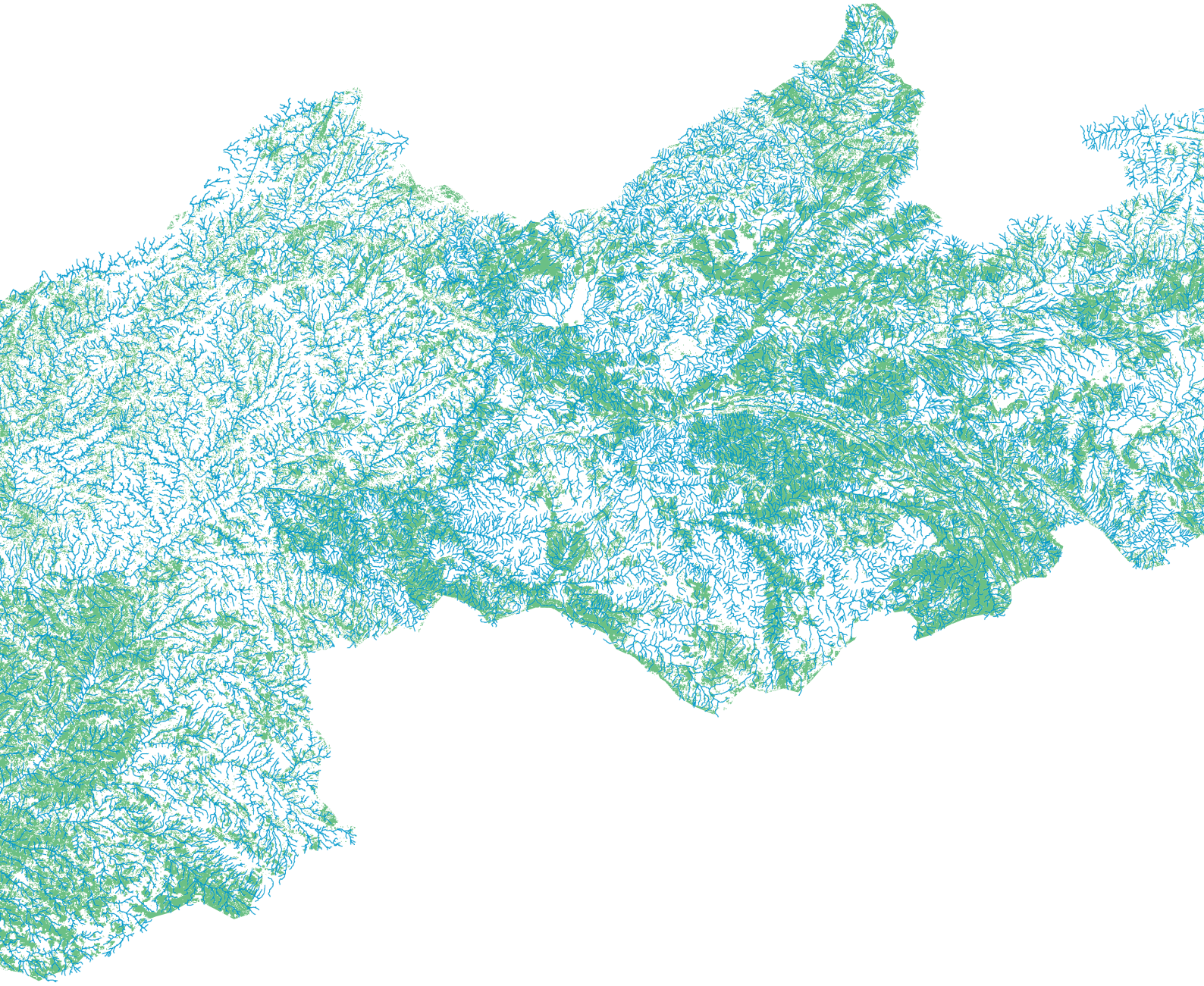

Collaborative Systems

A Water-Landscape Commons Shaped by Community-driven Resource Governance for Drought Resilience in the Tagus Basin

Jean Ong Wueng Kee | 5767628

Collaborative Systems:

An Adaptable Waterscape Commons for the Tagus River Basin

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Universidad Politécnica de Madrid

...For Their Perspectives and Advice.

Abstract

Drought resilience poses a significant challenge for the Mediterranean in today's climate crisis, given its already semi-arid conditions. The Tagus Basin in the Iberian Peninsula is a vital water source for agricultural activities and hydropower. Despite agreements under the Albufeira Convention to share transboundary river outputs between Spain and Portugal, the accelerating impact of global climate change has intensified water source depletion during dry seasons. This strain has pushed communities to overextend resources to meet water demands. In 2022, Spain declared it would no longer fully honor its responsibilities, prioritizing its citizens' needs due to severe water scarcity.

From local community scales, to regional and territorial scales, there was a lack of understanding and collaboration between the systems of the environment, society and governance. This has led to an exacerbation of these socio-ecological issues, leaving many communities in the agricultural industry struggling to make ends meet.

This thesis explores the concept of water-landscape commons as a collaborative medium for the environment, communities, and governance, a junction where these three intersect. The design of the commons will be represented, similarly, in three layers: systems of the environment, systems of society and systems of governance. The environmental systems will define the spatial boundaries and elements of the commons, while societal systems will explore community roles in maintaining and benefiting from the commons. Finally, governance systems will outline the responsibilities of different administrative layers and the processes essential for supporting the commons' maintenance.

Introduction

Problems from the global scale

Climate change and its impacts has been a pertinent problem of this contemporary age. It poses not only a challenge to society but also imperils all life engaged in today's socio-ecological dynamics. This is only one situation among a complex network of causes and effects that is largely owed to human activities. Moreover, this network can only become more convoluted with the passage of time.

Problems on the regional scale

These days, the Mediterranean, a semi-arid region of territories surrounding the Mediterranean Sea, is experiencing some of the most severe impacts of climate change. The drastic temperature rise and relatively deficient precipitation caused many areas including the Iberian Peninsula – Spain and Portugal – to experience severe droughts in the recent decade (Essa et al., 2023). However, the drought situation is more complex than simply an environmental problem. It is imperative to understand the many variables – environmental, social and political – that are entangled in this conflict.

Complex systems of society and governance were enacted to tame the unpredictable systems of the environment. Among these include the governance of water systems to manage droughts. Transboundary rivers within this context would encapsulate, on a regional scale, the difficulties of mitigating drought issues that demand collaborative efforts. With Spain declaring that it would not honour its full responsibilities in the Albufeira Convention anymore (Morris et al, 2023), both territories are left with uncertainties and a dire need to balance society's different needs.

Problems on the river basin scale

On the river basin scale, the rivers across the Iberian face different correlated problems that influence the droughts in varying degrees. The Tagus River is a highly documented example.

Despite the Tagus River being the largest in the Iberian Peninsula, spanning across Spain and Portugal, the basin struggles to maintain groundwater levels, contributing to the annual drought problems. The low aquifer recharge and groundwater levels that led to the severe droughts were largely resultant of environmental degradation and exacerbated by social issues within both territories. This situation is often reinforced by community and authority actions and reactions, consequently leading to low outputs from agriculture.

As the landscape is the medium in which the systems of the environment, society and governance interact, the responsibility of landscape architecture is inherently bound to them. This relationship is often understood as socio-ecological relationships, wherein societies rely on the resources and outputs of landscapes for sustenance and human well-being. On this river basin scale, agricultural practices and the requisite demand for water resources exert an impact on natural land and water sources. The intensification and specialisation of agriculture throughout history, despite being crucial to human society, has caused much pollution to the water, land and atmosphere. Consequently, agriculture has also become a victim to the pollution and the climate change it has partly caused (Kanianska, 2016).

The role of landscape architecture in this crisis can help alleviate the conflicts between the environment, society and governance, whereby the development of a landscape commons can help bring together these aspects as a collaboration rather than a cluster of conflicts. Furthermore, since landscape is the medium in which the environment, society and governance interact, it is thus the responsibility of the landscape architect to design for the balance between these layers.

Methodology

The world's awareness of landscape architecture and landscape urbanism began to grow during the peak of the industrial revolution, a period iconic for its urban centres, rife with industries that released pollutants into the water, soil and air. Heightened social awareness of the detrimental impacts of pollution resulted in a growing demand for greenspaces in the urban and preservation of nature and natural resources. This relationship between the environment and well-being persists today, now compounded with more consideration for sustainability as modern technology now affords a more profound understanding of the ecological, climatic and societal ramifications of human activities.

Landscape urbanism is a complex system and the dynamic relationship between the environment, society and resource governance. This is the basis for the perspective of landscape urbanism in this paper. In this context, society is characterised by its persistence in culture and survival, while the environment broadly encapsulates natural forces, both passive and impactful.

This dynamic can also be understood in Peter Jacobs' writings regarding his interpretation of landscape, where Jacobs opines that the idea that landscape is neither nature nor culture and yet is the medium for which these take place. Landscapes have always reflected society's perception of the environment which were influenced by its value systems – and what has historically shaped landscapes are culturally our literature and philosophy (Jacobs, 1991). Similarly, the analysis of this research will be explored in the perspective of the landscape as a medium for conflicting systems, and the synthesis will be in the perspective of the landscape as a medium for collaborative resolution.

The role of the landscape architect...

As modern problems become more complex, solutions and interventions have also evolved to become all-encompassing. This thesis explores and considers the many relevant aspects of the drought situation in the Tagus Basin, both spatial and otherwise. While the landscape architect is primarily focused on the spatial elements of a proposal, these spatial elements often serve as the foundation from which community engagement, policies, and governance can derive from. The role of the landscape architect here is to propose spatial solutions with these factors in mind, recognizing that successful plans, community engagement, and governance require the support of all three.

Analysis: the landscape as a medium for conflicting systems

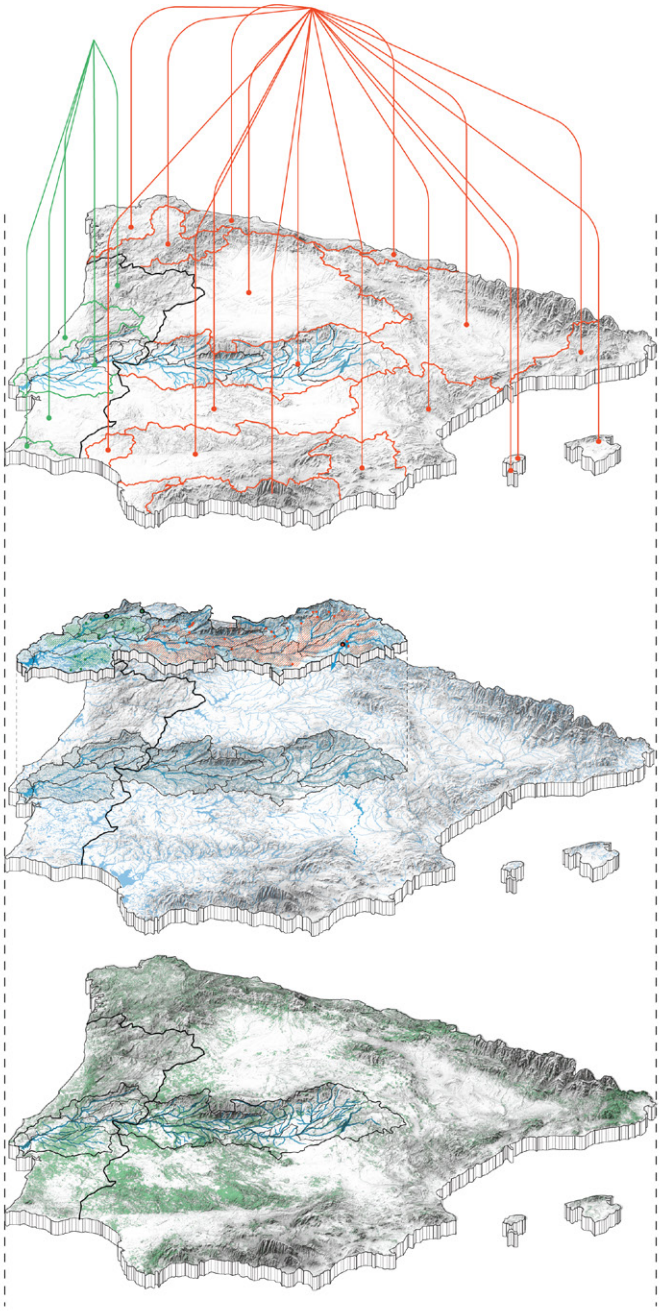
The conflicting systems will be explored in the analysis with their imperative corresponding questions that will help structure and guide the paper. These systems are:

Systems of the Environment:
- What are the changes to the environment in the Iberian Peninsula that contributed to these droughts?

Systems of Society:
- What were the main human activities that contributed to the changes to these environment?
- How did people react to the drought situation?

Systems of Governance:
- How did the authorities react to society's actions?

The analysis and research reveal a lack of collaboration within the societies of the Iberian Peninsula throughout history and a lack of collaboration between society and the environment. This opens up some opportunities for a collaborative system between the environment, society and governance as a synthesis and proposal to the exacerbating droughts in these unpredictable times.

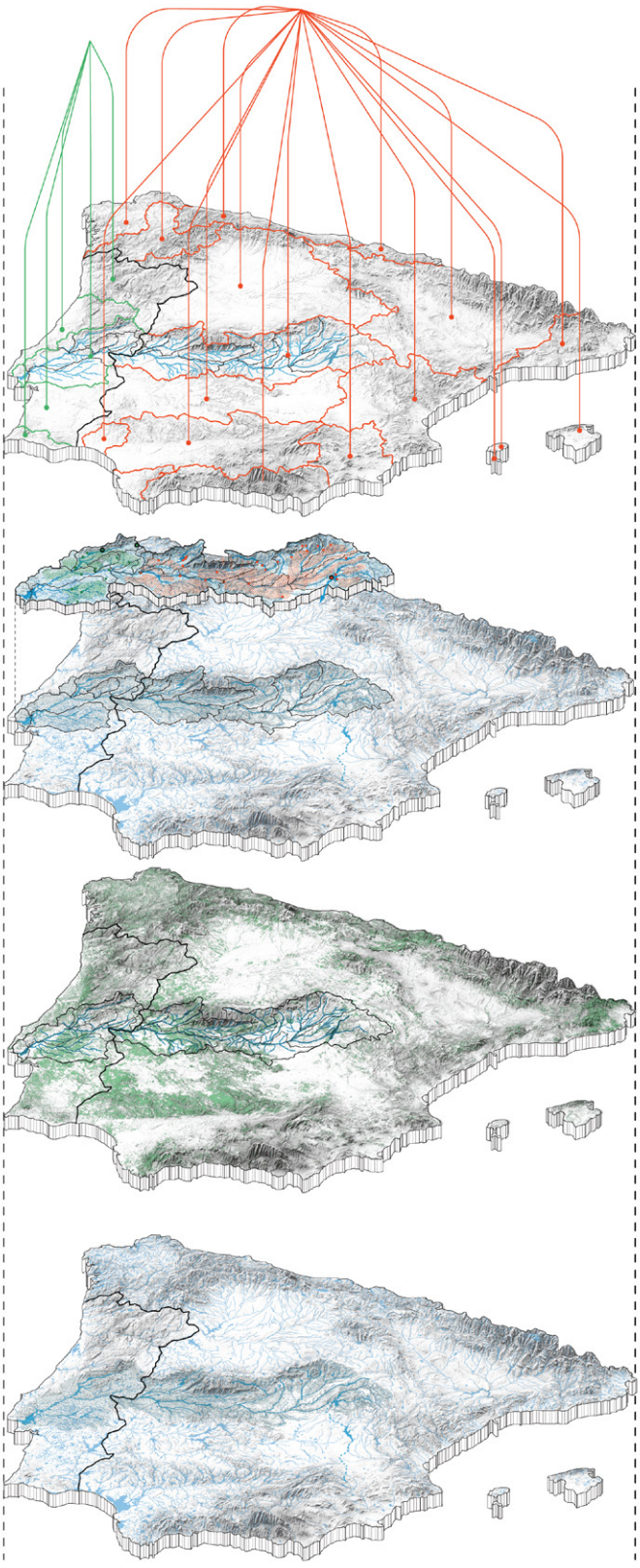


Systems of Governance

Systems of Society

Systems of the Environment

Diagrammatic represntation of the landscape as a medium for conflicting systems



Diagrammatic represntation of a landscape commons as a medium for a layered collaborative system

Design: a landscape commons as a medium for a layered collaborative system

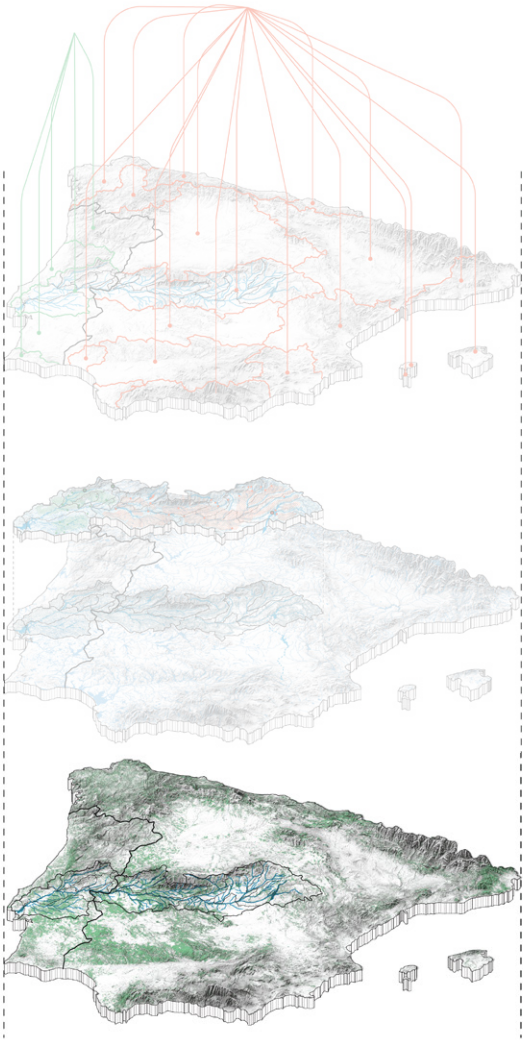
Similar to the analysis, the design of this thesis is a collaborative system will be explored with the same layers:

Systems of the Environment:
- How can the drought situation be alleviated with the management of water-landscape features?
- What are part of the water-landscape commons (and partial commons)?
- What long-term and short-term environmental strategies can be used to achieve the collaborative potential of the water-landscape commons?

Systems of Society:
- What are the rules and boundaries of the commons?
- What are some principles and strategies that the community can use to build the water-landscape commons?
- How can cultural landscapes become part of the commons?

Systems of Governance:
- What are the responsibilities of the different communities and stakeholders in this collaborative system?
- How can progress and conflicts be managed when building the water-landscape commons?
- What long-term and short-term governance strategies can be used to achieve the collaborative potential of the water-landscape commons?

These questions set the main structure for a comprehensive design for the thesis. This will be a theoretical exploration into a layered collaborative system as an adaptable water landscape commons in the Tagus River basin to alleviate the impacts of drought and climate change. These environmental issues are addressed through a multidimensional perspective: the interlinks of social, systemic and environmental problems that are uniquely elaborate. Complex problems demand an adaptable and flexible solution – static schemes that are more of an artifact may fail to be versatile to changes that the world encounters. Hence, the thesis will explore possibilities of designing a system and process that will facilitate collaboration between these layers.



Systems of the Environment

Analysing the Landscape as a Medium for Conflicting Systems

Climate change is an imperative problem faced globally but each region experiences different impacts and often they are exacerbated by a multitude of problems that changed the existing environment, society and governance. In the case of the Iberian Peninsula, the impacts of droughts are the most severe in recent years. The loss of native vegetation and natural habitats to agriculture are major contributors. This can be owed to many demographical shifts in these societies across history, as civilisations persisted until the modern era. Governance have long tried to manage agriculture, water and the landscape but without the collaboration of all these systems, solutions towards a resilient landscape would be difficult to realise.

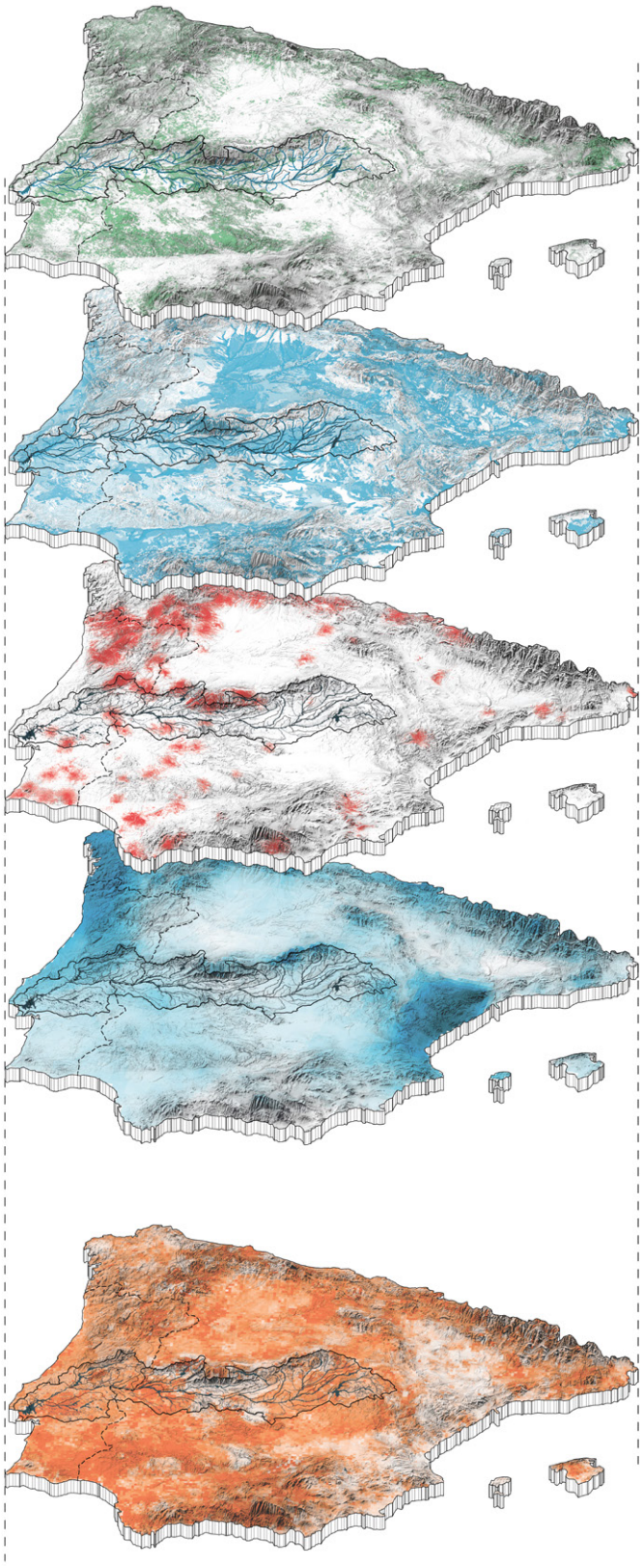
Systems of the Environment

What are the changes to the environment in the Iberian Peninsula that contributed to these droughts?

The dilemmas surrounding the drought situation can be observed most prominently in some areas such as the regions around the Community of Madrid, Spain. Many areas experience low to moderate rainfall, but despite relatively permeable soil, these areas face the brunt of the droughts within the Tagus Basin in 2022 (Copernicus, 2022).

However, this combination of issues that led to such severe droughts doesn't happen across the basin and the correlation between physical conditions are not always linear and consistent. This is likely due to the interference of external forces, such as social activity or implementation of new policies.

The regional agglomerative clustering grouped municipalities with similar values with the consideration of their spatial weights. This can help simplify a complex problem for a better understanding and drafting of proposals as well in the later part of this paper.



Layers of the environmental conditions that contributed to the droughts of 2022 (Copernicus, 2022)

This Exploratory Data Analysis (EDA) is focused on the GIS open data of the Iberian Peninsula in 2022, a year before Spain announced that it would no longer completely honour its end of the Albufeira Conventions. These datasets were obtained from Copernicus of the European Union Space Program for comparable and standardised data from the same source. Furthermore, as of the start of this analysis, data collection and processing for 2023 had not yet been complete.

This EDA takes into account 5 main factors environmental 'variables' that believed to largely contribute to the impact of droughts throughout the region. The variables are as follows:

Broadleaved and semi-deciduous forests:
Forests, based on 2022 data, around water sources can help reduce evaporation and maintain moisture of an area.

Soil permeability:
This estimated subsoil water content level is calculated based on soil permeability data. The higher the estimated water content, the higher the soil permeability.

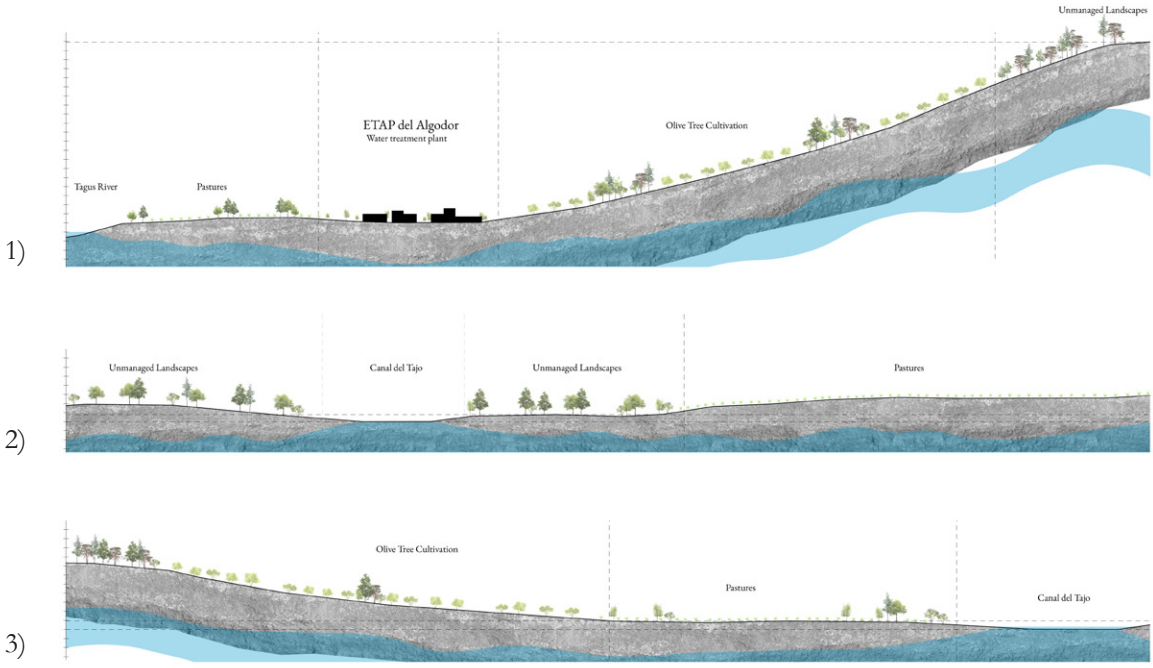
Burned areas:
Satellite estimation of areas where fires occurred in 2022 (typically from slash-and-burn agricultural practices).

Average Annual precipitation:
Calculated average based on precipitation across several 36 days in the year 2022.

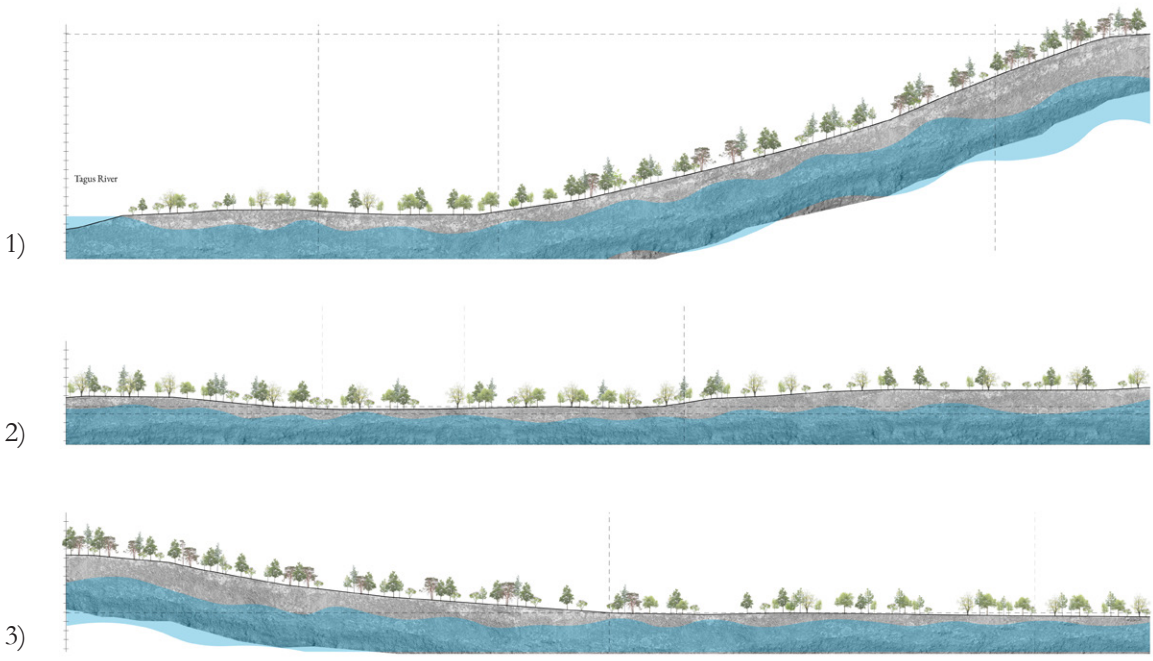
Combined Drought Indicators:
Drought intensity experienced across the peninsula in 2022.

(Copernicus, 2022)

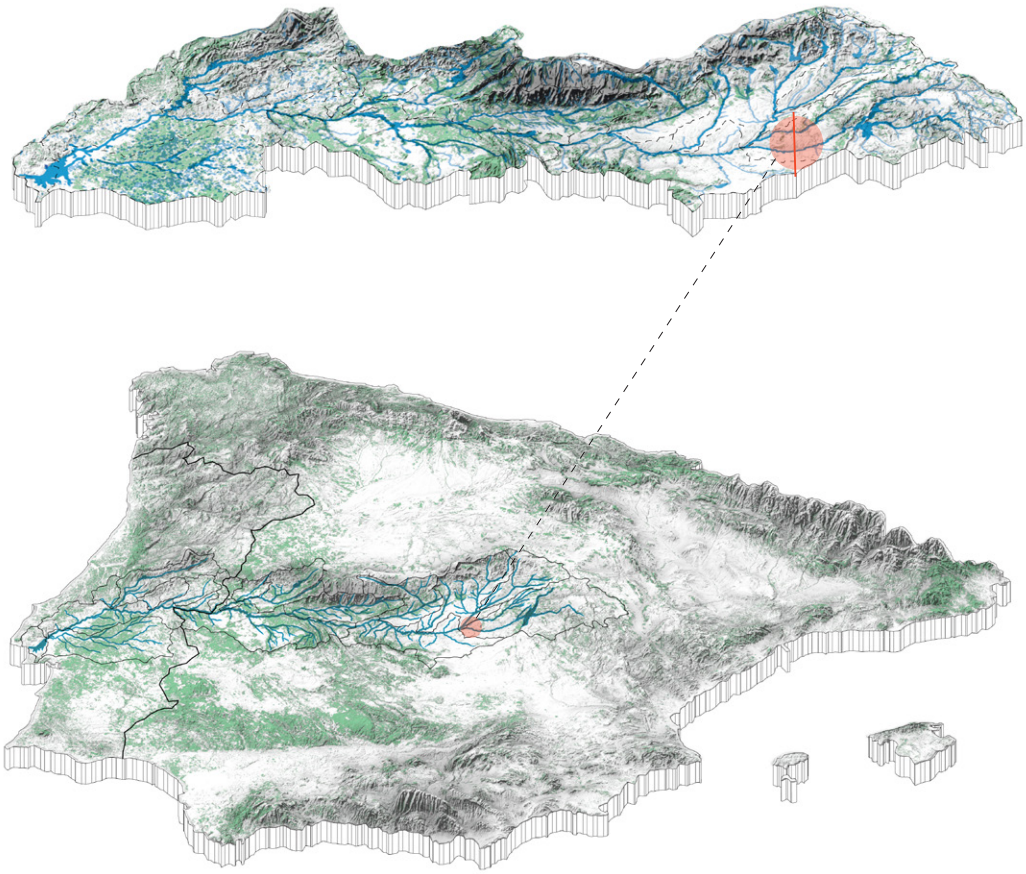
These physical conditions were not always that of the Iberian Peninsula. Historically, water systems were less complex and mechanical, and the naturally occurring vegetation were more diverse. The water and landscape have vastly changed since then, depicted in these sections across some areas near Madrid – where some of the most intense droughts are experienced today.



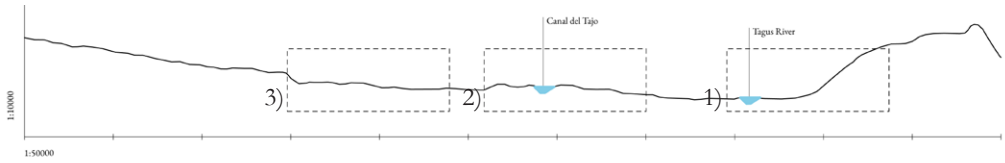
Sections of the modern-day vegetation and landscapes (Copernicus, 2022)



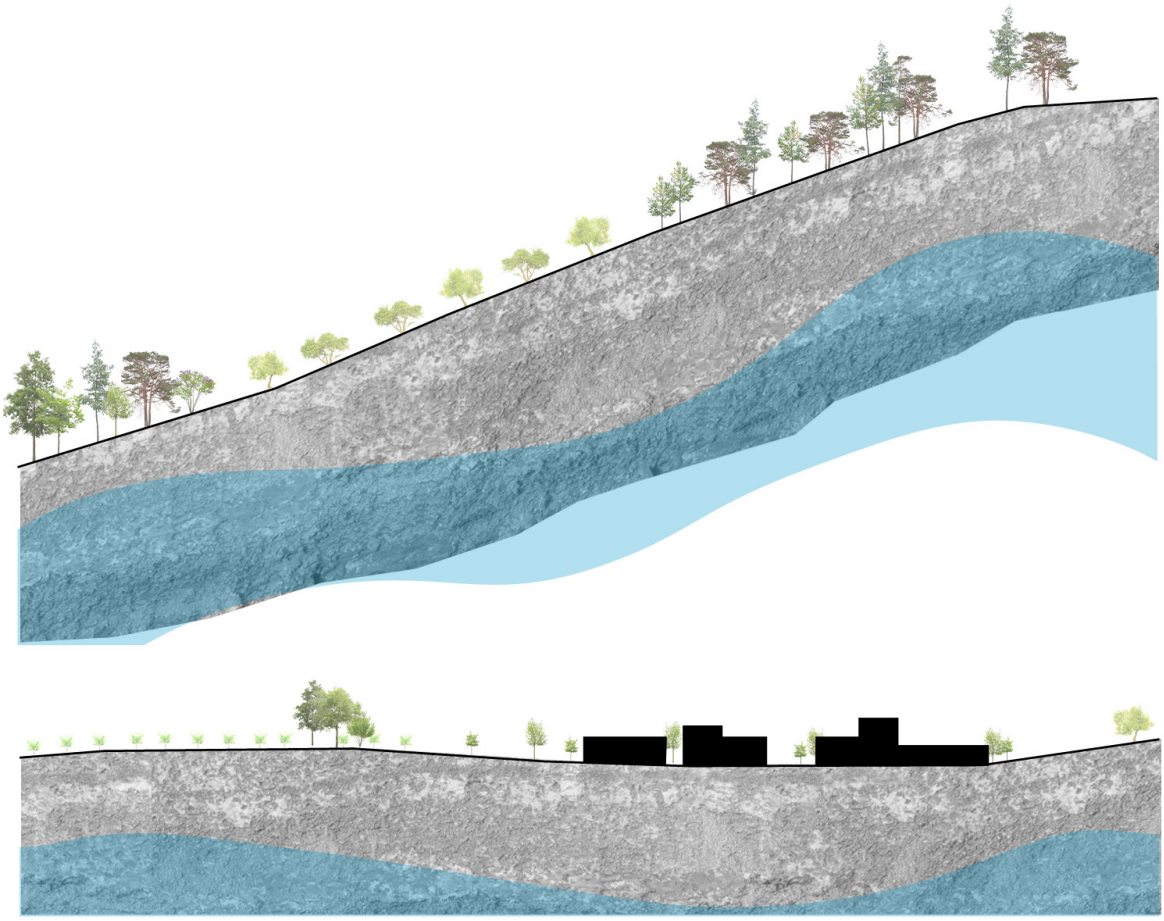
Sections of Potential Natural Vegetation landscapes (Sainz Ollero et al., 2010)



(Copernicus, 2022)



The Potential Natural Vegetation of the landscape is a hypothetical study of possible naturally occurring species that could have persisted across the Iberian today if not human activity, such as the intensive cultivation in agriculture and construction of the urban areas. Arguably, these activities led to a loss of native species and regions of natural habitats as depicted in this comparison, making many parts of the landscape less biodiverse than what it could have potentially been. Many areas now are also abandoned cultivated land that face a lack of vegetation regeneration, forming clusters of barren land and less permeable soil (Sainz Ollero et al., 2010).



Vegetation composition of today (Copernicus, 2022)

Quercus ilex

Quercus pyrenaica

Flueggea tinctoria

Pinus pinaster

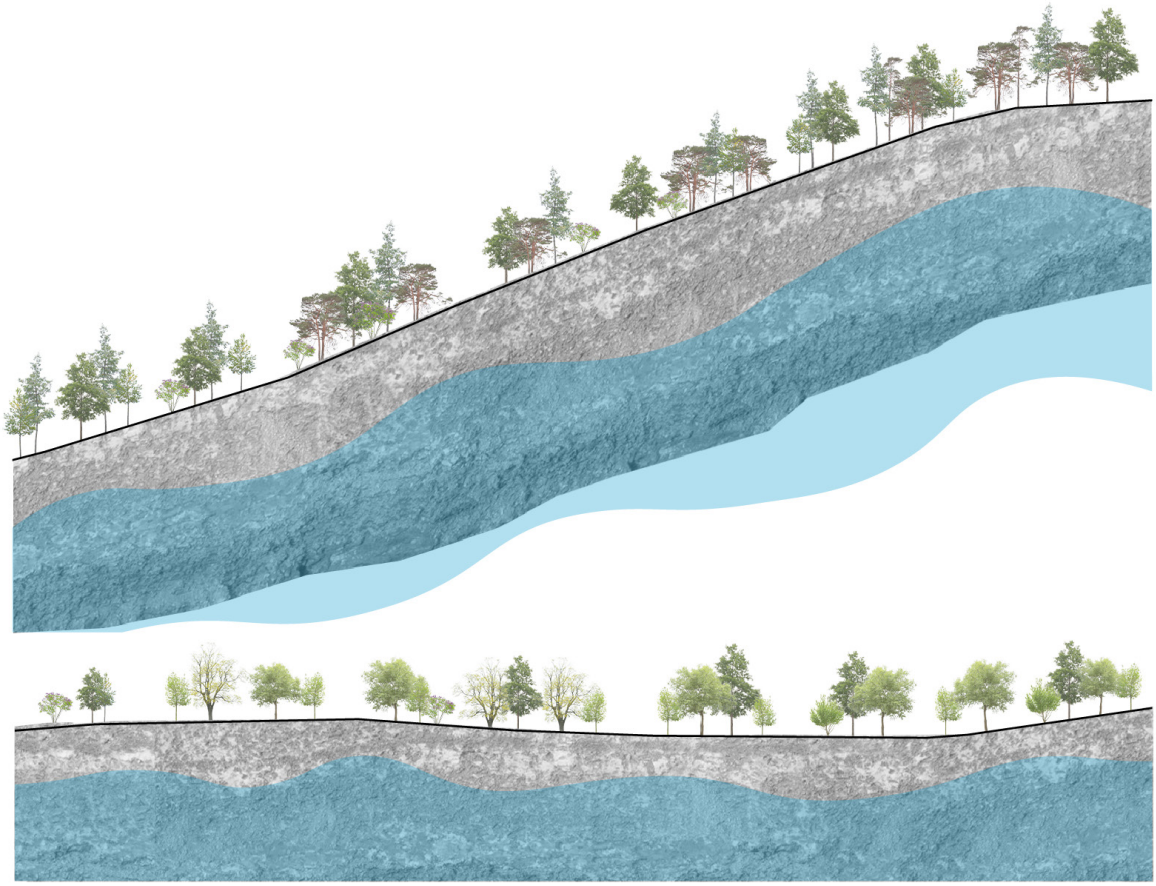
Fraxinus ornus

Pinus sylvestris

Hordeum vulgare sp. (Barley)

Triticum sp. (Wheat)

Olea europaea (Olives)



Vegetation composition according to Potential Natural Vegetation study (Sainz Ollero et al., 2010)

Quercus ilex

Quercus pyrenaica

Quercus faginea subsp. broteroi

Abies pinsapo

Flueggea tinctoria

Pinus pinaster

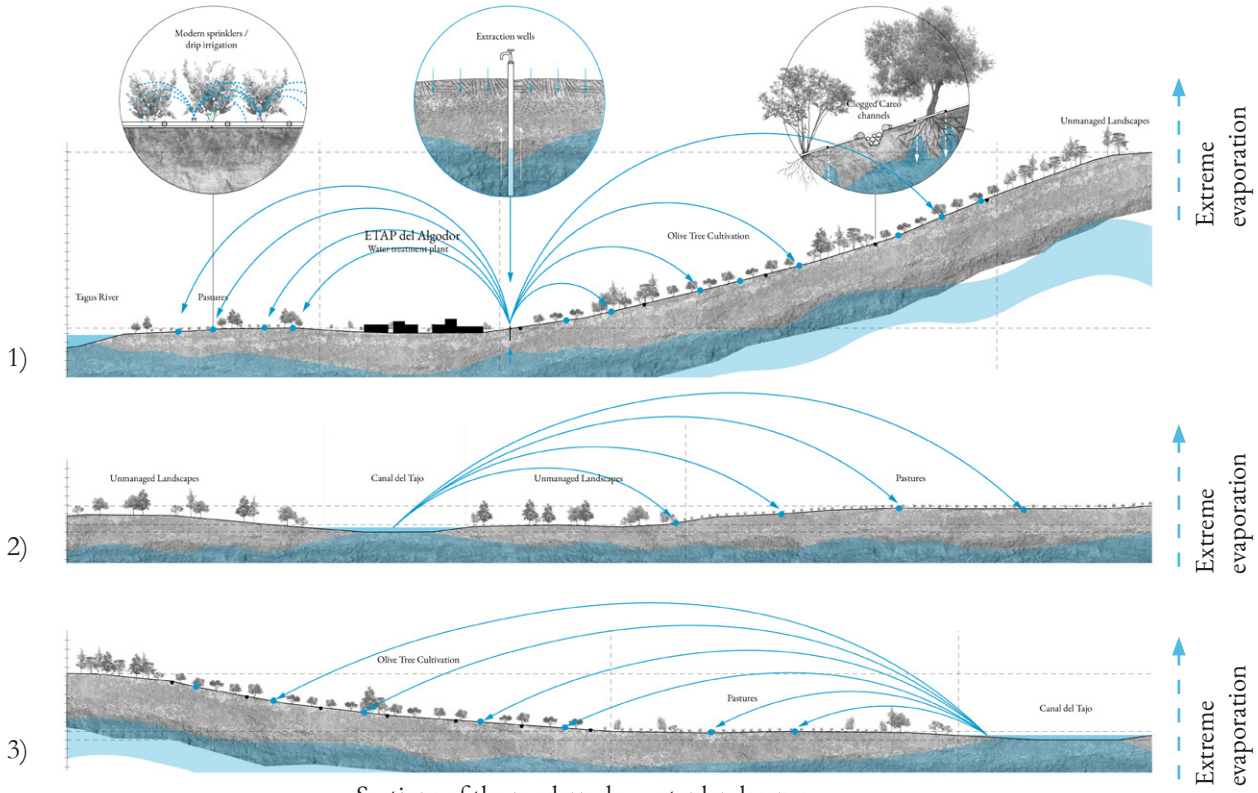
Fraxinus ornus

Quercus suber

Salix pedicellata

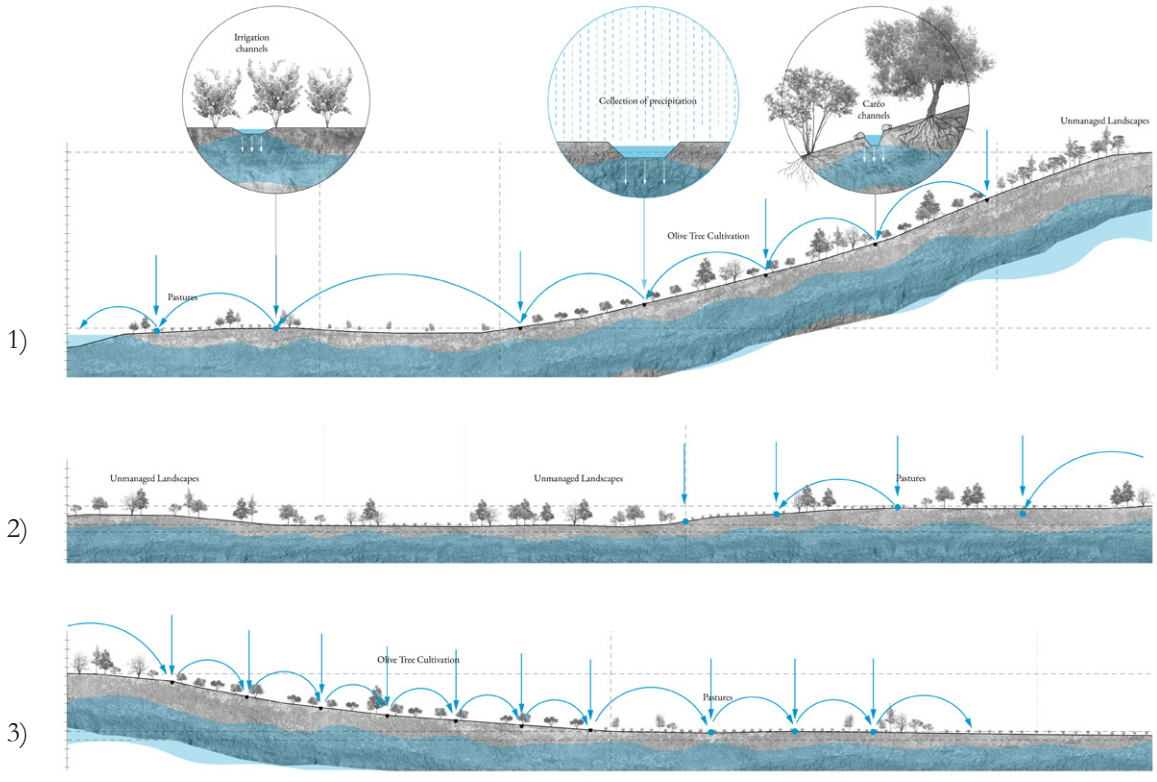
Cistus ladanifer

Nerium oleander

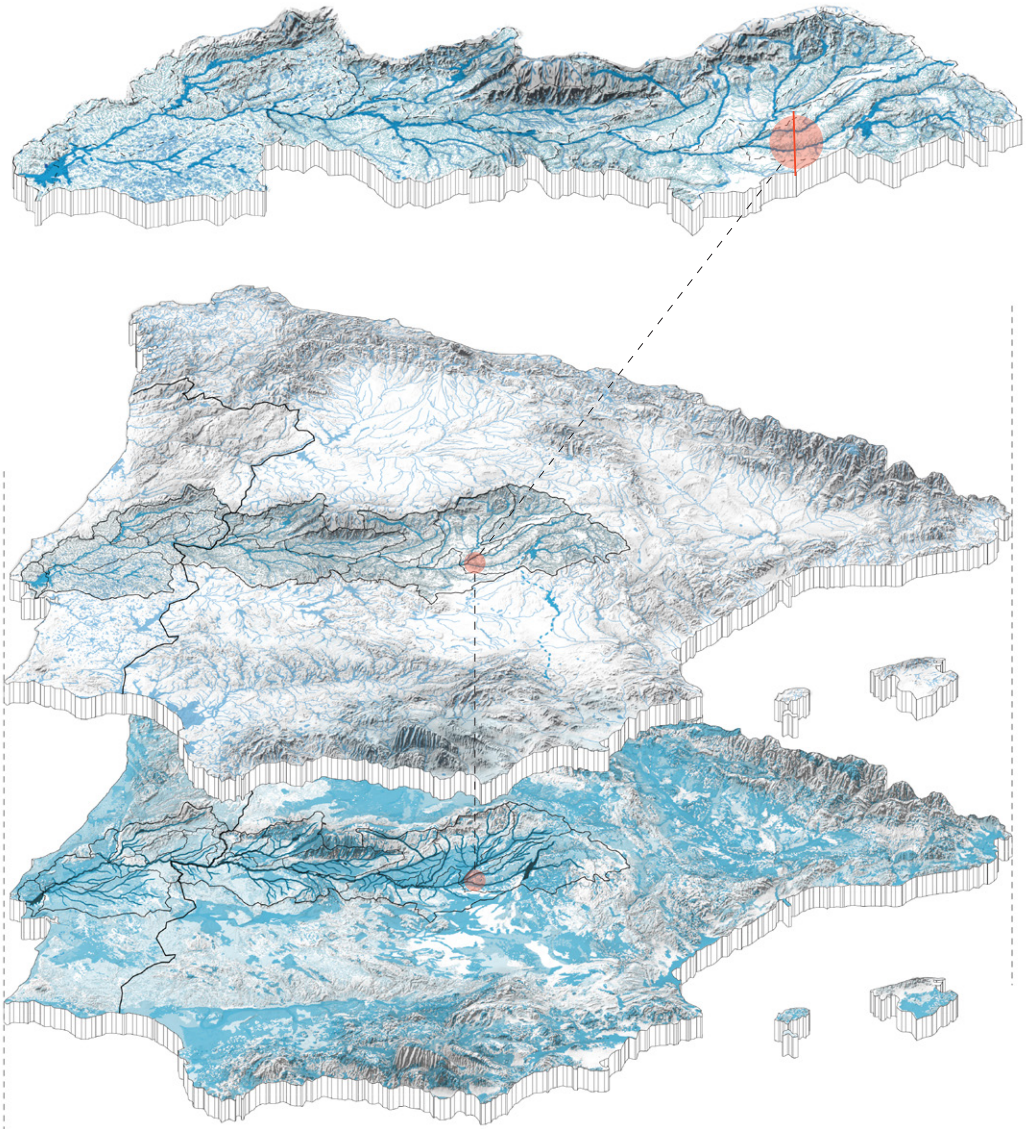


Sections of the modern-day water landscapes

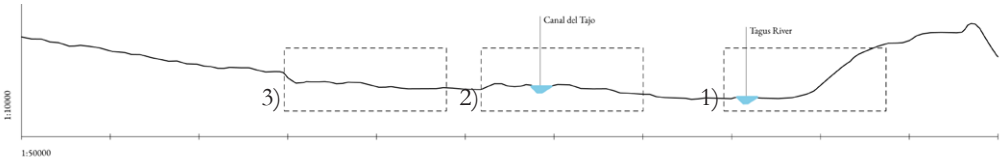
The growth of agriculture throughout history has devastated the area. While today's irrigation methods are moving away from surface irrigation to more efficient mechanised ways, the overextraction of groundwater still remains a pertinent issue in Spain and Portugal's agriculture industry. About 68% of groundwater extractions were for agriculture (European Commission, 2022). However, with overextraction and today's global warming



Sections of water landscapes during the Moorish era (Jódar et al., 2022)



(Copernicus, 2022)



threats, these areas throughout the Iberian are becoming increasingly vulnerable to droughts and even desertification – an impending issue that was not faced by the water landscapes of the Moorish era.

The acequia de careo (careo channels) were used by the Moors to irrigate crops in the past. This is a traditional irrigation system that takes advantage of the high terrains of some regions in the Iberian to transport precipitation from higher elevation to lower terrain. These channels help improve permeability for aquifer recharge (Jódar et al., 2022). However, this type of surface irrigation can be inefficient due to the extreme evaporation from global warming.

The Iberian sclerophyllous and semi-deciduous forests in Portugal.

Image source: Pedro Miguel F.A Patrício, 2012. Acessed via https://commons.wikimedia.org/wiki/File:Ribeira_da_Safareja_em_Agosto.JPG

Conifer forests.

Image source: Jorge Cancela - Cazorla, 2014. Acessed

File:Cazorla_(14091642828).jpg

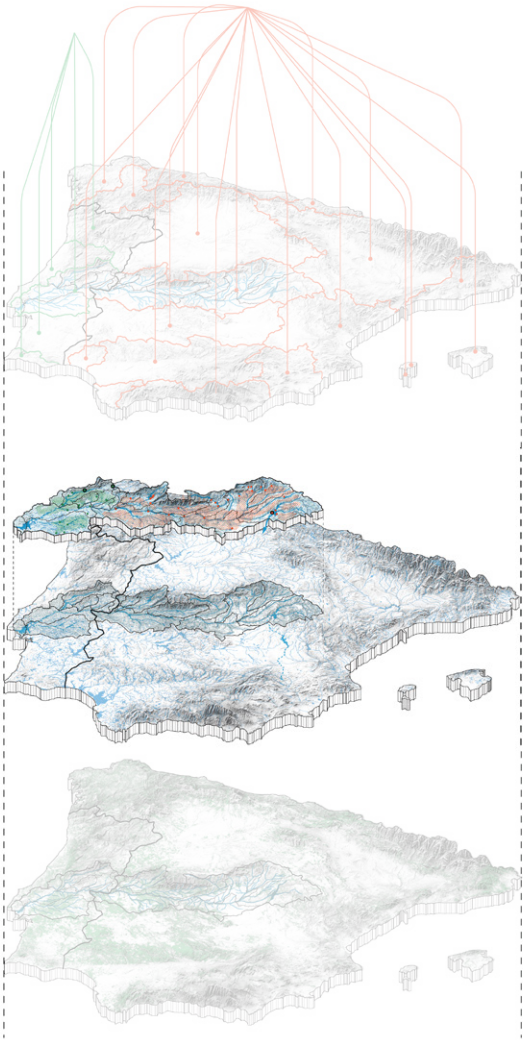
The Iberian broadleaved and semi-deciduous forests: they are widely common landscape types in the peninsula. They can be found in the valleys of many rivers across both Spain and Portugal.

Conifer forests: these are mostly found in higher terrain in Central and Southern Spain. These are areas that can reach freezing temperatures during winter months.

Semi-arid landscapes during spring around Central Spain.

via https://commons.wikimedia.org/wiki/

Semi-arid shrublands: these landscapes are very commonly found across the peninsula. The vegetation in these habitats grow well in dry seasons but recent extreme conditions have made them vulnerable to desertification.



Systems of
Society

Systems of Society

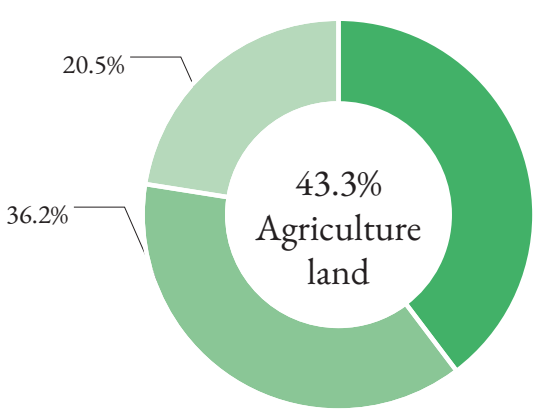
What were the main human activities that contributed to the changes to these environment?

