and nature, identity and innovation.

1.2. Overall issue

In an era marked by **climate change**, **demographic growth**, and escalating **energy consumption**, the built environment faces unprecedented pressures. Urban areas are

responsible for over 70% of global greenhouse gas emissions, with buildings accounting for a significant share due to their reliance on artificial lighting and mechanical cooling systems (IPCC, 2022). In response, the field of architecture has witnessed a growing shift toward **sustainable, passive design strategies** that minimize environmental impact while enhancing user comfort and well-being (Mba, 2024).

Natural lighting, in particular, plays a vital role in reducing energy consumption and improving spatial quality in public buildings, especially in **museums**, where it can shape visitors' experiences while preserving artwork integrity (Boubekri, 2010). At the same time, sustainable architecture is increasingly recognized not only as a technological or environmental challenge but also as a **cultural and social imperative**, where architects act as mediators between tradition and innovation (Mba, 2024).

In Algeria, and particularly in the coastal city of **Dellys**, this global challenge intersects with local realities. Following independence, Algeria's population grew rapidly, from 10 million in 1962 to over 46 million in 2024, placing immense pressure on cities and architectural infrastructures (Review, 2024). In this context, many urban expansions favored efficiency over identity, resulting in generic, resource-intensive structures that often disregarded local climate and cultural heritage.

Dellys, with its rich vernacular tradition, including elements like **courtyards**, **qbous**, and **filtered openings**, embodies a climatic intelligence that modern architecture can learn from. These features enabled comfort in hot Mediterranean climates while fostering social interaction and connection to nature. Leveraging this architectural heritage is crucial, especially as **cultural tourism** becomes an essential driver of economic development in coastal Algerian towns.

Given the urgency of climate adaptation, the region's cultural and climatic specificities, and the socio-economic importance of tourism, a critical question arises: **How can we design a sustainable cultural institution in Dellys that integrates natural lighting strategies to meet the functional and experiential requirements of a museum, while also responding to the region's climatic challenges, enhancing energy efficiency, preserving cultural heritage, and promoting ecological awareness and tourism?**

This thesis responds to that question through a site-specific architectural proposal that merges traditional wisdom with contemporary design. By reinterpreting passive lighting strategies in a modern cultural facility, the project aims to foster resilience, identity, and ecological responsibility in Dellys and similar contexts.

1.3. Specific problematic and Problem statement

In Dellys, a coastal city rich in layered history and cultural significance, architecture has traditionally reflected a close relationship with climate, topography, and local life. The traditional Dellysian house, characterized by inner courtyards, thick walls, small windows, and spaces like the qbou, exemplified a passive and sustainable response to the Mediterranean climate. These spaces not only regulated temperature and light but also enhanced social interaction and sensory experience.

However, modern interventions have largely disregarded these vernacular principles, leading to buildings that rely heavily on mechanical systems and that lack resonance with local identity. This disconnect is especially problematic in public cultural institutions, where

architecture should act as both a functional and symbolic vessel, conveying identity, offering comfort, and facilitating learning and reflection.

Meanwhile, the region faces increasing environmental pressures, including rising temperatures, urban densification, and a growing need for climate-resilient public spaces. Yet, the architectural response remains limited, often defaulting to generic or overly technical solutions without drawing from the environmental wisdom embedded in local heritage.

Given this context, the following key questions emerge:

1. **How can contemporary museum architecture in Dellys reinterpret traditional spatial features, such as the courtyard, *Qbou*, and narrow openings, to enhance natural lighting, and the sensory experience of visitors, without compromising the display and preservation of artworks?**
2. **How can passive lighting and climate-responsive strategies be integrated into a cultural institution that serves both as an educational tool and a community landmark, while simultaneously promoting environmental awareness and preserving Dellys' architectural identity?**

1.4. Hypothesis

To respond to ours problematics presented above, we suggest the following hypothesis:

1. Integrating natural lighting strategies inspired by the passive principles of traditional Dellysian architecture, such as courtyards, and controlled openings, can significantly enhance the sensory and cultural experience of museum visitors while reducing energy consumption and reinforcing the building's identity.
2. The use of natural lighting as a design tool, inspired by traditional Dellysian architecture, enhances the phenomenological experience in museum spaces, fostering emotional engagement and spatial memory.

1.5. Objectives

1. The enhancement of the phenomenological and sensory experience in museum spaces through natural light.
2. Identification of elements that symbolize the local identity of Dellys.
3. Minimize energy consumption through the implementation of appropriate architectural passive strategies.
4. Create a museum model suitable for the cultural and climatic context of Dellys and similar contexts.

1.6. Theme choice criteria

The criteria for choosing the theme revolve around reviving the cultural and architectural identity of the city of Dellys. Once a thriving coastal town known for its rich artisanal heritage, Mediterranean charm, and strategic maritime role, Dellys today faces a decline in cultural visibility and underuse of its urban and natural assets. The aim is to revitalize the city’s cultural potential by designing a contemporary cultural museum that merges art, craftsmanship, and education, while offering an experience rooted in the Dellysian identity.

This project seeks to highlight the city's unique character, particularly the spatial and symbolic essence of the traditional house, the qbou, and the courtyard. By doing so, it celebrates the local artisanal mastery and architectural language through sensorial experiences tied to natural lighting, spatial transitions, and passive bioclimatic strategies. The approach respects the city's historical layers and aims to restore its connection to the sea, the mountain, and the artisan soul of its people.

Additionally, the design seeks to reactivate the underutilized public spaces, especially those along the coast, and to establish a stronger day-night balance of activities by leveraging the coastal microclimate. The museum becomes a symbolic bridge between past and future, between residents and visitors, where cultural ecovalorization plays a central role in shaping an inclusive, sustainable, and identity-rich urban future for Dellys.

1.7. Research methods

The research for this thesis follows a two-step methodology, combining both theoretical and practical approaches to ensure a comprehensive understanding of the context and a well-founded design proposal.

1. Literature Review and Thematic Analysis

The first stage of the research involves an extensive literature review with the primary objective of understanding key concepts, methods, and findings from previous studies. This theoretical groundwork allows for a comparison between the results of this thesis and those established by other researchers. Through this process, the appropriate research method was identified to validate the proposed hypothesis.

Additionally, a thematic analysis was conducted to explore architectural, cultural, environmental, and phenomenological dimensions relevant to the project. This analysis provided a conceptual framework and helped identify the necessary activities and spatial requirements for designing a cultural museum that embodies the spirit of Dellys. This stage is entirely covered in the second chapter of the thesis.

2. Experimental and Field-Based Approach

The second phase of the research builds upon the orientations obtained from the theoretical stage and adopts a field-based, experimental approach to understand the specificities of the intervention site in Dellys. A **diachronic analysis** was first carried out to trace the historical evolution of the city across different time periods, identifying key transformations in urban form, architectural styles, and cultural functions. This analysis provided critical insights into the layers of identity that shaped Dellys over time and helped contextualize current urban challenges within a historical framework. Following this, A typo-morphological analysis was conducted to examine the structure and evolution of the urban fabric. To complement this, a sensorial approach was integrated to explore how elements like light, sound, materiality, and movement shape the user experience, in line with a phenomenological perspective. The findings were then synthesized using a SWOT analysis, which helped identify the site’s strengths, weaknesses, opportunities, and threats, and informed the development of a strategic framework for the design process. To ensure the sustainability of the project, several environmental simulation tools were employed: Meteonorm and Climate Consultant provided essential climate data and passive design guidance; and Ecotect and

Radiance were used to simulate natural light behavior ,and daylighting strategies, refining the design's response to environmental challenges.

1.8. Research structure

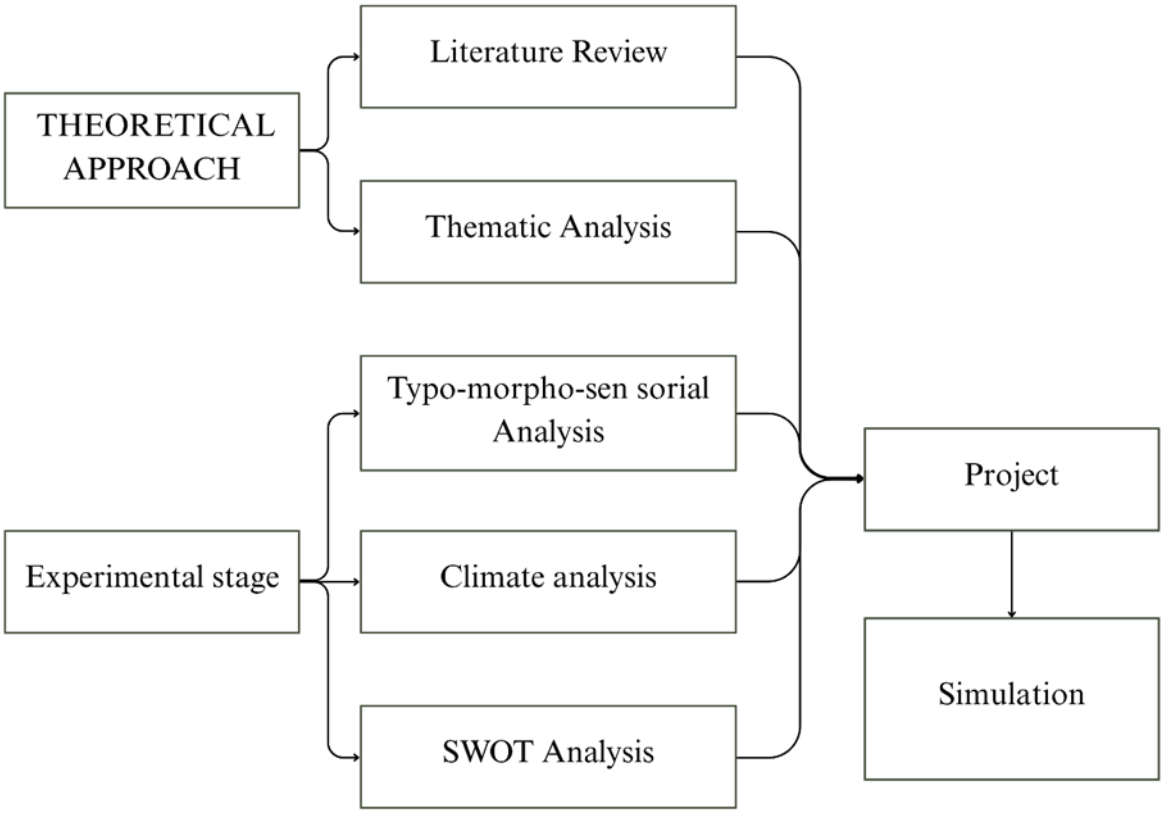


Figure 1/Research structure, Author (2025).

State of the art

Chapter 02

2. STATE OF THE ART

2.1. Introduction.

Climate change has become one of the most urgent global challenges, triggering a significant shift in architectural practices worldwide. As the environmental crisis deepens and the demand for energy efficiency grows, architecture is undergoing a transformation toward sustainability (Mba, 2024).

Algeria, like many nations, is currently navigating a critical energy transition. Confronted with rising energy consumption, the country has begun promoting efficiency and the integration of renewable energy sources.The residential and tertiary sectors alone account for over a third of Algeria's total energy use, with heating, lighting, and cooling being the main contributors (APRUE, 2014). In response, national energy policies have introduced measures such as thermal insulation, efficient lighting systems, and solar heating technologies (APRUE, 2014). However, deep energy subsidies continue to undermine conservation efforts and discourage investment in sustainable infrastructure. This reinforces the need for energy-conscious architecture, one that aligns with national sustainability frameworks while responding to local climate conditions and cultural realities.

Dellys is a city with a rich cultural and architectural heritage, yet much of its potential remains underutilized. Through urban analysis, it became evident that despite its historical significance, Dellys lacks initiatives that fully leverage its cultural and environmental assets. Many of its traditional buildings and urban spaces suffer from neglect, while its natural and architectural identity remains underexplored as a tool for urban development. In response to this issue, this research adopts the concept of **ecovalorization** originally used in waste management as a framework to propose the valorization of Dellys' overlooked potential through a cultural project.

Ecovalorization, in this context, refers to the process of repurposing and enhancing the existing cultural and environmental assets of Dellys to create a sustainable and meaningful architectural intervention. Museums, as cultural institutions, play a crucial role in preserving identity, and engaging communities. By integrating ecovalorization into museum design, this research aims to demonstrate how an architectural project can contribute to the sustainable and cultural revival of Dellys.

Within this context, museums, especially those in the cultural and heritage sectors, are increasingly called upon to adopt sustainable design principles. Traditionally, museums are energy-intensive buildings due to strict environmental controls and extensive lighting needs (Farreny, 2012). Yet they also hold unique potential to model environmentally responsible architecture, thanks to their educational role and symbolic significance.

At the heart of this vision lies **natural lighting**, not simply as an energy-saving strategy, but as a design tool that enhances **phenomenological experience**. In sustainable architecture, natural lighting plays a crucial role in reducing energy loads, improving visual comfort, and connecting buildings to their environmental context. However, its value also extends into the sensory and symbolic realm. When approached through the lens of **phenomenology**, light becomes a narrative and experiential medium. It gives shape to space, evokes memory, guides movement, and fosters a profound sense of place. For museums, where the visitor's

journey is both physical and emotional, phenomenologically considered daylight can support storytelling and intensify the relationship between the public and the exhibited content.

This theoretical framework thus lays the foundation for a project that weaves together sustainable development, bioclimatic strategies, and cultural identity. It places special emphasis on ecovalorization and phenomenology as key drivers of design. Supporting concepts such as **bioclimatic architecture**, **energy efficiency**, **passive design**, and **natural lighting strategies** will be explored in detail to establish the principles guiding the proposed museum in Dellys. Ultimately, this chapter provides the intellectual and contextual basis for a cultural institution that is not only environmentally responsible but also deeply anchored in place, meaning, and future vision.

2.2. Phenomenology and Sensory experience in Architecture.

Phenomenology emerged in the early 1900s with the German philosopher Edmund Husserl and was later developed by Martin Heidegger (1927) and Maurice Merleau-Ponty (1945). It entered the field of architecture more concretely in 1985 through Christian Norberg-Schulz's influential book Genius Loci: Towards a Phenomenology of Architecture. At its core, phenomenology is the study of "phenomena" the appearances of things as they are experienced focusing on how individuals interpret and give meaning to the world, rather than analyzing it solely through objective methods. It examines the structures of consciousness from a first-person perspective, emphasizing how experiences are intentionally directed toward objects based on their content and context (Stanford Encyclopedia of Philosophy, 2013, as cited in (Ahlawat, 2016)).

In architecture, phenomenology deepens spatial awareness by shaping how people perceive and inhabit built environments. It involves the thoughtful manipulation of space, materials, and the interplay of light and shadow to create meaningful and memorable experiences (Choudhury, 2016) Heidegger views architecture existentially, describing it as a means of transforming a mere location into a meaningful place, one that embodies identity and reflects the spirit of the site (Norberg-Schulz, 1980, as cited in (Choudhury, 2016)). Choudhury (2016) emphasizes that designing an experience is a central responsibility in architecture, and phenomenology supports this aim through its focus on sensory perception. This approach underscores the importance of emotional and experiential depth, ensuring that built spaces resonate with users beyond their physical form.

2.2.1. Examples of Phenomenological Architecture

Table 1/ Examples of phenomenological architecture, (Architecture, n.d.).

Architect	Key Projects	Phenomenological Features	Sensory/Emotional Impact
Steven Holl	- Nelson-Atkins Museum of Art (USA) 	- Use of natural light and translucent materials - Fluid spatial sequences - Environmental integration	- Creates multisensory, poetic spaces - Fosters visual and emotional engagement

Peter Zumthor	- Bruder Klaus Field Chapel (Germany) 	- Raw materials (concrete, stone) - Play of light and shadow - Emphasis on tactile textures and material honesty	- Evokes reverence and introspection - Deep sensory immersion in atmosphere
Alvaro Siza	- Serralves Museum (Portugal) 	- Minimalism and light composition - Sensitivity to context - Spatial calmness	- Promotes contemplation and reflection - Encourages personal and emotional connection
Tadao Ando	- Church of the Light (Japan) 	- Interplay of light, space, and silence - Simplicity in form and material - Harmonization with nature	- Spiritual and meditative experiences - Deep awareness of light, shadow, and spatial serenity
Louis Kahn	- Salk Institute (USA) 	- Monumental geometry - Masterful use of natural light - Material richness (concrete, wood)	- Inspires awe and reflection - Architecture as a spiritual and sensory journey

2.2.2. Importance of sensory experience in spatial perception:

Sensory experience is crucial in architecture because it shapes how people understand and connect with spaces. (Mohler, 2013) argue that understanding human spatial perception requires first examining how sensory signals convey information about various spatial properties. To perceive the spatial layout of the environment and successfully perform actions, humans rely on multiple types of sensory information gathered through different sense organs (Mohler, 2013).

Perception typically arises from processing multiple sources of sensory information simultaneously. This is particularly evident in how individuals navigate and interpret their built environment. (Bell et al. 1996, as cited in (Choudhury, 2016)) emphasize that people respond to their surroundings based on both visual cues and broader sensory experiences, highlighting the multisensory nature of spatial understanding.

2.2.3. Multi-Sensory Experiences:

In architecture, the senses do not operate in isolation; they interact and influence one another. Sensory experiences are deeply interconnected, and human perception is shaped by five primary sensory systems: the visual system, auditory system, taste-smell system, basic-

orienting system, and haptic system (Pallasmaa, 2005, as cited in (Choudhury, 2016)), For example, the sound of footsteps on a wooden floor can amplify the tactile perception of the material. This interplay between the senses creates a richer, more immersive spatial experience.

2.2.4. How different senses contribute to spatial perception

Different senses contribute uniquely to spatial perception, shaping how individuals

experience and interact with their surroundings. The table below outlines the role of each sense in perceiving space, based on the work of Hadjiphilippou (2013).

Table 2 /How different senses contribute to spatial perception (Author 2025).

Sense	Contribution to Spatial Perception	Examples
Vision	Dominant sense in perceiving depth, distance, and geometry of space . Shadows help determine depth.	The focused light experience in Bruder Klaus Field Chapel (Peter Zumthor) creates a spirituual atmosphere.
Touch	Provides information about texture, weight, density, and temperature. Enhances spatial memory.	The rough, cold metal walls and raw concrete in the **Jewish Museum, Berlin** create a sense of discomfort, loss, and isolation, while the smooth, warm stone surfaces of the **Thermal Baths at Vals, Switzerland** create a soothing, intimate connection to the body.
Hearing	Creates a three-dimensional experience of space. Sounds can evoke emotions and define atmosphere.	The echoes in the vast dome of The Pantheon (Rome, Italy) enhance the perception of scale.
Smell	Triggers memory and spatial recognition. Different places have distinct smells.	A blind person can recognize streets by their scents; hospitals and markets have identifiable odors.
Taste	Less direct but can be influenced by vision and texture. Enhances the sensory experience of space.	The presence of **orange blossoms, mint, and rosemary** in the air instantly evokes memories of **belonging and cultural identity**.

2.2.5. The dominance of vision in experiencing space.

Vision is often the primary sense through which we experience architecture. It allows us to quickly assess spatial qualities, such as depth, color, and light. This is supported by Pallasmaa's argument that "Architecture generates the lived space and spatial boundaries within which our experience is defined, and it is a common practice to investigate, appreciate, and experience architecture primarily from a visual perspective" (Pallasmaa, 2005, as cited in (Choudhury, 2016)).

2.2.6. The role of light in shaping perception of space

Light is a fundamental element in shaping human perception and experience within architectural spaces. According to (Muro, 2024), light interacts with spatial form, materials, and colors to influence emotions. The role of light in defining architectural atmospheres has been explored by Pallasmaa (2016), who asserts that "light is the strongest conditioner of the atmosphere of a place, the most comprehensive criteria of the character of space" (Pallasmaa, 2016, as cited in (Muro, 2024)).

Studies have shown that different lighting conditions evoke distinct emotional responses (Muro, 2024):

- Soft, warm lighting fosters calmness and introspection.
- Strong contrasts between light and shadow create a sense of mystery and depth.

- Dimly lit areas can induce claustrophobia or unease.
- Bright natural light is often associated with openness and comfort.

In addition, light serves as a tool that guides human behavior within space. Based on Gibson's theory of affordances (1979, as cited in (Muro, 2024)), architectural elements suggest specific actions depending on their perceptual properties. (Muro, 2024) applies this concept to lighting, showing that people subconsciously adapt their behavior in response to lighting conditions, for instance, seeking relaxation in softly lit areas or feeling energized in brightly lit, open environments.

The emotional power of light is also widely explored in visual storytelling. Filmmakers often manipulate lighting to reflect a character's psychological state or to elicit specific emotions from the audience. A compelling example is Bong Joon-ho's *Parasite* (2019), where lighting plays a critical role in visualizing themes of social hierarchy and emotional tension. The semi-basement apartment is depicted with dim, flat lighting and minimal natural light, evoking a sense of confinement and despair. Conversely, the wealthy Park family's home is bathed in abundant natural light, symbolizing ease, detachment, and privilege. This stark contrast in lighting not only distinguishes the two environments but also subtly conveys the characters' internal states and social positions. Such cinematic techniques parallel architectural lighting strategies, emphasizing how light can shape perception, behavior, and emotional response.

The wealthy Park family's home,
(Bong, 2019)

The semi-basement apartment,
(Bong, 2019)

Figure 2 / Still images from Bong Joon-ho's Parasite (2019), illustrating the contrast in natural light and spatial perception between the two households.

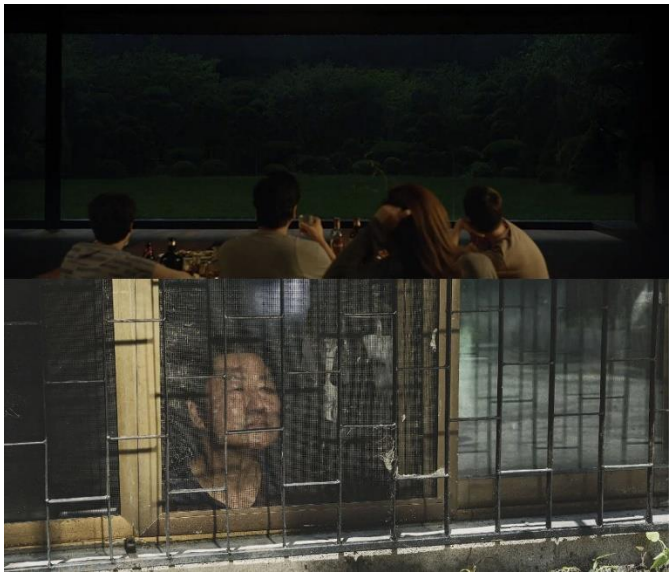


Figure 3 The 2 nd image shows Mr. Kim looking out of the semi-basement window, a confined opening that represents his family's limited social position and psychological confinement. The first image captures the entire Kim family seated in the Park family's luxurious living room, surrounded by openness and light. For a fleeting moment, they experience the illusion of upward mobility and comfort — a life not their own, but temporarily within reach. Lighting and spatial openness play a key role in expressing this emotional contrast. Stills from Bong Joon-ho's Parasite (2019).

