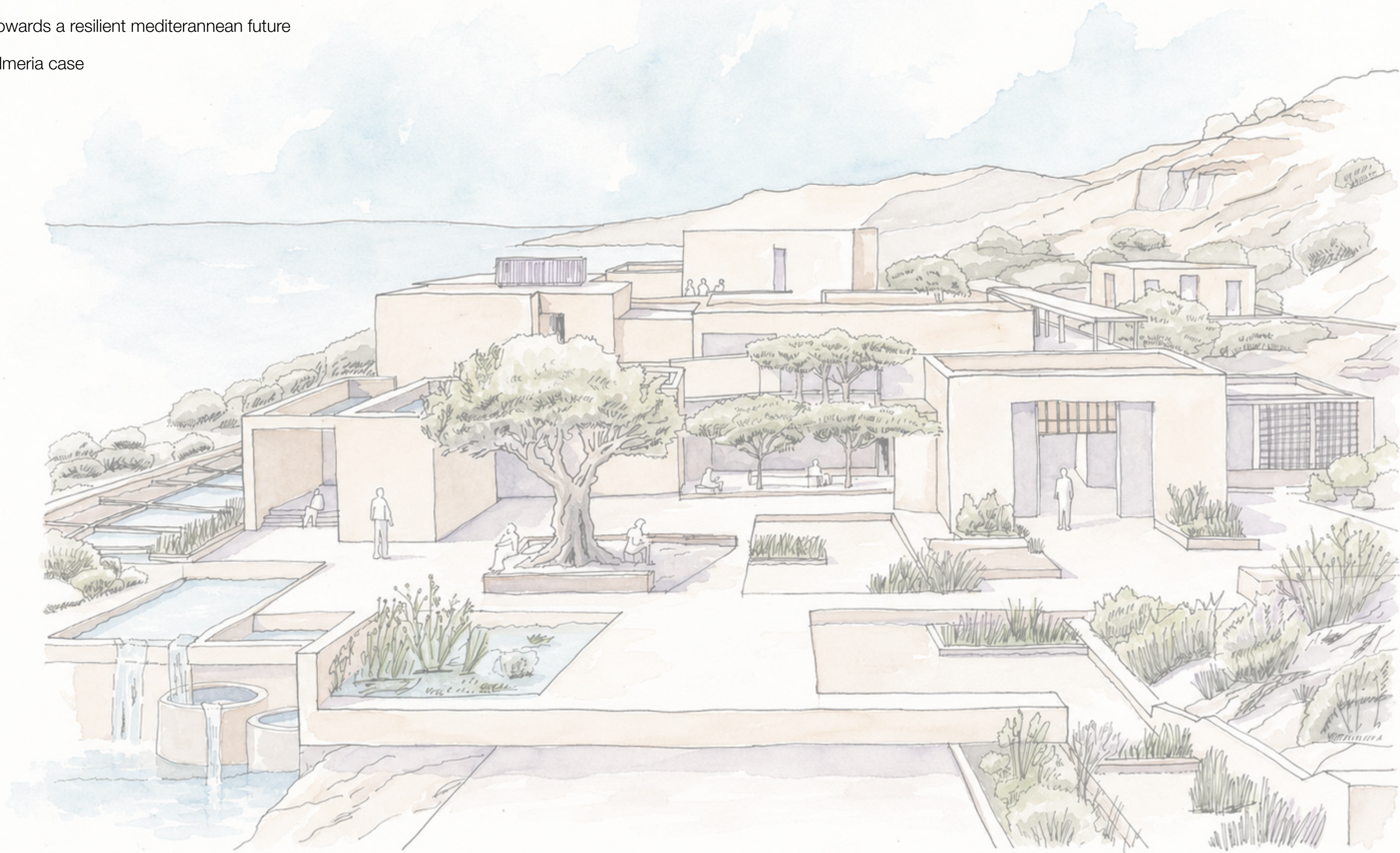


A Climate-Resilient Modular System Integrating Water Infrastructure and Earthen Construction in Mediterranean Coastal Settlements

Towards a resilient mediterannean future

Almeria case



Acknowledgments

This project is the result of a long process of exploration, experimentation, and learning. Like the settlement it proposes, it has been shaped through the interaction of many people, ideas, and experiences.

I would like to express my sincere appreciation to my supervisors, Mo Smit and Paddy Tomesen, for their guidance, constructive criticism, and continuous support throughout the development of this thesis. Their ability to challenge assumptions while encouraging exploration was instrumental in transforming initial ideas into a coherent architectural proposal.

I am equally grateful to the Architectural Engineering Studio for providing an inspiring environment in which research, design, and experimentation could develop together. The discussions with tutors, colleagues, and fellow students contributed significantly to the evolution of this work and continually broadened my perspective on architecture and its role in addressing contemporary challenges.

My deepest gratitude goes to my family and friends for their unwavering encouragement, patience, and belief in me throughout this journey. Their support provided the stability and confidence necessary to overcome difficulties and pursue this project with determination.

Finally, I would like to acknowledge all the teachers and mentors who, throughout the years, cultivated my curiosity about architecture, materials, landscapes, and the relationship between people and place. This thesis is not only the outcome of a single academic year, but the culmination of many experiences, conversations, and lessons that have shaped the way I think and design today.

Abstract

Climate change is increasingly affecting Mediterranean coastal regions through rising temperatures, prolonged droughts, water scarcity, and more frequent wildfire events. These interconnected challenges threaten both natural ecosystems and human settlements, highlighting the need for new architectural approaches that move beyond mitigation and actively contribute to climate adaptation. This thesis investigates how architecture can operate as an environmental infrastructure capable of regulating resources, improving resilience, and supporting vulnerable communities in climate-sensitive territories.

The project focuses on the case of Almería, Spain, a semi-arid Mediterranean region characterized by severe water stress, wildfire vulnerability, and strong dependence on engineered water systems. In response, the thesis proposes a climate-resilient modular settlement that integrates water infrastructure, earthen construction, and passive environmental design into a unified architectural framework. The intervention is conceived as a hybrid system combining habitation, production, research, and resource management. It accommodates approximately 120 residents, including climate-displaced inhabitants, agricultural workers, and researchers, while fostering social cohesion and collective resilience.

The design is structured around a layered environmental strategy. Water autonomy is achieved through a combination of solar desalination, reverse-osmosis desalination, underground storage, and reuse systems integrated within the spatial organization of the settlement. Simultaneously, locally sourced earthen materials are employed as the primary construction medium. Rammed earth and compressed earth blocks provide thermal mass, fire resistance, and low embodied carbon, while establishing a direct relationship between the architecture and the landscape from which it emerges. Excavation required for the water infrastructure becomes a source of construction material, creating a circular material cycle between ground, building, and resource management.

The project draws inspiration from Mediterranean vernacular architecture, particularly the cortijo typology, courtyard houses, and passive cooling systems such as windcatchers and solar chimneys. These principles are reinterpreted through a contemporary modular framework that responds to site orientation, prevailing winds, topography, and seasonal climatic variation. Courtyards, vegetation, water bodies, and transitional spaces operate as microclimatic regulators, reducing heat accumulation and strengthening outdoor living conditions.

Ultimately, the thesis proposes a place-responsive settlement model that positions architecture as an active mediator between climate, water, material, and community. Rather than functioning as a static object, the project operates as a resilient environmental system capable of adapting to future climatic uncertainties while remaining rooted in local resources, Mediterranean living patterns, and circular construction principles. Through the integration of water infrastructure and earthen materiality, the research demonstrates how architecture can contribute to the development of more resilient coastal settlements in the Mediterranean region.

Key words: climate changes, wildfire, water shortage, earthen construction , rammed earth, desalination, mediterranean settlement, passive cooling strategies

A) Research

A.1 Introduction | (What and Why?)

1.1 Problem statement

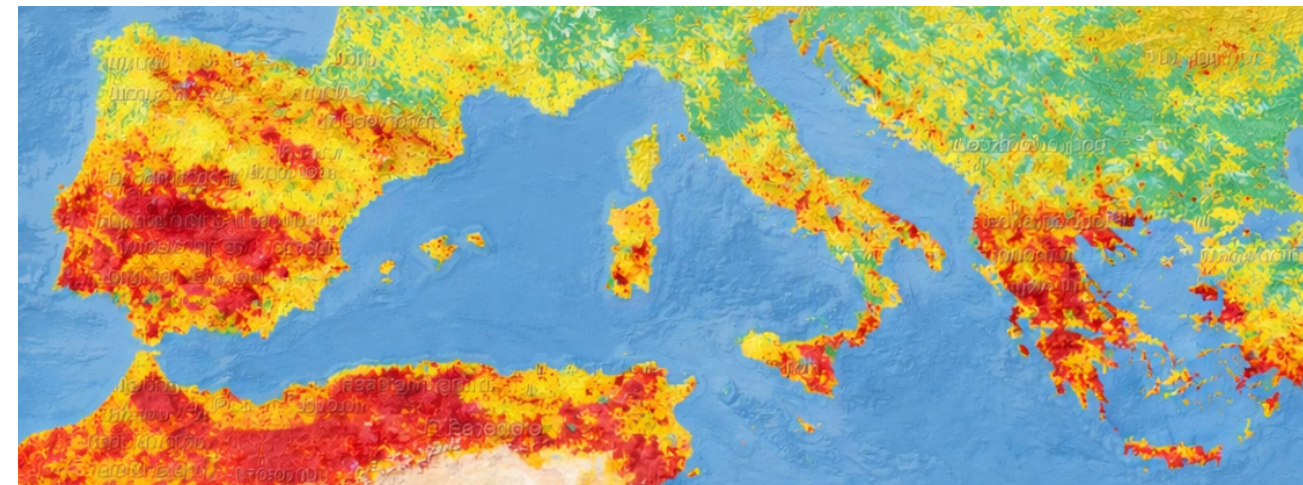
Climate change increasingly shapes the conditions under which architecture operates, particularly in regions exposed to rising temperatures, prolonged droughts, and extreme environmental hazards such as wildfires. The Mediterranean basin has been identified as one of the global climate-change hotspots, facing intensifying heatwaves, irregular precipitation patterns, and expanding fire-prone landscapes (IPCC, 2022). These developments place significant pressure on existing settlements and infrastructures, exposing the limitations of conventional architectural models that rely heavily on energy-intensive materials and centralized systems. At the same time, the contemporary construction sector remains one of the most resource-demanding industries worldwide. It is responsible for substantial energy consumption, greenhouse gas emissions, raw material extraction, and waste generation. According to Meir et al. (2024), buildings account for a significant share of global material flows and carbon emissions, raising urgent questions regarding the environmental responsibility of architectural practice. This dual condition — environmental degradation combined with infrastructural vulnerability — highlights a fundamental architectural challenge: how can architecture actively contribute to climate adaptation rather than responding solely through mitigation strategies?

Within this context, the design assignment of this thesis approaches architecture not merely as shelter, but as an operative environmental system. The project proposes the development of a modular architectural prototype conceived as a climate-resilience machine, addressing two closely interconnected challenges: freshwater scarcity and wildfire risk. Instead of depending on large-scale infrastructural interventions, the research intentionally focuses on the neighborhood scale, where architecture can directly influence everyday safety, accessibility, and resilience.

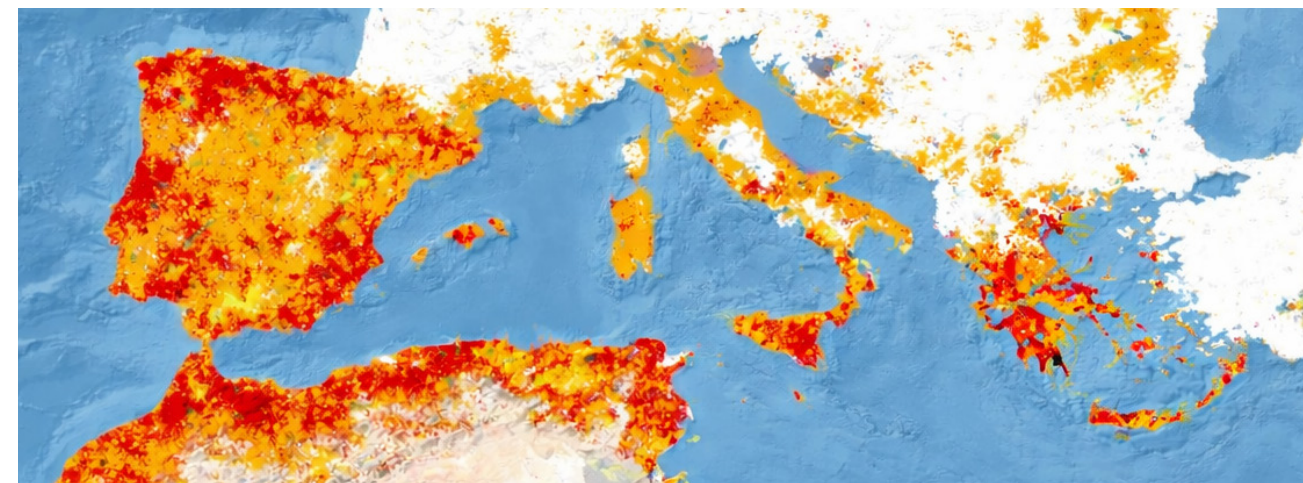
On one hand, the system investigates decentralized seawater desalination as a strategy for strengthening local water autonomy. On the other, it explores

earthen construction systems — particularly clay-based materials — as fire-resistant, low-carbon, and locally sourced building envelopes. Through this dual investigation, architecture is repositioned from an object-based discipline toward a system-based spatial response, in which structure, materiality, and infrastructure operate as a unified whole.

While the territorial focus is placed on Mediterranean regions such as Portugal, Spain, and Greece, the academic framework of the studio introduces Eindhoven as a parallel reference context. This dual framework enables a critical inquiry into how a climate-resilient system developed under Southern European conditions may be reinterpreted or challenged within a Northern European environment.



Wildfire risk map



Drought risk map

1.2 Relevance (Contribution to Profession and Society)

The relevance of this research lies in its contribution to ongoing architectural debates concerning sustainability, material ethics, and climate adaptation. As emphasized by Meir et al. (2024), the construction industry is among the largest contributors to global energy consumption, carbon emissions, and waste production, necessitating a fundamental reassessment of architectural material choices and construction paradigms.

In response, contemporary research increasingly advocates for sustainable design approaches based on locally sourced materials, low-energy fabrication processes, recyclability, and circular material flows. Natural building materials, bio-based composites,

and earth-derived construction systems have gained renewed attention as alternatives to cement- and steel-dominated practices (Fabbri & Morel, 2018). These materials demonstrate significantly lower embodied energy while supporting healthier indoor environments and reduced ecological footprints. Beyond environmental performance, earthen materials contribute to broader ecological systems. They are abundant, non-toxic, reusable, and capable of reintegration into natural cycles at the end of their life (Miccoli et al., 2014). Their hygroscopic properties support passive regulation of humidity and temperature, reducing operational energy demand. From a societal perspective, decentralized construction systems based on local materials strengthen community resilience. They reduce dependency on global supply chains and support local knowledge and craftsmanship — aspects that become increasingly critical under climate stress conditions. Through this lens, the thesis contributes to architectural knowledge by investigating how earthen materials, when reassessed through contemporary scientific research, can support climate-resilient and socially grounded architectural systems.

1.3 Objective and Motivation

1.3.1 Architectural and Technical Objectives

The primary objective of this thesis is to design a self-sustaining modular architectural system capable of responding to water scarcity and wildfire risk. The project explores how architecture can operate as an active environmental system, integrating material performance and infrastructural functions to support everyday life under climatic uncertainty.

Architecturally, the project investigates buildings as layered systems rather than isolated objects. Environmental mediation, structural logic, and social use are treated as interconnected components. Sectional design plays a central role, allowing climate interface, material mass, and infrastructure to become spatially legible rather than concealed.

Technically, the research focuses on natural and low-carbon construction materials, with particu-

lar attention to earthen systems. Fire resistance, thermal inertia, moisture behavior, and embodied carbon form key performance criteria. Given the increasing exposure of settlements to wildfire events, non-combustible mineral-based materials become a fundamental architectural concern.

Scientific research demonstrates that earthen typologies exhibit significantly different mechanical behavior and durability depending on composition, fabrication method, and stabilization strategy (Miccoli et al., 2014; Turco et al., 2025). For this reason, material investigation is not treated as a secondary technical layer, but as a driver shaping architectural form and system logic.

The motivation for this research is also deeply personal. Growing up in a Mediterranean region already affected by wildfires, droughts, and infrastructure failure transforms climate change from an abstract global phenomenon into an everyday lived condition. Observing landscapes burn and water resources decline raises urgent questions regarding the role of architecture in safeguarding basic conditions of living. This thesis therefore emerges from the desire to reposition architecture as a proactive agent of adaptation and collective resilience.

1.3.2 Material Research

Material Comparison: Earthen Typologies and Pozzolanic Optimization

As an initial research phase, the thesis compares a range of earthen construction systems, including adobe masonry, cob and straw–mud mixtures, wattle and daub, compressed earth blocks (CEBs), rammed earth, light clay, and hemp–lime composites.

Research indicates that these systems present distinct balances between structural capacity, thermal inertia, moisture regulation, and fire resistance. Rammed earth and CEBs typically achieve higher compressive strength but display more brittle failure behavior, while fiber-reinforced systems such as cob offer increased ductility (Miccoli et al., 2014). Adobe systems, although mechanically weaker, perform effectively in hygrothermal regulation and material circularity (Polidori et al., 2025).

Durability — particularly under water exposure — remains a critical limitation. Stabilization strategies therefore play a central role. Recent studies highlight the effectiveness of lime and natural pozzolanic additives in improving cohesion, moisture resistance, and long-term performance while maintaining signifi-

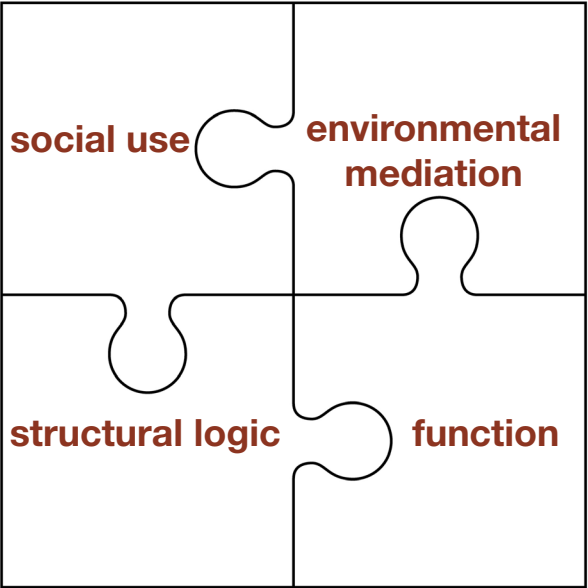
cantly lower embodied carbon compared to Portland cement (Turco et al., 2025).

This comparative analysis provides the technical foundation for selecting optimized clay-based systems as the material basis of the architectural prototype.

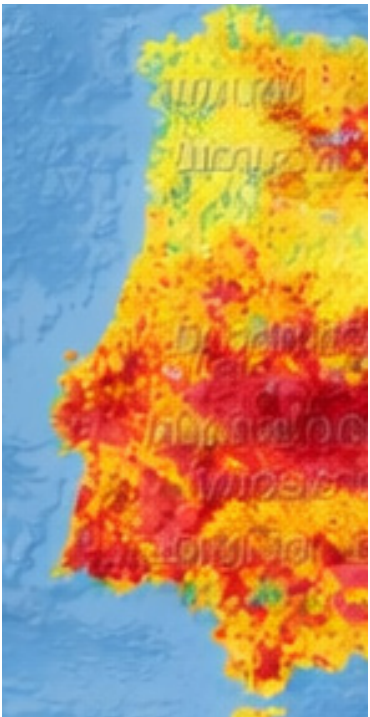
1.3.3 Personal Motivation

The motivation behind this research stems from a strong interest in architecture’s role in climate adaptation rather than mitigation alone. The exploration of earth as a building material reflects a desire to reconnect architectural production with local landscapes, material cycles, and environmental responsibility.

Personal experience of recurring wildfires, droughts, and infrastructure damage reinforces the urgency of this investigation. Climate change is no longer perceived as a distant future scenario but as a daily reality affecting housing, water access, and safety. This thesis therefore approaches architecture as both a spatial and social act — capable of supporting communities and redefining architectural responsibility within a rapidly changing climate.



Portugal



Wildfire risk

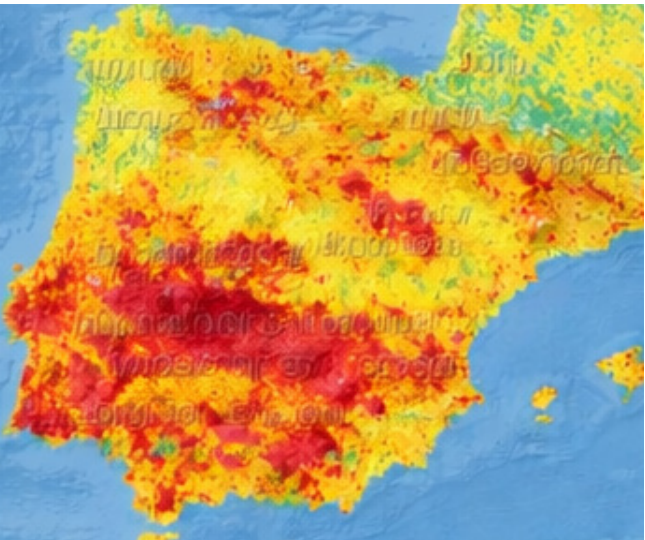


Drought risk

Spain

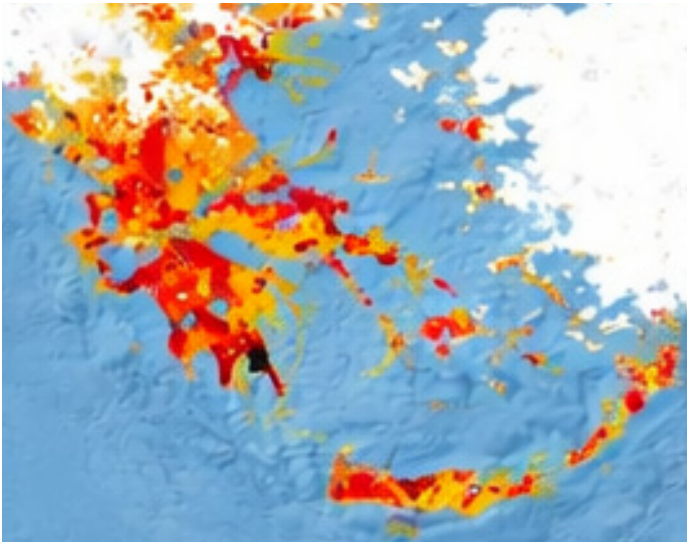


Drought risk

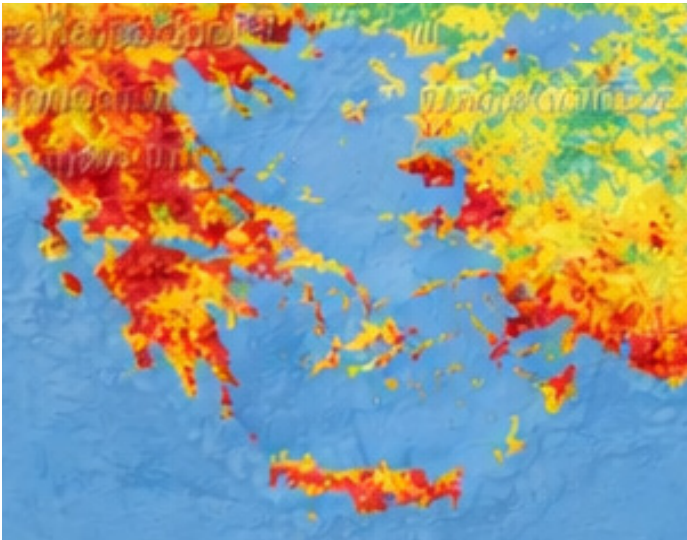


Wildfire risk

Greece



Drought risk



Wildfire risk

Aspect

Climate	Hotter summers, drought	Extreme heat, desertification	Heat waves, drought
Water stress	Seasonal scarcity	Structural scarcity	Increasing scarcity
Wildfire risk	Very high	Very high	Very high
Material tradition	Clay, lime, pozzolana	Clay, adobe, lime	Clay, pozzolana
Settlement pattern	Coastal + rural	Coastal + inland	Coastal + island

Earthen Materials		Structural capacity	Fire behaviour	Moisture resistance	Thermal performance	Construction logic	Optimization Potential	Main Limitations
Adobe			Non-combustible		 Very high thermal mass	Modular masonry	High – lime and pozzolans improve strength and durability	Vulnerable to rain; requires stabilization and protection
Cob block			Non-combustible		 High thermal mass	Hand-placed	Moderate – fiber and lime improve cohesion	Labor-intensive; limited standardization
Compressed earth blocks			Non-combustible		 High thermal mass	Industrialized masonry	Very high – lime/ pozzolans improve strength & durability	Requires mechanical pressing
Rammed earth			Non-combustible		 Very high thermal mass	Formwork-based	Very high – lime/ pozzolans enhance resistance	Construction skill and formwork needed
Light clay			Non-combustible		 Excellent hygro-thermal regulation	Infill panels	Moderate – lime stabilization possible	Structural dependence on frame
Hempcrete			Low flame spread		 Excellent insulation	Cast-in-place	Moderate – mineral binders essential	Not structural

1.4. Research and Design Questions

Main Research Question

How can a place-responsive modular architectural system, grounded in earthen materiality and layered infrastructural watersystem design, enhance climate resilience in Mediterranean coastal settlements facing water scarcity and wildfire risk?