These changes observed in throughout history in the systems of the environment were heavily interlinked with the changes undergone by Iberian societies. Vast cultural changes had led to vast changes in the way people interacted with their environment. As the Iberian experienced waves of demographical change all throughout history, shifts in agricultural traditions and water system infrastructures were also observed.

Germanic civilisations occupied the Iberian Peninsula in the early 5th century – first the Suebi and Vandals, then the Visigoth invaders. They cultivated a diverse variety of cereal grains such as wheats, barley, pea and several types of legumes. The Germanic water system was an infrastructural marvel for its time (Roman Aqueducts, 2023). Their first aqueducts dated back to the 3rd century and some parts of these structures still stand today, preserved or expanded upon. When the Moors, largely Islamic invaders from northern Africa, invaded the Iberian Peninsula, they brought with them different agricultural customs and irrigation techniques (Gethin & Gethin, 2019).

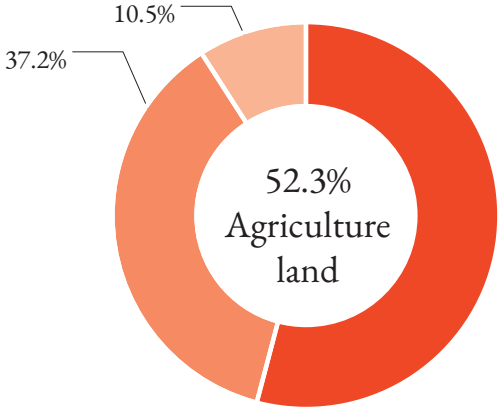
The Moors introduced olives and dates, tree crops that are today still widely grown across the Mediterranean (Fairchild Ruggles, 2008). Their irrigation and water management systems, unlike the highly-engineered structures of the Visigoths, utilised the elements of their environment to transport water. However, another wave of change followed after as Christian powers extended across peninsula in the following few centuries. It was around the 13th century when Iberian societies began to move away from Islamic influences (Restall & Lane, 2011). As these centuries of conquest gradually passed, so did these agricultural and water management customs of the past.

Although there are many disputes over the origins of modern Iberia and the complexities of historical events, this summarises the large demographical changes that occurred throughout the history of the Iberian Peninsula. Today, modern technology and capitalism has afforded the agriculture industry to expand to most corners of Portugal and Spain. As of 2018, 43.25% of Portugal's land and 52.48% of Spain's land were designated for agriculture (World Bank, 2021). These lands



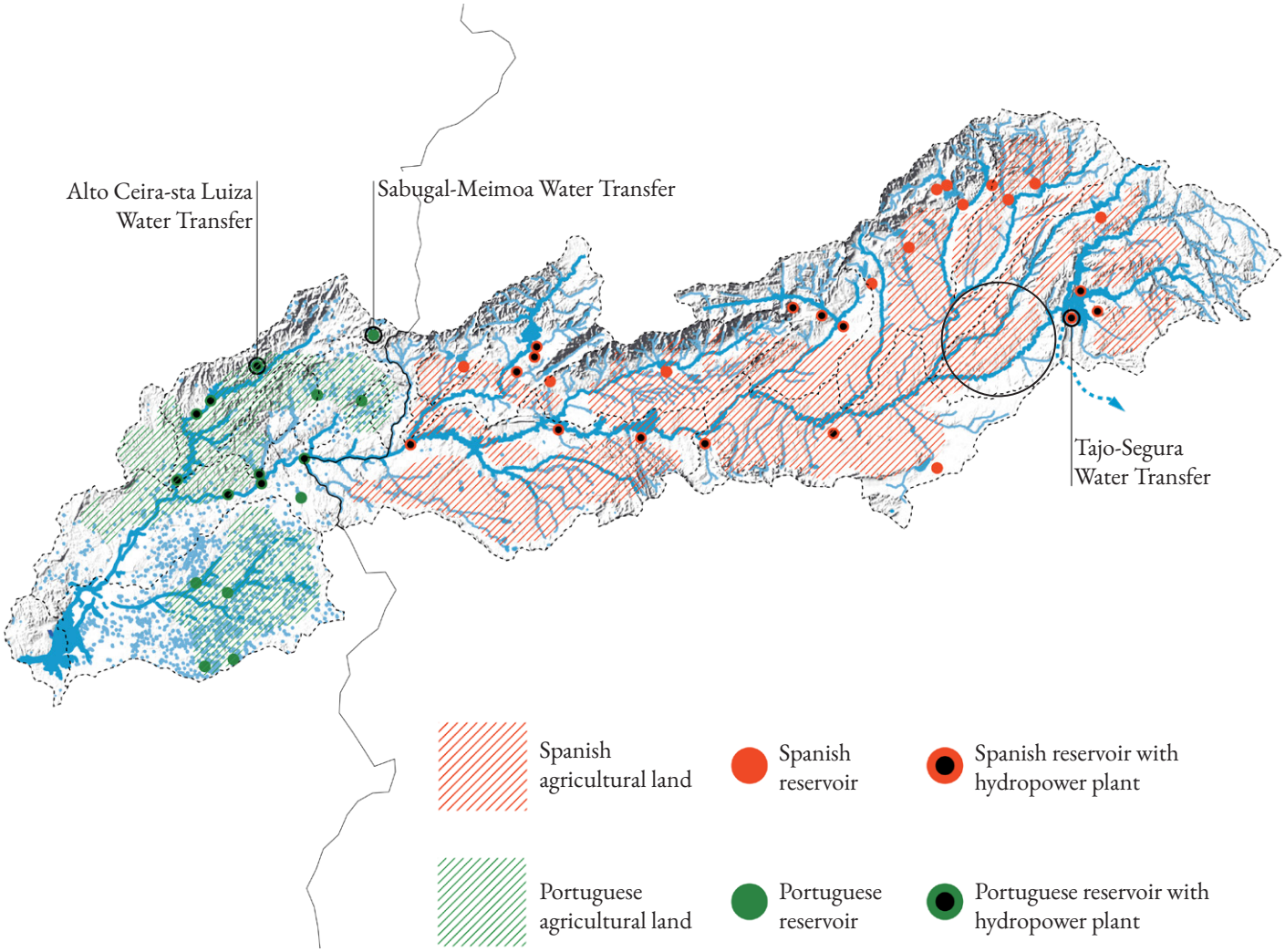
Land use of Portugal
(World Bank Open Data, 2021)

- Agriculture
- Forests
- Others



Land use of Spain
(World Bank Open Data, 2021)

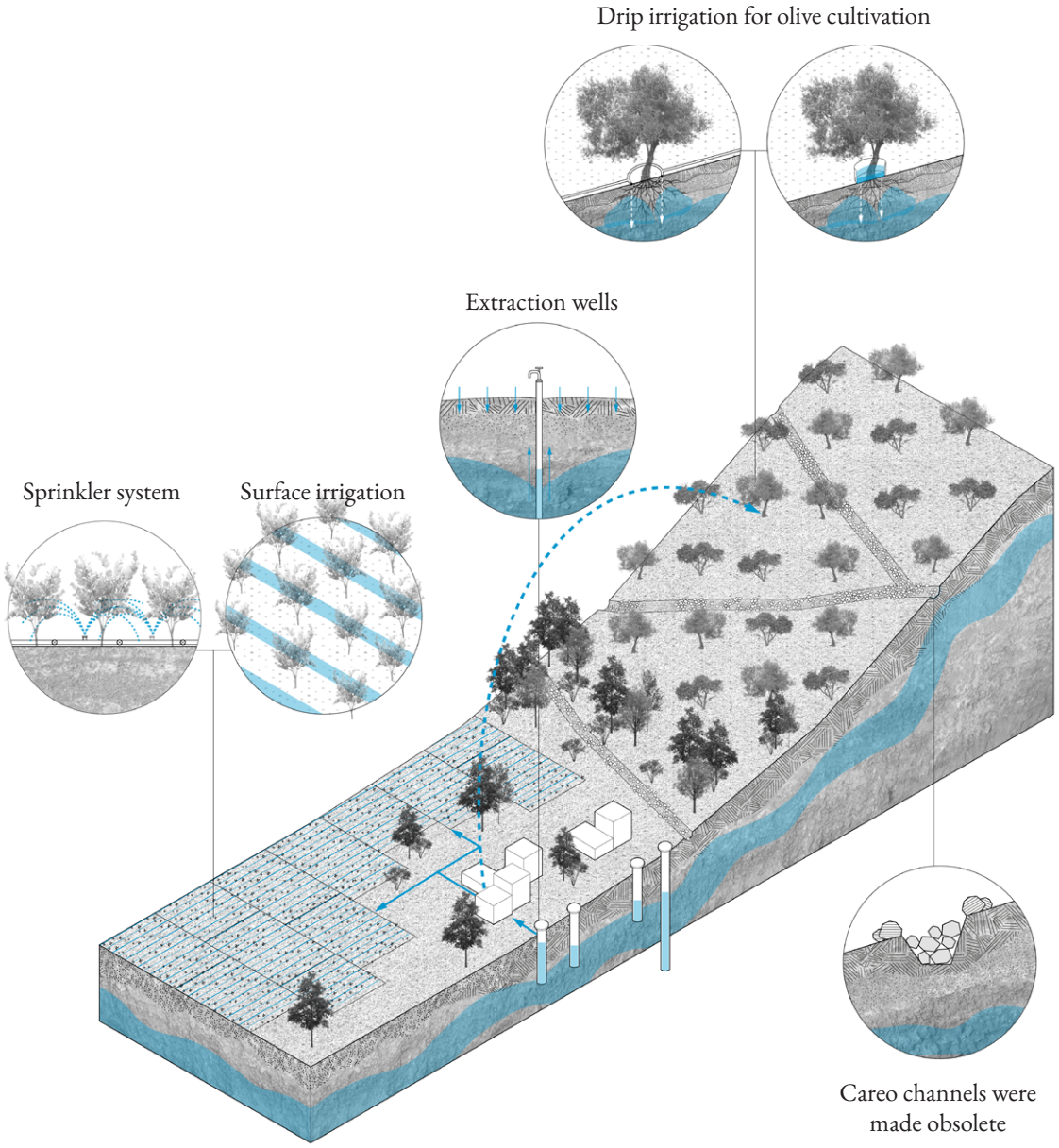
- Agriculture
- Forests
- Others

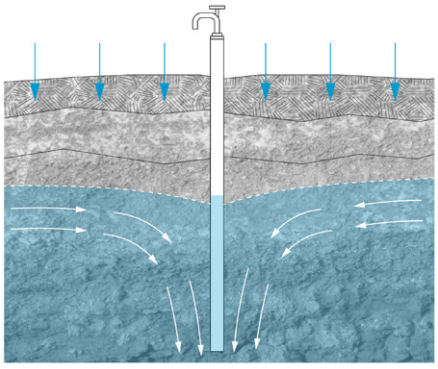


crowded along the course of the many rivers – like the Tagus River – in the peninsula for ease of irrigation. Human society's exploits over the river today are not exclusively agriculture-related. With the advent of modern technology, hydropower plants and water transfer aqueducts were constructed to utilise moving water for energy and to transport water to supply drier regions.

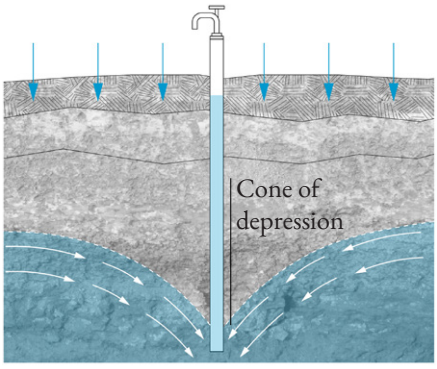
Naturally, the water transfers became very polemic in the region as it reduced the water supply that many municipalities within the basin relied on. Additionally, overextraction of groundwater across the peninsula grew into a massive problem as the state of the climate crisis worsens and water is drying up during warmer seasons at an alarming rate.

Droughts also hit the regions that lack forest covers the most and areas where there is a lot of barren / abandoned land.





Regular water extraction from extraction wells



Illegal / over-extraction from aquifers

How did people react to the drought situation?

Most sources in Spain and Portugal for irrigation are often large water bodies and groundwater. However, when climate change began drying up water faster, crops now require more water from the extreme heat and farmers had to extract more water from aquifers through extraction wells, and some even resort to building their own unregulated wells (Reuters, 2023a). Although, most reports find that these occur most prominently in the south of the Iberian, such activities still plague the Tagus Basin. This unfortunately exacerbates the impacts of the heat waves and are experienced today as the intense droughts that have been recently making headlines in global news.

Following the complexities of climate change, both Spain and Portugal are shifting to a variety of means to irrigate crops. Irrigated land is slowly decreasing as water restrictions tighten and the droughts become more severe, and farmers are turning to more water-conserving modes of watering crops (Ministerio de Agricultura, Pesca y Alimentacion, 2023). Many olive trees farms are now installed with drip irrigation or localised irrigation and the countries are now setting milestones to have more irrigated land to adapt these types of systems (Ministerie van Landbouw, 2019). This trajectory can help reduce groundwater extraction. However, such systems are not simple to employ. They require some capital to first adopt and install.

Surface irrigation, such as flooding and use of inundations to transport water to crops, are arguably one of the most water-inefficient methods, albeit the most affordable (Ministerie van Landbouw, 2019). They are vulnerable to the extreme evaporation experienced by the Mediterranean and additionally erode the soil and nutrients away from the crops. Often, more water is used than needed to ensure that all crops are able to attain the sustenance they need. Smaller farms may face difficulty in transitioning from such lower cost methods (U.S. Department of Agriculture, 2022) to mechanised systems that require more capital and maintenance. As such, some areas still rely on surface irrigation. In addition to that, local farmers are often conservative and protective of their agricultural traditions. They are often families that have owned these agricultural plots for generations and hope to preserve their way of life while making a living. Hence, introducing new methods and concepts – even for their benefit in a long run – may prove to be difficult.

Traditional inundations and channels – such as the acequias de careo – despite its inefficiency, can loosen up the soil, making it more permeable and increasing the rate of aquifer recharge (Jódar et al., 2022). Despite these channels being relics of an era long gone, some farmers and environmentalists are trying to bring back these traditions in an effort to use precipitation to help recharge aquifers on higher elevations (Walker, 2022). However, a possible difficulty that they may face is the high evaporation rates during dry seasons.

Around 711-720AD, the Moors overcame the Visigoths that preceded the Iberian Peninsula. They brought with them an enduring tradition of agriculture and culinary practices that collaborated with the landscapes to provide food with relative sustainability (Gethin & Gethin, 2019).

Cultivation olives and other tree crops

In medieval Islamic horticulture, Ibn Bassal and Abū l-Khayr al-Ishbīlī provided comprehensive explanations on propagating and nurturing cultivated trees and palms. Some of these crops, such as olives and dates, are also farmed today.

Origins of traditional Iberian irrigation methods

"Sowing water" is the modern-day dub for the Moorish innovative irrigation strategy that was widely used across the peninsula. Precipitation was diverted from headwaters to mountainsides by Careo channels to crops in lower lands. These porous channels help water to infiltrate the ground, subsequently recharging aquifers. This method of irrigation was beneficial to the landscape during this time without the rising global temperatures we have today.

Beginnings of regional animal husbandry

The rearing of certain animals, such as sheep were believed to have increased during the Islamic period in Southern Portugal. Archaeologists inferred that this increase was owed to the improvement of animal husbandry techniques as well as Islamic preferences for mutton.

(Fairchild Ruggles, 2008)

Over the next few centuries, as other powers from the north and west of the peninsula gradually swept the Iberian through conquests, some ways of their cultivation and irrigation systems were lost to time. However, with the advent of the groundwater problems in the Iberian Peninsula, some farms in Spain are bringing back traditions – such as the careo channel systems – to improve the aquifer recharge. This type of surface irrigation may help with the groundwater situation but with the current extreme evaporation that is consequential of today's climate crisis, it may not be an efficient use of precipitation as a source.

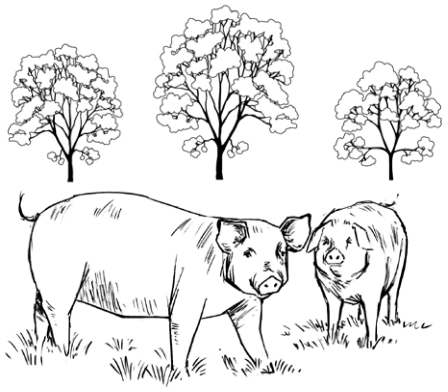
Medieval Islamic aboriculture: writings and details on how to cultivate dates and olives.

Image source: Dioscorides - Kitab al-hasha'ish, Topkapi Sarayi Museum, Istanbul, A 2147.

Acessed via https://commons.wikimedia.org/wiki/File:Arboriculture_Mediaeval_Islam.jpg

Illustrated scene of agricultural work from a mediaeval Arabic manuscript from al-Andalus.

Image source: Muslim Heritage, c. 1200. Acessed via https://muslimheritage.com/article/agriculture-muslim-civilisation-green-revolution-pre-modern-times



Monospecific Agriculture

- Maximising yield by intensively farming one type of crop, such as Olives, Iberian pigs, wheat, barley, etc.
- Use of greenhouses in Murcia is prevalent and has overtaken the Southern Mediterranean landscapes of Spain

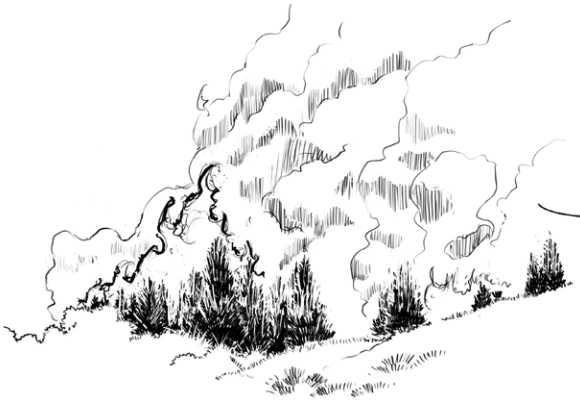
Slash-and-Burn

- Burning grasses and bushes to renew pastureland
- Clears space for agricultural fields (swidden)
- Ashes can provide a nutrient-rich layer to make the soil more fertile
- Temporarily eliminate pests and weeds
- Abandonment of land once land productivity decreases
- Move on to a new area to repeat the process

Irrigation

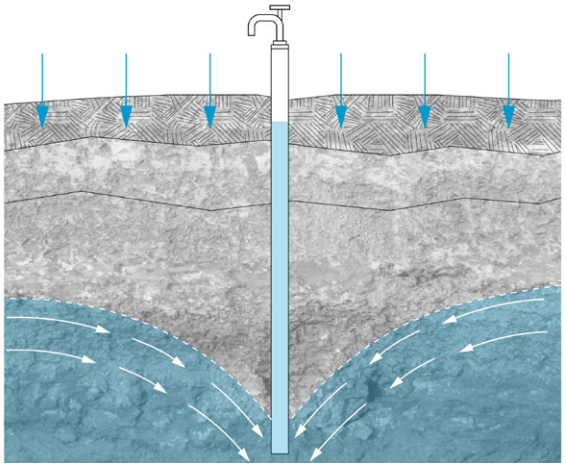
- The Acequia Careo channels collect water from headwaters and edges of the river basins. They help break up the soil so that groundwater can be recharged during precipitation.
- Transfer of water from Careo channels to irrigation channels to bring water to crops.
- Many Careo channels were abandoned and left to clog after this method became outdated in the advent of more advanced technology and historical demographic shifts. However, recent understanding of aquifer recharge has slowly brought this practice back.

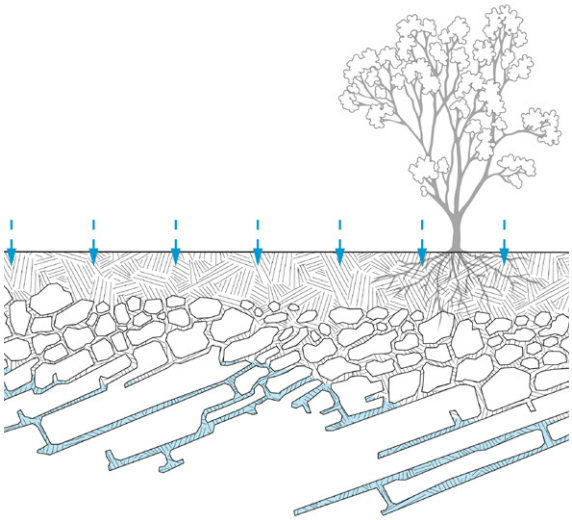
Barren land / low vegetation regeneration

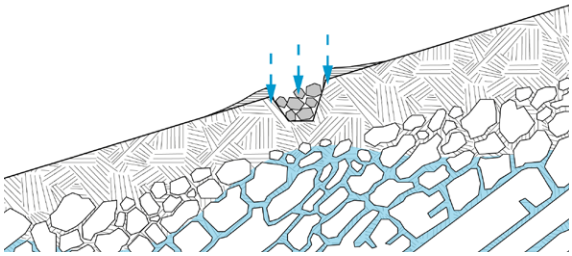


Uncontrollable wildfires

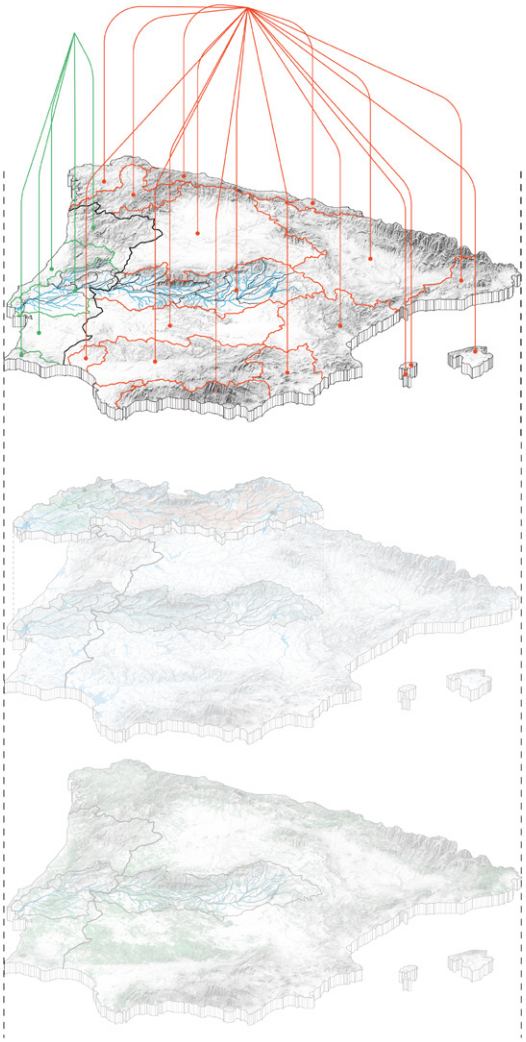
Clogged careo channels







Lowered groundwater levels and low aquifer recharge



Systems of
Governance

Systems of Governance

How did authorities react to society's actions?

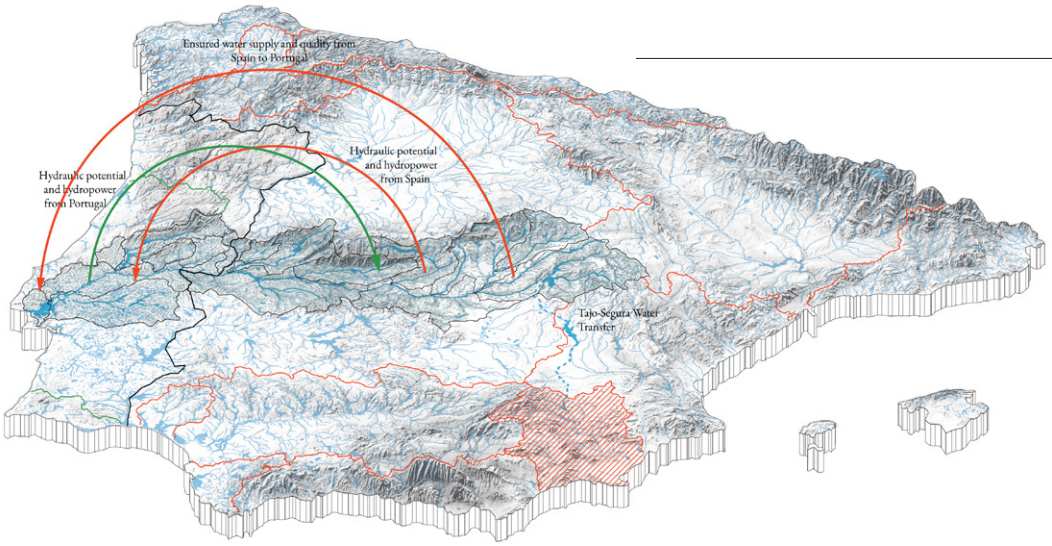
The politics and governance surrounding water resources across the peninsula has become more complicated with the advent of modern environmental problems. While both countries struggle with increasingly scarce water supply during dry seasons, they are also under obligation to share resources according to their water conventions (Zingstra, 2021). In 2023, Spain declared that it would no longer fulfil its full responsibilities of the Albufeira Water Convention, citing the dire situation of water scarcity faced by its own people. This revealed the severity of the drought situation that has hit Spain.

To understand the complicated relationship between the Iberian societies and their water governance, it is imperative to first analyse these governing structures. Both countries have their own structure of water governance that are similar in function and, like-wise, also have multiple layers of different administrative scales that follow a hierarchy: local, regional, national and international.

Many rivers, lakes and other water bodies stretch across the Iberian Peninsula. However, while most of these rivers fall within either Spain or Portugal, some rivers – such as the Duero and Tagus – span across both territories. These transboundary water resources are now managed and governed by international agreements such as the Albufeira Water Convention.

Most non-transboundary water resources are managed locally. The responsibilities of the municipalities manage how water is consumed in urban areas, treatment of wastewater, management of these infrastructures, and the planning of urban and civil protection plans relevant to droughts or flood risks.

Both territories have each their own regional form of water governance. Spain has its River Basin Authorities (RBA) and Portugal has its River Basin District Councils (RBDC). The work of the RBA concerns the management and maintenance of water bodies and water infrastructures that span across different municipalities and provinces. They prepare and execute River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs). Additionally, they also manage large scale water users such as farmers and hydropower plants, and they assist municipalities on



water-related work. Portugal's RBDC also offer similar technical assistance to the planning and implementation of RBMPs and FRMPs (European Commission of the Regions, n.d.).

On a national scale, both Spain and Portugal have centralised responsibilities and decision-making authorities over the various river basins that fall within their respective territories. Both countries, however, share responsibilities over transboundary basins such as the Tagus, Douro and Guadiana. These are collaboratively governed through the Albufeira Convention, a water convention that delineates the agreements between Spain and Portugal to share resources and responsibilities in management and maintenance (Zingstra, 2021).

The true complications and water conflicts arise when both countries are undergoing a water scarcity crisis. As Spain struggles with severe droughts faced by its own people, a decision was ultimately made to prioritise its residents over its responsibilities stipulated in the Albufeira Conventions, and that it would no longer fulfil every end of the agreements.

This was announced in 2023, after the country faced one of its worst droughts in history. Tensions over this water conflict rose as both territories struggle with an unpredictable climate crisis and annual threats of severe droughts.

National Level Water Governance of Spain:

Ministry for Ecological Transition and Demographic Challenge

Ministry of Health

National Council of Water

Ministry of Territory and Policy

Ministry of Agriculture, Fisheries and Food (Formerly)

Ministry of Development (Formerly)

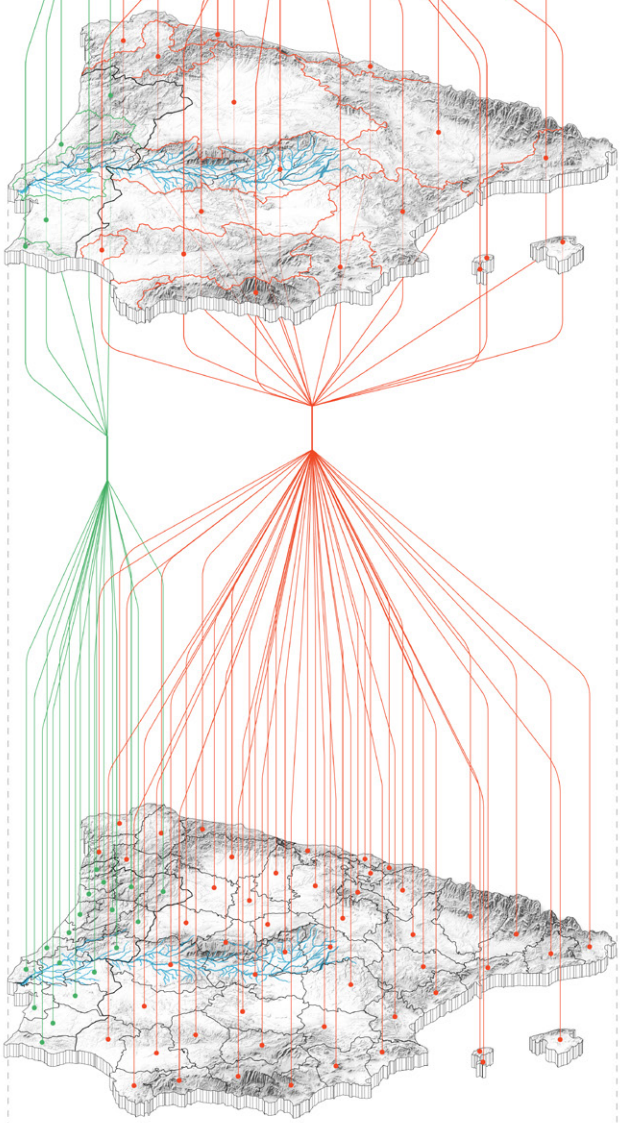
National Level Water Governance of Portugal:

Águas de Portugal (co-owner of water services)

Regulatory Entity for Water and Waste Services (Entidade Reguladora de Serviços de Águas e Resíduos)

River Basin District Administrations (Administração da Região Hidrográfica, ARHs)

Portuguese Environment Agency (Agência Portuguesa do Ambiente, APA)



Regional Level Water Governance of Portugal: River Basin District Councils

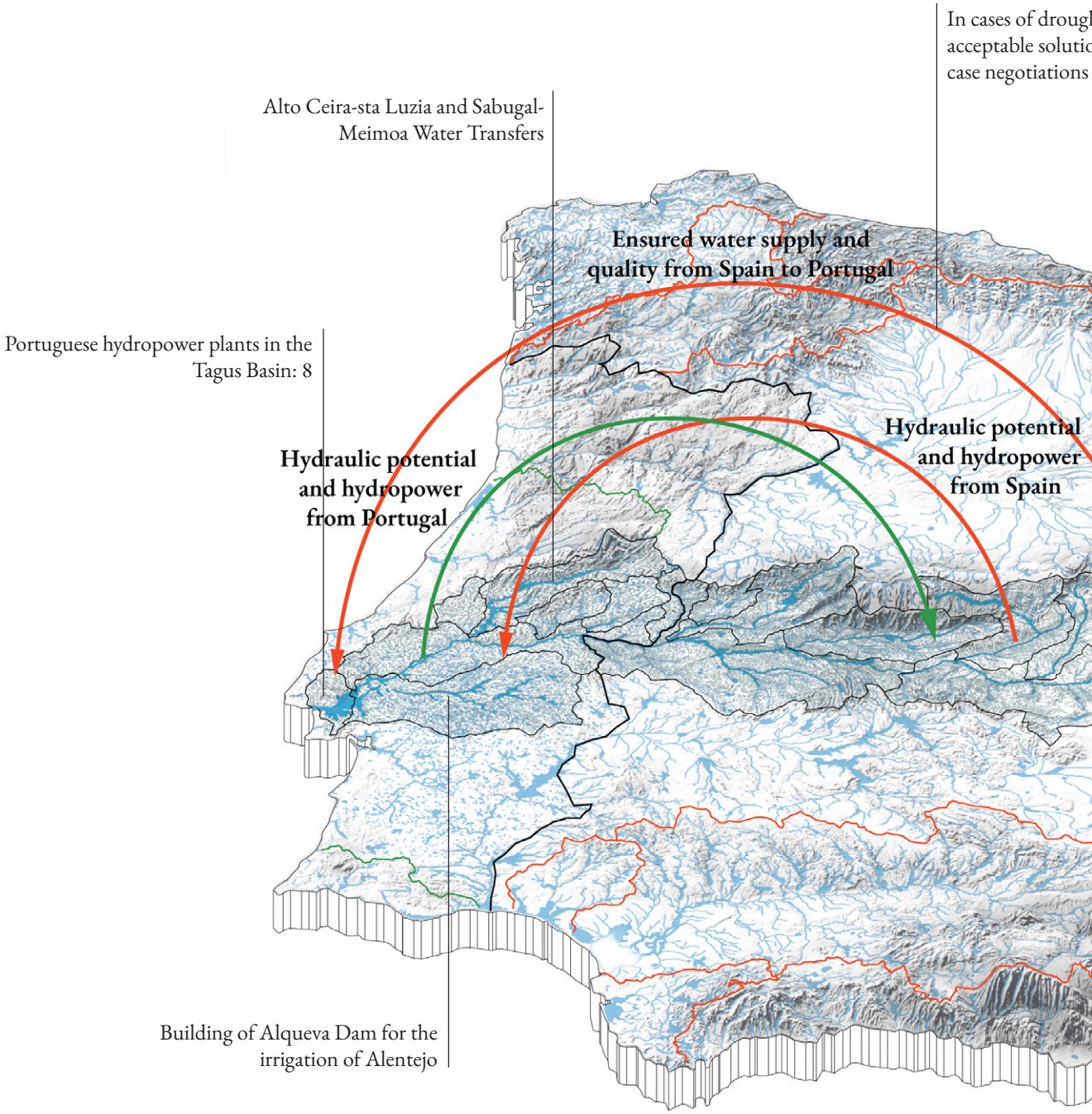
Regional Level Water Governance of Spain: River Basin Authorities

Regional Level Water Governance of Portugal: District Administration

Regional Level Water Governance of Spain: Province Administration

Municipalities and local Authorities: 308

Municipalities and local Authorities: 8000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Alto Ceira-sta Luzia and Sabugal-
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Ensured water supply and
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Portuguese hydropower plants in the
Tagus Basin: 8
Hydraulic potential
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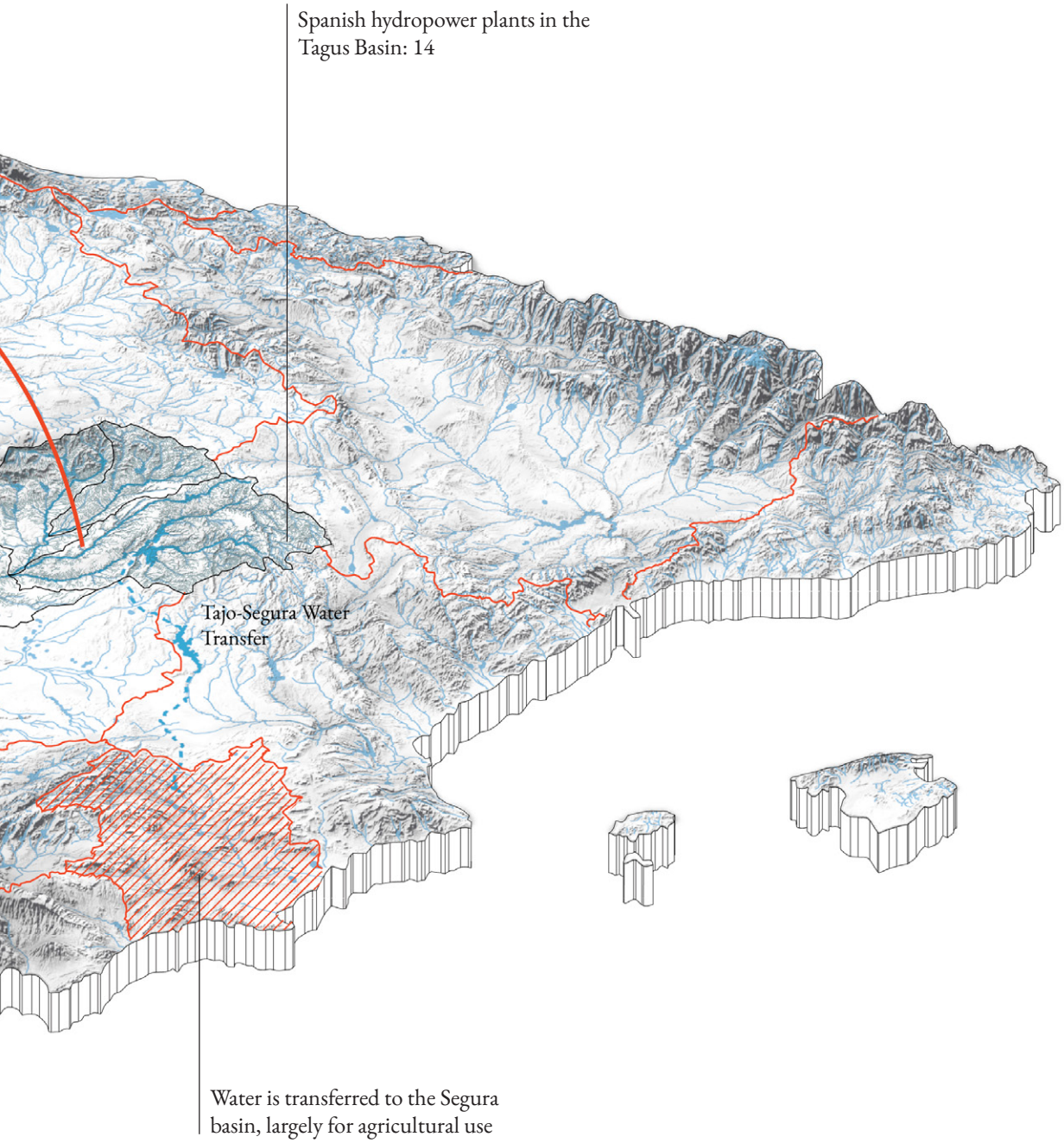
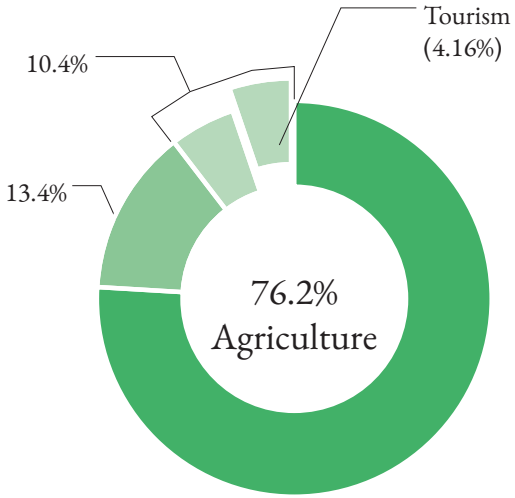
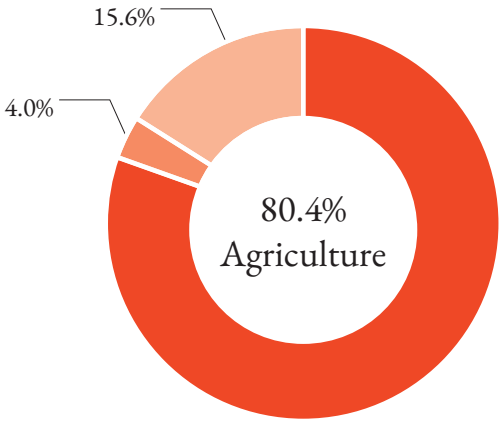


Areas with water restrictions as of 2022



Internal water footprint of Portugal (World Bank, 2021)

- Agriculture
- Industry
- Urban, others



Internal water footprint of Spain (World Bank,2021)

- Agriculture
- Industry
- Urban, others

The recent decade has seen a flood of news detailing the annual drought conditions in the Iberian Peninsula that is exacerbating every year. These sources often speculate or imply blame on farmers or overconsumption in cities, framing residents as profligate consumers. While this was quite exaggerated, both Spain and Portugal have seen some excessive use of water sources for farming, recreation, tourism and typical consumption. The authorities then put in place water restrictions on some regions within their territories in an effort to reduce excess consumption.

Portugal has implemented water restrictions to its agricultural region in Algarve and to its tourism industries. About 8% of Portugal's portable water goes to tourism activities such as watering golf courses – which are often populated by its wealthier residents or tourists. However, the dire drought conditions of today have rendered this recreational usage less necessary and hence the water restrictions on these activities (Faget, 2023).

Spain has also implemented water restrictions to more regions throughout its provinces. Galicia, Catalunya, Extremadura and Andalusia now face limits to their water usage for agriculture. Some of these regions, although not most, fall within the Tagus Basin. There were also limits to the water usage throughout the country. Despite this, many farmers and agricultural workers have found unregulated means to over-extract groundwater or construct illegal wells in order to maintain their crops and make a living. The state's response to this were severe as Spain's civil guards were deployed to raid these wells and arrest farmers involved, leaving many in the agricultural industry feeling neglected and disenfranchised by the Spanish government (Reuters, 2023a).

In January of 2023, thousands of farmers took to the streets of Madrid to decrease the limit of the water drawn from the Tagus River for agriculture (Reuters, 2023b). This included water used within the basin and routed to other agricultural regions of Spain through the Segura Water Transfer. Many opined that environmental protection as a reason was not sufficient to warrant such drastic measures. The state and the European Union (EU) have since delved into compensation and other rural developmental programs to alleviate the economic strain on the agricultural sector, such as the Common Agricultural Policy (CAP) (European Commission, 2023).

In addition to water restrictions for agriculture, recreational water uses have also been reduced. In May of 2024, municipalities in Spain have already ceased the operation of many public water features in gardens, parks and other types of recreational water-use.

Farmers protesting in Madrid in January 2023.

Image source: Violeta Santos Moura, 2023. Acessed via https://www.reuters.com/world/europe/spanish-farmers-protest-against-plans-curb-water-supply-irrigation-2023-01-11/

AP

Israel-Hamas war New York City Marathon

Spanish Civil Guard raid illegal wells amid drought

1 of 2 | FILE - A pond is filled with water from the Arteson river and used by local olive farmers in the southern town of … Read More

BY JENNIFER O'MAHONY

Published 4:59 PM CET, May 9, 2023

Share

MADRID (AP) — Spain's Civil Guard said Tuesday it had arrested 26 people in raids on illegal wells in the Andalusia region, as part of a widening crackdown on unauthorized water use amid a prolonged drought.

The Civil Guard's environmental crimes division said it had identified 250 infractions by fruit farmers including illegal wells and boreholes in the Axarquia area, east of the coastal city of Malaga. It estimated the damage to public water infrastructure at 10 million euros ($10.95 million).

REUTERS

My View Following Saved

Environment

Portugal's drought prompts water price rise, street-cleaning ban

By Sergio Goncalves

August 25, 2022 11:40 AM GMT+2 · Updated 2 years ago

Aa

Aerial view of a previously submerged village revealed by low water levels in Cabril dam reservoir in Pedrogao Grande, Portugal, July 13, 2022. REUTERS/Miguel Pereira *Purchase Licensing Rights*

…ON, Aug 25 (Reuters) - Facing an unprecedented

CNN World Live TV

Dozens of fruit growers arrested in Spain over illegal wells as drought grips the country

By Al Goodman, CNN

Published 2:41 PM EDT, Tue May 9, 2023

Carlos Gil/Getty Images

The Viñuela reservoir, located in La Axarquia, on September 01, 2022 in Málaga, Spain.

(CNN) — Spanish police have arrested 26 people in recent months for an alleged scheme to use water from illegal wells to grow subtropical fruit, as the country grapples with damaging heat and drought.

A Spanish Civil Guard statement said a four-year investigation had uncovered 250 illegal wells and ponds in the in a drought-stricken area Axarquia district east of Malaga, along the Mediterranean coast.

REUTERS

My View Following Saved

Europe

Fruit growers arrested for using illegal wells in drought-hit Spain

Reuters

May 10, 2023 4:30 AM GMT+2 · Updated 6 months ago

Aa

[1/6] A pedal boat is pictured on the cracked ground at a reservoir near Vic, Spain, May 6. REUTERS/Nacho Doce *Acquire Licensing Rights*

MADRID, May 9 (Reuters) - Twenty-six people have been arrested for tapping illegal wells to grow tropical fruit such as avocados and mangos in southern Spain amid a long-term drought, police said on Tuesday.

sic notícias

Endless drought: agriculture is suffering severe restrictions

Southwest Alentejo and the Algarve are the regions that cause most concern. The Barlavento Algarve is in the red zone. Proof of this is the level of water stored, which is the lowest on record.

Hugo Alcantara e Carlos Nascimento

01:12, 24 Sep.2023 Guardar

Endless drought: agriculture is suffering se…

The Portugal News EN

Tourism sector will comply with water cuts

The president of Algarve Tourism has expressed his conviction that the sector will be able to reduce water consumption by 15% this year, which the Government is expected to stipulate as a measure against drought in the region.

By TPN/Lusa, in News, Portugal, Environment, Tourism, Algarve · 10 Jan 2024 · 0 Comments

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Green | Climate Politics

Spain Police Crack Down on Illegal Water Wells as Drought Bites

Mango and avocado farmers in Málaga are accused of digging 250 wells without permits to irrigate their fields.

Extremely low water levels on the exposed bed of the Rialb reservoir during a drought in La Baronia De Rialb, Spain in 2022. *Photographer: Angel García/Bloomberg*

By Laura Millan

10 May 2023 at 12:22 CEST

safe communities portugal

Drought: Municipalities reduce garden watering and launch awareness campaigns

Measures being takenaround the country

Lisbon, Aug 21, 2022 (Lusa) – Municipalities across the country have adopted measures to minimize the general situation of drought, which include reducing garden watering, using recycled water in washing, reducing flows and more campaigns to awareness.

Since October of last year, it has rained practically half of what would be a normal hydrological year, according to the Portuguese Institute of the Sea and Atmosphere (IPMA) on August 9.

At least around eight thousand people from 50 localities in Trás-os-Montes are being supplied this summer with the help of auto-tanks due to the lack of water in the supply systems, namely

A fountain in a tourist area of Aranjuez has ceased its water works in response to the impending droughts as of May 2024.

Fountains in Arganda del Rey at parks have also ceased water works.

Collaboration

Throughout history, the lack of collaboration has spelled the disruption of the environment and ways of life of society. People often disregard the need to give back to nature when taking from it and over-prioritise their personal gains and profit. Across the globe, agricultural industries have strained natural land and water resources. It is a problem not unique to the Mediterranean. Conversely, on an urban scale, urban landscapes and gardens contribute restorative benefits to individual well-being (Kaplan, 1995).

However, this socio-ecological relationship is one-sided. Society is not necessary for the survival of nature, in fact human society has become a detriment. Modern agriculture has caused an immense scale of pollution to water, land and the atmosphere. Today, as this thesis will explore, the agricultural industry in some parts of the world is becoming a victim to its own actions.

Lack of Collaboration between Conflicting Systems

From the analysis of the Iberian Peninsula, it is apparent that many complications surrounding the progress towards sustainability stem from an inherent lack of collaboration. Industries across Spain and Portugal over use water for economic gains, Spain declared that it would prioritise the needs of its territories over its water conventions with Portugal, and the authorities' restrictions and arrests against illegal groundwater extraction for agriculture. Although these decisions were understandable to some extent, they often lead to a neglect of other participating stakeholders.

The different conflicting systems, in conclusion, are now mired in these drought-related predicaments due to the lack of collaboration between the environment, society and governance. Although there are many more nuances and more players in the global climate change, the neglect for nature, others in the community and the other territories in this crisis have exacerbated the impacts of droughts.

Landscape as the Commons

The drought situation, compounded with today's global climate crisis, has proven difficult to coordinate a solution for. Many forms of governance across the globe have realised the need of collaboration and have implemented international treaties, such as the Paris Agreement, where all participating countries pledge a commitment to reduce their emissions in an effort to alleviate climate change and its impacts (United Nations, n.d.). Despite such a large-scale collaboration, the prospects of the climate improving in the coming years are still uncertain, and improvements to the situation are gradual at best. Thus, in the meantime, societies within smaller regional scales should collaborate to support these efforts and each other's livelihoods.

There are many instances of other communities resolving environmental issues with collaborative efforts such as the use of landscape commons. This can be a solution to the lack of collaboration between the different parties involved in the Tagus Basin, considering the need for collaboration and accountability between the users and other stakeholders of the basin's resources.

The different landscape commons are often contextual to their communities but they also have common principles in practice that have made such an idea successful. Some of these are Nepal's community forests, the lobster fisheries of Maine and the urban green commons of Cape Town. There are valuable lessons to be learnt from these case studies that can be modified to fit the context of the Tagus Basin's case.

New Forest Northern Commons of The United Kingdom

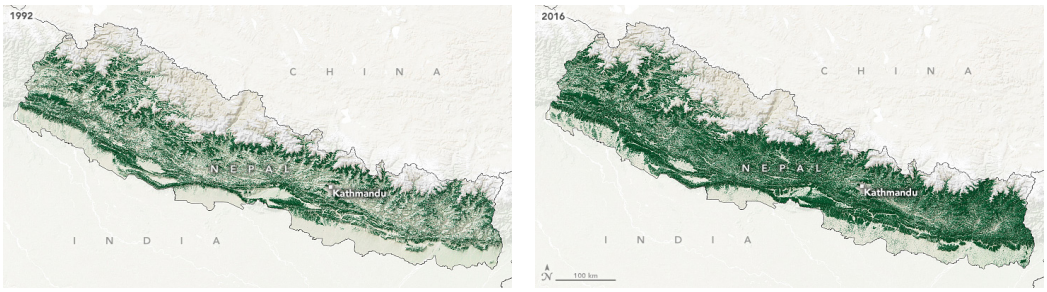
Systems of the Environment (impact): the conservation of historical heathlands and 'commonable' livestock for agriculture.

Systems of Society (community efforts): the community turn out livestock that graze in the commons while participating in efforts, such as controlled burning, cutting and mulching, to maintain the landscape.

Systems of Governance (policies and management): areas of the heathlands were designated for grazing, community members are to protect the landscape's wildlife and biodiversity by use of the aforementioned methods, in exchange for the rights to use part of its returns – the livestock.

(National Trust UK, n.d.)

Community Forests of Nepal



Systems of the Environment (impact):
the growth of the biodiversity and wildlife conservation in Nepali forests have been maintained since the 70s.

Systems of Society (community efforts): the forest is an agricultural resource and profit earned from this is invested back into efforts for forest cover growth and wildlife conservation. The community also invests efforts into keeping open data of the biodiversity.

Systems of Governance (policies and management): the community forestry program designates a limit to wood collection from the forests and approves divisional plans.

(NASA Earth Observatory, 2021)

Lobster Fisheries of Maine

Systems of the Environment (impact): maintenance of lobster populations and, by extension, the marine ecosystems around the coasts of Maine

Systems of Society (community efforts): community adherence to the rules of the conservation program

Systems of Governance (policies and management): rules of the conservation program that include (but are not limited to) trap limits to allocated fishing areas, mandatory tagging and release of egg-bearing female lobsters, releasing undersized and oversized lobsters, management of invasive species and use of low-impact gear.

(Department of Marine Resources, 2024)

In all these summarised cases of these commons are trade-offs where communities abide by certain guidelines in exchange for the right to a common good – be it livestock, wood or lobsters. These trade-offs are collaborations between the environment and society and are facilitated by a form of governance over the commons that are reflected in Elinor Ostrom's research. In Ostrom's Governing the Commons, 7 to 8 design principles were delineated as common traits of sustainable common pool resource (CPR) institutions (Ostrom, 1990), most of which are also evident in these aforementioned case studies. These can also be categorised into the landscape layers from the analysis to be developed as part of the synthesis.

Systems of the Environment:

The conservation of an endangered / limited resource that a community depends on.

Systems of Society:

Community involvement and collaboration to take care and maintain these resources, based on following a set of rules and guidelines.

Systems of Governance:

Similar to Ostrom's design principles to governing the commons, there needs to be a system in place, embodying these principles to ensure the collaboration between society and the environment in the commons. This includes ensuring the rules to the commons are not fixed and will be adaptable to changes in the environment.

Ostrom's principles make a good basis from which a water-landscape commons can be developed. However, a bottom-up approach could provide better support for the community and environment. Beginning with spatial strategies, this paper will lay out the resources which the community can use. By providing rules to these spaces, the plan strategises how communities can interact with these resources to provide for themselves in sustainable ways. This will be further reinforced by a system of governance, a process that ensures the collaboration between society and the environment within the commons.

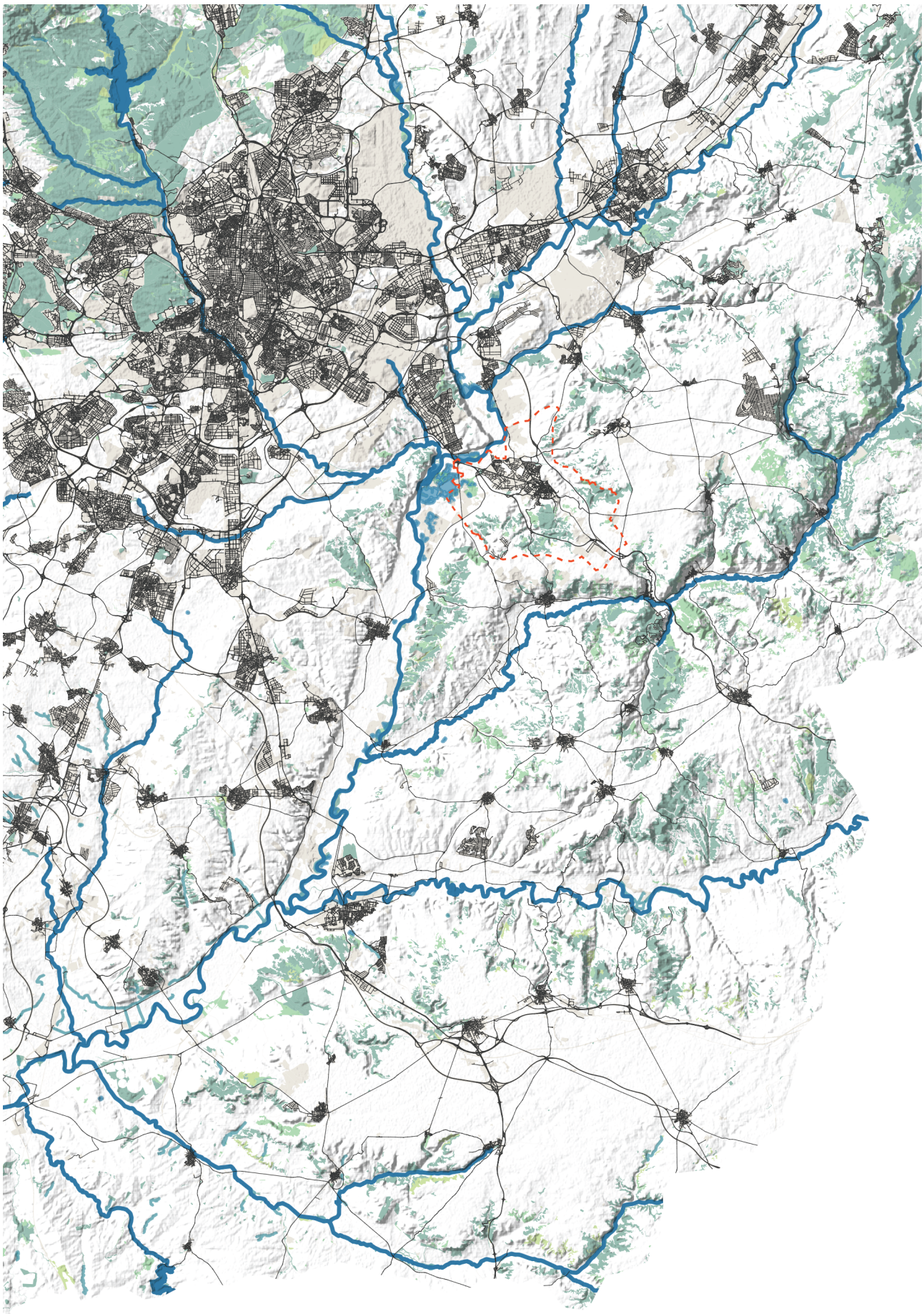
The 7-8 principles to governing the commons:

1. Clearly defined boundaries: what are the resources and who have the rights to these.
2. Congruence between appropriation and provision rules and local conditions: restrictions or rule to amount of provisions designated to individuals, or the type of tools involved, etc.
3. Collective-choice arrangements: individuals participating in the commons can collaborate to form or change the rules that are mutually agreed upon.
4. Minimal recognition of rights to organise: users have rights to plan their institutions without these rights being challenged by external forces.
5. Monitoring: monitors will actively track the conditions of the commons who either report to the users or are users themselves.
6. Graduated sanctions: violators of the rules will be assessed by other users of the commons or officials that are accountable to these users.
7. Conflict-resolution mechanisms: efficient and accessible methods and avenues for users to resolve conflicts with each other or with officials.
8. Nested enterprises (for CPRs that fire parts of larger systems): aforementioned activities to be planned and carried out in multiple layers of these nested enterprises.