2.2.7. How spatial organization influences visitor behavior and movement

The way museum spaces are structured significantly influences how visitors navigate, experience, and engage with exhibitions. Medaković et al. (2024) highlight that spatial layout can either guide visitors along a fixed path or allow free exploration. According to (Choi 1999, as cited in (Medaković, 2024)), museum layouts typically follow two primary models:

- Deterministic Model → Controls visitor movement, directing them through a structured exhibition sequence.
- Probabilistic Model → Provides flexibility, allowing visitors to choose their paths and engage at their own pace.

Further, Hillier & Tzortzi (2007, as cited in (Medaković, 2024)) argue that spatial configuration impacts visitor engagement and perception. Museums with structured layouts encourage a linear narrative, while those with open configurations create exploratory experiences.

2.2.8. The role of light, materials, and spatial sequences in shaping experience.

Light, materials, and spatial sequences play a crucial role in defining architectural experience. The interaction between these elements manipulates perception, influences movement, and creates atmospheric effects in museum spaces. According to (Saraoui, 2018), daylight in architecture is not merely a functional element but a tool for shaping spatial perception, particularly when combined with materials and sequential spatial organization.

2.2.8.1. Light as a Spatial Tool

Daylight and artificial lighting influence how visitors perceive space, depth, and materiality. Light can create contrasts, highlight textures, and guide movement. The study by (Saraoui, 2018) emphasizes that light in museum spaces is carefully designed through:

- Orientation Discontinuities → Changes in light direction influence spatial perception.
- Variation in Bay Openings → Different window placements alter light exposure, affecting ambiance.
- Interplay of Light and Shadow → Light sequences create a dynamic visitor experience by alternating between bright and dimly lit spaces.

2.2.8.2. Materiality and Its Influence on Sensory Experience

Materials play a critical role in modifying how light interacts with space. Certain materials absorb light, while others reflect it, creating varied visual and tactile experiences (Saraoui, 2018), found that:

- Transparent materials (glass, polished surfaces) enhance brightness and openness.
- Opaque and matte materials (wood, concrete) create a more intimate and enclosed experience.
- Reflective surfaces (metal, mirrors) alter light diffusion, affecting spatial perception and movement.

2.2.8.3. Sequential Organization of Space

Museums often employ sequential organization to guide visitors through curated experiences. (Saraoui, 2018), introduce the concept of topological sequences, where space is structured through routes and transitions between different lighting and material conditions.

- Linear Sequences → Fixed progression through exhibits, reinforcing a chronological narrative.
- Dynamic Sequences → Spaces with varied light and material transitions, encouraging exploration.

2.2.9. Synthesis:

Phenomenology in architecture emphasizes the importance of human experience, perception, and the sensory connection to space. This perspective is especially relevant in museum design, where the quality of experience is central. Spatial perception arises from the integration of multiple senses—sight, sound, touch, and orientation—each contributing uniquely to how visitors interpret space. Vision remains dominant, yet the interplay between senses creates a deeper, more immersive engagement with architecture. Among these sensory elements, light plays a particularly critical role: it shapes atmosphere, influences emotional responses, and defines spatial orientation. Materials further mediate these effects, affecting how light is perceived and contributing to both tactile and visual memory.

In this context, **natural lighting emerges as a vital design tool**, not merely a functional necessity, but a key element in enhancing phenomenological depth, guiding behavior, and reinforcing the identity of space.

2.3. Natural Lighting in Architecture.

2.3.1. Light as a Design Element

Natural lighting is a fundamental component of architectural design, not only for its functional benefits but also for its contribution to the experiential quality of spaces. It plays a vital role in shaping spatial perception and emotional response, particularly in culturally significant buildings such as museums. From a phenomenological perspective, light is more than illumination; it is an expressive medium that reveals form, modulates atmosphere, and anchors human experience within space (Zumthor, 2006).

2.3.2. Visual Comfort and Functional Requirements

The concept of visual comfort refers to the suitability of lighting conditions for performing visual tasks without causing discomfort or fatigue. In architectural design, achieving appropriate daylight levels is essential to support diverse spatial functions. For example, museum galleries require balanced illumination that avoids glare and excessive contrast, preserving the integrity of artworks while providing clear visibility for visitors. The integration of daylight must therefore consider luminance distribution, contrast ratios, and glare control (Baker, 2002).

2.3.3. Natural lighting Strategie

According to (Liébard, Traité d'architecture et d'urbanisme bioclimatique , 2005) "*The natural lighting strategy aims to better capture and penetrate natural light, then distribute and focus it effectively. It also ensures proper light control to prevent visual discomfort. Intelligent use of natural light helps reduce electricity consumption dedicated to lighting*" (Liébard, Traité d'architecture et d'urbanisme bioclimatique, 2005). See Figure bellow.

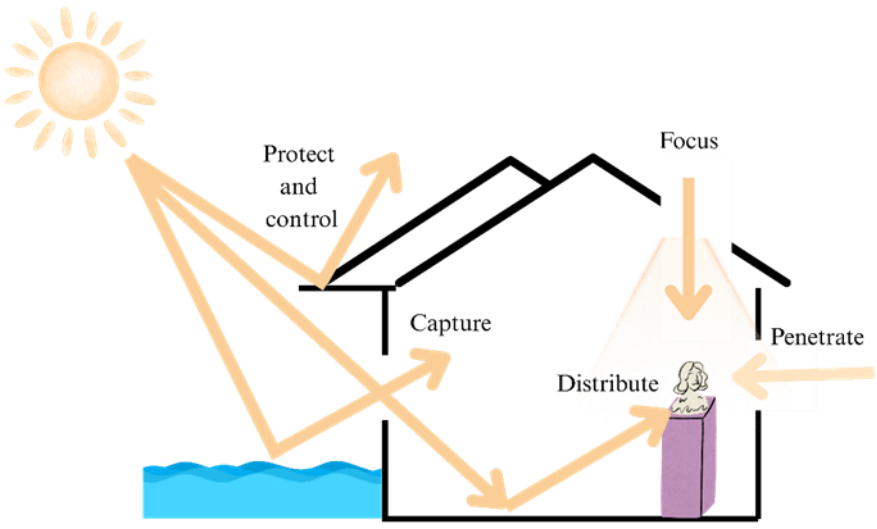


Figure 4/ Strategies for Passive Solar Lighting, (Author, 2025 according to (Liébard, Traité d'architecture et d'urbanisme bioclimatique, 2005).

2.4. Natural Lighting in Museums.

2.4.1. Introduction

Lighting in museums plays a vital role in enhancing the visitor experience and preserving exhibits yet it is also one of the most energy-intensive aspects due to the high levels of illumination required to highlight the exhibits (Dalipi, 2021). optimizing energy performance becomes a critical aspect of sustainable design, ensuring both the preservation of exhibits and visitor comfort while minimizing environmental impact. This section focuses

on the role of natural lighting in enhancing museum energy performance, outlining key principles, strategies, and influencing factors.

2.4.2. Considerations of Natural Lighting Design in Museums

Natural lighting in museums must consider visual perception, object conservation requirements, and environmental sustainability. The study by (Shahparnia, 2020) highlights a list of key criteria to be taken into consideration when designing a museum.

Table 3 Considerations of Natural Lighting Design in Museums

(Shahparnia and Nikghadam, 2020).

Consideration	Researcher	Description	How to Apply
Light Sensitivity of Artworks and Radiant Damage	Maghsoudi, 2009; Shawn, 1999; Drakou, 2019	Artworks degrade over time depending on their material, exposure to light, and environmental protection. UV and infrared radiation accelerate damage. A ten-year study categorizes materials by sensitivity: high (paper, textiles), moderate (wood, oil paintings), and low (glass, metal). Exposure to uncontrolled daylight (10,000–130,000 lux) can cause fading in 1–30 years for moderate-sensitivity works and up to 300 years for low-sensitivity ones (Drakou, 2019). .	Select materials based on their sensitivity, use UV-filtered glazing, and control natural light entry. Avoid direct sunlight and reduce exposure times to minimize damage.
Illuminance	CIBSE, 2009	The level of brightness in a space, which affects visibility and potential damage to exhibits.	Adjust brightness based on exhibit sensitivity. Look the table of recommended illuminance levels by function
Distribution of Brightness and Luminance	Zumtobel Staff, 2004; CIBSE, 2009	Museum lighting should be tailored to the type of exhibit. Wall-mounted artworks require uniform, glare-free lighting, achieved with local or scattered sources. Sculptures and 3D artworks need multi-angle illumination using rod and local lights for detail enhancement and balanced shading. Additionally, exhibit lighting must integrate with overall space lighting for clarity and comfort. Lighting uniformity is measured by the ratio of minimum to average illuminance (Uo = E_min / E_avg).	In this project, achieving the standard lighting uniformity (Uo $\geq$ 0.6–0.7) may not be feasible due to the nature of the space and lighting constraints. Therefore, the design prioritizes phenomenology and sensory experience over strict uniformity. Lighting should support spatial atmosphere and emotional resonance through soft, distributed illumination using skylights with diffusers or indirect lighting to minimize brightness variations.
Color Rendering Index of Light Source	CIBSE, 2009; Zumtobel Staff, 2004	The Color Rendering Index (CRI) measures a light source's ability to reveal true colors, ranging from 0 to 100. Daylight, with a CRI of around 100, is ideal for museums. Among artificial lights, LEDs offer the	Use controlled daylight to avoid fading and select light sources with high CRI (close to 100) for accurate color rendering of exhibits.

		highest CRI, followed by incandescent lamps.	
Eyes' Ability of Adaptation	Heidari, 2012; Shawn, 1999	The human visual system requires time to adapt to changes in light conditions. The more sudden and intense the changes, the longer the adaptation process takes.	The museum should be zoned in terms of lighting to allow visitors to transition smoothly between bright and dim spaces, supporting visual comfort and adaptation.
Reflection of Light	Smith, 2009; Weerdmeester & Dül, 2011	The combination of direct and reflected lights in space improves visibility. The position of the light source should be such as to prevent light reflection to the visitor's eyes and avoid shading and veiling reflection.	Light sources must be placed above or around the object, angled properly to enhance visibility and avoid glare or distracting reflections.
Glare	Zumtobel Staff, 2004	Glare and flicker disrupt visual comfort and concentration, making their control essential in museums. They can be minimized by filtering or diffusing light sources, whether natural or artificial. Another solution is controlling light flicker. Natural light, with minimal fluctuations, remains the most stable option.	Controlling glare is essential for comfort. This can be done using filters or diffusers. Natural light is preferred due to its stability. To assess glare presence, tools like the Unified Glare Rating (UGR) can be used—UGR values below 19 are ideal in museum settings.
Shading	CIBSE, 2009	Appropriate shading, contrast, and proportional uniformity effectively help in identifying the shape and details of 3D objects. However, improper shading disrupts object recognition.	A balanced approach to background reflectivity and light sources is essential for achieving the desired visual effect. Highly reflective backgrounds and rod lights minimize shadows, while low-reflective backgrounds and narrow light strips create stronger shadows. These elements should be adjusted based on design goals and display intentions.
Ease of Navigation	Shahparnia and Nikkhahdam, 2020	Lighting facilitates spatial orientation and movement in museums.	Providing a favorable level of illuminance.
Provision of Landscape	Ghiabaklou, 2013	Integrating landscape and lighting enhances both **visual comfort** and **cognitive engagement**.	In transitional spaces and open displays, landscape-integrated lighting creates a more engaging, immersive experience.
Flexibility	CIBSE, 2000; Shawn & Innes, 1993	Lighting should adapt to different exhibition types and needs.	Provide flexible lighting systems (e.g., adjustable intensity, direction, and filters) to protect sensitive works and suit rotating exhibits.
Safety and Emergency	CIBSE, 2000.	A minimum **20 lux** is required for safe public circulation.	Ensure **≥ 20 lux** in circulation and emergency routes for visibility and safety.
Repair and Maintenance	CIBSE, 2000.	Maintenance ease is crucial for lighting system sustainability.	**Ensure accessibility** for lamp replacement and inspection. Choose durable, easy-to-maintain lighting systems to reduce operational cost.

2.4.3. Recommended Illuminance Rates per Space:

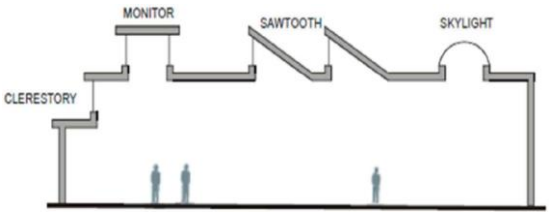
Table 4 /Recommended Illuminance rates per space ,(CIBSE, 2000).

Space	Recommended Illuminance (lux)	Notes
Exhibition Spaces	**50–300 lux**	Depends on the sensitivity of objects: 50 lux for **sensitive items** (textiles, paintings, organic materials), Up to 200–300 lux for **robust objects** (stone, metal, models). Use controllable/directional lighting.
Media Library	**300–500 lux**	Reading, browsing, and working require clear visibility. Uniform and glare-free lighting is preferred. Task lighting can be added at reading desks.
Polyvalent Area	**200–750 lux (adjustable)**	Depends on activity type. – 200 lux for general uses or social events.– 500–750 lux for workshops, conferences, or learning activities. Use dimmable and flexible lighting systems.

2.4.4. Types of lighting in a museum

2.4.4.1. Daylighting:

Table 5/ Daylighting strategies (Oyeyipo, 2024).

The strategy	Description	Example
Direct Lighting	This strategy allows daylight to enter directly into the building through openings, It provides strong illumination but must be carefully controlled to avoid excessive brightness, glare, and UV damage to sensitive exhibits. Techniques like blinds, drapes, or smart glass can help regulate light levels when needed.	 *Figure 5 / Skylights, clerestory windows, or large glazing areas (Aderonmu et al., 2019).*
Sunspace	A sunspace is a designated area within the building that captures direct sunlight and diffuses it into the adjacent spaces. It typically consists of a buffer zone, like an enclosed veranda or atrium, which absorbs and regulates daylight before it enters the main exhibition areas. This method helps in passive heating and ensures even light distribution while minimizing direct exposure to delicate artworks.	Utilizing courtyards, enclosed verandas, and moveable walls to regulate natural light levels and reduce direct exposure to artworks.
Sun Tempering	Involves **modestly increasing the size of south-facing windows** to optimize daylighting while minimizing heat gains and glare. In a **conventional design**, only about **3% of the total floor area** is allocated for south-facing windows. However, in a **sun-tempered design**, this proportion is increased to **a maximum of around 7%** of the floor surface.	It involves the use of clerestory windows, overhangs, and shading devices to control how much sunlight enters a space.
Combined System	For better results, a combination of the two is better. Direct gain works extremely well when combined	A well-integrated combination of the previously mentioned examples.

	with a sunspace or sun tempering. Such combinations need a huge amount of south-facing space, as well as careful design to ensure that the systems are well-integrated with one another and with the building's mechanical system.	

2.4.4.2. Artificial lighting:

Table 6/ Artificial lighting strategies (Oyeyipo, 2024).

The strategy	Description	Advantages	Disadvantages
Downlighting	This is the most common and conventional lighting strategy where fixtures are mounted or recessed in the ceiling, directing light downward. Common in buildings, it enhances visibility and is energy-efficient, especially with LED technology.	- Provides direct and focused illumination - Works well for general lighting - Highly energy-efficient with LED bulbs	- Can create harsh shadows - May cause glare if not diffused properly
Uplighting	Also known as indirect lighting, this method reflects light off the ceiling and bounces it back down, producing a diffused, soft glow. It highlights textures and colors without harsh shadows.	- Reduces glare and creates a more ambient feel - Highlights the texture and hue of objects - Provides a consistent illumination level	- Depends on surface reflectivity - Less energy-efficient due to light loss - Can be costly due to additional fixtures
Front Lighting	Light is projected directly onto an object from the front, ensuring uniform illumination. It is commonly used in museums and galleries.	- Provides even lighting across the object - Minimizes shadows on the front side - Simple and easy to implement	- Can make objects appear flat - May create unwanted silhouettes behind objects
Side Lighting	Light is projected at a 90° angle onto the object, creating a balance between highlights and shadows. It is commonly used to emphasize three-dimensional shapes.	- Enhances depth and form perception - Gives objects a more defined look - Reduces the flat appearance of front lighting	- Can cause minor glare if the angle is not well adjusted - May create deep shadows on the opposite side
Backlighting	Light is placed behind the object, surrounding it or passing through, creating a silhouette effect and adding depth. It is often used for dramatic emphasis.	- Adds depth and contrast - Creates dramatic or artistic effects - Enhances visibility in some cases (e.g., signs)	- Can obscure details if too strong - May create unwanted silhouettes

2.4.5. Some natural lighting systems

(Shahparnia, 2020) conducted a study on the application of ergonomics and natural-solar lighting systems in art museums, aiming to enhance both display quality and the visitors experience. Based on their findings, four widely used natural lighting systems were analyzed and ranked from most to least effective.

Table 7/ Examination of Widely Used Natural-solar Lighting Systems (Shahparnia, 2020).

The system	Reasearcher	Type of system	Illustration	Advantages	Disadvantages	Optimum condition
Photovoltaic shade	Karakitsiou, 2021; Golmohammadi, 2016; Baker, 2016; Rashidi, 2015	Combined with façade, shading, and electricity generation.	 *Figure 6 /Light shelf(Shahparnia and Nikghadam 2020)*	Efficient shading and energy generation Reduces overheating risk Enhances visual comfort	High initial installation cost May reduce natural daylight penetration if not well-designed	Best orientation depends on energy and shading needs Works well with high-performance glazing
Light Shield	Pirmohammadi, Ahmadi, & Sharifi, 2014; Ghiabaklou, 2013; Smith, 2009; Park, Joo, & Yang, 2007	Combined with skylight, light controller, and diffuser	 *Figure 7/Light shield (Shahparnia and Nikghadam 2020)*	Distributes light more evenly and efficiently . Creates uniform apertures, reducing radiant heat . Avoids sky glare.	Can obstruct the view of the sky	Aluminum-like material. Consist of two curved wings . Light materials of the interior walls for better reflection and diffusion of light
Light pipe	Ghiabaklou, 2013; Zareiy & Ghiabaklou, 2012; Pirmohammadi, Ahmadi, & Sharifi, 2014; CIBSE, 2009;	Receiver and Transmitter of light	 *Figure 8 /Light pipe (Shahparnia and Nikghadam 2020)*	Efficient daylight transmission . Reduces artificial lighting needs . Improves light distribution . Controls glare.	Can reduce efficiency under cloudy conditions . Requires good maintenance to avoid dust accumulation Placement	Works best for spaces that lack direct daylight access . Requires optimized angles for maximum reflection.

	Boubekri, 2008, Littlefair, 1990,				affects performance.	

2.4.6. Evaluation indicators

The work of (Zhou, 2023), explores metrics for evaluating building performance, including natural lighting and energy performance metrics, which we will specifically focus on to assess the design's effectiveness.

Table 8/ Evaluation indicators (Zhou, 2023).

Index	**Definition**	**General Calculation Method**	**What to Measure in Simulation**
Illuminance	Total luminous flux on a surface	E=ΦAE = \frac{\Phi}{A}, where Φ\Phi is luminous flux (lumens), AA is area (m²)	Illuminance (lux) at points on workplanes and displays
DA (Daylight Autonomy)	% of time a point exceeds a lux threshold	% of occupied hours when illuminance > threshold (e.g., 300 lux)	DA300lux at key points (e.g., display areas)
SDA (Spatial Daylight Autonomy)	% of area that meets DA over a time threshold	Area where DA ≥ 50% for at least 50% of occupied hours	Floor area percentage above threshold
DAV (Daylight Availability)	Time illuminance falls into daylit categories	% of time illuminance is within defined ranges: fully, partially, non-, or overlit	Timesteps categorized by light level
UDI (Useful Daylight Illuminance)	% of time illuminance is 100–2000 lux	Count of timesteps where 100 lx < E < 2000 lx / total timesteps	% of time exhibits receive comfortable light
DF (Daylight Factor)	Indoor ÷ outdoor illuminance under overcast sky	DF=EinEout×100DF = \frac{E_{in}}{E_{out}} \times 100	Measure illuminance inside vs outside
ASE (Annual Sunlight Exposure)	% of space with >1000 lux for >250 hrs/year	Count of hours with >1000 lux at each point; flag if over 250 hrs/year	Risk of glare/overexposure in each zone
DGI (Daylight Glare Index)	Glare perception based on contrast and brightness	DGI=10log⁡10(∑(Ls2ωLb2))DGI = 10 \log_{10} \left(\sum \left(\frac{L_s^2 \omega}{L_b^2} \right) \right), where LsL_s = source luminance	Requires luminance map and view direction
DGP (Daylight Glare Probability)	% of people perceiving glare	Based on vertical illuminance and luminance contrast; uses formula from Wienold & Christoffersen (2006)	DGP values from view-based analysis
VCP (Visual Comfort Probability)	% of people perceiving acceptable visual comfort	Simplified calculation from DGP < 0.35	% of time glare is at acceptable level
Annual Load	Total yearly power demand	Sum of hourly or sub-hourly loads across the year: ∑P(t)·Δt\sum P(t) \cdot \Delta t	Total annual kWh (heating,

			cooling, lighting)
Peak Demand	Max power demand in a time period	max⁡(P(t))\max(P(t)), where P(t)P(t) is the instantaneous power	Highest hourly (or 15-min) demand
Load Factor	Avg ÷ peak load	Load Factor=Average LoadPeak Load\text{Load Factor} = \frac{\text{Average Load}}{\text{Peak Load}}	Indicates how evenly energy is used
EUI (Energy Use Intensity)	Energy per unit area	EUI=Annual Energy Consumption (kWh)Floor Area (m²)\text{EUI} = \frac{\text{Annual Energy Consumption (kWh)}}{\text{Floor Area (m²)}}	Used for benchmarking building efficiency

To align with the phenomenological framework of the study, the simulation strategy is narrowed to focus exclusively on the behavior of **natural light** within the exhibition space. Radiance-based daylighting simulations will be used to analyze how light animates architectural elements, evokes emotion, and enhances spatial experience. This qualitative focus supports the creation of a **sensory-rich environment**, where light becomes a storytelling medium that reinforces cultural and architectural identity, rather than merely a source of illumination.

