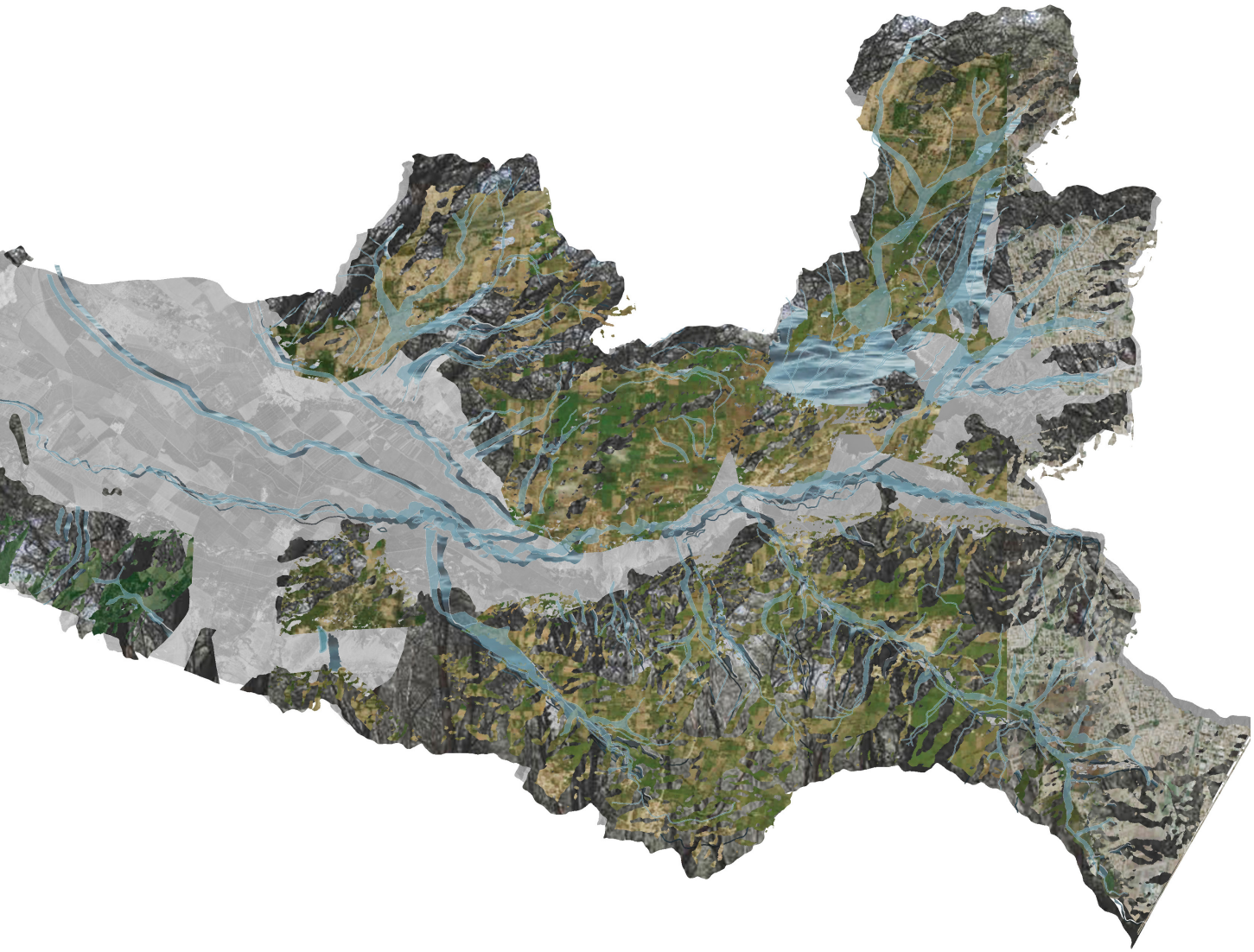
Intertwined Natures

Towards Territorial Cohesion & Flood Risk Adaptation in Lambayeque, Peru

Cristina Wong

TU Delft, Faculty of Architecture, Department of Urbanism
EMU – European Post-master in Urbanism



Intertwined natures

Towards Territorial Cohesion & Flood Risk Adaptation in Lambayeque, Peru

Cristina Wong

TU Delft, Faculty of Architecture, Department of Urbanism
EMU – European Post-master in Urbanism
cristina.wonglent@gmail.com

Supervisors

Dr. ir. Taneha Bacchin
Section Urban Design, Chair of Urban Compositions

Dr. Dominic Stead
Section Spatial Planning and Strategy, Chair Spatial Planning and Strategy

Prof. dr. arch Paola Viganò
IUAV Venice

Cover image: Abstraction of 'Intertwines natures' at the Chancay sub-basin scale

ISBN: 978-94-6366-056-3

EUROPEAN POST-MASTER IN URBANISM EMU
strategies and design for cities and territories

TU Delft

Contents

To my parents & siblings for their unconditional love and support.

‘A landscape is a space deliberately created to speed up or slow down the process of nature. As Eliade express it, it represents man taking upon himself the role of time’.

J.B. Jackson

Abstract

Historically, the regional landscape of Lambayeque has mainly been natural, agricultural, rural and lastly, urban. However, economic development, demographic growth and urban expansion have overpowered the more natural domain creating non–dynamic flows within the system, compressing all functions at the city scale, specially in Chiclayo as the capital of the region. Furthermore, due to climate change, natural disasters are getting more acute leaving behind devastated productive land, infrastructure and small rural towns, affecting mostly vulnerable population. Given that almost half of the region is cover by un–built areas with mixed ecological value, this broader –currently disconnected– landscape holds great opportunity as a linking element with the urban tissue, putting forwards the idea for creating symbiotic relations through green and blue multifunctional infrastructure and, at the same time reinforcing the regional identity. From the aforementioned context, the urgency for an integrative planning comprising urban, rural and natural landscapes arise.

Due to the importance of agriculture not just in the economic dimension, but in the regional idiosyncrasy, productive lots hold the capacity to be integrated into the proposed green and blue initiative re–drawing the inherent connection between wilderness and, man–made landscapes focusing in gathering spaces, which are mainly non–existent within city boundaries.

Furthermore, the territorial understanding is comprised by three natures, the first one refers to wilderness landscapes, the second one to man–made landscapes and the third one to 'highly designed' landscapes, where the third nature is understood as a complex intertwining of ecological elements, communities, cultural services and flows through processes of space & time.

PART 1

Introduction

Introduction | Problem Field | Research Question & Hypothesis | Methodology | Objective | Societal & Scientific Relevance

FIG. 1.1 Location of Lambayeque, Peru
Source: Made by the author

Introduction

FIG. 1.2 Provinces of the region
1- Lambayeque 2-Ferreñafe 3-Chiclayo
Source: Made by author with data from INGEMMET

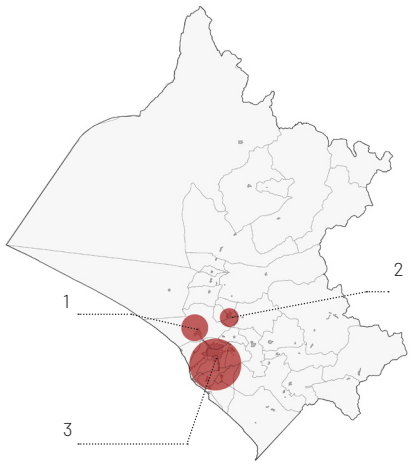


FIG. 1.3 Districts of the region: 38
In red are the cities where most of the population is settled, according to the last census (INEI 2007)
1 Lambayeque: 296 645 inhabitants
2 Ferreñafe: 100 000 inhabitants
3 Chiclayo: 857 405 inhabitants

Source: Ibídem

Economic development experienced by many Latin American countries, such as Peru, has lead to massive movement of population thriving for better opportunities from rural to urban environments, triggering rapid urbanisation in cities, which have been growing organically –without any kind of planning– for decades, causing a myriad of environmental, social and economic challenges to the region, such as climate variability, demographic growth, occupation of hazardous areas and disconnection between the different types of landscapes. Moreover, due to climate change natural phenomenons are getting more acute leaving behind devastated productive land, infrastructure and small rural towns, affecting mostly vulnerable population.

Lambayeque region is located in north–western Peru, 13 kilometres inland from the Pacific coast and 780 kilometres from the capital of the country, Lima. In the year 2007, the population reached 1 260 650 inhabitants (INEI 2015) 1. The city of Chiclayo is the capital of the region, its the fourth major city of the country and the second one regarding density [87,1 inhabitants/km^2] after Lima [282,4 inhabitants/km^2].

The hydrography of the region is mainly comprised by four rivers: Olmos, La Leche, Chancay–Lambayeque and Zaña.

Lambayeque is politically subdivided into 3 provinces –Chiclayo, Ferreñafe and Lambayeque– and 38 districts. The continental and insular area of the region is 14 231km2 (INEI 2008); the small insular area of 18km2 is comprised by two islands: Lobos de Afuera, and Lobos de Tierra. This islands hold great ecological potential due to the diverse fauna settled there. By the last century, large amounts of guano –natural fertiliser– were found in the islands, which caused an unsustainable extraction of the resource, which until nowadays, has not being recovered.

Economic flows are driven by agriculture –rice, sugar cane and fruits–, commerce, agriculture, tourism and services. The GDP of the region accounts for the 8.6% of the total of the country.

The climate is arid semitropical, with high atmospheric humidity and scarce rainfall –50 mm per year in the lower areas and 1000 mm per year in the higher areas–. During extreme events such as El Niño or La Niña Phenomenons, precipitations levels increase up to 1800 mm per year in the lower areas, as what happened in 1983 and 1998.

1 This shift started in the decade of 1960, when the urban population started its rapid growth. Data from United Nations: World Urbanization Prospects, the 2014 revision on https://esa.un.org/unpd/wup/Country-Profiles/ [Accessed on March 2018]

FIG. 1.4 Patterns along the territory: Pacific Ocean, desert/dunes, temporal lagoon, rivers, productive land, mountains.
Data source: Apple Maps, 2018

Problem Field

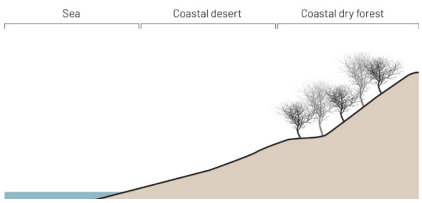


FIG. 1.5 Altitudinal section showing the main ecoregions of Lambayeque: sea, coastal desert, coastal dry desert.
Source: Made by author

Introduction: Three Natures

The leap from general landscape to landscape urbanism can be well understand by the description of what John Dixon Hunt called the 'Three natures', in which the first nature refers to wilderness and natural landscapes, the second nature refers to agriculture, urban development, and infrastructure; finally, the third nature are highly designed landscapes, comprised by ideas and experiences, which are reflections of the processes of the first and second natures, resulting in interventions of the landscape.

> 'It must be emphasised that the arithmetic of 'three natures' is symbolic, not literal and certainly not prescriptive, nor does it necessarily privilege the third over the other two natures. It is meant to indicate –after the manner of Taegio and Bonfandio– that a territory can be viewed in the light of how it has or has not been treated in space and in time'. (Dixon Hunt 2000: 35)

It is on this regard, that Dixon's theory is taken as the first step for the initial understanding of the territory, since the scope of the theory is not only the natural world, but the unveiling of relationships among these three natures.

First Nature: Wilderness Landscapes

Territory of Contrasts
Lambayeque is a territory of contrasts, from the sea to the mountains different landscape patterns arise in between: the open ocean with its sandy beaches, dunes and dry forests bathed by a bright sunlight almost every day of the year, agrarian interventions, wild territories and finally, the mountains. The Andes is where rivers emerge from the highest point at 3,078 m meters above sea level, to subsequently run across the region until its catchment areas either on La Niña Lagoon or the Pacific Ocean.

The relatively untouched countryside accounts for more than half of the region, however its totally unlinked from the cognitive map of the inhabitants. Economic development thriving in the region lead to the shift from an agrarian society to a more urban one [1], causing a breach between the urban environment and its outskirts. It is worth noting that this disconnection among landscape patterns represents a potential to the construction of a sustainable urban dimension. Moreover, this void can create a sense of opportunity for new relationships within the system.

