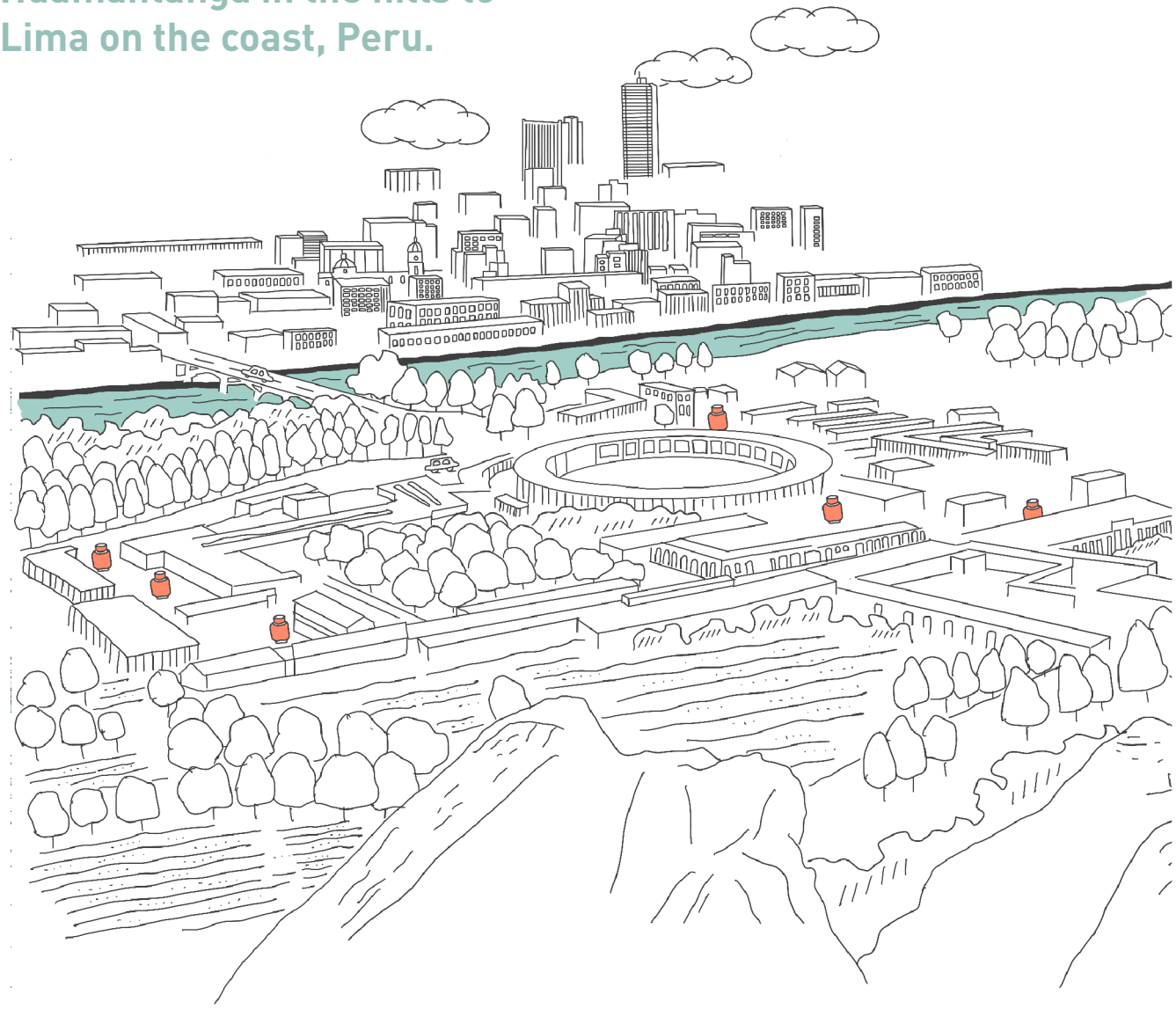
Quenching Thirst:

cooperation and interaction by living with water from Huamantanga in the hills to Lima on the coast, Peru.



COLOPHON

AUTHOR
Wanning Liang
5561280

FIRST MENTOR
Inge Bobbink
Architecture and the Built Environment, Landscape Architecture, Delft University of Technology

SECOND MENTOR
Luca Iuorio
Architecture and the Built Environment, Environmental Technology and Design, Delft University of Technology

EXAMINATION COMMITTEE
Pierijn van der Putt
Architecture and the Built Environment, Form, Space & Type, Delft University of Technology

Academic Year 2022-23
June 2023

Department of Urbanism,
Chair of Landscape Architecture
Flowscapes Studio - Circular Water Stories Lab
MSc Landscape Architecture
Faculty of Architecture and Built Environment
Delft University of Technology
Delft, The Netherlands

TU Delft
BK Bouwkunde

ACKNOWLEDGEMENTS

I am deeply grateful for the invaluable support and guidance I have received throughout my academic journey, and I would like to express my heartfelt appreciation to those who have played a significant role in shaping my experience.

First, I extend my sincere gratitude to my first mentor, Inge Bobbink. From the moment I set foot in the Model Hall during the summer of 2021, her passion and dedication left an indelible impression on me. Gathered around a long table, she invited each of us to introduce ourselves, thus commencing my enriching two-year exploration of landscape studies at TU Delft. Throughout this period, I have been fortunate to benefit from her vast expertise, meticulous teaching style, and insightful feedback. Her unwavering patience, coupled with her ability to recognize and nurture the unique qualities in each student, has been truly remarkable. I am particularly grateful for her encouragement in allowing me to discover my strengths and constantly affirming my drawing ability, which has given me a lot of confidence. Within the relaxed and well-structured environment she fostered, I have made significant strides in my personal and academic growth. She is, without a doubt, the epitome of an exceptional educator and the best teacher I have ever had the privilege of encountering.

I would also like to extend my deep appreciation to my second mentor, Luca Iuorio, for choosing to guide me during my final year of study. Luca's exceptional design skills and mature thought processes have been a constant source of inspiration. His unwavering encouragement and belief in my abilities have instilled in me the confidence to pursue my design aspirations. I am sincerely grateful for his invaluable guidance and eagerly anticipate witnessing his future professional accomplishments.

Furthermore, I wish to express my thanks to all the students at the Circular Water Stories Lab. Their invaluable contributions and collaborative spirit have greatly enriched my design process. I deeply cherish the time we spent together, exploring the fascinating realm of water stories.

To the friends I have made in the Netherlands, I am forever grateful for our unwavering friendship. Over the course of these two short years, we have supported, encouraged, and shared our lives with one another. The bond we have formed is truly invaluable, and I consider it one of the greatest treasures I have gained during this period.

Finally, I would like to express my deepest gratitude to my parents and friends in China for their unconditional love and support.

CONTENTS

FOREWORD
Abstract
Fascination
Glossary

SECTION I
THE NARRATIVE FRAMEWORK
01/ Lima: Where the story begins
01/01 The heartbeat of Peru
01/02 City of water tanks: Severe water scarcity
01/03 The more complex water challenges behind the scenes
- **01/03/01** Seasonal flooding
- **01/03/02** Unequal water distribution
- **01/03/03** Water pollution

02/ Zooming out to Lima Región
02/01 Land, Climate, and Water of Lima Región
02/02 Sustaining water in the high Andes: The vital role of Bofedales-Lake system as a natural sponge
02/03 Amunas: The ingenious Andean water system
02/04 The sacred flow: Exploring the Andean Cosmovision of water
02/05 The intersection of Andean Cosmovision and traditional water life in Huamantanga town

03/ Zooming in on Huamantanga town: A turning point
03/01 Opportunities
- **03/01/01** The emergence of Blue-Green infrastructure in government strategies
- **03/01/02** Reviving the Waters: Restoring Amunas for sustainable solutions to Lima's water scarcity
- **03/01/03** Other enhancement during the restoration of Amunas

03/02 Challenges
- **03/02/01** Water and community in Huamantanga nowadays: Navigating population loss, mono-production, and infrastructural conflict
- **03/02/02** The decline of water values in modern society

04/ Research framework
04/01 Research questions
04/02 Research objectives
04/03 Theoretical framework
- **04/03/01** Sustainable water management
- **04/03/02** Landscape identity

04/04 Methodological framework

06/ References

SECTION II
THE DESIGN PROJECT

07/ Research-by-design
07/01 The concept
07/02 Design framework
07/03 Process design
07/04 Water Design
- **07/04/01** Water forms
- **07/04/02** Water works
- **07/04/03** Ensembles

07/05 Design locations
- **07/05/01** Renewal of the traditional water system in Huamantanga town
- **07/05/02** Re-valuing water in Chillón River Floodplain

SECTION III
THE REFLECTION

08/ Conclusions and reflections
08/01 Conclusions
08/02 Reflections

FOREWORD

Abstract

Keywords: water crisis, Lima, Huamantanga, water system restoration, landscape intervention, sustainable water management, landscape identity.

As the capital of Peru and one of the largest metropolises in South America, Lima's rapid development has attracted worldwide attention. In recent years, the water crisis has become a pressing problem as people flock to Lima with a thirst for opportunity.

Lima is located in a coastal desert area on the Pacific coast, backed by the Andes Mountains, a unique natural condition that has resulted in the formation of this 'city without rain'. The 1,2 million residents of the city obtain their daily water supply from water trucks and water tanks. However, seasonal flooding accompanies the dearth of water. The abundance of water in the Andes does not appear to alleviate Lima's water crisis; rather, the three principal rivers that originate in the Andes, Chillón, Rímac and Lurín, are always accompanied by flooding as summer approaches. At the same time, along with the unequal distribution of water resources and water pollution, residents in large cities have developed a very negative attitude towards water.
In contrast, Huamantanga, located in the Andean highlands, still relies on natural groundwater recharge systems and traditional man-made water systems. However, these systems have suffered damage due to climate change and mismanagement. At the same time, for the town's residents, a single mode of production has caused population loss and the devaluation of traditional water-related practices.

The graduation project proposes landscape interventions as a means of water system restoration. From the Andean highlands to the lower Chillón River, Huamantanga and Lima have the opportunity to be connected through the restoration of the water system, thus helping to alleviate Lima's water crisis. The different communities through which the water system flows are also viewed as stakeholders in sustainable water management, and the project will provide multiple environmental, social, and spiritual improvements to their water-related lives.

The design framework focuses on the restoration of water systems at different scales, utilizing water as a central element. Through an in-depth study of spatial and landscape identity, the project highlights the role of the landscape in facilitating water system restoration and the consequent positive changes in people's water-related practices. The analysis zooms in on two specific sites: Huamantanga town and the floodplain located in the lower Chillón River, offering a concrete understanding of how the landscape can contribute to water system restoration and shape people's water-related lives.

Fascination

As I grew up in China, I realized that although this vast land is rich in water resources such as rivers, lakes, and groundwater, I feel somewhat disconnected from them. This is because my hometown, a large inland city, no longer has a water-dependent lifestyle. Unfortunately, during the time I was born, the nation was going through a rapid development phase, and the protection of natural resources was ignored, resulting in severe water pollution issues. Therefore, my water-related memories are primarily from brief encounters during my travels, which made me admire the natural beauty while yearning for the lives of the local people.

Fortunately, my first year of landscape studies at Delft University of Technology in the Netherlands provided me with an in-depth understanding of the country's water systems. Living by the water throughout the year allowed me to rediscover a connection to water and sparked my interest in water systems worldwide. I became fascinated by Peru, a distant and mysterious South American country, which also possesses abundant water resources. However, the city of Lima, the country's capital, still faces a significant water crisis that remains unresolved. As the city expands, more and more people migrate to Lima, increasing the demand for water and creating severe water shortages.

During my research, I discovered the Amunas system, an ancient water system situated deep in the Andes. The Amunas water system diverted the abundant water resources during the rainy season underground to support local agricultural production and daily life. I was intrigued by the ancient and ingenious design of the system and the traditional culture and water-related lifestyle of the local people.

However, I also learned that the majority of the Amunas canals had been abandoned due to poor management. This realization led me to question whether restoring the Amunas and supplying water to the surrounding communities could help alleviate the water crisis in Lima during the dry season. I was delighted to discover that scientists have already confirmed that this assumption is correct. As a future landscape architect, I decided to focus my graduation thesis on how to use landscape means to realize the restoration of the Amunas and alleviate the water crisis in Lima.

Glossary

Amunas

Or mamanteo. This is a pre-Columbian water harvesting system used in the mountains of Peru, Amunas is a Quechua word meaning reserved, and it works by "delaying" rainfall runoff in the mountains, so it can be used in lowland settlements during the dry season. The system uses canals to direct water to the permeable part of the soil or rock. The water is filtered by the subsurface layers and emerges weeks or months later in springs downhill that can be used to mitigate drought.

Bofedales

Singular bofedal. A type of peatland found in the Andes of Peru and Chile, typically in high-altitude regions at altitudes above 3,800 meters (12,500 feet). They are characterized by the accumulation of partially decomposed plant material called peat, and they serve as important habitats for unique wetland vegetation and wildlife.

Qochas

(1) Small reservoirs or artificial lagoons constructed in natural underground depressions, using local materials such as rocks and earth blocks, can store and infiltrate water.

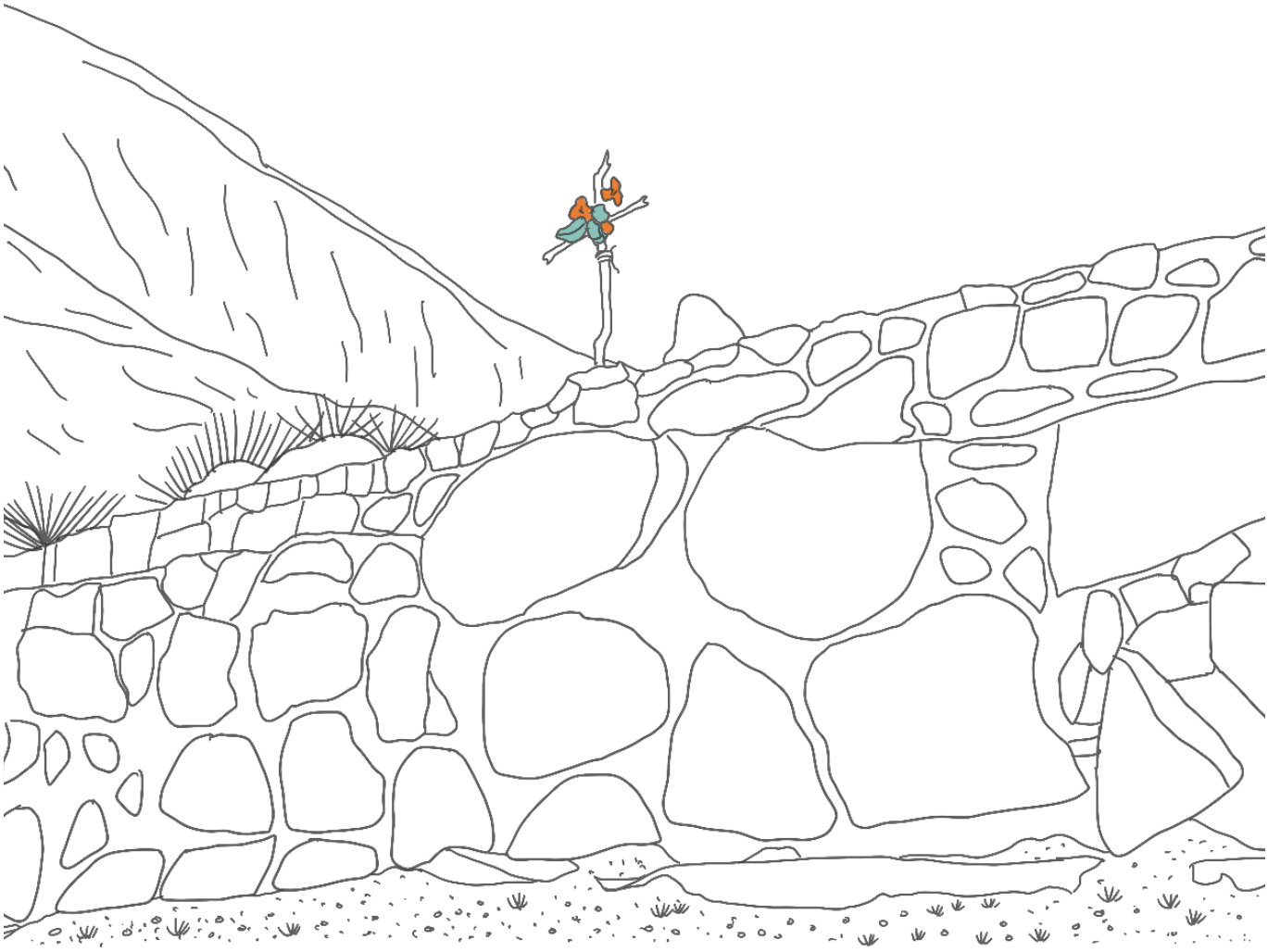
(2) Dams built with stone or earth blocks.

Andean Cosmovision

A way of perceiving and interacting with reality, based on the worldview of the traditional native cultures of the Andes. This worldview emphasizes that humans are a part of nature.

Comuneros

The community members who perform the maintenance of the Amunas. They have rituals surrounding the cleaning and blessing of the canals.



A prayer cross on the newly built Qochas. Drawn by author.

View of Lima, Peru. Photo by Artdino

01 Lima: Where the story begins

01/01 The heartbeat of Peru
01/02 City of water tanks: Severe water scarcity
01/03 The more complex water challenges behind the scenes
- **01/03/01** Seasonal flooding
- **01/03/02** Unequal water distribution
- **01/03/03** Water pollution

01/01

The heartbeat of Peru

Located in the desert region of Peru's west coast, at 12.0464°S and 77.0428°W, Lima is the capital and largest city in the country, with a population of 9.7 million, constituting approximately one-third of the country's population. Lima is situated near the Pacific Ocean and, together with the port of Callao, forms the metropolitan region of Lima, one of the largest cities in South America. The city is the second largest capital city in a desert climate zone (BWn according to the Köppen climatic classification), with an average annual precipitation of just 9mm and an annual average temperature of 19°C. The humidity can reach 100%.

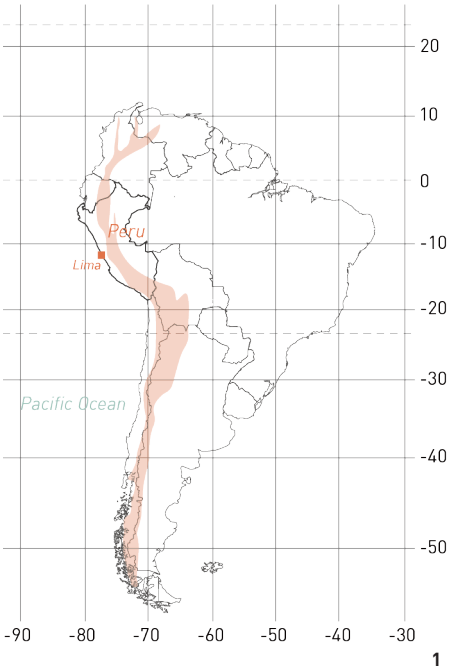
Lima is responsible for more than half of Peru's Gross Domestic Product, over two-thirds of industrial production, and the majority of the tertiary sector. It is home to numerous national corporations and has the greatest export industry in South America. The western region of the city is the regional hub of the logistics industry, with principal exports including oil, steel, silver, zinc, cotton, sugar, and coffee.

Lima serves as the beating heart of Peru, pumping lifeblood throughout the country, while simultaneously attracting a steady stream of individuals seeking to flow towards its pulsing center. Lima faces significant challenges due to rapid urbanization, driven by urban-rural migration in search of economic opportunities. In 1940, only about 10% of Peru's total population lived in urban areas, but by 2020, that number had risen to about 30%.

The city's location exacerbates these challenges. Lima was founded on the Pacific coast in 1535 by Spanish colonist Francisco Pizzero to serve as a maritime capital connecting South America and Europe. However, both the Inca capital of Cuzco and the first Peruvian capital of Jauja were located in the mountains. Inca settlements were typically not situated along desert shores due to the extreme lack of water. As a result of Lima's location, 66% of Peru's population now resides on the coast west of the Andes, with access to less than 2% of the country's fresh water supply.

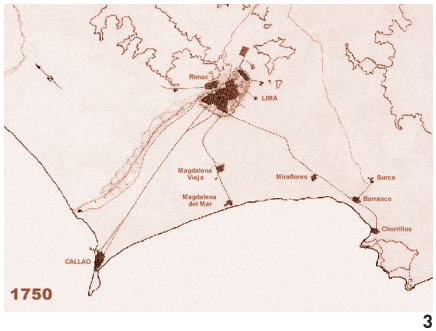
Lima's climate and geography pose additional challenges. When the Spaniards constructed the city, the weather definitely misled them. The city's founding date of January 6 coincides with a less humid month, but from February to October, a grey mist blankets the entire region, one must travel to the mountains in order to view the sun or the stars, with neither wind nor sun, creating ideal conditions for air pollution and respiratory ailments. The lack of wind leads to the buildup of smoke and dust under the thin layer of fog, resulting in the grey color of the city's buildings. Summer, which lasts for only about four months, has a more pleasant climate.

Lima relies on surface water from the Chillón, Rímac, and Lurín rivers and underground water from the Rímac-Chillón and Lurín aquifers. These three rivers, which descend from the Andes, are the primary sources of water for the city. However, river basins are highly seasonal, with an average flow rate of 30 cubic meters per second in winter and 400 cubic meters per second in summer. In the winter, there is insufficient water, while in the summer, there is a constant risk of floods due to the narrowness of the valleys. As a result, many areas of Lima rely on water tanks for their daily drinking water needs.

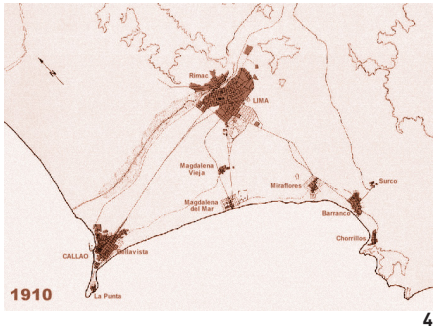


1

2

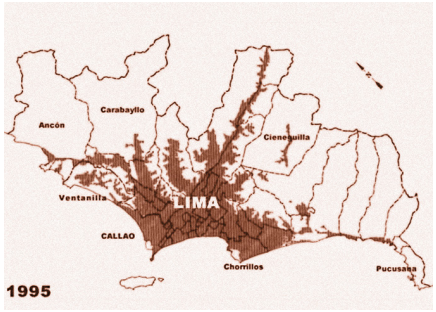


3



4

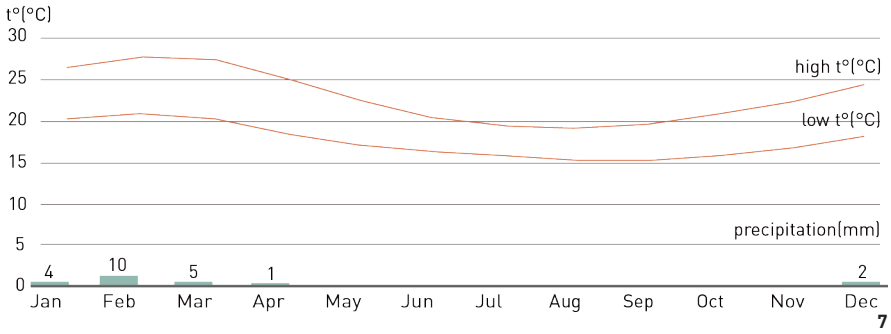
5



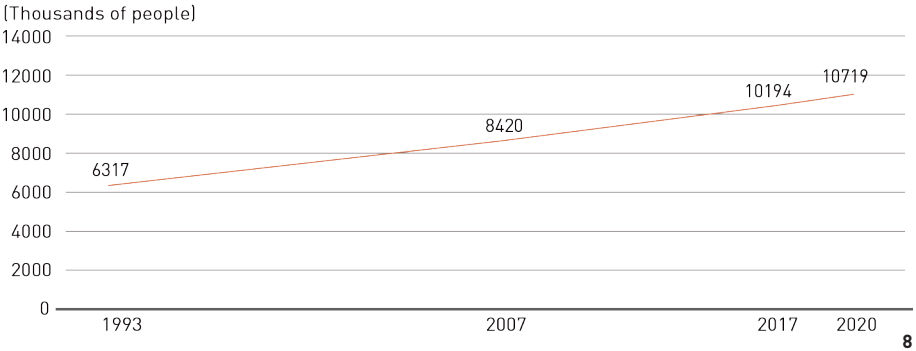
6

Like so many other cities, continuous migration to Lima has resulted in it being the urban powerhouse of the country[...] In 1940, two out three Peruvians lived in the Sierra but only one out of ten in Lima. Today 1 out 3 live in Lima and the metropolitan area has multiplied by 13 times since mid XX century. Unsurprisingly, urban sprawl is alive and well in Lima and the city now envelops in the area of 1,000 square miles. But despite its size, Lima has very few Central Business Districts, making it a 'monocentric' city[...] And with this sprawl and monocentricity comes the well-known challenge of informal settlements which Lima is not immune to. Informal housing has developed everywhere, covering hillsides, river banks, and the urban peripheries.

Eric Dickson, 2015

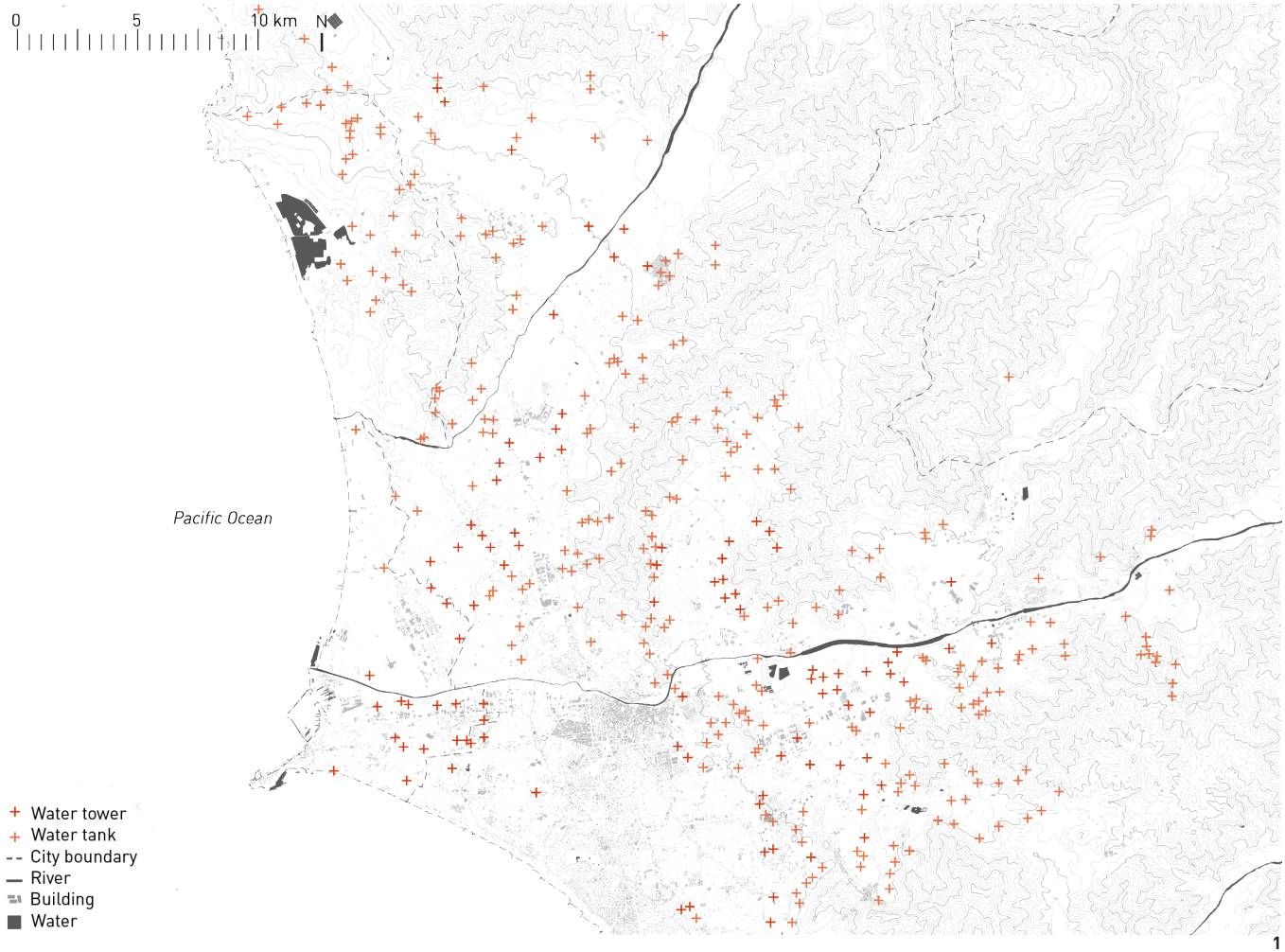


7



8

1 Lima, Peru in South America map
2-6 Urban expansion of lima: 1953-1995. Drawn by Kani Pirwanu, kani Chulu kani sunqu hunta.
7 Climate of Lima, Peru
8 Population in Lima, Peru


0
5
10 km
N
Pacific Ocean
Water tower
Water tank
City boundary
River
Building
Water

1

2

3

4

01/02

City of water tanks: Severe water scarcity

Imagine living in a picturesque house on the outskirts of a large city, nestled halfway up a hill with a stunning courtyard overlooking a lush green park and a glimmering coastline in the distance. The table is prepared with a variety of fresh foods from the supermarket, you're hosting an afternoon tea with your guests, and despite appearances, there is one vital thing missing: running water. This is the reality for many people living on the outskirts of Lima, a city that has been struggling with water and sanitation issues exacerbated by the rapid growth of urbanization.

Although water coverage has improved over the years, with an average of 93.5% in 2014 and 21.6 hours of water per day, the majority of houses in Lima have low water pressure and frequent water supply outages. In the city's outskirts, around 1.2 million poor people lack access to safe drinking water and sanitation. As a result, water tanks have become the everyday supply of water for many city dwellers. These tanks are either trucked in from government water agencies or purchased from private suppliers for distribution.

According to the Peruvian National Water Authority, around 27% of Lima's population obtains water through tanks, and in some areas, such as the districts of Villa El Salvador, San Juan de Miraflores, and Villa María del Triunfo, the proportion of households relying on water tanks can be as high as 70%. Unfortunately, trucked-in water is often untreated and collected from polluted sources, such as rivers, streams, and ditches. Moreover, the internal cleanliness of the tanks is often questionable, and people lack the time or resources to maintain their own tanks, which can lead to insect infestations and other hygiene issues.

To ensure that the water is safe for consumption, people often boil the water before using it, which increases the price. Those without access to piped water end up spending 10 to 20 times more on water than those with access. In the Villa El Salvador district, households receive one tank of water every four or five days. Typically, the plastic water tank has a capacity of 1,100 liters (290 gallons). This corresponds to approximately 50 gallons of water per family each day, which is eight times less than the average American family's daily consumption of 400 gallons.

In addition to the water issue, there are no sewer pipes in the dwellings, which means that there are no flush toilets. This lack of basic sanitation facilities exacerbates the already dire water and sanitation situation in Lima's low-income areas.

1 Map of Lima's water tank. Source from Indra Sistemas S.A.
2 On the dusty slopes of Pachacútec on the outskirts of Lima, water tanks for people's daily water are lined up along the road. Photo by Jan Sochor
3 A man delivers water from a tanker in San Juan de Miraflores on the outskirts of Lima, Peru. Photo by REUTERS/Mariana Bazo
4 Residents of a populous district of Lima queue to collect drinking water from a municipal tank truck on Friday. Photo by AFP / CRIS BOURONCLE)

01/03

The more complex water challenges behind the scenes

When considering the roots of Lima's pervasive and enduring water scarcity, it becomes evident that conflicts are at the core of the city's water woes. A plethora of multi-faceted water problems have arisen in the region, each interacting with one another to create the complex water situation that exists today. These issues encompass seasonal flooding, unequal water distribution, and water pollution.

01/03/01

Seasonal flooding

Lima's seasonal flooding is caused by the convergence of two weather phenomena: the cold Humboldt Current and the warm El Niño Southern Oscillation. The Humboldt Current brings cold water to the region, which leads to low rainfall due to low evaporation levels. During El Niño years, however, warm ocean currents move towards the Peruvian coast, causing an increase in rainfall and melting of Andean snow caps, leading to flooding. The combination of these two phenomena leads to erratic weather patterns and severe flooding in Lima.

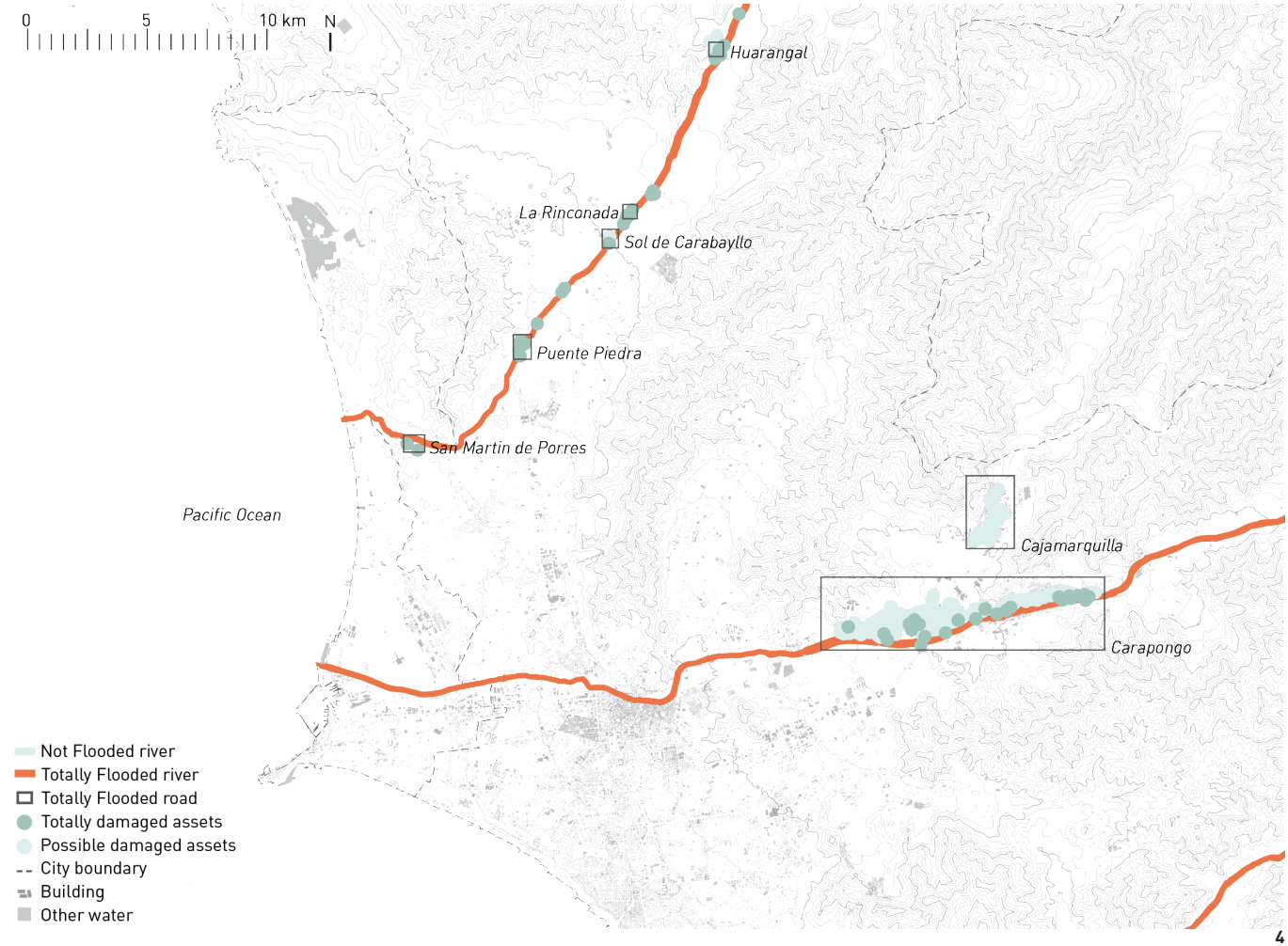
In 2017, Lima experienced the world's worst flood disaster due to several weeks of heavy rainfall on normally arid terrain. The floods from the Andes affected many regions downstream between the mountains and the coast, including Lima, and displaced more than 110,000 people, while causing over 100 deaths. The highest precipitation was observed on the western slope of the Andes, mainly in the north, the damage was severe throughout the city of Lima, despite receiving very little precipitation (just 0.7 mm at Lima airport between 2 February and 23 March 2017). The floods also resulted in significant destruction and the failure of the municipal water system.

Unfortunately, Lima has a long history of flooding, even though it is a city without much rainfall. Extreme floods have occurred in the city over the years, including in 1982 and 1998. The 1982 flood resulted from heavy rains, particularly in the Andean highlands, which led to landslides and flooding in various Lima districts. Over 100 people died, and hundreds were displaced due to the lack of adequate drainage infrastructure and urban planning, which allowed for settlements in flood-prone areas.

In 1998, El Niño caused heavy rainfall and flooding in Lima and other regions of Peru, resulting in the deaths of over 300 people and causing significant damage to infrastructure and homes. The flooding was triggered by torrential rainfall related to El Niño, which impacted the entire Peruvian coastline. The flooding in Lima was particularly severe due to the absence of suitable drainage systems and the expansion of informal settlements in flood-prone areas.

The causes for the significant destruction in Lima, beyond the flood itself, are apparent in the absence of urban planning, construction of buildings on floodplains, rapid urbanization, and inadequate stormwater drainage facilities.

1

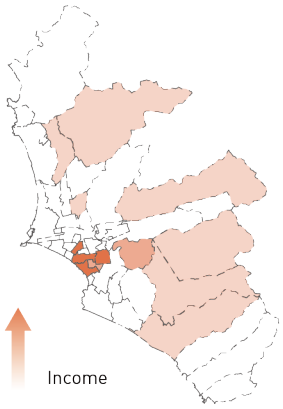


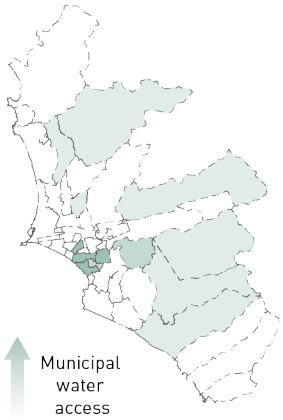
4

2

3

1 Aerial view after a massive landslide and flood in the Huachipa district of Lima, on March 17, 2017. Photo by The Atlantic
2 People await rescue on a building engulfed by floodwaters. Photo by The Atlantic
3 A volunteer cleans a flooded home, after rivers breached their banks in Cajamarquilla. Photo by The Atlantic
4 Damage map after the 2017 catastrophic floods. Source from Indra Sistemas S.A.





1

2

01/03/02

Unequal water distribution

Typically, when we discuss the water crisis, it is usually in the context of polluted rivers or remote villages that force people to walk for hours every day to find clean water. These are significant issues, but the water dilemma as a whole is considerably more complicated. In the suburbs of developing nations like Peru, the issue cannot be solved by digging wells or installing water filters. Here, the water crisis is more related to infrastructure and money, which is directly reflected in the unequal distribution of water.

Lima is divided into 43 districts, each with different standards of living and water supply. High-income neighborhoods such as Santa Maria, Miraflores, San Borja, and San Isidro typically have running water pipes installed inside homes and receive 99% to 100% of their water from the public water company. The residents of these neighborhoods use an average of 447 liters of water per day, which is much higher than the WHO recommended 50-100 liters per day. Middle-income areas receive about 98% of their water supply from the public water corporation, while low-income peri-urban areas often rely on water delivery trucks, which are frequently owned by private companies, for their water supply. In some of these areas, such as Pachacamac, only 11% of water is supplied by utilities, while 73% is supplied by trucks.

As a result, over 1.2 million inhabitants of Lima do not have access to running water, and many of these are informal settlements on the outskirts of the city. The lack of land ownership exacerbates the situation, as the government-affiliated water supplier, SEDAPAL, will only install piped water on properties where inhabitants possess legitimate ownership certificates. Most homes that rely on water trucks do not have these documents and thus have little chance of gaining access to piped water.

Although Lima has a water supply coverage of over 90%, this number hides the vast disparity in service quality and cost between the city center and the suburbs. People with piped water pay SEDAPAL 1.3 soles (US$0.40) per cubic meter of water, whereas water transported by truck costs over 20 soles (US$6) per cubic meter, an exorbitant price for the poor.

The lack of water in Lima is not only due to the city's geographical location but also the local government's lack of institutional and management capacity. As the city's water sources become increasingly unreliable and the population continues to rise, the unequal distribution of water remains a significant challenge for Lima.

01/03/03

Water pollution

The water supply in Lima primarily comes from three main rivers - the Chillón, Rímac, and Lurín. However, due to a 40% decrease in glacier cover over the past four decades and rapid population growth, the water supply has become increasingly uncertain. By 2030, the population is projected to reach 12 million, and the average

3

flow of each river is decreasing, making it challenging to provide for the growing population. The Rímac River is particularly critical, providing approximately 80% of the city's water.

Sadly, the three rivers are facing numerous challenges due to discharges from mining, industry, agricultural activities, and households. In 2013, Peru's Minister of Agriculture, Milton Von Hesse, declared that the Rímac River "has long ceased to be a river and has become a sewer because of the high level of pollution in its waters." From its source to its mouth, the Rímac River has hundreds of domestic, industrial, and mining wastewater discharges. There are at least 1,185 pollution sources in the total river basin, with 260 (22%)

1 Strong correlation between wealth and water supply. Source from WATER INEQUALITY IN LIMA, PERU(Brett Harris, 2019).
2 The Wall which divides the poor Nueva Rinconada, from the affluent Casuarinas neighbourhood. Photo by Orestis Karagiannis
3 Map of city expansion and water pollution. Source from urban growth of Lima since 1935 (Desco, 2005), Redrawn by the author.

in the upstream region, 336 (28%) in the central region, and 589 (50%) in the downstream region. The pollution problem starts at high altitudes, where the natural ecosystem is severely damaged by agricultural activities in rural areas, such as overgrazing, agrochemical use, wetland degradation, and grass burning. Additionally, mining waste runoff from the highlands is a significant source of pollution. Industrial complexes located near the basin also contribute to pollution by frequently discharging untreated organic and inorganic compounds into the river. 60% of the Rímac River's pollution comes from mining activities, while domestic and industrial waste runoff accounts for 25% and 15%, respectively. During the rainy season in the Andean region, landslides contribute to the water's turbidity by introducing tons of mud and rocks into the river.