2.4.7. Design Factors Affecting Natural Light Use.

2.4.7.1. Environment:

Environmental and contextual factors play a crucial role in shaping effective daylighting strategies in architecture. Latitude, for example, affects both the intensity and angle of sunlight throughout the year, influencing key design decisions such as building orientation and opening placement (Kaheneko, 2021) Regional climate conditions, including cloud cover, solar radiation, and seasonal daylight variations, determine the availability and quality of natural light. In areas with limited sunlight, it becomes essential to optimize light capture during peak hours (Ahani, 2011, as cited in (Kaheneko, 2021)). Building orientation is another critical factor, positioning the building's longer axis along the east–west direction and minimizing exposure on the east and west façades can reduce glare, improve thermal comfort, and ensure balanced daylight distribution throughout the day (Onuwe, 2015). The urban context further impacts daylight performance. Dense construction, tall buildings, and narrow streets can obstruct sunlight and reduce daylight penetration

2.4.7.2. Building form:

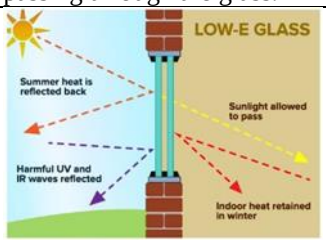
Architectural form determines how light penetrates and spreads through interior spaces. Compact forms improve thermal efficiency, while features like courtyards, atriums, and skylights enhance daylight access in deep-plan buildings. Shallow forms allow for multiple façade exposures, facilitating even light distribution (Kaheneko, 2021).

2.4.7.3. Envelope and material selection for daylight:

Museums use glass to protect collections, control light, and enhance aesthetics. Glazing designs must balance environmental conditions, light quality, UV resistance, aesthetics, thermal performance, and security.

According to (America, 2005), here is a table of glass types that could be used in a museum and their roles:

Table 9/ Glazing types (America, 2005).

Glass Type		Role in Museums
UV-Blocking Glass	UV-blocking glass contains special coatings or additives that absorb or reflect UV radiation, preventing it from passing through the glass.	Protects artifacts from fading and damage caused by ultraviolet radiation in frames, windows, and light fixtures. Blocks a wide band of UV radiation
Low-E(Emissivity) Glass	 *Figure 9 /Low-E Glass Example (Glazcon, n.d.)*	Reduces infrared light penetration, minimizing heat gain and loss, enhancing thermal performance. Contributes to maintaining stable temperatures and preventing condensation.
Laminated Glass	Made of two or more glass layers with an **interlayer** (usually **PVB - Polyvinyl Butyral** or **SGP - SentryGlas Plus**) that blocks **99% of UV rays**.	Provides resistance to accidental breakage and break-ins, offering security. Enhances UV protection due to polyvinyl butryal interlayers.
Insulating Glass	Consists of two or more glass panes separated by a spacer and sealed to create an air- or gas-filled space between them.	Improves thermal performance, helping to maintain stable internal temperatures 8. Can be combined with low-e coatings and argon gas to minimize U-value 9.
Self-Cleaning Glass	Self-cleaning glass typically has a hydrophilic and photocatalytic coating, usually made of titanium dioxide (TiO_2)	Reduces maintenance by using a photocatalytic exterior surface to break down dirt, which is then rinsed away by rain
Tinted Glass	Tinted glass is a type of glass that has been treated with additives or coatings to reduce glare, control heat gain, and enhance privacy.	Controls solar heat and glare while also reducing the color rendering index slightly
Triple Glazing	Using **three panes of glass**, separated by insulating gas-filled spaces. This increases the insulation performance compared to **double glazing** and helps reduce heat loss, improve energy efficiency, and enhance sound insulation.	Improves thermal performance compared to double glazing

2.4.8. Synthesis :

Natural lighting plays a pivotal role in museum architecture, enhancing both the sensory experience of visitors and the environmental performance of buildings, while supporting the conservation of sensitive artifacts. Beyond its functional benefits, natural light can serve as a phenomenological tool, shaping how spaces are perceived, experienced, and remembered. Through its changing intensity and quality, daylight allows for dynamic, emotionally resonant spaces that connect visitors with both the exhibits and the architectural atmosphere.

Throughout this section, multiple dimensions of natural lighting have been explored. (Table 3) examined the key considerations in museum lighting design, including visual comfort, conservation needs, spatial orientation, and the often-overlooked but essential issue of maintenance, ensuring long-term functionality and user satisfaction. (Table 5) outlined strategies to introduce and control daylight effectively, while (Table 6) presented artificial lighting techniques that complement natural light, allowing curators to maintain consistent exhibition conditions. Emerging hybrid systems combining daylight with energy-efficient technologies were discussed in (Table 7), highlighting innovative approaches to reduce energy demand while preserving lighting quality.

To support these strategies with measurable data, the chapter introduced evaluation indicators adapted from (Zhou, 2023). These metrics, Daylight Autonomy (DA), Spatial Daylight Autonomy (SDA), Useful Daylight Illuminance (UDI), and Energy Use Intensity (EUI), provide valuable insight into lighting performance and energy consumption. In this study, To align with the phenomenological approach of this study, the simulation strategy focuses on the **qualitative experience of natural light** within the exhibition space, rather than on quantitative performance metrics. The aim is to explore how daylight defines **atmosphere**, enhances **spatial perception**, and evokes **emotional and sensory responses**. Using **Ecotect** in combination with **Radiance-based simulations**, the study will produce visual representations, such as daylight renderings and shadow studies, that reveal how light interacts with architectural forms, materials, and textures throughout the day and year. This climate-responsive, visual analysis supports the creation of spaces that are not only environmentally sensitive but also **deeply experiential and culturally meaningful**.

The discussion also emphasized broader architectural factors that influence daylighting outcomes. These factors can be grouped into three main categories: the environmental context, building form, and the building envelope and material selection. Environmental and contextual aspects such as latitude, climate, urban surroundings, and building orientation were shown to significantly shape daylight availability and behavior. While building form is discussed in a dedicated section, the envelope and material choices, particularly glazing systems,demonstrate how thoughtful detailing can enhance daylighting. As illustrated in (Table 9), materials like low-emissivity, laminated, and UV-protective glass enable designers to manage solar gain, ensure artifact protection, and improve interior light quality. Architectural elements such as light shelves, shading devices, and reflective surfaces further support these goals.

In conclusion, integrating natural lighting into museums requires a holistic and context-sensitive approach. When thoughtfully implemented, daylight becomes more than a technical element, it contributes to the spatial narrative, evokes emotional responses, and reinforces the cultural and environmental values of the institution. It is this union of aesthetics, phenomenology, functionality, and sustainability that defines successful daylighting in museum architecture.

2.5. Thematic Research.

2.5.1. Introduction :

Cultural institutions, particularly museums, play an important role in promoting ecovalorization by integrating sustainability practices into the preservation, interpretation, and promotion of cultural heritage.

Museums contribute to this process by educating the public about the environmental and cultural significance of heritage, encouraging a deeper understanding of sustainable practices. As Gustafsson and (Gustafsson, 2017) note, some 'green' museums integrate sustainable architecture and technology into their building design and maintenance systems, covering aspects such as heating, cooling, lighting, and plumbing, while also developing exhibitions, educational programs, and events focused on green design and sustainability topics.

Beyond education, museums actively contribute to cultural tourism, which supports economic growth while aligning with sustainable development. As Jun et al. (as cited in (Perera, 2013) state, "tourists are attracted to natural heritage, cultural heritage, as well as built heritage", making museums important platforms for both heritage conservation and economic stimulation. Cultural museums, in particular, promote ecovalorization by repurposing historical and cultural artifacts into educational tools, fostering cultural awareness, engaging local communities, and encouraging heritage preservation. Economically, museums attract tourism, create job opportunities, and stimulate local businesses, generating revenue for the city. Environmentally, sustainable museum designs that integrate renewable energy and energy-efficient systems help reduce their ecological footprint, positioning them as exemplary models of ecovalorization in the cultural sector. Through these combined efforts, museums serve as living demonstrations of sustainability, bridging cultural heritage with ecological responsibility.

2.5.2. Museum :

The International Council of Museums (Museums, 2022), has defined the museum as "*a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets, and exhibits tangible and intangible heritage. Open to the public, accessible, and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally, and with the participation of communities, offering varied experiences for education, enjoyment, reflection, and knowledge sharing.*"

2.5.2.1. Types of museums:

As architects, it is crucial to consider museum classifications that influence design approach, spatial organization, and visitor experience. A well-structured classification system helps in understanding how different museums function and how their design can align with their purpose. For example, in the thesis by (AMMOUR, 2019), museums were categorized based on three key aspects:

Table 10/ Types of museums (Author, (2025), based on the work of (AMMOUR, 2019))

Type of museum		Description
Discipline.	Art Museums	Focus on artworks like paintings and sculptures, emphasizing artistic and stylistic value.
	History Museums:	Centered around historical themes or periods, preserving human history and memory
	Science Museums	Educational institutions dedicated to experimentation, pedagogy, and scientific learning.
	Cultural Museums	Highlight cultural aspects of a specific region, country, or era.
	Multi-Disciplinary Museums	Include multiple departments covering varied fields like art, science, and history.
	Specialized Museums	Dedicated to a specific subject, object, or niche interest.

Openness	Open Museums	Emphasize transparency and a strong visual connection with the external environment.
	Closed Museums	Focus inward, guiding attention to the exhibits and creating a more immersive internal experience.
	Open-Air Museums:	Use outdoor spaces, often historical or archaeological, blending nature and cultural heritage.
Layouts and what kind is your project ?	Branching Layout	➢ Encourages exploration of main and secondary spaces. ➢ Suitable for museums with diverse themes or sections that require categorization.
	Ribbon Layout	➢ Ensures a linear, continuous flow for storytelling or chronological exhibitions. ➢ Ideal for narrative-driven museums.
	Circular Layout	➢ Centralizes attention while enhancing accessibility and lighting. ➢ Great for museums that want to emphasize a focal point or a cohesive design.
	Maze Layout	➢ Offers an immersive, exploratory experience. ➢ Fits well with modern art museums or spaces designed to evoke curiosity and surprise
	Linear layout	➢ sequential experience aligned with site geometry. ➢ Clear Circulation Path. ➢ Narrative Flow./Opportunities for Framed Views.

2.5.3. Cultural and architectural identity:

Shayan (2011) suggests that identity is closely tied to culture, a connection that manifests in various forms, including architecture, As noted by (Ettehad S. K., 2015), and referencing Madadpoor (2000), "*The impact of culture in different areas of life, including art, architecture and urban planning and development, and ways of life is undeniable*" (as cited in (Ettehad S. K., 2015) In this context, architecture stands out as a powerful expression of cultural identity. It not only reveals the values, history, and traditions of a society but also mirrors human identity much like art does. Each civilization or ethnic group creates distinctive architectural styles that, over time, reflect and reinforce their unique cultural identities (Ettehad S. e., 2015). This identity can be expressed through physical attributes such as shape, size, decoration, and construction style, or through specific activities, practices, and functions within a space (Ghotbi, 2008, as cited in (Torabi, 2013)). Ideas, effects, and functions derived from cultural features embedded in an architectural work define its architectural identity (Torabi, 2013).

Dellys possesses a strong cultural and architectural identity shaped by its rich history, unique geography, and traditional urban fabric. Respecting and enhancing this identity in contemporary architectural interventions requires a thoughtful and contextual approach. In this section, we aim to explore some of the key elements that define architectural identity in order to integrate them meaningfully into our project.

According to the work of (Torabi, 2013), architectural identity is expressed through several main characteristics, which serve as analytical tools to evaluate and reinforce the cultural essence of a place within architectural design.

Table 11/The main characteristics of architectural identity, (Torabi, 2013).

The Main Characteristics of Architectural Identity	Spatial Organization	The way spaces are arranged reflects cultural values, traditions, and functional needs. The layout of buildings, courtyards, and pathways helps create a recognizable identity.
	Time Organization	Architecture should reflect both historical continuity and adaptability to contemporary needs. It should preserve cultural and social structures while evolving with time.
	Semantic Organization	Architecture conveys meaning through symbols, forms, and materials. It can represent cultural beliefs, historical events, and local traditions.
	General Design Principles	The design process should incorporate ideas that align with cultural and environmental contexts, ensuring coherence and meaningful expression.
	Shape and Form	The physical appearance of buildings, including their proportions, scale, and harmony, carries cultural significance and contributes to a distinct architectural identity.
	Building Materials	Materials have symbolic and sensory values. Traditional materials like wood, brick, or stone often reinforce cultural continuity, while modern materials can offer new interpretations.
	Relationship with Context	Architecture interacts with its surroundings through harmony, contrast, or opposition. A building's connection to its environment strengthens its identity and sense of place.

2.5.4. Synthesis

Museums, by definition, serve as key institutions for preserving and interpreting both tangible and intangible heritage. They aim to be inclusive, accessible, and sustainable, fostering cultural diversity. The design of museums is multifaceted and can be shaped by various factors, including the discipline of the museum, its openness to the environment, and its spatial layout. These elements determine how visitors experience the space and engage with the exhibits.

Cultural identity plays a significant role in the architectural design of museums. In the context of Dellys, the traditional architecture reflects a deep connection to local and regional influences. The spatial organization of traditional Dellysian houses, responds to the climate and topography, reflecting a harmonious relationship with the environment. reinforcing the cultural identity of Dellys.

2.5.5. *Case studies synthesis:*

Table 12 / Case studies synthesis (Author 2025).

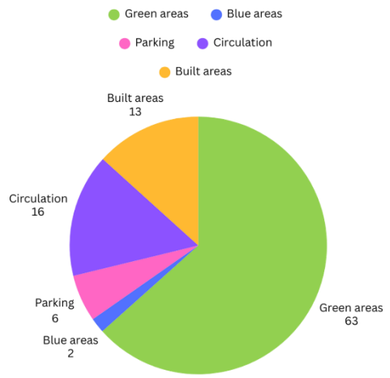
<table>
<tr><th colspan="5">Case studies synthesis</th></tr>
<tr><th>Project's name</th><th>Environment</th><th>Form</th><th colspan="2">Envlope</th></tr>
<tr>
<td>The Aga Khan Museum</td>
<td>➢ Located in a suburban area of North York, away from the dense urban core of Toronto, Canada.
➢ Access Points:
Vehicular: Main entrance from Wynford Drive; on-site parking available.
Pedestrian: Pathways from surrounding areas and the park lead visitors smoothly to the entrance.
➢ The museum is arranged along a central axis that respects both visual order and spiritual symbolism.
➢ The land use distribution, showcase compact layouts with clear zoning for public and green and bleu areas balancing accessibility and functional organization.
 

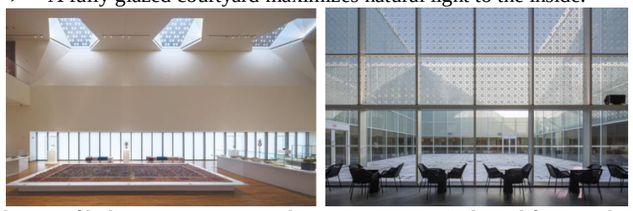
Figure 10 : Land Use Distribution (Author 2025)</td>
<td>➢ A compact building designed by Fumihiko Maki; minimalist, modern, yet rooted in Islamic geometry with a courtyard in the center.
➢ The Museum, incorporates the concept of light as a central theme, both physically and symbolically.
➢ Material and Reflectivity: The surfaces interact dynamically with sunlight.
➢ A fully glazed courtyard maximizes natural light to the inside.
 
Figure 11 : The use of light creates a contemplative experience. (Adapted from ArchDaily, 2018)
➢ The program includes exhibition and education spaces .
Table 16 : The program of the Aga Khan museum (Author2025)
<table>
<tr><th>Main function</th><th colspan="2">Secondary fuctions</th><th>Area</th><th>percentages</th></tr>
<tr><td rowspan="4">EXHIBITION
33.5%</td><td rowspan="3">EXHIBITION</td><td>HALL No. 1</td><td>1165.4m²</td><td>13.32%</td></tr>
<tr><td>HALL No. 2</td><td>138.15m²</td><td>1.58%</td></tr>
<tr><td>HALL No. 3</td><td>1370.4m²</td><td>15.67%</td></tr>
<tr><td colspan="2">Courtyard</td><td>256.7m²</td><td>2.93%</td></tr>
<tr><td rowspan="4">EDUCATION
22.63%</td><td rowspan="2">AUDITORIUM</td><td>AUDITORIUM</td><td>1503.4m²</td><td>17.19%</td></tr>
<tr><td>FOYER</td><td>327.7m²</td><td>3.75%</td></tr>
<tr><td colspan="2">Classroom</td><td>68.4m²</td><td>0.78%</td></tr>
<tr><td colspan="2">Work shop</td><td>80m²</td><td>0.91%</td></tr>
<tr><td colspan="5">support spaces
15.74%</td></tr>
</table></td>
<td>Structure</td>
<td>➢ Load-bearing walls in reinforced concrete and a three-dimensional structure for the auditorium to accommodate the large span.
 
Figure 12 : Ground floor . (Adapted from ArchDaily, 2018)</td>
</tr>
<tr>
<td>Museum of European and Mediterranean Civilizations</td>
<td>➢ The MUCEM is strategically located at the junction of the historic center of Marseille and the Mediterranean Sea. at the entrance of the Old Port of Marseille, close to the Fort Saint-Jean.
➢ The main entrance to the MUCEM in Marseille is located at the J4 Esplanade.Another key entrance to the MUCEM is through Fort Saint-Jean, connected by a striking pedestrian bridge.Both entryways are designed to merge the museum with its surroundings</td>
<td>➢ The museum is primarily a perfect square, giving it a simple and geometric cubic form. Its compact and rectilinear shape emphasizes modernity while maintaining symmetry and order.
➢ The architectural concept of the MuCEM is rooted in the dialogue between land and sea, history and modernity, culture and nature.</td>
<td>Facades</td>
<td> 

Figure 13:Facade analysis(Adapted from ArchDaily, 2018, edited by author, 2025)
➢ White and Off-White Shades The predominant color is white, which symbolizes purity and light.
➢ Reflective Qualities The interplay of sunlight with the granite and glass gives the facade a dynamic quality, with shifting tones depending on the time of day and weather conditions.</td>
</tr>
<tr>
<td></td><td></td><td></td><td>Structure</td>
<td>➢ The overall structural system of the MuCEM is a reinforced concrete frame with prefabricated tree-like columns supporting a perforated concrete façade.
➢ The pedestrian bridge has three spans with bearing guardrails measuring 21 m, 68 m, and 30 m in length, for a total span of 130 m. It is composed of 26 segments (voussoirs) made of BFUP (Ultra-High-Performance Concrete), which are assembled under prestress using post-tensioning.</td>
</tr>
</table>

➢ The building is oriented at an angle of approximately 45° to the west:. This orientation was chosen by the architect to align the building with the natural and urban context of its surroundings.

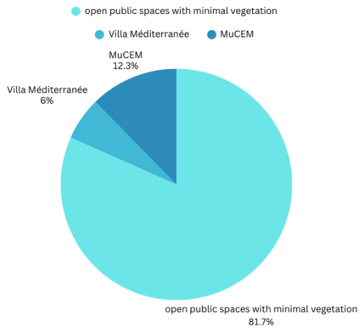


Figure 14: Figure 15 : Land Use Distribution (Author 2025)

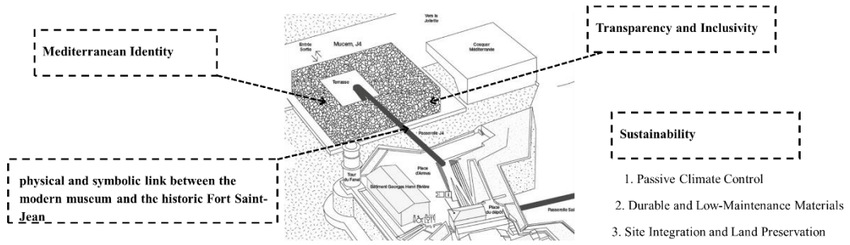


Figure 16 :Key ideas incorporated in the concept .

Table17 : The program of the MUCEM

Main functions	Secondary fuctions	Area	Percentages
Exhibition	Gallery of the Mediterranean	1600M²	20.00%
	Exhibition spaces.	200M²	2.50%
	Media Library	90M²	1.13%
Education	Work shop and stor rooms	3694M²	46.18%
Support Spaces	Administration; conservation and research	2415M²	30.19%

Facades

Figure 17 : Facade analysis (Author 2025)

➢ The perforated concrete screen (made from Ultra-High-Performance Fiber-Reinforced Concrete - BFUP) has a light gray color, which complements the Mediterranean surroundings.

➢ The glass elements in the façade, particularly the large windows, are typically clear or slightly tinted . and it has a reflective quality, helping the building interact dynamically with light and its surroundings.

The Musée Départemental Arles Antique,

➢ The Musée Départemental Arles Antique, designed by Henri Ciriani, is located near the ruins of the Roman circus in Arles, France.

➢ The museum project site is accessible via Av. Jean Monnet, with a path leading visitors to the museum entrance and guiding them to the parking area.

➢ The axis of the building is oriented southeast (towards the southeast direction). This orientation likely plays a role in the museum's integration with the surrounding landscape

Figure 18 : Land Use Distribution (Author 2025)

➢ The Henri Ciriani Antiquities Museum in Arles is noted for its compact and geometric form. Its architectural design emphasizes clean, modern lines and a minimalistic aesthetic, which contrasts and complements the rich historical surroundings of Arles.

➢ Ciriani's concept of a "Museum City," realized through a triangular structure enveloping a central patio, divides the museum into three wings dedicated to permanent collections, cultural activities, and scientific research. This division not only facilitates a comprehensive visitor experience but also mirrors the multifaceted nature of Arles' archaeological heritage.

➢ The Henri Ciriani's Antiquities Museum is designed with a triangular floor plan and is organized around a central patio, which separates the building into three distinct wings. Each wing serves a specific function:

➢ **Permanent Collections Wing:**

➢ This area showcases the museum's archaeological collections and is designed to facilitate a chronological and thematic exploration of Arles' history.

➢ **Cultural Activities Wing:**

➢ This wing includes facilities for educational programs, public services, and visitor reception.

➢ **Scientific Wing:**

➢ Dedicated to research and conservation activities related to the museum's collections.