Dry Forest
Dry forests 'are the transition between the desert in the south of Peru and the humid coastal jungles of Ecuador and Colombia' (Minam 2014: 134). The term 'dry' does not imply the total absence of rainfall, but highlights the irregularity and unforeseen

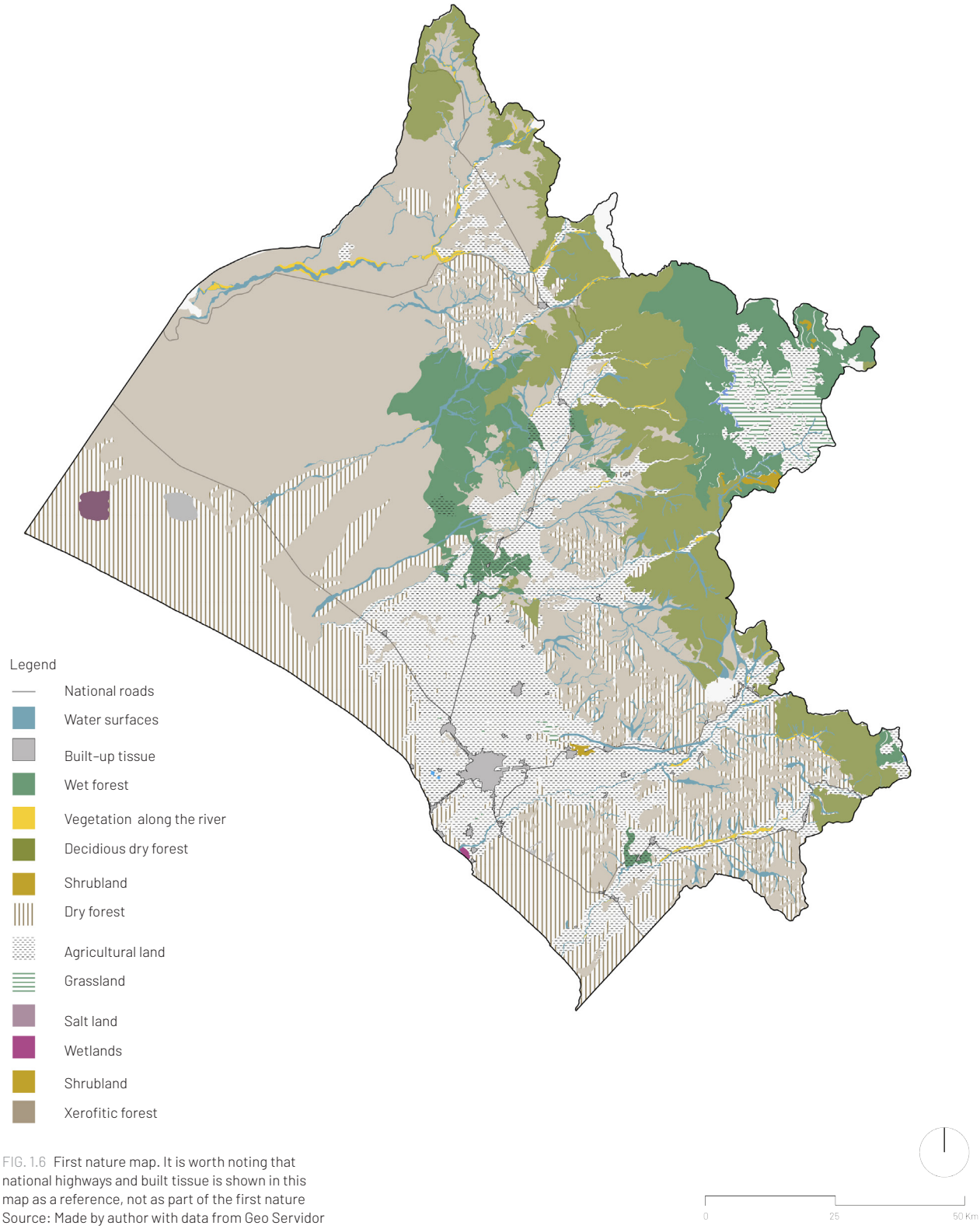


FIG. 1.6 First nature map. It is worth noting that national highways and built tissue is shown in this map as a reference, not as part of the first nature
Source: Made by author with data from Geo Servidor MINAM

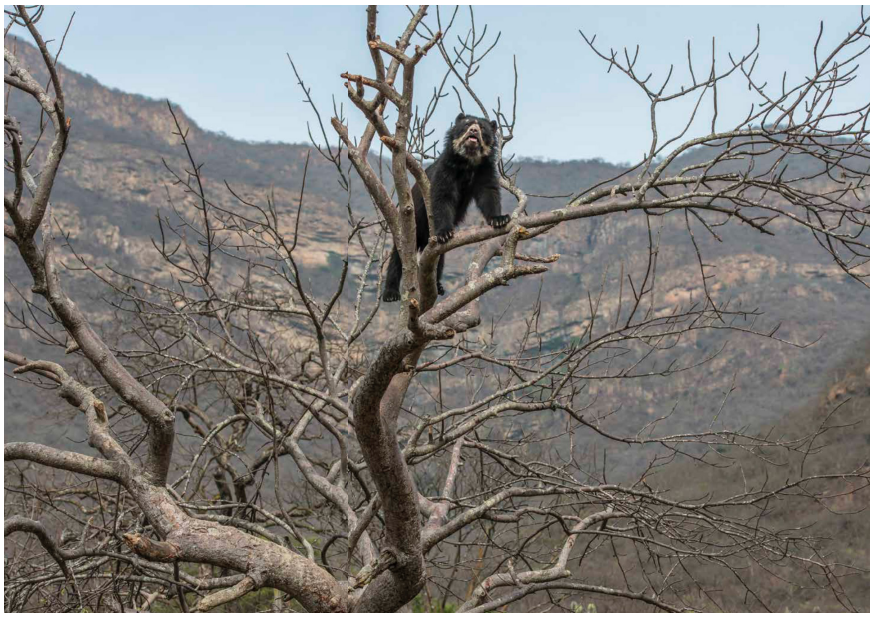


FIG. 1.7 Ceiba tree

FIG. 1.8 Porotillo tree

FIG. 1.9 Spectacled bear
Source: Peru, Kingdom of Forests. 2014

rains.

The ecosystem of the coastal dry forest can maintain its rich fauna and flora without any precipitations, sometimes up to 9 months. Within thousands of years, species learn how to cope with the dryness of the forest, such as the ubiquitous carob tree 'never fades or loses its leaves even on the driest and hottest days' (Minam 2014: 147), moreover, its roots can go deep into the ground until 40 meters looking for water. Or the case of the ceiba tree, which 'functions as a camel', since its hump shaped trunk fills with water during rain season. A myriad of cacti species can be found in the dry forest, growing up the size of a tree.

> 'During the rainy seasons, the people of the north burn kindling [of *Palo Santo* or Holy Wood] to repel mosquitoes and to perfume their houses at vigils performed during *Semana Santa*, the Peruvian Holy Week. They believe that the white penetrating smoke will do them well and protect them from sadness. However, another one is the miracle tree of the dry forest'. (Minam 2014: 137)

Moreover, national endemic species such as white-winged guan and the spectacled bear are being protected in restricted areas.

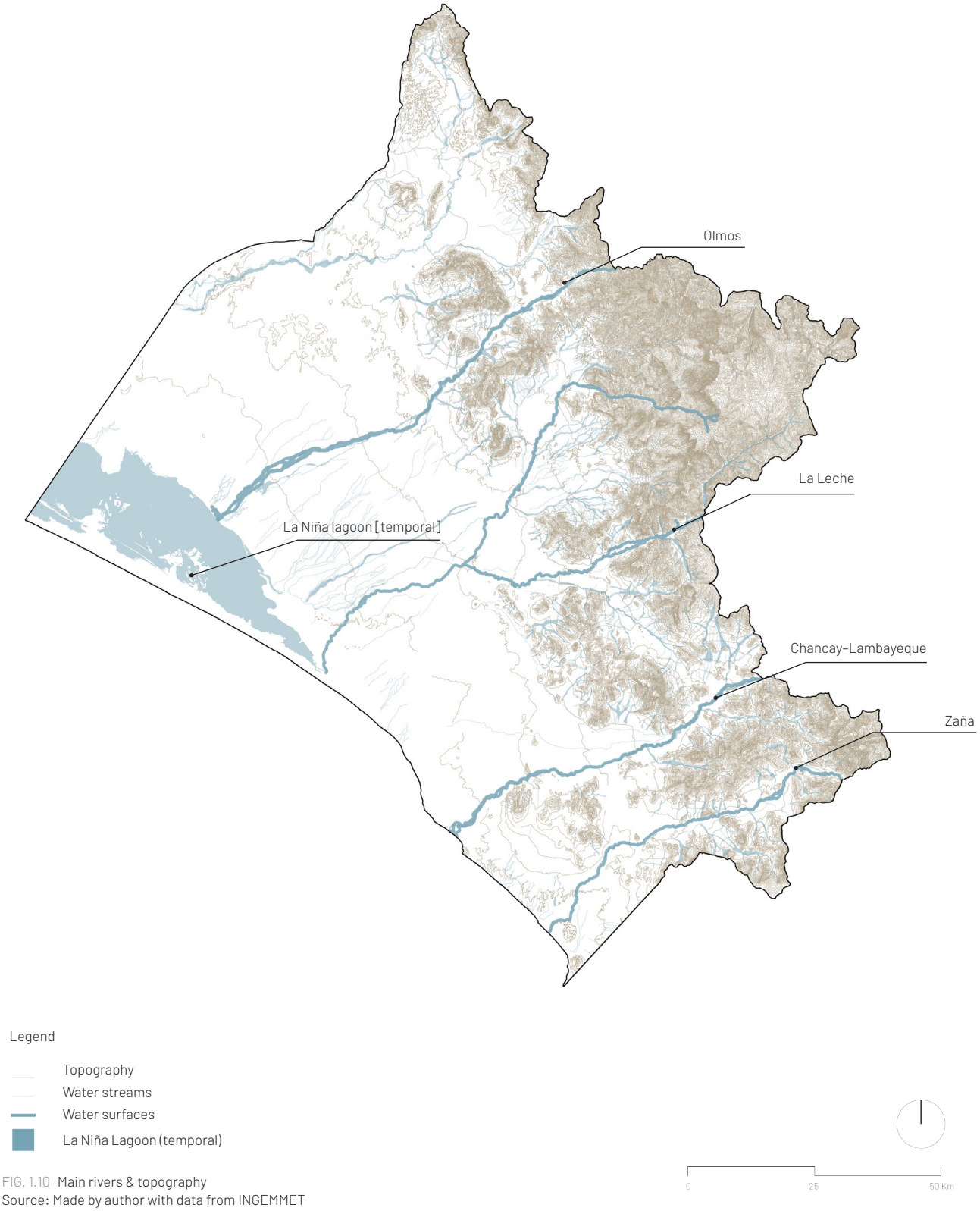


FIG. 1.10 Main rivers & topography
Source: Made by author with data from INGEMMET

1 Olmos river

2 La Leche river

3 Chancay–Lambayeque river

4 Zaña river

FIG. 1.11 Four rivers: [1] Olmos, [2] La Leche, [3] Chancay–Lambayeque, [4] Zaña
Source: Author

Four rivers

Main rivers of the region have similar features: irregular discharge regime, with periods of major flow from January until March and long periods of groundwater recession flow. Amidst the rivers and streams of Lambayeque region, the following rivers are of particular importance:

– Olmos River

Olmos is a seasonal river with low and irregular volume that origins at the altitude of 2055 metres, and runs mainly throughout the coastal desert of the region with the exception of the city with the same name, where the river passes by at 500 metres.

An irrigation and hydro-energetic project is been under planning and construction for more than 50 years, *Proyecto Especial de Irrigación e Hidroenergético de Olmos*, in this zone. The project consists on transferring of the water from the Huancabamba river from the Atlantic slope to the Pacific catchment area through a trans-Andean tunnel of 20km in order to irrigate a highly productive but deserted area, increasing agricultural production.

– La Leche River

La Leche river responds to Motupe or Mórrope river as well, depending on the settlement that crosses. The river originates in 'Las Juntas' at the altitude of 40 metres and, ends in La Niña Lagoon, where the Mórrope desert and the dunes prevent it from reaching the sea.

In 1998, after the Fenómeno el Niño –El Niño phenomenom– a 800 m3 / s capacity canal was built and two streams were geared towards the desert through emergency dikes. Water volumes resulting from this diversion created La Niña Lagoon.