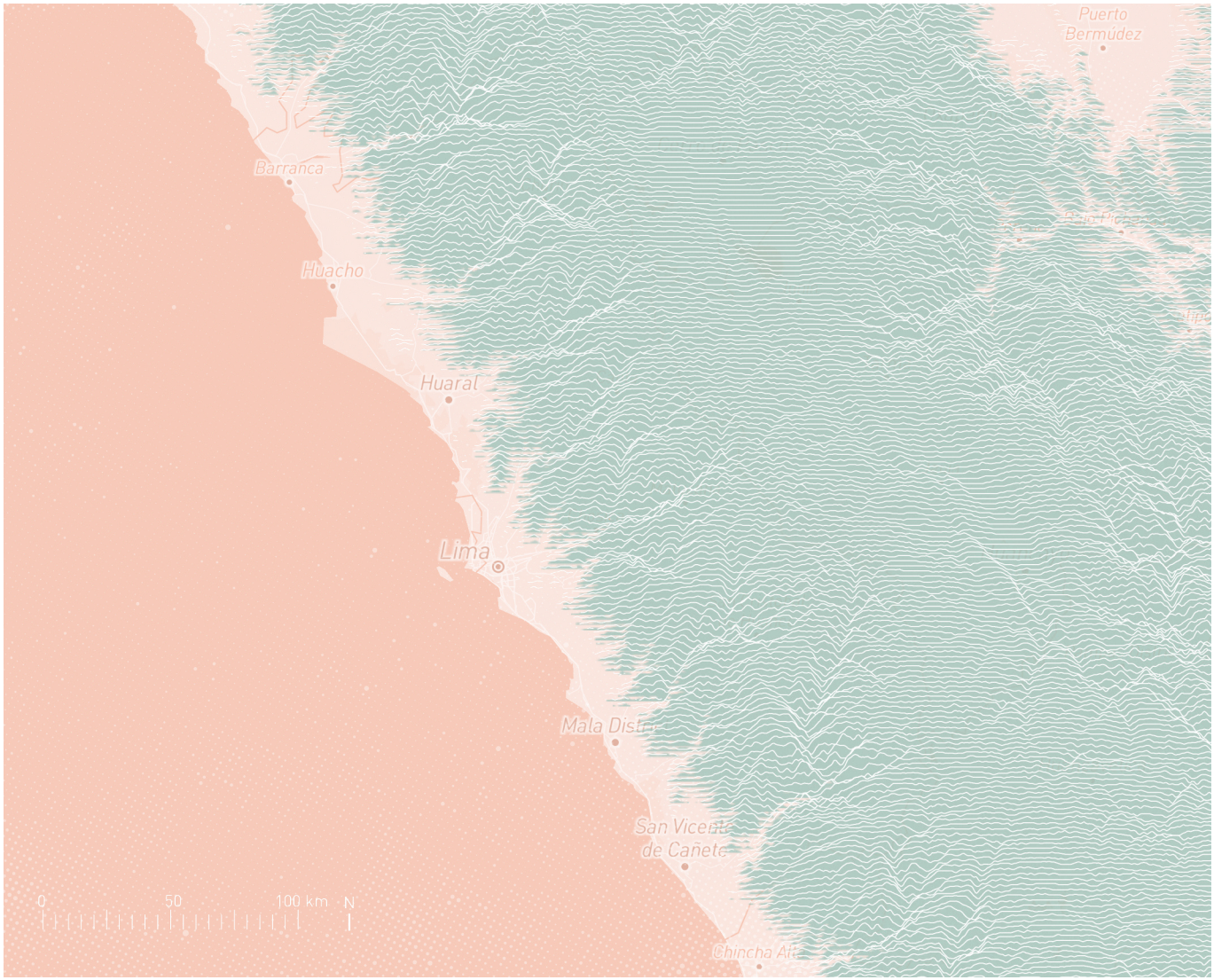
As the Rímac River flows towards Lima's metropolitan area, it continues to collect large amounts of debris and waste from surrounding communities. This, in combination with the previous pollution, has led to a decline in water quality. The primary contaminants found in the water are metals (such as lead, manganese, and mercury), solid waste, pathogens, and other dissolved compounds (2016).

References

EL Comercio(2016). Día Mundial Del Agua. From: http://elcomercio.pe/sociedad/apurimac/dia-mundial-agua-que-tan-potable-agua-cano-noticia-1888305

ERIC DICKSON(2015). Lima, from Gastronomic Center to Capital of Urban Transformation. From: https://blogs.worldbank.org/latinamerica/lima-gastronomic-center-capital-urban-transformation

Valois, Remi, Nicole Schaffer, Ronny Figueroa, Antonio Maldonado, Eduardo Yáñez, Andrés Hevia, Gonzalo Yánez Carrizo, and Shelley MacDonell(2020). "Characterizing the Water Storage Capacity and Hydrological Role of Mountain Peatlands in the Arid Andes of North-Central Chile" Water 12, no. 4: 1071. https://doi.org/10.3390/w12041071



Map of Lima province, Peru. Drawn by author.

02 Zooming out to Lima Región

02/01 Land, Climate, and Water of Lima Región
02/02 Sustaining water in the high Andes: The vital role of Bofedales-Lake system as a natural sponge
02/03 Amunas: The ingenious Andean water system
02/04 The sacred flow: Exploring the Andean Cosmovision of water
02/05 The intersection of Andean Cosmovision and traditional water life in Huamantanga town

02/01

Land, Climate, and Water of Lima Región

The vast majority of Lima Región presents a distinct picture than the city of Lima in terms of geography, climate, and water issues. Similarly, the potential to resolve Lima's water crisis is concealed here.

Land

1

Lima Región, officially known as the Department of Lima, is located in the central coastal region of Peru, covering an area of 32,129.31km^2. The region has a narrow desert strip along the Pacific Ocean and the Andes Mountains to the east. The government of Lima Región has jurisdiction over 4,807 centers, of which 99% are rural. However, the autonomous administration of Lima, i.e., the Metropolitan Municipality of Lima, lies outside the jurisdiction of Lima Región. Still, from a geographical standpoint, it is included in this study.

Despite being the second-smallest region in Peru, Lima Región is one of the most populous and economically significant areas of the country. The region has a diverse landscape, with the Andes and coastal regions offering a distinct contrast. The cities, including Lima, are located along the coast and are densely populated with developed industries; other coastal regions also play an important role in the country's agricultural, mining, and industry, as well as its tourism industry.

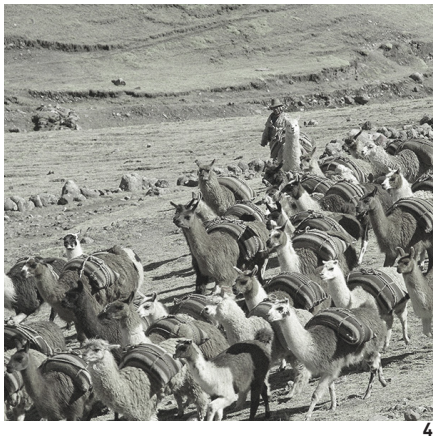
The Andes occupy a significant portion of Lima Región's overall area and are located in the eastern portion of the coastal zone. The region's elevations range from around 2,000 meters to over 5,000 meters, with the highest point reaching 5,654 meters. The hilly and rugged terrain causes soil erosion and the exposure of bedrock, making cultivation and other terrestrial operations difficult. The medium and high altitudes are characterized by their wide valleys and steep slopes, frequently covered by grasses, bushes, and forests. At high altitudes, the severe temperature and poor soil quality make it difficult for plants to survive.

In the Andes, human communities were widely dispersed, clustering around water sources such as rivers and streams, and located on habitable high terrain. The traditional settlement pattern in the Andes was a dispersed society with small clusters of houses and agriculture scattered throughout the terrain. Despite the challenges of agricultural production, the region's ancestors devised techniques such as Andean terraces and crop rotation to manage thin, stony soils, aiding soil and water conservation and increasing soil fertility over time.

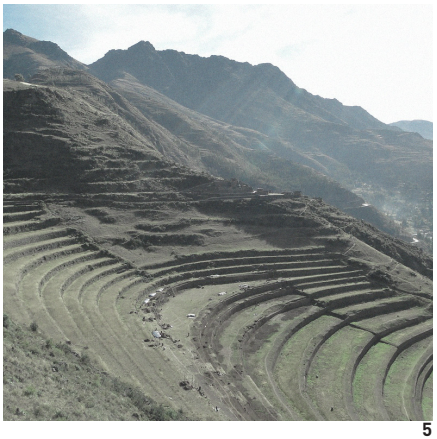
Additionally, several factors such as water availability, transit routes, and economic opportunities influenced settlement patterns. Some villages may be located in valleys or along rivers, while others may be situated in the Andean highlands at higher elevations. Some communities may be more populous than others, while others may be smaller and more remote.

2

3

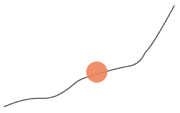


4

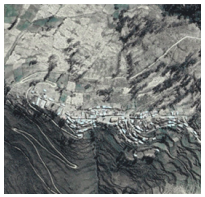


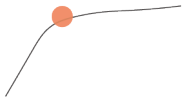
5

1 Lima Región in Peru map
2 Landscape of the western slopes of the Andes. Photo by Wonders of Columbia
3 Ancient water canals wind through the Andean mountains. Photo by Sam Grainger
4 Land and alpacas in the Andes. Photo by Mr Gregson
5 Andean Agriculture. Photo by FAO / Liana John
6-9 Different forms of community, agricultural ensemble in the Andes. Photo from Google earth



6





7

8

9

Climate

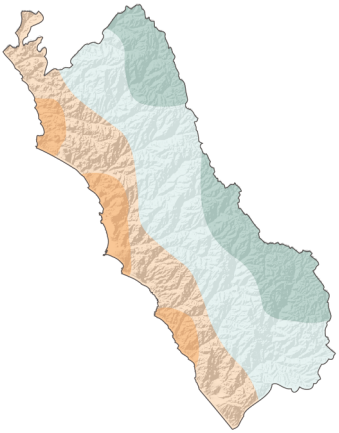
Lima Región's climate is divided between the Andean and coastal zones, with distinct differences between the two regions. The Andean portion has colder temperatures, greater precipitation, and pronounced seasonality, while the coastal zone is characterised by a narrow desert strip along the Pacific Ocean.

The rainy season in the Andean portion lasts from December to February, with the highest elevations on the eastern side receiving up to 200-300mm of precipitation. This is crucial for agriculture, as it facilitates the growth of crops such as potatoes, corn, and quinoa. However, high precipitation can also cause frequent landslides and flooding, which can endanger human communities and infrastructure.

During the dry season from June to August, the Andean portion receives little precipitation, making it a popular destination for adventure tourism. The clear sky and low humidity attract those who enjoy outdoor activities like hiking and climbing. However, at higher elevations, nighttime temperatures drop substantially and frequently fall below freezing.

Lima Región map of Köppen climate classification

- Warm desert climate
- Warm semi-arid climate
- Tropical savanna climate
- Humid subtropical climate
- Subtropical oceanic highland climate
- Temperate oceanic climate
- Cold semi-arid climate
- Monsoon climate



Precipitation (Dec-Feb)

- < 3mm
- 4 - 99mm
- 100 - 199mm
- 200 - 300mm

Precipitation (Jun-Aug)

- < 3mm

Water

Water always is a crucial resource in Lima Región, with the Andean portion of the region providing a vast network of rivers, lakes, and wetlands that support diverse ecosystems and significant rivers and lakes that provide water for agriculture, mining, and other activities. These water sources are supplied by the melting Andean snow and glaciers. Additionally, the region contains major reservoirs such as the Huascacocha Reservoir, which serves hydroelectric power generation and irrigation.

The Chillón-Rímac-Lurín basin, located in Lima Región, has a primary water system that includes the Chillón, Rímac, and Lurín rivers, as well as their tributaries, creeks, and lagoons. As stated previously, this basin is the main source of water supply for the metropolitan city of Lima. Domestic water licenses mainly correspond to the Rímac river basin, while the Chillón and Lurín river basins mostly serve agricultural users.

Surface water satisfies about 75% of the water requirements, while groundwater fulfills the remaining 25%. The Chillón, Rímac, and Lurín aquifers currently provide 310 hm3 of groundwater, which is less than one-third of the quantity provided by surface water. Water in the Andes is distinct because of its high elevations and dramatic seasonal and climatic variations. At the same time, however, the water resources of the Andes hold immense potential due to the abundant presence of water-bearing rocks, which indicates that the groundwater capacity is significantly higher than its current state.

Water map of Lima Región, Peru

02/02

Sustaining water in the high Andes: The vital role of Bofedales-Lake system as a natural sponge

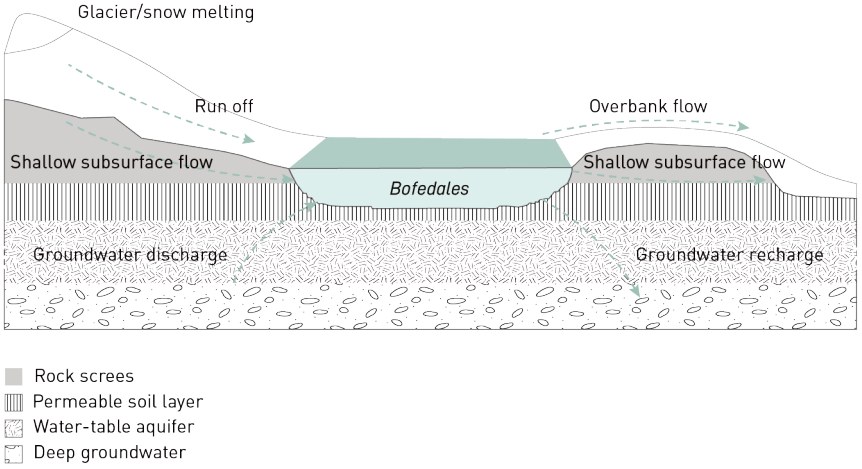
The Andes Mountains boast a diverse geography and climate, which give rise to a broad range of ecosystems and abundant biodiversity. Between the upper forest line and the permanent snow line at elevations exceeding 3,000 meters, extensive grasslands can be found throughout the Andes, from the humid páramo of Colombia, Ecuador, and northern Peru to the semiarid puna of southern Peru and Bolivia. In addition, these regions are home to numerous wetland habitats that provide crucial ecosystem services such as water supply, carbon storage, and fodder provision, thereby sustaining both Andean wildlife and human populations. These wetland ecosystems are known as Bofedales. They can be seasonal or permanent, natural or manmade, and are situated along creeks, lagoon boundaries, and other water sources such as springs, rivers, and melting ice at an altitude over 3,800 meters.

Bofedales are shallow basins or depressions that contain water from glacial melt, precipitation, or subsurface sources. At high elevations, the low temperature and high atmospheric pressure result in low evaporation rates. Scree plays a vital role in their formation by restricting the flow of water and allowing alluvial material to accumulate at the barrier, forming an alluvial layer of peat, sand, gravel, and clay that progressively advances upstream. They can range in size from a few square meters to several hectares and in thickness from a few centimeters to 8m, with an average peat depth of 30cm. Typically, they are surrounded by Andean grasslands or mountain forests. Wetland soils are composed of organic matter, peat, and mineral deposits, and are thoroughly saturated with water, making them an ideal habitat for aquatic plants and animals.

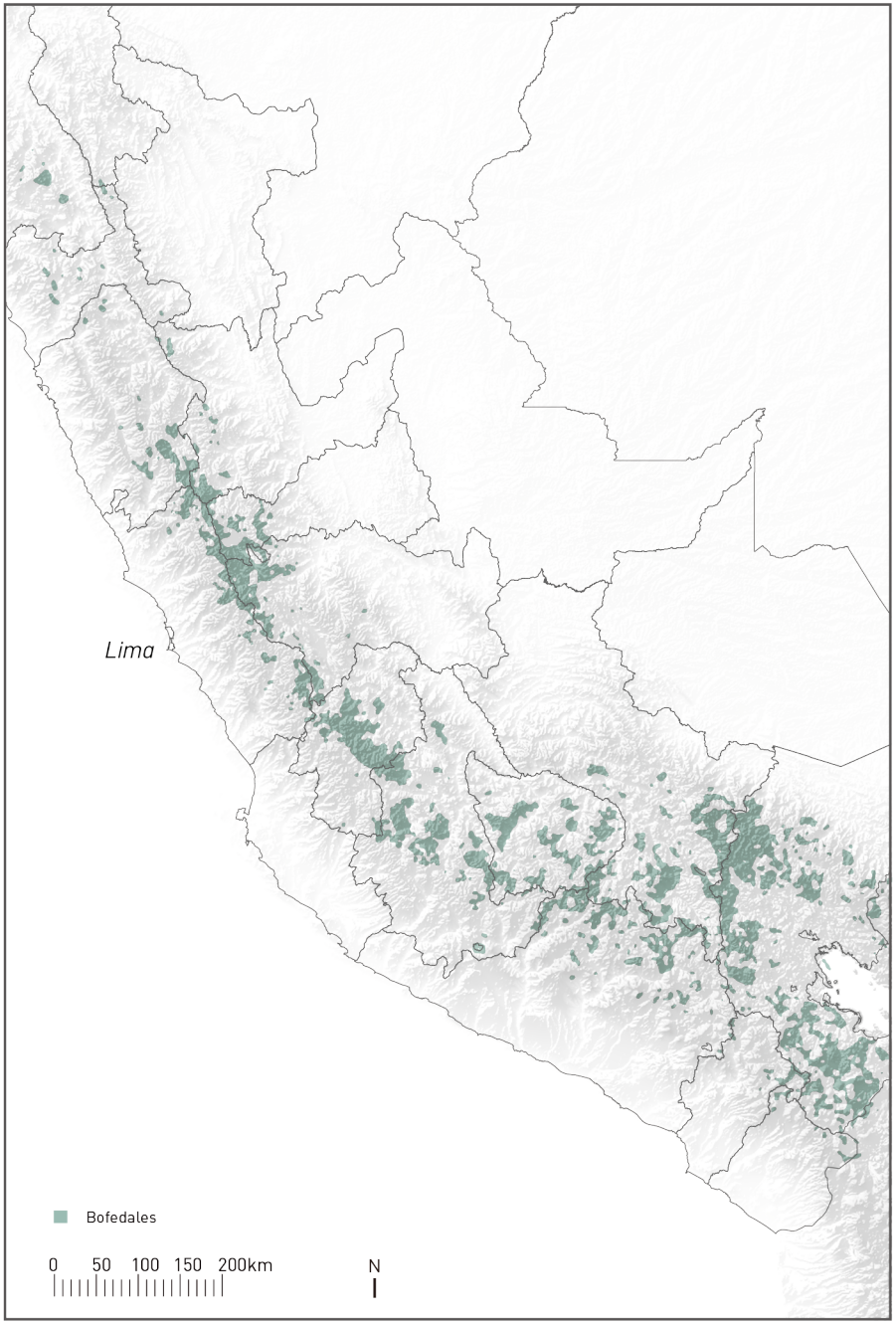
The vegetation in Bofedales consists of herbaceous plants adapted to water-saturated soils, such as mat plants, rosettes, grasses, and sedge, and is adapted to the severe high altitude environment. The Andes buffer plants (Azorella compacta and A. madreporica) are the most abundant plant species in Bofedales and produce a dense, unique layer of vegetation. These matted plants protect the subsoil against wind erosion, offer shade for other plants, and store water in the soil.

Although precipitation is the primary source of replenishment for Bofedales, they may also absorb water from groundwater and glacial melt. Their contribution to the water cycle relies on their ability for water storage and hydrological connection, similar to other wetland ecosystems. Bofedales runoff is gradual, and water often infiltrates through the ground before emerging at lower water level lakes. During the dry season, the Bofedales system acts as a natural sponge and becomes a critical water source for people, animals, and agriculture. The water stored in these wetland areas gradually filters down into the surrounding soil, recharging groundwater supplies, supporting streams and rivers, and supplying water to the surrounding ecosystems and human communities.

Furthermore, the Bofedales system helps to reduce the risk of landslides and other natural disasters that are common in the Andean region. The vegetation in these wetlands stabilizes the soil and prevents erosion, thereby reducing the likelihood of landslides.



1



2

1 Formation of Bofedales. Source from Hydrology of high-Andean bofedales wetlands(Jose Cuadros Adriazola et al, 2020).
2 Map of Bofedales in Peru. Source from Mapa Nacional de Ecosistemas(MINAM, 2019).
4 Bofedales en Pilpichaca. Photo by Michell León / Forest Trends

"Because they stay green year-round, bofedales are also biodiversity hotspots, frequented by birds and mammals, including deer, pumas, Andean fox, pampas cats, and vicuña and guanaco, wild ancestors of domesticated alpacas and llamas."

Erica Gies, 2021

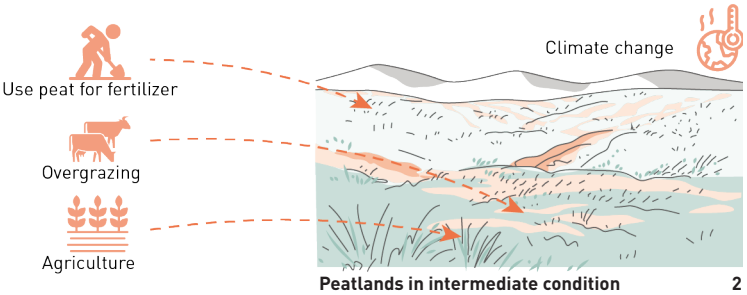
3

The Bofedales, which are vital for the water supply of nearby communities, have begun to degrade and disappear due to various issues such as climate change, overgrazing, and mud puddle rustlers. This degradation has had a severe impact on the availability of water in the area.

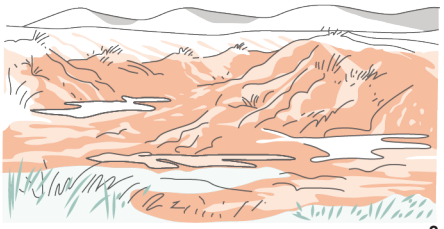
To address this problem, different restoration strategies have been implemented. One of these strategies involves installing barbed wire fencing around the Bofedales to protect parts of the area from overgrazing. Additionally, native grasses are planted in and around the Bofedales to enhance water infiltration.

Another restoration strategy is based on the pre-colonial practice of cosecha de agua, which involves water harvesting and digging canals, berms, and depressions to strategically direct water to the Bofedales and maximize water infiltration and flow to natural springs. This approach aims to ensure that water is efficiently directed to the Bofedales to support their restoration and protect the surrounding areas from further degradation.

Peatlands in good condition **1**



Peatlands in intermediate condition **2**



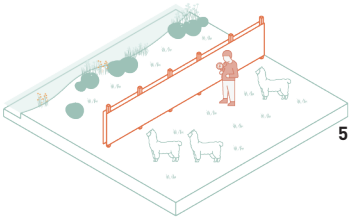
Peatlands in bad condition **3**

Year 1

Year 2

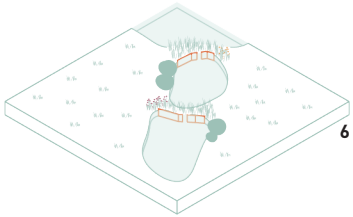
Year 3 4

Direct separation of livestock and human activities with **barbed wire**



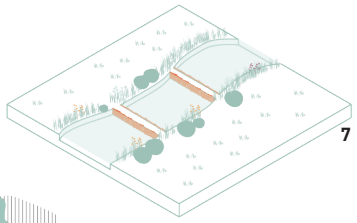
5

Wooden board made to slow water flow along ditches and promote rewetting of peatlands

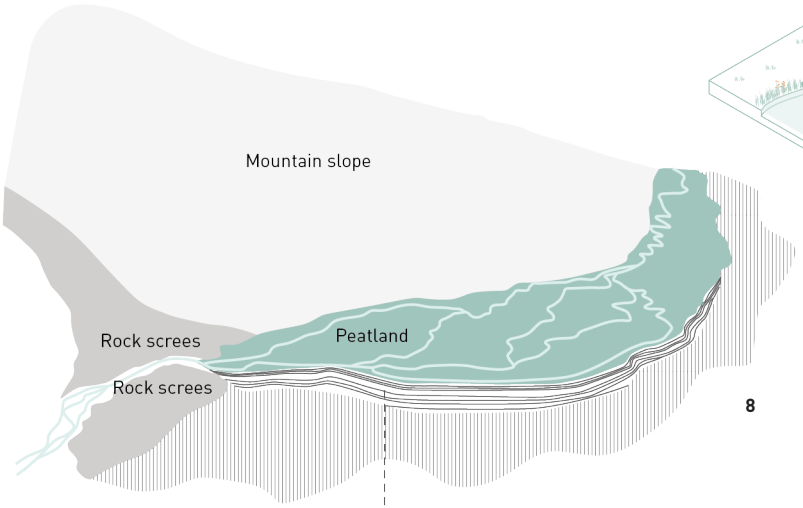


6

Example of a barrier constructed from **straw bales** Works as wooden board



7



8

1-3 Categories of peatland condition. Drawn by Ximena Maier, redrawn by author.
4 Recovery of Bofedales in the sample area. Photo from Challenges and opportunities for restoration of high-elevation Andean peatlands in Ecuador(Esteban Suarez,2022)
5-7 Existing means of restoring Bofedales.
8 Bofedales geomorphological interpretation according to the geophysical results. Drawn by Remi Valois et al, redrawn by author.

02/03

Amunas: The ingenious Andean water system

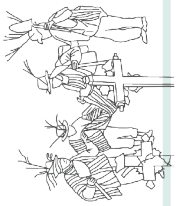
Artificial recharge aquifer systems aim to store water from rainfall and surface runoff in underground aquifers, to be used for various applications including year-round human activity, agriculture, industry, and recreation. By storing water in the rock or soil, By storing water in rocks or soil, which then re-emerges or is preserved from lakes, wetlands, springs, etc. This practice is referred to as "water cycle management" and is employed in regions that receive rainfall for only a few months per year. One example of an ancient aquifer artificial recharge system is the Amunas water system in the Lima Región of Peru.

Amunas, which refers to "retaining" in Quechua, refers to the diversion of water from natural streams during the rainy season in order to increase water infiltration on hillsides. In the Andes, most of the ground is covered by fissured rocks, which also have low permeability and are the main material for building Amunas. During the dry months, the Amunas system allowing water absorbed by soil replenish the water table. This is accomplished through a network of canals, including diversion canals, infiltration canals, infiltration hillslopes, ponds and spring systems. Locals refer to this technique as water sowing, as it enables the community to harvest water during the dry season, when there is no rain.

Created **1,400 years ago**

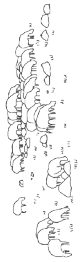
By prehistoric peoples who lived in what is now the province of **Huarochiri**

For extending the rainy season's bounty



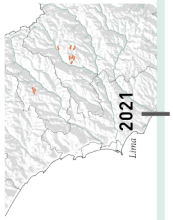
The so-called **Comuneros** uphold customs for the upkeep of the Amunas

They hold **ceremonies** around their cleaning and blessing



Recent centuries have seen a decline in the ability of water to infiltrate as a result of local people **overgrazing** the hillsides

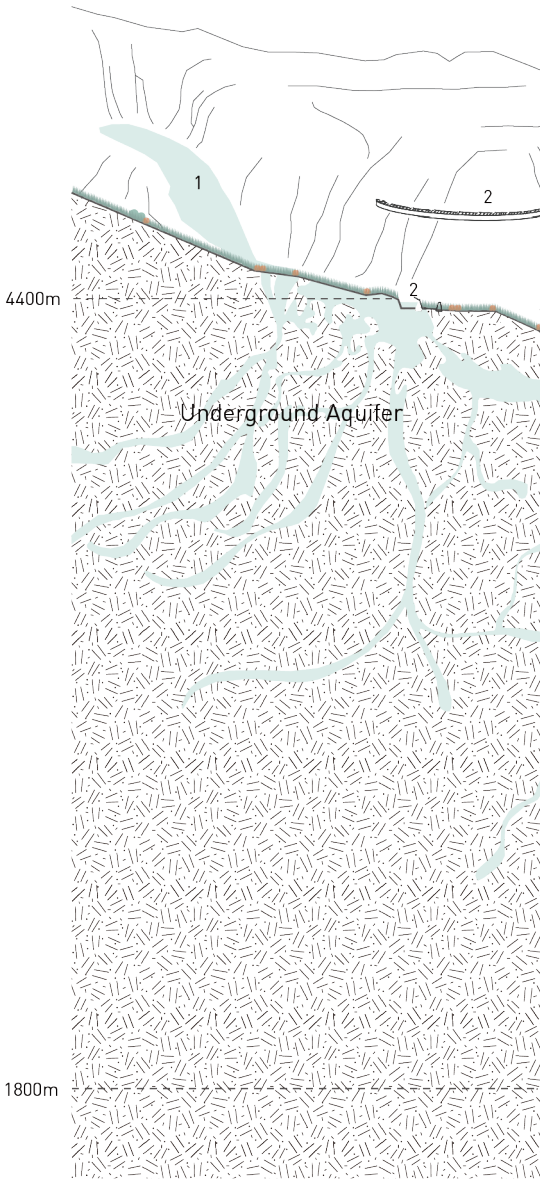
Numerous Amunas have been **abandoned** as a result of poor management



9 Amunas have been restored, they contribute **3,275,925.75 m³/year** to the Chillón and Rímac river basins

2025

Government plans to complete restoration of 67km of Amunas by 2025



Big-scale section of Amunas

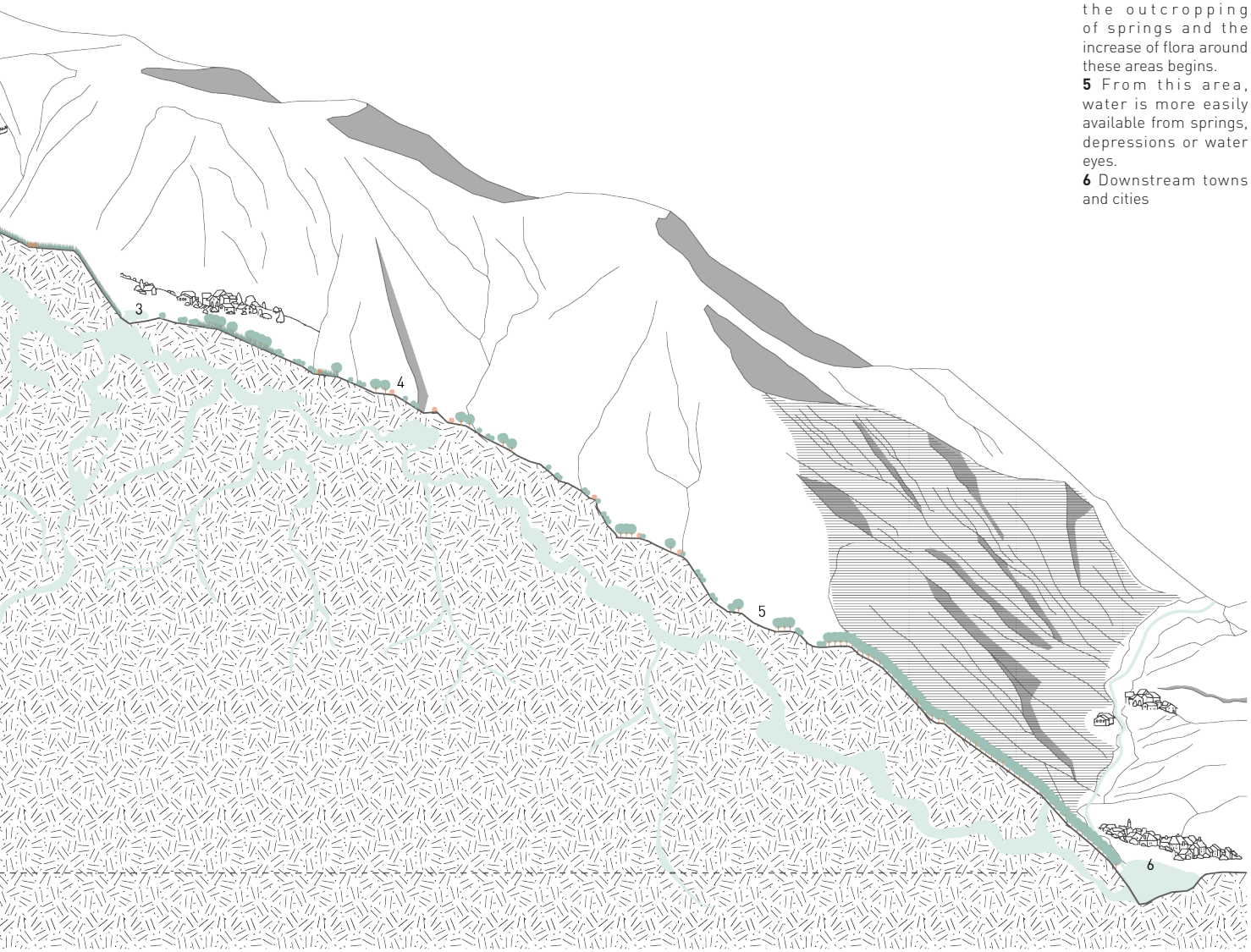


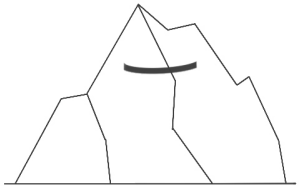
Figure legends
1 Valley Creek
2 Amunas system
3 Towns for building and managing the Amunas, access to water from amunas through ponds.
4 Down the mountain, the outcropping of springs and the increase of flora around these areas begins.
5 From this area, water is more easily available from springs, depressions or water eyes.
6 Downstream towns and cities

The Amunas system was developed by the Wari tribe around 1500 years ago and continued to be used by the Incas until the Spanish invasion of Peru in the 16th century. The Spaniards replaced the Amunas system with their own, less efficient water management system based on individual property ownership and the use of tiny irrigation systems. Additionally, environmental factors such as deforestation and soil erosion may have contributed to the decline of the Amunas system. Canals and ponds may have gotten blocked with sediment and debris over time, reducing their ability to capture and distribute water.

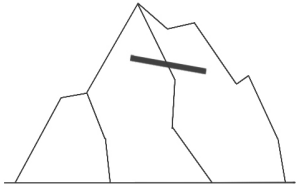
Today, around 11 of the original Amunas canals are still operational, located in San Pedro de Casta and Huamantanga, respectively. These canals feed water to 65 active springs and 14 minor ponds, providing approximately 225,000 cubic meters of water per kilometer each year during the dry season.

1

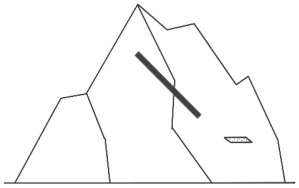
1 Junction of diversion canal and infiltration canal. Photo by aquafondo
2 Canals with different inclination angles are used for different functions.
3 Small-scale section of Amunas.



Canal parallel to the contour



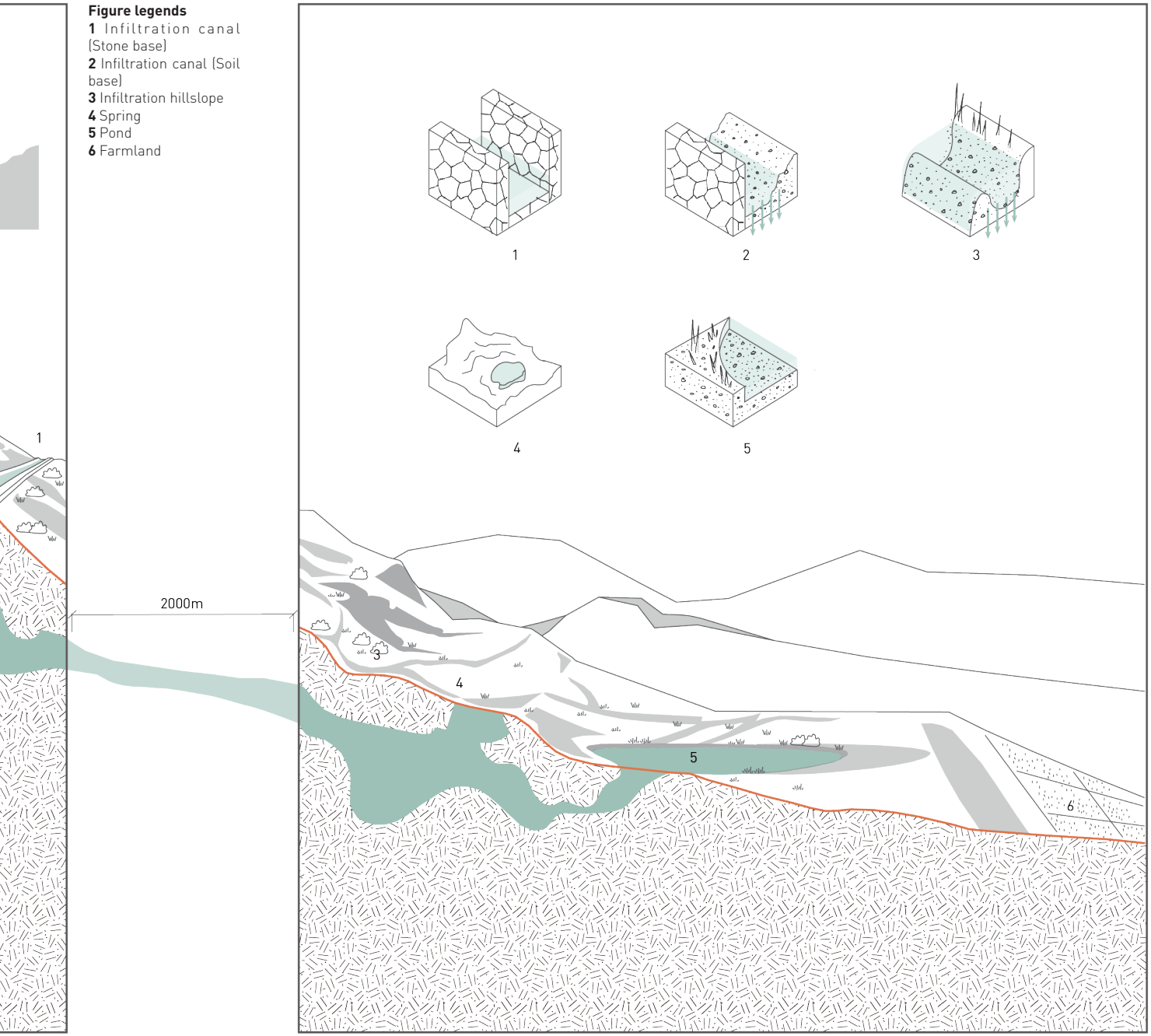
Slightly inclined canal for water flow



Canal with a clear inclination for irrigation and other functions

2

Figure legends
1 Infiltration canal (Stone base)
2 Infiltration canal (Soil base)
3 Infiltration hillslope
4 Spring
5 Pond
6 Farmland



3

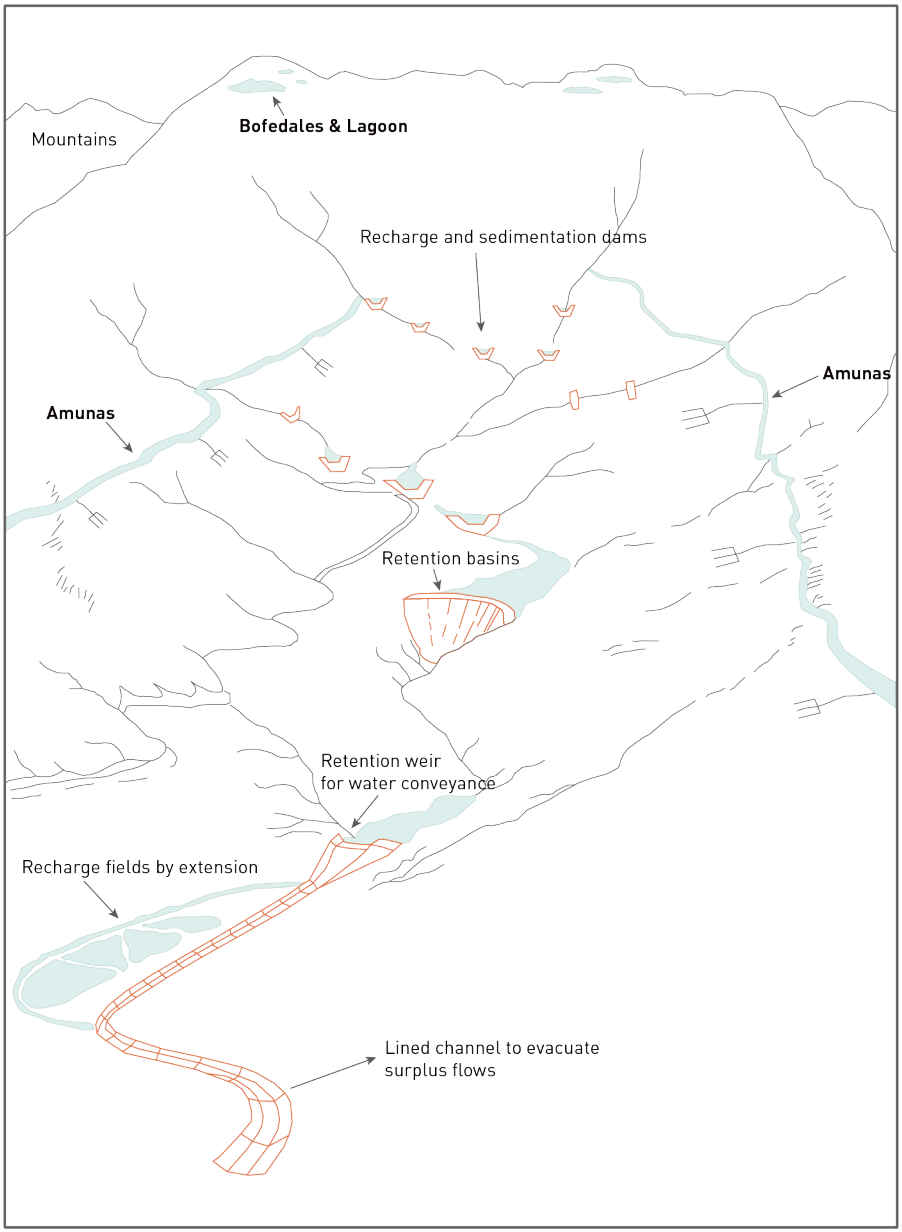
02/04

The sacred flow: Exploring the Andean Cosmovision of water

The Andean Cosmovision was a belief system held by the people who once lived in the Andes, a region of South America characterized by rugged mountains, rivers, and harsh weather conditions. They believed that everything in the world was interconnected and alive, and that the natural world reflected the human world.

Hanan Pacha, Kay Pacha, and Uku Pacha are the three interdependent and dynamic spaces that comprise the universe in the Andean Cosmovision. Hanan Pacha is the superior kingdom, representing the sky world inhabited by living creatures, natural phenomena, and Andean gods, such as the condor. It is connected to the spiritual world and symbolizes the future. Kay Pacha is the human realm, the present, where everything is in motion, and where we perceive and experience the world around us. It is a bridge between the past and the future and constitutes the physical world we inhabit. Finally, Uku Pacha is the past time, the world of the dead and the spirits of the past. It is the underground world, the root that supports the whole universe, and the cradle of the seeds that will be reborn. These three levels interact and correspond to form the universe, where the microcosm reflects the macrocosm.

The Andean people held a profound reverence for the land and the environment. They believed that



Recharge systems in basin. Source from: adaptación realizada por D. Apaza y otros-GSAAC 2006.

The Andean ancestors believed that if all the **snow** disappeared, the world will end.

Waterfalls, like lakes, are creative places where worlds merge into one another, where you can find treasure or be bewitched by the mountain spirits.

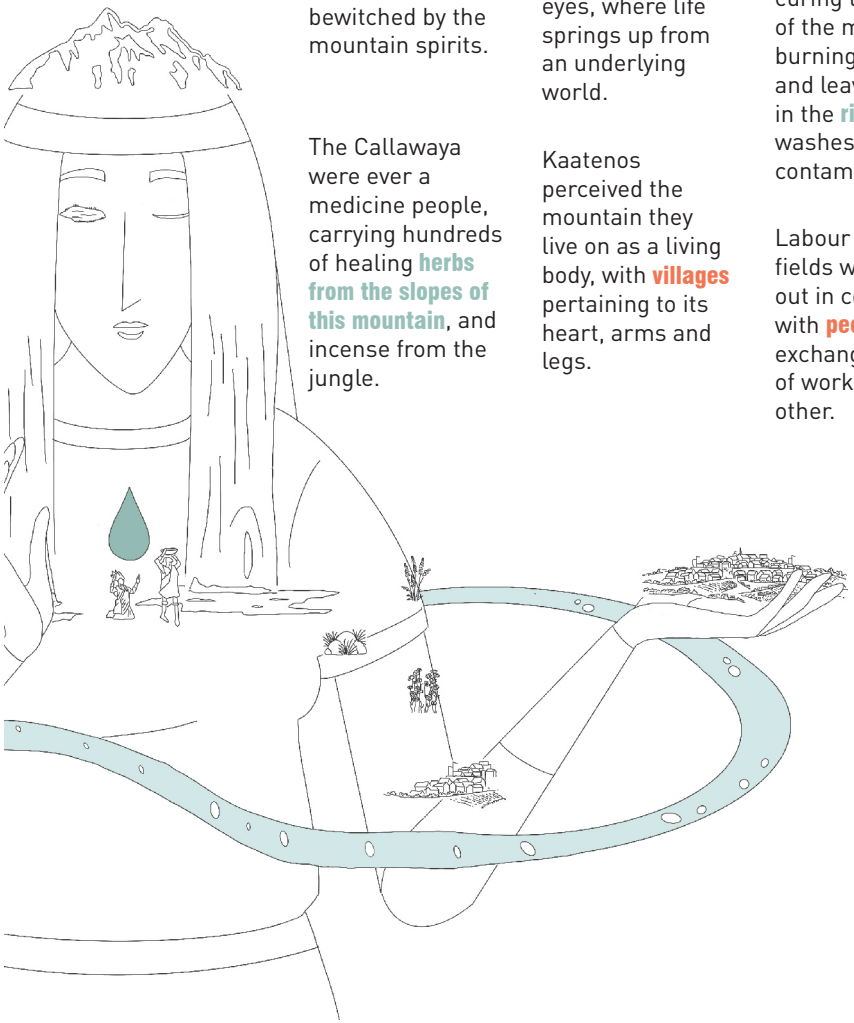
The Callawaya were ever a medicine people, carrying hundreds of healing **herbs from the slopes of this mountain**, and incense from the jungle.