(Ostrom, 1990)

The Tagus' resources – mainly the river's water – are plenty but limited, and especially so during dry seasons. While there is a pertinent need to intervene in usage of the landscape on a governmental level, the situation still requires a spatial solution first to the physical problems faced by many communities that reside within the river basin.

This research will delve first into a regional design on the river basin scale, then further into a case study area around the Community de Madrid, Arganda del Rey, as it is a place in the province that was facing high drought intensity (high CDI values) in 2022 and is additionally upstream of the main river network.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15 km
30 km
60 km

Arganda del Rey

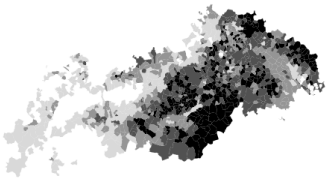
Arganda del Rey is a small city and municipality of Spain along the outskirts of Madrid. The area is home to important historical monuments and sites embedded in its landscapes, such as the Fortificación del Cerro del Melero. The city sits along the Jarama, a major tributary of the Tagus River, and is surrounded by undulating terrains shaped by former and current brook (arroyo) systems. These are dry water courses that ebbs and flows seasonally during rainfall. Surrounding the these are vast fields of agricultural land and some protected forests, such as the Parque regional del Sureste. These agricultural lands are often private properties cultivating mostly olive trees or grains, such as barley or wheat. The city was also formerly known for its prolific wine production and high-quality olive oils, but today the most visible crops remain the olive trees and grains.

Today, agriculture no longer contributes a large proportion to the city's economy. About 0.2% of its GDP comes from agriculture as the city grew and moved towards industries, and only 4% of food consumed by Arganda's residents was produced locally. Evidently, agriculture is on a decline in Arganda, but the relatively fewer croplands still dominate the dry landscapes of the city today (Cities2030 & Universidad Politecnica de Madrid, 2020).

The dryness of Arganda's landscapes is relevant to a few factors: the low precipitation it receives annually, high coverage of cropland in the landscapes, relatively low soil permeability and the lack of forests in its surroundings (Copernicus, 2022). Furthermore, as the city expanded, the built urban area also created a concrete landscape that is relatively short of urban green, compared to cities like Madrid. The lack of green spaces allowed an urban heat island effect to overwhelm the built areas of Arganda.

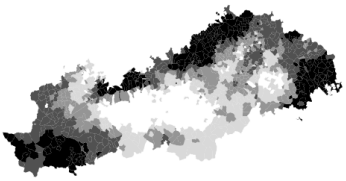
The native vegetation (non-cultivated) of Arganda consists of species that are able to thrive in dry and hot climates. The Gall Oak and Holm Oak trees, Esparto grass, Spanish Snapdragons, White Flax and Rough Marsh Mallow are some species that are still found on site. However, due to the intensifying conditions caused by climate change and droughts, some species may be lost from this area in the near future (Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2020).

CDI



Land productivity potential

Fire burned areas

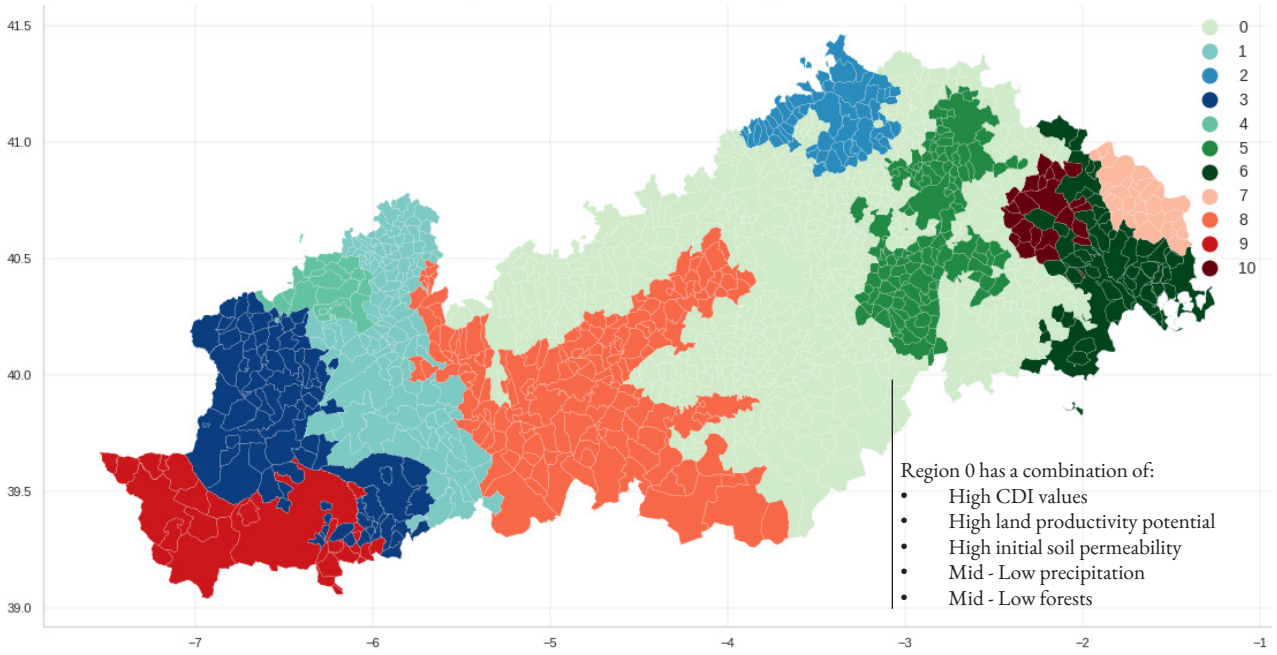


Annual precipitation

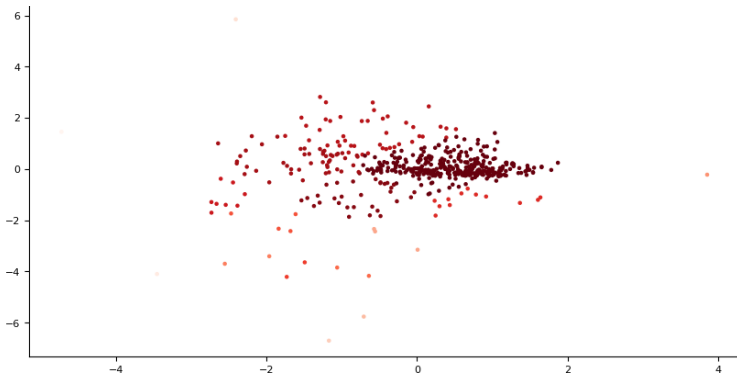
Forest covers

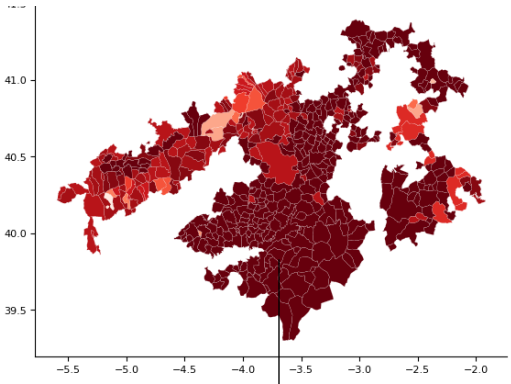
Soil permeability

Distribution of variables per municipality



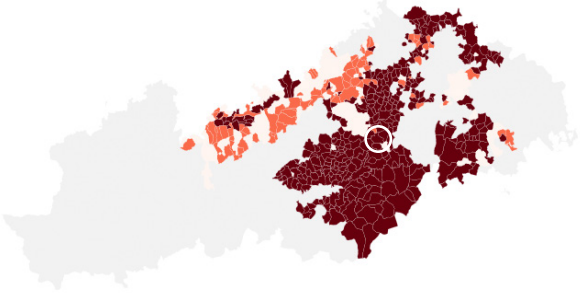
This regionalised clustering was used to group similar values that might affect each other. This is to understand which areas have similar combination of values, implying similar situations that are contributing to the drought problems and that each situation may affect its neighbours. The next part will analyse Region 0 more as it has the highest drought intensity levels.



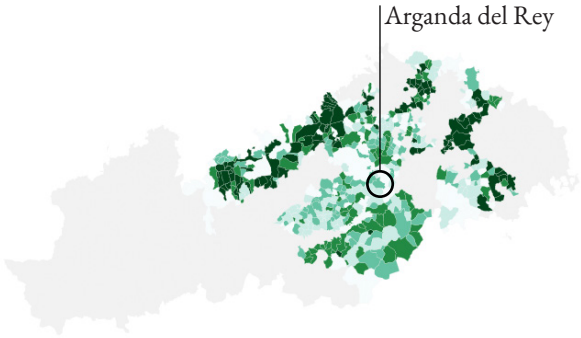


Meanshift clustering of forest land and productive land

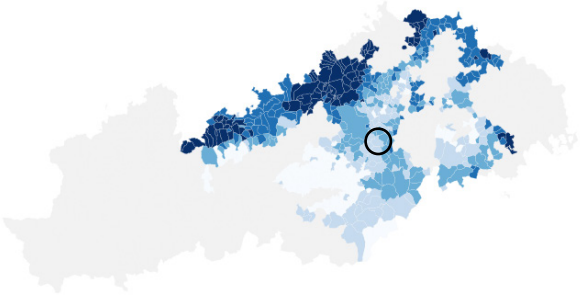
Regions that have low forest cover and high production land



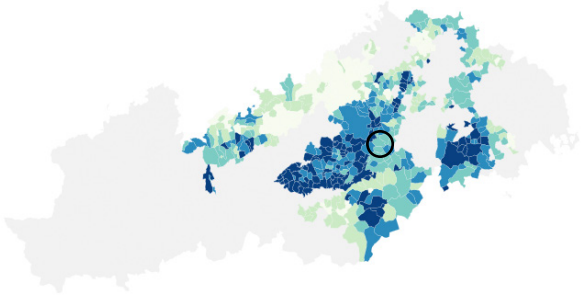
Regional priority scale for land-sharing



Regional priority scale for forest growing



Municipalities to focus on water storage



Municipalities to focus on groundwater recharge

The landscapes around Arganda del Rey have some motifs of terraces around hilly areas as well that slow down runoff to allow water to seep into the ground.


Terraces outline the
contours


Sisymbrium loeselii
"False London-Rocket"
Antirrhinum graniticum
"Spanish Snapdragon"
Hirschfeldia incana
"Mediterranean Mustard"


Pinus sylvestris
"Scots Pine"


Hirschfeldia incana
"Mediterranean Mustard"
Linum suffruticosum
"White Flax"


Echium vulgare
"Viper's Bugloss"
Echium vulgare
"Viper's Bugloss"


Pinus sylvestris
"Scots Pine"


Quercus canariensis
"Zean Oak"


Quercus ilex
"Holm Oak"

The Municipality of Arganda del Rey.

Image source: Google Maps, 2024. Acessed via https://www.google.com/maps/place/Municipality+of+Arganda+del+Rey,+28500,+Madrid,+Spain/

Arroyos, Barrancos y Bosques de Arganda

The Arroyo de Vilches is a small brook system with a stream that connects to Canal del Porcal, a drainage canal that routes urban run-off during wet seasons to the Jarama river. The arroyo stretches far and is used by neighbouring cropland for its water. In upstream parts of the arroyo, there are small forests around the brook system (Google Maps, 2024a).

Upon visiting, these spaces felt more humid than the rest of the dry landscapes around Arganda. Trees and vegetation often contribute to a higher humidity due to their transpiration process (Procházka et al., 2011). These small strips of forest habitats along the brook have helped shelter this part of Arganda from the dry climate, however, they are not ubiquitous throughout the brook system, and almost non-existent near agricultural areas.

The reduced forested areas downstream could make the brook vulnerable to excess evaporation during dry seasons, which could worsen the drought impacts. The Arroyo de Vilches is not the only brook system around Arganda (Google Maps, 2024a).

There are several other brooks and ravines (barranca) that are now occupied by cropland (Google Maps, 2024b). These are areas that tend to flood during high rainfall and erode to form small valleys, but the absence of former biodiversity and monocultures dominating these areas, the dry land has become less permeable. These can become big hurdles for aquifer recharge and drought resilience in these areas. Therefore, it is imperative that the design proposal enhance the brooks and ravines surrounding Arganda.

Trees and dense vegetation can help reduce excess evaporation from water sources and aquifers. However, the resolution between the needs of the environment and the farming community should not consist of simply a spatial proposal. Part of the issues that surround the drought situation throughout Spain is the farming communities feeling disenfranchised by the government's decisions over water usage. Farming communities are often family-run businesses that are embedded in their cultural heritage and traditions. Without considering these aspects in a collaborative system is to cause a social disruption within communities.

To gain the collaboration of the farming community in a collaborative system, a fair trade of resources and rights should go hand-in-hand with a spatial proposal. Hence the design proposal of this paper will be approached by resolving the layers of conflict in the previous chapter.

The urban greenery around Arganda is limited, providing little shade against the Urban Heat Island Effects.

The Arroyo del Vilches happened to be just a small stream and the riparian vegetation around it were mainly these grass species.

Landscape Restoration of the Loess Plateau

The Loess Plateau, is a landform that is comprised of mostly loess. It is a silt-like sediment that was blown and accumulated into the massive plateau structure in north-central China. The northern part of the Loess Plateau, similar to the Iberian Peninsula, has a semi-arid climate. The area also receives little annual rainfall and the expansion of human activities throughout this region has caused the landform to become susceptible to soil erosion, droughts and floods.

The advent of climate change has increased the region's ambient temperature and reduced annual precipitation, and the persistence of agricultural activities across the plateau depleted the vegetation cover to a significant degree. The populations around the plateau cleared forests to provide more land for agriculture and livestock rearing, while the forest wood was then used for fuel and building material. With massive erosion, depleted vegetation, low precipitation and increasing temperatures, the Loess Plateau faces massive soil erosion that culminates into lasting dust storms in addition to the loss of soil, extreme droughts and floods.

With these lasting environmental impacts, the Chinese government now recognise the importance of sustainable agricultural practices and conserving the environment and soils of the Loess Plateau. The formulated strategies are comprised of ecological initiatives to restore the landscapes while building a robust economic foundation for the agricultural communities living around the region.

The landscape restoration of the Loess Plateau involved three main stages:

1. Initial restoration: focuses on ecological redevelopment. This includes converting land-use to optimise agronomic and ecological functions by regrowing forests and pastureland.

2. Stable improvement: focuses on improving agricultural inputs and outputs from cash crops, pastures and other agricultural work, to enhance profits and the sustainability of production. Education also plays a crucial role at this stage, as the farming communities were also being encouraged to shift away from their traditional farming methods, such as deforestation and other soil-quality degrading practices.

3. Final development: by this stage, farmers would have been able to achieve a stable stream of profits with sustainable practices and would understand the role of environmental conservation efforts in this socio-ecological relationship to reduce soil erosion, and its consequent droughts and floods, while improving their economic returns.

   (Liu, 1999)

The Loess Plateau.

Image source: 黄河山曲, 2012. Acessed via https://commons.wikimedia.org/wiki/File:Loess_Plateau_geomorphology%E2%80%94%E2%80%942012-4_-_panoramio.jpg

The methods to many successful case-studies of landscape restoration involves the implementation of site-specific and contextual spatial interventions. However, the principles behind these are similar and imperative to study in order to achieve the ecological redevelopment in the initial restoration stage of the Loess Plateau's restoration scheme, the Grain for Green project.

Methods of Landscape Restoration

1. Consideration of climate, soil conditions and native plant species

Assessment of climate: semi-arid and sub-humid

Type of soil and minerals present: majority of the loess is formed calcite, feldspar, mica and quartz.

Native species: deciduous broadleaf forest of oak and maple with birch, aspen, linden, etc grow on higher terrain. Elm, Ash, Hovenia and Pistacia in lower terrain near the Yellow River.

It is imperative to understand the kind of conditions that made vegetation growth possible before degradation or what made the current conditions uninhabitable for some species. Following this analysis, decisions can be made to either restore native vegetation or grow alternative forms of forests depending on the situation. For the case of the Loess Plateau, the Chinese government strived to improve ecological standards and agricultural outputs. This implied that the ecological structure was still, to some extent, compromised (Delang & Yuan, 2015).

2. Soil preparation

The assessment of the type of soil present not only reflects what kinds of nutrients were lost during the degradation of agricultural activities but also what is needed to foster the growth of native or ecological species again. However, the restoration of the Loess Plateau was decidedly less interested in restoring the native landscapes of the plateau but rather more interested in striking a balance between the benefits gained by both farmers and the local ecology.

In the case of this project, little surrounding the soil composition was changed in order to plant trees, and the care of the land was left to the farmers' devices. Most of the soil preparation involved were the built terracing and pit structures that helped retain water.

3. Growing vegetation

Most landscape restoration projects span several years and even decades. The initial drafting and formulation of the Grain for Green project focused intensely on expanding forest growing. This process often involves growing trees first in nurseries. In USA, the afforestation of arid and semi-arid areas of Arizona began with a controlled environment to germinate seeds before transplanting them as saplings to the site (Bean et al., 2004). At this point, the land should have undergone soil preparation for new saplings.

4. Establishing local water management

Apart from the vegetation strategies to assist in runoff management, the Grain for Green project also has built types of water management along its slopes. The slopes of the Loess Plateau were known to have issues with water retention, allowing excess precipitation to run off instead of seeping into the soil to replenish groundwater supplies.

Various forms of slope protection dams were constructed along the valleys of the Loess Plateau to slow down water flow.

By reducing the speed of the water flow, more time is afforded for it to retain in an area and be absorbed underground. These techniques are also used for tree crops used by the farming communities. Rice terraces were constructed along gentler slopes to provide crops with sufficient water and mechanical or other means of irrigation for rice crops were less necessary (Wu, 2005).

These strategies contributed greatly to some successes of the Grain for Green project and they can even be seen today as terraces and pits along the contours of the plateau's terrain.

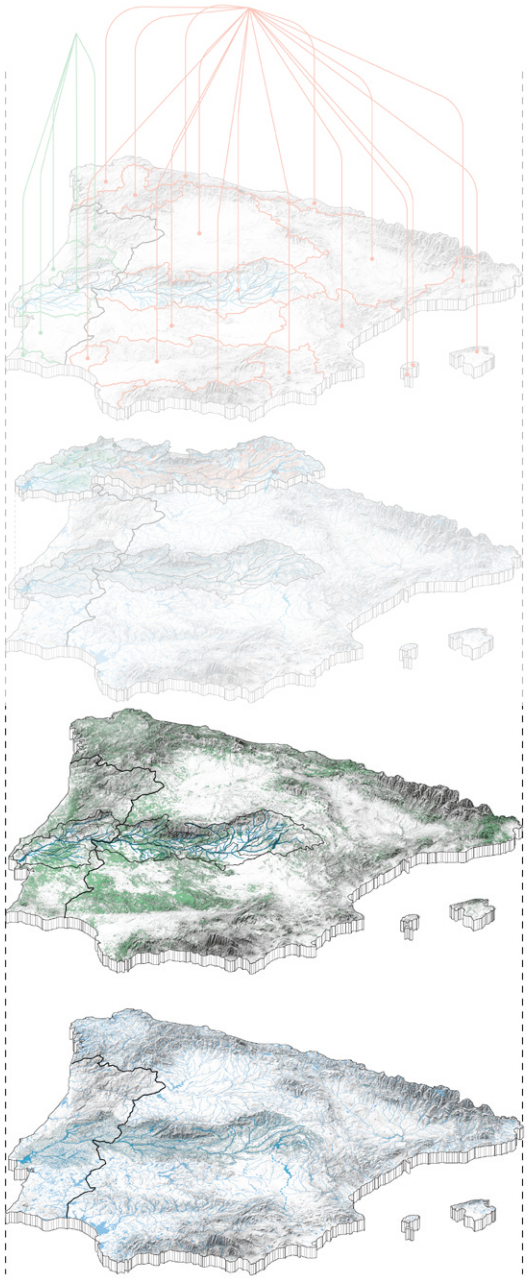
5. Re-establishing vegetation cover

The choice between restoring forestland or grassland was a predicament for the Grain for Green project. Some areas were better suited for grasslands, considering the type of soil and nutrients present. However, the project was focused on afforestation regardless, drawing many criticisms for the eventual lack of vegetation diversity and non-native species (Delang & Yuan, 2015).

Poplars were commonly used for some areas, but after deeper analysis, it was observed that their deep-root systems tend to deplete groundwater quicker and can become counterintuitive to the cause. Additionally, even though runoff reduced significantly, research has shown that these poplar forests draw from the groundwater more than it can be recharged. Eventually, the groundwater levels were still depleting.

However, reforestation areas along slopes saw improvements in soil nutrient and water retention. Runoff was a severe problem in these areas. However, the reforestation results reflected an increase in the porosity of the soil, suggesting that there are higher amounts of water seeping into the ground. This also suggested that there was less soil erosion on slopes and less nutrients removed by runoff.

The general impact of the project implementation is an overall positive improvement to the soil, nutrient and water retention. However, some arid areas where the reforestation was less successful faced further degradation due to the lack of native species and low diversity of forest tree species. The tree survival rates of these areas were much lower and would benefit more from a conversion to grasslands or native species (Delang & Yuan, 2015).



Systems of the Environment

Landscape Commons

Designing Water-Landscape Commons as a Medium for a Collaborative System

Designing commons for communities that may fall into conflict with each other and the environment can prove to be complicated. There were some alterations to existing developmental programs and policies that have been set in place since Spain's last experience with intense droughts. One of these is the Common Agricultural Policy (CAP), which is a financial policy for all EU countries that support farmers and their agricultural productivity while ensuring a sustainable food supply. These are more relevant at state levels of resource governance.

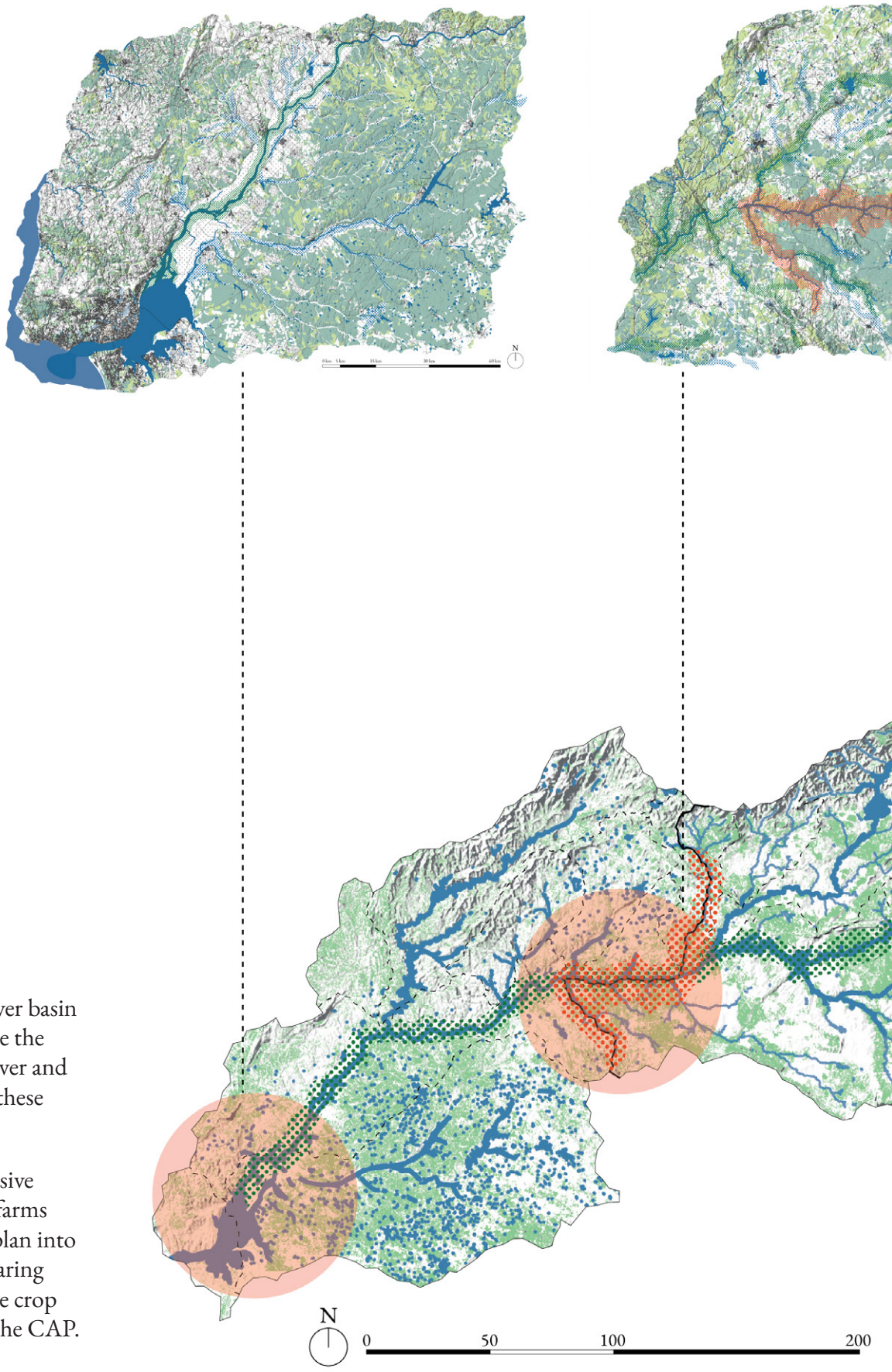
Strategic plans are carried out by EU states, involving pledging parts of their budget to certain forms of development, such as eco-schemes and rural development. Some forms of crop rotation and crop diversification options are encouraged, and farmers are obligated to devote at least 4% of their land to non-productive features, such as eco-friendly habitats. A smaller strategy of similar end-goals can help begin to fulfil sustainable plans (European Commission, 2023).

Systems of the Environment

How can the drought situation be alleviated with the management of water-landscape features?

The considerations of the commons across all layers should begin with an overall vision from the river basin scale. Due to the geographical nature of the basin, the spatial plans need to be considered as a whole instead of directly analysing one municipality. Throughout the EDA in the analysis chapter, the clustering done was also with consideration of the spatial autocorrelation of the geographic variables.

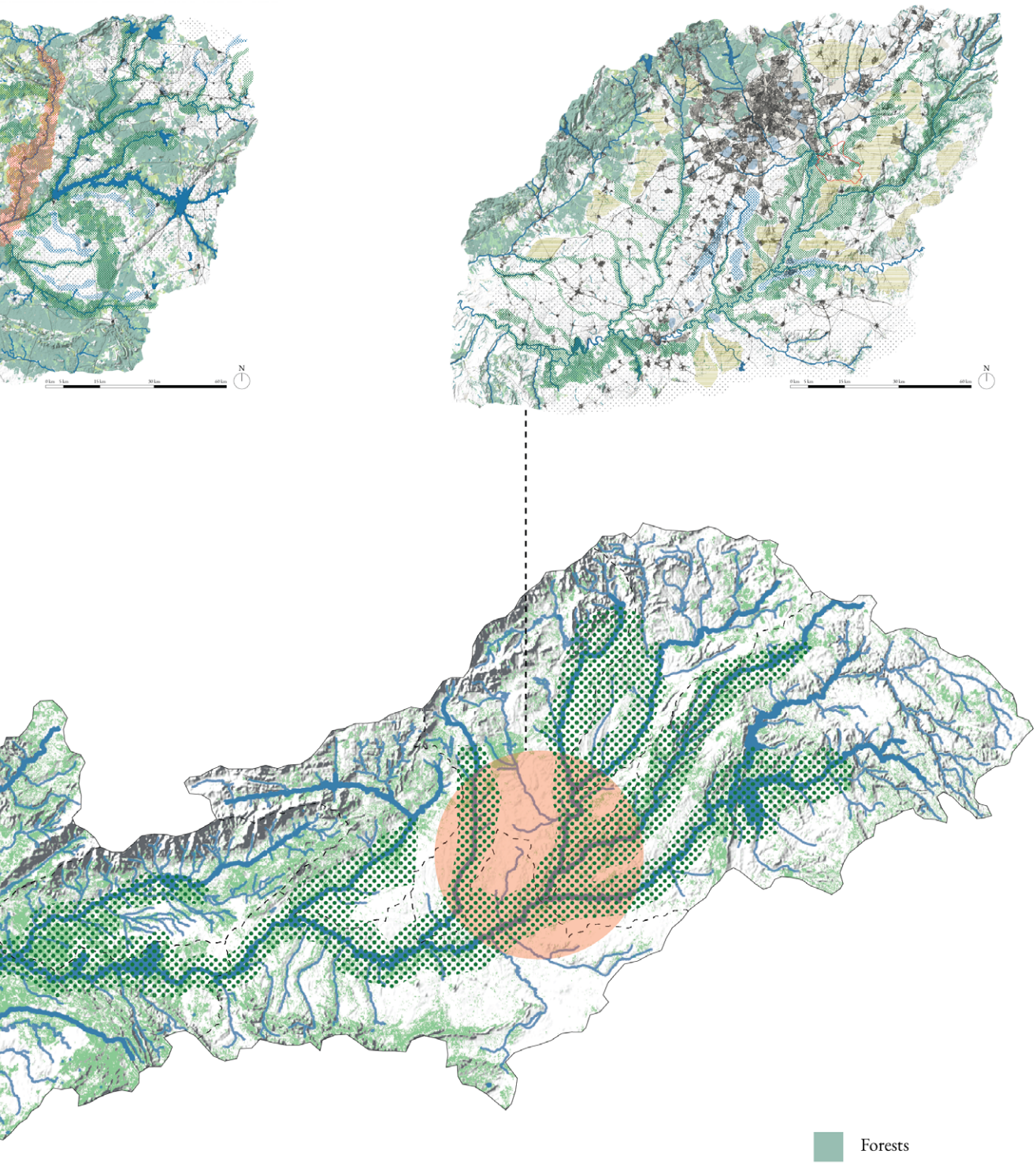
Arganda del Rey's issues with brooks, ravines and forests are not unique to itself. The forests of the Iberian Peninsula do not stretch across evenly throughout the basin. However, forests are essential to a river system to maintain and regulate the water content in the air and ground. The roots of these vegetation will keep soils porous and the transpiration from these plants will help maintain the area's humidity, reducing the level of evaporation during dry seasons. Therefore, a main goal of the river basin spatial plan is to increase the forest cover along the river and connect dry areas with these river-forest systems.



River Basin Plan

The main goal of the river basin spatial plan is to increase the forest cover along the river and connect dry areas with these river-forest systems.

Areas with highly intensive farming or abandoned farms will be encouraged on plan into land-sparing or land-sharing practices – similar to the crop rotations stipulated in the CAP.



Protected forest links and cultural landscapes

Expanded Tagus International Natural Park

Land involved in land-sparing

Land involved in land-sparing on sloping terrain

Underground stormwater storage and purification

Land involved in artificial groundwater recharge

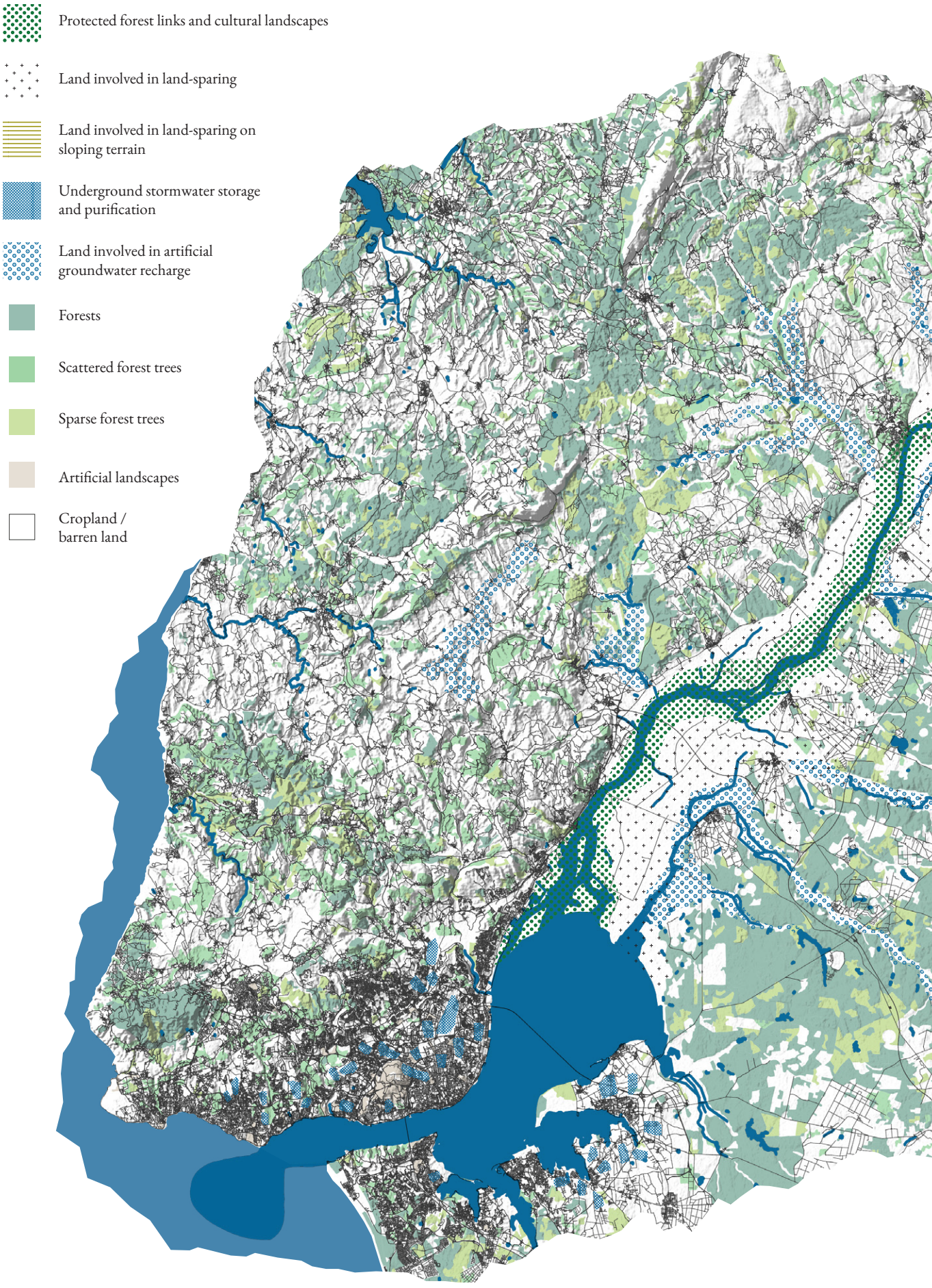
Forests

Scattered forest trees

Sparse forest trees

Artificial landscapes

Cropland / barren land


Protected forest links and cultural landscapes
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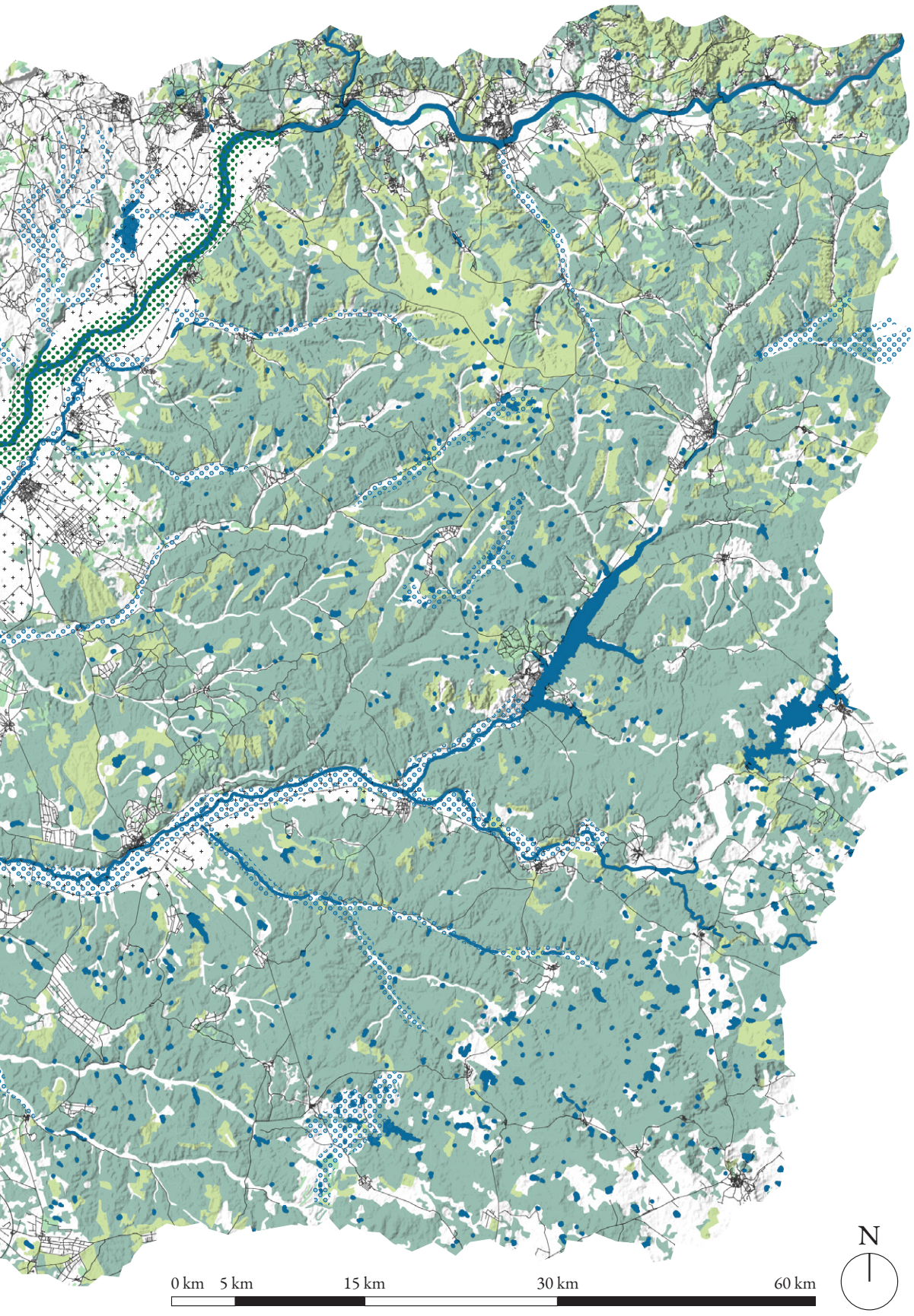
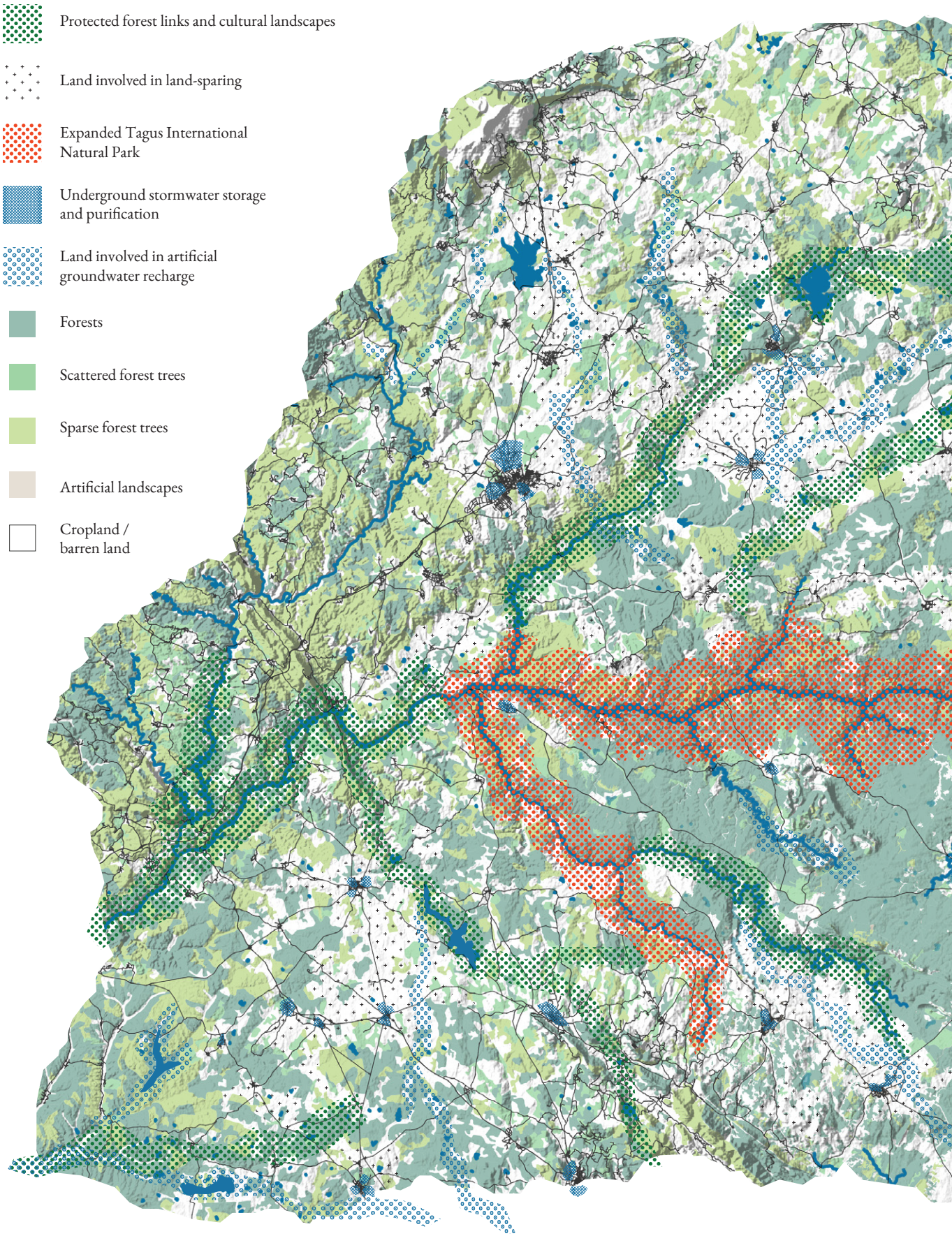
Cropland / barren land



Downstream regional plan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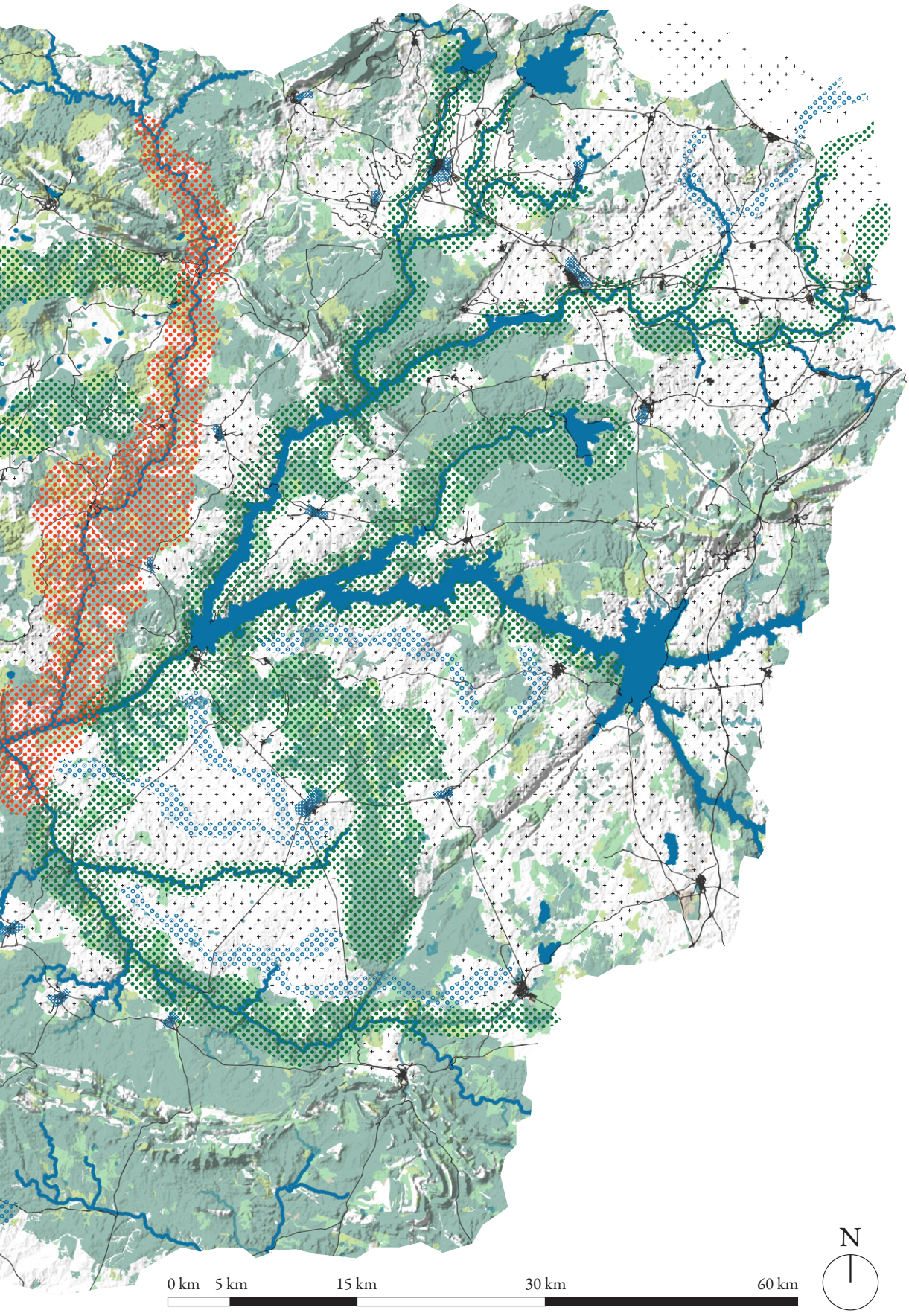
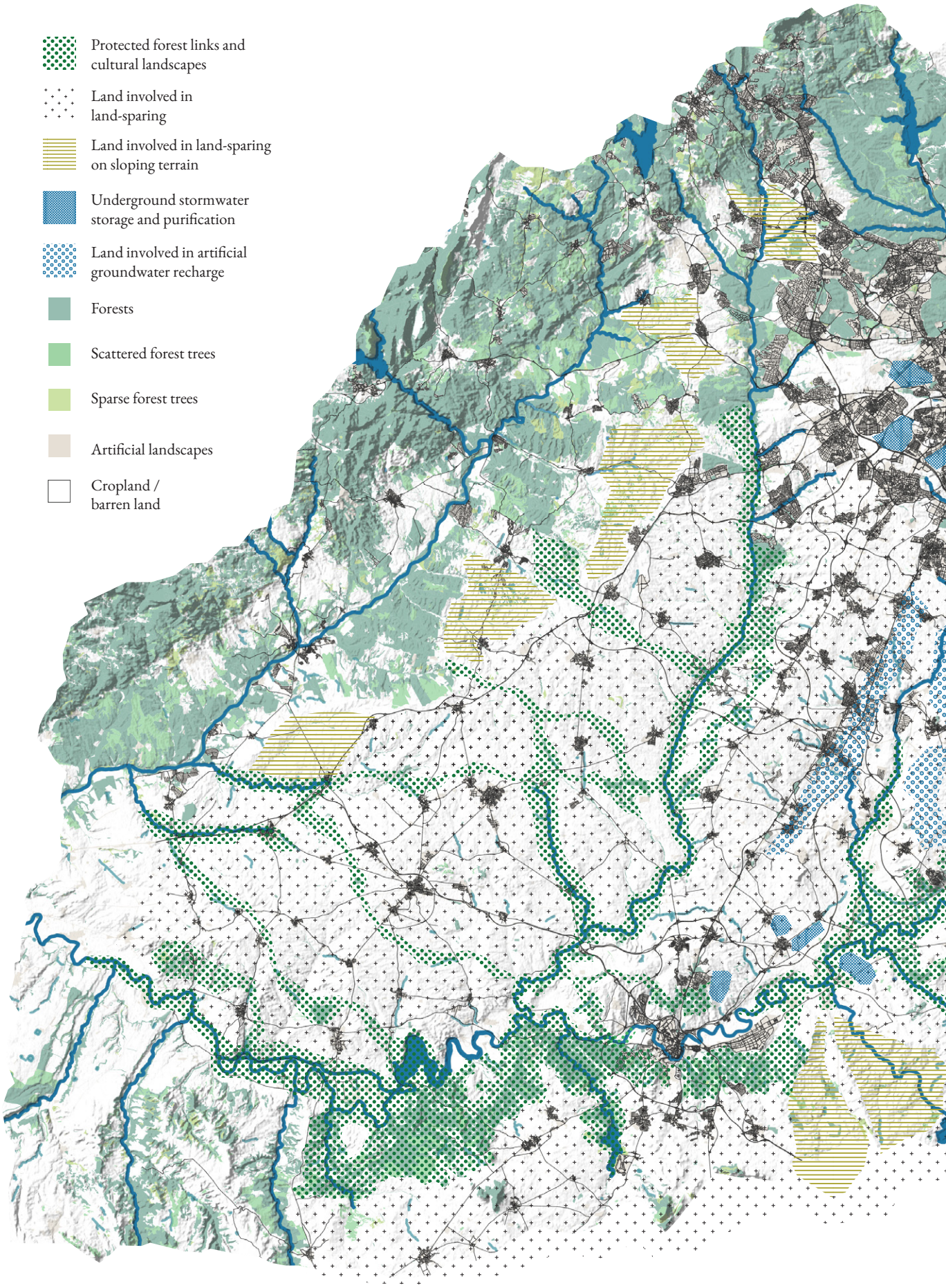


Midstream regional plan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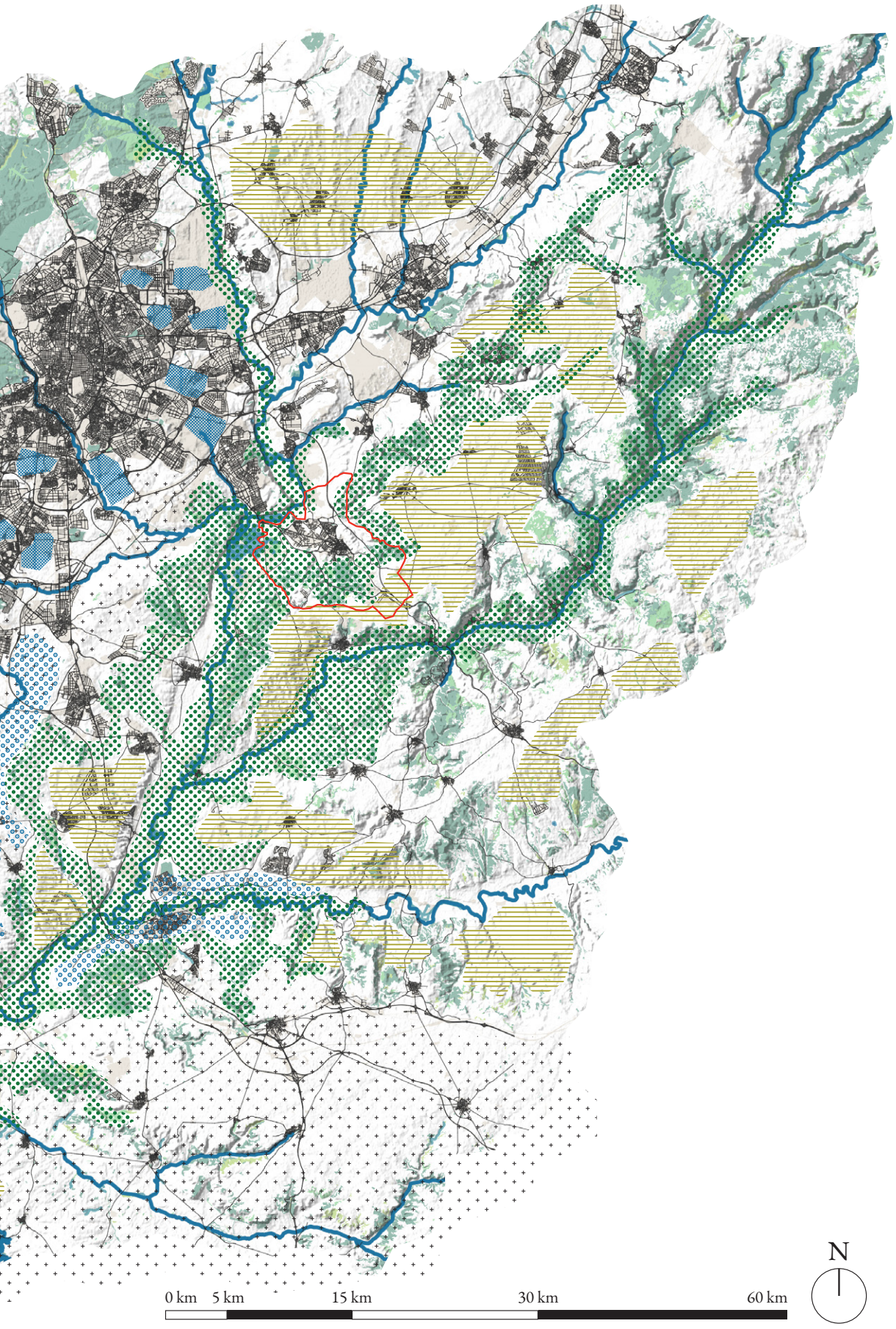
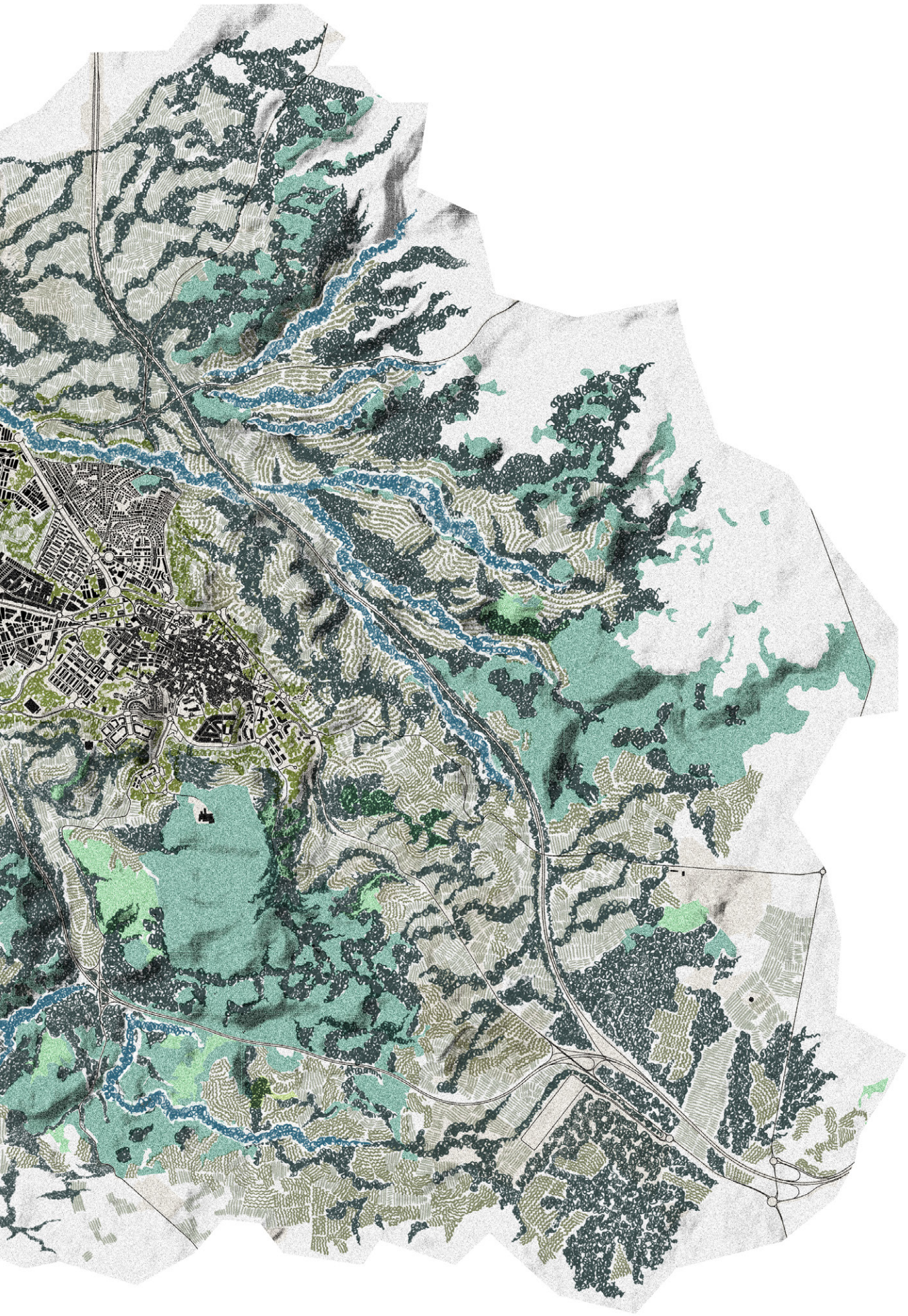
Cropland / barren land



Upstream regional plan


Water catchment brooks (arroyo)
New riparian forests
New forests
New urban landscapes
New crop land / vineyards
New tree-crop land
Existing forests
Existing sparse forests
Existing sparse trees
Existing crop / barren land
Water bodies
River / tributaries
N
0km
1km
2km
4km



What is part of the commons?