– Chancay–Lambayeque River

This river starts at the latitude of 3800 metres in the Cajamarca region and is the one that runs more closely to the city of Chiclayo, thus, it is the water course that is more ingrained physically and mentally for the inhabitants. Furthermore, it is the main affluent for the Tinajones dam.

While in the middle slope, Chancay river gets to a distribution point, near the rural settlement Pampa Grande, where the river is divided into three: Lambayeque river, used for irrigation purposes in the valley, Taymi canal –which is the main water source of Chiclayo– and Chancay river, also known as Reque river, for its proximity with the city of the same name.

– Zaña River

This river starts at the latitude of 3800 metres in the Cajamarca region and runs through the cities of Zaña, Cayalti, Oyotún and small rural towns.

FIG. 1.12 Reservoir part of Olmos Special Project for irrigation purposes
Source: Author

FIG. 1.13 La Leche river
Source: Author

FIG. 1.14 Chancay river
Source: Author

FIG. 1.15 Zaña river, nearby to the catchment area in the sea
Source: Author

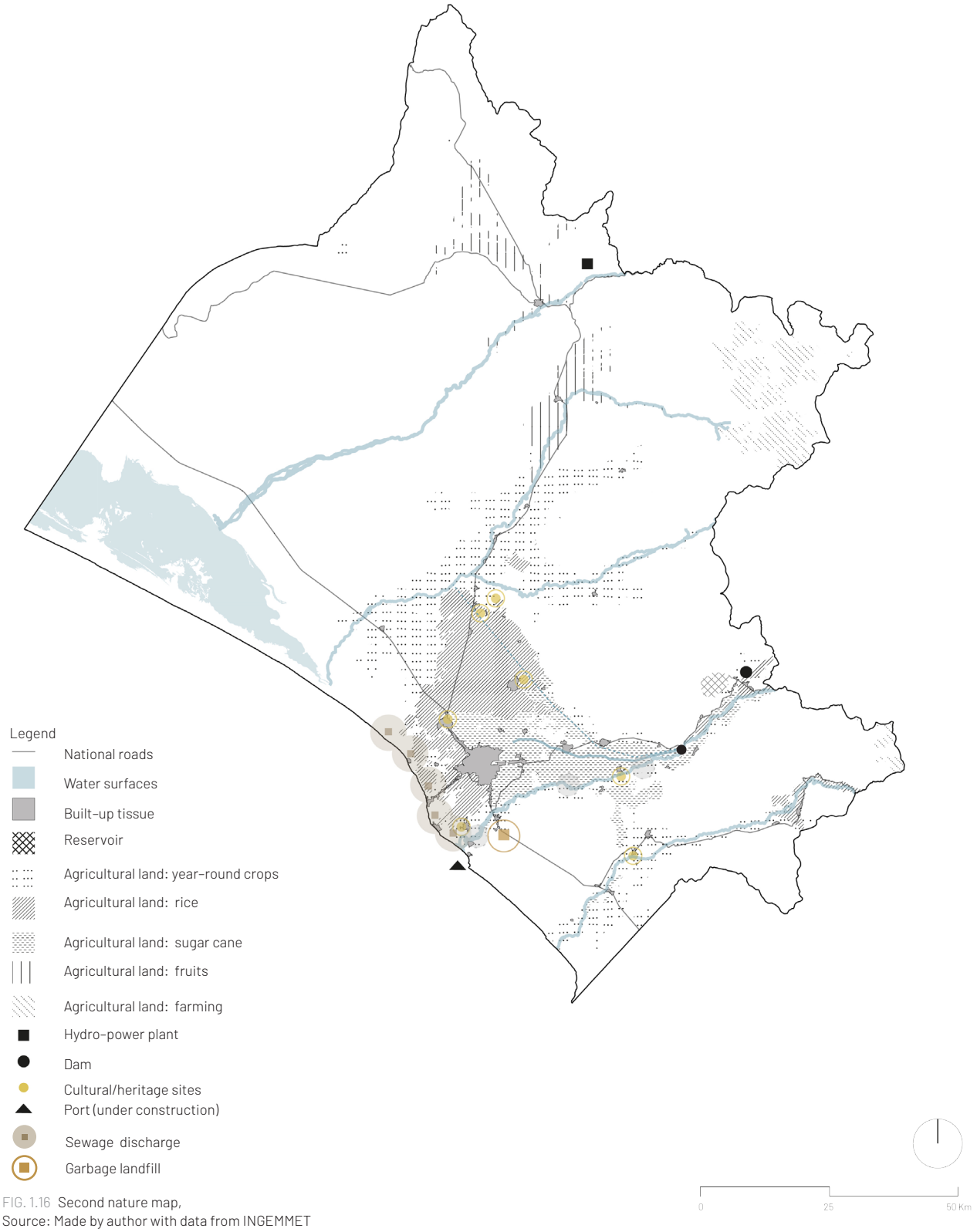
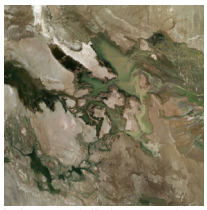


FIG. 1.16 Second nature map,
Source: Made by author with data from INGEMMET


Landscape pattern: La Niña Lagoon -temporal


Landscape pattern: dunes


Landscape pattern: La Leche river

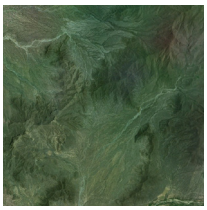

Landscape pattern: Laquipampa -decidious dry forest

FIG. 1.17 First Nature patterns: La Niña temporal lagoon, dunes, La Leche river, and dryf forest of Laquipampa reserve.
Source: Made by author with data from: Apple Maps, 2018


Landscape pattern: Chiclayo city


Landscape pattern: Panamericana highway crossing Chancay-Lambayeque river


Landscape pattern: industrial agriculture

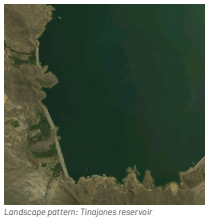

Landscape pattern: Tinajones reservoir

FIG. 1.18 Second Nature patterns: built tissue of Chiclayo city, Panamericana highway crossing the Chancay valley, agriculture and Tinajones reservoir.
Source: Ibídem

Second Nature: Agricultural, Cultural & Infrastructural Landscapes

Dixon's second nature can be understood as the landscapes where man-made constructions appear: agricultural and cultural landscapes, urban development and infrastructural landscapes such as roads, bridges, ports, among others.

The remarkable cultural landscape of Lambayeque derives mainly from its natural condition, constraining urban developments to settle south-west of the region, benefiting from the direct link to the sea, as in its origins. In fact, the name of Lambayeque derives from the legend of the mythological figure of Naylamp and its birth and relationship with the sea.

Agriculture

Agriculture is one of the main economic actives of the region. Most of the crops that can be found in the region are: rice and sugar cane, fruits such as mango and grapes. A part of the agricultural production is exported.

Heritage

Lambayeque is one of the most important regions of the country regarding heritage, given to the pre-Inca culture settled here in the VIII and XIV century: Lambayeque -also called Sicán- culture.

Lambayeque culture excelled in architecture, construction, ceramics and navigation. Some of the sites still remaining are: Túcume Pyramids, Huaca Rajada, Sipán tomb, Ventarrón. These archeological zones are usually accompanied by museums.

Other important heritage sites are: the city of Monsefú for its traditional handcrafts, San Agustín church in Zaña, among others.

Built tissue

The main city of the region is Chiclayo, which comprises most of its population, economic flows, services and activities. Given its strategic place as a geographic and commercial node between Andean and other Northern coastal cities, growth of population has resulted in the expansion of the city to the nearest smaller cities along main highways: specially concentrated in Chiclayo-Lambayeque (North-West), Chiclayo-Pimentel (West) and Chiclayo-Reque (South) highways.

Waste infrastructure

The term 'waste' is not understood as the under-used or wasted landscapes defined by Berger in Drosscapes (2006) but as the infrastructural landscape related to it given that 'nature produces waste as it grows' (Berger 2006: 1).

This category highlights the importance to incorporate waste flows as part of the main layers for design. Landfills for solid waste and grey water flows are considered waste -infrastructural- landscapes, as well as their subsequent treatment.

FIG. 1.19 Pimentel city, view towards the east
Source: Author

FIG. 1.20 Traditional agriculture production
Source: Author

FIG. 1.21 Built patterns along the years. Zoomed–in area where the three main cities are located. Source: Made by author / Data: Google Earth 2018, INEI 2015

When describing garden as the third nature, Cicero and Bonfadio are the main authors Dixon Hunt refers to. On the one hand, Bonfadio mentioned the territory of unmediated nature, what nowadays can be understood as 'wilderness', term coined by Dixon Hunt as the first nature. On the other hand, Cicero refers to the second nature as *alteram naturam* or alternative nature, which is where humans create by their own work 'a second second nature within the natural world'. Making reference from Cicero, Dixon Hunt continues: 'Garden now takes their place as a third nature in a scale or hierarchy of human intervention into the physical world: gardens become more sophisticated, more deliberate, and more complex in their mixture of culture and nature than agricultural land '. (Dixon Hunt 2000)

Furthermore, third nature is understood as the combination of the other two natures, where the first two natures can be used as a background for the making of new relations.

The 'highly designed landscapes', where 'meaningful distinctions and gradations of interventions' are proposed' (Dixon Hunt 2000: 35), will be further illustrated in the design part of the thesis.

Problem Field

Following the term 'territory of contrasts' the first challenge to take into consideration on Lambayeque is related to water: either exceedance or lack of the resource. On the one hand, flood risk, can be coastal due to sea level rise; on the other hand, river flood, mostly caused by natural phenomenons. Moreover, taking into consideration that a great portion of the territory is cover by dry forests, the region is prone to droughts as well. Furthermore, the first section "Flood Risk takes into consideration water–related issues such as water pollution, negative mentality towards canals and ditches due to its unpleasant view on the urban tissue, hidden water infrastructure and finally, no treatment for waste water.The second challenge faced by Lambayeque is the lack of physical and mental connection among the different types of natural landscapes.

External Threats

By the year 2050, the national population could increase from currently 30.8 to 40.1 million people.

Demographic and economic development (>5%/year over the last years) experienced by Peru, has lead to massive movement of population thriving for better opportunities from rural to urban environments –from the 1950's–, triggering rapid urbanisation in cities, which have been growing organically –without any kind of planning– for decades, causing a myriad of environmental, social and economic challenges to the region, such as climate variability, demographic growth and occupation of hazardous areas. Moreover, challenges resulting from increasing urbanisation are urban heat island effect, alteration of hydrological regime, loss of biodiversity and increased vulnerability in case of climate change and natural phenomenons, which are getting more acute leaving behind more devastated productive land, cities and small rural towns, affecting mostly vulnerable population.

FIG. 1.22 El Niño phenomenon, 1997 at Tres Tomas dam
Source: Ignacio Alva

1 Flood from Coastal El Niño, La Leche valley

2 Flood from Coastal El Niño, La Leche valley

3 Tinajones reservoir during drought season, 2014

4 Poor condition of ditches in city of Chiclayo

FIG. 1.23 Sources:
[1] AFP news
[2] www.elcomercio.pe
[3] Ibidem
[4] www.peru.com

1. Flood Risk

Historically, natural disasters have mainly triggered water related issues such as floods, increase of river flows, extreme rainfall –10 times higher amount than average–, drought, pollution, among others. According to Tucci (2009) floods resulting from natural disasters are the main vulnerability suffered by developing countries.

In the Peruvian context Fenómeno El Niño is the main natural phenomenon to take into consideration, it affects the country every 3 to 7 years, during the months of December and January, resulting in a sever impact not only on the national level but in the global weather.

> 'The term El Niño refers to the large-scale ocean-atmosphere climate interaction linked to a periodic warming in sea surface temperatures across the central and east-central Equatorial Pacific'. (NOAA)

Consequences of this phenomenon are: heavy rains, extreme rise of the temperature due to the heating of the Humboldt Current, diseases outbreak such as cholera, which become an epidemic in the past, intense cloud formation, extremely wet periods, low atmospheric pressure, and finally, given the temperature changes some fauna and flora dies.

The years when El Niño Phenomenon affects the country, there is a decrease of the national GDP, 7% in 1983 and 5% in 1998 respectively. With the current GDP this would account for 10 000 millions US dollars.