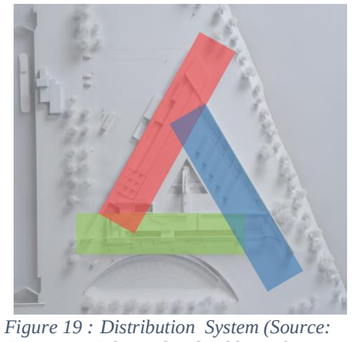


Figure 19 : Distribution System (Source: Ciriani-en-Arles, n.d., edited by author 2025)

Structure

➢ The structural system of the Musée de l'Arles Antique incorporates reinforced concrete columns. The building's framework, which is designed to support its complex and dynamic form, utilizes reinforced concrete to provide stability and strength.

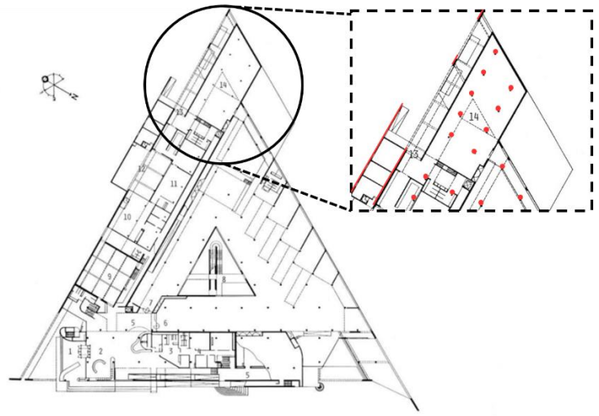


Figure 21 :The structural system of the Musée Départemental Arles Antique, (Source: Ciriani-en-Arles, n.d., edited by author 2025)

Main functions	Secondary fuctions	Area	percentages
EXHIBITION	Permanent Exhibition.	3488.4M²	21.8%
	Temporary Exhibition.	325.7M²	2%
	Court yard	364.2M²	2.3%
	Galerier	1084M²	7%
EDUCATION	Children's workshop	183.3M²	1.1%
	Tourist guides school	227.8M²	1.4%
	Workshop	283.2M²	2%
	Library	344M²	2.15%
	Reading room	70.6M²	0.4%
	Auditorium	339.3M²	2.12%
	Foyer	122.5M²	0.8%
	Archaeology shcool	195.9M²	1.2%

Main functions	Secondary fuctions	Area	percentages
Scientific	Laboratories	141.2M²	0.9%
	Patio	152.9M²	1%
	Loading bay	409.2M²	2.5%
	Store (heavy items)	691.2M²	2.1%
	Curator's room	182.3M²	1.1%
	Store (light items)	340.3M²	2.1%
SUPPORT SPACES	Entrance	237.5M²	1.4%
	Lobby	417.3M²	2.6%
	Cafeteria	299.2M²	1.9%
	Terrace	59.1M²	0.4%
	Staff sitting room	111.5M²	0.7%

Figure 20 : The program of the Musée Départemental Arles Antique (Author 2025)

Facades

Figure 22 : View of the Musée de l'Arles antique.(Source: Ciriani-en-Arles, n.d.)

Emalit Panels: The façade is clad in blue Emalit panels, This choice of material provides a vibrant color and also reflects light beautifully, enhancing the building's visual appeal. The blue hue contributes to the museum's nickname, "Musée bleu"

oncrete: The primary structure of the museum is constructed from concrete, providing durability and a modern aesthetic.

Red Terracotta
prominently featured on the scientific wing of the museum. This area is visually distinguished by its red walls, which symbolize vitality and strength while resonating with the earthy tones of archaeological finds.

Figure 23: Material (Author 2025)

2.5.6. Recommendations

Table 13/ Synthesis of the key elements from each example (Author 2025).

		The Aga Khan Museum	Museum of European and Mediterranean Civilizations	The Musée Départemental Arles Antique,
Environment Urban aspect		Integrate similar reflective water features	Use the natural landscape to enhance the museum's connection to the Mediterranean. Large open terraces, outdoor galleries.	A central gathering space could act as a public plaza,
form	Architectural aspect	Compacted minimalist form, with large, angular volumes that emphasize clean lines and openness.	Compacted geometric form, composed of intersecting volumes and open-air galleries.	Blending traditional architecture and modern forms could create an interesting dialogue between the past and the future
	Program aspect	The integration of courtyards or central open spaces will help define the museum's form and promote natural light.	The open-air gallery concept can help bring the outdoor landscape into the museum, creating a continuous experience from the interior to the exterior.	Open, flexible spaces with clear circulation paths would make the museum functional and visitor-friendly.
Envelope		Using **local stone** to create a sense of local identity. Combined with glass panels to provide natural light and transparency, which will engage visitors with both the interior and exterior environment.	Considering a façade that creates a patterned effect while providing shading for the museum. This approach can help to control solar gain while offering visual interest and aligning with the Mediterranean tradition.	Use climate-responsive materials such as stone, glass, and wood to create a textural variety in your museum's envelope.

2.6. General synthesis.

Lighting plays a central role in museum design. Beyond its basic function of illuminating spaces and exhibits, lighting profoundly shapes how visitors perceive and experience architecture. It influences visual clarity, emotional atmosphere, movement through space, and the level of engagement with displayed objects. Carefully designed lighting can support meaninigful narratives, guide attention, and create memorable spatial sequences.

Natural light, in particular, presents both opportunities and challenges. When used effectively, it enhances spatial quality, introduces dynamic rhythms of shadow and brightness, and supports sustainable design by reducing energy consumption. However, without thoughtful control, it can produce glare, damage sensitive artworks, and create uneven conditions. Thus, the integration of daylight in museum architecture requires a balance between performance, conservation, and visitor experience.

In this context, phenomenology in architecture offers a valuable framework. It emphasizes the lived experience of space, where elements such as light, material, and sound contribute to atmosphere, memory, and emotional connection. Light, seen not just as a technical element but as a phenomenological tool, becomes essential in shaping mood, revealing textures, and enhancing the sensorial depth of architectural space. Through rhythm, contrast, and transitions, light plays a narrative and experiential role in how spaces are perceived and inhabited.

Furthermore, architecture is not experienced in isolation from its cultural context. Many traditional architectures around the world, developed in response to local climate, materials, and ways of life, offer timeless principles for contemporary design. These vernacular strategies, including passive lighting solutions, courtyard layouts, and filtered light techniques, achieve both environmental comfort and a strong sense of identity. In museum architecture, where storytelling and cultural representation are central, drawing lessons from such traditions allows for designs that are not only sustainable, but also emotionally and culturally meaningful.

In sum, lighting in museums is both a technical and poetic concern, one that intersects with sustainability, phenomenology, and cultural identity. Studying both contemporary practices and traditional wisdom offers a richer, more integrated approach to designing spaces that are efficient, immersive, and rooted in place.

2.7. Conclusion.

This chapter has provided a comprehensive examination of the use of natural lighting in museum design through an extensive review of relevant theoretical and empirical studies. Its primary objective was to identify the key factors that influence the effective integration of daylight and to explore its potential in enhancing both energy performance and visitor comfort. The synthesis of existing literature has shown that natural lighting, when thoughtfully controlled, contributes not only to reduced energy consumption, but also to enriched spatial experiences, emotional resonance, and cultural expression within museum environments.

The research also highlighted a range of passive strategies, that can be adapted to achieve a balance between conservation requirements, thermal comfort, and immersive spatial quality. These principles underscore the potential of drawing from architectural traditions that are rooted in local climate and cultural identity.

In this context, the next chapter will delve into traditional architectural practices, particularly those found in the historical context of Dellys, to identify how vernacular lighting strategies can inspire innovative, context-sensitive solutions for contemporary museum design. By examining these heritage-based approaches, Chapter 3 will bridge the gap between theoretical research and site-specific application, laying the groundwork for the conceptual and spatial development of the project.

Moving forward to the thematic research, a comprehensive analysis was conducted on **climatically relevant museums** and **culturally inspired adaptations**, drawing from relevant literature and case studies. The objective was to develop a thorough understanding of the urban, architectural, and programmatic dimensions of museums, and their ability to adapt to prevailing climatic conditions. This analysis informed the formulation of both qualitative and quantitative aspects of the project program, ensuring alignment with its specific requirements and objectives. By critically examining the interrelationships among these components, a well-informed and integrated approach to design and implementation was achieved. This synthesis will be further elaborated in **Chapter 3**, where the project's conceptual development will reflect the harmonious integration of **cultural heritage**, **urban vitality**, and the **natural beauty.**

CASE STUDY

Chapter 03

3. Chapter 3

3.1. Introduction :

Dellys is a city rich in natural resources and historical layers, offering an intriguing urban structure that invites deep analysis. A project in Dellys can only succeed if it is strongly connected to the city's essence and fully integrated within its environmental context.

To achieve optimal integration, we begin by analyzing the site, breaking it down into its essential elements to gain a clearer understanding of their interrelations. This case study, enriched by external reference research, focuses on three primary dimensions:

- Climate Analysis
- Diachronic (Historical) Analysis
- Typo-Morpho-Sensory Analysis

These dimensions will guide the development of targeted strategies for the project.

3.2. City presentation :

3.2.1. Key Factors for Choosing Dellys:

- Natural Potential: Sea, forest, mountains.
- Rich Heritage: Both tangible and intangible.
- Strategic Location: Positioned between Algiers and Bejaïa.
- Tourism Potential.
- Mediterranean Climate.

Dellys, a national heritage site since 2007, presents a unique opportunity for sustainable development that respects its historical and cultural layers.

3.2.2. Name origin

Ibn Khaldoun informs us that during the medieval period, Dellys, under the reign of the Hammadids of Bejaïa, was known as Tadlése. According to a popular legend, the name Tadlése is believed to refer to a type of reed called Arundo, locally known as Eddaliss. This material was historically used to cover the roofs of houses, likely combined with a mixture of earth and straw (Lutum punicum). The technique of using Lutum punicum for roofing was adopted by the Phoenicians and Punic populations, reflecting the rich historical layers of Dellys (Chaïd-Saudi, 2010).

3.2.3. Geographical and Administrative Context of Dellys:

The commune of Dellys is situated at the easternmost edge of the wilaya of Boumerdès, between 1.69° and 1.89° East longitude and 40°9’ and 41°3’ North latitude. It spans a total area of 5,132 hectares, with an estimated population of 32,954 inhabitants and a housing stock of 6,836 units, according to the RGPH 2008, as cited in the (PDAU de la commune de Dellys).

The commune is bordered by:

- The Mediterranean Sea to the North.
- Benchoud to the South.

- Afir (oued Oubey) to the East.
- Sidi Daoud (oued Sebaou) to the West.

3.2.4. Accessibility:

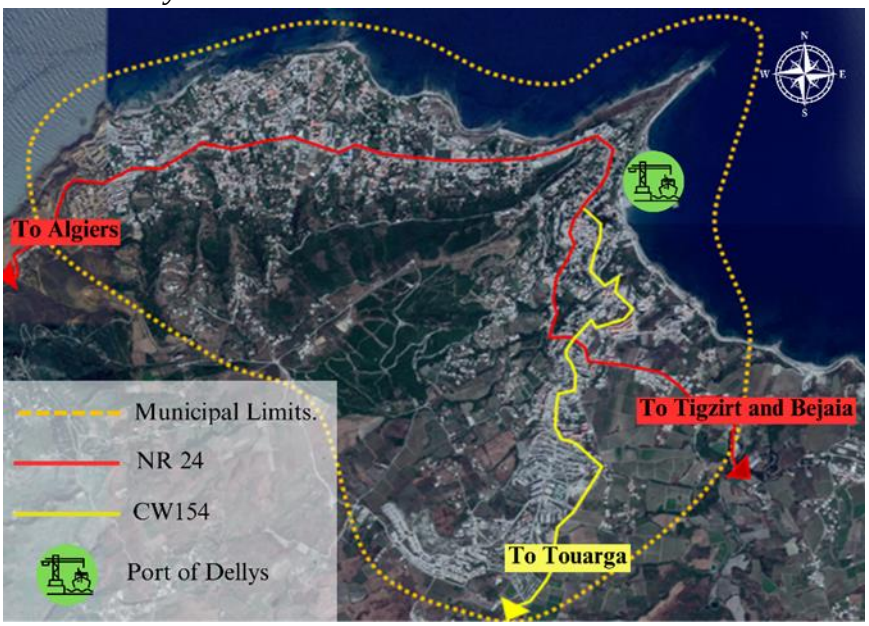


Figure 24 / Access to Dellys: Main Roads and Regional Gateways, (Google earth, edited by author, 2025).

According to the (PDAU de la commune de Dellys (2015)), accessibility to the commune is ensured by several transportation routes:

- National Road RN 24, which connects Dellys to Algiers and Boumerdès to the west, and to Tigzirt and Béjaïa to the east.
- National Road RN 25, linking Dellys to Naciria, Tizi-Ouzou, and Bouira, towards the west.
- National Road RN 25A, starting from Benchoud, bypasses the town of Dellys and leads to Les Salines beach.
- Wilaya Road CW 154, connecting the commune to the inner areas.
- The commercial and fishing port, which provides maritime access and connections.

3.2.5. Traditional Craftmanship in Dellys.

Dellys, a coastal town in Algeria, is renowned for its rich cultural heritage, particularly its traditional craftsmanship. This heritage reflects the town's historical identity and its connection to various civilizations, such as the Phoenicians, Romans, and Berbers. Below is an exploration of the traditional crafts in Dellys.

3.2.5.1. Basketry (Doum)

Basketry is one of the most prominent crafts in Dellys, utilizing the dwarf palm tree ("Doum") as a primary material. Artisans create baskets, hats, and decorative objects that are both utilitarian and artistic. This craft has been passed down through generations, preserving knowledge and techniques, (Necissa, & Rayane. 2024)

3.2.5.2. Handcrafted Musical Instruments

Dellys is also known for its production of musical instruments. These handcrafted items contribute to the preservation of local music traditions, particularly chaabi music, which is deeply embedded in the region's identity (Necissa, & Rayane. 2024).

3.2.5.3. Wooden Boat Models

Reflecting Dellys' maritime heritage, artisans craft detailed wooden models of boats. This tradition highlights the town's historical connection to fishing and seafaring (Necissa, & Rayane. 2024)

3.2.6. Analysis of the traditional architecture of Dellys through identity factors.

this analysis is conducted based on the theoretical concepts and criteria discussed in the state of the art (Chapter 2). Specifically, the identity factors.

3.2.6.1. Form

- Spatial Organization (Allal Cherif, 2017, p. 54):

- The Dellyssienne house is centered around a patio “Elhouech”.
- Arcades surround the patio on three or four sides.
- A gallery connects the rooms “elsetwane”.
- The entrance has a zigzag layout to block direct views into the inside.
- Some houses include a space for animals, called “Eldaynin”.
- Ground-floor “Biouts” have only a door for light and airflow.

- Shape and form:

Compact units around a patio with a double-pitched tile roof.

- Semantic Organization:

The house reflects a blend of Kabyle, Mediterranean, Andalusian, and Ottoman influences, symbolizing Dellys’s rich cultural heritage (Chaid Saoudi, 2010, p. 47; Bougdal, 2006, p. 154).

3.2.6.2. Environment

- Time Organization

The house reflects Dellys' rich cultural history, Andalusian for its Ryads, Ottoman for its mashrabiya, Mediterranean for its atrium, and Berber for integrating the stable into the house (Chaid Saoudi, 2010, p. 47).

- Relationship with Context (Chaid Saoudi, 2010)

- Use local materials and traditional techniques for harmony.
- Adapt to topography

- Central patio ("El Houech"): Acts as a thermal regulator, promoting air circulation and cooling through shaded areas.
- Small openings: Located in upper rooms ("Ghorefs"), these allow cross-ventilation without excessive heat gain.
- Mashrabiya elements: Some houses incorporate wooden screens to filter air and provide privacy while enhancing airflow.
- Staggered entrance ("Skifa"): Prevents direct heat gain by creating a thermal buffer zone between the street and interior.
- Houses are closely packed, providing mutual shading and reducing exposure to direct sunlight.
- Double-pitched tile roofs: Allow for efficient water drainage .
- Green elements in courtyards: provide evaporative cooling and enhance air quality.
- Use of local stone and wood.

3.2.6.3. Envlope

- Building Materials (Bougdal, 2006)

- Stone (Main Structural Material)

Used for walls, foundations, and structural elements.

Sourced locally.

Walls are typically 50-60 cm thick, with a core filled with earth and rubble for insulation.

- Clay & Earth (Mortar & Coating)

Clay-based mortar is used to bind stones and enhancing insulation.

Walls are plastered with lime or cow dung, which provides moisture resistance and insulation.

- Wood (Structural & Decorative Elements)

Used for beams, ceilings, doors, windows, and mashrabiya screens.

- Tiles & Roofing Materials

Terracotta tiles ("tuiles romaines") used for double-pitched roofs, providing thermal protection and water drainage.

- General Design Principles
- Thick stone walls provide thermal mass for temperature regulation.
- Small openings minimize heat gain.
- Shaded patio ensures natural ventilation.

Simple façade with minimal ornamentation (could be influenced by religious principles).

3.2.7. Natural lighting in traditional Dellyssian houses.

Table 14 /Natural lighting in traditional Dellyssian houses (Author 2025).

Traditional Daylighting Strategy (Dellys)	Function in Traditional Houses	Lessons for Modern Museum Design
Courtyard as a Primary Light Source.	Distributes daylight evenly, reduces glare, and provides natural cooling.	Central atriums and open-air courtyards allow soft, diffused daylight into exhibition spaces.
Small Openings for Controlled Lighting.	Limits excessive daylight entry to maintain stable indoor lighting conditions.	Adaptive façade designs and narrow light openings help control daylight exposure for artifact conservation.
Use of Reflective Surfaces & Materials.	Increase light diffusion, brightening interiors without artificial lighting.	High-albedo materials (light-colored walls and floors) maximize daylight reflection and distribute light evenly across museum spaces.
Mashrabiya & Wooden Screens (Qbou)	Filters harsh sunlight while allowing airflow and maintaining privacy.	Perforated façades and shading devices regulate light entry while reducing UV exposure.

3.3. Climate analysis :

3.3.1. Introduction

To develop climate-responsive design strategies for the site in Dellys, weather data was gathered from **Meteonorm** and the **Climate.OneBuilding.org** platform. The data was then analyzed using **Climate Consultant** to visualize key climatic factors such as temperature, humidity, solar exposure, and wind patterns. This analysis supported passive design decisions like orientation, ventilation, and daylighting, in line with the project's sustainable goals.

3.3.2. Thermal Comfort Analysis and Improvement Strategies for Dellys

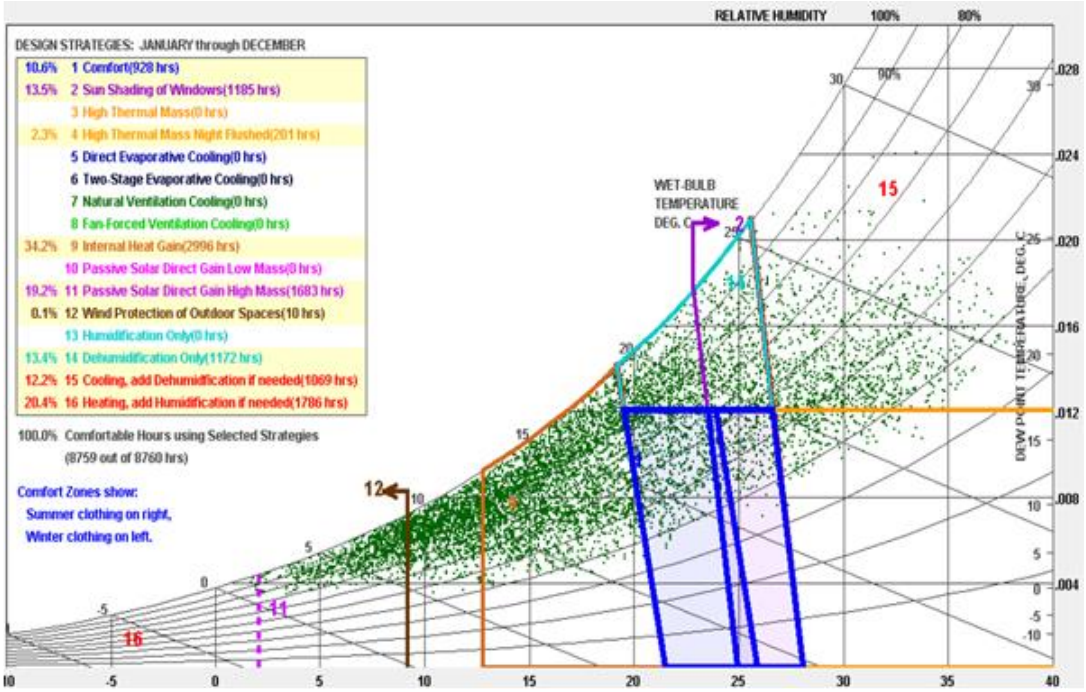


Figure 25/ The psychrometric chart of the city of Dellys.
Source: Climate Consultant.

The **Givoni diagram** identifies three thermal zones in Dellys:

- A **comfort zone** (20°C–26°C) during June, September, and October.
- An **underheated zone** (-3°C–20°C) in January, February, March, April, May, November, and December.
- An **overheated zone** (26°C–35°C) in July and August.

Using the **Szokolay chart**, the initial comfort level is 27.1% without any strategies. By applying passive solutions, comfort increases to **87.1%**, through:

- Window shading (11%)
- Adaptive ventilation (27.1%)
- Internal heat gains (45.1%)
- Passive solar gain with thermal mass (16.1%)
- Dehumidification (20.4%)

With active systems (heating/cooling), comfort reaches **100%** year-round

3.3.3. *Recommendations of climate analysis*

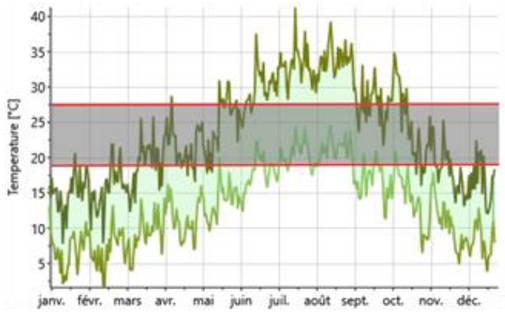
Identification of the Climatic Zone

IDM = (P / T) + 10	IDM=(660/18.17)+10
P: Annual precipitation	IDM≈46.32
T: Average temperature	30 < IDM < 55

In terms of climate zone, a Martonne Aridity Index of approximately 46.32 corresponds to the humid climate zone.

Temperature

Figure 31/ Temperature diagram. Source:Meteonorm.



In the study area, temperatures range from 7°C to 17°C in winter, with an average of 11°C, and from 18°C to 33°C in summer, averaging 27°C. The comfort zone lasts through May and then from September to mid-October, although there are some moments of overheating during this period.

Radiation.