Research Sub-Questions

- How do climate risks influence architectural requirements in Mediterranean environments?
- How do different earthen typologies compare in performance and durability?
- How can pozzolanic stabilization improve clay-based materials sustainably?
- How does local material sourcing influence embodied carbon?
- How can principles of genius loci inform adaptable architectural systems?

Design Sub-Questions

- How can architecture operate as a layered environmental system?
- How can water infrastructure be spatially integrated into architectural form?
- How can earthen envelopes function as structure and climatic buffer?
- How can sectional design express environmental processes?
- How can modular systems support long-term neighborhood resilience?

Theoretical Framework

The theoretical framework integrates three complementary approaches: critical regionalism and genius loci, research by design and prototyping, and climate-resilient system design. Together, they support an architecture that is adaptable yet place-responsive, experimental yet grounded, and technologically informed yet materially rooted.

Genius Loci and Critical Regionalism

The concept of genius loci emphasizes the relationship between architecture, climate, landscape, and human experience. Frampton’s theory of critical regionalism expands this understanding by arguing for architecture that engages with local conditions while resisting global homogenization (Frampton, 1983). In this thesis, the modular system maintains structural consistency while allowing material, spatial, and programmatic variation according to place.

Research by Design and Prototyping

Research by design positions architectural production as knowledge generation. Drawing, modeling, and prototyping function as investigative tools through which complex material and environmental questions are explored. Prototyping enables testing, comparison, and refinement through iterative feedback (Kim, 2019).

Climate-Resilient Architecture

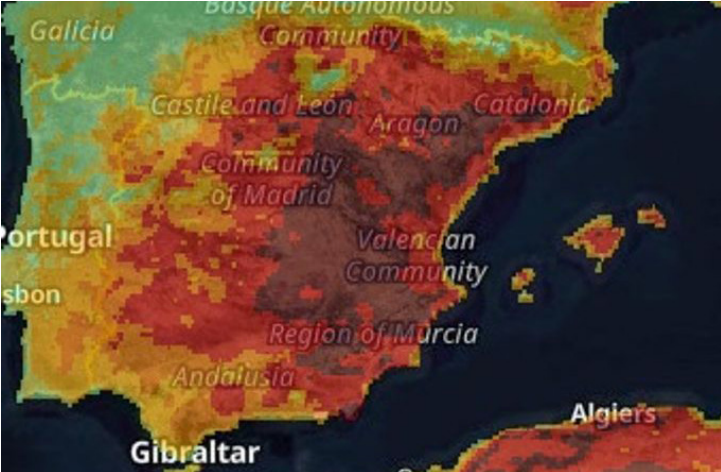
Climate resilience is approached through system design, where resilience emerges from the interaction of architectural layers. These include the climate interface, materiality, function, and social use. Together, these layers form an integrated system capable of adapting to diverse climatic contexts while maintaining architectural coherence.

A.2 Site | (Where?)

Spain



Drought risk



Wildfire risk

Aspect	
Climate	Extreme heat, desertification
Water stress	Structural scarcity
Wildfire risk	Very high
Material tradition	Clay, adobe, lime
Settlement pattern	Coastal + inland

Almería: Climate, Landscape, and Urgency

The project is situated in the region of Almería (Southern Spain), a territory defined by its semi-arid climate, extreme solar exposure, and increasing vulnerability to climate change phenomena, particularly drought and wildfires. Over recent decades, the region has experienced rising temperatures, prolonged dry periods, and intensified fire events, leading to seasonal displacement of populations and the degradation of both natural and built environments.

At the same time, Almería is home to one of the largest artificial agricultural landscapes in Europe: the extensive greenhouse system often referred to as the “plastic sea.” This landscape represents a paradox. On one hand, it is highly productive and economically vital; on the other, it is extremely dependent on water resources and contributes to environmental stress.

The project positions itself within this tension, aiming to propose a new type of settlement that responds simultaneously to:

- Climate instability (heat, drought, fire)
- Water scarcity and management
- Temporary and permanent displacement of populations
- Integration with productive agricultural landscapes.

A.2 Site | (Where?)

Cabo de Gata: Landscape, Materiality, and Environmental Character

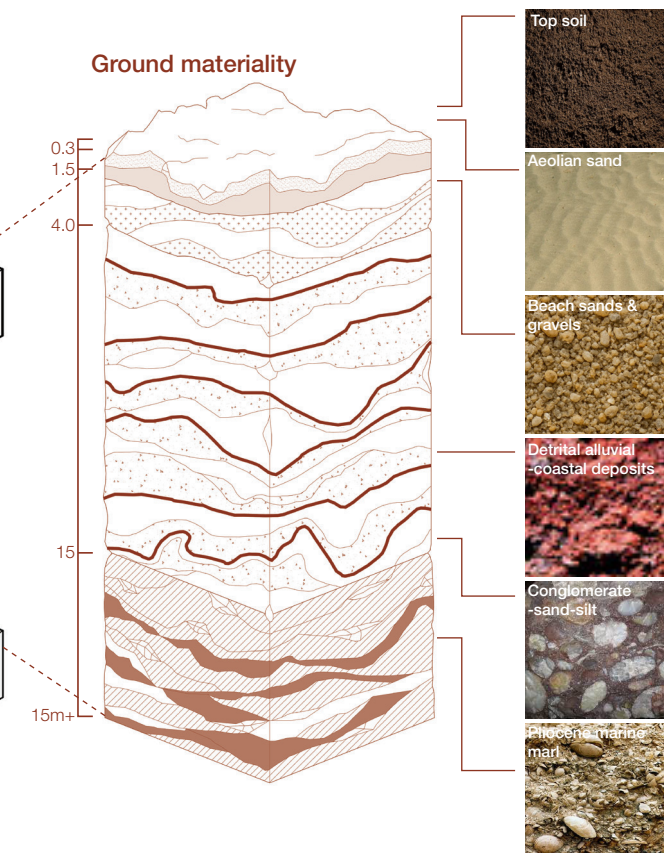
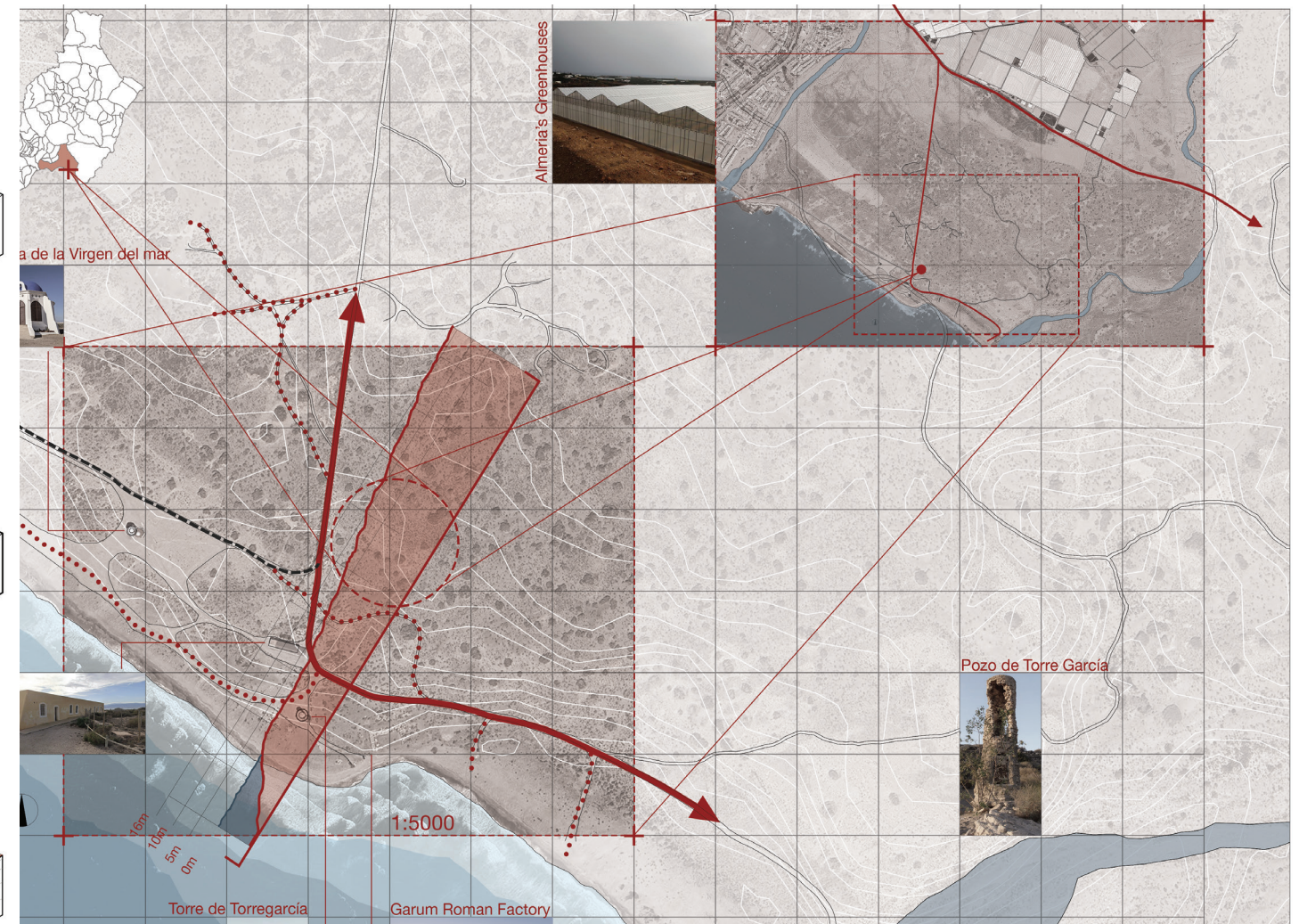
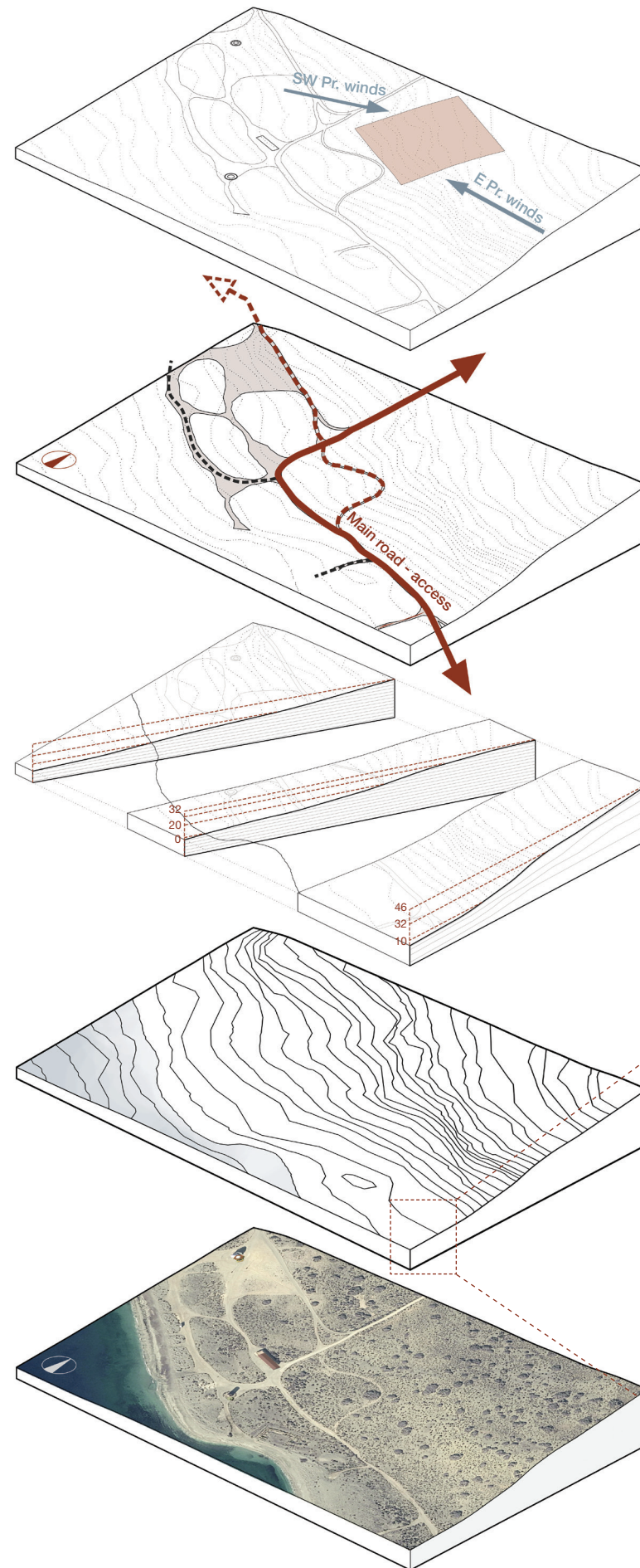
Located on the southeastern coast of Spain within the province of Almería, Cabo de Gata is one of the most distinctive and environmentally unique landscapes in the Mediterranean basin. The area is characterized by a semi-arid climate, volcanic geology, low annual precipitation, and a strong relationship between land and sea. As one of the driest regions in Europe, Cabo de Gata experiences long periods of drought, intense solar radiation, strong seasonal winds, and increasing environmental pressure resulting from climate change.

The landscape is defined by a combination of volcanic mountains, coastal cliffs, dry valleys, alluvial plains, and gently sloping terrains that gradually descend towards the Mediterranean Sea. This geological history has produced a terrain rich in mineral deposits, volcanic rock formations, gravel, sand, clay, and sedimentary soils. The dominant colours of the landscape range from ochre and reddish earth tones to dark volcanic rock and pale limestone formations, creating a strong visual connection between the ground and traditional construction materials.

The soils found throughout the region generally consist of mixtures of clay, silt, sand, gravel, and weathered volcanic material. These mineral-rich soils have historically been used for earthen construction and are particularly relevant for the development of rammed earth and stabilized earth building techniques. The abundance of local earth resources creates an opportunity for a direct relationship between excavation, material extraction, and construction, supporting circular and low-carbon building practices.

The coastal character of Cabo de Gata is equally significant. The proximity to the Mediterranean Sea generates a constant environmental dialogue between water scarcity and water abundance. While freshwater resources remain limited, the sea represents a potentially inexhaustible source of water through desalination technologies. This duality forms a central condition of the site and directly informs the project's approach to water autonomy and climate adaptation.

Site Analysis



Vegetation is sparse but highly adapted to drought conditions. Native species such as esparto grass, agave, prickly pear, thyme, rosemary, olive trees, and other Mediterranean shrubs dominate the landscape. These plants have evolved to survive in environments characterized by low rainfall, high temperatures, and saline coastal conditions. Their resilience provides valuable lessons for the selection of vegetation within the proposed settlement.

Overall, Cabo de Gata represents a landscape where geology, climate, water scarcity, and vegetation are inseparable. Its rugged coastal environment, mineral-rich soils, and extreme climatic conditions create an ideal context for investigating how architecture can emerge directly from local resources while simultaneously responding to the environmental challenges of the Mediterranean future.

Existing vegetation



A.3 Place analysis| (What already exists there?)

A.3.1 Vernacular Architecture | Typologies

Typologies, Forms, Heights, Spatial Organization, Materiality, Passive cooling strategies

The built environment of Almería and the wider Mediterranean region is characterized by:

- Low-rise, compact volumes
- Horizontal expansion rather than vertical growth
- Thick walls and minimal openings
- Integration with topography

These characteristics are not aesthetic choices, but climatic responses.

Vernacular Typologies

The project draws from three key typological precedents:

1. Bohío (Open, Ventilated Structure)

A lightweight, permeable structure allowing full cross ventilation.

Advantage: maximum airflow and cooling

2. Courtyard House (Microclimate Generator)

A compact structure organized around an internal courtyard.

Advantage: controlled microclimate, shading, airflow regulation

3. Cortijo (Thermal Mass and Compact Form)

A rural Mediterranean farmhouse with thick walls and small openings.

Advantage: thermal inertia, heat delay, and protection from extremes

Materiality

Traditional materials include:

- Earth (rammed earth, adobe)
- Stone
- Lime plaster
- Timber

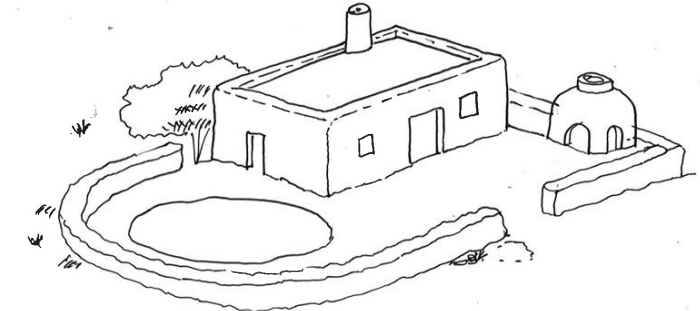
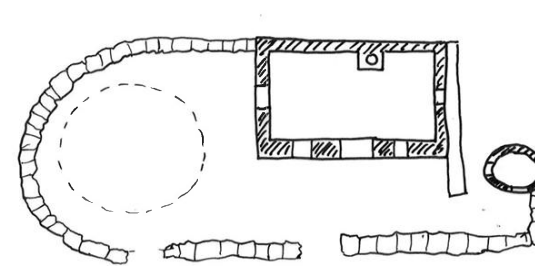
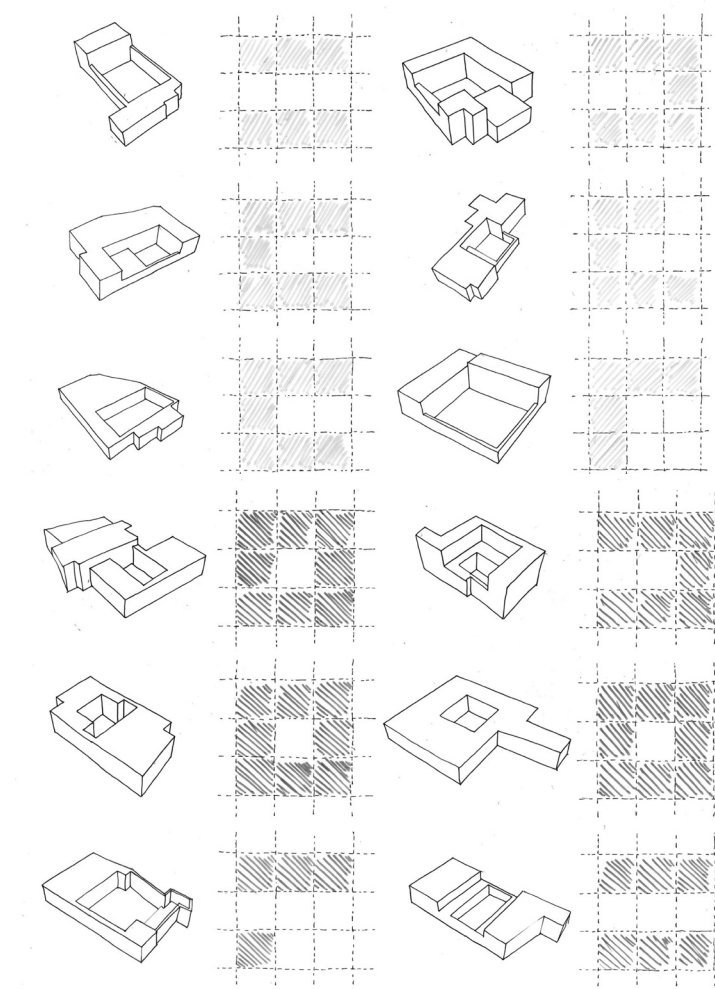
These materials share key properties:

- High thermal mass
- Low embodied energy
- Local availability
- Fire resistance (especially earth and stone)

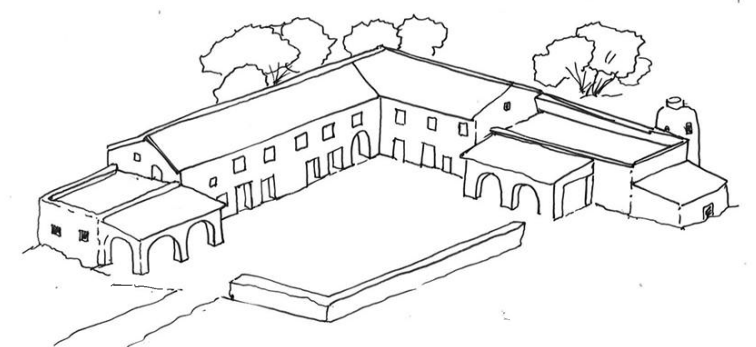
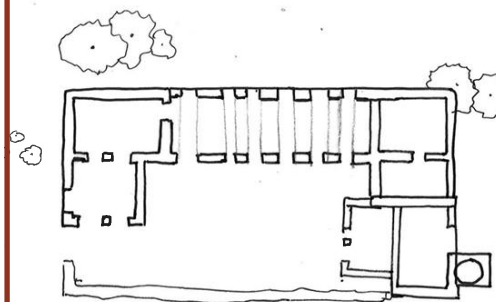
The project adopts rammed earth as the primary material, due to:

- its fire-resistant properties
- its thermal performance
- its compatibility with excavation processes

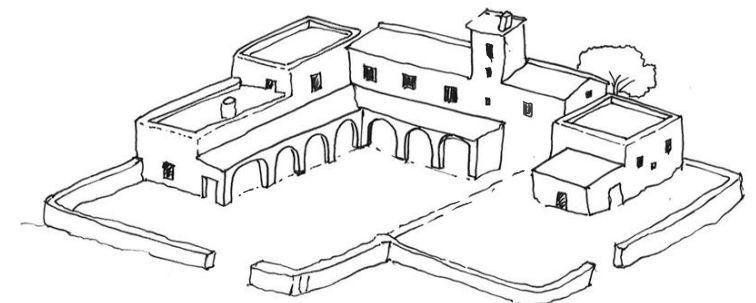
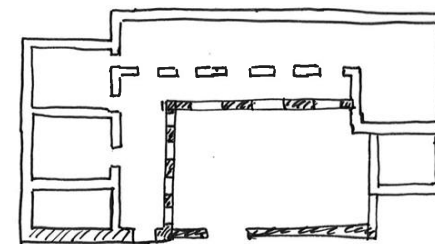
Variations of mass and courtyard relation



- best thermal comfort | stable int. temperature
- heat mitigation during summer
- balance / flexibility in functional programs



- functional capacity
- flexibility | expandability
- vertical spatial organization | air buffer between floors
- possibly more facilities of different kinds



A.3.2 Landscape research | skyline

What already exists?_Past

Andalusian -rural- landscape

In the region of Almería and the wider Andalusian territory, the relationship between architecture and landscape is deeply shaped by topography, climate, and material availability. Settlements are rarely imposed as flat, geometric grids; instead, they tend to develop in a stepped, almost amphitheatrical manner, adapting to slopes, hillsides, and natural contours. This results in a terraced morphology where buildings are arranged in successive horizontal layers, following the inclination of the terrain and often creating a cascading visual effect towards valleys or the sea. Such organization is not only spatial but environmental, as it allows for optimized solar exposure, protection from prevailing winds, and integration with drainage patterns.