The Commons

Public good but not accessible: Protected forests

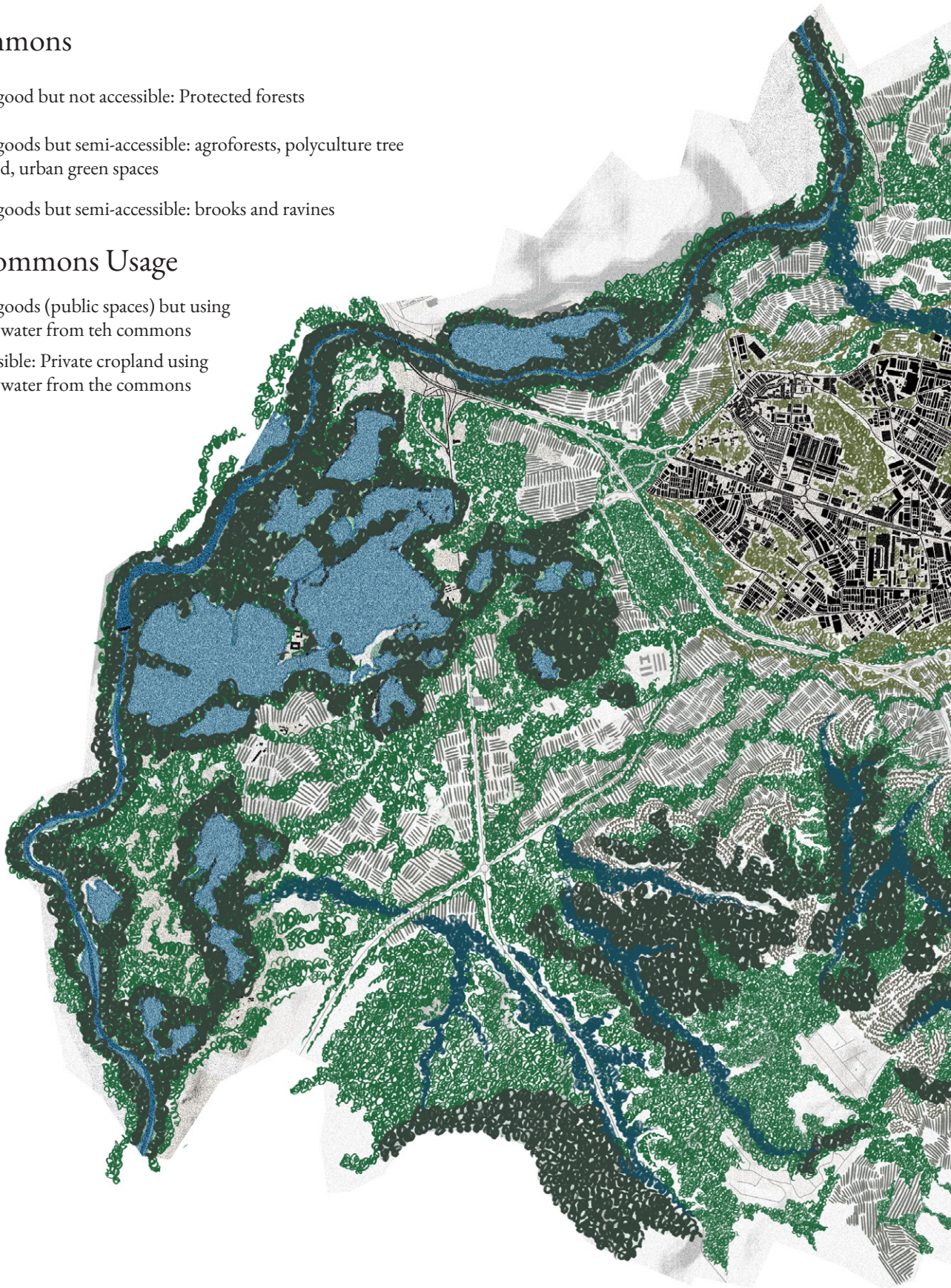
Public goods but semi-accessible: agroforests, polyculture tree cropland, urban green spaces

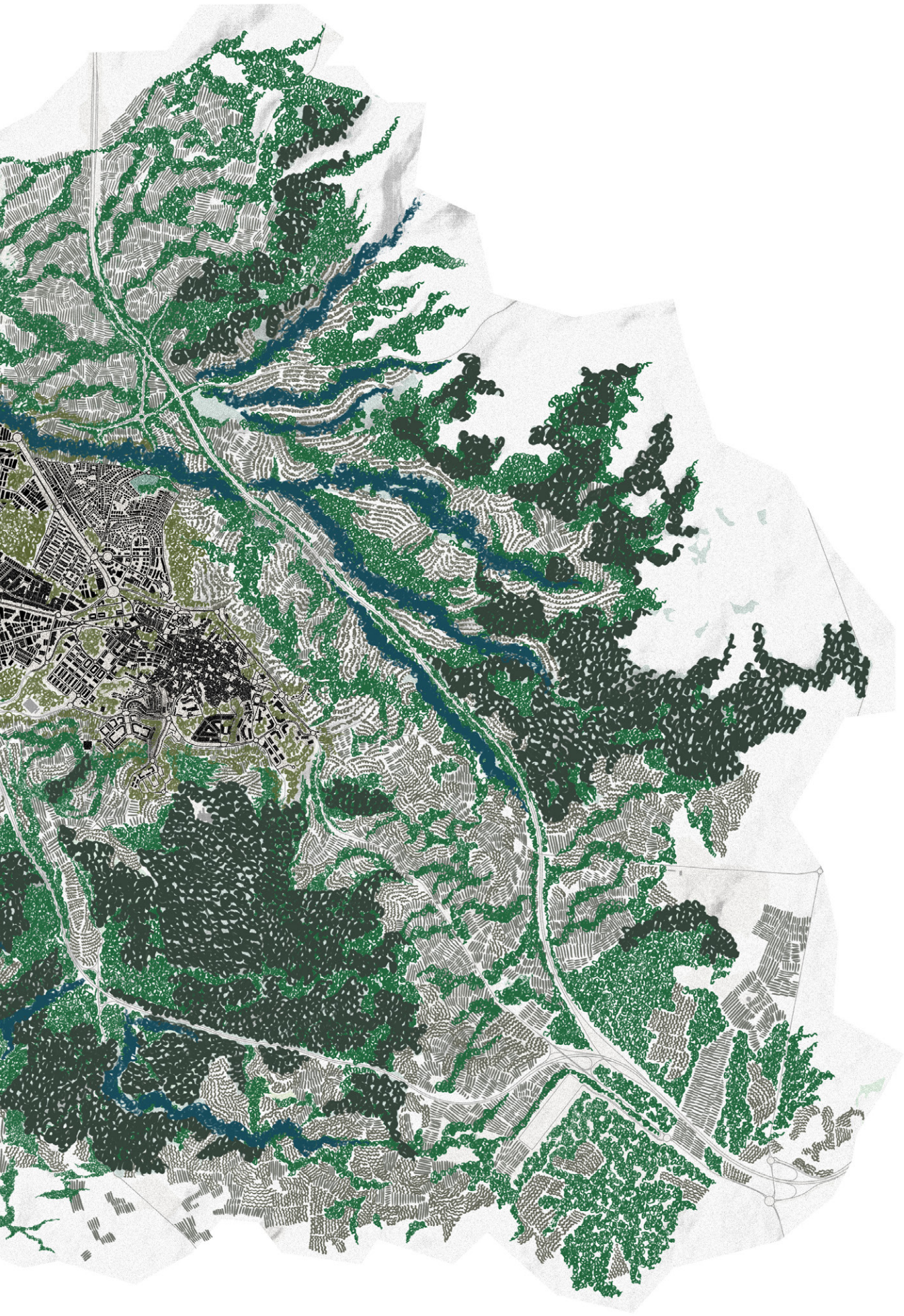
Public goods but semi-accessible: brooks and ravines

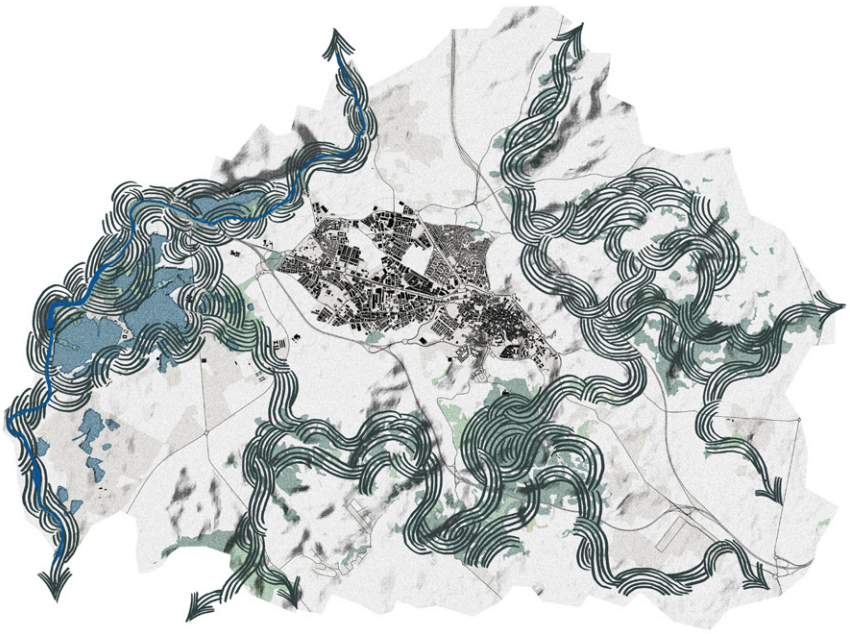
Partial Commons Usage

Public goods (public spaces) but using limited water from teh commons

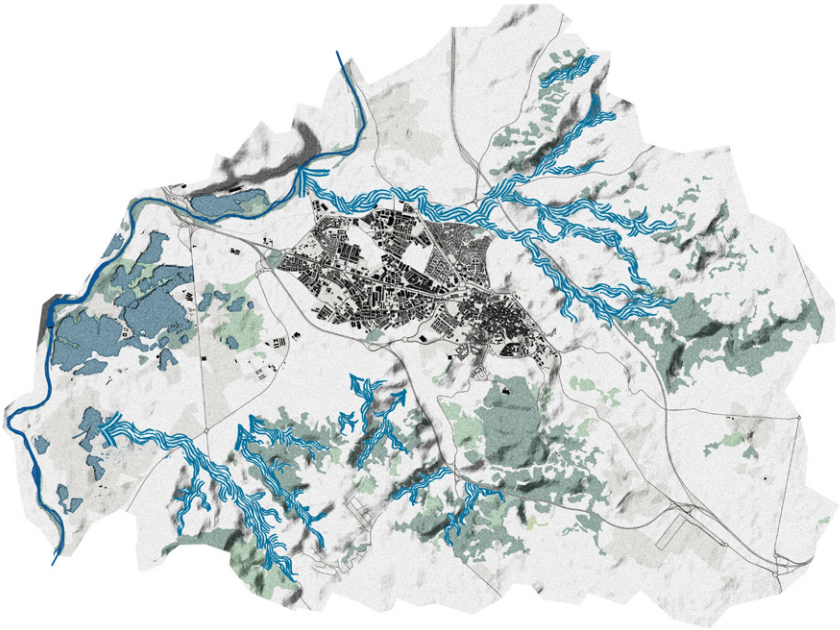
Inaccessible: Private cropland using limited water from the commons





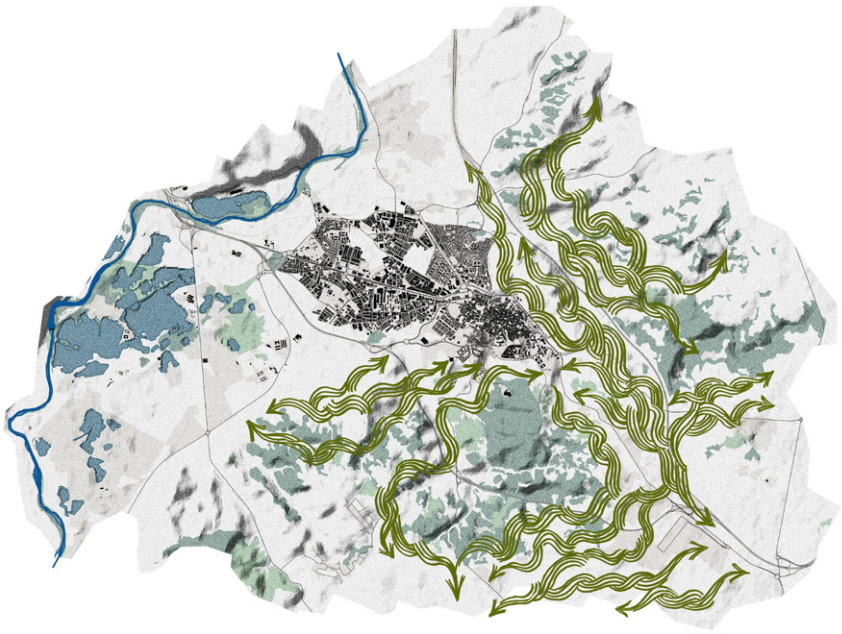


Connecting forests from brook and ravine systems to the Jarama

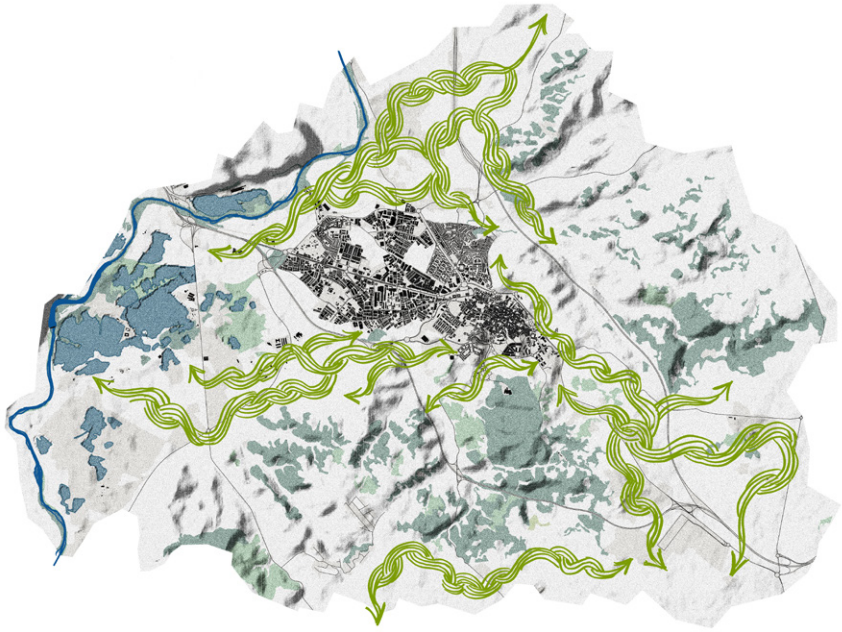


Strengthening brook and ravine systems and connecting them to other water bodies

Following the river basin plan is the design proposal is a spatial plan for Arganda del Rey. This will be based on the river basin plan and elaborated in more detail according to its context. In the aforementioned, there are some unique landscape features, such as brooks, ravines and forests that connect to the river that have been altered due to

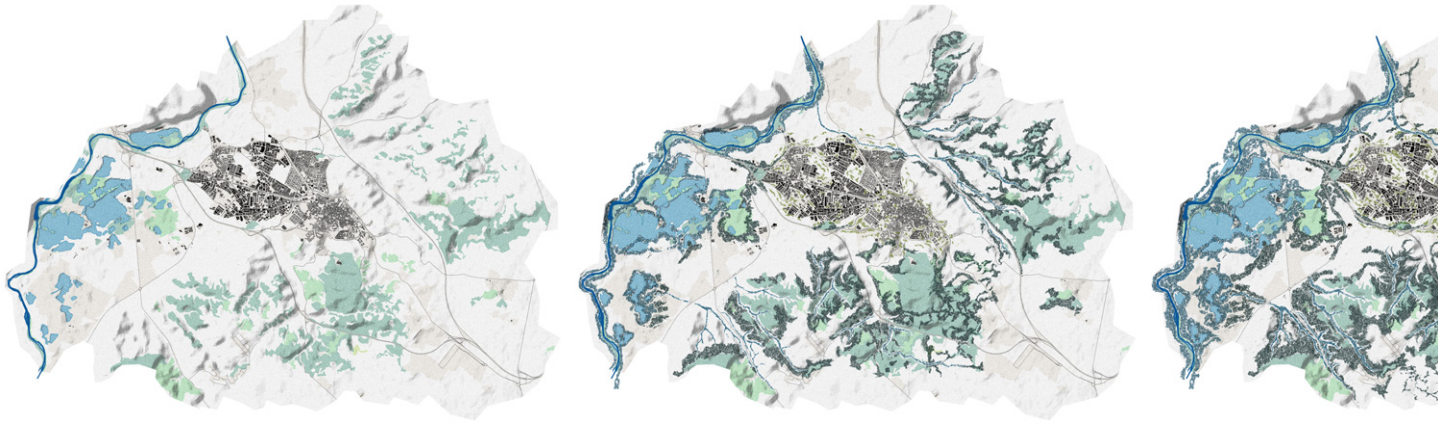


Tree crops and vineyards on higher terrain surrounding Arganda del Rey



Low-terrain cropfields to be spread across gentler terrain / flat land

dominating agriculture activity. Hence the design concept explores these areas as centrepieces of the local commons. Although most parts of this plan are dependent on the cooperation of the farming community, the visionary plan will proceed as an imagined ideal situation.

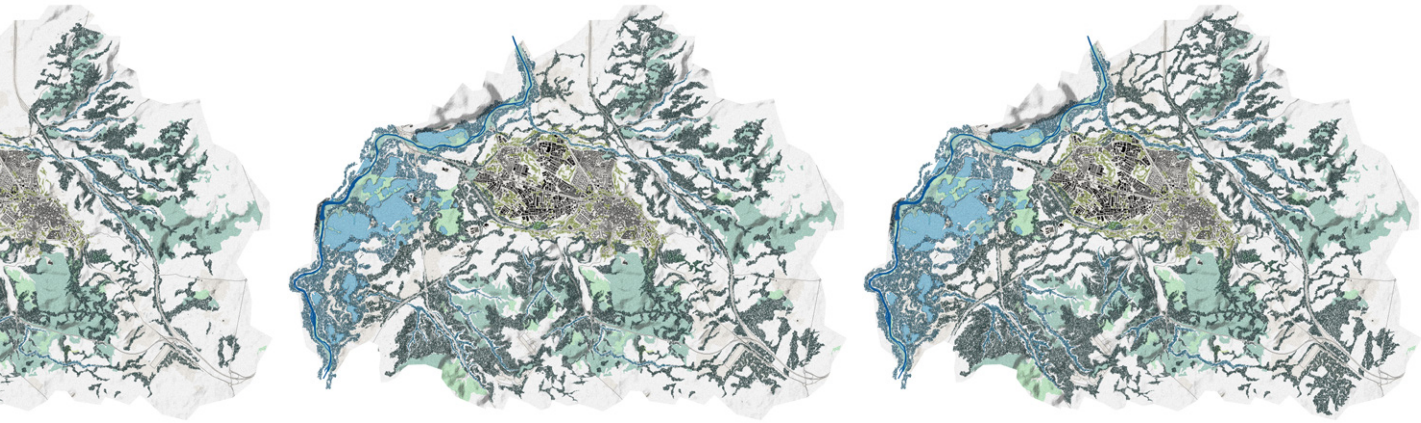


Now *In 6 - 8 years* *In 9 - 15 years*

What long-term environmental strategies can be used to achieve the collaborative potential of the landscape commons?

Freshwater withdrawals for agriculture in Spain have shown notable variations over the years. In 2003, the total withdrawal was 35.5 billion cubic meters. By 2012, this figure had increased to 36.8 billion cubic meters. This was the year of Spain's first intense drought since the 1940s. However, since then, the climate situation only got worse. The spike in water withdrawals in 2012 were largely due to an increased need for water and a lack of effective policies. However, by 2020, withdrawals had decreased to 29 billion cubic meters (World Bank Open Data, n.d.). This was owed to the implementation of new restrictions and less amount of water available. There are again, caveats to this, as many in the agricultural industry resorted to building illegal and unregulated wells that were difficult to gather data on. Additionally, considering that profligate water consumption by households, industries and agriculture in the past, it is difficult to distinguish what proportion of water was necessary and what proportion was wasted.

Forest areas can significantly enhance groundwater recharge rates, increasing them

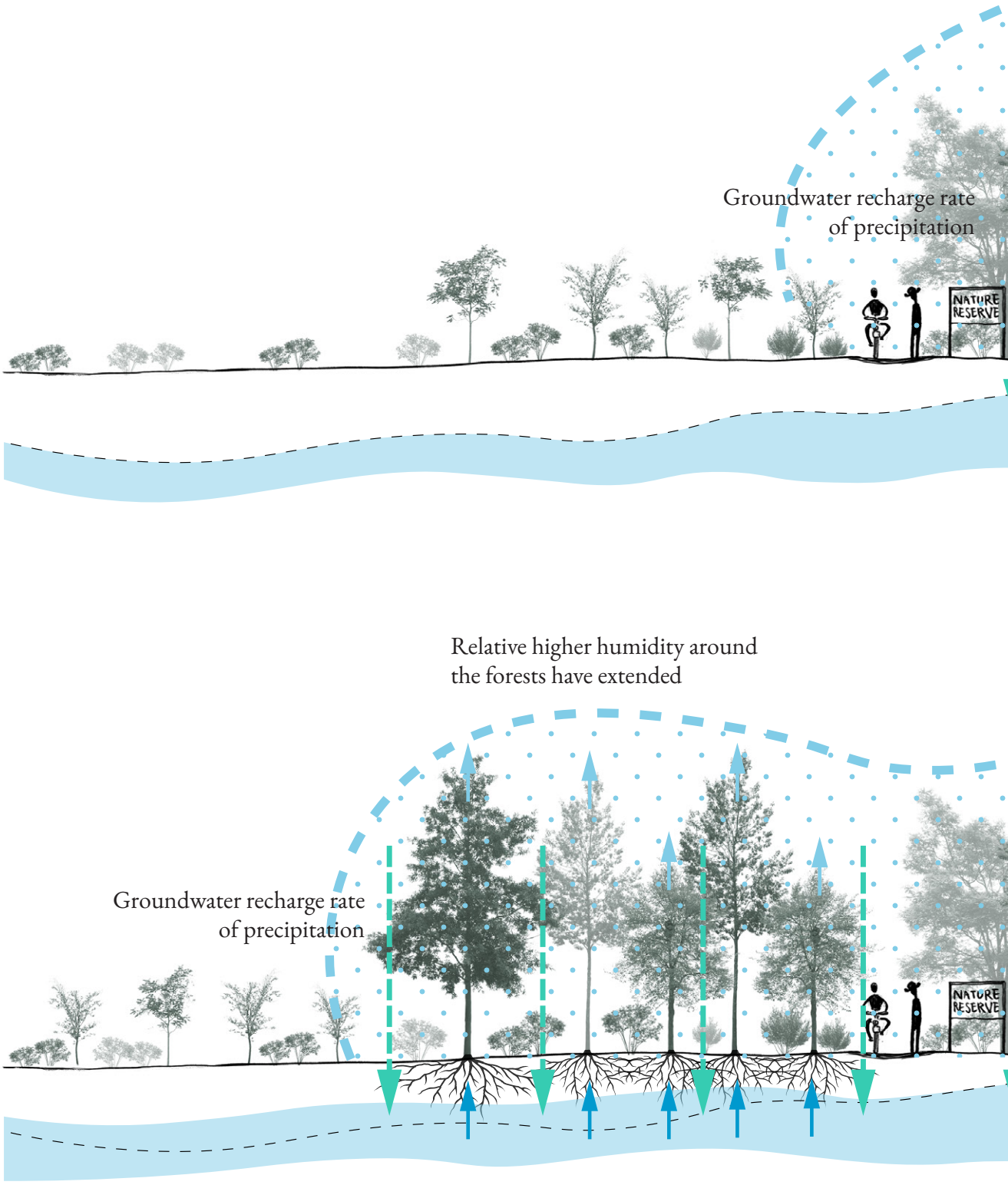


In 16 - 23 years

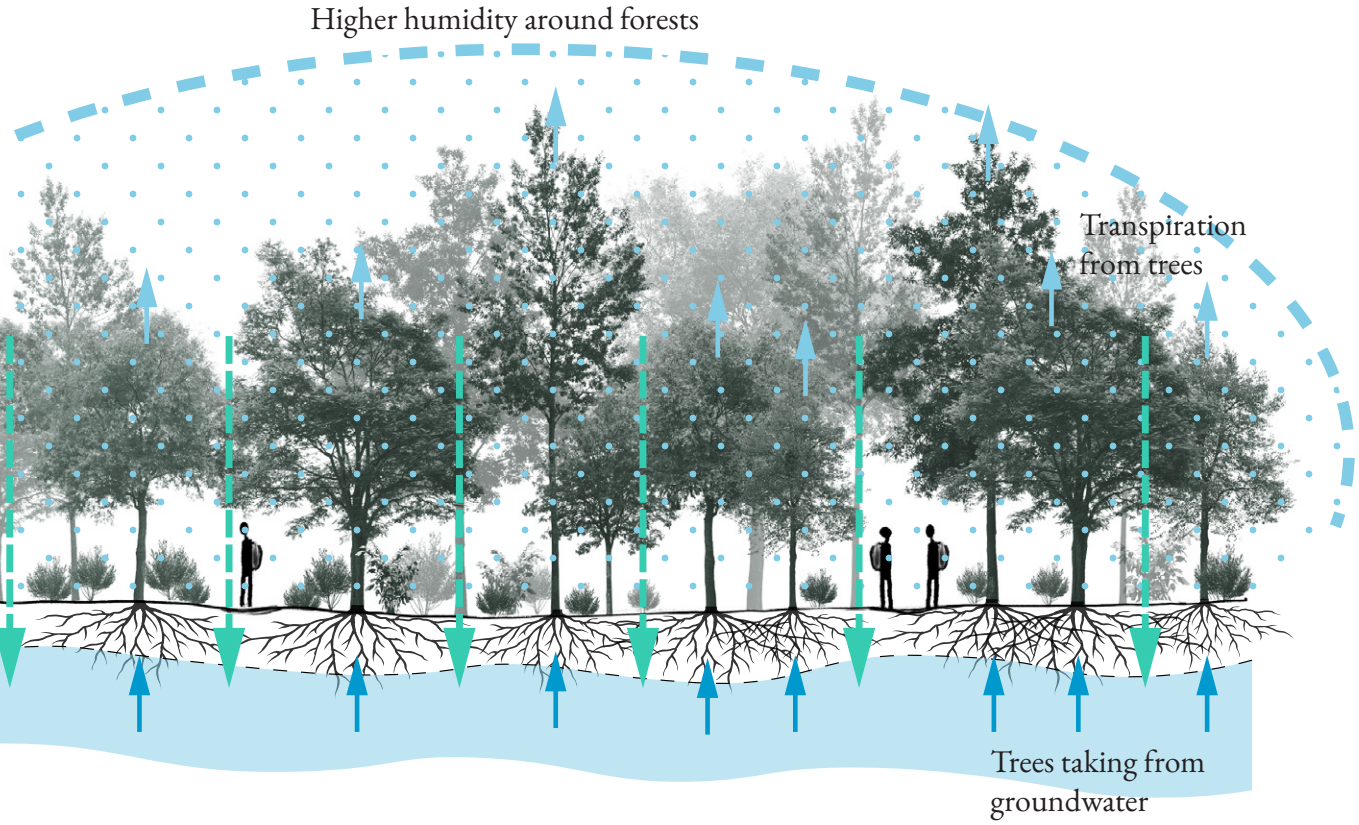
In 24 - 30 years

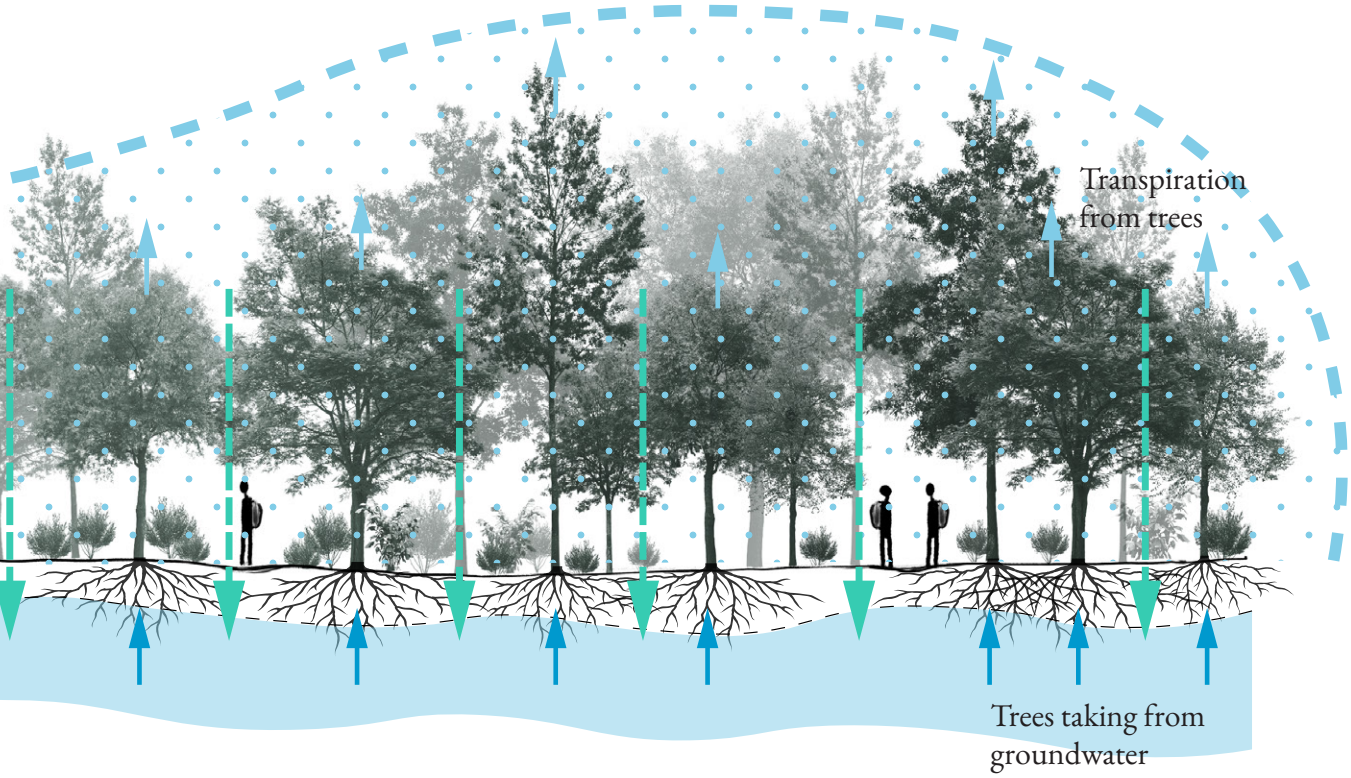
by 1.5 to 2 times compared to shrubland, grasslands, and barren lands (Mongil-Manso et al., 2022). The effectiveness of this increase depends on the type of soil and vegetation, with shallow-rooted systems such as pine forests being particularly effective at enhancing water infiltration into the soil and elevating groundwater levels. Pine forests are particularly effective in increasing groundwater recharge rates at nearly twice that of other habitats. Increasing forest cover by about 3 - 5% annually from now until 2050 could improve the annual water supply to compensate for water lost due to the global climate crisis. In regions like Arganda, which currently have low forest cover, maintaining this rate of afforestation could potentially double the total forest cover by 2050 or more. This would significantly replenish the water supply, supporting current water needs and usage. This is also congruent with the Spanish Forest Policy (EFE2050), which aims to achieve a state total of 0.6 million hectares of new forests by the end of 2050, which is equivalent to about 20,000 hectares per year (Ministerio para la Transición Ecológica y el Reto Demográfico, 2022).

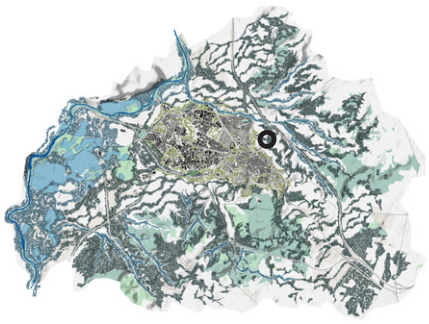
Ideally, these forest expansions should begin from edgees of existing forests each time as the water content in the soil and humidity of the areas nearest to the forests are relatively high and regulated by these habitats.



Sections showing how forests can be extended from the edge of existing forests.


Higher humidity around forests
Transpiration from trees
Trees taking from groundwater


Transpiration from trees
Trees taking from groundwater

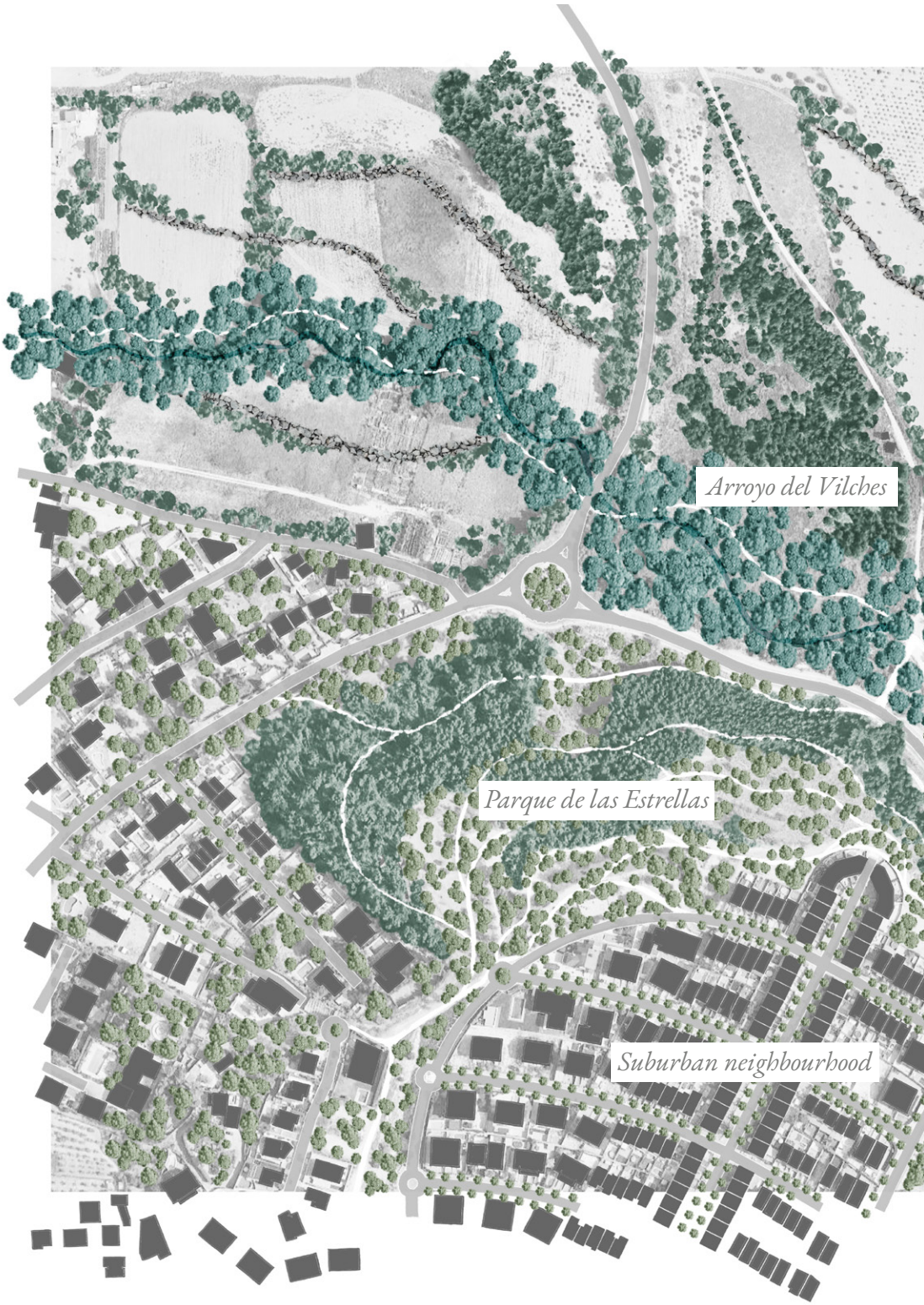


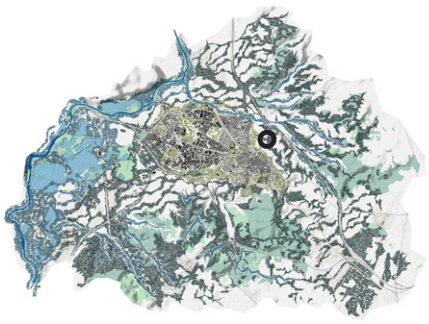
This detailed design follows the decision to connect the different types of landscapes - the tamed urban landscapes of the Parque de las Estrellas, the riparian vegetation around the Arroyo del Vilches, the preserved forests around the area and the private cropland.

Forest connection

Park connections

Riparian connection of the arroyo





Enlarged site plan of a suburban area and park near Arroyo del Vilches

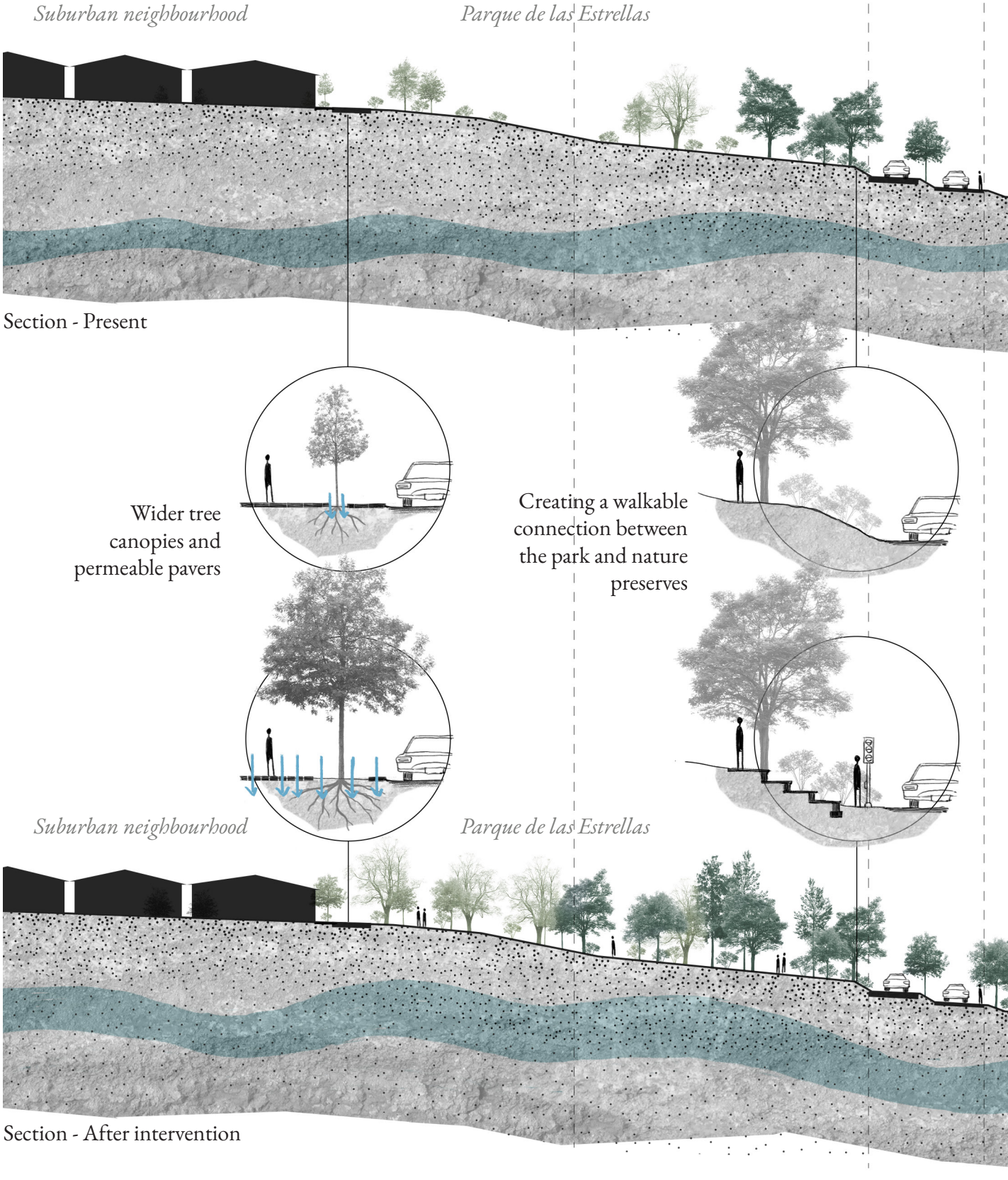
Protected forests / nature reserves

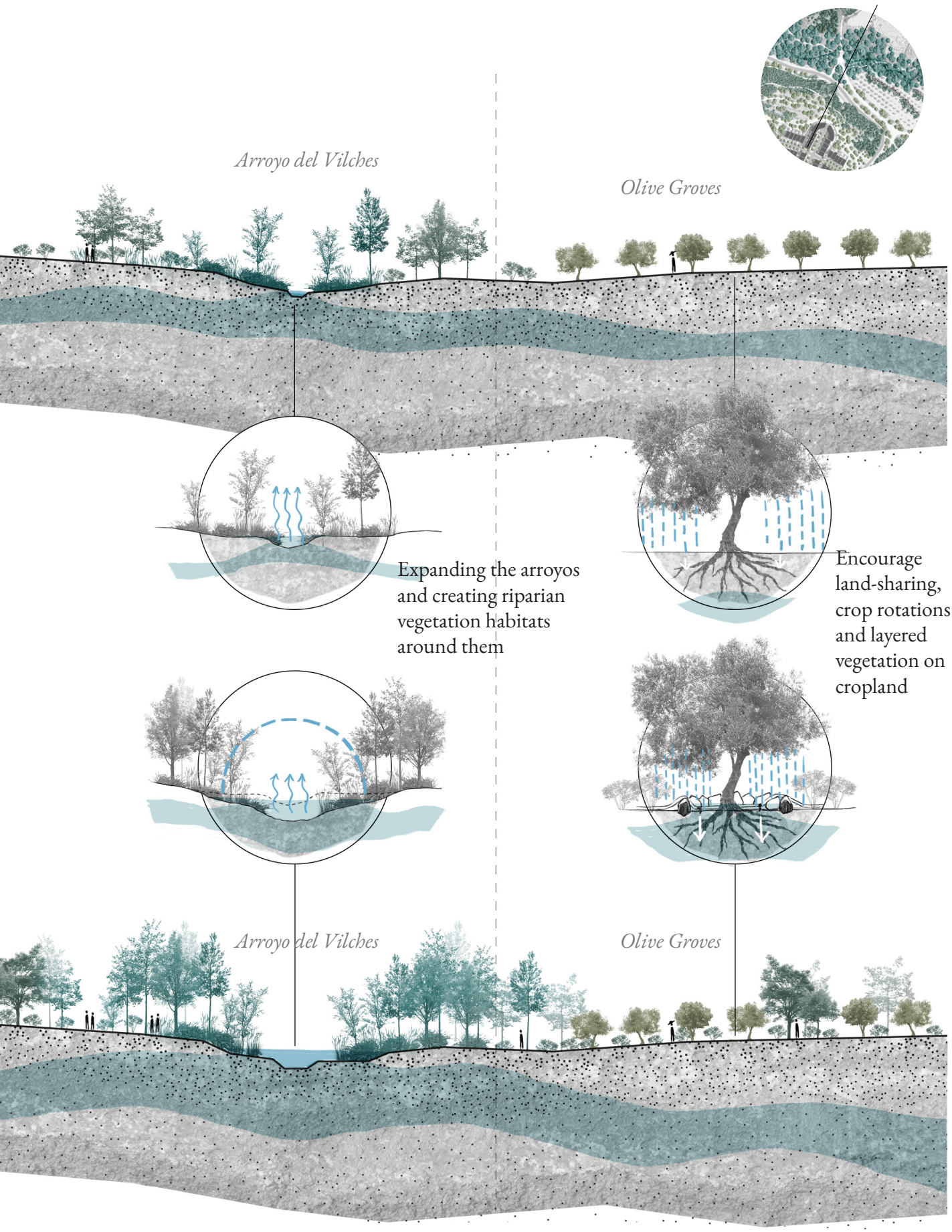
Agroforests

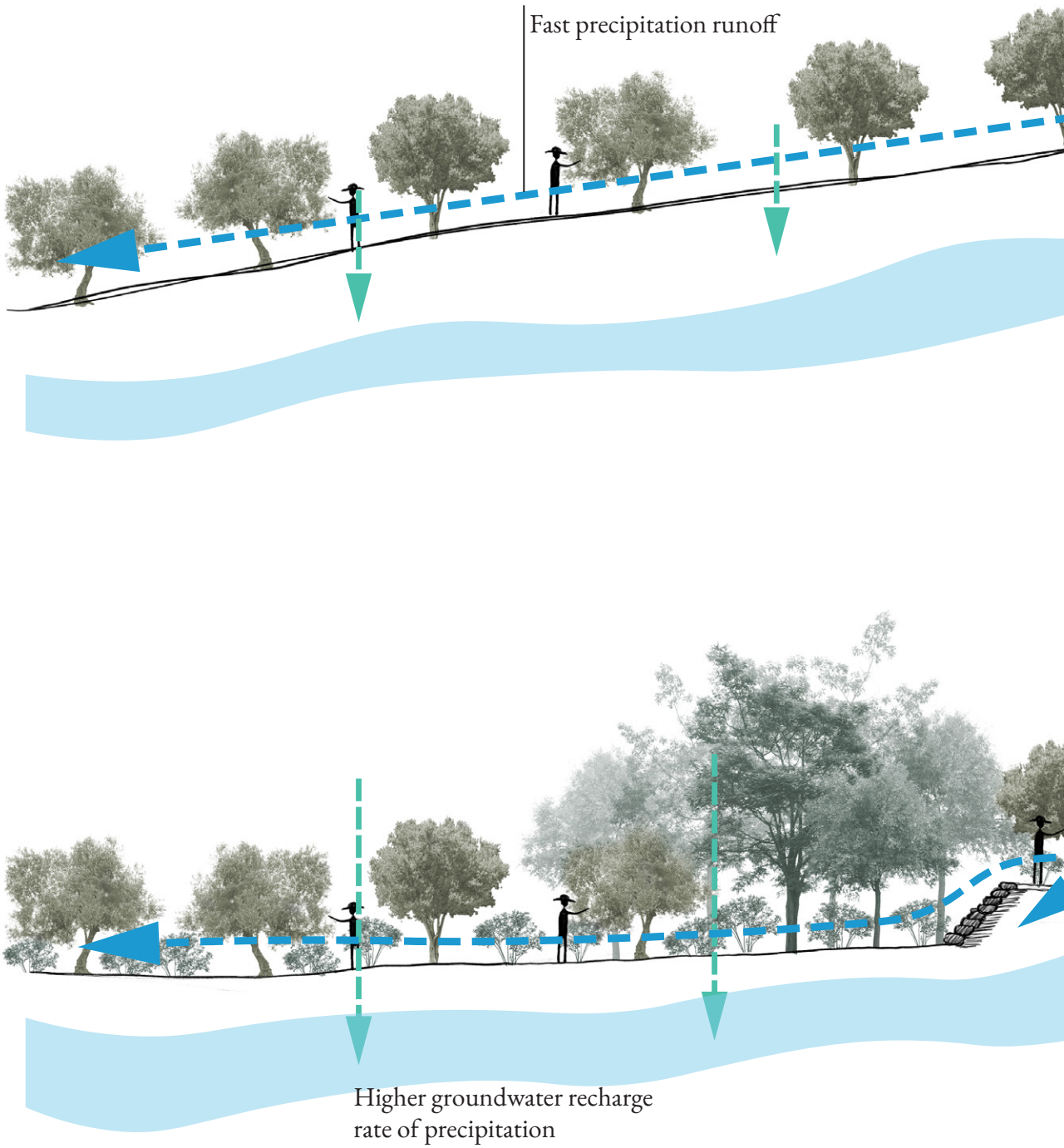
Riparian forests of Arroyo del Vilches

Parks and Urban Green Spaces

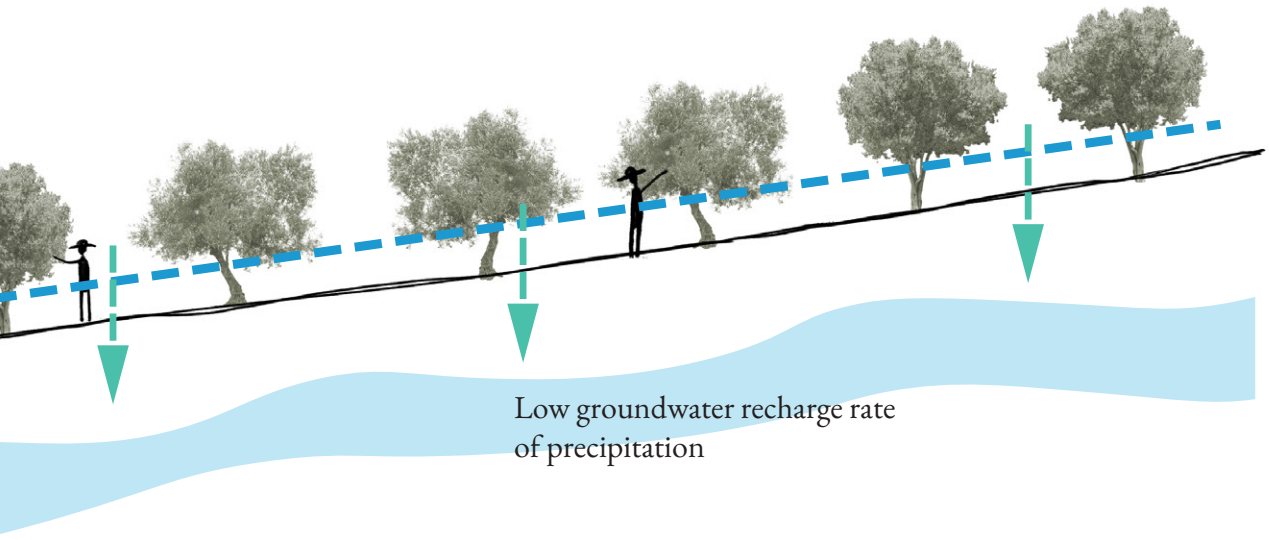
What short-term environmental strategies can be used to achieve the collaborative potential of the landscape commons?



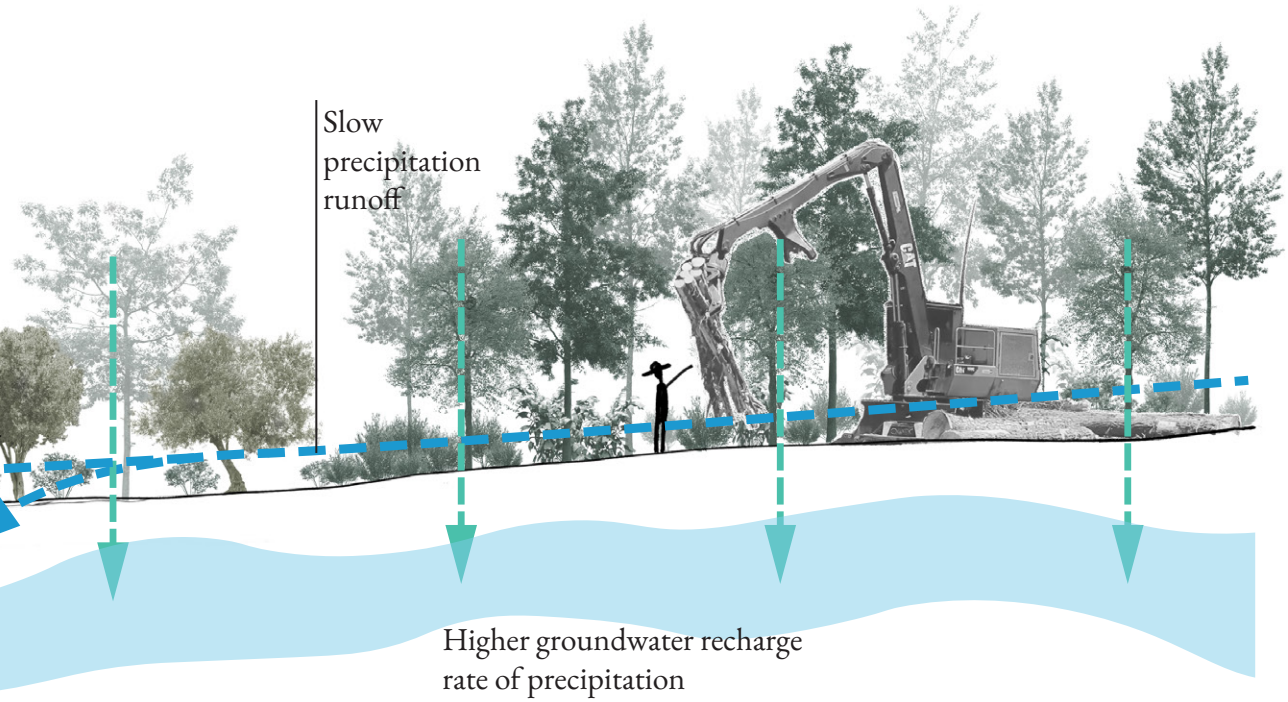

Arroyo del Vilches
Olive Groves
Expanding the arroyos and creating riparian vegetation habitats around them
Encourage land-sharing, crop rotations and layered vegetation on cropland
Arroyo del Vilches
Olive Groves



How changes such as terraces, layering and afforestation along cultivated slopes can improve rate of groundwater recharge.