Mountain lakes making up the eyes, where life springs up from an underlying world.

Kaatenos perceived the mountain they live on as a living body, with **villages** pertaining to its heart, arms and legs.

To heal illness, the Andean carried out ritual curing the body of the mountain, burning offerings and leaving them in the **river**, which washes away contamination.

Labour on the fields was carried out in common, with **people** exchanging days of work with each other.



everything in the world and every action had an impact on the natural world's balance. They saw themselves as caretakers of the environment and considered it their duty to safeguard and preserve the natural world for future generations. Water played a crucial role in the Andean Cosmovision as it was the source of life, sustenance, and mobility for the people.

The Andean people believed that water was a powerful spirit with its own energy and identity. They believed that the rivers, lakes, and oceans were alive and that they could interact with these water spirits. Mama Cocha, the ocean's mother, was one of the most significant water deities in Andean Cosmovision, and the Andean people revered and respected her as the origin of all life in the water. They also believed that the mountains, which held the snows that nourished the rivers, were powerful water spirits that controlled the flow of the rivers. By honoring and respecting the mountains, they believed the rivers would flow abundantly and their harvests would flourish.

The Andean people also believed in the power of water to cleanse and purify. They frequently performed rituals and ceremonies in rivers and lakes to purify themselves and seek blessings from the water spirits. During the planting and harvesting seasons, when the Andean people relied on rain to nourish their crops, they performed rituals to honor and request the graces of rain.

1 Indigenous Andean people making herbal medicine. Photo by Pachayachachiq Cultural Institute
2 Four Incan ceremonies as depicted by Felipe Guaman Poma de Ayala(1615).

1

2

“Wending our way through the narrow Chillón River Valley, a slim swath of irrigated green crops hemmed in by sheer walls of tawny rock, we crossed the river and began grinding up a single-lane dirt road clinging to the side of a steep mountain. At about 3,500m (11,500ft), we reached a plateau with fields of avocados, hops, potatoes and beans and, finally, the village, where two-storey buildings of mud bricks and concrete lined narrow dirt streets. Burros, horses, cows, dogs and people puttered around.”

Erica Gies, 2021

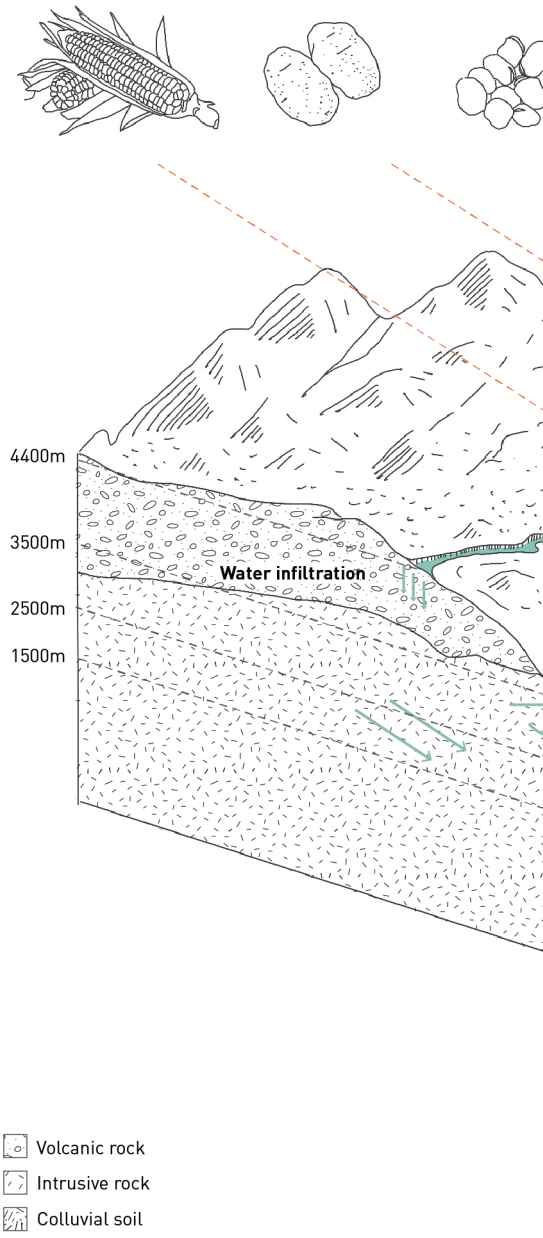
02/05

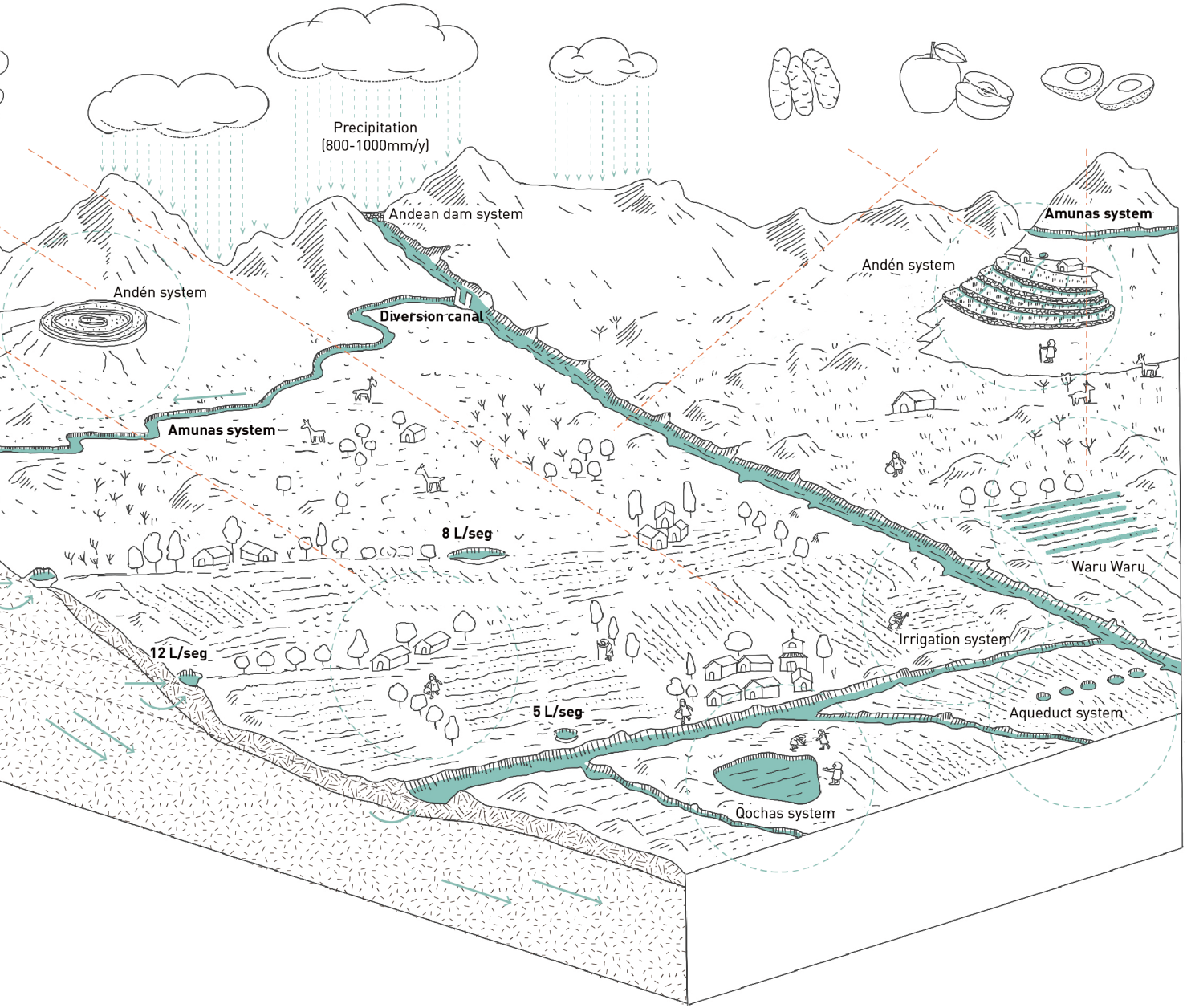
The intersection of Andean Cosmovision and traditional water life in Huamantanga town

The Andes are one of six regions in which complex civilizations have emerged. Multiple times, seasonal precipitation has served as a catalyst for hydrological innovation. Generations of people have cultivated an intimate understanding of water and the subsurface, deploying the still-amazing Amunas system that is still in use in the town of Huamantanga.

Huamantanga is part of the Huamantanga district of the Lima Región, which is located in the upper Chilón river basin. Humantanga means "the place where the falcons roost," and during the dry season, the locals have access to more water and better grazing land. On its territory, people can observe the influence of pre-Inca and Inca cultures, as well as later Spanish colonies, on the water culture, in which this valuable resource was

1





Water system and circularity in the Andean highlands have Amunas systems

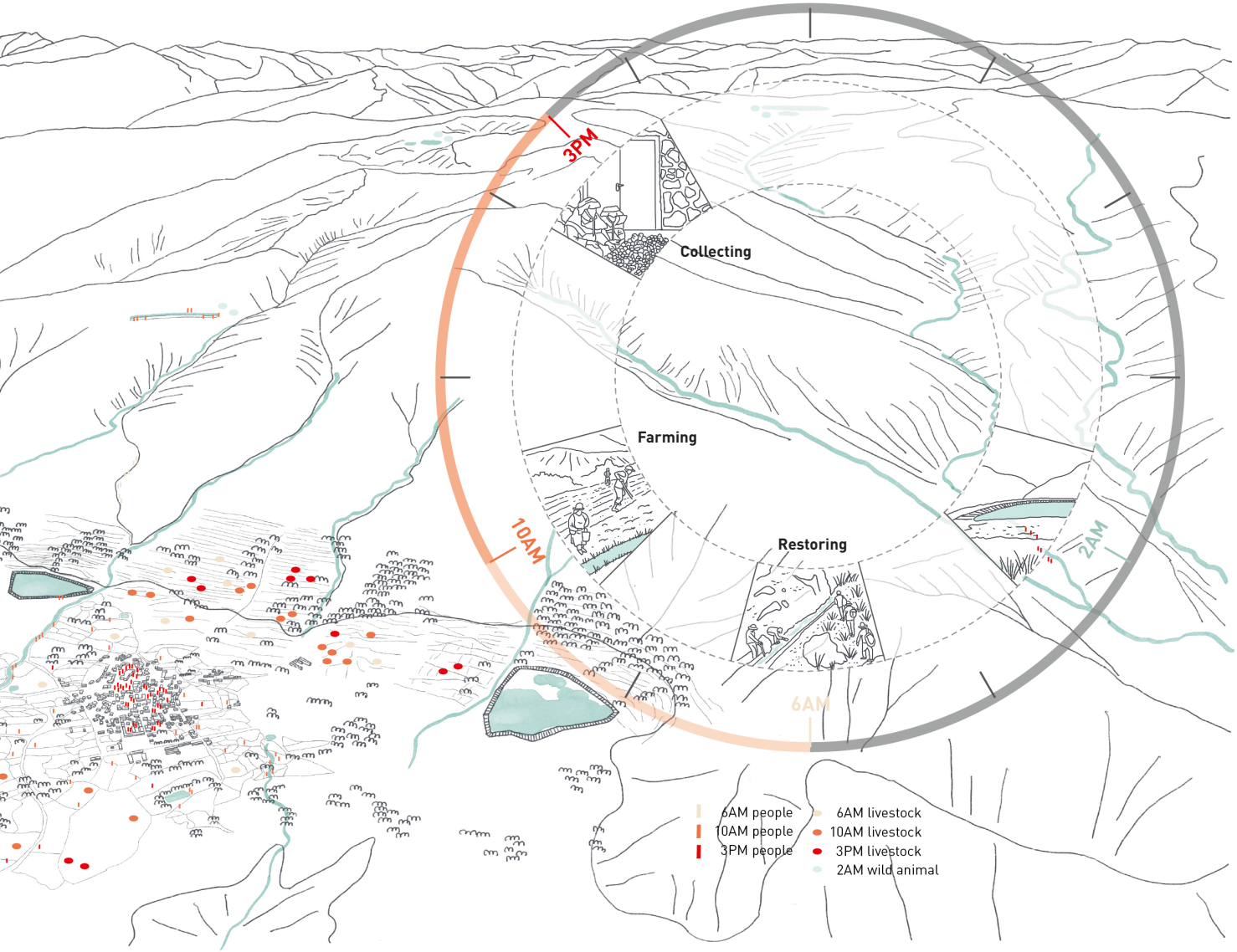
associated with divinity. During the pre-Inca and Inca periods, water sources were associated with Huancas or sacred stones, through which people connected with nature and participated in universal spiritual rituals. Currently, the Amunas system that protects the Huancas can be found in Huamantanga.

The canals through Huamantanga town meander through the steep slopes, collecting rainfall and water from the highland streams during the rainy season, allowing them to seep into the mountains and percolates naturally over several months rather than flowing directly through the streams.

The people who live here are members of the Comuneros: agricultural collectives. People have been using and maintaining parts of the old Amunas for centuries. 2 of the original canals are still in operation.

According to anthropologist Fánel Guevara, "Amunas cannot exist without organised communities. In many sites where communities have vanished or diminished, it is no longer apparent to the current residents how and why the

2



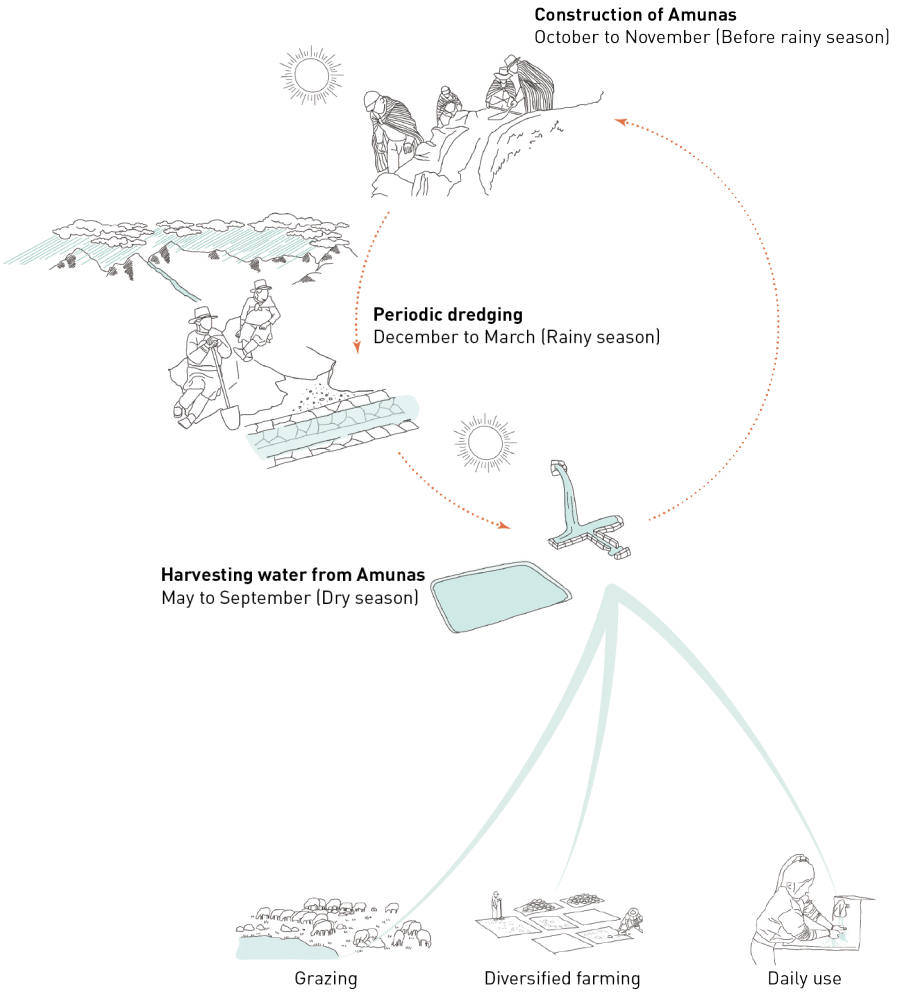
One-day life cycle in Huamantanga town in 2023

aquifer is recharged." The presence of the community is required for Amunas to function, as it is an integral part of the work, both physically and in the organisation of the rainwater sowing, harvesting, channelling, and infiltration processes, in order to "humanely" recharge the aquifer.

According to the Comuneros, the Amunas protect the water in springs and streams during the dry season for domestic and agricultural use, as well as public service; as a result, they organise year after year, with reverence and ritual, to complete a significant public task of gratitude and commitment.

The Comuneros know which canal nourishes which spring, indicating that they comprehend the underground path of water. It is a knowledge that has been handed down from generation to generation among the locals.

The entire community worked from February to March, armed with rocks and mud, to maintain the Amunas system and guarantee water for irrigation and filtration. Men, women, and children once again went to work in the Amunas following the forecast of a new deluge.



3

References

ANDINA(2012). Relaves mineros componen el 60 % de contaminación del río Rímac. From: https://andina.pe/agencia/noticia.aspx?id=430721

Erica Gies(2021). Peru is turning to ancient indigenous techniques and natural ecosystems to keep its taps running, as climate change threatens to dry out its water supply. From: https://www.bbc.com/future/article/20210510-perus-urgent-search-for-slow-water

Maldonado Fonkén, Monica Sofia. (2014). An introduction to the bofedales of the Peruvian High Andes. Mires and Peat. Volume 15. 1-13.

María J. Monge-Salazar, Carolina Tovar, Jose Cuadros-Adriazola, Jan R. Baiker, Daniel B. Montesinos-Tubée, Vivien Bonnesoeur, Javier Antiporta, Francisco Román-Dañobeytia, Beatriz Fuentealba, Boris F. Ochoa-Tocachi, Wouter Buytaert(2022). Ecohydrology and ecosystem services of a natural and an artificial bofedal wetland in the central Andes. Science of The Total Environment, Volume 838, Part 2. From:https://doi.org/10.1016/j.scitotenv.2022.155968.

1 Dredging rituals near Amunas. Photo by Ronald Ancajima
2 Pilgrims along the trails of the Sinakara Valley. Photo by Danielle Villasana
3 One-year cycle of local residents maintaining Amunas

View of Huamantanga, Peru. Photo by Timothy Karpouzoglou

03 Zooming in on Huamantanga town: A turning point

03/01 Opportunities

- **03/01/01** The emergence of Blue-Green infrastructure in government strategies
- **03/01/02** Reviving the Waters: Restoring traditional water system for sustainable solutions to Lima's water scarcity
- **03/01/03** Other enhancement during the restoration of traditional water system

03/02 Challenges

- **03/02/01** Water and community in Huamantanga nowadays: Navigating population loss, mono-production, and infrastructural conflict
- **03/02/02** The decline of water values in modern society

We need more water. Lima, with more than 10 million inhabitants, accounts for 44% of the national GDP; however, its location in the middle of a desert generates significant water risks that impact the water supply used by productive sectors. The water situation of the city in the next 10 to 15 years will be unfavorable, given a scenario of a 30% decrease in water availability and water supply, around 35 thousand jobs would be lost, taking into account the family composition, this would affect approximately 120 thousand inhabitants.

Water Crisis, a silent threat to economic development (Aquafondo, 2020).

03/01

Opportunities

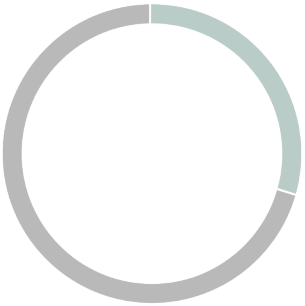
03/01/01

The emergence of Blue-Green infrastructure in government strategies

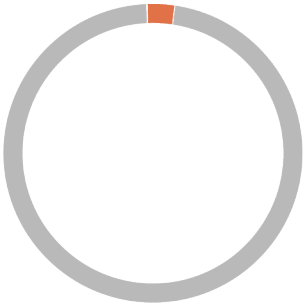
Climate change models predict that Lima will experience more frequent natural disasters, such as seasonal flooding. However, traditional grey infrastructure is no longer sustainable and cannot meet the long-term water demands of the city. To address this issue, the implementation of Blue-Green Infrastructure (BGI) is crucial for the development of a climate-resilient urban and landscape. BGI is an interconnected network of natural and semi-natural regions that restores the environment, maximizes ecosystem services, and contributes to the well-being of local communities. In Peru, BGI includes wetland areas, traditional water systems, and urban floodplains.

The incentive mechanisms for ecological services statute, which was enacted in 2014, provides the legal framework for allowable interventions. It emphasizes the importance of combining scientific knowledge with indigenous knowledge, and highlights the need for restoration of water collection infrastructure and cost-effective solutions for water supply and drought response.

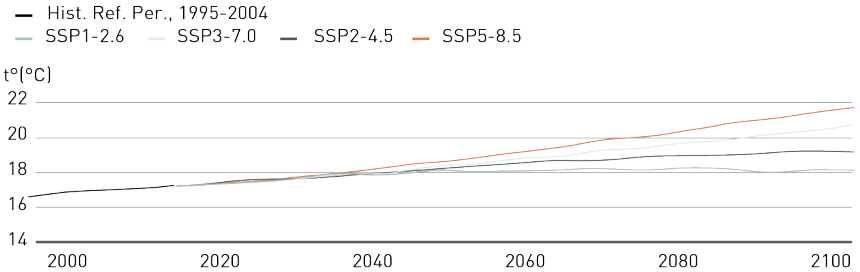
1 Projected Mean-Temperature of Lima, Peru. Information from world bank
2 Sectors with the greatest negative impact. Information from Aquafondo



A 30% drop in the availability of drinking water in 10-15 years

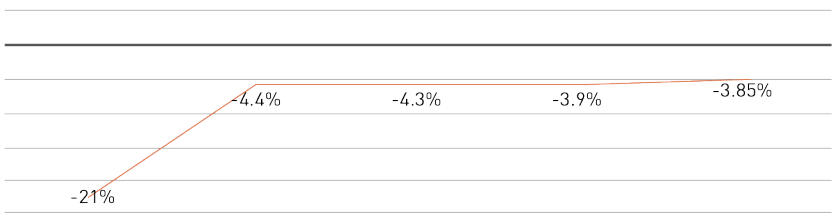


Total Lima production would have a reduction of 2.22%



SSPs: Shared Socioeconomic Pathways. SSPs are meant to provide insight into future climates based on defined emissions, mitigation efforts, and development paths.

1



1 Drinking water 2 Beverages 3 Social service 4 Steel industry 5 textiles

2

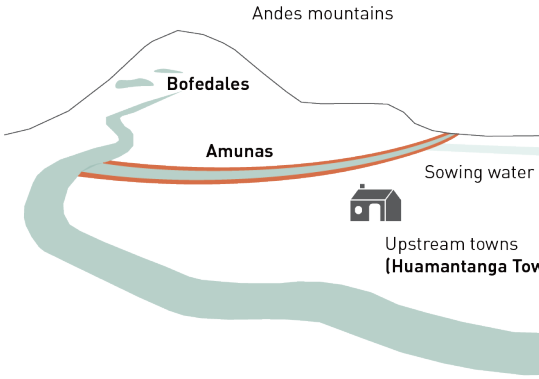
03/01/02

Reviving the Waters: Restoring traditional water system for sustainable solutions to Lima's water scarcity

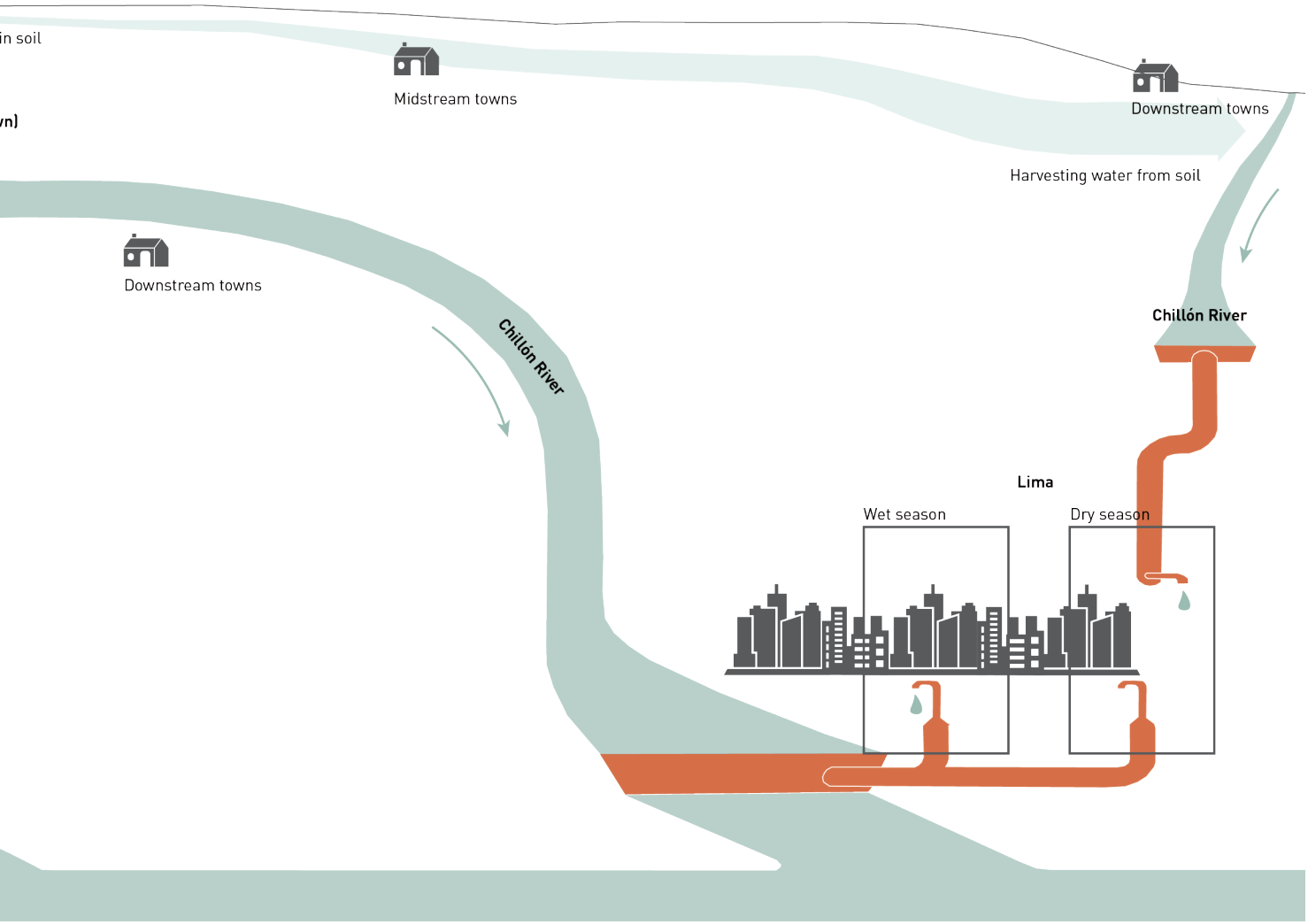
The Bofedales, covering 549,360 hectares or approximately 0.4% of Peru's area, are situated above 3,800 metres in altitude(MINAM, 2012). Acting as natural sponges, they play a crucial role in purifying and retaining water in the upper part of the basin, thus protecting species in the basin. Besides, they act as traps for sediment retention, filter water, provide fodder and water for livestock, and are a significant source of biodiversity. Bofedales can serve as blue-green infrastructure, they are also fragile ecosystems that have been adversely affected by human activities like overgrazing, metal mining, and peat extraction. Urgent restoration is required for about 2,500 to 3,000 hectares of Bofedales in the Chillón-Rímac-Lurín basin, and several others in other basins of Peru.

The Amunas system supports surface and groundwater recharge, ensuring a constant supply of water throughout the year. With climate change leading to prolonged droughts, Amunas have become a lifeline for highland farmers, while also contributing to water supply from downstream dams. The restoration of 135 kilometers of Amunas in the Chillón-Rímac-Lurín basin shows the potential of blue-green infrastructure. Implementing Amunas in the basins would capture an additional 6.7 cubic meters per second of rainfall in the upper basin zone and at least 1.4 cubic meters per second in Metropolitan Lima, according to a World Bank Report.

To connect Bofedales and Amunas from the Andes to the cities, they can be combined with other complementary measures like vegetation cover along the watershed from the mountains to the coastal cities. This natural vegetation can store and buffer a portion of the water deposited through increased plant retention and evapotranspiration. Similarly, floodplains along river margins can also be seen as blue-green infrastructure since they temporarily store water, slowing down runoff and reducing river velocity. By combining these measures, Lima could receive 3,275,925.75 cubic meters of water per year during the dry season by restoring this traditional water supply system.



Provide **3,275,925.75 cubic meters** of water per year during the dry season



Groundwater recharge systems supply water to cities downstream

"Ancient infiltration techniques were once used to increase water storage and slowly release flows that would reappear in downslope springs after a time lag of several months, which could also be part of a landscape strategy," the study notes. "Implementing these types of green interventions can have additional social, cultural and environmental benefits because upstream communities are involved in supporting improved management of the region's watersheds and water resources, and because natural systems can also filter out water pollutants, stabilize soils and provide habitat for biodiversity."

03/01/03

Other enhancement during the restoration of traditional water system

Economic Values

The water crisis in Lima has forced the city to rely on costly and unsustainable water sources, including desalination plants and water transfers from other regions. According to a report by the Inter-American Development Bank (IDB), Lima's desalination costs range from $1.90 to $2.70 per cubic metre, making it one of the world's most costly water sources. In contrast, restoring the traditional water systems in the Andes could provide Lima with a sustainable and cost-effective water supply.

Restoring traditional water systems can also provide employment opportunities for upstream communities. For instance, the Amunas system necessitates restoration and maintenance of canals and reservoirs, which could provide locals with a sustainable source of income.

In addition, the tourism potential of the Andean highlands is largely unrealized, and traditional water systems, which are significant cultural and natural heritage sites, could increase tourism in the region. Tourism has become one of the fastest-growing sectors of the Peruvian economy, with international tourism increasing from 2.7 million in 2011 to 4.4 million in 2019 according to the Peruvian Ministry of Tourism. Restaurating unique Andean landscapes such as Bofedales and Amunas could help diversify the region's tourism

product and attract travellers interested in natural and cultural tourism, thereby providing local communities with an additional source of income.

Cultural Values

Bofedales and Amunas are significant cultural sites for indigenous communities in the Andean region, and they represent the Andean people's practise of Andean cosmovision. Restoring these ecosystems can aid in the preservation of these communities' cultural heritage. In addition, traditional knowledge and practises pertaining to water management in these ecosystems can be restored, allowing for the transmission of knowledge between generations. This knowledge transmission can aid in preserving the Andean people's cultural identity and relationship with the natural environment.

Ecological value

The Andean highlands provide a habitat for a variety of plant and animal species, and traditional water systems serve as a source of life for both plants and animals while also being utilised by humans. According to a report by the United Nations Development Programme (UNDP), 10% of the world's plant species are found in this region. Restoring ecosystems surrounding traditional water systems can aid in the conservation of biodiversity and the promotion of ecosystem services such as carbon sequestration, erosion control, and water regulation. It can also contribute to the aim of sustainable development and the mitigation of climate change.

Landscape values

The traditional water systems of the Andes produce a varied landscape along the way. Containing the Bofedales, the unique peatland landscape, the Amunas Canal landscape and the terraced agricultural landscape that accompanies it, and continuing downstream to create a wetland landscape on the lower slopes, among others. Restoring these ecosystems will increase the aesthetic value of the landscape, promote scenic tourism, and enhance the regional residents' quality of life.

03/02

Challenges

03/02/01

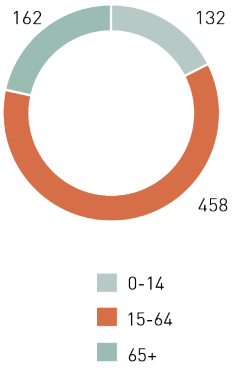
Water and community in Huamantanga nowadays: Navigating population loss, mono-production, and infrastructural conflict

The town of Huamantanga has approximately 600 residents and an urban centre at an elevation of approximately 3,400 metres, surrounded by approximately 98.5 square kilometres of natural pasture and agricultural land. Public land from 1,600 to 4,600 metres above sea level is allocated for residential and productive use by community members.

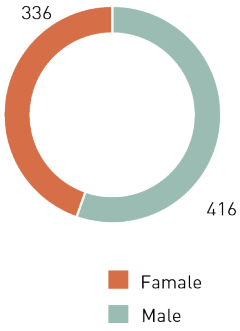
Agriculture and livestock raising are the primary economic activities in Huamantanga. At lower elevations, crops like maize and fruit trees such as apples, avocados, and lemons are grown in the soil. At middle and high altitudes, staple crops such as potatoes, wheat, and barley are grown, as well as fodder. At higher altitudes, the soil is predominantly uncultivated for grazing. The town's principal commercial products are potatoes and cheese, and Huamantanga potatoes are primarily marketed on the Peruvian market, as well as in certain regions of South America, particularly in Andean villages. The production of cheese, which is sold in markets north of the city, is growing in importance. In addition to the farming community, no more than 30 people own local small businesses such as restaurants, grocery stores, and buses that take passengers to Lima every day.

Over the past fifteen years, Huamantanga town has experienced a significant increase in population loss, with families relocating to larger urban areas in search of greater economic opportunities, education, and healthcare. As a result, many houses have been abandoned, and there are few non-agricultural employment opportunities in the area. Agriculture is the primary source of income for the population, and the lack of economic opportunities has led to the town's decline.

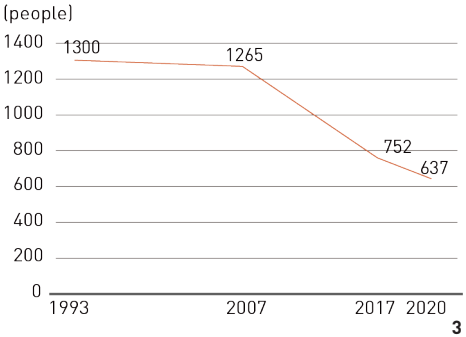
Moreover, the town has been caught in a pernicious cycle, in which the desire of its residents to increase their income has led to an increase in grazing in the ecosystem that provides water, the upper portion of its territory. This has resulted in less water being available for irrigation and less grass being available, leading to a decline in household income. This has increased the burden on the ecosystem, worsening the problem and creating a vicious cycle.



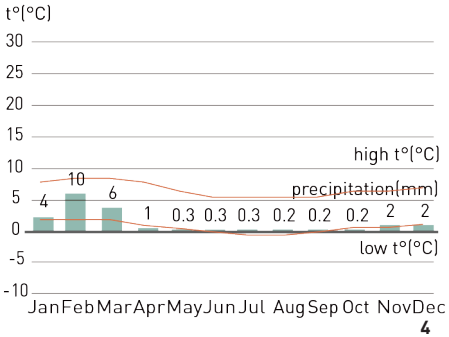
1



2



3



4

03/02/02

The decline of water values in modern society

The people of Lima, who share the same ancestry as the Andes and have expanded their territory at the foot of the Andes, have a complex and multifaceted view of water. However, this view often neglects the importance of water, and there are several causes for this disregard:

_The local commodityization of water
Water is frequently commodified in contemporary Lima, viewed as a product to be bought and sold rather than a natural resource to be protected and conserved. This has led to a significant bias between the right to exist and viewing water as a commodity, resulting in a lack of awareness regarding the importance of water in daily life. Residents of affluent neighbourhoods tend to misuse or waste water, whereas the high cost of water is prohibitive for residents of impoverished neighbourhoods.

_Dependence on water tanks
Many Lima residents rely on water trucks to provide them with a constant supply of daily water. This dependence on centralised water infrastructure can result in a feeling of estrangement from natural water sources.

_Inequitable access to water
In some areas of Lima, the availability of pure and safe drinking water is limited or nonexistent. This can cause residents to feel desperate, as they may be compelled to rely on unclean or unsafe water sources. This may result in a dearth of concern for the region's water resources' long-term sustainability.

_Impacts of Climate Change
As a result of climate change-induced increases in the frequency of droughts and other extreme weather events, the significance of Lima's water resources is becoming increasingly apparent. Nonetheless, this increased awareness may not turn into a greater appreciation for the importance of water in daily life. Without a corresponding commitment to conservation and sustainable use, it may induce a sense of dread or anxiety regarding the future availability of water.

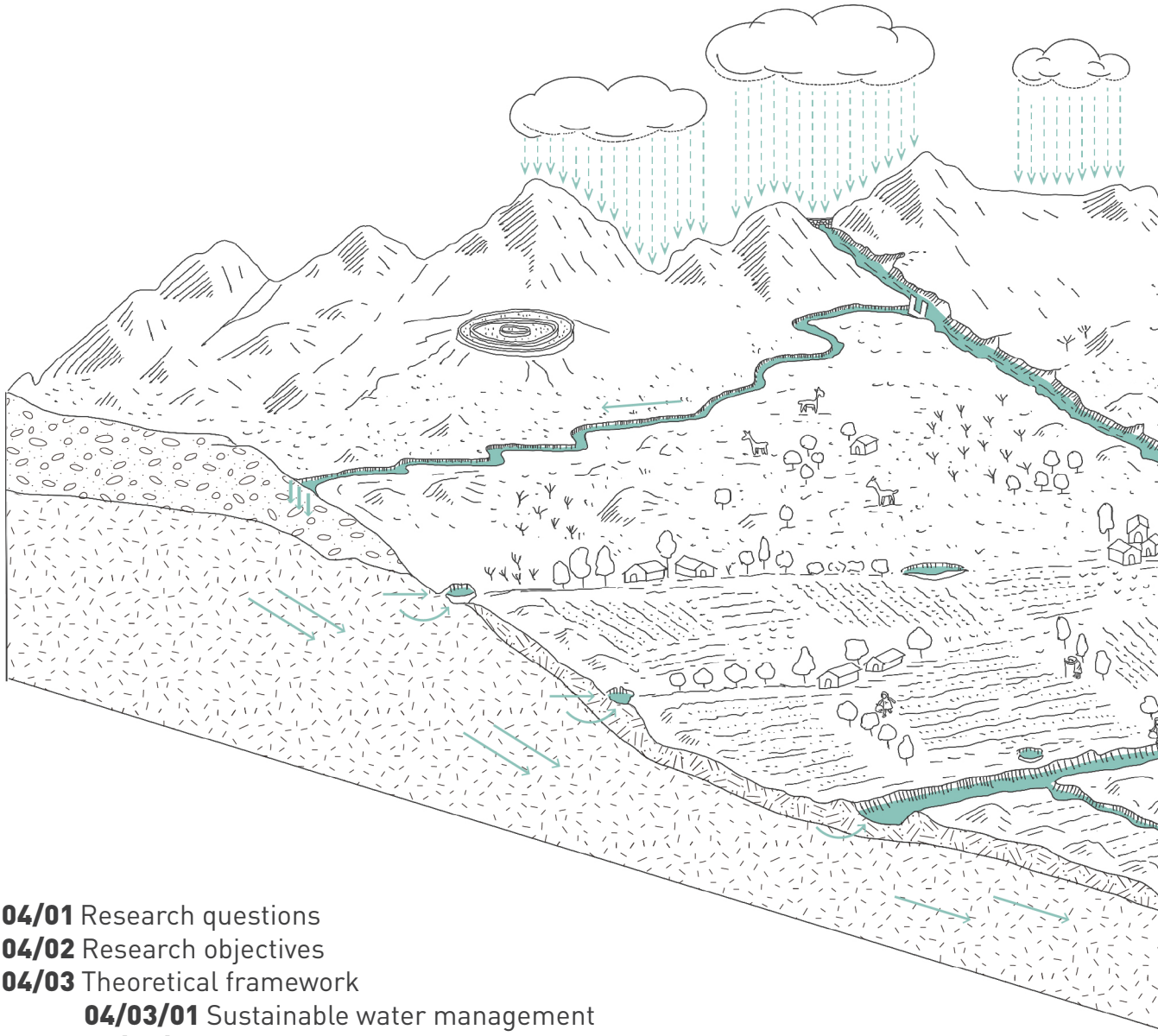
1 Age structure of Huamantanga, Peru. Information from Citypopulation.de
2 Gender structure of Huamantanga, Peru. Information from Citypopulation.de
3 Population of Huamantanga, Peru. Information from Citypopulation.de
4 Climate of Huamantanga, Peru. Information from Weather and Climate

References

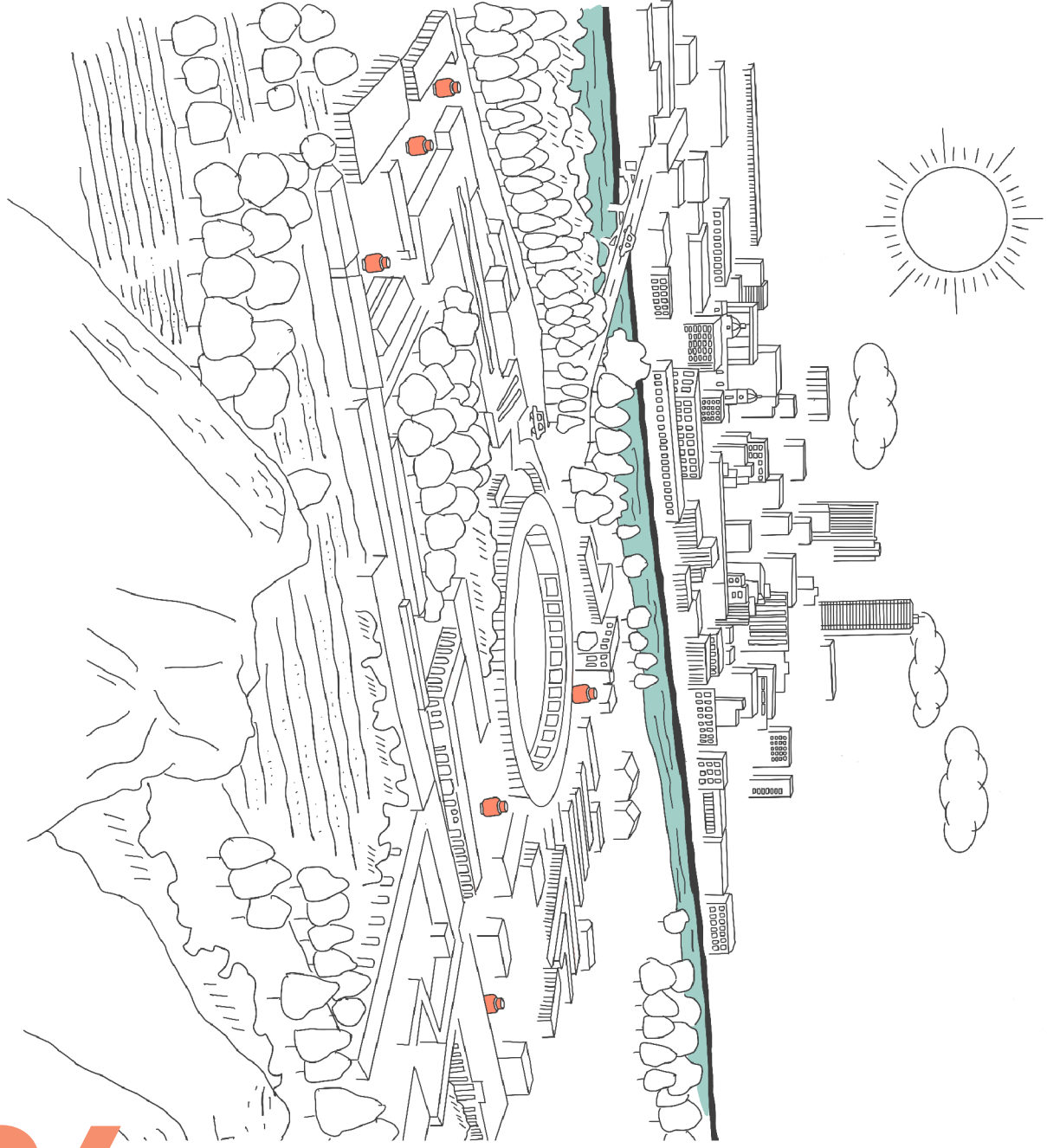
Aquafondo(2020). Water Crisis, a silent threat to economic development.