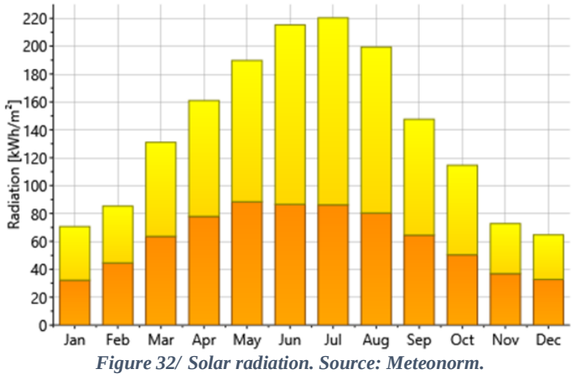


Figure 32/ Solar radiation. Source: Meteonorm.

The highest radiation occurs during the summer season, and the lowest during the winter season.
Installing solar panels in this region can maximize energy production between April and August.
Take advantage of passive solar heating in winter by increasing the penetration of sunlight.

Duration of sunshine

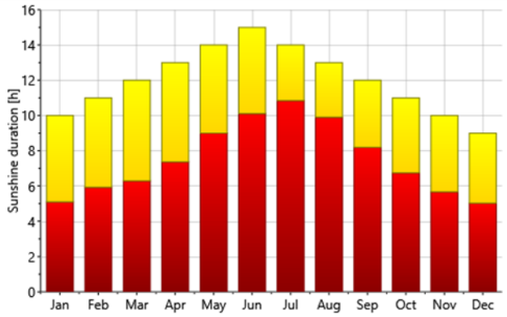


Figure 29/ Sunshine duration. Source: Meteonorm.

Summer period (May to August): **The actual duration of sunshine reaches its peak, with days receiving 10 to 12 hours of direct sunlight.**
Winter period (November to February): **The actual duration of sunshine is significantly reduced, sometimes dropping to just 4 to 6 hours per day.**
Natural lighting in buildings is most effective during the long summer days.
Additional artificial lighting is essential during the darker winter months.

Relative humidity

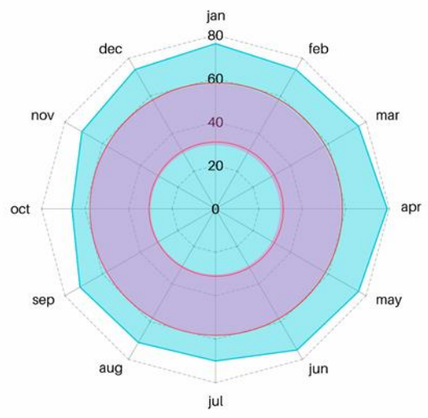


Figure 30/ Relative humidity. Source: Author.

Relative humidity **is consistently above 70% throughout the year, which exceeds the comfort levels (represented between the two red circles).**
Dehumidification: **Use dehumidifiers in indoor spaces to reduce excess moisture and improve comfort.**
Ventilation: **Ensure proper building ventilation to allow moisture removal and promote air circulation.**

Precipitation.

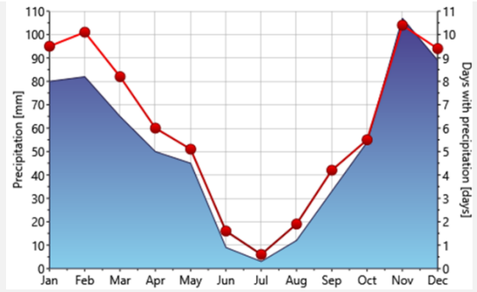


Figure 26/ ram. Source: Meteonorm.

An annual precipitation of 660 mm is considered moderate.
Maximum rainfall occurs during the winter season, while in summer, precipitation drops significantly, with values ranging from 0 to 10 mm.
Water management strategies:
Drainage systems
Weather-resistant materials
Rainwater harvesting

Wind

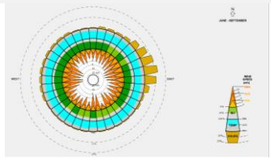


Figure 27/ Wind rose in summer. Source: Climate Consultant

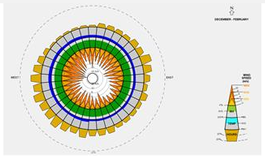


Figure 28/ Wind rose in winter. Source: Climate Consultant

A cold wind blows from the southwest, especially in winter, while a hot wind from the northeast is active during the summer months, with speeds reaching up to 14 m/s. These conditions strongly influence the local climate, creating a contrast between the cool feeling of winter and the beneficial natural ventilation in summer.
Strategic building orientation **is essential to minimize exposure to prevailing winds.**

The Mahoney Table.

Recommendations from the Mahoney Table (Liébard, Traité d'architecture et d'urbanisme bioclimatique , 2005):

- **Orientation along a longitudinal axis (East–West)**
- **Wind protection**
- **Continuous air circulation**
- **Massive walls**
- **Heavy roofs**
- **Rain protection**

3.4. Typomorphological analysis

3.4.1. Diachronic analysis :

3.4.1.1. Introductin :

This chapter focuses on the western periphery of Dellys, beyond the constraints of the Plan de Sauvegarde, offering greater design freedom while respecting the city's identity. Using a typo-morphological and sensorial approach, it analyzes spatial forms, architectural types, and experiential qualities to uncover contextual insights. These findings aim to inform the design of a cultural facility that reinforces urban identity and supports Dellys' revitalization.

3.4.1.2. Understanding the Formation and Transformation Process of the City of Dellys:

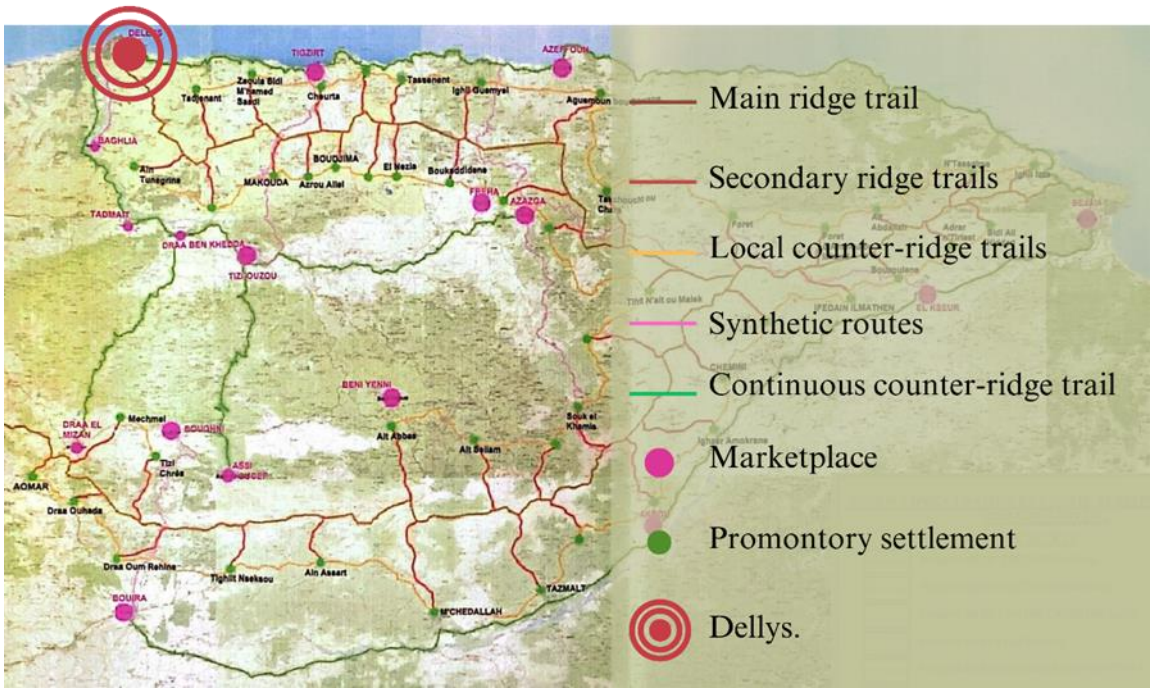


Figure 33/ Morphological Analysis of the Relief and Human Transformation of the Territory. Adapted from Ameziane & Hadjer Brahem (2017), edited by the author (2025).

According to Caniggia, as cited in the work of Ameziane and Hadjer Brahem (2017), the notion of territory is certainly the broadest, as it does not necessarily involve fully built structures. Instead, it is characterized by a morphological structure shaped by its relief, which gives it a distinct identity. The occupation of the territory occurs progressively through the succession of four phases.

- First Phase

The first anthropic structure corresponds to the main ridge line located between the two rivers, Sebaou and Oubay.

- Second Phase

The first settlements appeared on the high promontories, gradually approaching the two rivers and the Cape of Dellys, mainly due to the development of agriculture and livestock farming.

- Third Phase

The emergence of marketplaces (proto-urban centers) occurred downstream, near clusters of villages dedicated solely to agriculture and livestock, along with the creation of local counter-ridge routes.

- Fourth Phase

The emergence of major urban cores as primary marketplaces. The creation of continuous counter-ridge routes positioned parallel to the Sebaou River and the Mediterranean coast, along with the development of a synthetic route.

3.4.1.3. Historical overview:

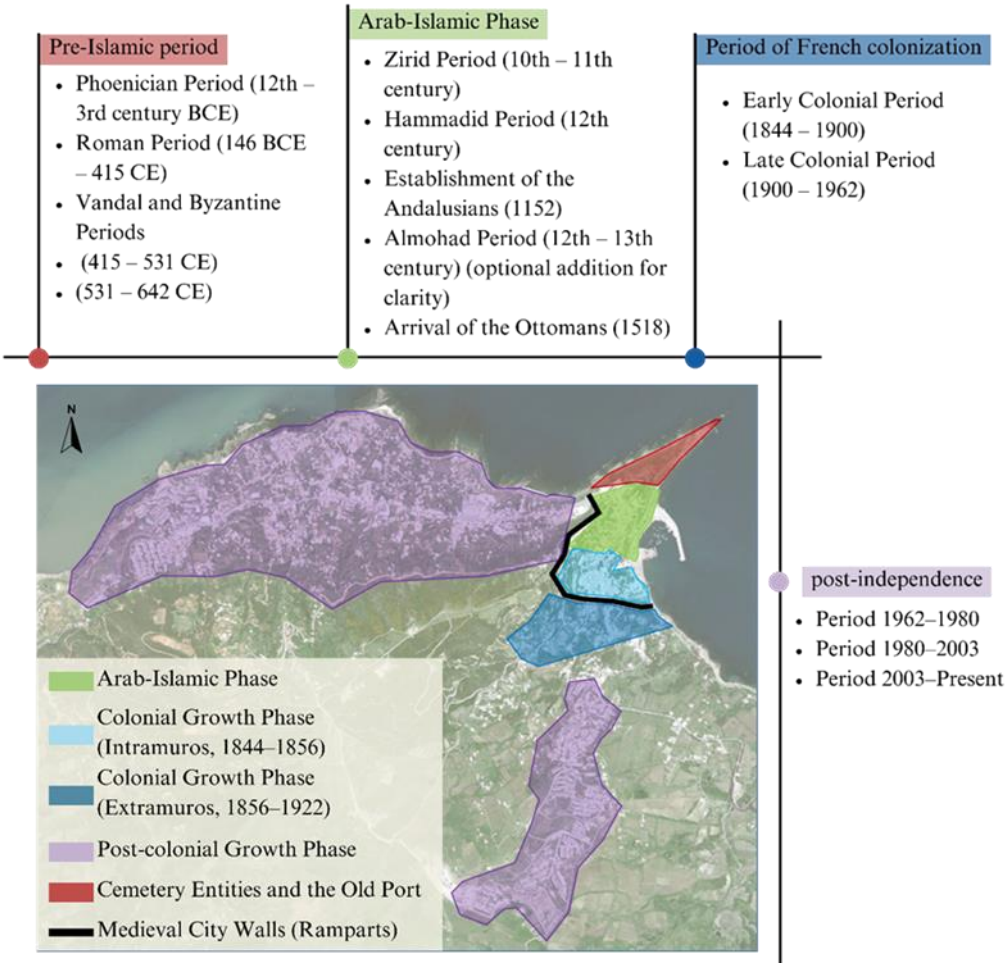


Figure 34/ The historical overview of the city of Dellys (source: Bougdal, 2006, author's analysis.

3.4.1.4. City evolution :

Table 15/ Urban and Architectural Characteristics of Dellys Across Historical Periods,(Author, 2025).

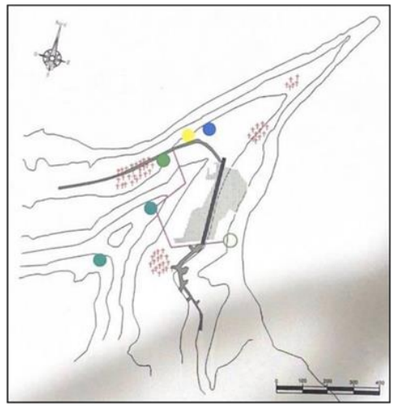
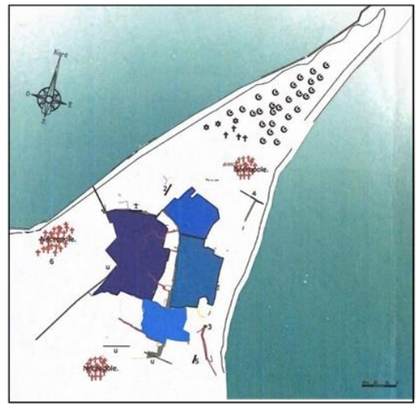
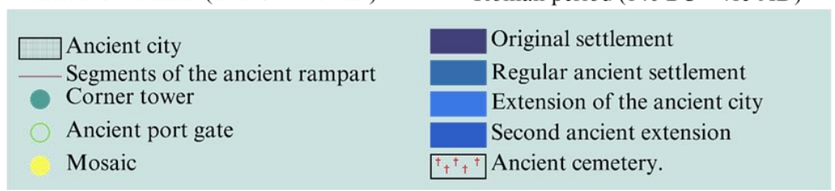
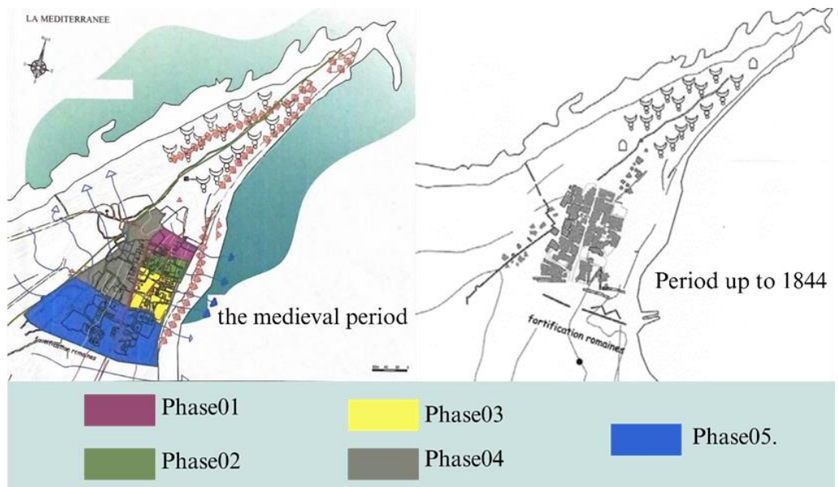
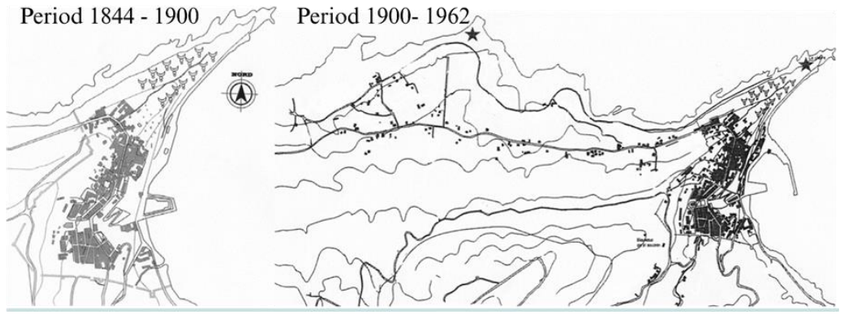
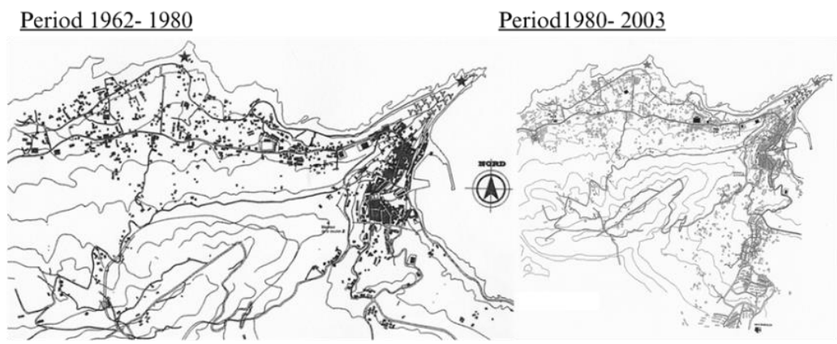
Historical Period	Describtion	Illustration
Pre-Islamic period.	➢ The original settlements followed the natural topography, located near water sources (Ain Salem), with favorable sunlight exposure and protection from the wind. ➢ The regular ancient settlement featured an orthogonal grid with a modular layout (based on Roman units), and the orientation followed the cardo-decumanus axis. A second subdivision to the south introduced a new orientation and parceling logic. Another extension occurred, still governed by the orthogonal order, but featuring varied dimensions and orientations.	 Hypothesis of the restitution of the ancient settlement (12 BC – 415 AD)  Synthesis map of the city during the Roman period (146 BC – 415 AD)  *Figure 35/ Development Phases of the Ancient City of Rusucuru (12 BC – 415 AD), Adapted from Ameziane & Hadjer Brahem (2017), edited by the author (2025).*
Islamic-Arab period.	The initial settlement was established on the southern watershed, around the hydrographic units near the port. The settlement later expanded southward, forming an urban core with specialized structures, including kilns and the site of **Sidi El-Boukhari**. A second urban core emerged, connected by **Rue des Femmes**, with notable specialized buildings, including religious and community sites. The settlement continued expanding westward, transforming peripheral routes into central axes for the organization of urban space. The final expansion occurred southward, with **Rue des Marabouts** becoming the central axis. The urban boundaries were defined by ancient ramparts that followed the natural topography of the area.	

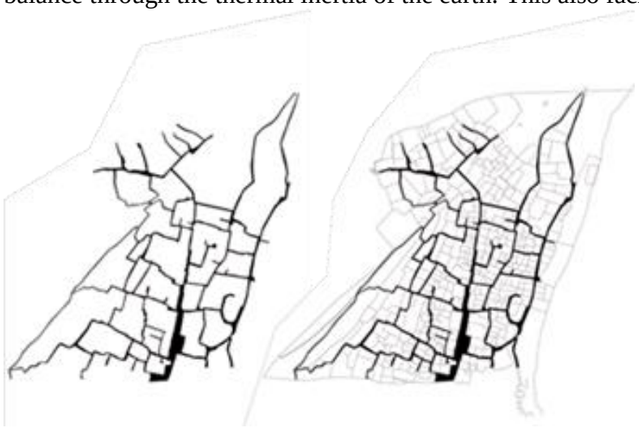
		Figure 36/ Development Phases of the City of Dellys during the Islamic age, Adapted from Ameziane & Hadjer Brahem (2017), edited by the author (2025).
French colonization period .	The European city of Dellys developed in two phases. **The first (1844–1856)** was military, marking its role as a garrison town. Key changes included fortifying the medieval wall, relocating the mosque (1847), constructing a church and abattoir (1851), gendarmerie barracks, and widening the central road in 1855, which split the Casbah into upper and lower parts. **The second phase** brought colonial expansion and modernization: a technical school and port expansion (1860), a military hospital replacing the Great Mosque (1866), the Bengut lighthouse (1881), and a railway line (1885), shaping a European-style urban layout (Bougdal, 2006).	 *Figure 37 Figure 38/ Development Phases of the City of Dellys during the French colonial era, Adapted from Ameziane & Hadjer Brahem (2017).*
Post-independent	The urban expansion occurred outside the ramparts, extending westward toward the gardens along National Road 24 (RN24) in the direction of Algiers, and southward along the provincial road CW N154 toward Touarga. • **1957**: Construction of dormitory-style housing complexes. • **1970**: Development of housing units and public facilities as part of the Municipal Development Plan. • **1980**: Creation of the new town of Boumerdès and the implementation of the first Urban Development Plans.	  The narrow strip of gardens, Photo taken by: Bougdal Kamel, 2005  The collective housing, Photo taken by: Author, 2025

3.4.1.5. Climate responses :

After analyzing the city’s transformation across three distinct historical periods, it is essential to deepen the investigation by examining Dellys at three interrelated spatial scales: the environmental scale, the form, and the architectural envelope. This multiscale approach aims to uncover the embedded environmental strategies and contextual adaptations that have shaped the city's resilience and architectural identity over time.

- Arab-islamic period :

Table 16 Synthesis and climate response and synthesis of Arab-islamic period Source: author.

Environmental	Form	Envelope
The Riyad: Located in the immediate proximity of the house, sometimes in a courtyard or adjacent space. It acts as a thermal regulator, contributing to a favorable microclimate. **Road system**: Accessibility to public spaces is organized in a hierarchical manner, extending to dead-end alleys. The narrowness of the streets combined with the height of the buildings reduces the duration of sunlight exposure on façades. **Offsetting and narrowing of alleys**: Improves natural ventilation by creating windbreaks and shaded areas, thus contributing to a pleasant microclimate in the urban space. **Orientation**: The Casbah of Dellys is positioned to benefit from natural protection against harsh western winds by being located on the eastern slope of the Cape of Dellys. This strategic orientation also provides panoramic sea views for all the houses situated on the sloped terrain. **Adaptation to the terrain**: The traditional house is built on multiple levels to manage the site's unevenness, minimize exposure to dominant winds and summer sun, and maintain temperature balance through the thermal inertia of the earth. This also facilitates the drainage of rainwater.  *Figure 39 : The Casbah’s Urban Structure, (Casanovas Boixereu, 2012)*	**Compactness**: The compact form and its small openings reduce thermal losses. **Patio**: Allows natural light to enter the interior space. It also enables natural ventilation. **Skifa**: The house entrance is designed with a zigzag layout to block direct views into the interior space. **Galleries**: Help organize the interior space and provide hygrothermal comfort inside the rooms. **Water well**: Also brings coolness through the evaporation of water, which helps regulate temperatures. **Qbou**: It features a small opening on the façade or lateral openings to observe and monitor the street without being seen.	**Thick walls** provide both thermal and acoustic inertia. **Interior walls** are made of stone and covered with a thin layer of gypsum. Typically, the wall consists of two parallel layers of stone, with the gap between them filled with earth and rubble to ensure thermal and acoustic comfort. The **stone used in construction** is often extracted from ancient buildings from the Antiquity period, as stone remains reusable in construction. In general, **the houses in the Casbah are covered with double-pitched tile roofs**.  