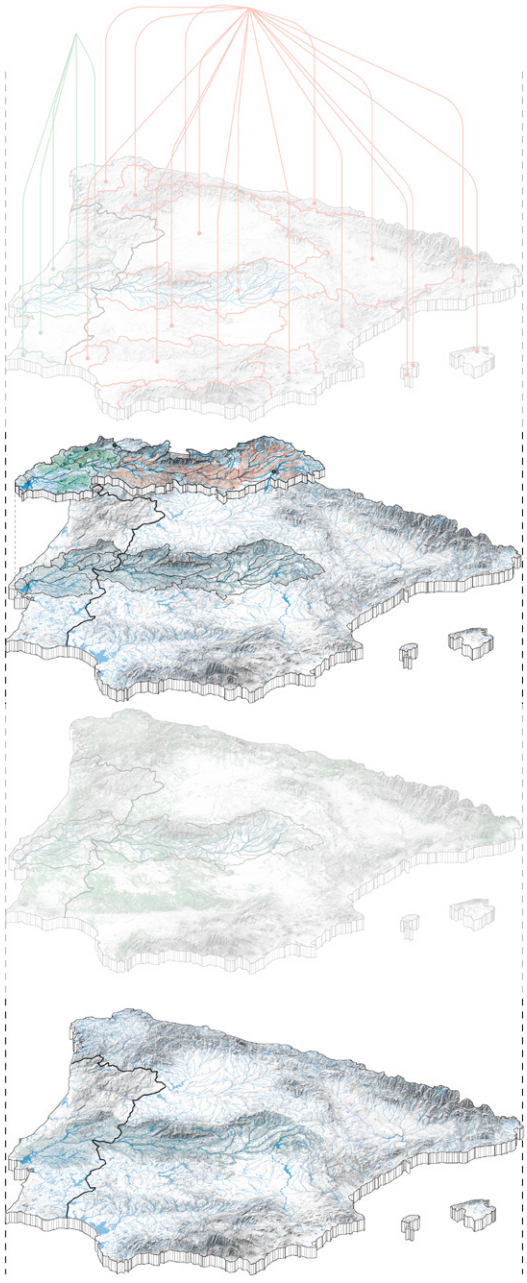


Low groundwater recharge rate
of precipitation



Higher groundwater recharge
rate of precipitation

An imagined transformation of the landscape from now and through the process of implementing the commons, formed with collages of landscape paintings from the 1850s by Carlos de Haes, a Spanish-Belgian artist.



Systems of Society

Landscape Commons

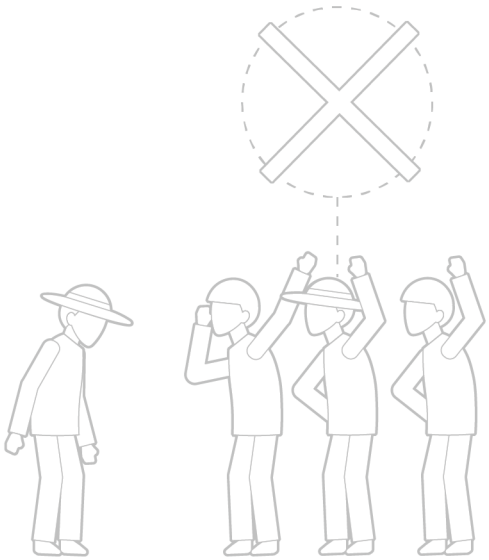
Systems of Society

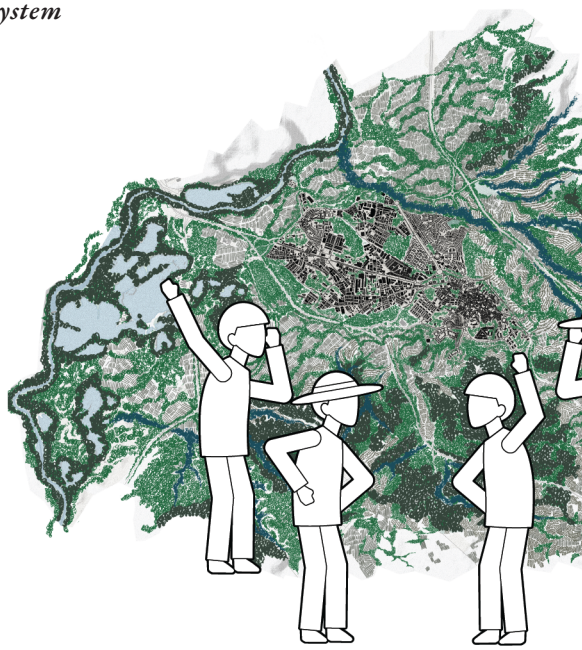
What are the responsibilities of the different communities and stakeholders in this collaborative system? In an ideal situation, all parts of the landscape will be part of the commons as a public good, but to achieve this will take an extensive period of change. Perhaps in the future this is possible when farming communities approach the industry with different perspectives. However, in the context of today's zeitgeist, designing the commons to facilitate this transition would be more relevant.

There is collaborative potential among the farming communities residing in the Tagus Basin. Many family farms were cultivated with generations of traditional practices and techniques, this could pose as a common ground amongst small to medium local farms that are most vulnerable to the droughts and water restrictions. As most of the large intensive farms in Spain are located in the south and southeast of the country, most farms within the Tagus Basin are these small to medium agricultural establishments. For most of these families, their land and property, like their family business traditions, were passed down for generations. These are parts of the landscape that also inherit community identity and heritage.

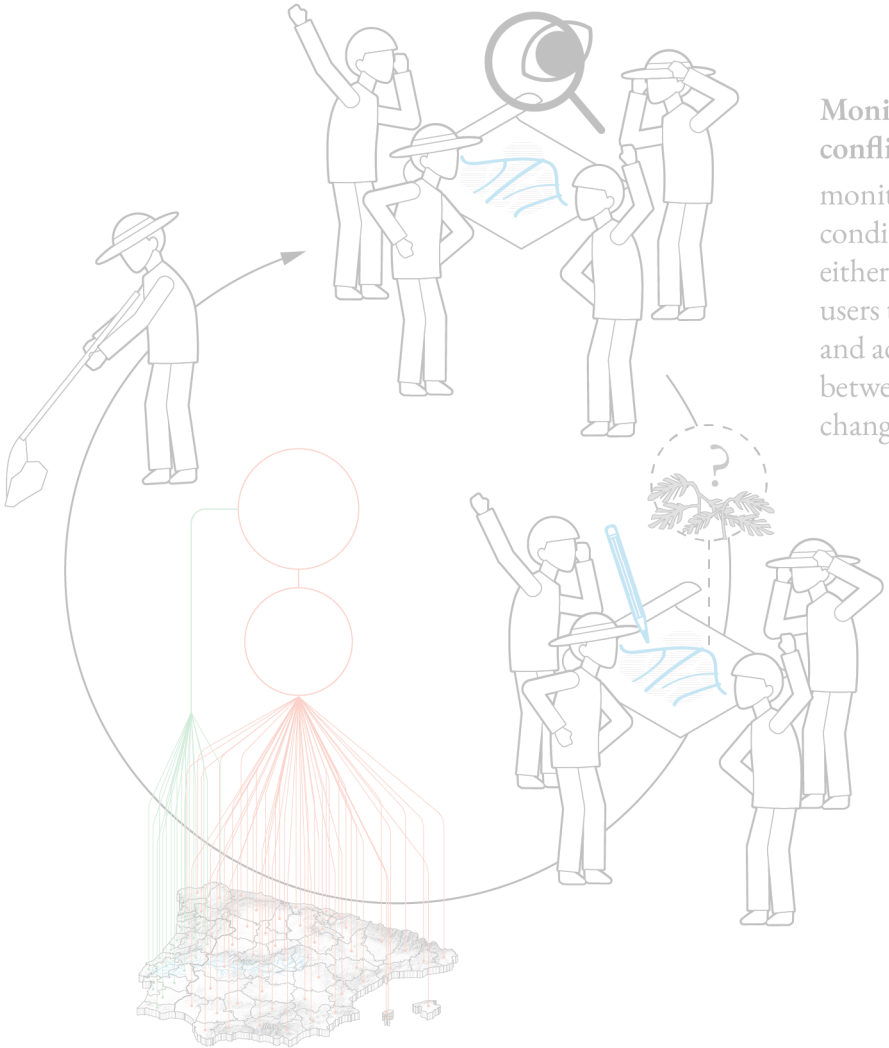
While agriculture in Arganda del Rey now contributes only a small portion of the city's GDP, there is a lot of history and culture to the olive groves, vineyards and grains that are cultivated in the landscapes. It could be transformed into something that the rest of Arganda and even Spain appreciate as a preserved cultural landscape as a public space – such as a recreational landscape for hikes and cyclists – under the rules of the commons. A concept for the zoning and levels of privacy is part of the proposal, detailing the different features of the aforementioned municipal plan and their corresponding functions.

The commons will consist of the expanded forest cover, existing forest land and the rivers, brooks and ravine systems that are connected by them. Forest cover expansions connect existing forest land to the river, brooks and ravines, they can be done by encouraging some farmers to adopt agroforestry or a polyculture of trees on their land. Part of the collaborative system will be the process of converting monoculture cropland or abandoned former cropland into cultural landscapes, agroforestry land or polyculture tree cropland. However, it was difficult to detail which areas were exactly abandoned cropland and which business had propriety over certain land. Thus, some assumptions were made in order to proceed with the visual representations in the spatial parts of this project.

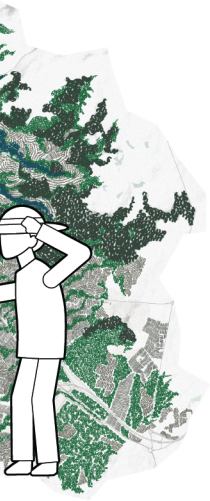




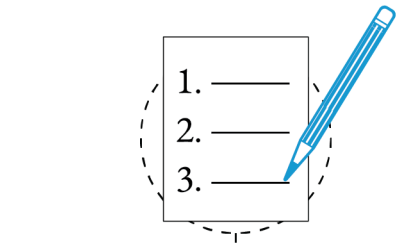
Graduated sanctions:
violators of the rules will be assessed by other users of the commons or officials that are accountable to the users.



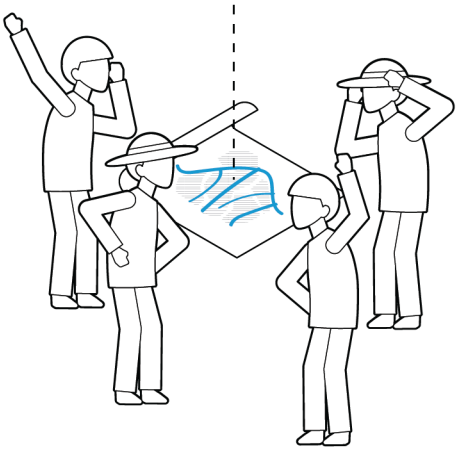
Monitoring and conflict-resolution system:
monitors will actively track conditions of the commons either report to the users or users themselves. Also an eff and accessible way to raise co between users, stakeholders changes to the environment



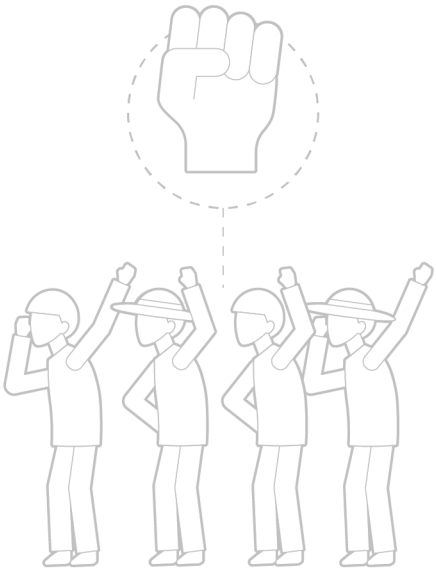
Clearly defined boundaries:
what the resources are and who have the rights to partake - stipulated in systems of society



Congruence between appropriation and provision rules and local conditions:
according to that stipulated in the systems of society



Collective -choice arrangements:
individuals participating in the commons can collaborate to form or change the rules that are mutually agreed upon



Minimal recognition of rights to organise:
users have rights to plan their institutions without rights being challenged by external forces.

What are the rules of the commons (and partial commons)?

New agroforests and polyculture tree cropland will be part of the extended forest network and will abide by rules of the new commons.

Conditions and provisions for Arganda agroforestry land:

1. Agroforests will become common land, where farmers will be able to harvest from any part of these forests within a stipulated limit.

2. An encouraged limit on the amount of wood that can be harvested by each person in the community.

3. Ensure forest layers by including understorey and shrubs / groundcover layers among crop trees.

4. Alternatively, farmers can involve crop diversification with less pressure to provide vegetation layering.

5. Harvesting of wood resources will be done mechanically and regular maintenance will be done using approved sustainable methods.

6. Farmers of agroforests will be able to use the water from the protected brooks and ravines.

7. Brooks, ravines and existing forests will be preserved and maintained.

The remaining cultivated land will become a part of the landscape as a representation of traditional local cultivation. Under this arrangement, landowners will be protected and required to employ eco-schemes in exchange for using water from rivers and streams from enhanced brooks and ravines to some extent.

Conditions and provisions for the partial commons:

1. Part of the cultivated land will be encouraged to be devoted to sustainable non-productive uses, for example, forest growing.

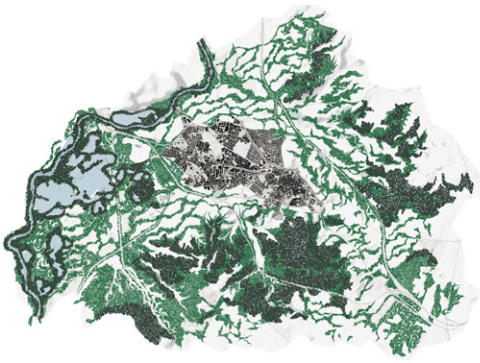
2. Farmers should practice crop rotations or land-sparing across the land area they own.

3. Use of vegetation layering together with crops.

4. Farmers can draw a limited amount of water from the ravines and brooks, proportional to the size of their agricultural businesses.

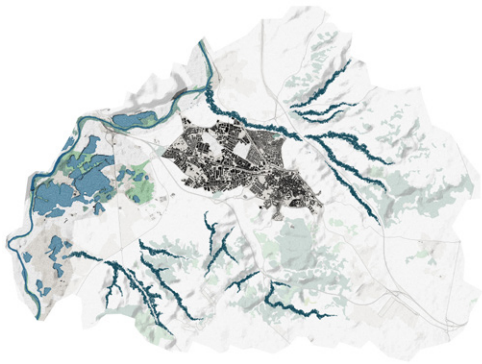
5. Use of approved seasonal irrigation rotations. During wet seasons, farmers will use traditional acequias – a variety of traditional Spanish irrigation methods – to gather water from rainfall and route them to irrigate crops. During dry seasons, more mechanical means such as drip / localised irrigation should be used to reduce water consumption.

The Commons



Protected forests, agroforests and polyculture tree crops

Existing forests are strictly protected. Farmland or abandoned land will be recommended to adopt agroforestry or vegetation layers to become more polycultural. These will form the commons where farmers can freely harvest and use water from the commons in exchange for sustainable maintenance.



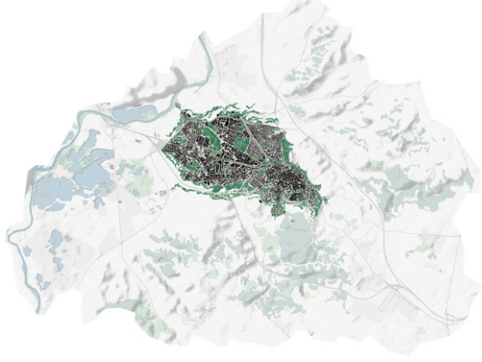
Brooks and ravines

Channels in brooks and ravines will be widened and have their banks reinforced with small riparian forests. Cropland along these brooks and ravines will incorporate these features on their land as part of their eco-schemes. These will also be part of the commons.

Partial Commons Usage

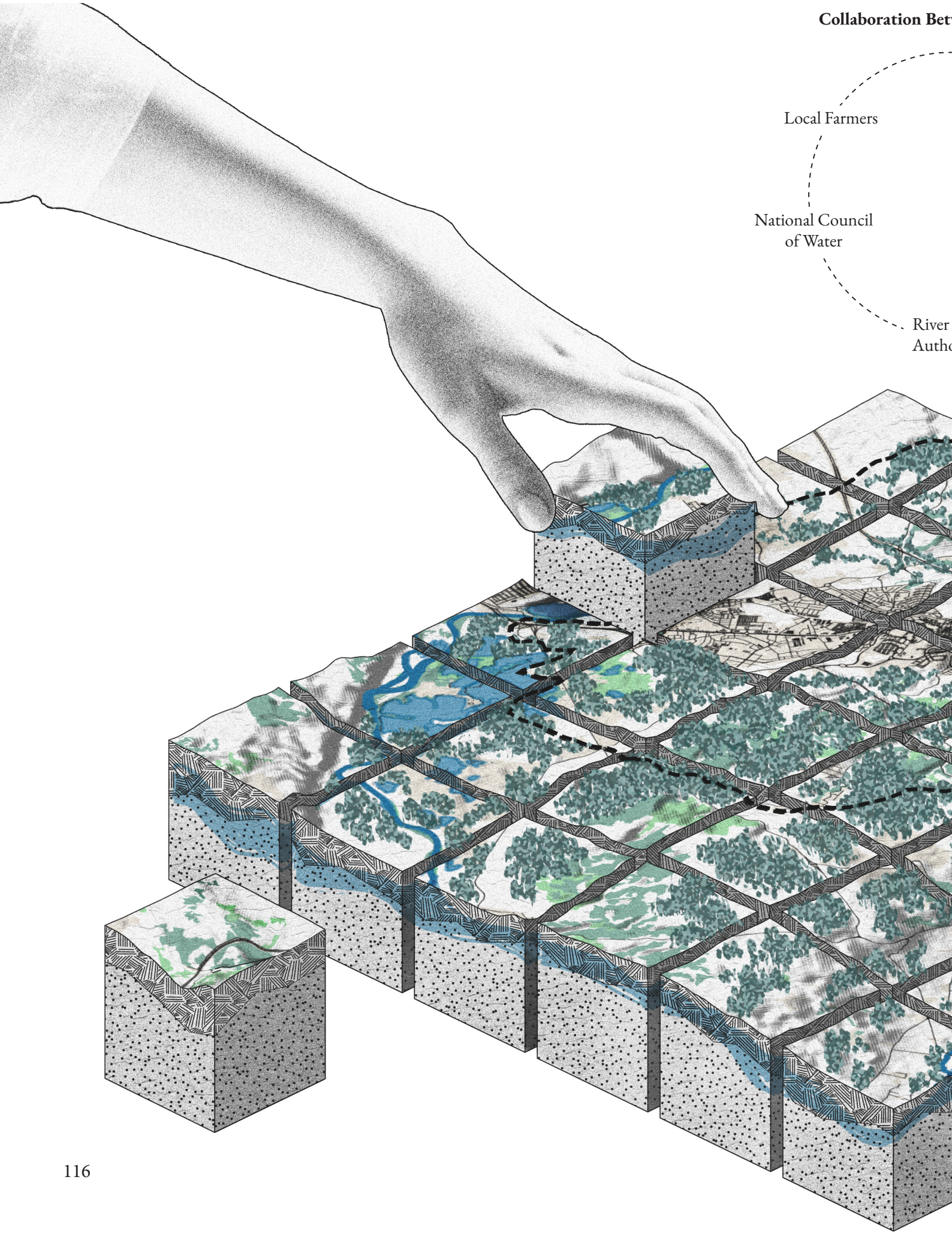
Private cultivated land

These landscapes will adopt seasonal irrigation rotations. Wet seasons will allow them to use traditional acequias while dry seasons will let them use localised / drip irrigation. Some aspects of the eco-schemes are encouraged, such as growing of non- productive features and crop rotations.

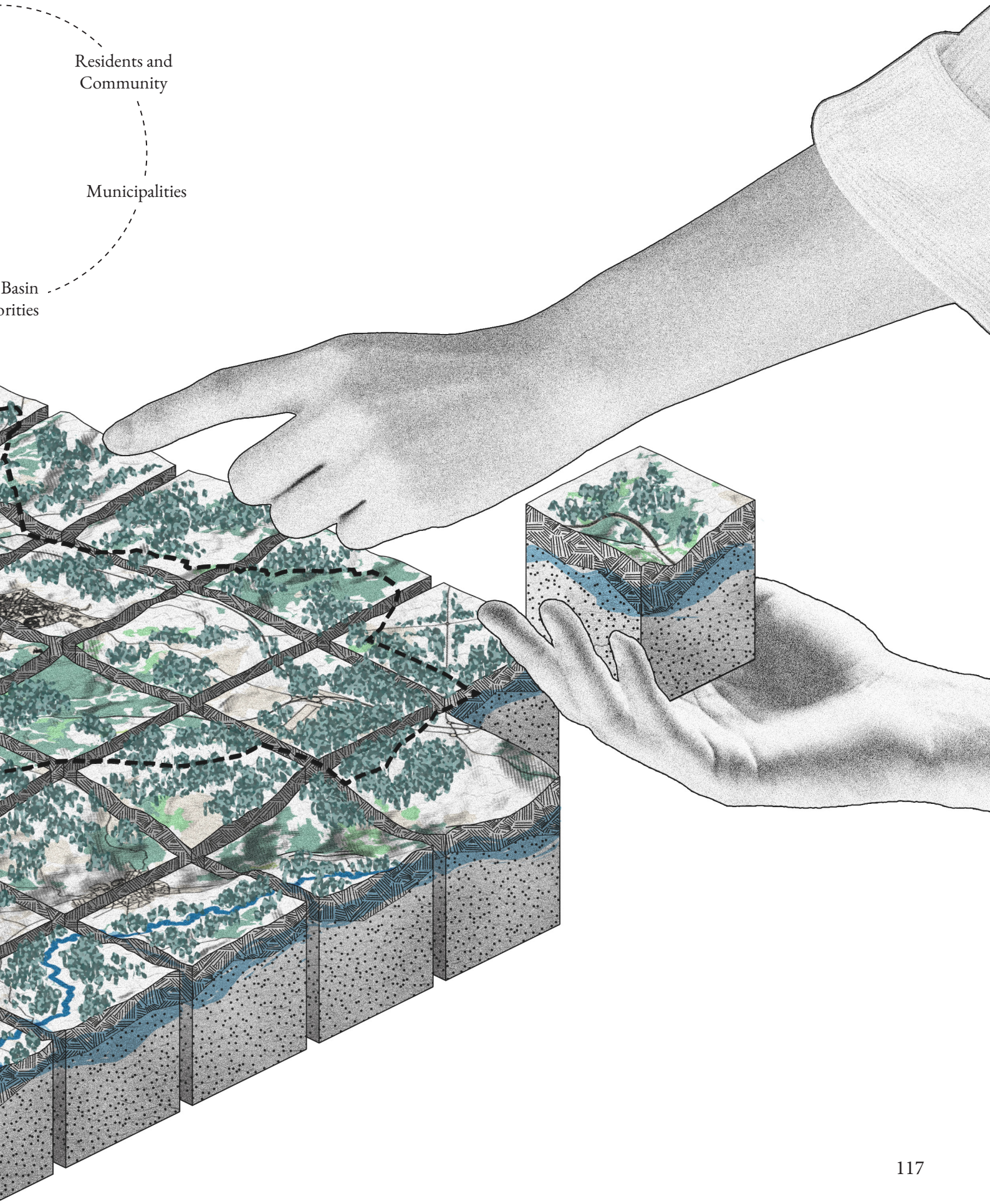


Urban landscapes

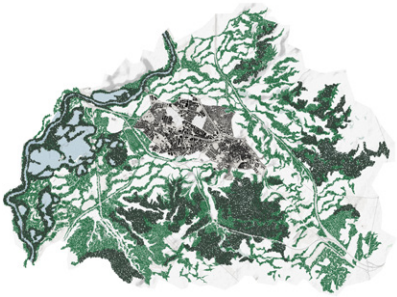
Parks will be extended to connect to the commons. Greenery planted along road sides will strive towards layered planting and trees with wider canopies to reduce urban heat island effects. Other features like permeable pavers will be recommended to allow urban runoff and precipitation to seep into the soil more easily.


Collaboration Bet
Local Farmers
National Council
of Water
River
Autho

ween Stakeholders



What are the boundaries of the commons?

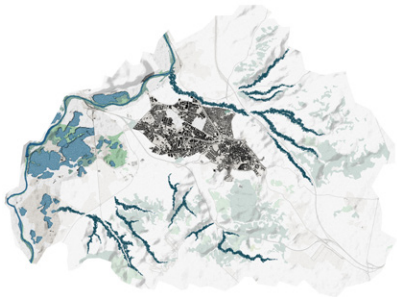


Levels of Accessibility for protected forests, agroforests and polyculture tree crops

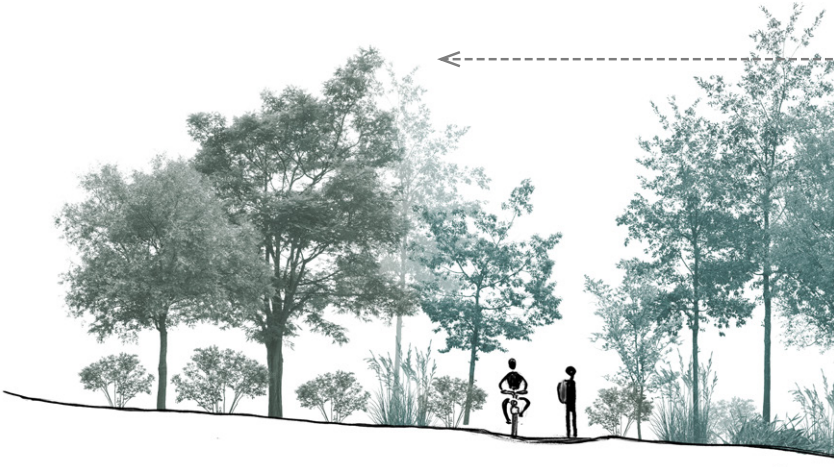
Agroforests

Farmers participating in the commons only

Protected Forests & Nature Reserves



Levels of Accessibility for brooks and ravines

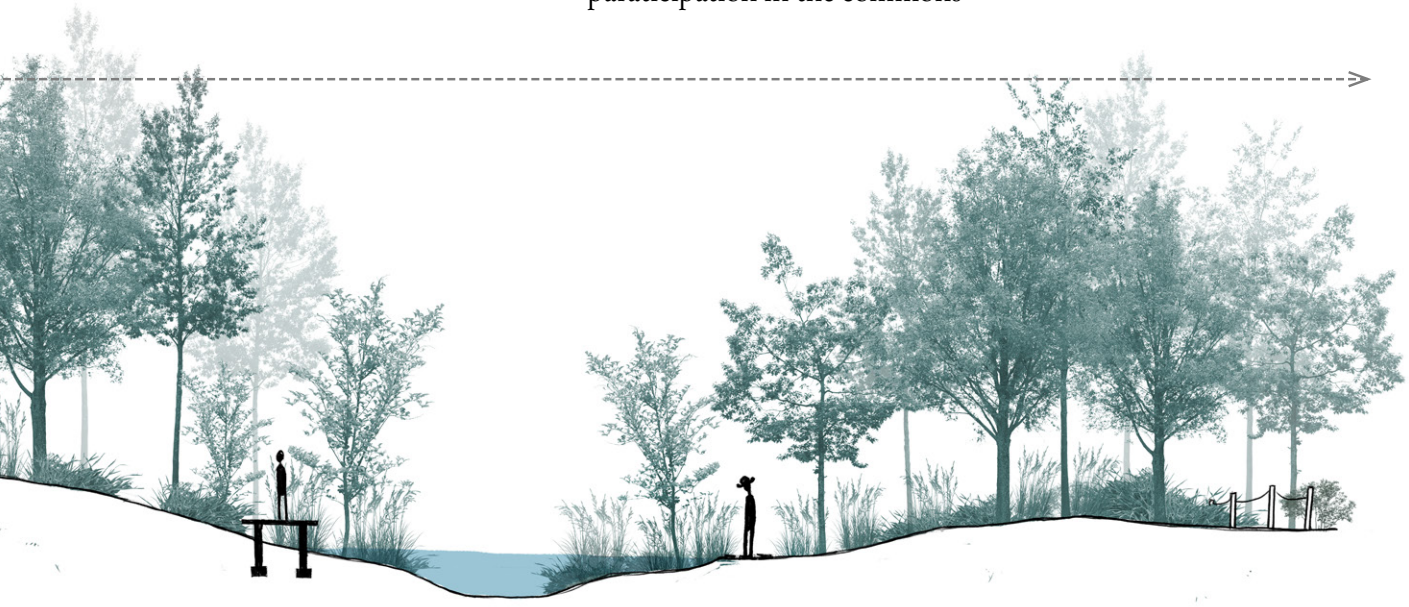


Protected Forests & Nature Reserves

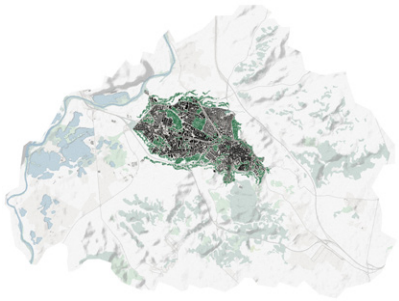
Members of the public and community can enjoy the outdoors but not stray from paths. Rangers of the commons also patrol the area.

Brooks & Ravines

Members of the public and community can enjoy the outdoors but not stray from paths. Farmers can use amounts of water depending on their paraticipation in the commons



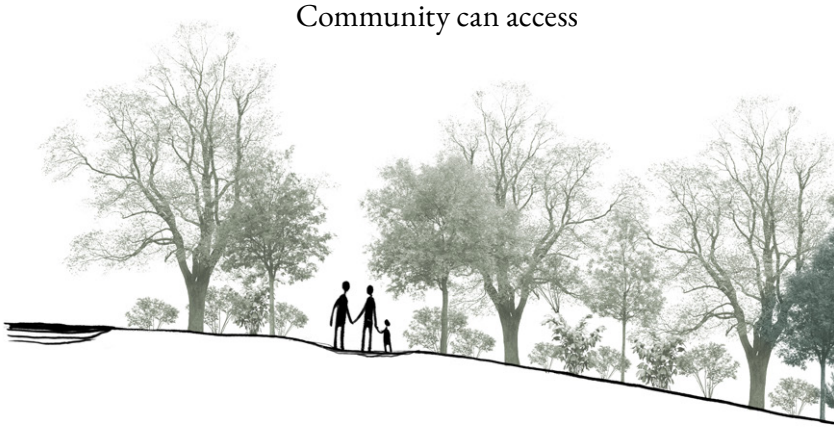
What are the boundaries of the partial commons?



Levels of Accessibility for urban landscapes

Parks (Public Green Spaces)

All members of the Community can access



Private-owned Cropland

Farmers or owners of the land only.

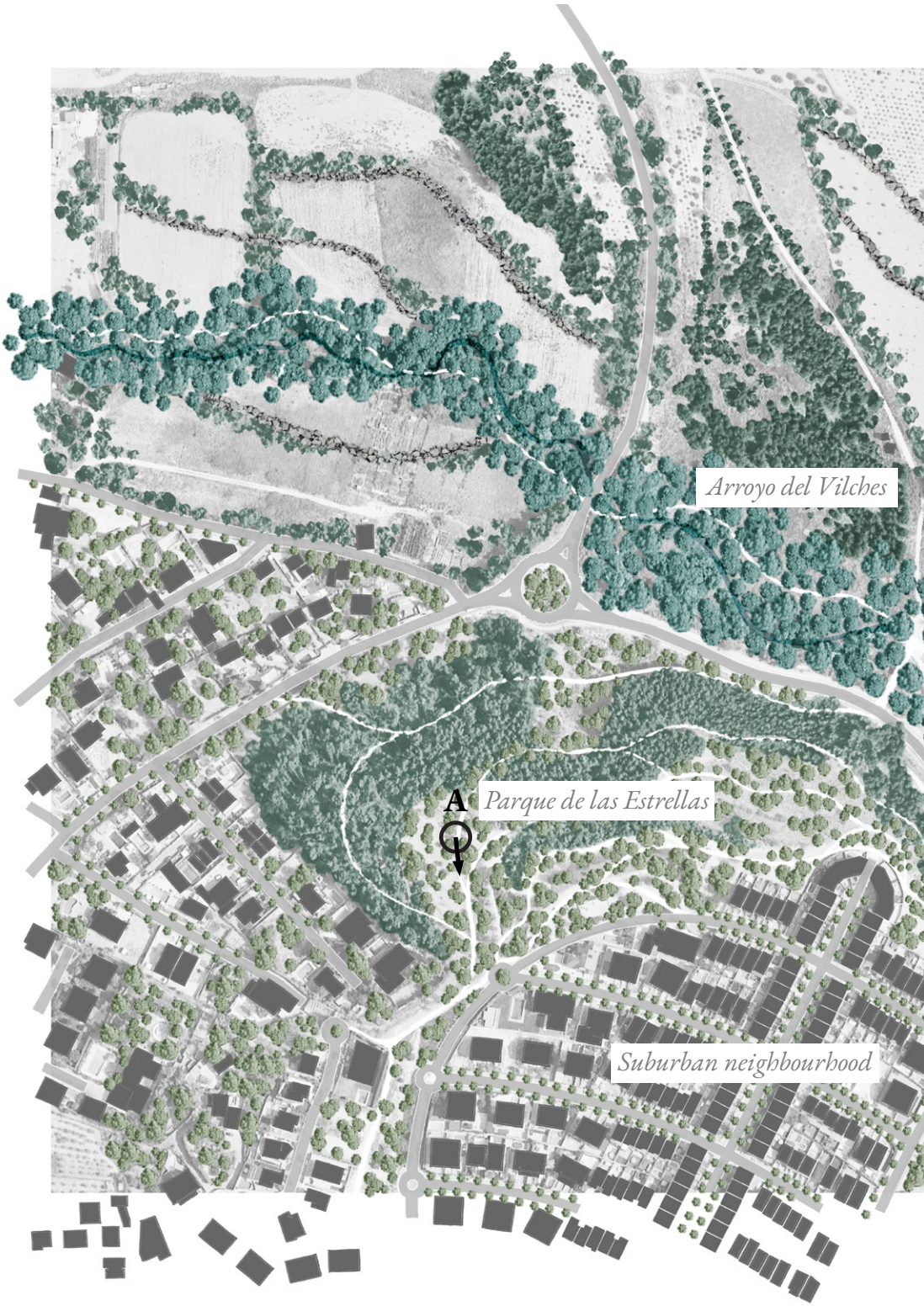
Levels of Accessibility for private cropland

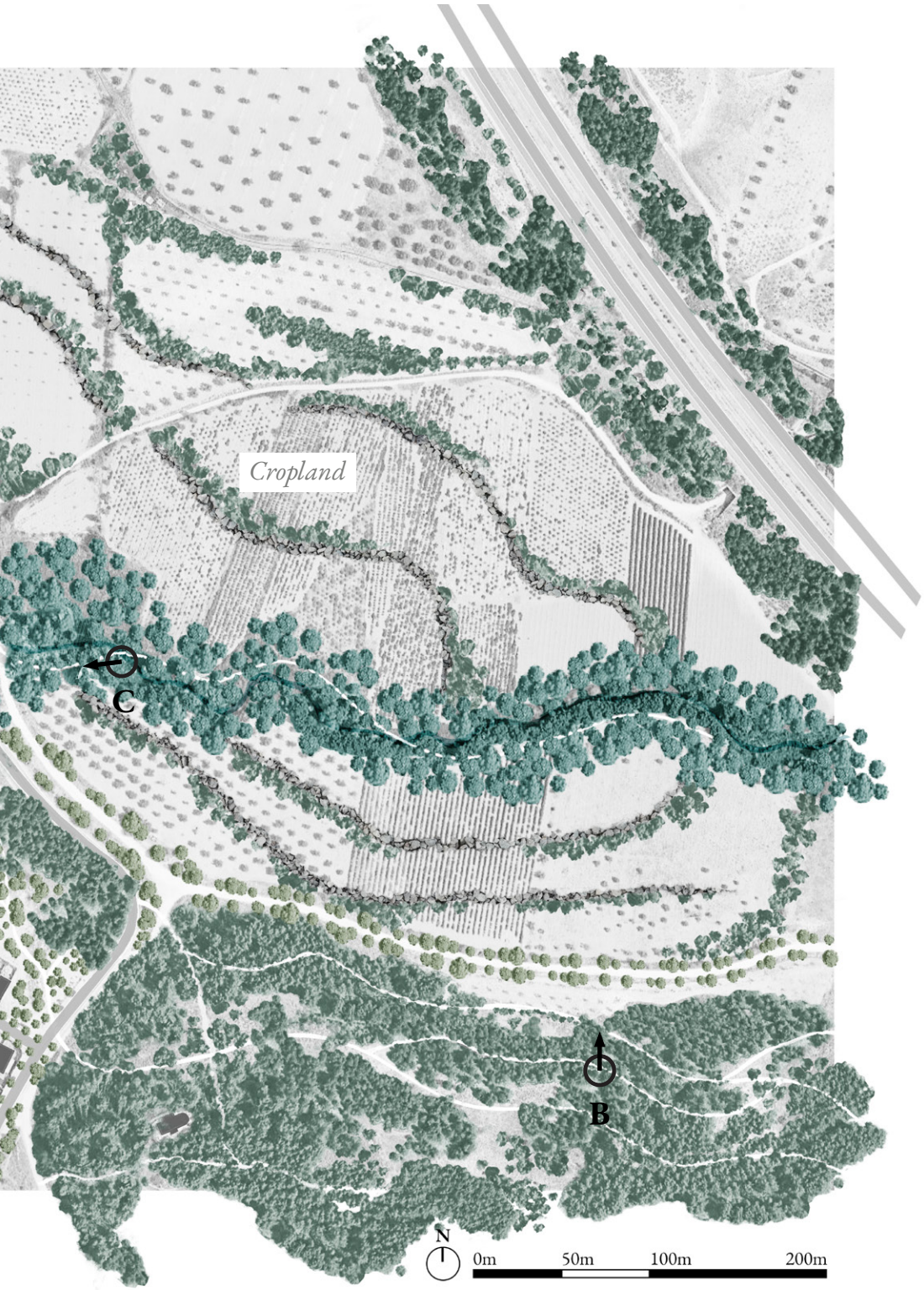
Protected Forests & Nature Reserves

Members of the public and community can enjoy the outdoors but not stray from paths. Rangers of the commons also patrol the area.

Agroforests

Farmers participating in the commons only.


Arroyo del Vilches
A
Parque de las Estrellas
Suburban neighbourhood

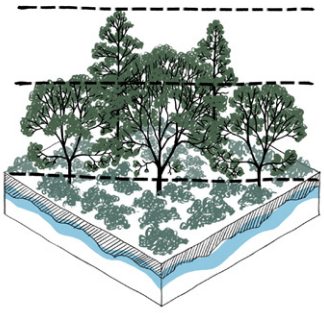

Cropland
C
B
N
0m
50m
100m
200m

A: Perspective of the space through the connected parks

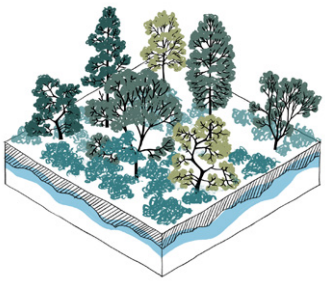
B: View of the traditional olive groves from the top of a forested hill.

C: Accessible and intimate boardwalk through the riparian landscapes surrounding the Arroyo del Vilches

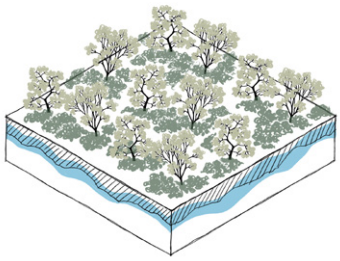
What are some principles and strategies that the community can use to build the water-landscape commons? How can a cultural landscape be part of the commons?



Adding / maintaining layers of vegetation

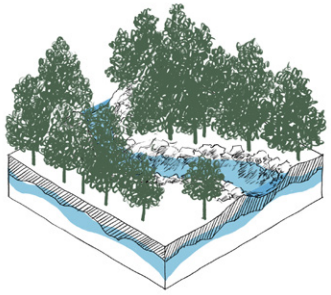


Diversifying vegetation



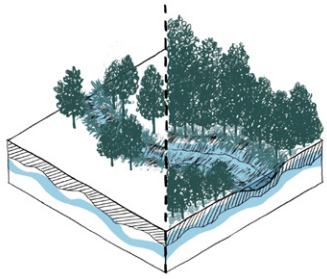
Tree crop layering

Maintaining vegetation layers and diversity are ways to promote biodiversity in the landscape. Once a strong ecosystem is established, the sustainable cycle of growth and production of resources such as crops, wood, biofuel and groundwater can be stably maintained. Addtionally the benefits of growing perennials to tree crops are that they establish a regular ecosystem that is not often disrupted and help provide a sustainable cycle of nutrients to the soil while maintaining groundwater levels by improving water infiltration.



Extending riparian forests along channels to maintain moisture

Areas along water channels, such as brooks or ravines, that are not supported by vegetation tend to be less porous and have less water retention. Forests can help regulate the humidity and soil moisture content in the surrounding areas.

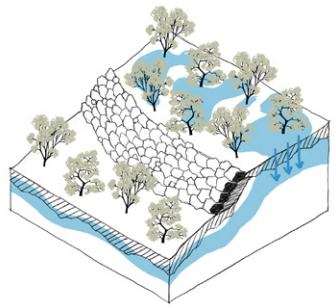


Expanding existing brooks or ravines

Widening the channels of brooks and ravines can help slow down the flow of water, giving them enough time to seem into the soil to replenish the groundwater. Planting more riparian trees along these brooks also help regulate the humidity and soil moisture of the surroundings.

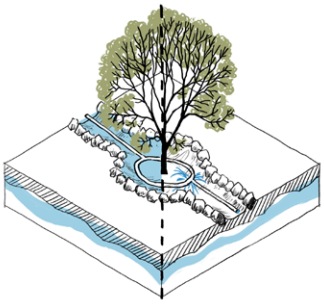
Connecting different types of landscapes

Connecting different landscapes would also connect the water system underground. This can help vegetation nearby share water sources and reduce reliance on human intervention in some areas, making watering and irrigation more efficient.



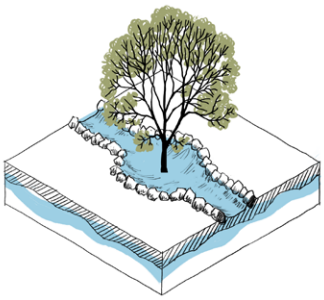
Use of terracing on hilly terrain to retain water

Terraces can be constructed along slopes to slow down runoff during wet seasons such that the water will have sufficient time to seep into the soil to replenish groundwater sources. These terraces are also secured with rocks and backfill.



Different seasonal irrigation methods

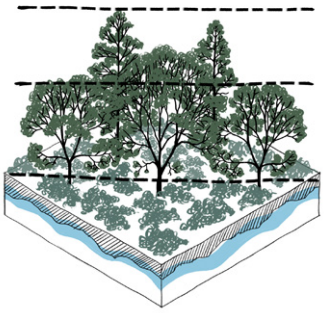
This type of irrigation is recommended to polyculture tree crops or agroforests that are less dense as this method requires some capital. Switching from acequias to drip/ localised irrigation during dry seasons can help farmers use water to precise amounts and reduce excess usage. This method will mostly be used for seedlings or vulnerable trees that require assistance before they can survive independently.



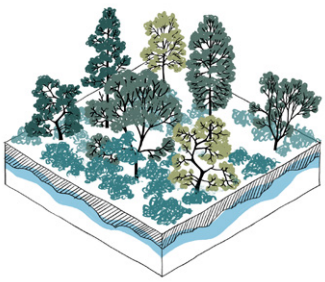
Use of traditional acequias to capture water during high rainfall

A low cost measure to help with watering in large and scenic areas with tree crops or forests is the use of acequias to capture water during high rainfall. The acequias also help slow water runoff, allowing time to it to seep into the ground. These are often employed while trees are no longer seedlings but still are saplings that require some assistance before they can survive independently.

What are some principles and strategies that the community can use to build the urban landscapes and partial commons? How can a cultural landscape be part of the commons?



Adding / maintaining layers of vegetation

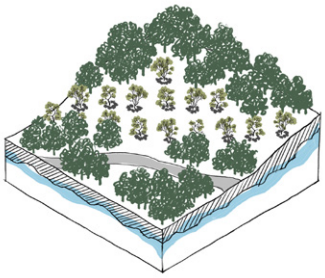


Diversifying vegetation

Maintaining vegetation layers and diversity are ways to promote biodiversity in the landscape. Once a strong ecosystem is established, the consistent production of resources that are necessary for sustaining a landscape can be maintained, even for an urban type.

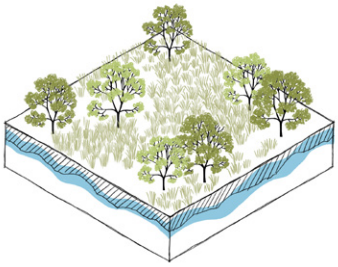
Connecting urban landscapes to other landscape types

Connecting different landscapes would also connect the water system underground. This can help vegetation nearby share water sources and reduce reliance on human intervention in urban landscapes, making watering and irrigation more efficient.



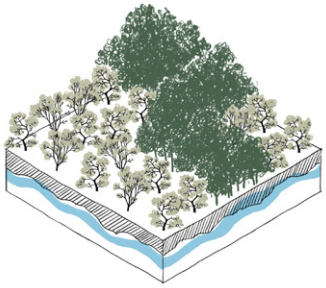
Cropland as part of cultural landscapes

Traditional cropland and tradtional methods of agriculture should be preserved and exemplified to some extent. For instance, the use of terracing, acequias and the groves of olives should be harmoniously integrated into the landscapes, among the forests.



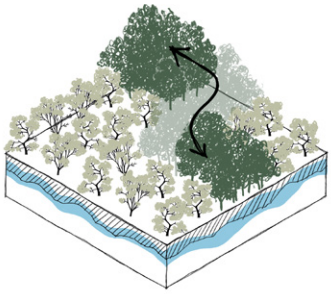
Adopting crop rotations

Crop rotations can help maintain a sustainable supply of nutrients in the soil. This is especially helpful to retain water when tree crops can help shade the soil and the understorey layer of smaller crops from the heat during dry seasons. It can help protect the ground from excess water loss to evaporation during these times.



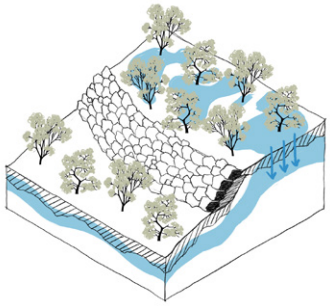
Devoting part of cropland to ecological forests

Ecological forests help regulate the humidity of the air and the water in the soil. Introducing ecological forests back to even just small portions of private cropland can help improve the water-landscape. The CAP recommends at least 5% of cropland to be designated to non-production, such as ecological forests.



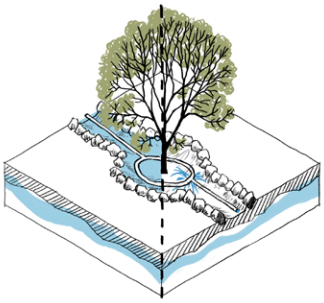
Connecting small forests

It would be also beneficial to connect these small forests together. Connecting forests helps improve their survivability, creating a stronger environment to regulate the water in the ground and humidity of the surroundings.



Use of terracing on hilly terrain to retain water

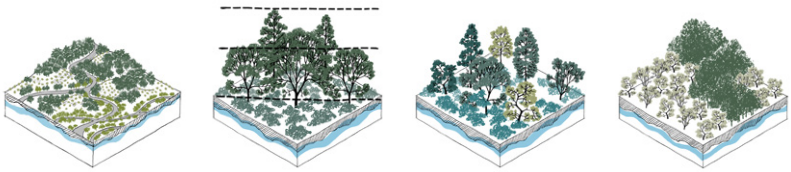
Terraces can be constructed along slopes to slow down runoff during wet seasons such that the water will have sufficient time to seep into the soil to replenish groundwater sources. These terraces are also secured with rocks and backfill.



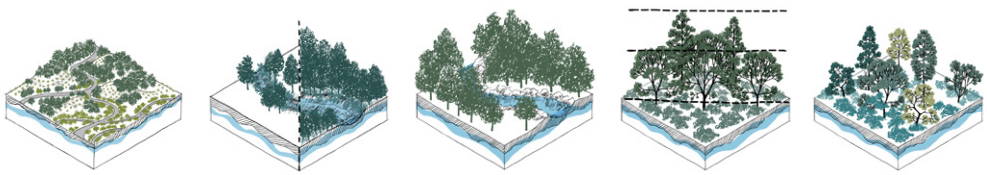
Different seasonal irrigation methods

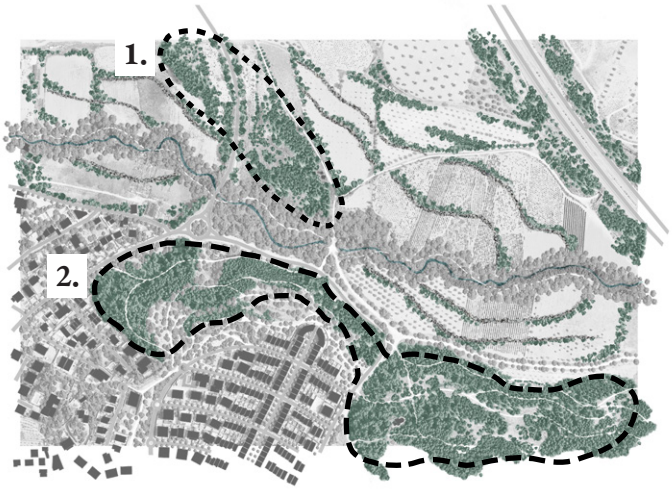
As part of the cultural landscape, it is important to uphold the agricultural traditions of the region. This type of irrigation is recommended to less drought resilient tree crops. Switching from acequias to drip/ localised irrigation during dry seasons can help farmers use water to precise amounts and reduce excess usage.

Spatial principles for urban landscapes

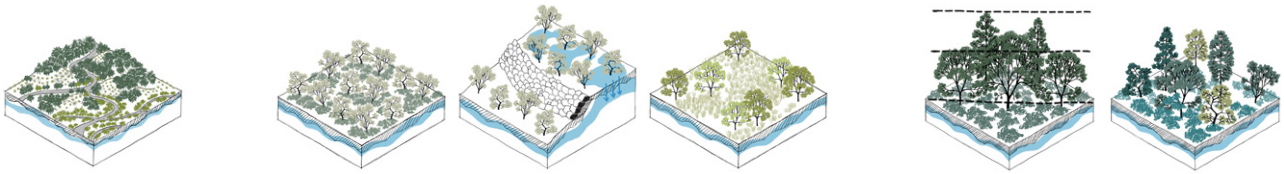


Spatial principles for the Arroyo del Vilches





Spatial principles for protected forests and agroforests

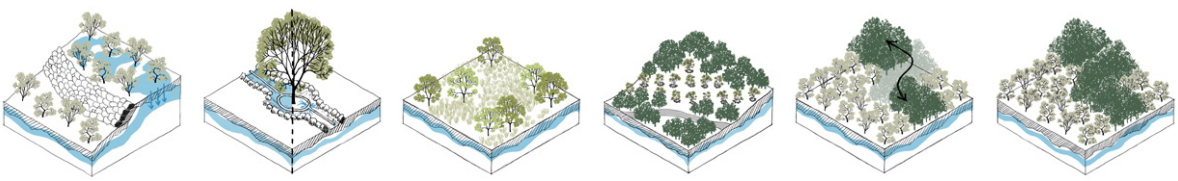


Both

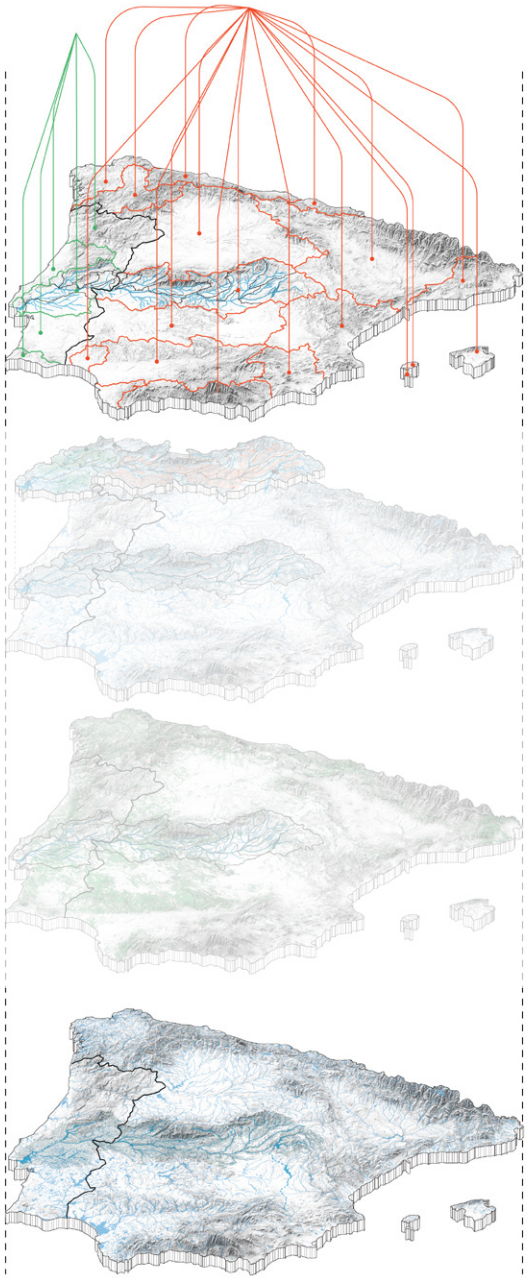
1. Agroforests

2. Protected forests

Spatial principles for cropland



A collage of a public park area connected to the great outdoors also formed with the paintings of Carlos de Haes and other Spanish artists.