Jim Morrison(2016). Back to Basics: Saving Water the Old-Fashioned Way. From: https://www.smithsonianmag.com/science-nature/saving-water-old-fashioned-way-180959917/

Wetlands International(2019). Blue-green infrastructure for climate change adaptation in Peru. From: https://urbanresiliencehub.org/articles/blue-green-infrastructure-for-climate-change-adaptation-in-peru/



04/01 Research questions
04/02 Research objectives
04/03 Theoretical framework
04/03/01 Sustainable water management
04/03/02 Landscape identity
04/04 Methodological framework



04 Research framework

04/01

Research questions

Main question

How can landscape architecture aid in the restoration of the traditional water systems at Huamantanga to alleviate the water crisis in Lima?

Sub-questions

_What is the water crisis in the context of Lima?	**SECTION I _01**
_What is the traditional water systems in Huamantanga and what is the life of the local people with water?	**SECTION I _02**
_What are the opportunities and challenges of restoring traditional water systems in Huamantanga to help alleviate Lima's water crisis?	**SECTION I _03**
_How can both environmental and social goals be achieved through landscape architecture in this restoration process?	**SECTION II**
_How will the restoration of traditional water systems enhance the quality of life for people in both places?	**SECTION II**

04/02
Research objectives

At the scale of the Landscape

_Phased restoration of traditional water systems, including Amunas (artificial recharge systems) and Bofedales (natural recharge systems), combined with soil and wetland rehabilitation, agricultural land reorganization, and infrastructure planning.

At the scale of the Lima Región

_Providing a solution to the problem of water crisis for city Lima, while offering other towns in the Andes the possibility of access to water during the dry season, economic income, ecological restoration, and the regaining of a sense of cultural belonging through traditional water systems.

At the scale of Huamantanga

_Tackling livelihood issues such as poverty, lack of labor due to population loss by introducing a variety of new industries.

At the scale of Lima

_Implementing public water intakes and flood plains along the system and the Chillón River by the concept of the water value points, implementing flood resilience strategies while giving residents of large cities direct access to water, achieving progressive wastewater use, and creating new spaces for learning and recreation.

04/03

Theoretical framework

04/03/01

Sustainable Water Management & Landscape as infrastructure

Sustainable water management is the practise of managing water resources in a way that balances environmental, social, and economic needs; it entails implementing strategies and policies to ensure the efficient, equitable, and sustainable use of water resources to meet the needs of current and future generations (Water foundation, 2020). Yet, input from a landscape architecture perspective is often lacking in water management practices. The choice of specific tools for sustainable water management is impacted by the type of implementation region, which in this study pertains mostly to green infrastructure in arid metropolitan areas and highland communities. In this context, landscape as an important tool in sustainable water resources management, based on the three principles of landscape planning in sustainable water management strategies proposed by Boyuan et al. (2023), combined with the implementation of sustainable water resources management in a cultural context as mentioned by Lida and Linda (2009) in *Water: a way of life*, this study defined the following four principles:

_Landscape performance and site specificity

This principle involves considering the biophysical and site-specific attributes of the landscape to support the benefits and multifunctionality of green infrastructure. This approach aims to achieve the multiple functions and ecosystem services that green infrastructure can provide, including environmental, social, and economic benefits.

_Multiscale and landscape connectivity

Interconnected green infrastructure networks across multiple spatial scales are essential for sustainable water management. This principle advocates for increased integration between land use planning and water management to support landscape restoration, maintenance, hydrological and ecological connectivity, and reduce the adverse impacts of urbanization on water stability.

_Multi-stakeholder engagement

Effective engagement with multiple stakeholders, including communities and professionals, at an early stage of the green infrastructure planning process, is crucial to ensure their involvement in sustainable water management plans.

_Retention of cultural significance of water

This principle emphasizes the importance of respecting traditional practices and beliefs in the construction of green infrastructure. Understanding how water is perceived and used by local people is crucial in the sustainable use of water resources. In addition, education and awareness programs can help people understand how to use water in a sustainable manner, benefiting themselves, their communities, and the environment.

This study is undoubtedly an example of utilising landscape tools to promote sustainable water management. As two nodes of the same basin, the large city of Lima and the little town of Huamantanga offer diverse landscape characteristics at the scale of the entire water system, while having contrasting opportunities as well as challenges at their respective scales. The transformation of landscape as infrastructure into a tool for water management is the focus of this study, which is based on research by design for various zones and components along the water system. Multi-stakeholder collaboration is key to the Process Design. Considering the profound influence of the Andean Cosmovision on Peruvians, the positive aspects of the human-water relationship in its development, and the pressing need for local people to find their cultural identity, the preservation of the cultural significance of water was also considered as a design objective. outdoor activities like hiking and climbing. At higher elevations, nighttime temperatures drop substantially and frequently fall below freezing.

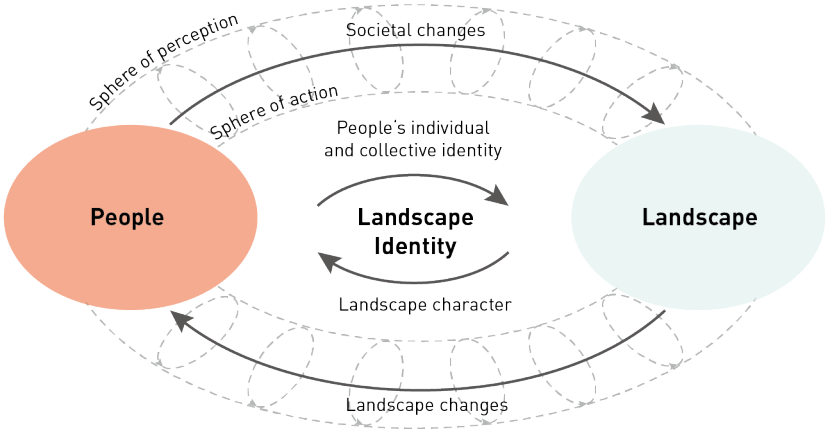
04/03/02

Landscape Identity

The European Landscape Convention already includes in its preamble that "landscape contributes to the formation of local cultures, is an essential component of Europe's natural and cultural heritage, contributes to human well-being and consolidates European identity". Furthermore, the ELC states in its general measures that each country ratifying the Convention should "legally recognize the landscape as an essential part of people's surroundings, as an expression of the diversity of their common cultural and natural heritage, and as the basis of their identity" (CoE, 2000, Article 1a). This is only the European level policy document with its reference to landscape as a part or basis of people's (collective) identity. Landscape Identity, which can refer to both the landscape itself and the features that present its differences, and how people use it to construct their individual or collective identity, can always be understood as the interrelationship between landscape and people (Ramos et al., 2016). This theory includes the following two aspects:

_The construction of individual and collective identity

People's identity is related to their need to understand themselves, which includes characteristics from the surrounding environment such as the quality of the landscape. People desire to see themselves, others and things related to them in a positive way(Smith and Mackie, 2007). Positive self-esteem is achieved through a connection to something that has social value, and the landscape can play an important role in shaping community identity. Elements of the landscape that are perceived as significant and that promote the display of uniqueness compared to other places are used as symbols of community identity. The quality of the landscape also influences the relationship between communities through social practices.



1

_The identity of the landscape

The term "identity of a landscape" is closely related to landscape character. Landscape identity is described as a distinctive, recognizable, and consistent pattern of elements in a landscape that distinguishes one landscape from another and gives each part a unique sense of place(Swanwick, 2002, p8). The characteristics of the landscape make different areas unique, so they can be considered as distinct spatial entities with their own identity. Areas can have the same characteristics, but evolve differently depending on different cultural practices and political choices. Change is a fundamental feature of the landscape, which means that the overall landscape character changes over time and may create "new" landscapes (Van Eetvelde and Antrop, 2009).

Climate, terrain, and water forms characterise the many zones of this study and serve as the defining characteristics of the landscape in each zone. Simultaneously, at the humanistic level, the above features, as the core, have shaped the identity of individuals in each community over time and under the impact of several causes. With the rapid expansion of modern civilization, however, people's sense of these two identities has become somewhat muddled. Landscape identity therefore guides the research by design in this study, which aims to achieve the strengthening of landscape identity and community identity through the restoration of traditional water systems, the restoration of traditional agriculture and the restoration of unique Andean ecosystems.

04/04

Methodological framework

Description

Mapping: Collect information to mapping the city Lima's land use, urban expansion, water system, relationship between wealth and water supply, and distribution of water pollutants and water facilities. Collect information to mapping Huamantanga town's water system, land use, vegetation types, traditional water system's locations, etc. By using the method of confronting these different maps to get answers on how the people, flora, and fauna of Lima and Huamantanga live in relation to water.
Modelling(Descriptive/synthetic modelling): A descriptive model produced by summarizing the water-related life patterns of Huamantanga town's residents to comprehend the spiritual value of water to the locals.

Interpretation

Ethnography: By collecting the history of the ancient Andeans who constructed the Amunas system to store water, emphasizing the significance of this traditional water system in their lives.
Historiography: The historical causes of water scarcity in the province of Lima (connected to geography and climate), the different rainwater harvesting systems constructed by the ancient Andean people in their struggle against nature, and the development of the Andean agricultural system. As a starting point, this leads to the whole water system and the problems that this system has to solve today.

Modelling

Simulation modelling: Separate models are developed for the High Andes-Huamantanga-Lima and Huamantanga scales. By modelling the entire water system at the High Andes-Huamantanga-Lima scale, studying and speculating on the potential of the traditional water system located near Huamantanga to ease Lima's water issue. At the Huamantanga scale, the functional model of the traditional water system located nearby is simulated, as are the expected benefits of restoring this traditional water system through landscape means. The integration of these two scales of modelling can aid in the development of a model of cooperation between different stakeholders in the sustainable water management between the two sites.

Literature review

Read literature related to Amunas water system, Andean agricultural systems, city Lima urban studies, etc. Learn about the principle of Amunas, its function, the surrounding vegetation, the different forms and products of the Andean agricultural system, the functional zoning of Lima, and the problems and solutions faced along the urban section of the Chillón river.

Case study

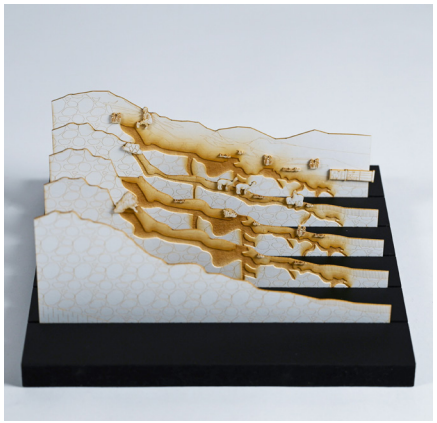
Projects related to the conservation of highland peatlands. Learn about the relevant measures and results that already exist for peatland conservation.
Projects related to the creation of spirituual points for people through landscape forms. Learn about the different forms of spirit points and summarise the toolboxes that can be used.
Projects for city Lima to solve the problem of water scarcity. To understand the extent and direction in which landscaping can help to address water scarcity, and to see if the aspects considered in the research for these projects have been taken into account in this project.

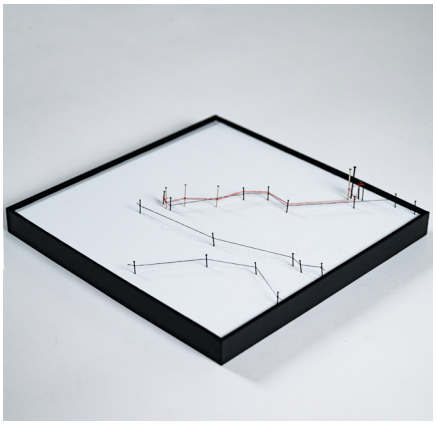
Design Projection

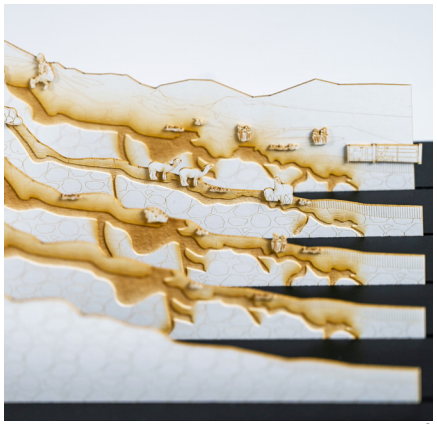
Design process: Three stages designed for 'Sowing and Harvesting', 'Regaining and Retaining', 'Circularity and Win-win'. Separate designs at different scales for restoration of the traditional water system around Huamantanga including ecological enhancement, physical restoration and redesign of agricultural land, redesign of preserved green spaces in the city of Lima and redesign of the tourist route for the entire Huamantanga-Lima water system.

Logical Systems

Logical Argumentation: Design of a phased programme of mutual assistance between Huamantanga and Lima on water resources, landscape, economy, technology and agricultural products.



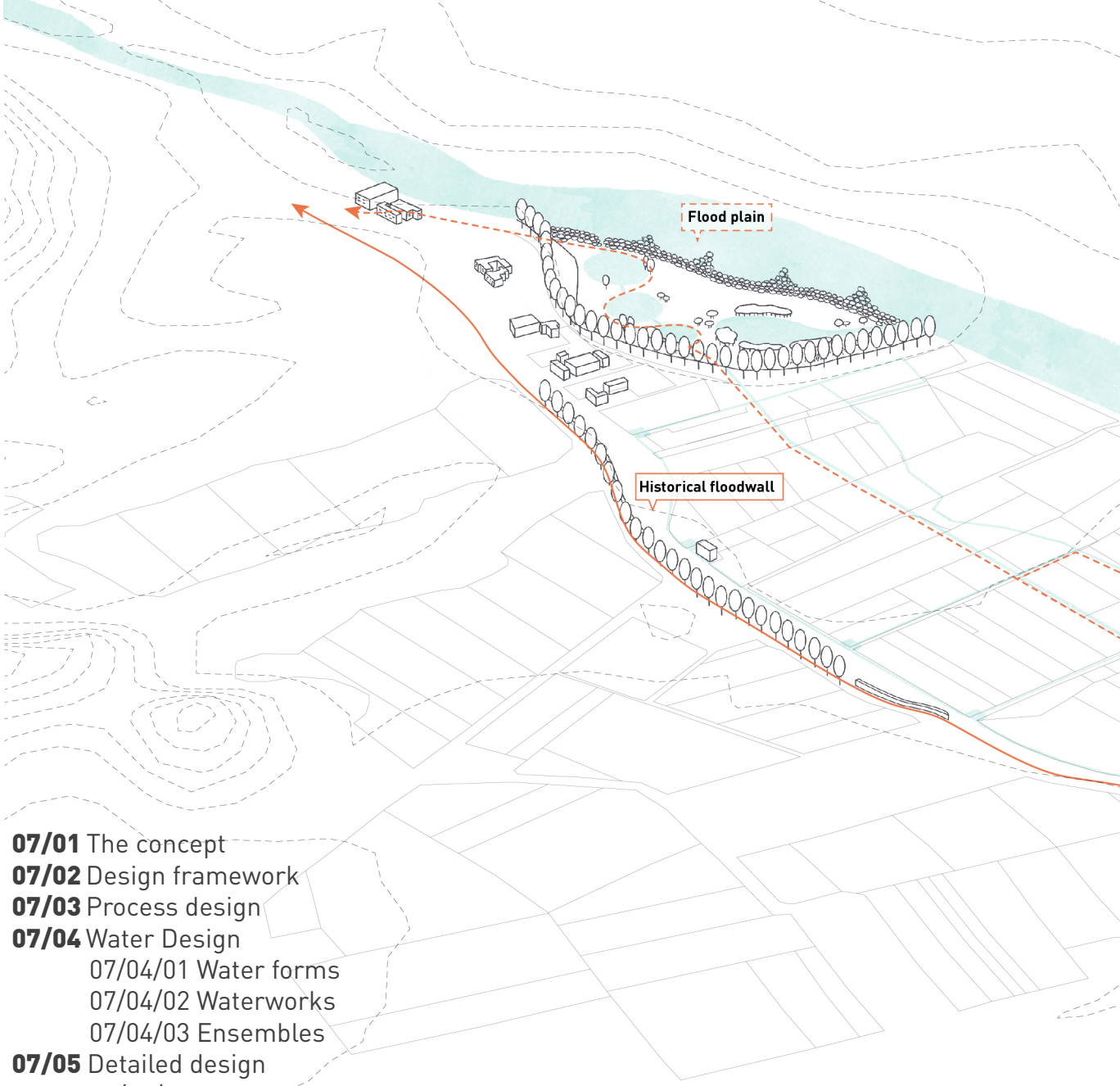




2

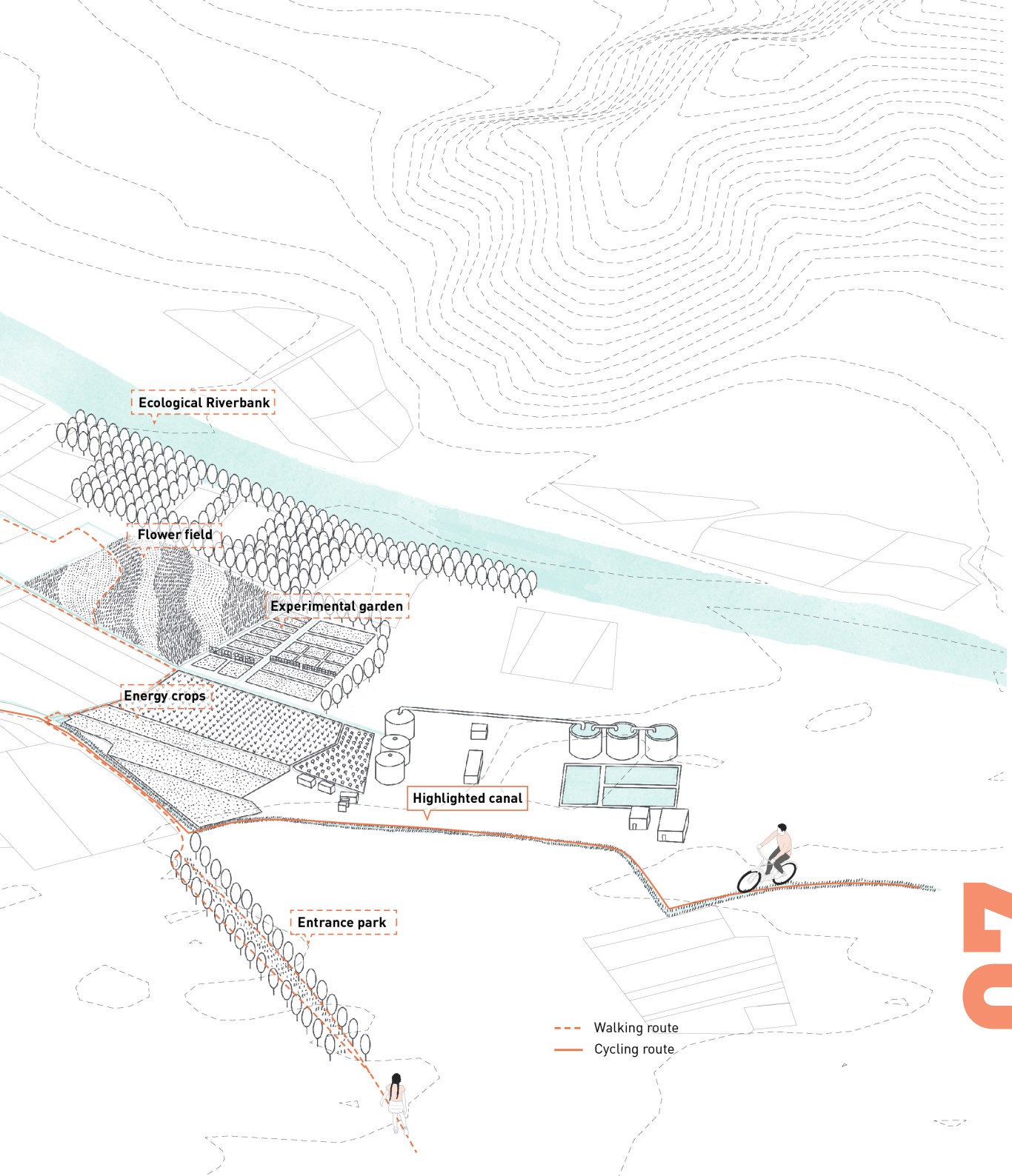
3

1 Transactional model of landscape identity.
Drawn by Isabel Loupa Ram os, Fátima Bernardo, Sónia Carvalho Ribeiro, Veerle Van Eetvelde.
2 Model reflecting Amunas being built, used, abandoned, and restored. Made by author
3 Project Concept Model. Made by author



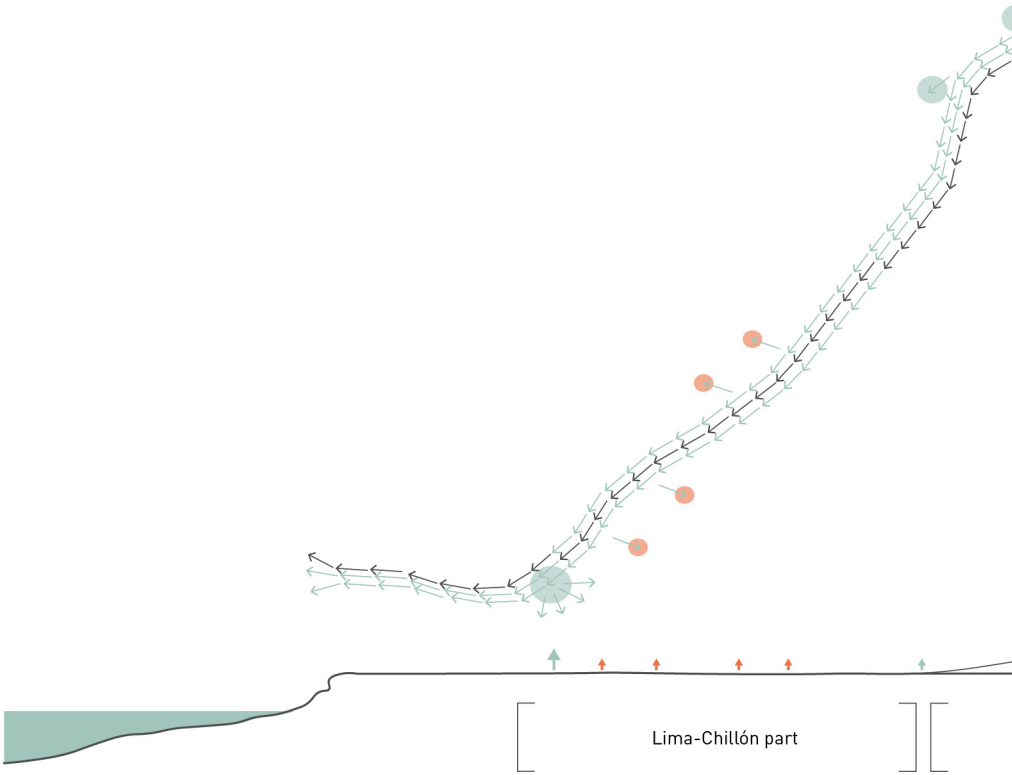
07/01 The concept
07/02 Design framework
07/03 Process design
07/04 Water Design
07/04/01 Water forms
07/04/02 Waterworks
07/04/03 Ensembles
07/05 Detailed design
07/05/01 Renewal of the traditional water system in Huamantanga town
07/05/02 Re-valuing water in Chillón River Floodplain

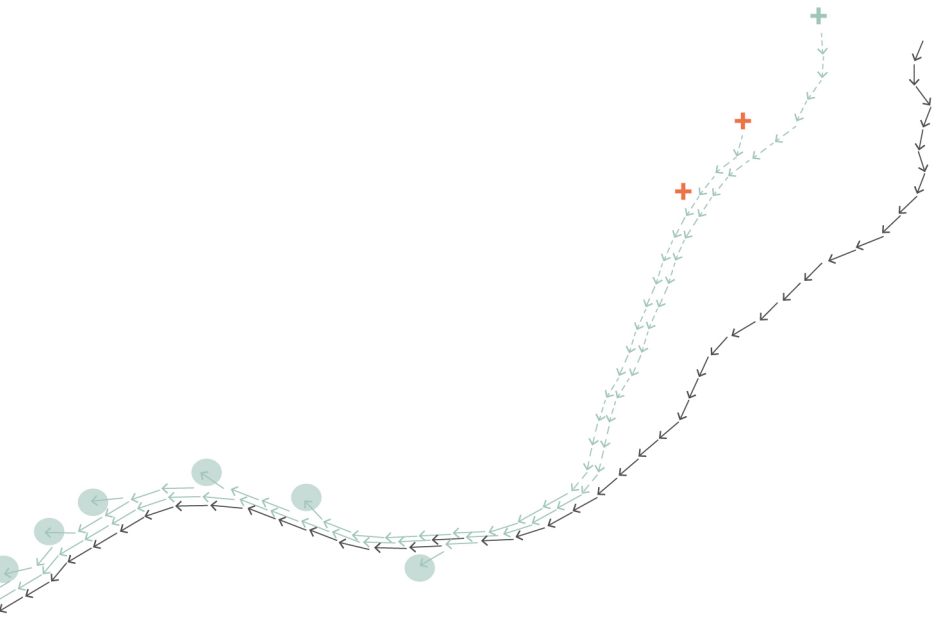
07 Research-by-design



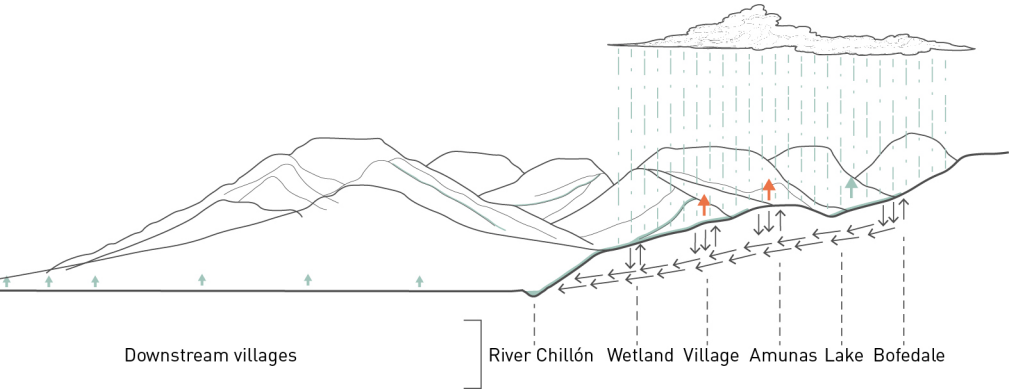
07/01

The concept





The design concept aims to establish a comprehensive approach to sustainable water management by encompassing the entire water system, spanning from the Andean highlands to the upstream and downstream villages, ultimately reaching the Chillon section of Lima. Each site within this system is taking into account the specific characteristics and needs of the region it belongs to. Furthermore, the engagement of diverse stakeholders from different regions is integral to the successful restoration of the entire water system and the revival of the traditional water spirit, facilitating a harmonious flow throughout the interconnected network.

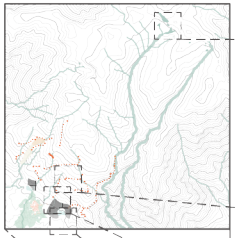


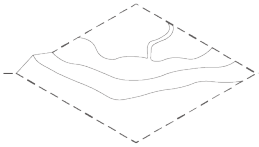
07/02

Design framework

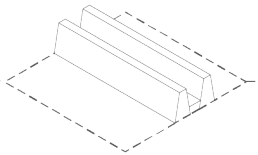
Scales

Huamantanga town

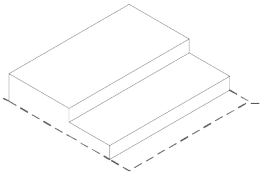




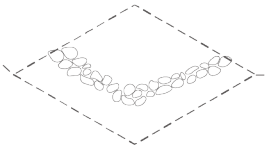
Highlands: *Bofedales*



Hillside: *Amunas water system*

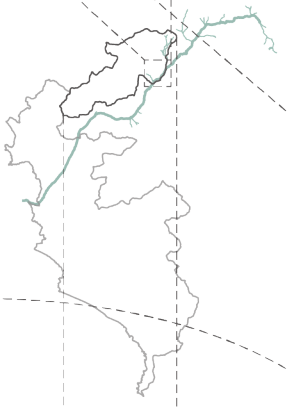


Hillside-Community: *Andean terraces*



Community: *Ponds*

Huamantanga distinct

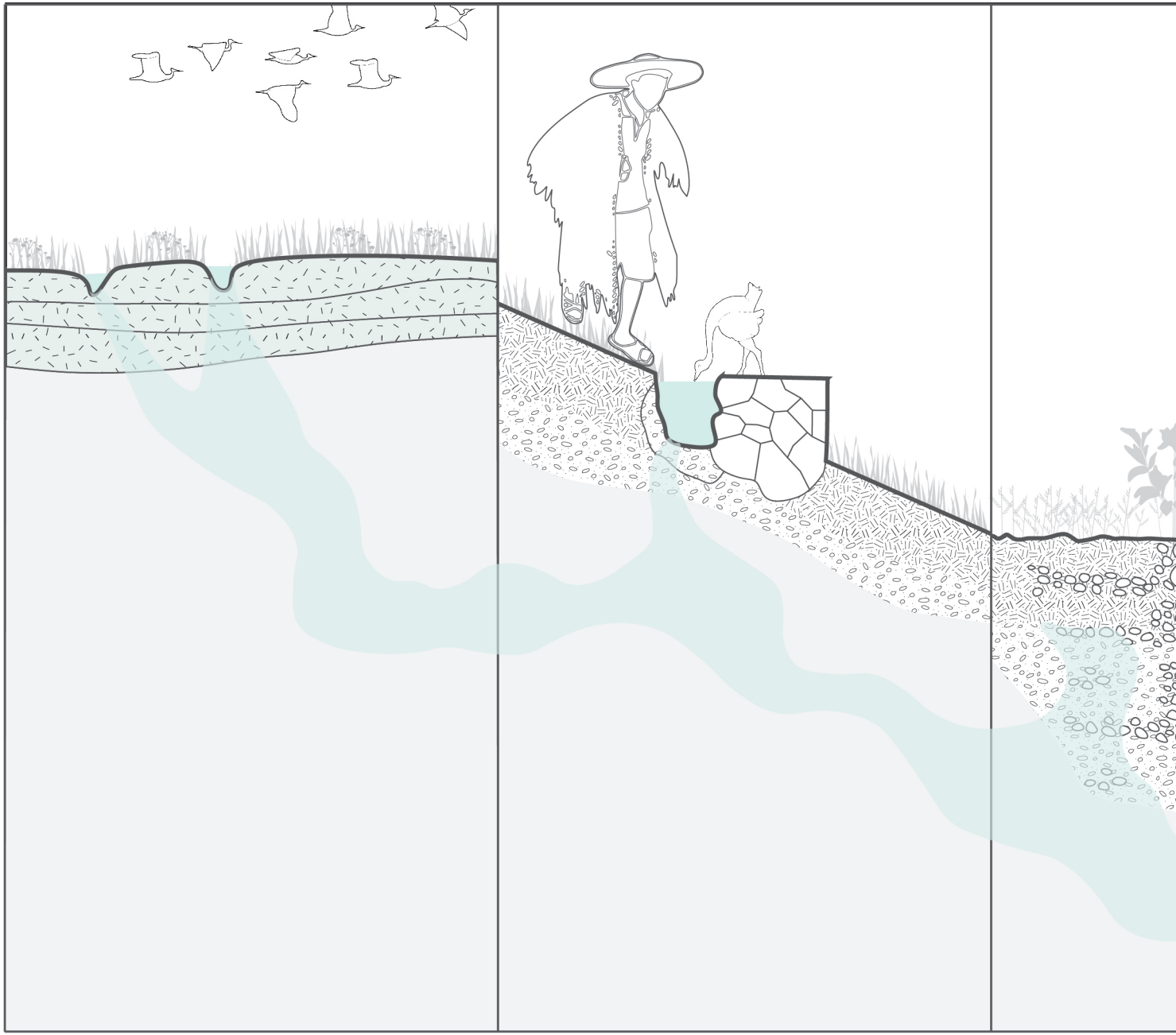


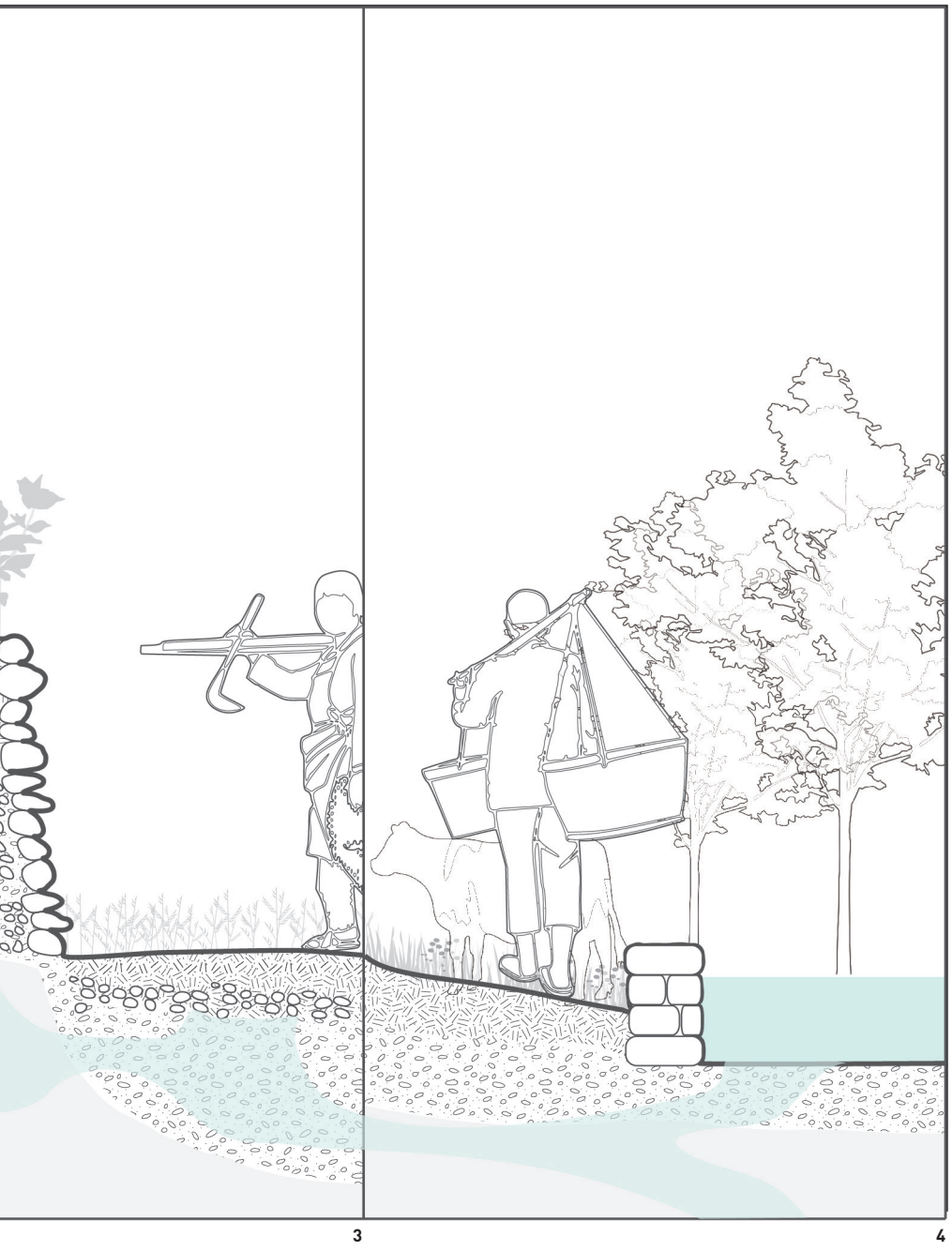
Chillón-Rímac-Lurín basin

Lima Región

Goals

	Environmental	Social
	Recharge the aquifer Conservation of biodiversity	Value peatland ecosystem
	Recharge the aquifer	Water self-sufficiency in the dry season Preservation of traditional wisdom
	Recharge the aquifer Mitigation of soil erosion Water filtration	Food self-sufficiency and diversity Preservation of traditional wisdom
	Recharge the aquifer	Water self-sufficiency in the dry season Recreation and rituals
	Recharge the aquifer **Connectivity of water systems**	**Paradigm for the integration of water system restoration with ecology and agriculture**


1
2

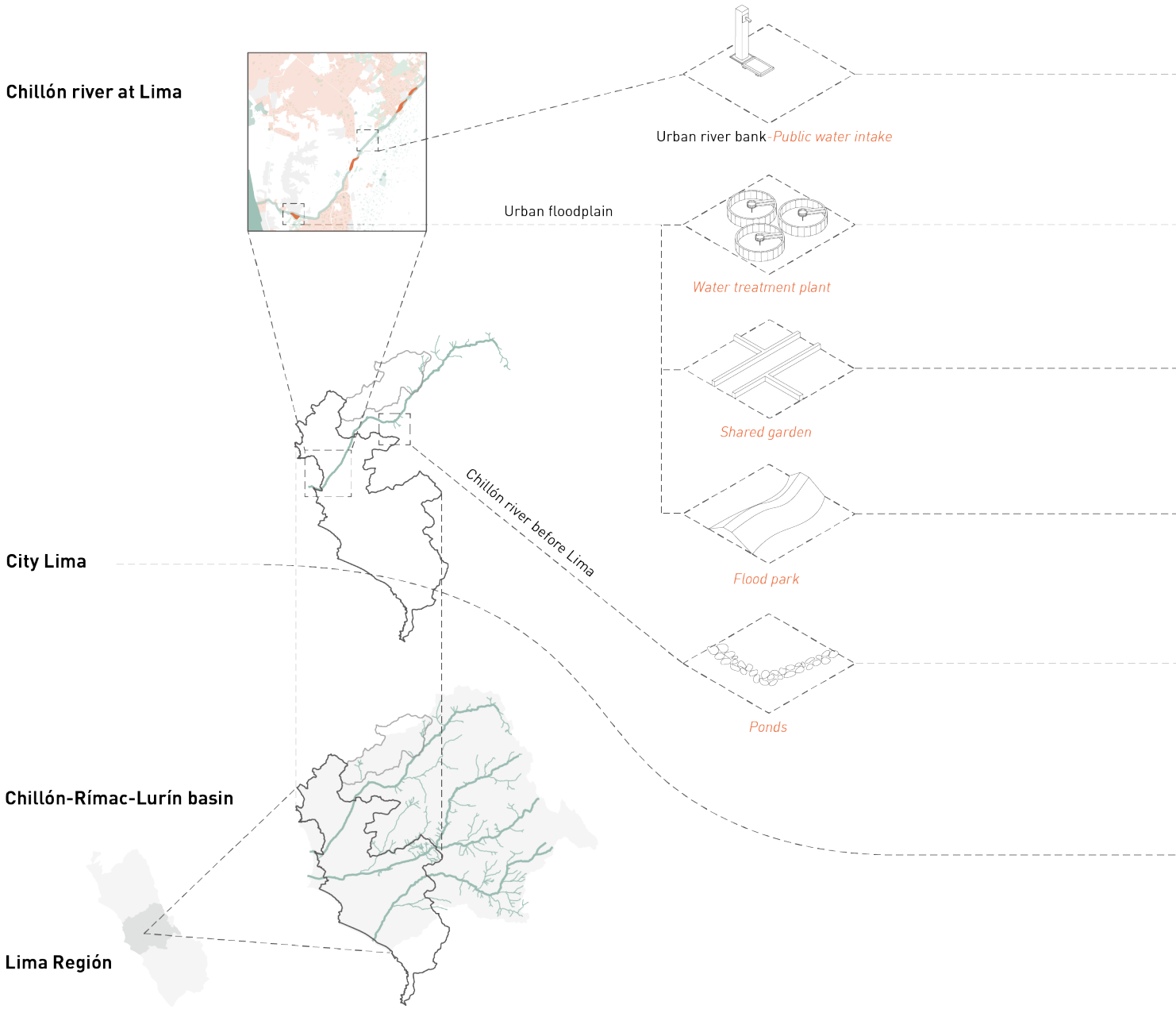


Rock
Peat
Soil
Gravel

1 Section of bofedales
2 Section of Amunas water system
3 Section of Andean terraces
4 Section of upstream ponds

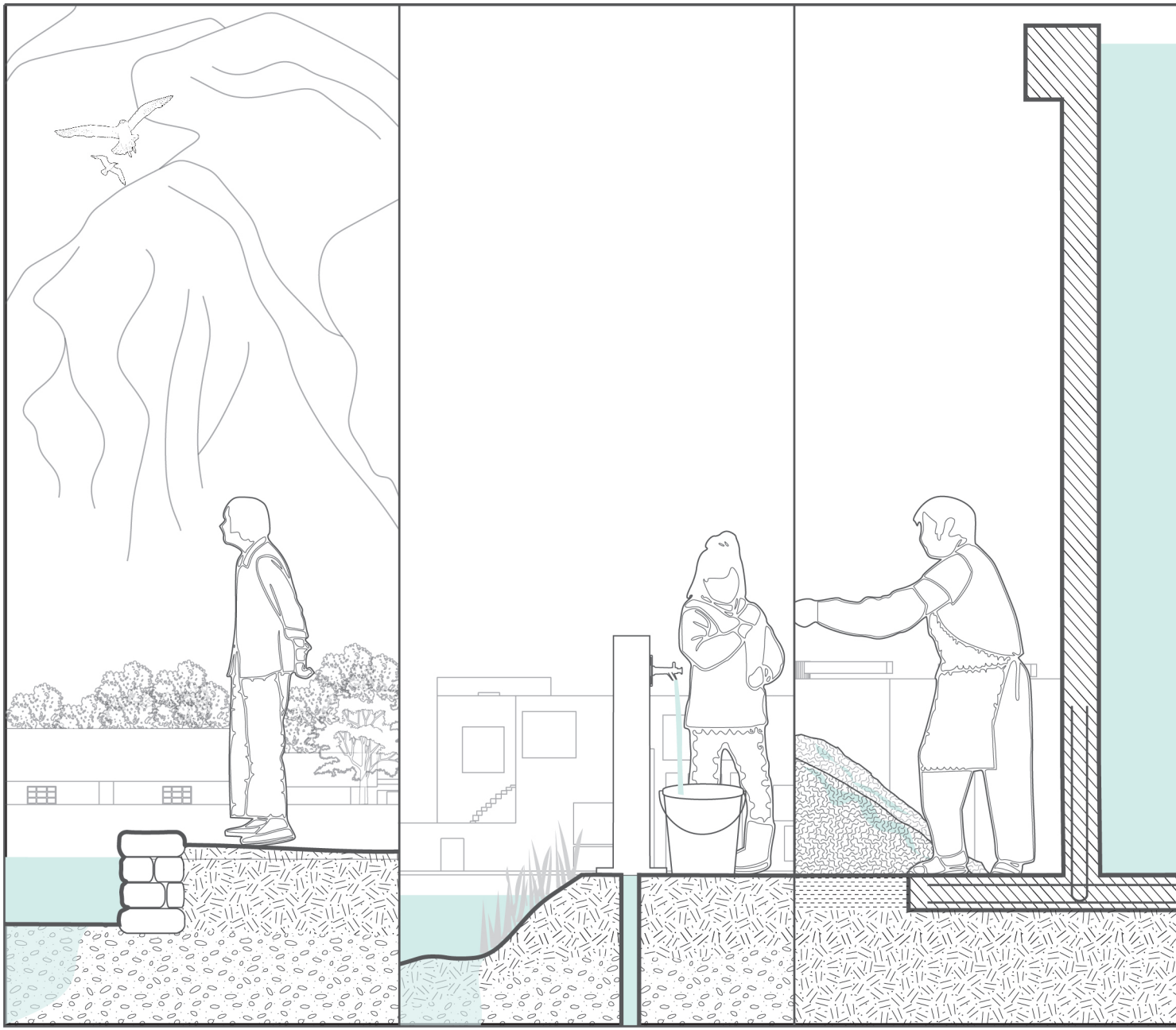
Aquifer replenishment and water system connectivity are successfully achieved by employing landscape-based methods to enhance water infiltration capacity in three key areas: the Andean highlands, the slopes near Huamantanga, and within the town itself. This comprehensive approach combines water system restoration, ecological principles, and agricultural practices, creating a model of sustainable water management.