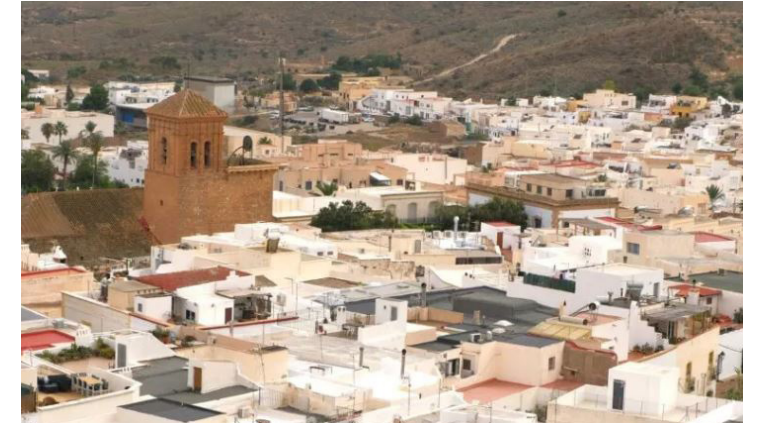
The built fabric is predominantly low-rise, typically consisting of one or two storeys. This limitation in height is not accidental but closely linked to the material logic and climatic performance of traditional construction. Thick masonry or earthen walls—constructed from stone, adobe, or rammed earth—provide high thermal mass, stabilizing indoor temperatures in a region characterized by extreme heat and diurnal variation. These heavy, load-bearing systems naturally favor horizontal expansion over vertical growth, reinforcing the compact and grounded character of settlements.

In many Andalusian villages, a church or bell tower emerges as the primary vertical landmark, acting as both a visual and social anchor within the otherwise low and continuous fabric. Even in dispersed rural contexts such as cortijo landscapes, a central element—whether a chapel, courtyard, or main house—organizes the surrounding structures.

Materially, the architecture is inseparable from **its environment**. The palette is dominated by earth tones, lime-washed surfaces, stone textures, and clay tiles, all derived from local resources. The surrounding landscape reinforces this continuity, characterized by sparse, drought-resistant vegetation such as olive trees, almond trees, fig trees, and low Mediterranean shrubs. Together, these elements create a unified territorial identity in which architecture,



material, and landscape operate as a single environmental system, rather than as separate components.



A.3.3 Volumes and Landscape Integration

Vision postcard

Vision

This project explores architecture as a climate-resilient system rather than a static object. It proposes a modular coastal settlement that integrates water infrastructure, earthen construction, and social resilience into one architectural machine. The project addresses two Mediterranean risks simultaneously: water scarcity and wildfire exposure.

Ingredients

- Desalination + water management integrated into architecture
- Rammed earth as load-bearing, fire-resistant envelope
- Makerspace/lab for material production and knowledge transfer
- Hybrid accommodation for displaced residents + workers
- Modular logic that allows expansion over time

Design criteria

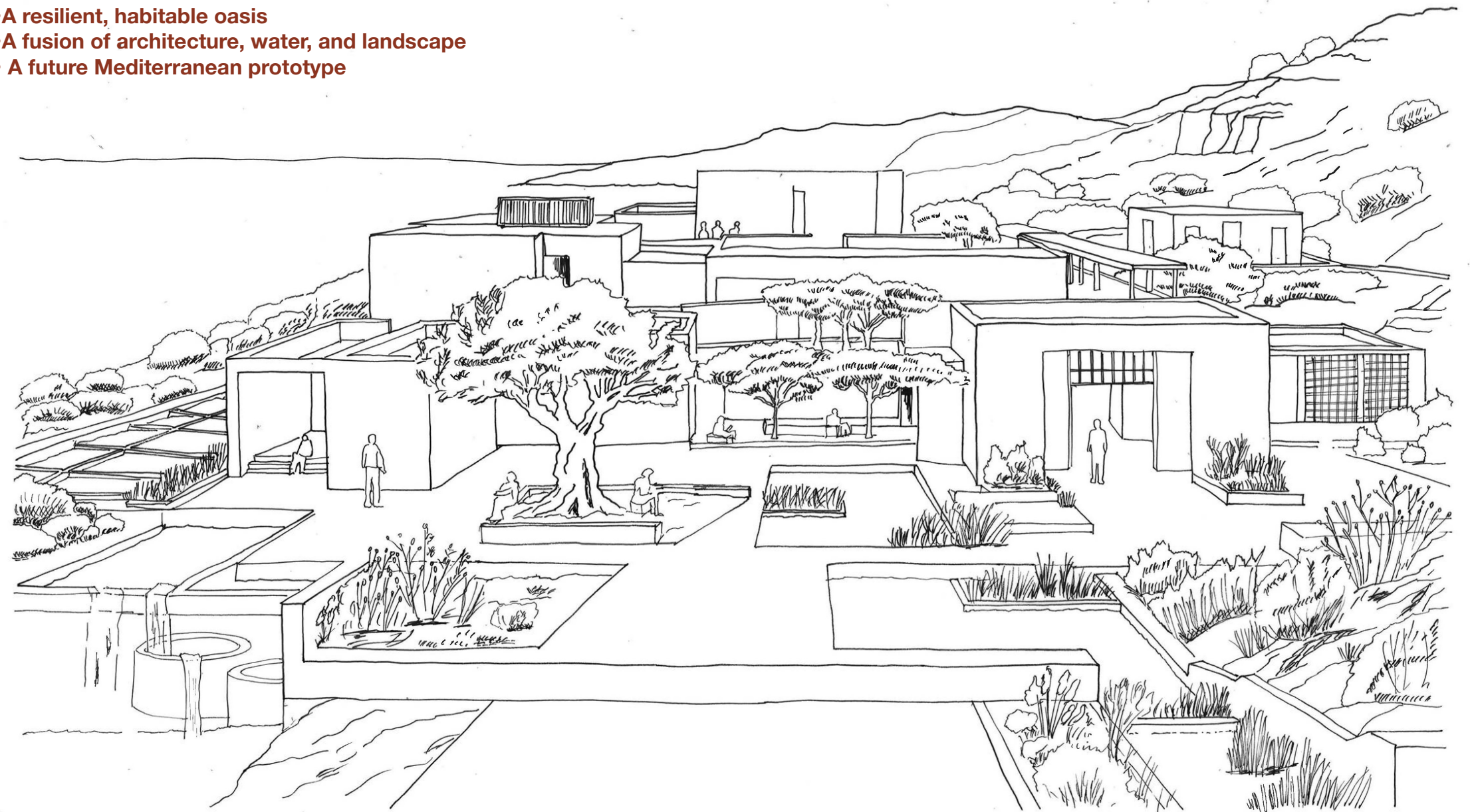
architecture must:

- Operate as infrastructure + building simultaneously
- Be place-based (critical regionalism / genius loci)
- Use locally sourced materials
- Allow incremental growth
- Express environmental processes through section

Research-by-design proposal

- Material prototyping of rammed earth mixtures
- Sectional design exploring environmental layering
- Spatial testing of the modular cluster system

- **A resilient, habitable oasis**
- **A fusion of architecture, water, and landscape**
- **A future Mediterranean prototype**



A.3.4 Site- Landscape Possibilities and design directions

Volumes and Landscape Integration

The project explores different strategies of embedding architecture into the landscape:

Strategy 1: Surface Settlement

- Buildings sit on terrain
- Minimal excavation
- Weak thermal performance

Strategy 2: Semi-Embedded Settlement

- Partial integration into slope
- Improved thermal stability

Strategy 3: Fully Integrated Terrain Architecture

- Volumes carved into the landscape
- Maximum thermal performance, minimal visual impact

The final proposal adopts a hybrid approach, where:

communal and infrastructural spaces are embedded
residential volumes emerge as articulated courtyards

Landscape Strategies

The landscape is not treated as background, but as active infrastructure:

- Water channels regulate microclimate
- Vegetation provides shading and cooling
- Courtyards act as climatic mediators

**Massing experimentation on the landscape
Assessment**

Purpose: Residence cell

1. climatically self- sufficient
2. repeatable in rows, clusters, terraces
3. buildable in phases
4. able to expand without losing:

- fire safety
- water logic
- drainage capacity

Conclusion of the design

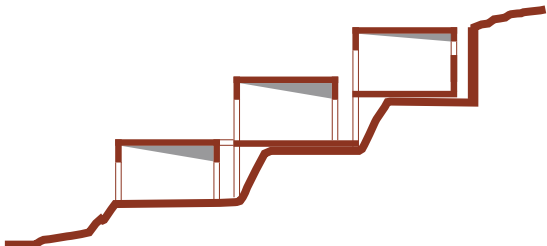
The strategies that can work best in the site of the project is the low- rise cluster and the stepped hill-side cluster, because:

- If the modularity is based on a vertical expansion, then the units will have to rely on a central system that can be designed from the beginning
- The mixed density hybrid cluster is faster for the construction since the fabrication method will not only depend on the material, but it is more complex regarding the design of the water system and its possible expandability**

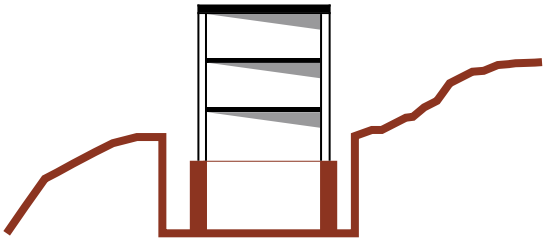
Low- rise cluster



Stepped hill-side cluster



Mixed density hybrid cluster



Drought/ Water shortage			
Wildfire resilience			
Intensive rainfall			
Rammed earth compatibility			
Future expandability/ multiplication			

A.4 Water system | Desalination, storage, recycle

Hybrid water strategy

Solar desalination + SWRO desalination

Hybrid water strategy

The settlement is organised as a hybrid desalination system with two complementary layers. At the cluster scale, a low-tech solar still system provides water for the most critical uses—primarily drinking and cooking, and emergency supply during drought or failure of the central network. At the settlement scale, a central SWRO plant acts as the main support system for the wider domestic load: washing, cleaning, hygiene, and general household demand. This creates a resilient hierarchy: the clusters remain minimally autonomous in extreme conditions, while the central plant carries the everyday demand efficiently. Typical passive solar still output is only about 2–5 L/m²/day, so it is well suited to small, high-value potable demand rather than full domestic supply. Basic domestic demand is estimated around 50 L/person/day, while the minimum drinking requirement is about 5.3 L/person/day.

How the two systems are divided functionally

For a settlement of 120 residents, a practical concept is to divide the site into about 8 clusters of 15 people each. Each cluster-scale solar system can be sized to deliver roughly 75–100 L/day, which covers drinking and cooking plus a modest emergency reserve. At about 4 L/m²/day as a design assumption, that means around 25–30 m² of active solar still area per cluster. Across 8 clusters, the decentralised solar layer would therefore provide around 0.6–0.8 m³/day in total. The central SWRO plant would then be sized for roughly 6–8 m³/day, which covers the bulk of normal domestic demand for the settlement and provides operational margin. This division is spatially and technically sensible: solar systems are distributed and visible, while the pressure-based plant, pretreatment, storage, and brine management remain concentrated in one service hub.

Spatial distribution of the decentralised solar systems

Each cluster should include a small solar water court positioned in the open sunny part of the shared outdoor space, ideally on the south to southwest side of the cluster where solar gain is strongest and overshadowing is lowest. A good concept-size allowance is:

- 25–30 m² active solar still surface
- 10–15 m² planted buffer / maintenance strip
- 8–12 m² shallow water channels or cooling basins
- 4–6 m² technical corner and small storage

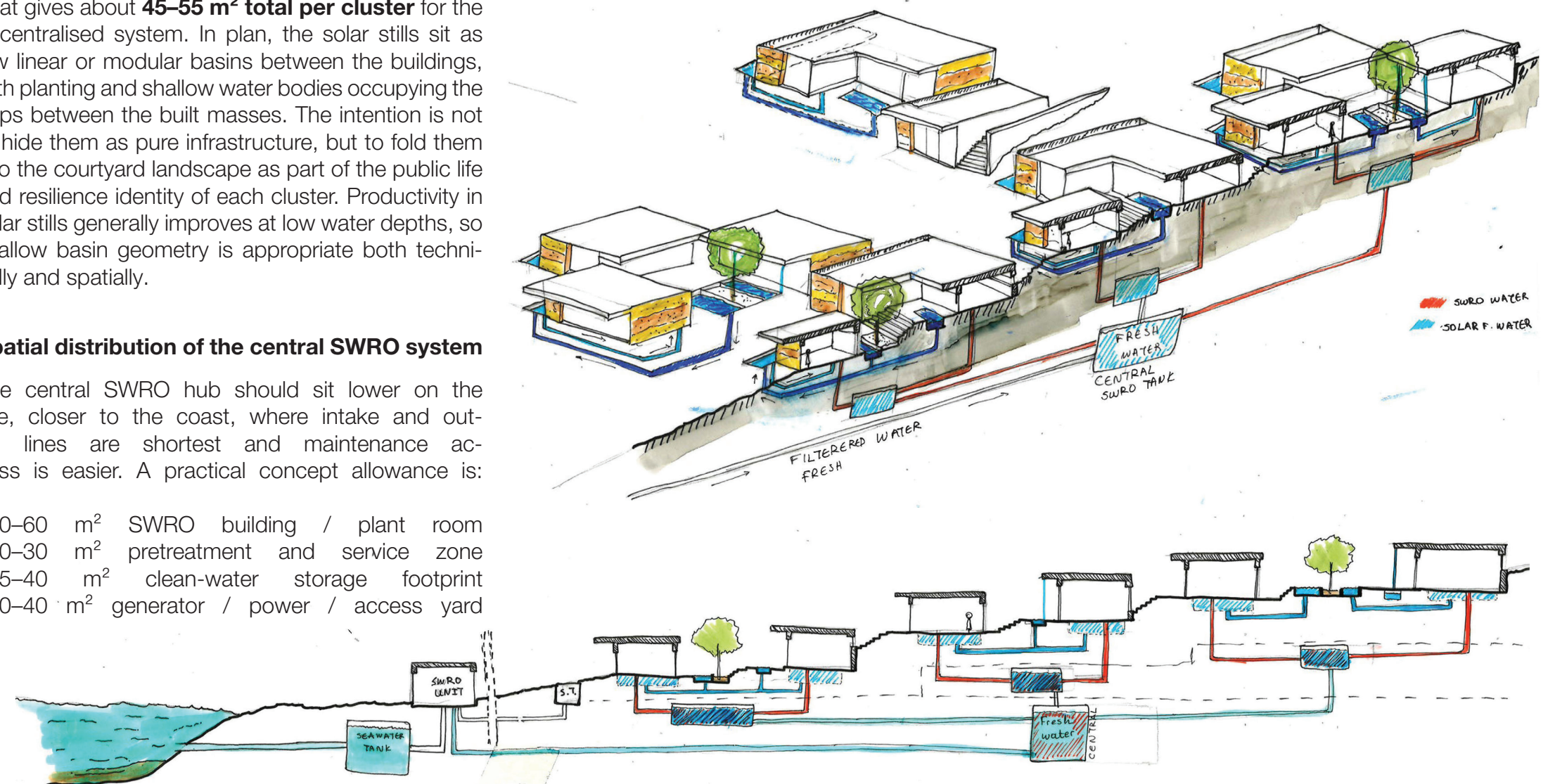
That gives about **45–55 m² total per cluster** for the decentralised system. In plan, the solar stills sit as low linear or modular basins between the buildings, with planting and shallow water bodies occupying the gaps between the built masses. The intention is not to hide them as pure infrastructure, but to fold them into the courtyard landscape as part of the public life and resilience identity of each cluster. Productivity in solar stills generally improves at low water depths, so shallow basin geometry is appropriate both technically and spatially.

Spatial distribution of the central SWRO system

The central SWRO hub should sit lower on the site, closer to the coast, where intake and outfall lines are shortest and maintenance access is easier. A practical concept allowance is:

- 40–60 m² SWRO building / plant room
- 20–30 m² pretreatment and service zone
- 25–40 m² clean-water storage footprint
- 20–40 m² generator / power / access yard

This gives an onshore desalination compound of roughly **120–200 m²**, excluding the marine intake and outfall corridor. The plant room contains pretreatment, high-pressure pump, membranes, controls, and chemical/CIP space. The storage can be partly buried or above-ground depending on the architectural intent and geotechnical conditions. In the overall masterplan, the central plant should read as a service infrastructure edge rather than a civic courtyard element, while the cluster solar systems remain embedded in everyday residential space. SWRO is the dominant modern technology for seawater desalination and requires dedicated pretreatment and membrane infrastructure.



3. Site–Landscape Possibilities and Design Directions

3.4 Water system | Desalination, storage, recycle

Hybrid water strategy Solar desalination + SWRO desalination

Concept excavation depth: decentralised solar system

At concept stage, I would assume the cluster solar systems are semi-recessed into the ground rather than fully buried. This keeps them visually integrated and reduces wall height. A reasonable concept section is:

- solar still basins: 0.35–0.45 m excavation
 - shallow water channels / plant-ed basins: 0.30–0.40 m excavation
 - optional small emergency freshwater cistern: 1.5–1.8 m excavation to formation level
- The basin itself only needs shallow operating water depth, and solar still studies consistently show better productivity at low water depth, often around 1–2 cm or similarly shallow conditions. For underground tanks, typical installation guidance commonly requires around 300–600 mm cover depending on tank type and loading, with side allowance for backfill and installation.

Excavation volume: decentralised solar system

Using a concept-sized cluster court of 30 m² solar still field excavated to 0.40 m, the excavation is:
30 × 0.40 = 12 m³

If you add 12 m² of shallow water channels / plant-ed basins at 0.35 m average depth:
12 × 0.35 = 4.2 m³

If you also bury a small 1–2 m³ emergency cistern, a realistic excavation envelope is around 2.5 m × 2.5 m × 1.6 m = 10 m³ once cover and working space are included.
So a good concept estimate is:
•about 26 m³ excavation per cluster
•for 8 clusters: about 208 m³ total

That is a useful masterplan number for early cut/fill thinking. The exact number will change with tank geometry, retaining edges, and how much of the water landscape is at grade versus recessed.

Concept excavation depth: central SWRO system

For the central SWRO hub, the building itself can often be almost at grade, so the main excavation comes from the storage and utility elements rather than the membrane hall. A reasonable concept assumption is:

- building pad / slab zone: 0.40–0.60 m
- buried or semi-buried feed / equalisation tank: 1.8–2.2 m
- central clean-water storage tank: 2.0–2.5 m if partially buried
- utility trenches: 0.8–1.2 m
- intake / outfall trenches: highly site-specific and should be treated separately

Underground tank guidance commonly uses 300–600 mm of cover as a minimum order of magnitude for non-traffic conditions, while deeper or trafficable installations require more robust structural solutions.

Concept excavation depth: central SWRO system

For the central SWRO hub, the building itself can often be almost at grade, so the main excavation comes from the storage and utility elements rather than the membrane hall. A reasonable concept assumption is:

- building pad / slab zone: 0.40–0.60 m
 - buried or semi-buried feed / equalisation tank: 1.8–2.2 m
 - central clean-water storage tank: 2.0–2.5 m if partially buried
 - utility trenches: 0.8–1.2 m
 - intake / outfall trenches: highly site-specific and should be treated separately
- Underground tank guidance commonly uses 300–600 mm of cover as a minimum order of magnitude for non-traffic conditions, while deeper or trafficable installations require more robust structural solutions.

Excavation volume: central SWRO system

A practical concept estimate for the onshore plant is:

- 60 m² building footprint × 0.50 m cut = 30 m³
- feed tank excavation ≈ 18 m³
- 20 m³ clean-water tank excavation ≈ 50–55 m³
- utility trenches / sump / CIP / pipe gallery ≈ 20–35 m³

So the onshore central SWRO hub is roughly: 120–140 m³ excavation, excluding offshore or near-shore intake/outfall works

Total concept excavation for the whole hybrid system

Using the assumptions above:

- decentralised solar systems: ~208 m³
- central SWRO hub: ~120–140 m³

So the whole hybrid strategy is roughly:

- ~330–350 m³ excavation on site
- plus any additional marine trenching if you count intake and brine outfall

3. Site–Landscape Possibilities and Design Directions

3.4 Water system | Desalination, storage, recycle

Amount of possibly used rammed earth from the excavation

How much of the excavated soil can be reused for rammed earth

This is the part that needs the most caution. Not all excavated soil is automatically suitable for rammed earth. Suitable rammed earth soils generally need a balanced grading with substantial sand and gravel and a limited but important clay fraction. Published guidance commonly places suitable material in ranges such as roughly 45–80% sand, 10–30% silt, and 5–20% clay, with low organic content and testing of grading, plasticity, and moisture-density behaviour before use. Excavated soils intended for reuse should be checked for physical, chemical, and geotechnical suitability rather than assumed to be reusable.

Because of that, at concept stage I would not assume that 100% of your excavation can become rammed earth. A safe placeholder is:

- 30–60% potentially reusable for rammed earth after screening, grading correction, and trial mixes
- the rest reused in landscaping berms, subbase, fill, or amended with imported aggregates/clay depending on test results

That 30–60% is a design assumption, not a code rule. It reflects the fact that suitability is site-dependent and often only a portion of excavated soil matches earth-building requirements without correction. Studies on excavated-soil reuse consistently show that reuse potential exists, but it depends on the local soil profile and testing.

How much finished rammed earth wall that could become

Rammed earth commonly has a dry density around 1700–2200 kg/m³, often cited around 1800–2200 kg/m³.

So, for the hybrid system total of roughly 330–350 m³ excavated soil:

- at 30% suitability → ~100–105 m³ of potentially usable soil
- at 50% suitability → ~165–175 m³
- at 60% suitability → ~200–210 m³

As a concept-stage conversion, you can assume that 1 m³ of finished rammed earth wall usually needs slightly more than 1 m³ of selected loose soil once oversize removal, moisture correction, and compaction are accounted for. So the practical output would be somewhat lower than the raw “usable soil” number. A reasonable early-stage estimate is:

- 100–105 m³ usable soil → about 75–95 m³ finished wall
- 165–175 m³ usable soil → about 125–155 m³ finished wall
- 200–210 m³ usable soil → about 150–185 m³ finished wall

To sum up:

The project adopts a two-level hybrid water infrastructure. At the cluster scale, distributed solar still systems are integrated into shared courtyards and landscape voids between the buildings, providing potable water for drinking, cooking, and emergency drought resilience. At the settlement scale, a central SWRO desalination plant located closer to the coast supplies the broader domestic demand through a common network. This arrangement combines decentralised autonomy with centralised efficiency.

Spatially, each residential cluster incorporates approximately 45–55 m² of solar-water landscape, including 25–30 m² of active solar still area, shallow water basins, planting, and a small technical/storage zone. The central SWRO hub occupies approximately 120–200 m² as a coastal service compound with pretreatment, RO membranes, storage, and energy support.

At concept stage, the combined infrastructure is expected to generate approximately 330–350 m³ of excavation, part of which may be reused in rammed earth construction subject to soil suitability testing. A provisional reuse assumption of 30–60% is adopted until geotechnical and material tests confirm the grading and plasticity of the excavated subsoil.