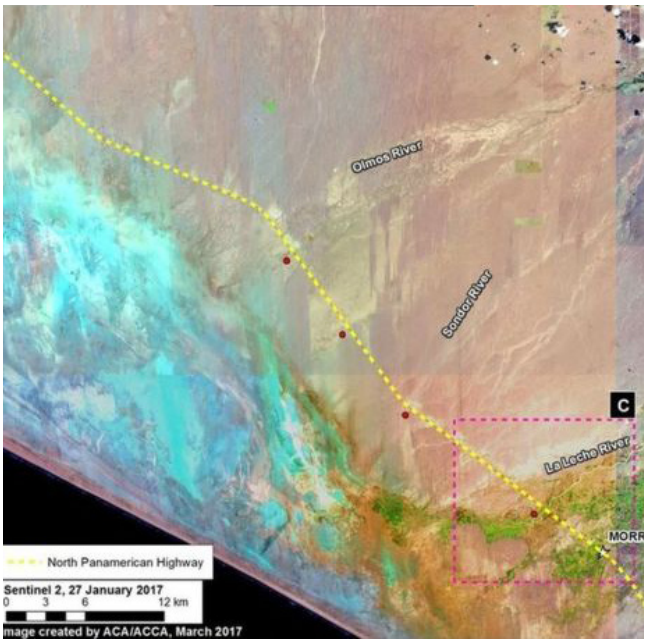
Superficial Hydrological Resources

Anual Catchment Rate / River	Average	El Niño Phenomenon 1998
Chancay-Lambayeque	850 Hm3/year	3000 Hm3/year
La Leche	165 Hm3/year	1800 Hm3/year
Zaña	850 Hm3/year	1200 Hm3/year

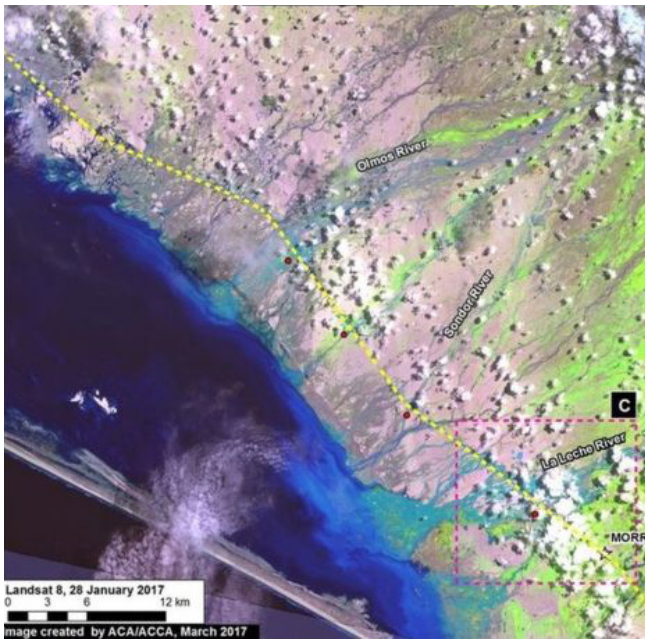
Source: Made by author with data from Hydrological Development Plan of Lambayeque Region,

It is worth noting that water related issues are the most striking in the region. This sub-chapter is called 'Flood risk' since its the vulnerability that causes more damage. However, other challenges related to water that are going to be addressed in the design part are: drought, pollution, lack of connection and visibility of water streams in the greater region, negative mentality towards canals and ditches due to its unpleasant view on the urban tissue, hidden water infrastructure and finally, no treatment for waste water.

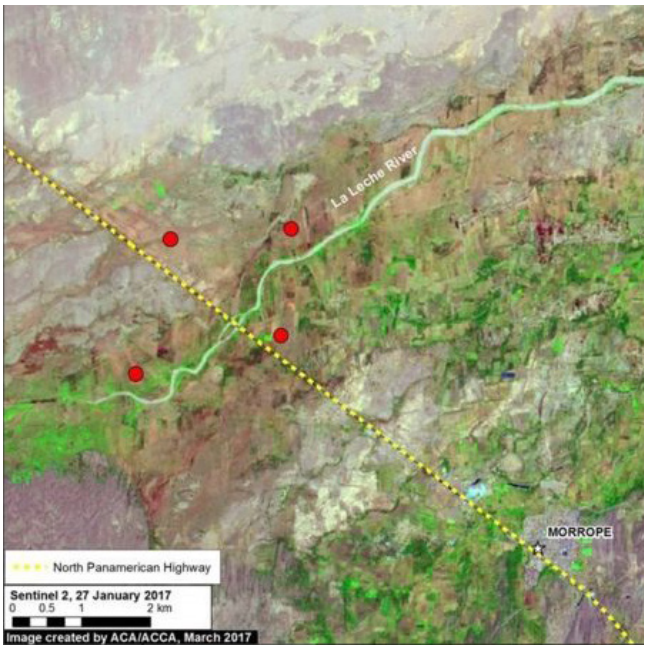
> 'High rates of water withdrawal and groundwater depletion already represent a problem for a sustainable water supply in different coastal catchments, especially for small-scale cultivators and in the context of saline intrusions'. (Drenkhan et al. 2015: 723)



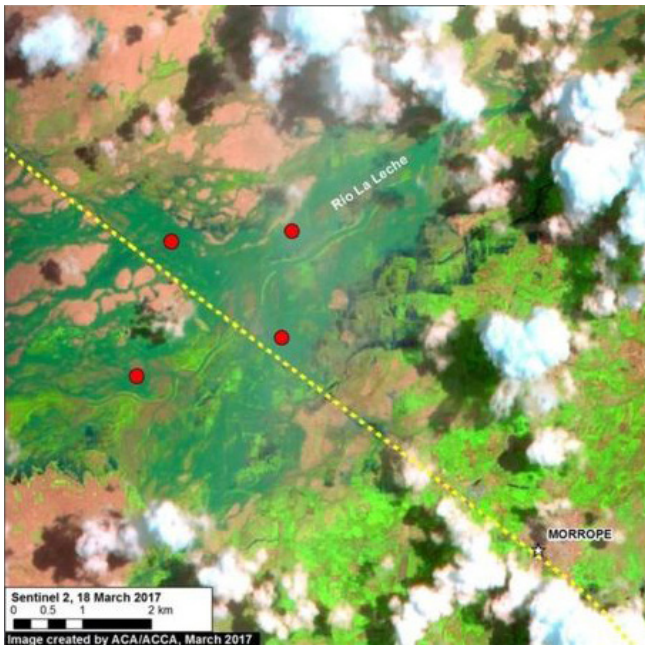
1



2



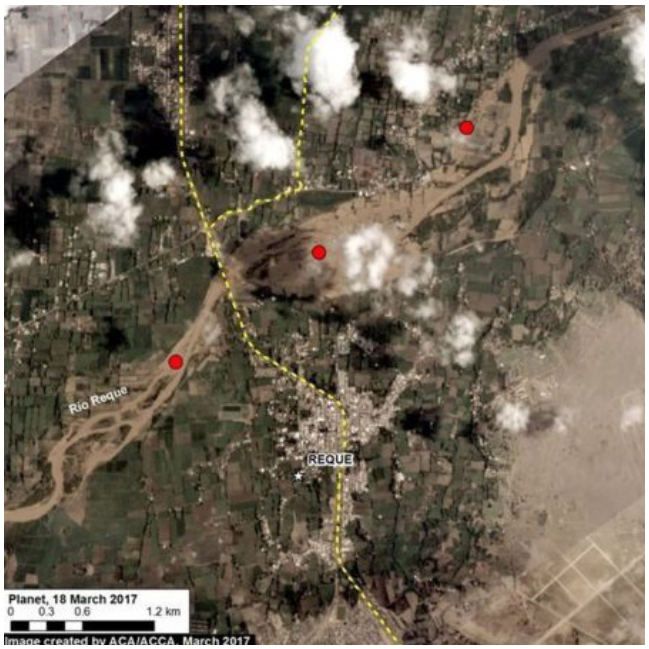
3



4

[1] Average view of La Niña lagoon, located in the coastal desert.
[2] La Niña lagoon after one and a half month of intense rainfall, receiving water flows from Olmos river, Sondor river and La Leche River. In ordinary conditions, these streams which in normal conditions cease when encounter the dunes. The location of images [3] and [4] is shown with a pink square.
[3] Average view of La Leche river.
[4] Flooding of several hectares of agricultural land. Small rural towns along the river were affected as well
Source: MAAP, Monitoring of the Andean Amazon Project

1



2

FIG. 1.24 [1] January, 2017. Average view of Chancay river.
[2] March, 2017. Flooding of several hectares of agricultural land. Small rural towns along the river were affected as well
Source: MAAP, Monitoring of the Andean Amazon Project

Coastal El Niño

In the year 2017, a short-term climate variation emerged named 'Coastal El Niño'. Unlike El Niño phenomenon, Coastal El Niño had a localised effect, affecting the northern part of Peru and Ecuador.

It caused extreme rainfall, flooding and mudslides in the country, specially in the coastal northern part. 14 out of the existing 25 regions of the country were declared in state of emergency, leaving 158 casualties, 1 097 859 affected population and several hundreds of houses and critical infrastructure such as bridges and highways collapsed (INDECI 2017), leaving entire communities disassociated from the rest of the region and the country Moreover, several disease outbreaks occur as a consequence of the phenomenon –having to declare 9 regions in state of health emergency–, and vast agricultural areas were flooded, resulting in large economic losses.

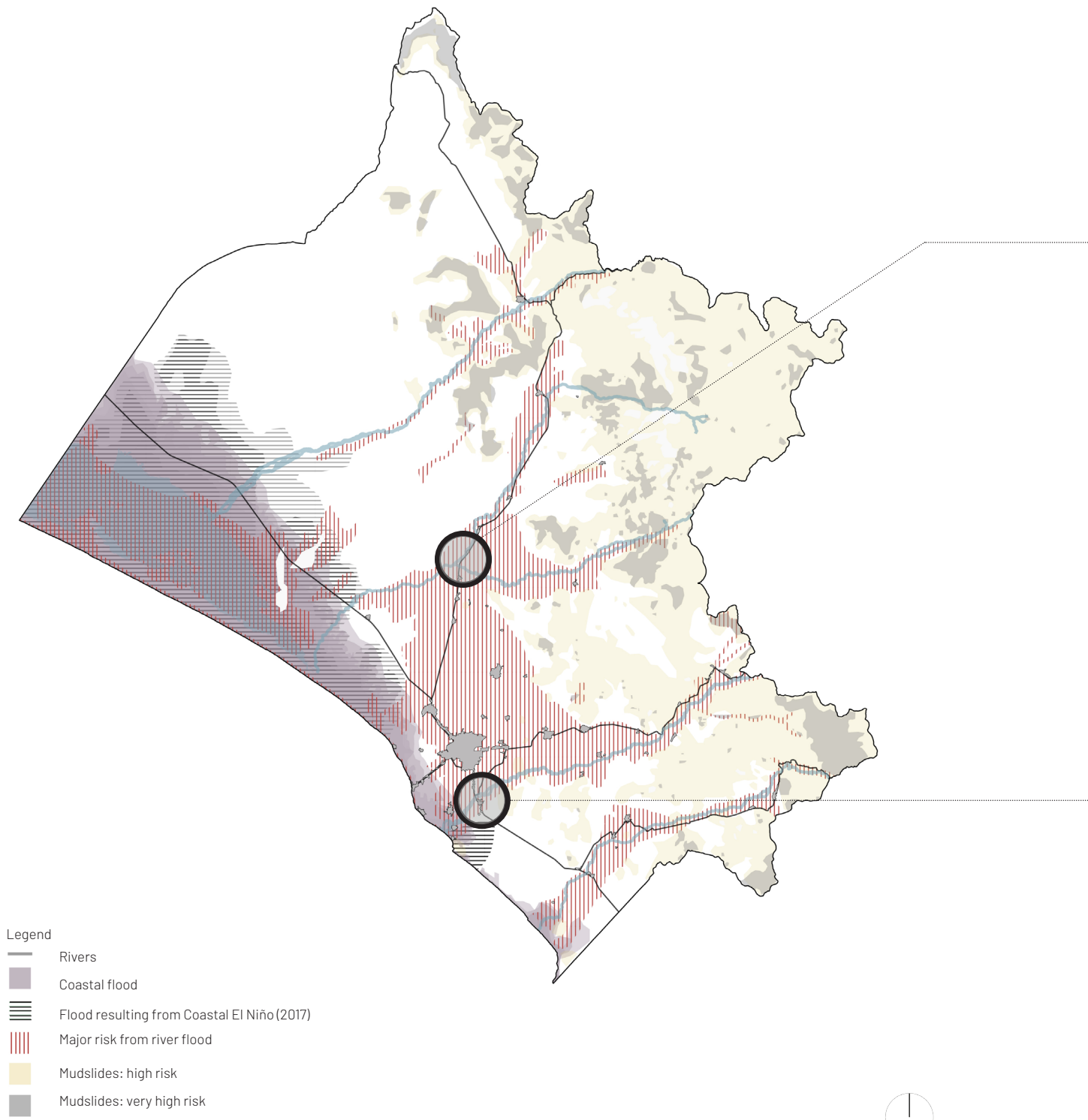


FIG. 1.25 Vulnerability map
Source: Made by author with data from Geo Servidor MINAM