Scales

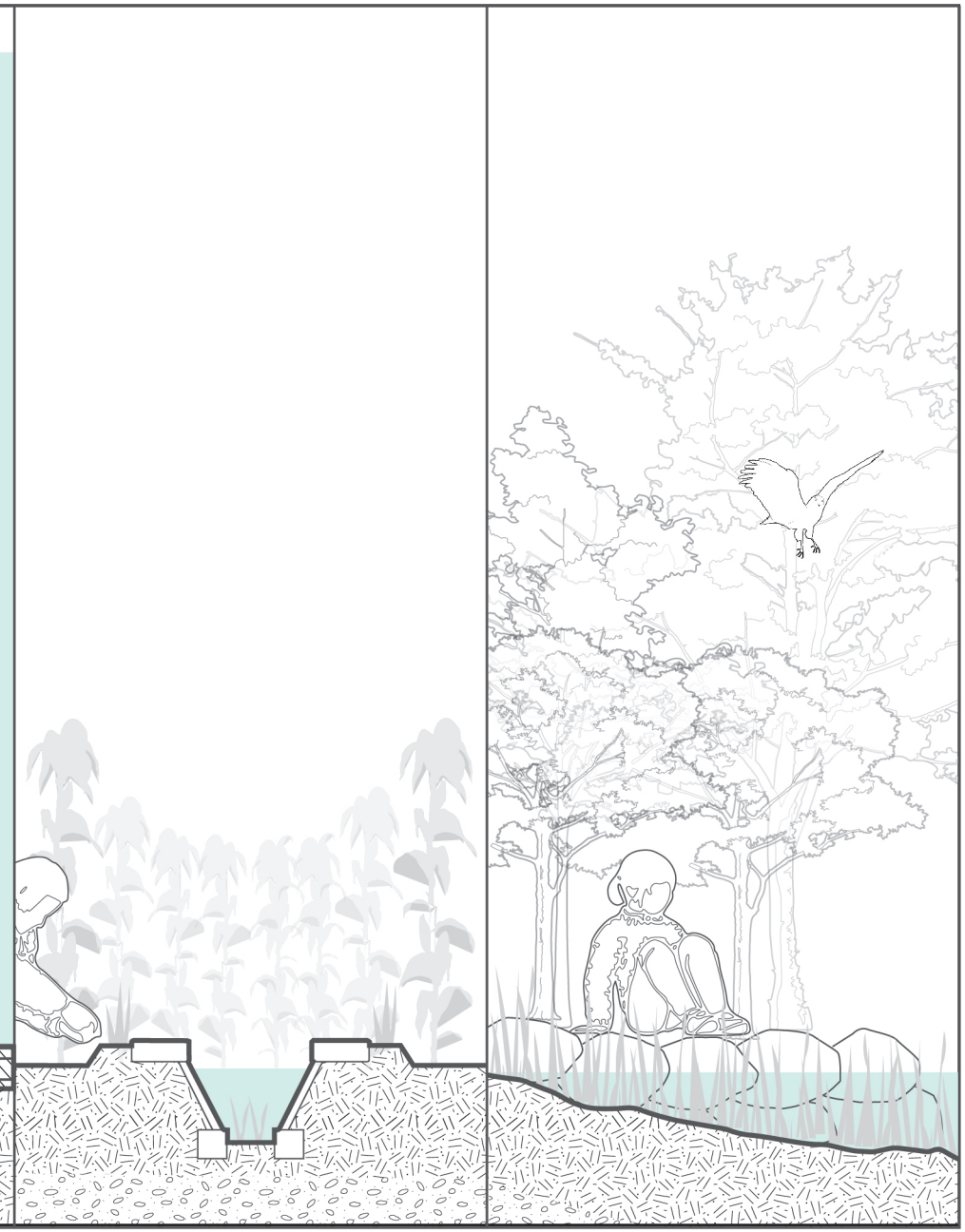

Chillón river at Lima
Urban river bank
Public water intake
Urban floodplain
Water treatment plant
Shared garden
Chillón river before Lima
City Lima
Flood park
Ponds
Chillón-Rímac-Lurín basin
Lima Región

Goals

Environmental	Social
Flood risk resilience strategy	More convenient access to water New gathering points
Water purification	Maximum use of waste water Education and recreation
Further purification of water Soil fertility	Food self-sufficiency and diversity Community cooperation
Further purification of water Flood risk resilience strategy	Education and recreation
Recharge the aquifer	Water self-sufficiency in the dry season
Increase in green space **Increase resilience to flooding**	**Alleviate the water crisis**
Recharge the aquifer **Balance river flow**	**Public awareness of water** **Regional cooperation**



1 2



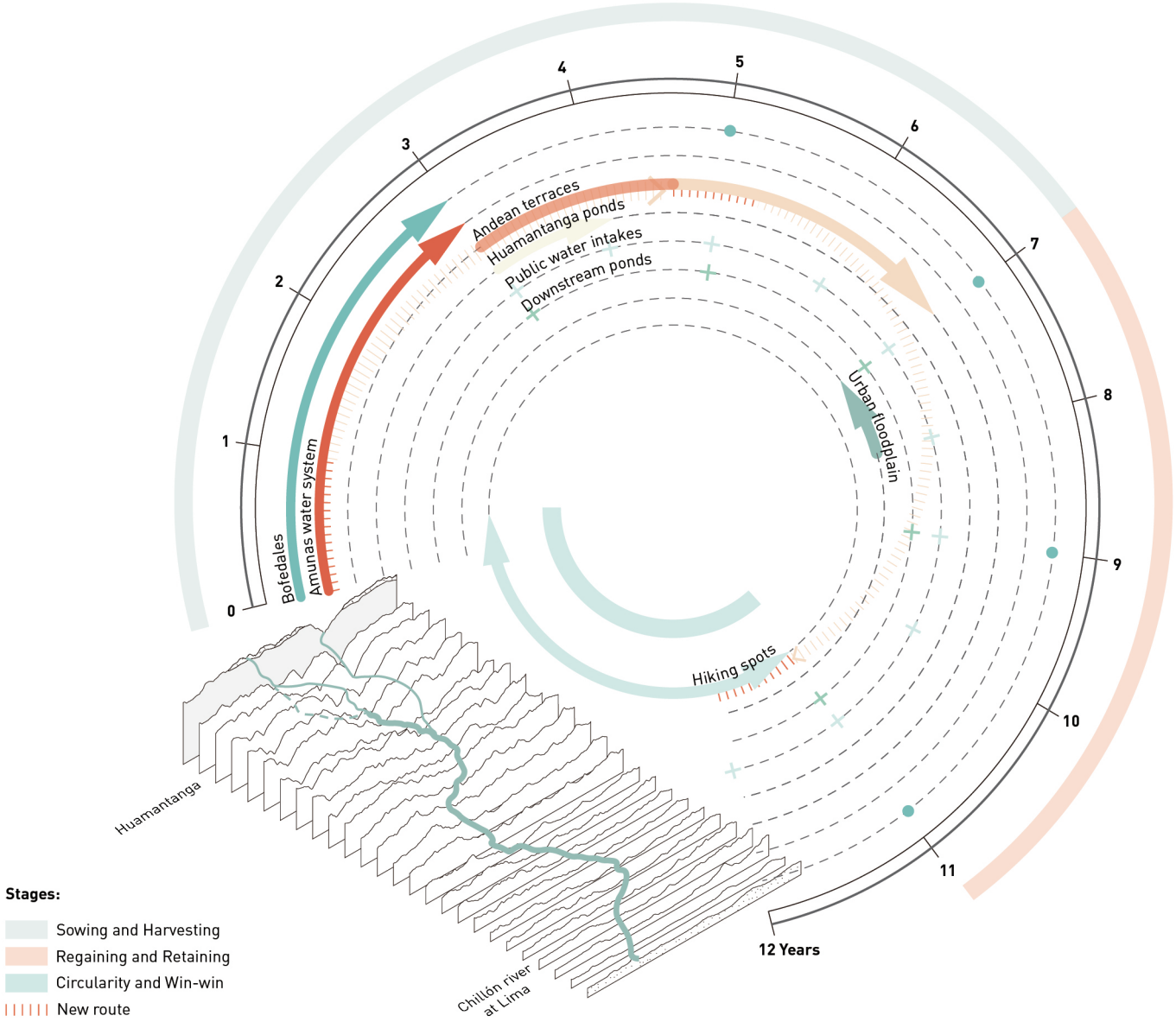
Soil
Concrete
Gravel

1 Section of downstream ponds
2 Section of public water intake
3 Section of water treatment plant
4 Section of shared garden
5 Section of floodplain

The residents of downstream towns and the Chillón area in Lima experience significant benefits from the establishment of new ponds and wetlands equipped with water intakes. These water bodies not only provide easier access to water for the communities but also contribute to the replenishment of groundwater resources. The floodplain, as a result of these initiatives, showcases the outcomes of water system restoration and instills a positive attitude towards water among the local population. This visible improvement in the flooding situation and the accessibility to water resources foster a sense of appreciation and understanding of the importance of sustainable water management practices.

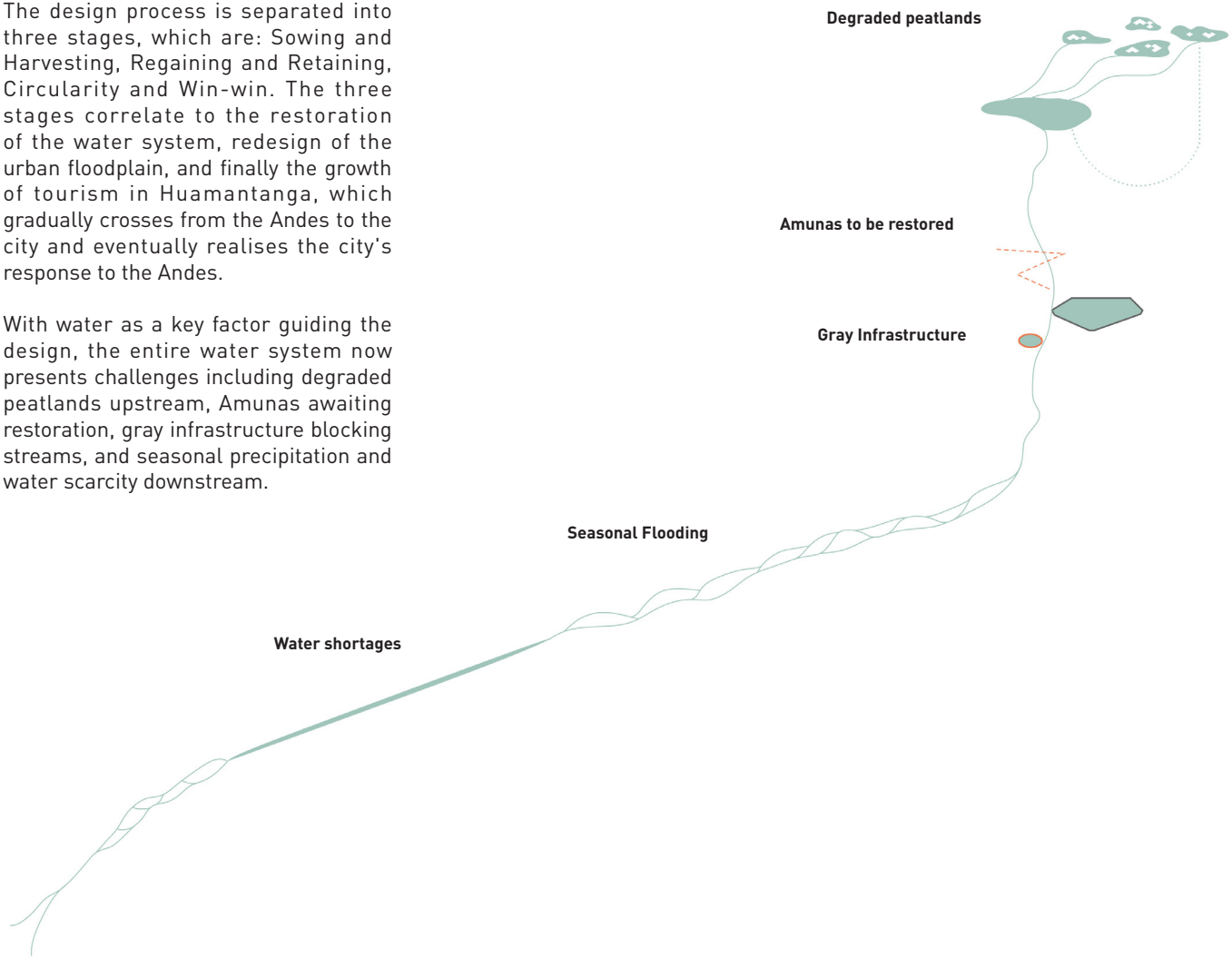
07/03

Process design



The design process is separated into three stages, which are: Sowing and Harvesting, Regaining and Retaining, Circularity and Win-win. The three stages correlate to the restoration of the water system, redesign of the urban floodplain, and finally the growth of tourism in Huamantanga, which gradually crosses from the Andes to the city and eventually realises the city's response to the Andes.

With water as a key factor guiding the design, the entire water system now presents challenges including degraded peatlands upstream, Amunas awaiting restoration, gray infrastructure blocking streams, and seasonal precipitation and water scarcity downstream.

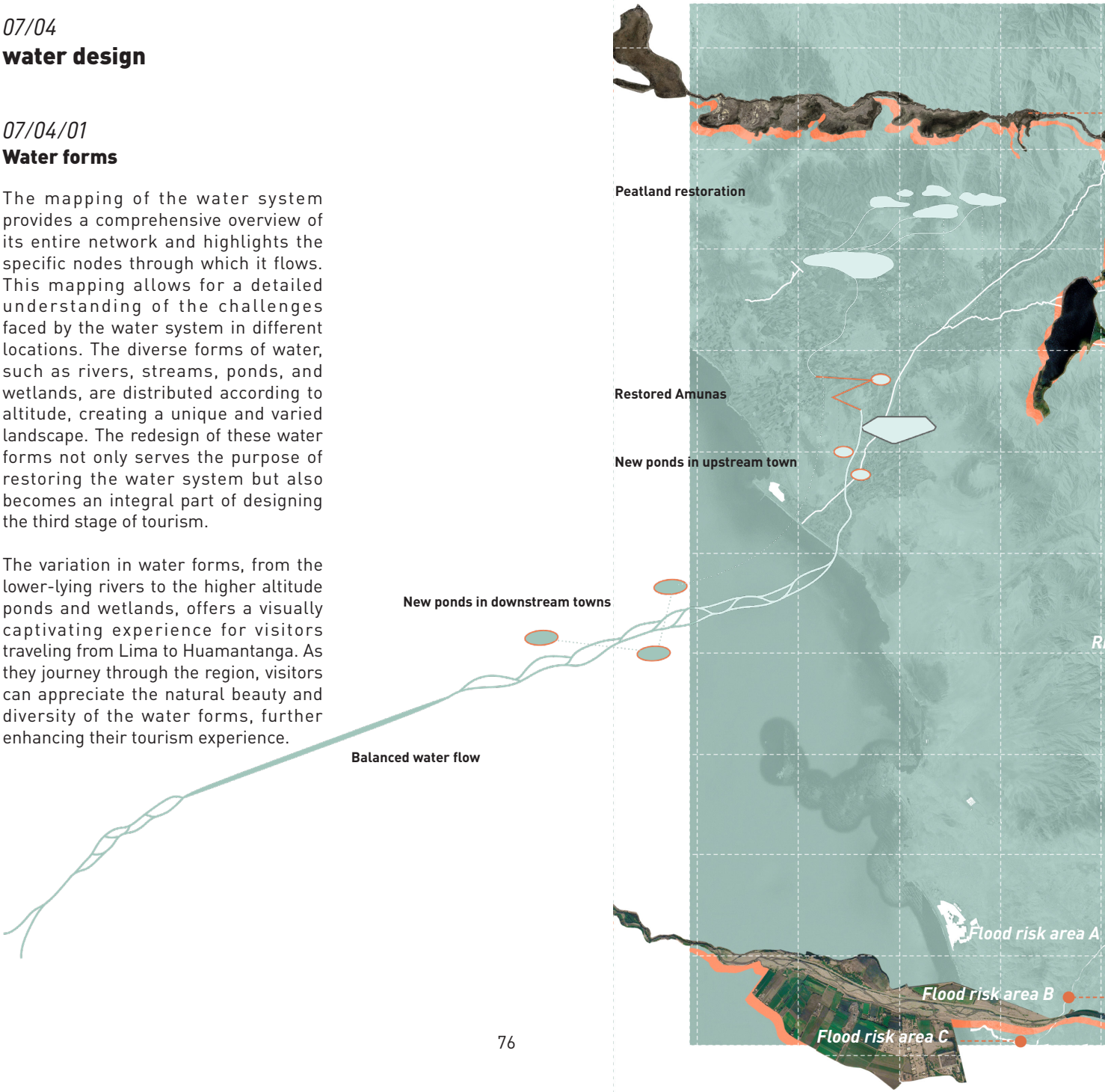


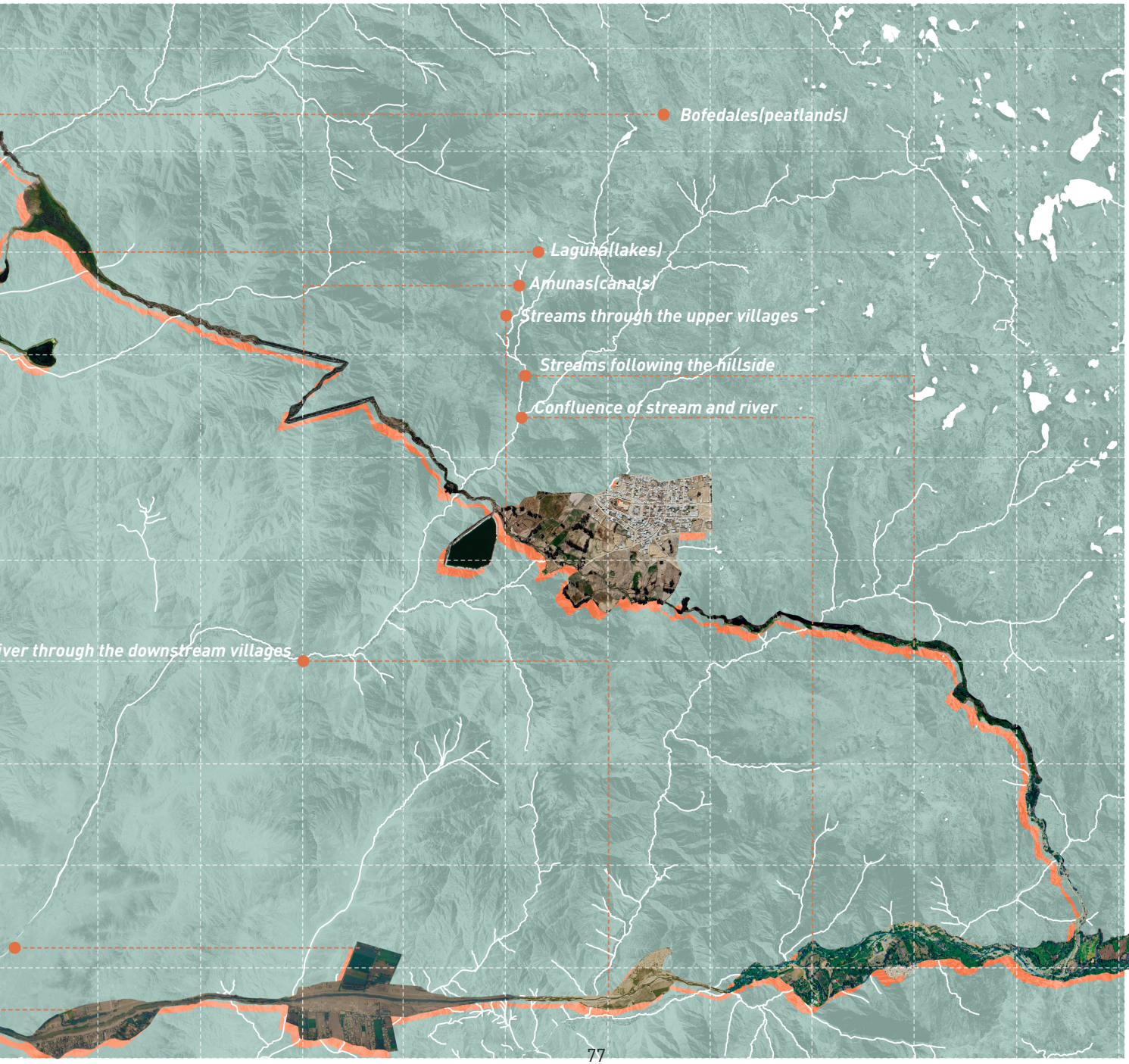
07/04
water design

07/04/01
Water forms

The mapping of the water system provides a comprehensive overview of its entire network and highlights the specific nodes through which it flows. This mapping allows for a detailed understanding of the challenges faced by the water system in different locations. The diverse forms of water, such as rivers, streams, ponds, and wetlands, are distributed according to altitude, creating a unique and varied landscape. The redesign of these water forms not only serves the purpose of restoring the water system but also becomes an integral part of designing the third stage of tourism.

The variation in water forms, from the lower-lying rivers to the higher altitude ponds and wetlands, offers a visually captivating experience for visitors traveling from Lima to Huamantanga. As they journey through the region, visitors can appreciate the natural beauty and diversity of the water forms, further enhancing their tourism experience.

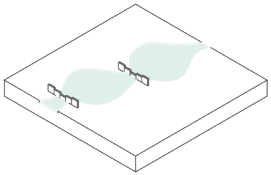
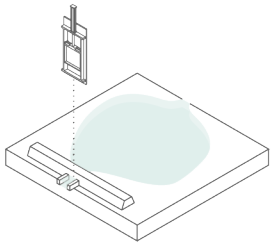
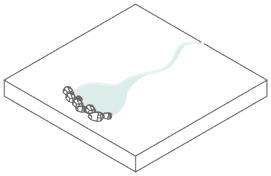
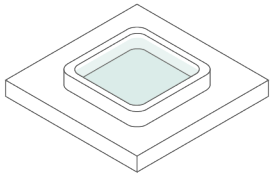



Bofedales(peatlands)
Laguna(lakes)
Amunas(canals)
Streams through the upper villages
Streams following the hillside
Confluence of stream and river
iver through the downstream villages

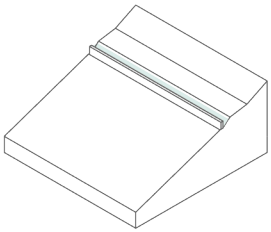
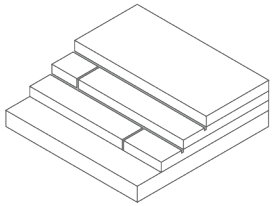
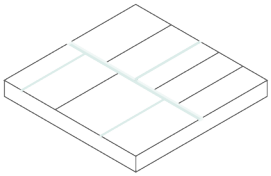
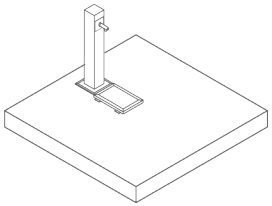
07/04/02

Water works

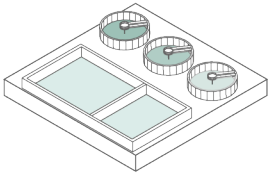
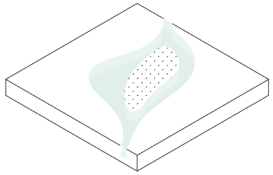
Storing/Slowing down water

Guiding water

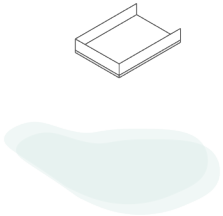
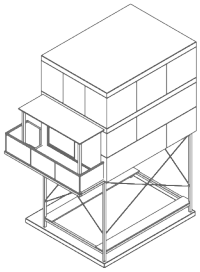
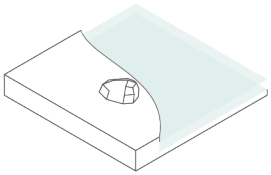
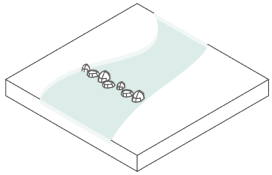
Purifying water

In this project, landscape infrastructure plays a crucial role in restoring the water system. Traditional and modern water works serve as the foundation for the design, with their diverse functions being reclassified and combined to create a comprehensive toolbox for the project.

The four different roles of water works are identified and utilized as essential elements in the design process.

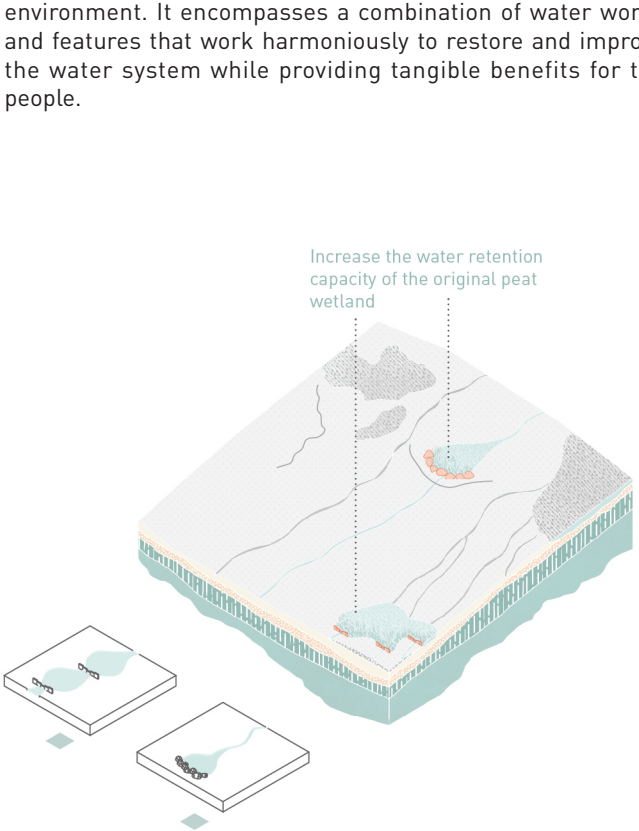
Experiencing water

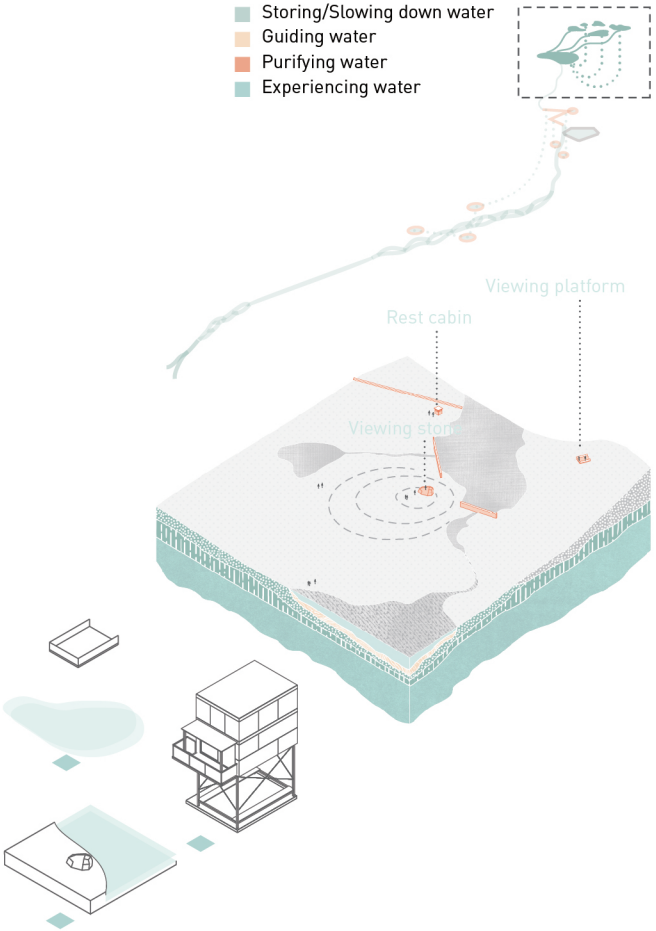





07/04/03

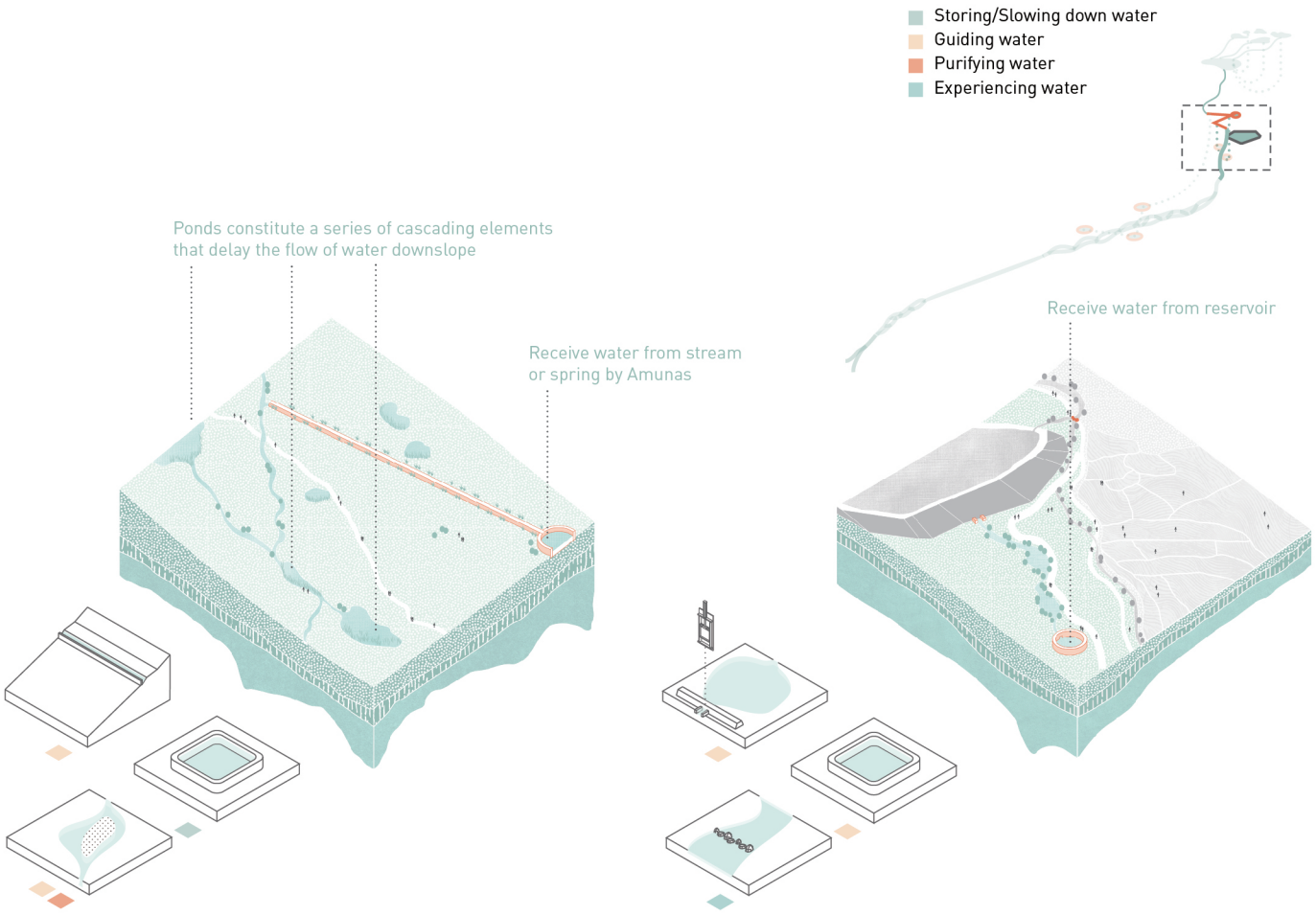
Ensembles

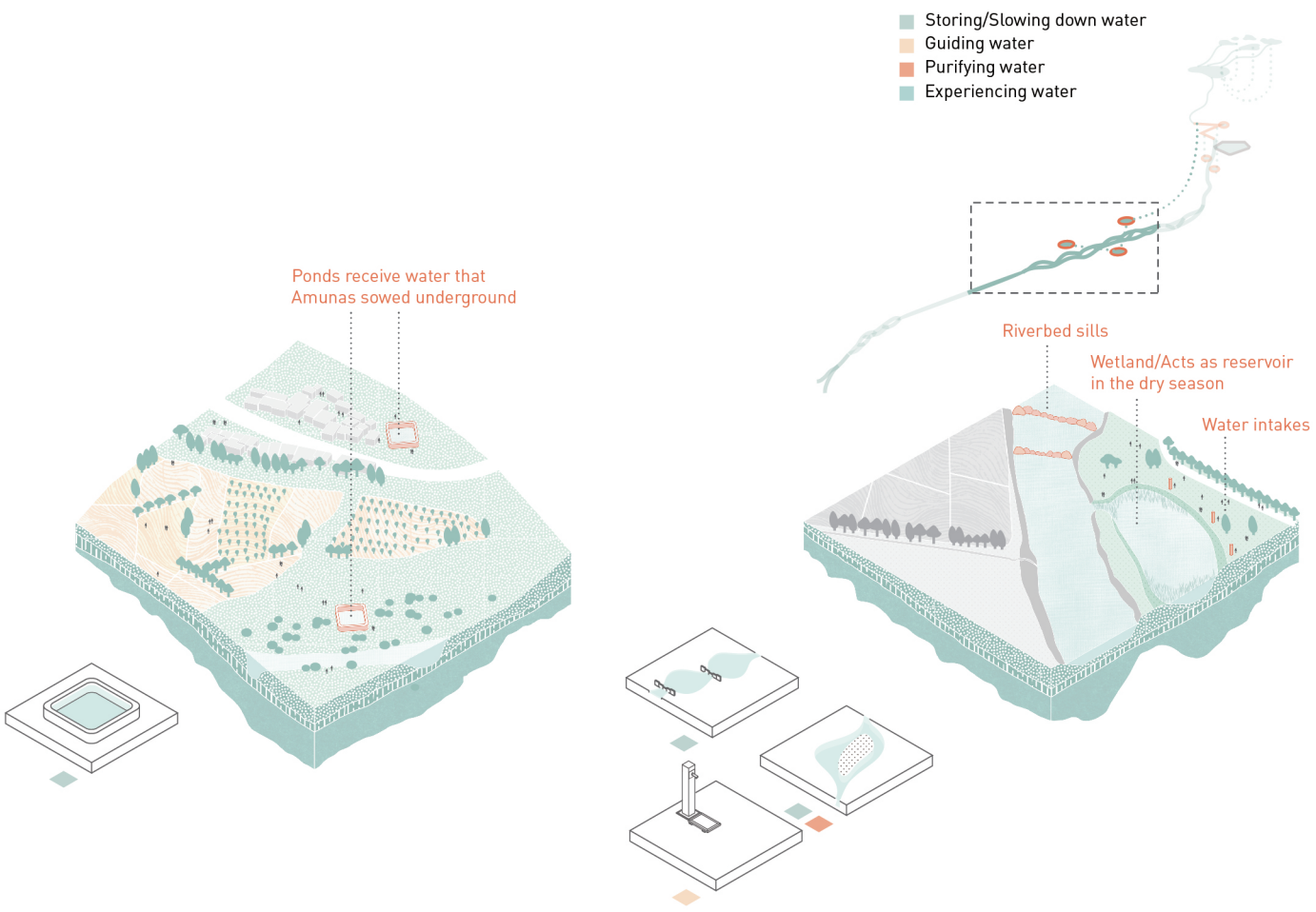
The recombination of water works in the toolbox forms the design ensembles. Each ensemble within the design considers the unique characteristics of the site and its surrounding environment. It encompasses a combination of water works and features that work harmoniously to restore and improve the water system while providing tangible benefits for the people.

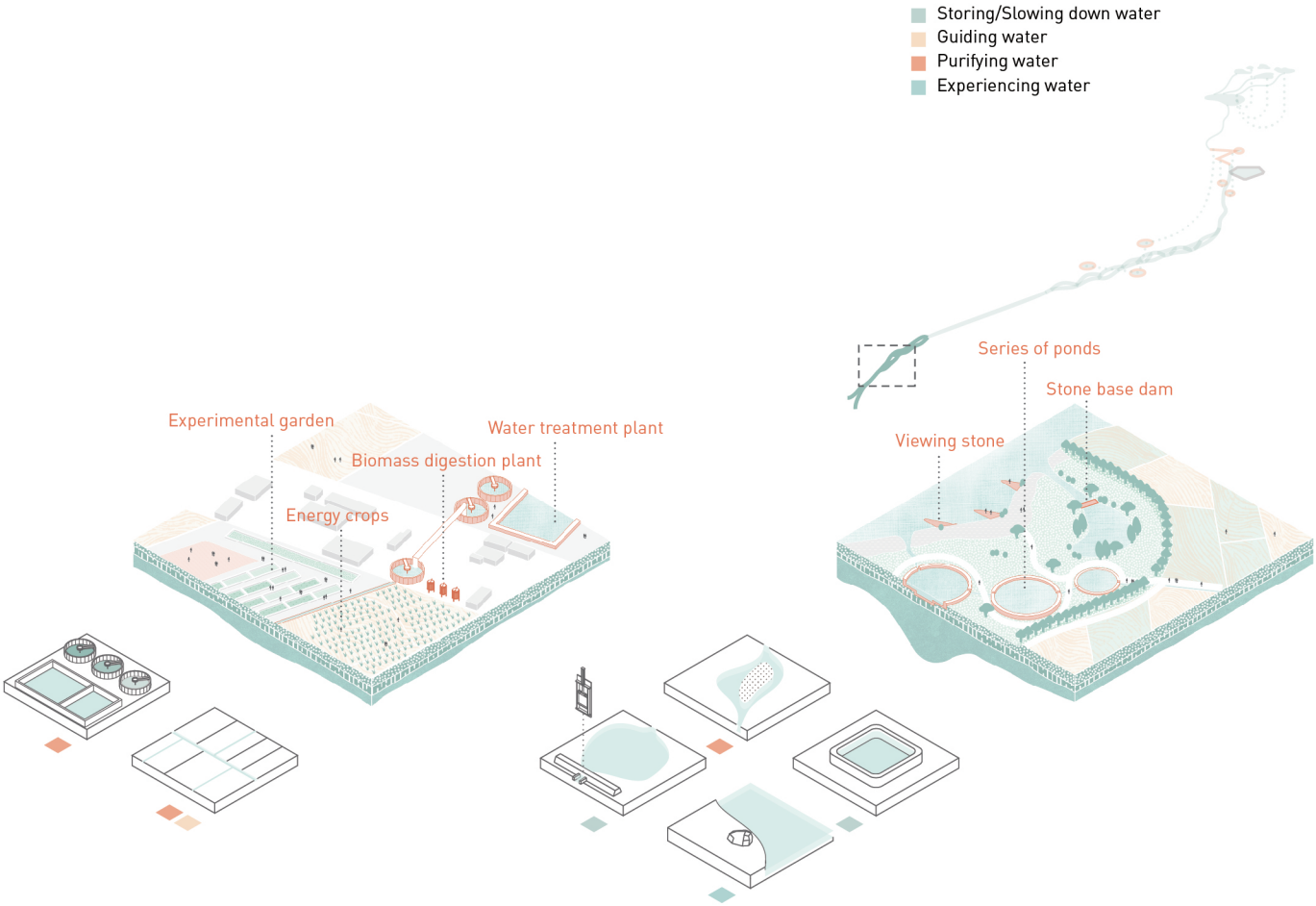




* The different color words represent the different stages of the design process, in line with the colors mentioned earlier.