B) Proposal

B.1 Goals, Intentions, Program

B.1.1 Strategies That Defined the Intervention

Based on the preceding research regarding climate adaptation, Mediterranean vernacular architecture, wildfire resilience, and water scarcity, a series of key design strategies were established. These strategies formed the conceptual and spatial manifesto that guided the intervention and informed all subsequent design decisions.

1. Orientation, Topography, and Climate Integration

The first and most important strategy concerns the orientation of the settlement in relation to the sun path, the prevailing winds, the coastline, and the escalation of the slope. The intervention is organized according to a new axis system, where one axis runs parallel to the coastline while the second axis follows the contour escalation of the landscape.

This rotational system emerged as a direct response to climatic and topographic conditions. Through this orientation:

The harsh western solar exposure during summer is minimized.

Daylight from the south and east is maximized.

The prevailing winds from the east and southwest can be utilized for natural ventilation and outdoor thermal comfort.

Views toward the sea are maintained.

The settlement follows the topography in an almost amphitheatrical way, integrating the intervention into the landscape instead of imposing it upon it.

In the region of Almería and the wider Andalusian territory, settlements often develop through terraced and stepped organizations that adapt to the natural terrain. Traditional villages rarely flatten the landscape; instead, they expand gradually along slopes, producing an architectural language deeply connected to the ground itself. This relationship between architecture and terrain strongly influenced

the project.

The stepped arrangement of the masses allows the intervention to maintain visual continuity with the surrounding landscape while simultaneously improving ventilation, solar control, and social interaction between levels.

2. The Concept of the Square and Collective Space

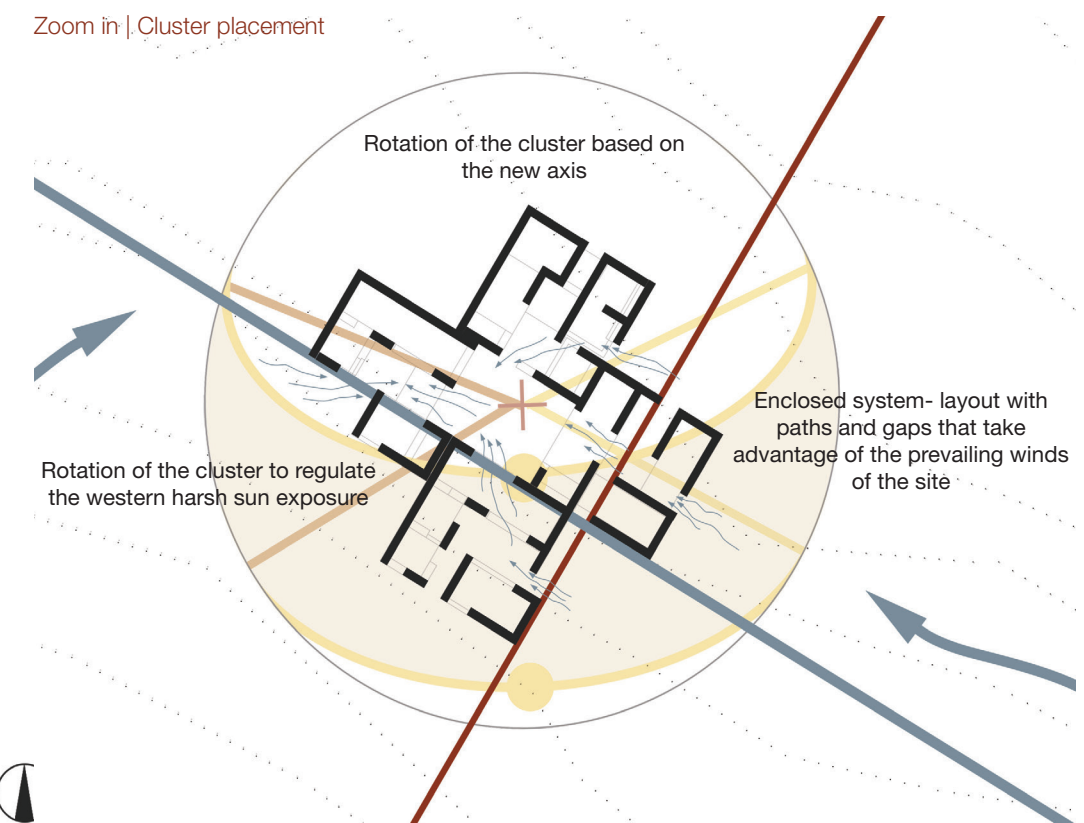
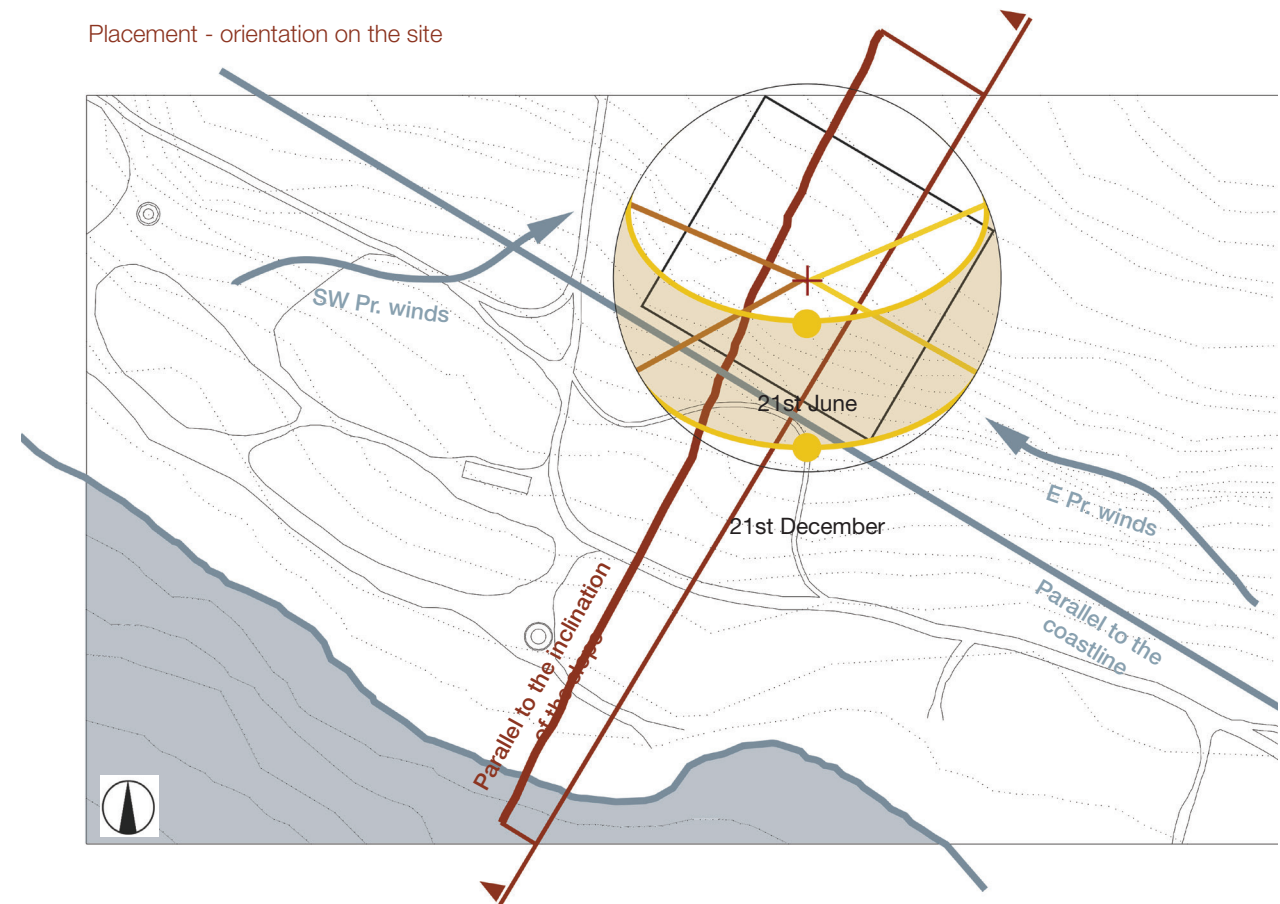
The second defining principle derives from the concept of the Roman square and the Mediterranean plaza, where circulation axes begin and terminate in collective open spaces.

Within the proposal, this principle is translated into a system of interconnected courtyards and platforms that connect spaces both horizontally and vertically. Instead of functioning solely as circulation, these transitional spaces become climatic and social condensers.

The main courtyard acts as the core of the settlement, from which smaller courtyards branch toward the residential clusters. The intention is to create a hierarchy of collective and semi-private spaces that encourage social interaction while preserving intimacy.

These spaces are designed not merely as voids between buildings, but as environmental regulators that mediate:

- Indoor and outdoor living
- Public and private activities
- Climatic transitions
- Social interaction
- Water collection and vegetation growth



3. Courtyards as Climatic and Social Devices

The courtyard became one of the central architectural elements of the project.

The Mediterranean courtyard historically functioned as a climatic machine capable of regulating heat, ventilation, and humidity while simultaneously supporting social life. In this proposal, the courtyard is reinterpreted as a layered environmental system.

The courtyards enhance cross ventilation, improve thermal comfort through shading, support evaporative cooling through integrated water bodies, and create outdoor living conditions suitable for Mediterranean lifestyles. They function as transitional zones between indoor and outdoor environments while simultaneously operating as extensions of the interior spaces.

The project emphasizes the idea that outdoor life is inseparable from Mediterranean habitation. Therefore, the courtyards are not residual spaces but rather the core of domestic and communal life.

Vegetation further strengthens this strategy. Drought-resistant deciduous species such as *Celtis australis*, *Gleditsia triacanthos*, and *Koelreuteria paniculata* are integrated within the courtyards. These species provide dense shading during summer while allowing solar penetration during winter after leaf loss.

This seasonal behavior transforms the vegetation into a passive climatic mechanism that contributes to cooling during warm periods and solar gain during colder months.

4. Landscape and Earthen Materiality

Another key strategy involves allowing the landscape itself to enter the intervention.

The proposal avoids a strict separation between architecture and terrain. Instead, landscape qualities such as:

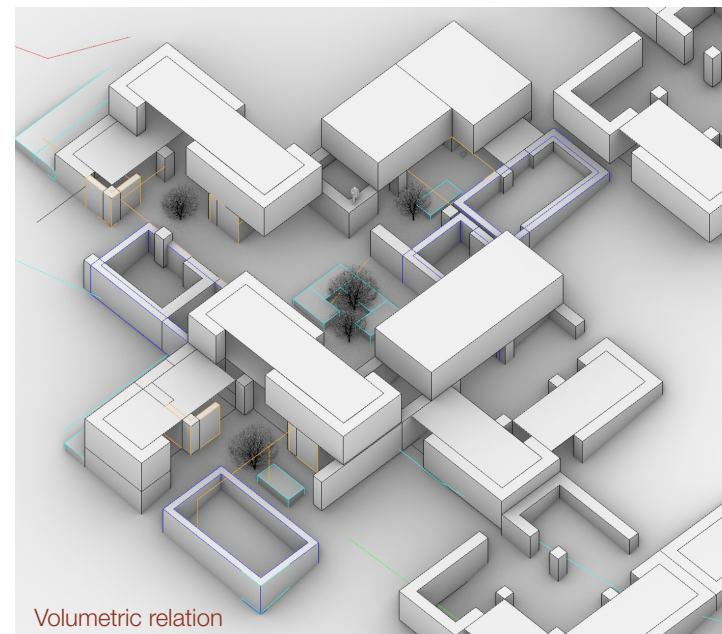
- Earthen materiality
- Vegetation
- Water systems
- Topographic fragmentation

are integrated directly into the spatial organization.

The courtyards and open spaces work as climatic sponges capable of collecting water, reducing heat accumulation, and strengthening environmental resilience.

The use of rammed earth further reinforces this continuity between ground and architecture. The material palette of the intervention emerges directly from the site itself, creating a visual and tectonic relationship between settlement and landscape capable of collecting water, reducing heat accumulation, and strengthening environmental resilience.

The use of rammed earth further reinforces this continuity between ground and architecture. The material palette of the intervention emerges directly from the site itself, creating a visual and tectonic relationship between settlement and landscape.



B.1.2 Program

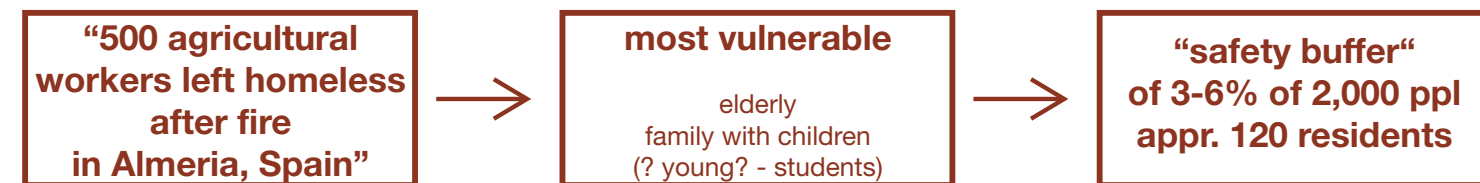
A Settlement for Displacement and Production

The proposed settlement is conceived as a hybrid habitation and infrastructure system designed to accommodate approximately 120 displaced residents alongside agricultural and research workers.

The project responds to increasing climate displacement within Mediterranean territories, particularly in relation to drought and wildfire events. Seasonal wildfires across southern Spain and the Mediterranean basin have increasingly led to temporary evacuations and population displacement, especially in vulnerable rural and coastal areas.

The decision to design for approximately 120 people reflects the scale of a small Mediterranean community while maintaining social cohesion and manageable infrastructure systems.

Nearly 400 farmworkers rendered homeless after fire guts a settlement in Níjar (Almería)



design assumption grounded in modular logic and emergency-use patterns, not as a statistical fact.

temporary displacement (wildfire evacuation / smoke events / water supply crisis)

operational staff + researchers (lab + water system)

short-stay community uses (training, volunteers, visiting specialists)

60-120 people (temporary accommodation)

In a 2,000-person settlement, even severe events rarely displace 100% of residents at once.

A resilience module should cover the most vulnerable and those who cannot self-relocate (elderly, families with small children, people without cars, etc.).

A capacity of 3-6% of the settlement is a realistic "safety buffer" for emergency shelter at neighborhood scale.

For a settlement of ~2,000 residents, the accommodation is designed as an emergency and support layer sized for ~3-6% of the population (~60-120 people), enabling temporary relocation during wildfire events, heat stress, or water supply disruption.

Hybrid kind of accommodation mix of family rooms + shared dorm units

The program integrates three primary user groups: displaced inhabitants temporarily relocated after wildfire events, permanent workers related to agriculture, maintenance, and water systems, and research and production staff working within the material and water infrastructure hub.

Rather than functioning as a static housing project, the proposal becomes a living environmental system that combines accommodation clusters, agricultural production, water infrastructure, material research and fabrication, and social and communal spaces.

The spatial organization follows a cluster-based system where groups of residences are arranged around courtyards, forming micro-communities.

From Whom

The intervention is based on the combination of local knowledge, traditional Mediterranean construction techniques, and contemporary material research.

The project relies on expertise from architects, material engineers, researchers, construction specialists, and environmental designers.

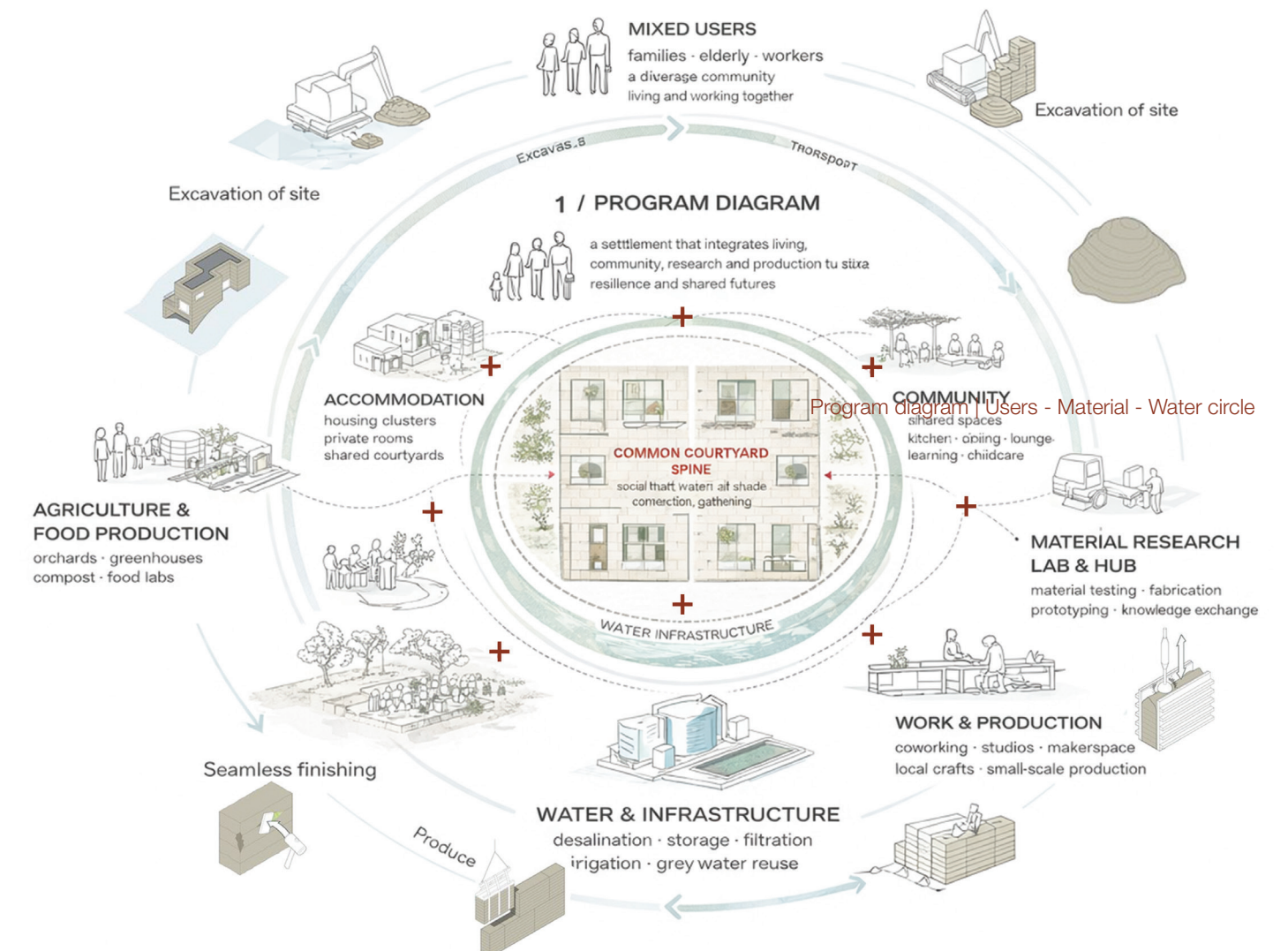
The proposal is therefore not conceived as a purely self-built system but rather as a professionally supported framework capable of evolving through research, prefabrication, and technological optimization.

To Whom

The target group is the everyday Mediterranean resident seeking a more resilient and climate-adaptive way of living.

The project addresses families, elderly people, seasonal workers, climate-displaced inhabitants, and researchers and craftsmen.

The proposal aims to reintroduce qualities of traditional Mediterranean living that have gradually disappeared from contemporary development, including outdoor social interaction, shared communal spaces, a strong relation to nature, climatic adaptation through architecture, and simplicity and collective coexistence.



B.1.3 Boundaries and Possibilities of the Tools

Material Harvest and Excavation

One of the primary boundaries and possibilities of the project concerns the relationship between excavation and construction material. The implementation of the underground water infrastructure requires excavation across significant areas of the site. Instead of treating this excavation as waste production, the proposal transforms it into a material harvesting process.

The excavated soil is analyzed and partially reused for rammed earth production, compressed earth block production, landscape stabilization, and water retaining walls. This creates a circular material logic where the excavation required for the water infrastructure simultaneously generates the material necessary for construction.

Assuming underground reservoirs and infrastructural layers reaching depths between 2.5 and 4 meters, a substantial volume of compactable soil can

be extracted. Depending on soil composition and stabilization requirements, a large percentage of this excavated material can be reused for construction after sieving, mixing, and stabilization.

Prefabricated Stabilized Rammed Earth

The proposal explores the use of prefabricated stabilized rammed earth elements. The stabilization process combines lime additives for structural reinforcement with pozzolanic materials for hydraulic and moisture-resistant properties. Prefabrication improves construction efficiency, modularity, speed of assembly, and material consistency. At the same time, it introduces limitations regarding spatial flexibility and future modifications.

However, the flexibility of the project does not rely primarily on changing structural layouts. Instead, flexibility emerges through multiple ways of inhabiting the spaces, adaptability for different age groups

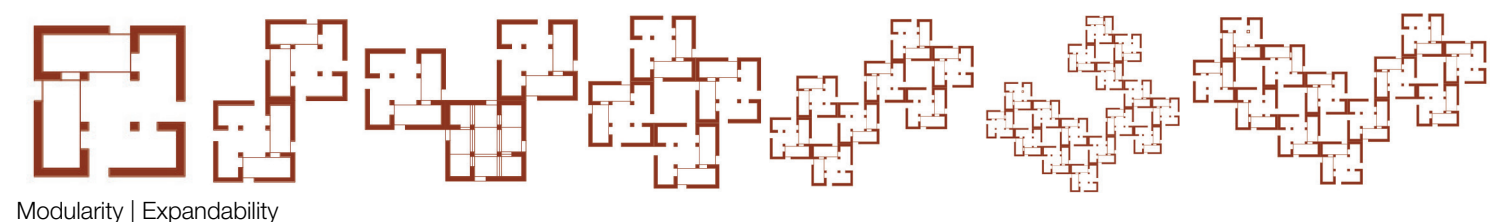
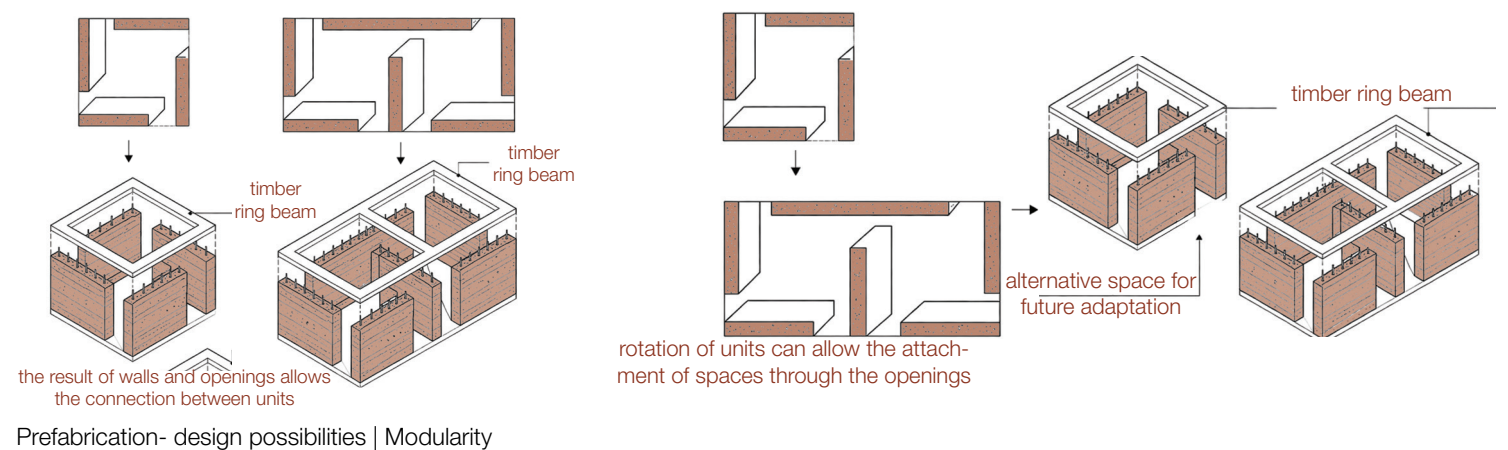
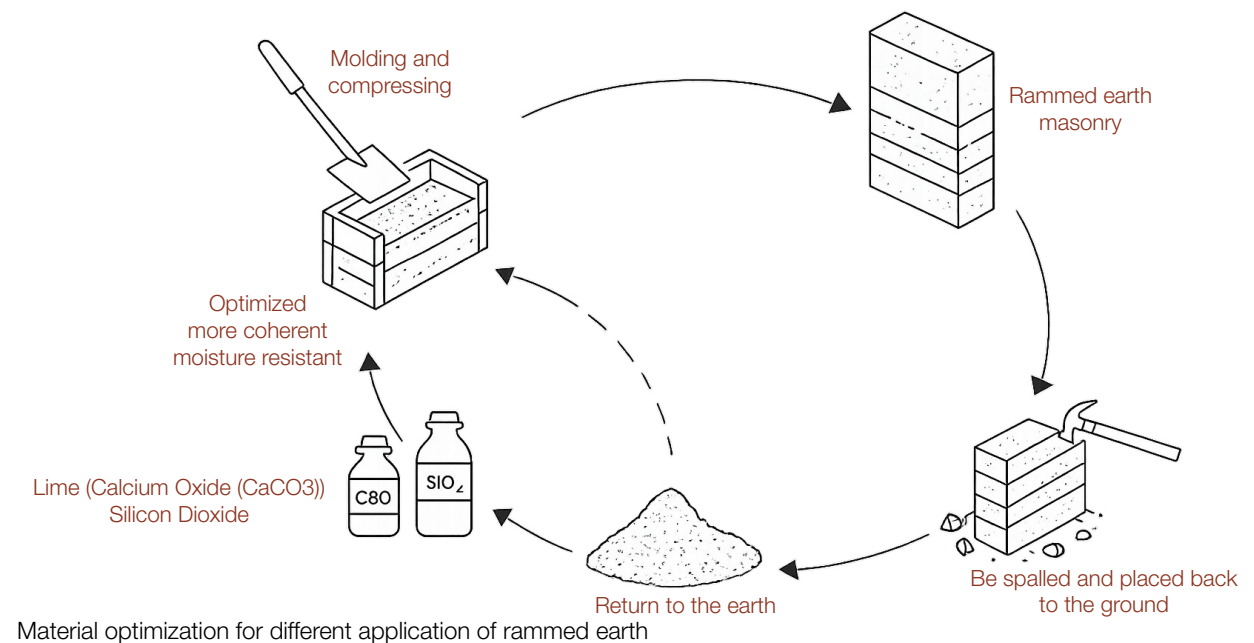
and users, the fluid relationship between interior and exterior living, and shared communal systems.