1

2

3

4

FIG. 1.26 [1] Chancay river, with view of Reque bridge. El Niño Phenomenon, 1998.
Source: Hydrological Development Plan of Lambayeque Region, 2014

[2] Chancay river, with view of the Reque bridge. El Niño Costero Phenomenon, 2017.
Source: www.elcomercio.pe

[3] La Leche river flooding of 2008 left the North-east part of the country inaccessible for several weeks.
Source: Ibidem

[4] La Leche river during Coastal El Niño, 2017.
Source: www.andina.pe

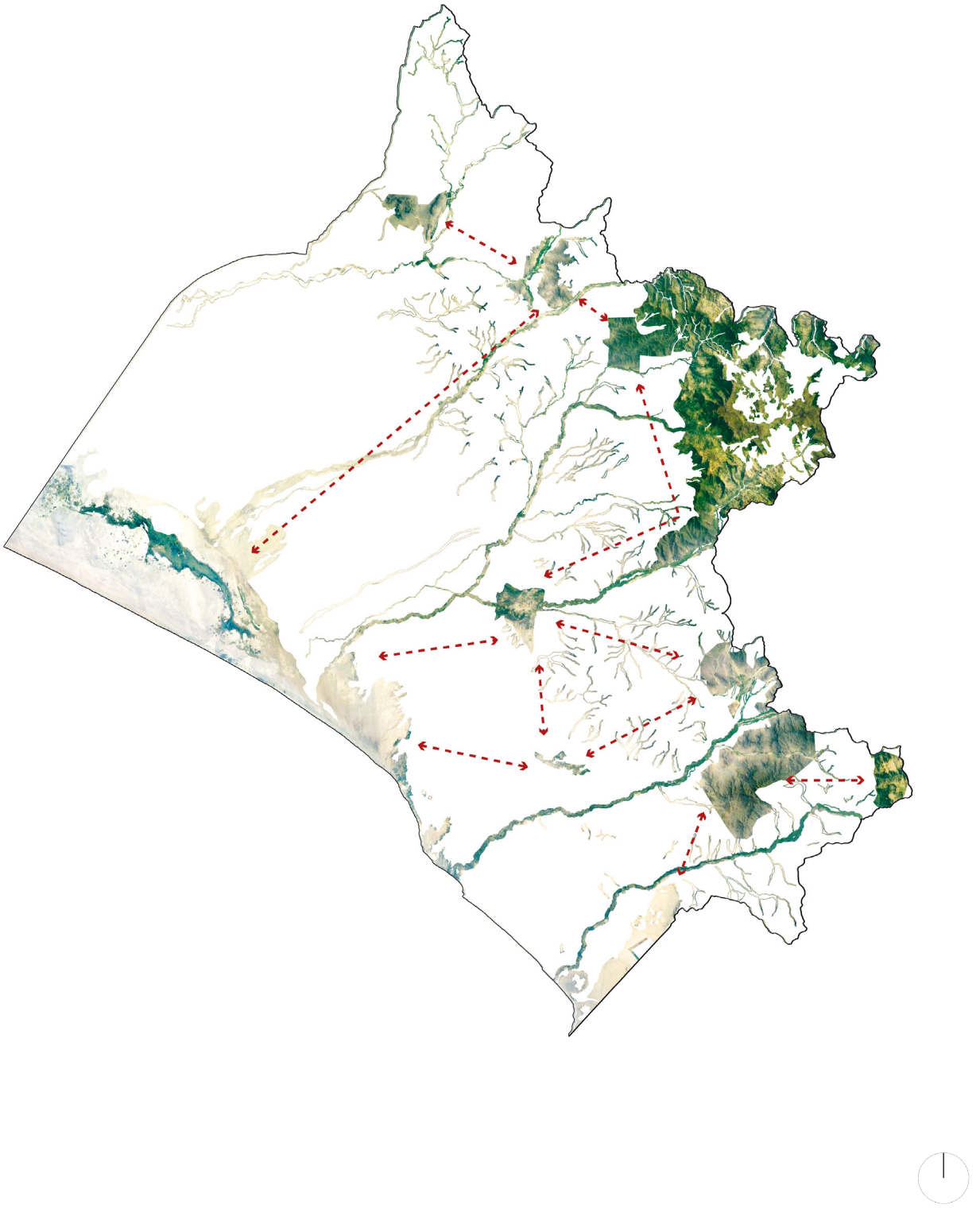
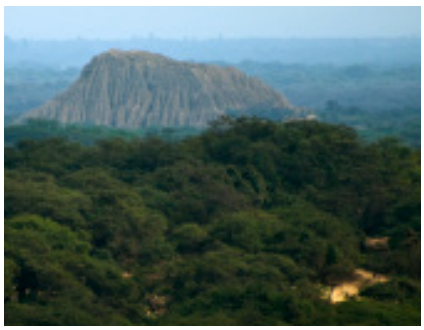


FIG. 1.27 Disconnection of green patches diagram
Source: Made by author

1

2



3

FIG. 1.28 [1] Dry forest during dry season
Source: Peru, Kingdom of Forests, 2014
[2] Dry forest during wet season
Source: Ibidem
[3]Pómac forest with view of the pyramids
Source: SERNANP, Peru

2. Disconnected Landscape

Historically, the regional landscape of Lambayeque has mainly been natural, agricultural, rural and lastly, urban. However, as explained before economic development, demographic growth and urban expansion have overpowered the more natural domain creating non-dynamic flows within the system, compressing all functions at the city scale, specially in Chiclayo as the capital of the region.

Given that almost half of the region is cover by un-built areas with mixed ecological value, this broader landscape holds great opportunity as a linking element with the urban tissue, holding the capacity for creating symbiotic relations through green and blue multifunctional infrastructure.

The national and regional protected areas are designated by SERNANP -Service of National Natural Protected Areas -. The region has 5 areas:

– National Historic Sanctuary: Pómac forest [5 887,38 hectares]
Pómac Forest is one of the four Historic Sanctuaries of the country, along with Machu Picchu, Chacamarca and Pampa de Ayacucho. It is worth noting that is the only one located in the coastal-northern part of the country.

It is the main natural area of the region and it is categorised as tropical dry forest, where the emblematic carob tree is found in abundance. Its importance lies not only on the ecological dimension but in the archeological site located in it called Sicán (or Batán Grande), where an architectural complex of 20 truncated adobe pyramids were found. Moreover, Sicán is the most important archeological zone from Lambayeque Culture, that dates back to the VIII and XII centuries, and it is considered National Cultural Heritage.

– National Wildlife Refuge: Laquipampa [8,328.64 hectares]
Laquipampa offers a unique set of ecological conditions and landscape given its altitude -from 200 until 2500 meters of altitude-, specially in a region where most of the population lives at less than 30 meters above sea level. However, extremely poor conditios of the roads makes it almost unaccessible.

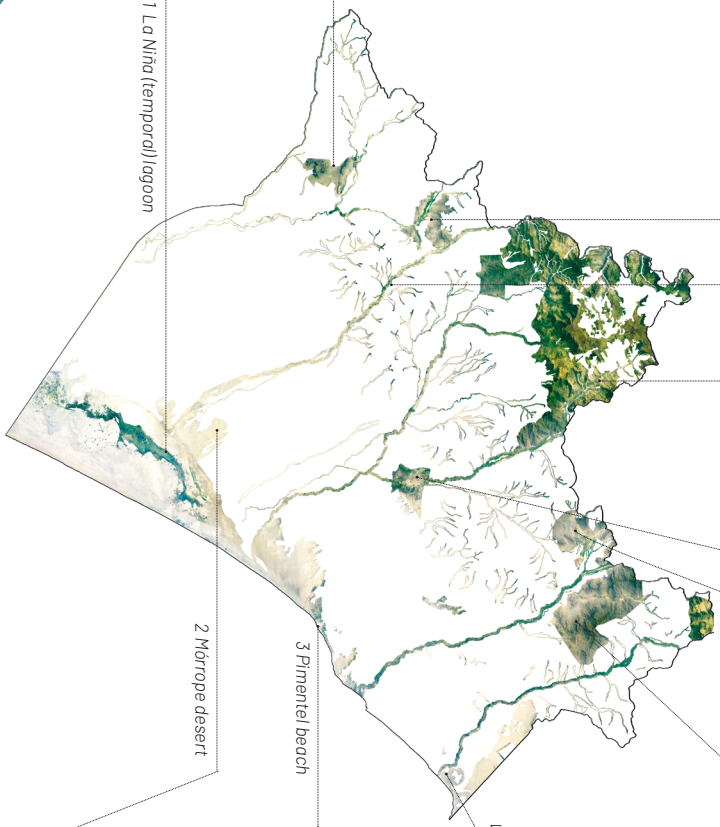
– Regional Conservation area: Huacrupe-La Calera forest

– Regional Conservation area: Moyán Palacio forest

– Regional Private Conservation Area: Chaparrí [34,412 hectares]
It is a unique kind of conservation area in the country, since it is lead by the peasant community Muchik Santa Catalina de Chongoyape, since its formation in 1999. It is an innovative model for community involvement in conservation and ecotourism; however, the area is frequently threatened by fires, invasions and land traficking.

11 Huacrupe – La Calera Forest [RCA]

1 La Niña (temporal) lagoon



7 Pómac Forest [NHS]: vie

2 Mórrope desert

3 Pimentel beach

4 Zaña river mouth

5 Chaparrí [RPCA]

10 Moyán-Palacio Forest [RCA]

9 Olmos' surroundings

8 Laquipampa [NWR]

ew of Tucume Pyramids and La Leche River [NCA]

6 Tinajones Reservoir

FIG. 1.29 Main green patches and natural-cultural attractions of the region.
Sources:
1 & 2 www.suramericaencleta.com/2009/08/05/una-semana-de-mucho-esfuerzo-y-reflexion/dunas/
3, 4, 9, 10 Author
5 www.turismoruralcomunitario.com.pe
6 www.piuraenlambayeque.com
7, 11 Environment Ministry, SINIA
8 www.chaskiventura-travel-peru.com/ecotourism-in-peru-laquipampa-the-door-to-the-sky
Abbreviations:
[RCA] Regional Conservation Area | [NWR] National Wildlife Refuge|
[RPCA] Regional Private Conservation Area | [NHS] National Historic Sanctuary

FIG. 1.30 Natural landscape near Olmos city
Source: Author

Problem Statement

Historically, the regional landscape of Lambayeque has mainly been natural, agricultural, rural and lastly, urban. However, economic development, demographic growth and urban expansion have overpowered the more natural domain creating non–dynamic flows within the system, compressing all functions at the city scale, specially in Chiclayo as the capital of the region. Furthermore, due to climate change, natural phenomenons are getting more acute leaving behind devastated productive land, infrastructure and small rural towns, affecting mostly vulnerable population. It is worth noting that natural disasters such as Fenómeno El Niño not just affects communities and agricultural land in the middle and lower slope of the region, but the few remaining dry forest patches , which are mainly comprised by carob trees,a native specie able to survive without water from most part of the year, however excess water kills them.

From the aforementioned context, the urgency for an integrative planning comprising urban, rural and natural landscapes arise. An opportunity to use green and blue networks and to design landscape as infrastructure as the linking element among the broad territory. Moreover, this can be taken as an opportunity to address both problems along different timeframes, the sporadic one and the permanent one, ensuring the creation of a regional identity.