Storing/Slowing down water
Guiding water
Purifying water
Experiencing water
Ponds constitute a series of cascading elements that delay the flow of water downslope
Receive water from stream or spring by Amunas
Receive water from reservoir


Storing/Slowing down water
Guiding water
Purifying water
Experiencing water
Ponds receive water that
Amunas sowed underground
Riverbed sills
Wetland/Acts as reservoir
in the dry season
Water intakes

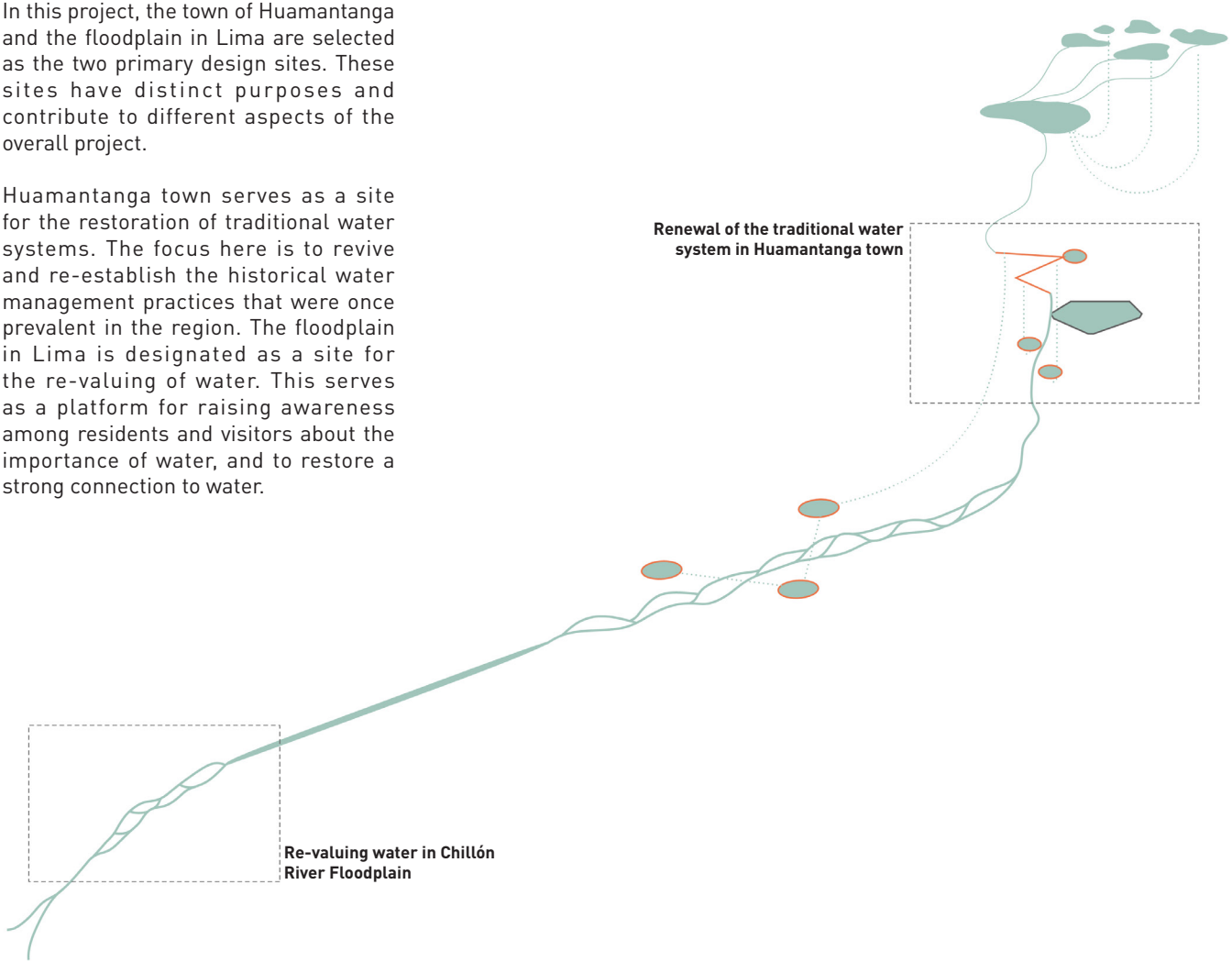

Storing/Slowing down water
Guiding water
Purifying water
Experiencing water
Experimental garden
Water treatment plant
Biomass digestion plant
Energy crops
Series of ponds
Stone base dam
Viewing stone

07/05

Design locations

In this project, the town of Huamantanga and the floodplain in Lima are selected as the two primary design sites. These sites have distinct purposes and contribute to different aspects of the overall project.

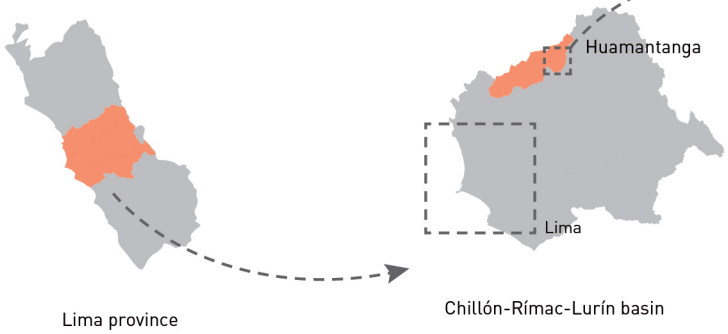
Huamantanga town serves as a site for the restoration of traditional water systems. The focus here is to revive and re-establish the historical water management practices that were once prevalent in the region. The floodplain in Lima is designated as a site for the re-valuing of water. This serves as a platform for raising awareness among residents and visitors about the importance of water, and to restore a strong connection to water.

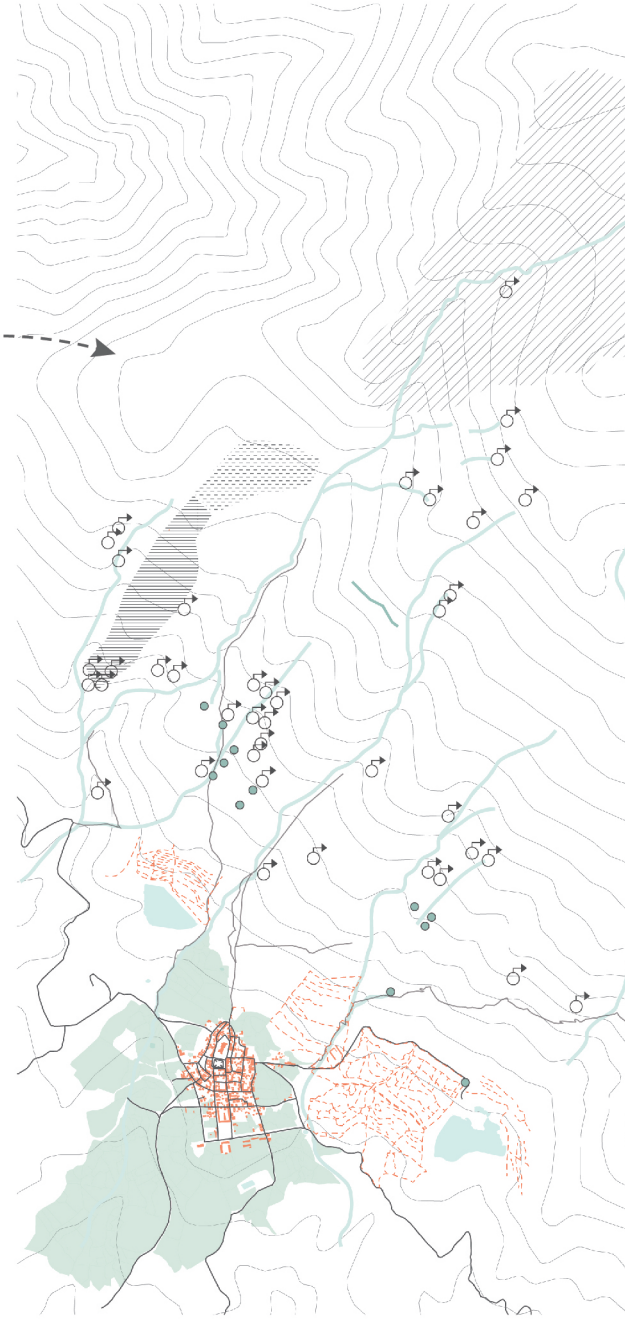


07/05/01

Renewal of the traditional water system in Huamantanga town

Site plan & Future prospects

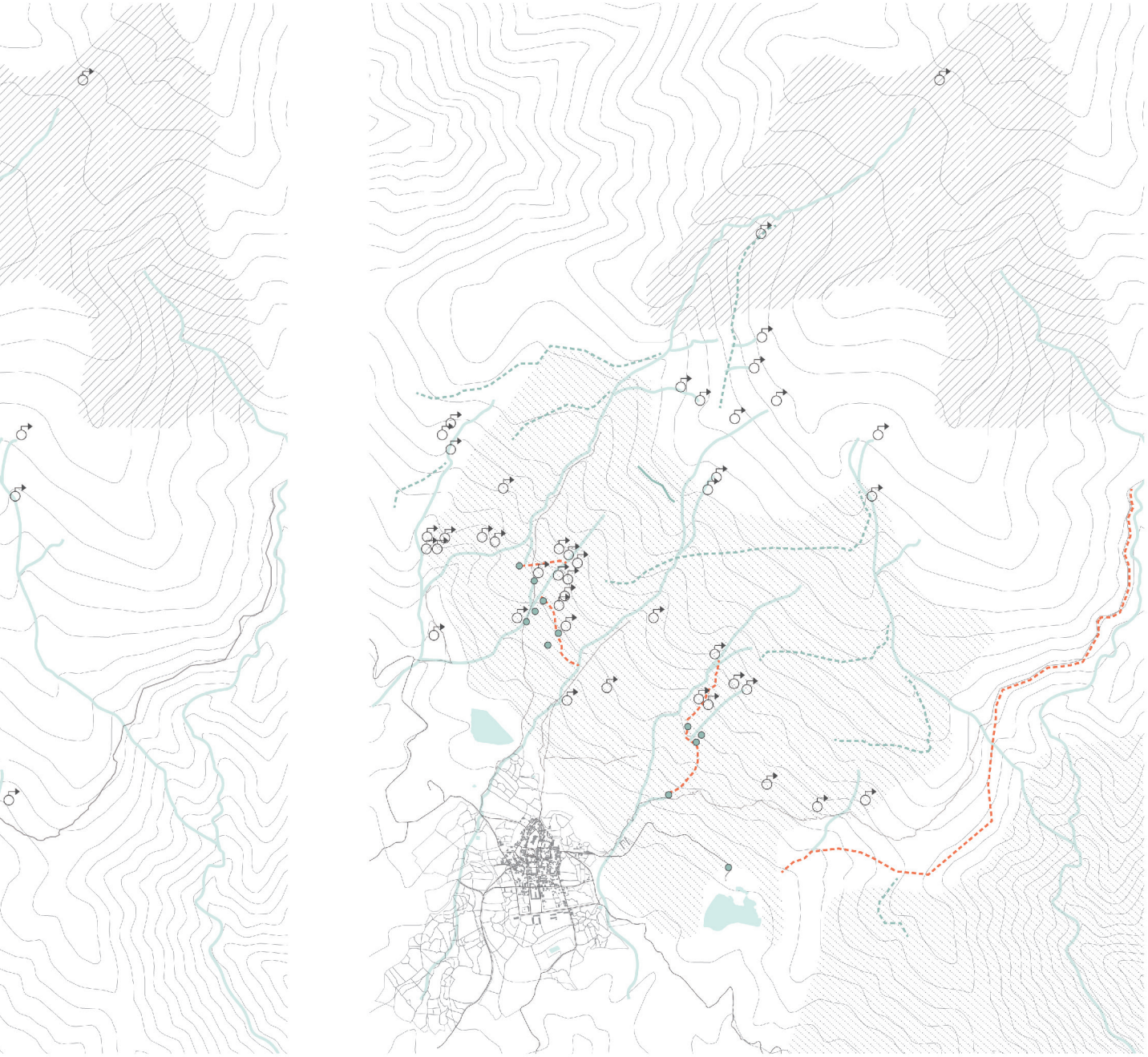




Current map of Huamantanga

Stream
Road
Route trace
Amunas infiltration canal
Trace of terraces
Water
Residential area
Spring
Wetland
Catchments
Infiltration area
Percolation area
Infiltration canal to be restored
Diversion canal to be restored

0 1 2 km N

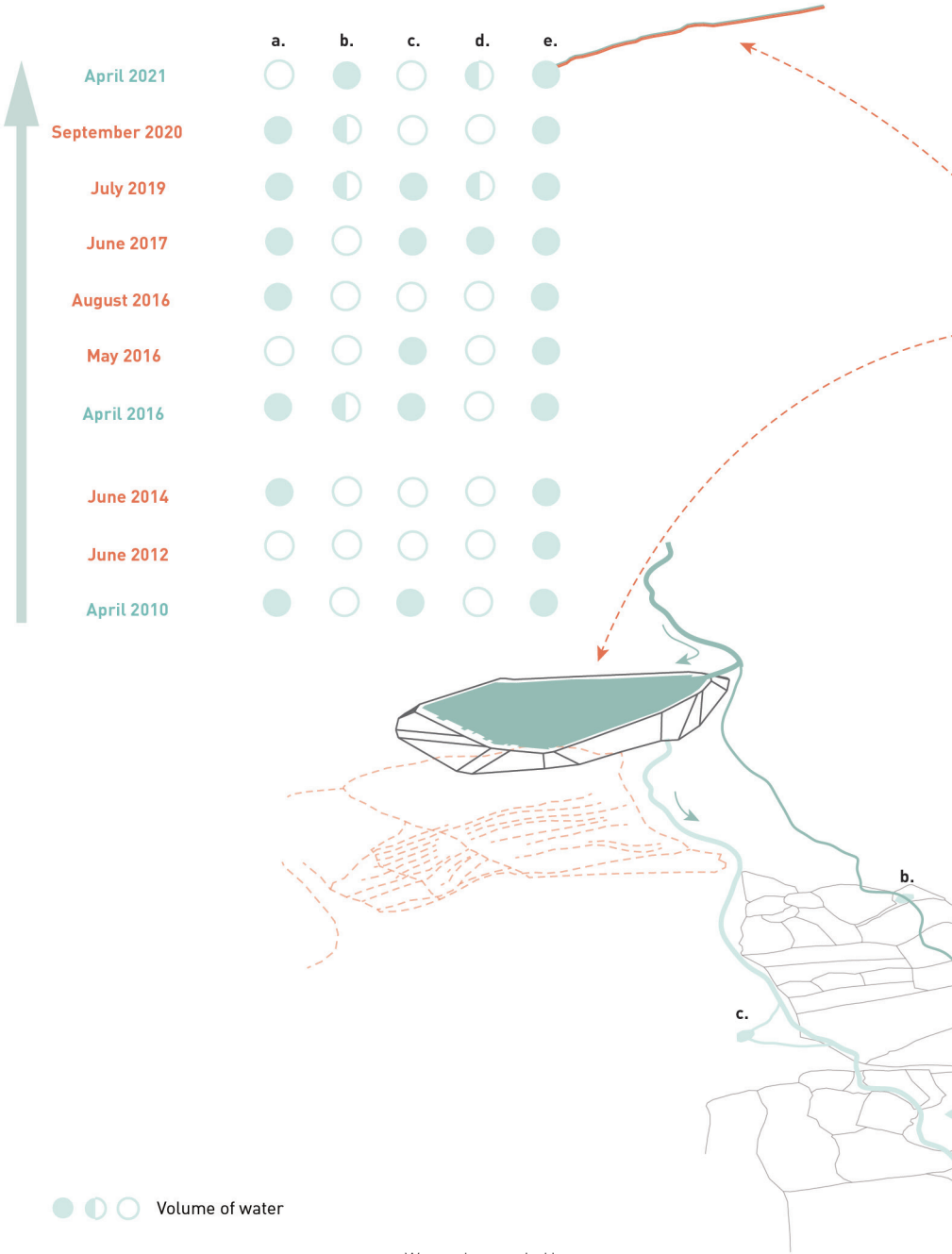


Potential map of Huamantanga

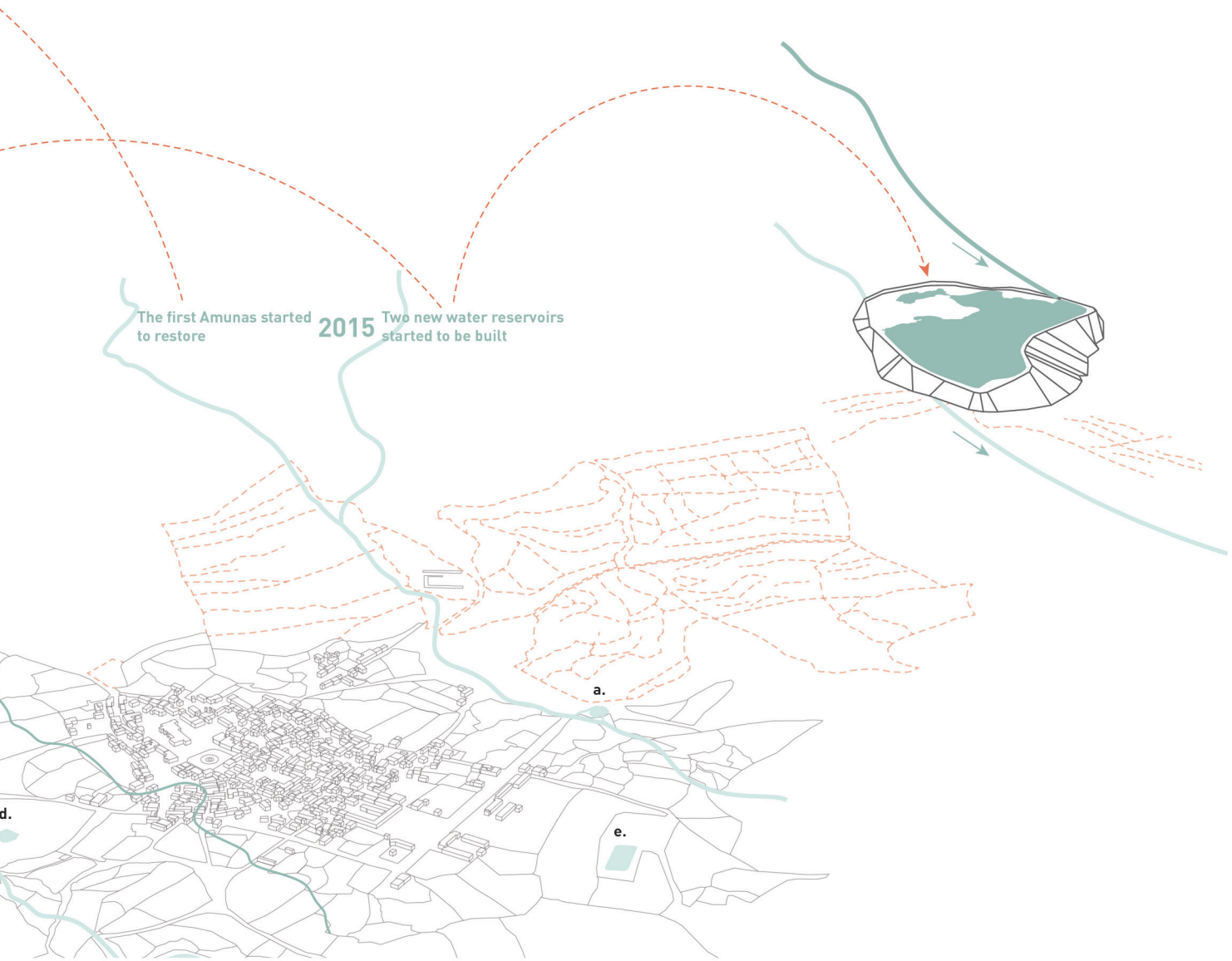
Changes in water conditions

The presence of two reservoirs in a town with a population of 600 may seem relatively large. These reservoirs were constructed in 2015, coinciding with the rehabilitation of the first Amunas project, which received government policy and funding support. While the reservoirs serve as a valuable water reserve during the dry season, their construction has also had some negative impacts on the lives of the town's residents due to inadequate planning.

The primary source of water for the town's residents is the five Qochas ponds located in close proximity. These ponds receive water from streams, rainwater, and underground storage in the Amunas during the dry season. However, the construction of the two reservoirs intercepts the streams that would typically supply the Qochas, resulting in two of them being left without water for the first time during the rainy season. Consequently, apart from Qochas E, all the other Qochas experience seasonal water shortages.



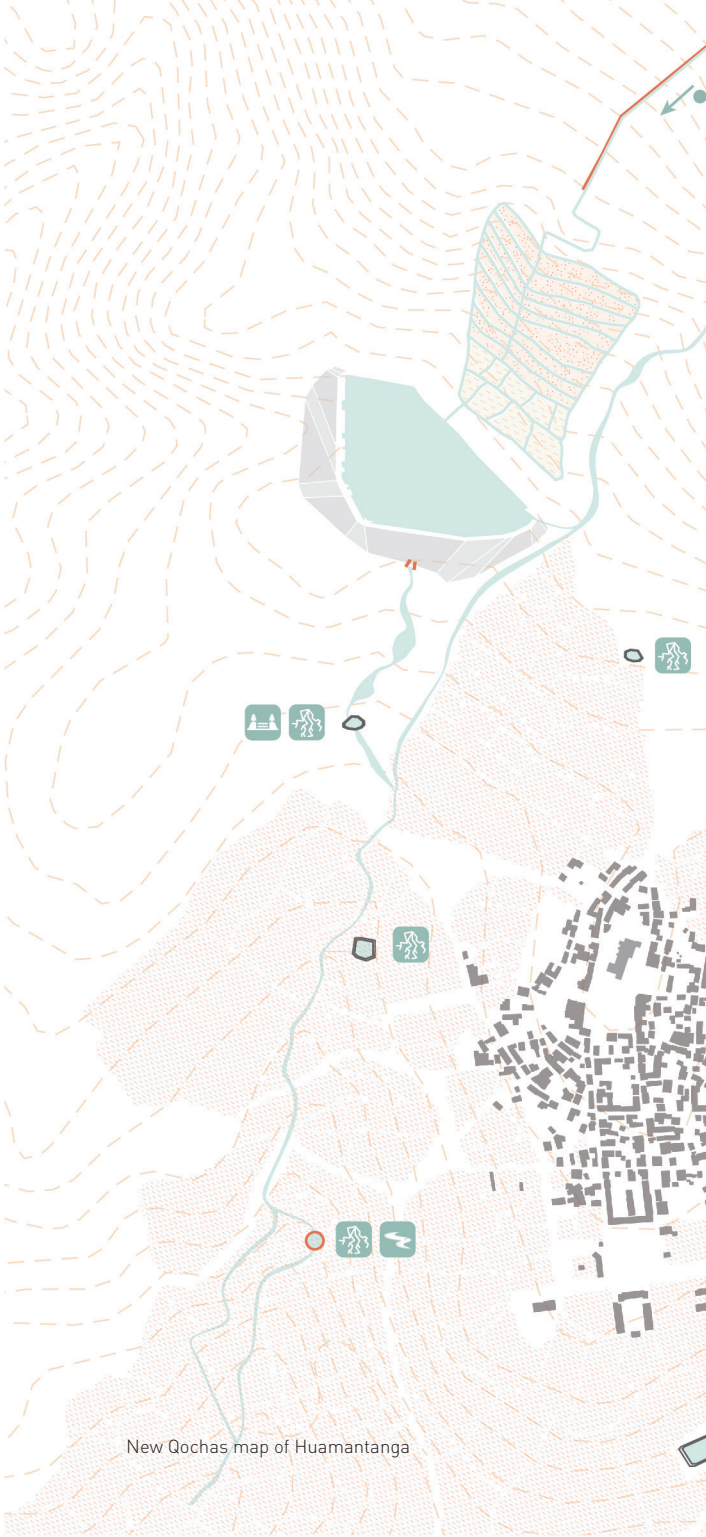
Water changes in Huamantanga


The first Amunas started to restore
2015
Two new water reservoirs started to be built
a.
d.
e.

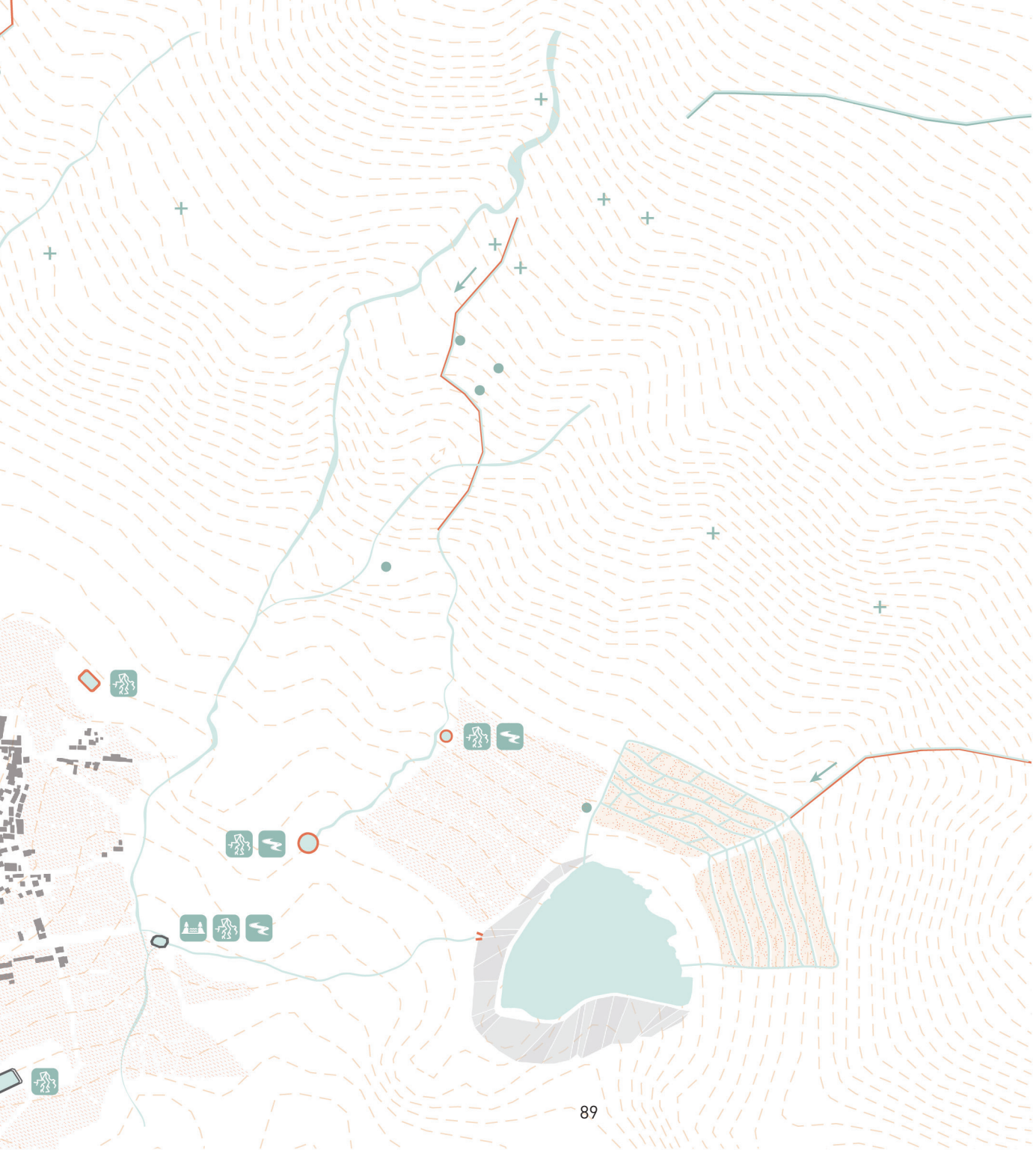
Water design in Huamantanga

As part of the design, four new Qochas have been introduced to enhance the availability and utilization of water resources in the area. These additional Qochas serve the purpose of facilitating daily water usage and diversifying the water sources for the existing Qochas.

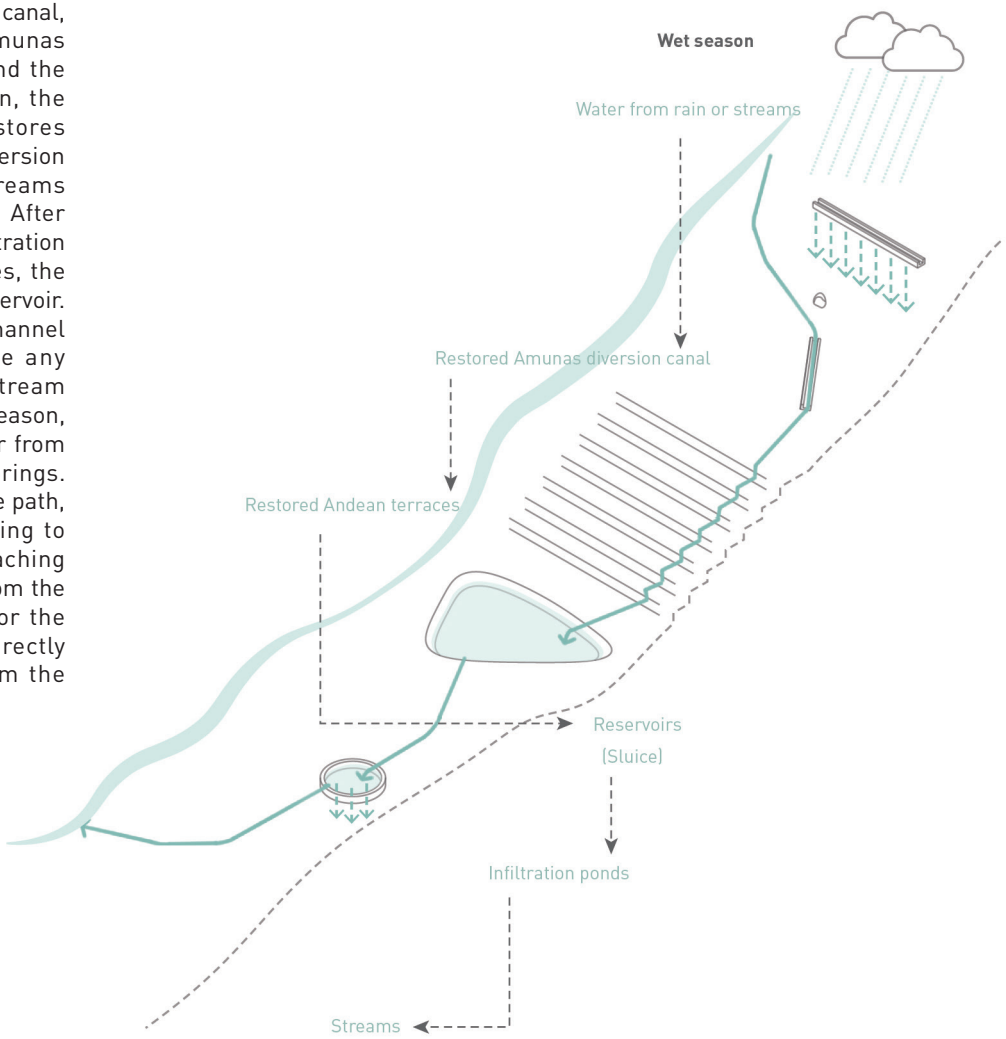
With the introduction of these new Qochas, the water supply for the Qochas is enriched, extending beyond streams and groundwater. Now, the Qochas also receive water from the reservoirs. This integration of water from the reservoirs, streams, groundwater, and the restored Amunas ensures a year-round water supply for the Qochas.



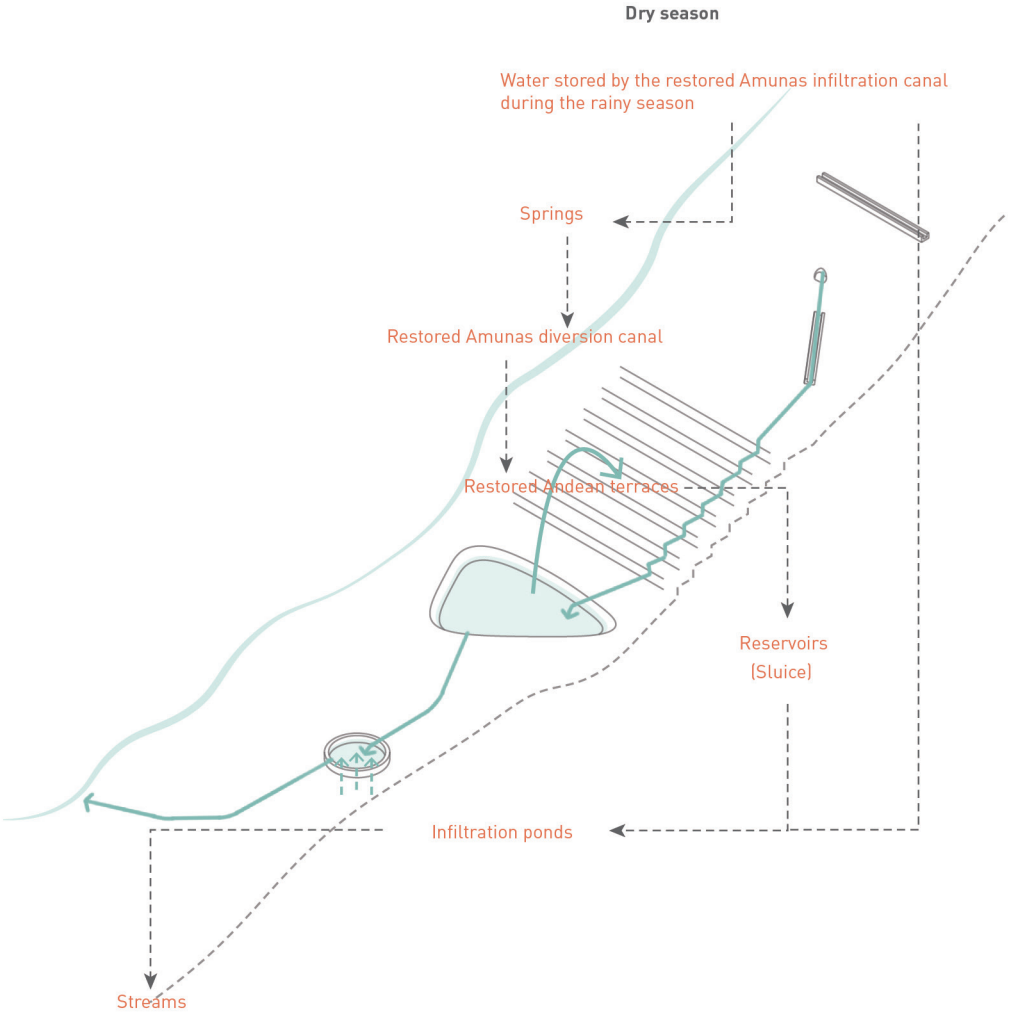
New Qochas map of Huamantanga



The new water system is divided into four parts: the Amunas infiltration canal, the Andean terraces with the Amunas diversion canal, the reservoir and the Qochas. During the rainy season, the infiltration canal collects and stores water underground, while the diversion canal transports water from streams to the restored Andean terraces. After undergoing multiple layers of infiltration and utilization within the terraces, the remaining water flows into the reservoir. From there, controlled sluices channel the water to the Qochas, while any surplus water continues downstream into the streams. During the dry season, the diversion canal receives water from underground storage through springs. The process then follows the same path, from the Andean terraces, leading to the reservoir, and ultimately reaching the Qochas. Additionally, water from the reservoir can be directly used for the terraces, and the Qochas can directly access groundwater stored from the rainy season.



Water flow in wet season

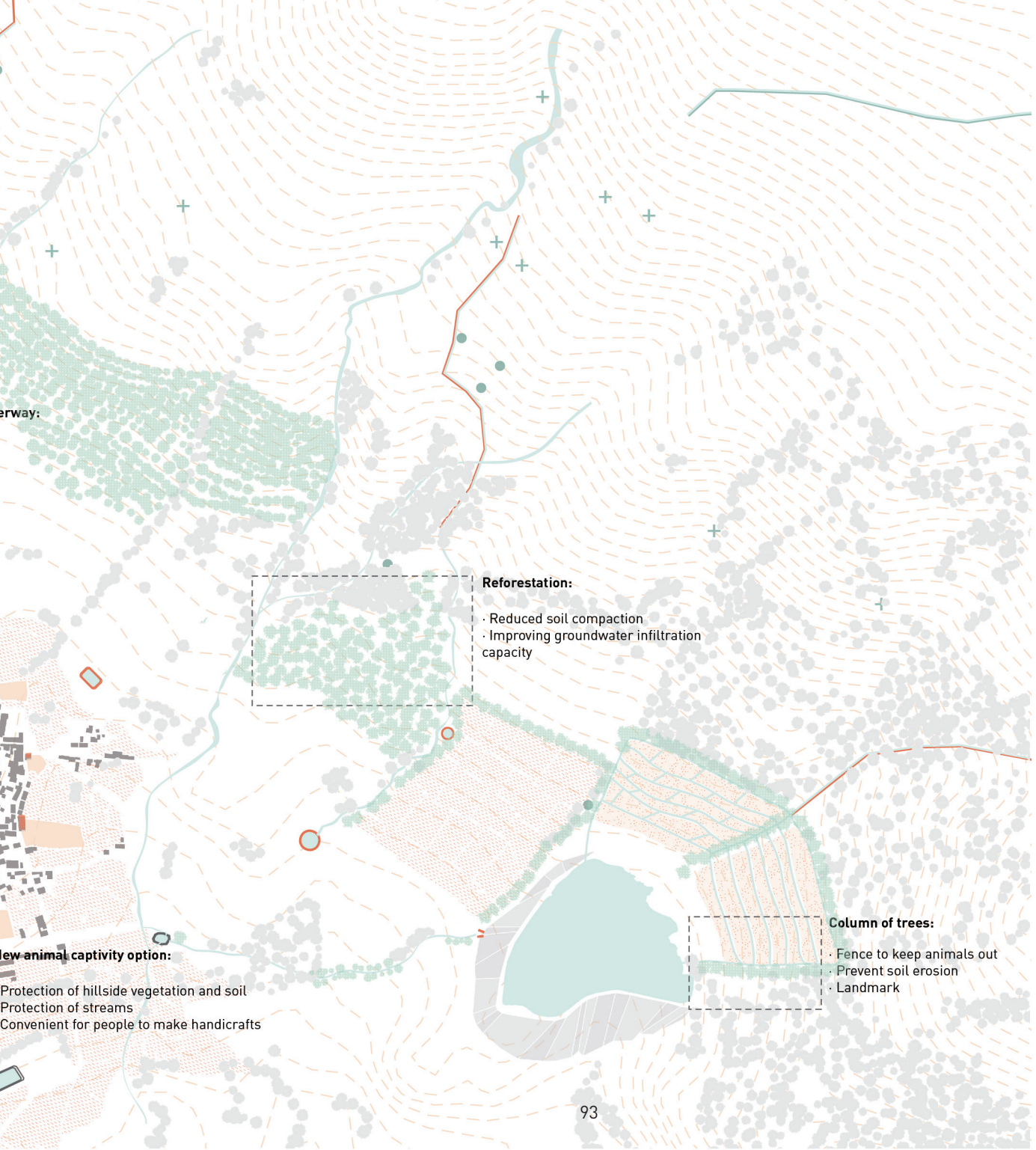


Water flow in wet season

Masterplan

The restoration of the water system will be carried out alongside reforestation efforts and the re-planning of the residential area. Reforestation will improve the infiltration capacity by enhancing soil compaction on other hillsides with abandoned terraces, while strategically planted rows of trees along terrace edges will prevent erosion and serve as recognizable features of the Andean terraces.

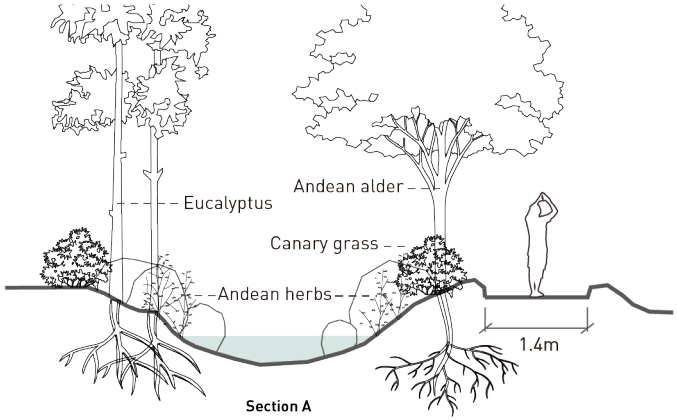
Additionally, trees will be planted along the new waterway that connects the reservoir to the Qochas, creating public spaces that enhance the overall landscape. To facilitate the restoration of Andean terraces, vacant farmland will be transformed into pasture areas for livestock captive breeding. Unused houses within the residential area will be repurposed as warehouses for animal feed and materials for handicrafts.


erway:
Reforestation:
· Reduced soil compaction
· Improving groundwater infiltration capacity
lew animal captivity option:
Protection of hillside vegetation and soil
Protection of streams
Convenient for people to make handicrafts
Column of trees:
· Fence to keep animals out
· Prevent soil erosion
· Landmark

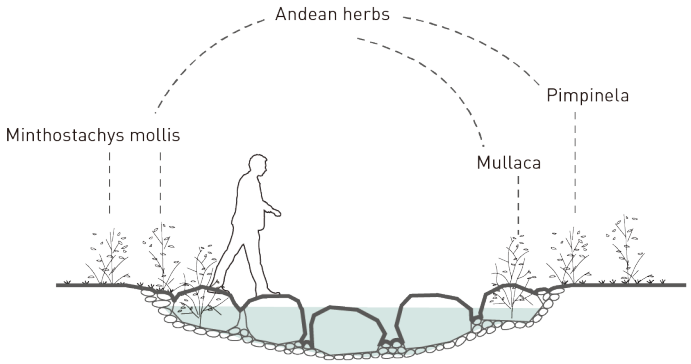
Designed layers

The detailed design focuses on the synergistic integration of restored Andean terraces and water systems, yielding significant benefits for the local community. By reintroducing traditional Andean terrace crop types such as broad beans, Andean tubers, corn, and avocados, the aim is to enhance the variety and quality of local produce. Notably, avocados, which require a longer management cycle, are strategically planted at higher terraces to facilitate convenient access for the residents. The newly established route encompasses three main entrances to the terraces, and the incorporation of traditional stone stairs between the layers allows for flexible movement and navigation.

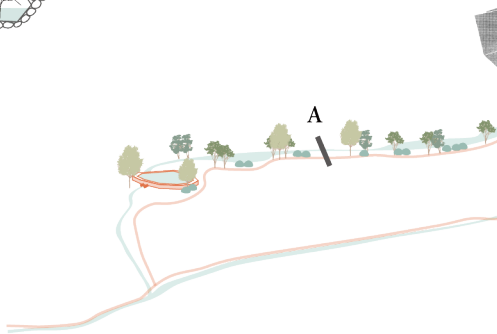
In terms of the water system, the new waterway is adorned with a selection of suitable plants, including Andean alder, eucalyptus, and canary grass, known for their soil conservation properties. Along the streams, a diverse array of traditional Andean herbs are thoughtfully cultivated, enriching the landscape and offering residents and visitors the opportunity to engage in herbal gathering. Furthermore, the inclusion of stone bridges at the convergence points between the route and the streams enhances the overall landscape experience, blending functionality and aesthetic appeal seamlessly.