Replicability

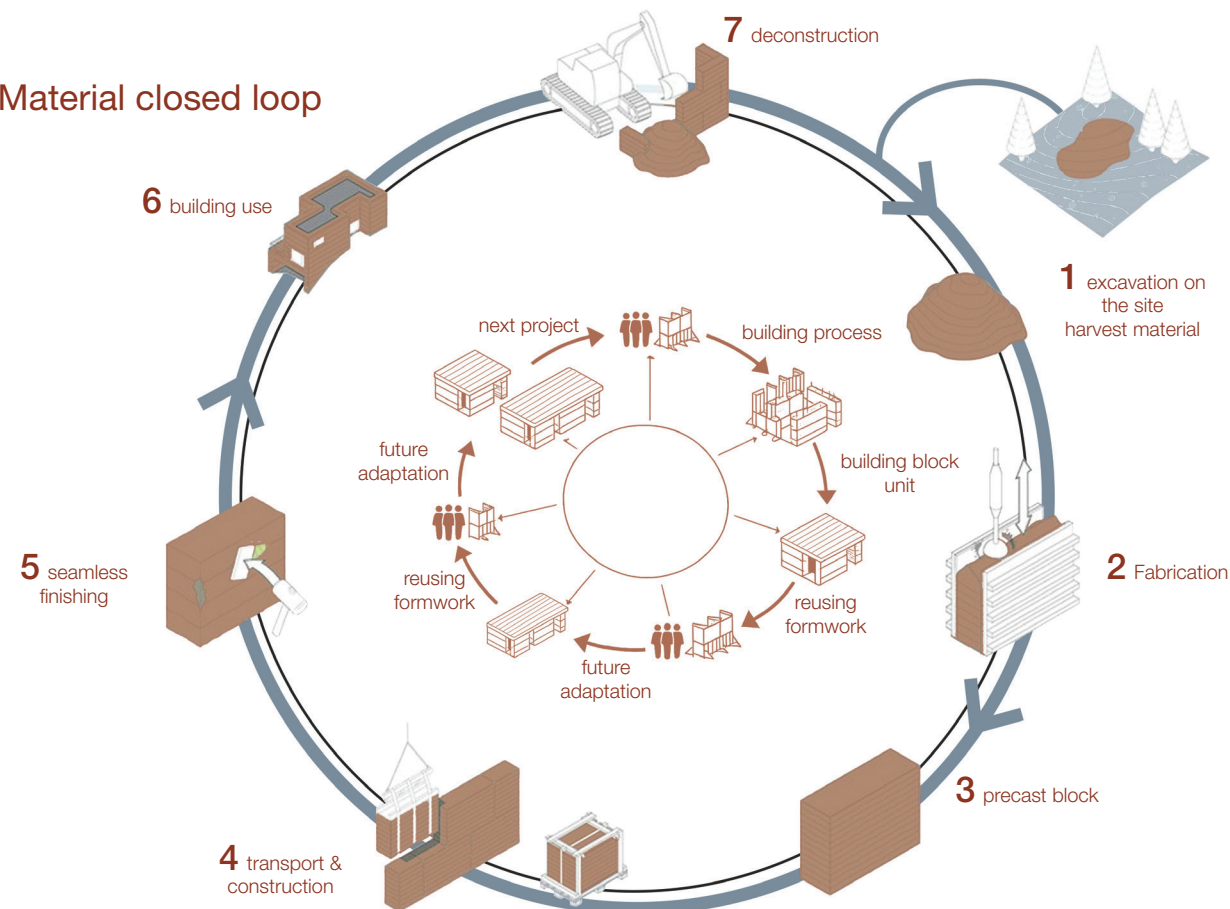
The settlement is conceived as a modular and scalable system. Its replication potential depends pri-

marily on the availability of earthen material, climatic compatibility, access to coastal water infrastructure, and adaptability to local topographies.

The proposal is therefore not intended as a universal prototype but rather as a place-responsive framework that can be adapted to other Mediterranean and semi-arid contexts.



Material closed loop



B.2 Design

B.2.1 Spatial Organization of the Program

The spatial organization of the project directly follows the strategies established in section B.1.1.

The material hub is positioned closer to the main road access on the northwestern side of the site due to its more public character, the logistical requirements of loading and unloading heavy materials, easier vehicular accessibility, and its connection to agricultural and production infrastructures.

The accommodation zone is positioned toward the south and closer to the sea in order to maximize sea views, strengthen the relationship with the coastline, enhance access to cooler air currents, improve connection with the desalination systems, and create a quieter and more private residential atmosphere.

Between these two primary zones lies the central collective area consisting of:

- The main three-level courtyard square
- Workers' and researchers' residences
- Shared social spaces
- Transitional platforms

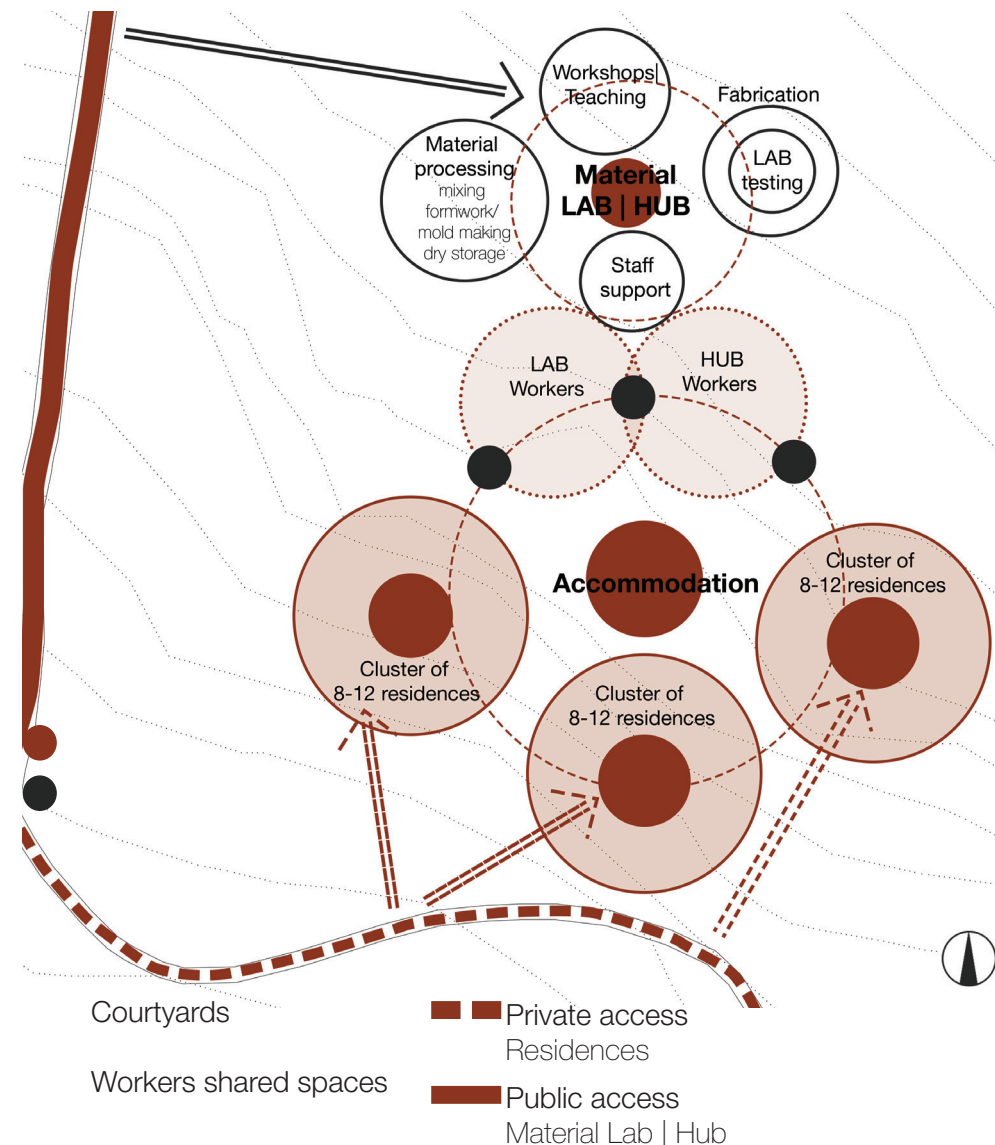
This intermediate zone acts as both a physical and social connector between production and habitation.

Material Hub

The material hub operates as the productive core of the settlement.

It includes material processing areas, soil preparation spaces, rammed earth prefabrication workshops, material testing laboratories, research spaces, shared workshops, tool storage, loading and unloading areas, and public exhibition and educational spaces.

The hub is conceived not only as an industrial infrastructure but also as an educational and research environment where traditional earthen construction techniques are reinterpreted through contemporary technologies.



Program | Uses distribution

Residences

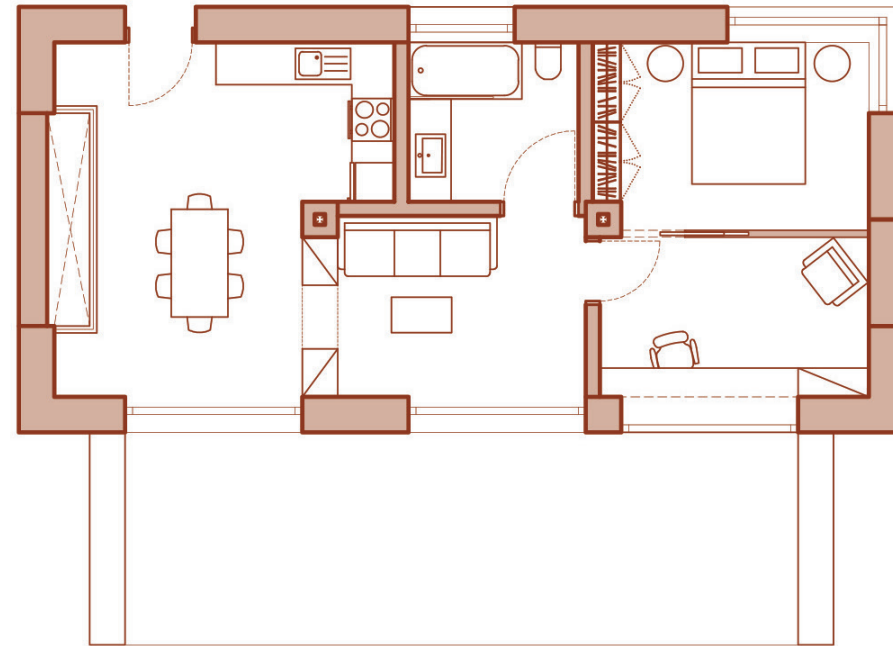
The residential system is organized into six typologies of varying sizes and spatial configurations.

The variation between typologies allows:

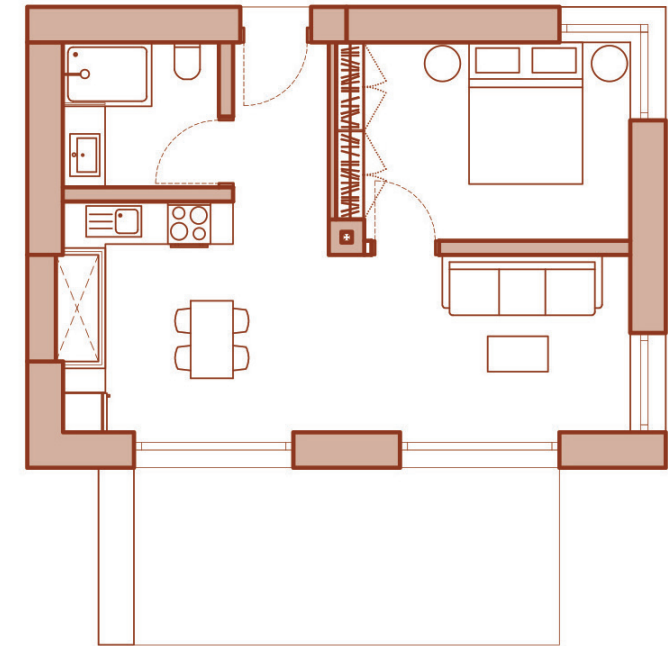
- Different household compositions
- Adaptability to age groups
- Flexibility for temporary or permanent living
- Diverse relationships with courtyards and communal spaces

The residences are designed according to Mediterranean living patterns where the distinction between indoor and outdoor spaces becomes intentionally blurred.

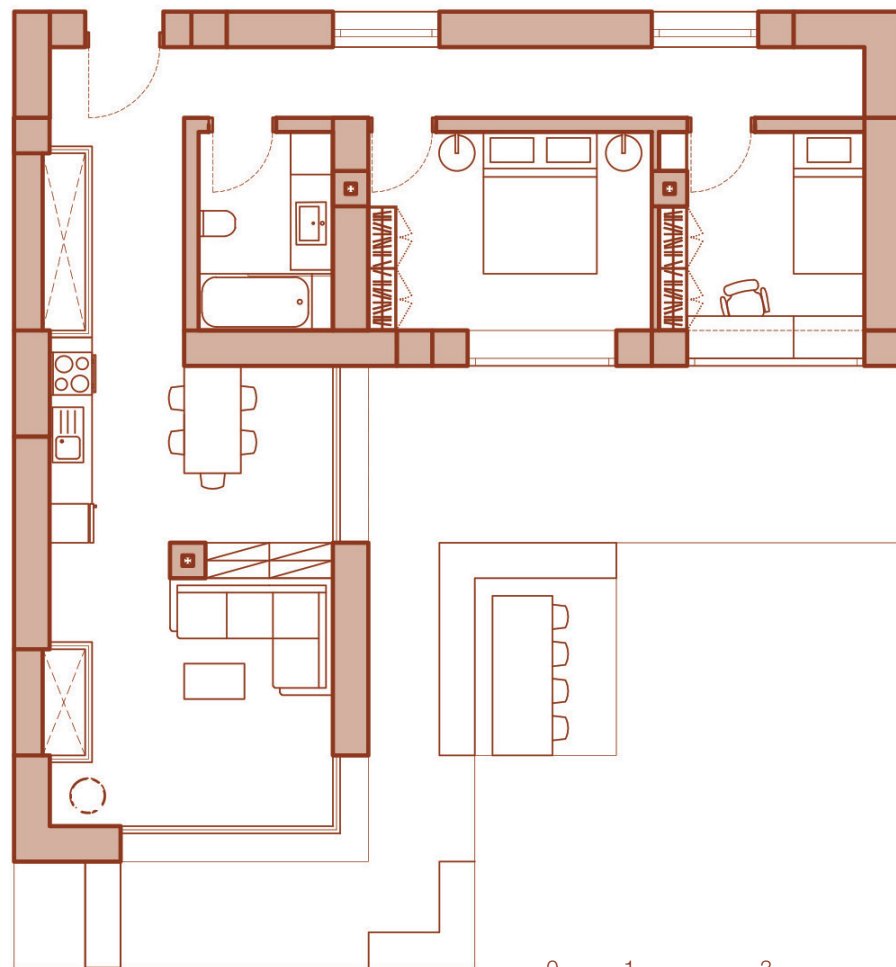
Large openings toward the courtyards and south-east orientations strengthen the continuity between domestic life and outdoor social interaction.



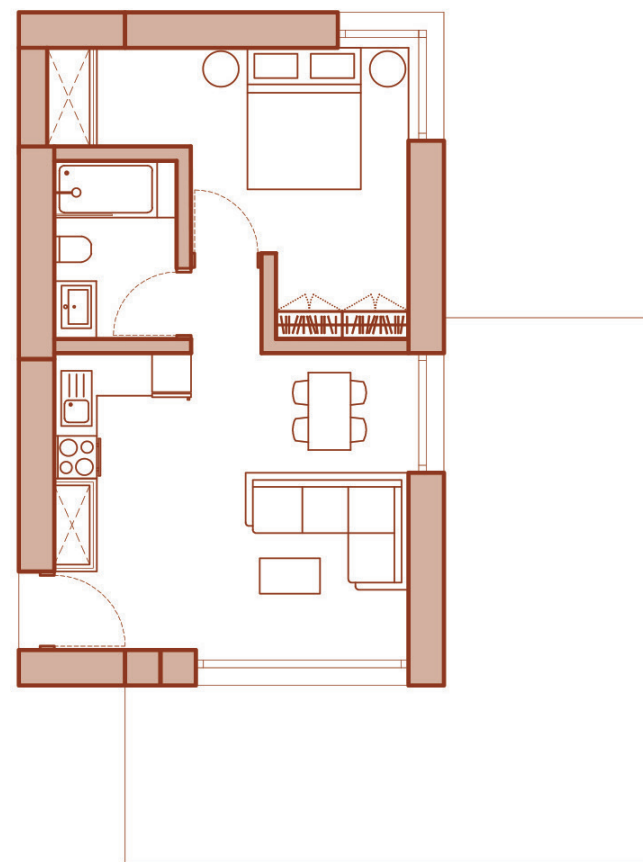
Type B_57 m2



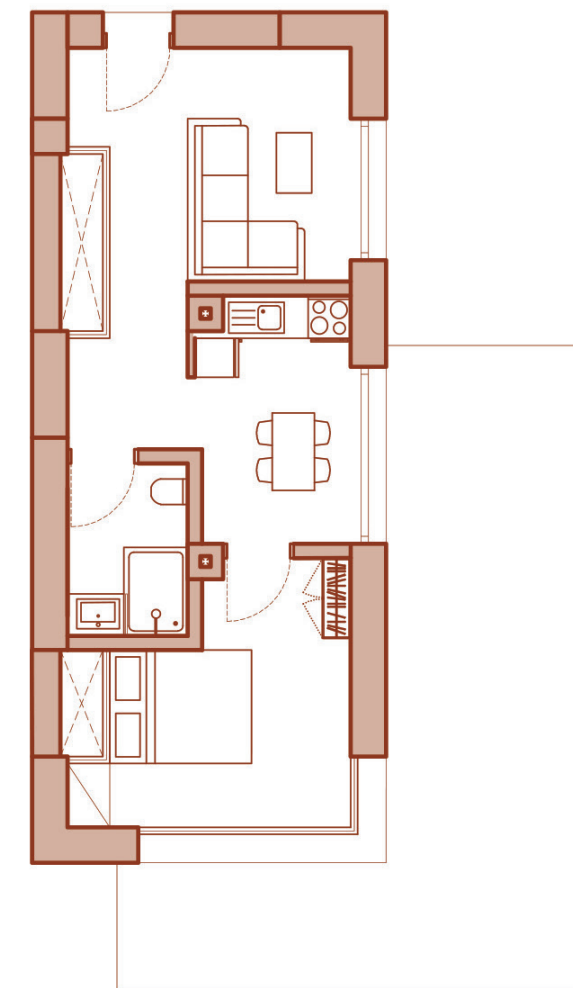
Type D_50 m2



Type A_75 m2



Type C_45 m2



Type E_45 m2

B.2.2 Focus on the Cluster

The settlement is organized through a system of residential clusters that function as small micro-communities within the larger intervention. Each cluster consists of approximately eight to twelve residences arranged around a shared courtyard system. The organization of the clusters is based on a modular grid of 1.5, 3, and 6 meters, which supports both spatial flexibility and the logic of prefabricated earthen construction. This modular system allows the settlement to maintain a coherent architectural language while adapting to the different conditions of the site, including orientation, slope inclination, privacy gradients, and accessibility levels.

The primary intention of the cluster organization is to create a balance between collective life and individual privacy. Instead of organizing the residences through rigid linear circulation, the intervention creates a sequence of courtyards, platforms, passages, and transitional zones that gradually mediate between public and private space. In this way, movement through the settlement becomes experiential and climatic rather than purely functional.