- French colonization period :

Table 17 Synthesis and climate response and synthesis of French colonization period, Source: author.

Environmental	Form	Envelope
Centralized public squares offer advantages for the microclimate. **Wide streets** are designed for commercial activities, with arcades providing protection against intense solar radiation. **Access**: The old hierarchical road system is absent; houses are directly accessible from the main street.	**European style** with an outward orientation, characterized by commercial arcades facing the street and the absence of patios, which is not well suited to the climatic conditions. **Form**: Plots are square or rectangular in shape. **Architectural typology**: The houses have an extroverted design with exterior arcades. Most houses do not have interior courtyards and feature large openings toward the outside. **Ventilation**: Ventilation is provided by large windows on the exterior façades.	**Light-colored façades** with windows and false balconies contribute to thermal gains, unlike the precolonial exterior façades which had no windows. Brick cornices and openings, as well as the use of tiles, help reduce solar heat gain. **Decoration**: Decorative elements are often present.  *Figure 40 / Colonial house along the opening of National Road No. 24, which divided the historic Casbah into two parts, (Casanovas Boixereu, 2012)*

- Post-independence period :

Table 18 Synthesis and climate response and synthesis of Post independence period, Source: author.

Environmental	Form	Envelope
Lack of vegetation and climate-appropriate urban furniture in public spaces.	**Residential area**: Includes both individual and collective housing, along with various amenities. **Form and volume**: Cubic-shaped buildings with setbacks that create shading effects. **Architectural style**: A mix of architectural styles that do not reflect the local identity, combining traditional and modern elements. The use of balconies is also observed.	**Building heights**: Range from 2 to 5 stories. **Materials**: Construction mainly uses concrete and brick., glass, and metal. **Façades**: Colored surfaces with openings.

3.4.1.6. Conclusion

The appropriate passive strategies employed during the Arab-Islamic period, notably in the selection of construction materials and the adoption of climate-responsive architectural typologies proved to be remarkably well-suited to the dominant environmental conditions. These strategies demonstrated a deep understanding of the relationship between built form and climate, enabling thermal comfort and spatial harmony within their context. However, in contemporary times, there has been a notable departure from these time-tested principles, replaced increasingly by what is widely termed modern architecture. This shift has prioritized the use of industrial materials and globalized aesthetics, often at the expense of environmental responsiveness.

Simultaneously, demographic pressures have played a critical role in the deterioration of architectural quality, favoring quantity over integrity. The push for rapid and low-cost construction has overshadowed considerations of passive performance and climatic adaptability. As a result, the concern for environmental comfort once central to architectural design has largely faded from the dominant architectural discourse.

3.4.2. Synchronic Analysis :

3.4.2.1. Introdction

This chapter focuses on the western periphery of Dellys, beyond the constraints of the *Plan de Sauvegarde*, offering greater design freedom while respecting the city's identity. Using a typo-morphological and sensorial approach, it analyzes spatial forms, architectural types, and experiential qualities to uncover contextual insights. These findings aim to inform the design of a cultural facility that reinforces urban identity and supports Dellys' revitalization.

3.4.2.2. Situation / Limits

The site is located at the western entrance of Dellys, bordered by the Mediterranean Sea to the north and the historic core to the east. Crossed by National Road RN 24, it holds strategic importance as a point of arrival. The area is mainly residential, with individual houses, schools, and key landmarks such as a mosque, Château Faure, and the Cap Bengut lighthouse, highlighting its cultural and civic significance.

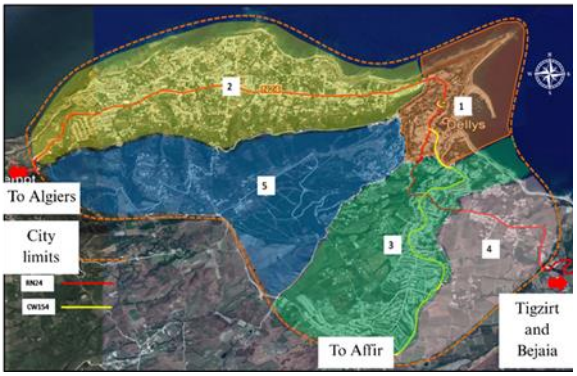


Figure 41/Zoning map of Dellys showing the case study area (Zone 2) , (Google earth, edited by author, 2025).

Figure 42/The case study limits, Municipality scale, (Google earth, edited by author, 2025).

3.4.2.3. Site choice criteria

The selected site is one of two neighboring plots identified during a joint urban analysis conducted with classmates, located at the western entrance of Dellys, results from a careful evaluation of urban, historical, and environmental factors.

- Supporting urban growth patterns.
- Freedom from preservation restrictions.
- Proximity to cultural landmarks.
- Strong natural potential.
- Local need for cultural and public infrastructure.

Figure 43/ Location of the Proposed Project Site. (Google earth, edited by author, 2025).

3.4.2.4. Road system

- Road and node hierarchy:

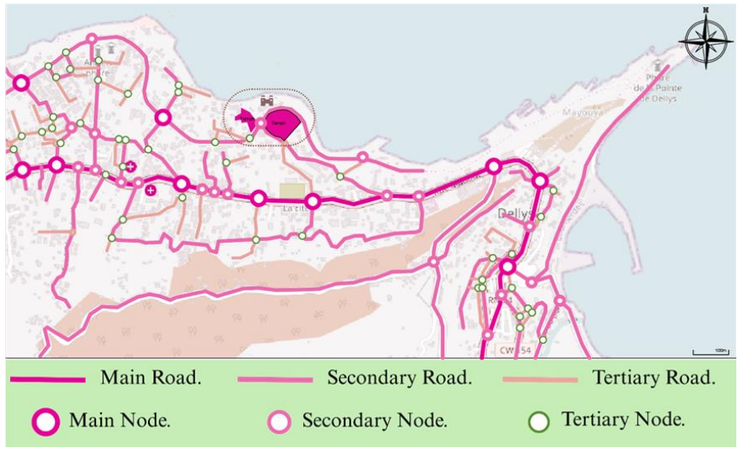


Figure 44/The hierarchy of road / node system. Source: Google earth, edited by author (2025).

Figure 45/NR n°24 Source: Google maps.

Figure 47/Site Access Road. ,Source: Author (2025).

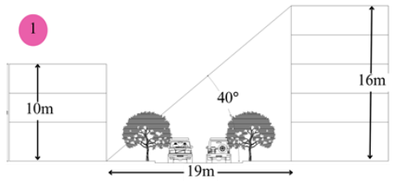


Figure 46 /Section 01, Author (2025).

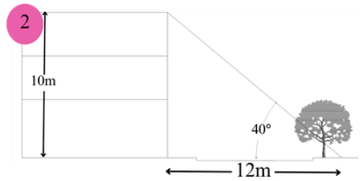


Figure 48/ Section 02 , Author (2025).

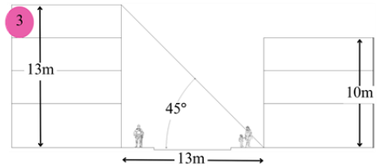


Figure 51/ Section 03, Author (2025).

Figure 49 /Sensorial nodes hierarchy map, Source : Google earth edited by author (2025).

Figure 50 /The 3 observation points,Source: Author(2025).

As part of the urban diagnosis, three observation points were chosen along the main road linking central Dellys to the project site, highlighting the spatial and functional diversity of the urban fabric.

- Point 1 marks a civic hub near key intersections, featuring wide sidewalks, clear signage, and vibrant street life, serving as a central urban node.
- Point 2 transitions into a residential zone with mid-rise buildings, visible infrastructure, and surrounding vegetation, indicating a shift from central to peripheral character.

Table 19/ Comparison of Street Section Profiles and Prospect Ratios, Author, (2025).

Section	Height(s) (m)	Width (m)	Angle	Prospect Ratio (Left / Right)
1	10 / 16	19	40°	0.53 / 0.84
2	10	12	40°	0.83
3	13 / 10	13	45°	1.00 / 0.77

- Point 3, closer to the city's edge, features denser development and narrow, pedestrian-friendly streets, reflecting a more modest and peripheral environment.

- Security:

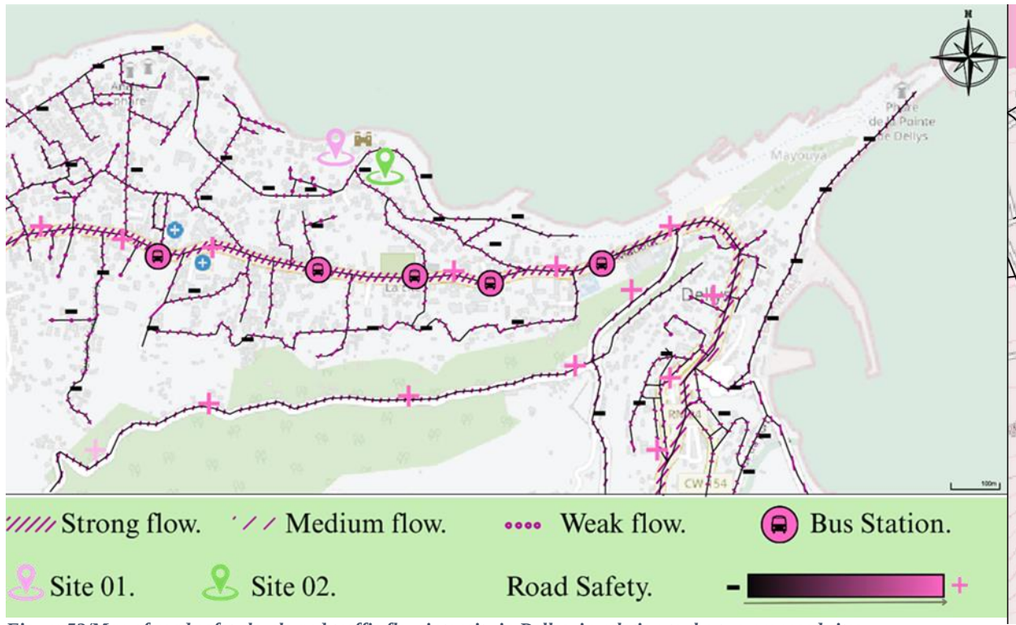


Figure 52/Map of road safety levels and traffic flow intensity in Dellys, in relation to the two proposed sites,

Source : Google earth edited by author (2025).

The map illustrates the urban circulation patterns, road safety levels, and public accessibility in Dellys, focusing on their relation to the two proposed project sites: Site 01 and Site 02.
In conclusion, although both sites are set in less trafficked quieter area, would require enhanced transport links and pedestrian infrastructure to reinforces their potential as integrated yet peaceful urban intervention zones.

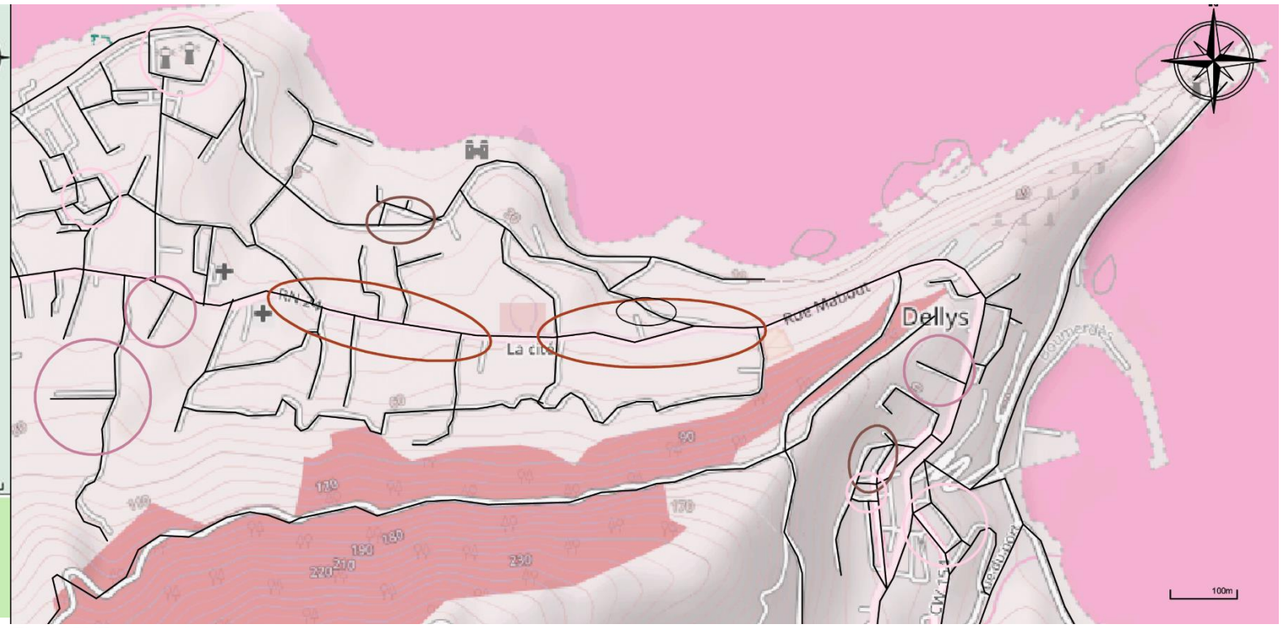


Figure 53/The map of road geometry.
Source: Google Earth satellite image, edited by the authors (2025).

Table 20/Street Network Typology and Distribution, Source:Authore, (2025).

Road	Loop System	Grid System	Linear System	Dead End
Percentage	15.45%	10%	40%	32.55%

3.4.3. *Parcel system*

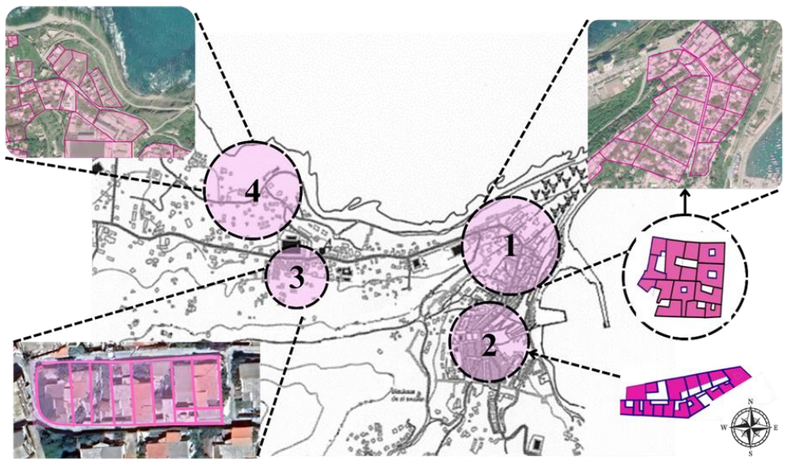


Figure 54/ The four urban zones in Dellys based on parcel structure.

Table 21/a summary table of the four urban zones in Dellys based on parcel structure and characteristics.

Zone	Name	Parcel Structure	Urban Characteristics	Key Notes
1	Casbah	Organic, compact, irregular	Traditional Islamic-medieval; narrow alleys, high density, climate-adapted	Historic core; culturally significant; complex spatial logic
2	European City	Regular, orthogonal grid	Colonial-era planning; wider streets, larger plots	Transition zone between old and modern Dellys
3	Along the Main Road	Modular, regular	Mixed-use potential; highly accessible and visible	Strong connectivity; suited for public-facing or commercial programs
4	Urban Periphery / Coastal Expansion	Large, loose, semi-rural	Recent development; lower density; landscape potential	Ecologically sensitive; visually exposed; suitable for integrated design

3.4.3.1. Built system

- Visual reference point :

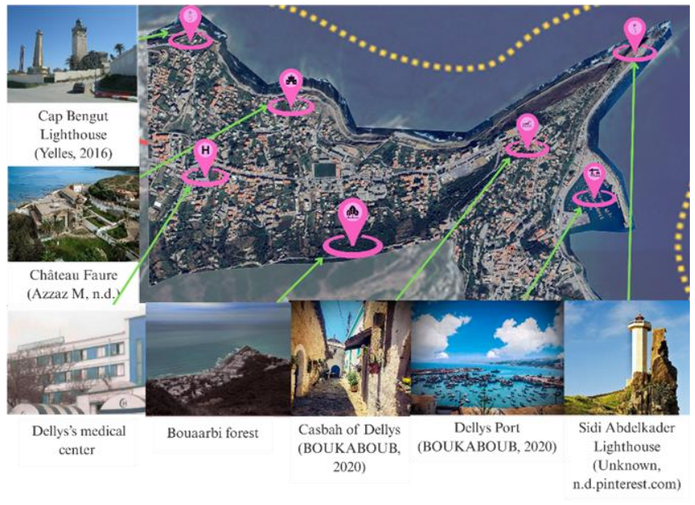


Figure 55 / Reference point on case stydt paremeter scale,

Source : Google earth edited by author (2025).

- Density

Figure 56/ Occupancy pattern case study scale, Author, (2025).

High-Density Zones (Along RN24)

- Building height: R+3 to R+5
- CES (Coefficient d'Emprise au Sol): 0.6 to 0.8
- COS (Coefficient d'Occupation du Sol): 2.6 to 4.8

Medium-Density Zones

- Building height: R+1 to R+3
- CES: 0.4 to 0.6
- COS: 1.2 to 2.6

- Facility

The map illustrates the spatial distribution of built and open (void) areas in Dellys. In this representation, white areas correspond to built structures, while black areas indicate open spaces. Built-up zones cover approximately 46.98% of the total surface area, whereas

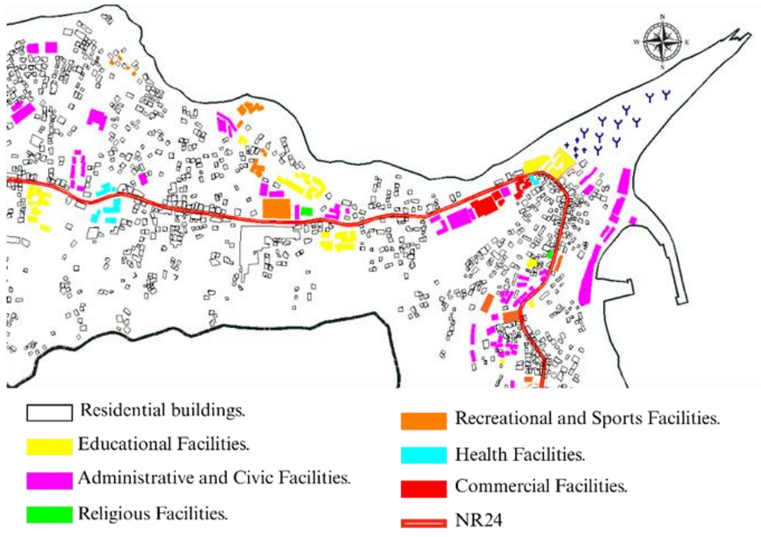


Figure 57/ Facility map case study scale. Source: Author(2025).

53.02% remains unbuilt. The highest built density is observed in the eastern and central zones, characterized by compact white clusters. Moderate-density development appears in the southwest, showing a more dispersed urban fabric. In contrast, the northwestern coastal zone remains relatively open, while the northeastern sector features a mixed-use coastal edge, with denser port-related infrastructure surrounded by open buffer zones.

According to the provisions of the Plan d'Occupation des Sols (POS) No. 02, revised in 2015, for zones designated for major facilities along National Road 24 (RN24), the urban planning parameters, including specific density regulations, are illustrated in the accompanying figure. In addition to these regulations, the following servitudes must also be respected:

- Watercourse protection: Construction must not encroach upon the boundaries of natural water streams.
- Medium-voltage power line (Ligne MT): A setback of 3 meters must be maintained from the outermost wire.
- DMP (Distance Minimale de Protection): A minimum distance of 100 meters is required from sensitive or protected zones.

- Building’s condition

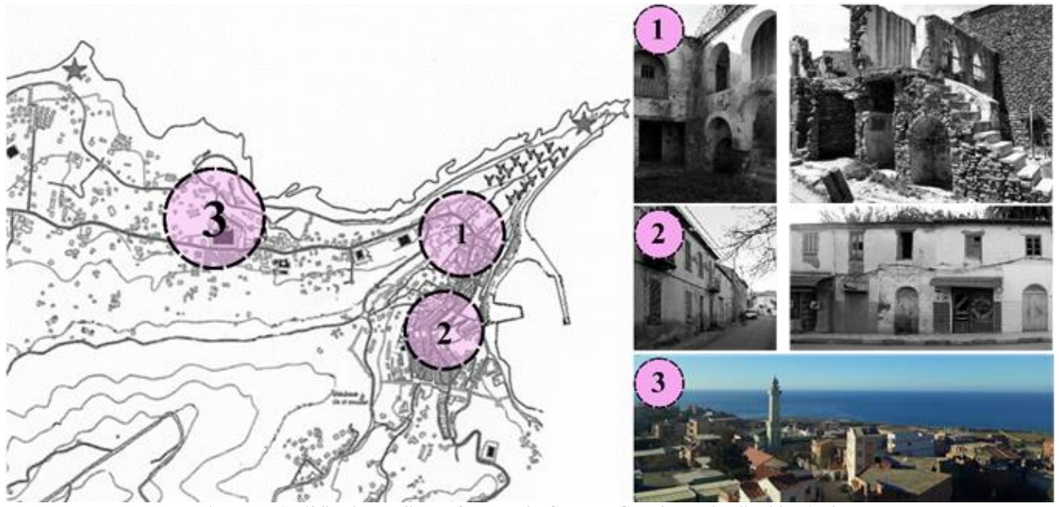


Figure 58 Building’s conditon of cas study, Source: Google earth edited by Author .

The architectural fabric of Dellys reflects a diverse range of building conditions, shaped by both its historical evolution and more recent urban development. In the traditional core, particularly the Casbah, many buildings exhibit advanced deterioration, such as damaged masonry, collapsed roofs, and damaged façades, largely due to age, inadequate maintenance, and exposure to natural elements. This situation was significantly worsened by the 2003 Boumerdès earthquake, which caused severe structural damage to many heritage buildings, accelerating their decline. Although some restoration efforts have been initiated within the framework of heritage conservation, much of the historic fabric remains fragile and at risk.
In contrast, the European quarter and the modern extensions along RN24 show a range of building conditions, from well-preserved colonial-era structures to recent constructions in generally better shape. Nonetheless, issues such as unauthorized extensions, uncoordinated renovations, and the unfinished reinforced concrete structures are present and point to the need for better regulation and urban management. Overall, the stark contrast between deteriorating heritage zones and relatively stable modern sectors underscores the urgency of targeted rehabilitation strategies and context-sensitive preservation policies, especially for historically significant areas like the Casbah.