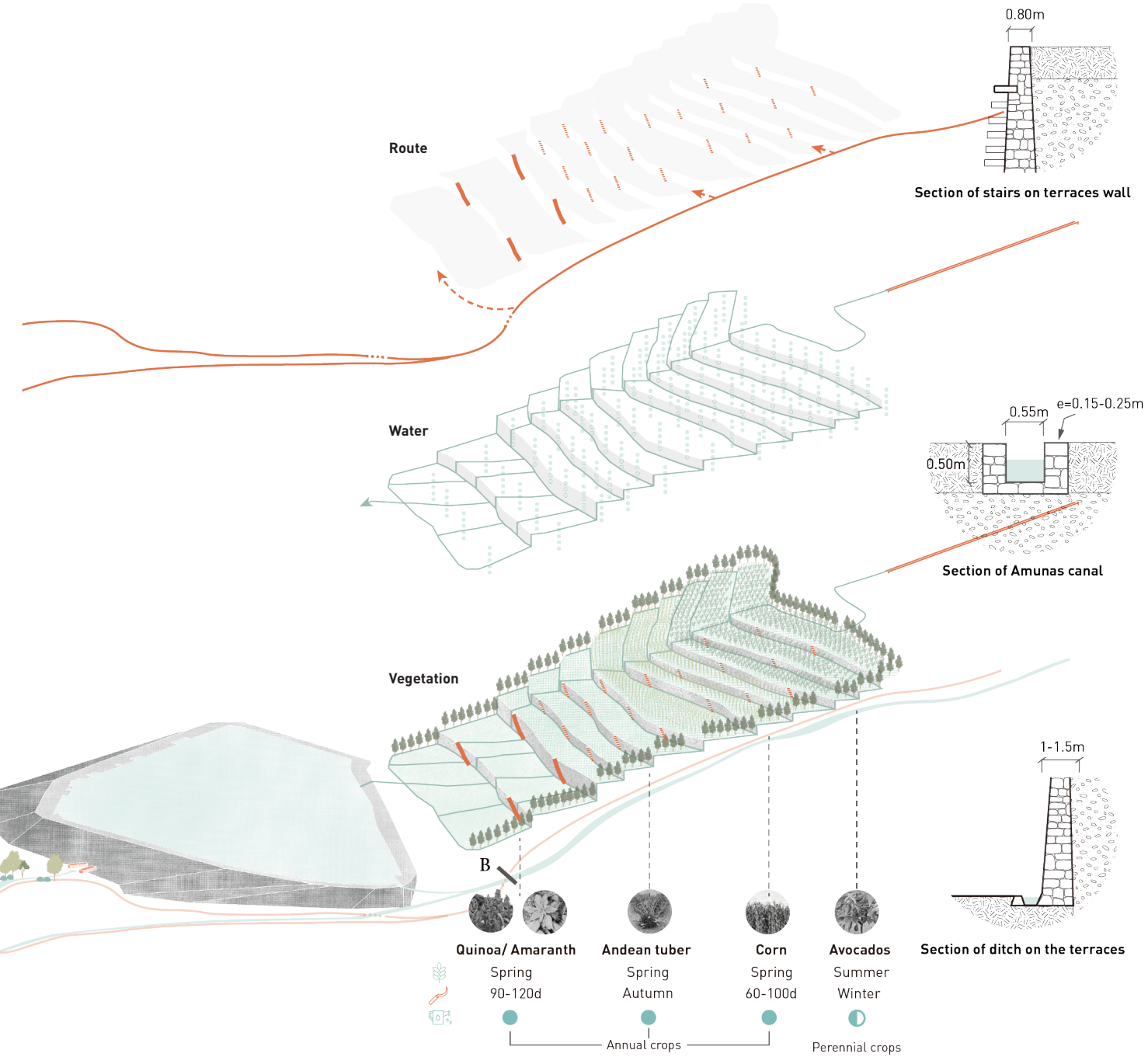


Section A



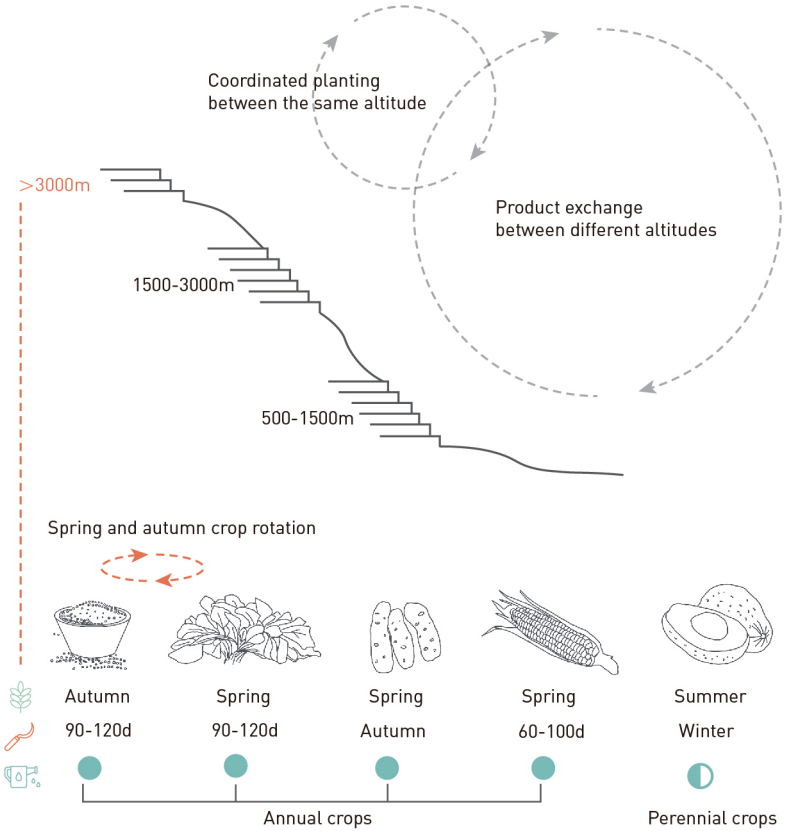
Section B

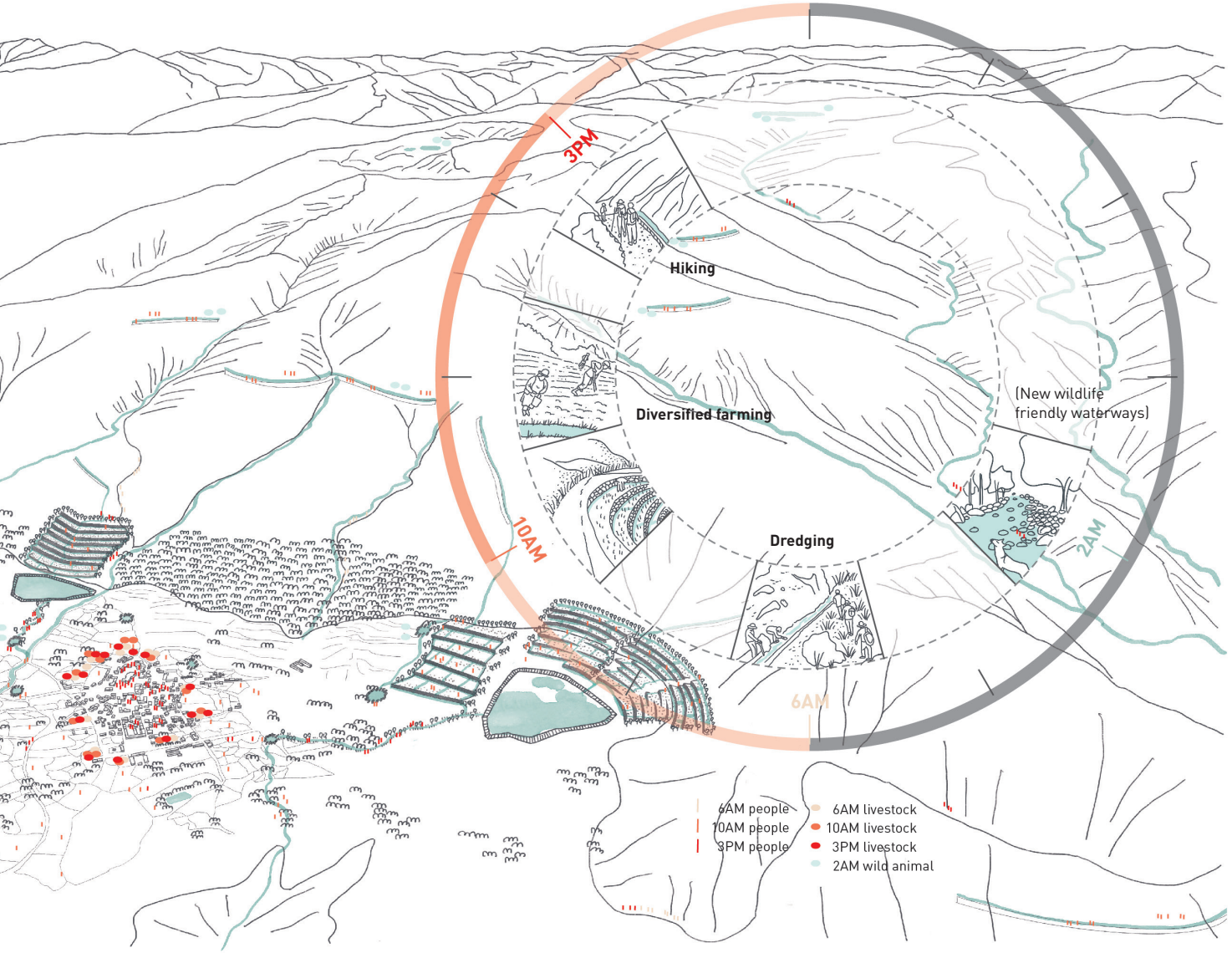



Route
Water
Vegetation
B
0.80m
Section of stairs on terraces wall
0.55m
e=0.15-0.25m
0.50m
Section of Amunas canal
1-1.5m
Section of ditch on the terraces
Quinoa/ Amaranth
Spring
90-120d
Andean tuber
Spring
Autumn
Corn
Spring
60-100d
Avocados
Summer
Winter
Annual crops
Perennial crops

Designed water related life in Huamantanga

The design enhances the activity trajectory of people in Huamantanga. It has a well-functioning water system, diversified planting patterns, a greater variety of activities and experiences, and attracts visitors and hikers.





One-day life cycle in Huamantanga town in 2035

Routes for 3 stages

To complement the three phases of restoring the Amunas, restoring the terraces and introducing tourism, three different routes were designed and planned, each building on the previous phase.

Routes to restore Amunas

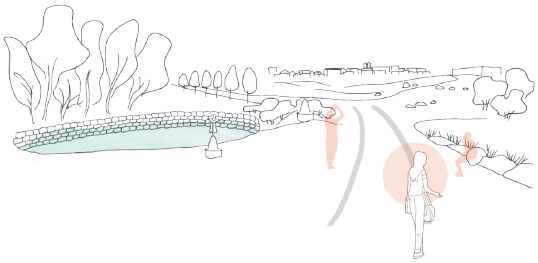
Routes for terrace farming

A For visiting

B For hiking

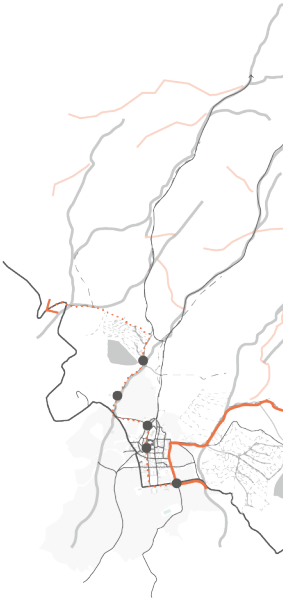
Routes for visiting and hiking

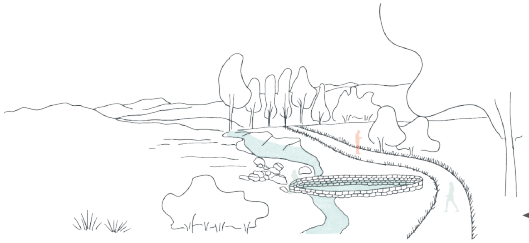
Routes for visiting and hiking



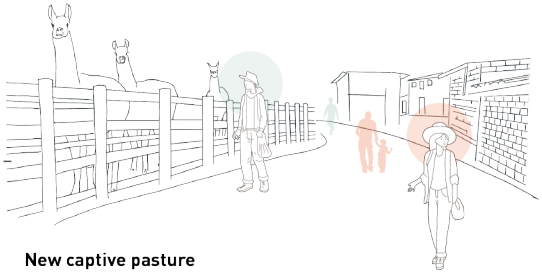
Entrance to the town

Town Center: Alpaca wool products store

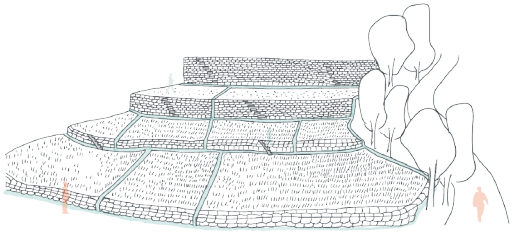




Path follows the new waterway

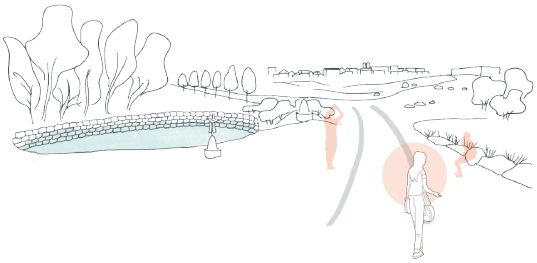


New captive pasture



Restored terraces

For visiting
For hiking

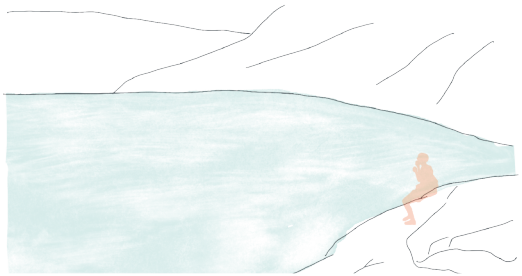


Entrance to the town

Mountain Path

Seeing Amunas from a distance

Path along the Amunas



Hiking Terminal Lake

Visitor

Resident

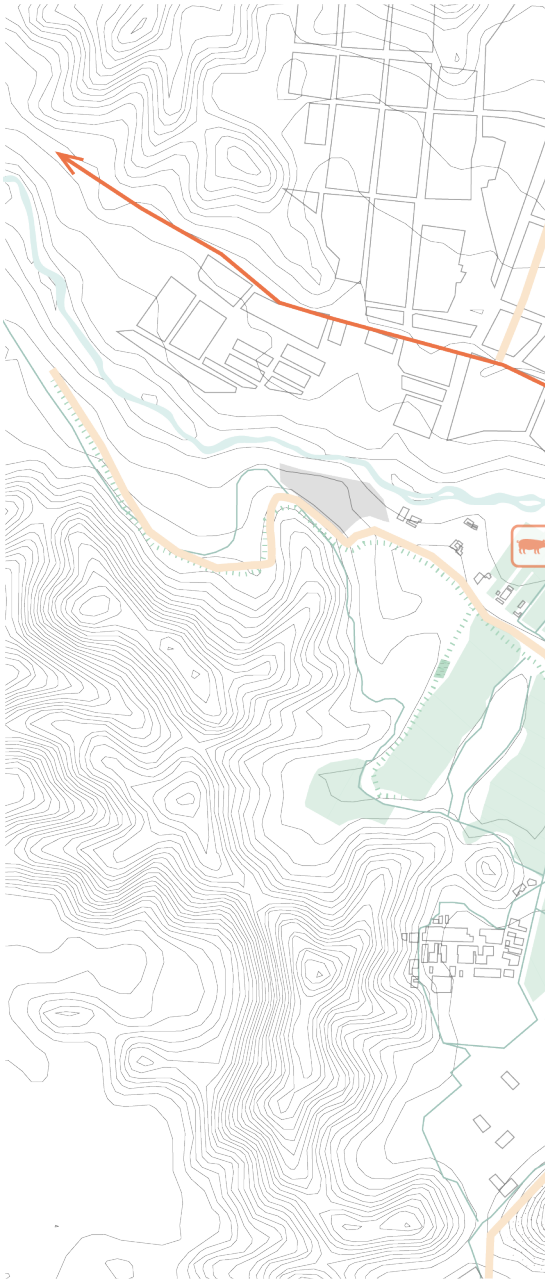
07/05/02

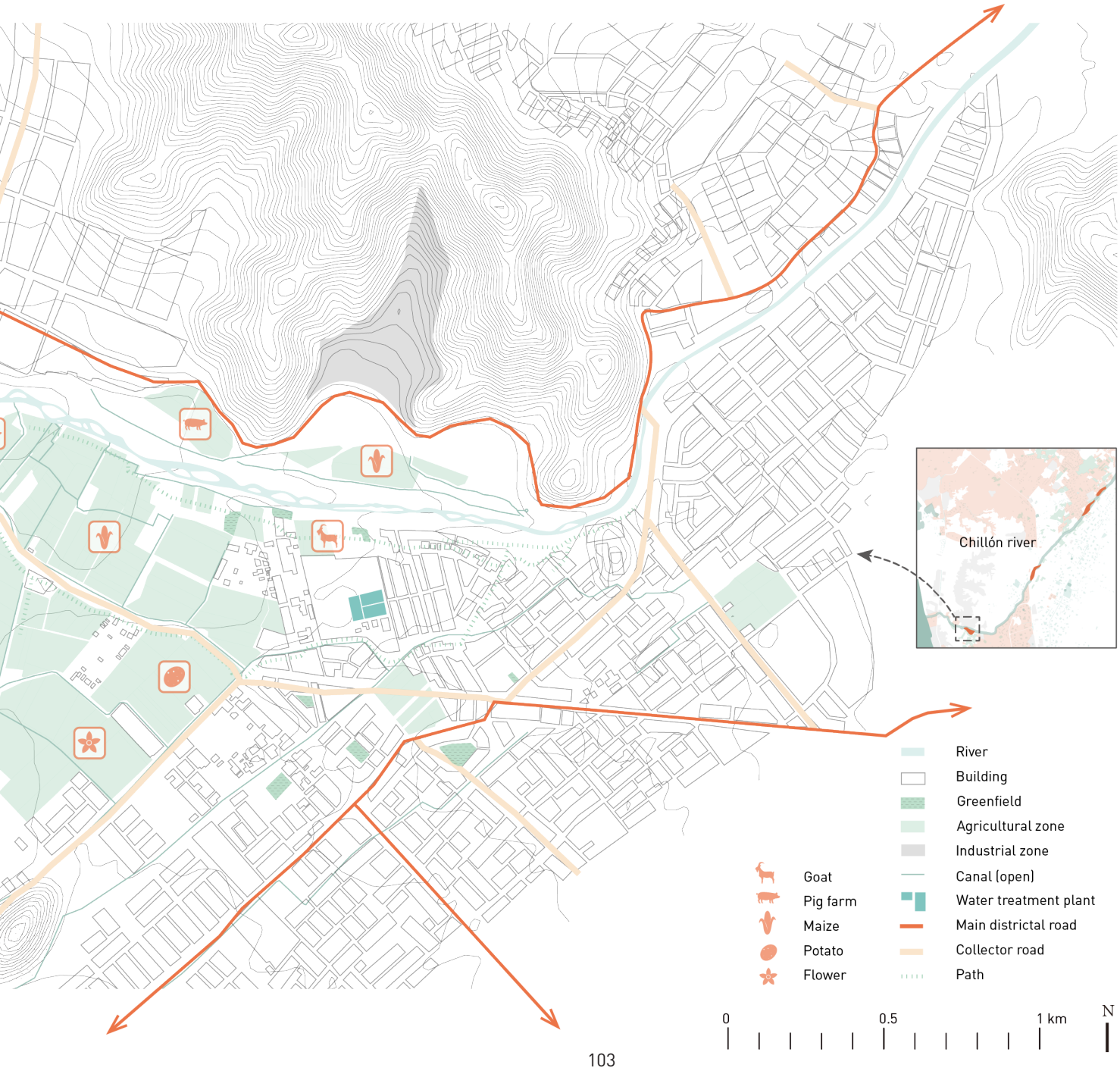
Re-valuing water in Chillón River Floodplain

Site plan

The floodplain situated downstream of the Chillón River is the largest among the areas at risk of flooding along its course. Given its vulnerability to floods, this region is deemed unsuitable for residential purposes and primarily serves agricultural activities. The agricultural sector predominantly cultivates potatoes, corn, flowers, and engages in pig and goat breeding. Furthermore, this particular agricultural land represents the sole remaining area dedicated to farming within the urban confines of Lima.

Within this vicinity, a municipal wastewater treatment facility, operated by SEDAPAL, is also situated. This plant effectively treats a staggering volume of 422 liters of water every second.



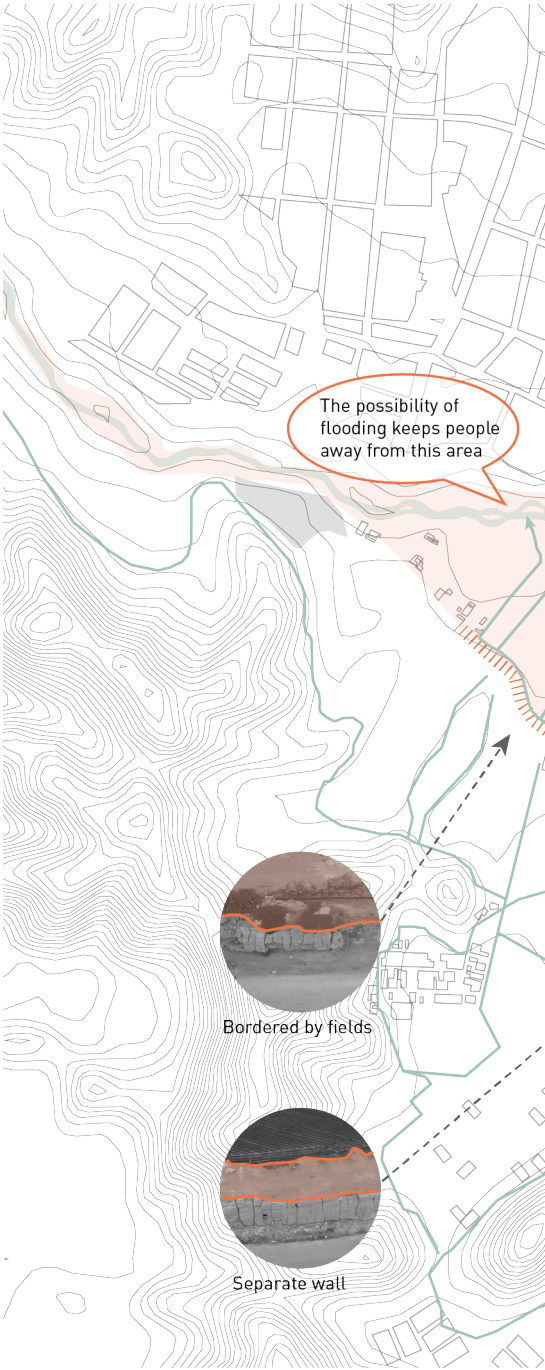

Chillón river
River
Building
Greenfield
Agricultural zone
Industrial zone
Canal (open)
Water treatment plant
Main districtal road
Collector road
Path
Goat
Pig farm
Maize
Potato
Flower
0
0.5
1 km
N

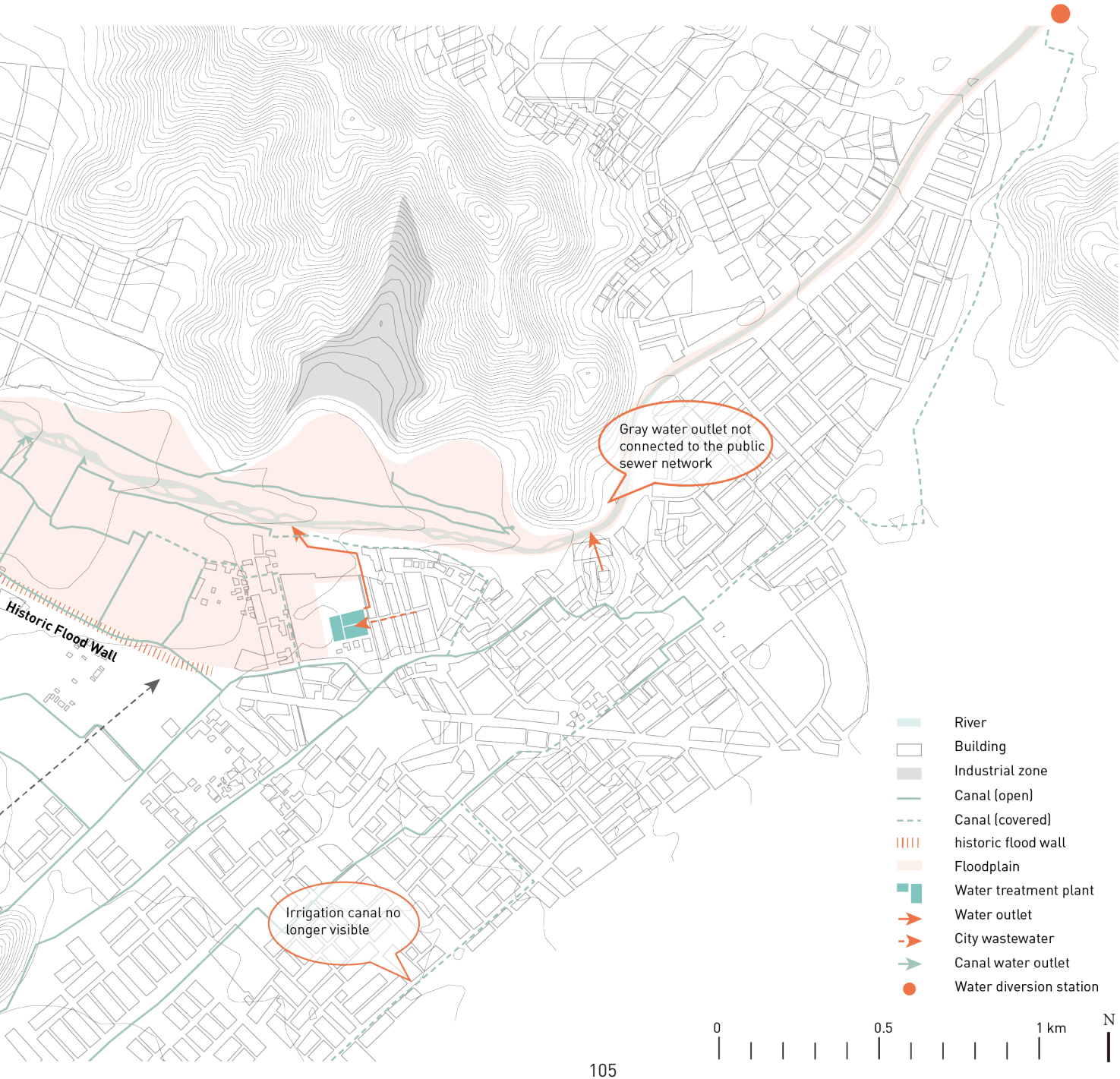
Current water challenges

Despite being one of Lima's most efficient wastewater treatment plants, a significant amount of untreated wastewater is still discharged into the Pacific Ocean. Despite being one of Lima's most efficient wastewater treatment plants, a significant amount of untreated wastewater is still discharged into the Pacific Ocean. Moreover, the plant faces water-related challenges, including flooding and the neglected state of traditional irrigation canals.

Historically, a flood wall was constructed between 1000 and 1470 AD on the southernmost side of the site. However, this wall does not provide protection for the farmland and farmers' living areas during floods in the present day. Consequently, an increasing number of people have relocated from this vulnerable area.

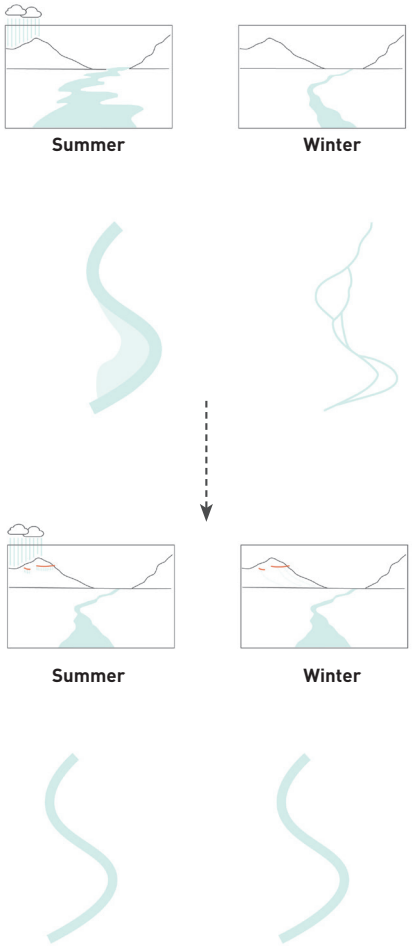
Archaeological findings indicate that early indigenous cultures established an extensive system of irrigation canals in Lima around 2000 years ago. These canals were primarily designed to irrigate the desert and facilitate agricultural activities. Initially, these waterways were prominent features in the urban landscape, but in recent decades, some of them have been obscured or covered over.

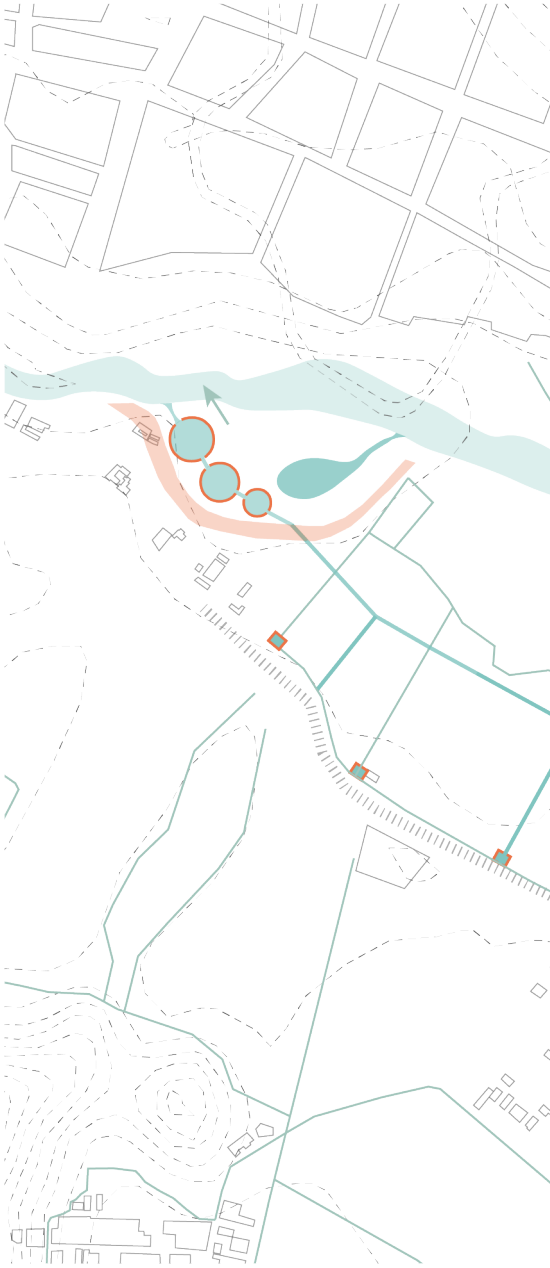


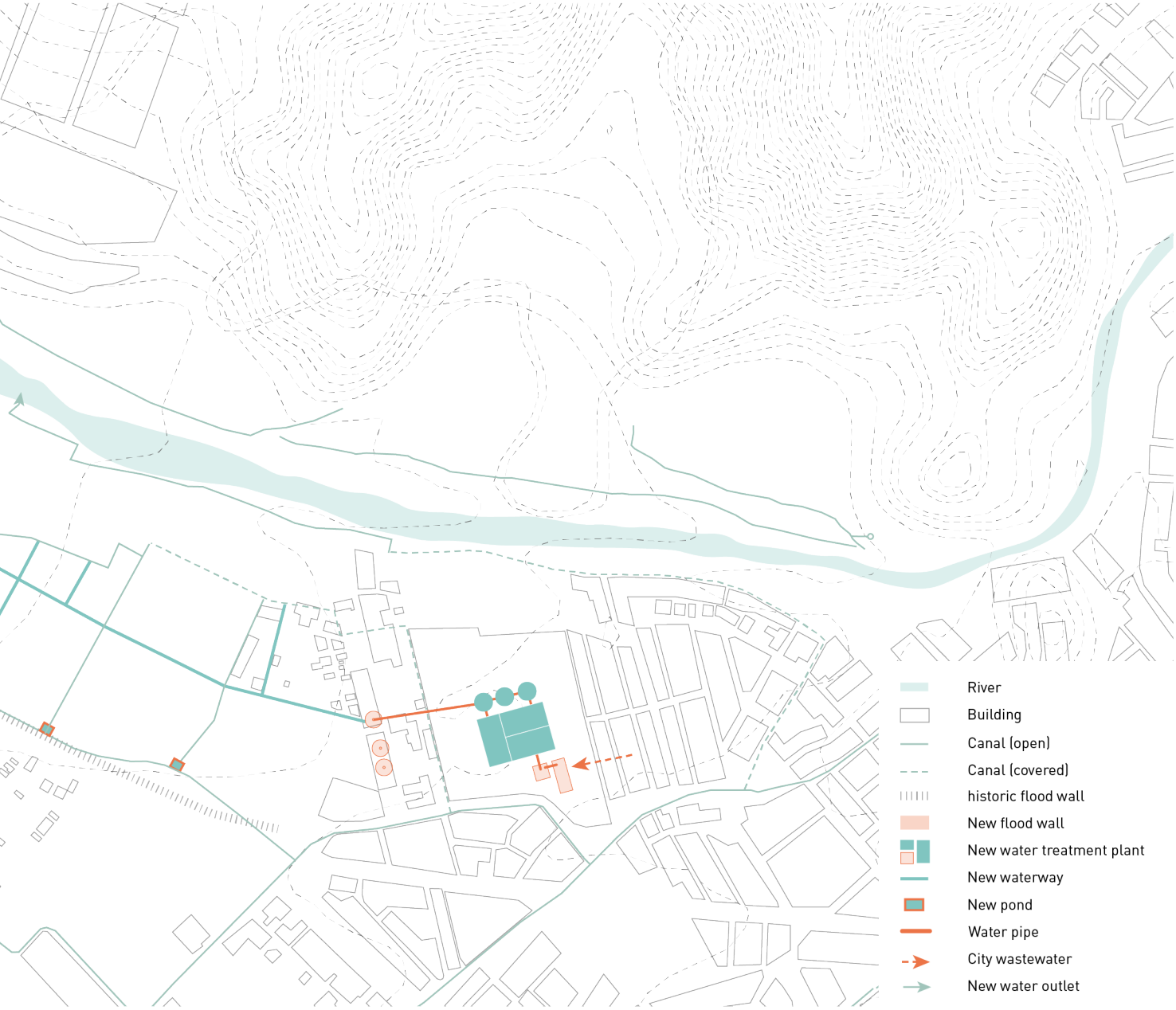

Gray water outlet not connected to the public sewer network
Historic Flood Wall
Irrigation canal no longer visible
River
Building
Industrial zone
Canal (open)
Canal (covered)
historic flood wall
Floodplain
Water treatment plant
Water outlet
City wastewater
Canal water outlet
Water diversion station
0
0.5
1 km
N

Designed water layer

The restoration of the Andes and the upper Chillón River water system holds the potential to mitigate the risk of flooding by creating a more consistent seasonal flow in the river. This transformation not only addresses the water crisis experienced during the dry season in Lima but also presents an opportunity to reshape the city's perspective on water management. A key strategy involves expanding the capacity of the wastewater treatment plant and establishing a connection to the city's direct sewage outlet. Additionally, a shift in the current approach of directly discharging treated water from the treatment plant to introducing new waterways is proposed. This progressive purification process would take place in stages on agricultural land, ultimately guiding the new waterway and the modified irrigation canals into the new floodplain. Within this ecologically purified setting, the water would be discharged into the Chillón River.



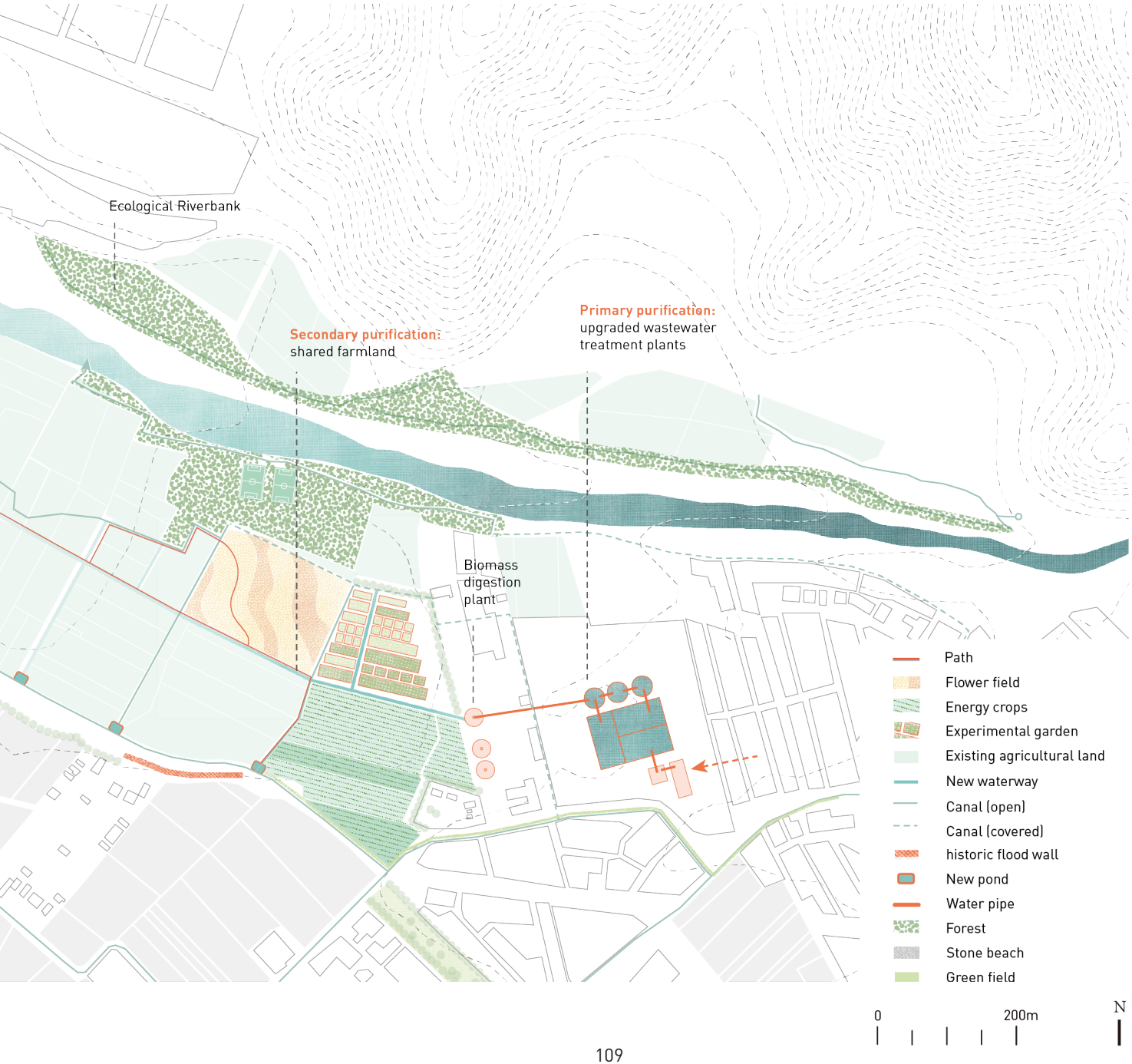



River
Building
Canal (open)
Canal (covered)
historic flood wall
New flood wall
New water treatment plant
New waterway
New pond
Water pipe
City wastewater
New water outlet
0
500m
N

Masterplan

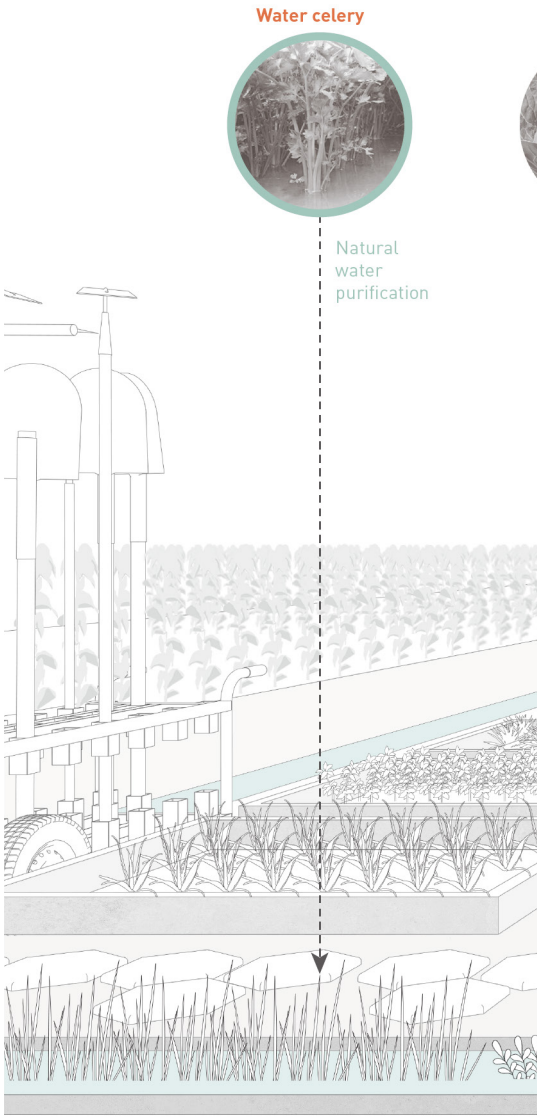
Alongside the development of the new waterway, three types of shared farms have emerged, namely the experimental garden, energy crop field, and flower field. These shared farms serve as innovative models for agricultural practices in the area. In addition, various forms of tree planting have been implemented, including bushes, rows, and solitary trees, each serving distinct functions based on their specific locations.

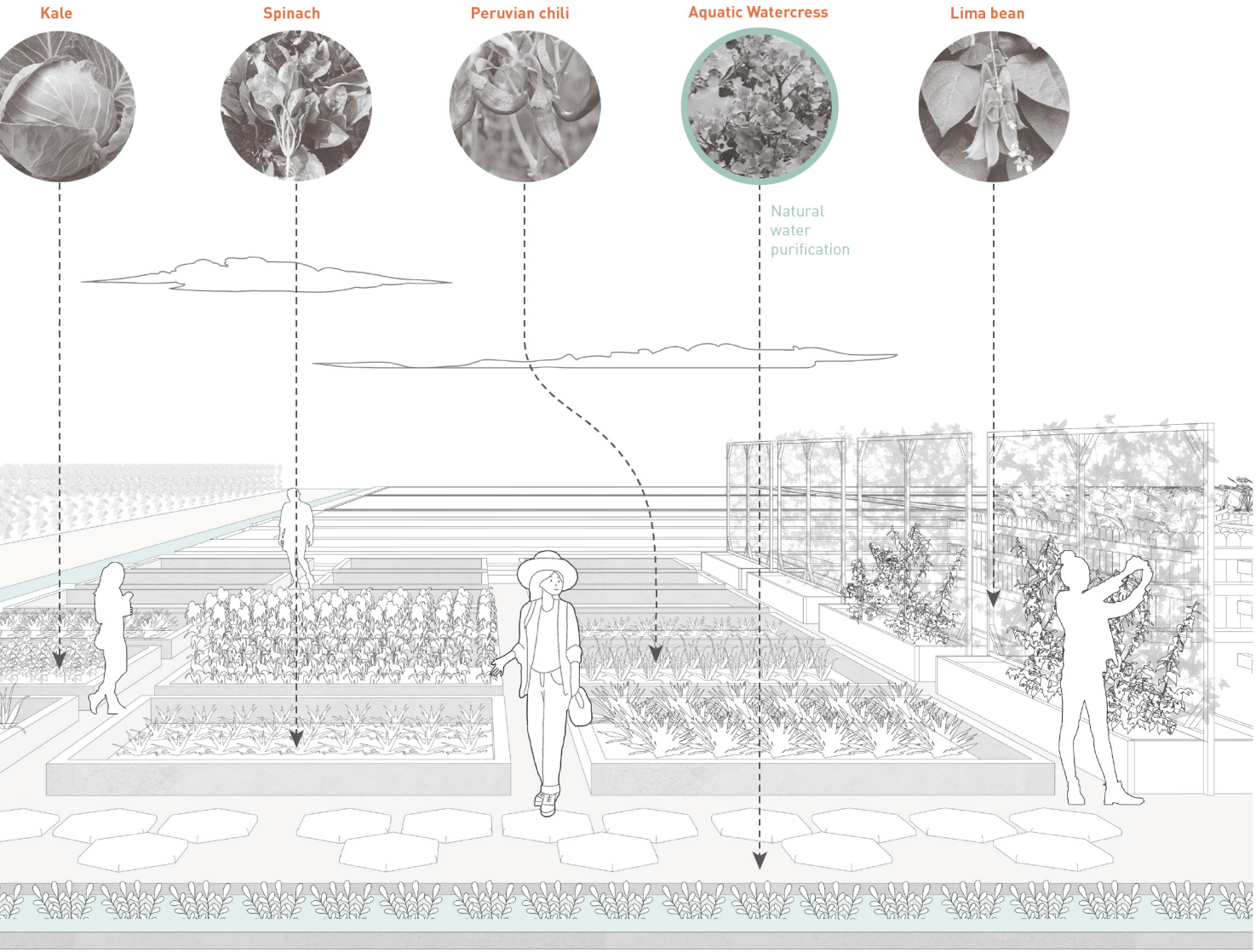
This site helps people reconnect more closely with water, awakening respect for water by maximizing its use and purifying it stage by stage.