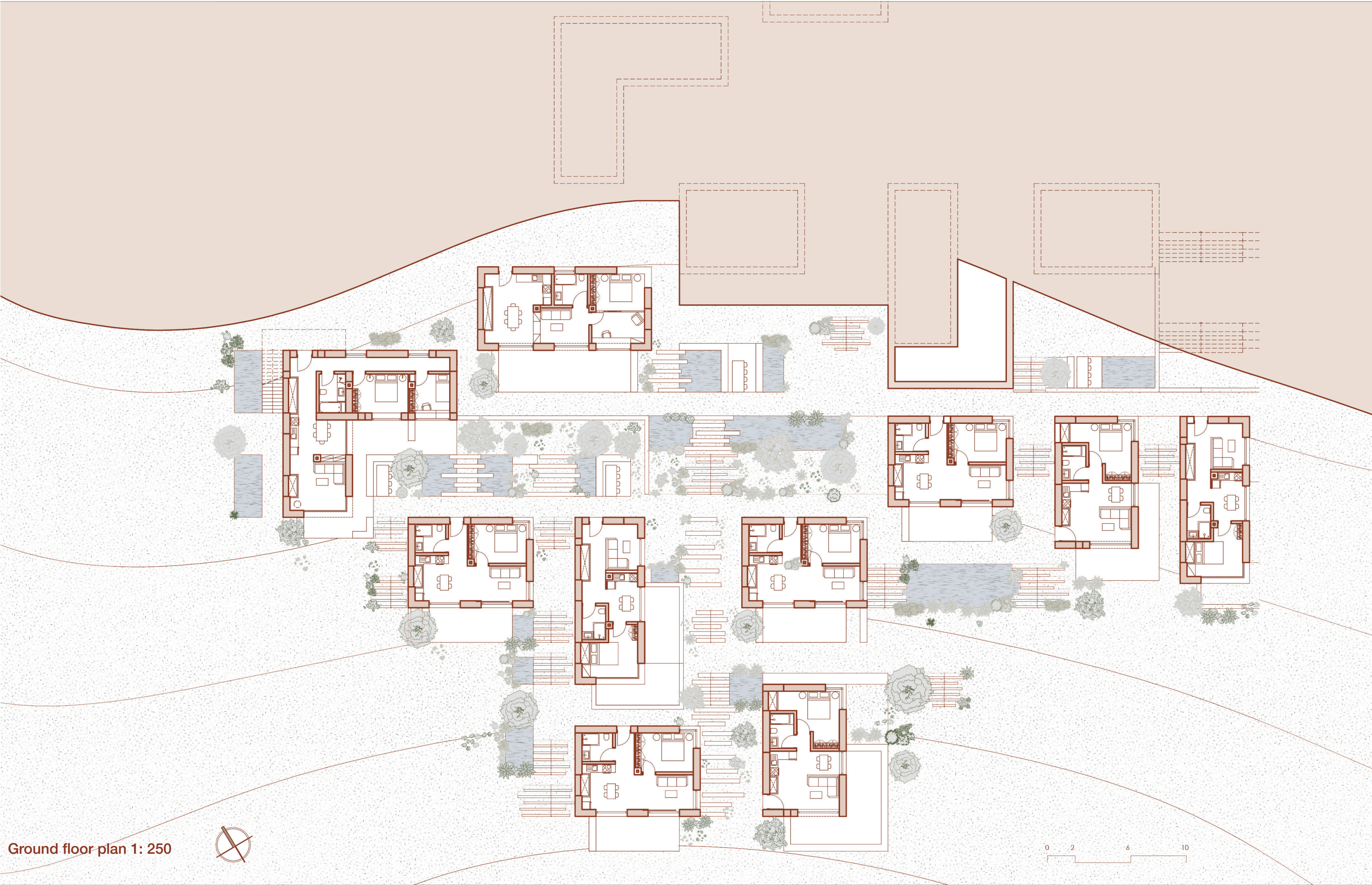
One of the most important spatial principles is the amphitheatrical escalation of the masses following the slope of the terrain. Rather than flattening the landscape, the clusters step gradually along the contour lines, allowing the architecture to merge with the topography. This strategy minimizes excavation, strengthens the visual continuity of the landscape, and improves solar exposure and natural ventilation. At the same time, the changes in level create a hierarchy of courtyards and terraces where social interaction can occur across different elevations.

The courtyards operate as the environmental and social cores of the clusters. They are designed not only as gathering spaces but also as climatic regulators. Vegetation, water bodies, and shaded transitional zones reduce heat accumulation and improve outdoor thermal comfort. The integration of drought-resistant deciduous trees creates seasonal environmental adaptation by providing dense shade during summer while allowing sunlight penetration during winter. Water channels and shallow water

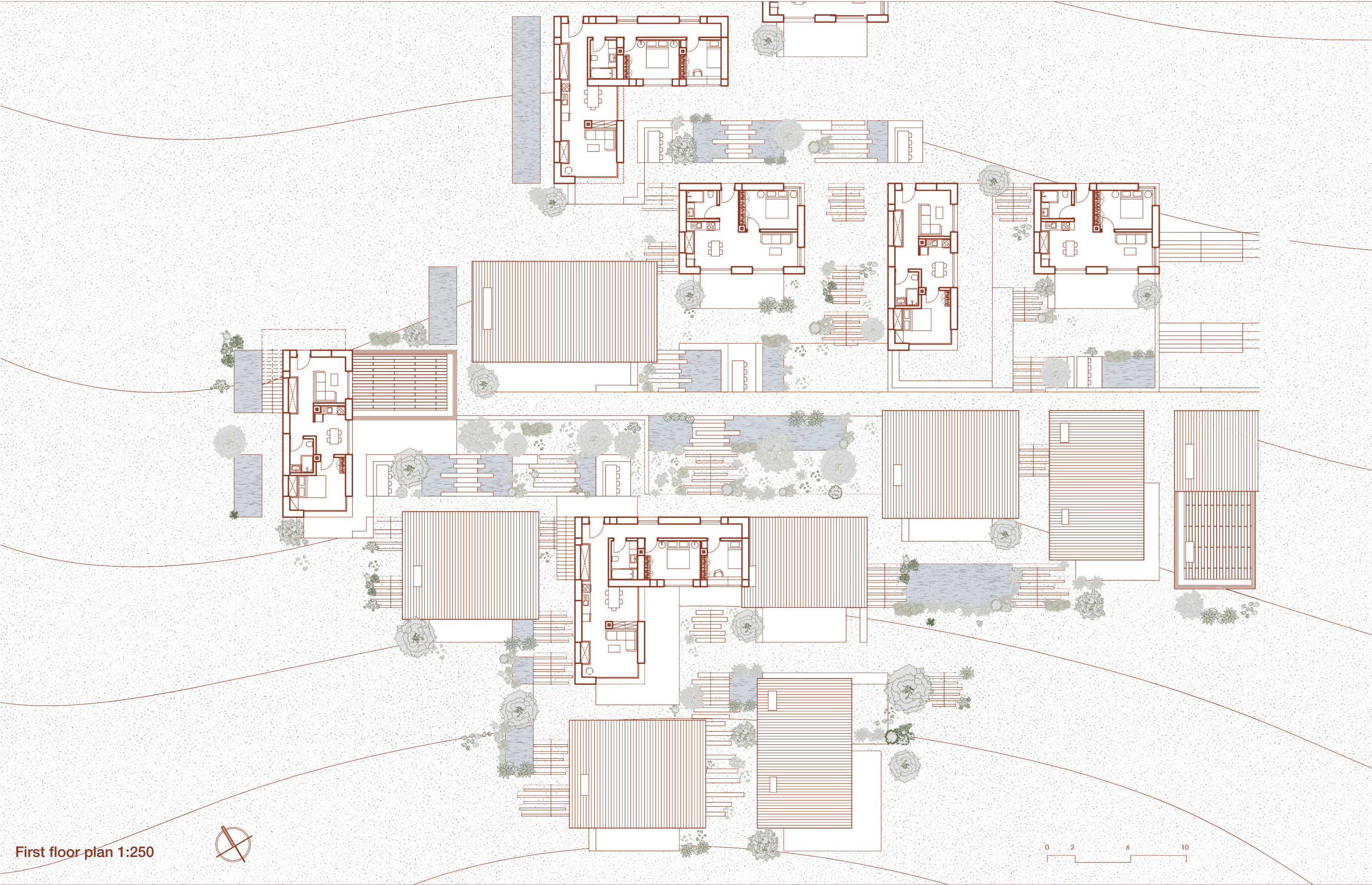
bodies connected to the desalination system contribute to evaporative cooling, lowering the temperature of the air before it enters the interior spaces.

Another key principle is the creation of western buffer zones. On the western side of each residence, circulation spaces and vertical ventilation shafts are positioned to protect the interiors from harsh afternoon solar exposure. These transitional zones function simultaneously as circulation corridors, solar chimneys, and climatic filters. Skylight openings and vertical air channels enable cross ventilation while limiting direct heat gain from the west. Through this layered environmental approach, the clusters become passive climatic systems capable of responding to the extreme conditions of the Mediterranean environment.

Ultimately, the cluster is conceived not simply as a housing arrangement but as a social and environmental organism. It supports outdoor living, collective interaction, climatic adaptation, and gradual expansion while maintaining a strong relationship with the landscape and the Mediterranean way of life.



Ground floor plan 1: 250



First floor plan 1:250



Cluster section 1: 150

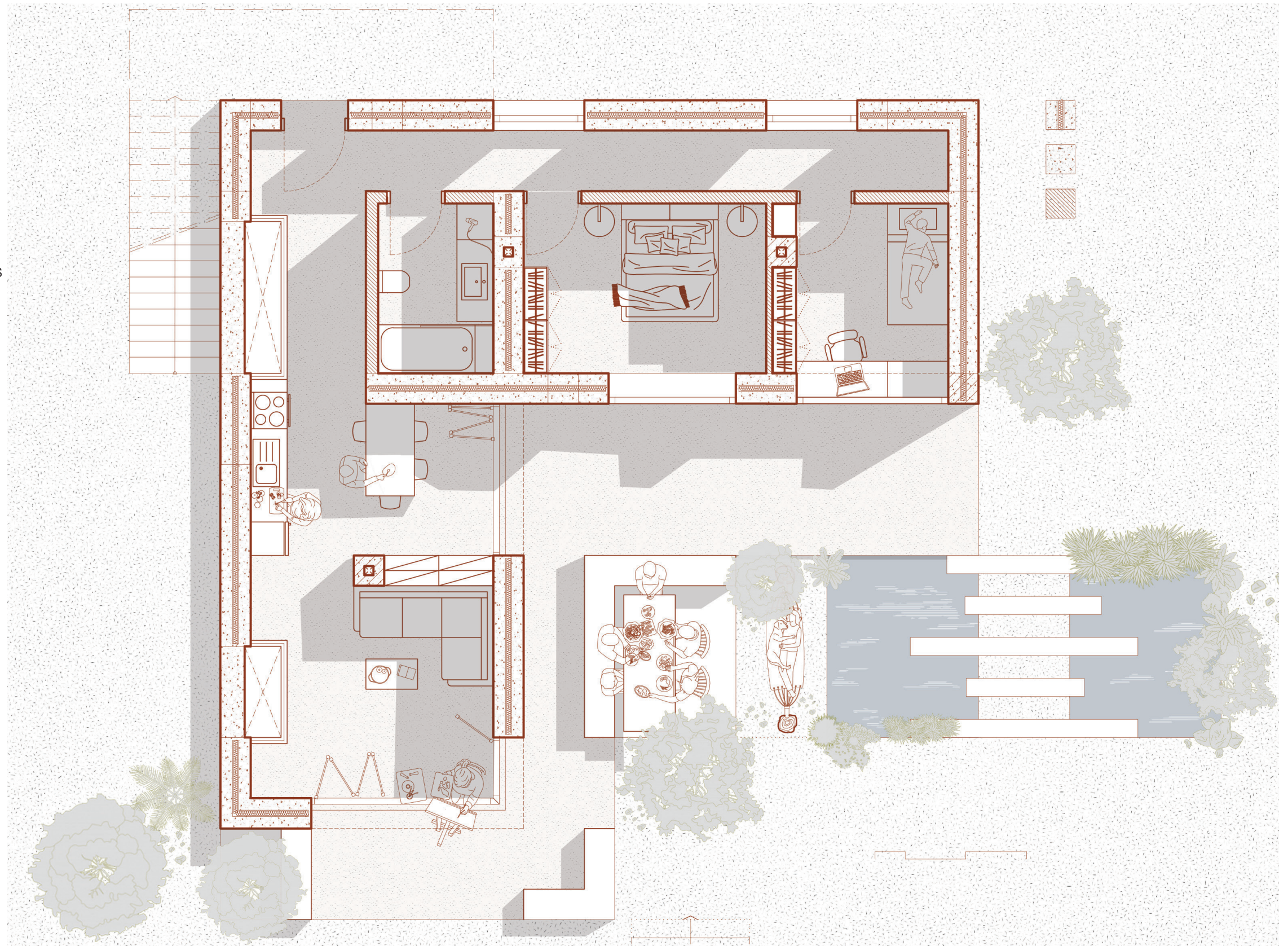
0 2 6 10

B.2.3 Residence modulo

The residential typology of the project is based on the reinterpretation of the traditional Mediterranean cortijo, particularly the L-shaped courtyard house commonly found in Andalusian rural architecture. The intention is not to reproduce vernacular architecture literally, but to reinterpret its environmental intelligence and spatial qualities within a contemporary climate-resilient framework.

The organization of the residence follows a layered spatial and environmental logic. The spaces are arranged according to daylight requirements, orientation, privacy, and climatic performance. Bedrooms are primarily positioned toward the eastern side of the residence in order to benefit from softer morning sunlight and cooler thermal conditions, while the kitchen and living areas are oriented toward the south and southeast to maximize daylight and visual connection with the courtyards.

The relationship between indoor and outdoor space is intentionally blurred. Large openings toward the courtyards, continuous floor materials, integrated benches, and shaded transitional zones create a smooth and almost unconscious transition between the interior and exterior. The outdoor courtyard is therefore perceived as an extension of the domestic environment rather than as a separate exterior space. This spatial continuity reflects the Mediterranean way of living, where daily life frequently expands outdoors due to climatic and social conditions.



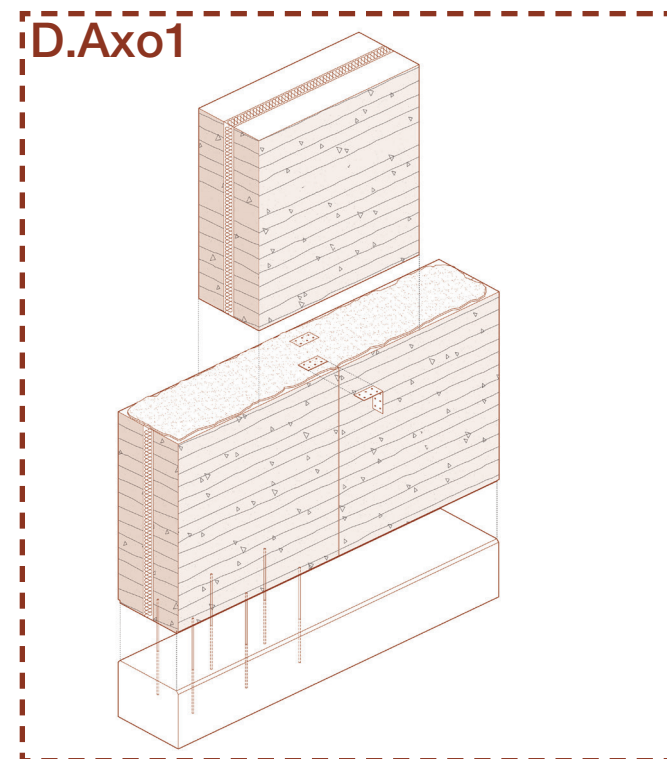


Construction logic | Materiality

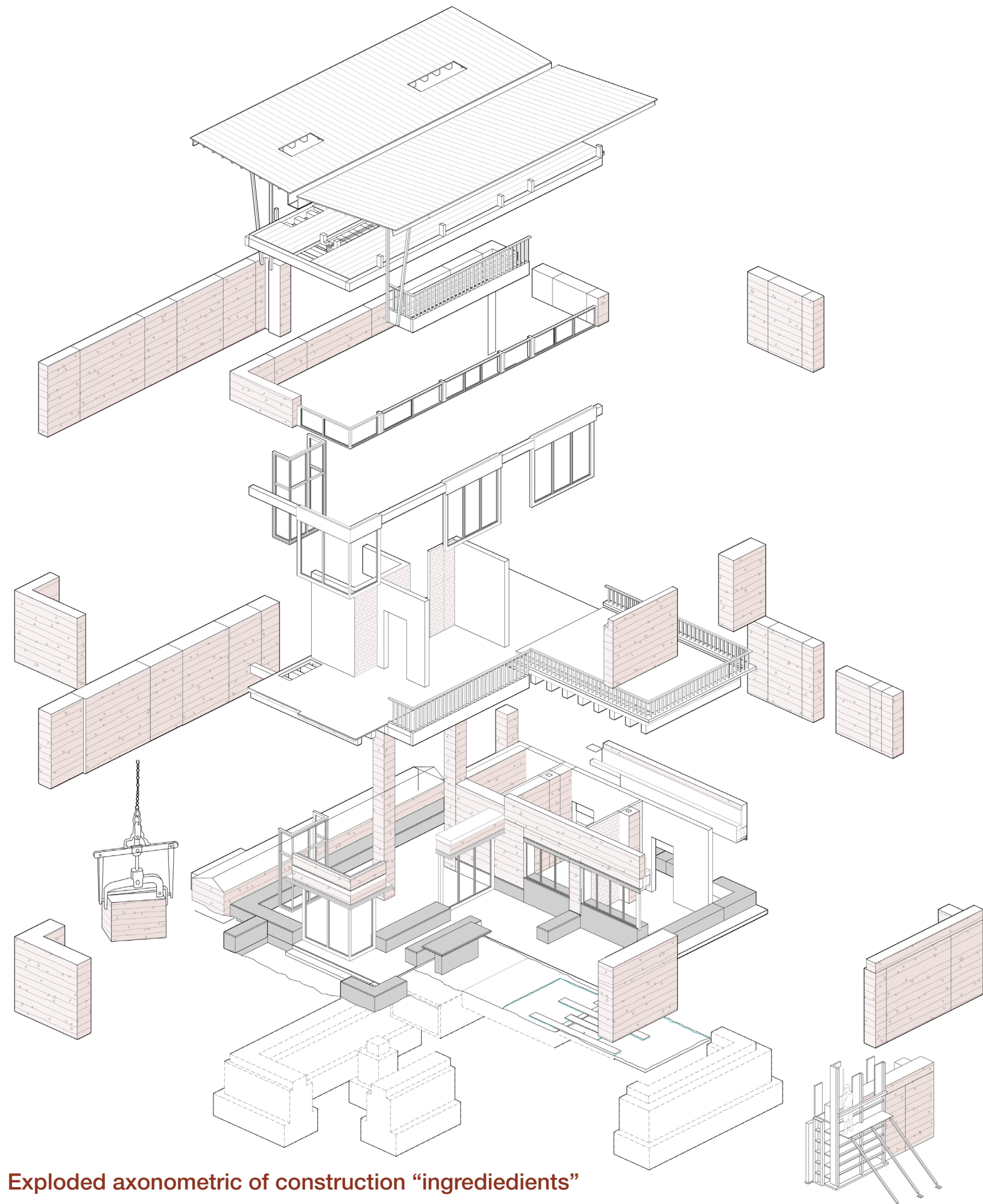
The residence operates through a layered environmental system consisting of the water infrastructure layer, the material envelope layer, the climatic layer, and the user layer. These systems are not independent but interconnected and mutually supportive.

The proposal investigates optimized stabilized rammed earth mixtures incorporating lime and pozzolanic additives to improve structural performance and moisture resistance. In addition to in situ applications, prefabricated earthen components are explored to improve construction efficiency and modularity while maintaining tectonic continuity.

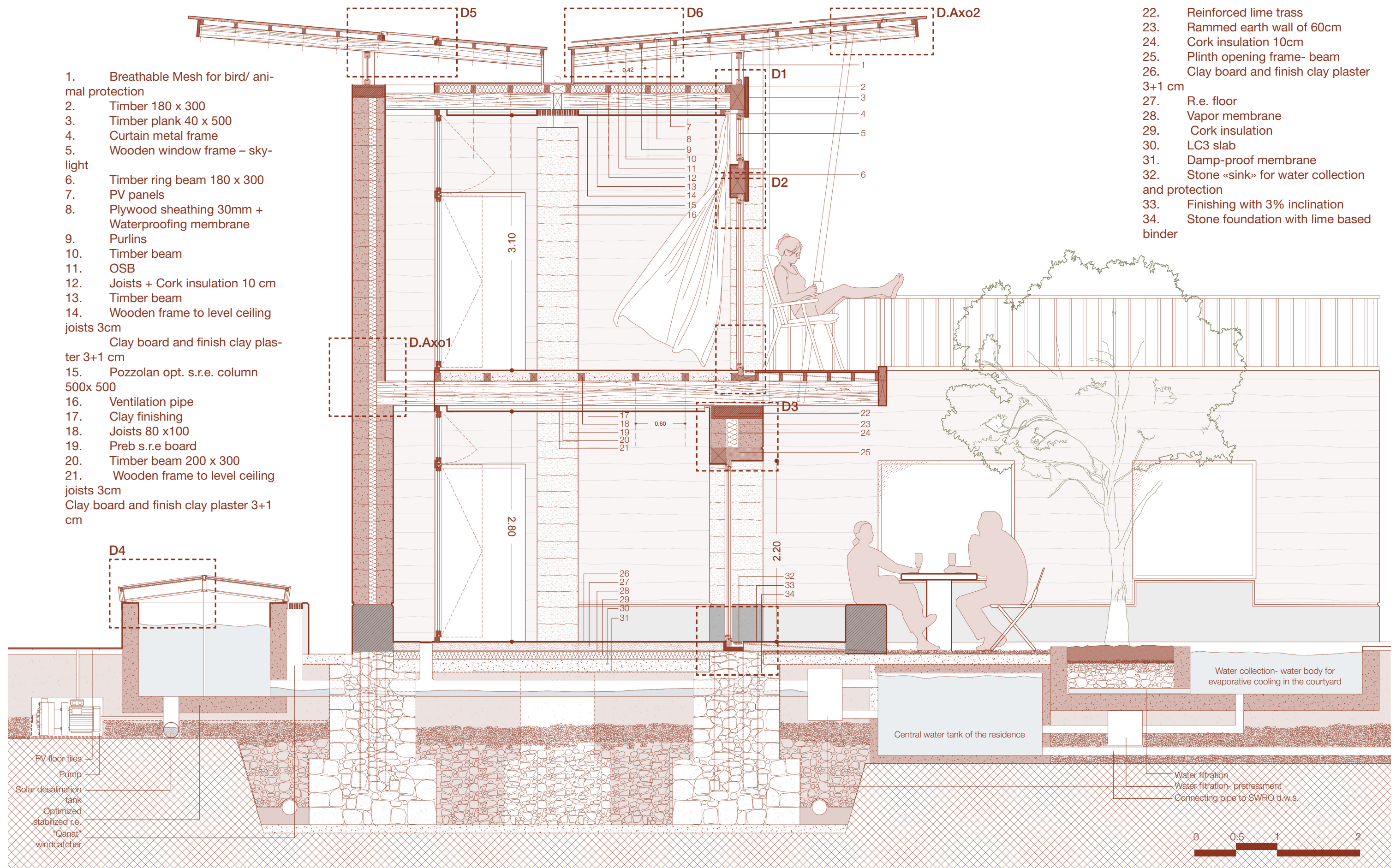
Structurally, the residences combine prefabricated stabilized rammed earth walls, compressed earth block interior partitions, wooden horizontal structural systems, cork insulation, and clay finishing layers. Stone foundations and raised plinth bases protect the earthen walls from rising damp and improve durability.



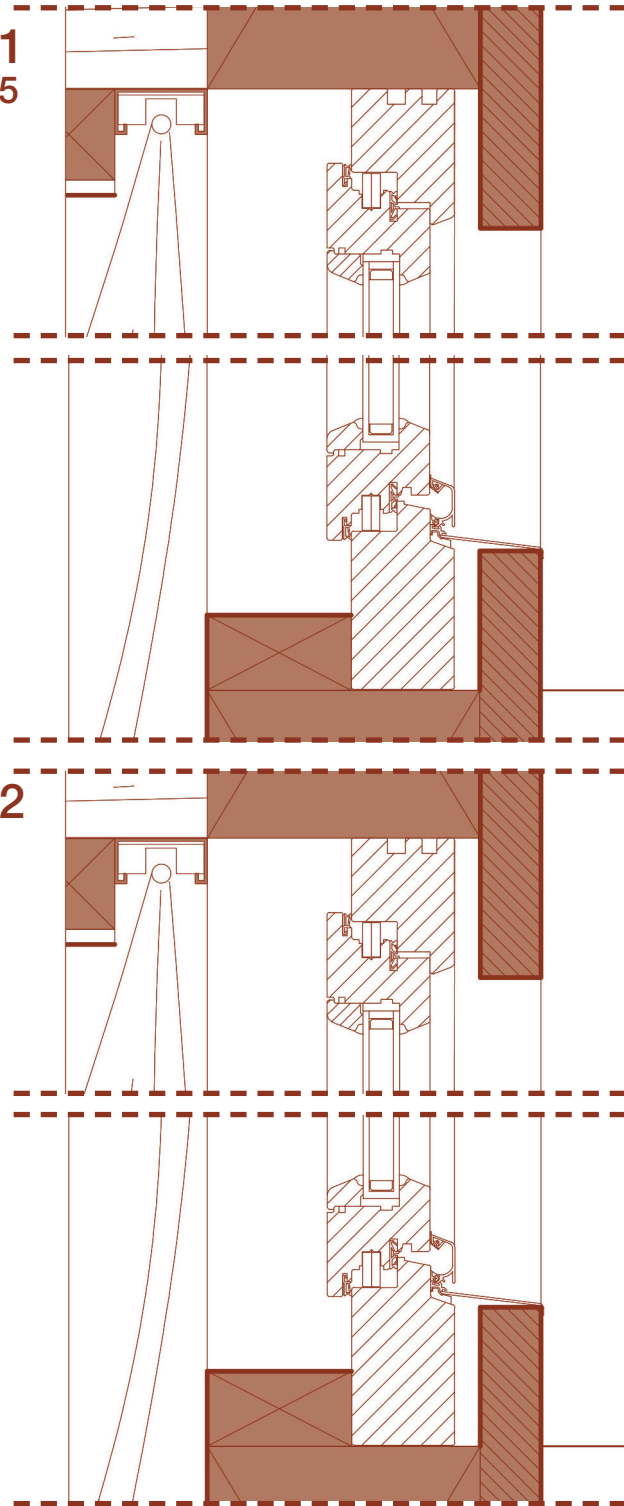
D.Axo1. Limebased binder and bolted steel brackets for s.r.e. components connection



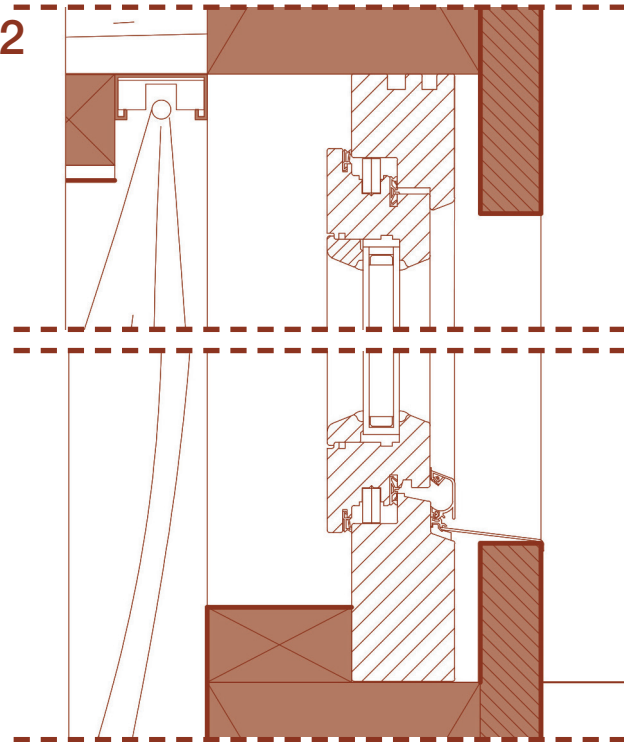
Exploded axonometric of construction "ingredients"



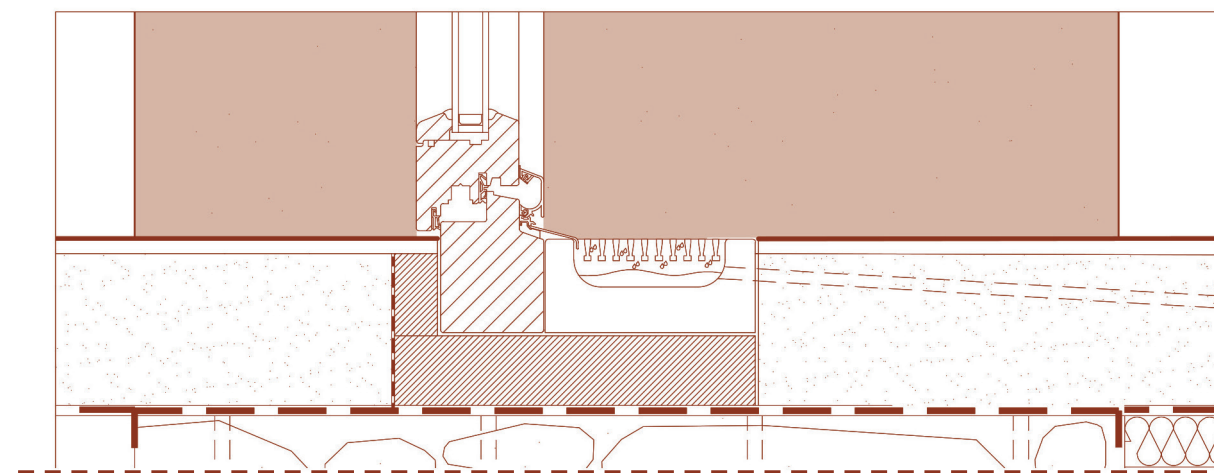
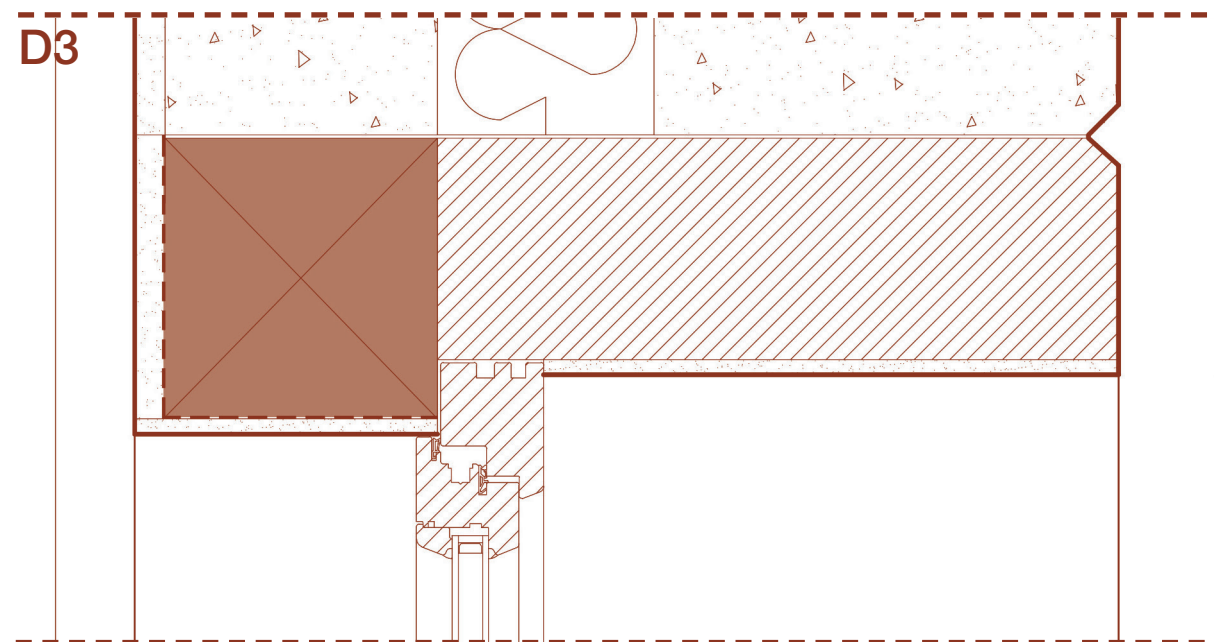
D1
1:5



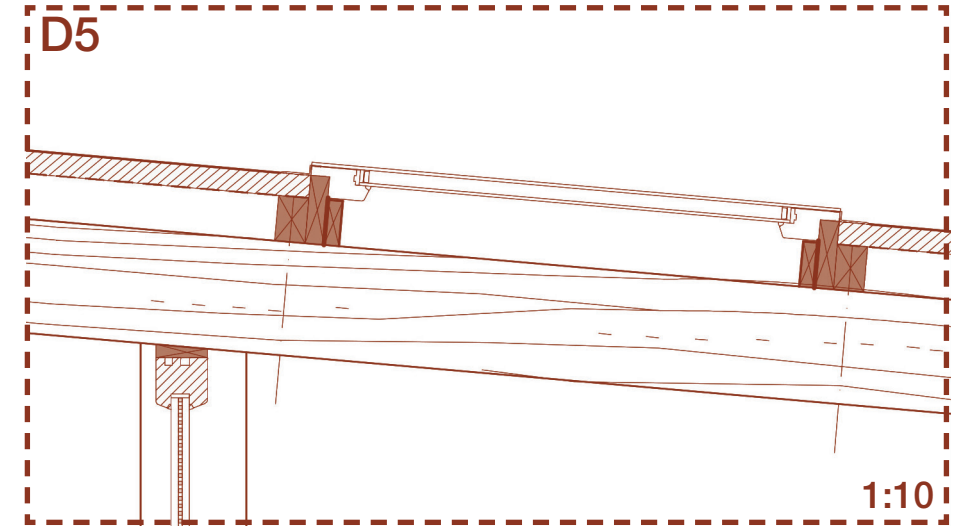
D2



D3



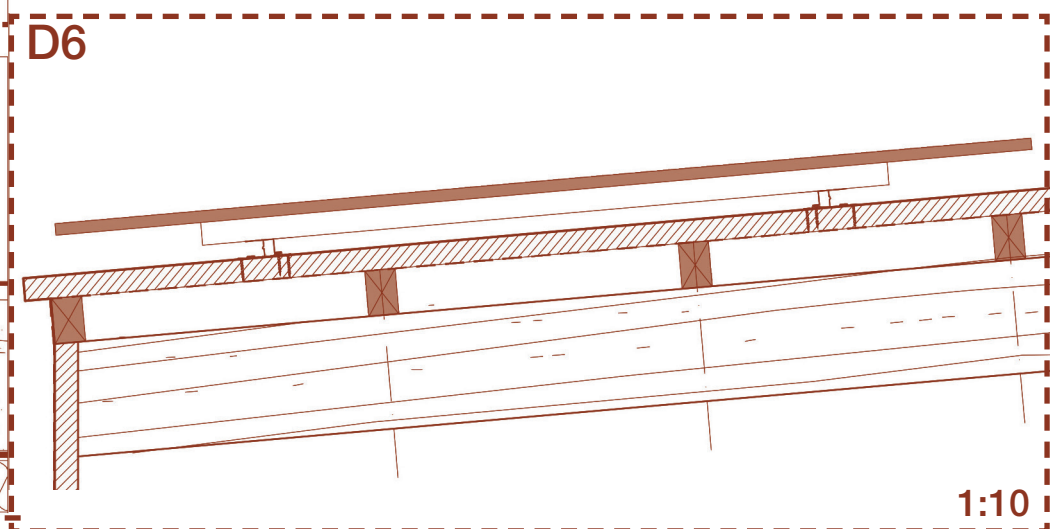
D5



1:10

D5. Skylight on second "butterfly" roof

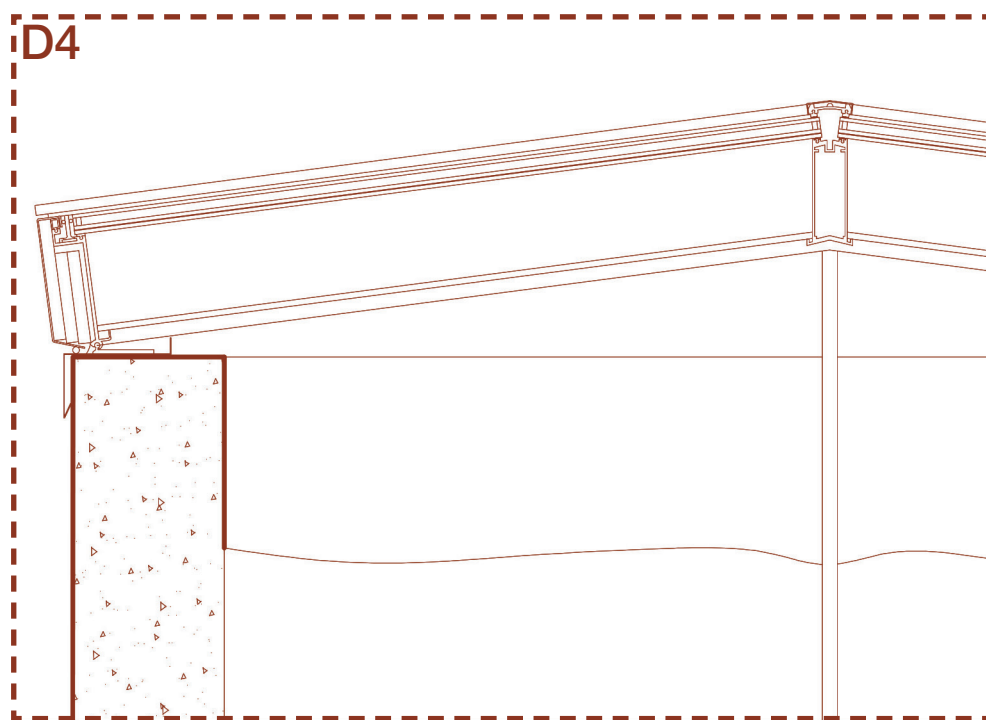
D6



1:10

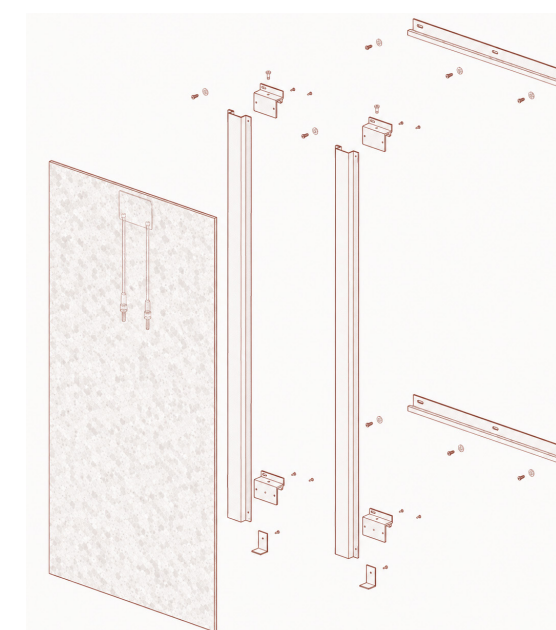
1:5 D6. PV panel on the roof

D4

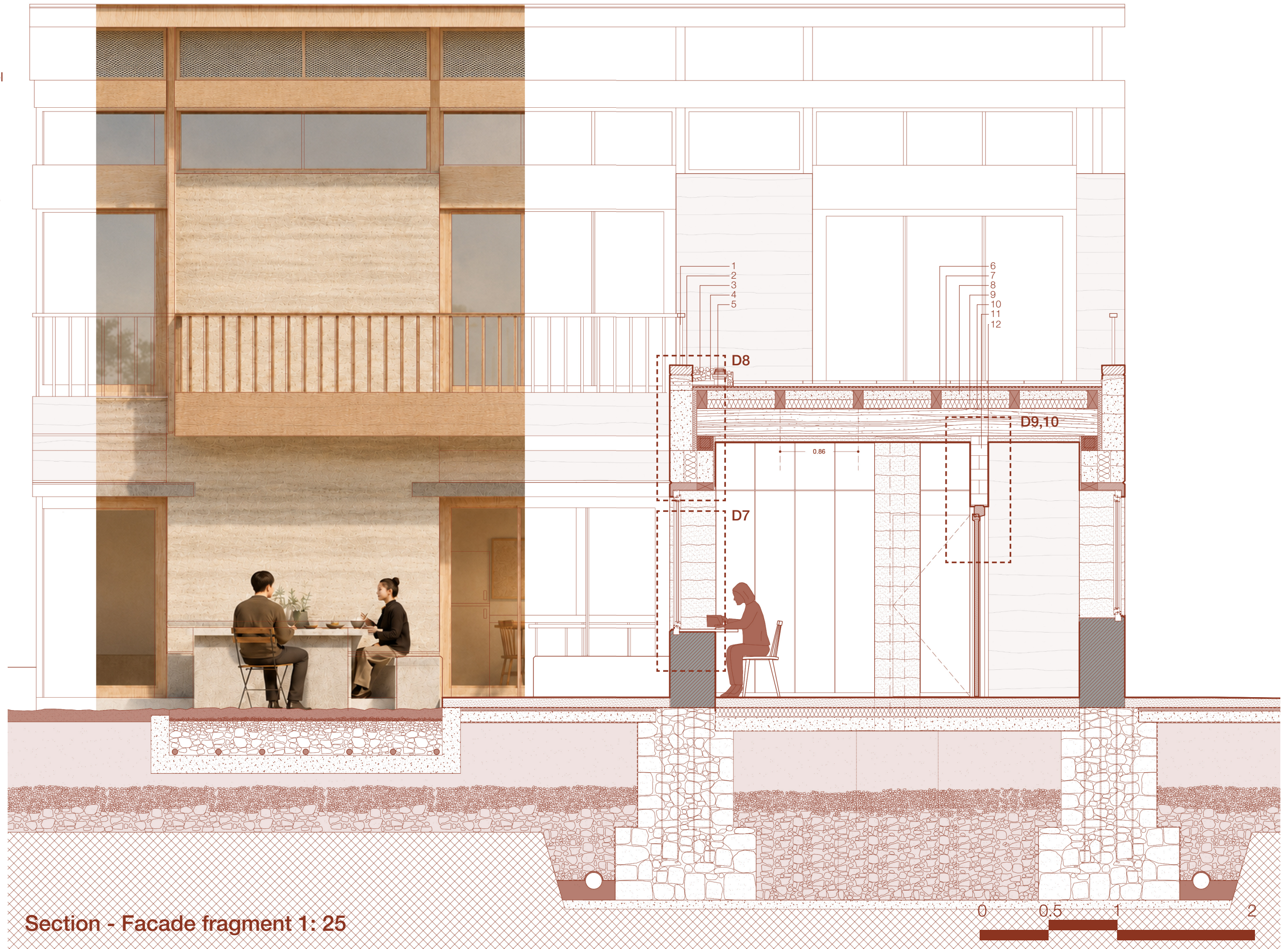


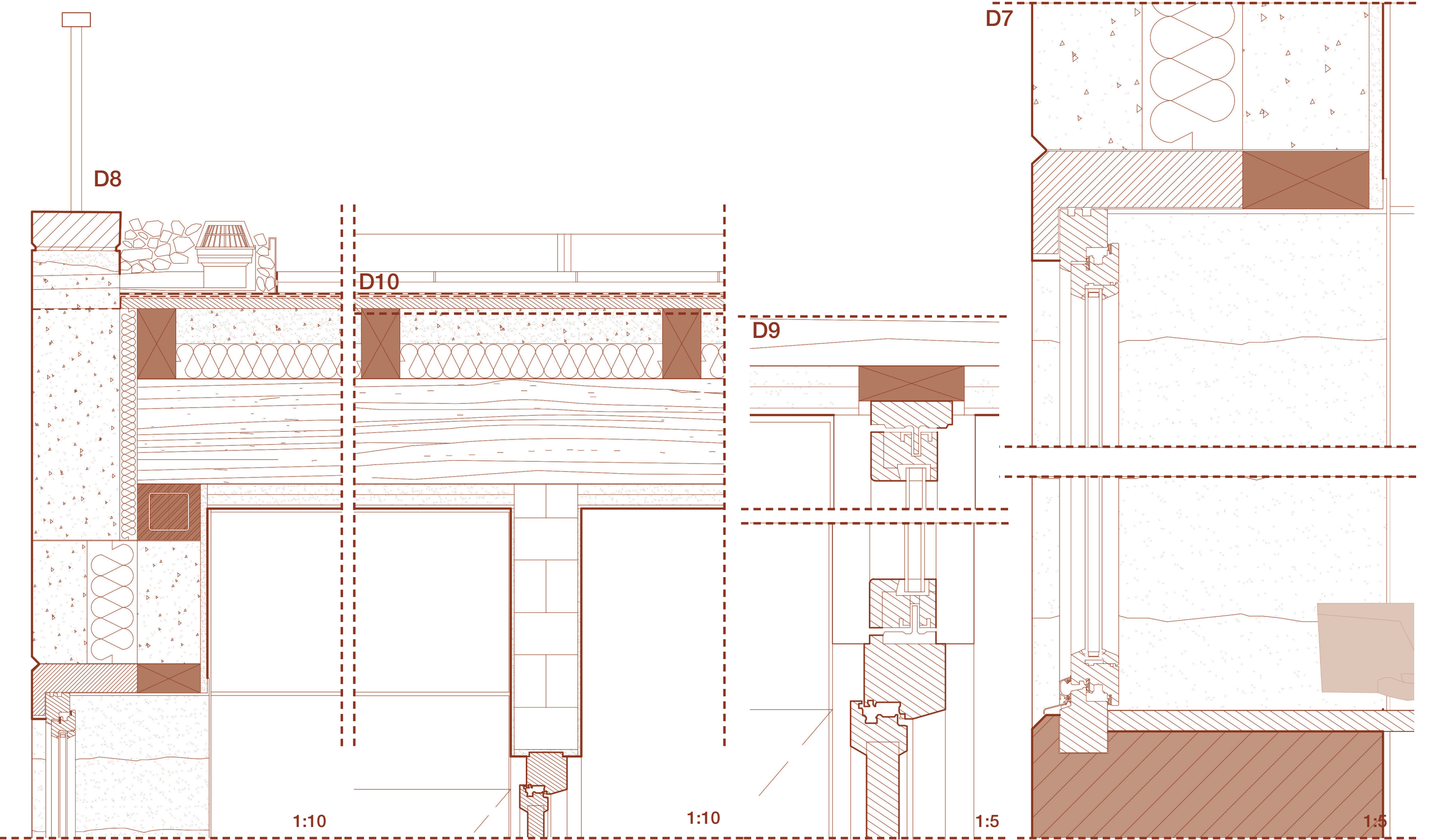
1:10

D4. Desalination tank glass cover on r.e.