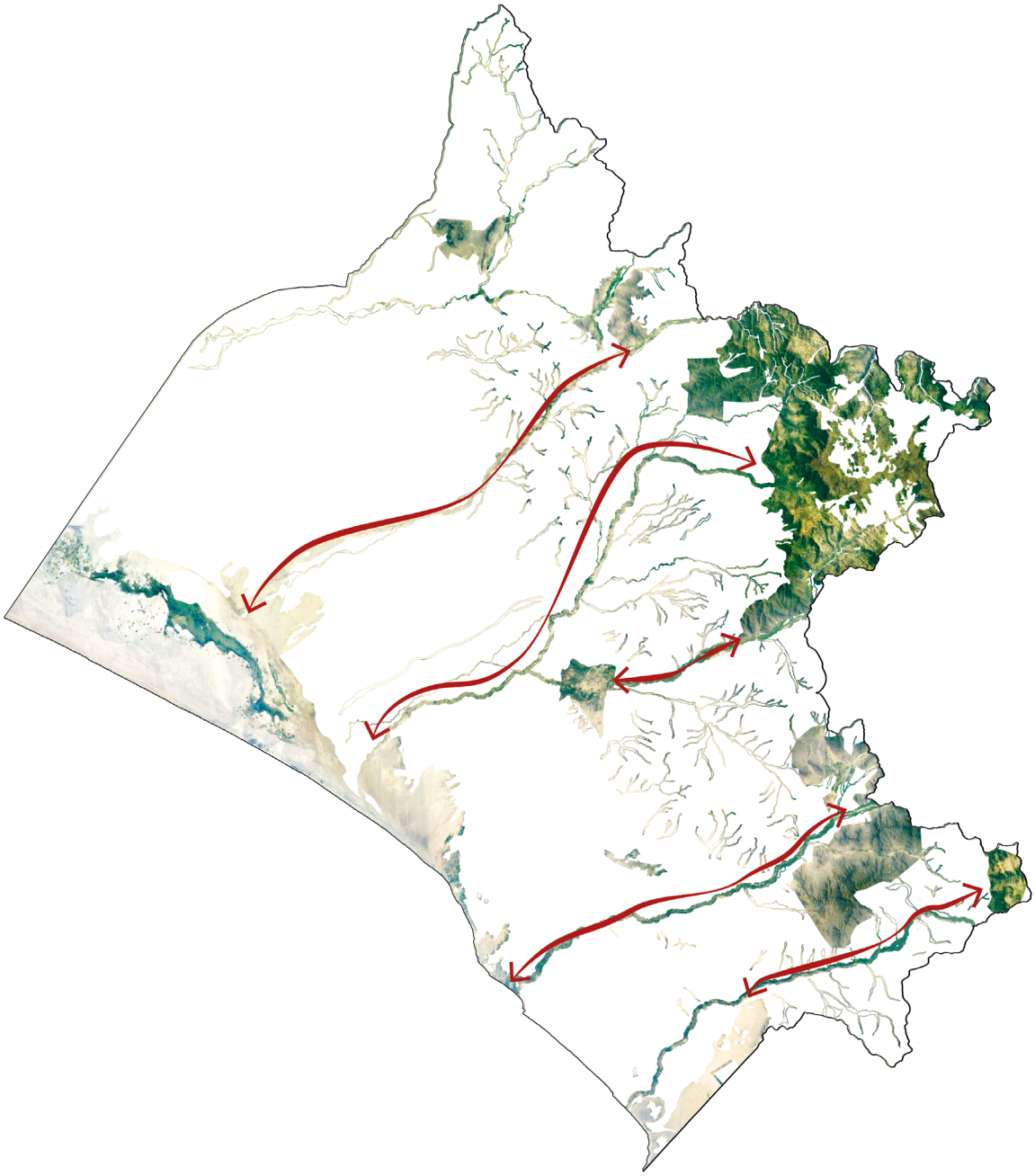


FIG. 1.31 Hypothesis: regional matrix designed using existing patches and rivers as ecological corridors in order to enhance the cohesiveness and robustness of the region.
Source: Made by author / Data: Google Earth

Research Question & Hypothesis

This research addresses the question: **How can green and blue spatial strategies be used in Lambayeque to reduce flood risk and improve landscape quality and connection?**

In order to answer the main research question, the following sub-questions arise:

– How to manage a cohesive ecological performance throughout the territory?

– How to design landscape as infrastructure using green and blue spatial strategies in order to cope with flooding and ecological disconnection?

– How to build a resilience perspective in the region in order to cope with uncertainty?

To answer these questions the present research is built on the hypothesis that the integrative approach of intertwining the main territorial 'natures' or layers will enhance the performance of the whole matrix, turning it into a cohesive space, where a new equilibrium –of flood risk adaptation– can be achieved through the design of green & blue multifunctional infrastructure. Moreover, by creating awareness, new physical and mental connections from the inhabitants to the greater landscape will be accomplished.

Methodology

The structure of this research is comprised by four parts: problem field, theoretical framework, analysis and the design process, which constructs the regional strategy and spatial interventions at different scales as a way of exploration of the specific manipulation of the territory to achieve safety and ecological cohesion. The intertwined approach among the outcomes of each stage and the constant coming-and-going allowed for feedback and enrichment within each stage.

Problem Field

Problem field introduces the two main problems of the region, on the one hand flood risk & water related issues and on the other hand, disconnected landscapes, which have common external triggers: climate change, natural disasters, economic development, rapid urbanisation, demographic growth and non-dynamic flows. The aim for the first problem is to 'achieve adaptivity in order to transition to a new equilibrium', while the aim for the latter is to 'achieve a cohesive ecological performance throughout the territory using existing patches or natures'. From this two separate objectives, the overarching aim arises.

Theoretical Framework

The research question 'How can green and blue spatial strategies be used in Lambayeque to reduce flood risk and improve landscape quality and connection?' is powered by the aforementioned problem field taking into account the external threats plus, the exploration of the theoretical framework, which mainly explores Social-ecological System, Landscape as Infrastructure, Green & Blue Multifunctional Infrastructure, and Adaptive Capacity.

Theoretical principles arising from the literature review are: multifunctionality, flexibility, adaptability and connectedness

It is worth noting that the theory of Three Natures is explored from the beginning –at the introduction stage– as an initial exploration of Lambayeque. First Nature refers to wilderness landscapes, Second Nature refers to man-made landscape and the Third Nature to 'highly designed landscapes'. This theory keeps appearing throughout the thesis, specially at the Design methodology stage, where along with the outcome from the Analysis part is supposed to result in the Third Nature, namely, the project.

Hypothesis

Up to this stage, the working hypothesis is that the integrative approach of intertwining the main territorial 'natures' or layers will enhance the performance of the whole matrix, turning it into a cohesive space, where a new equilibrium –of flood risk adaptation– can be achieved through the design of green & blue multifunctional infrastructure. Moreover, by creating awareness, new physical and mental connections from the inhabitants to the greater landscape will be accomplished.

The objectives are categorised in five: Co-existence with exceedance & absence of water, reforestation & protection of dry forest, unveiling landscapes, gradual retrofitting, accommodation of urban growth, which are going to be achieved spatially and in-site through the design principles. Furthermore, these objectives are fed by the theoretical principles, and in turn, will be the starting point for the design principles.

Design Framework

As part of the Design Framework, the project is approached in a multi-scalar way resulting in (1) regional strategy, (2) sub-basin intervention -later on called sub-basin structural map-, (3) spatial interventions at city scale and finally, (4) the streetscape scale aims for the in-site exploration of design principles.

Strategies embedded in the project are: scenic routes, pollution remediation, water emergency and water use, which will be explained in the design chapter, like the design principles and spatial interventions resulting from them.

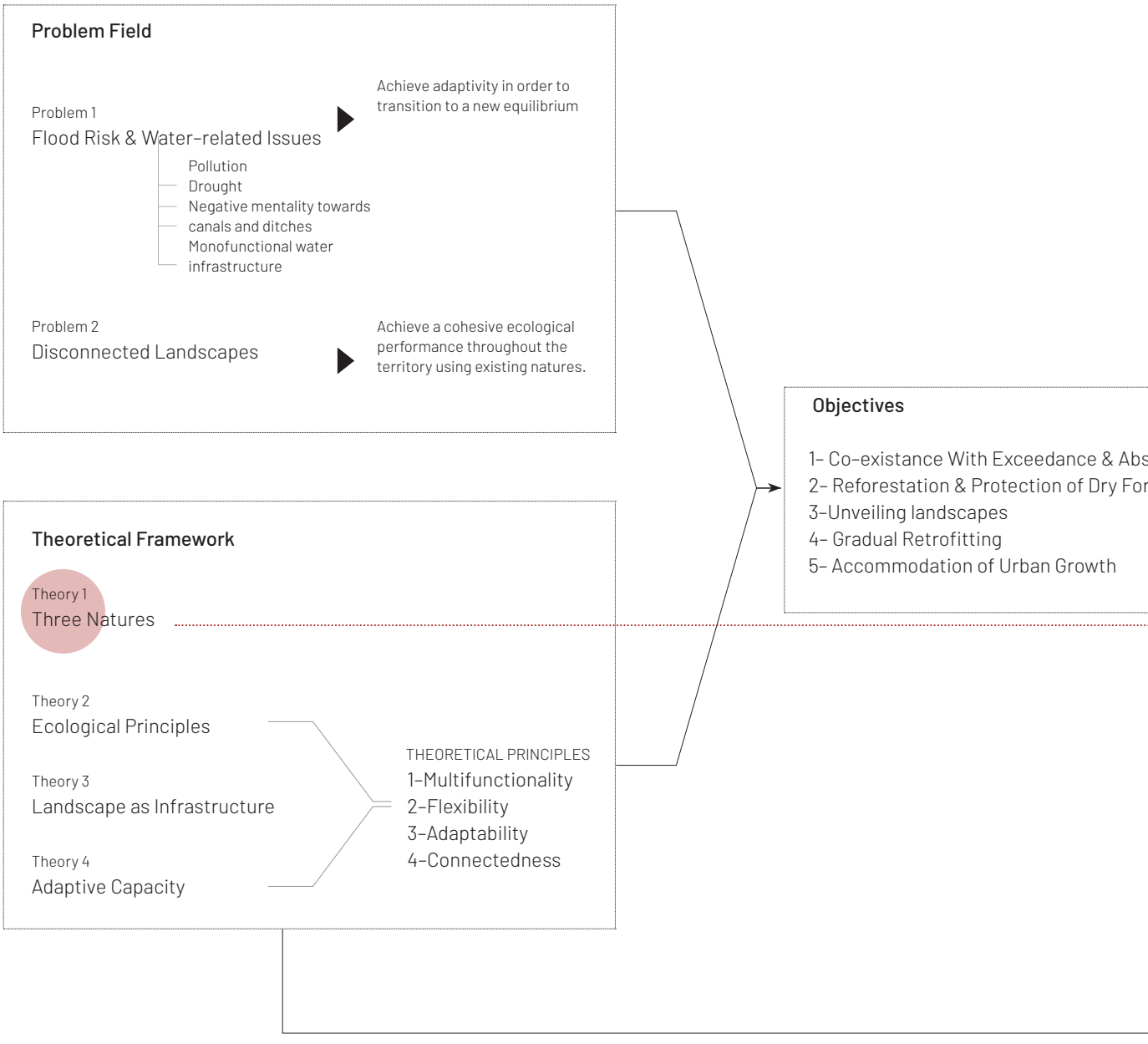
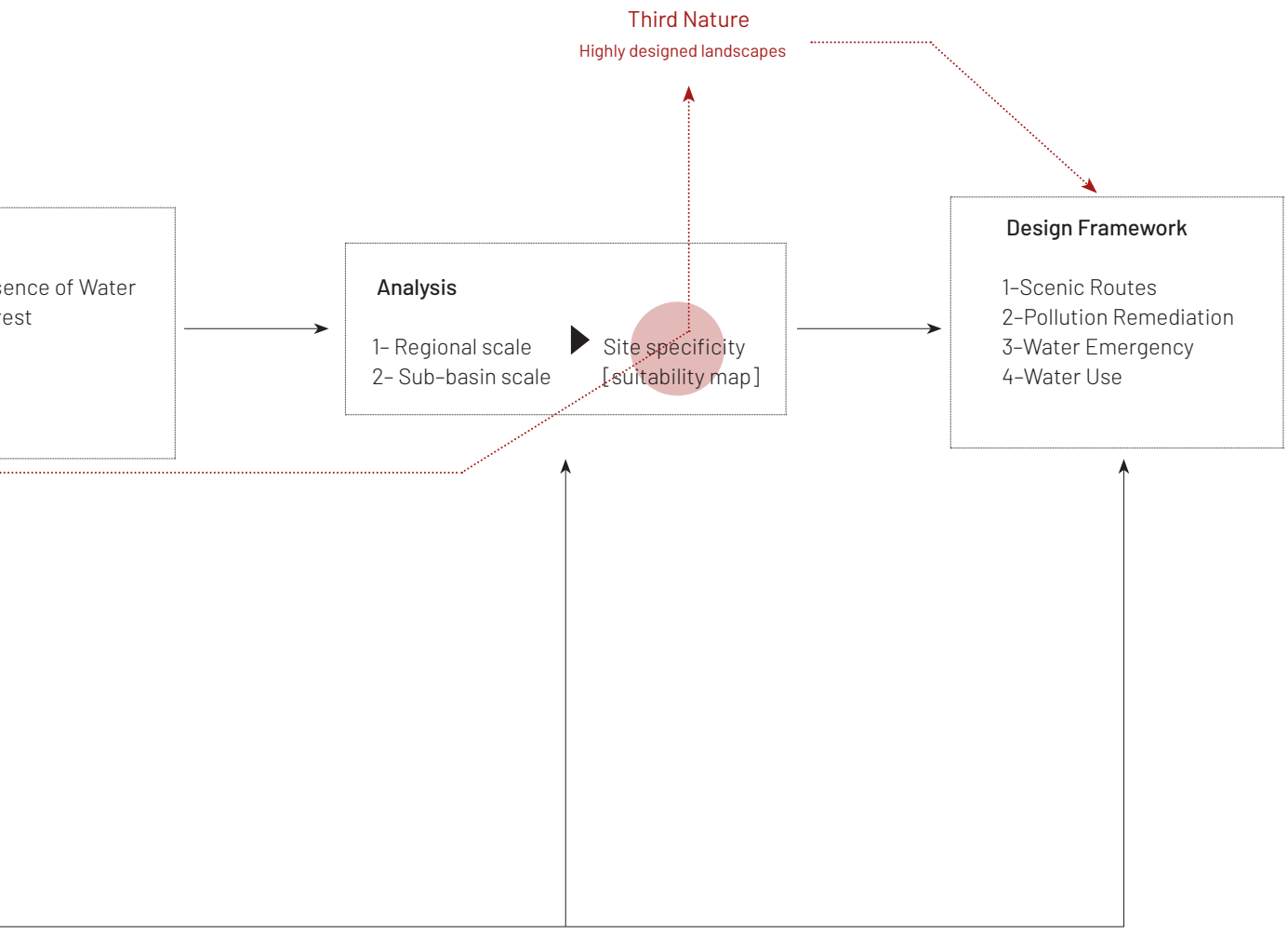