Ecological Riverbank
Secondary purification:
shared farmland
Primary purification:
upgraded wastewater
treatment plants
Biomass
digestion
plant
Path
Flower field
Energy crops
Experimental garden
Existing agricultural land
New waterway
Canal (open)
Canal (covered)
historic flood wall
New pond
Water pipe
Forest
Stone beach
Green field
0
200m
N

Design of experimental garden

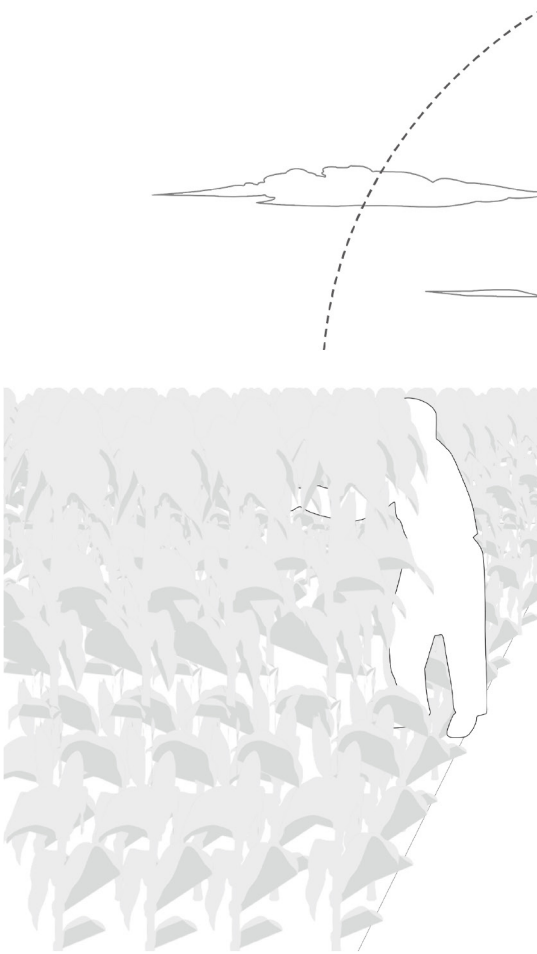
The experimental garden serves as a collaborative space where nearby residents and farmers can explore different species and engage in experimentation. It acts as a focal point for neighborhood cooperation, fostering a sense of community involvement. Furthermore, by introducing the cultivation of aquatic vegetables in the new waterway, not only does it contribute to purifying the water, but it also offers an opportunity to diversify the crop selection in the region.

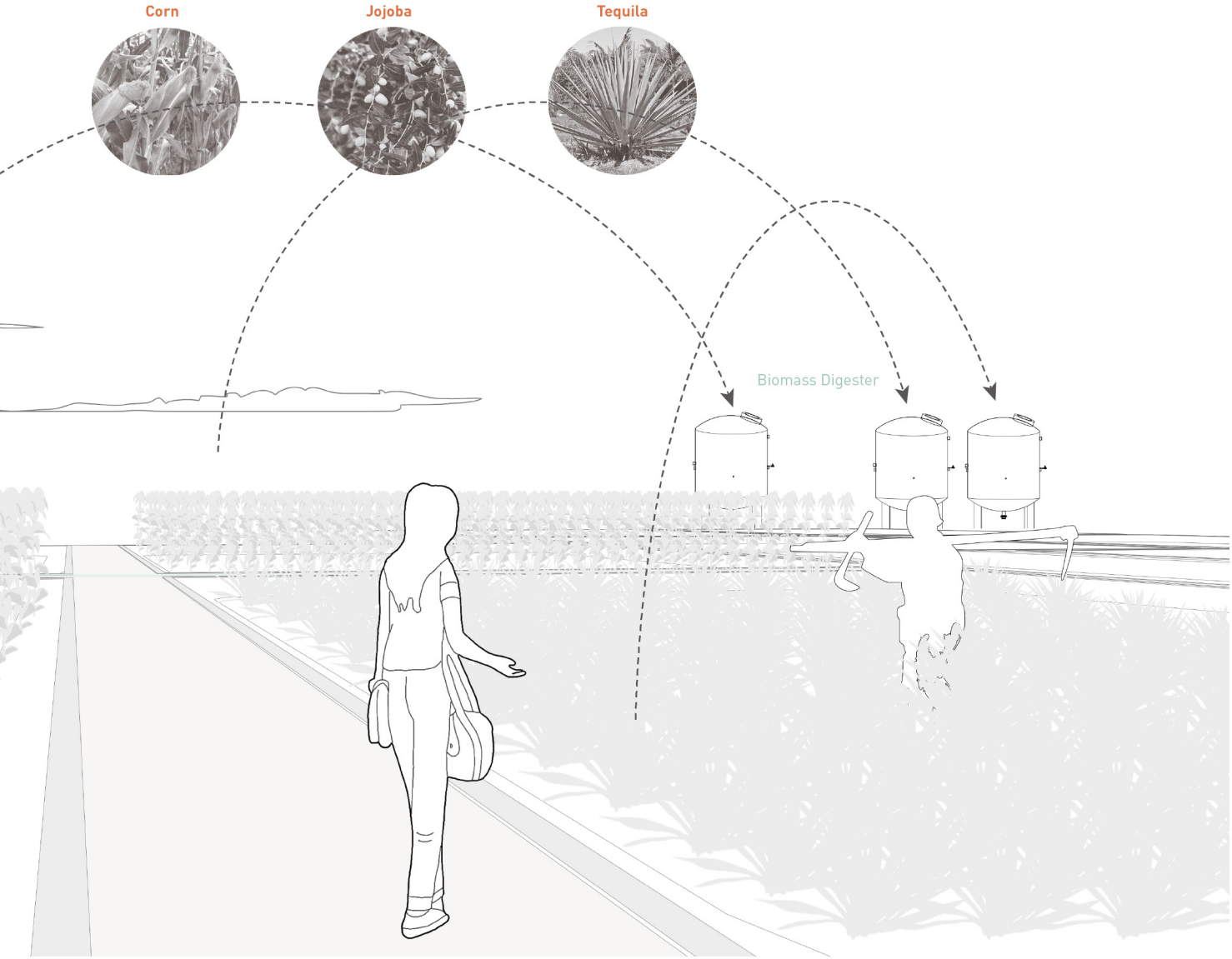



Kale
Spinach
Peruvian chili
Aquatic Watercress
Lima bean
Natural
water
purification

Design of energy crop field

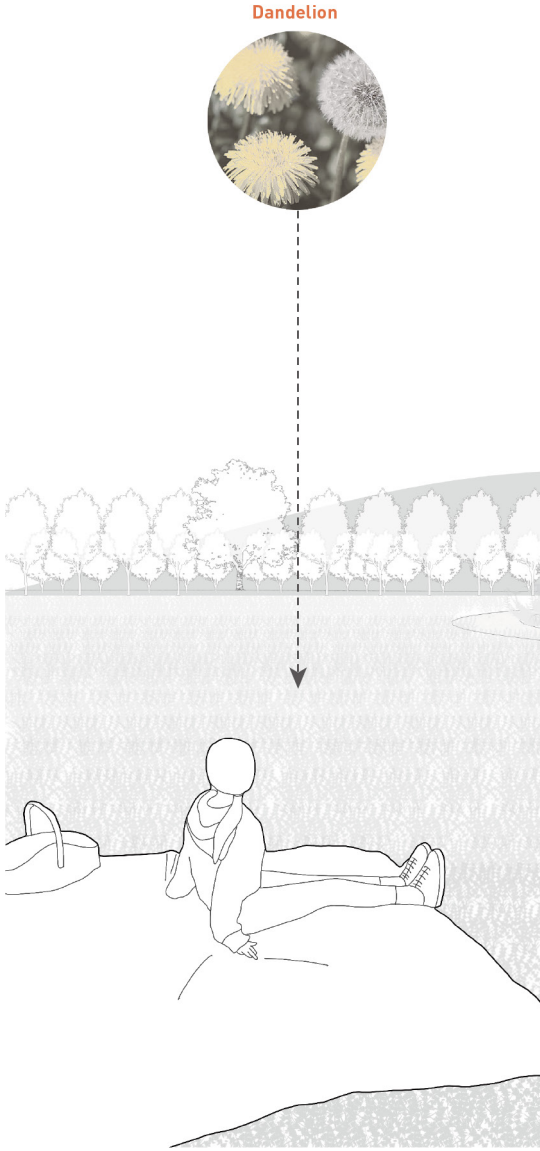
In the Energy crop field, the cultivation of corn, a traditional agricultural product, has been retained. Simultaneously, new energy crops such as jojoba and tequila, which are well-suited for the Lima region, have been introduced. The primary objective is to generate biomass, which will then be utilized in a nearby biomass digester. This digester will not only process the biomass from the Energy crop field but also incorporate biomass from the sewage of the wastewater treatment plant. By combining these various sources, the resulting enriched biomass can be used for various purposes like fertilizer. This entire process is visible and participatory, allowing people to observe and engage in this sustainable agricultural practice.

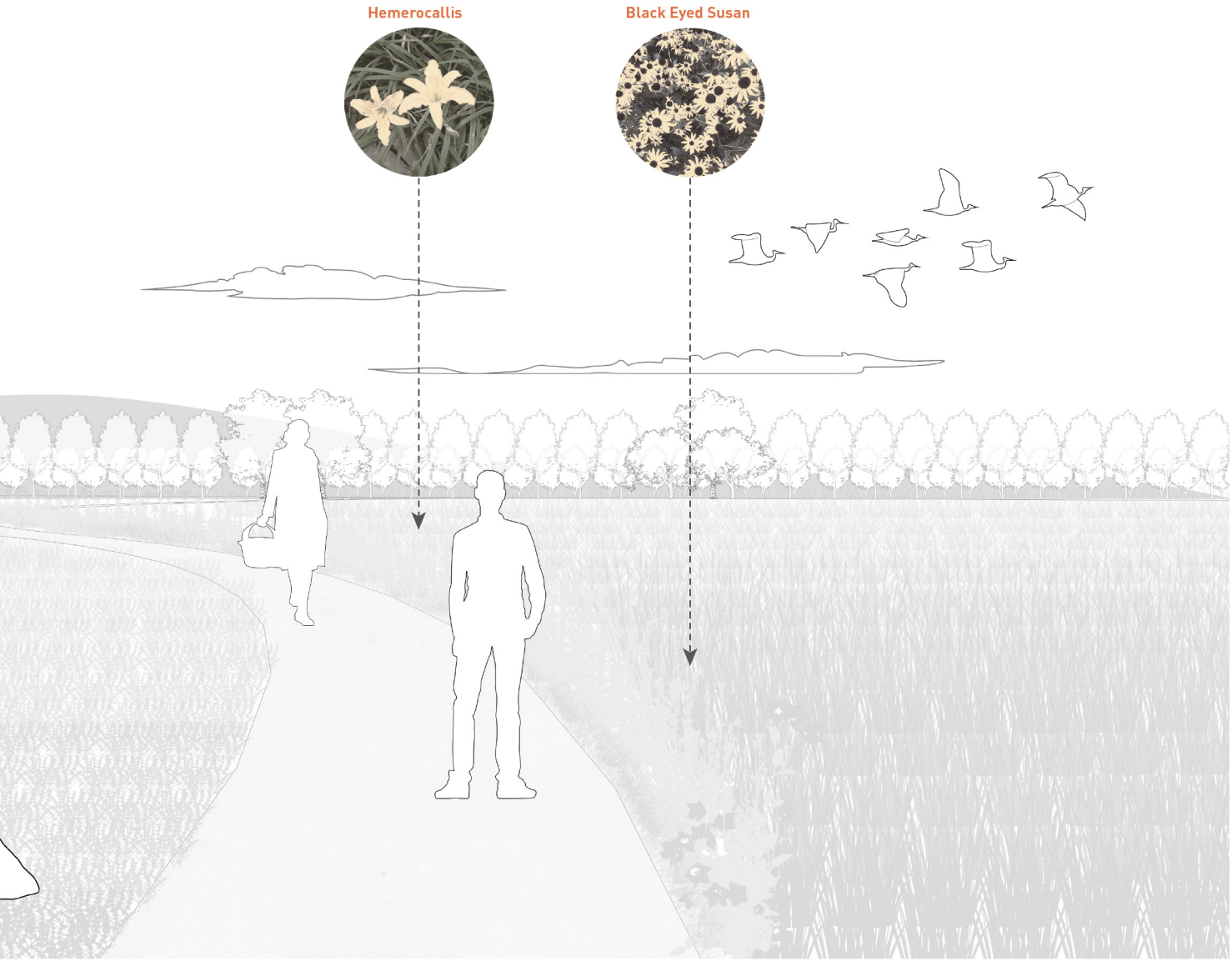



Corn
Jojoba
Tequila
Biomass Digester

Design of flower field

The flower fields serve as a valuable recreational space for the residents of this area, providing them with an opportunity to immerse themselves in the beauty of open fields and the adjacent forest. The presence of the nearby mountain further enriches the landscape experience. Previously, the mountain had been primarily utilized for industrial purposes. However, the combination of the flower fields, forest, and the mountain creates a harmonious landscape effect, enhancing the aesthetic appeal of the area and offering a respite where people can connect with nature.

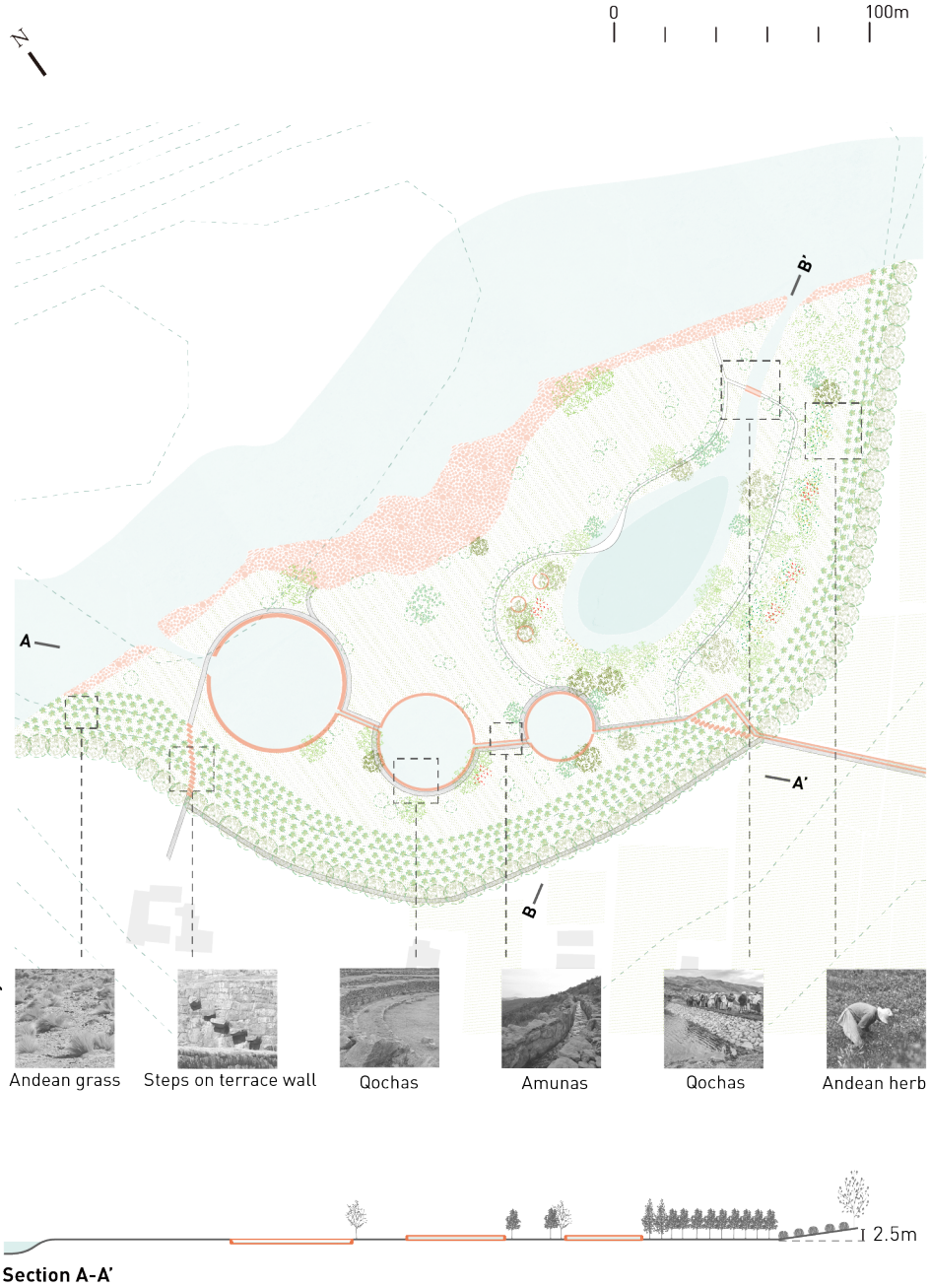


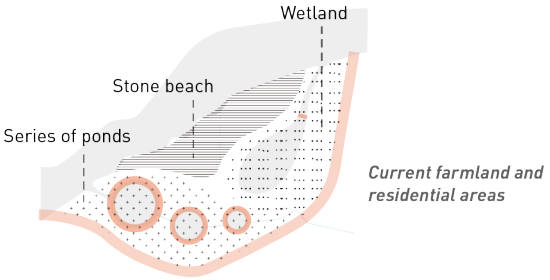

Hemerocallis
Black Eyed Susan

Detail plan

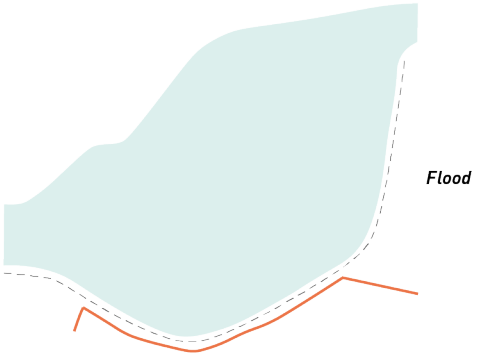
The design of the Floodplain area is divided into three distinct components: a series of ponds, a wetland, and a stone beach. These elements serve multiple purposes, extending beyond their function as a tertiary purification area. They also serve as a space for mapping the Amunas water system and reflecting the Andean Cosmovision.

The design focuses on the selection of materials, aiming to evoke a sense of connection to the traditional water system. The choice of materials, such as stone, is intended to remind people of the historical and cultural significance of water management in the region. By incorporating these materials, the design seeks to create a tangible link to the traditional practices and the rich heritage associated with the water system.

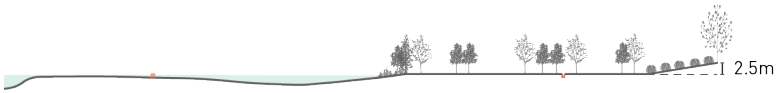




Zoning Diagram



Extreme water conditions still possible

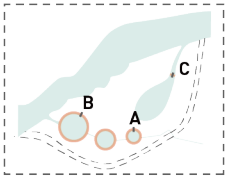


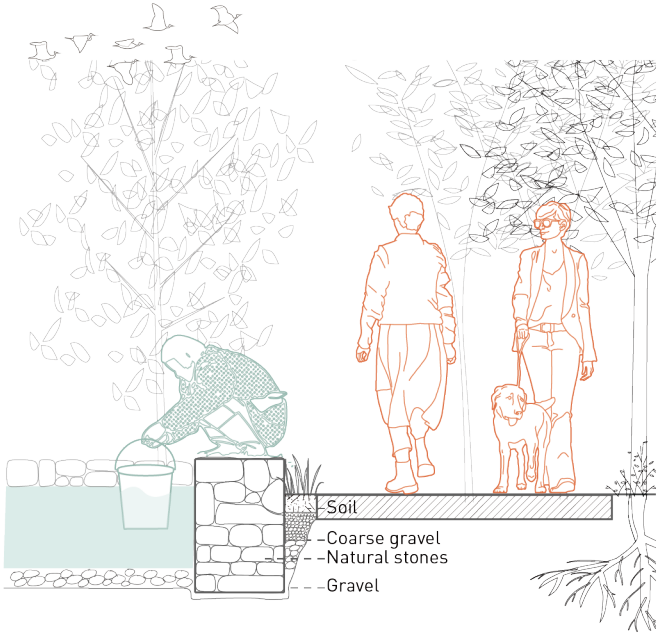
Section B-B'

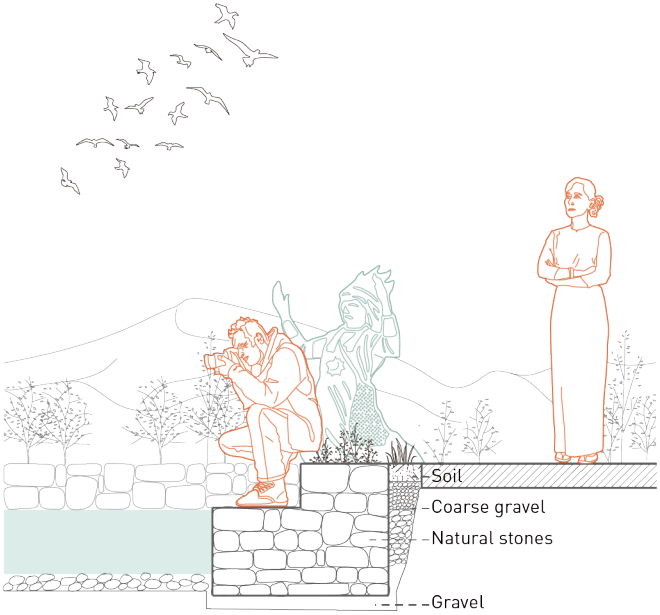
In the design, a series of ponds is strategically incorporated to serve as water purification systems within the new waterways, and the wetland is utilized to regulate the water level of the river. By controlling the sluice on the stone dams, the wetlands can effectively manage water levels, particularly during extreme drought conditions. In such situations, the sluice can be closed, transforming the wetlands into an ecological reservoir, ensuring a sustainable water supply even during periods of scarcity.

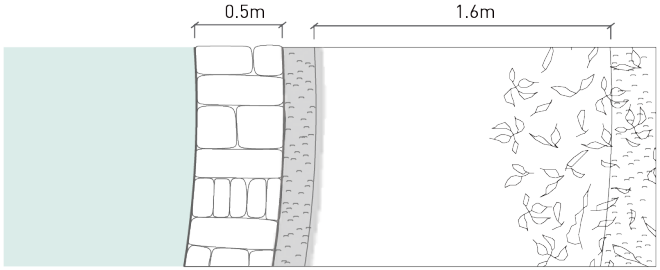
Additionally, the design considers the possibility of extreme flooding events. Although the entire area may experience flooding during such events, a road on the south side of the floodwall is planned to remain accessible.

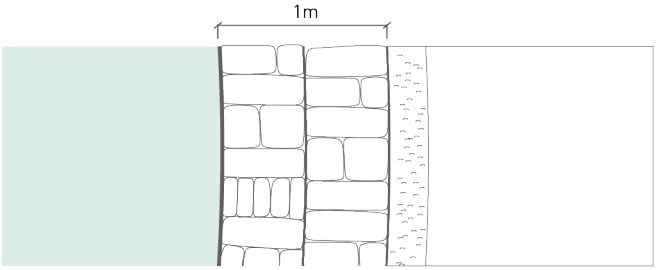
The height, form, and surrounding tree planting of each pond are crafted to create distinct senses of space, which in turn influence the way people utilize and interact with them.







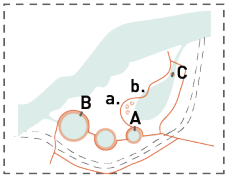


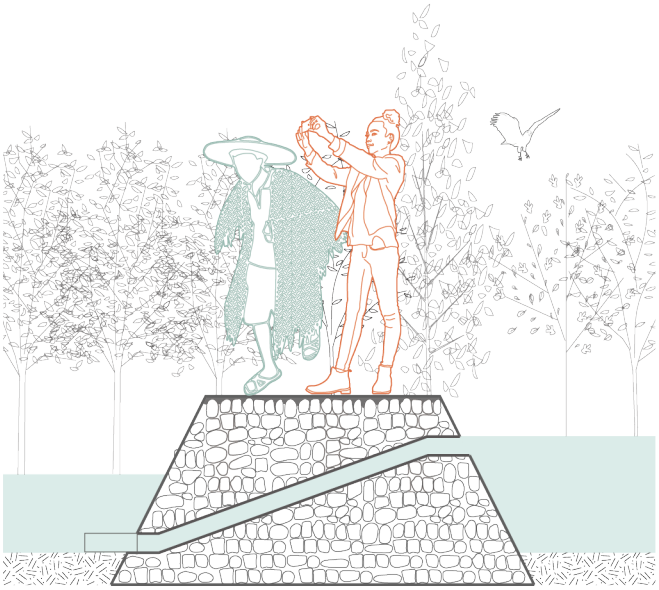


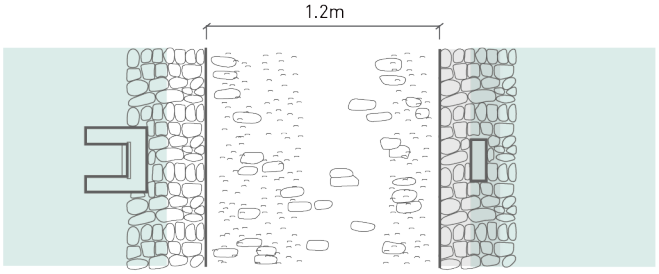
Location A

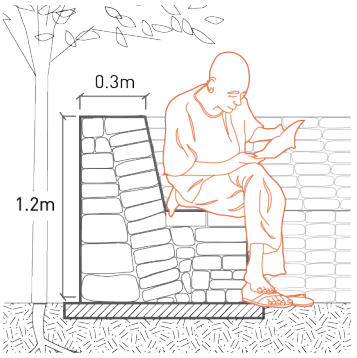
Location B

The presence of both blue and orange people in the design sections symbolizes the continuity between the historical Andean people and the modern users of the space. The blue people represent the Andes, who fetched water through the Qochas and performed rituals near them, while the orange modern people walk around these ponds for rest or recreation.

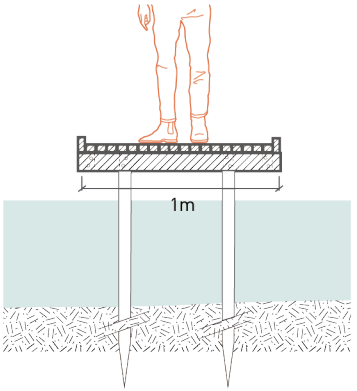








Section a.



Section b.

Quiet and open space

Part of the landscape, reservoir

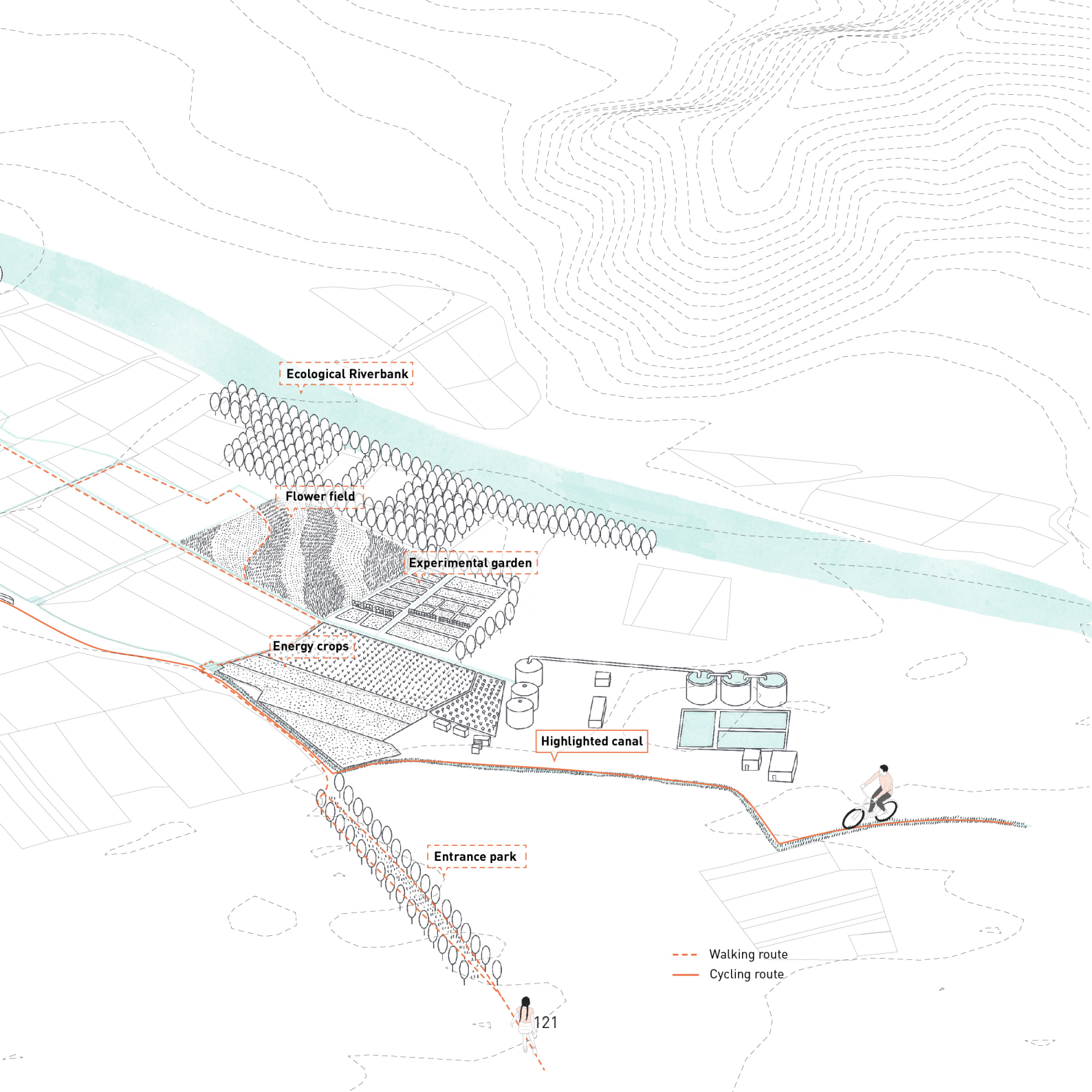
walking on the dam

Location C

Routes for walking and cycling

The design of the route encompasses two distinct sections tailored for walking and cycling experiences. The walking route commences from a serene green space that features an ancient irrigation canal. Upon entering the designated site, visitors embark on a captivating journey, sequentially encountering different clusters of shared farm. The route then meanders across the original farmland, offering picturesque vistas of the historic flood wall in the distance, before ultimately leading to the newly created floodplain.

Conversely, the cycling route traces the scenic greenway alongside the old irrigation canal, guiding cyclists to the vicinity of the design site. From there, riders traverse the path adjacent to the southern side of the site's original flood wall. Continuing on, they seamlessly transition through an existing ramp that grants access to the flood wall itself. At this elevated position, cyclists are treated to a magnificent panoramic view of the entire site.


Ecological Riverbank
Flower field
Experimental garden
Energy crops
Highlighted canal
Entrance park
Walking route
Cycling route

08/01
Conclusion

_What is the water crisis in the context of Lima?

The water crisis in Lima is a complex and multi-layered issue that encompasses various dimensions.

From a natural perspective, Lima faces water scarcity due to geographic and climatic conditions, which is further compounded by seasonal flooding. These factors not only contribute to the instability of public water facilities but also increase the risk of water pollution. With the backdrop of climate change, the current reliance on gray infrastructure for water storage is inadequate to meet the city's future sustainable water needs.

The unequal distribution of water resources within society is another significant factor contributing to the Lima water crisis. This disparity is evident in the prevalent use of water tanks as a primary source of daily water for residents on the urban fringe. Furthermore, government regulations pertaining to piped water connections, water pricing, and other factors potentially exacerbate the existing imbalance in water distribution.

From a landscape perspective, the construction of high hard banks along the city's three main rivers was intended to address seasonal flooding. And together with water pollution, this alteration has resulted in the rivers losing their attractiveness, leading residents to relocate away from the area.

Additionally, the water crisis in Lima has a spiritual dimension characterized by an increasingly negative attitude towards water. Factors such as limited accessibility to water and its sole role in everyday life have contributed to a decline in the perceived value of water among the population.

_What is the traditional water systems in Huamantanga and what is the life of the local people with water?

Bofedales, situated in the Andean highlands, serve as vital natural groundwater recharge systems. Meanwhile, the Amunas system, an ancient water harvesting system located in Huamantanga, holds significant cultural value as part of the region's pre-Columbian heritage. During the dry season, the Amunas system preserves water by storing it within water-bearing rocks beneath the Andes, ensuring a sustained supply for local use. The inhabitants of Huamantanga rely on the Amunas system not only for daily water needs but also as a gathering point for rituals that demonstrate their deep respect for the nature.

The water-related activities of the local community encompass three key domains: agriculture, animal husbandry, and daily life.

The Amunas system plays a pivotal role in supporting agricultural practices by providing direct irrigation. Additionally, through the implementation of traditional Andean terraces, the inhabitants of Huamantanga have contributed to the improvement of water infiltration.

As for animal husbandry, Bofedales serve as natural pastures for the thriving livestock industry in Huamantanga, catering to highland livestock.

In terms of daily life, the ponds within the Amunas system serve as a vital water source for the community. These ponds not only fulfill immediate water needs but also facilitate the infiltration of water, supporting downstream communities during the dry season. The significance of water is further exemplified through the performance of rituals, while the iconic Amunas canal and its accompanying infiltration slope enhance the landscape quality of the hillside, becoming a notable landmark within the local landscape.

_What are the opportunities and challenges of restoring traditional water systems in Huamantanga to help alleviate Lima's water crisis?

The decline of the Amunas, primarily attributed to a lack of maintenance, has resulted in widespread abandonment of these traditional water systems. Additionally, because of overgrazing, the Bofedales have degraded, which also affects the ability of the soil to infiltrate into the slopes of the hills. In light of the water crisis in Lima, the restoration of these traditional water systems

emerges as a highly promising solution, integrating blue-green infrastructure. By reviving groundwater recharge systems, the infiltration time of water in the high Andes can be extended, thereby harmonizing the seasonal flow of the Chillón River and providing water to the vast city of Lima during the dry season.

In the context of Huamantanga, the restoration of the water system holds considerable significance. Not only will it enhance the availability of water resources within the town, but it will also facilitate the revival of abandoned Andean terraces. Additionally, it will help regulate livestock farming practices and address issues related to obstructed water flow resulting from existing gray infrastructure. These collective efforts will enrich the agricultural product range and contribute to the overall industrial model of the town.

To achieve comprehensive water system restoration, a large-scale approach encompassing both Lima City and Huamantanga town is imperative. This endeavor necessitates the involvement of diverse stakeholders at various sites, supporting the sustainable management of water resources, bolstering connectivity within the water system, and fostering different forms of water landscapes at different elevations. Through the engagement of multiple stakeholders, the restoration efforts can be effectively coordinated, resulting in sustainable water management practices that benefit both urban and rural communities alike.

_How can both environmental and social goals be achieved through landscape architecture in this restoration process?

The landscape design is a critical component of the restoration process, contributing to various aspects, as outlined below:

_Sustainable Water Management
The design adopts sustainable principles, integrating green infrastructure elements like peatlands, ponds, and vegetated buffers. These elements facilitate water infiltration, groundwater recharge, and improve water quality. By prioritizing native plantings, the design supports local ecosystem stability and mitigates the impacts of climate change. Soil conservation and erosion control measures are also implemented to ensure sustainable water management.

_Community Engagement
The design actively involves local communities as stakeholders in the restoration process. By incorporating their input and considering their cultural values, the design addresses their needs and aspirations. The creation of inclusive and accessible public spaces promotes social interaction, recreational activities, and cultural events, enhancing the overall well-being of the community. Infrastructure and facilities are integrated to provide amenities that support community engagement.

_Cultural Preservation and Identity
The landscape design plays a vital role in preserving and promoting cultural heritage. It respects and incorporates traditional elements, such as the restoration of Andean terraces at Huamantanga and Andean stone in the Urban Floodplain . By preserving cultural practices and protecting the landscape identity, the design fosters a sense of pride, belonging, and cultural continuity within the community.

_How will the restoration of traditional water systems enhance the quality of life for people in both places?

The restoration of traditional water systems has significantly enhanced the quality of life across various aspects, including industry, daily life, and recreation.

In Huamantanga town, the revitalization of Andean terraces as part of the traditional water system restoration has resulted in a diversified local agriculture, fostering mutual assistance and product exchange among communities. The introduction of tourism has additionally generated increased income for the locals through the promotion of handicrafts, while instilling a greater sense of community pride and belonging.

In terms of daily life, the restoration efforts have brought about a transformation in the seasonal dryness experienced by the town's ponds, ensuring a consistent water supply throughout the year. The establishment of new green spaces has also provided residents with cozy areas for relaxation and social gatherings.

For Lima, the restoration of the

traditional water system holds direct benefits for the residents along the Chillón River, who previously relied on water tanks for their water supply. The creation of the new Floodplain serves as an exemplary model for cascading wastewater use, offering neighboring farmers a novel approach to cultivate crops and fostering community cooperation. Furthermore, it provides accessible recreational spaces for nearby residents. The alleviation of water scarcity has also led to a shift in negative attitudes towards water, with the Floodplain serving as a catalyst for this positive change.

The collaboration between the two sites, Huamantanga and Lima, offers an added advantage by granting Lima citizens the opportunity to explore the traditional water systems in the Andes. This engagement opens avenues for cultural exchange and provides Lima residents with firsthand experiences and knowledge about these historically significant water systems, fostering a deeper appreciation and understanding of traditional practices.

08/02

Reflection

08/02/01

Relation between graduation topic, studio topic, and master track

Focusing on the Circular Water Stories Lab and its theme of Water Systems, I delved into the Amunas water system in Peru as part of my study on traditional water systems. Through this exploration, I gained insights into how the Amunas water system functions and its impact on the lives of the people associated with it. I identified significant potential and opportunities for improving this water system.

My graduation project aims to capitalize on this potential and apply a landscape-based strategy to enhance the Amunas water system and also the downstream locations related to it. By doing so, I intend to improve the quality of life for the people connected to this system, promote ecosystem health, and raise public awareness about water-related issues on a broader scale.

Water is an indispensable element in Landscape Architecture, serving as a vital resource for sustaining life. The security and availability of water profoundly influence societal development. As a landscape architect, I recognize the capacity of this discipline to address both direct and indirect challenges. These challenges encompass ecological degradation, water scarcity, population decline, simplistic agricultural practices in small towns, and the need for cultural identity and spiritual connection between individuals and nature. By leveraging Landscape Architecture, we can tackle these multifaceted problems.

08/02/02

Research approach

The aim of this graduation design project is to investigate the potential of using landscaping to restore the traditional water system in Huamantanga, with the goal of alleviating the water crisis in Lima. The project adopts a "research by design" approach, using design as a research strategy.

Initially, the research focused on the workflow of the traditional Amunas water system and the water-related lives of the local people. I gathered a significant amount of information on the engineering, human, and historical aspects of the system. The primary design concept in this phase was to make the restoration process of Amunas more efficient through landscaping interventions in the upstream villages, with a beneficial impact on ecology, agriculture, and people's lives.

After the first phase, I began to consult more information about city Lima at the suggestion of my mentor. In addition to the basic climate information learned in the first phase, I turned my attention to the water-related lives of people in the city, collecting and drawing the corresponding mappings. It became apparent that a more rational framework was needed for the restoration process, which would involve different stakeholders, with their contribution and feedback considered at various stages. Also consider the connectivity of the water system, I began to focus on the natural peatland higher up, and the downstream villages in the intermediate section, leading to the prototype of the various scales in the final design framework.

The next phase involved considering the practical effects of restoring traditional water systems. While the restoration of Amunas had been proven to provide water upstream and downstream to some extent during the dry season, it was somewhat hypothetical due to the complexity and uncertainty of the geological structure. The research explored the maximum contribution that landscape design could make to the restoration process.

Supported by a comprehensive design framework, I developed preliminary designs for various sites, drawing inspiration from water interventions commonly found in traditional water systems. Throughout this process, I recognized that these interventions could be classified into distinct categories based on their functionality. By combining different waterworks, I was able to create diverse types of new landscape spaces. This research journey led me to design different ensembles, and these ensembles, along with subsequent detailed designs, form a cohesive storytelling experience.

Beyond addressing the physical aspects, I aimed to evoke an emotional appreciation for the value of water through the detailed design phase. Creating a spatial atmosphere became crucial in achieving this goal. During this

phase, I relied heavily on experimental research methods, utilizing an array of materials and spatial configurations to craft various types of spaces.

Reflecting on the entire thought process, my research progressed hand in hand with the design, following a step-by-step approach. At any given point, I would build upon existing findings while simultaneously advancing the design in an organized manner based on the research outcomes. This approach ensured the overall design's integrity and logic, establishing a strong foundation for my project as a whole.

08/02/03
Design process

Through the experience of my first year of study at Delft University of Technology in Landscape Architecture, I have continued to reflect on my design process on four levels: Palimpsest, Process, Perception of space and Scales.

_Palimpsest
The design not only responds to the concept of Palimpsest on a physical level, but also incorporates the cultural, social, and historical dimensions of the site's significance. The Amunas water system in the Andes, along with the remnants of terraces in the village, represents the productive activities of ancient Andean communities who respected and adapted to nature. However, the erosion of these traces and the loss of reverence for nature have occurred due to neglect. The restoration of the Amunas and Andean terraces becomes a means of reconnecting with nature in the present.

In the case of urban flood plains that have faced repeated destruction from floods, people have reconstructed their farmland to survive but gradually moved away from the area due to fear and instability. The design proposes an ecological flood wall that works in harmony with the river's flow, following the topography to provide maximum protection for farmland and residential areas. It also presents a new model for responding to future floods.

_Process
The design establishes a collaborative framework between Huamantanga and Lima, divided into three phases: Sowing and Harvesting, Regaining and Retaining, and Circularity and Win-win. Each phase involves the participation of different stakeholders, gradually completing the reconstruction of the entire water system. Additionally, feedback is generated after each design stage, considering seasonal or yearly processes. While the landscape's future is uncertain, the design accounts for various scenarios, including the possibility of flooding after equalizing the river flow.

_Perception of space
The design considers the landscape's essence as a service to people, catering to different sensory experiences of space observers. For local residents, it includes planned routes for restoration stages, agriculture, and daily activities, along with new public spaces for relaxation, farming, gathering, and storage. For visitors, the design incorporates changes in elevation and landscape layout to create diverse routes and ways to explore the site.

_Scales
This design operates across multiple scales, with the largest being the Lima Región. It then extends to the parallel scales of the downstream Chillón River in Lima City and Huamantanga town, and finally to various smaller sites within them. The connectivity of the water system between these sites is also considered, including the downstream town and the urban riverbank. The design framework focuses on the division of scales, with the different ensembles at parallel scales connected through a logical design sequence.

08/02/04
Relevance

In terms of relevance to my graduation project reflection, it is important to note that many arid regions around the world contain remnants of ancient rain harvesting structures. Unfortunately, numerous systems, including the Amunas system, have been abandoned due to unsustainable development practices that exploit natural resources. However, it is worth acknowledging that these structures have proven to be effective in storing water, and they often offer a more cost-effective and environmentally friendly alternative to industrial infrastructure. Restoring the Amunas system can serve as a compelling example and potential model for other arid locations facing similar challenges.

In my graduation project, the connection between Lima, a major city, and Huamantanga, a small town situated in the Andes, through the Amunas water system holds significant relevance.

This connection not only illustrates the importance of the traditional water system in the lives and spiritual world of indigenous communities but also emphasizes its significance within the collective memory of all humanity. The water valuing points mentioned in my graduation project, which highlight the operation of traditional water systems, should be replicated wherever traditional water systems exist.

08/02/05

Feedback and Response

The most rewarding part of my nine-month design journey was learning how to systematically approach a whole design process. Unlike the first year where I designed after learning about the site and the problem to be solved, the final year broke the mold of responding directly to the problem and gave me the opportunity to explore on my own how to find the starting point of design and the desired outcome, and to bridge the gap between the two.

Also, for each phase of research and design, I found the 'research by design' approach to be very helpful. This determined that I had a complete story line of design and research echoing each other at each stage. This allows me to always clear my mind and be able to discuss with my mentor in the right direction.