- Road alignment

The historical core of Dellys is characterized by an organic and irregular road alignment, Narrow, winding streets form a compact and pedestrian-oriented network, often defined by spatial constraints and the topography of the old city.
In contrast, the RN 24 (Route Nationale 24), presents a linear and structured alignment, The roads around the proposed project site, alignment is ensured by the buildings themselves or boundary walls.

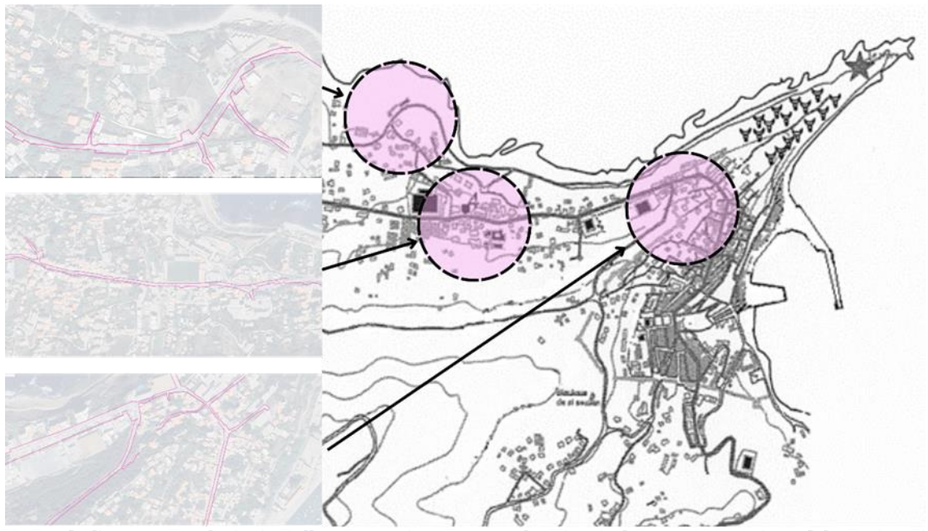


Figure 59/ Road Alignment Typologies in Dellys: Comparison Between the Historical Core, RN 24 Axis, and the Project Site Area , Google earth edited by Author .

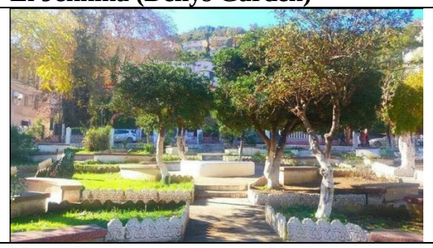
3.4.3.2. Facade, colors and texture

Table 22/Comparative Analysis of Façade Typologies in Dellys, Source:Author (2025).

Urban area		Facade	
Historical core		Colors	White, blue shutters, natural stone tones, red roofs.
		Textures & Materials	Rough lime plaster, exposed stone, aged surfaces.
		Facade Characteristics	Small openings, thick walls, whitewashed façades, simple detailing.
European quarter		Colors	Cream, pastel yellow, light brown.
		Textures & Materials	Smooth plaster, stucco finishes, colonial stone and brikck elements
		Facade Characteristics	Symmetrical facades, Wide openings, decorative cornices, red roofs.
Modern extensions		Colors	Beige, grey, red, sometimes vivid tones.
		Textures & Materials	Painted or tiled concrete, occasional stone cladding, some unfinished surfaces.
		Facade Characteristics	Concrete block façades, larger windows, balconies, and red roofs still present.

3.4.3.3. Open public spaces

Table 23 / Comparison of Key Public Spaces in Dellys: Garden, Square, and Seaside Promenade.

Criteria	El Jennina (Dellys Garden)	Dellys Public Square	Manège de la Plage (Beach Promenade)
Visual illustration			
Location	Near the historic center (Kasbah)	Central, adjacent to major circulation arteries	Seaside, near the coastline and public beach
Type of Space	Garden / Urban park	Urban plaza / Civic square	Recreational space / Seafront promenade
Main Function	Leisure, walking, shade, greenery	Social gathering, events, market, political and civic use	Recreation, seaside view, informal gathering
Landscape & Vegetation	Rich vegetation, shaded by trees	Minimal to moderate vegetation	Sparse vegetation, open to the sea breeze
Topography	Slightly elevated	Flat	Flat
Paving & Materials	Natural elements, benches, stone paths	Mostly paved, with benches and lighting	Mixed pavement, concrete and sand nearby
Accessibility	Moderate, through pedestrian paths	Highly accessible by foot and car	Easily accessible; adjacent to main roads and beach walk
Views	Overlooking part of the old town and green areas	Surrounded by urban buildings, limited views	Open panoramic view of the sea and coastline
Use by Locals	Frequent for relaxation and children's play	Common for socializing, waiting, and community events	Popular for youth, families, and tourists
Cultural/Historical Value	High – traditional public garden in local memory	Medium – functional civic space	Low to moderate – more recent recreational space
Microclimate	Cooler due to shade and vegetation	Hotter, more exposed	Windy, refreshing sea breeze but no shade
Lighting (at night)	Dim to moderate	Well-lit	Moderate, depending on maintenance
Furniture & Amenities	Benches, shade, some play areas	Benches, lighting, open surface	Few benches, close to cafés and beach amenities
Current Condition	Aging but preserved	Maintained but needs upgrading	Underused; could benefit from revitalization

3.4.3.4. Sequential analysis

1.Scenic Gateway.


Characteristics:
- Wide, open views of the sea and horizon.
- Calm, bright, and sunlit atmosphere.
- Low security and limited mobility, especially during low-traffic hours.

2.Transition Corridor


Characteristics:
- Dominated by Château Faure, a strong heritage reference.
- Enclosed by walls, visually and physically isolated from the surrounding urban fabric.
- Poor pedestrian infrastructure and road safety; presence of youth gatherings creating noise disturbances.

3Active Residential Quarter


Characteristics:
- Underused and unmaintained space with overgrown vegetation and low activity.
- Litter, odors, and poor visual quality contribute to a feeling of abandonment.
- Perceived insecurity limits user comfort and movement.

4

3.4.3.5. SWOT

Table 24/SWOT. Source: Author(2025).

Strengths	Road system	• The RN24 road plays a major role as a main traffic axis, connecting the city to nearby urban centers and facilitating accessibility. • A hierarchical road network ensures organized access from major roads to small streets and residential areas.	• Improving road safety and accessibility through better pedestrian infrastructure and traffic management. • Modernizing roads could boost tourism and economic activities.	Road system	Opportunity
	Parcel system	• The historic center provides a unique heritage value that can enhance tourism and reinforce the city's cultural identity. • Along the main roads and the national road, this alignment allows easy access and smooth connectivity with newer areas.	• Large land parcels offer freedom in design and creation.	Parcel system	
	Built system	• Significant cultural monuments such as the Casbah give the city a unique architectural identity. • Strategic location near the sea, offering views and attraction for buildings.	• Restoring historic buildings could attract more tourists and encourage cultural activities. • Using local construction techniques and sustainable materials could enhance durability and provide economic opportunities.	Built system	
	Open space system	• Numerous natural landscapes, such as the coast and surrounding forests, offer opportunities for leisure and tourism.	• Developing parks and outdoor spaces could strengthen community interaction and improve quality of life. • Projects with green roofs or living walls could address environmental challenges.	Open space system	
	Sequential analysis	• Each sequence presents a unique atmosphere, which allows for the creation of a varied and attractive tourist village. • The diversity of needs in each sequence makes it possible to plan specific interventions.	• Introducing sensory elements, such as fragrant plants and solar lighting, could enhance the experience of urban sequences. • Creating pathways for pedestrians and cyclists.	Sequential analysis	
Weaknesses	Road system	• Lack of parking and bus stops, leading to traffic problems and mobility challenges. • Many streets, particularly around historic areas, suffer from safety issues and poor maintenance.	• Heavy vehicle traffic on main roads increases the risk of accidents.	Road system	Threats
	Parcel system	• The current layout may not meet diverse needs, such as public spaces.	• Functional diversion of unoccupied parcels may lead to insecurity.	Parcel system	
	Built system	• Many historic buildings are in poor condition and require restoration. • Variations in building heights and a lack of coherent architectural style harm the city’s visual harmony.	• Continued neglect could result in the loss of irreplaceable architectural heritage. • Lack of restoration and new projects that don’t respect traditional building typologies.	Built system	
	Open space system	• Lack of well-developed urban spaces and parks, limiting places for social interaction and relaxation. • Some open spaces are poorly maintained or poorly integrated into the urban network.	• Rapid urbanization could encroach on natural and open spaces, degrading environmental quality. • Poor urban planning could further reduce available recreational areas.	Open space system	
	Sequential analysis	• Some areas lack lighting and security, affecting accessibility and user comfort. • Unpleasant smells in some sequences may discourage visitors.	• The perception of insecurity in poorly lit areas may limit the effective use of public spaces. • Environmental pollution or poor waste management may continue to negatively impact the visitor experience.	Sequential analysis	

3.4.3.6. Conclusion and recommendation :

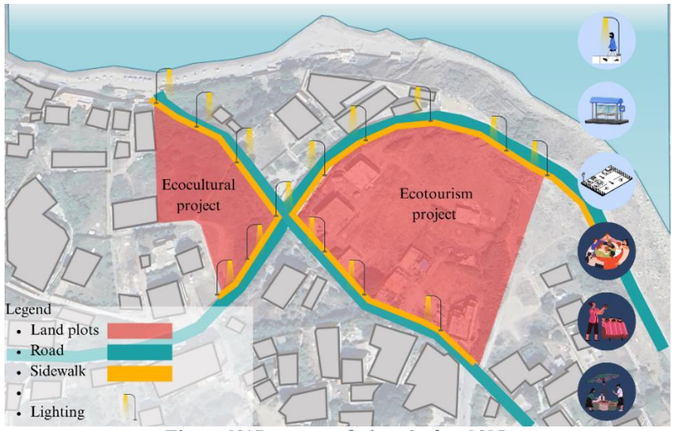


Figure 60/ Recommendation, Author 2025.

To enhance the urban experience and support the cultural and social vitality of the area, the following actions are recommended:

- Develop plazas and public spaces to encourage community interaction and leisure activities.
- Create parking and transportation solutions to improve accessibility and reduce congestion.
- Establish safe and continuous sidewalks to support walkability and pedestrian comfort.
- Improve public lighting to enhance safety and nighttime ambiance.

3.4.3.7. The urban strategy

Ecovalorization of Delys through sustainable design that celebrates heritage, enhances sensory experience, and reinforces urban identity.

Table 25/Strategies. Source: Author 2025.

	Opportunities	Threats
Strengths	**SO1:** Improve accessibility and road safety to boost tourism. **SO2:** Restore historic buildings to attract tourists. **SO3:** Use local and sustainable materials for durable architecture. **SO4:** Develop green spaces to strengthen community life. **SO5:** Respect urban alignment according to urban planning rules.	**ST1:** Reduce accidents by improving road safety and managing traffic flow. **ST2:** Prevent heritage loss due to neglect. **ST3:** Preserve building integrity by respecting traditional architectural styles. **ST4:** Reduce the impact of densification to preserve natural and open spaces.
Weaknesses	**WO1:** Create parking and transport solutions to improve mobility. **WO2:** Launch restoration programs to enhance historical heritage. **WO3:** Promote a harmonious architectural style to reinforce urban identity. **WO4:** Plan green spaces to improve quality of life and public health. **WO5:** Integrate natural elements (green roofs, green walls) for a healthier environment.	**WT1:** Create bus stops and stations in strategic locations to promote public transport and reduce car use. **WT2:** Convert vacant lots into public/semi-public spaces (gardens, squares, leisure areas). **WT3:** Respect typology and traditional construction materials of the city. **WT4:** Develop new gardens and integrate leisure and relaxation spaces.

Table 26/ Recommendation table of thematic, diachronic and urban analysis. Source: Author 2025.

	Environment	Form		Envelope	Climate responses
		Architectural aspect	Program aspect		
Diachronic analysis	• Architecture was integrated with topography. • Courtyards and Riyads ensured thermal comfort and greenery. • Local materials reflected ecological awareness.	• Compact, inward-looking forms. • Courtyard-centered spatiality (wast ed-dar). • Hierarchical spatial organization: public → semi-public → private. • Organic morphology responding to terrain and climate.	• Daily life revolved around artisan activities, souks, hammams, religious learning. • Semi-public spaces encouraged community and ritual.	• Thick walls with thermal inertia. • Small, shaded openings. • Simple façades with climate-conscious design. • Light colors reflect sun.	• Passive design embedded in spatial logic. • Courtyards, ventilation shafts, vegetation, thick walls all worked together. • No AC needed nor artificial lighting.
Urban analysis	• Project site is underused but contextually rich (near Château Faure).	• Adopt compact, context-aware massing. • Use courtyards to anchor spatial hierarchy. • Reintroduce human scale and walkable, shaded paths. • Adapt forms to terrain.	• Create multi-functional spaces for artisans, exhibitions, and workshops. • Foster social cohesion with courtyards and gathering zones. • Promote cultural continuity through program.	• Prioritize thermal mass and shading. • Use recessed windows, mashrabiyas, or brise-soleil. • Combine simplicity with local ornamentation. • Avoid heat-trapping materials.	• Design for natural ventilation and lighting. • Use courtyards for stack effect and cooling. • Restore passive cooling with shading, vegetation, and compact massing.

3.5. Site analysis :

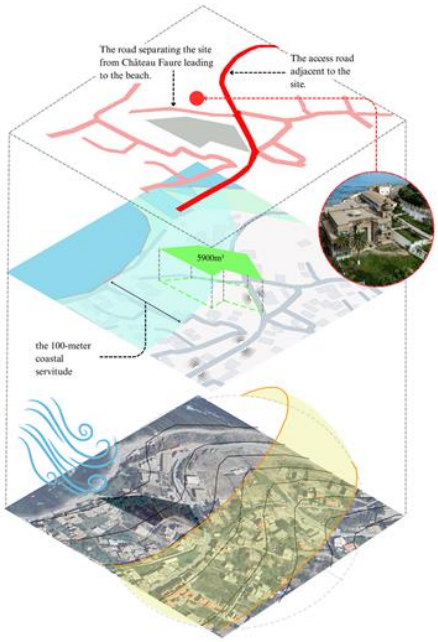


Figure 61Site analysis synthesis,

Source: Google earth, edited by author 2025.

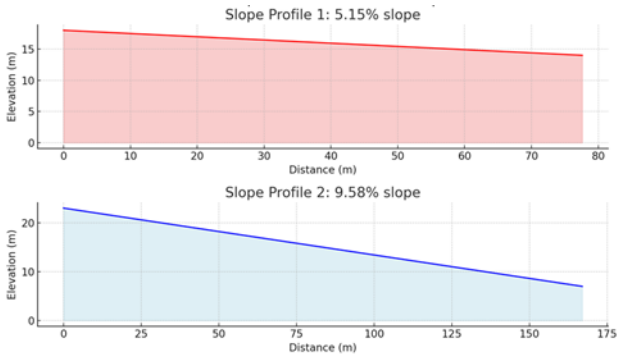


Figure 62/ Site sections,

Source: Google earth, edited by author 2025.

- Transverse Profile (Profile 1) : 5.15%
- Longitudinal Profile (Profile 2) : 9.58%

3.6. Fundamental concepts of the project :

What's THE vision and mission?

Vision	Mission
	
A cultural institution that bridges past and future, land and sea, tradition and modernity, rooted in local identity, ecology, and sensory experience to ecovalorize Dellys.	• Promote **cultural awareness** and **education** through exhibitions, workshops, and learning spaces • **Ecologically and contextually integrate** architecture within the Dellys landscape • Reinterpret **traditional elements** to serve as **passive bioclimatic strategies** • Enhance the **experiential quality of space** using a **phenomenological approach** (light, material, and atmosphere)

The conceptual framework of the project is structured around several key principles:

Ecovalorization	The project contributes to the revitalization of underexploited urban, cultural, and natural resources, emphasizing sustainability and cultural continuity.
Bioclimatic integration	Passive strategies such as natural lighting, ventilation, and compact massing are employed, taking inspiration from the traditional architecture of Dellys.

Cultural identity	Architectural elements like courtyards, small openings, and the *qbou* are reinterpreted not only for climate adaptation but also to celebrate and preserve the local architectural heritage. The project becomes a vessel for expressing collective identity and belonging.
Phynomenological approach	The spatial design prioritizes the sensory experience of the user, engaging sight, touch, to promote a deeper connection to place and memory.
Symbolic bridging	The architectural form and spatial logic express the idea of a bridge uniting natural and cultural contrasts such as land/sea, history/future, and vernacular/contemporary.

This conceptual framework serves as the foundation for the subsequent stages of form development, spatial organization, and environmental integration.

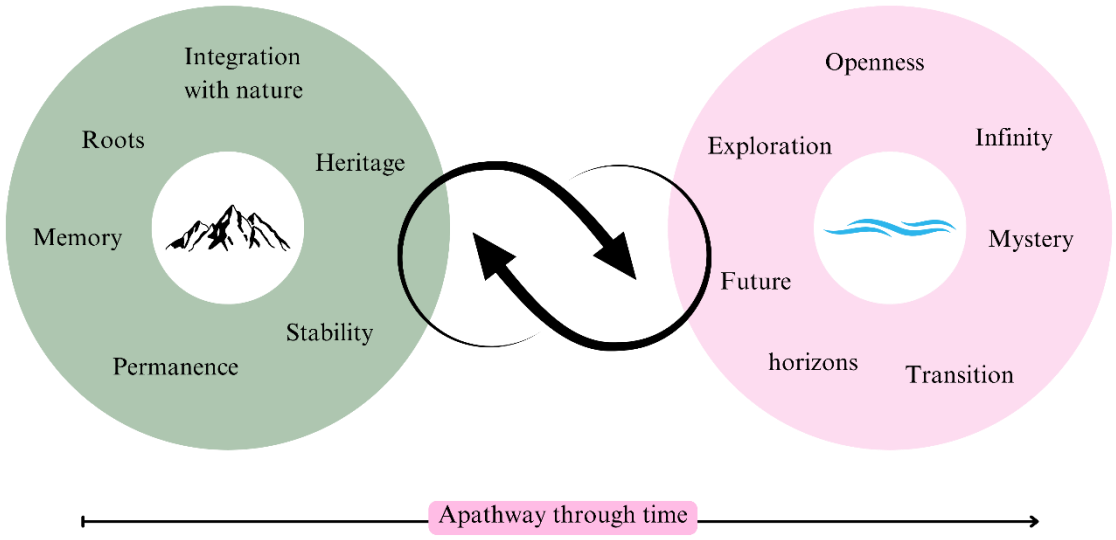
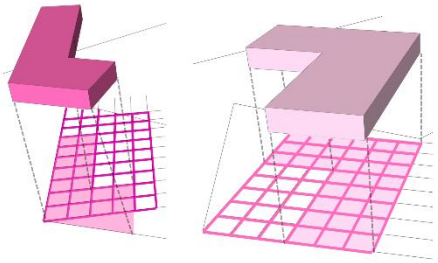


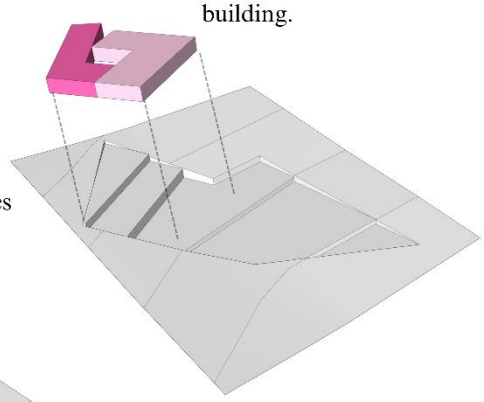
Figure 63/ The main idea of the concept, Author 2025.

Where the sea meets the mountains. The design aims to reflect this connection by creating a space that acts as a bridge not physically, but rather symbolically. The museum links the past and future by preserving cultural identity while embracing modern design approaches

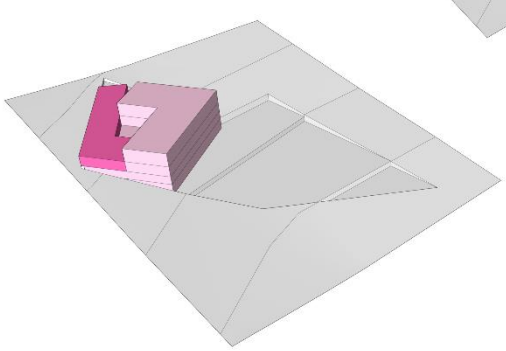
3.7. Form developement :



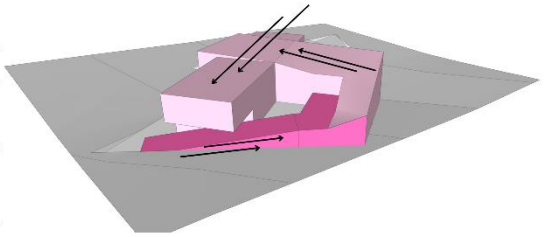
1. Initially 2 grids were established, each aligned with different roads one following the principal road and the other following the secondary path.
2. The main volume pf the project was designed to act as a protective barrier against the north wind for the rest of the building.



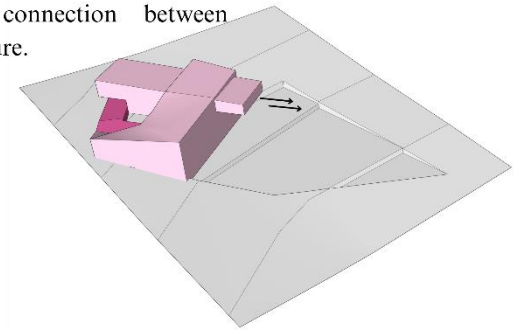
3. An additional form form was created to enclose the main volume, forming a central courtyard that facilitates natural ventilation for the building .