FIG. 1.32 Methodology structure
Source: Made by author


Third Nature
Highly designed landscapes
sence of Water
rest
Analysis
1- Regional scale
2- Sub-basin scale
Site specificity
[suitability map]
Design Framework
1-Scenic Routes
2-Pollution Remediation
3-Water Emergency
4-Water Use

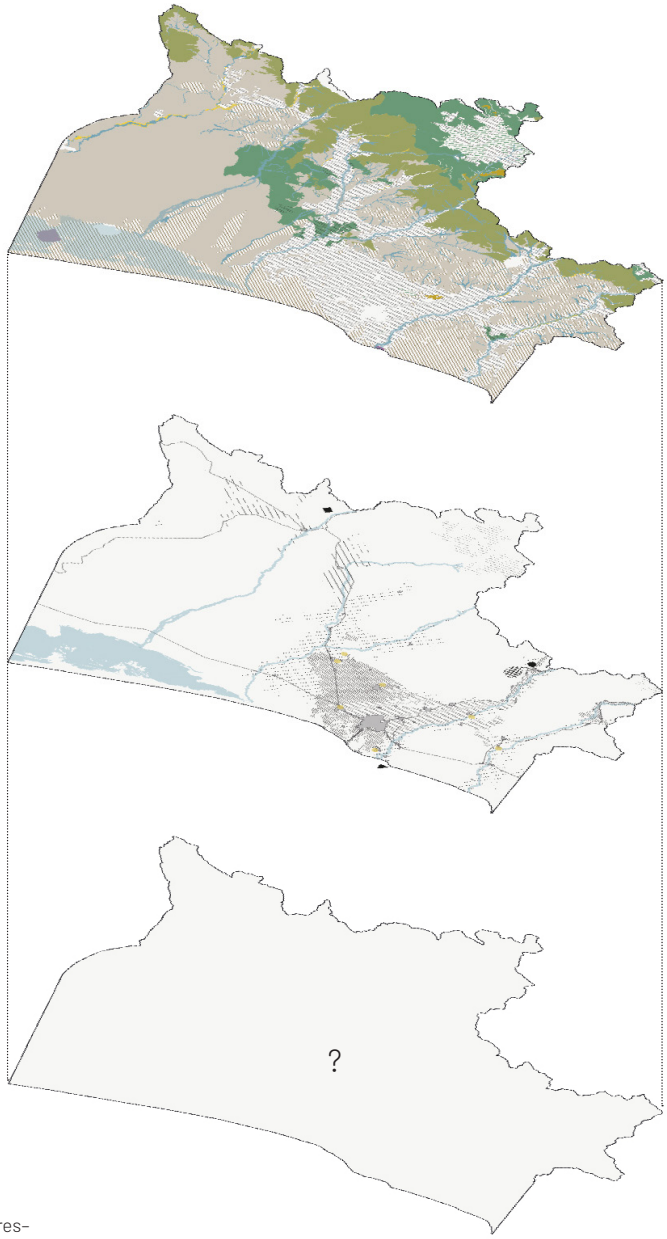


FIG. 1.33 Main layers –also understood as natures– to use for the project: existing first and second natures will give as a result the third nature, where the five objectives will be put into spatial terms
Source: Made by the author

Objectives

The overarching aim of the graduation project is to elaborate a regional strategy that alleviates flood risk by designing a long-term adaptive plan, while creating a cohesive territory and regional identity using green & blue multifunctional infrastructure. Furthermore, the openness of the socio-ecological system will allow for the design to test possible combinations of intervention resulting in spatial interventions in four testing locations in order to achieve connectedness and safety. Additionally, the relationships between systems will be improved as a way of adding robustness to the whole matrix.

The proposed set of principles might be replicable in the northern regions of the country taking into consideration the similarities regarding flood risk, weather and broad unexplored landscape around the built-up environment.

By addressing a permanent problem -disconnected landscape- and an uncertain one -flood risk resulting from natural disasters- the element of time is taken into account. The reading of the landscape as a palimpsest, as a series of processes formed in time will provide tools for exploration of new relationships among the region. Furthermore, this territorial understanding is complemented with the 'sense of identity and cultural belonging' that Girot refers in the lines that follow:

> 'The word passage means landscape (as in land and countryside) and much more, conveying qualities that are both visible and invisible. It refers not only to issues of environment and ecology but also to the mood of an entire nation, to its changing sense of identity and cultural belonging. There is thus a deep sense of temporal continuity (both historical and inventive) that pervades the idea of landscape in France'. (Girot in Corner 1999: 59)

In order to achieve the overarching objective, the matrix will be re-designed in an integrative way, with landscape urbanism at the core of the design by research:

> The central interest is the fundamental manner in which the entire site is treated as a large-scale landscape, as kind of tissue and bonding agent that ties all disparate parts together. Corridors, patches, mosaics, bridges, pathways, landforms, & matrices create a fabric within which the city can grow new roots'. (Corner, 2014)

Furthermore, the objectives will be classified in categories in order to evaluate its relevant scope in the final part of the thesis. The categorisation is:

1. Co-existence with exceedance & absence of water
2. Reforestation & protection of dry forest
3. Unveiling landscapes
4. Gradual retrofitting
5. Accommodation of urban growth

1 Co-existence with Exceedance & Absence of Water
This objective is related to safety flexible design, either for safety reasons in case of flood or for drought season.

Safety as a means of not thinking about water as a 'threat' but as an asset, as a catalyst for liveability and economic improvement. Moreover, the learning on how to cope with uncertainties will be embedded in the design stage aiming for this particular objetive.

Recreation addresses the lack of public spaces within the city and explores the idea of deisigning water as a public space for the benefit of the greater population.

The aim of 'Co-existence with water' is to create a new regional water identity where infrastructure designed (and used) as landscape can be part of the collective imaginary and public realm of the Lambayeque inhabitants.

2 Reforestation & Protection of Dry Forest
Although just a small percentage of the country's tropical forest is located in Lambayeque region, the data shows a remarkable decrease of forested areas at the national level, 1 800 000 hectares have being lost due to deforestation in 15 years (Amazonian Monitoring Project MAAP). On the other hand,although there is no exact data, significant areas of dry forests are decreasing due to land traficking. Given that this kind of forest is located just in the northern part of Peru and some areas of Ecuador, the importance regarding its conservation arises. Specially taking into account that some endemic flora –carob, gualtaco, sapote among others– and fauna –spectacled bear, white-winged guan, among others– species are currently in endangered situation. Appropriation, education and policies play an important role in this initiative.

3 Unveiling landscapes
This objective highlights the disclosure and use of existing landscapes, understanding 'use' as the re-exploration of the traditional relationship of communities with water and natural landscapes.

4 Renew (gradual) retrofitting
Although this objective is related to water , it is considered as an independent one since its not as related to improving ecological performances, but to stormwater management, meaning, it is one objective to be explored in the built environment scales.

5 Accommodation of Urban Growth
As mentioned before, most cities in the country grow without planning, which is the reason of the fifth objective: accommodation of future development in order to decrease the uncontrolled urban expansion.

Relevance

Societal Relevance

The response from part of the Peruvian government regarding flood resulting from natural disasters is to canalise natural water courses, clean lower parts of the rivers and relocate people who live in hazardous zones, not being successful most of the time. It is worth mentioning that these should not be a seen as a negative approach if this would be a mitigating measure: however, this plans are mainly comprised by engineering structures, such as dams with no proper research about improving the ecological matrix of the region, blindly focusing just on the technical features of water.

Challenges resulting from flooding might lead to human loses, health outbreaks – which could lead to public health emergency as the one occurred on 2017, collapse of infrastructure such as bridges, highways and roads –leaving towns and cities inaccessible, economic loss due to flood of extensive agricultural and productive land, as well as a high number of collapsed housing.

Scientific Relevance

Natural phenomenons can make us aware of the vast landscape around us, 'turning crises into windows of opportunity' (Folke 2016), aiming not just for a scenic landscape, but a multifunctional one focusing towards a new equilibrium. By aiming to create a regional identity and awareness as well as achieving a new equilibrium in the territory, a more a sustainable development is proposed. Moreover, the integral design should allow for new connections in order to not just mitigate flood risk, but to enhance the ecological capacity of the region.

Given that cities in the region have grown organically the lack of open and green spaces inside the built environment is a major challenge, not only for recreation purposes but for health issues as well, since green spaces within the built tissue helps fight heat island effect, air, water and noise pollution, and help to reduce the emission of greenhouse gases. Furthermore, it addresses the improvement of the quality of life of the citizens. This is where the importance of the connection among the regional and local natural landscapes arise, as a compensation for the lack of open spaces within the city.

From this context, the urgency for an integrative regional plan comprising urban, rural, productive and natural landscapes arise, as an opportunity to use green and blue spatial interventions and to design landscape as infrastructure as the linking element among the broad territory. Furthermore, this can be taken as an opportunity to address both problems along different timeframes, the uncertain/temporal one

FIG. 1.34 Pomac Forest, dry forest
Source: Peru, Kingdom of Forests, 2014

and the permanent one, ensuring the creation of a regional identity though the spatial exploration.

Finally, this thesis contributes to an integrative approach of urbanism, landscape architecture, ecology and planning, which has been proven to have major positive social and ecological impacts. However, it is not being applied in the Peruvian context. On the other hand, as stated by Bacchin (et al, 2014) 'there is a knowledge gap in planning and designing green and blue infrastructure in a systemic way, addressing city (macro-scale), district (meso-scale), and local (micro-scale) planning levels and their interrelationships'. This thesis aims to reduce said gap, by addressing specific issues in each spatial scale and giving solutions for each of them. Lastly, the integration of theory and practical design, to treat the theoretical terms as spatially as possible, mainly in the case of green and blue multifunctional infrastructure and, with resilience, adaptive and transformability capacities of the systems, taking Lambayeque as a testing ground.