Systems of Governance

Landscape Commons

Systems of Governance

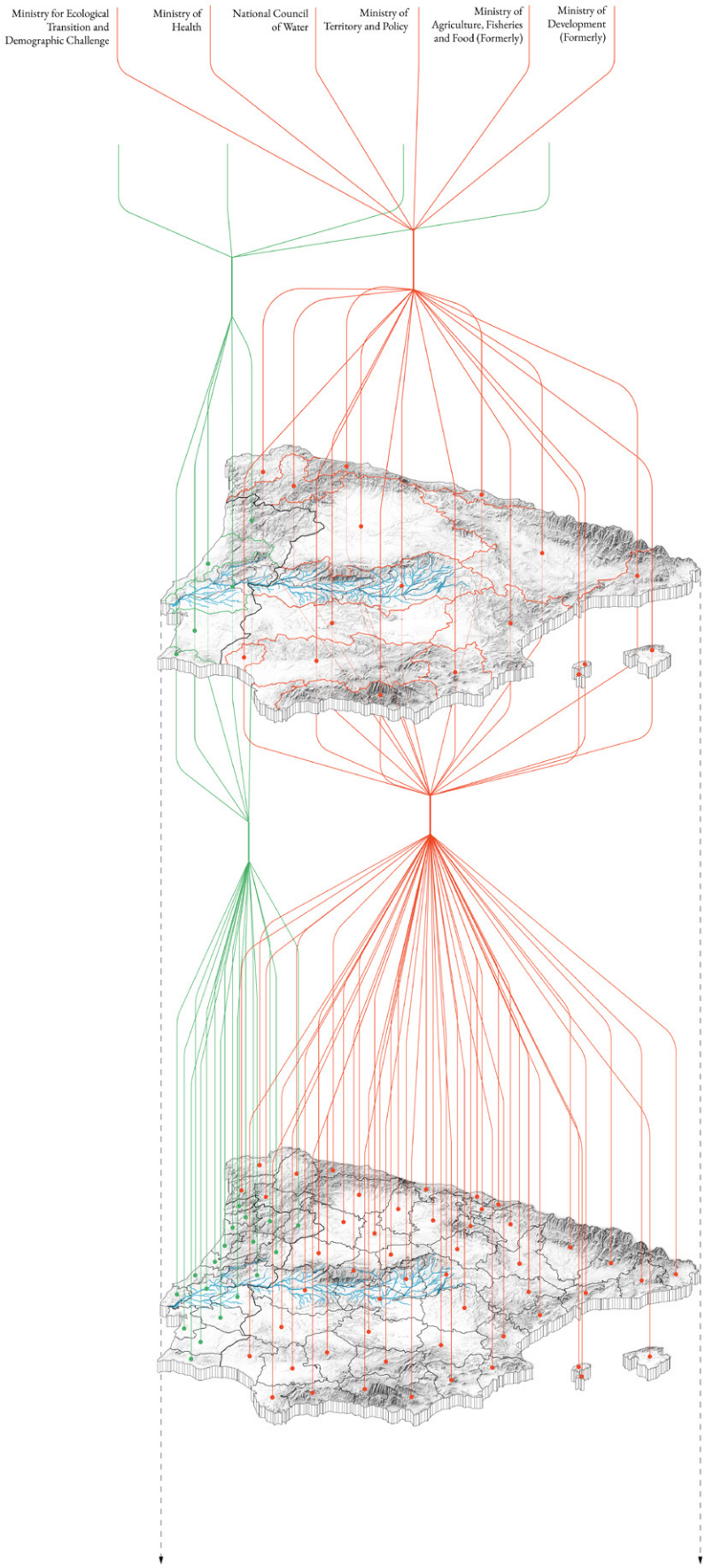
A form of system should be in place, with a definitive set of rules, clear set boundaries and rights given to users of the commons should be in place to form confidence around it. The Systems of Environment delineated which areas are part of Arganda's commons and the Systems of Society discussed how people will work with the landscape through a set of conditions and how users of the commons can keep each other in check. The Systems of Governance will first, recognise those who have the rights to organise, provide conflict-resolution mechanisms and graduated sanctions.

Exploring the rights to organise the commons and avenues for conflict-resolution, the ever-changing state of the world would demand frequent revisiting through a cyclic revision process. This revision process should occur once every few years or occur whenever drastic changes to the environment should occur – for instance, after a year of extreme droughts caused by climate change. This involves first a thorough analysis of the situation at hand, including environmental conditions or social conflicts. Thereafter, a participatory session of the process will involve stakeholders: farmers, resident communities, municipalities, province administration, water companies, River Basin Authorities and others.

Often, in participatory design, should this involve workshops to engage the aforementioned stakeholders to provide their opinions to the design and planning process. Although this is not more thoroughly explored in this thesis, it is part of the concept of the commons and its revisiting process.

Once a strategy or a plan is agreed upon amongst participants, it would be submitted to the authorities for approval. If it is in congruence with the overall RBMP, funds can be granted to the commons for the community to develop it.

Through this revision process can the commons be improved to adapt to new conditions of the environment while reducing the disruption to the social fabric of communities that depend on it. Today's environmental issues consist of high temperatures and droughts but problems in the future may include different challenges that cannot be predicted. Furthermore, and artifact type of landscape solution is not relevant here due to the dynamic nature of nature itself. Left alone, organic matter will change and water will run, hence designing a process with space for change and growth is far more relevant to the commons


Ministry for Ecological Transition and Demographic Challenge
Ministry of Health
National Council of Water
Ministry of Territory and Policy
Ministry of Agriculture, Fisheries and Food (Formerly)
Ministry of Development (Formerly)
National Level Water Governance of Spain:
Regional Level Water Governance of Spain: River Basin Authorities
Regional Level Water Governance of Spain: Province Administration
Municipalities and local Authorities: 8000

What are the responsibilities of the different communities and stakeholders in this collaborative system?

National Council of Water and Other Ministries (Spain)

- Coordinating between different municpalities and RBAs to resolve any conflicts.
- Coordinating proposals with Water Conventions with Portugal
- Monitor environmental conditions to assess if progression of resource usage is sustainable in the coming years

River Basin Authorities and Agriculture Ministry (Spain)

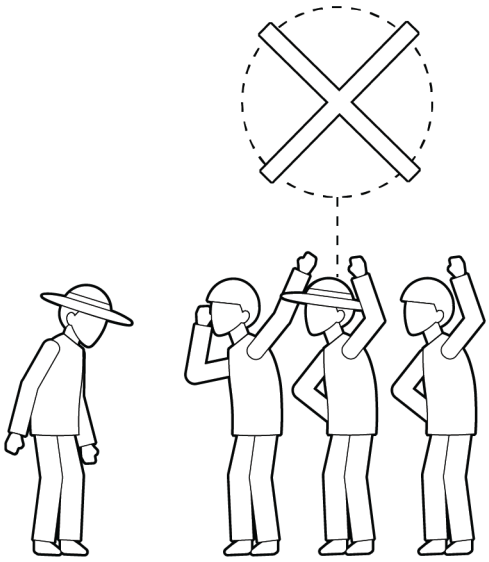
- Monitors water quality, water transfers, agriculture and forests.
- Assists maintenance team designated to these features and the commons.
- Forests, land and cultivation that became national parks / international parks / cultural landscapes will be closely monitored together with the impacts of droughts across river basins

Municipalities & Water Agencies

- Investing in rainwater harvesting systems and underground detention reservoirs within urban areas.
- Investing more in water purification systems such that run-off and waste water can be re-used.
- Maintain some limits urban water consumption & quality while the water scarcity persists.

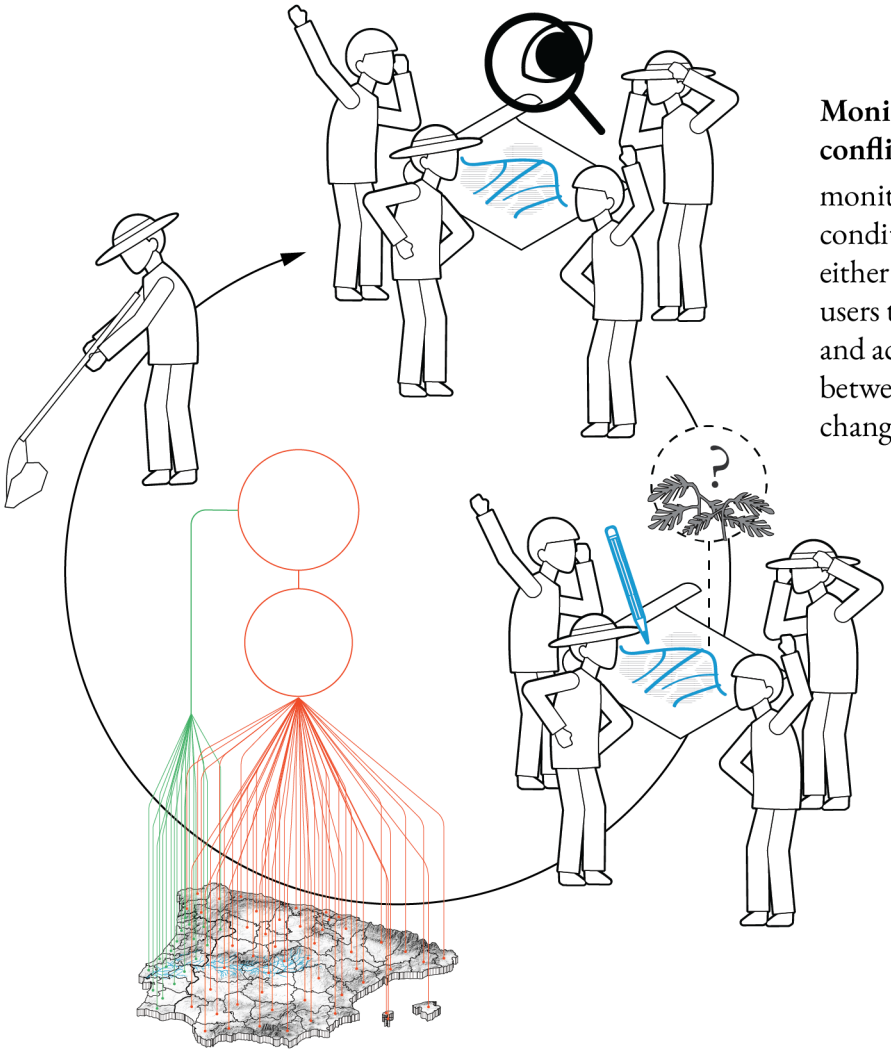
Farmers, Communities & Other Labourers

- Regulated use of water for agriculture: amount of water to use is proportionate to scale of business and level of participation in the commons.
- A percentage of profit will be invested into maintenance of the commons
- Would receive compensation for adhering to ecoschemes and participating in the commons.
- Would receive subsidies for materials needed to participate in the commons.
- Adherence to sustainable means of agriculture.
- A community to monitor water channels, reservoirs, forest planting and manual land clearing, and other natural resources.



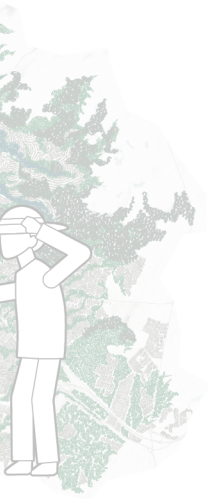
Graduated sanctions:

violators of the rules will be assessed by other users of the commons or officials that are accountable to the users.

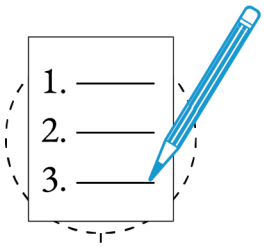


Monitoring and conflict-resolution system:

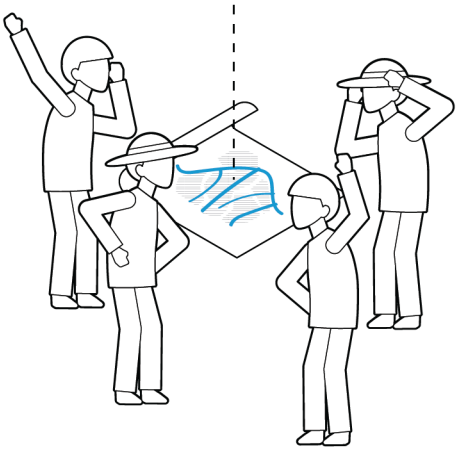
monitors will actively track t
conditions of the commons
either report to the users or
users themselves. Also an eff
and accessible way to raise co
between users, stakeholders
changes to the environment



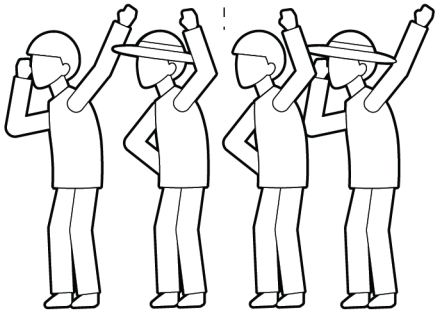
Clearly defined boundaries:
what the resources are and who have the rights to partake - stipulated in systems of society



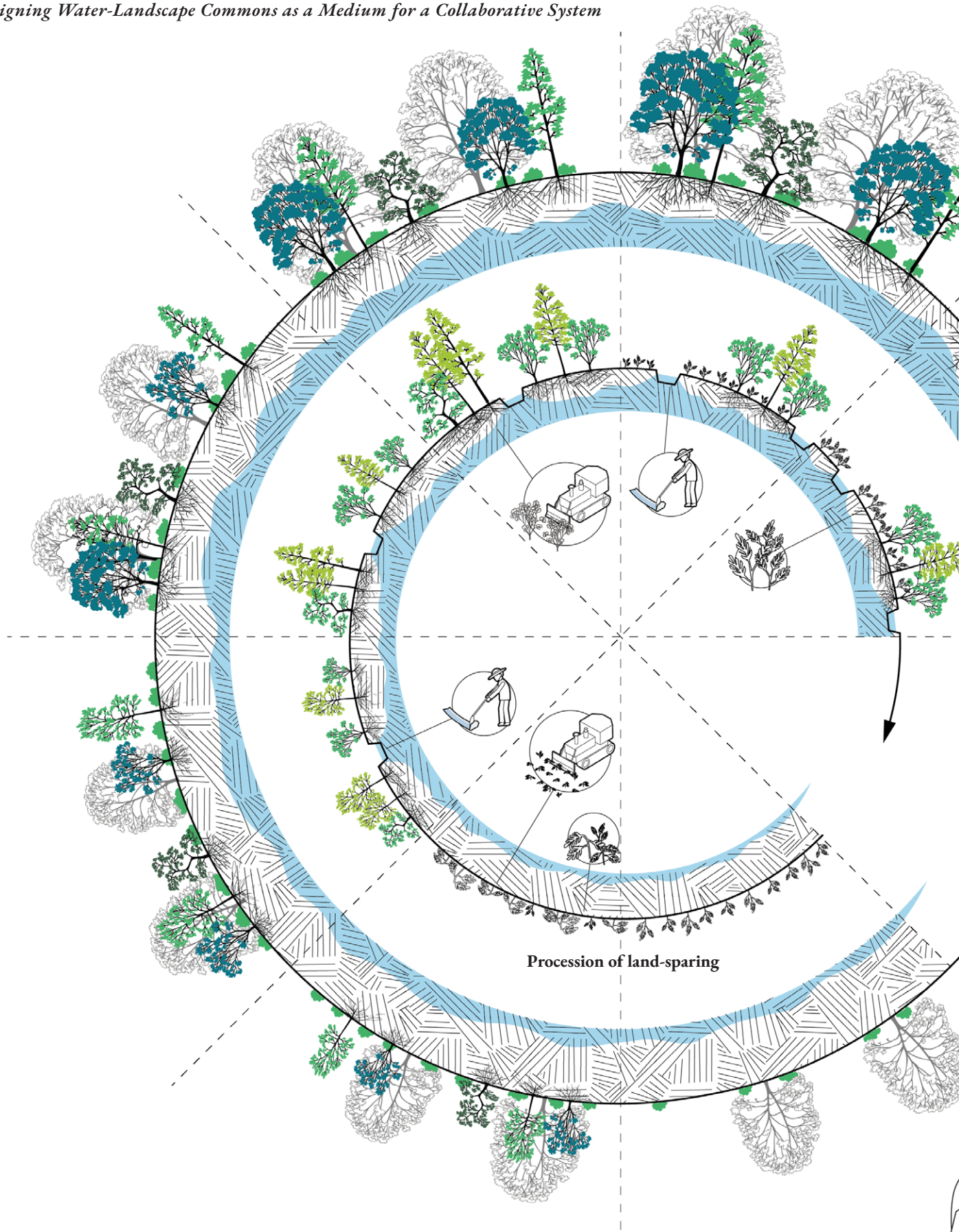
Congruence between appropriation and provision rules and local conditions:
according to that stipulated in the systems of society



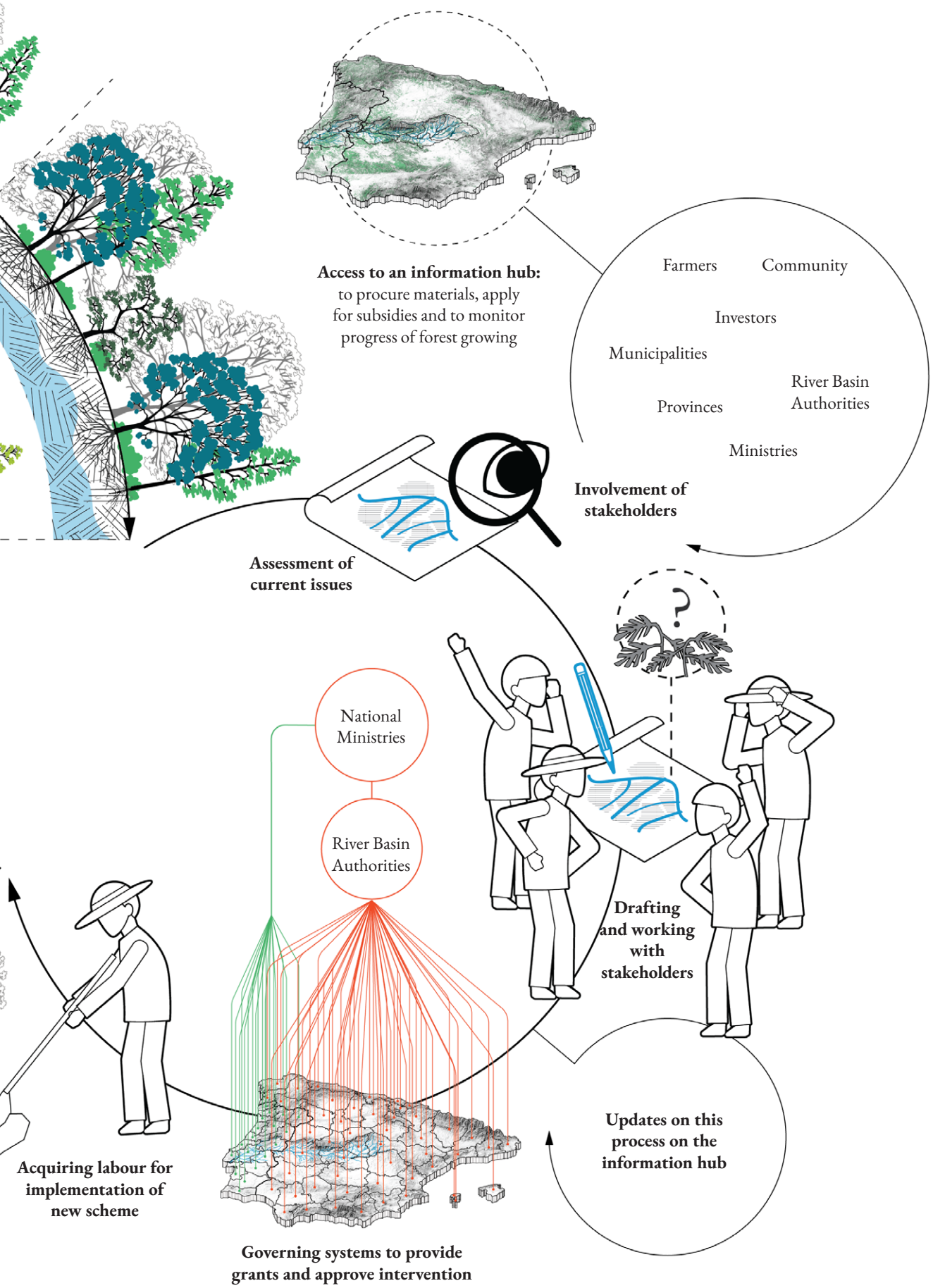
Collective -choice arrangements:
individuals participating in the commons can collaborate to form or change the rules that are mutually agreed upon

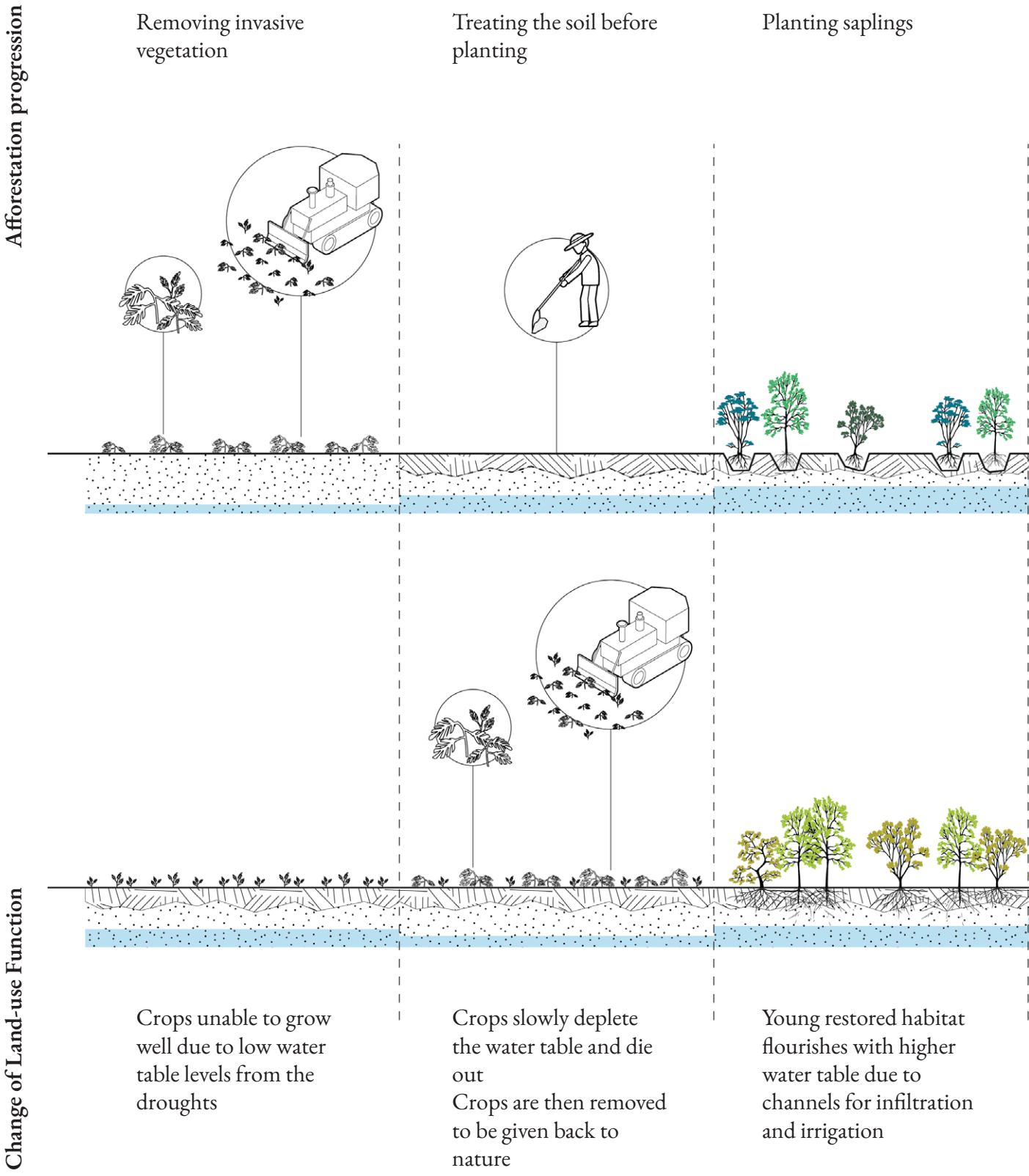


Minimal recognition of rights to organise:
users have rights to plan their institutions without rights being challenged by external forces.



How can progress and conflicts be managed when building the water-landscape commons?

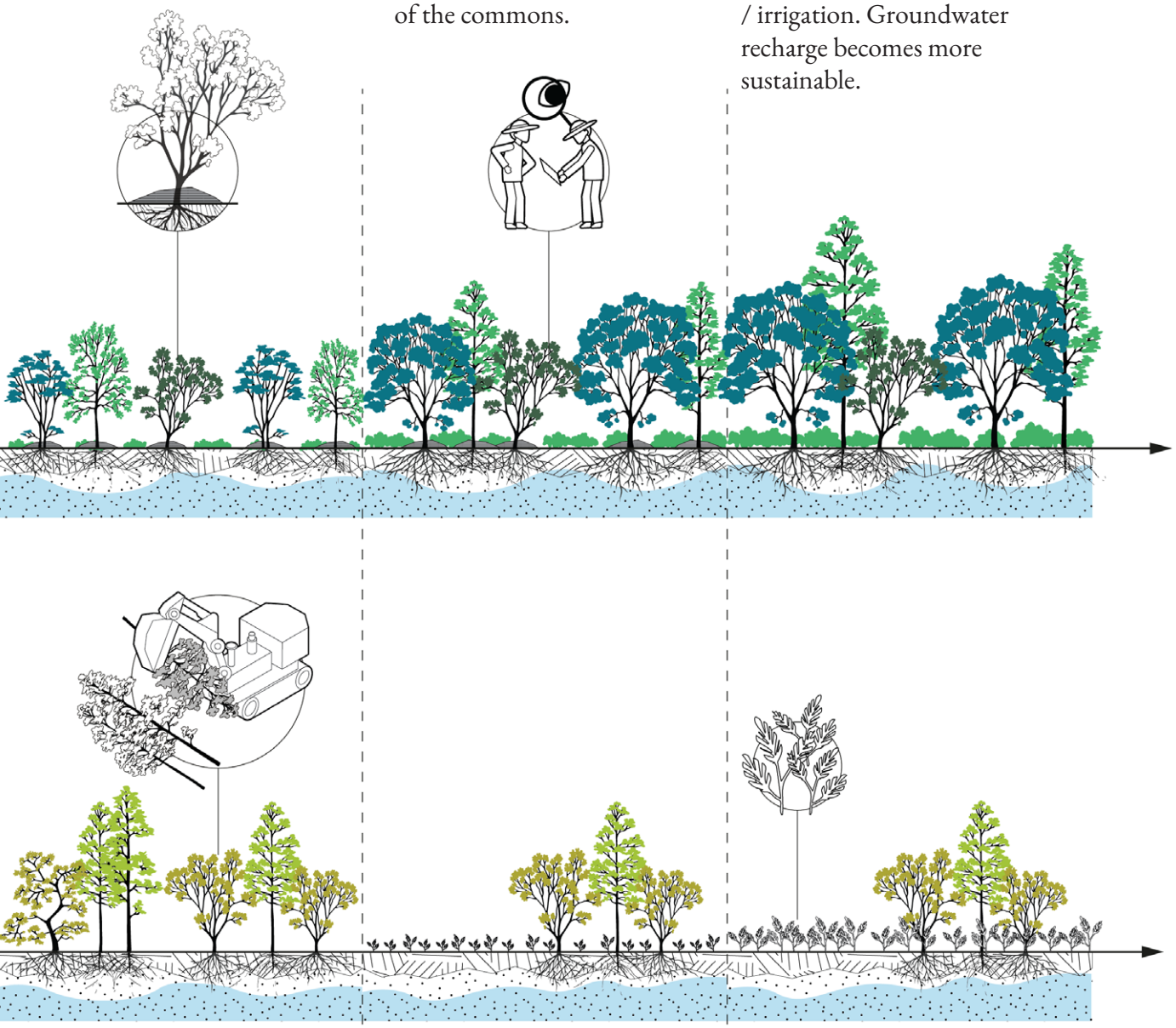

Access to an information hub:
to procure materials, apply for subsidies and to monitor progress of forest growing
Farmers
Community
Investors
Municipalities
River Basin Authorities
Provinces
Ministries
Involvement of stakeholders
Assessment of current issues
?
National Ministries
River Basin Authorities
Drafting and working with stakeholders
Updates on this process on the information hub
Governing systems to provide grants and approve intervention
Acquiring labour for implementation of new scheme


Afforestation progression
Removing invasive vegetation
Treating the soil before planting
Planting saplings
Change of Land-use Function
Crops unable to grow well due to low water table levels from the droughts
Crops slowly deplete the water table and die out
Crops are then removed to be given back to nature
Young restored habitat flourishes with higher water table due to channels for infiltration and irrigation

Adding seasonal mulch layer for protection as saplings grow

Groundwater rises as water is able to infiltrate more easily. Monitoring by participants of the commons.

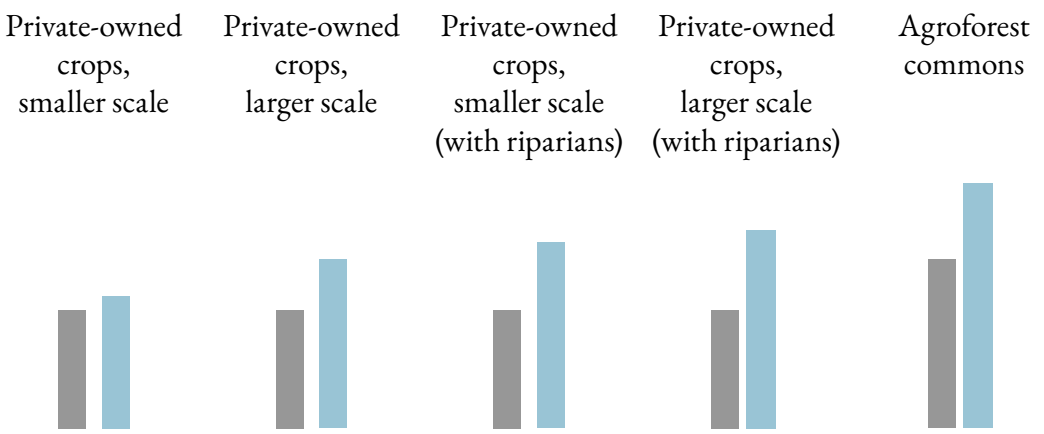
Forests are allowed to grow larger and no longer require the assistance of human intervention / irrigation. Groundwater recharge becomes more sustainable.



After some time, the habitat is removed / transplanted to switch with existing cropland in need of renewal

The position of the channels change and help break up the soil, making it more permeable

With new nutrient-rich soil and higher water table levels, the new crops can grow well



Compensation & access to water from natural sources according to scale of business and level of participation in the commons

What long-term governance strategies can be used to achieve the collaborative potential of the water-landscape commons?

Outreach for this program may face challenges due to the reclusiveness and traditional farming practices of some local communities. To overcome this, it is crucial to engage these communities in rural development programs, helping them understand the importance of sustainable practices. Numerous local groups exist both globally and in Spain, and their strategies can be integrated into the water-landscape commons. Similar to the Grain for Green project of the Loess Plateau, there should be subsidies for materials needed for agroforestry and afforestation efforts, lowering the entry barrier to participate in the commons.

All stakeholders, including farmers, authorities, and other users, must recognize that while adopting sustainable agricultural methods is essential, it is equally important to support farmers in these initiatives and alleviate the hurdles they might face, ensuring sustainability is not burdensome. Additionally, allowing individuals to engage in the commons at various levels will enable them to contribute according to their capacity and gradually progress to higher levels of participation in the commons.

Farmers should receive compensation for engaging in sustainable practices, which can be provided through tax reliefs or monetary support for their businesses, based on how much they have invested in the sustainability efforts economically. The amount of water farmers can draw from sources such as lakes, brooks, ravines, and rivers will also depend on their participation in the commons and the size of their businesses. Agroforest owners will share the water allocated to their lands collectively, as these forests will be community-owned. In contrast, private-cropland owners will have their water usage and compensation determined by the scale of their businesses and their commitment to sustainability.

It is important to highlight to farming communities that unsustainable methods like surface irrigation and slash-and-burn have detrimental effects on the environment, ultimately harming both the individual farmer and the broader community. However, the colossal scale of environmental problems may be difficult to comprehend quickly. The concept of the commons spans many years and potentially changes over decades. Therefore, introducing environmental education to the youth in local school curriculums is vital. This education should include informative agricultural knowledge and the importance of the commons, ensuring future generations have the foresight and broader perspective to engage in future work with environmental and global community considerations.

What short-term governance strategies can be used to achieve the collaborative potential of the water-landscape commons?

For the farming community already involved in agricultural work, providing an easy way to access information is an effective method to start their engagement. This can be achieved through an online information repository offering the necessary channels for subsidies and materials for participating in the commons or partial commons. Additionally, an offline approach involves distributing a guidebook to the farming community, addressing those who may not be internet savvy. This guidebook will explain the need for collaboration in the current climate crisis and outline steps farmers can take, from small initiatives to large-scale afforestation efforts.

Partaking in the Agricultural Commons: A Guide to Growing Agroforests

If you are a farmer and you would like to be a contributing part of the water-landscape commons by adopting agroforestry, you can approach the AGFE (Spanish Agroforestry Association) or grow your economic / ecological forests on your own. Whether you are growing forests with help or by yourself, you may apply for some subsidies for the necessary materials and process by visiting the website.

If you are interested in growing these economic forests yourself, there are some steps you can take to achieve this.

1. Consideration Climate, Soil and Native Plant Species

Climate Assessment

Some areas of Central Spain, such as the Community of Madrid and including Arganda del Rey, are semi-arid. Dry summers are experienced throughout the region.

Type of soil and minerals present

The geological map of Arganda details what types of soils are naturally present in your plot of land and around it. Most crops present are grown on clay type soils that are variations of marls, carbonates, gypsum, mixed with sandy type soils.

Native vegetation present

It is important to assess which species are native and non-native. For instance, some species like the Holm Oak are now rare in the landscapes of Arganda due to the changing climates. Knowing this information will guide you on which species are appropriate to introduce in your forests.

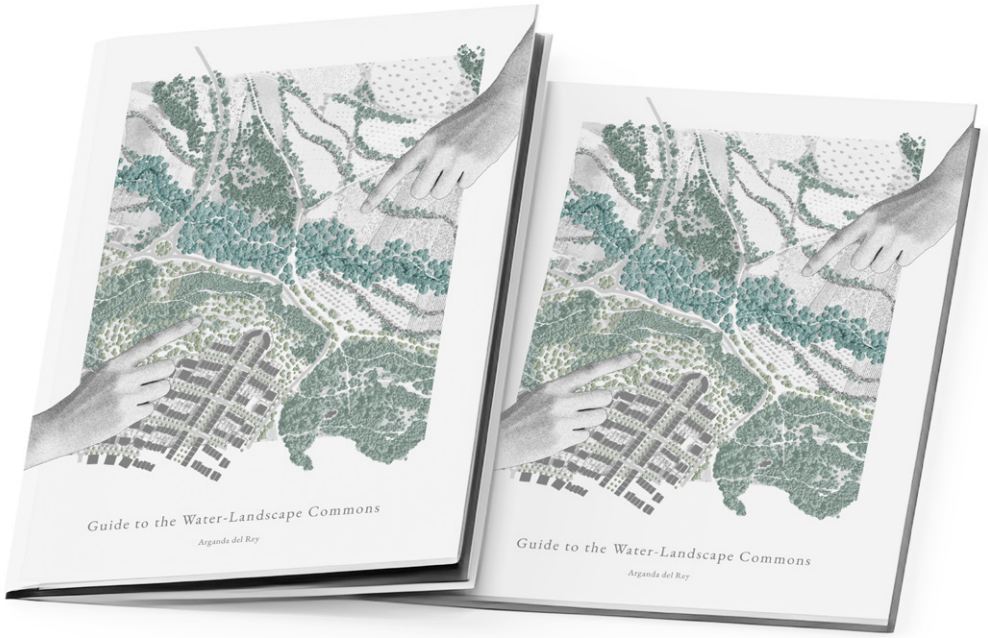
2. Soil Preparation For Low-Nutrient Soils

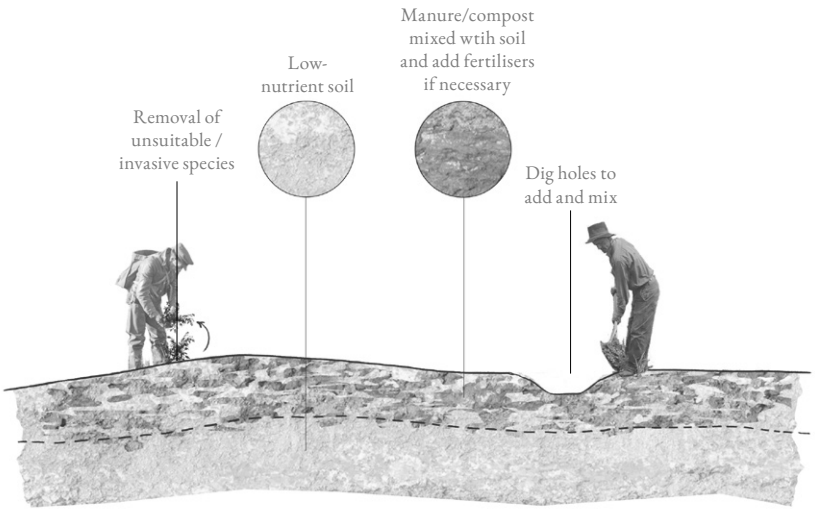
Do you have trouble growing crops or has your land been bare for the last few years? The land you are working on may be low on nutrients. Fertilisation of the soil is imperative to support any form of plant life. There are a few options for you to treat your soil before planting:

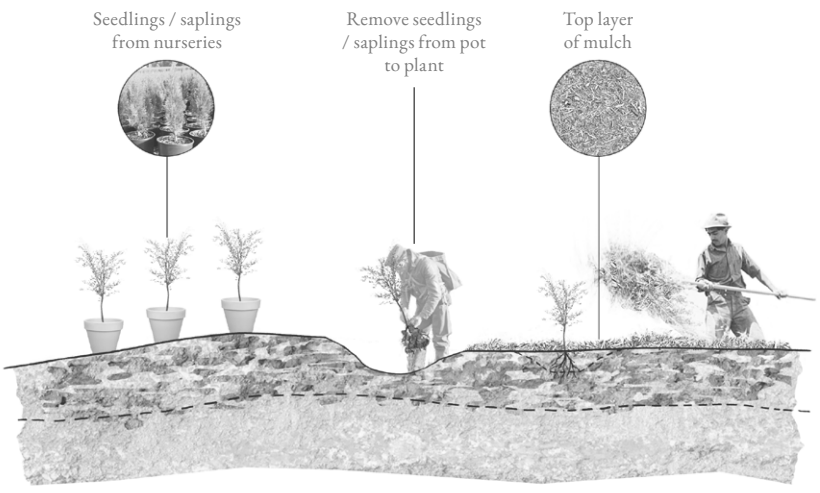
- *Remove invasive species or unsuitable plants:* there are some species of plants that will out-compete your crops, so it's essential to remove these invasive species. You may refer to the National Catalogue of Invasive Exotic Species.
- *Inorganic fertilisation*, depending on your crop: ammonium sulfates, ammonium nitrosulfates, ammonium nitrates, urea, nitrogen solutions, other nitrogenous solutions.
- *Organic fertilisation*: manure, compost, etc. Adding manure to the surface of the soil is less efficient and its effects would not last. Hence, mixing them at subsoil layers would be more beneficial.
- *Adding a mulch layer* could help with water retention in drought conditions during dry seasons. Having this layer of organic material can help regulate the temperature of the soils and keep the water from being lost unnecessarily to evaporation.

3. Growing The Selected Vegetation

Most landscape restoration projects span several years. This process often involves growing trees first in nurseries. The afforestation of arid and semi-arid areas across the world began in a controlled environment, such as greenhouses and nurseries, to germinate seeds before transplanting them as saplings to the site. At this point, the land should have undergone soil preparation for new saplings.


Guide to the Water-Landscape Commons
Arganda del Rey
Guide to the Water-Landscape Commons
Arganda del Rey


Manure/compost mixed wtih soil and add fertilisers if necessary
Low-nutrient soil
Removal of unsuitable / invasive species
Dig holes to add and mix


Seedlings / saplings from nurseries
Remove seedlings / saplings from pot to plant
Top layer of mulch

What short-term governance strategies can be easily used by farmers?

Not every farmer would have the means to immediately convert their business, therefore it is imperative to provide alternatives and recommend smaller contributions they can make to allow them to gradually participate in the over all water-landscape commons.

Partaking in the Partial Commons: Building A Sustainable Cultural Landscape

Understandably, there are many hurdles to making changes and adopting new agricultural practices. You can take part in the commons in other smaller ways. You can also slowly expand your ecological contributions overtime or even join the afforestation efforts of the commons in the future!

1. Designating A Portion of Your Land To Growing Ecological Forests

Ecological forests are not grown for production. They are grown to reinforce the ecosystem of the landscape and expand the forest cover of the general region. The upstream of the Tagus Basin is facing intense droughts partly due to the low forest cover and high monospecific agricultural activities. Introducing ecological forests back to even just small portions of private cropland can help improve the water-landscape.

The Common Agricultural Policy (CAP) of the European Commission recommends at least about 5% of farmland to be designated for non-productive ecological use, such as growing ecological forests.

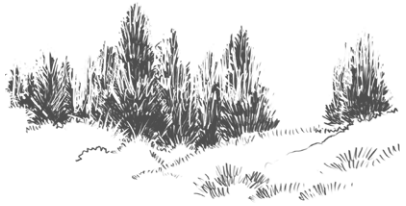
Ecological forests help regulate the humidity of the air and the water in the soil. There are steps in the previous section to guide you on how to grow forests. However, the species of trees you may use would not necessarily be crop trees but native trees of the semi-arid Spanish landscape.

It would be also beneficial to connect these small forests together. Connecting forests helps improve their survivability, creating a stronger environment to regulate the water in the ground and humidity of the surroundings.

So talk to your neighbours!

You can refer to the aforemention guide to growing agroforests. Instead of production trees, you may use native tree species. Remember to...

1. Consider the climate and soil conditions of your plot of land.
2. Prepare your soil for planting. Remove unsuitable vegetation or invasive plants. Mix organic or inorganic fertilisers with the existing soil if necessary.
3. Procure seedlings / saplings of your selected species from your preferred nusery.
4. Establish a water-management system. Ideally, they should be watered regularly during dry seasons using localised or drip irrigation during their seedling phase. Alternatively, growing your forest near an existing forest can help the survivability rate of your plants.
5. Plant your seedlings / saplings on your land and add an additional layer of mulch to protect the soil and roots from excess water losses to evaporation during dry seasons.



2. Incorporate Crop Rotations To Your Farming

Plant different types of crops that are compatible with each other to improve the health of the soil and maintain a sustainable supply of nutrients.

This is especially helpful to retain water in the soil if one of these crops are tree crops that can help shade the soil and the understorey layer of smaller crops from the heat during dry seasons. It can help protect the ground from excess water loss to evaporation during these times.

For instance, if you own a wheat field, you can plant some walnut trees amongst the fields.

3. Adding Non-Productive Layers To Your Cropland

If you own an olive grove or grow other tree crops over bare soil, you could consider planting smaller perennial shrubs that are native to the landscape.

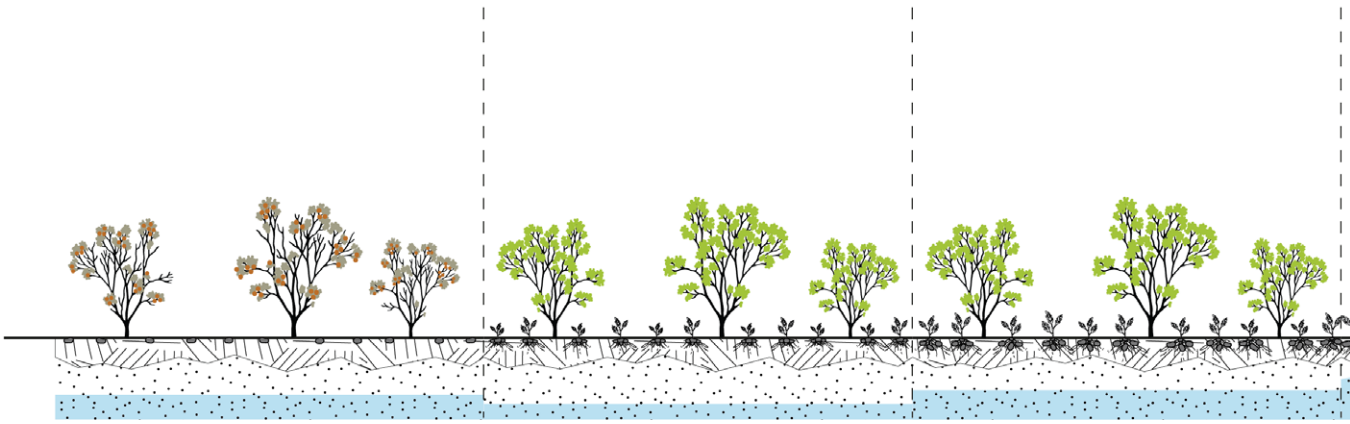
Avoid non-native species, especially those classified in the National Catalogue of Invasive Exotic Species. Invasive species are likely to out-compete your crops or surrounding native species for water and nutrients.

Make sure that these non-productive layers are compatible with your existing crop. Ideally, they should have shallow root systems that do not need more water than your crops do. These layers and their combined root system of these layers can help break up the soil and allow water to infiltrate more easily.

The benefits of growing perennials with fruiting trees are that they establish a regular ecosystem that is not often disrupted and help provide a sustainable cycle of nutrients to the soil while maintaining groundwater levels by improving water infiltration.

Gargüera de la Vera
Olive tree grove with potato cultivation as an understorey layer.

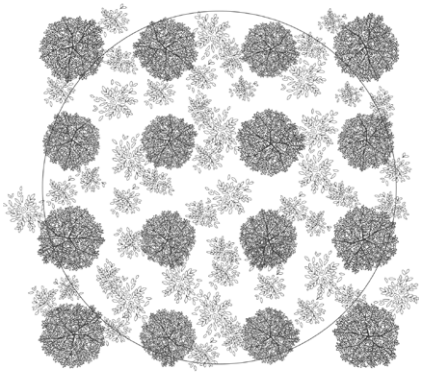
Landete
Walnut tree cultivation for wood amongst a wheat understorey layer



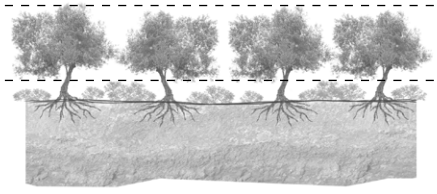
Olive harvesting

Potato planting

Potato growing

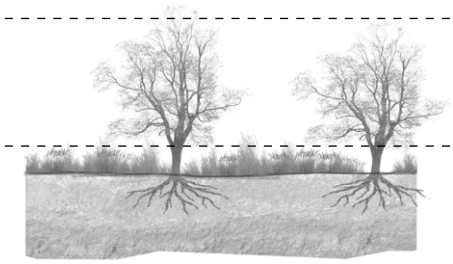


Crop layering option 1
Tree crops mixed with low understorey crops, preferably with shallow root systems.



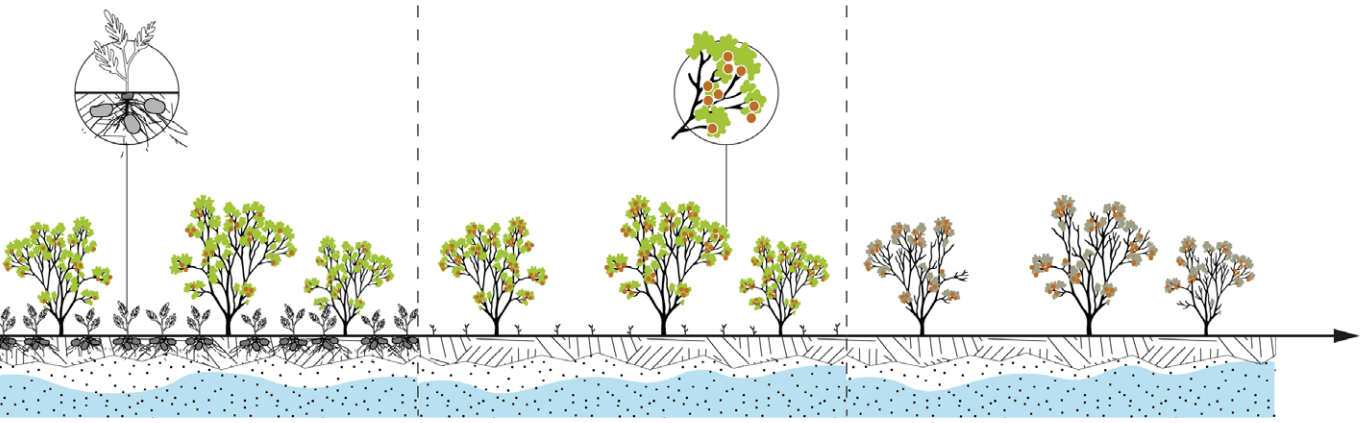
Olive Tree, *perenial crop*

Potatoes, *annual crop*



Walnut Tree, *perenial crop*

Wheat, *annual crop*

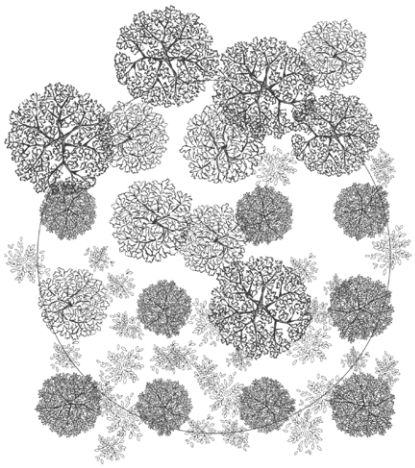


July - August **September - October** **November - December**

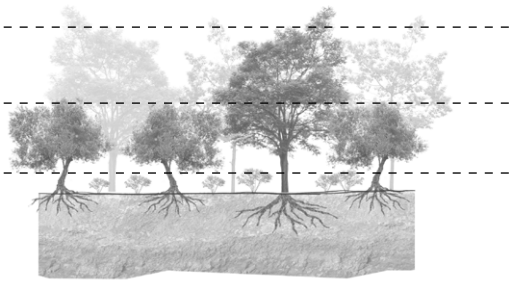
Olive harvesting

Olive trees fruiting season

Potato harvesting



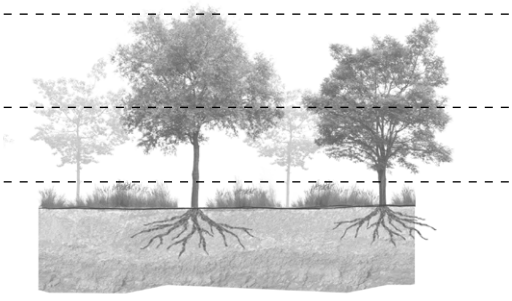
Crop layering option 2
Crops mixed with ecological forests, preferably with shallow root sytems.



Forest Layer, *perennial trees*

Olive Trees, *perennial crop*

Understorey Layer, *perennial shrubs*



Forest Layer, *perennial trees*

Olive Trees, *perennial crop*

Wheat, *annual crop*

Overview perspective

Conclusions & Discussions

The Tagus is the largest river within the Iberian Peninsula, it not only supplies water to communities within the basin but also to other parts of Portugal and Spain through water transfers. However, due to the pressing climate crisis across the globe, water is in the Iberian Peninsula is drying up faster, leaving communities with scarce water resources even within the Tagus River Basin. A majority of its users were agricultural workers.

Farming communities began to extract more water from aquifers and even build unregulated or illegal wells that were not approved by the state. This exacerbated the drought situation as even more water is leaving the land. Eventually, after the most intense droughts experienced in 2022, authorities of both Spain and Portugal began implementing water restrictions and strictly enforcing the policies on groundwater extraction.

Dissent and protest within the farming communities grew, especially in Spain, as they felt neglected and disenfranchised by their government. Spain also declared in 2023 that it would no longer ensure that they will fulfil its end of the water agreements in the Albufeira Convention.

There was a distinct lack of collaboration between the layers of the environment, society and governments and the consequences of these can be seen in the drying landscapes.

The central theme to the synthesis and design proposal of this research is to foster collaboration between the Systems of the Environment, Systems of Society and Systems of Governance. The design came in the form of a spatial strategy for the environment, community guidelines for members of society and a governing process

respectively. This was the basis to form the water-landscape commons. It is a means to facilitate collaboration as the environmental crisis cannot be resolved by an individual alone but requires the cooperation of all who partake in this socio-ecological exchange with the landscape.

The results of the design were idealistic. It imagines a community that eventually cooperates to form the commons and adopts an optimistic perspective that there would be ubiquitous understanding of the state of global climate crisis right now. The initial steps of this proposal involve outreach, requiring substantial persuasion and rural development efforts to gain the confidence of traditional farming communities. Realistically, this process might take longer than anticipated, potentially even falling short of the afforestation goals set by EFE2050 or the 30-year projection. However, the concept remains feasible by incorporating smaller, alternative contributions for the farming community, making sustainability an achievable goal rather than an overwhelming task.

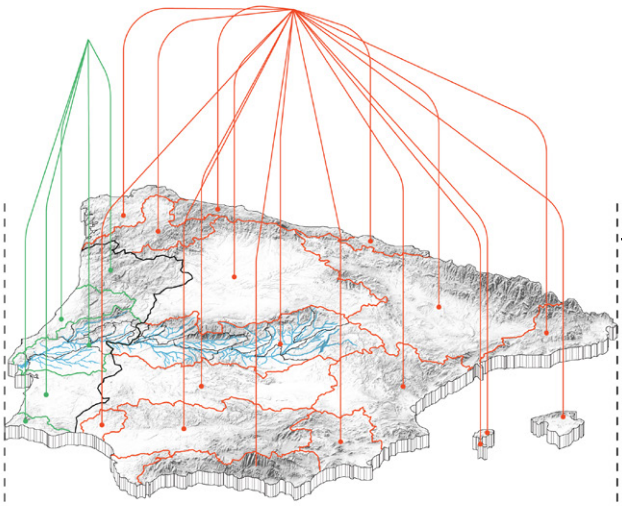
Education can also be an investment, by the state, to help these communities to understand the importance of sustainable practices from a young age and the need for certain changes, such as the implementation of the water-landscape commons. This can help raise a future generation of communities who will be more aware of environmental issues and understand the need for collaboration in a climate crisis. This can also equip future members of society with the knowledge to navigate environmental uncertainties and a global perspective on the situation.

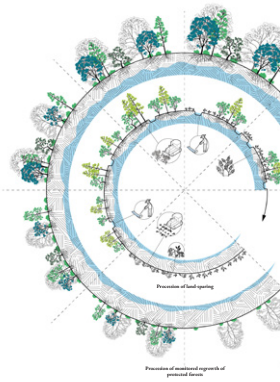
The project could also expand on the boundaries of the commons. The Systems of the Environment section presented various spatial strategies, including a regional plan for the entire river basin. However, the strategies for the Systems of Society and Governance were confined to a municipal scale to maintain simplicity in the thesis. Objectively, incorporating collaboration between different municipalities and recommending amendments to existing water conventions could have enhanced the proposal's comprehensiveness. Similar to how Nepal's commons extend across the entire country's forests, the water-landscape commons could be expanded throughout the whole river basin and integrated into water conventions. Although, this may add a layer of complication, considering the basin being part of two territories.

Ultimately, the design proposal of this paper is feasible but would require a lot of educating and cooperating with the public to form the commons. In this instance, the

potential spatial plans could even be different from what was imagined in this project and the rules for the commons may also differ. However, the main essence for this work will still stand and it encapsulates how collaboration can be facilitated between systems of the environment, society and governance by means of the water-landscape commons.

Conflicting Systems
of Governance





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Conflicting Systems
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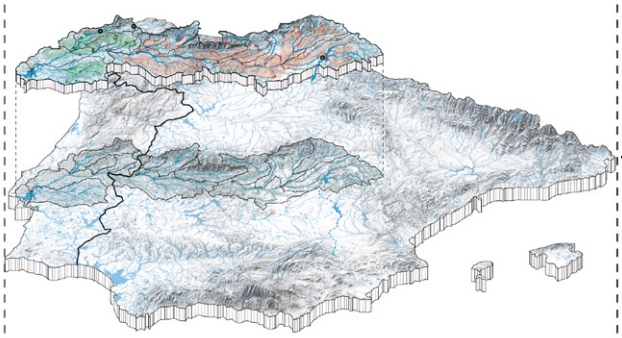

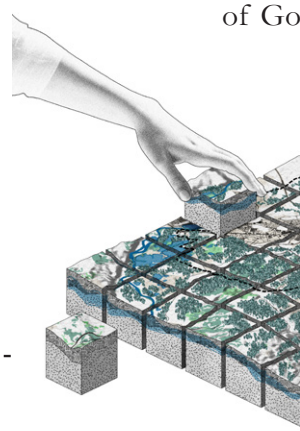

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Conflicting Systems
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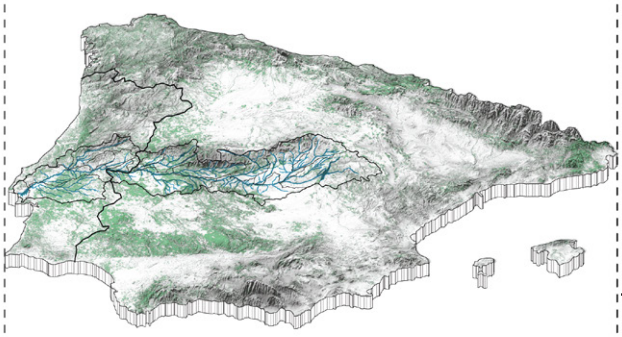

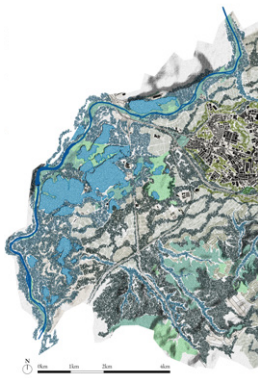

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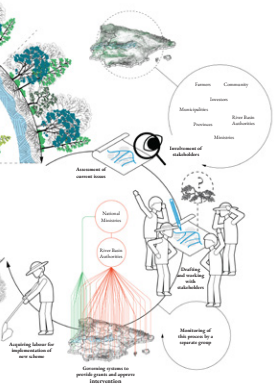

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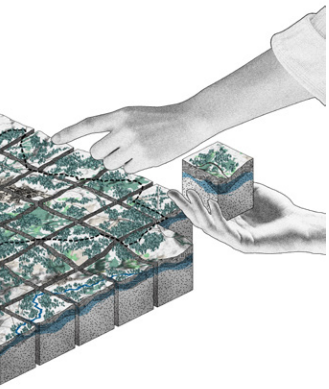

tive Systems
Society

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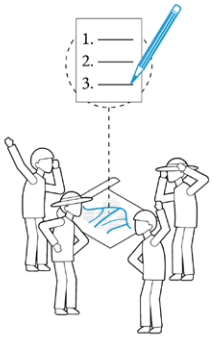
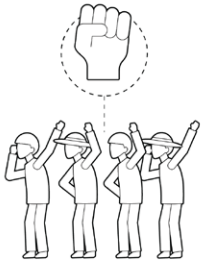
nvironment

Clearly defined boundaries:
what the resources are and who have the rights to partake - stipulated in systems of society

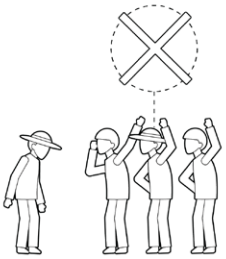


Congruence between appropriation and provision rules and local conditions:
according to that stipulated in the systems of society

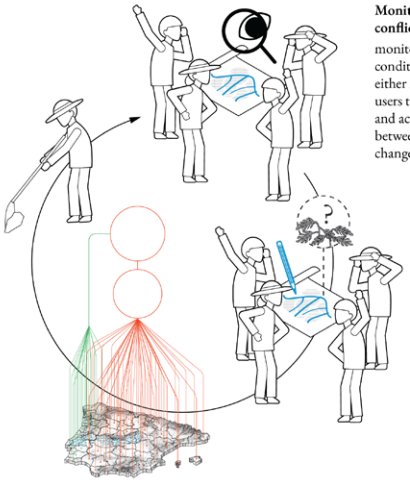
Collective -choice arrangements:
individuals participating in the commons can collaborate to form or change the rules that are mutually agreed upon



Minimal recognition of rights to organise:
users have rights to plan their institutions without rights being challenged by external forces.



Graduated sanctions:
violators of the rules will be assessed by other users of the commons or officials that are accountable to the users.



Monitoring and conflict-resolution system:
monitors will actively track the conditions of the commons who either report to the users or are users themselves. Also an efficient and accessible way to raise conflicts between users, stakeholders or changes to the environment.

The culmination of this collaboration between the systems is the commons, and these are the principles that are the basis of the proposed water-landscape commons.

Reflections

What is the relation between your graduation (project) topic, the studio, your master track, and your master program?

Delving into water-landscape commons to tackle pressing issues of droughts in the Iberian Peninsula was a large and ambitious landscape urbanism project. I explored how the environment, society and governance systems interact in uncooperative ways with each other, and how landscape architecture and urbanism can play a role in finding solutions. It fits into the studio's broader theme of researching and designing resilient coastal (and by extension rivers and deltas) landscapes, possibly revolving around sustainable design or environmental solutions. This synergy allowed me to explore my ideas through different scales, as many complex issues need such multilayered approaches. It directly tackles the social challenges stemming from drought in the Iberian Peninsula. By creating a water landscape commons, I intended to explore the potential to foster collaboration and ease tensions over water resources in the community. Furthermore, as the world becomes more entangled with more complex environmental and social problems, the role of the landscape architect becomes more important to address these contemporary issues. This thesis is only a small piece of the puzzle needed to move forward towards a more sustainable future.

What is the relevance of your graduation work in the larger social, professional and scientific framework?

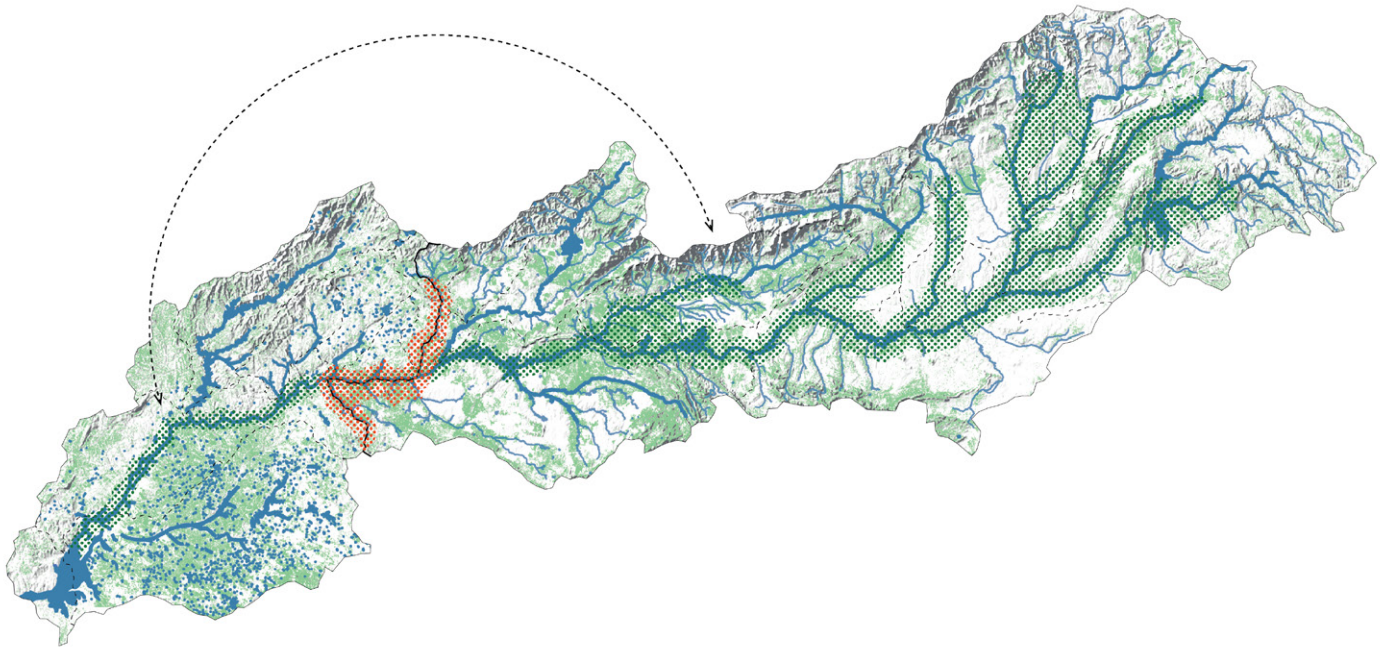
In the grand scheme of things, with climate change being a global concern, my project, focused on a region grappling with severe climate impacts, is contributing to the broader understanding of how landscape architecture can be a proactive solution in adapting to environmental changes.

The relationships between society and its environment are frequently characterized by a delicate balance that is susceptible to disruption by conflicts arising from the competing needs of human societies and the natural world. Balancing societal needs with environmental imperatives presents a complex challenge requiring nuanced approaches. Moreover, recognizing landscapes as integral to spatial and temporal processes adds the challenge of guiding their evolution for sustainability and enhanced experiences, a task complicated by the difficulty in determining their optimal growth direction. These are topics and complexities today's landscape architects are trained to do with modern methods of research and data collection. These are relevant skills and knowledge that the contemporary world needs, making this role highly relevant in the larger social, professional and scientific framework.

What were some things that could have been improved the thesis or some things that could not be considered due to circumstances and how did that affect the research?

This project has ambitiously addressed the drought situation of the Iberian Peninsula. The approach was not only complex in terms of large-scale regional planning but also in its detailed focus on spatial design, community engagement, and resource governance. While the design aimed to foster collaboration through the water-landscape commons in a small-scale implementation in Arganda del Rey, there remains much unexplored potential in other areas of the thesis.

The Systems of the Environment section presented various spatial strategies, including a regional plan for the entire river basin. However, the strategies for the Systems of Society and Governance were confined to a municipal scale to maintain simplicity in the thesis. Objectively, incorporating collaboration between different municipalities and recommending amendments to existing water conventions could



have enhanced the proposal's comprehensiveness. Similar to how Nepal's commons extend across the entire country's forests, the water-landscape commons could be expanded throughout the whole river basin and integrated into water conventions.

Another area for improvement was the initial outreach to the farming communities around Madrid. Not many responded to my interview requests, which led to my reliance on experts in agriculture rather than direct engagement with the farmers. Although these experts had experience working with the communities, understanding the farmers' perspectives second-hand was not ideal for a project designed for them. Despite the valuable advice from experts like Sergio and Javier, direct communication with the farmers would have made the research more robust.

Additionally, I overlooked the diversity within the farming community regarding their outlooks and general temperament. I assumed the receptiveness of the communities around Madrid and its outskirts, many of whom are already making small steps toward sustainable farming on their private lands. However, some areas are less receptive to these ideas and would require more than informational books to engage them. Addressing this issue sensitively is crucial, as the proposal might be perceived as imposing on agricultural traditions and cultures in other parts of Spain.

Overall, while the project proposed a detailed and ambitious design for addressing water scarcity through collaborative water-landscape commons, it could have been strengthened by broader regional collaboration, more direct farmer engagement, and a nuanced understanding of the diverse farming community.

What is the role of the Landscape Architect?

Throughout the process of writing this thesis and developing the design proposal, I have been deeply engrossed in many non-spatial aspects, particularly the social and governance components of the commons. Landscape architects, in practice are often siloed into predominantly spatial design. However, as the world becomes more complicated, being put into a box this way, may become a detriment to stakeholders of the design proposal.

I believe landscape architecture and landscape urbanism is at the junction where the environment, society and governance intersect, and these layers cannot simply exist on their own and function without the others.

This thesis explores and considers the many relevant aspects of the drought situation in the Tagus Basin, both spatial and otherwise. While the landscape architect is primarily focused on the spatial elements of a proposal, these spatial elements often serve as the foundation from which community engagement, policies, and governance can derive from.

My role as a landscape architect here is to propose spatial solutions with these factors in mind and explore how all these can come together, recognizing that successful plans, community engagement, and governance require the support of all three.

How were the research questions answered in this thesis?

Overall, this paper from analysis to synthesis to the design proposal, has answered all the research questions posed in the beginning of the research. The research questions were also used to organise the structure of the analysis and design parts of the paper.

The structure and questions that were elaborated in the **analysis** part of the report, with short summaries on how they were addressed are as follows.

Systems of the Environment:

What are the changes to the environment in the Iberian Peninsula that contributed to these droughts?
The dominance of monospecific agriculture all across the Iberian Peninsula and possibly also the depletion of forests and native species. These, coupled with the changes in agricultural practices all throughout history and the increasing global temperatures have caused water within the Iberian Peninsula to become scarce during dry seasons.

Systems of Society:

What were the main human activities that contributed to the changes to these environment?
Intensification of agriculture throughout the whole peninsula and demographic changes have pushed Iberian societies to drain more from the ground and take more from the Tagus River (including by means of water transfers)

How did people react to the droughts?
Farming communities increased extraction from groundwater sources passed state limits and even built illegal unregulated wells. Some farmers in Spain also protested restrictions to the water usage for agriculture.

Systems of Governance:

How did the authorities react to society's actions?
The authorities began lowering water usage limits, decreasing the amount of water supplied to farming communities that are already strained on water resources. Authorities also began enforcing the water restrictions more strictly with more severe repercussions, even deploying civil guards to raid illegal wells and arrest farmers involved in this. As a result, the farming community feels wronged and disenfranchised by the state.

The structure and questions that were elaborated in the **design** part of the report were as follows.

Systems of the Environment:

How can the drought situation be alleviated with the management of water-landscape resources?
A spatial plan towards that can be strived towards by those forming the commons can help find an agreed upon give-and-take arrangement to manage water-landscape resources. This includes increasing forest covers, restoring habitats to some degree around brooks and ravines and connecting these features in the landscape together.

What are part of the commons (and partial commons)?
A spatial regional plan delineates a vision of the afforestation and reinforcement of water networks to help groundwater recharge. The spatial plans also delineate which tyeps of landscapes are commons (protected forests and agroforests) and which are partial commons (private crop-land with ecological features).

What long-term and short-term environmental strategies can be used to achieve the collaborative potential of the water-landscape commons?
Long term strategies: 30-year projection of how the water-landscape can be slowly built by increasing forest cover by 3 - 5% each year.
Short term strategies: Small-scale landscape interventions such as use of wider tree canopies and permeable pavers in urban areas and encouraging layering options for crops to farmers.

Systems of Society:

What are the rules and boundaries of the commons?
Different types of landscapes will have different levels of accessibility and different multi-functions. Different landscape types will also have different users with different rules to adhere to. These were expanded upon in the design proposal.

What are some principles and strategies that the community can use to build the water-landscape commons?
The lanscape principles and strategies were devised and broken down into smaller and manageable steps in the proposal to detail how the long-term vision can be achieved when these strategies are combined.

How can a cultural landsacpe become part of the commons?
Traditional practices involving the acequias can be incorporated into the system of water-landscape management system. Some areas are designated as cultural landscapes according to the spatial plan and will have farming communities uphold these valuable aspects of their heritage and identity.

Systems of Governance:

What are the responsibilities of the different communities and stakeholders in this collaborative system?
Explained with a diagrammatic representation of different levels of stakeholders in the design section.

How can progress and conflicts be managed when building the water-landscape commons?
A cyclical process that continues to monitor, assess or evaluate the commons and the community governing it, making changes to strategies or reorganising according to any changes to the environment or state of the community.

What long-term governance strategies can be used to achieve the collaborative potential of the water-landscape commons?
Constant outreach to assist in rural development is essential and will be implemented along with incorporating the concept of sustainable farming and the commons into the education curriculum of the youth as the process of building the commons and fighting climate change will last for years. Education can help teach the future generation that these effects are gradual but in the long-run they will be worth it.

What short-term governance strategies can be used to achieve the collaborative potential of the water-landscape commons?
Outreach to farmers now is important. A guidebook was made to be delivered to farmers to inform them about the importance of the commons and sustainable farming. It also gives a step-by-step guide on how to begin afforestation and alternative smaller steps that are more manageable to adopt to lower the barrier of entry.

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Appendix

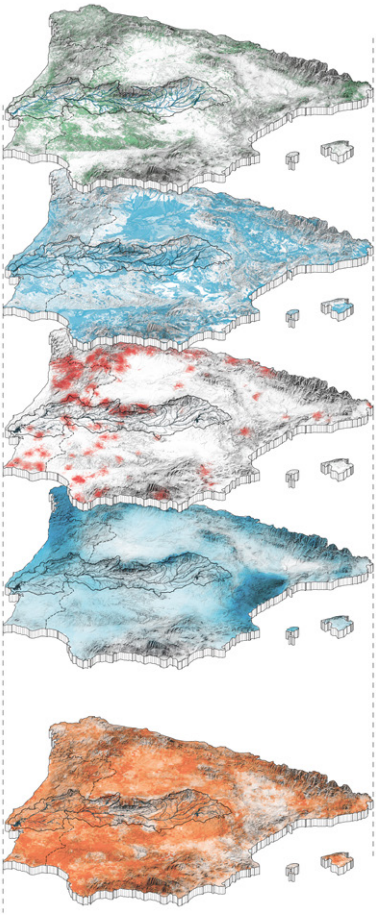
Attached to this report is the full document of
'The Guide to the Water-Landscape Commons'

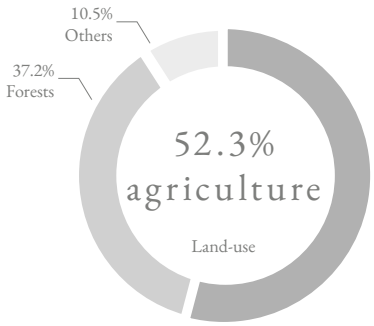
Guide to the Water-Landscape Commons

Arganda del Rey

Why do we need

the commons?

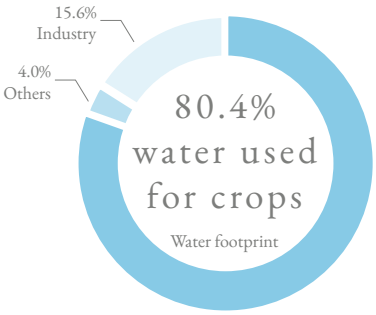

Forest cover
Soil permeability
Burned-areas
Precipitation
Drought Intensity



The Need For A Collaborative System in Today's Climate

In the advent of today's climate crisis, water scarcity in Spain has become more severe than it has ever been. Such an extensive problem cannot be alleviated by a person alone, but together as a community, we can help make things better.

Groundwater levels are dropping quicker every year due to the rising global temperatures, leaving little for farmers to water their crops. Moreover, monospecific agriculture, practiced by many farmers throughout the country, has contributed to the low vegetation regeneration and hardening of soil. This makes the ground less porous and permeable for water infiltration.



How Can the Community Collaborate in These Trying Times?

What we can do as a community is to organise water-landscape commons, a community-owned pool of resources that everyone collaborates to help restore the landscape's conditions for the benefit of everyone.

The Current Situation Of The Irrigation System And Water-Landscapes

Most water sources in Spain are often large water bodies, such as rivers, lakes and canals, or groundwater. However, with today's extreme evaporation, most farming communities are now switching to more efficient modes of irrigation.

1. Localised Irrigation
2. Drip Irrigation
3. Sprinkler Systems

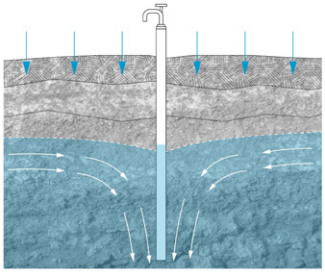
These types of irrigation reduce wasted water compared to surface irrigation, which undergoes high evaporation due to the high surface exposure to the extreme heat. This can help relieve some strain on groundwater sources to some extent.

However, with the increasing trends of global warming, the water bodies and groundwater are susceptible to excessive water loss from evaporation.

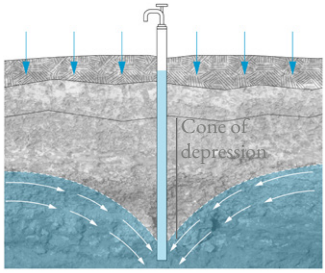
Over the past year, there have also been unregulated wells and over-extraction of groundwater, harming the aquifers across the country and depriving other users of their share of the clean water. This has put a strain on the farming community as many croplands produce lower yields. Some farms are also struggling to make ends meet.

Additionally, with agriculture dominating the land-use of the country, forests cover less than 40%. This has contributed to the excess water loss from the ground, rivers and lakes during dry seasons. Some areas even experience perpetual low water tables levels, and these places are at risk of desertification.

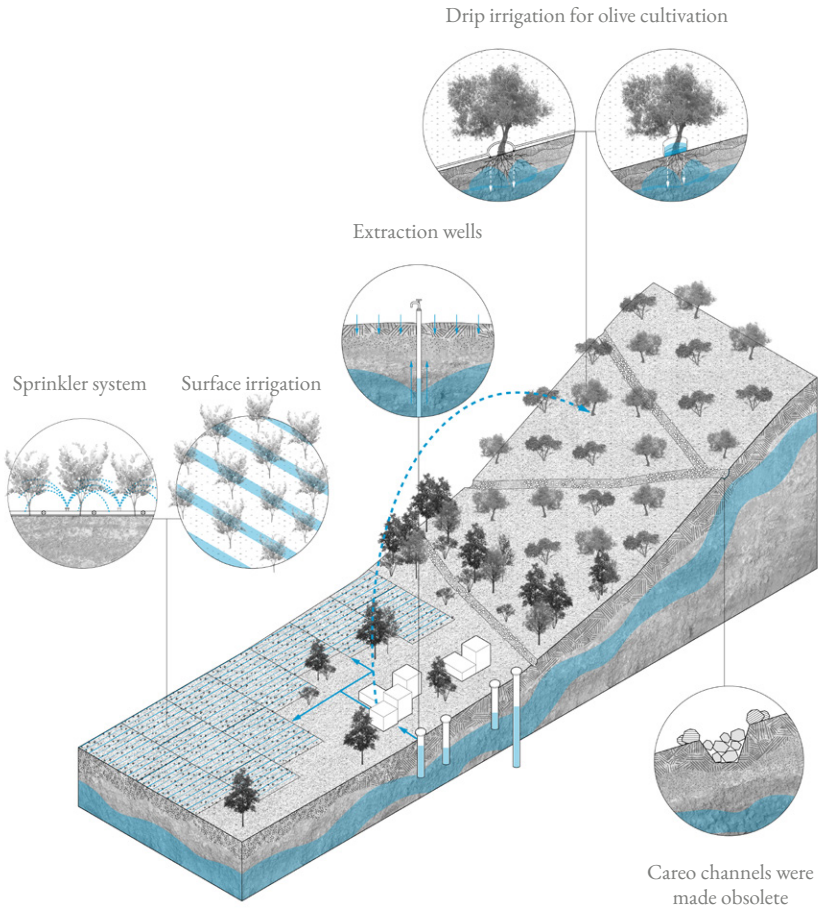
If water becomes part of a common pool of resources, every member of the community will be responsible for each other and their livelihoods. This could help foster a collaborative system between the environment, society's needs and community-driven resource governance.



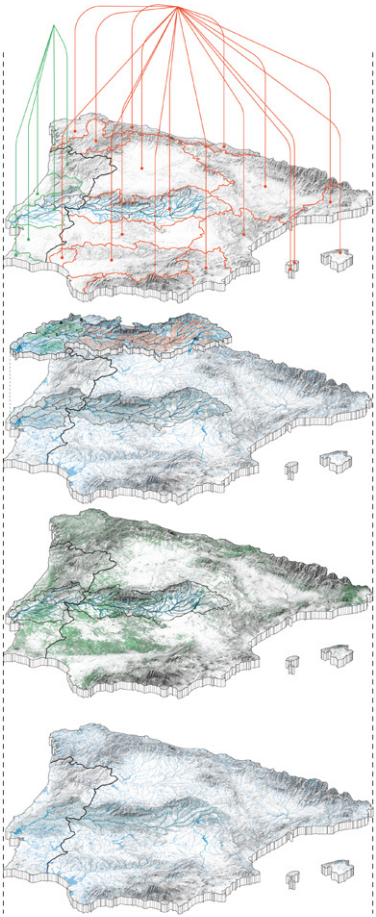
Regular water extraction from extraction wells



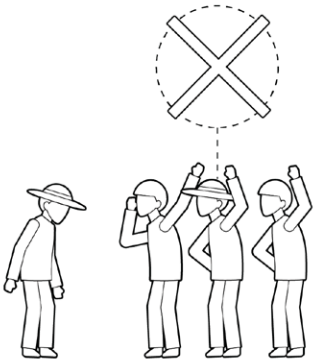
Illegal / over-extraction from aquifers

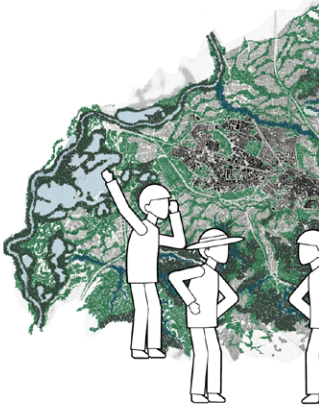


Existing modes of irrigation


Governance
Society
Environment
Commons

What does it mean
to establish the
commons?



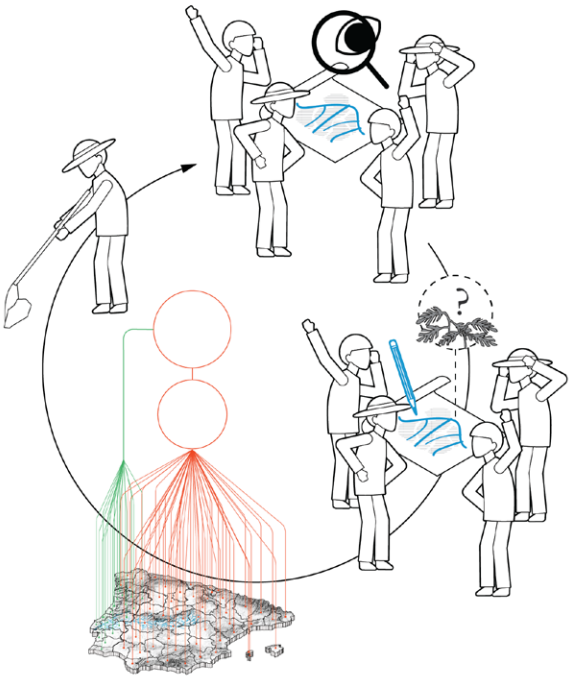


Graduated sanctions:

violators of the rules will be assessed by other users of the commons or officials that are accountable to the users.

Monitoring and conflict-resolution system:

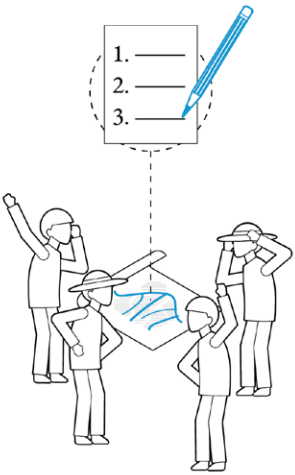
monitors will actively track the conditions of the commons who either report to the users or are users themselves. Also an efficient and accessible way to raise conflicts between users, stakeholders or changes to the environment.



Clearly defined boundaries:

what the resources are and who have the rights to partake

Principles That Form The Basis Of The Commons

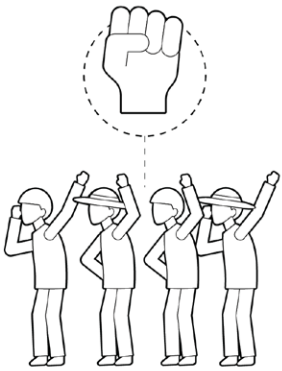


Congruence between appropriation and provision rules and local conditions:

Agreement and organisation of the rules of the commons and the partial commons

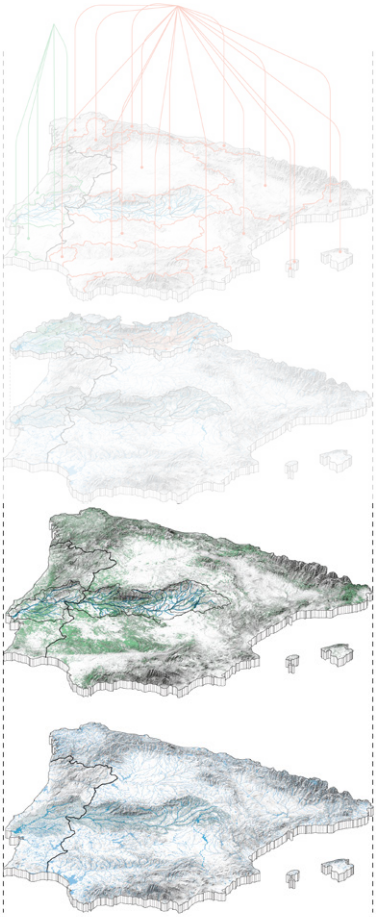
Collective -choice arrangements:

individuals participating in the commons can collaborate to form or change the rules that are mutually agreed upon



Minimal recognition of rights to organise:

users have rights to plan their institutions without rights being challenged by external forces.


Environment
Commons

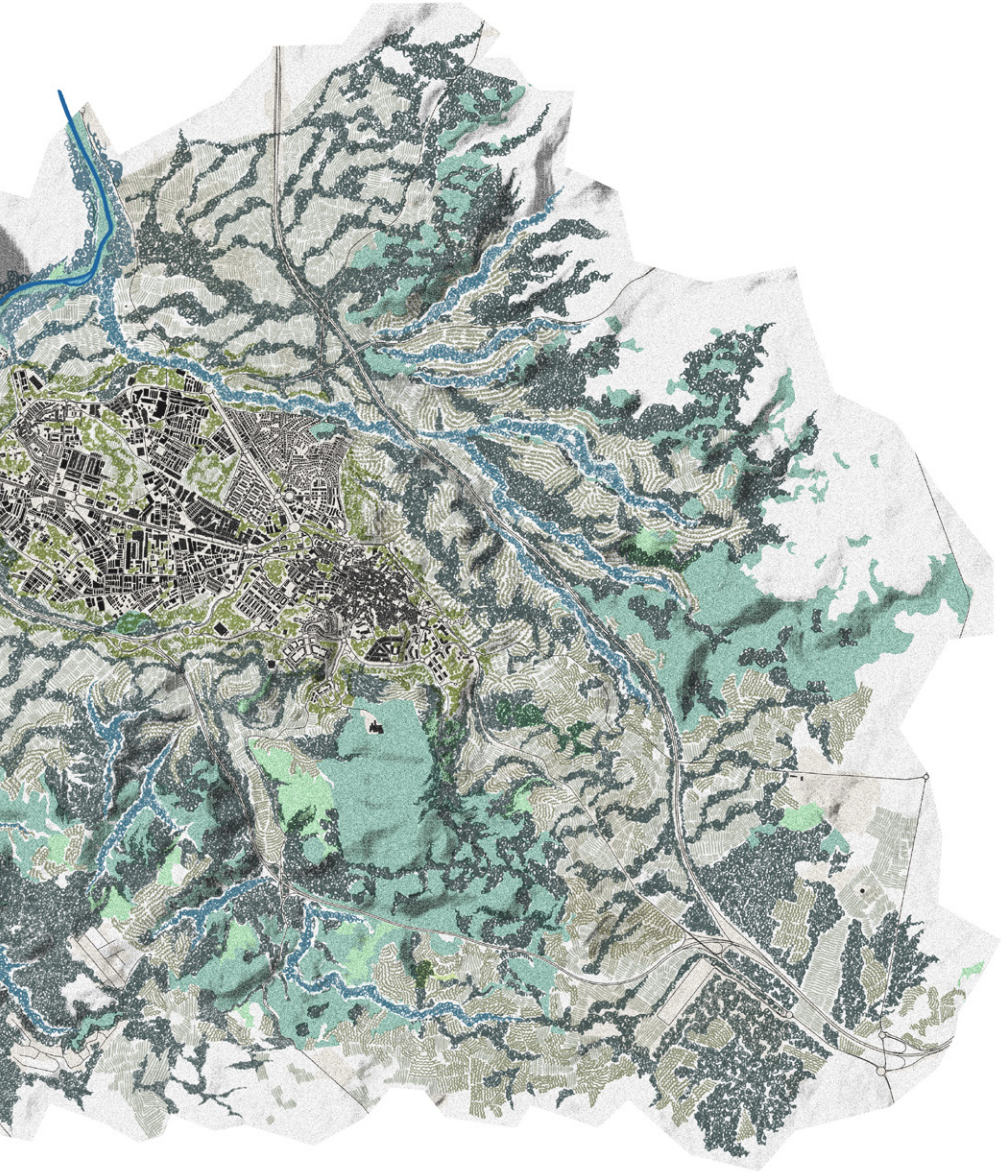
What is part of the
water-landscape
commons?

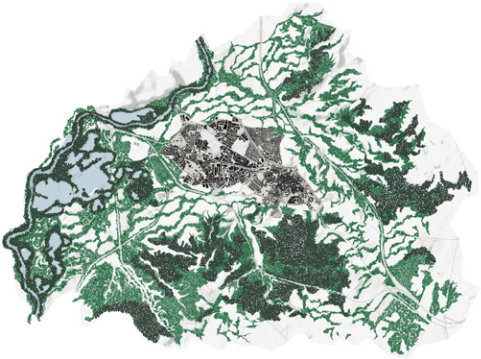
New Vision for Arganda Del Rey

- Brook and ravine habitats
- New riparian forests
- New forests
- New urban landscapes
- New crop land / vineyards
- New tree-crop land
- Existing forests
- Existing sparse forests
- Existing sparse trees
- Existing crops / barren land
- Water bodies
- River / tributaries

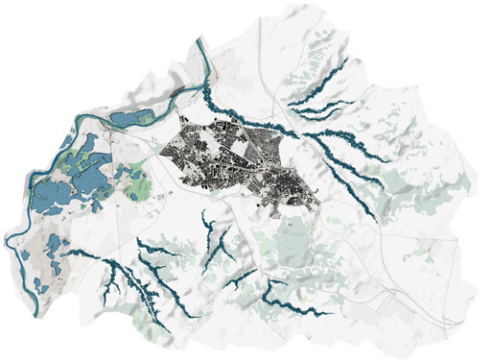
The water-landscape commons is the community-owned space of cultural and natural resources that are accessible to each member of the community. As a member of the community, you have some basic rights to use the common pool resources in exchange for maintaining them. This would involve a set of rules and values to adhere to in order to protect the resources, cultural practices and those partaking in the commons. The commons is not governed by a state or market but rather the community of users.

People have different stakes in the commons and some are more vulnerable than others. The farming community, for instance, depend on the Tagus River's water to irrigate their crops. If you are a farmer, you can help participate in the organisation of the commons. Depending on your level of participation, you will then have the rights to reap the harvests and water from the commons.





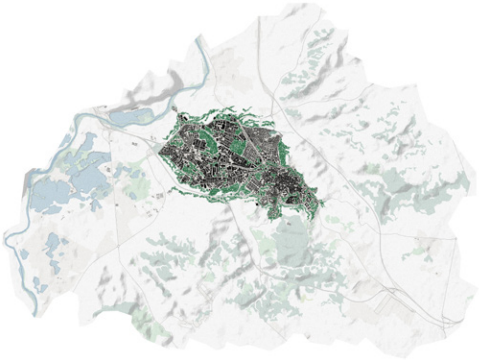
Protected Forests and Agroforests



Brook and Ravine Habitats

The Agricultural Commons:

Protected forests, agroforests, brooks and ravines

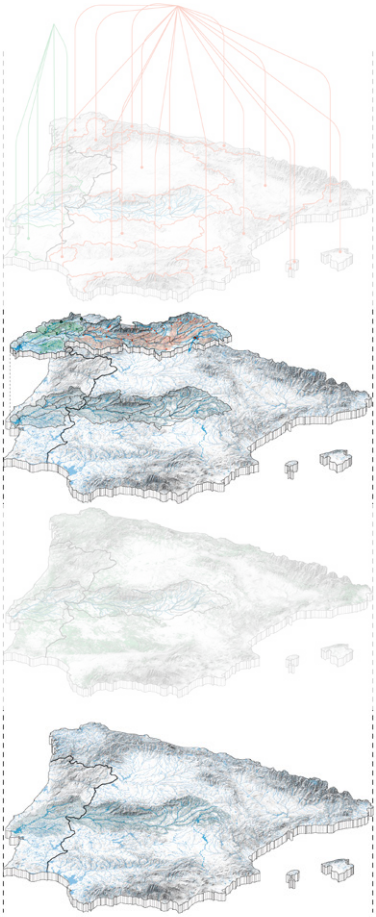


Public Green Spaces

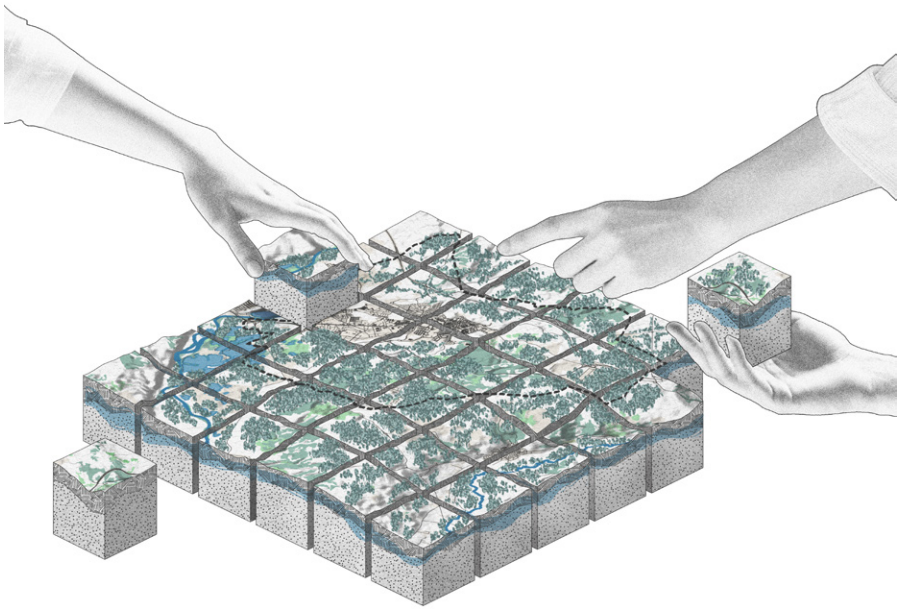
Private-owned Cropland as the Partial Commons and Cultural Landscapes

The Partial Commons:

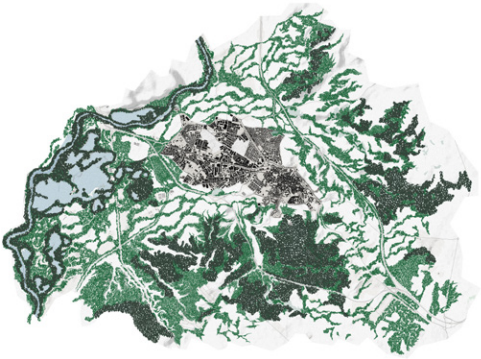
Public Spaces and Private Cropland


Society
Commons

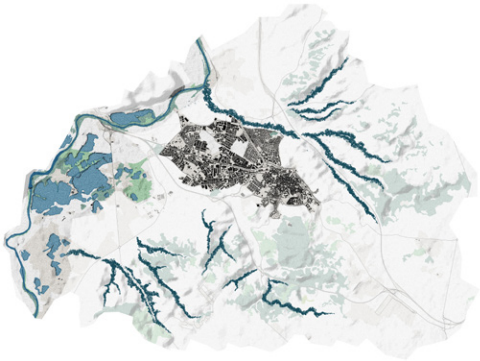
Who can use the commons?



Collaboration Between Stakeholders



Protected Forests and Agroforests



Brook and Ravine Habitats

The Agricultural Commons:

Protected forests, agroforests, brooks and ravines

Agroforests

Farmers participating in the commons only

Protected Forests & Nature Reserves

Members of the public and community can enjoy the outdoors but not stray from paths

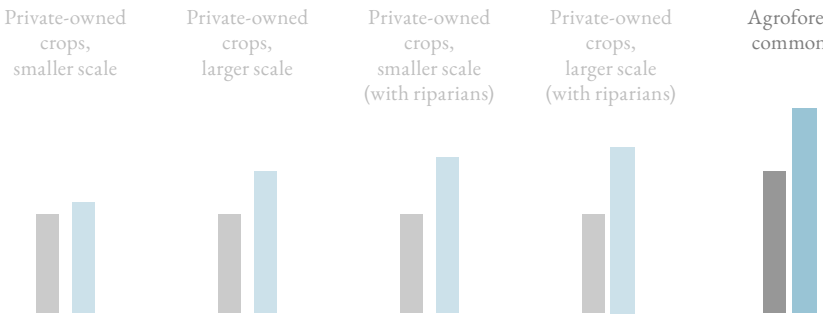
Protected Forests & Nature Reserves

Brooks & Ravines

Members of the public and community can enjoy the outdoors but not stray from paths. Farmers can use amounts of water depending on their paraticipation in the commons

Levels of Accessibility

How much water and compensation can you get?



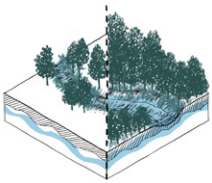
Compensation & access to water from natural sources according to scale of business and level of participation in the commons

What Are The Recommended Rules Of The Agricultural Commons?

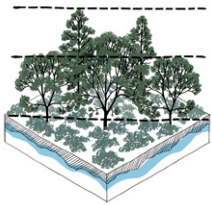
These are recommended rules of the commons to start off. Members of the community and those who have the rights to partake in the commons (ie. farmers) can come together to discuss these terms and reorganise the rules and values necessary to establish a sustainable and collaborative system to manage natural resources and preserve cultural agriculture customs.

The commons will consist of the expanded forest cover, existing forest land and the rivers, brooks and ravine systems that are connected by them. Forest cover expansions connect existing forest land to the river, brooks and ravines, they can be done by encouraging some farmers to adopt agroforestry or a polyculture of trees and other crops on their land.

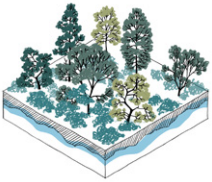
1. Agroforests will become common land, where farmers will be able to harvest from any part of these forests within a stipulated limit.
2. An encouraged limit on the amount of wood that can be harvested by each person in the community.
3. Ensure forest layers by including understorey and shrubs / groundcover layers among crop trees.
4. Alternatively, farmers can involve crop diversification with less pressure to provide vegetation layering.
5. Harvesting of wood resources will be done mechanically and regular maintenance will be done using approved sustainable methods.
6. Brooks, ravines and existing forests will be preserved and maintained.
7. Farmers of agroforests will be able to use the water from the protected brooks and ravines.



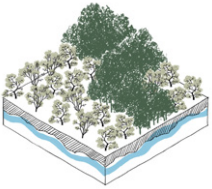
Expanding existing brooks or ravines



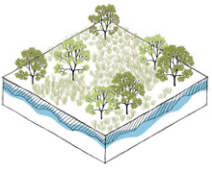
Adding layers to vegetation



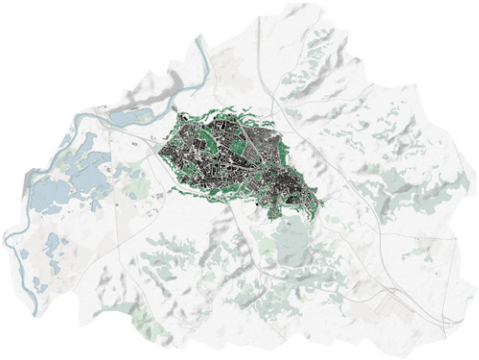
Diversifying vegetation



Connecting forests to cropland



Adopting crop rotations



Public Green Spaces

Private-owned Cropland as the Partial Commons and Cultural Landscapes

The Partial Commons:

Public Spaces and Private Cropland

Parks (Public Green Spaces)

All members of the
Community can access

Protected Forests & Nature Reserves

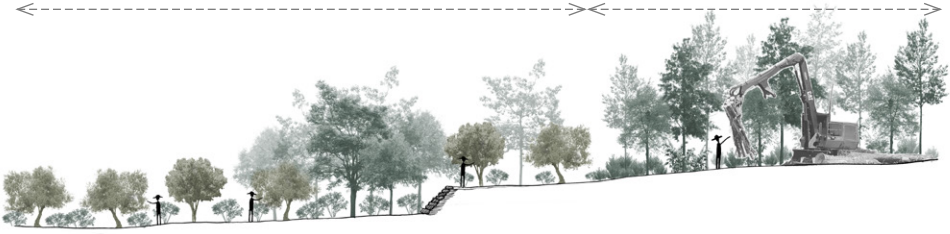
Members of the public and community can
enjoy the outdoors but not stray from paths

Private-owned Cropland

Farmers or owners of the
land only

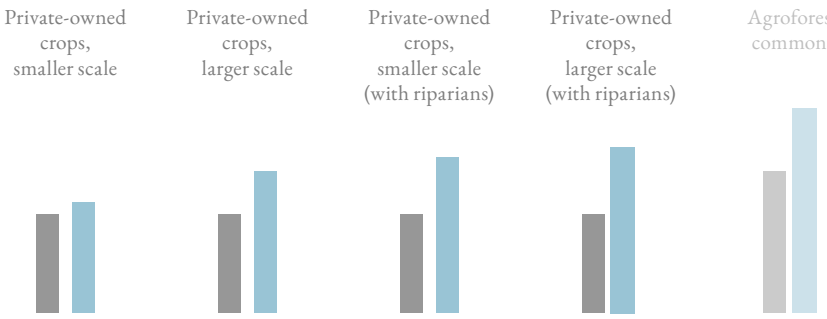
Agroforests

Farmers participating in the
commons only



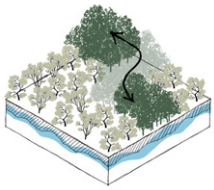
Levels of Accessibility

How much water and compensation can you get?

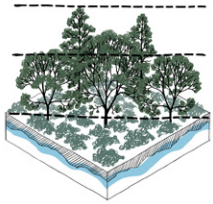


Compensation & access to water from natural sources according to scale of business and level of participation in the commons

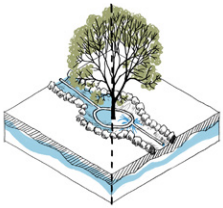
Connecting public greenspaces to forests and other cropland



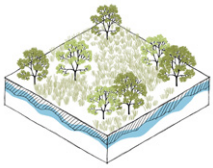
Connecting small forests



Adding layers to vegetation



Different seasonal irrigation methods



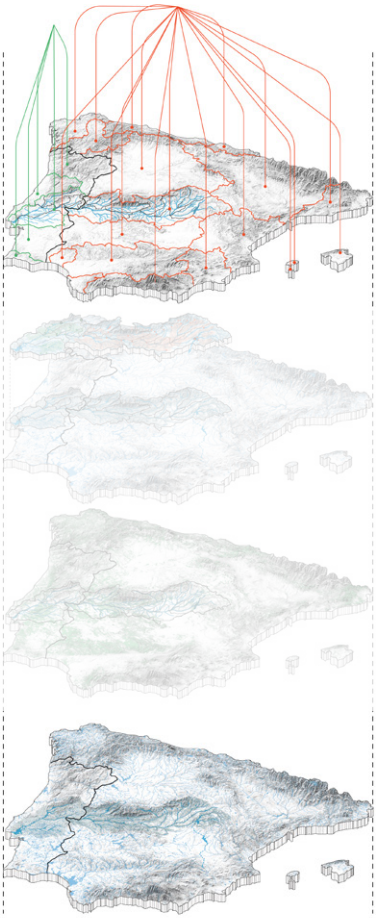
Adopting crop rotations

What are the Recommended Rules of the Partial Commons?

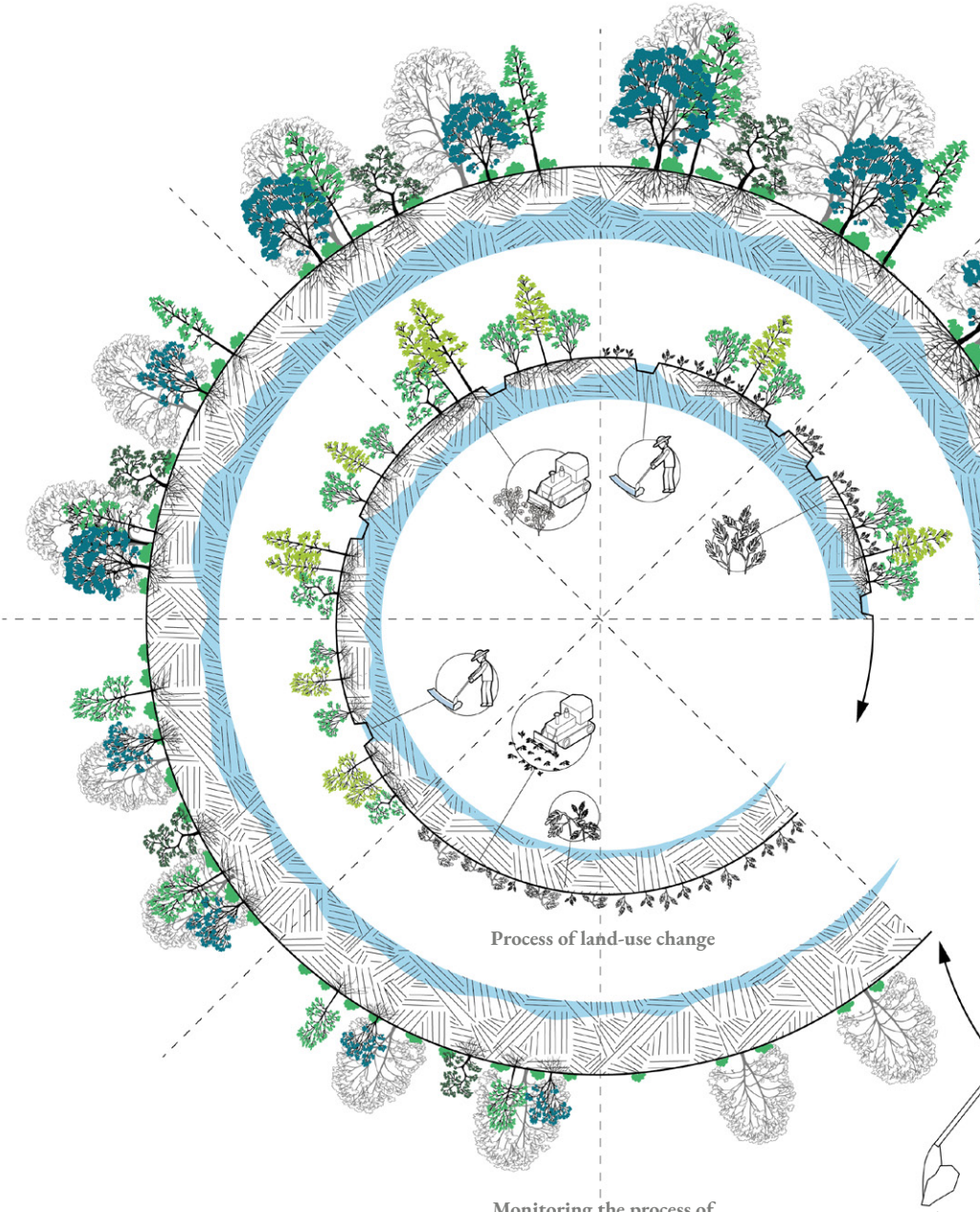
The initial phases of establishing the commons will be gradual and full participation of the farming community is not expected due to the lasting cultural traditions and affordability of joining the commons. The remaining cultivated private land will become a part of the landscape as a representation of traditional local cultivation. Under this arrangement, landowners will be protected and recommended to employ eco-schemes from the Common Agriculture Policy in exchange for using water from rivers and streams from enhanced brooks and ravines to some extent and other financial assistance.

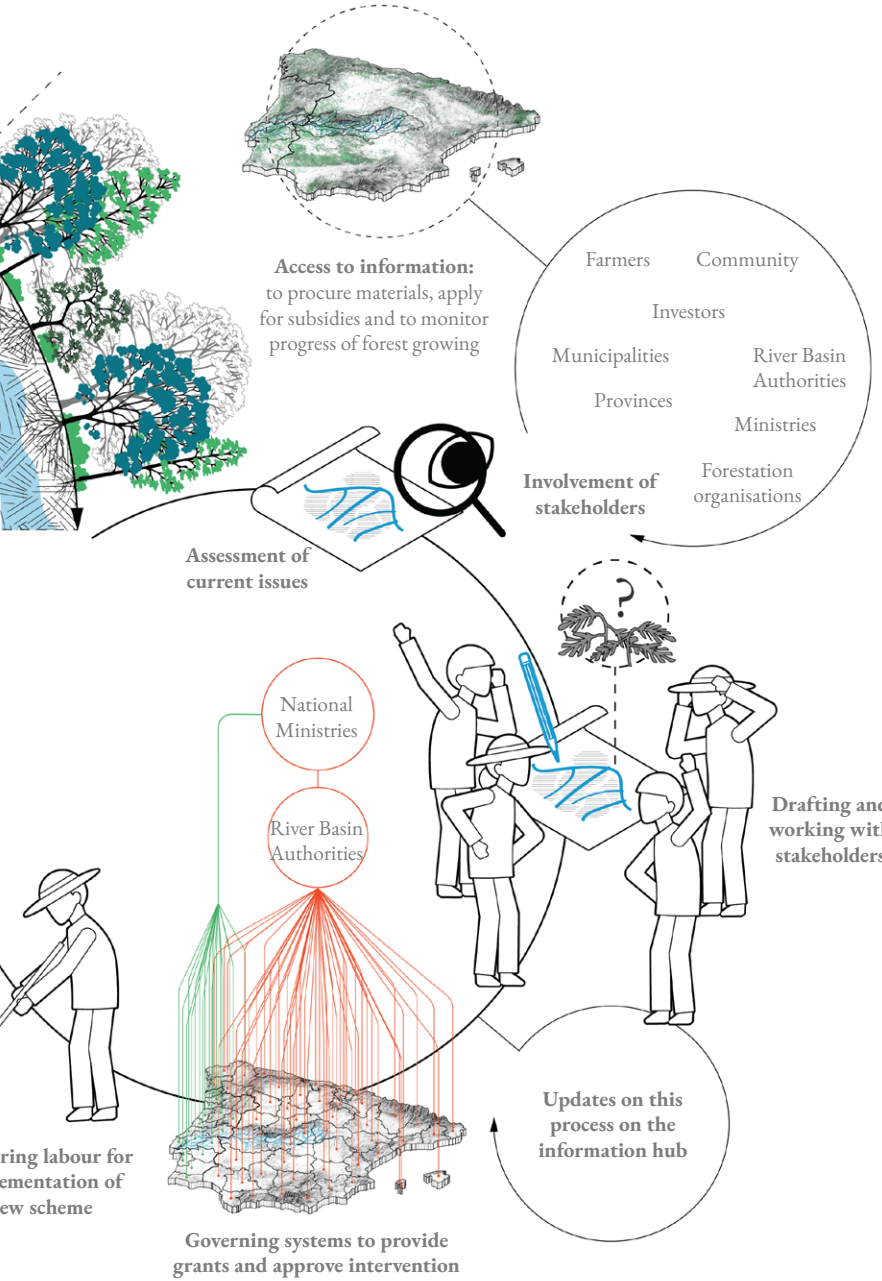
1. Part of the cultivated land will be encouraged to be devoted to sustainable non-productive uses, for example, forest growing.
2. Farmers should practice crop rotations or land-sparing across the land area they own.
3. Use of vegetation layering together with crops.
4. Use of approved seasonal irrigation rotations. During wet seasons, farmers will use traditional acequias – a variety of traditional Spanish irrigation methods – to gather water from rainfall and route them to irrigate crops. During dry seasons, more mechanical means such as drip / localised irrigation should be used to reduce water consumption.
5. Farmers can draw a limited amount of water from the ravines and brooks, proportional to the size of their agricultural businesses.

Farmers can collaborate with local organisations that specialise in afforestation to begin growing small forest habitats on their land. Procurement of seedlings, saplings and other material will be subsidised. Furthermore, the initiatial phases of establishing the commons should provide farmers with compensation for forest growing and even tax reliefs to encourage participation of the farmers and reduce the barrier of entry.

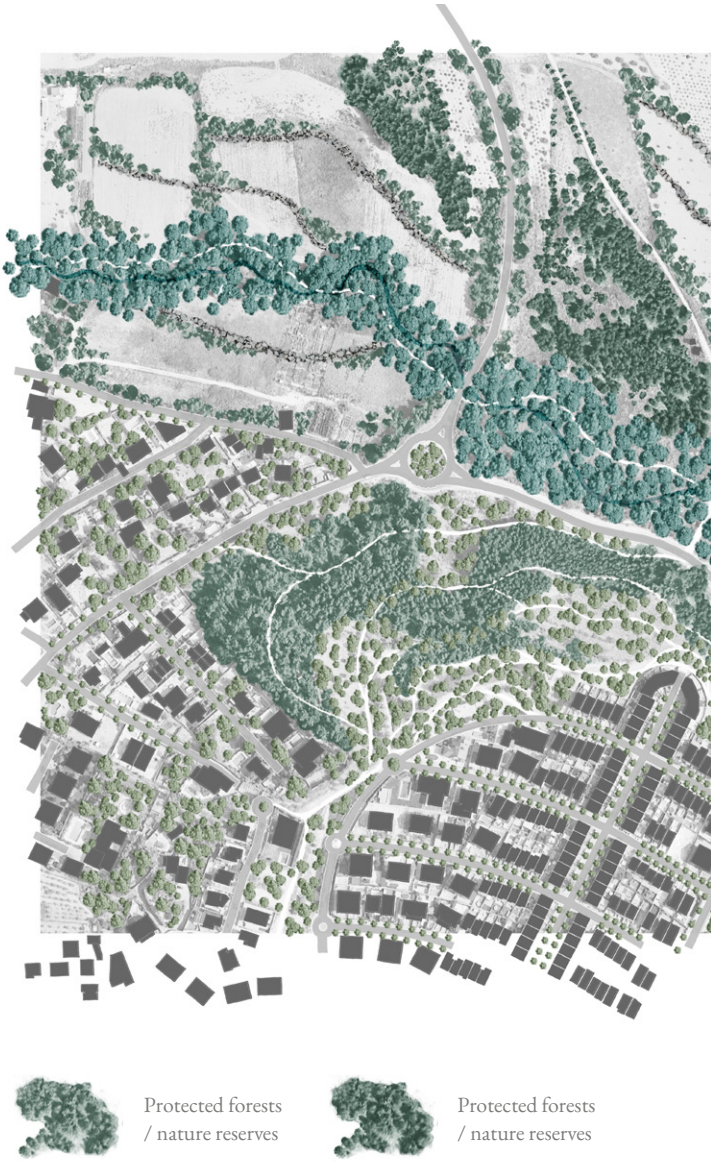

Government
Commons

How can the commons be managed?


Process of land-use change
Monitoring the process of
afforestation and protected forests
Acqui
impl
n

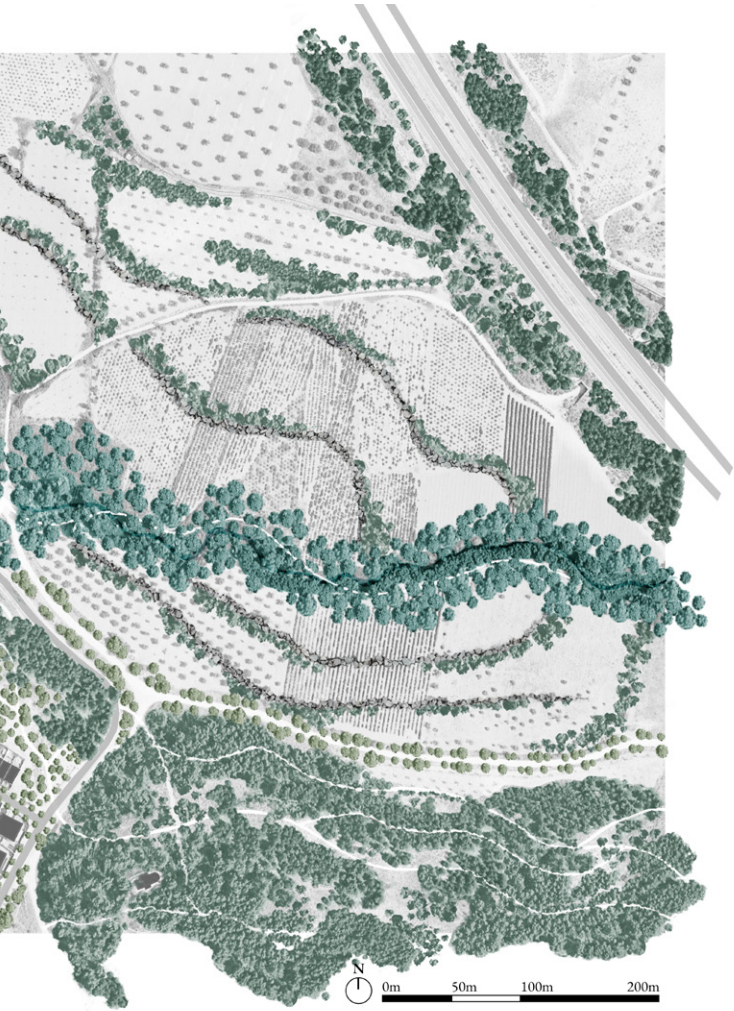

Access to information:
to procure materials, apply for subsidies and to monitor progress of forest growing
Farmers
Community
Investors
Municipalities
River Basin Authorities
Provinces
Ministries
Forestation organisations
Involvement of stakeholders
Assessment of current issues
?
National Ministries
River Basin Authorities
Drafting and working with stakeholders
Updates on this process on the information hub
Governing systems to provide grants and approve intervention
ring labour for
ementation of
ew scheme

Why should these places become public spaces?



Protected forests / nature reserves

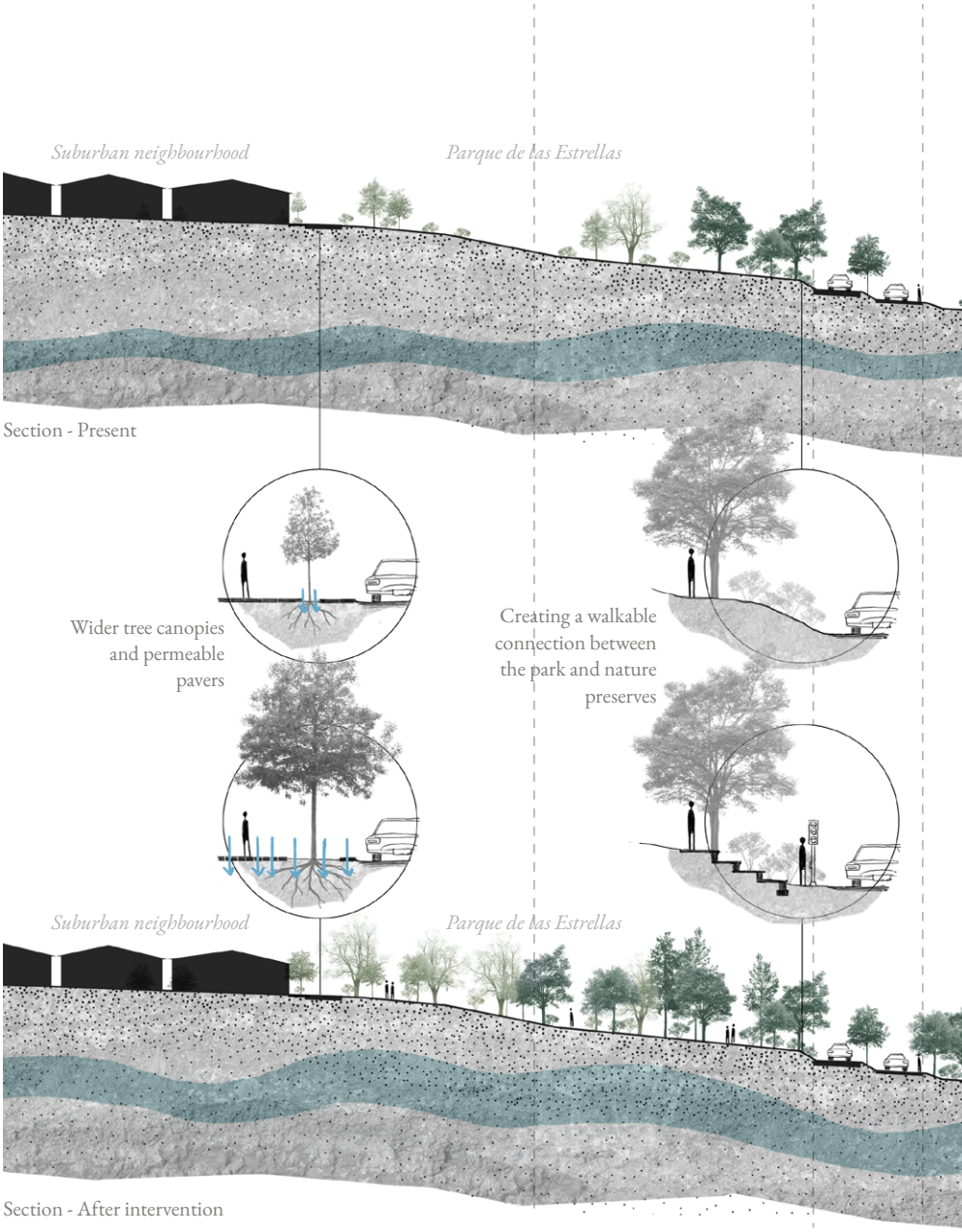
Protected forests / nature reserves

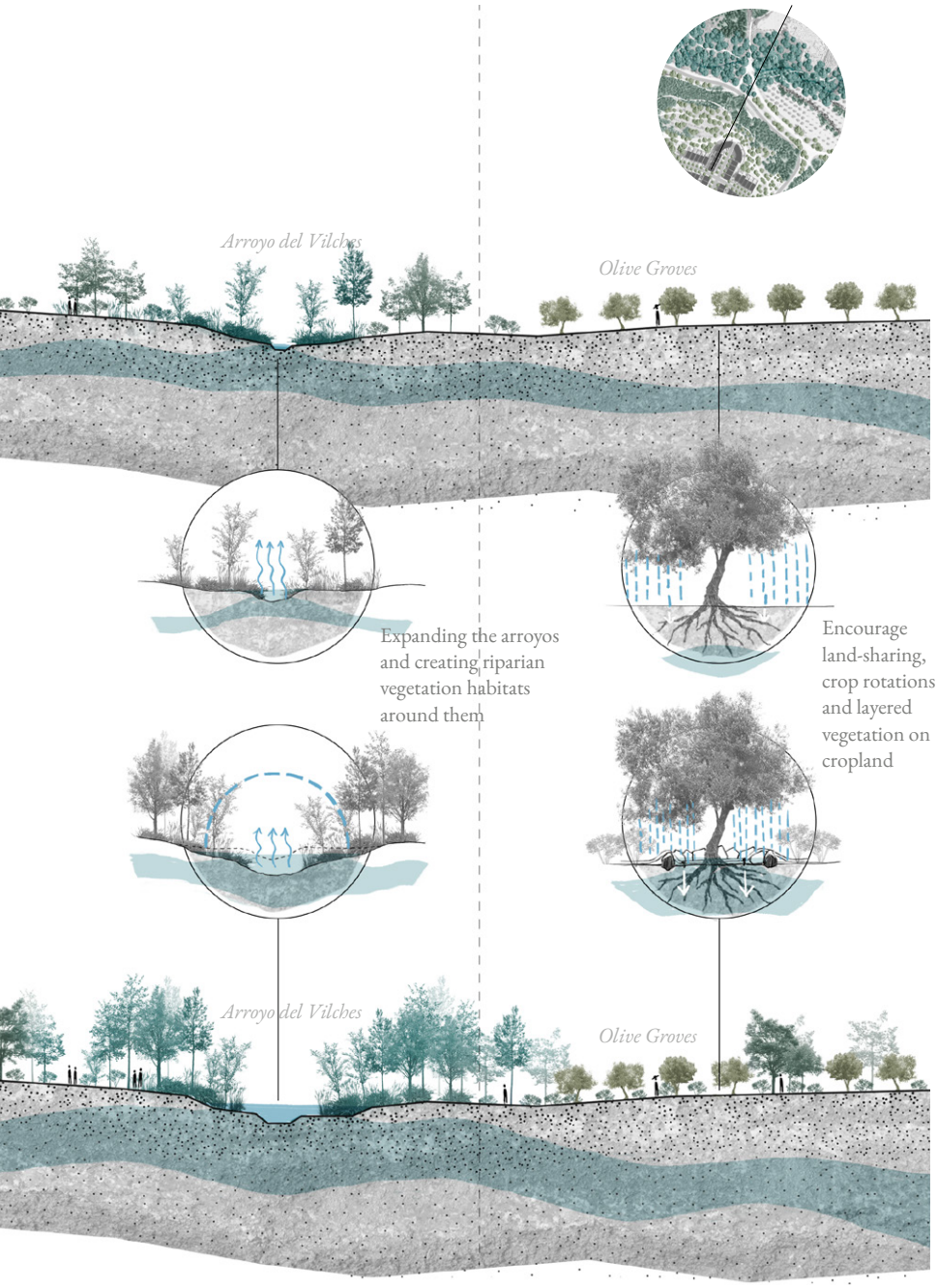


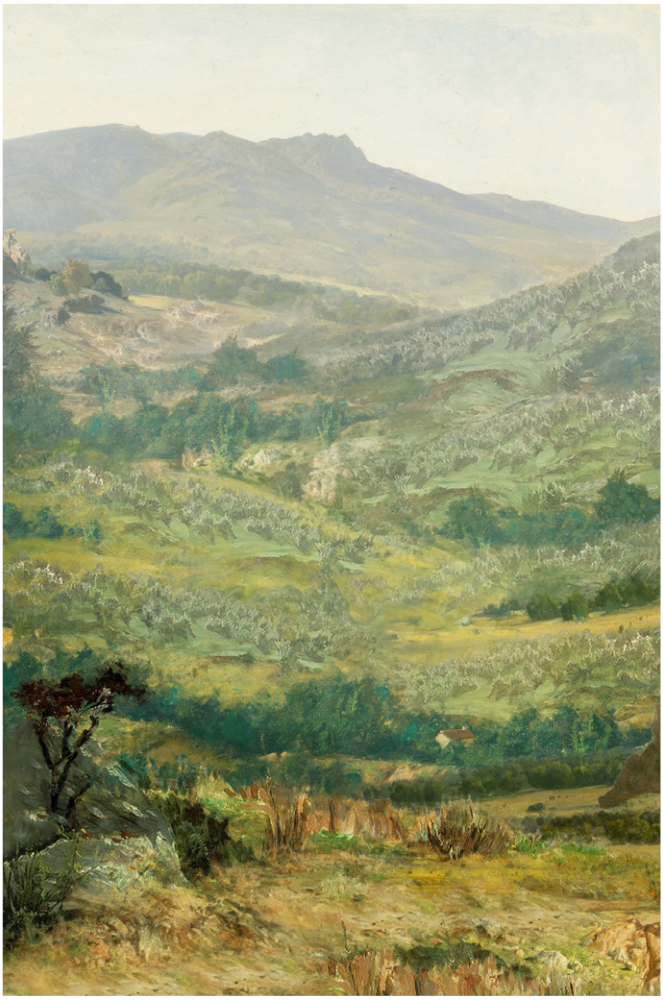
Riparian forests of Arroyo del Vilches

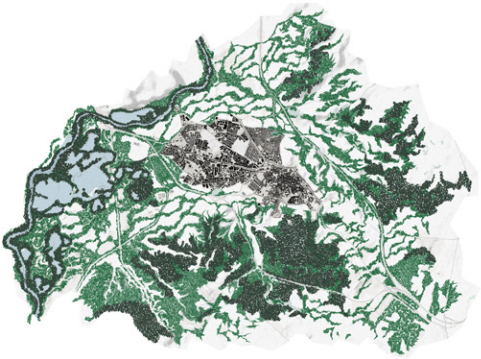
Parks and Urban Green Spaces

Because the community can bring value to the land and bring life back to the soil.

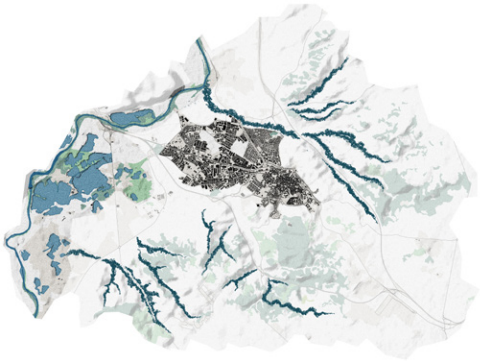

Suburban neighbourhood
Parque de las Estrellas
Section - Present
Wider tree canopies and permeable pavers
Creating a walkable connection between the park and nature preserves
Suburban neighbourhood
Parque de las Estrellas
Section - After intervention
0m
50m
100m
200m


Arroyo del Vilches
Olive Groves
Expanding the arroyos and creating riparian vegetation habitats around them
Encourage land-sharing, crop rotations and layered vegetation on cropland
Arroyo del Vilches
Olive Groves





Protected Forests and Agroforests



Brook and Ravine Habitats

The Agricultural Commons:

Protected forests, agroforests, brooks and ravines

How can we
start growing
agroforests?

Partaking in the Agricultural Commons: A Guide to Growing Agroforests

If you are a farmer and you would like to be a contributing part of the water-landscape commons by adopting agroforestry, you can approach the AGFE (Spanish Agroforestry Association) or grow your economic / ecological forests on your own. Whether you are growing forests with help or by yourself, you may apply for some subsidies for the necessary materials and process by visiting the website.

If you are interested in growing these economic forests yourself, there are some steps you can take to achieve this.

1. Consideration Climate, Soil and Native Plant Species

Climate Assessment

Some areas of Central Spain, such as the Community of Madrid and including Arganda del Rey, are semi-arid. Dry summers are experienced throughout the region.

Type of soil and minerals present

The geological map of Arganda details what types of soils are naturally present in your plot of land and around it. Most crops present are grown on clay type soils that are variations of marls, carbonates, gypsum, mixed with sandy type soils.

Native vegetation present

It is important to assess which species are native and non-native. For instance, some species like the Holm Oak are now rare in the landscapes of Arganda due to the changing climates. Knowing this information will guide you on which species are appropriate to introduce in your forests.

Quercus ilex
"Holm Oak"
Native

Pinus sylvestris
"Scots Pine"
Non-native

Quercus canariensis
"Zean Oak"
Native

Olea europaea
"Olive"
Native

Linum suffruticosum
"White Flax"
Native

Antirrhinum graniticum
"Spanish Snapdragon"
Native

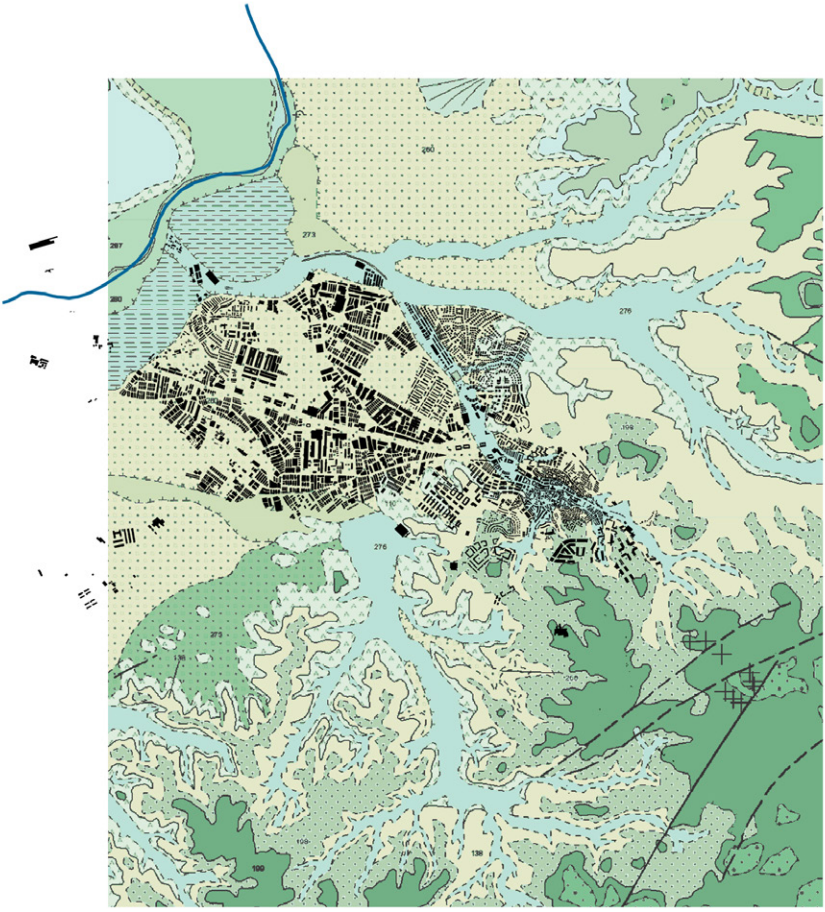
Stipa tenacissima
"Esparto Grass"
Native

Malva multiflora
"Cretan mallow"
Native

Echium vulgare
"Viper's Bugloss"
Native

Hirschfeldia incana
"Mediterranean Mustard"
Native

What species are present in Arganda today?



Micritic limestones with algae and black and red limestones.

Gravels and polygenic stones, sands, silts and clays. Carbonates.

Alternations of white gypsum marls, carbonates, gypsum and green clays.

Sandy clays with rock fragments.

Gray silt and sand.

Gravels and polygenic stones of quartzite and quartz. Sands, silts and sandy clays. Tuffaceous carbonates.

Disorganized pebbles, blocks and sandy clays.

Pebbles, gravel, sand and clay.

Conglomerate, sandstone and red shale.

Tablet and nodular plasters interspersed between green, chalk, brown and red clays

What kind of trees can be planted in Arganda?

More information on the Catalogue of Base Materials, on the Ministerio para la Transición Ecológica y el Reto Demográfico website.

National Catalogue Of Base Materials For The Production Of Identified Forest Reproductive Material

Abies alba Mill.
Abies pinsapo Boiss.
Acer platanoides L.
Acer pseudoplatanus L.
Alnus glutinosa (L.) Gaertn.
Arbutus canariensis Veill.
Arbutus unedo L.
Betula pendula Roth
Betula pubescens Ehrh.
Carpinus betulus L.
Castanea sativa Mill.
Fagus sylvatica L.
Fraxinus angustifolia Vahl.
Fraxinus excelsior L.
Ilex aquifolium L.
Juglans nigra L.
Juglans regia L.
Juniperus communis L.
Juniperus oxycedrus L.
Juniperus phoenicea L.
Juniperus thurifera L.
Larix decidua Mill.
Larix kaempferi Carr.
Olea europaea Brot.
Phoenix canariensis Hort.
Picea sitchensis Carr.
Pinus canariensis Chr. Sm. ex DC.
Pinus halepensis Mill.
Pinus nigra subsp. nigra Arn.
Pinus nigra subsp. salzmannii (Dunal) Franco
Pinus nigra var. corsicana Arn.
Pinus pinaster Ait.
Pinus pinea L.
Pinus radiata D.Don
Pinus sylvestris L.
Pinus uncinata Mill.
Pistacia atlantica Desf.
Populus alba L.*
Populus x canescens (Aiton) Sm.*
Populus nigra L.*
Populus tremula L.*
Prunus avium L.*
Pseudotsuga menziessii Franco
Quercus canariensis Willd.
Quercus coccifera L.
Quercus faginea Lam.
Quercus ilex L.
Quercus petraea Liebl.
Quercus pubescens Willd.
Quercus pyrenaica Willd.
Quercus robur L.
Quercus rubra L.
Quercus suber L.
Robinia pseudoacacia L.
Sorbus aria Crantz.
Sorbus aucuparia L.
Tamarix gallica L.
Taxus baccata L.
Tetraclinis articulata Masters
Tilia cordata Mill.
Tilia platyphyllos Scop.
Ulmus glabra Huds.
Ulmus minor Mill.

**Populus spp. generally have extensive root systems that may become invasive and dominate water systems. Diversify your populus crops with other species and maintain their population.*

Dehesa

In Dehesa is a low-density oak forests to produce acorns for rearing livestock and to shelter the land from the intense heat during dry seasons.

2. Soil Preparation For Low-Nutrient Soils

Do you have trouble growing crops or has your land been bare for the last few years? The land you are working on may be low on nutrients. Fertilisation of the soil is imperative to support any form of plant life. There are a few options for you to treat your soil before planting:

- *Remove invasive species or unsuitable plants:* there are some species of plants that will out-compete your crops, so it's essential to remove these invasive species. You may refer to the National Catalogue of Invasive Exotic Species.
- *Inorganic fertilisation*, depending on your crop: ammonium sulfates, ammonium nitrosulfates, ammonium nitrates, urea, nitrogen solutions, other nitrogenous solutions.
- *Organic fertilisation*: manure, compost, etc. Adding manure to the surface of the soil is less efficient and its effects would not last. Hence, mixing them at subsoil layers would be more beneficial.
- *Adding a mulch layer* could help with water retention in drought conditions during dry seasons. Having this layer of organic material can help regulate the temperature of the soils and keep the water from being lost unnecessarily to evaporation.

Acacia dealbata
"Silver Wattle"
Non-native, Invasive

Agave americana
"Century Plant"
Non-native, Invasive

Ambrosia artemisiifolia
"Ragweed"
Non-native, Invasive

Cortaderia spp.
"Pampas grass"
Non-native, Invasive

Pennisetum setaceum
"Fountain Grass"
Non-native, Invasive

Senecio inaequidens
"Narrow-leaved Ragwort"
Non-native, Invasive

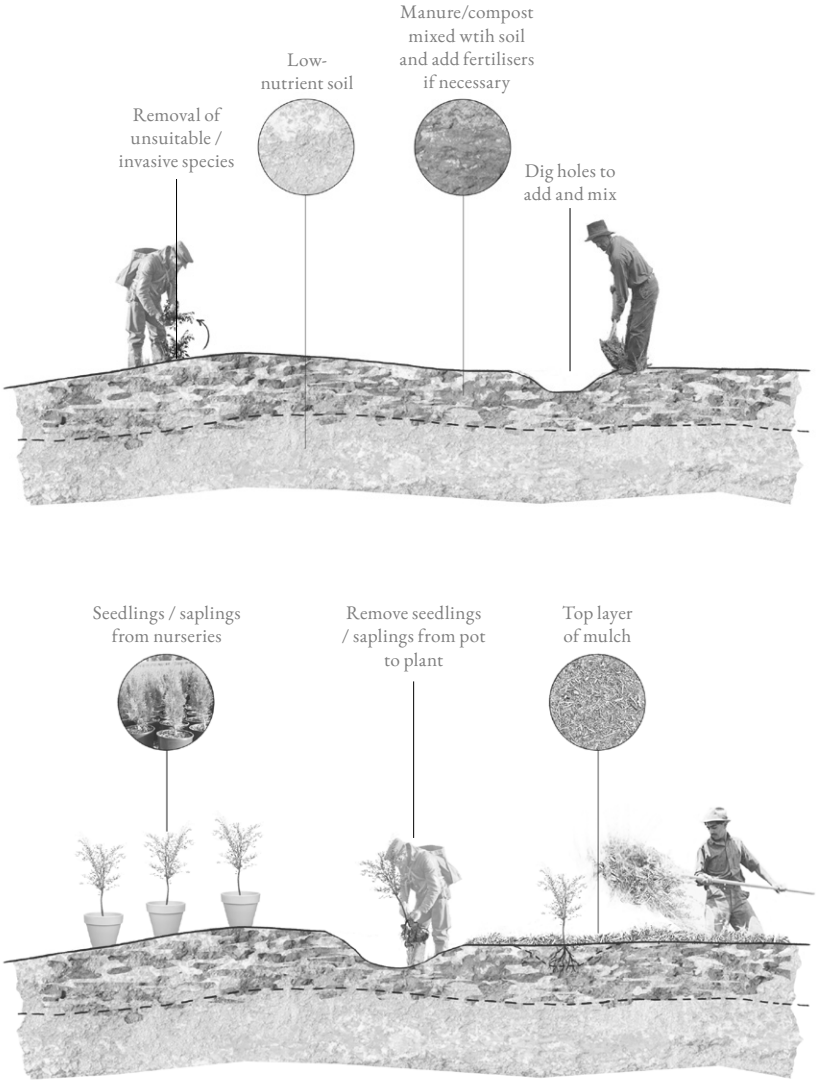
Heracleum mantegazzianum
"Giant Hogweed"
Non-native, Invasive

Baccharis halimifolia
"Sea Myrtle"
Non-native, Invasive

3. Growing The Selected Vegetation

Most landscape restoration projects span several years. This process often involves growing trees first in nurseries. The afforestation of arid and semi-arid areas across the world began in a controlled environment, such as greenhouses and nurseries, to germinate seeds before transplanting them as saplings to the site. At this point, the land should have undergone soil preparation for new saplings.

More information on the Catalogue of Invasive Exotic Species, on the Ministerio para la Transición Ecológica y el Reto Demográfico website.


Manure/compost mixed wtih soil and add fertilisers if necessary
Low-nutrient soil
Removal of unsuitable / invasive species
Dig holes to add and mix
Seedlings / saplings from nurseries
Remove seedlings / saplings from pot to plant
Top layer of mulch

4. Establishing Water Management

There are mechanical methods of irrigation and traditional low-tech methods practiced today to irrigate tree crops. More sparse types of agroforests, where tree numbers are lower, are often irrigated by mechanical means such as drip or localized irrigation. These can be costly for denser types of agroforests, or forests with a higher tree count.

Alternatively, there are traditional methods used since centuries ago to irrigate tree crops and retain water.

There are existing terraces that outline the contours of the slopes around Arganda. These are ways to slow water flowing down the slopes so that more seep into the soil instead of running off.

Pits, made of rocks around the base of trees, are also often constructed to catch water during wet seasons to allow precipitation to infiltrate the soil easily.

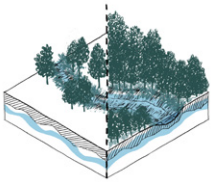
5. Re-Establishing Vegetation Cover

Some spatial principles, when it comes to sustaining a forest, are essential.

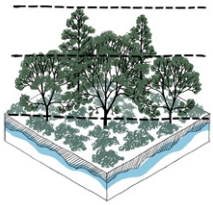
Agroforest lands should be connected for efficient water retention and irrigation.

Agroforests should have a multi-layered structure. In order to maintain the porosity and nutrients in the soil, a shallow root system of perennial native shrubs around the tree crops should be established ideally. However, there are also other alternatives.

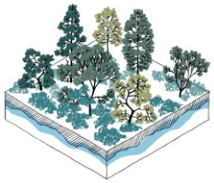
Planted shrubs can also be smaller crops such as wheat or barley. These smaller crops are often not perennial and would require dedication to replant the same crops according to a strict timeline annually.



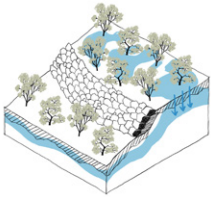
Expanding existing brooks or ravines



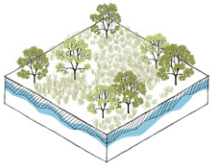
Adding layers to forest vegetation



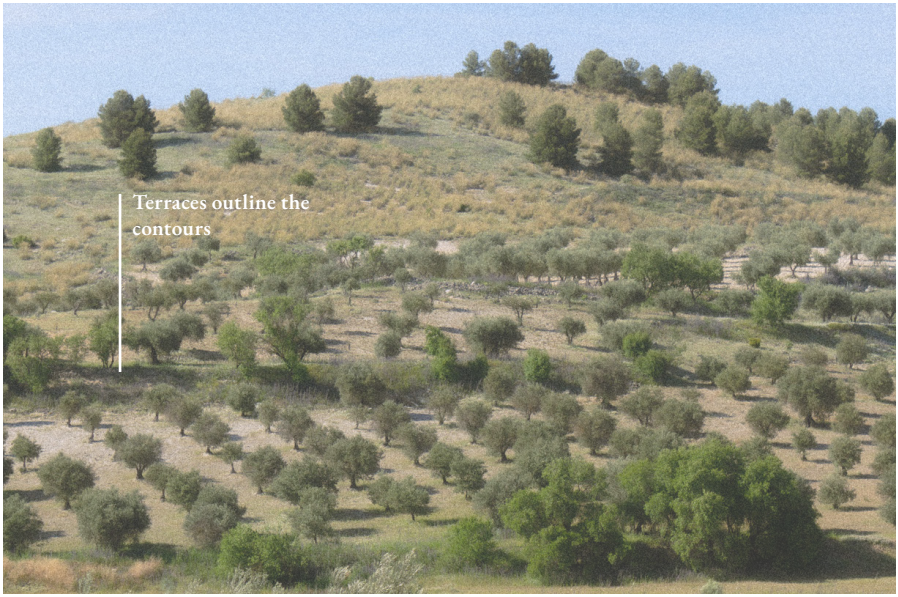
Diversifying forest vegetation

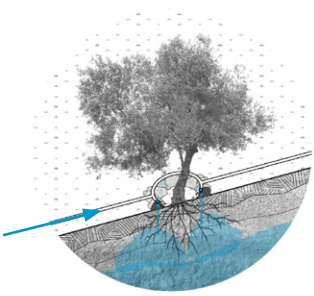


Use of terracing on hilly terrain to retain water

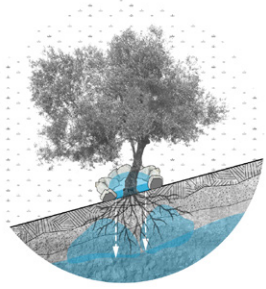


Adopting crop rotations

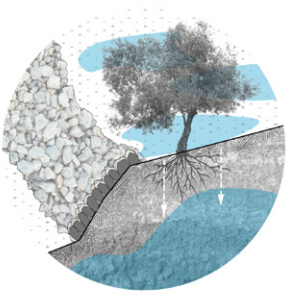




Drip irrgation with water
from brooks and ravines

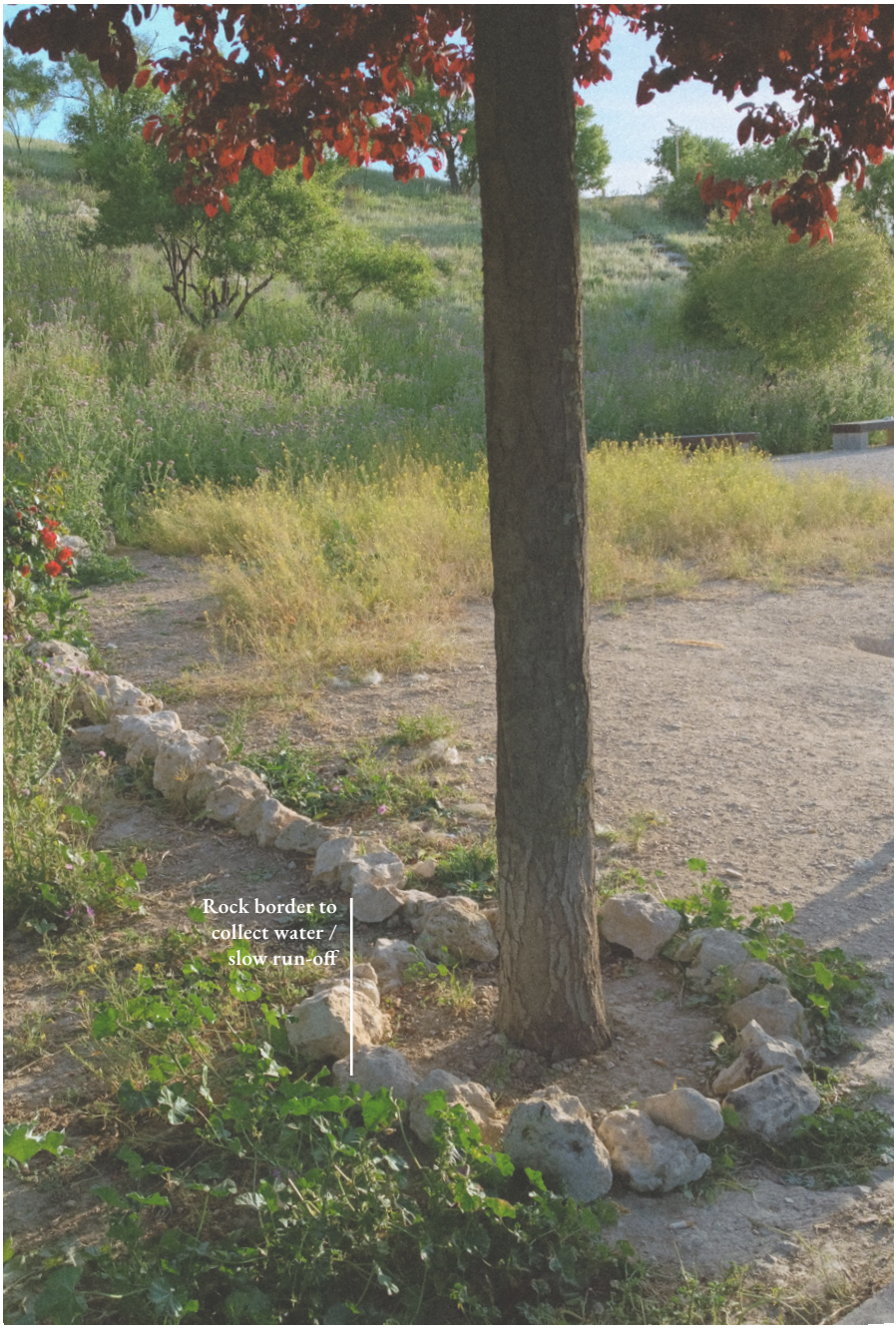


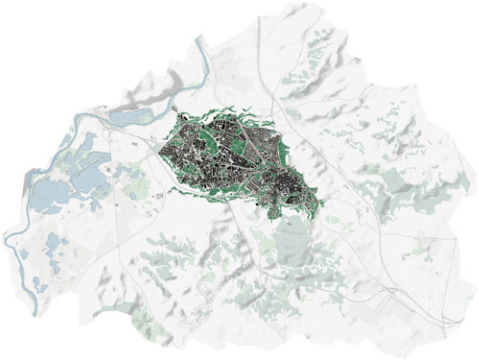
Water from precipitation
collected to seep into the soil



Water runoff slowed
down by terraces


Drip irrigation


Rock border to
collect water /
slow run-off



Public Green Spaces

Private-owned Cropland as the Partial Commons and Cultural Landscapes

The Partial Commons:

Public Spaces and Private Cropland

If we cannot commit to agroforestry, what other options are there?

Partaking in the Partial Commons: Building A Sustainable Cultural Landscape

Understandably, there are many hurdles to making changes and adopting new agricultural practices. You can take part in the commons in other smaller ways. You can also slowly expand your ecological contributions overtime or even join the afforestation efforts of the commons in the future!

1. Designating A Portion of Your Land To Growing Ecological Forests

Ecological forests are not grown for production. They are grown to reinforce the ecosystem of the landscape and expand the forest cover of the general region. The upstream of the Tagus Basin is facing intense droughts partly due to the low forest cover and high monospecific agricultural activities. Introducing ecological forests back to even just small portions of private cropland can help improve the water-landscape.

The Common Agricultural Policy (CAP) of the European Commission recommends at least about 5% of farmland to be designated for non-productive ecological use, such as growing ecological forests.

Ecological forests help regulate the humidity of the air and the water in the soil. There are steps in the previous section to guide you on how to grow forests. However, the species of trees you may use would not necessarily be crop trees but native trees of the semi-arid Spanish landscape.

It would be also beneficial to connect these small forests together. Connecting forests helps improve their survivability, creating a stronger environment to regulate the water in the ground and humidity of the surroundings.

So talk to your neighbours!

You can refer to the aforemention guide to growing agroforests. Instead of production trees, you may use native tree species. Remember to...

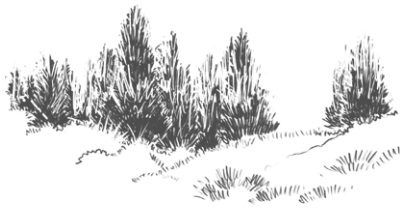
1. Consider the climate and soil conditions of your plot of land.

2. Prepare your soil for planting. Remove unsuitable vegetation or invasive plants. Mix organic or inorganic fertilisers with the existing soil if necessary.

3. Procure seedlings / saplings of your selected species from your preferred nusery.

4. Establish a water-management system. Ideally, they should be watered regularly during dry seasons using localised or drip irrigation during their seedling phase. Alternatively, growing your forest near an existing forest can help the survivability rate of your plants.

5. Plant your seedlings / saplings on your land and add an additional layer of mulch to protect the soil and roots from excess water losses to evaporation during dry seasons.



Forests sharing land with crops

2. Incorporate Crop Rotations To Your Farming

Plant different types of crops that are compatible with each other to improve the health of the soil and maintain a sustainable supply of nutrients.

This is especially helpful to retain water in the soil if one of these crops are tree crops that can help shade the soil and the understorey layer of smaller crops from the heat during dry seasons. It can help protect the ground from excess water loss to evaporation during these times.

For instance, if you own a wheat field, you can plant some walnut trees amongst the fields.

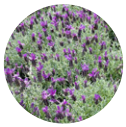
3. Adding Non-Productive Layers To Your Cropland

If you own an olive grove or grow other tree crops over bare soil, you could consider planting smaller perennial shrubs that are native to the landscape.

Avoid non-native species, especially those classified in the National Catalogue of Invasive Exotic Species. Invasive species are likely to out-compete your crops or surrounding native species for water and nutrients.

Make sure that these non-productive layers are compatible with your existing crop. Ideally, they should have shallow root systems that do not need more water than your crops do. These layers and their combined root system of these layers can help break up the soil and allow water to infiltrate more easily.

The benefits of growing perennials with fruiting trees are that they establish a regular ecosystem that is not often disrupted and help provide a sustainable cycle of nutrients to the soil while maintaining groundwater levels by improving water infiltration.



Lavandula stoechas
"Spanish Lavender"
Native, Perennial

Antirrhinum graniticum
"Spanish Snapdragon"
Native, Perennial

Stipa tenacissima
"Esparto Grass"
Native, Perennial

Cistus creticus
"Cretan Rockrose"
Native, Perennial

Echium vulgare
"Viper's Bugloss"
Native, Perennial

Asphodelus ramosus
"Branched Asphodel"
Native, Perennial

Malva multiflora
"Cretan mallow"
Native, Annual/Biennial

Hirschfeldia incana
"Mediterranean Mustard"
Native, Perennial

What kind of common shrubs are native and perennial?

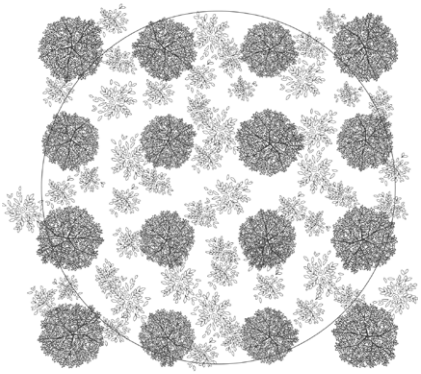
Gargüera de la Vera

Olive tree grove with potato cultivation as an understorey layer.

Landete

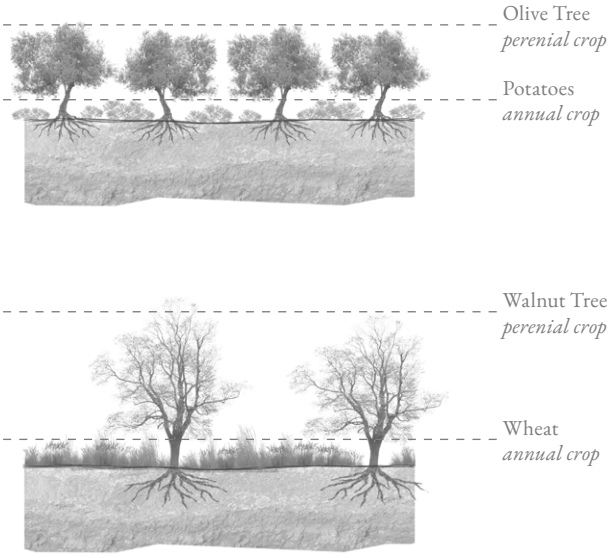
Walnut tree cultivation for wood amongst a wheat understorey layer

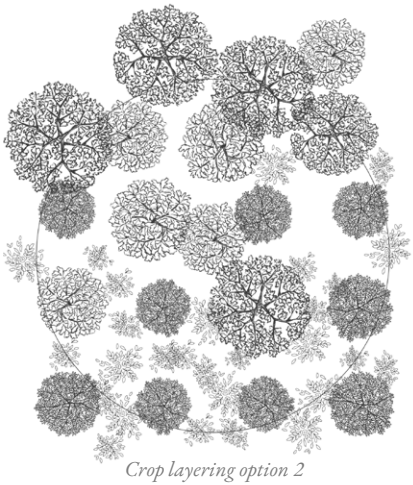
What are some combinations that are already in practice?



Crop layering option 1

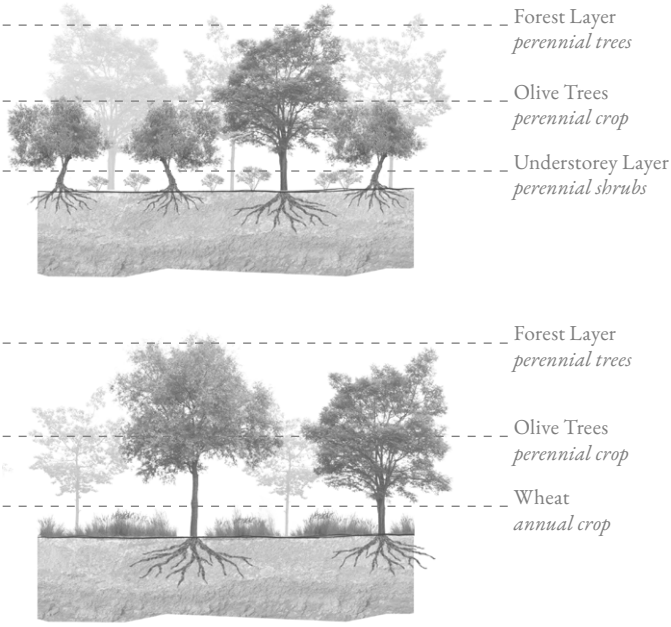
Tree crops mixed with low understorey crops, preferably with shallow root systems.



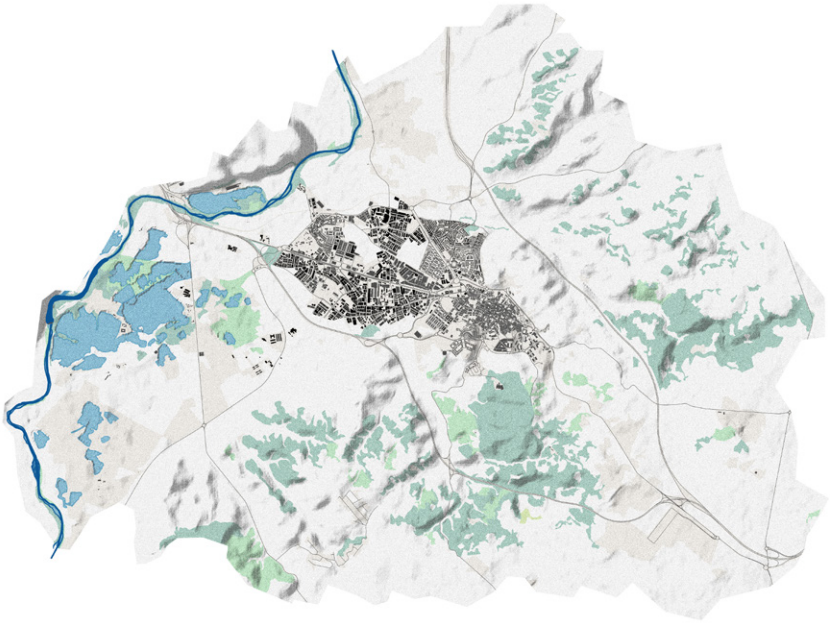


Crop layering option 2

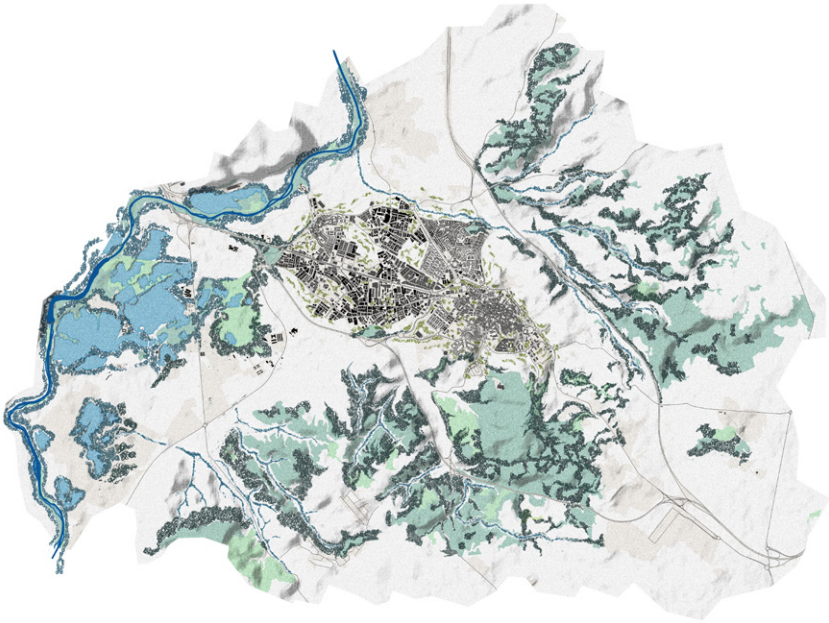
Crops mixed with ecological forests, preferably with shallow root sytems.



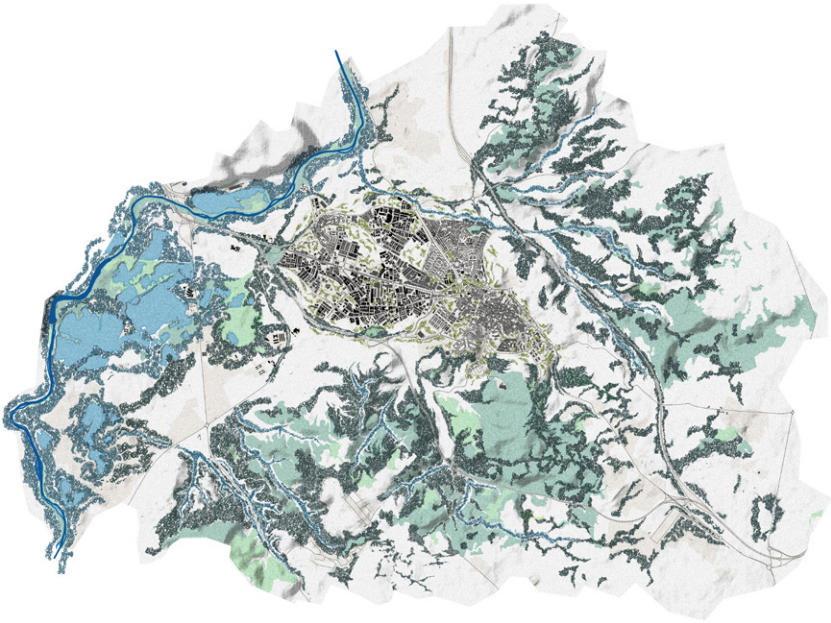
If we collaborate
and grow a little
every year, we can
help sustain the
water-landscape for
the future...



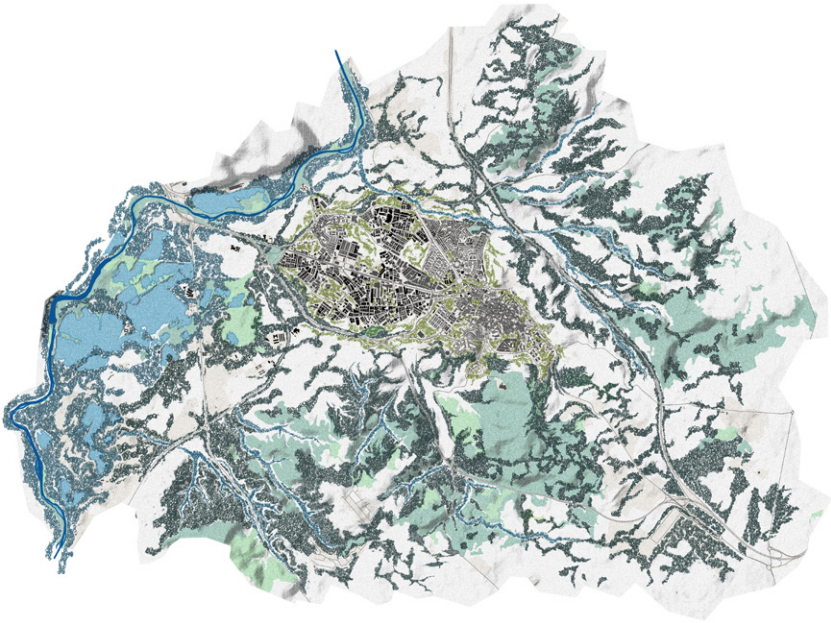
In 6 - 8 years...



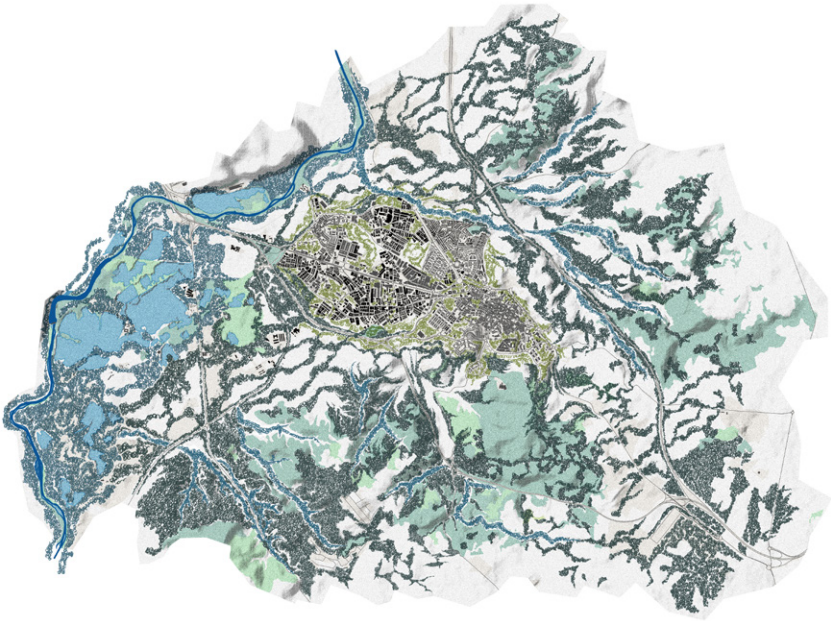
9 - 15 years...



16 - 23 years...



24 - 30 years...



Thank you