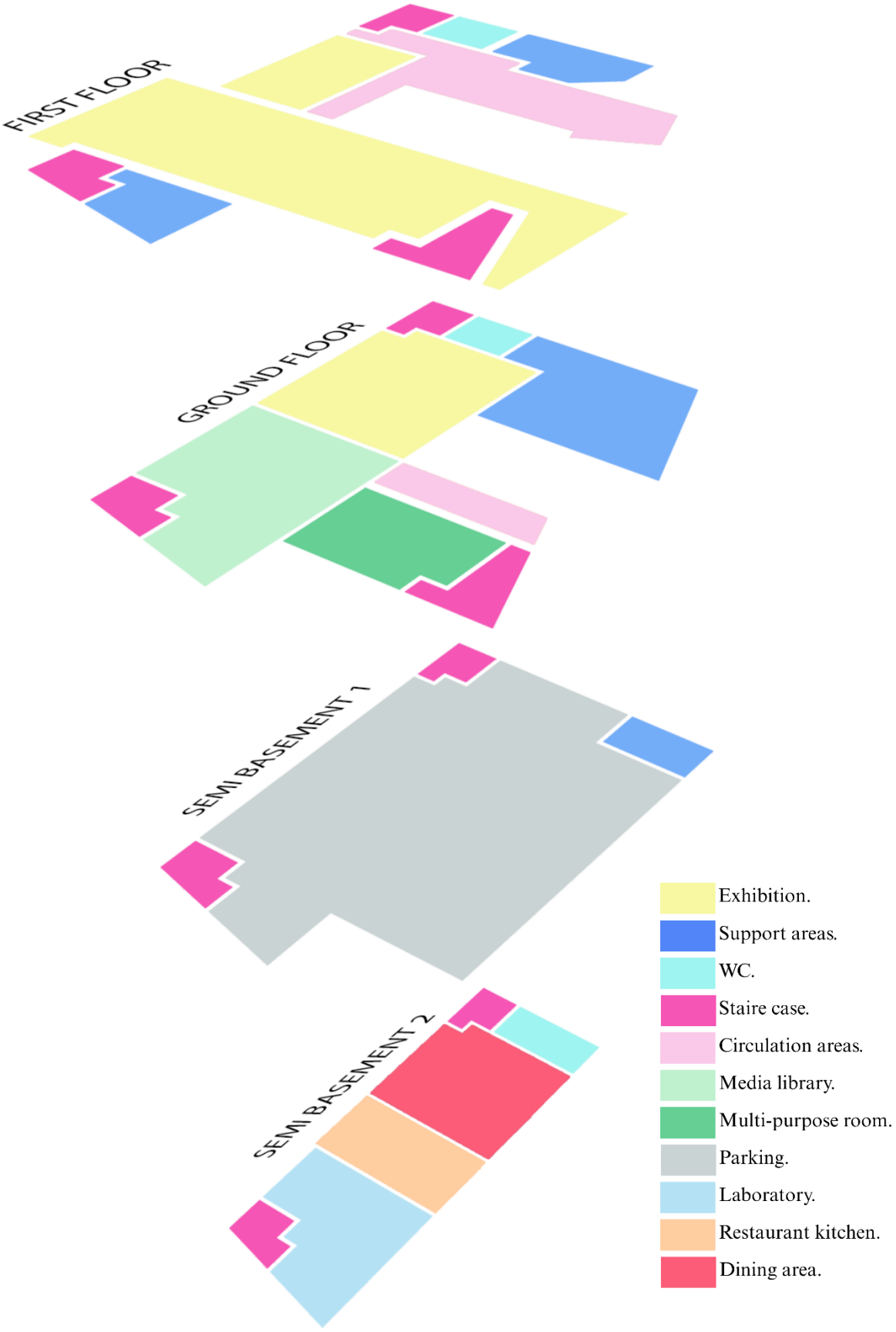
4. The building levels were adapted to fit the varying levels of the sloped terrain, ensuring the integration with the site's topography.



5. Final modification were made to the form, including pushing and pulling volumes, inclining and declining surfaces, to evoke a sence of rising from the earth, symbolizing the ground, mountain and sea, reflecting the project's conceptual connection between past and future.



3.8. Spatial organization :



3.9. Phenomenological Dimension (Spatial Experience and Sensory Journey):

The design of the Museum of Dellys embraces a phenomenological approach, where architecture is not just seen but lived, touched, heard, and felt.

3.9.1. Arrival & Entrance:

The museum offers two distinct entrances, each evoking a different spatial and symbolic experience.

The first entrance, dedicated to the main exhibition spaces, invites visitors to ascend a staircase wrapped in vegetation. This elevated path creates a sense of progression, both physical and metaphorical, as one rises towards culture and creativity. The natural shading, the texture of the steps, and the reflected light on the greenery prepare the senses and build anticipation for the exhibition journey.

The second entrance, nestled below the main staircase, leads directly into the educational wing of the museum. This passage is more intimate and grounded, guiding visitors into a quieter, introspective space. Here, the architecture invites a metaphorical "dive" into knowledge and heritage, allowing students, researchers, and curious minds to immerse themselves in learning.

The duality of these entrances reinforces the project's phenomenological intention: to offer varied paths that reflect the diversity of human engagement with culture, whether through elevation and discovery or depth and reflection.

3.9.2. Movement & Journey Through Spaces:

First Sequence (The Past: Mystery and Depth):

The spatial journey begins in a dimly lit, enclosed space that immerses the visitor in an atmosphere of mystery and reflection. This environment, enhanced by high-end exhibition technologies such as projections and interactive media, evokes the mysterious nature of the past, a time not fully seen or understood, yet deeply felt. The lack of natural light, combined with textured surfaces and a controlled ambiance, slows down the visitor’s pace and encourages personal reflection. Here, the past is not presented through clarity but through emotional depth, emphasizing its role as the foundation of identity and memory.

Second Sequence (The Present: Awareness and Appreciation):

Emerging from darkness, the visitor enters an open, calm space where a large screen frames the northern sea, offering a moment of pause and clarity. The soft, indirect light from the northern orientation creates a tranquil atmosphere, symbolizing the peace and stability of the present. This space suggests that only once we have understood the past can we begin to fully appreciate the present. The expansive view, minimal intervention, and calm acoustics encourage mindfulness and grounding, highlighting the value of what we often overlook: the beauty of the now.

Third Sequence (The Future: Ascent and Enlightenment):

The final leg of the journey leads the visitor southward and upward, as the floor begins to rise gently, and the space is increasingly filled with natural light. This architectural movement, both vertical and luminous, represents a hopeful transition toward the future. At the highest point, a screen frames the mountains of Dellys, symbolizing resilience, rootedness, and enlightenment. This culminating moment expresses an optimistic vision, where the future is not detached from

the past, but rather emerges from a deep understanding and appreciation of it. The movement through space thus becomes an emotional and symbolic ascent toward awareness and possibility.

3.9.3. Materiality & Memory:

To evoke a **tactile memory** and a deep connection to the traditional Dellys house, materials such as **stone and plaster** are prominently used throughout the museum. These materials carry the **textural and visual qualities** characteristic of the local architecture, creating a sensory link to the region's cultural heritage. The roughness of limestone walls and the smooth, whitewashed plaster surfaces recall the **physicality and craftsmanship** of traditional Dellysian homes, inviting visitors to experience a **bodily awareness** of place. Through these material choices, the architecture not only references history visually but also **awakens memories through touch and atmosphere**, making the past present in the visitor's sensory experience.

3.9.4. Light as an Experiential Element:

The museum is primarily **illuminated through natural light**, which plays a central role in shaping the spatial and emotional experience. As previously discussed, **light and shadow** are carefully used to **mark the transitions between sequences**, reinforcing the narrative journey from past to future. One of the most evocative moments occurs when **sunlight filters through mashrabiya screens**, casting intricate **motif patterns onto the floor**. This dynamic play of light not only animates the space but also **awakens a shared sensory memory**, a nostalgic recall of the **sun softly touching the skin**. These fleeting light patterns stimulate the senses and deepen the connection between body, space, and memory, turning the architecture into a living, breathing experience.

3.10. Environmental strategies used in the project :

The architectural design of the museum integrates a series of passive environmental strategies aimed at enhancing user comfort while minimizing energy consumption.

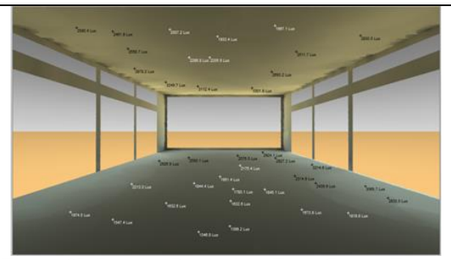
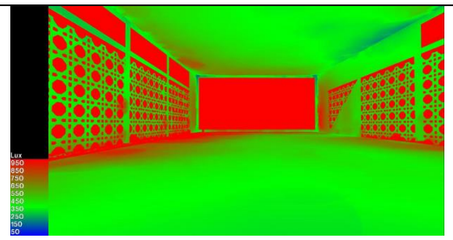
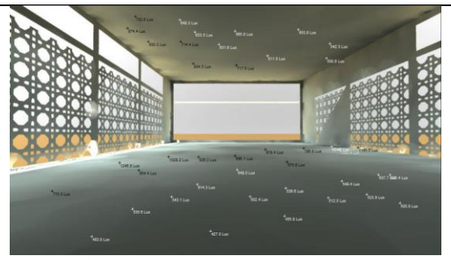
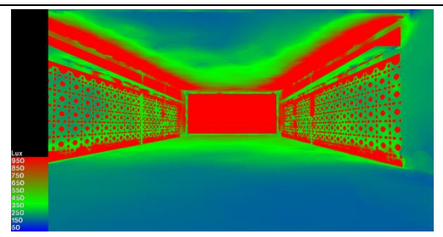
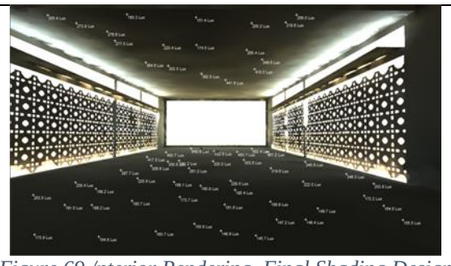
Table 27/ Environmental strategies used in the project, Source: Author(2025).

Environment	Form	Envelope
- Integration with Terrain. - Wind Protection via Mass Placement. - Outdoor Shaded Spaces and founaint for cooling. - Green Roof	- Compact Form with Courtyard. - Orientation of Mass.	- Use of light shelves, glazed surfaces, and moucharabieh-inspired screens to diffuse light. - Optimized Openings Based on Orientation. - Wall-to-Window Ratio Optimization .

3.11. Simulation

This table compares three daylighting scenarios tested using simulation under Radiance, The purpose is to analyze how each treatment affects natural lighting levels and the phenomenological quality of the space, particularly within the museum's exhibition area.

Table 28 /Lighting Simulation Comparison.

Scenario	Lux Levels Observed		Light Distribution	Visual Comfort	Phenomenological Impact
1. No Shading (Reference)	 *Figure 64/Baseline Lux Distribution, Fully Glazed Façade (Ecotect X Radiance simulation)*	 *Figure 65 /Interior Rendering, Fully Glazed Façade (Ecotect X Radiance simulation)*	**Overlit**, harsh and uniform.	**Poor**, excessive glare and overheating risk.	Flattened atmosphere, no shadows, no contrast. Space feels sterile, visually uncomfortable. Loss of sensory layering.
2. Mashrabiya Screen	 *Figure 66/Lux Distribution with Perforated Screens, (Ecotect X Radiance simulation)*	 *Figure 67/Interior Rendering, Perforated Screen Façade (Ecotect X Radiance simulation)*	Diffused light, patterned shadows.	**Moderate to good**, reduced glare, but not optimal for museum experience.	Slight control over light but still lacks strong shadow-play or spatial rhythm. Less harsh than reference, but still generic.
3. Light Shelves + Horizontal brise- soleil	 *Figure 68 /Lux Distribution with Full Shading System, (Ecotect X Radiance simulation)*	 *Figure 69 /nterior Rendering, Final Shading Design (Ecotect X Radiance simulation)*	Best distribution, smooth gradient front to back.	**Very good**, reduces direct light, balances daylight.	Shadows evoke intimacy, mystery, and temporal rhythm. Connects with vernacular identity of Dellys. Enhances sensory perception.

Synthesis

The lighting simulations reveal the critical role of shading strategies not only in optimizing daylight levels but also in shaping the **experiential and symbolic quality** of the museum space. The reference scenario, though highly illuminated, creates an uncomfortable and monotonous environment that lacks narrative depth, In contrast, the light shelves and perforated screen strategys achieve a balanced daylight level ideal for exhibition spaces, while also introducing **shadows, texture, and rhythm**, elements that evoke the **vernacular language of Dellys** and foster a **deeper phenomenological connection**.

Moreover, the progressive increase in brightness along the museum's chronological path enhances the **concept of optimism and forward movement**, a symbolic gesture of hope toward a **brighter future**. This experiential journey, guided by light, reinforces the architectural narrative and supports the museum's mission to celebrate heritage while inspiring new perspectives.

3.12. Conclusion

The deliberate selection of Dellys as the project site was driven by its rich historical layers, strong artisanal culture, and exceptional coastal landscape. The architectural strategy aimed to transform these qualities into a cultural museum that acts not only as a space of exhibition but also as a tool for ecovalorisation, reviving underutilized urban and cultural potential through sustainable, contextual design.

To guide the design process, a comprehensive approach was adopted, combining diachronic urban analysis, typo-morphological studies, and sensorial mapping. These methodologies, grounded in fieldwork and contextual research, shaped a concept rooted in phenomenology and the symbolic relationship between space, memory, and light.

A particular focus was placed on natural lighting, both as a passive strategy and as a design element that enriches the visitor's spatial experience. The lighting simulations revealed that while the reference scenario provided maximum light, it failed to offer spatial comfort or narrative depth. In contrast, the introduction of elements inspired by traditional houses, demonstrated significant improvement, achieving a balanced illumination while echoing traditional spatial patterns.

Symbolically, the museum layout guides visitors along a chronological journey from past to future. The gradual increase in daylight intensity throughout the path not only improves visual comfort but also supports the project's conceptual message: a movement toward a brighter, more hopeful future.

In essence, this chapter confirms that sustainable strategies, when thoughtfully integrated with cultural narratives and spatial identity, can result in architecture that is both environmentally responsible and emotionally resonant.

General Conclusion

Within the framework of the specialization *Architecture, Environment, and Technology*, this research has explored the potential of architecture to act as an agent for the **ecological and cultural valorization** of Dellys, a coastal city with a layered history and a rich architectural heritage. The project aimed to address the **underexploited cultural and environmental resources** of the city by proposing a sustainable museum that not only exhibits local art and craftsmanship but also enhances the **collective memory and identity** of its inhabitants.

The deliberate choice of Dellys was rooted in its **geo-cultural significance**, its Mediterranean climate, and its strong vernacular identity. The city, often overlooked despite its unique qualities, served as a fertile ground for an approach that integrates **passive environmental strategies**, **local know-how**, and **phenomenological design principles**. Through this, the project seeks to rekindle a sense of pride, belonging, and future possibility.

Our thematic research and urban analysis adopted a **diachronic, typo-morphological, and sensorial methodology**, which helped shape a museum that is both **context-sensitive and symbolically rich**. This institution aims to become a contemporary cultural anchor while respecting and reinterpreting the **traditional spatial logic of Dellysian architecture**, especially elements like the *courtyard*, and *qbou*.

At the environmental level, the project integrates **natural lighting strategies** not only for energy efficiency but also for crafting **emotional and symbolic experiences**. The simulations conducted using Ecotect and Radiance validated the proposed design choices. The use of light, through elements such as perforated screens, light shelves, and brise-soleil, allowed for a controlled, meaningful spatial atmosphere. The gradual intensification of natural light along the museum's path metaphorically echoes a **transition from the past toward a brighter future**, aligning with the concept of **optimism through design**.

The simulation results confirmed that passive strategies, when thoughtfully integrated with the building's spatial and cultural concept, can significantly improve **visual comfort**, **reduce energy consumption**, and **enhance the visitor's sensory engagement**. The architectural experience thus becomes not only functional but **immersive and emotionally resonant**.

Ultimately, this project underscores the potential of **site-specific, sustainable design** to bridge the gap between **heritage preservation and forward-thinking innovation**. It invites further research into architecture's role in reactivating neglected urban identities and adapting traditional knowledge to contemporary environmental challenges, particularly in Mediterranean and coastal Algerian cities like Dellys.

Bibliographic references.

Aboudaram, S. (. (2013). *MuCEM / Rudy Ricciotti [Photograph]*. Récupéré sur ArchDaily: https://www.archdaily.com/400727/mucem-rudy-ricciotti

Aderonmu, P. e. (2019). Assessment of daylighting designs... *IOP Conf. Series: Materials Science and Engineering*.

Ahlawat, J. (2016, February 26). *Architectural Phenomenology: Exploring the Experiential Potentiality of Architecture*.

Allal Cherif, K. (2017). *Les caractéristiques et l'origine de la maison Dellyssienne.* Université Saad Dahleb de Blida (Master's Thesis) .

America, G. (2005). Museums.

Amina. (2015). *Boumerdes: un centre de formation et de promotion des métiers de la vannerie à Dellys [Photograph]*. Récupéré sur Algerie360: https://www.algerie360.com/boumerdes-un-centre-de-formation-et-de-promotion-des-metiers-de-la-vannerie-a-dellys/

AMMOUR, S. (2019). *Qualité de l'éclairage naturel dans les salles d'expositions.* Université Abderrahmane Mira – Bejaia .

APRUE, G. /. (2014). *Guide pour une construction éco-énergétique en Algérie* . Récupéré sur GIZ.

ArchDaily. (2018). *The Aga Khan Museum [Photograph]* . Récupéré sur ArchDaily: https://www.archdaily.com/899013/the-aga-khan-museum-maki-and-associates

Architecture, P. (n.d.). *Architectural Phenomenology*. Récupéré sur Parametric Architecture: https://parametric-architecture.com/architectural-phenomenology/?srsltid=AfmBOoq_3p6j6h9MJxp4e4l4kOhHojgn_RUsIcwcqtpnJ5DW0nPKt8_K

Baker, N. &. (2002). *Daylight Design of Buildings: A Handbook for Architects and Engineers.* James & James.

Bong, J. H. (Réalisateur). (2019). *Parasite* [Film].

Bougdal, K. (2006). *Caractéristiques typologiques du bâti de la Casbah de Dellys.* Université Saad Dahleb de Blida (Magistère Thesis) .

Casanovas Boixereu, F. X. (2012). *Manuel pour la réhabilitation de la ville de Dellys.*

Chaid Saoudi, Y. (2010). *Dellys aux mille temps.* Dar El Waai.

Choudhury, D. (2016). Sensory Experience of Architecture: Creating Meaningful Spaces.

Ciriani-en-Arles. (n.d.). *Analyse du musée*. Récupéré sur Ciriani en Arles: https://ciriani-en-arles.blogspot.com/p/analyse-du-musee.html

Contributors, W. (2025). *Musée départemental Arles antique [Photograph]* . Récupéré sur Wikipedia: https://fr.wikipedia.org/wiki/Mus%C3%A9e_de_l%27Arles_antique

Dalipi, S. (2021). Natural Lighting of Museums.

Drakou, D. A. (2019). Museum Lighting – A Holistic Approach.

El-Sayed, R. M. (2023). Review and analysis of bioclimatic design approach . *Engineering Research Journal* .

Ettehad, S. e. (2015). The role of culture in promoting architectural identity . *European Online Journal...*

Ettehad, S. K. (2015). The Role of Culture in Promoting Architectural Identity. *European Online Journal of Natural and Social Sciences: Proceedings*.

Farreny, R. e. (2012). Metabolism of cultural services in museums. *Energy and Buildings, 47*.

Fernandes, A. e. (2022). Eco valorization of Eucalyptus globulus... . *Applied Sciences*.

Glazcon. (n.d.). *What is Low-E Glass?* Récupéré sur Glazcon: https://www.glazcon.com/what-is-low-e-glass/

Gustafsson, C. &. (2017). Museums: An incubator for sustainability . *International Journal of Development and Sustainability* .

IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report*. Récupéré sur IPCC: https://www.ipcc.ch/

Julian, W. G. (2010). *Daylighting, Architecture and Health: Building Design Strategies* .

Kaheneko, O. (2021). Research on Application of Natural Light in Modern Architecture Design. *The International Journal of Science & Technoledge*.

Li, Y. e. (2021). Review on green buildings research . *nvironmental Science and Pollution Research*.

Liébard, A. &. (2005). *Traité d'architecture et d'urbanisme bioclimatique.* Le Moniteur.

Liébard, A. &. (2005). *Traité d'architecture et d'urbanisme bioclimatique* . Le Moniteur .

Manzano-Agugliaro, F. e. (2015). Review of bioclimatic architecture strategies... *Renewable and Sustainable Energy Reviews, 49* .

Mba, E. J. (2024). Trends and challenges in sustainable design . *Heliyon*.

Medaković, J. e. (2024). The Interplay between Spatial Layout and Visitor Paths. *Buildings, 14(7)*.

Mohler, B. J. (2013). Multisensory Contributions to Spatial Perception.

Muro, R. (2024). Light and Emotional Architecture. *IOP Conference Series*.

Museums, I. C. (2022). *Museum definition*. Récupéré sur ICOM: https://icom.museum/

Onuwe, J. O. (2015). Assessment of Daylight Design Considerations in Kogi State Museum.

Oyeyipo, F. J. (2024). Review of Lighting Strategies... *IEEE Conference Proceedings*.

Perera, K. (2013). *The role of museums in cultural and heritage tourism.* Regional Centre for Strategic.

Review, W. P. (2024). *Demographics of Algeria*. Récupéré sur World Population Review: https://worldpopulationreview.com/countries/algeria-population

Saidi, F. A. (2023). Urbanization in Algeria: Toward a More Balanced and Sustainable Urban Network? . *Social Sciences, 12(3), 174* .

Saraoui, S. B. (2018). Analysis and Visualization of the New Architectural Spatiality: Light and Sound Topologies in Museums.

Shahparnia, M. &. (2020). rgonomic Natural-Solar Lighting in Museums. *Armanshahr Architecture & Urban Development*.

Torabi, Z. &. (2013). Effective Factors in Shaping the Identity of Architecture. *Middle-East Journal of Scientific Research*, 15(1), pp. 106–113.

Yamaguchi, N. U. (2023). Sustainable development goals... . *Environmental Science and Pollution Research*.

Yau, Y. H. (2013). Thermal comfort in the National Museum Malaysia. *Indoor and Built Environment* .

Zhou, K. &. (2023). State-of-the-art research of performance-driven architectural design for low-carbon urban underground space: Systematic review and proposed design strategies . *Renewable and Sustainable Energy Reviews*, Vol. 182, Article 113411.

Zumthor, P. (2006). *Thinking Architecture (2nd ed.).* Birkhäuser.

Appendices.

Appendices: