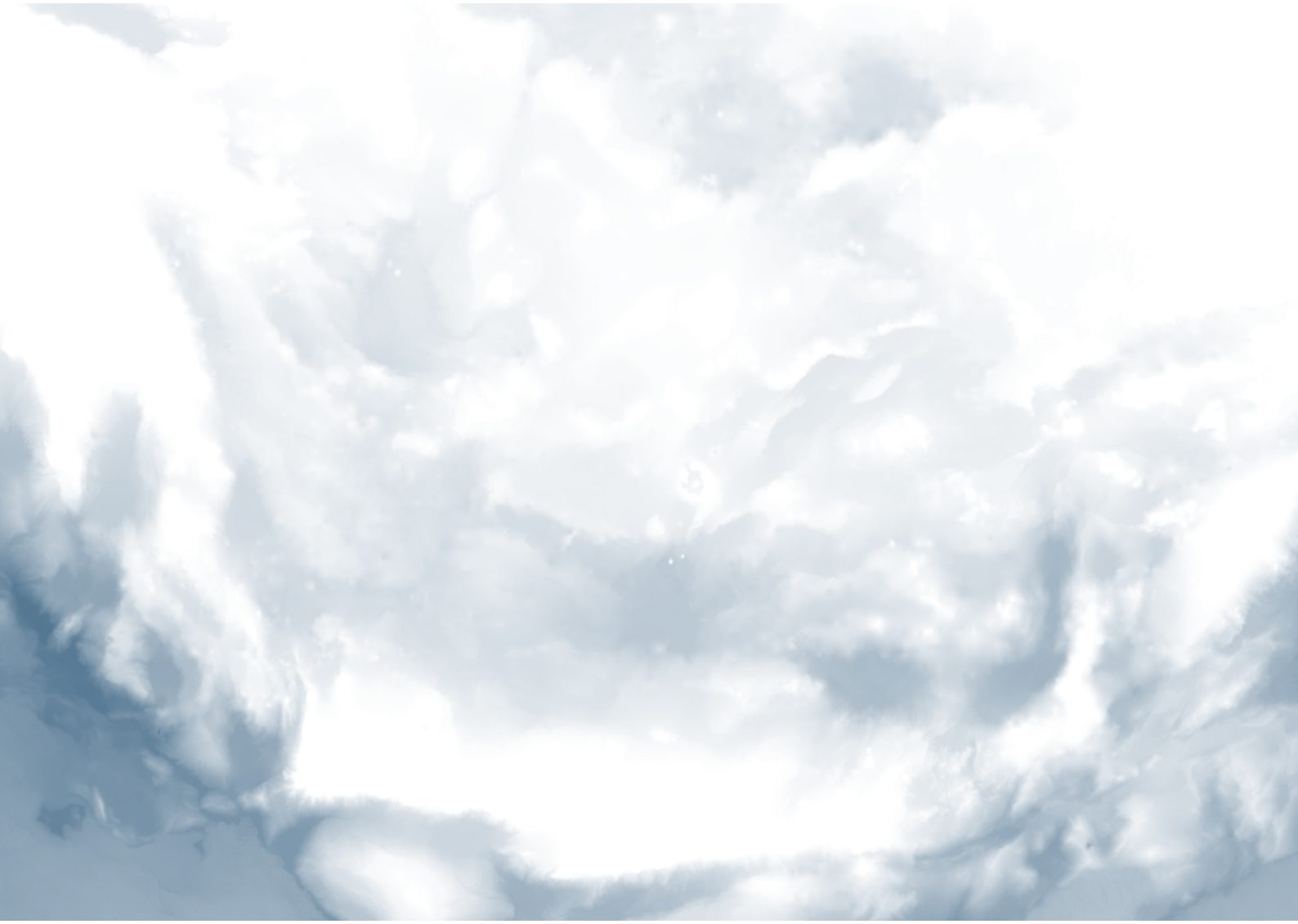

bound by water, limited by land
rethinking the metabolism of tourism-transformed island territories in South Aegean, Greece

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Colofon

Master thesis P5 report
June 2025

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rethinking the metabolism of tourism-transformed island territories in South Aegean

MSc Architecture, Urbanism and Building Sciences | Track Urbanism
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2024/2025: Graduation Lab

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Altered Nature. Poetics of Change

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Figure 1. Bathymetry of the Cyclades archipelago

Figure 2. View from Kamari, Santorini towards Anafi island, January 2025

Abstract

Islands exist in geographical isolation, with limited natural resources, and surrounded by the vastness of the sea. However, their metabolic profiles are often shaped by fluctuating socio-economic systems shaped by international tourism influxes, creating circular pressure on already strained domestic socio-ecological systems. The relationship between tourism and metabolism has led to their development as import-oriented systems, highly reliant on external regions and broad infrastructuralization. The transition from agropastoralism to a service economy hyper-connected the area with the world but created local disconnections, with the imports- and infrastructure-based systems providing an illusion that resources are infinite, disclosing the complications of limitless growth.

The project addresses these challenges by examining the Cyclades at the local, regional, and global scale, appropriate to the various scales of metabolic flows. By adopting a multi-scalar approach to exploring island metabolism, it examines the notion of urban metabolism through its spatial footprint. Using islands as the tool for experimental conceptualization highlights the burden of infinite development by shedding light on the hidden metabolism that supports life in such geographies. The methodology includes examining historical transitions, mapping metabolic dependencies, exploring projective metabolic capacities of the islands, and proposing an alternative organizational structure and a cross-scalar design approach for landscape-based interventions.

Centering on the Cyclades archipelago and the Santorini island complex, the project investigates the impacts of seasonal tourism on island metabolism and the landscape's role in rethinking the metabolic systems. Given the insufficiency of state policy in addressing the challenges, this proposal aims to shift the dynamics by exploring an imaginary through which metabolism-related activities could indirectly control tourism.

In this context, the project proposes the restoration, reactivation, adaptation, transformation, or addition of metabolic structures to revitalize dormant landscapes, promote inter-island collaboration, and blend production with consumption zones. The findings highlight the aftermath of dependency on a seasonal tourism economy and a fully outsourced or infrastructuralized metabolism. Rather than offering fixed solutions, it proposes adaptable structures that could initiate the change, aiming to raise awareness about scarcity and the need for behavioral change. By looking at the landscape as infrastructure, inspired by its past function, the project proposes the full utilization of it as part of the island metabolism, incorporating aspects of situated and artisanal knowledge, commoning, and care as an alternative to current carrying capacity assessments. Through spatial prototypes, it aims to elaborate further on these structures and their manifestation in space, emphasizing that the system is flexible and can be partially or fully adapted.

Overall, it highlights the potential of reactivating currently dormant but previously operationalized landscapes, fostering archipelago collaboration, and embracing the biospheric systems as active players in shaping flexible metabolisms.

keywords: island archipelago, island metabolism, grounding metabolism, carrying capacity, landscape as infrastructure, system of care

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Nikos for his constant encouragement and support, along with his critical questions that challenged the project's directions by challenging my broader understanding of urban metabolism in its situated form and its interactions with tourism, always emphasizing the logic of every decision. Luca, for constantly challenging me and believing in me, even when I was doubting. His creative contributions, suggestions, and trust in my methods and capacities. I am grateful for having them as my mentors during this big personal and academic challenge. Their theoretical, conceptual and methodological contributions constantly pushed me to reflect on my goals, rethink and think deeper and broader, broadening this project to directions that made it more than "a project about my island region" and understand its importance in a larger context.

I am also deeply grateful to Michalis and his son, Lefteris, for opening their home and hearts to me and sharing their lifestyles and struggles when it comes to working in the agricultural sector on an island like Santorini, to Dionisis and Manolis for their insights and discussions about life on the island and their employment, and my friend Ioanna for being my fieldwork buddy.

On a more personal level, I am grateful to my oldest friend, Ioanna, for her support and discussions, and my newest ones for the duck memes, the collaborative environment, and the fun. My sincere gratitude to my mum, who became my real-time reporter on the site, my dad and aunt for sharing their insights on the infrastructure of the island, now and in the past, my grandma for her knitting advice, and to my two partners in life, human and more than human, who accompanied and supported me along this journey.

Figure 3. Fieldwork

“any island, any islander, is a contradiction between ‘here’ and ‘there’,

gripped by negotiating the anxious balance between roots and routes;

like the body, both sustained and yet threatened by incursion”

G. Baldacchino, 2006

Figure 4. Winter hobbies, January 2025

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Figure 5. My winter neighborhood

Figure 6. My summer neighborhood

Motivation

Personal

Being from an island myself, I have experienced firsthand the seasonality and the transformation that tourism has brought to my island, Santorini. Growing up, I witnessed an empty, under-repair island during the winter and a "tourism frenzy" during the summer. I lived in different neighborhoods, as the tourism business was by the sea, while the permanent residence was located further inland. I experienced water shortages, energy blackouts, but never questioned why. I never thought about issues of metabolism—only about what felt different. For me, that difference was the changing landscape. Tourism was creating urban sprawl, and the material stock of the island kept growing, encroaching on my playfields. During my bachelor's studies, I began exploring these challenges, but through this graduation project, I am delving deeply into the realities and transformations of the island.

Academic

Islands are unique geographies due to their constrained land capacities and fluctuating economies. Some island regions are also driven international tourist influxes. These dynamics shape import-oriented systems that are heavily dependent on external regions and supply chains. Their susceptibility is exacerbated by "maladaptive practices," such as reliance on imports for basic needs and coastal squeeze (Singh et al., 2020). Particularly in the context of sustainability transitions and climate change, such practices increase metabolic risks, making these systems vulnerable to disruptions.
Greek islands, the broader case study for this project, are deeply interconnected with the mainland and global networks, revealing a relationship marked by dependency and vulnerability. These islands tend to urbanize rapidly due to constant economic development and hyper-connectivity to global networks of flows and capital. The South Aegean islands, especially the Cyclades archipelago, exemplify this urbanization. As a result, rapid development and its fluctuating demands challenge the ecological value of these areas, alter their landscapes, and test the limits of local systems.

1. Introduction

Introduction

Islands have hard and well-defined boundaries and have, by nature, an intimate domestic quality that can create space for "radical difference" (Callejas & LCLA Office, 2012). The insularity embodied in their geography is causing significant limitations to their communities (Pitoglou, 2017) and, as a consequence, their economies. This has been overcome partially by infrastructural development that supports proper accessibility of people and goods to such areas. However, this reliance on external resources and infrastructure often creates a perception of infinite growth while straining local socio-ecological systems.

> "an island is a device in which you can make a room-sized landscape…they behave as platforms to enjoy the vast space that separates them"
> - (Callejas & LCLA Office, 2012) p.43

Greece has a long tradition in the hospitality sector due to its history, location, geomorphology, and an archipelago of more than 2.500 islands (Buhalis, 1999). Tourism has grown and is a crucial contributor and "vital motivator" of the Greek economy (Buhalis, 1999), accounting for 13% of the national GDP in 2024 (INSETE, 2025). Additionally, in an analysis from 2000 to 2019, the Cyclades had a higher GDP than the highest performance compared with other island regions in Greece (EETAA, 2023).

For the Cyclades archipelago tourism emerged in the beginning of the 20th century, with the tourism infrastructure that now attracts visits from all around the globe, being absent (Tsartas, 1992) (Pitoglou, 2017). With the gradual infrastructural development, including six airports, and other geopolitical and economic events in other destinations, the tourism flow towards the Cyclades was reinforced (Pitoglou, 2017). Tourism's initial form was connected to the appreciation of the landscape and the co-existence of humans and more than humans. The current form has a destructive character, that of mass tourism, and has had an extensive impact on the alteration of the islands' landscape and economic profile. The socio-cultural transformation is also extensive, with traditional industries disappearing (Pitoglou, 2017) and the primary sectors shrinking. Gradually, the archipelago started to urbanize, with some islands taking the lead. Different policies, historic events, and other events led to a different chronological development of each island's tourism sector (Pitoglou, 2017). Nowadays, the islands are moving at "different speeds" (Kafouros, 2025) with different capacities of tourism facilities and infrastructure.

The Cyclades islands are a case of geographical isolation, limited resources, overreliance on seasonal tourism, and hyperconnection to global nerworks. Since the development paradigms have proven insufficient and often detached from the local context, it proposed a situated, bottom-up approach for carrying capacity assessment and community awareness. Current policies often consider the landscape as static and endlessly accommodating by focusing on expanding the systems' carrying capacities rather than controlling the growth. The project addresses challenges related to limitless growth by analyzing the relationship between tourism and island metabolism by using landscape as a lens. By investigating island metabolism as a spatial phenomenon, it uses the Cyclades and the Santorini complex as a case study to explore landscape-based strategies that can support a new spatial logic for the co-existence of tourism with the islands' landscapes, communities, and ecological system.

To unpack the points mentioned above and dive further into them, the project is structured across nine chapters. Starting with the personal motivation and the framing of the research scope and initial problematization in chapters 1 and 2. Chapter 3 focuses on the methodology followed to conduct the project as well as the different methods included in the process. Chapter 4 explores fictional scenarios for the future, based on a conversation between tourism and island metabolism, to highlight the limitations of the model and critique current planning approaches. Chapter 5 presents a thorough analysis of the case study, focusing on island metabolism and its spatial manifestations. Chapter 6 unpacks an elaborate multiscalar vision for the area, and Chapter 7 elaborates on some "proof-of-concept" experimentation through exemplary spatial prototypes. The report closes with the conclusion, reflections, bibliography, and appendix.

Figure 7. From global to local

Visitors

- Core tourism markets
- Secondary tourism markets
- Tertiary tourism markets
- Emerging markets

global

Mikrónisos
Antimilos
Milos
Kimolos
Polyegos
Kythnos
Serifos
Sifnos
Gyaros (Gioura)
Andros
Syros
Tinos
Rinia
Mykonos
Folegandros
Sikinos
Ios
Thirasia
Thira (Santorini)
Irádeia
Schoinoussa
Kato Koufonisi
Ano Koufonisi
Keros
Amorgos
Donousa
Despotiko
Antiparos
Paros
Naxos

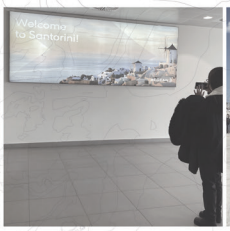
regional

50km
0

Global and local connections

- port
- international aiport
- national airport


landing



arrivals


airport


ocean

ferry

local

2. Problematization

2.1 Problem field
2.2 Problem statement
2.3 Research question and sub-questions
2.4 Hypothesis
2.5 Theoretical framework

2.1 Problem field

Sustainability transitions in tourism-transformed island regions face significant challenges due to tourism's disruptive nature, its transformative power, and the delineated geography of islands. Seasonal tourism, while driving international arrivals and economic activity, often leads to mono-functional economic models characterized by high dependency on global and regional networks and infrastructural development. This reliance exacerbates infrastructuralization and usually prioritizes short-term solutions and financial gains over long-term visions. As a result, island territories suffer from urban-like challenges, such as waste accumulation, environmental degradation, and cultural identity loss. These challenges are intensified by geography-related vulnerabilities, including rising sea levels, extreme weather events, coastal erosion, and saltwater intrusion, that reveal the fragile relationship between islands and their natural resources as tourism intensifies pressure on finite resources and their domestic socio-ecological systems.

At the same time, the urgency for such transitions and challenging models based on limitless growth has become paramount. Frameworks like the European Green Deal and the 2030 Agenda for Sustainable Development emphasize climate action, emissions reduction, circular economy principles, electrification, climate neutrality, and localized production. Pathways that could mitigate the environmental and infrastructural pressures induced by tourism. However, achieving meaningful, long-term change requires balancing tourism-driven development with site-specific, resource-efficient strategies that respect and engage local capacities and knowledge to promote alternative activities. Without intervening, the "consumption" of land and resources, that sometimes provides an illusion of abundance, will continue to threatenen the long-term resilience of island regions. This underscores the urgency for integrating adaptive and place-based approaches to inform planning and design for such transitions.

2.2 Problem statement

The South Aegean, and particularly the Cyclades archipelago, has undergone a major transformation due to the emergence of tourism, which arrives seasonally each year, disrupts the islands' systems, and highlights the interconnectedness of tourism influx and resource consumption in territories with limited capacities due to their delineated geography.

Focusing specifically on the Santorini complex, the island transitioned from having a closed, situated metabolism to an economy highly dependent on imports, to support its emerging tourism sector and the substantial resource demands. This balance was disrupted when tourism grew during a period of economic decline and societal vulnerability, exacerbated by events like the earthquakes of the 1950s. Gradually, this shift led to the complete substitution of other land uses that had previously sustained the local metabolism.
In fact, without the current building regulation that are in place, the entire island could potentially be developed, since no other land use is competitive enough to resist the dominance of "luxury" clustering.

A. Islandness and sustainability transition

Island systems have unique geomorphological characteristics. They are delineated geographies, isolated geographically with limited land and resources capacities. These conditions position them as "special focal points for sustainability challenges" (Noll et al., 2022). Islands are excessively affected by climate change, heavily depend on fossil fuels, and face resource and space scarcity, economic dependency on tourism, seasonal pressure, and other challenges.

This is why the implementation of many EU directives on islands can often face obstacles. Limited capacities and infrastructure, logistical challenges, difficulties in accessing materials or advanced technologies, and usually insufficient governance capacity often delay their ability to fully follow such directives.

B. Fluctuated metabolism, import-oriented system and infrastructure

The metabolic systems of islands are under high pressure due to the seasonal activities of tourism, requiring them to accommodate extreme demands every year.
The growing resource needs of islands led the development of connectivity networks and import relationships with the mainland. Over time, the metabolism became detached from the land and landscape, creating an inverted city-hinterland relationship, where islands function as cities and mainland serves as their hinterland. In a way, all Cyclades share a common hinterland, but their hinterland is no longer their own land.

C. Infrastructuralization, landscape and tourism

As tourism-related development rises, additional infrastructure is required to meet the needs of both local community and visitors. Therefore, the islands by gradually displacing "less competitive" and profitable land uses, are ultimately being composed by tourism clusters that continue to sprawl and the infrastructure that needs to be developed to support their function. However, an aspect that is often overlooked is the lasting impact of infrastructure on the landscape.

D. Carrying capacity and planning paradigm

Planning for the Greek islands is currently high on the government's agenda but is also a very controversial topic which has sparked a lot of debate lately. However, these debates have their limitations.

On one hand, preserving the cultural landscape's identity as it was in the past and keep it in a "museum-like" state is unrealistic for the current needs. On the other hand, there is the growing push for infrastructuralization, supporting the need to increase the island's carrying with more infrastructure development.

Both approaches have limitations. The "preserving" mindset has its limits, as does the idea of infrastructural growth. It is important to consider that, on the one side these landscapes are largely anthropogenic, and in the past they were fully utilized to support the local metabolism. On the other side, massive infrastructural projects have their limitations. When discussing about carrying capacity we should consider that the landscape's identity and value have their own capacities too.

E. Regulatory apparatus

Over the years, there have been policies that were conceived as means that would be able to manage and control urban sprawl but have been proved to be inefficient. The planning apparatus is struggling to keep up with the growing dynamics, failing to respond to the demands and challenges resulting in unchecked infrastructural growth, resource mismanagement, water scarcity, waste accumulation, and excessive construction.

F. Competition and island mentality

The communities of the islands tend to have a selective mindset, and between the islands competition prevails. What the Cyclades archipelago islands share is their geography and the fluctuations in their metabolisms due to population influx. While there are some administrative and service-related connections, there is no truly fruitful relationship taking place.

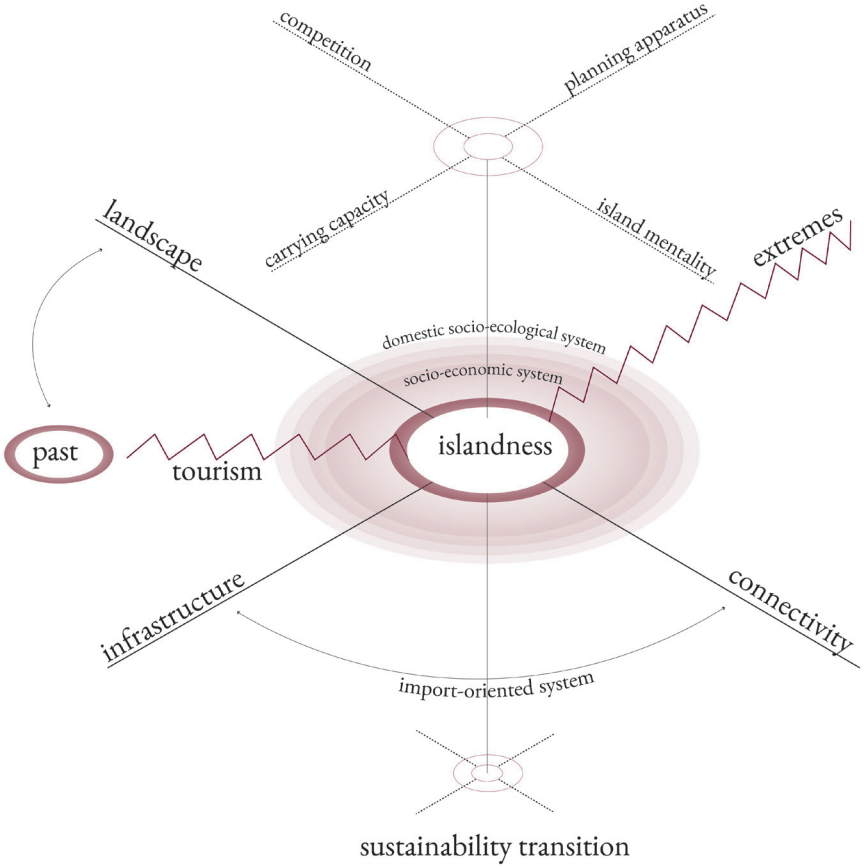


Figure 8. Problem statement outline

2.3 Research question and sub-questions

How can tourism-dependent island territories of the Cyclades archipelago re-think their metabolic systems and carrying capacity through alternative design paradigms to address fluctuating resource demands while re-inventing the landscape's identity ?

	A. Island metabolism and archipelago	B. Infrastructure and landscape
analysis	A1. What are the challenges islands are facing due to their spatial-geographical features and the current planning apparatus?	B1. What are the limitations of current planning approaches that relate to extended infrastructuralization, cultural preservation and artisanal knowledge?
	A2. How have the islands' metabolic systems changed throughout the years to support the emergence of tourism?	**B2. What is the regenerative and productive potential of Santorini's landscape?**
	A3. What are the current relationships and dynamics between the islands of the Cyclades archipelago?	B3. What is the relationship between seasonal tourism, metabolism and landscape?
	A4. What are the spatial traces of seasonality, how is it perceived by the local community and how it impacts quality of life?	
concept and design	A5. How can the endogenous capacities of islands be included in a design paradigm that supports flexibility?	**B4. How can crafted fiction and extreme visioning inform design decisions and be used as a communication tool ?**
	A6. How can islands act as novelty sites for the broader understanding of socio-economic metabolism?	**B5. How can the landscape be utilized as an active system while balancing infrastructure and landscape identity?**
	A7. What spatial and infrastructural design strategies can islands adopt to shape a robust and flexible metabolism?	**B6. What are the spatial qualities and values of the landscape while it goes under such transformation?**
	A8. How can alternative metabolism design establish new dynamics and relationships in the archipelago?	

Figure 9. Research questions overview

2.4 Hypothesis

Tourism-transformed island territories, such as the Cyclades archipelago, can achieve a balance between resource demands and cultural preservation if their metabolic systems are redefined as flexible and adaptive through landscape-based design approaches. Blending areas of production with areas of consumption could foster circularity, reactivate dormant landscapes, and raise awareness about scarcity, ecological limits, and the implications of imported dependency and extended infrastructuralization.

If the archipelago is reconceptualized as an archipelagic federation, a unified yet distributed system of islands with shared resources and capacities, it becomes possible to mitigate seasonal pressures by controlling tourism, generate positive spillover effects across sectors, and rethink the cultural landscape's identity. This cross-scalar framework can serve as an adaptive alternative to static, top-down carrying capacity assessments by supporting mutual support, systems of care, and situated knowledge across islands.

2.5 Theoretical framework

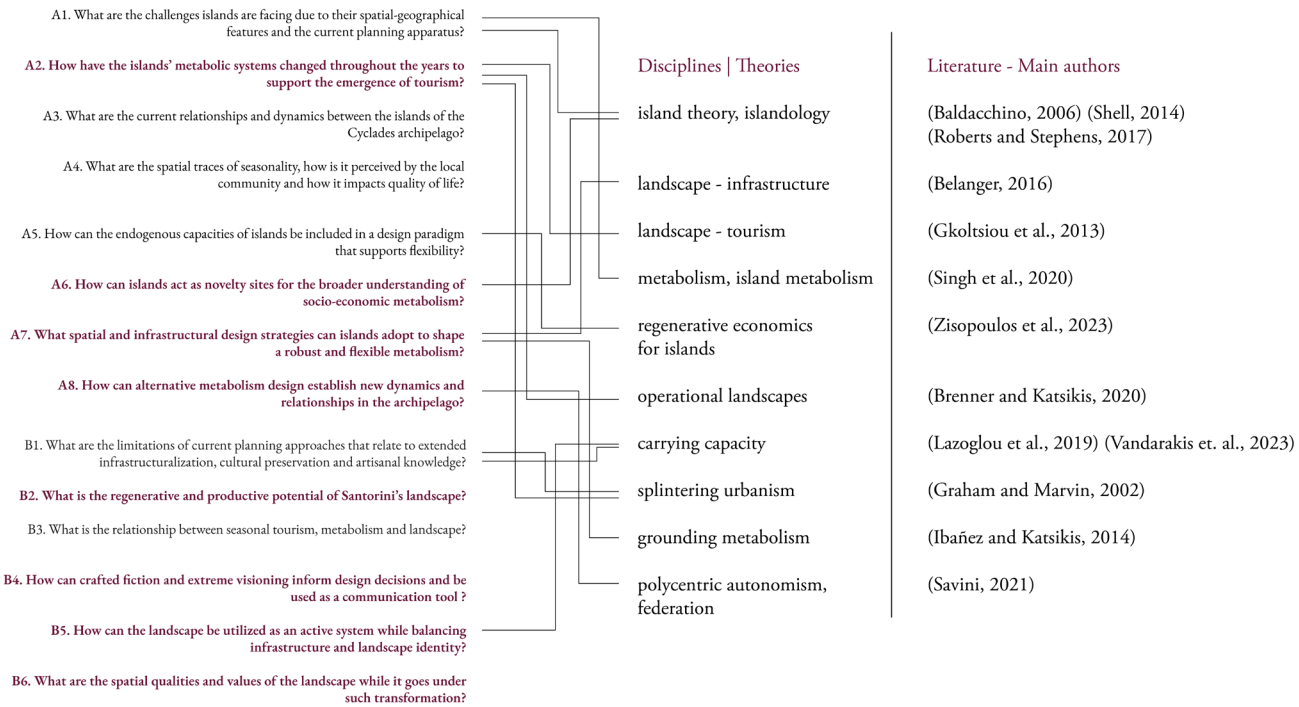


Figure 10. Theoretical framework overview

Island theory, islandology

"Islands are sites of innovative conceptualizations, whether of nature or human enterprise, virtual or real"

They are platforms for the emergence of national identity and cultural specificity, important resources in an era of globalization (Baldacchino, 2006). Additionally, they have been "catapulted" by the world's largest service industries – travel and tourism (Baldacchino, 2006).

Landscape – infrastructure

"It is above all that the landscape orientation looks at the world as a human being looks at it: an individual with a point of view, taking it all in at once, part of the life of the place and time, part of the landscape, not its imperial overlord"
Rosalind Williams,
foreword Landscape as infrastructure: a base primer

Bélanger is challenging the traditional ideas of infrastructure, which most of the time focus only on technical and functional aspects, and he proposes that a holistic approach that considers infrastructure as interconnected with natural and human systems (Bélanger, 2017). In response to the "underperformance of master planning" and the excessive reliance on technological systems, he argues that strategic design of infrastructural and territorial ecologies is the way forward, and proposes a synthetic landscape of living, biophysical and sociopolitical systems as the urban infrastructure that shape the future of urban economies and cultures.

Metabolism, island metabolism

"Metabolism" is a biological concept that refers to the chemical conversion and breakdown of organic matter to sustain reproduction. Analogous to biological metabolism, "any given society organizes material and energy flows through their natural environment (or through imports with other societies) for their sustenance and reproduction. Some materials and energy become waste (outflows), while the rest of the flows are net additions to "material stocks" (or built environment)" (Singh et al., 2020). "Social metabolism" is this process of "organizing and reproducing material stocks and flows" by our societies (Fischer-Kowalski & Weisz, 2016) (Singh et al., 2020). Exactly as metabolism influences a human body, the process of social metabolism has a footprint in the natural environment by altering "land-and-sea-use" (by mining, urbanization, fishing, and agriculture) and, over time, causes pressure on ecosystems, the atmosphere and bio-geo-chemical cycles (Steffen et al., 2015).

Regenerative economics for islands

Zisopoulos et. al (2023) propose that approaches from regenerative economics, which draw on the analogy of an "island economy-as-an-organism analogy", provide valuable and complementary perspectives to socio-metabolic research. In order to promote a more sustainable social metabolism of islands, Noll et al. (2022) enhancing material circularity by addressing not only the material output side but also by reducing the overall scale of the biophysical economy, is necessary (Zisopoulos et al., 2023).

Operational landscapes

As discussed by Katsikis and Brenner (2020), operational landscapes are broader zones essential to the functioning of capitalist urbanization processes, typically extending beyond the limits considered urban (Brenner & Katsikis, 2020). According to the authors, the term "hinterland" describes non-city areas that are drawn into the processes of urbanization as supply zones, logistics corridors and others. In this project, I'm using this theory to support that the Cyclades archipelago should be considered as an inverted city-hinterland case due to its dependency on mainland Greece.

Ephemeral urbanism

Mehrotra et. al. (2017) suggest contemplating the transient nature of physical materials, while acknowledging the impermanence as essential for urban development (Mehrotra et al., 2017). Ephemerality is used in this project as an aspect that could support modular changes in the islands' infrastructure in circular and not linear time.

Carrying capacity

The concept "carrying capacity" originated from biology to explain the interactions between living organisms and their surroundings (Lazoglou et al., 2019). More specifically, it referred to the capacity of a spatial system to recover from the pressures created by the activities occurring within it (Manning, 2002) (Lazoglou et al., 2019). In tourism, the term has been defines as "the maximum tolerable level of visitors that an area can accommodate" (Buckley, 1999) (Lazoglou et al., 2019). A more elaborated definition refers to "tourism carrying capacity" (TCC) not only as the number of tourists but also to "the capability of the local community to manage tourism flows", and O'Reilly (1986) recommended TCC applies to the maximum rate of growth, above which it is harmful as well .

Splintering urbanism

Graham and Marvin (2002) discuss, among others, how globalization and infrastructuralization has fostered global connections and at the same time caused local disconnections (Graham & Marvin, 2002). According to Lovering (1998), there is a shift from the "old model" - the interconnected one - that was the skeleton of the local economy, to a fragmented "post-Fordist" model, where the local economy is "a thing of fragments" (Lovering, 1998) (Graham & Marvin, 2002).

"National boundaries have ceased being continuous lines on the earth's surface and have become nonrelated sets of lines and points situated within each country".
(Andreu, 1997)

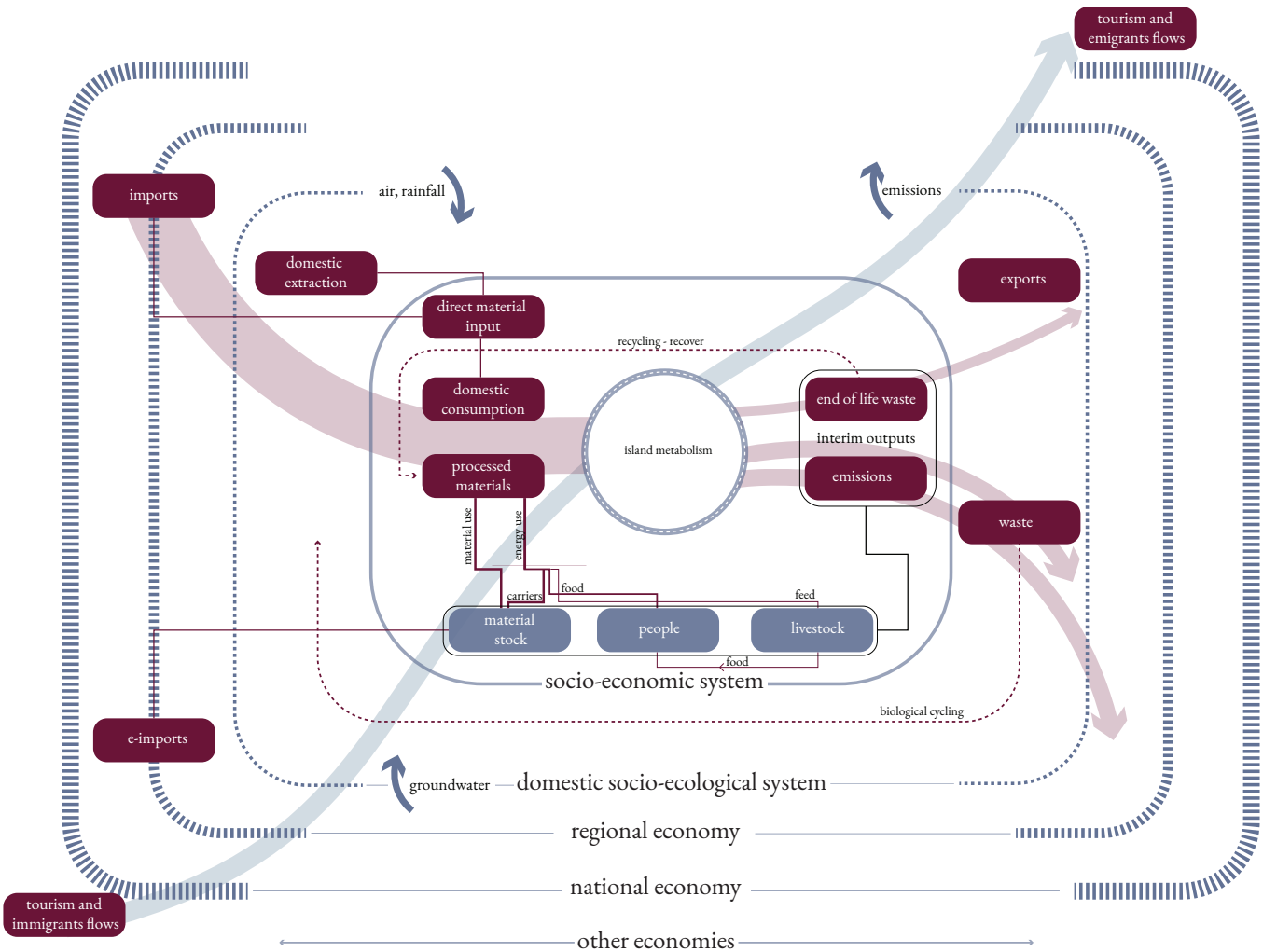


Figure 11. Island metabolism diagram, adapted from (Singh et. al., 2022) (Noll et. al., 2022)

Island metabolism

In order to understand the concept of island metabolism I adapted and simplified a material and energy flow analysis (MEFA) diagram showcasing the socioeconomic materials and primary energy use, infrastructure, along with the outputs and emissions (Noll et al., 2022b) (Zisopoulos et al., 2023).

The socio-economic systems exists withing the domestic socio-ecologial system, and those systems within regional, national and larger economies, which are most of the time dependent on for their metabolic flows. Some key concepts to understand the diagram are the following (Noll et al., 2022b) (Zisopoulos et al., 2023):

- imports: nonmetallic minerals, metal ores, along with biomass and fossil fuels imported by energy carriers for combustion and the endosomatic metabolism of humans and livestock.
- e-imports: imported electricity through a deep-sea cable
- domestic extraction: locally extracted materials
- direct material input and domestic consumption: material inflow and use
- processed materials (PM), interim outputs (Int/Out), and end-of-life (EoL) waste: materials at various stages of processing and disposal.

Material input includes material use (mUse) and energy use (eUse):

- mUse : Encompasses stock-building materials (lasting over one year in the socioeconomic system) and throughput materials (e.g., packaging).
- eUse: Includes biomass and fossil energy carriers for combustion and the endosomatic metabolism of humans and livestock.
- material stock, people and livestock are the main energy, material, food and feed "users".

Waste management:

- Waste: municipal solid waste is sometimes burned, placed on landfills, or exported to the mainland.
- recycled or recovered waste: Other waste is recycled or recovered and reintroduced to processed materials (PM) through socioeconomic cycling.
- biological cycling: Includes outputs from the use of renewable biomass that re-enter biogeochemical cycles, contributing to plant growth.

The whole system is being impacted by the tourism and immigrants flows that impact directly the material demands.

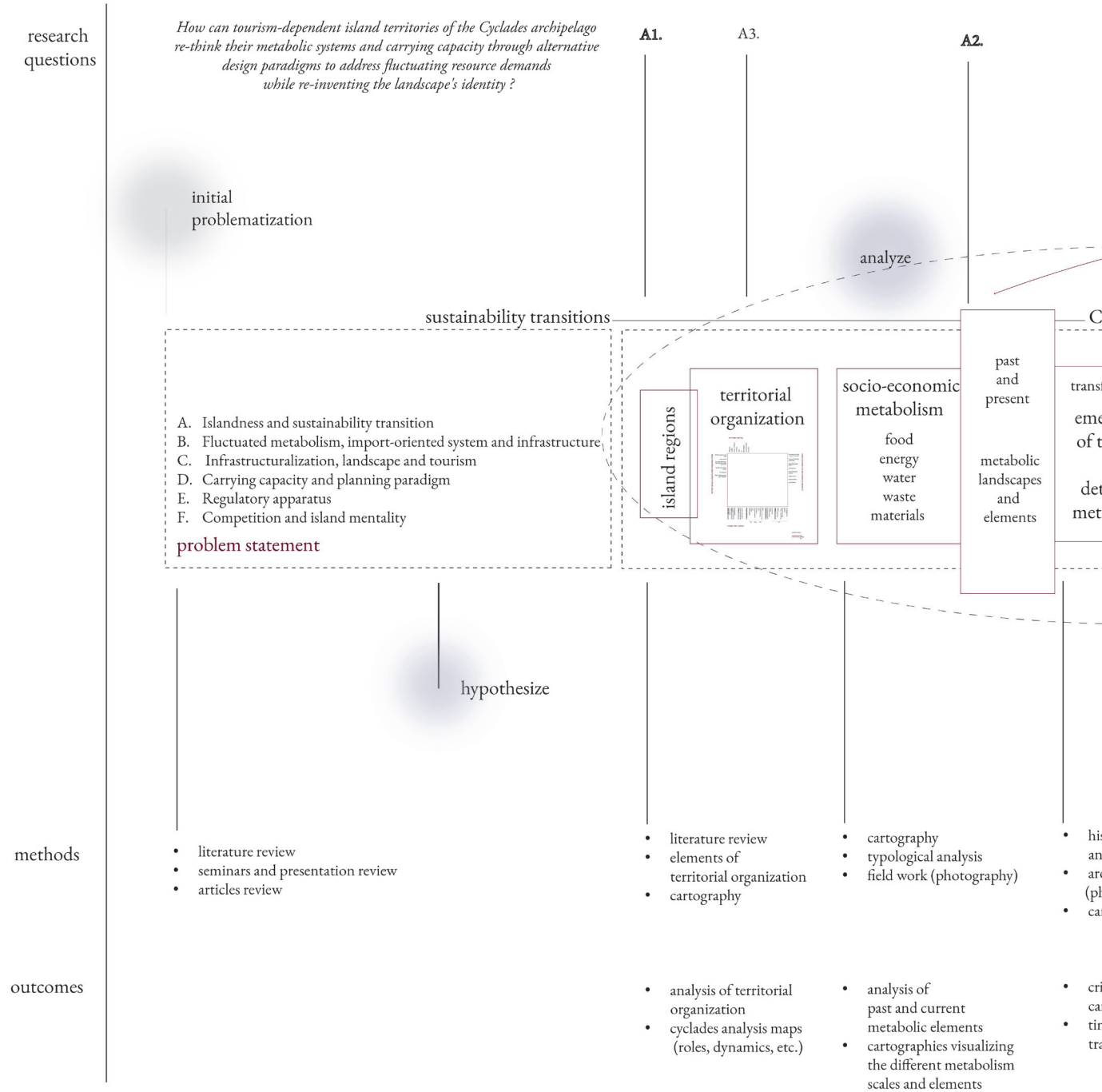
For this research, when referring to island metabolism I consider the water, energy, food, material flows, along with the waste consumption. Due to the unavaible or unregistered data, it is impossible to quantitate all flows. Although, qualitative data will be presented when available.

3. Methodology

3.1 Methodological framework
3.2 Methods

3.1 Methodological framework

Starting with the initial positioning and problem statement, this project explores various methods to analyze, synthesize, and conclude. The analysis focuses on key concepts related to island regions and their socio-economic metabolism. Using the Cyclades archipelago, particularly the island complex of Santorini, as project sites, it tests the hypothesis by spatializing critical elements and conditions. The research examines how tourism has altered the metabolism of destinations as part of globalization, which has enabled global connectivity. Central to this investigation is the role of landscape, systemic carrying capacity, and the ongoing debates surrounding the dichotomy between infrastructural development and cultural preservation. Landscape serves as a tool for understanding the historical and current metabolic and other capacities of the islands, and serves as the primary object of design. The project's main outcome is a catalogue of metabolic landscape types that reflect the conditions of the islands and aim to reactivate currently "dormant" productive



landscapes, fostering harmony within the socio-ecological synergies.

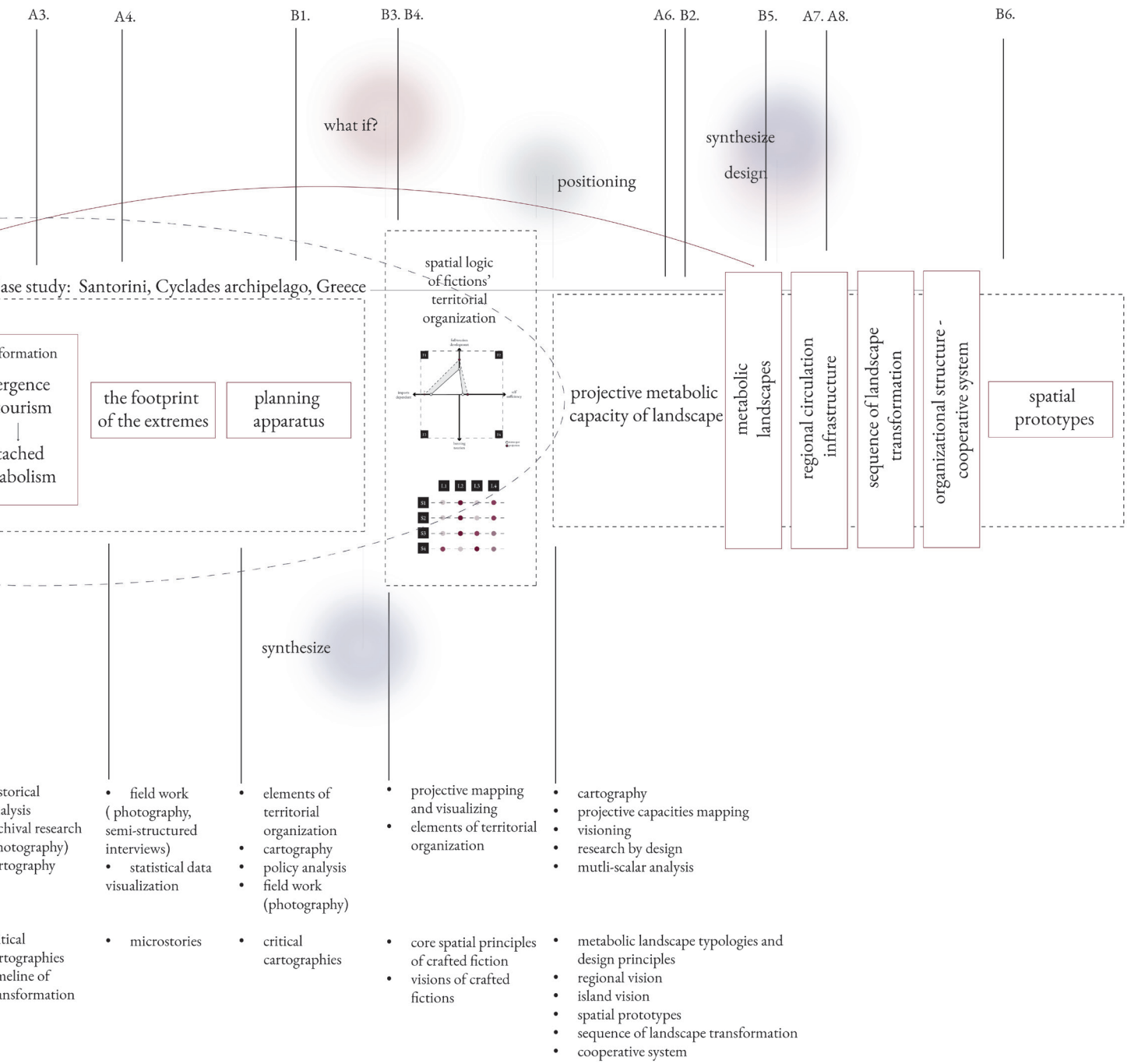


Figure 12. Methodological outline

3.2 Methods

The methods used during this project are the following and will be unpacked further as the project progresses.

Literature review

The literature review involves establishing a theoretical foundation for the project, along with a constant academic and grey literature review to remain up to date with the current discussions related to tourism, island metabolism, and relevant topics in academia, political debates and community discussions.

Socio-spatial analysis

The socio-spatial analysis incorporates the Studio Essentials course, along with the Geographical Urbanism focus and integration course, and the collective studio assignment on material ecologies and territorial organization. Cartography is the main method used, along with other types of visualizations.

Policy analysis

The policy analysis refers mainly to the understanding of the planning apparatus, past and present, to assess the decisions that were taken and their effectiveness to handle the challenges. Part of the policy analysis involves attending seminars and reviewing presentations, to understand the current "hot" debates and discussions among experts in the field of the planning of Greek islands and the limitations and opportunities they present.

Historical analysis and archival research

This method focuses on analyzing and understanding the economic and landscape transformation that took place with the emergence of tourism in the archipelago. It showcases the complex history of the area, and the transformation from a feudal-quasi economy to a fully-fledged service economy (Lichrou et al., 2017).

Field work

This method includes tools such as photography, documentation, and semi-structured interviews. Its aim is to understand how the "extremes" affect the island physically and impact community's quality of life, along with documenting traces of the past productive landscape and understanding its role and potential in the project. By using semi-structured interviews, the research will showcase how locals experience the summer peak, which then gives way to winter serenity.

Crafted fiction

This method is used to explore the spatial dynamics that four fictional relationships between tourism and metabolism can create for the area. It visualizes what fictional futures could look like, using conditions such as banning tourism, full tourism development, full dependency on imports and self-sufficiency. These conditions demonstrate what these fictions could mean for the islands, and how tourism and metabolism relate and interact with each other.

Design explorations

This method aims to visualize the project's proposal by testing with different available futures and elaborates on one. It includes concept plans, experimentation, design principles and more.

4. Crafted fiction

4.1 Crafted fiction- why?
4.2 Crafted fictions unpacked
4.3 Reflective positioning
4.4 Conceptual framework

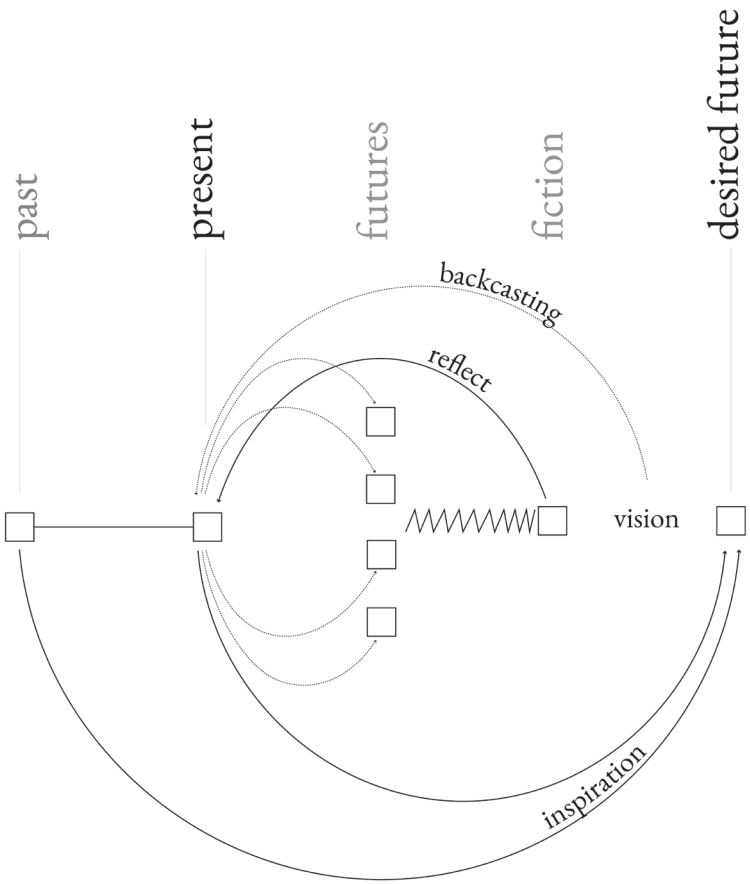
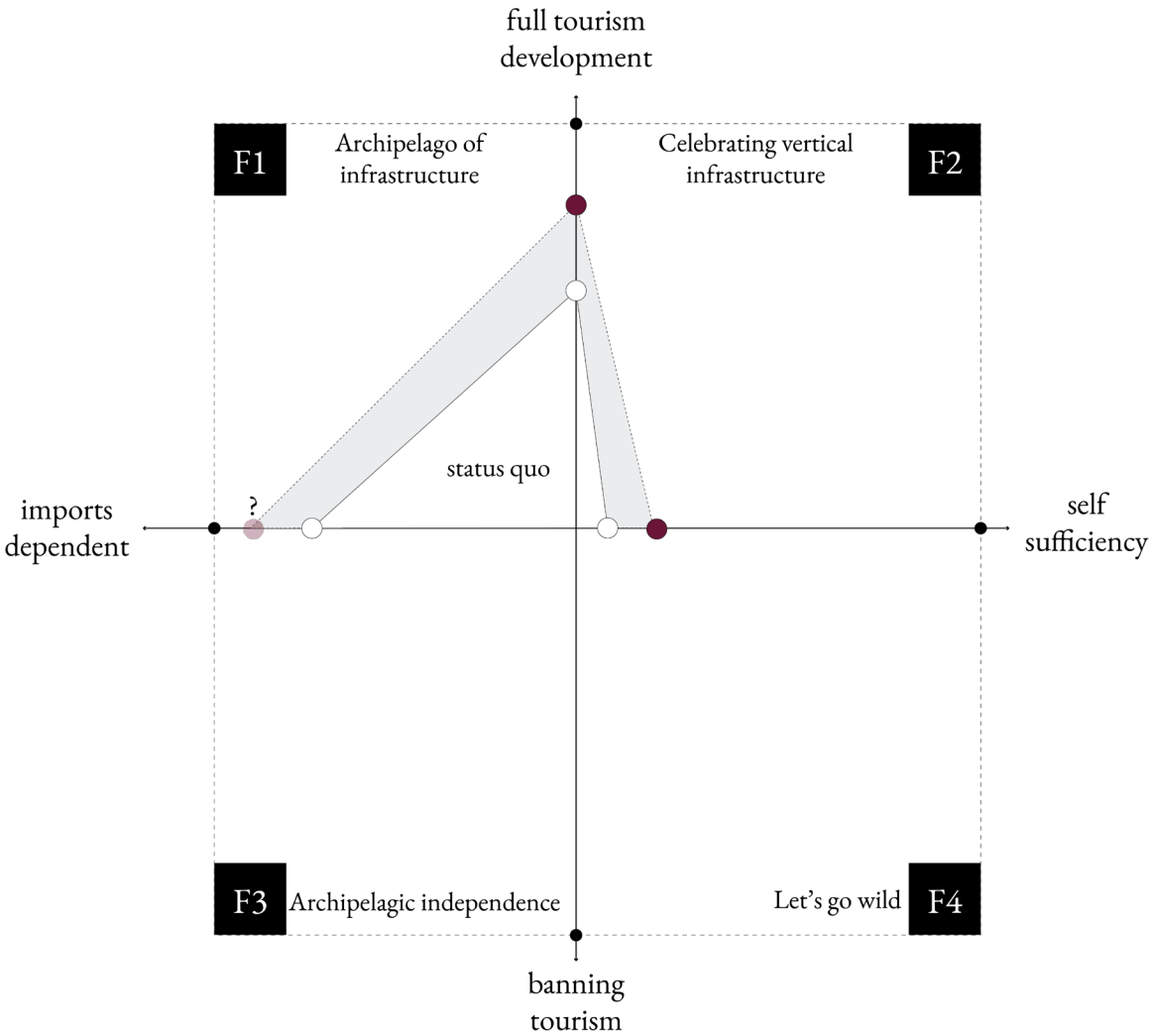


Figure 13. Backcasting, positioning and visioning, inspired by "The Lake of Venice", p.28 (Fabian and Centis, 2022)

4.1 Crafted fiction- why?

Before further unpacking the case study and elaborating on the design approach, an intermediate part of drawing experimentation is presented here. This step addresses different purposes. It gives freedom for speculative exploration ("literary method of urban design") and opens up the imagination for alternative futures. Usually, such technique is used to "speedily explore as many innovations as possible" and create designed fictions that are not destined for the real world but allows for a "degree of technical experimentation as well as the imagining of new arrangements" (Marshall, 2023) as an instrument to understand the power of design.

Additionally, this chapter complements the problem statement and frames the project's critique of the current planning apparatus and carrying capacity methodological approach while exploring the spatial dynamics between tourism and metabolic processes. Reflecting on the crafted fiction's results sharpens the project's positioning from the beginning of its elaboration. They are furthermore used to explore their projective contribution to the project as an exercise that knowledge can be gained from mainly related to the different carrying capacity design possibilities. And get a preliminary idea about the vision as a negotiation between the two variables.



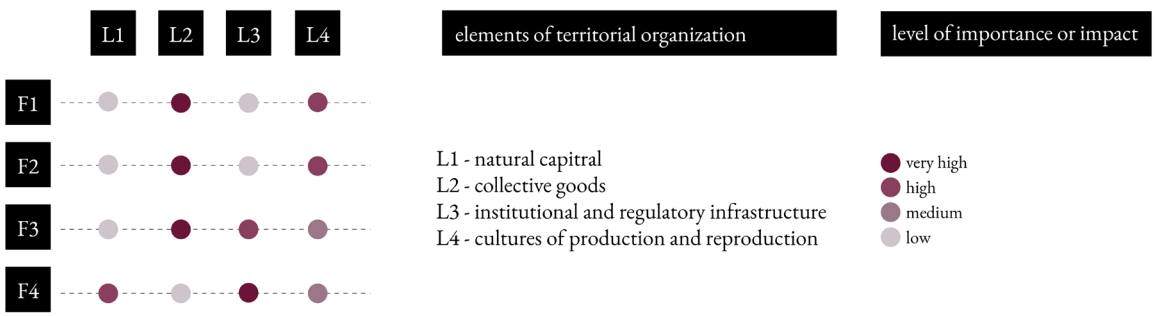


Figure 14. Crafted fiction methodology outline

4.2 Crafted fictions unpacked

The four fictions are created by using variations of two variables, tourism and supply system/metabolism. As illustrated in the diagram, four scenarios are being developed using combinations of the variables' extremes, considering elements of territorial organization and the island metabolism diagram. Between the scales and the variables, the scale changes appropriately to highlight the scales of metabolic flows connected with the islands. Through the fiction' drawings, a draft exploration of their spatial manifestations is conducted using concept plans and collages.

Territorial organization

In order to understand deeper the territorial organization of the area this project is using the framework Swyngedouw (1992) suggested. According to him, the four categories of elements of territorial organization (E. A. Swyngedouw, 1992) (Katsikis, 2024) are:

- Natural goods: natural resources, environmental conditions, work of nature
- Collective goods: public and private structures and infrastructures
- Institutional & regulatory infrastructures: public institutions or private coalitions, exercising forms of geopower through regulation
- Cultures of production & reproduction: characteristics of human labor (skills, knowledge), cultures of social reproduction (care)

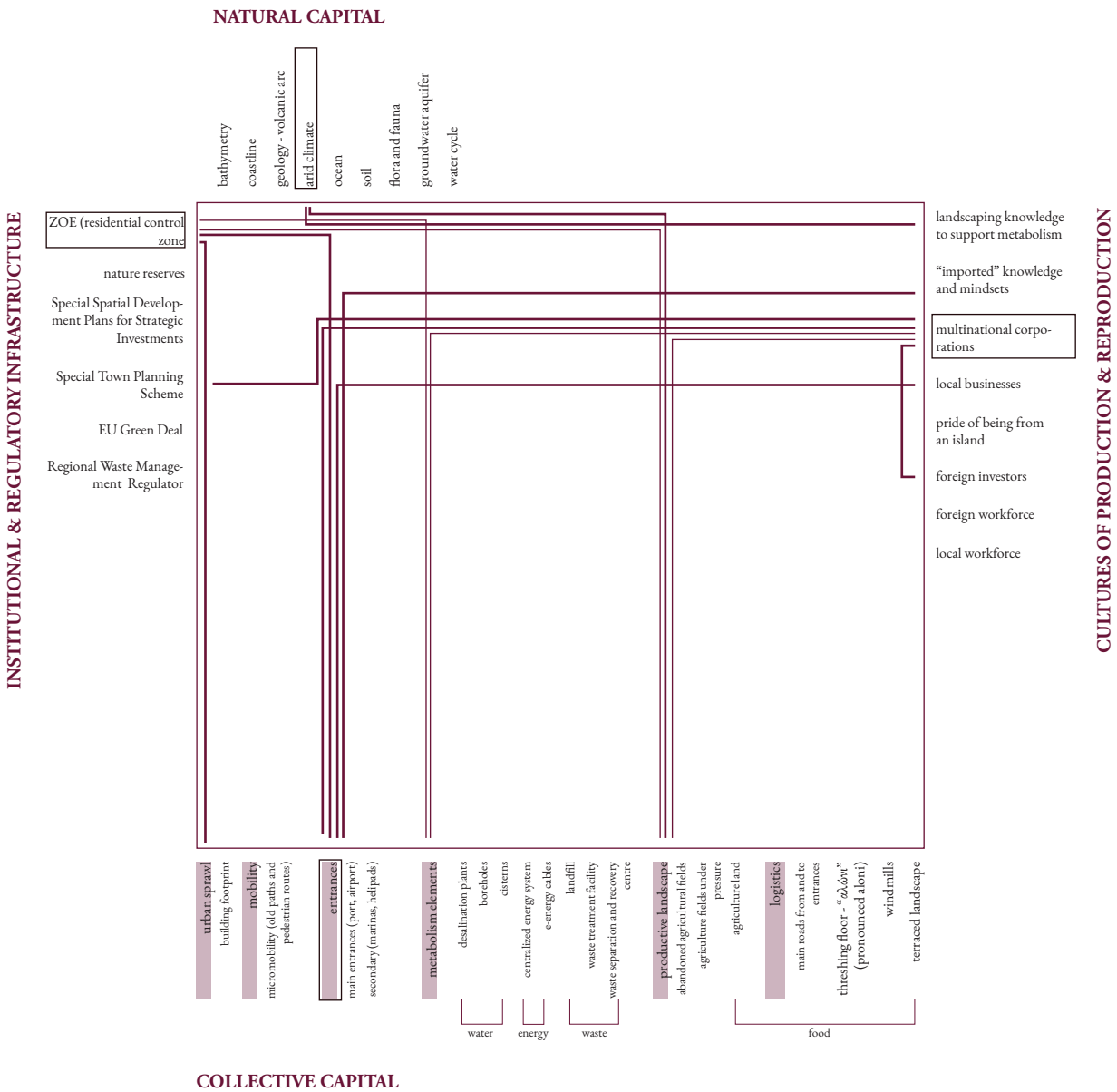


Figure 15. Territorial organization diagram for Santorini, starting from the most important element from each category

Fiction 1. Archipelago of infrastructure

"In order to support the tremendous tourism demand which is growing every day we had to expand towards the sea, building artificial islands and operationalizing our islets, that will support us logistically and facilitate the distribution between Athens and our expanded ports. Travelling there every day is tiring".

-

Operations manager of Glaronisi

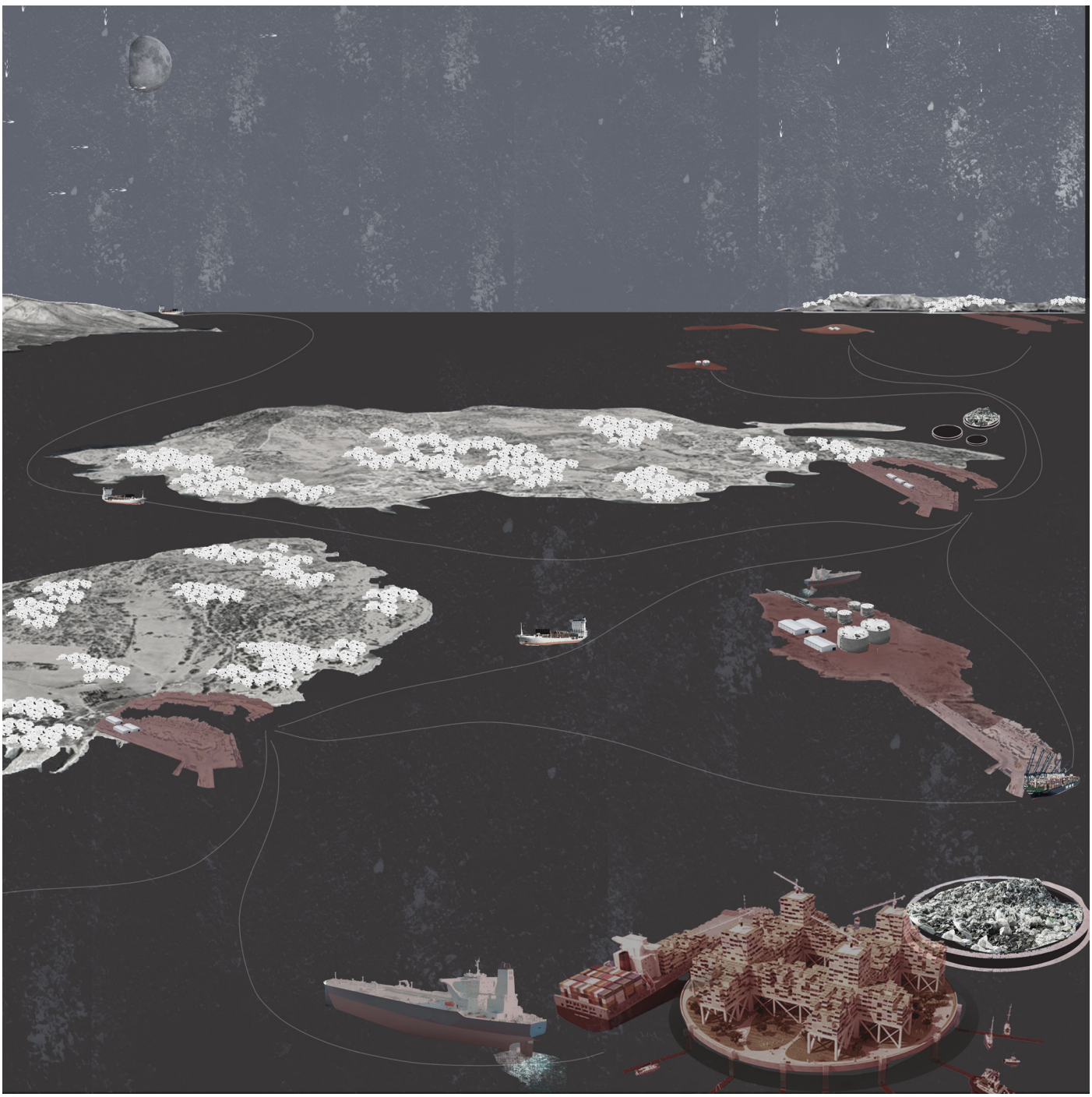
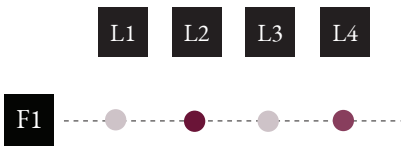


Figure 16. Archipelago of infrastructure collage

In a future where tourism development and import dependency are maximized, infrastructure plays a crucial role. Everything is imported, and further logistics activities are needed. The need for more space and new land to accommodate infrastructure rises, and there is a need for bigger seasonal stability since the peak will be higher. Artificial islands and islets can act as distribution centers – we need to connect them to the water and energy supply system. The primary focus is building a stable distribution network that is well-connected to the mainland and supports extremes.



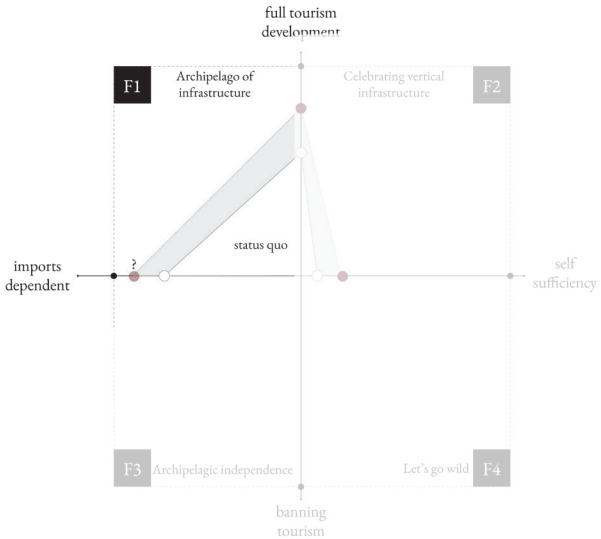


Figure 18. Crafted fiction - F1

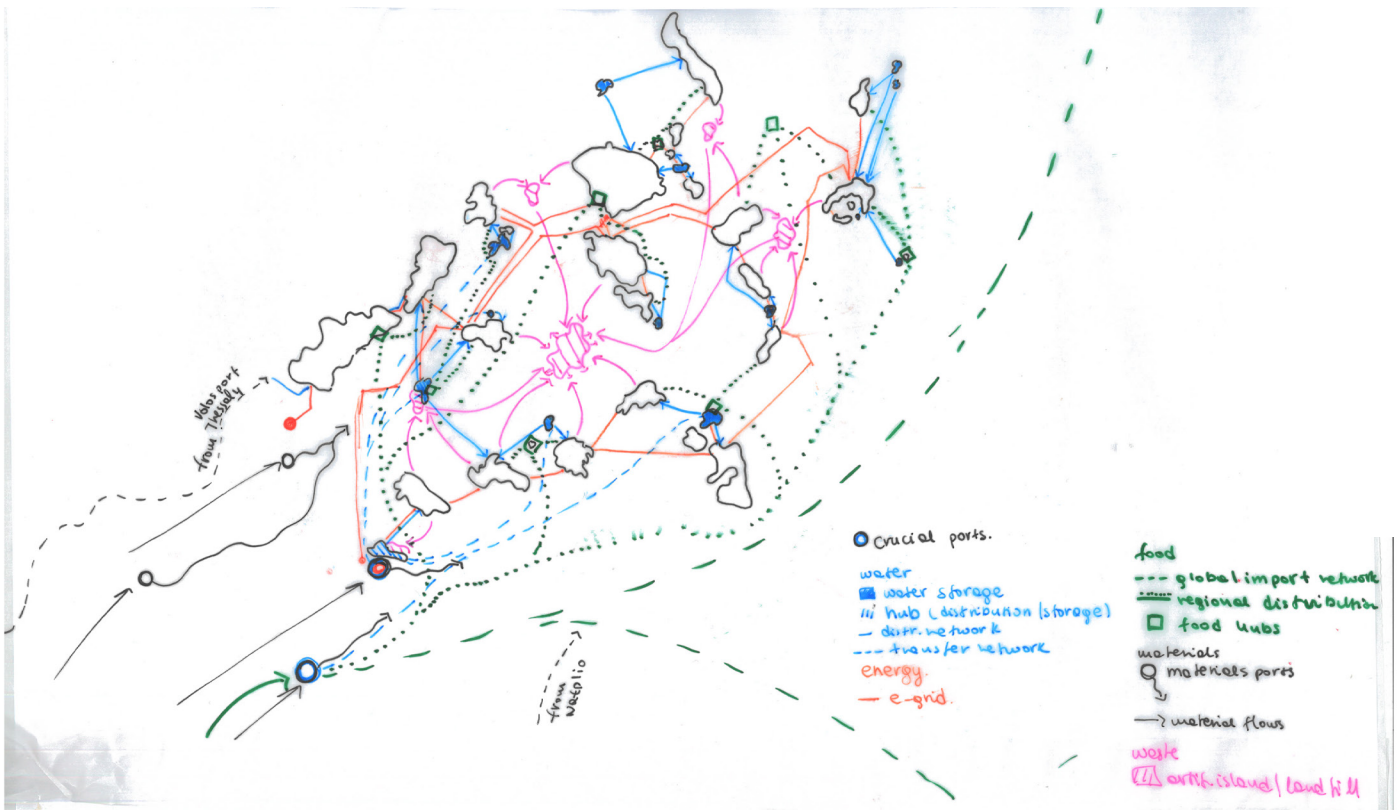


Figure 17. Fiction 1 concept plan

Fiction 2. Celebrating vertical infrastructure

"You can find the cheapest hotels next to the nuclear power plant".
-
Jen, Travel Blogger

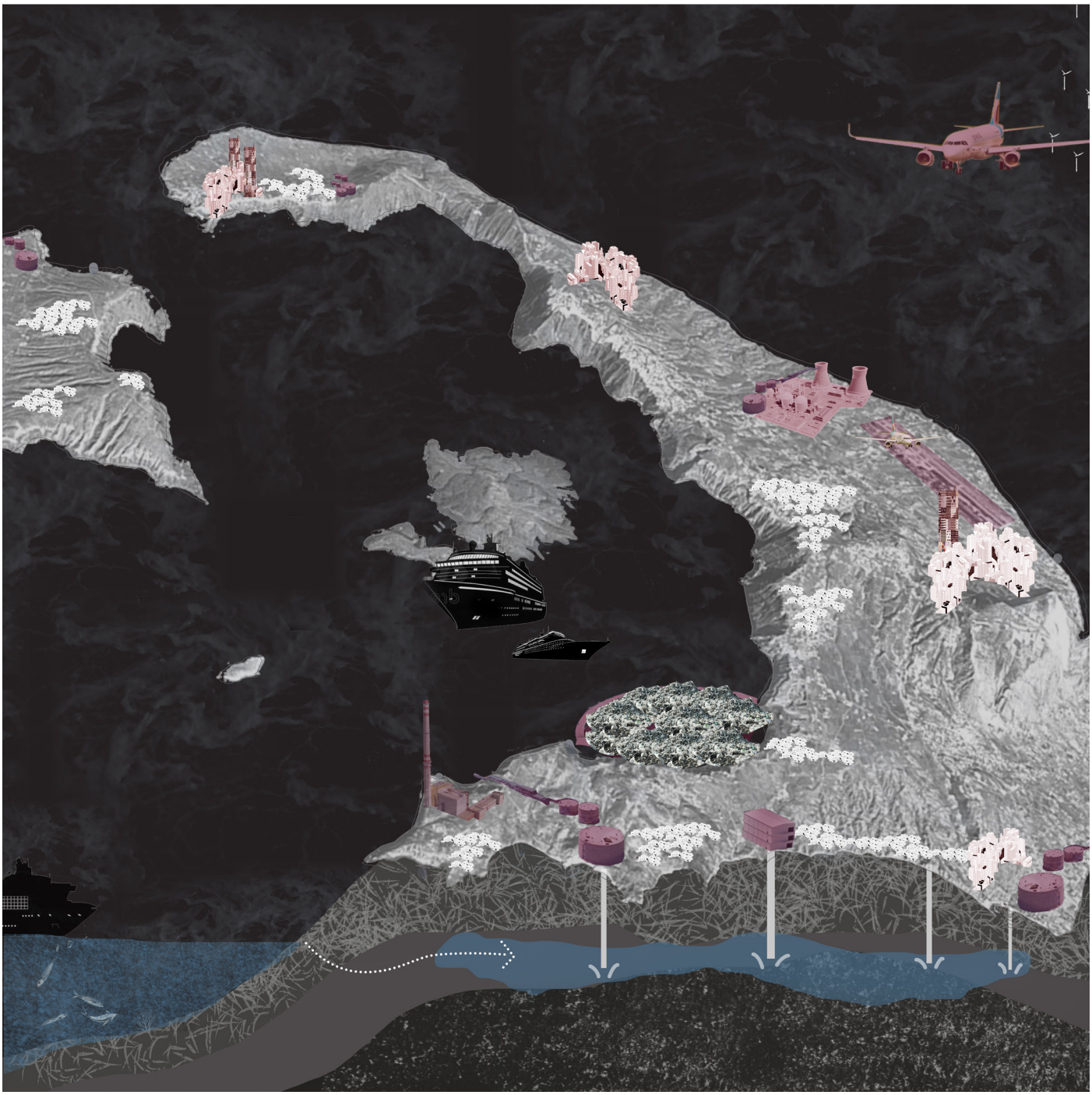
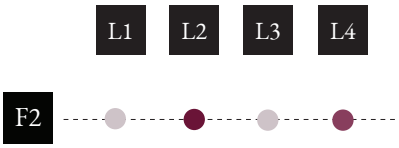


Figure 19. Celebrating vertical infrastructure collage

In a future where tourism development is maximized, and self-sufficiency is the goal, extended infrastructuralization is required, but mainly on the vertical axis due to the need to utilize the maximum capacities of the land. The need to grow vertically to accommodate growing demands is necessary. The development is highly unregulated and based on collective goods. Institutional and regulatory elements are weak and nearly non-existent.



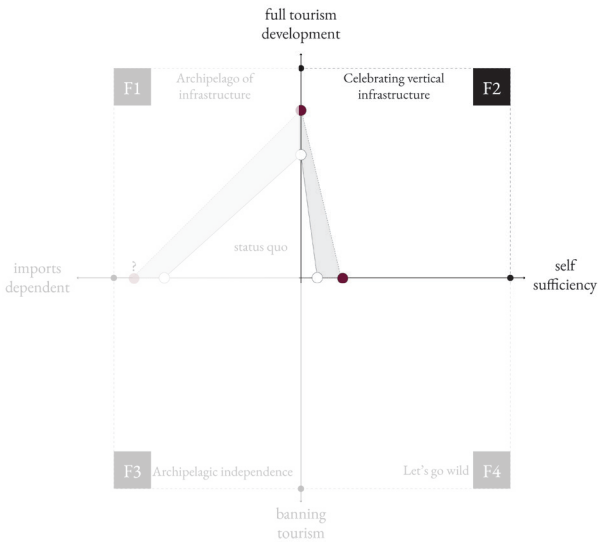


Figure 20. Crafted fiction - F2

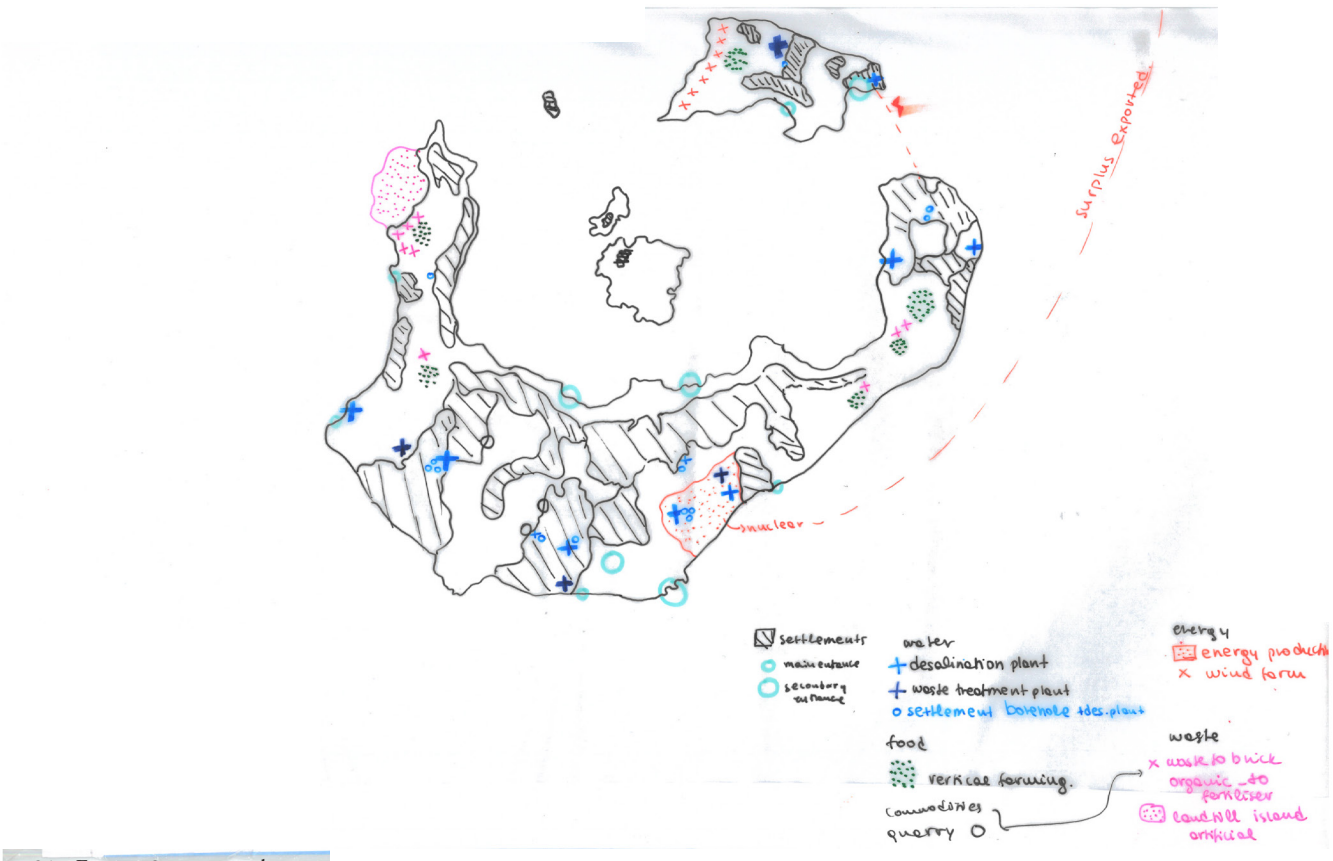


Figure 21. Fiction 2 concept plan

Fiction 3. Archipelagic independence

" What do we do without tourism? The demand is less so we can survive by sharing with our neighbors. Potatoes from Naxos are tasty, although the production the past years has decreased. How about fishing?".

-

young farmer who goes fishing occasionally

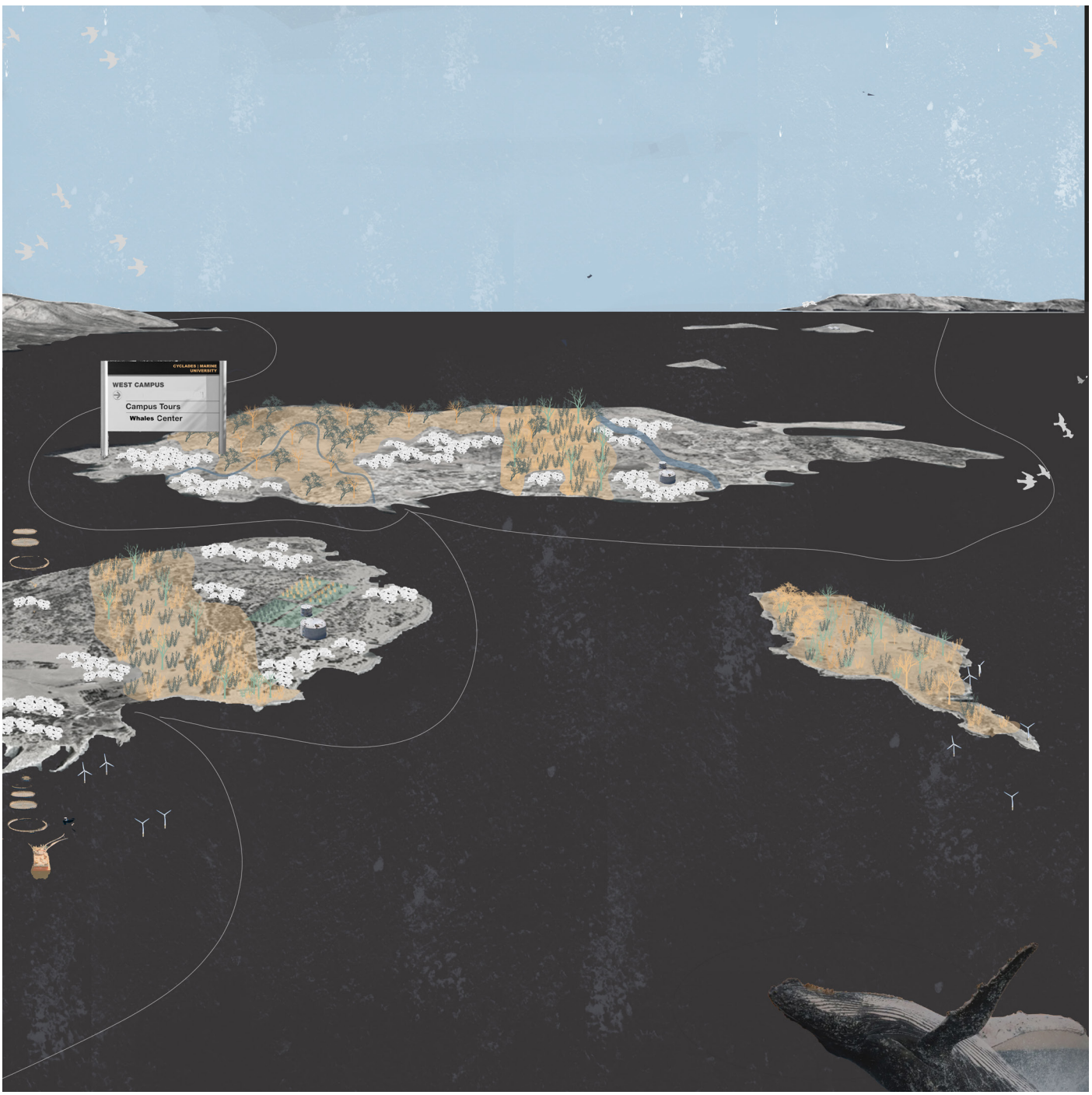


Figure 22. Archipelagic independence collage

In a future where tourism is banned and the islands depend on imports, the focus lies on the resource distribution network. Still, since the islands have smaller demands, parts of the islands could be rewilded, becoming biodiversity hot spots. The economic model is more linear, but the settlements are shrinking. Part of the archipelago can become a national park where biodiversity exists but is being challenged by infrastructural fragmentation. There are possibilities for other activities to grow, like education and research related to volcanic studies, agriculture, mining, and renewables. Regulatory and institutional elements play a key role in shaping the dynamics.

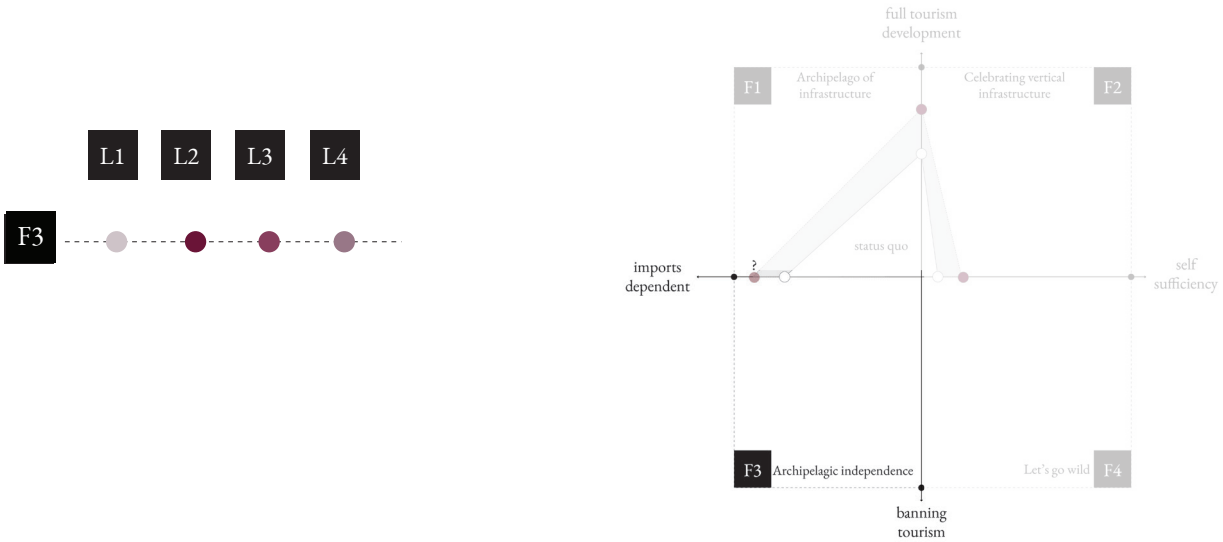


Figure 23. Crafted fiction - F3

Figure 24. Fiction 3 concept plan

Fiction 4. Let's go wild

"My house is next to where the Hilton used to be, and yesterday a sami-amidi (Greek for gecko) came in! The last time I had such visitors was when I was a child. Plus I have a vegetable garden and chickens now, but a fox killed five of them last week".

-

resident of Ia

Figure 25. Let's go wild collage

In a future where tourism is banned but self-sufficiency is the goal, there is room for experimentation. By containing urban sprawl, there are opportunities to rewild parts of the island. The economy is more diversified and circular. Regulatory and institutional elements play a key role in shaping the dynamics.

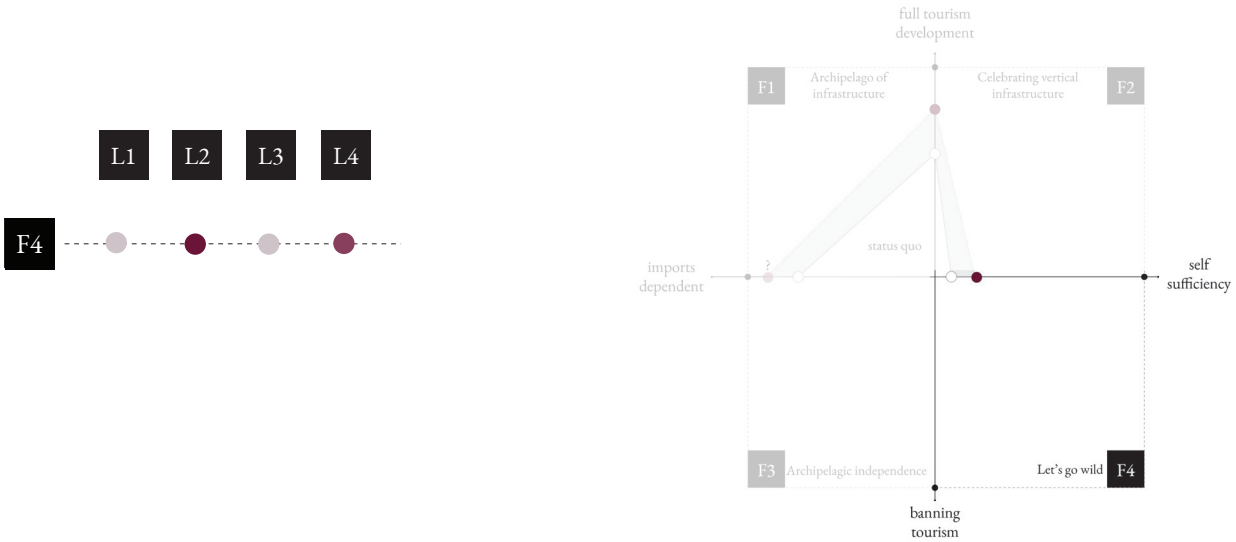


Figure 27. Crafted fiction - F4

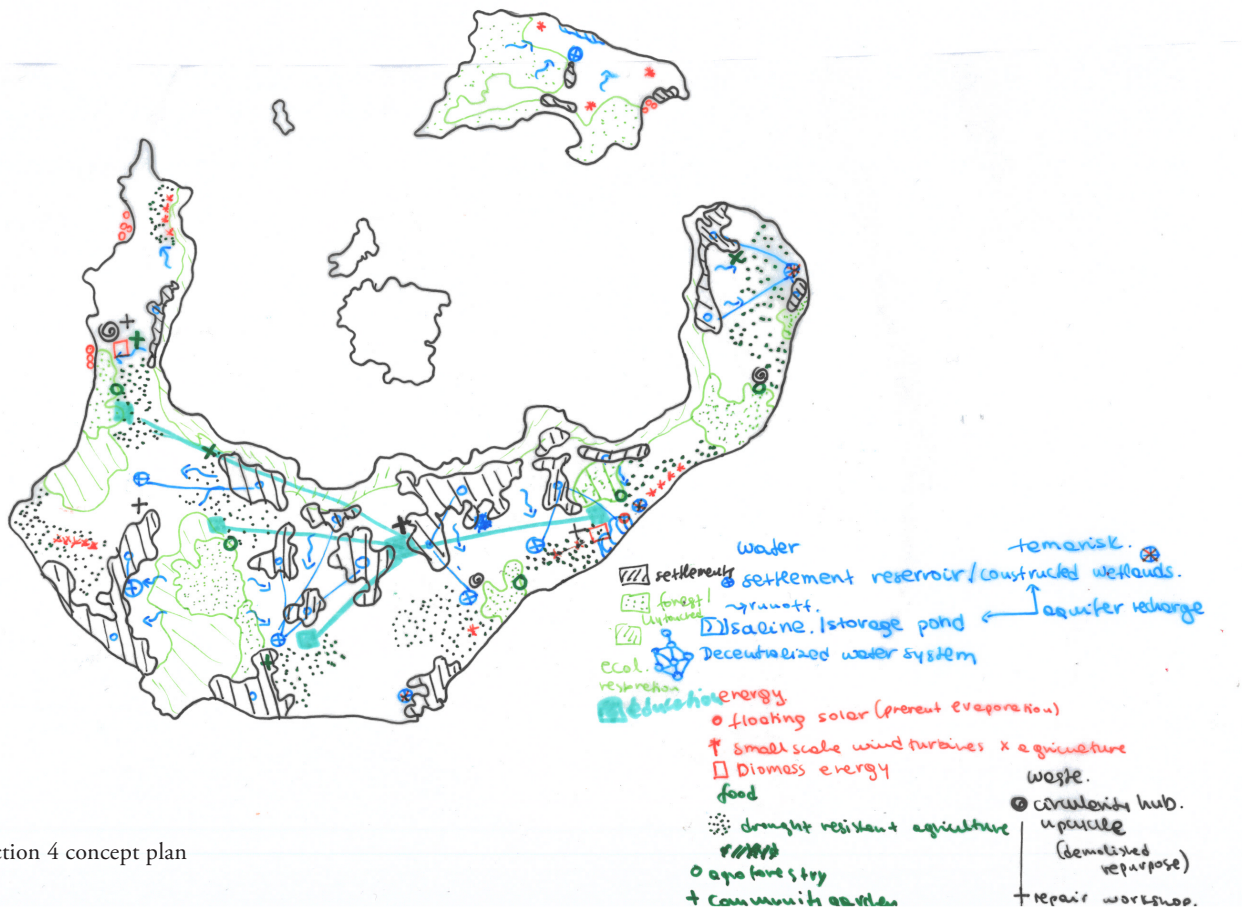


Figure 26. Fiction 4 concept plan

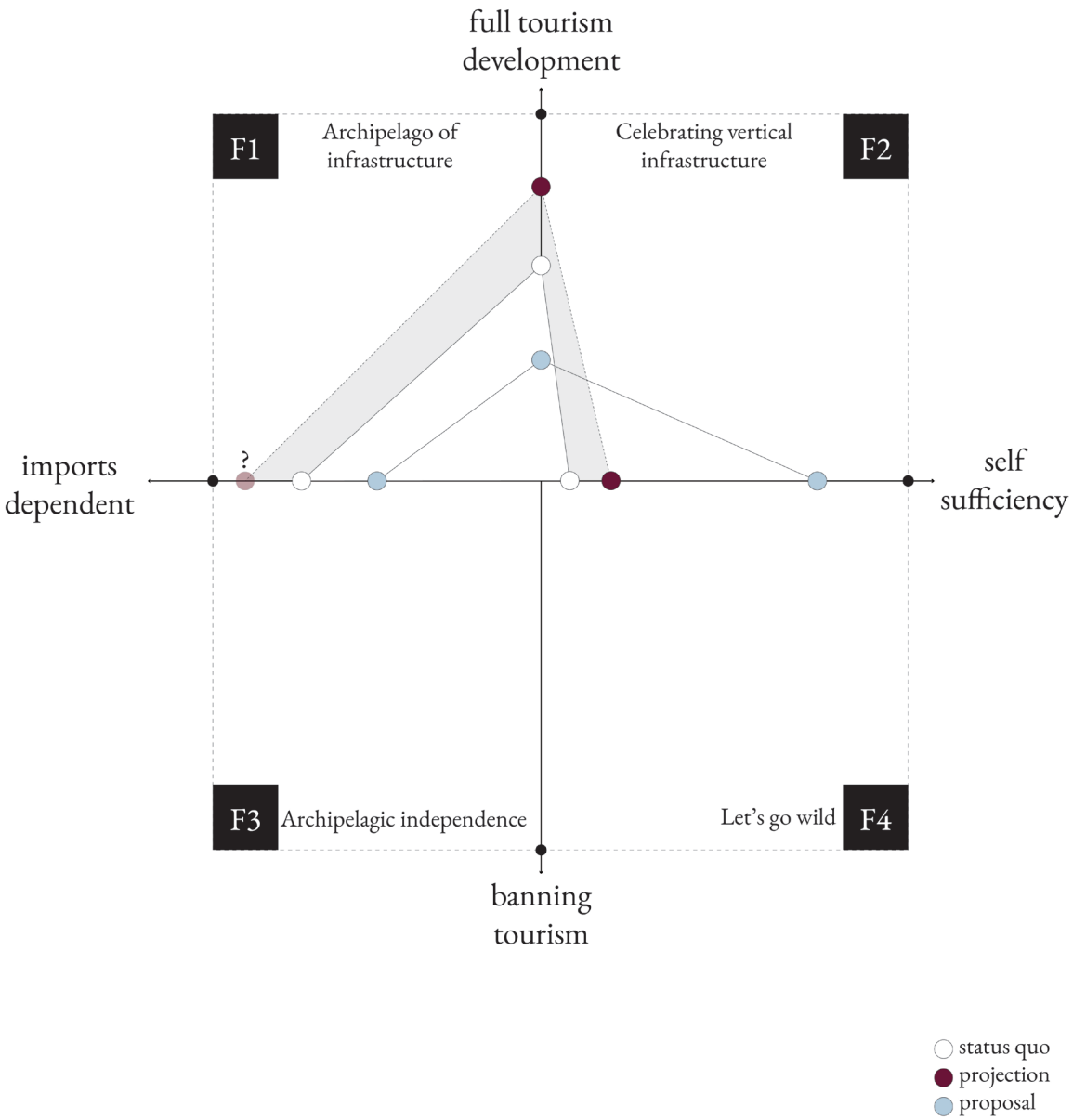


Figure 28. Personal positioning across the fictions' axes

4.3 Reflective positioning

While reflecting on the axes, and taking into account that banning tourism is not realistic and being completely self-sufficient would require extensive infrastructural investment, some initial thoughts and positions can arise. During this experimentation, spatial conflicts were created between the activities, creating a non-institutionalized, indirect regulatory framework. Although, banning tourism is unrealistic, regulating it indirectly, by creating spatial conflicts with other land uses and activities, could be possible. Therefore, my personal gaze prioritizes small-scale infrastructure that align with the islands' carrying capacity and identity, integrating both traditional and contemporary elements. The approach adopted will not engage with policy-making directly. It rather focuses on providing alternatives that could encourage the shift through care and repair initiatives. The main aim is to unpack a broader transformation of Cyclades, moving beyond a pure cultural lens that can often limit innovative thinking. Reflecting on island competition, it needs to be highlighted that the current island mentality fosters competition and not collaboration, concentrating wealth and crucial infrastructure on specific islands. By focusing on the islands' domestic socio-ecological systems, exploring potential cooperations within the archipelago, and reactivating regenerative processes, these dynamics can be dismantled in time. Lastly, it has become clear that design principles such as adaptability will be vital in creating a flexible approach that allows collective progress.

4.4 Conceptual framework

Through this project, a different model is proposed for the Cyclades archipelago. Starting from the individual island's metabolic flows (materials, food, energy, water, and waste), the project focuses on developing a regional cooperation model, forming an archipelagic federation. By unpacking the notion of metabolism through the spatial manifestations of its processes, it highlights the challenges arising from limitless growth and the need to maintain a certain level of flexibility throughout the year. The reorganized structure considers the landscape's projective capacities to support the metabolism by maximizing its regenerative potentials and synergies. Thus, activities related to the primary and secondary sectors are reactivated and indirectly contribute to the control of tourism development. It is essential to mention the multiplicity of scales associated with this concept since they vary per flow. When looking at the archipelago as a common, the territory's landscape and its endogenous capacities and identity become central. By using the landscape lens, a more grounded approach to the existing detached metabolism is being developed. Connected to the archipelagic federation, a cross-scalar system of collaboration is proposed, starting from the local to the sub-island and then island scales, supporting that the communities can have a crucial role in assessing and evaluating the limits of the islands' metabolisms. Thus, a different way of approaching the concept of carrying capacity is proposed.

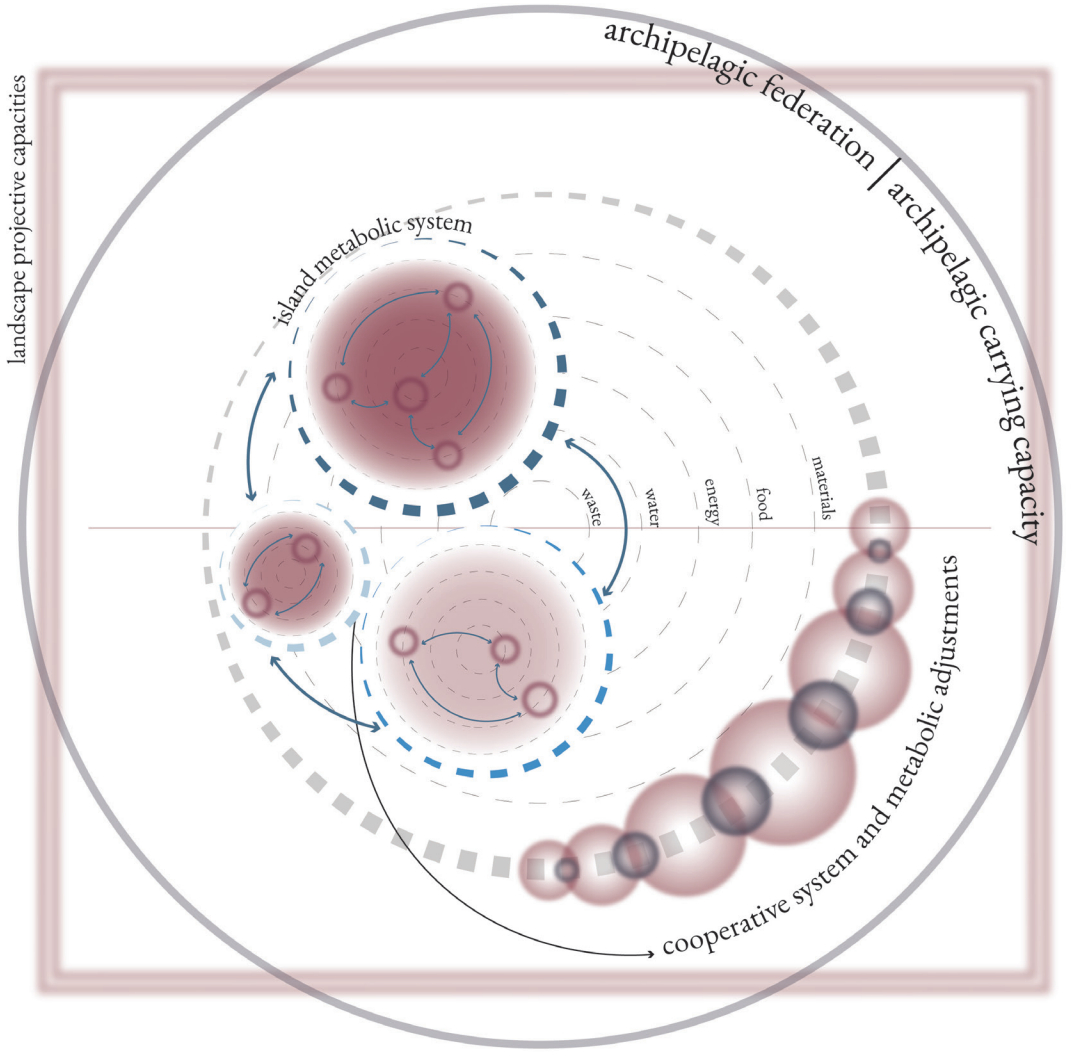


Figure 29. Conceptual framework

5. Unravelling Cyclades

5.1 Cyclades archipelago
5.2 Debating carrying capacity
5.3 Complex, Santorini
5.4 Tidal pressure
5.5 Elements of metabolism
5.6 Situated metabolism

5.1 Cyclades archipelago

The Aegean archipelago is accommodating approximately 500.000 people, consists of 95 inhabited islands, and is considered the largest island complex in Europe (Buhalis, 1999). The Cyclades archipelago is located within the South Aegean region and includes 220 islands, with the major ones being Amorgos, Anafi, Andros, Antiparos, Delos, Ios, Kea, Kimolos, Kythnos, Milos, Mykonos, Naxos, Paros, Folegandros, Serifos, Sifnos, Sikinos, Syros, Tinos, and Thira or Santoríni. There are also many minor islands (the Lesser Cyclades) including Donousa, Eschati, Gyaros, Irakleia, Koufonisia, Makronisos, Rineia, and Schoinousa. Today, the majority of the smaller islands are uninhabited ("Cyclades," 2025).

The area's economy relies mainly to tourism and since it was established as a destination around the 1960s' (Buhalis, 1999) it is growing rapidly. And this is why the South Aegean, together with Attica and the Ionian Islands are the only growing regions in terms of population of the country (ELSTAT, 2023). The islands of Mykonos and Santorini are among the most famous global tourism destinations (Terkenli & Georgoula, 2022) and compete with other "luxury" destinations worldwide, as they offer "a truly exotic experience at a price better or equal to a holiday in Europe" (INSETE, n.d.). Additionally to their strong attractiveness through the "3Ss" (sea, sand, and sun), they are identifies by their natural and environmental elements, diverse landscapes, and a rich cultural identity that dates back to antiquity (Prokopiou et al., 2018)(Terkenli & Georgoula, 2022).

Figure 30.Kykladitisses: Untold stories of women in the Cyclades - Museum of Cycladic Art, exhibition about the societies of the islands of the Archipelago from the Neolithic period until the 19th century, (Museum of Cycladic art, 2024)

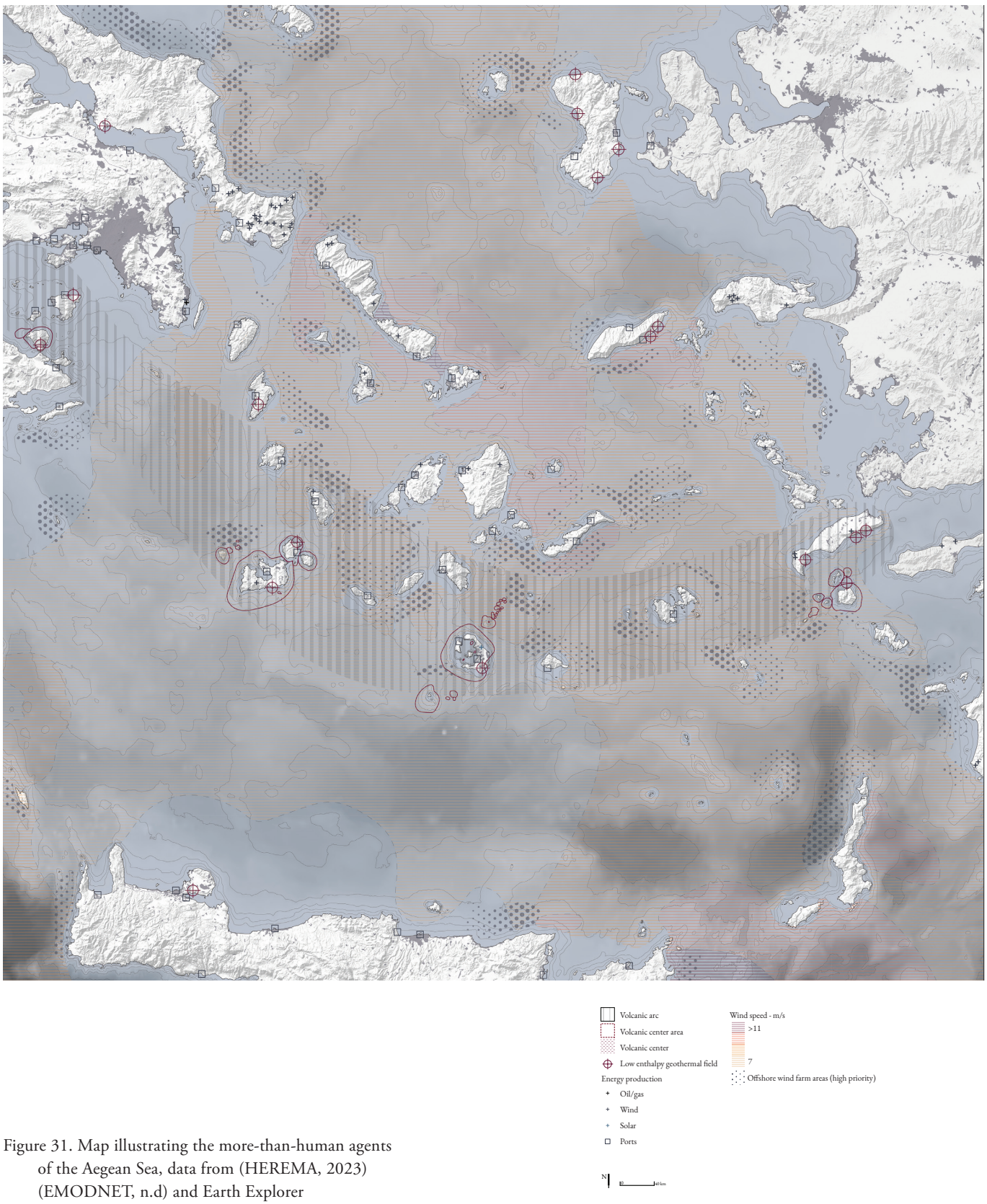


Figure 31. Map illustrating the more-than-human agents of the Aegean Sea, data from (HEREMA, 2023) (EMODNET, n.d) and Earth Explorer

More than human

The South Aegean is a region with high energy endowment due to its more-than-human systems – volcanic activity and weather conditions. Nature acts as a source of labor, and this idea extends beyond human work. As Moore (2015) explains, labor "does not develop on the basis of specific relations of labor alone but through the co-production of nature with human work" (Moore, 2015). Heat, for example, is a form of energy, and geothermal energy—"literally the heat contained within the earth—drives geological phenomena on a planetary scale" (Mihalakakou et al., 2002). In geothermally favorable regions, like South Aegean, volcanic activity plays a key role in shaping the landscape and is appropriated to sustain human functions (Mihalakakou et al., 2002).

In the area the Hellenic volcanic arc is located, which is a 500 km long curvilinear feature located approximately 200 km north of the Hellenic trench. The trench, occurs to the south of Crete isalnd, defines the position where part of the African Plate is subducted beneath the Hellenic Microplate (Scoon, 2021). Santorini and Milos of Cyclades have active volcanoes and geothermal well of high enthalpy. Additionally, thanks to the high wind velocity in the Aegean Sea, the Greek government has indicated multiple areas for the development of offshore wind farms locations taking into account the bathymetry, the shipping routes, heritage areas, wind speed and direction, distance from shore and others (HEREMA, 2023).

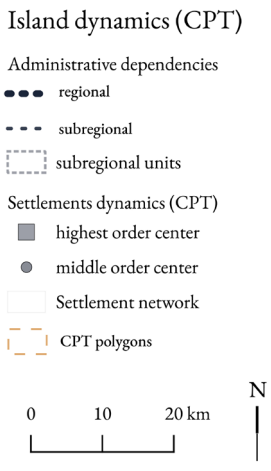
These capacities are shaped by non-human agents and are powered by natural forces like volcanoes, wind, and the sun. These processes contribute to energy production, as more-than-human labor that is harnessed and transformed to support human needs. The concept of the geobiosphere, defined as "the spatial scale from 100 km above to 100 km below the earth's surface", plays a key role in the fluxes of available energy (Brown et al., 2016). Natural systems provide energy that humans harness for their purposes, as Odum (1971) suggests (Odum, 1971). A foundational principle in his work is that energy is the basis of all systems, both ecological and economic. Energy flows, such as geothermal power, are drivers for both human and natural processes. This offers inspiration for thinking about energy metabolism beyond the human realm, recognizing its flow in both the human and more-than-human context. Energy is present in everything around us: in the subterranean, in waves, in volcanic activity, in the sun and the soil. This demonstrates the interconnectedness of human and non-human energy flows.

Figure 32. Map illustrating the current island dynamics

Cross-island dynamics

Regarding the relations between the islands, this project explores an analysis across three dimensions: services, resources, and tourism.

To analyze dynamics related to services and administrative structures, experimentation with the Central Place Theory (CPT) of Water Christaller from the 1940s was conducted, considering the existing dynamics of the settlements and the types of services they provide. Originally, the theory takes into account “the size, number, functional characteristics, and spacing of settlements” that act as focal points for services and goods to the surrounding “market areas” (Malczewski, 2009). This project adjusts the theory to islands according to the existing dynamics and relations regarding services, infrastructure, movement, and administrative structures. The market areas are conceptual polygons that include islands following the CPT analysis. Each polygon has different levels of centers, like the regional capital and highest-order center (Syros), which has administrative power, followed by middle-order centers that act as commercial and business hubs (Santorini, Mykonos, Naxos). The rest of the settlements/islands are low-order centers that offer services, though they serve a small population. It is interesting to highlight that although the capital of the region is Syros, the islands of Santorini and Mykonos tend to serve as higher-order centers as well due to the concentration of services, mobility infrastructure, and their economic role in the region and the country due to their touristic profile.



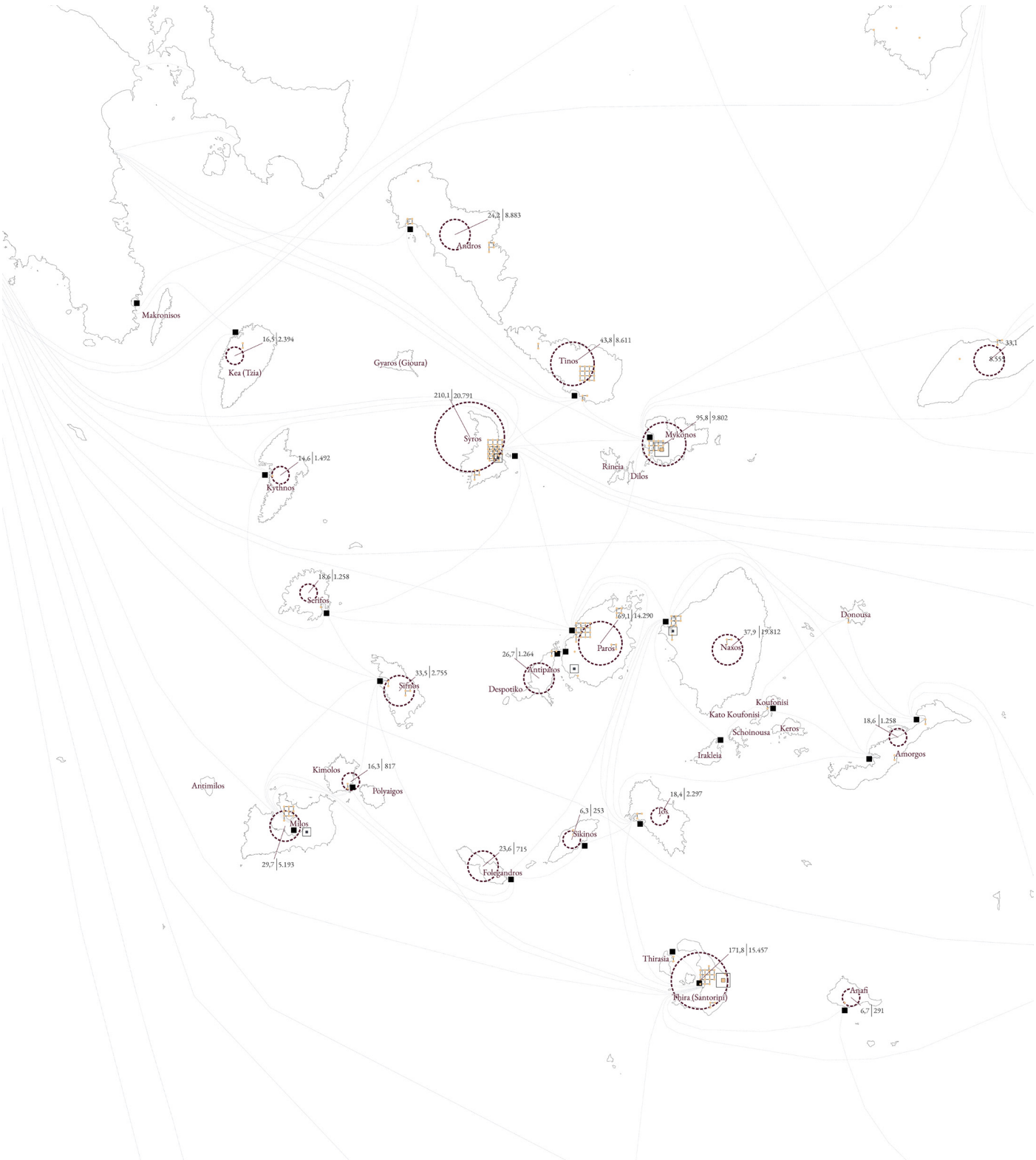


Figure 33. Services, infrastructure, connections, and population dynamics

Cross-island dynamics

The factors considered for the CPT analysis are population density, service clusters, transportation connections, administrative structures, and settlement hierarchy according to their dependencies. In that way, different "market" areas were identified as abstract polygons that shape group-of-island areas with higher levels of relations. Thus, the islands that host larger populations and services are highlighted. Population density provides an idea about the island's urbanization level as well as urban sprawl and the ratio of built-up area with other land cover such as forests or agricultural land. An interesting case is the case of Naxos, which has a population density of 37,9 people per square meter and settlements concentrated in the northwest part of the island. It has suitable geomorphology compared to the southeast part, which is mainly mountainous and sparsely populated.

When describing dynamics, it is crucial to mention that in this analysis and the current profiles of the islands, tourism plays a pivotal role. Islands such as Mykonos or Santorini can even be considered more powerful in comparison to the regional capital since they are crucial for the hospitality sector, and therefore, the concentration of services and commercial activities is growing rapidly.

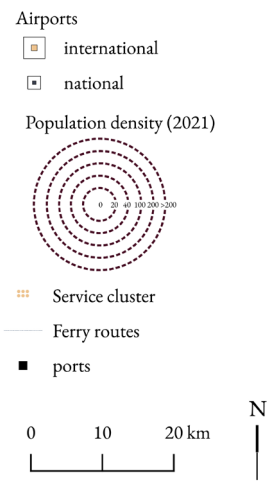


Figure 34. Greek island landscape in tourism campaigns. Poster by the Greek National Tourism Organization (EOT) by painter Giorgos Moschos. From the collections of the National Gallery- Alexandros Soutzos Museum (Mela, 2024)

Commodification

Tourism involves reimagining a geographical location as a tourism destination, combining infrastructure, services, and materials into a package designed for consumption (Buhalis, 2000) and therefore, adopts a "business" approach with its "products, markets, and customers" (Kotler et al., 1993)(Lichrou et al., 2017). Early studies in anthropology regarding tourism have highlighted differences between "hosts" and "guests", focusing on the extend that tourism leads to a commodification of local cultures (Greenwood, 1978; Lichrou et al., 2017).

In the case of the Aegean landscape and other tourism regions the picturesque scenery has been the subject of commodification next to the cultures. Tourism discources in Greece often focus on the islands of the country and their landscapes (Lichrou et al., 2017). A perfect combination of "geographical, geomorphologic and climatic features marks such landscapes as a characteristic Greek landscape" (Terkenli, 2001) (Lichrou et al., 2017). According to Terkenli, factors such as climate, history, traditions, and hospitable culture contribute to the composition of an easygoing lifestyle that is somehow inherent in Greece as a holiday destination, but has also exoticized some Greek locations for Greeks as well. This commodification has led to the Greek islands being portrayed as "vulnerable peripheries, romanticized landscapes", and commercialized areas for tourism (Mela, 2024).

> "The Aegean is therefore imagined as a vacationland, the playground of both Greek and international tourism".
> (Terkenli 2001, p. 204) (Lichrou et al., 2017)

In conclusion, the evolution of international tourism had a broad effect as it led to the idealization and commercialization of traditional aspects of rural life in order to serve as attraction for visitors (Papadimitriou, 2000) (Lichrou et al., 2017). This leads to the gradual spatial restructuring where traditional land uses and activities are gradually replaced by tourism-related elements, observed on the landscape and the social structure (Baldacchino, 2006).

Import-oriented system

The emergence of tourism and the availability of electricity led the development of infrastructure to support the increased resource demands and the substitution of most of the internal production to imports. Although, the reality wasn't always this. From the ancient times until the end of the 19th century the dynamics of Cyclades were shapes by the power of trade, religion and governance (Pitoglou, 2017).

The islands became very much known for their landscapes and became famous during the '90s as tourism destinations and since then, they have been thriving economically, with the dominant sector being tourism-related activities and are now connected with global networks of people and material flows that are needed to support "Greece's heavy industry" (Vythoulkas & Delezos, 2024). Very little of their activities relate to their lands as they have replaced the inland flows with connectivity networks and import systems connecting mainland Greece and the islands (Kizos et al., 2022). In fact, many Aegean islands import up to 90% of their total cargo from the metropolitan area of Athens (Kizos et al., 2022).

In contrast to the conventional city-hinterland relationship, the Cyclades showcase an inverted dynamic with the metropolitan area of Athens and mainland Greece. They are disruption the traditional model since they act as the "city"- the "consumer" of resources imported from mainland Greece and international markets. At the same time, they serve as hubs of important economic power that generate high revenues and attract global attention as tourism hotspots.

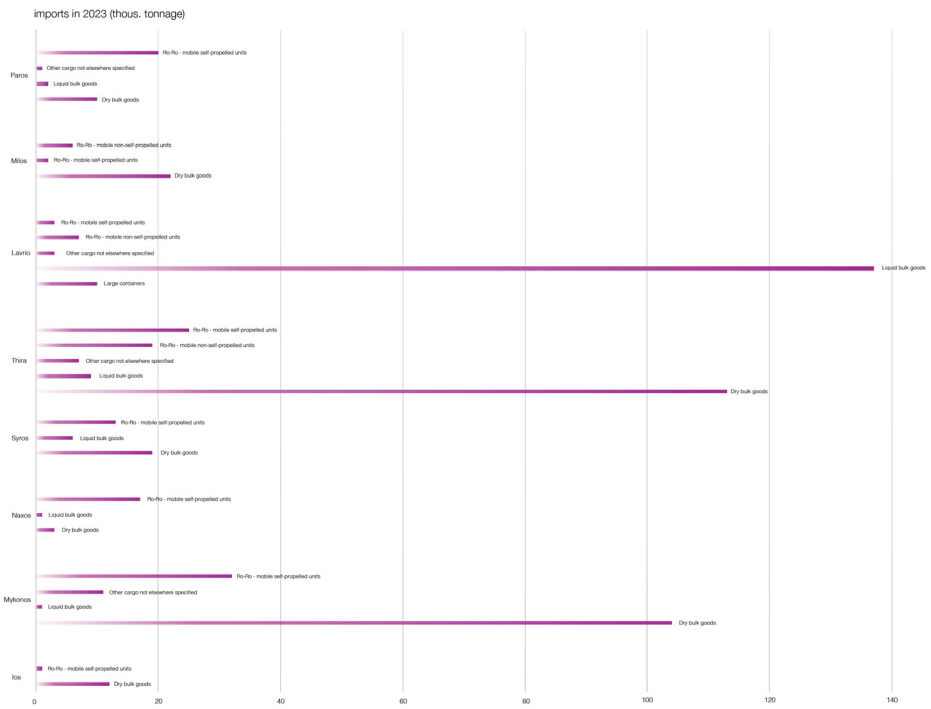


Figure 35. Imports in main ports of Cyclades, 2023, (EMODNET, 2023)

5.2 Debating carrying capacity

By integrating the carrying capacity concept, the project builts on an ongoing and heated discussion in academia, among experts, and within island communities regarding the future of the islands, particularly in relation to the pressures of tourism, identity loss, cultural preservation, and green transitions. However, the debate is often lacking in depth. Often the conversations include the consideration of metabolism as an engineering approach to landscapes. Another issue is the "monopoly game" of zoning elements and the focus on financial gains over the beliefs and needs of local communities. In the planning apparatus, spatial qualities and the notion of identity are also neglected leading to the emergence of two approaches: one through the lens of the state, which tends to focus on top-down regulations, and the other through the perspective of the community, which emphasizes local values and needs. Plans are often made from central knowledge institutions or companies without considering the localities. Or on the other side, a more romantic approach of keeping the cultural landscape in a museum-like state, without it being actively evolved, is often discussed.

*"Our islands **are not a museum** to be put behind a glass, **nor a backdrop for the vacations of the entire planet.**"*

*"A limit must be established based on the **carrying capacity of each island** and its human environment to preserve island identity".*

Figure 36. Debates around carrying capacity and spatial plans

Inefficient regulatory apparatus

The main takeaway from the territorial organization analysis is that regulatory and institutional infrastructure, although very much present, has proven weak and insufficient. From the analysis, it is clear that urbanization has expanded into non-built zones and preservation areas, particularly in Santorini and the broader archipelago. Additionally, different insights can be observed for different scales through such multiscalar cartography, from urbanization within preservation areas (A) to the "stretching" and gradual merge of settlements (B), as well as qualities of the productive landscape and traditional terracing (C) that has shaped the landscape of these islands profoundly.

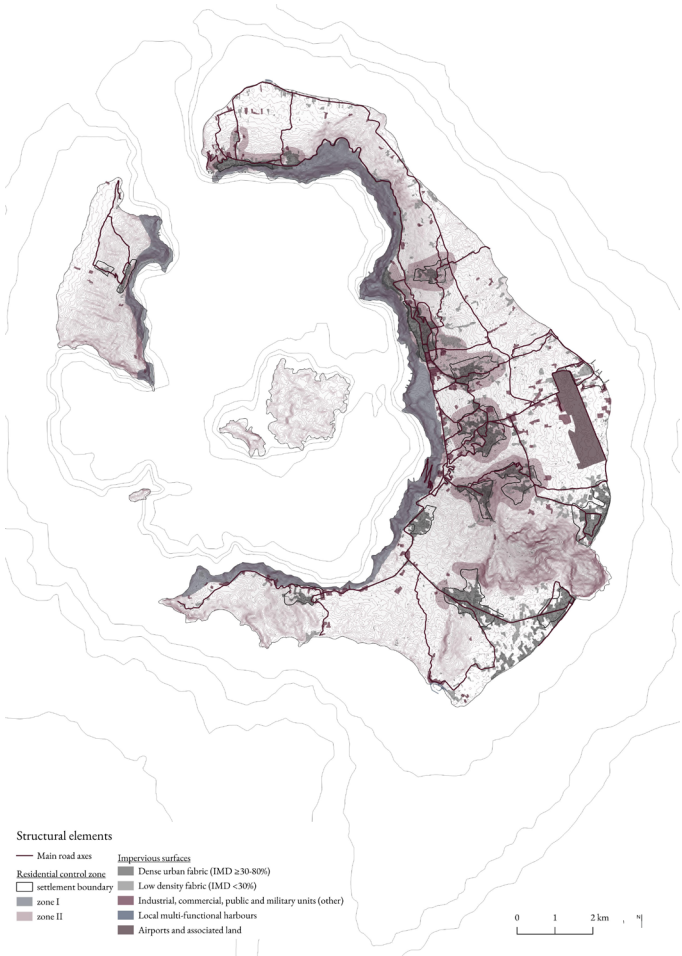
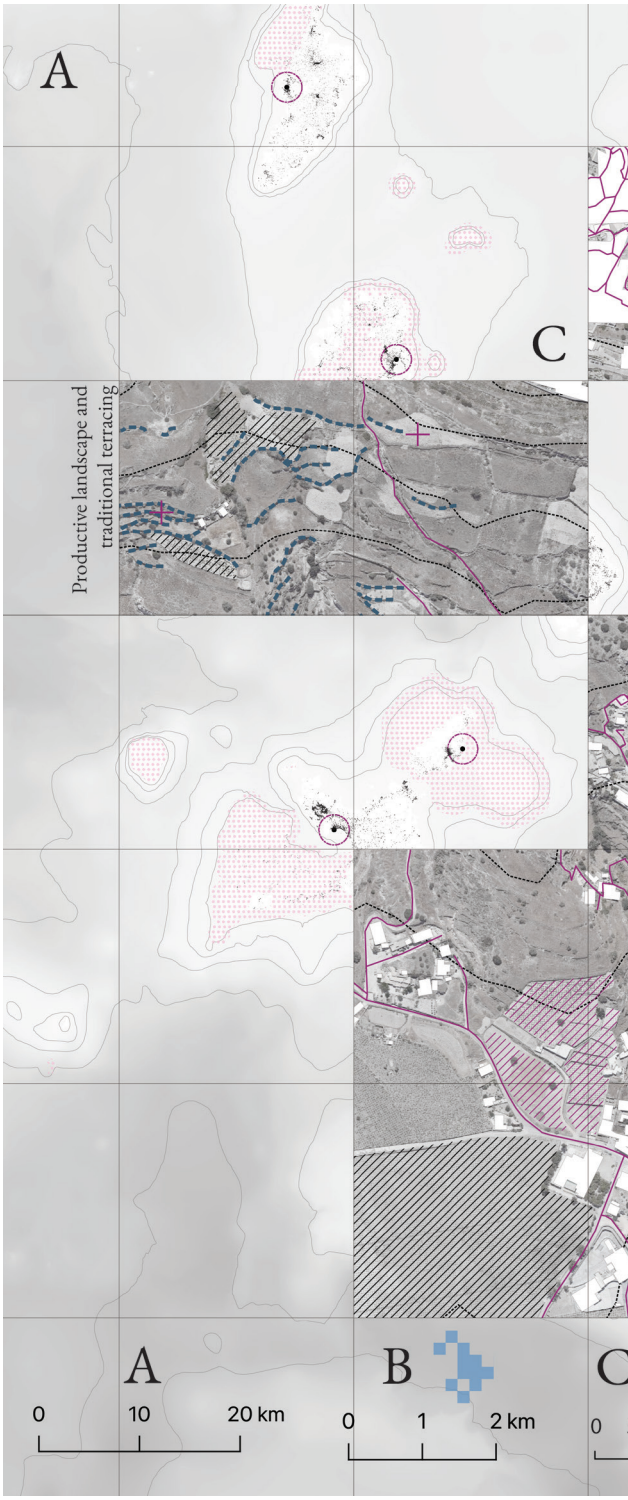
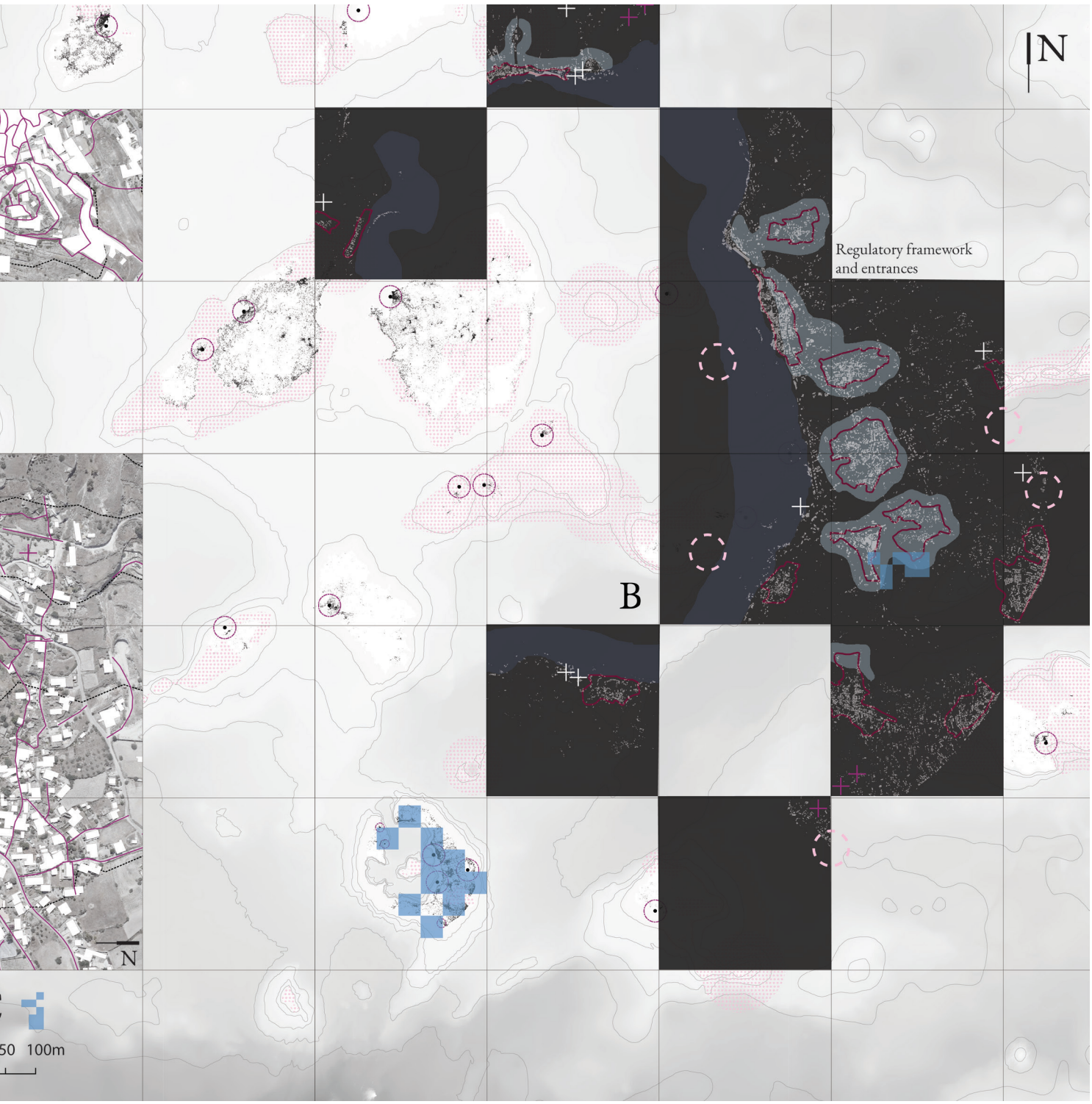


Figure 38. Main spatial structural elements of Santorini





settlement boundary
ZOE
Zone I
Zone II
Natura 2000
abandoned productive land
drywalls
contours
entrances
past metabolism
current metabolism elements
reference area

Figure 39. Map illustrating in different scales the building footprint in relation to regulatory infrastructure and metabolic elements

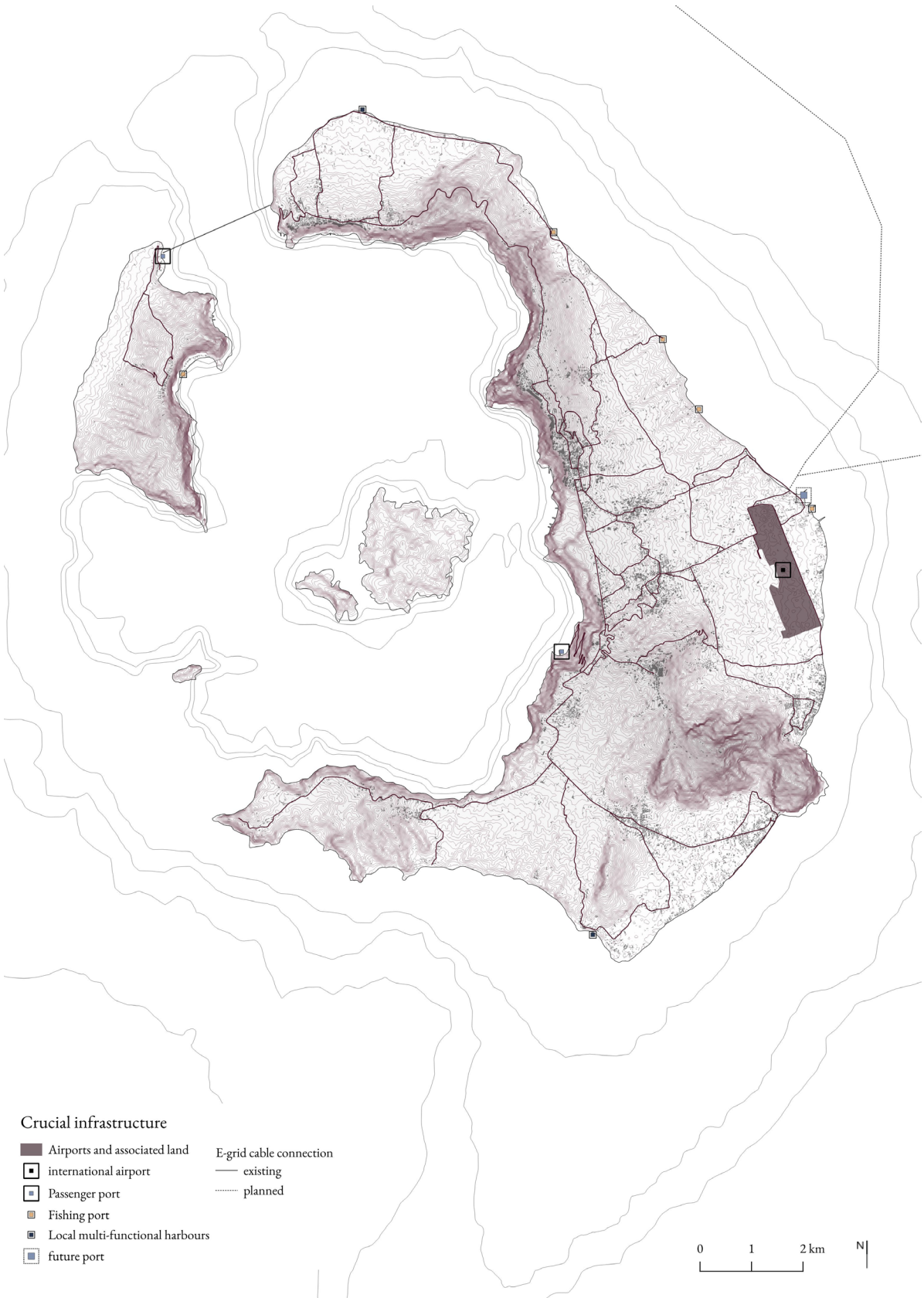


Figure 40. Santorini as a hub, data from from: EMOD-NET, Geofabrik, Earth Explorer

5.3 Complex, Santorini

To test and further develop the hypothesis, this graduation project focuses on Santorini, the globally known island, famous for its sunset and luxury tourism services. This was not always the case. In the beginning of the 20th century, when tourism in the Cyclades emerged, visitors were not attracted by the infrastructure, since it was almost absent (Pitoglou, 2017). Visitors were attracted by the "moderate climate, the unique natural and built landscape, and the archaeological sites and history of the Cyclades" (Tsartas, 1992) (Pitoglou, 2017).

Over the years, the volcanic island has been urbanized rapidly due to the constant economic development and hyperconnection with global networks of flows and capital. Therefore, gradually the island's landscape and settlements transformed, and today old and new settlements co-exist next to each other without one being able to recognize their previous boundaries.

Due to the existence of an airport and its central position in South Aegean, the island serves as a key node for both air and water transportation. This is beneficial especially for visitors who wish to avoid the chaos of the island's summer season and prefer to travel by sea to nearby islands.

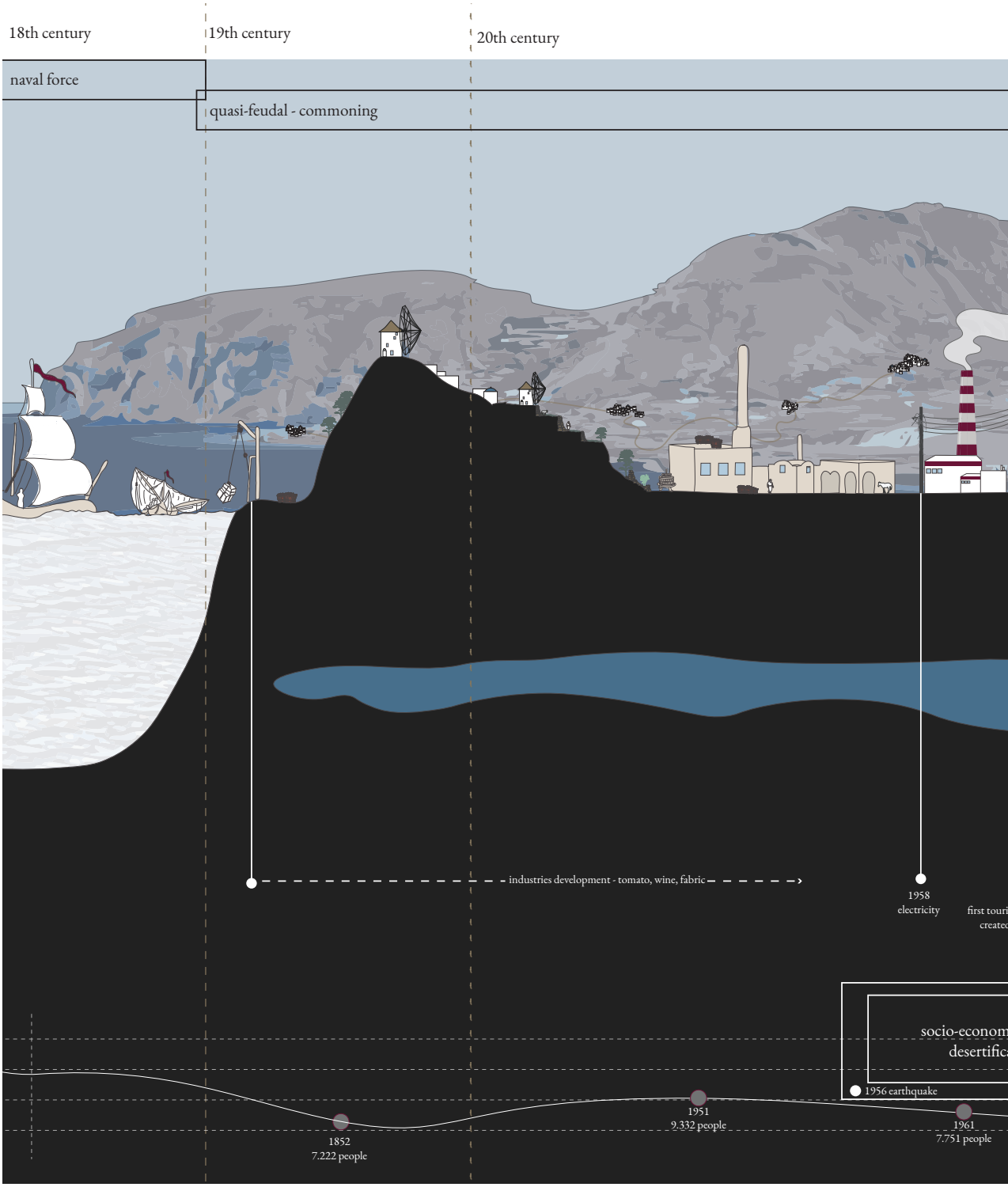
The airport facilitates numerous flights, especially between May and September, connecting it to multiple domestic and internatioal destinations. According to Fraport, in 2024 the airport received a total of 2.8 million passengers, while Mykonos received 1.6 million (Fraport, 2024). This showcases an increase of 3,7% for the former and a decrease of -2,7% for the latter.

The emergence of tourism

Santorini's rapid tourism development has fueled a "transition from a declining quasi-feudal economy into a fully-fledged service economy within the passing of two decades" (Lichrou et al., 2017). Tourism begun in the 1960s, and supported by infrastructural construction, experience a massive growth between the 1980s and 1990s (Lichrou et al., 2017).

"By the end of the 1990s, the island's landscape and way of life had dramatically changed".

As illustrated below, tourism arrived at a moment when the island was in decline, following the earthquake of 1956, the rural economy was hit by mass emigration to Athens and desertification.



"Tourism development brought economic relief to the island, and was accompanied by modernization and improvement of the standards of living within a generation".

In order to support growing demands, the previously self-sufficient island had to rely on extensive infrastructural development and connectivity networks to replace inland material flows and facilitate imports. Along with this transformation, tourism is seen as a force that changed the "human values, traditional occupations and ecological balances" (Kontaratos, 2007) (Lichrou's translation from Greek) (Lichrou et al., 2017) on the island.

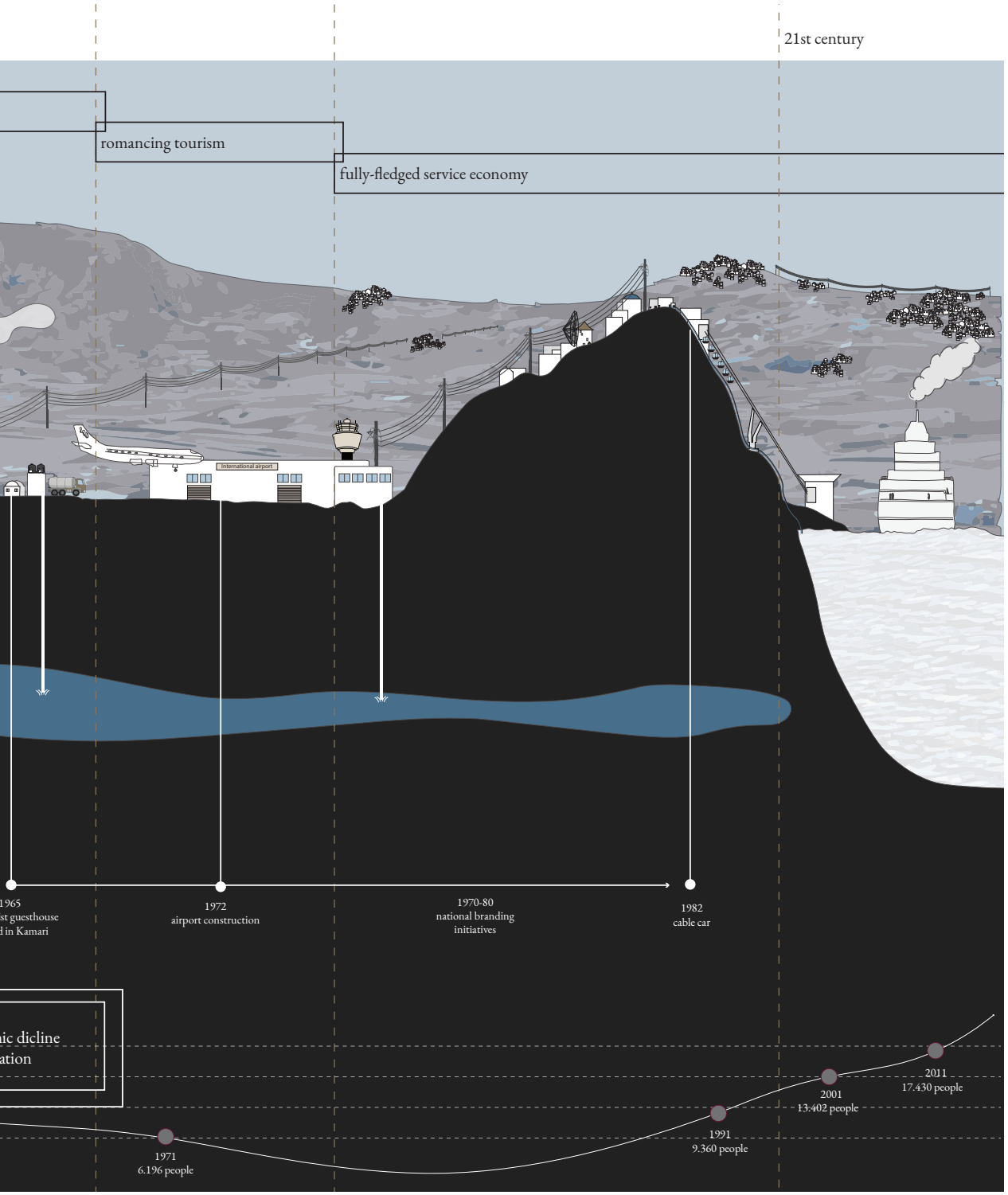


Figure 41. What was the crucial moment it time when everything changed?, made by the author with data from Lichrou et. al., 2017 and ELSTAT

Sprawl and transformation

Built up area expansion is the main visible expression of tourism development on the island. Following on broader Greece's faulacies, unregulated, very oftern illegal urban sprawl is a "common process for peri-urban areas on islands and coastal zones" (Salvati, 2013) (Tsilimigkas & Derdemezi, 2020). This is reinforced due to the lack of a strategic framework and the anarchic nature of tourism (Lichrou et al., 2017).

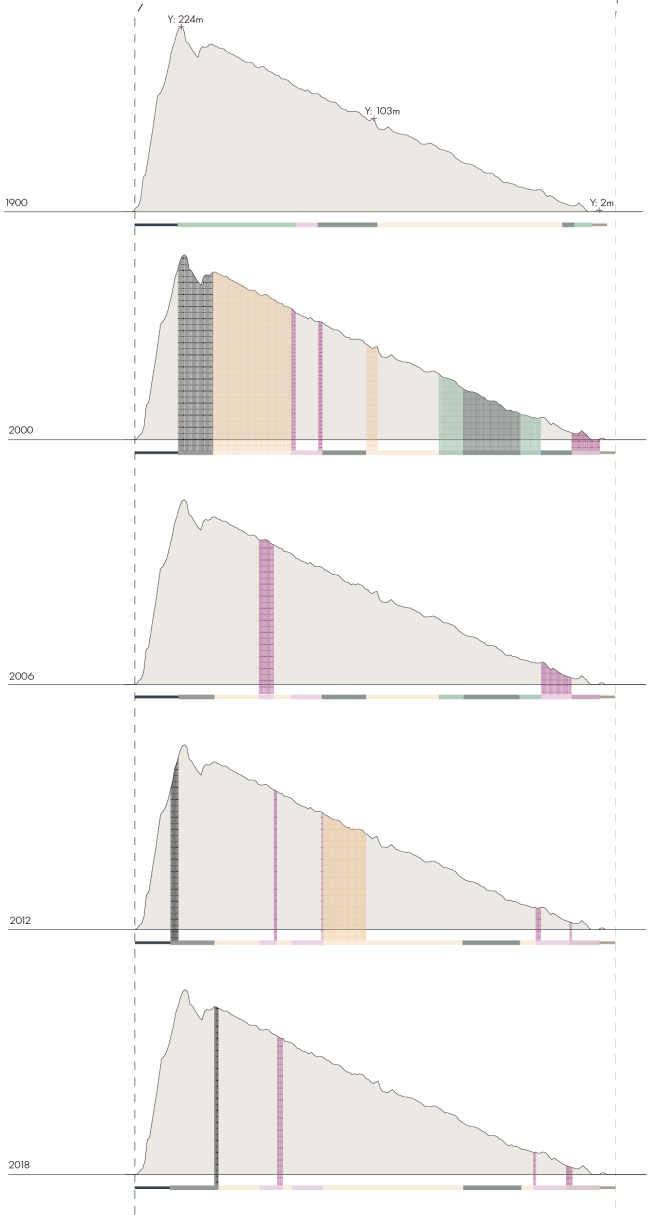
Figure 42. Alteration drawing showcasing the expansion of built-up are on the island, data fromCopernicus

Artificial surface expansion
- 2000 - 2006
- 2006 - 2012
- 2012 - 2018
- after 2018

Land cover 2000
- Artificial surfaces
- Agricultural areas
- Semi natural land

0 2 km

N



- Bare rocks
- Industrial unit
- Beach
- Non-irrigated arable land
- Cultivated area
- Vineyards
- Urban fabric

0 1 km

Figure 43. View from Akrotiri overlooking the volcanic complex and remnants of rapid urbanization, January 2025

Figure 44. New building “jumping”, January 2025

5.4 Tidal pressure

Santorini's metabolism is experiencing significant fluctuations in its material economy and increases in key metrics through the years driven by tourism and environmental challenges. Tourist arrivals rose from 26.000 in January 2023 to 500.000 in August of the same year, reflecting the island's peak-season influx. Similarly, resource consumption has escalated, with water usage rising from 891,028 m^3 in 2012 to 1,706,055 m^3 in 2018. Energy demand follows a similar pattern, jumping from 8,000 MWh in January 2023 to 38,000 MWh in August. Adding to these pressures, decreasing precipitation patterns and coastal erosion are intensified due to climate change, further impacting the island's natural resources.

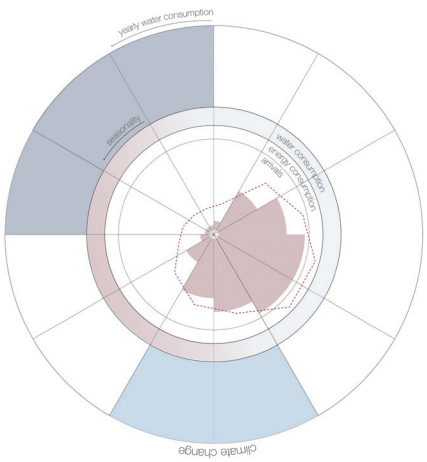
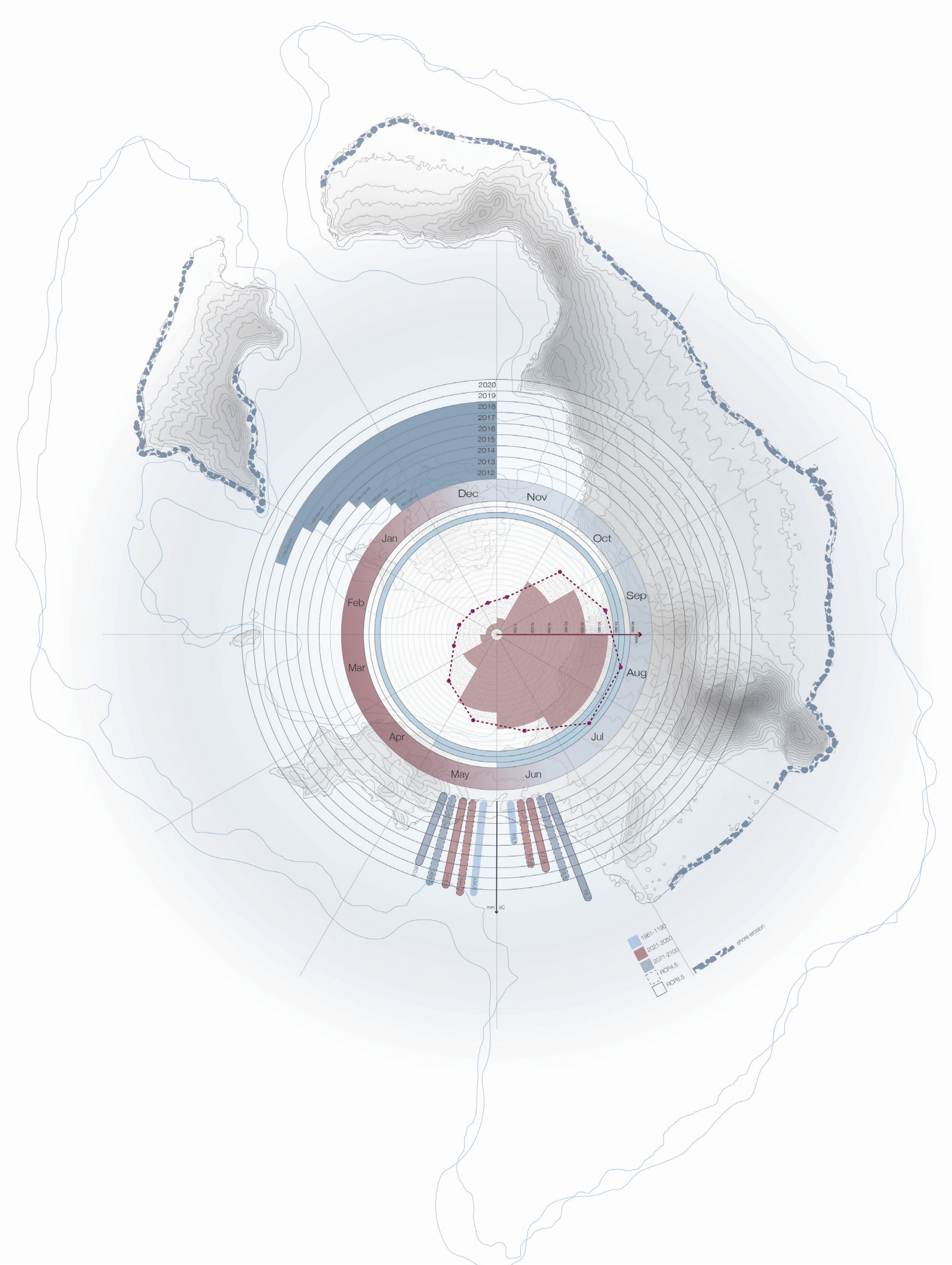


Figure 45. Limits drawing – tidal pressure, data from: IPTO, Fraport, EYATH, ERA Beach project


2020
2019
2018
2017
2016
2015
2014
2013
2012
Dec
Nov
Oct
Sep
Aug
Jul
Jun
May
Apr
Mar
Feb
Jan
mm
°C
1861-1190
2021-2050
2071-2100
RCP4.5
RCP8.5
shore erosion

Extreme microstories

As mentioned before, the extremes the islands' are facing are being translated in population influx, larger energy and water consumption, waste production, contamination and more. But the local community perceives these changes in their quality of life, in their everyday life, the way they live and their surrounding spaces.

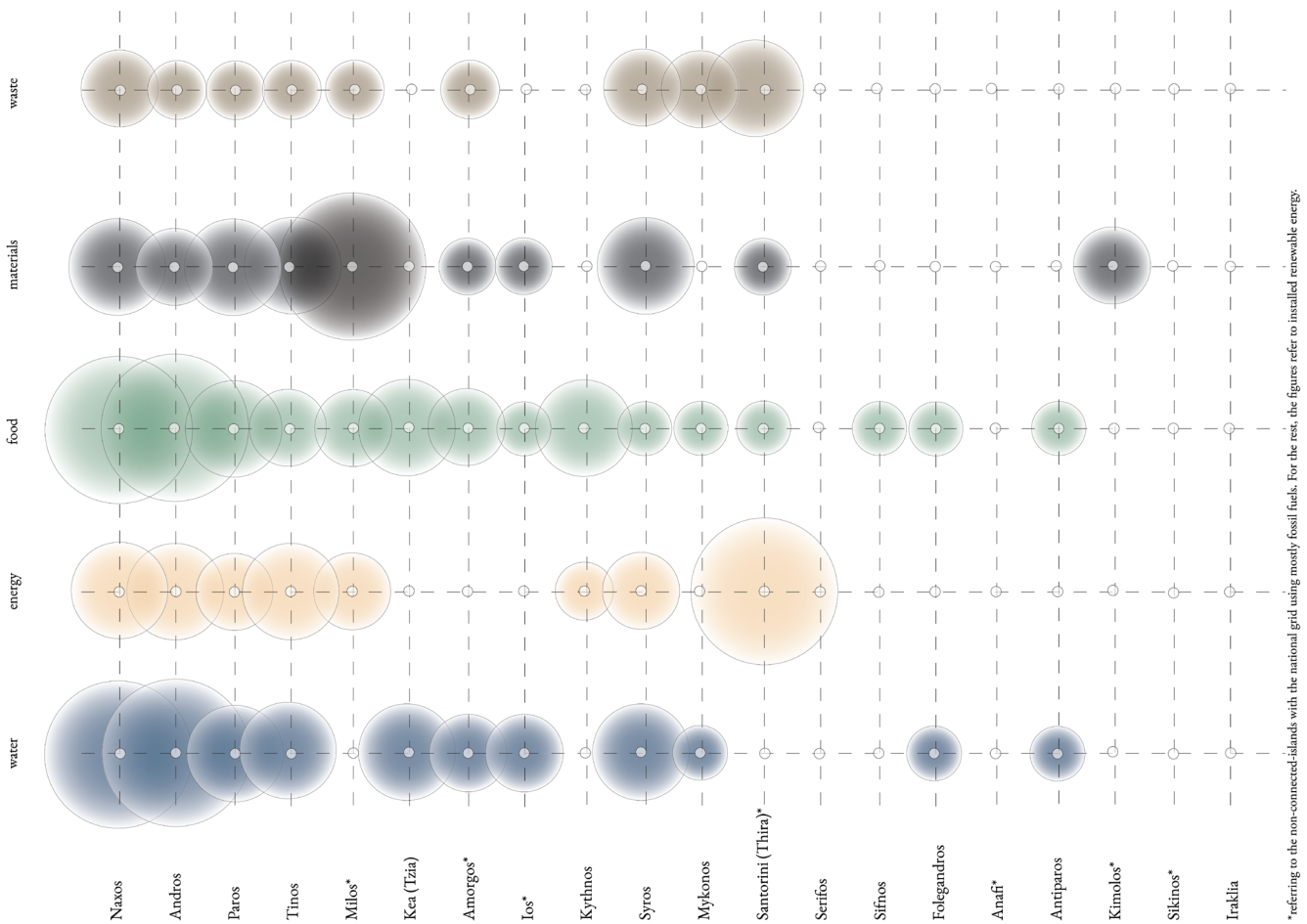
Figure 46. Collection of photos showcasing the winter serenity, January 2025


DIMITRIS

5.5 Elements of metabolism

As previously mentioned, the island's metabolism was once closely tied to its land, relying primarily on inland flows and exports, as the thriving primary production supported its economy. This section will explore the elements—both past and present—that define the island's metabolism.

Figure 47. Qualitative assessment of the current metabolic profiles on the archipelago



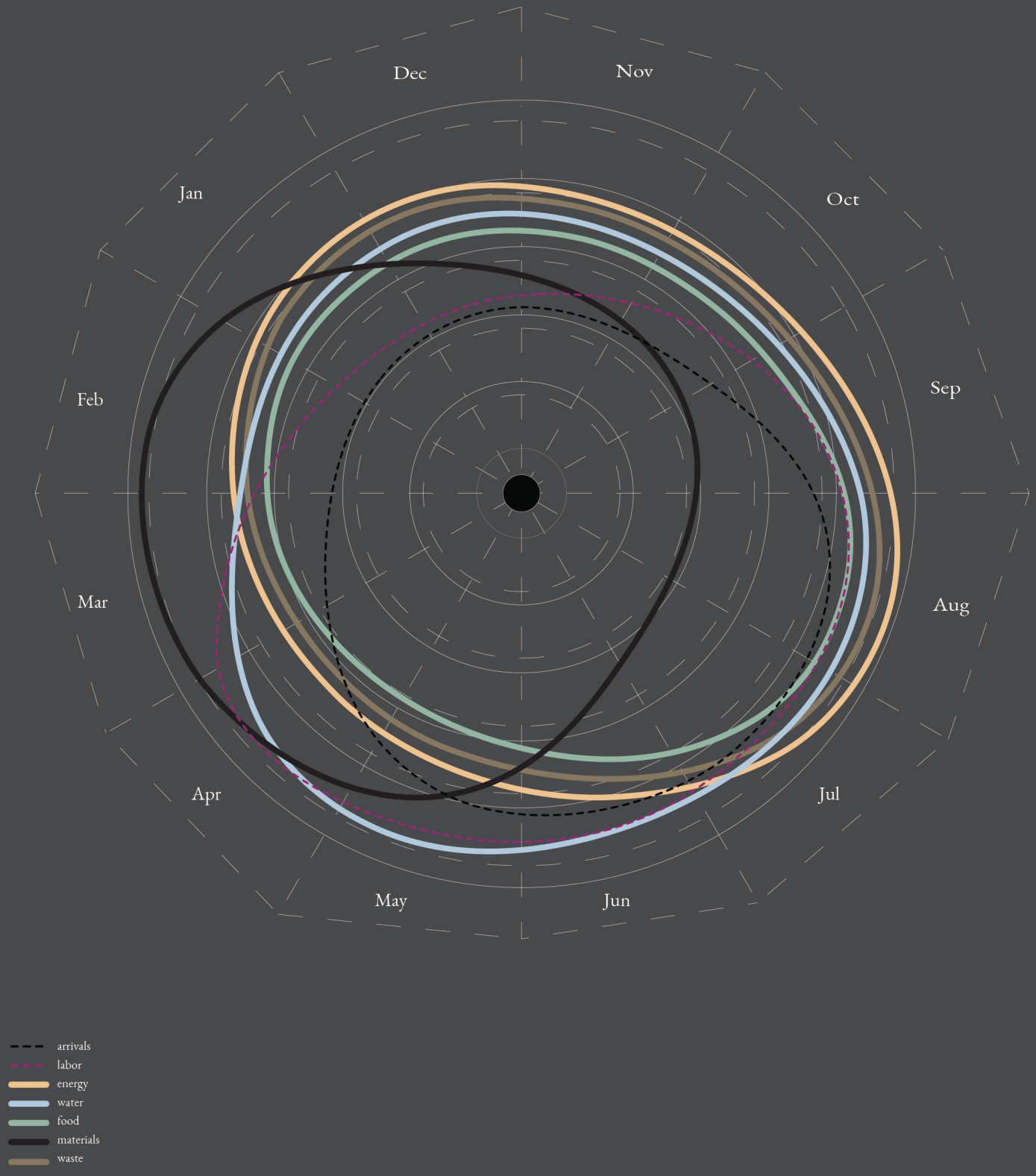


Figure 48. Metabolic processes, arrivals and seasonal labor

Energy landscape

Most Cycladic islands rely heavily on fossil fuels supplied from the metropolitan area of Athens, specifically through the port of Lavrio and the oil refineries in Aspropyrgos. Tankers transport the necessary fuels to power the islands' oil thermal units. However, as part of Greece's electrification policy and the ongoing project to connect all Cycladic islands to the mainland electricity grid, several of these units are being decommissioned or kept in an emergency standby state. Not all islands are connected to the grid yet, but Santorini's connection is projected to begin supplying power by the summer of 2025.

Figure 50. The hinterland - wind farms in Evia

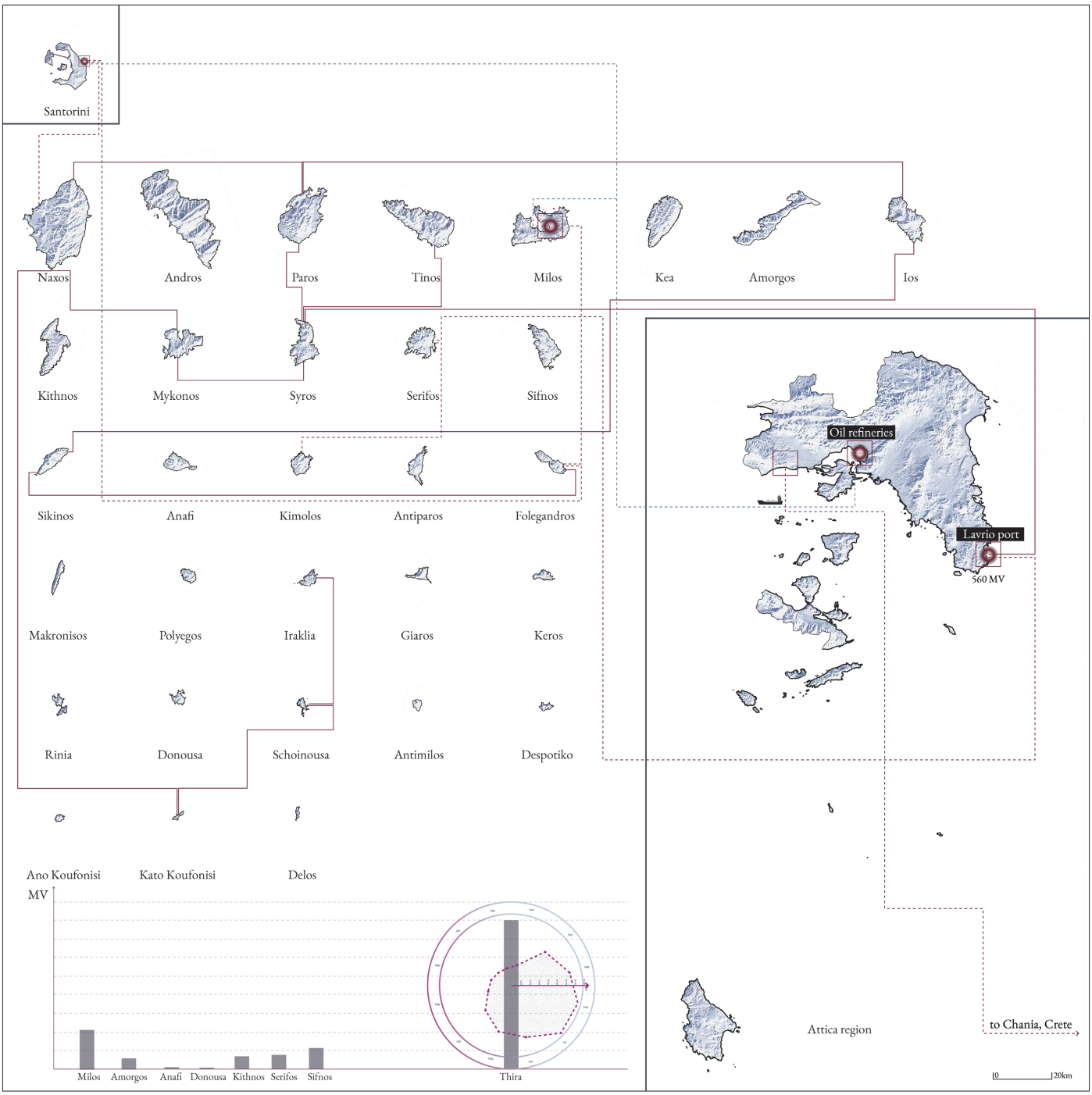


Figure 51. More than city - human drawing

Energy landscape

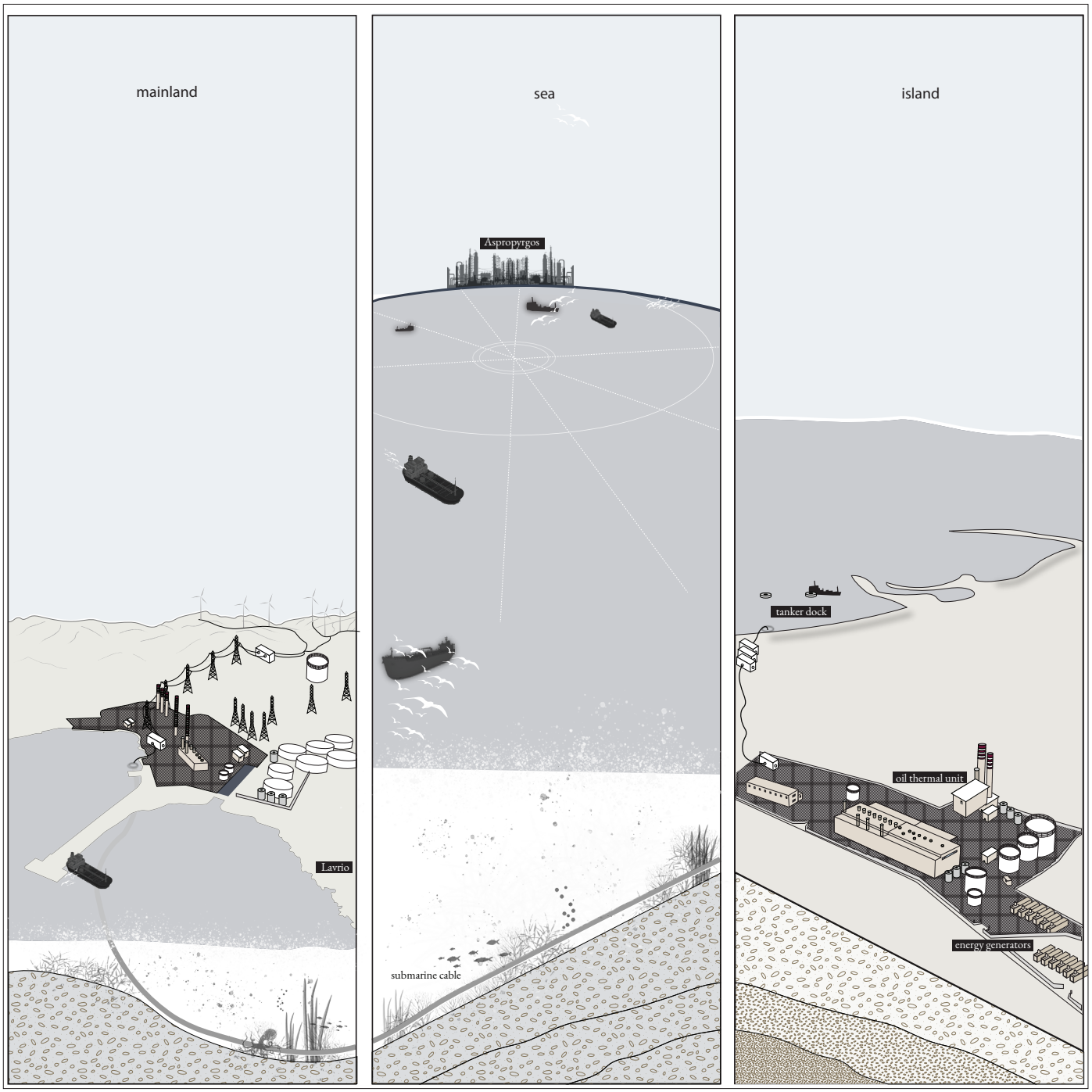


Figure 52. Energy landscapes, from Lavrio to Santorini

Figure 53. Oil thermal unit and additional generators in Monolithos, January 2025

Figure 54. Warm water on its way from the power plant back to the sea

Figure 55. High to medium voltage transformation

Figure 56. Crossing of airforce fuels

Figure 57. Electricity grid

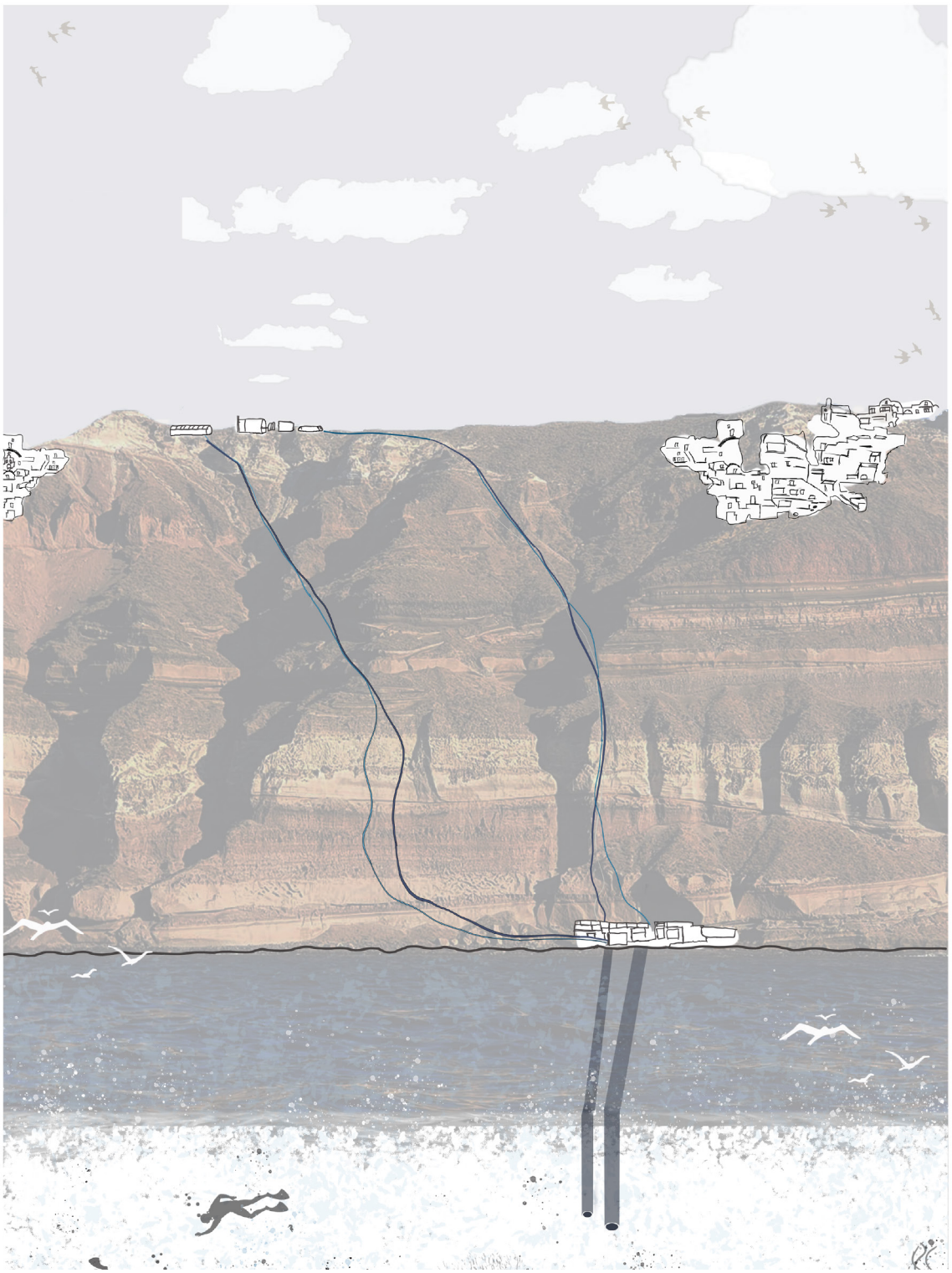


Figure 58. Object drawing, desalination plant in Ia, Santorini

Water supply

Water supply is a significant challenge on the island. Santorini has four official desalination plants, although not all of them are currently operational. These plants source water either directly from the sea or via municipal boreholes. Most of the island's water needs are met through the local water grid, which is continually being expanded to cover more areas. However, in remote or inaccessible locations, water is delivered by tanker trucks, which source water from desalination plants or, in some cases, private—often illegal—boreholes.

Figure 59. Pipes over the cliff

Figure 60. Brine - salt back

Figure 61. Private borehole

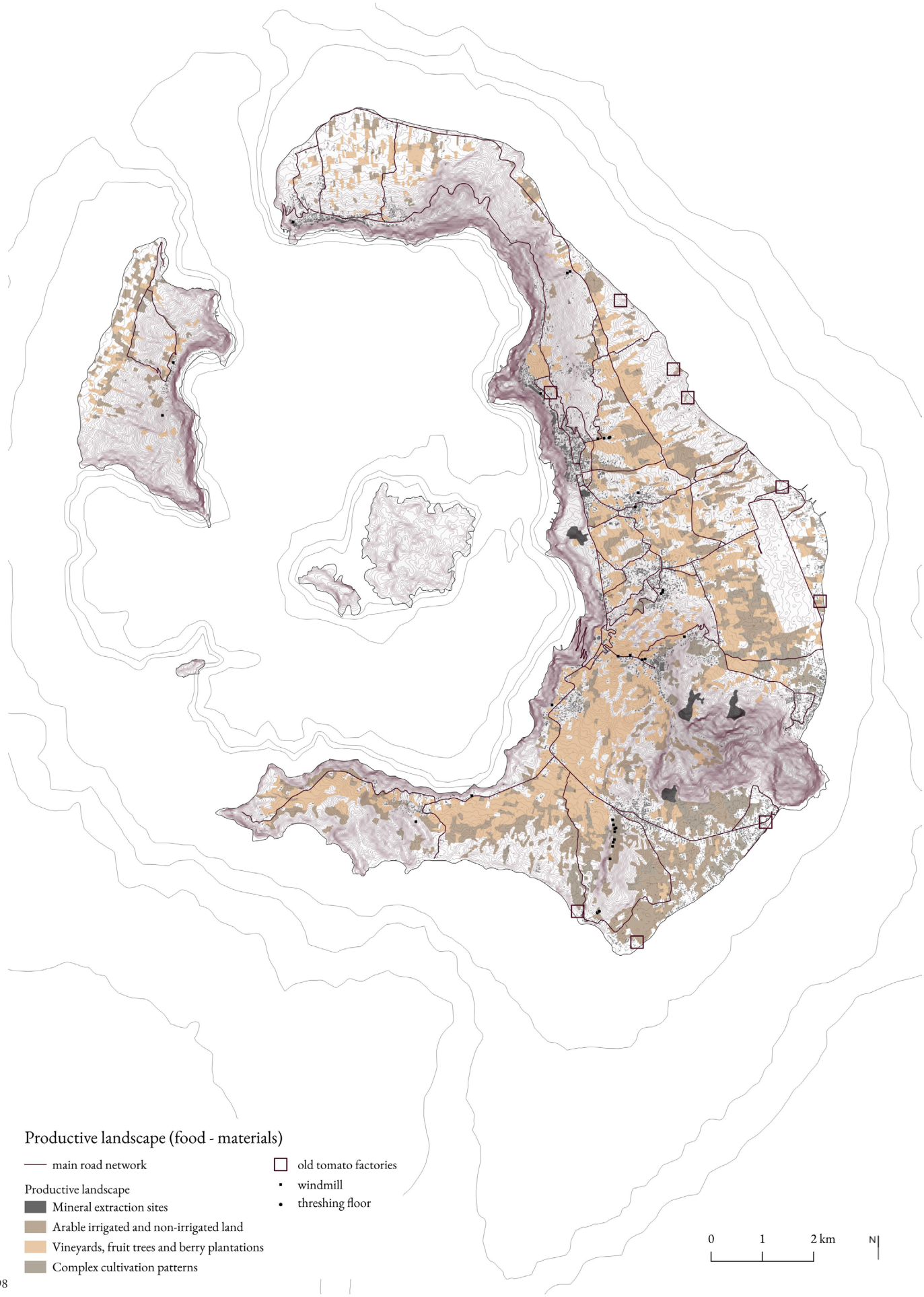
Figure 62. Water carrier

Figure 63. Materials arriving from Aliveri, Evia

Figure 64. Quarry

Materials

Most construction materials are transported to the island through the port of Athinios and then delivered to their destinations or stockyards by trucks. While the island previously operated three quarries for local material extraction, these have been recently shut down due to regulatory compliance issues.


Productive landscape (food - materials)
main road network
Productive landscape
Mineral extraction sites
Arable irrigated and non-irrigated land
Vineyards, fruit trees and berry plantations
Complex cultivation patterns
old tomato factories
windmill
threshing floor
0
1
2 km
N

Food

Although large areas of the island's land are classified as agricultural, they are mainly dedicated to viticulture, an activity renowned due to unique soil conditions. In terms of food production, some households still own small-scale vegetable gardens, although in minimal-scale production. Large agricultural areas utilized in the past are now abandoned since the primary sector has gradually been abandoned. Large amounts of food and products are imported from mainland Greece through the port and distributed in the supermarkets around the island.

Figure 65. Vineyards in Thirasia

Figure 66. Burn them all, January 2025

Figure 67. Landfill materials towards the sea, April 2025

Waste

Most of Santorini's solid waste is disposed of in a landfill located near the capital, Fira. However, agricultural waste is still frequently burned, following traditional practices. The island operates three waste treatment facilities that serve the majority of settlements, but some areas remain uncovered, with cesspits still in widespread use.

5.6 Situated metabolism

As previously mentioned, these islands once operated under a very different reality. Their metabolism was closely linked to the land, which was fully "operationalized"(Brenner & Katsikis, 2020), particularly the handmade productive landscapes they cultivated. Terracing was a technique to maximize arable land in the island's hilly terrain. The steep topography, combined with limited water resources, made traditional cultivation difficult. Therefore, terraces were constructed to prevent soil erosion, optimize land use, and improve water retention.

Figure 68. Terraced landscape, January 2025

Figure 70. The energy of the past

Figure 71. Threshing floors - “aloni”in greek

Figure 72. Old quarries of Santorini land

Figure 73. Windmills

6. Diverse archipelago | a spatial vision

6.1 A diverse archipelago

The vision reimagines the Cyclades archipelago as a resource-conscious and economically diverse territory. One that reactivates its landscapes and local productive capacities while fostering socio-ecological balance and regional collaboration. In response to the circular pressure of seasonality and the limitations of mono-functional development, the project envisions a diverse region, with its metabolism being an adaptive, decentralized, and landscape-driven system rather than infrastructure-heavy and externally dependent. It promotes cross-scalar and collaborative archipelago relations, in which each island contributes to a shared carrying capacity based on place-specific potentials and regional interdependence. More specifically, the project's goals are:

- Reactivate the productive landscape while integrating localized knowledge and small-scale technological interventions.
- Enable decentralized and site-specific metabolic processes, reducing dependency on large-scale centralized infrastructure and networks
- Embrace spatial and functional conflicts by promoting land uses that compete with tourism
- Develop an alternative framework for carrying capacity, originating from the communities involved, based on cooperation, care, repair, and adaptability.

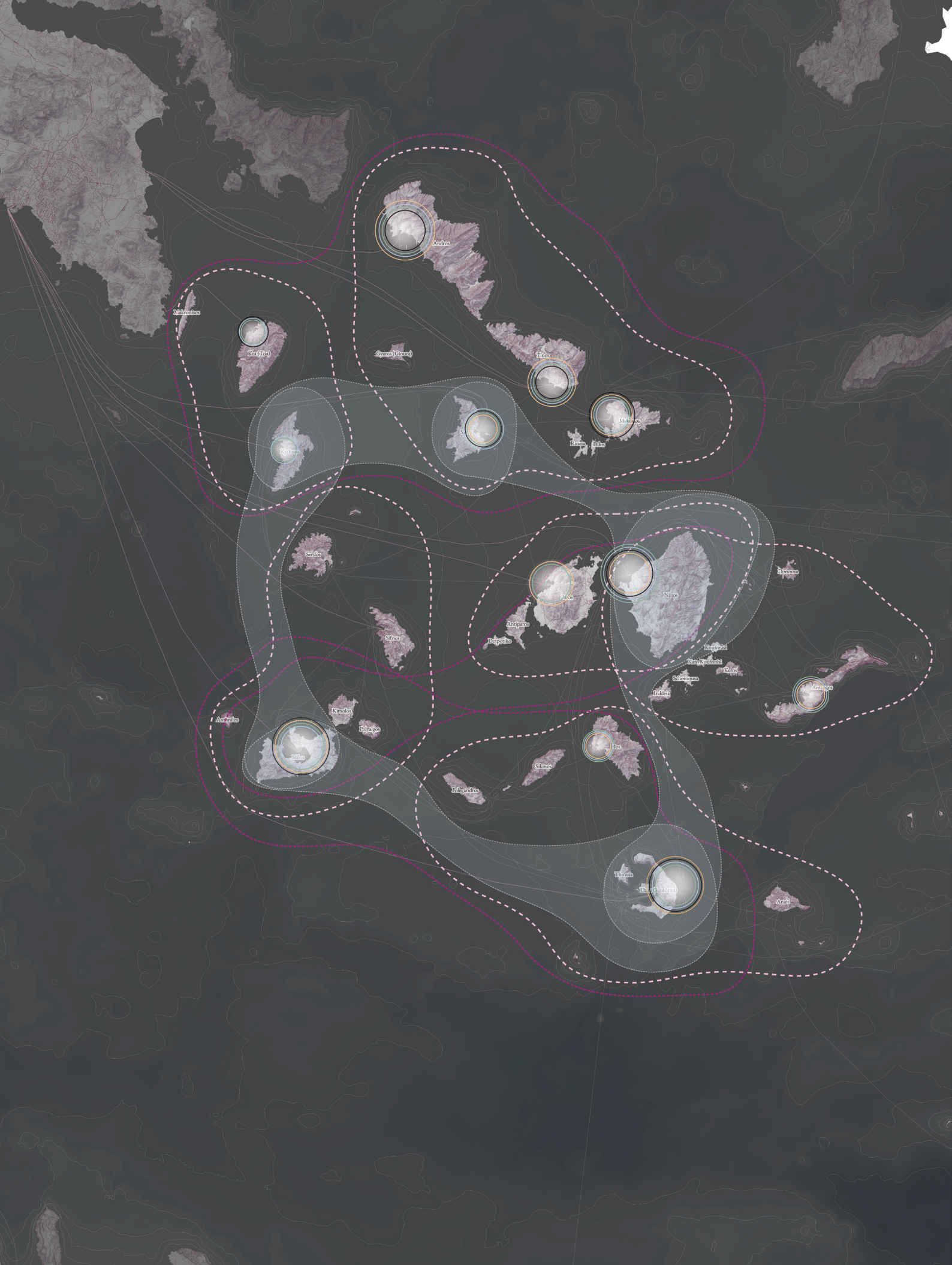
A resource-conscious and economically diverse archipelago that reactivates its landscape by embracing local capacities and harnessing natural processes, while supporting synergies and collaboration across scales

re-activate the productive landscape while integrating small scale technological elements

decentralized metabolic processes

spatial conflicts by supporting competitive to tourism functions

archipelagic and flexible carrying capacity assessment


Andros
Makronisos
Kea (Ioúlis)
Gyaros (Gioura)
Tinos
Mykonos
Rinia
Dilos
Kythnos
Serifos
Sifnos
Paros
Naxos
Donousa
Antiparos
Despotiko
Koufonisi
Iraklia
Schoinousa
Keros
Amorgos
Ano Koufonisi
Antimilos
Kimolos
Polyaigos
Milos
Ios
Sikinos
Folegandros
Thirasia
Thira (Santorini)
Anafi

Regional vision

The proposed vision embraces the islands' projective metabolic capacities, their current metabolic profile, the existing infrastructural elements in place, and the planned or ongoing projects proposed for the area, such as the submarine cable that will soon connect most of the islands with each other and mainland Greece. The projective capacities for each island are qualitatively calculated based on endogenous capacities and are taking shape as four metabolic landscape typologies that highlight synergies between the metabolic processes.

Archipelago of sharing

process capacities

waste and material repurposing

energy

water

food

primazy synergy zone

secondary synergy zone

archipelagic synergy

emergency mainland connection

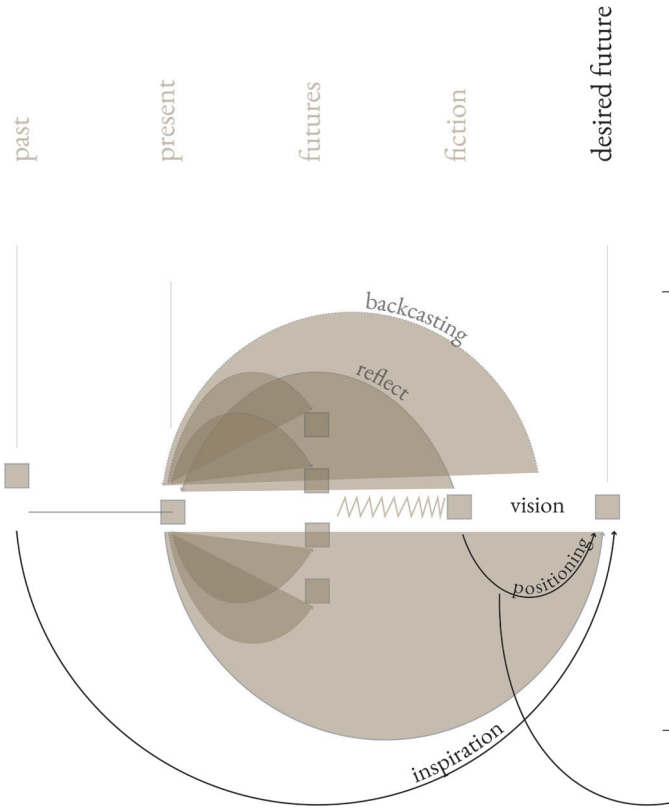
cargo and passenger routes

0 10 20 km

N

6.2 Vision outline

Building on personal positioning, reflecting, backcasting, research, cross-scale and temporal analysis, and an exploration of island metabolism through the lenses of energy, food, water, materials, and waste, but also tourism, landscape, and carrying capacity, this project proposes a multiscalar and multidimensional vision. The vision consists of four dimensions: metabolic landscape typologies, regional infrastructure, sequence of landscape transformation, and an organizational structure of care. It functions in six spatial scales: the mainland and Cyclades region, the Cyclades archipelago, primary and secondary zones within the archipelago, the island, sub-island territories, and the local scale. The conceptual framework is tested and spatialized through two exemplary design prototypes.



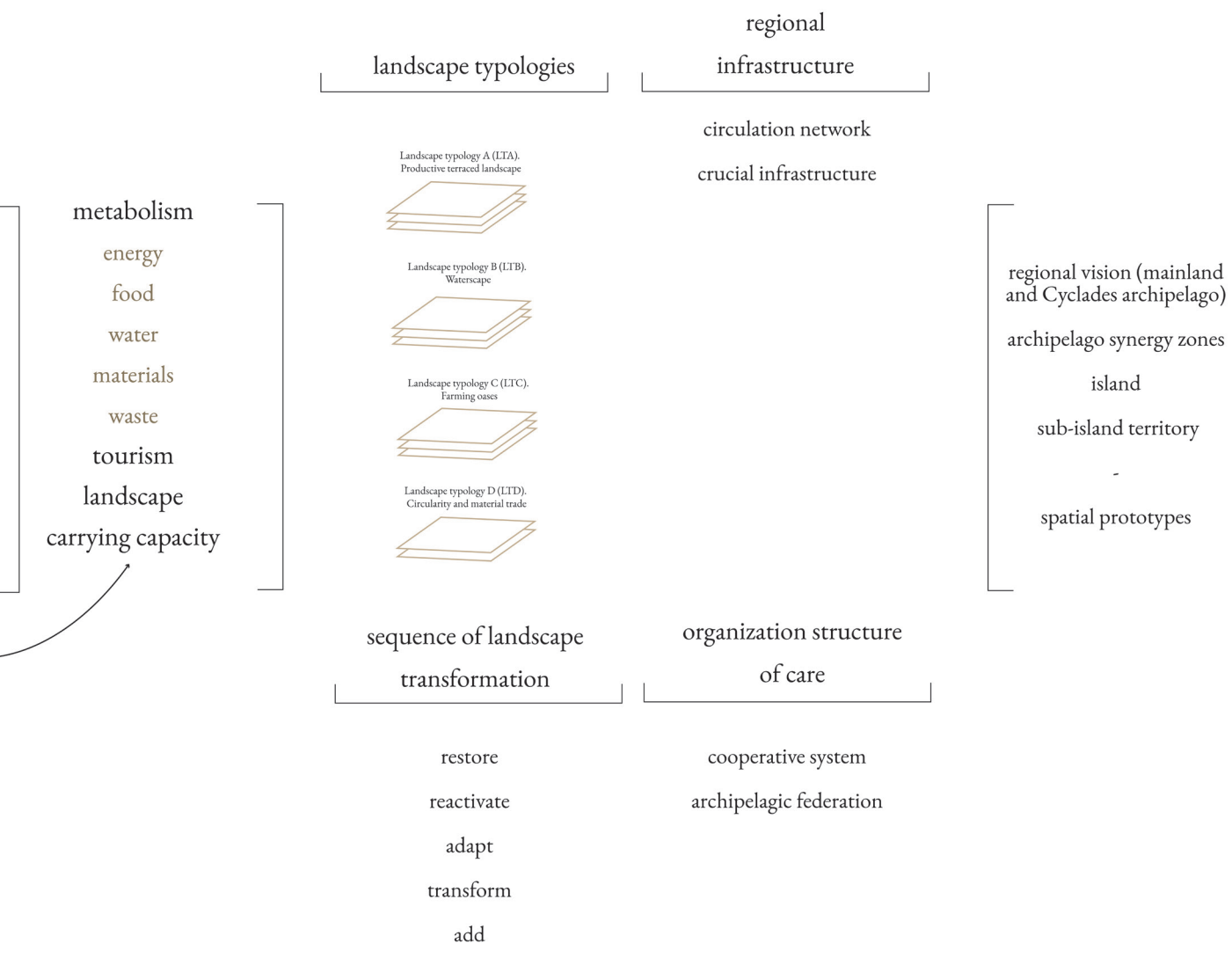


Figure 77. Vision outline

projective capacities

anthropogenic

terraced lanscape, land cover, permeability, accommodation density, existing infrastructure
(ports, windmills, abandoned functions)

geomorphology and hydrology

topography, slope, water course, flow accummulation, humidity, aspect analysis

biophysical

soil types and infiltration capacities

landscape typologies
[250x250m grid cell gis analysis and literature review]

Landscape typology A (LTA).
Productive terraced landscape

A.1
Terraced agricultural landscape
(food production)

A.2
Primary and solar energy productive landscape
(food and solar energy production)

A.3
Multifunctional terraced landscape
(food, wind and solar energy production)

Landscape typology B (LTB).
Waterscape

B.1
Fog and dew harvesting areas

B.2
Rainwater harvesting areas

B.3
Aquifer recharge and infiltration areas

Landscape typology C (LTC).
Farming oases

C.1
Low lying farming areas

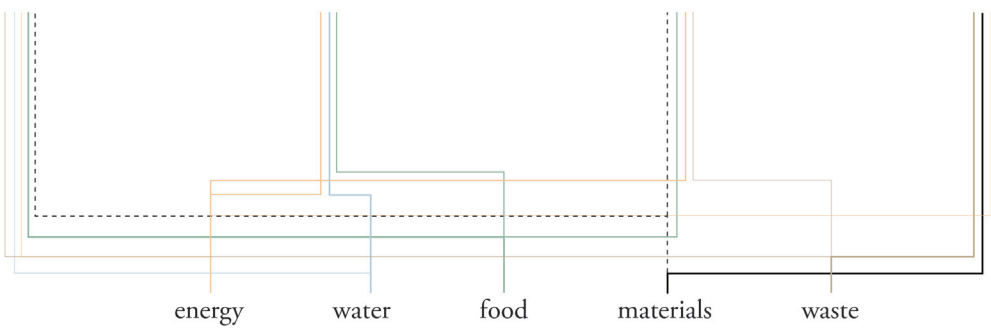
C.2
Agrotourism areas

C.3
Multifunctional agrotourism

Landscape typology D (LTD).
Circularity and material trade

D.1
Circular hubs and material banks

D.2
Waste and material trade infrastructure



level of synergy

maximum
medium
low

6.3 Metabolic landscape typologies

A core element of the vision and the approach are the metabolic landscape typologies, which are built on the cartography of the projective capacities for the islands. Considering three groups of criteria (anthropogenic, geomorphological, hydrological, and biophysical), this analysis uses a 250x250m grid system for the archipelago and Santorini and creates a generalized approach for the endogenous capacities of the islands' landscape that could be utilized as part of their metabolism. This process aims to reestablish synergies between the metabolic processes inspired by the multifunctionality of specific elements of the past. Depending on their capacities and multifunctionality some typologies showcase greater level of synergy compare to others.

Figure 78. Suitability analysis for landscape typologies and metabolic processes

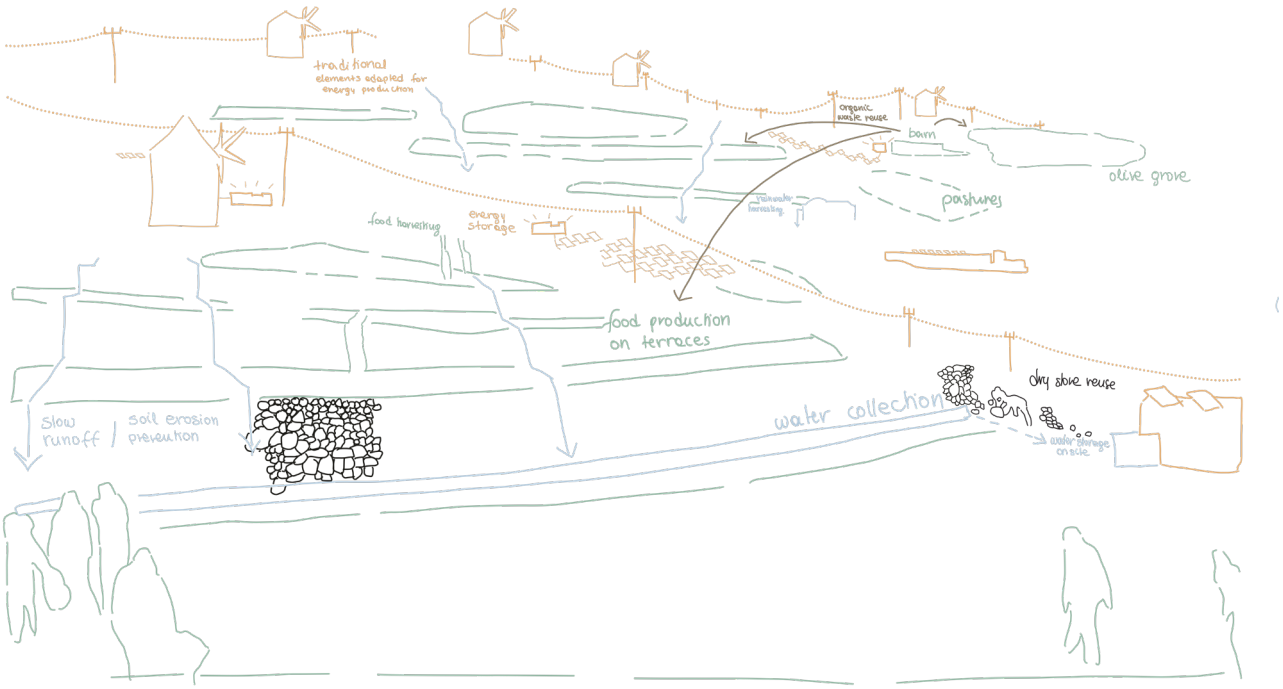


Figure 79. Design principles on terraced landscapes

Figure 80. Hyper-realistic drawing - LTA

LTA. Productive terraced landscape

The first landscape typology builds on an important structural element of the Cycladic landscape: terraces. The suitability analysis of this typology was conducted by considering the existing land cover and vegetation patterns, the topography, an aspect analysis, and the presence of windmills already on the landscape. All metabolic processes are activated in such landscape, combining food production on terraces, energy production and storage, microgrids, water harvesting, soil erosion prevention, material reuse, and organic soil composting and reusing. This typology showcases the maximum level of synergy between the metabolic processes.

		A.1 Terraced agricultural landscape	A.2 Primary and solar energy productive landscape	A.3 Food, wind and solar landscape
land cover | vegetation types	necessary condition	agricultural (active or abandoned) or seminatural areas	agricultural (active or abandoned) or seminatural areas	agricultural (active or abandoned) or seminatural areas
topography		elevation > 50m slope: 15-30%	slope: 10-30%	slope: 10-30%
aspect	complementary condition	-	south facing	south facing
traditional windmills		-	-	yes

Figure 81. LTA mapping criteria

LTA. Productive terraced landscape

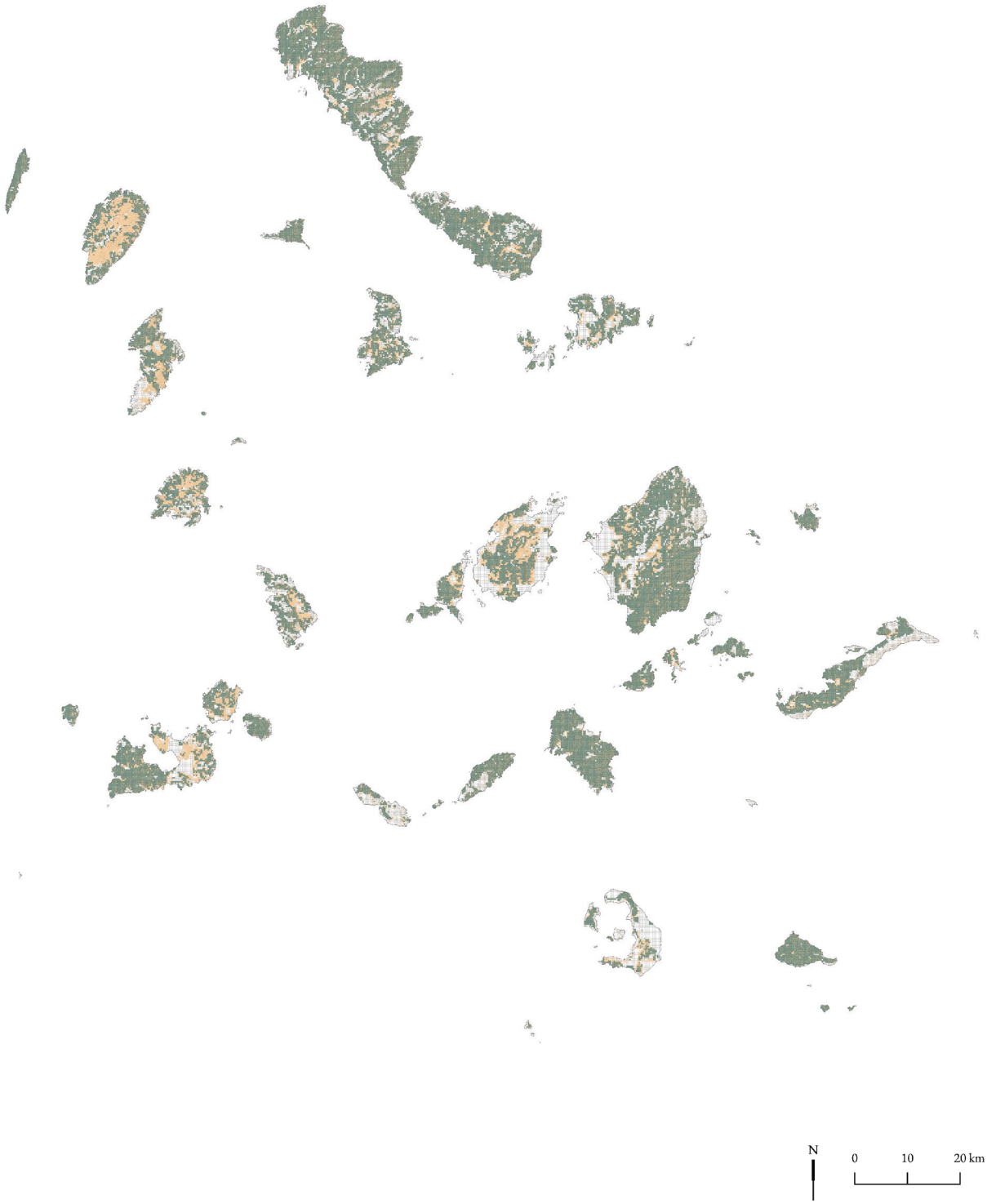


Figure 83. LTA Cyclades mapping

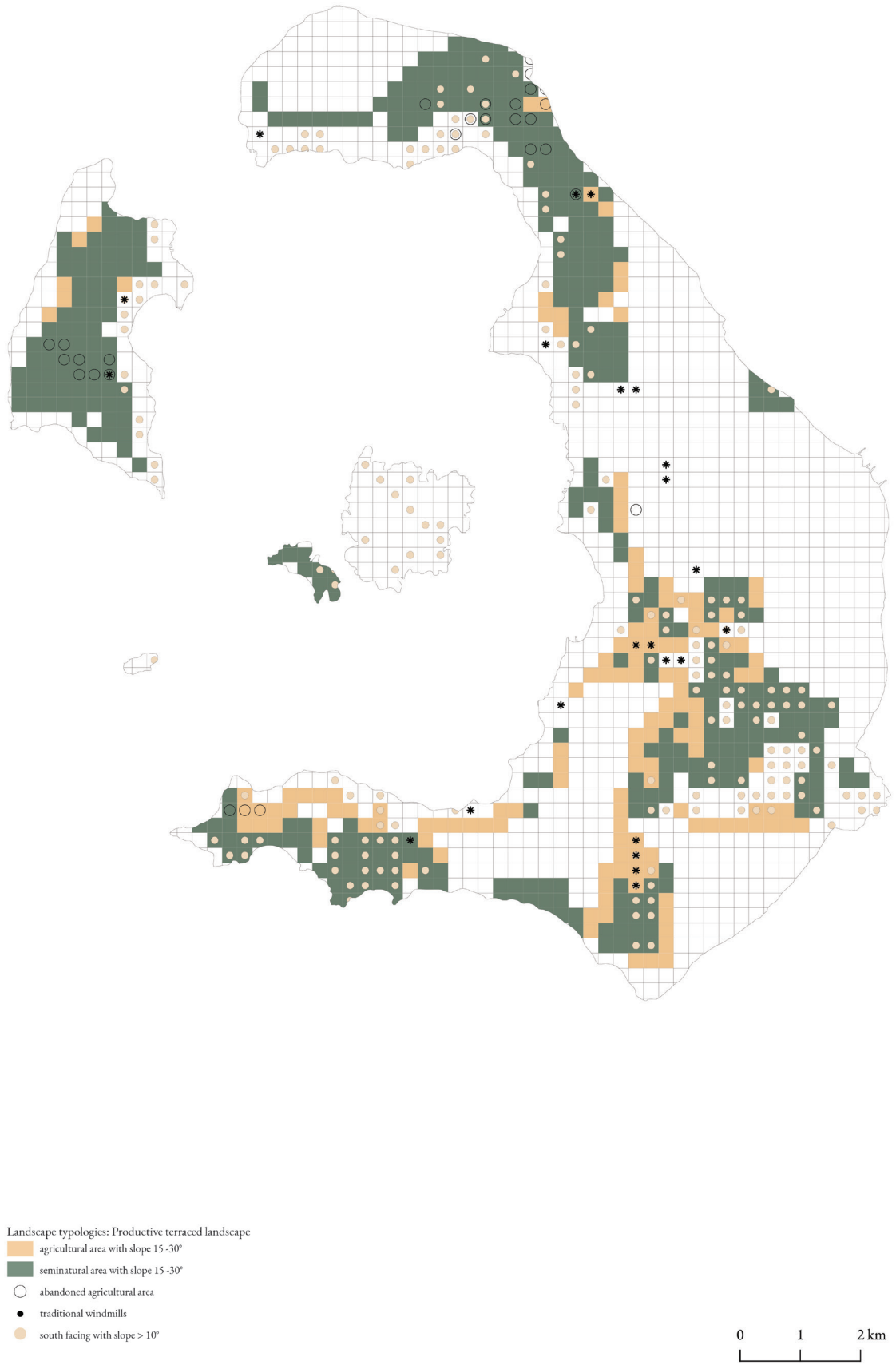


Figure 84. LTA Santorini mapping

LTA. Productive terraced landscape

Figure 85. LTA Cyclades mapping - synthesis

Figure 86. LTA Santorini mapping - synthesis

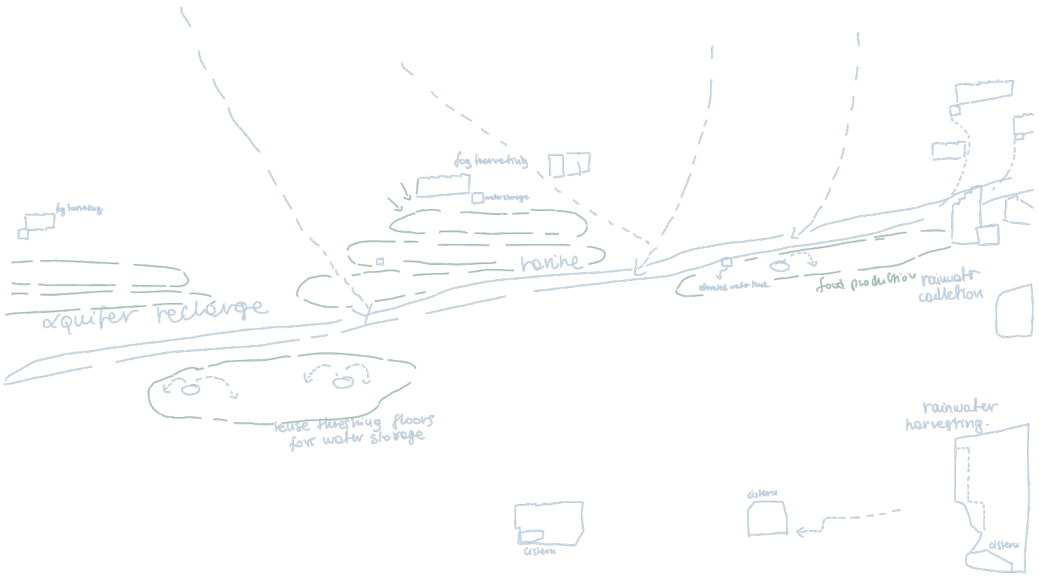


Figure 88. Design principles of waterscapes

Figure 89. Hyper-realistic drawing - LTB

LTB. Waterscape

The waterscape typology consists of different conventional and non-conventional water harvesting methods, as well as infiltration and aquifer recharge areas. It takes into consideration land cover and vegetation types, topography, soil types and their infiltration capacities, water course flow accumulation, and rainfall trends. This analysis was conducted with spatial and literature-reviewed data. The main structural element of this typology is the hydrological and geomorphological profile of the islands.

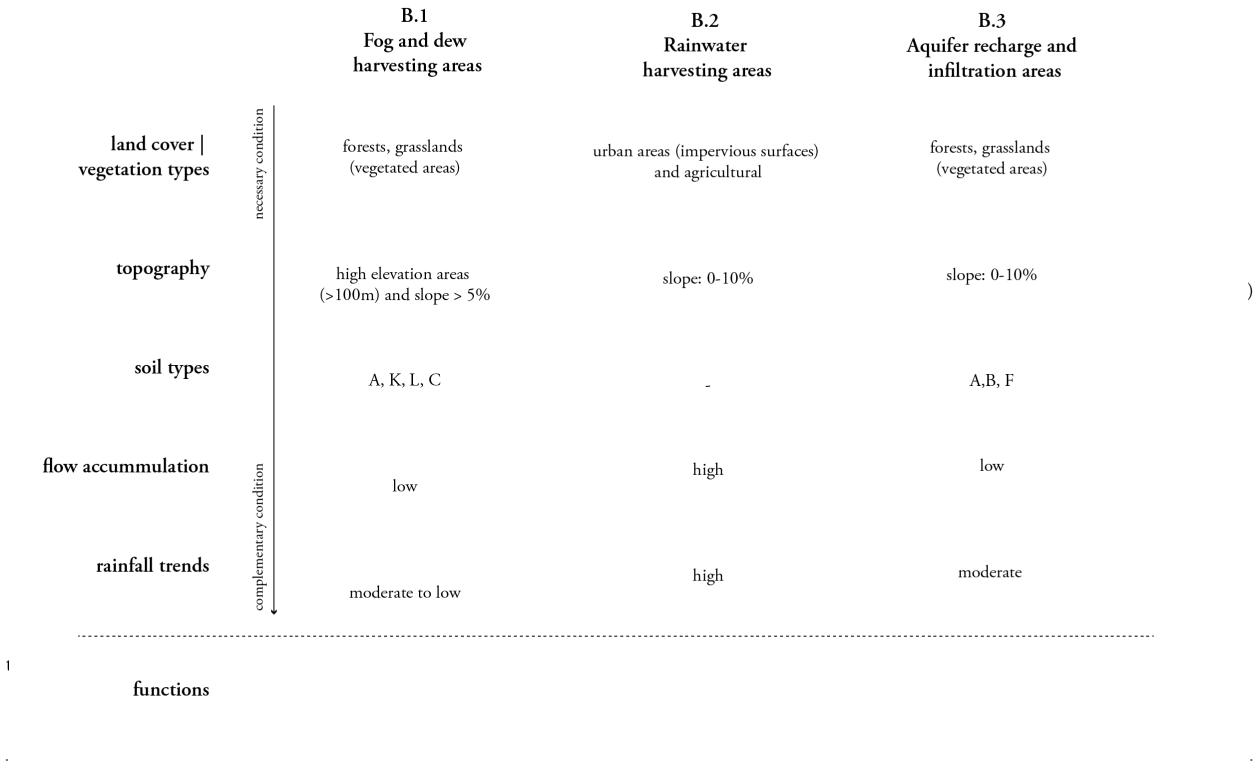


Figure 90. LTB mapping criteria

Figure 91. LTB Cyclades mapping

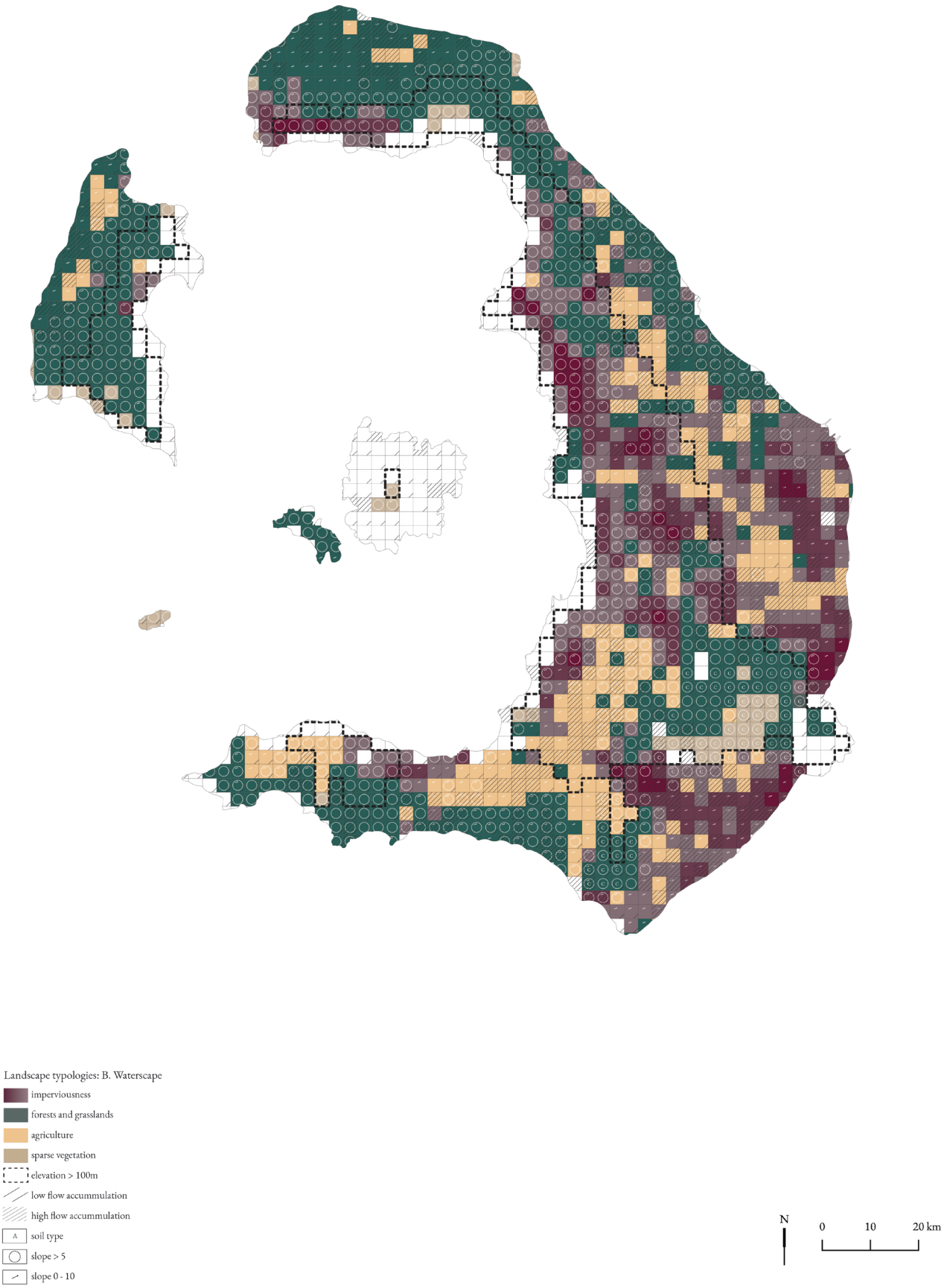


Figure 92. LTB Santorini mapping

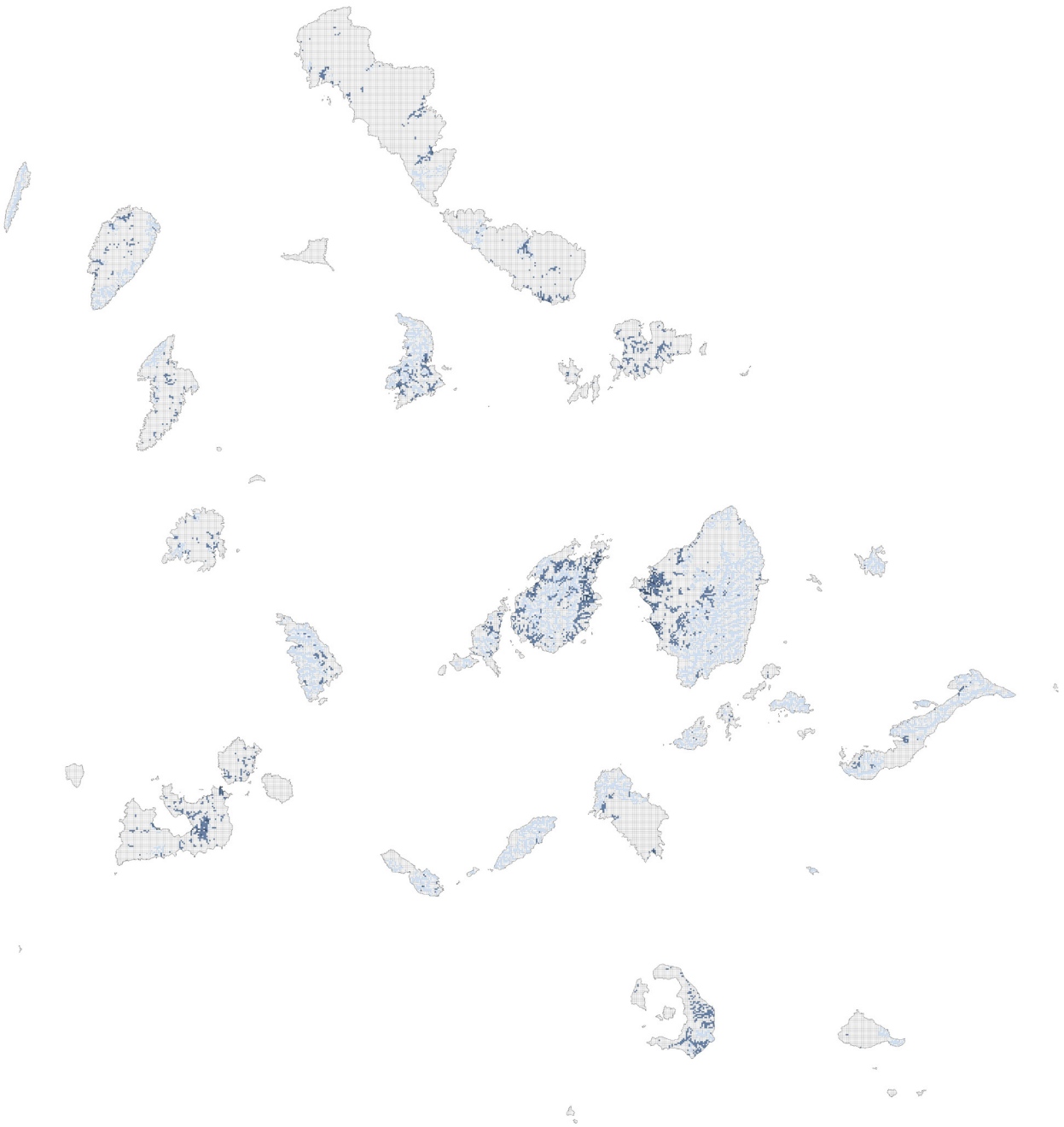


Figure 93. LTB Cyclades mapping - synthesis

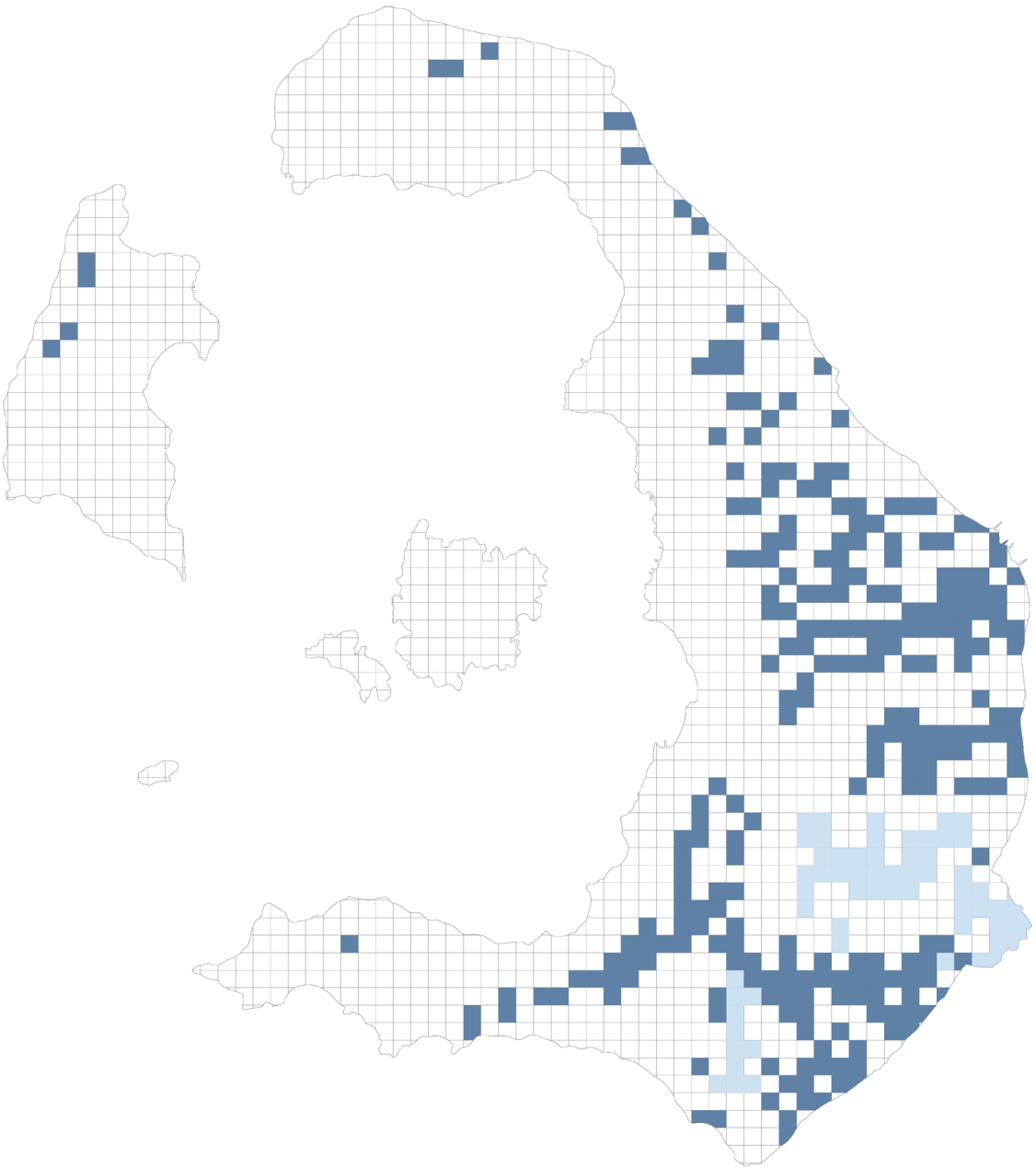


Figure 94. LTB Santorini mapping - synthesis

Figure 95. Design principles on farmins oasis

Figure 96. Hyper-realistic drawing - LTC

LTC. Farming oasis

This typology incorporates low-lying agricultural land with alternative tourism and energy production, taking into account the vegetation types, the topography, the proximity to existing accommodation facilities, and the aspect analysis. It combines tourism of care, collaborations between the local workforce and incoming labor, water storage and reuse for irrigation, waste and material reuse, and energy production.

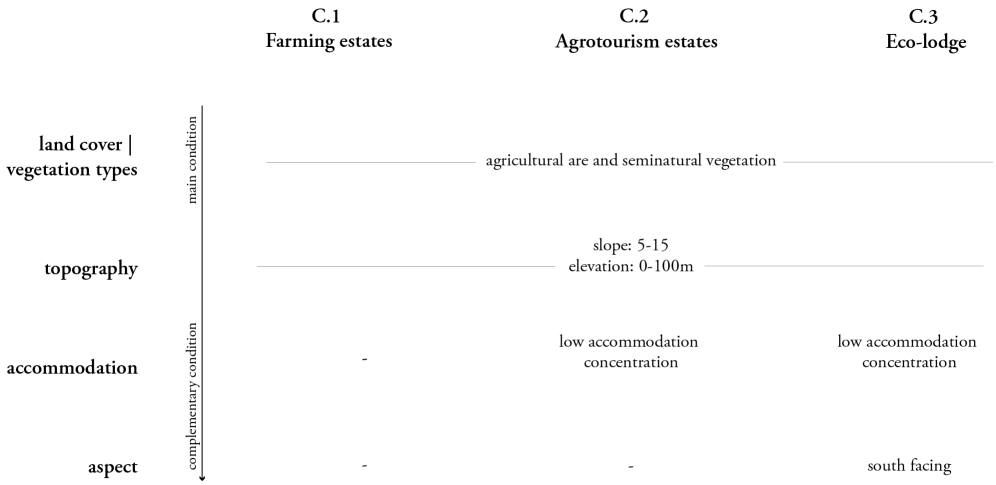


Figure 97. LTC mapping criteria

LTC. Farming oasis

Figure 98. LTC Cyclades mapping

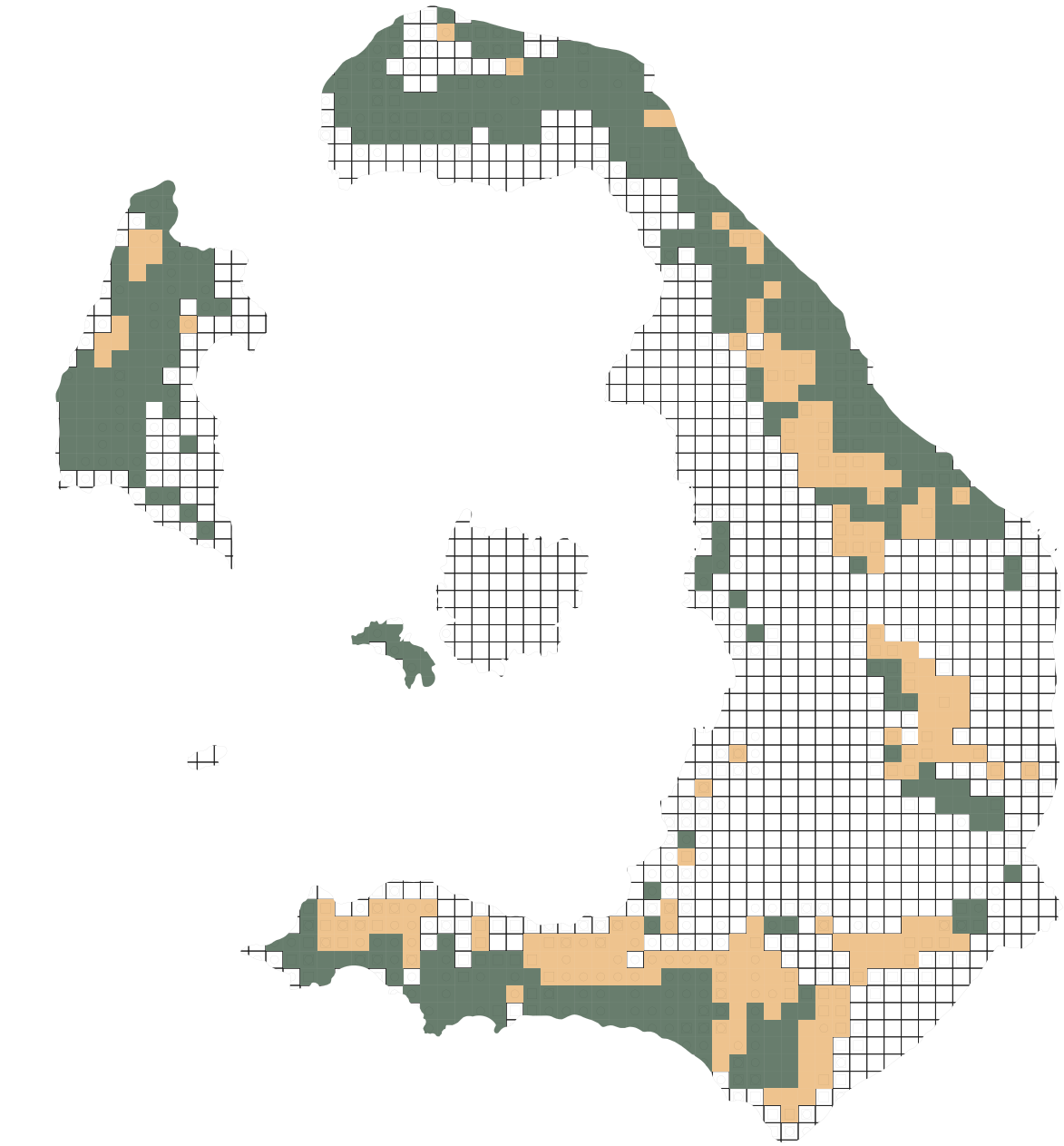


Figure 99. LTC Santorini mapping

LTC. Farming oasis

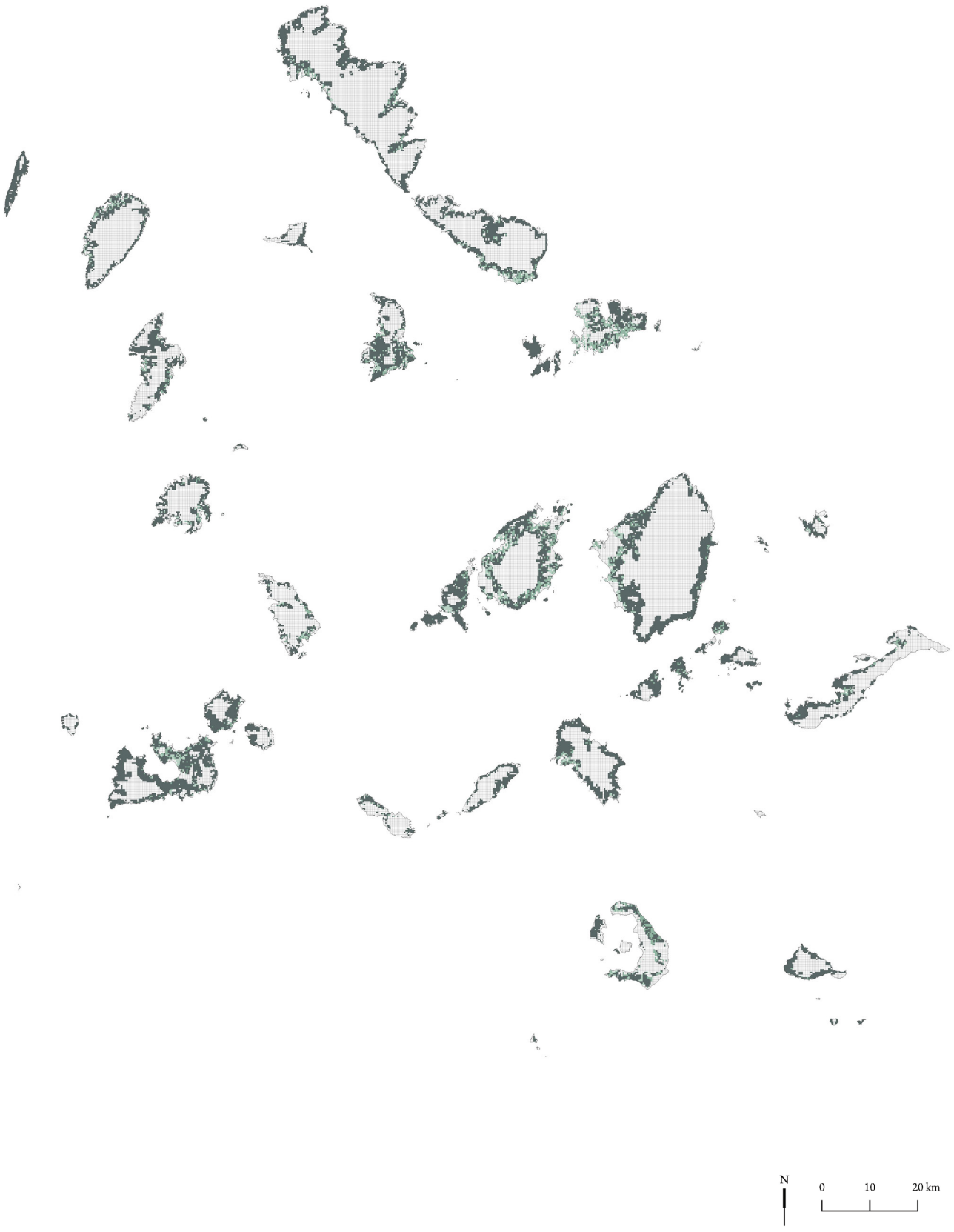


Figure 100. LTC Cyclades mapping - synthesis

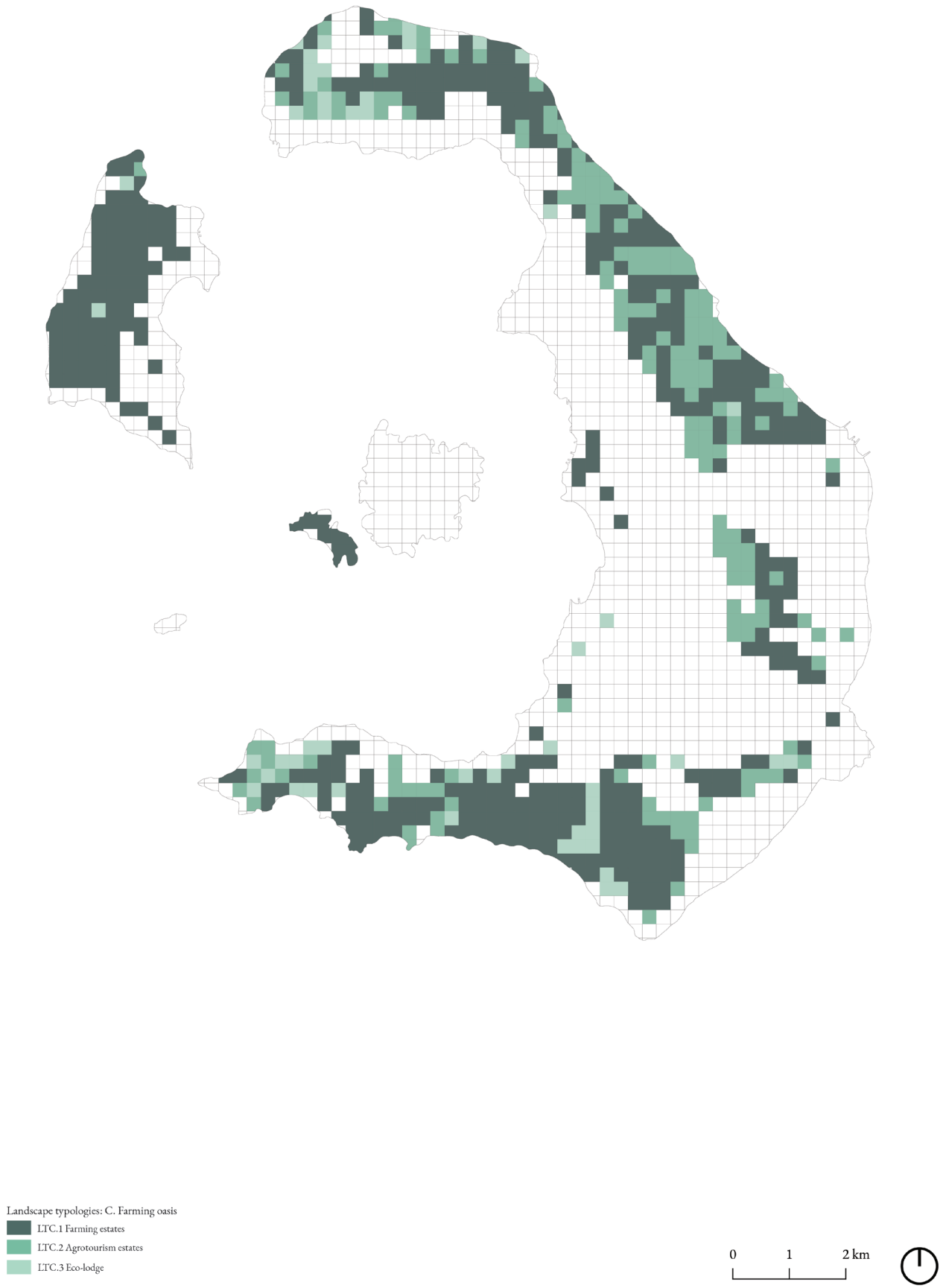


Figure 101. LTC Santorini mapping - synthesis

Figure 102. Design principles on circularity and material hubs

Figure 103. Hyper-realistic drawing - LTD

LTD. Materials and circularity

This typology builds on existing infrastructural elements, such as mining and quarrying areas, industrial heritage sites, industries in transition, and different types of ports. It showcases broad synergy between the waste and materials processes and focuses on upcycling, repurposing, sorting, and transshipping if needed.

	D.1 Circular hubs and material banks	D.2 Waste and material trade infrastructure
mineral extraction sites	gradual phase out and tranformation to circular hubs	industries and mineral extraction sites near the coast
fossil fuel industries	industries in transition that will be transformed	
abandoned industries	abandoned industrial heritage that will be transformed	repurposed as storage areas
ports	-	typologies: cargo and passenger multi-functional small trade marinas

Figure 104. LTD mapping criteria

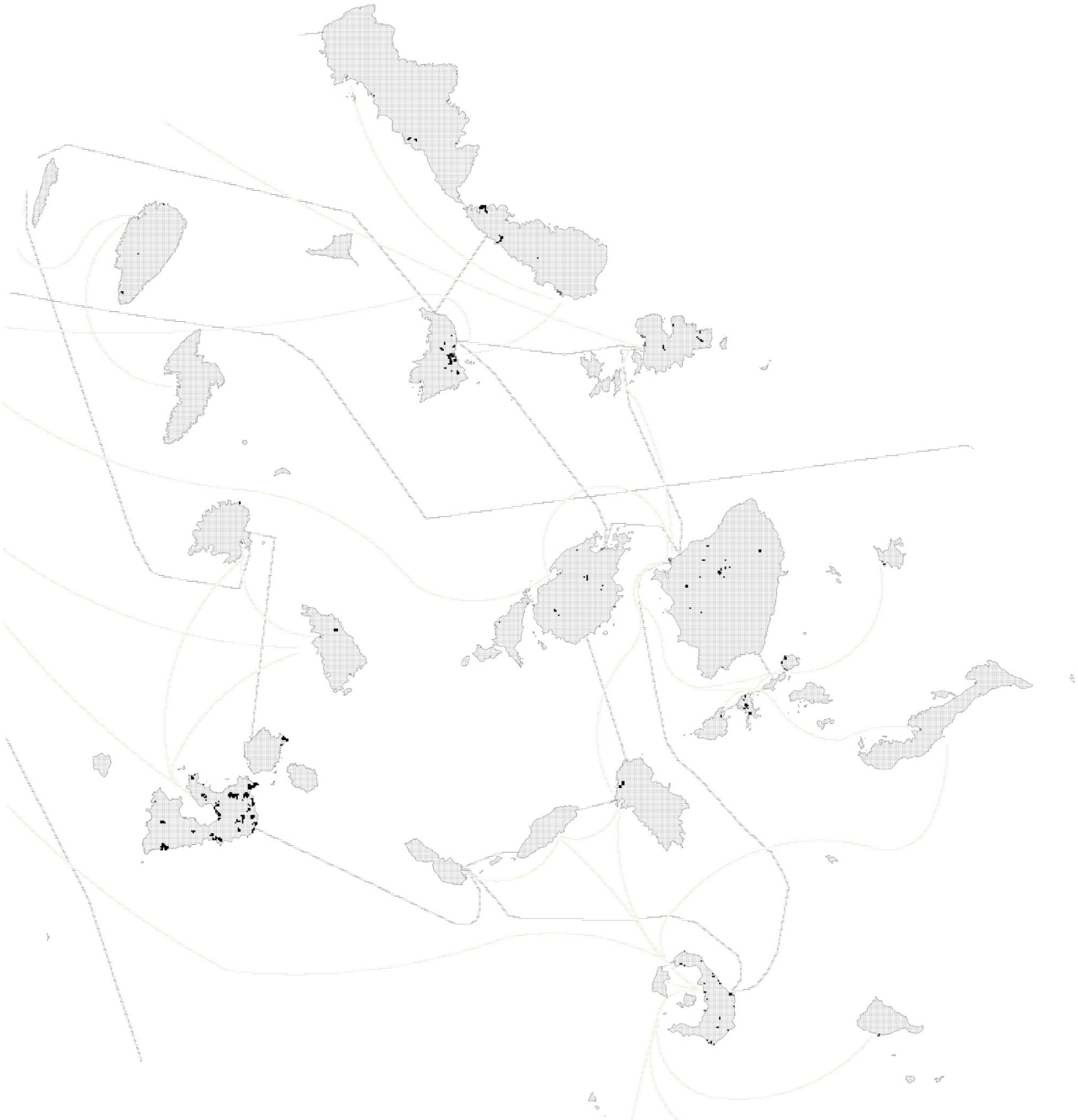


Figure 105. LTD Cyclades mapping

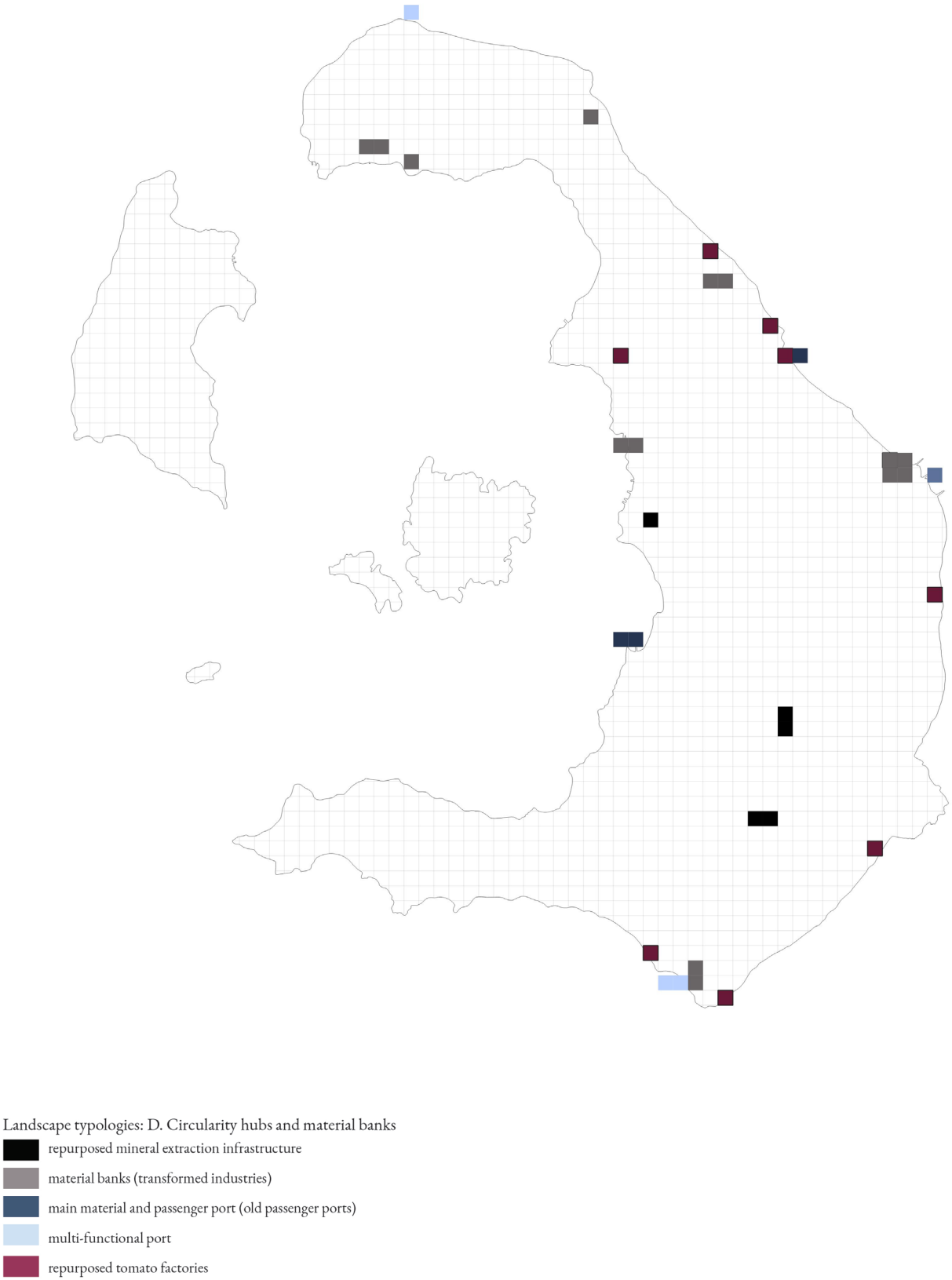


Figure 106. LTD Santorini mapping

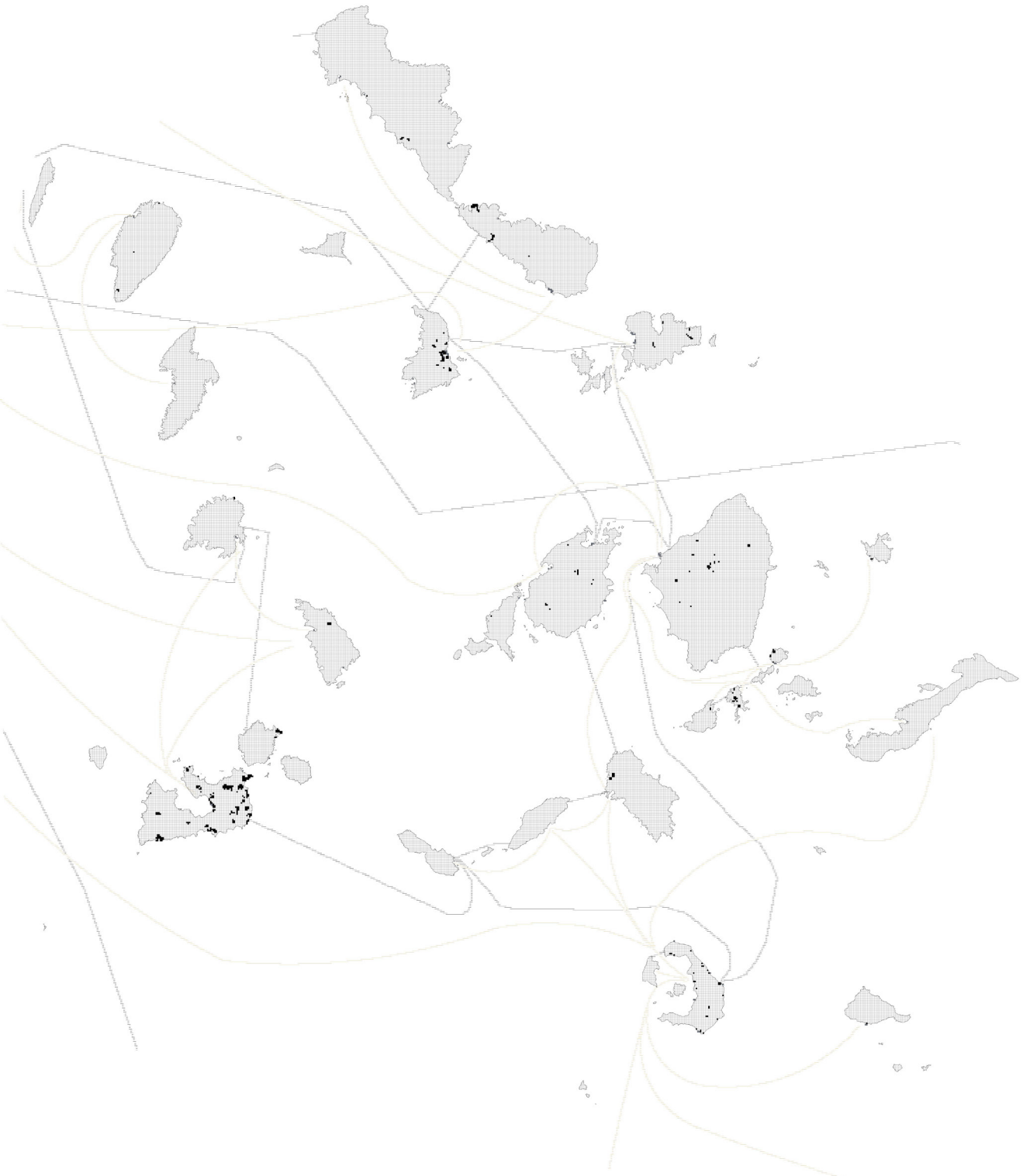


Figure 107. LTD Cyclades mapping - synthesis

Figure 108. LTD Santorini mapping - synthesis

Metabolic landscape typologies synthesis

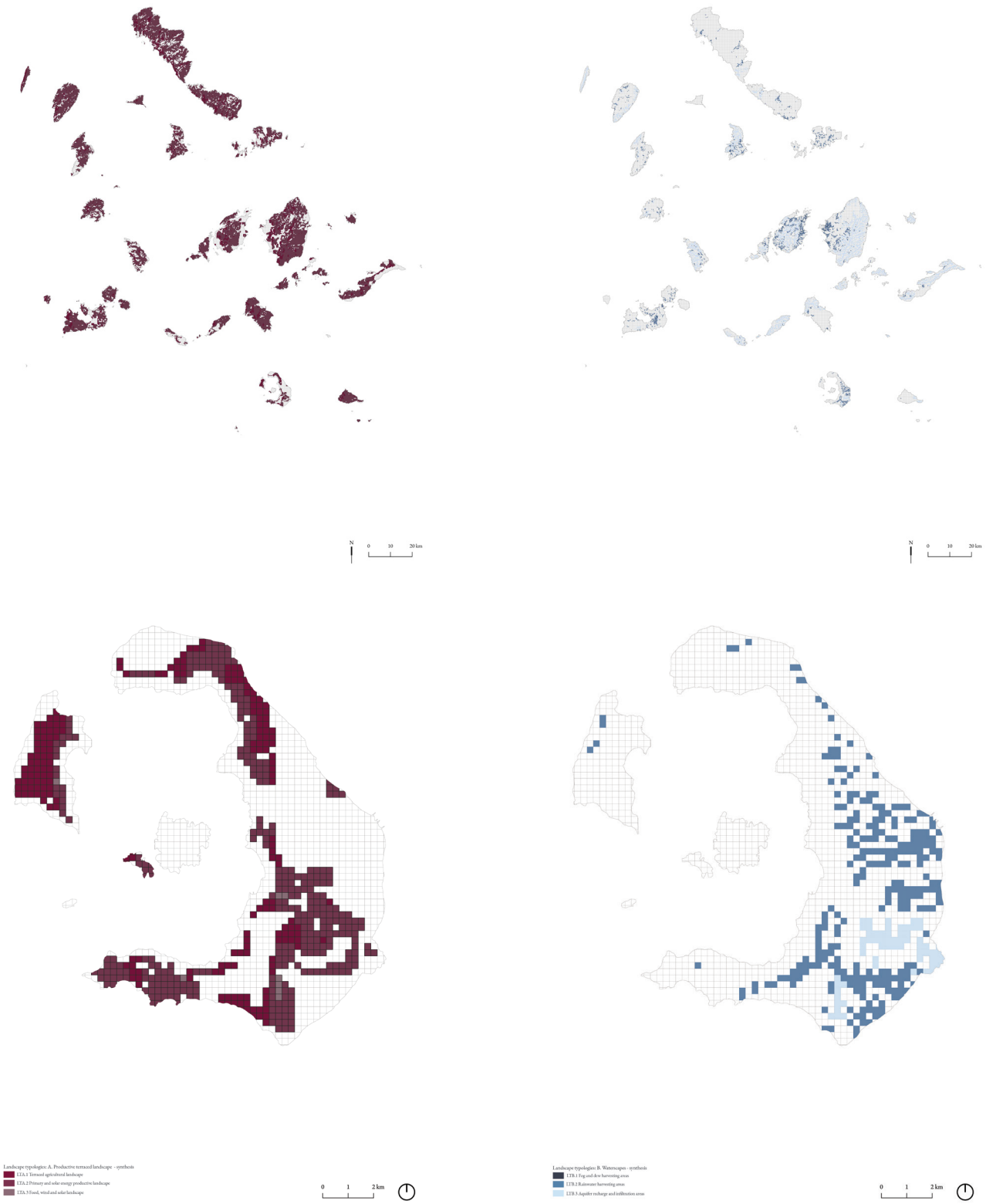
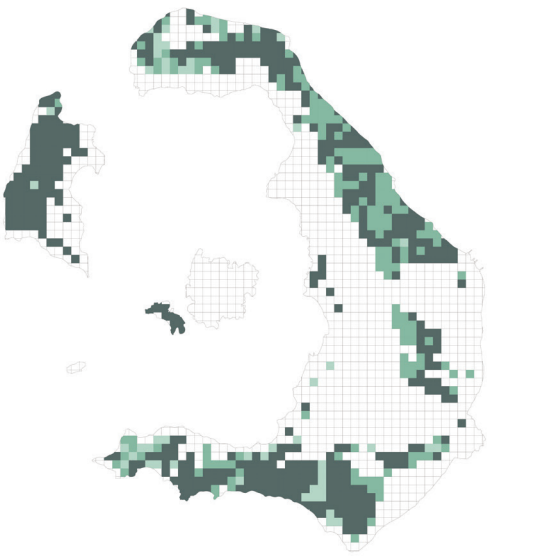


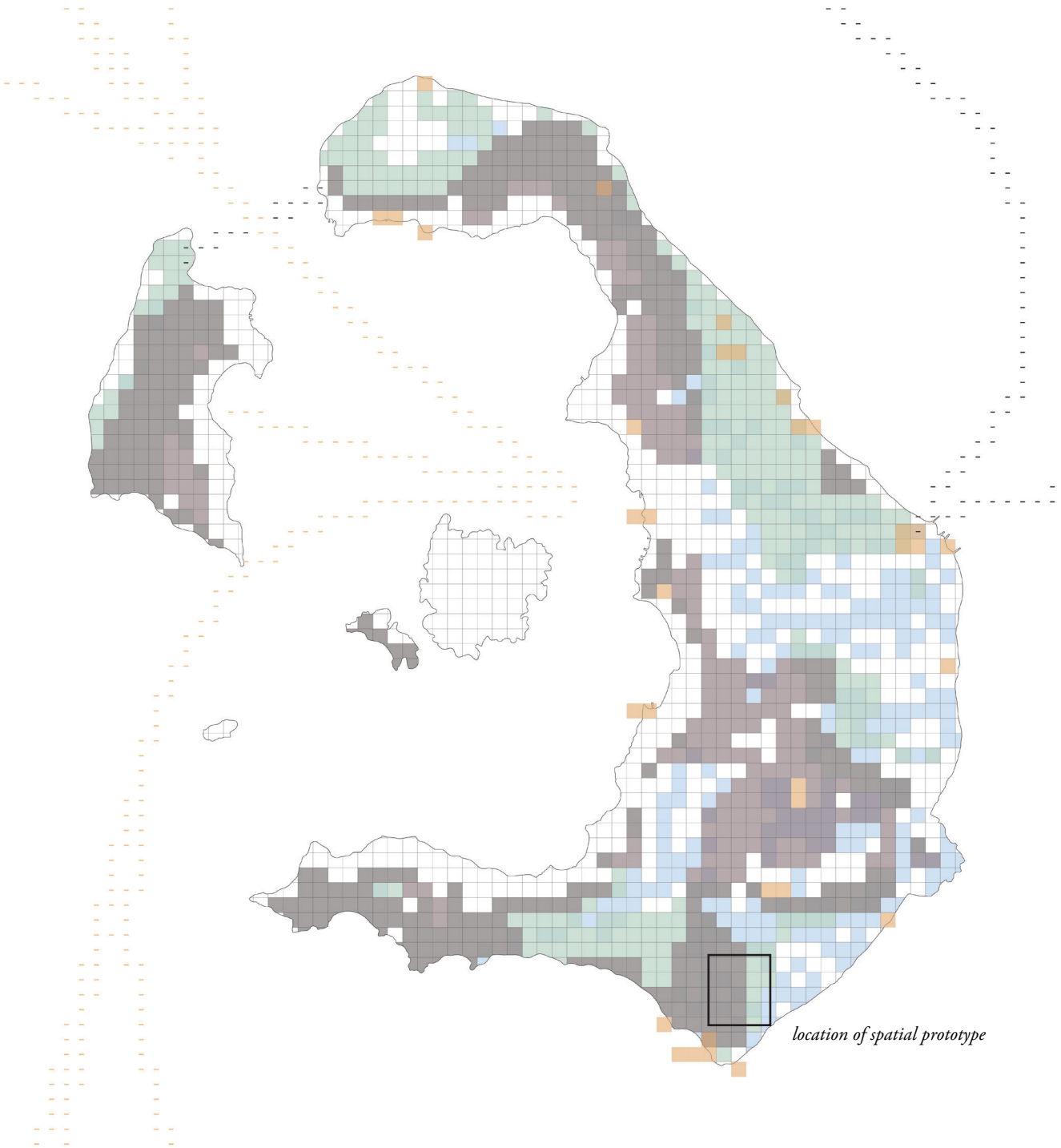
Figure 109.Landscape typologies synthesis overview

Landscape typologies: D. Circularity hubs and material banks
repurposed mineral extraction infrastructure
material banks (transformed industries)
main material and passenger port (old passenger ports)
multi-functional port
repurposed tomato factories



Landscape typologies: C. Farming oasis
LTC.1 Farming estates
LTC.2 Agrotourism estates
LTC.3 Eco-lodge

Landscape typologies: D. Materials and circularity
LTD1. Circular hubs and material banks
LTD.2 Trade infrastructure



Landscape typologies: synthesis Santorini

- LTA.
- LT1 & B
- LTA & C
- LTA & D
- LTB
- LTB & C
- LTD.
- LTC & D
- LTB, C &D
- all LT

N

0 1 2 km

Metabolic landscape typologies synthesis

By overlapping all spatial though generalized typologies shaped through this process, areas of high synergistic potential between different processes and landscapes are identified. Thus, multifunctional zones with endogenous capacities to host multiple metabolisms can be highlighted. As a result, multiple sub-island territories are taking shape. These areas are characterized by higher capacities to accommodate interventions that promote community interactions and metabolism functions. These types of zones are located around the island but are not static. They are dynamic and flexible territories where the multiplicity of functions makes them strategic for further design experimentation. One of them will be elaborated further later on.

Figure 110. Metabolic landscape synthesis Santorini - overview

6.4 Regional infrastructure

For such a system to operate multiple connectivity structures, existing, planned, or additional are needed. The basic port typologies arise based on the landscape typology that relates to material and circularity. These small-scale trade marinas focus on resource trade around the archipelago. Local multi-functional harbors were previously multimodal ports, marinas, or fishing ports that will be gradually transformed with small-scale interventions to support storage and loading/unloading functions. Most storage facilities are located near or in such ports to facilitate distribution. They utilize industrial heritage structures or fossil fuel industries in transition.
The passenger mobility and transportation of goods between the islands happens mainly through the different port typologies alongside water routes that either specialize in material and goods trade and passenger mobility or could be multifunctional. It is essential to highlight that there are also emergency connection routes with mainland Greece and cross-archipelago trade that facilitate trade with other islands of the South Aegean.

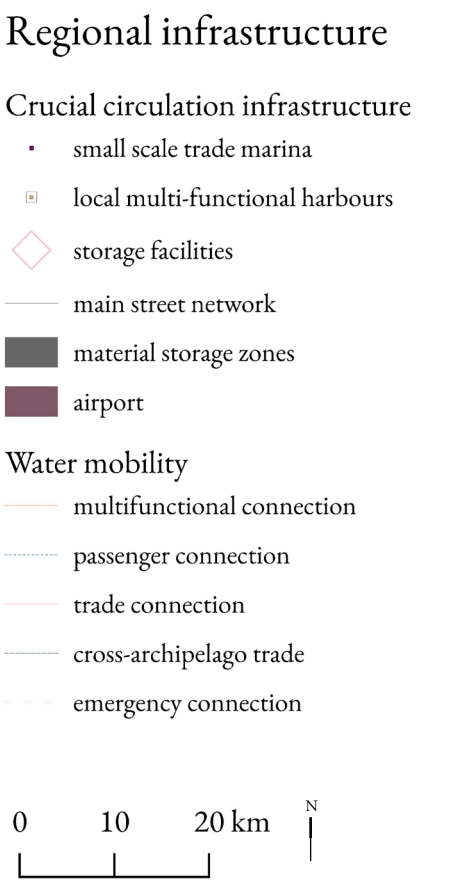


Figure 111. Regional infrastructure that support the archipelagic federation


Andros
Makronisos
Kea (Tzia)
Gyaros (Gioura)
Tinos
Mykonos
Syros
Rinaia
Dilos
Kythnos
Serifos
Paros
Naxos
Donousa
Antiparos
Despotiko
Sifnos
Koufonisi
Kato Koufonisi
Keros
Schoinousa
Iraklia
Amorgos
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Antimilos
Polyaigos
Milos
Ios
Sikinos
Folegandros
Thirasia
Thira (Santorini)
Anafi

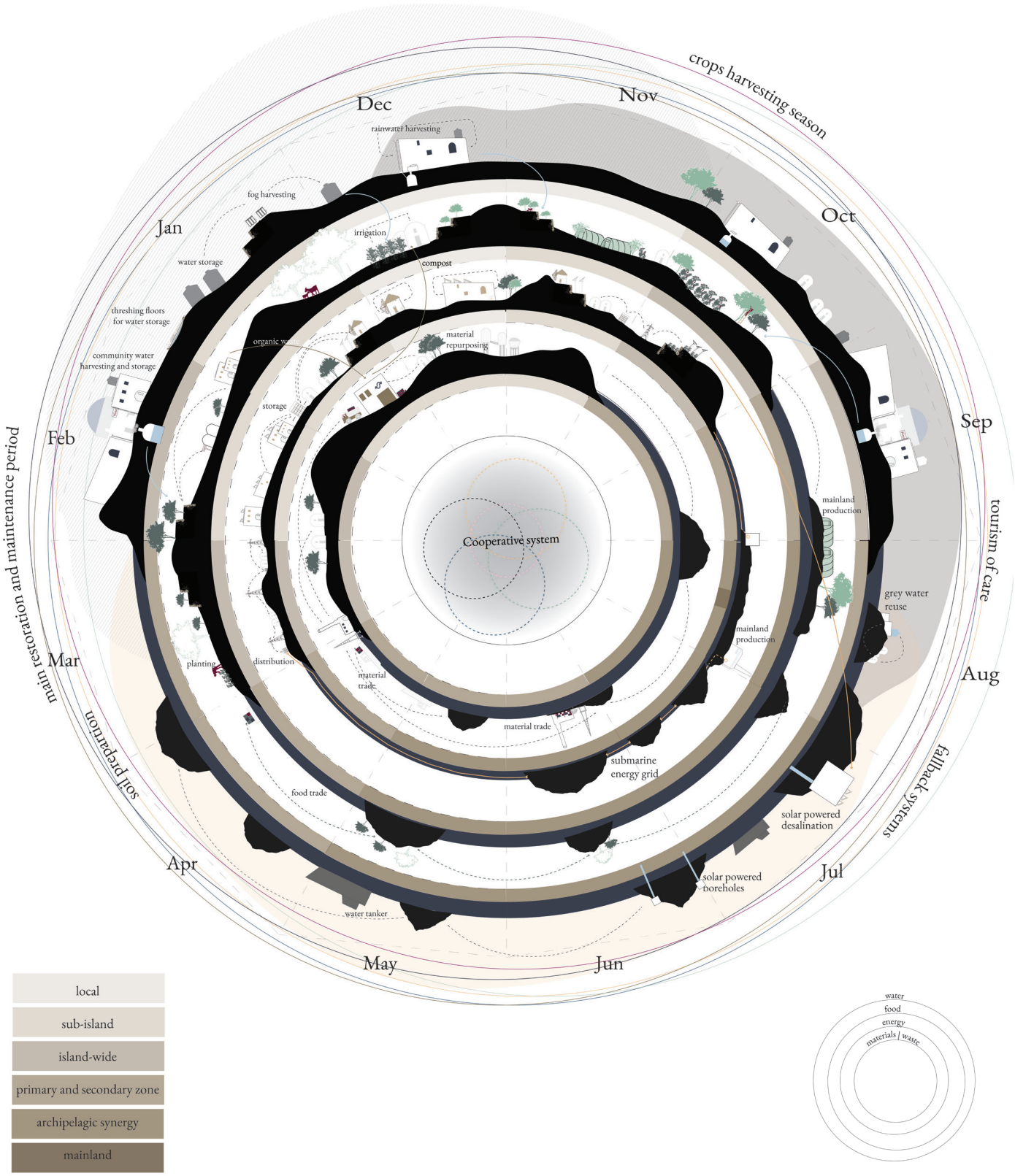


Figure 112. Cooperative system of care and repair

6.5 Infrastructure of care and repair

The idea of incorporating an organizational element in the project stems from the notion that communities (and therefore their metabolic activities) can be successfully managed by people involved in them, rather than central administration or private owners (Ostrom, 1990). It tries to provide an alternative to current top-down, centralized carrying capacity assessment methods, by highlighting the need for dynamic assessment carried out by those directly involved in the processes, those capable to set limits and evaluate the pressure. At the same time, it proposes the establishment of archipelagic "federations" (Savini, 2021) that expand island-focused capacities to multiple islands.

> "What we have ignored is what citizens can do and the importance of real involvement of the people involved – versus just having someone in Washington… make a rule."
>
> Elinor Ostrom, Nobel Prize Lecture, 2009

This component of the project adds an organizational multiscalar structure as an additional layer inspired by notions of care, commoning, collaboration, "autonomous polycentrism" (Savini, 2021), and limits. The key components of this structure are a cooperative system and its role in the metabolic processes and the cross-, inner-island, and landscape synergies, along with the labor required to sustain it. By acknowledging that complete autonomy while respecting ecosystemic limitations is impossible, an archipelagic federation aims to build solidarities from bottom-up, along metabolic processes and across islands.

The cooperative system has multiple roles that of steward, mediator, knowledge holder and connector.

It is the infrastructure of care and repair, and consists of different cooperatives that each focus on one process (water, energy, food, waste, materials), to ensure the highest level of specialization. To avoid the formation of silos, a central council takes the role of representing each cooperative. This body is in close contact with the public and the hospitality sector.

In detail this system observes the metabolic processes, and their production/consumption patterns, calculates limits (maximums and minimums) throughout the year and develops a series of strategies that highlight priorities in metabolic scales (where do the resources originate from?) and fallback systems (which system must be activated to support the demand?) that provide a level of flexibility. However, the priority lies in creating a polycentric (islands and landscapes) and autonomous (as much as possible) regional system that identifies the limits of its economy in relation to the limits and specificities of its ecosystems. As supported by doughnut economic theory "only through the making of limits can our societies reach regenerative and redistributive economy" (Savini, 2021).

This initiative coordinates with and is part of the shared resources network, and it boosts inter-landscape and inter-island synergies while educating and communicating these limits and strategies with the community to support behavioral change. An interconnected and interdependent network is thus formed, supporting cooperation among connected partners.

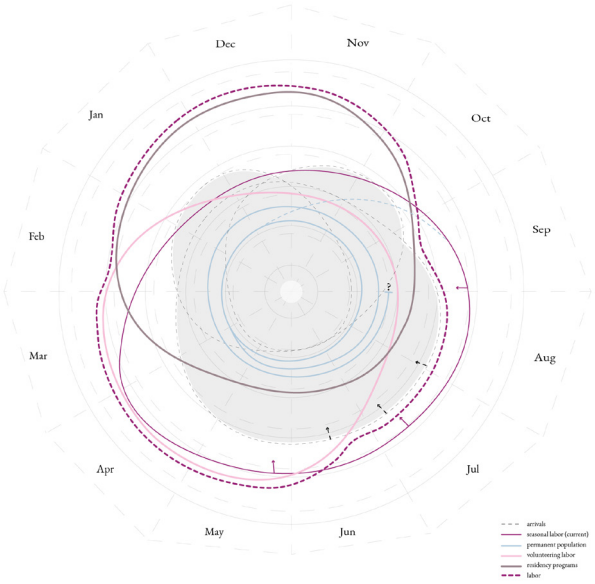


Figure 113. Labor profile and shifts

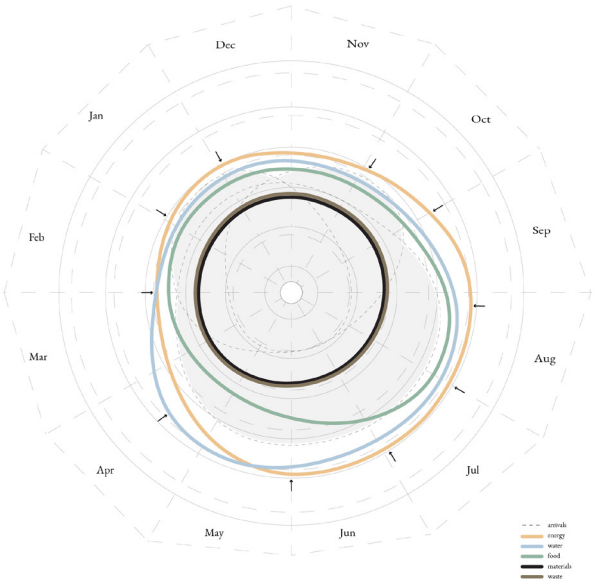


Figure 114. Metabolic processes and degrowth

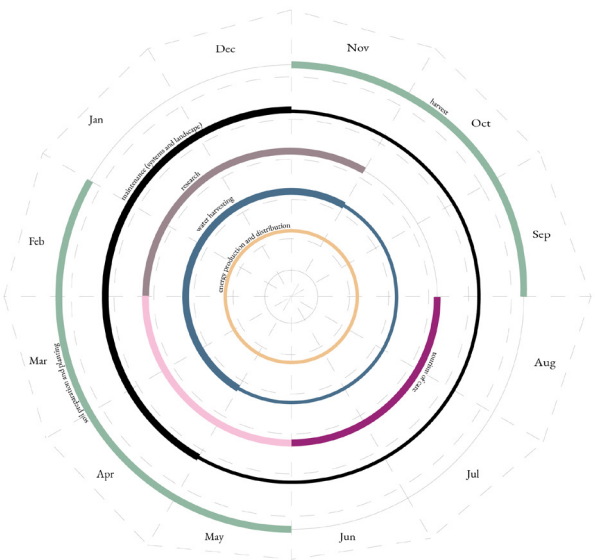
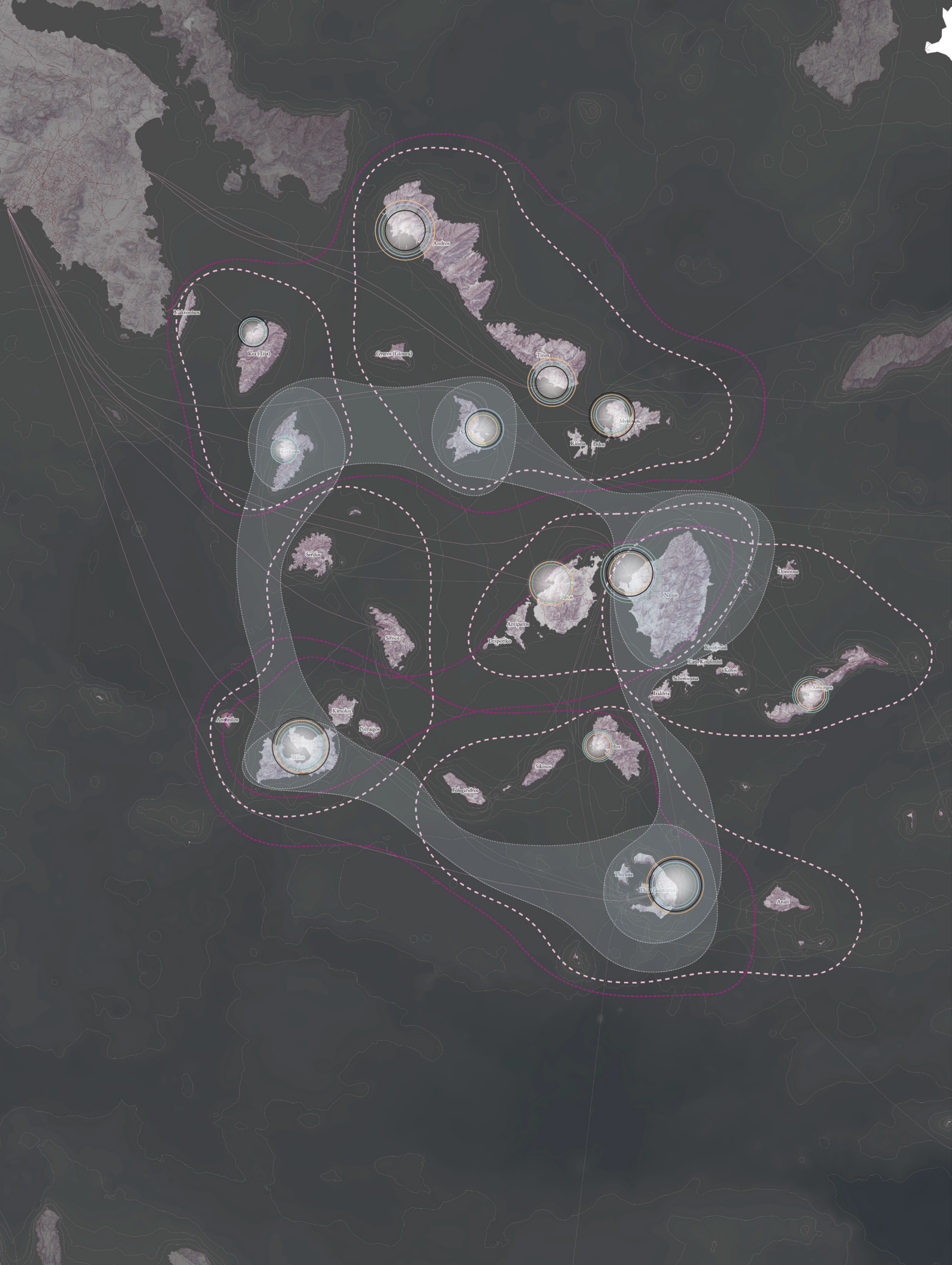


Figure 115. Processes and seasonality

Labor and metabolic processes

There are three complementary elements that support the cooperative system of care: labor, degrowth, and seasonality. The labor that supports such systems consists of a core workforce connected to the permanent population and seasonal labor, which fluctuates around the year depending on the needs per season. The proposal builds on a degrowth-oriented scenario, in which parts of the current seasonal labor remain on the island longer since other types of activities extend throughout the year, gradually integrating into the permanent population. The growth of the permanent population cannot be limitless, though. The economy gradually becomes stabilized, and tourism infrastructure can be repurposed to accommodate housing demands. Additionally, parts of the current tourism profile move towards tourism of care and alternative forms, complemented by residency and volunteering programs that participate in the maintenance of such systems and the landscape. The five metabolic processes shrink and showcase fluctuations around the year rather than peak demands.


Andros
Makronisos
Kea (Ioúlis)
Gyaros (Gioura)
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Rinia
Dilos
Kythnos
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Paros
Naxos
Donousa
Antiparos
Despotiko
Koufonisi
Iraklia
Schoinousa
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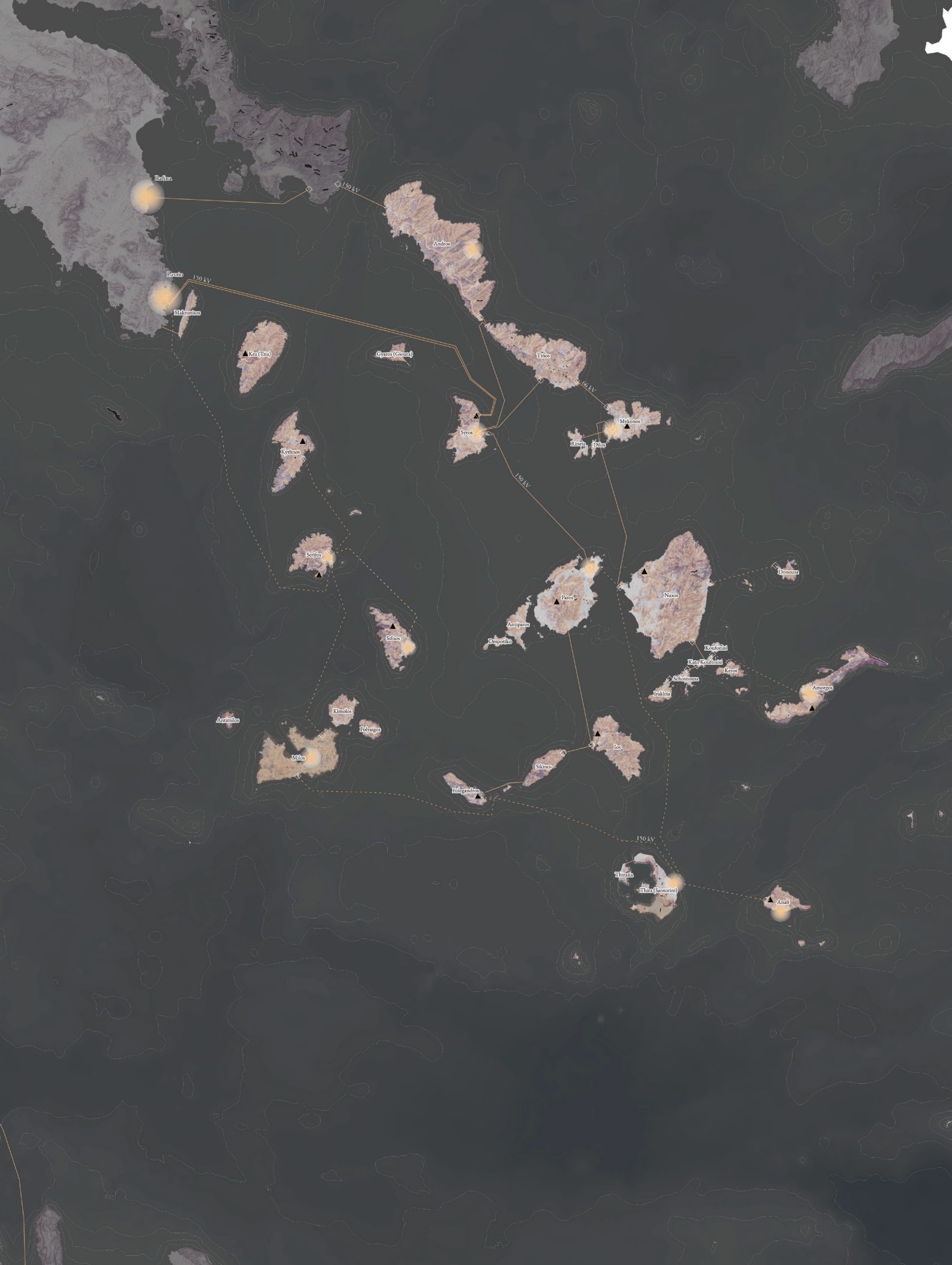
Amorgos
Ano Koufonisi
Antimilos
Kimolos
Polyaigos
Milos
Ios
Sikinos
Folegandros
Thirasia
Thira (Santorini)
Anafi

6.6 Multiscalar vision

As mentioned before, the vision engages with multiple scales. This section presents an analysis of the vision's formation along different scales. It is key to highlight that the main regional vision stems from visions per metabolic process that take into consideration the projective capacities mapping and existing dynamics on the islands. As a result, chains of intertwined metabolic scales are created, where each island's metabolic profile and specialization contribute to the archipelagic metabolism.

Archipelago of sharing


Rafina
150 kV
Andros
Lavrio
150 kV
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Kea (Tzia)
Gyaros (Gioura)
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Mykonos
Syros
Rineia
Dilos
Kythnos
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Sifnos
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Kato Koufonisi
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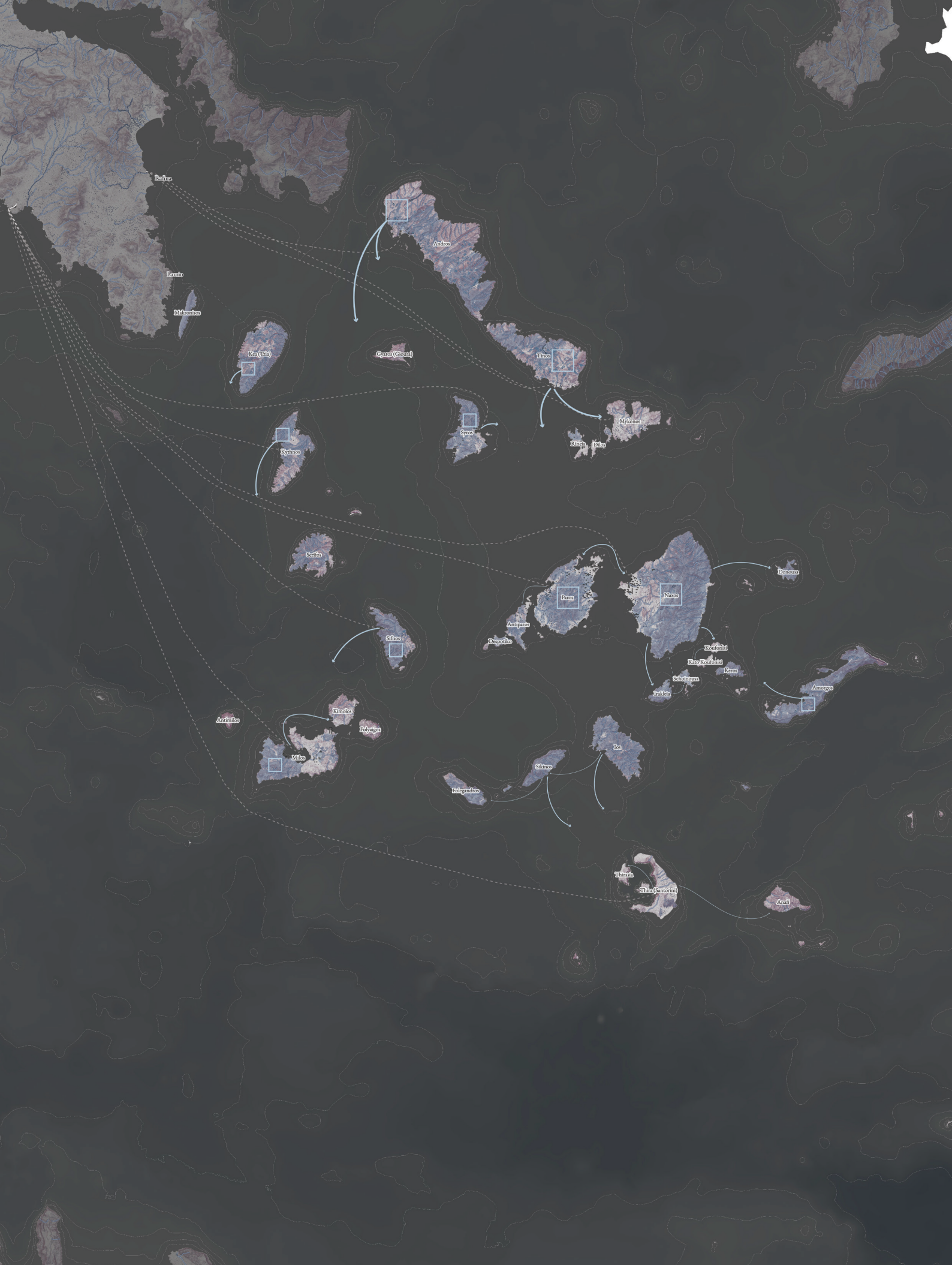
Schoinousa
Irakleia
Amorgos
Antimilos
Kimolos
Polyaigos
Milos
Ios
Sikinos
Folegandros
150 kV
Thirasia
Thira (Santorini)
Anafi

Energy

Regarding energy, the approach focuses on decentralized energy production and storage, as well as the utilization of existing and planned infrastructure for energy distribution. Islands with fossil fuel plants become energy hubs utilizing the infrastructure as they transition to renewable forms of energy. Alternative fuel is produced using organic waste, and along the volcanic arc, the geothermal fields support the energy mix. The scales of energy that bond the islands are shaped by their infrastructural connection through submarine cables, though the priority lies in autonomism coming from the endogenous capacities, at the highest level possible.

Figure 116. Energy production and distribution in Cyclades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Folegandros
Thirasia
Thira (Santorini)
Anafi

Water

Overall, the vision for water supply includes conventional and non-conventional water harvesting, water storage, and infiltration areas. Principles that can slow down runoff, such as terracing or micro-dams, are adopted. Due to the climate conditions, the arid but hilly landscape's moisture capture, like fog and mist, could support conventional water harvesting methods (Xaidas, 2018). Existing desalination plants and well systems remain in place and are activated based on seasonal needs and evaluations from the cooperative system in place.

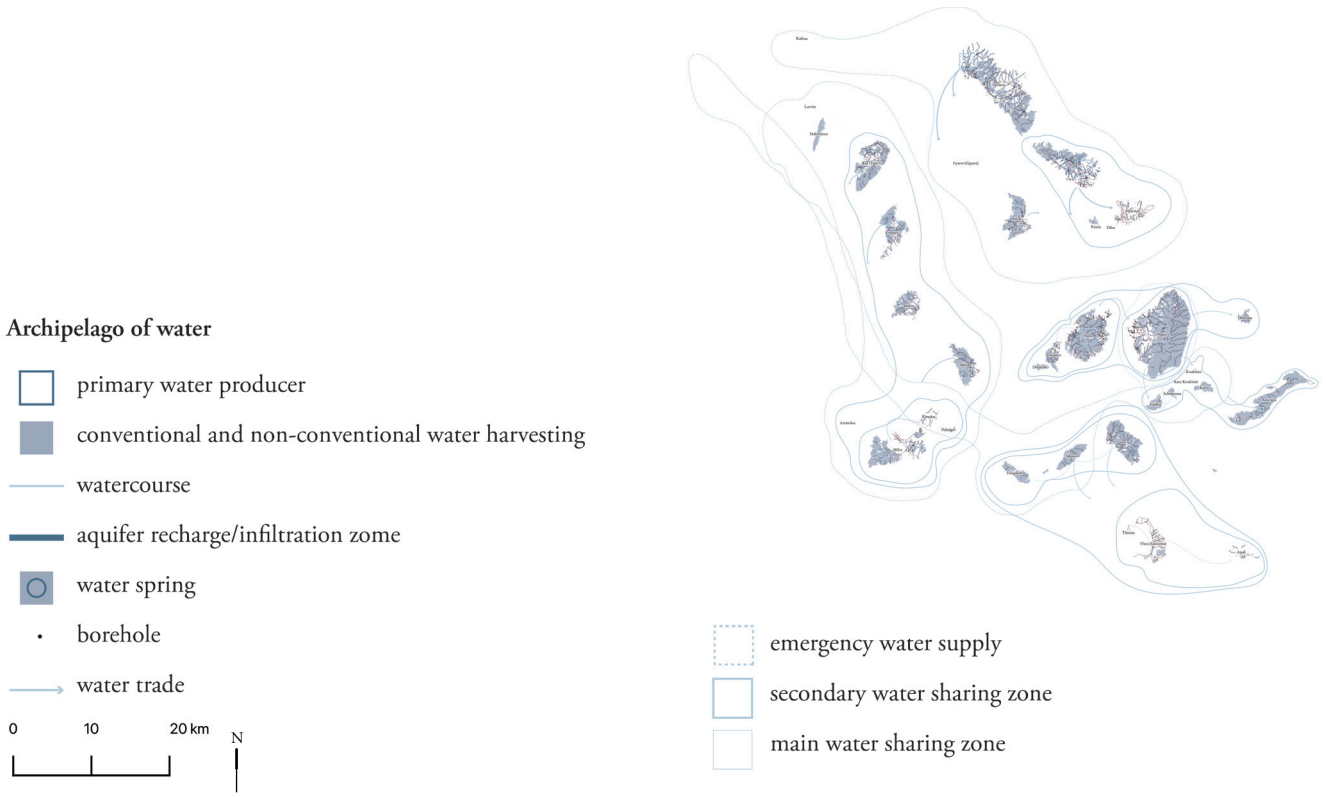


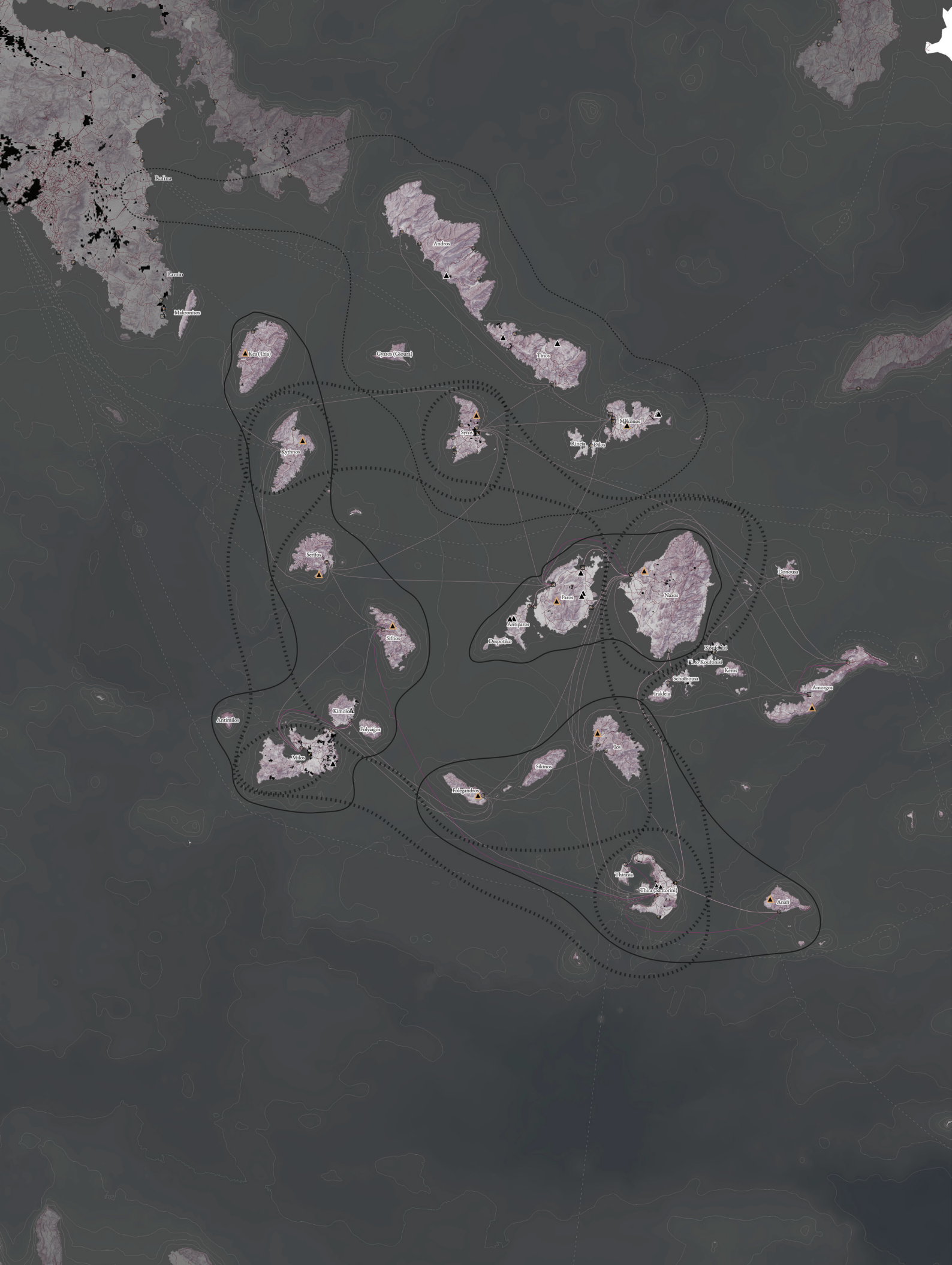
Figure 117. Water harvesting, supply and distribution


Rafina
Lavrio
Makronisos
Kea (Ilzia)
Gyaros (Gioura)
Andros
Tinos
Mykonos
Syros
Rineia
Dilos
Kythnos
Serifos
Sifnos
Paros
Naxos
Donousa
Antiparos
Despotiko
Koufonisi
Kato Koufonisi
Keros
Schoinousa
Irakleia
Amorgos
Antimilos
Kimolos
Polyaigos
Milos
Ios
Sikinos
Folegandros
Thirasia
Thira (Santorini)
Anafi

Food

The overall goal when it comes to food production stems from reactivating the primary production and the dormant productive landscapes. Some islands like Naxos are taking the lead in this process due to their longstanding expertise and availability of land and land cover. However, since all islands have terraced structures in place, the potential lies in restoring and maintaining them and activating them. The capacities for each island come from the terraced landscape typology exploration and the low-lying farmlands.

Figure 118. Food production and trade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Gyaros (Gioura)
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Paros
Naxos
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Schoinousa
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Amorgos
Kimolos
Antimilos
Polyaigos
Milos
Ios
Sikinos
Folegandros
Thirasia
Thira (Santorini)
Anafi

Materials and waste

The overall goal for waste and material is to develop the highest level of synergy possible. A waste trade framework is established, given the islands' different sorting and handling capacities. Decentralized waste recycling and repurposing are prioritized, minimizing linearity and supporting local material loops. Organic waste is used for soil enrichment and small-scale biogas production where possible due to the existing infrastructure. The quarries in place gradually close and are transformed, hosting other functions like energy production, material sorting, or storage.

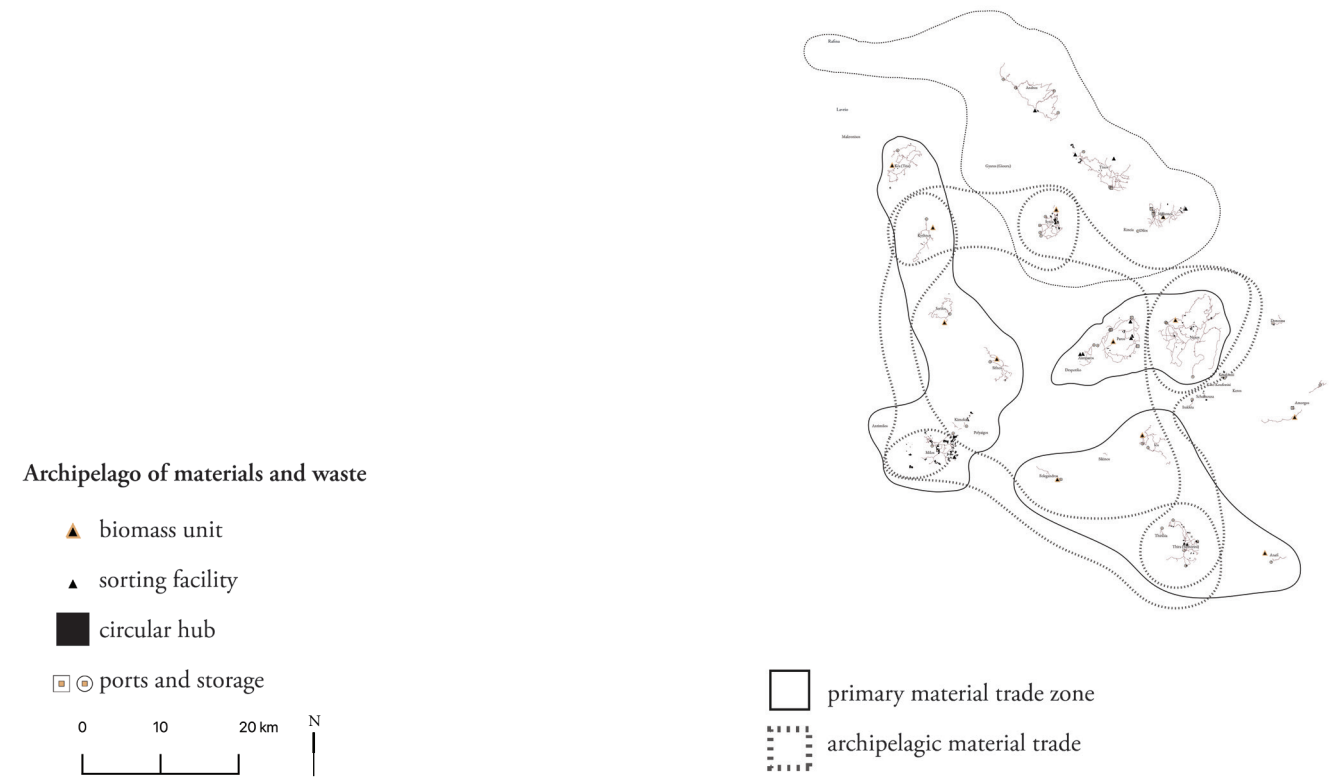


Figure 119. Material circulation and waste repurposing

Vision Island

The Santorini complex showcases diverse endogenous capacities in reactivating its landscape to support the island's metabolism. Due to the island's geomorphology, extensive terracing techniques are in place, while in areas where altitude did not necessitate terraces, agricultural land prevail between the settlements. When delving into the area's structure and correlating the landscape typologies with structural elements such as mobility networks, contour lines, and parcellation, a clearer vision of the metabolic landscape is formulated.

Figure 120. Santorini terraced landscape

Productive terraced landscape

- Settlements
- Main street network
- Additional street network
- Sea contours

Land cover

- Dense urban fabric (IMD ≥30-80%)
- Low density fabric (IMD <30%)
- Airports and associated land

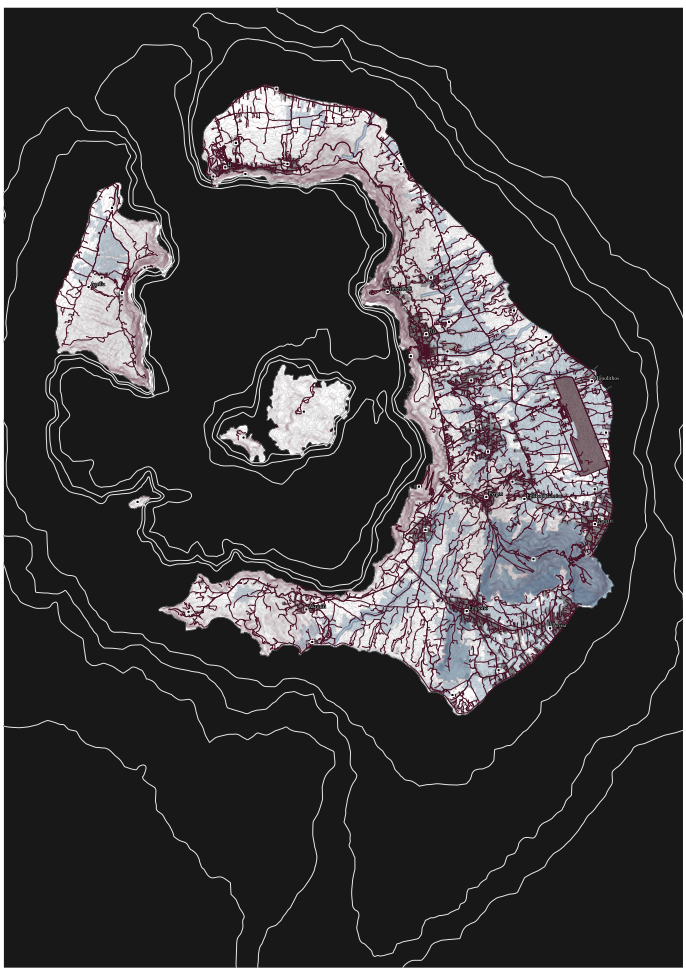
Landscape typologies

- Restored terraced agriculture
- Agrovoltaic zone
- Multifunctional terraced landscape

N

0 1 2 km

Figure 121. Santorini waterscape



Waterscape

- Settlements
- Main street network
- Additional street network
- Sea contours
- 5m contour line

Land cover

- Dense urban fabric (IMD ≥30-80%)
- Low density fabric (IMD <30%)
- Airports and associated land

Landscape typologies

- Fog and dew harvesting zone
- Rainwater harvesting zone
- Water course
- Aquifer infiltration buffer

N

0 1 2 km

Figure 122. Santorini farming oasis

Farming oasis

- Settlements
- Main street network
- Additional street network
- Sea contours
- 5m contour line

Land cover

- Dense urban fabric (IMD ≥30-80%)
- Low density fabric (IMD <30%)
- Airports and associated land

Landscape typologies

- Multifunctional agrotourism
- Low lying agrotourism
- Low lying farming zones

N

0 1 2 km

Figure 123. Santorini circularity and material trade

Circularity and material trade

- Settlements
- Main street network
- Additional street network
- Sea contours
- 5m contour line

Land cover

- Dense urban fabric (IMD ≥30-80%)
- Low density fabric (IMD <30%)
- Airports and associated land

Landscape typologies

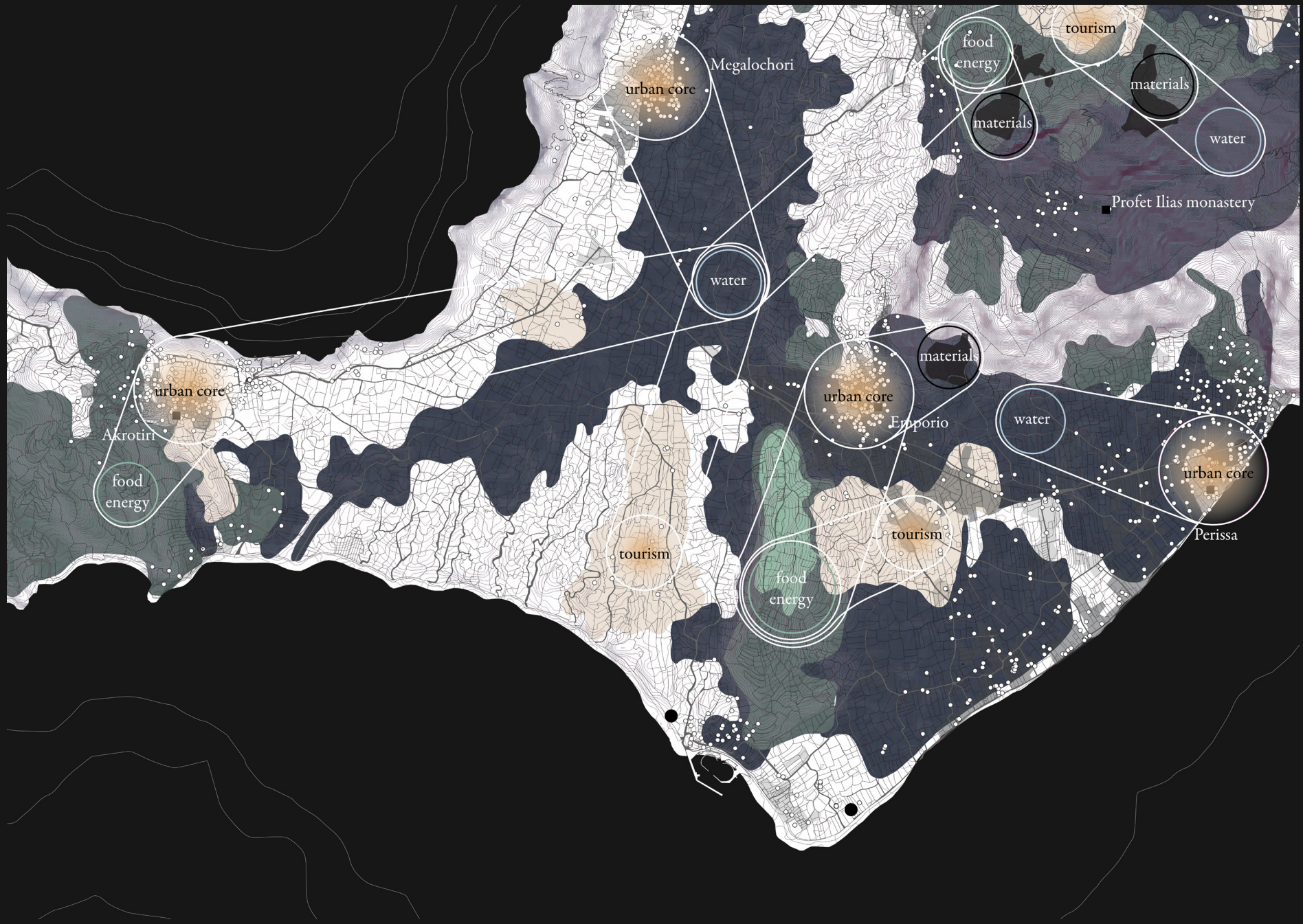
- Circularity hub
- Material bank
- Post extraction sites

Crucial infrastructure

- Passenger port
- Local multi-functional harbours

N

0 1 2 km


Megalochori
urban core
food
energy
tourism
materials
materials
water
Profet Ilias monastery
water
materials
urban core
Emporio
water
urban core
Perissa
urban core
Akrotiri
food
energy
tourism
tourism
food
energy

South Santorini - vision and synergies

When focusing on a sub-island territory, the level of synergy between the settlements, tourism, and metabolic processes can be examined. This scale identifies the maximum level of synergies between the cooperatives and the communities. By blending the areas of production with those of consumption, providing consultation on collaborative practices between the stakeholders, and promoting space-specific approaches, the communities shape a territory that can showcase the maximum level of autonomism since the local scale alone cannot do so.

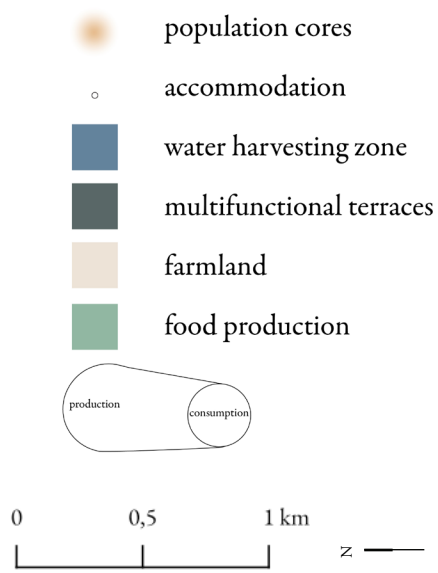
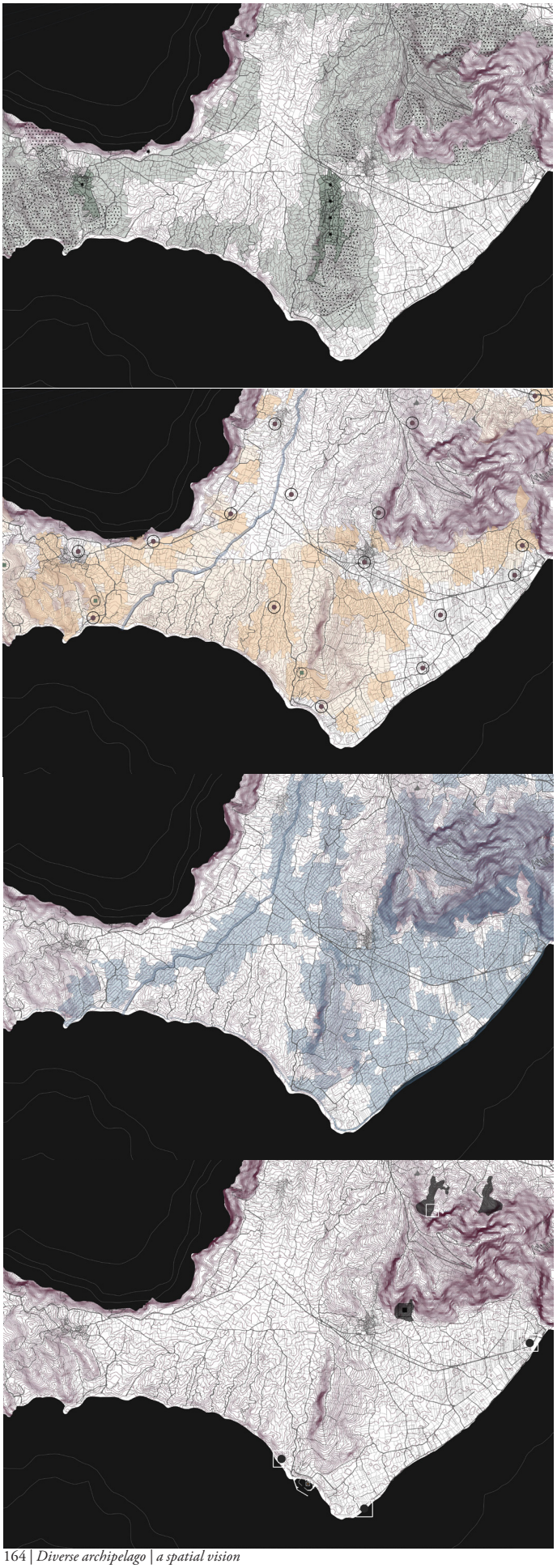


Figure 124. South Santorini vision - synergies

Landscape typologies and structure

As mentioned before, the structural elements that create and shape landscape typologies in real space are considered to situate them. This series of maps illustrates this structure for South Santorini and is the base for the vision and synergies that were presented for the area.



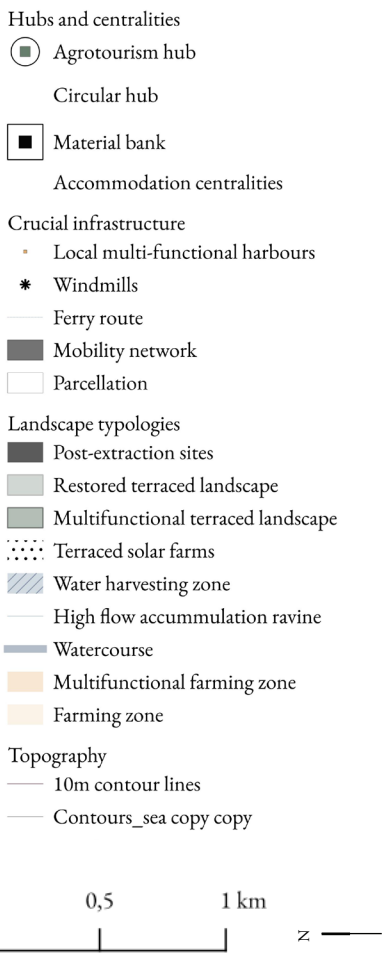


Figure 125. South Santorini vision

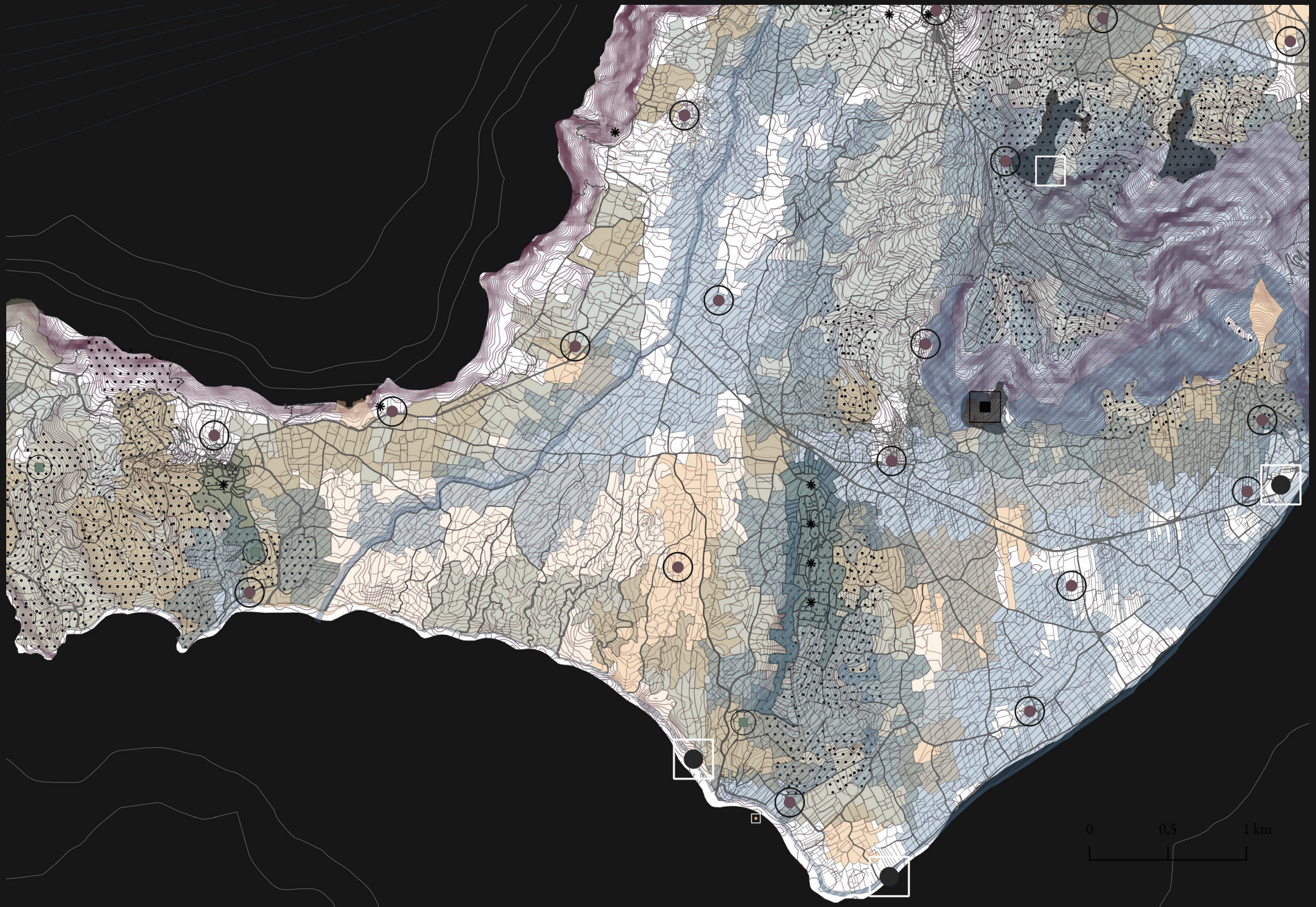
Figure 130. (right) Landscape typologies and structure

Figure 126. (left 1) Terraced landscape

Figure 127. (left 2) Farming and agrotourism

Figure 128. (left 3) Water harvesting zones

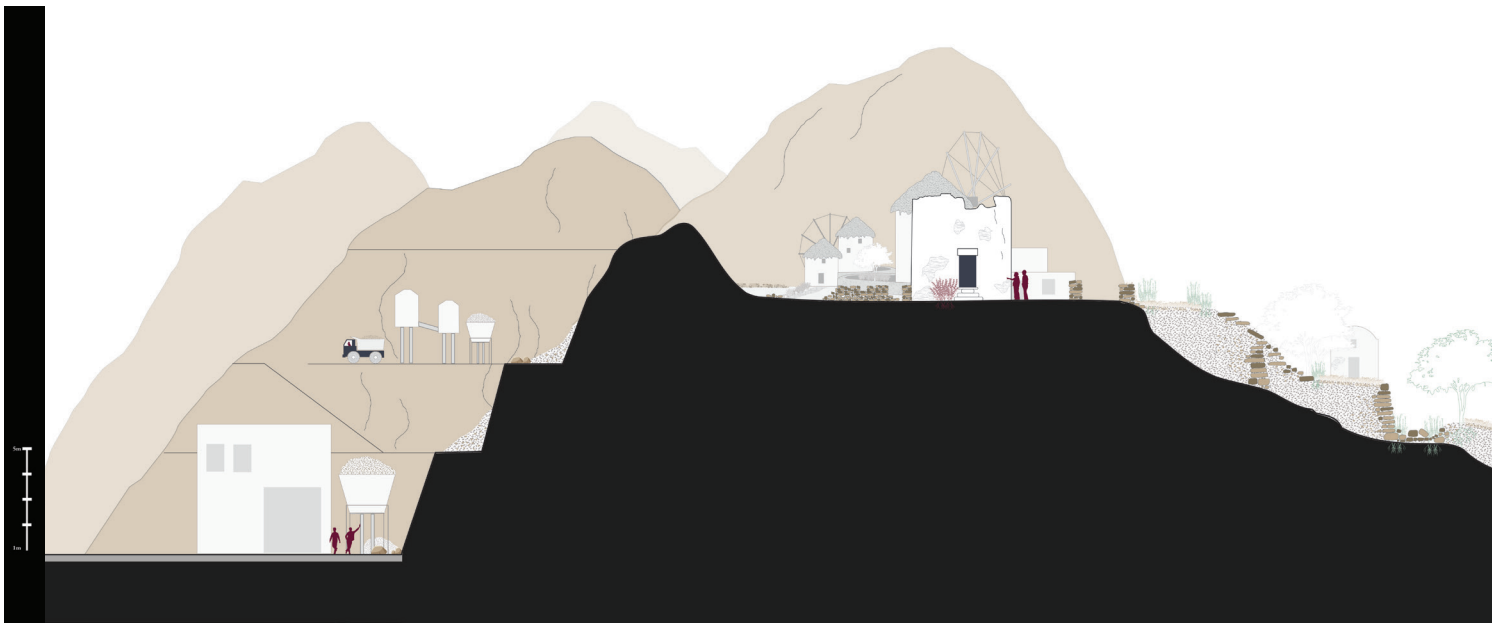
Figure 129. (left 4) Materials and waste circularity

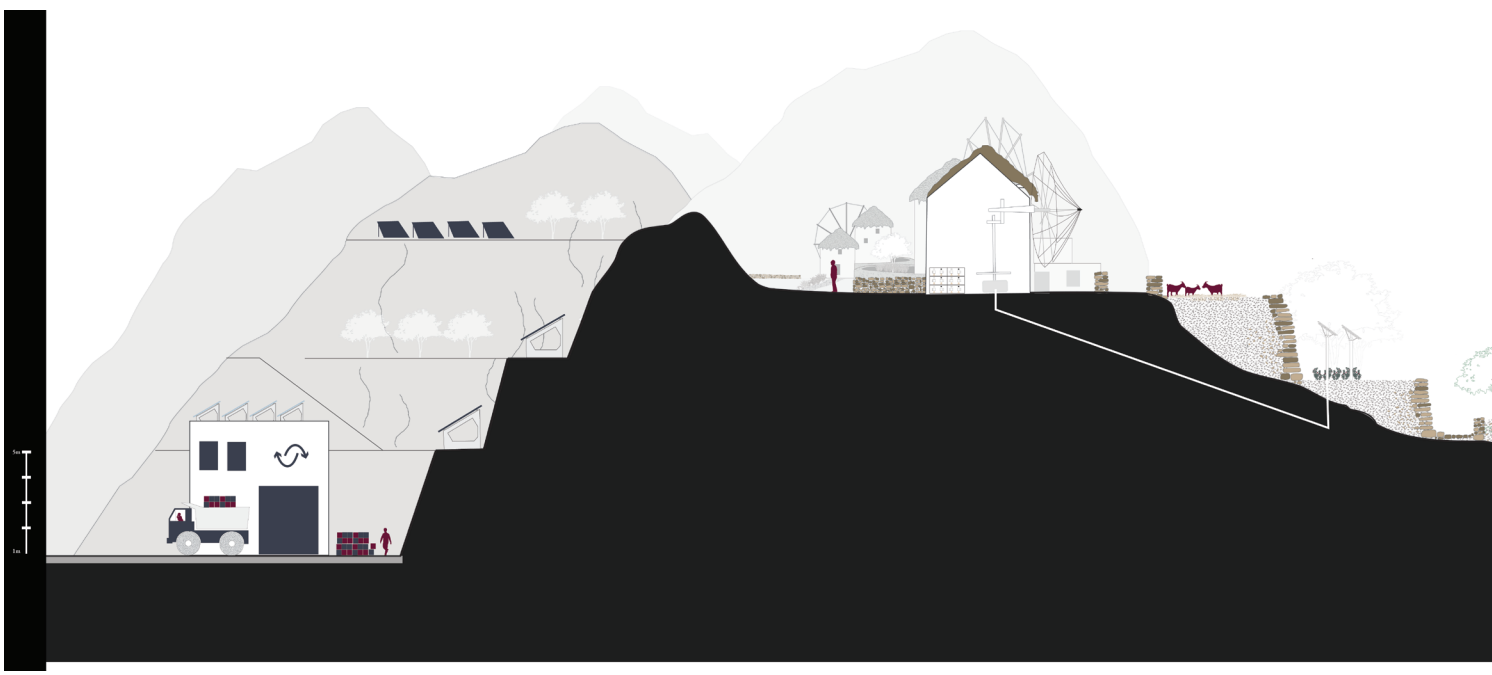

0
0,5
1 km

6.7 Landscape alteration

By repairing past operational landscapes and integrating small-scale contemporary technological solutions, this project proposes alternative landscape configurations that can support island metabolism (energy, water, food, materials, waste) by utilizing their endogenous capacities. These configurations take time. Thus, the project proposes that the landscape alterations will unfold through a sequence of actions due to the different levels of priority and considering the existing capacities and infrastructure in place. This process consists of three steps: restore/reactivate, adapt/transform, and add.

- **restore and reactivate** important traditional elements that have been damaged or inactive. These actions involve repairing dry-stone walls to reduce erosion and stabilize terraces, restoring cobblestone pathways, and restoring cisterns and water channels for rainwater collection. Ravines and seasonal streams are cleaned and serve as dry-season paths and waterways. Additionally, traditional buildings like tomato factories, and small-scale fishing ports need to be restored as well. Rotational grazing can reactivate dormant productive landscapes and activate abandoned farms and processing facilities. Revitalizing terraced agriculture, promoting seasonal activities, such as dry farming and sowing, and activating small-scale port infrastructure will also be key.





- **adapt and transform** existing systems to meet modern needs while preserving their original character and introducing new functions. Traditional windmills can be updated to generate renewable energy, and water and energy infrastructure can be adapted to current needs and technologies. Additionally, threshing floors are transformed into multifunctional areas for water storage, sports, and community meetings, and quarries and extraction sites are repurposed into solar farms, composting, or material hubs.
- **add** new systems and technologies to improve functionality and sustainability. Innovations like dew and fog harvesting systems in high areas, decentralized natural wastewater treatments such as wetlands and greywater loops, and renewable energy microgrids can improve functionality. Agrovoltaic installations and local sorting hubs to support a circular economy are introduced.

This temporal approach to the transformation can gradually foster community engagement and involvement in the processes since projects of restoration and maintenance demand long-term commitment.

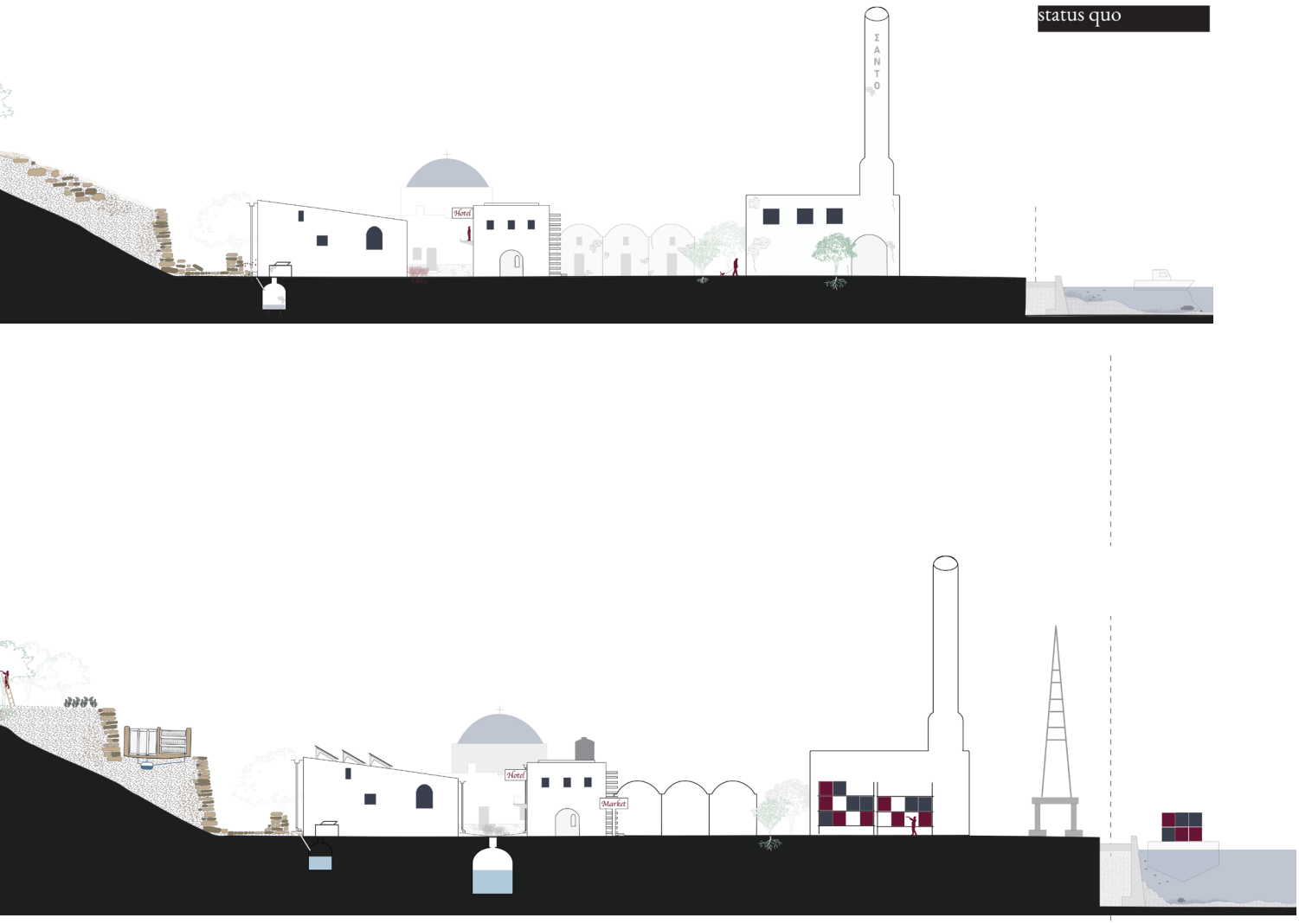
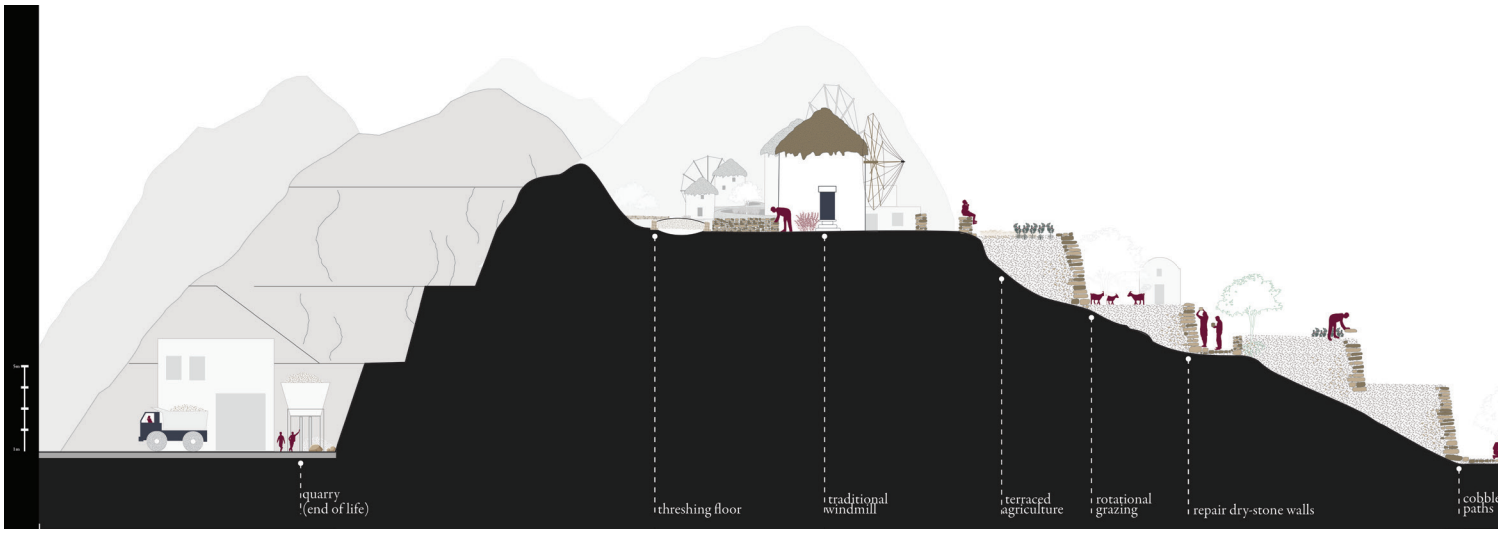
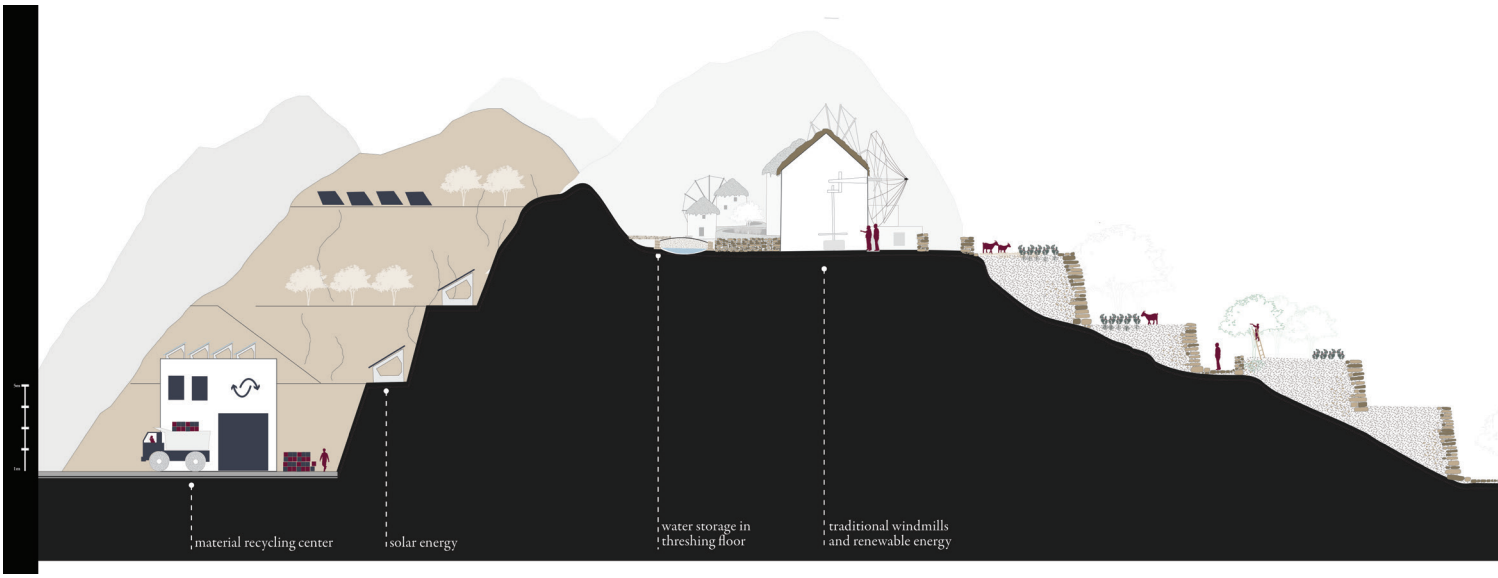
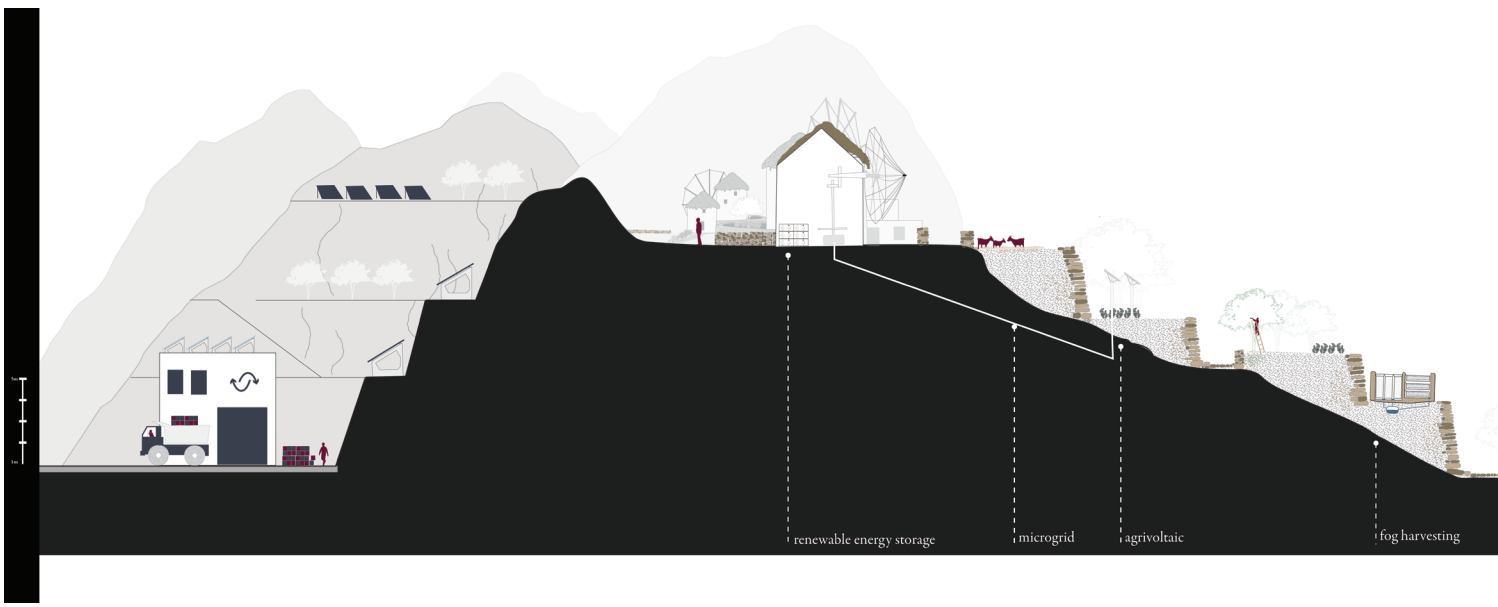


Figure 131. Landscape alteration over time, before, after


quarry
(end of life)
threshing floor
traditional
windmill
terraced
agriculture
rotational
grazing
repair dry-stone walls
cobble
paths


material recycling center
solar energy
water storage in
threshing floor
traditional windmills
and renewable energy


renewable energy storage
microgrid
agrivoltaic
fog harvesting

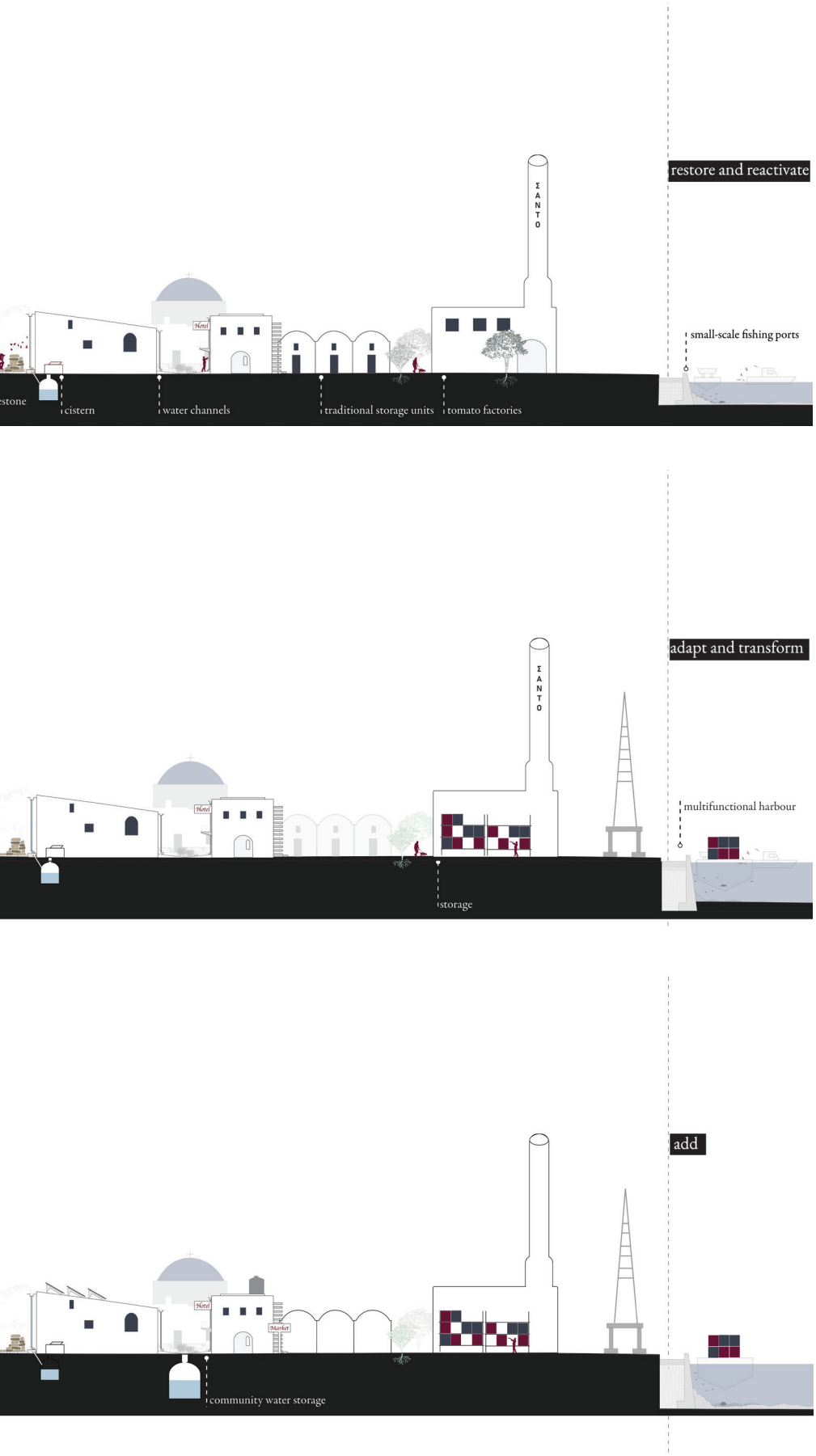


Figure 132. Sequence of landsape alteration

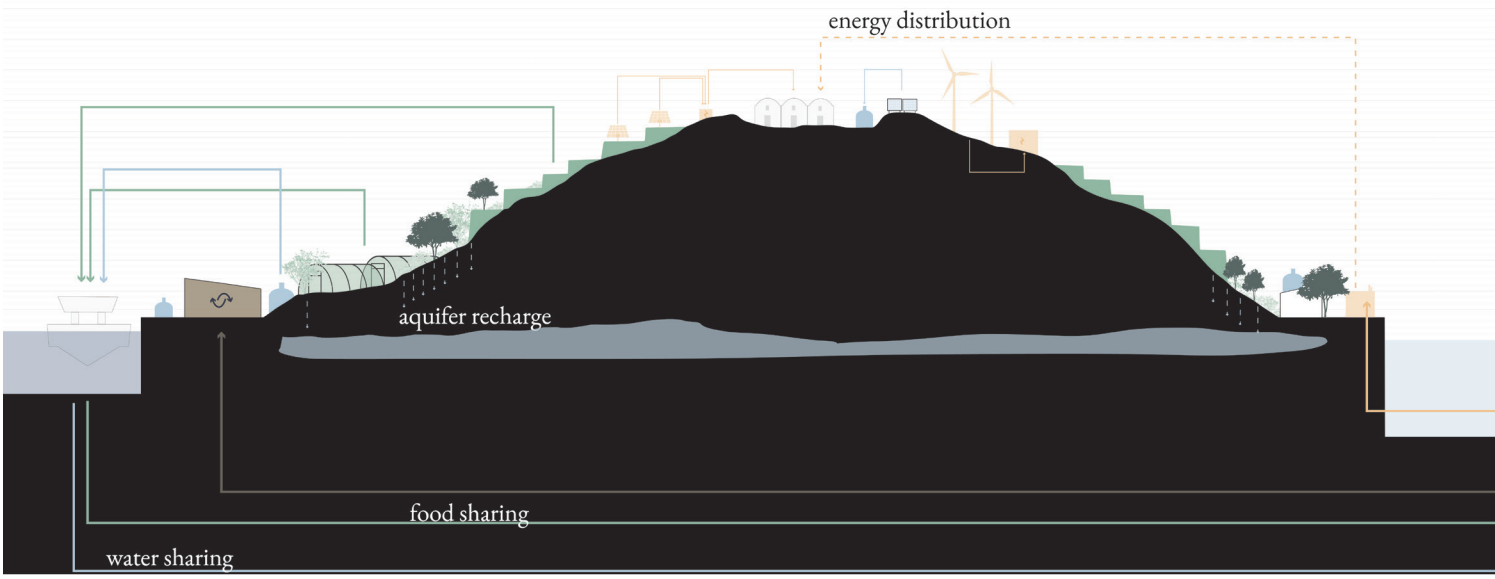
7. Exemplary spatial prototypes

7.1 Naxos and Thira in conversation
7.2 Multifunctional terraced landscape and waterscape in South Santorini
7.3 Aquifer recharge and agrotourism

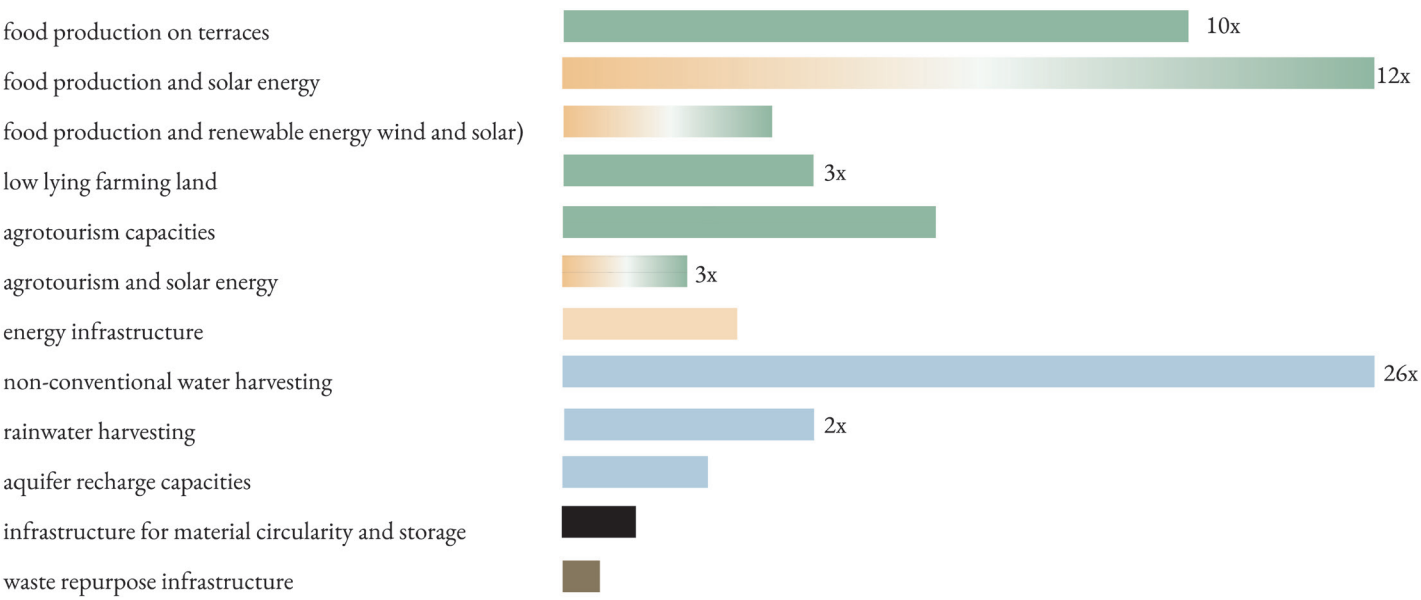
7.1 Naxos and Thira in conversation

The two islands selected for further testing and proof-of-concept design experimentation are Thira from the Santorini complex and Naxos. Following the vision discussed in the vision, the two islands are crucial nodes for the “archipelagic synergy” metabolic scale. Considering that their projective capacities are different enough, their collaboration becomes complementary, with each island supporting the federation and the metabolic processes in various ways.

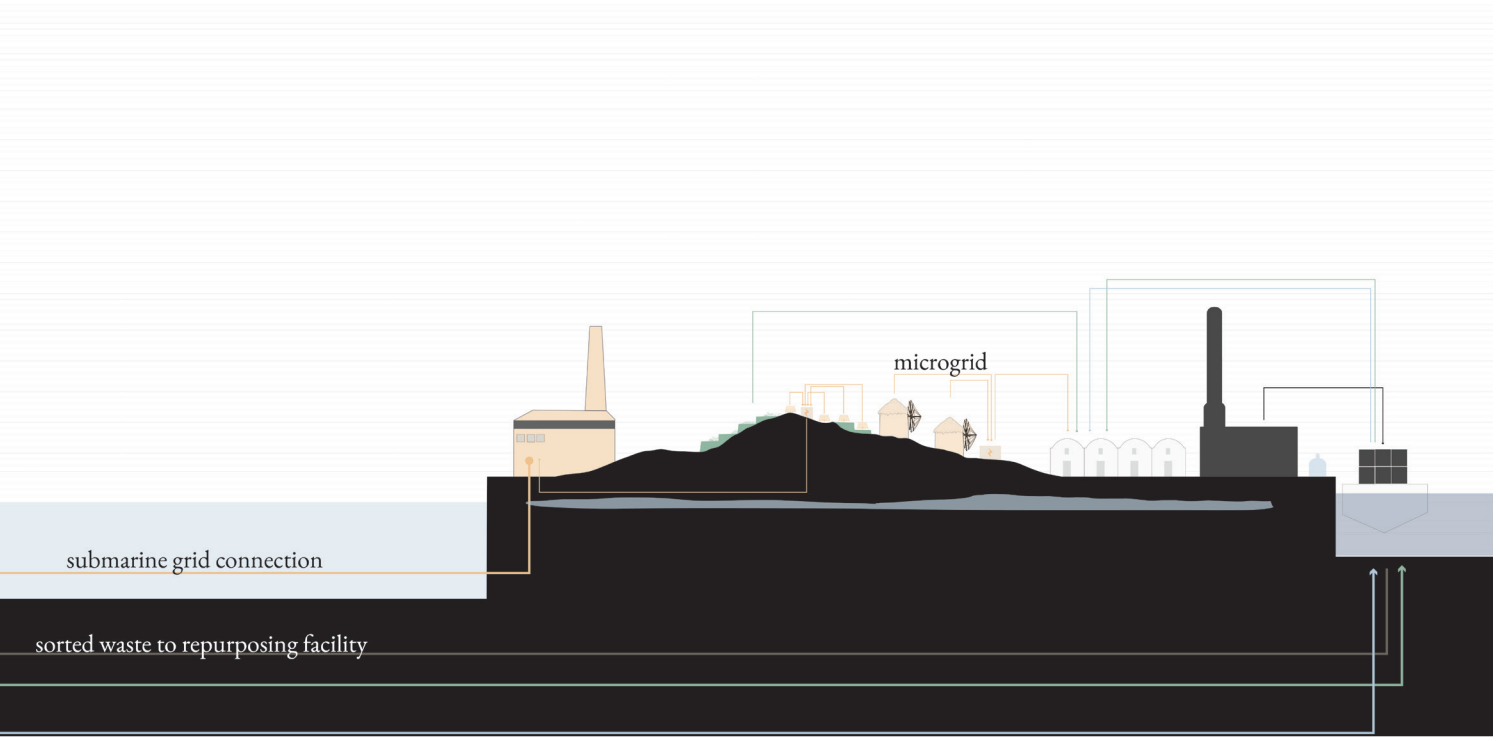
Figure 134. Naxos - Thira, metabolic profiles


energy distribution
aquifer recharge
food sharing
water sharing

Naxos


food production on terraces
10x
food production and solar energy
12x
food production and renewable energy wind and solar)
low lying farming land
3x
agrotourism capacities
agrotourism and solar energy
3x
energy infrastructure
non-conventional water harvesting
26x
rainwater harvesting
2x
aquifer recharge capacities
infrastructure for material circularity and storage
waste repurpose infrastructure

The collaboration of the two islands is evaluated based on their projective capacities (landscape typologies), the existing infrastructure (energy and water infrastructure, connectivity infrastructure, material, and waste-related infrastructural elements), the area, their positioning along essential shipping routes, and their current metabolic profiles, as presented earlier.
Therefore, Santorini's strong energy infrastructure, large waste production, and vacant industrial heritage sites provide a base for the island to become a strong energy hub and a storage-focused island as an intermediator where waste is sorted and either upcycled within the island or shipped to islands with greater waste repurposing projective capacities such as Naxos. Naxos, on the other hand, takes a leading role in the processes of water and food, following the extensive knowledge and practices already in place but slightly adopting them to harness their full potential based on their projective capacities for aquifer recharge, food production on terraces, energy production, and agrotourism. Of course, both islands support all processes to different extents.



Thira

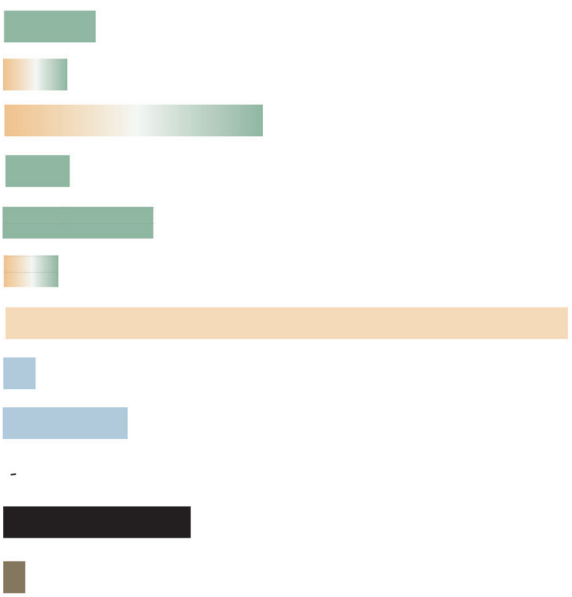


Figure 135. Naxos - Thira, systemic section showcasing the specialization of each island

7.2 Multifunctional terraced landscape and waterscape in South Santorini

This area is located in South Santorini at a higher altitude with a 5-15% slope. Most of the area is shaped in terraced form. However, a big part of it is abandoned. This spatial prototype focuses on reactivating the terraced productive landscape while combining it with water harvesting and energy production.

Figure 136. Satellite image of the windmills area in Emporio, South Santorini

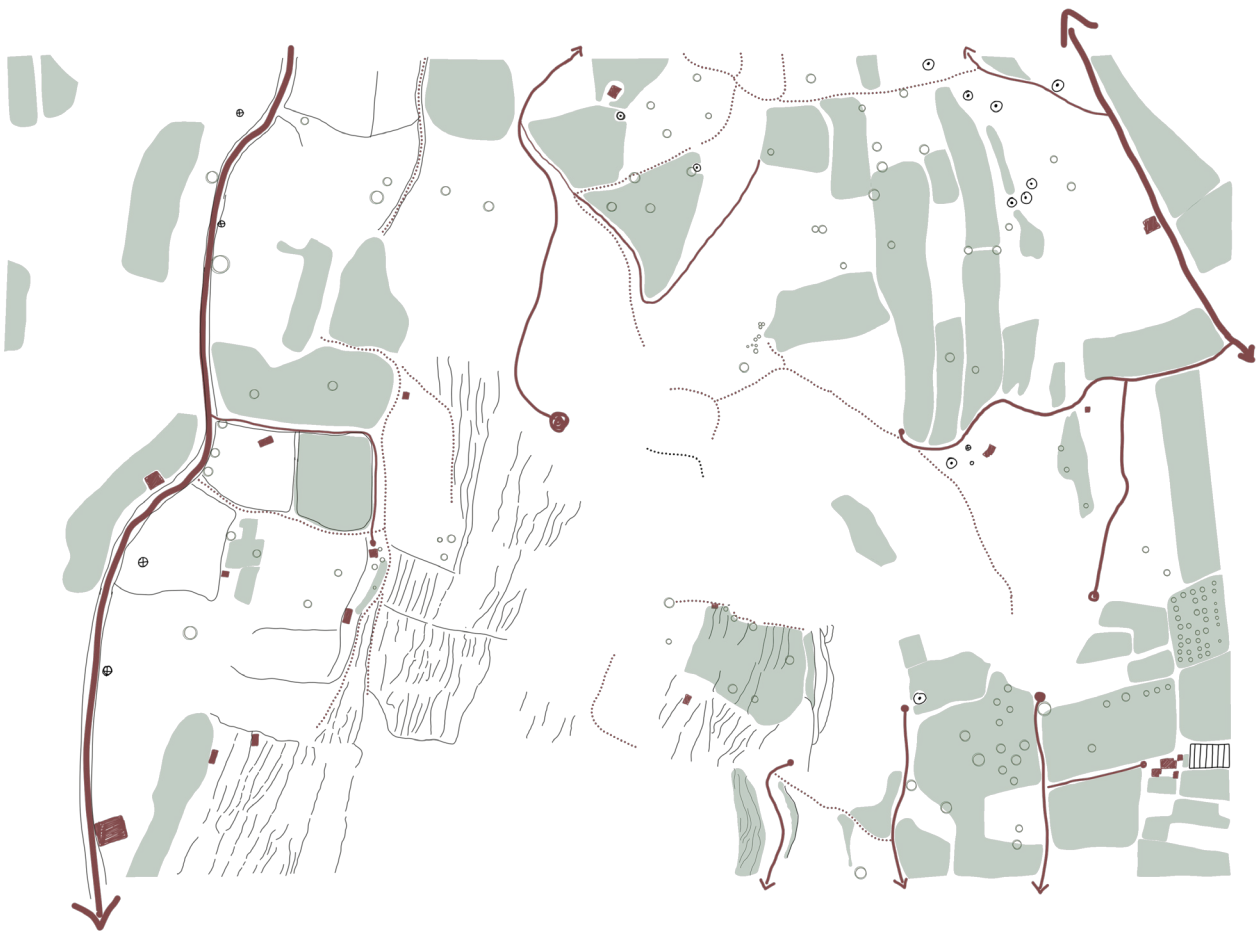


Figure 137. Status quo

Some of the cobblestone paths are in good condition, so the accessibility to the terraces is easy. Still, some remain inaccessible, so the focus, in the beginning, is to start restoring and reactivating the parts of the area that are accessible and then move more into the core. Multiple traditional architectural elements like windmills and threshing floors are restored and gradually adapted.

Figure 138. Restore and reactivate

The traditional windmills are converted for renewable energy production, and the threshing floors are being converted to water storage units for rainwater and fog harvesting.

Figure 139. Adapt and transform

New systems like agrivoltaics and fog harvesting elements are then added to the landscape.

Figure 140. Add

Water harvesting, energy production and storage

Figure 141. Section AA'


A
A'


rainwater for
irrigation
agrivoltaics
water delay and
soil stabilization
energy transformation
and storage
micro-grid

1:100

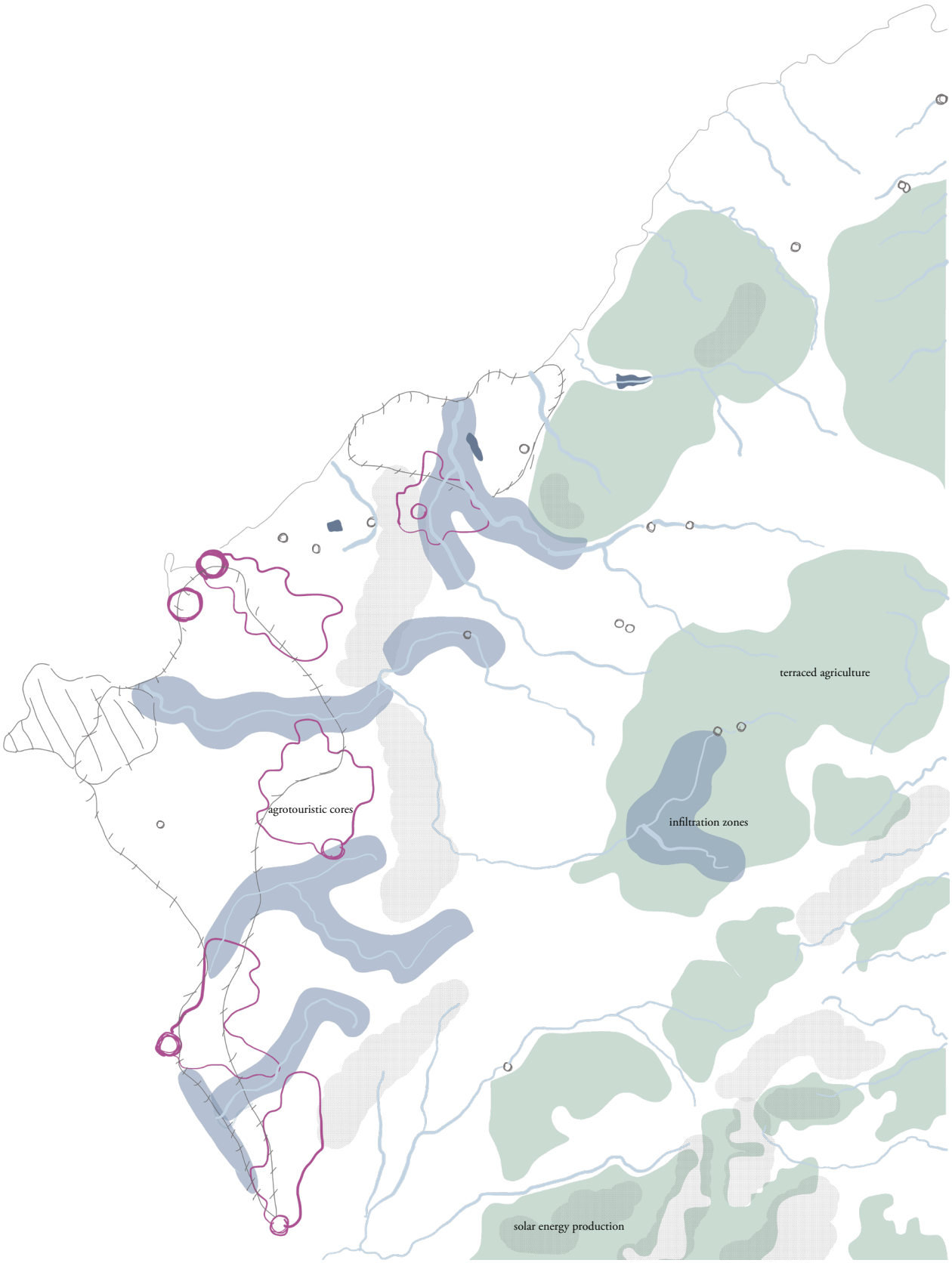


Figure 142. Northwest Naxos

7.3 Aquifer recharge and agrotourism

The second spatial prototype is located in Naxos, which belongs to Santorini's broader archipelagic synergy zone. The island's specialization is food and water production and waterscapes that combine infiltration and slow down runoff. Due to the presence of accommodation cores and agricultural estates, there are multiple ideal areas for agrotourism development.

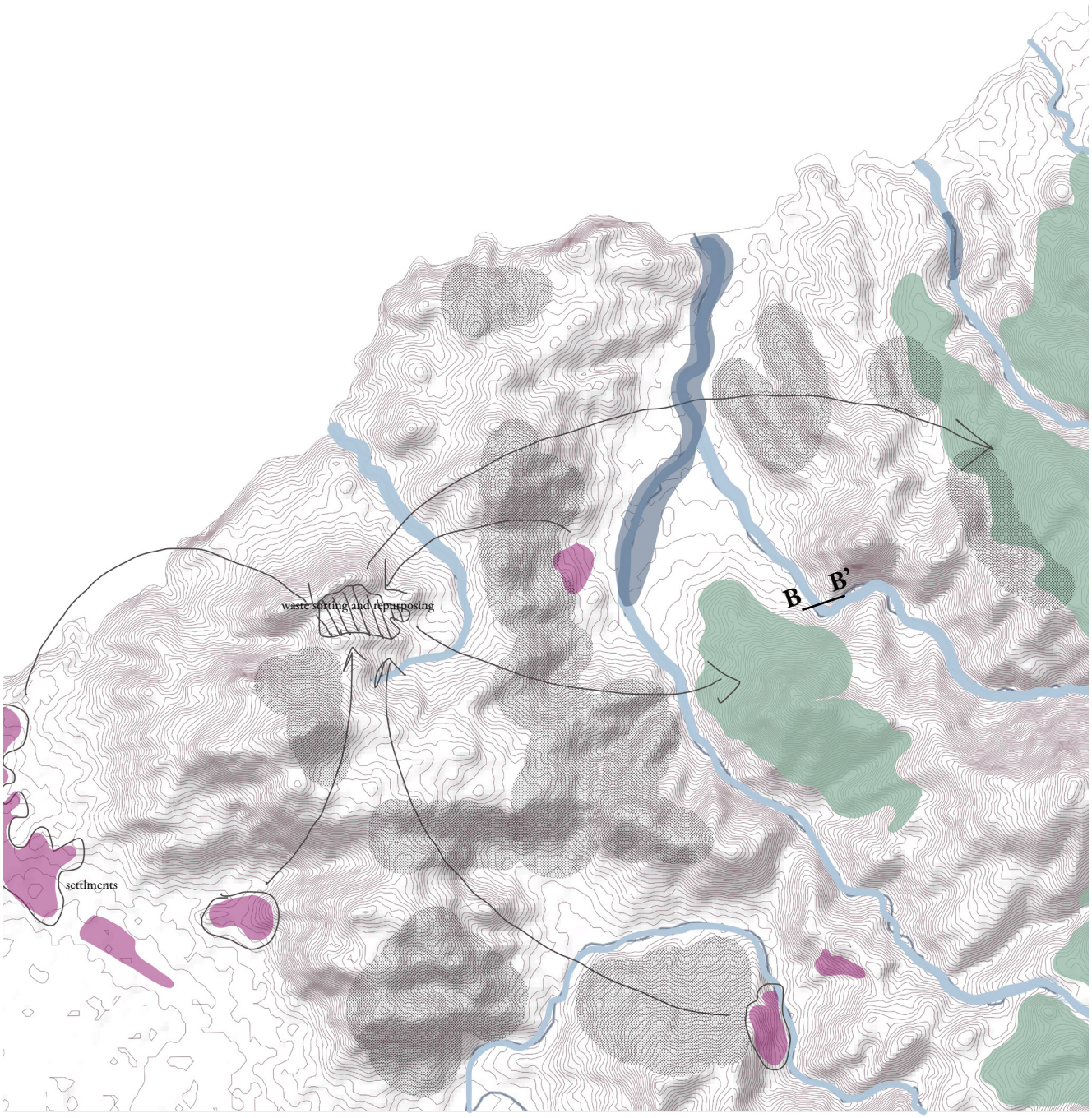
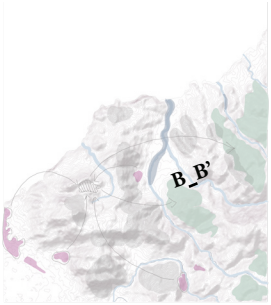


Figure 143. Concept plan

Aquifer recharge and tourism of care

Figure 144. Section BB'



1:200

8. Conclusions and reflection

8.1 Conclusions

The Cyclades archipelago is a clear manifestation of how globalization can change rapidly change a region by simply creating the necessary conditions for it to become more connected to global value and travel chains. Over the decades, with the necessary infrastructural development to meet increasing demands the region was transformed, using tourism as a perfect opportunity to transition from agropastoralism and recession to what has now become a fully-fledged service economy. By correlating tourism with the way it intensifies the pressure on the islands throughout the year, the project aims to showcase how problematic it is for an economy to rely on a monoculture of a single seasonal sector. Considering that state policy has proven insufficient to control this phenomenon, this proposal seeks to shift the dynamics by exploring an imaginary through which tourism could be controlled, indirectly. In this future, other activities, and therefore land uses, are competitive enough with the ones connected to hospitably. These activities are related to the five metabolic processes the project investigates.

By exploring the notion of urban metabolism through its spatial footprint, this project aims to highlight the complications of limitless growth and a fully outsourced metabolism by using islands, delineated geographies, for experimental conceptualization. Their clear boundaries facilitate the study of their metabolism and its manifestation in space due to specific entry nodes and structures that support it now and in the past.

An important role in the project is played by the proposed organizational structure which becomes an alternative to the current governance system and the methodology of carrying capacity assessments. Through this, the need to set limits on our activities, while maintaining adaptability and a certain level of flexibility for change, is emphasized. This flexibility originates from the different scales that are being addressed and expands the carrying capacity to synergy zones between the islands rather than assessing each one individually, with the multiscalarity of the structure ensuring collaborations both within islands' boundaries and across islands.

To disrupt the current import-oriented system on which the islands depend, this project proposes a metabolic structure that operates on different scales. It recognizes that islands can't be completely self-sufficient but can radically reduce their dependency on imports, to some extent, by seeking partnerships at nearby scales and creating cross-scalar federations.

The import-oriented and fully infrastructuralized system currently in place provides an illusion that resources are infinite, that we can keep extracting, importing, and therefore growing. The Cyclades archipelago once had fully operationalized landscapes, but now depend on hinterlands far away, such as the Metropolitan Area of Athens or other regions. This project attempts to shed light on the hidden metabolism that supports everyday life and which is usually "send to the back office" of our territories, into specialized areas, away from our frequent routines, or concealed under the surface or into our oceans. By blending the areas of production with areas of consumption, bringing the hinterland closer, it aims to raise awareness about scarcity and the need for behavioral change. And by looking at the landscape as infrastructure, inspired by its past function, the project proposes the full utilization of it as part of the island metabolism, incorporating situated and artisanal knowledge with small-scale technological elements.

The way the proposal unfolds imagines an alternative future from the one we are currently heading toward if we continue with the same practices. It does not focus on providing solutions, but rather flexible alternatives and key structures that could initiate the change. Through spatial prototypes, it aims to elaborate further on these structures and their manifestation in space, while emphasizing that the system is flexible and can be adapted either partially or fully.

8.2 Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

This project includes multidimensional perspectives, though it focuses on the relationship between urban metabolism and external factors, in this case tourism, that cause disruptions and push a territory's capacities within a circular timeframe. Islands, and specifically the Cyclades, were chosen as the testbed to unpack these relationships due to my personal connection to the place, and interest in such geographies. It highlights limitations of current planning paradigms and contributes to discussions related to the problematization of limitless growth and resource scarcity, the value of flexibility and adaptability, and the need to understand a territory's capacities by embracing situated knowledge and practices that go beyond "one-time interventions" and are sustained by the community directly involved.

The Transitional Territories graduation studio theme for 2024-2025 is "altered nature - poetics of change". My chosen case study is a territory that has undergone great alteration due to the emergence of tourism and the infrastructuralization, connectivity networks, and resource management that came along with. The islands' "handmade nature" has transitioned and been substituted to support greater demands. Additionally, some of the themes I am exploring throughout the project relate to notions of resource scarcity and political ecology which are aligned to some of the studio's focus themes.

The Urbanism track provides us with a variety of stimuli especially during the first year, through the different topics we had the chance to explore in studios, lectures and workshops, while also allowing room for personal exploration and deepening into methods and topics that we wish to engage with. The integration of spatial planning and urban design and the opportunity to explore their interrelations in a trans-scalar manner is introduced at multiple moments and it is an approach I adopted for this project by choosing to work with territorial design. By bridging multiple scales of metabolism, I am attempting to unpack how the global interacts with the regional, the local, down to the object scale of a single infrastructural element.

When it comes to the track overall, although I come from a non-architectural background, I have had the opportunity to explore scales and lenses that extend beyond urbanism alone, intersecting with other disciplines like landscape architecture and architecture. The program has a cross-disciplinary approach, which could be improved through further collaboration with other tracks and departments, which I firmly believe is necessary in order to keep expanding our knowledge spectrum and approaches to contemporary challenges and discussions.

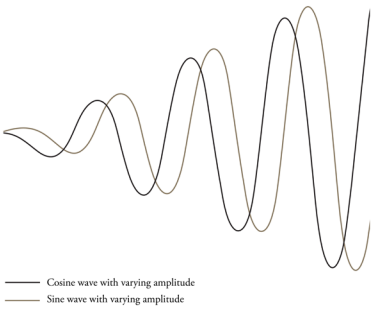
2. How did your research influence your design/recommendations and how did the design/recommendations influence your research?

Throughout my entire graduation process research had a strong influence on my products and design, and the other way around, through a itterative way that shaped the project. My initial thoughts and visions, which later became more concrete concepts and designs, fueled the topics of research I was looking to explore, while the research, in turn, shaped and deepened my design proposal. Through research I managed to structure my initial more "messy" ideas while expanding the project's complexity and further diving further into the discussions with the mentors and uncover new directions that I had not considered previously.

Research and design went hand in hand throughout the whole process, from initial literature review to extending to specific design interventions and potential possibilities. The initial literature review centered on islands and urban metabolism introduced me to principles such as flexibility, multifunctionality, ephemerality. Yet as the project evolved, new challenges continuously required returning to literature to refine the project's objectives, sharpen my methodology, clarify its scope, and identify interventions that would fit the context and sensitivities. And as research grew so did the design proposal by being inspired from other practices I could find through desk research, but also gained inspiration from the discussion I had with individuals during my visits on the island. Of course the choices made are a result of my personal story and experience as well, since I was aware and had the "tourism" discussion multiple times with people from other islands but also academics during my bachelor's graduation project. Therefore, research helped me contextualize and reassess personal knowledge and lived experience, and allowed me to critically connect this experience to broader global, regional and national discussions, such as the aftermath of globalization, infrastructuralization and many others.

In general, the project's approach was reinforced by a continuous feedback loop between research and design, which I metaphorically connect to two evolving wave curves, similar to sine and cosine

curves, with changing amplitude but which both grow in relation to time.



3. How do you assess the value of your way of working (your approach, your used methods, used methodology)?

The project integrates multiple methods in a multidimensional way including spatial, systemic and institutional perspectives. Throughout the process, I experimented with different ways of mapping using the Studio Essentials and Intensive Course to experiment as much as possible from the very beginning. It combines multi-scalar mapping and analysis, from the scale of the archipelago to the island, and then to more detailed local scales. Through photography and conceptual mapping, it attempts to shed light on the multiplicity of scales and structures related to the metabolism of Santorini and Cyclades. Through collaged and hyperrealistic images, I tried to communicate the extreme conditions and the visionary ideas I had in mind, while minimizing trying to limit personal interpretation as much as possible.

The different methods I would like to explore were somewhat clear to me from the beginning of the project, although they were adapted and additional ones emerged during the process depending on the narrative I wanted to build and the message I wanted to communicate. An example of this could be the landscape typology construction I conducted in order to create generalized patterns of projective capacities that could be operationalized as parts of the island metabolism. This methodology shifted a lot due to the lack of data and was combined with literature review when available spatial data were not sufficient. However, several aspects such as climate data, which could have added further complexity were not included as much due to the unavailability of them at certain scales. Mapping remained a challenge due to the limited availability of centralized datasets. Although by attending different events such as the presentation of the upcoming spatial plan for the island, my previous knowledge, fieldwork, and some initiatives by fellow Greeks to concentrate Greek datasets in QGIS plugins, I managed to navigate. With more available data the chosen methods might of course, have changed.

My approach in assessing urban metabolism through an island was a way to explore conceptualization in an environment that has defined entrances and measurable capacities. However, I soon realized that the case was different due to the activities and structures that are not formally registered or private actions that are not part of the official metabolic infrastructure provided by the administrative bodies. Therefore, the full extent of the flows could not be calculated fully. That was one of the reasons I embraced a qualitative approach that seeks for spatial manifestations rather quantitative measures.

Methodologically, this approach helped avoid an exhaustive data collection process. This was supported by the fact that I have my own embodied knowledge about the island and am part of the community. This "non-conventional" data collection was continuous, due to my connection with the circles of discussions on the island, through news articles, social media, discussions with members of the community that I knew personally, and my family. My deep involvement with the place of research proved to be both insightful and challenging due to the constant constraints I was aware of and had to navigate through or around. There were many moments that my personal involvement held me back, and at those moments discussions with like-minded students or my mentors, and further research helped maintain continuity and motivation in the project.

I believe the project has a very broad catalogue of methods and explorations that somehow attempt to communicate and structure the "mess" my brain navigated throughout the year. And I believe that depending on the means chosen, it can be communicated with different communities, academics or not.

4. How do you assess the value of the transferability of your project results?

Although the project is location-specific, I firmly believe that several insights can be valuable in other contexts. There are many archipelagic regions caught in similar cycles of monofunctionality. The Cyclades and Santorini serve as a testbed for an alternative metabolism that operates by first acknowledging that there is no limitless growth, utilizing local landscape capacities, promoting synergies between metabolic processes and the broader territory, and seasonally adapting its strategy by utilizing a federal governance structure.

Investigating the concept of urban metabolism by using islands and focusing on five core processes (energy, water, food, materials, waste) contributed to simplifying the concept's complexity and while giving room for exploration. Approaching it from its spatial manifestation and not through an extensive flows analysis, contributed to a better grasp of it and what it entails, what are the architectures and elements that are necessary for it to work.

I can imagine the approach or different outcomes being valuable in other geographies that have been transformed by their over-connection to global networks that led to local disconnections such as tourism-transformed islands and cities. These territories, cities, islands, could incorporate the goal of supporting activities that challenge dominant sectors by diversifying local functions. Another aspect that could be valuable is the method of assessing carrying capacity as one that is co-defined by those involved, and supported by fallback systems that offer flexibility while also recognizing the need for design and planning to impose limits on a limitless growth.

One particularly insightful aspect raised when I investigated the history of these islands, and through discussions with my mentors, I started seeing the landscape I was very familiar with through a

lens I wasn't experienced in using. This, for me, highlighted the need to exit the centralized policy production cycles, and instead look at the territories we are dealing with firstly by understanding what is already there, to draw inspiration and grasp reality. Getting inspiration from the past was something that worked in my case, but I did try to frame it in a contemporary life frame. Such methods could be valuable for our profession overall.

Limitations and further research

Although the project provides relevant insights, there are multiple aspects missing or are beyond its scope, which could be explored further.
I believe one significant limitation is the fact that it relies primarily on qualitative analysis and lacks quantification. Exactly because urban metabolism takes usually the form of SANKEY diagrams and quantitative evaluation of the flows a full quantification of the dynamics for production in relation to the demands of the proposed future would be very useful to complement the qualitative approach and ground the proposal more firmly in reality.

Furthermore, in order to explore all possible spatial manifestations of the project at the local level deeper and more site-specific research and continuous community engagement would be needed. The project was developed with a half-insider perspective, while also incorporating the viewpoints of multiple stakeholders. However, further engagement with communities from other islands or communities working towards or against similar goals could have been insightful.

As a graduation student that had specific capacities and limited time, I framed the proposal in the way I thought most relevant. However, this project could expand in different directions if discussed with other disciplines, such as energy, civil or coastal engineering. Such input could complement the approach and offer more technical insights. And this is where collaboration across disciplines becomes essential, and the need to had conversations horizontally is highlighted.

Another potential limitation is the fact that the proposed organizational structure plays a critical role, but agency, participation, and trust are sometimes difficult to cultivate. If this project was to be utilized, a long period of conversations and discussions would be needed to prepare and create the social base that will act as the system of care and repair. Of course, for the greater vision to happen holistically, a greater institutional and financial support would be required from state and regional administration. Especially for processes that are technologically complex and financially demanding such as the waste to energy systems or the transformation of energy systems from a fuel to another such as geothermal energy.

Additionally, the complete dynamic of utilizing tourism's potentials was not fully explored, a personal choice to avoid making the project tourism-centered. Still, integrating tourism's positive spillover effects more deeply across other economic sectors and islands could have provided additional insights and made the project more attractive and realistic from a financial perspective as well.

5. How do you assess the academic and societal value, scope and implication of your graduation project, including ethical aspects?

An aspect I consider socially important, and one that reflects on a personal change through this project and the master's program more broadly, is my evolving ability to perceive landscapes not just in isolation, but as parts of broader regional or global processes. I've experienced recognizing both hidden and more prominent spatial manifestations of metabolism: from a submarine electricity cable lying beneath the sea to the connection between a steel plant in the Netherlands and a mine in Kiruna, and how they both relate to our everyday lives. In fact, I believe that much of society remains unaware of the systems that support our lifestyles precisely because these systems are often invisible. Even when growing up on an island with such limited geography, such infrastructures are usually distant from everyday experience. By making these systems visible and exposing their flaws and the limitations of our living patterns and economic models, the project aims to raise awareness and foster critical reflection.

I need to highlight that in my site the present more-than-human agents reminded me of nature's endowment. This project did not go into disaster management though it could have, as the heated discussions initially and personal interests were different. These discussions shifted completely in February 2025, when for weeks the islands of Santorini and Amorgos nature were daily reminders of what the islands' futures could hold. I felt so small discussing and designing for an area that could change dramatically, or even stop existing within weeks. I believe that by reflecting back on those moments, we can put situations in different perspective. What makes the island globally known is its very flaw: the fact that we have commodified, manipulated and covered its cliffs in unregulated construction, a landscape that was shaped by the same forces that could vanish it. At that time, there were many discussions around the subject, and the multiple alarms this should have raised. Yet, when the earthquakes gradually decreased, the discussion moved to "what we can do to avoid losing the season". And this is interesting because it is the same pattern that emerged during and after the COVID-19 pandemic. Instead of "build back better", we built up the same way. While I believe that these continuous reminders most of the times did not bring immediate effects, hopefully they can start discussions, and by discussing I believe change can come.

Additionally, the project's societal relevance lies in its contribution to addressing the challenges posed by the seasonal influx of tourism, which often disrupts the quality of life for local communities. By promoting more evenly distributed activities throughout the year, the project aims to mitigate resource shortages, discomfort, and scarcity issues. It also seeks to boost cooperation between the islands of the archipelago, encouraging shared resources management, by creating a sense of belonging to a "common". Within this framework, knowledge and mindsets are shared, moving beyond competition to address shared challenges of resource management and endogenous capacities that often remain overlooked. Furthermore, the project touches on and builts upon the ongoing debate between cultural preservation and infrastructuralization, proposing that landscape identity, artisanal value, and infrastructural needs can be respected.

From a scientific perspective, the project critically examines globalization's role in creating global interconnectedness while fostering local disconnections. It proposes an alternative way of understanding urban metabolism, moving beyond traditional Sankey diagrams and emphasizing the physical and spatial impacts of metabolic systems on the landscape. The analysis highlights the Cyclades' unique inverted city-hinterland relationship, where the islands act as urban centers supported by a hinterland that extends to the Greek mainland and global supply chains. By combining islandology and urban metabolism, the project explores the challenges of applying these frameworks to geographically delineated systems like island territories. It also explores speculative design experiments and crafted fictions as tools to inform design approaches. Ultimately, the work offers adaptive multi-scalar proposals for metabolic systems that balance the landscapes' inherent capacities with fluctuating resource demands, presenting a new way of understanding carrying capacity. Rather than as a fixed number per island, the project proposes a flexible, federated governance model that works with synergy zones, not isolated units along the archipelago.

6. How does the project challenge current design paradigms and the role of urbanism in shaping behavioral change?

The project challenges current design paradigms by highlighting the limitations of top-down planning and design from actors lacking situated knowledge, while also questioning the model of continuous tourism-focused development. It redefines the role of the urbanist, not as someone who is intervenes radically on space, but as someone who provides imaginaries, understood as "frames that create meanings and express values" (Savini, 2021a). It also calls for a shift from rigid zoning as a method toward an approach that investigates synergies and relations between the local systems and broader socio-economic structures.

An urbanist is not only someone who shapes urban forms but can act as a facilitator of possibilities and alternatives with interventions that respect the local context and sensitivities while stating the need to set boundaries. By exposing hidden infrastructures that sustain life, and reconnecting them to everyday experienced space, the projects invite a behavioral shift from consumption to "prosumption" and stewardship, and from individualism to collective agency. Design thus becomes a tool to understand what a place can be and how we can live in it.

"Is this region self-sufficient? What does it mean to be self-sufficient? What are the functions that might be missing? It's important to rethink the regional networks not through economic success but also in terms of the ability to provide for the people living there. [...] Of course we are not going to be completely self-sufficient but by simply start asking these questions we can open different perspectives that can lead to a change in mentality as well".

(Savini, 2021a)

7. What is the role of care in your design framework?

Care is a fundamental principle of the project and takes shape through the proposed organizational structure. It manifests through the restoration and maintenance of the landscape, the activation of artisanal knowledge, and the shaping of relational systems that require ongoing stewardship. The structures supporting the project are not one-time interventions, but living systems sustained by human and ecological forces. In this way, cooperation and commoning practices that embed responsibility for the communities rather than the state or regional administrative bodies. Thus, care becomes a collective effort, an approach to metabolism that values highly flexibility, collaborations and reciprocity.

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9.2 Appendix

Scales of metabolism model

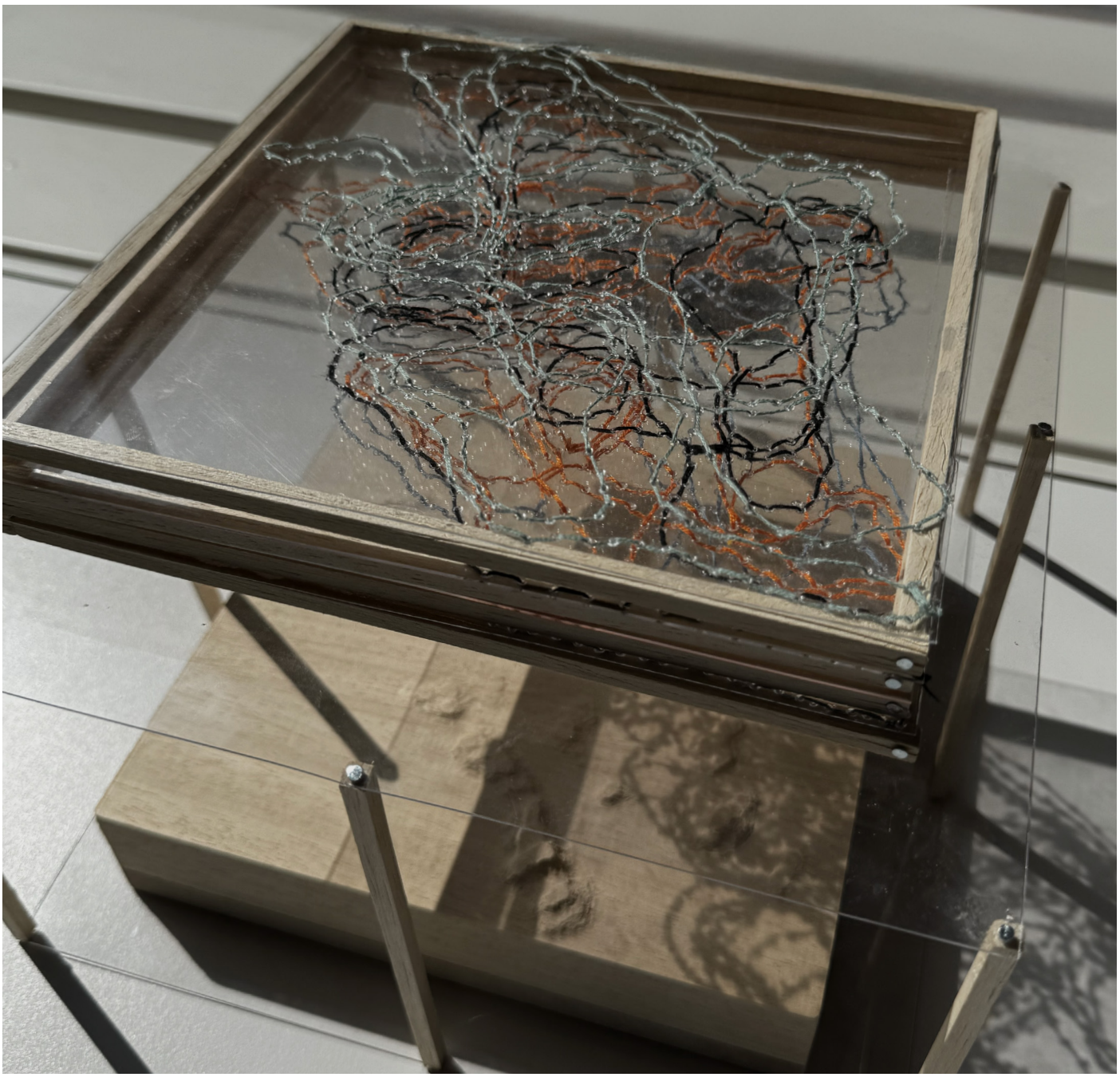

Figure 145. Conceptual model of Cyclades and four metabolic processes, from top to bottom: food, materials/waste, energy, water

Figure 147. Reflection of the water scale on the model

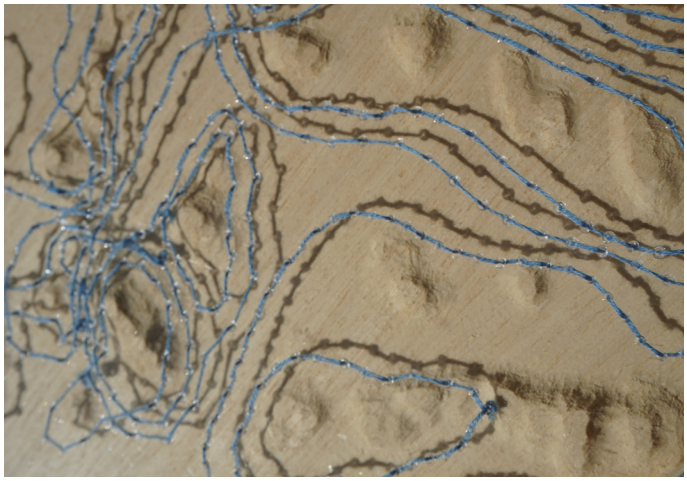

Figure 146. Water scale, details

Santorini model

Figure 148. 3D model of Santorini island complex

Aspect analysis

Figure 149. Aspect analysis

Figure 150. Solar potentials analysis

Slope analysis

Figure 151. Slope analysis

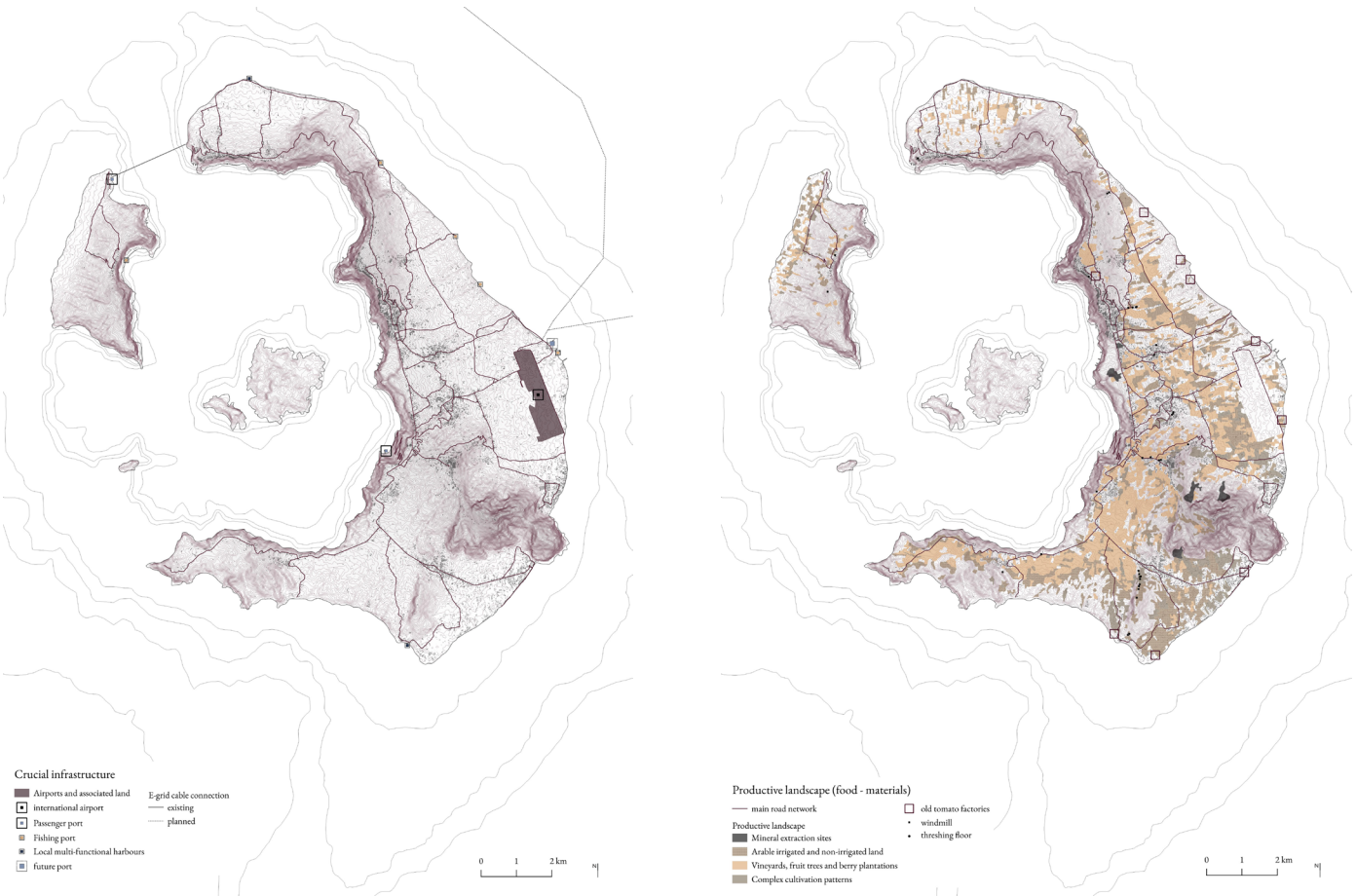

Figure 152. Mapping gallery - analysis for landscape typologies and metabolic processes


Natural and semi-natural areas
building footprint
5m contour line
coastline
sea contours
Natural and semi-natural areas
Semi-natural grassland
Sclerophyllous scrubs
Sparse vegetation on rocks
Bare rocks and outcrops
Coastal cliffs
0
1
2 km
N

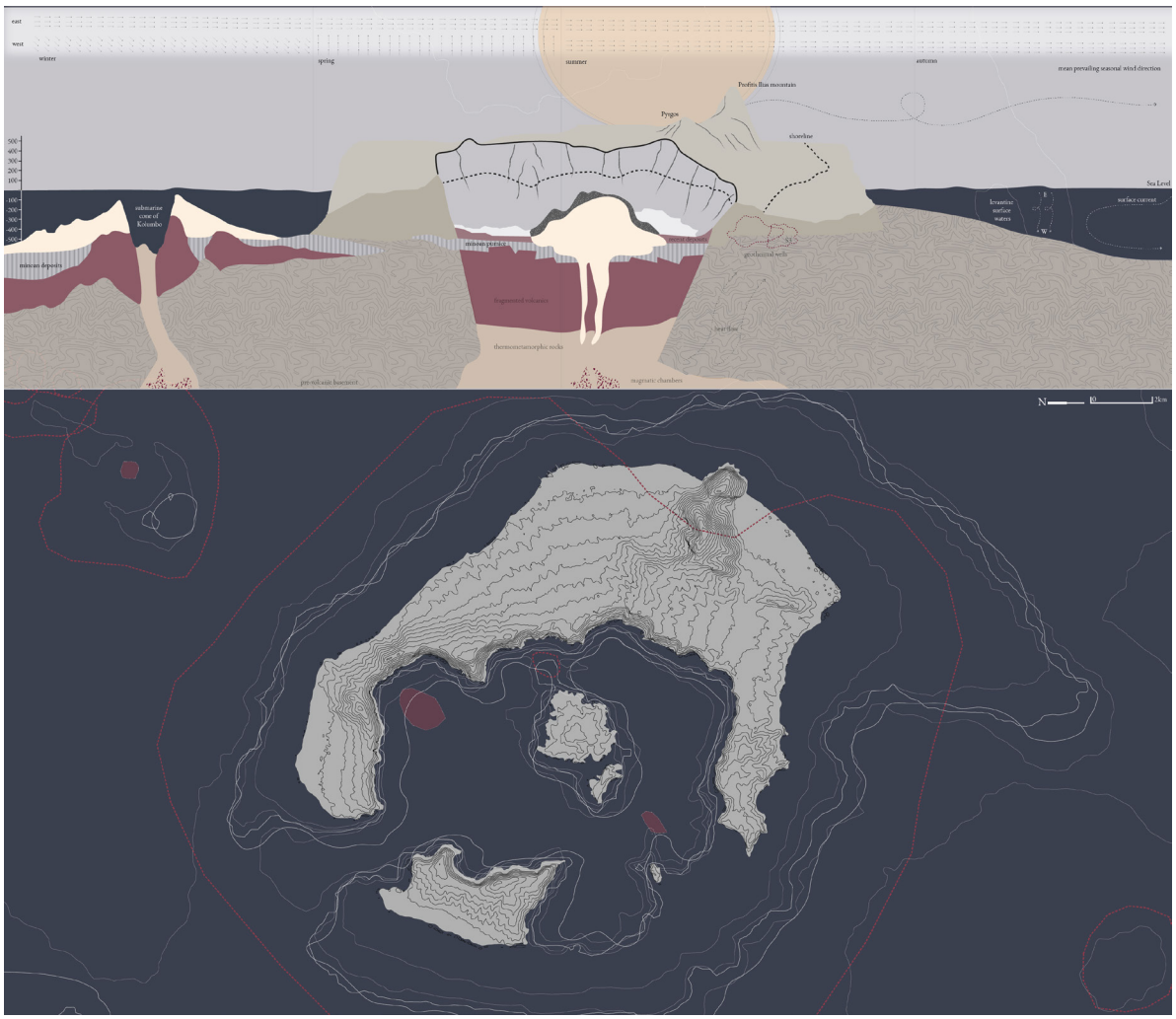

Figure 153. Investigation: City / More-than-Human

Nature is a source of labor, and this idea extends beyond human work. As Moore (2015) explains, labor "does not develop on the basis of specific relations of labor alone but through the co-production of nature with human work" (Moore, 2015). Heat, for example, is a form of energy, and geothermal energy—"literally the heat contained within the earth—drives geological phenomena on a planetary scale" (Mihalakakou et al., 2002). In geothermally favorable regions, like South Aegean, volcanic activity plays a key role in shaping the landscape and is appropriated to sustain human functions (Mihalakakou et al., 2002).

Capacities shaped by non-human agents, such as earth's systems, are powered by natural forces like volcanoes, wind, and the sun. These processes contribute to energy production, as more-than-human labor that is harnessed and transformed to support human needs. This highlights the role of earth's systems, possibly as subterranean new geographical frontiers.

The concept of the geobiosphere, defined as "the spatial scale from 100 km above to 100 km below the earth's surface", plays a key role in the fluxes of available energy (Brown et al., 2016). Natural systems provide energy that humans harness for their purposes, as Odum (1971) suggests (Odum, 1971). A foundational principle in his work is that energy is the basis of all systems, both ecological and economic. Energy flows, such as geothermal power, are drivers for both human and natural processes. This offers inspiration for thinking about energy metabolism beyond the human realm, recognizing its flow in both the human and more-than-human context. Energy is present in everything around us: in the subterranean, in waves, in volcanic activity, in the sun and the soil. This demonstrates the interconnectedness of human and non-human energy flows.