1. Wooden rail
2. Stone crown with 2% inclination +lime based binder+ In situ fabricated r.e.
3. Crushed volcanic gravel filling
4. Gutter for rain water collection
5. OSB board with water-proof membrane 2.5cm
6. Low fired mud tile covering 4cm
7. Damp-proof membrane
8. R.E. prefab panels
9. Cork insulation
10. Vapor membrane
11. CEB wall 20cm
12. Clay undercoat and finish plaster

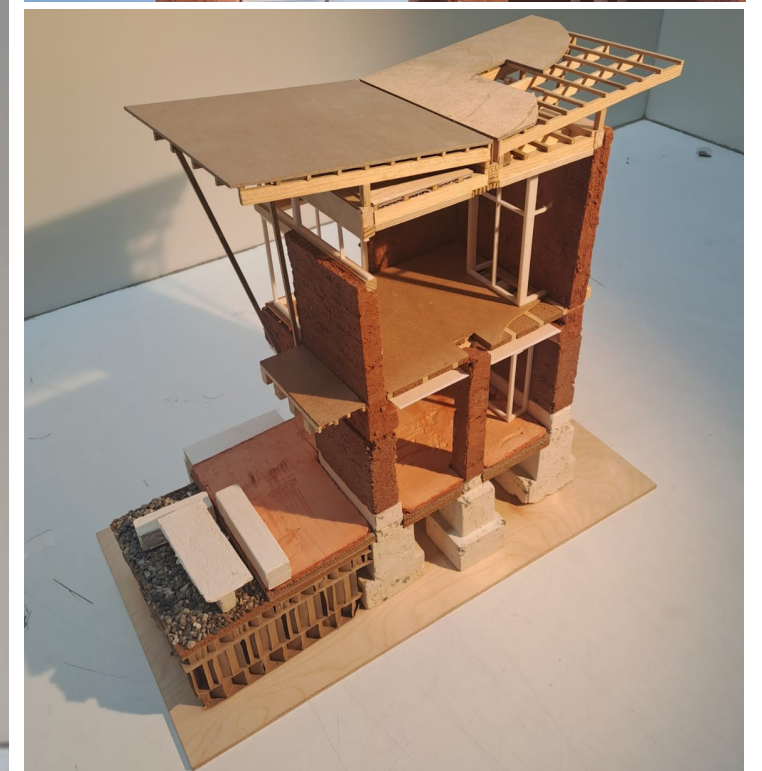
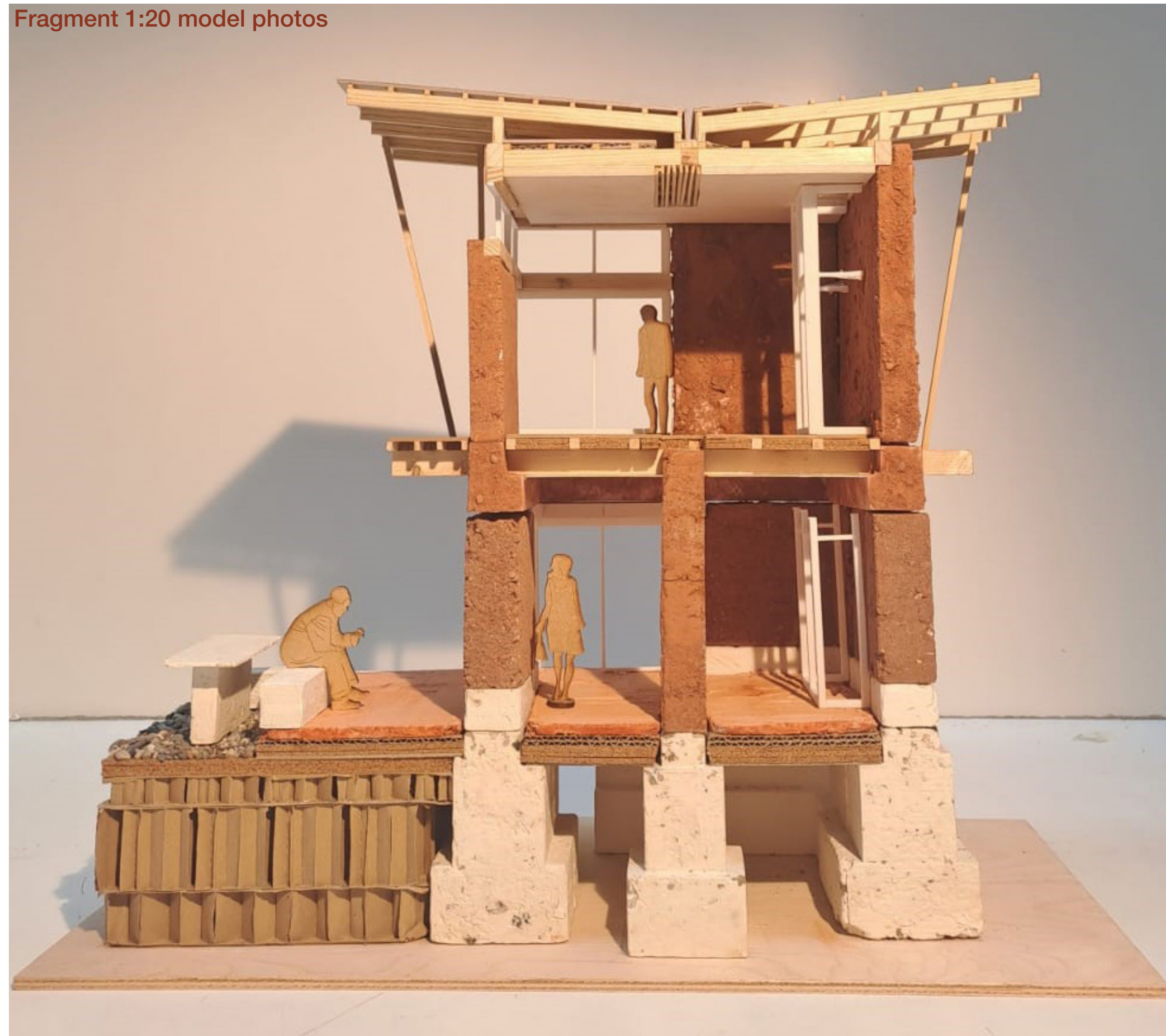






Fragment 1:20 model photos

Fragment 1:20 model photos

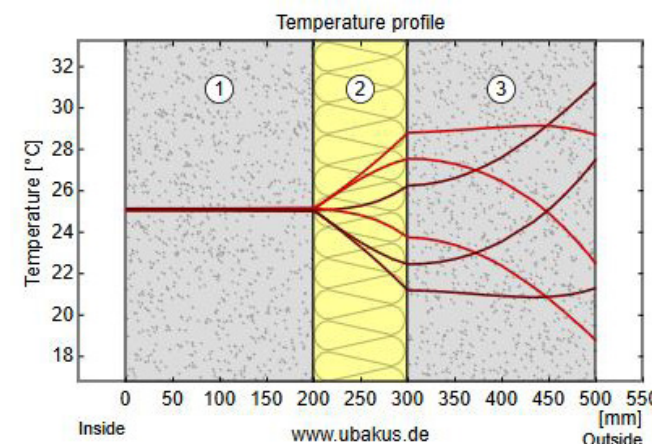
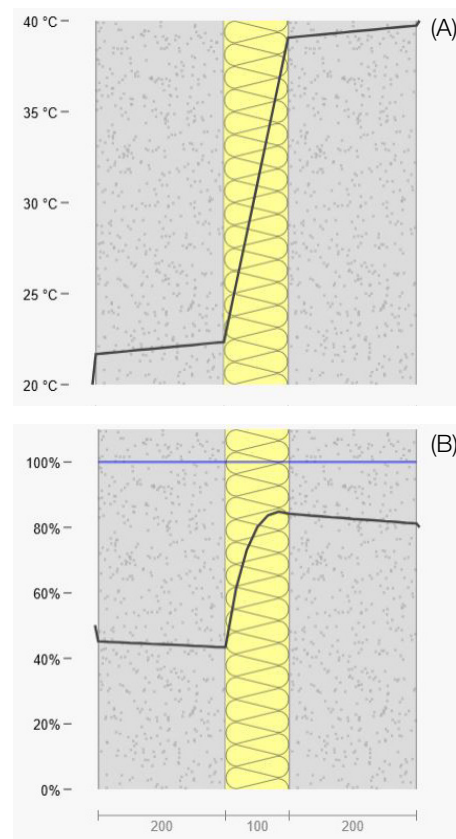


Climate

Passive climatic strategies play a fundamental role in the operation of the residence. The orientation minimizes harsh western solar exposure while maximizing daylight from the east and south. On the western side, a double-layered buffer zone functions as a solar chimney and ventilation corridor. Vertical openings and skylights allow warm air to rise and escape while supporting cross ventilation throughout the interior spaces.

The primary construction material is rammed earth, used mainly for the exterior walls due to its thermal mass properties and fire resistance. The thick earth-en walls absorb heat during the day and slowly release it during the night, stabilizing indoor temperatures and reducing the need for mechanical cooling. Because the material is locally sourced from the site excavation, it also significantly reduces transportation emissions and embodied carbon.

In the graphs below, it is visible that a masonry consisting of rammed earth and cork insulation can reduce the temperature inside the residence even from 40 °C to 22 °C (graph A) and the relative humidity from 80 % outdoors to 48% indoors (graph B), while keeping the temperature stable throughout the day and the night (graph C).

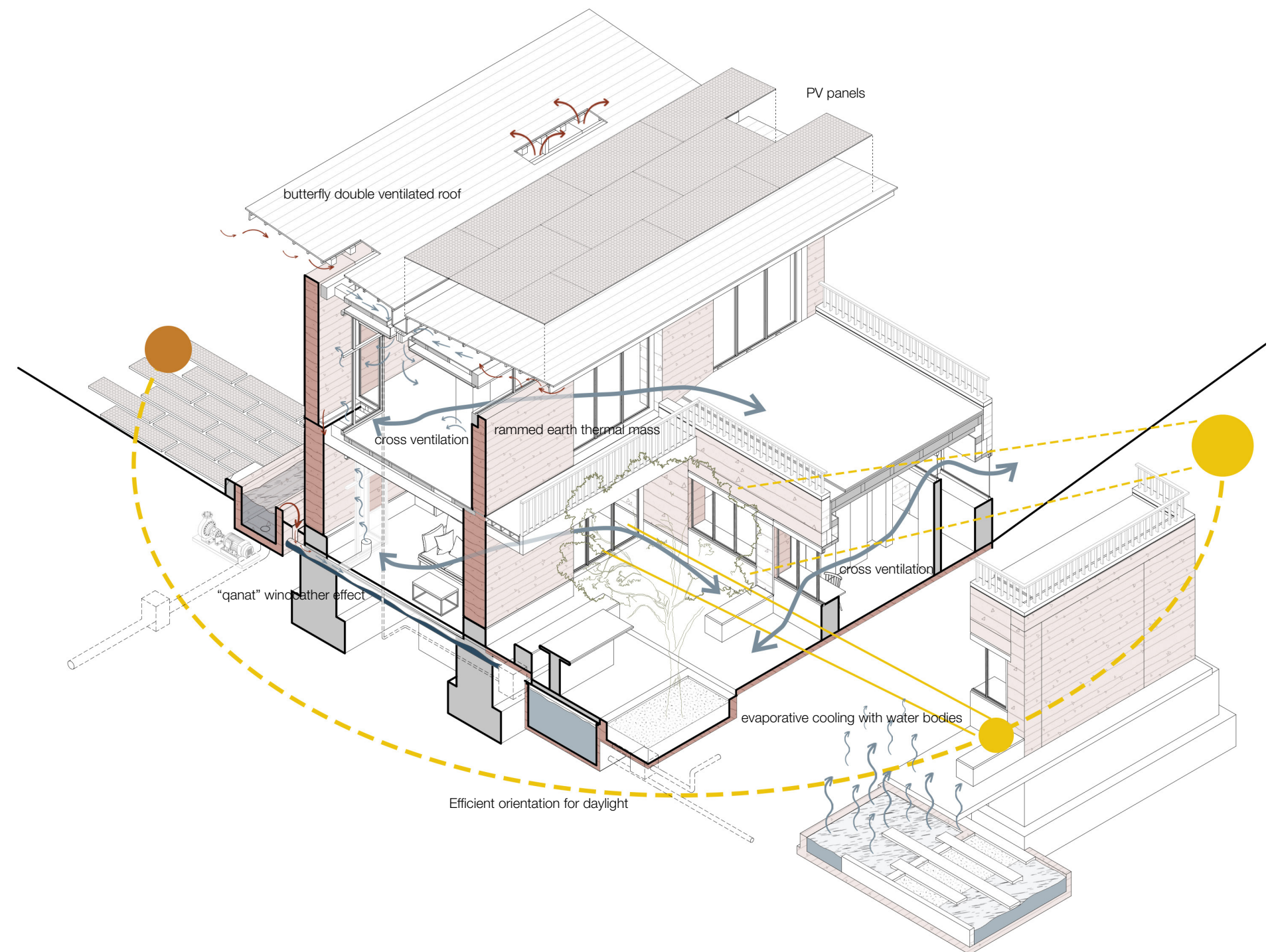


The courtyards further enhance thermal comfort through vegetation and water integration. Shallow water bodies connected to the desalination infrastructure cool the surrounding air through evaporation, while deciduous drought-resistant trees filter sunlight seasonally. During summer, dense foliage creates shaded microclimates, whereas in winter the loss of leaves allows sunlight to penetrate deeper into the spaces.

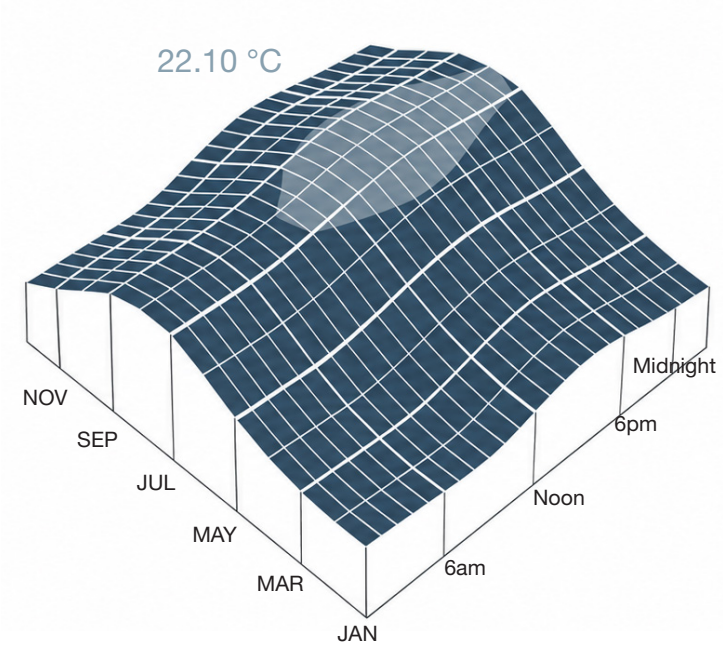
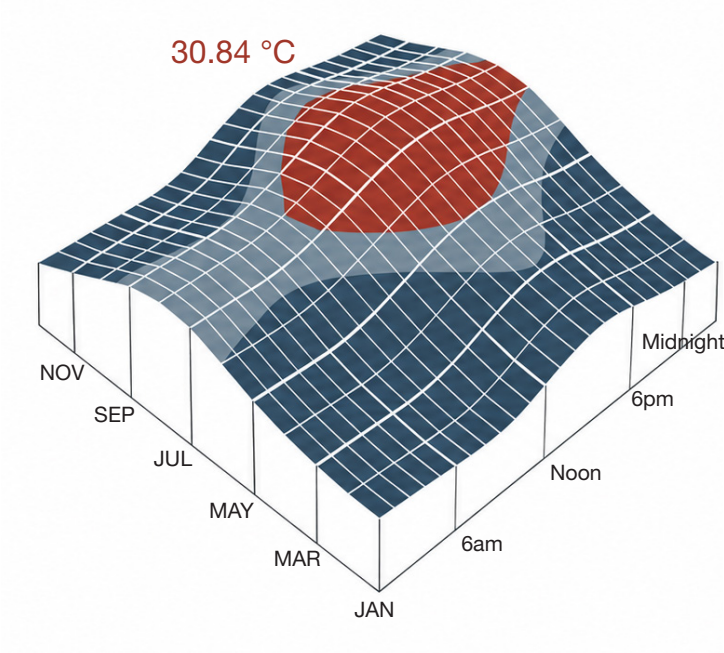
The project also incorporates reinterpretations of traditional Middle Eastern windcatcher and qanat systems. Vertical ventilation shafts combined with underground cooled water channels guide fresh

air into the interiors. As hot external air passes through the cooled underground infrastructure, its temperature decreases before entering the living spaces through the vertical columns integrated into the walls. Through this method the air temperature can decrease up to 8 °C.

The roof system operates as an additional climatic device. A double Venturi roof creates accelerated airflow between roof layers, reducing heat accumulation and enhancing passive cooling. Simultaneously, the roof collects rainwater and contributes to the overall water management system of the settlement.



Through the integration of these strategies, the residence becomes more than a shelter. It operates as a climatic mediator capable of regulating temperature, airflow, humidity, and social interaction while remaining deeply connected to the materiality and environmental conditions of the Mediterranean landscape.



Conclusions | Reflections

Conclusions

This thesis set out to investigate how a place-responsive modular architectural system, grounded in earthen materiality and a layered water infrastructure, can enhance climate resilience in Mediterranean coastal settlements facing increasing water scarcity and wildfire risk. Through the case study of Almería, Spain, the research explored the potential of architecture to move beyond its traditional role as a passive shelter and instead operate as an active environmental system capable of managing resources, regulating climate, and supporting resilient forms of habitation. The project demonstrated that the challenges of climate change cannot be addressed through isolated architectural interventions alone. Water scarcity, wildfire vulnerability, material extraction, food production, habitation, and social resilience are deeply interconnected systems that influence one another. As a result, the proposal adopted a layered approach in which architecture, landscape, infrastructure, and community operate together rather than independently. This integrated perspective became one of the most significant findings of the project.

The research showed that water can function not only as a resource but also as a spatial and climatic generator. Through the combination of solar desalination, reverse osmosis desalination, underground storage, water reuse, and evaporative cooling strategies, the water system contributes simultaneously to resource autonomy, thermal comfort, landscape regeneration, and social life. Rather than remaining hidden underground, water becomes visible within the courtyards and public spaces, strengthening both environmental performance and the identity of the settlement.

Similarly, the investigation into earthen construction revealed the potential of locally sourced materials to contribute to climate adaptation. Rammed earth provides high thermal mass, fire resistance, low embodied carbon, and a strong relationship between architecture and place. By linking excavation for water infrastructure with the harvesting of construction material, the proposal

establishes a circular relationship between landscape and building, reducing dependence on external resources while reinforcing local identity. The exploration of stabilized and prefabricated rammed earth further suggests opportunities for combining traditional knowledge with contemporary construction methods.

The project also demonstrated the continued relevance of Mediterranean vernacular architecture. Courtyards, transitional spaces, thermal mass, windcatchers, and climate-responsive orientation are not merely historical precedents but valuable environmental strategies that can inform future design. Through their reinterpretation within a modular framework, these principles contribute to a settlement capable of adapting to both current and future climatic conditions.

Beyond the architectural object itself, the thesis proposes a broader way of thinking about settlement design. The proposed intervention is not conceived as a collection of buildings but as a living environmental organism, where water systems, material cycles, vegetation, landscape, and social life are interconnected. In this sense, resilience is understood not as resistance to change but as the capacity of a system to adapt, evolve, and continue functioning under environmental stress.

Ultimately, the project suggests that the future of Mediterranean coastal settlements may depend on a renewed relationship between architecture and local resources. By integrating water infrastructure, earthen construction, passive climatic strategies, and community-oriented spatial organization, the proposal offers a model for habitation that is simultaneously environmental, social, and territorial. While developed for the specific context of Almería, the underlying principles are transferable to other Mediterranean regions, provided that they are adapted to local climatic, cultural, and material conditions.

Rather than proposing a universal solution, this thesis advocates for an architecture that learns from its context, works with natural systems, and embraces resource limitations as opportunities

for innovation. In doing so, it argues that climate adaptation should not be considered an additional layer applied to architecture, but rather the foundation from which architecture is conceived. The settlement therefore becomes not only a response to climate change, but a framework for imagining new ways of living within the environmental realities of the Mediterranean future.

Reflection on the project

Looking back on the project, one of the most valuable aspects of the process was the opportunity to work simultaneously across three different scales: the territorial scale of the site, the architectural scale of the settlement and buildings, and the tectonic scale of materials and construction details. Initially, this approach was challenging, as it required constant movement between large-scale strategic decisions and small-scale technical considerations. However, over time I realized that designing across these scales creates a stronger and more coherent project, where environmental performance, spatial quality, and construction logic are interconnected rather than treated as separate design problems.

Throughout the project, a personal hierarchy of priorities gradually emerged. The first priority became the creation of a site-specific settlement that responds directly to its environmental context. The second was the ambition to create healthier, safer, and more enjoyable living environments that enhance everyday experiences and social interaction. The third priority was expandability and adaptability, ensuring that the proposal could evolve over time rather than remain a fixed architectural object. Although the project focuses primarily on water scarcity, wildfire resilience, and earthen construction, an interesting future direction would be to explore its relationship with the agricultural landscape of Almería in greater depth. The region produces a significant amount of agricultural waste and organic by-products, which could potentially be integrated into future material research, construction systems, or circular resource cycles. Expanding the project in this direction could strengthen the relationship between habitation, agriculture, and resource

management. Returning to the original intention of investigating multiple Mediterranean contexts, including Almería, Crete, and Faro, one important realization was that these territories share many common challenges while simultaneously requiring different architectural responses. Water scarcity, climate change, and environmental vulnerability are present in all three cases, yet differences in topography, vegetation, humidity, material availability, and cultural landscapes produce distinct design conditions. This led to the understanding that the proposal should not be considered a fixed settlement prototype, but rather a place-responsive environmental framework. Future research could further investigate how the same principles could be adapted to other Mediterranean territories through comparative studies and context-specific modifications.

One of the most important questions that remains concerns the limits of expansion. The project is intentionally based on local resources, particularly soil and water. While this creates a strong circular relationship between landscape and construction, it also raises the question of scalability. In my view, the settlement should not expand indefinitely. Its growth should remain tied to the carrying capacity of the site and the availability of local resources. If the extraction of earth, the consumption of water, or the occupation of land begins to generate a greater environmental impact than the resources it saves, then the settlement would lose the very principles that justify its existence.

From an architectural perspective, this suggests that future expansion should occur through a network of smaller settlements rather than the continuous growth of a single large one. Such an approach would maintain a close relationship between communities and their landscapes while reducing pressure on local ecosystems. Spatially, expansion should follow the logic of the terrain, allowing the settlement to grow incrementally through additional clusters rather than through large-scale interventions that transform the landscape. In this way, the project remains consistent with its original ambition: to create an architecture that works with environmental systems rather than against them.

Bibliography

- Achenza, M., & Fenu, N. (2006). On earth stabilization with natural pozzolans and lime. *Construction Materials Journal*, 12(4), 55–67.
- Addington, D. M., & Schodek, D. L. (2005). *Smart materials and technologies for the architecture and design professions*. Architectural Press.
- Correia, M., Carlos, G., & Rocha, S. (2014). *Vernacular heritage and earthen architecture: Contributions for sustainable development*. CRC Press.
- European Environment Agency. (2020). *State of the environment report 2020*. Publications Office of the European Union.
- Fathy, H. (1986). *Natural energy and vernacular architecture: Principles and examples with reference to hot arid climates*. University of Chicago Press.
- Frampton, K. (1983). Towards a critical regionalism: Six points for an architecture of resistance. In H. Foster (Ed.), *The anti-aesthetic: Essays on postmodern culture* (pp. 16–30). Bay Press.
- Heathcote, K. (1995). Durability of earthwall buildings. *Construction and Building Materials*, 9(3), 185–189. [https://doi.org/10.1016/0950-0618\(95\)00021-6](https://doi.org/10.1016/0950-0618(95)00021-6)
- Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- Kim, D. Y. (2019). A design methodology using prototyping based on the digital–physical models in the architectural design process. *Sustainability*, 11(16), 4416. <https://doi.org/10.3390/su11164416>
- Laborel-Préneron, A., Aubert, J. E., Magniont, C., & Tribout, C. (2018). Characterization of earthen materials for construction: Thermal and fire performance. *Construction and Building Materials*, 172, 650–662. <https://doi.org/10.1016/j.conbuildmat.2018.03.183>
- Mileto, C., Vegas, F., Cristini, V., & García-Soriano, L. (2018). *Rammed earth conservation*. CRC Press.
- Minke, G. (2006). *Building with earth: Design and technology of a sustainable architecture* (2nd ed.). Birkhäuser.
- Norberg-Schulz, C. (1980). *Genius loci: Towards a phenomenology of architecture*. Rizzoli.
- Oliver, P. (2006). *Built to meet needs: Cultural issues in vernacular architecture*. Architectural Press.
- Pomponi, F., & Moncaster, A. (2017). Embodied carbon in buildings: A review. *Energy and Buildings*, 143, 220–234. <https://doi.org/10.1016/j.enbuild.2017.03.060>
- Rudofsky, B. (1964). *Architecture without architects: A short introduction to non-pedigreed architecture*. Museum of Modern Art.
- United Nations Environment Programme. (2023). *Mediterranean climate change adaptation report*. UNEP.
- van den Hurk, B., Klein Tank, A., Lenderink, G., van Ulden, A., van Oldenborgh, G. J., Katsman, C., Hazeleger, W., et al. (2014). *KNMI climate change scenarios*. Royal Netherlands Meteorological Institute.

AI Use Declaration

Artificial Intelligence (AI) tools were used during the development of this thesis as supportive instruments for language refinement, text editing, visualization assistance, and the exploration of literature. All research, critical analysis, design decisions, drawings, conclusions, and final content remain the author’s own work and responsibility. AI-generated outputs were reviewed, evaluated, and adapted where necessary to ensure their accuracy, relevance, and consistency with the objectives of the project.