PART 2

Theoretical framework

Social–ecological System | Ecological Principles | Landscape as Infrastructure | Adaptive Capacity | Integration of Theories

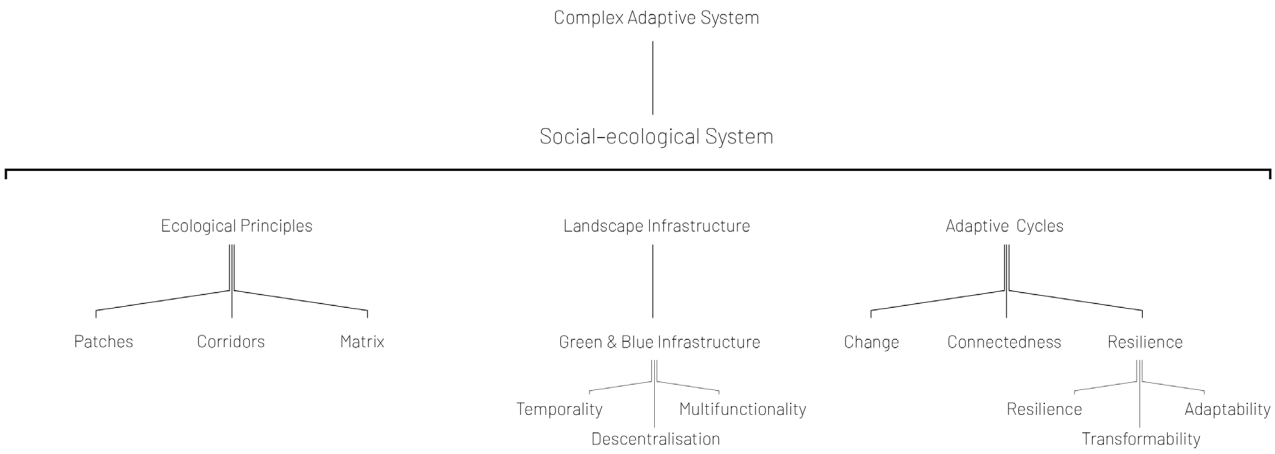


FIG. 1.35 Theoretical framework diagram
Source: Made by author

Social–ecological System

Introduction

The theoretical methodology is organised by three main 'themes' in accordance with the expected results: Ecological rationality & principles, Landscape as infrastructure and, Adaptive capacity. In a way, the first and second parts function as tools to achieve 'adaptive capacity' in the spatial strategies design. Moreover, Social–ecological system works as the theoretical backbone, where the three sections intertwine.

Social–ecological System

Systems approach has been widely used since 1960s in urban planning and natural sciences. Systems are comprised by sub–systems and components resulting from exchange, interaction and interdependency processes (Bacchin et al. 2014).

System thinking enabled the idea of seen a territory as a complex set of networks that are highly interconnected and interdependent among each other. These connections are the ones that are explored in the third chapter, from a hierarchical and multi–scalar point of view since even the smallest interventions affect the greater whole. (Hung 2011: 14) The importance of systems thinking relies on its components and the interchanges among them. As said by Bacchin (2015) 'Complex systems are formed by a myriad of nested systems, sub–systems and components and the complex interdependence and exchange between these'.

According to the degree of internal complexity, system thinking classifies the following: morphological systems, cascading systems, process–response systems, control systems and complex systems.

Complex adaptive systems –CAS– specifically focus on the 'adjustment' –adaptation– of the region from future uncertainties and hazards, such as the ones regarding climate change and natural disaster. Components that influence the development of complex systems are robustness, resilience and adaptability (Meyer et al. 2015: 17)

The term landscape –widely use in this thesis– is more closely related to what the French used to call vill, in order to refer to it, as Corner explains: 'the word meant more than an organization of space; it connoted too the inhabitants of the place and their obligations to one another and to the land' (Corner 2014: 243). In systems thinking, the social–ecological approach is an 'integrated perspective of human–in–nature' related to resilience, where the limits between social dimensions encompassing economic, political, technological and cultural features, and natural sciences are 'artificial and arbitrary' (Folke 2016).

The social-ecological system approach highlights the symbiotic relationship among the human dimension –people, communities, economies, societies, cultures– and the ecological dimension, and how these shape each other. Furthermore, Folke argues that the interaction among these dimensions 'shaped its resilience in diverse ways, from the local to the global, consciously or unconsciously'. (Folke 2016)

Ecological Principles

Patch–corridor–matrix model

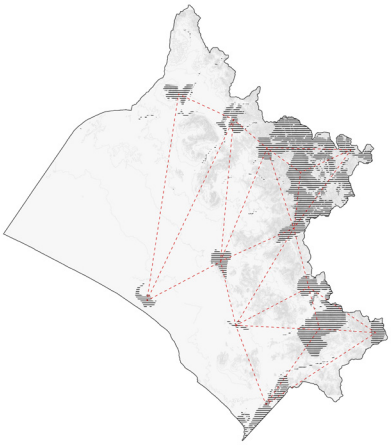


FIG. 1.36 Geometrical connections –possible corridors– linking the main green patches of the region.
Source: Made by author

Ecological principles from Dramstad, Olson and Forman (1996) illustrating patches, corridors and matrix are the main elements for a 'land–mosaic' plan, mapped in the next analytical chapter, where special attention is given to the inter–connectedness and inter–dependency of systems and sub–systems. Moreover, spatial pattern strongly moderate movement and flows on social–ecological systems (Forman 2008: 18).

The patch–corridor–matrix model is a tool for comparing non–similar landscapes in order to produce basic principles, which will be intervened in different manners according to their performance on an specific place and time. This model functions as an analytical tool and provides for the basic principles for the first stage of design.

Furthermore, as stated by Hung (2011) 'the global landscape is mosaic–based, where edges are permeable and the boundaries between cities and countryside are in flux'.

It is worth noting that the illustrative nature of understanding the theory mixed with projects is taken as a role model and a way of explanation for this thesis. In the case of Urban Regions: Ecology and Planning Beyond the City by Forman (2008) the case of 'The Barcelona Region's Land Mosaic' is taken as a reference specially with the following quote:

> 'This disconnect between nature's fundamental patterns and processes and current development trends could lead to crises, forcing prompt costly actions. Irrespective, it calls for new thinking or vision, with the core objective to mesh nature and people so they both thrive'. (Forman 2004)

Barcelona's Agriculture–Nature Park
Furthermore, the proposal of Barcelona's agriculture–nature park results from the lack of approaches or cases study that combine nature and human dimensions. This spatial framework aims for nature and people to thrive in the long–term, while accommodating 'flexibility and adaptability to provide stability in the face of big changes and surprises ahead' (Forman 2008: 245).

The combination of farming and natural protected areas in the productive valleys 'appear to be the optimum long–term solution', improving the economy and stability

at the local and regional scale. Moreover, water–related design in the park answers to temporality: too much or too little water, a similarity with Lambayeque, territory of contrasts.

Finally, the importance to design the region as a system, understanding the processes and linkages within them, revealing a dynamic mosaic of people and nature is taken as one of the main objectives of this research: connectedness.

The importance of Forman's approach lies in the idea of putting forward the mixing of the natural and human landscapes, aiming for the correct and intertwined use of the myriad of landscapes found in the territory.

Landscape as Infrastructure

Introduction

This section of the theoretical framework reflects on an innovative way of understanding infrastructure, not from the hard, engineering point of view but as an 'ecological infrastructure' able to deliver services to the socio–ecological system.

Taking into consideration the rapid urbanisation process happening around the globe, concerns about not purely ecological nor urban patterns are being widely discussed. Landscape architecture is considered a 'shared form of practice' among ecology, urbanism, planning, and urban design, and it traces its origins from the term 'landscape ecology' (Troll, 1934). It is argued that landscape urbanism has replaced architecture and urban design to become the 'framework for contemporary city–making' (Hung 2011: 14), since the coining of the term by Charles Waldheim in 1997, where landscape urbanism is described as the intertwining of both concepts into one. (Corner 2014: 306)

Landscape Urbanism

> 'Landscape has become a lens through which the contemporary city is represented and a medium through which it is constructed' (Waldheim in Hung et al. 2011: 14)

Landscape urbanism is a new understanding of the city as an 'ecological metabolism' that 'function much like a landscape, channeling flows and energy, connecting and dispersing, and expanding and contracting with varying degrees of fixity and open–endedness over time'. (Corner 2014: 10). The difference between landscape urbanism approach and 'cityscape', 'infrascape', 'green city' is the special attention paid to dynamic structures and processes that relate to future development (Corner 2014: 293).

Landscape urbanism is considered a response to the rigid traditional urbanism, in

which the relationships among dynamic structures and processes offer a set of possibilities. However, it is worth noting that the conjugation of 'landscape' and 'urbanism' should not be completely coalesced within each other as Corner (2014) argues:

'The union of landscape with urbanism promises new relational and systematic workings across territories of vast scale and scope, situating the parts in relation the whole, but at the same time the separateness of landscape from urbanism acknowledges a level of material physicality, of intimacy and difference, which is always nested deep within the larger matrix or field'. (Corner 2014: 315)

As explained by Hung (2011) the purposes of landscape architecture are becoming broader in the understanding of ecological processes and design, leading to more infrastructural, sociopolitical, economic and environmental objectives, functioning as an umbrella where all the aforementioned disciplines coalesce.

Another very similar approach to landscape urbanism is given by Viganò, with the concept of 'ecological rationality' , which explores the idea of urbanism within the ecological processes embedded in city–making. In words of Viganò: 'Ecological rationality is the capacity of human and natural systems to handle complexity, variability in space and time and uncertainty' (Viganò 2013: 408). Therefore, a clear link can be traced to social–ecological systems and landscape urbanism.

Landscape Infrastructure

Economic development is directly linked to the exchange and distribution of goods and services, resources, knowledge and people across territories (Hung et al. 2011: 16). Roads, water and power lines, bridges, subways, airports, public institutions can be noted as traditional planning infrastructure, a 'hidden system that not only support but also instigate development' (Corner 2014: 293) positioning the city within territorial influence.

Infrastructural systems that operate on the background result in incompatibility and conflict when put in context with the rest of the territorial systems. Instead, landscape infrastructure aims for the integration of the infrastructural and ecological systems.

> 'Once married with architecture, mobility, and landscape, infrastructure can more meaning- fully integrate territories, reduce marginalization and segregation, and stimulate new forms of interaction. It can then truly become 'landscape.'" (Shannon & Smets in Hung et al. 2011: 17)

Infrastructure becoming landscape is a recurrent topic explored nowadays. The defiant excerpt by Corner (2014) stating that 'cities and infrastructures are just as 'ecological' as forests and rivers' refers to the codependency of relationships and link to its surroundings. Moreover, it is argued that infrastructures that perform and produce can become infrastructural catalysts of socio–cultural change (Corner 2014: 293) 'and as an instrument for water resilience' (Bacchin 2015: 29), aiming to become new supports for the evolution and growth of innovative urban planning.

Temporality

Given that a myriad of ecological and dynamic processes take part in landscapes, the unpredictable results when adding external flows such as geopolitical and economic forces, uncertainty and changes –disturbances and developments– are permanent features that must be taken into account when designing, hence the need for flexibility and adaptability embedded in the system's design to increase resiliency.

Decentralisation

As mentioned before, traditional way of conceiving infrastructure is as an isolation system, with this innovative approach the aim is to 'become decentralized, where the need to address, for instance, stormwater runoff, energy, farming, or transportation are resolved at a local level'. It is worth noting that hierarchical and multi–scalar approach regarding design goes hand in hand with the decentralisation feature.

Multifunctionality

> "The strength of multifunctional landscapes is their ability to afford the needs of diverse users, thus appealing to diverse constituents with various recreational, cultural and ecological needs/objectives. Multiple uses also facilitate efficient use of time and space.' (Kato & Ahern 2009: 799)

Allowing a landscape to perform in multiple ways can fulfil the demand for public spaces while achieving sustainable development. According to Holling 'sustainability is the capacity to create, test and maintain adaptive capability', while 'development is the process of creating, testing and maintaining opportunity', hence, sustainable development can be understood as the feature that absorbs adaptive capabilities while creating opportunities (Holling 2001).

The realisation of a multifunctional system is being explored through landscape infrastructure, expanding the tradition concept os spatial planning and design strategies.

Green and Blue Infrastructure

> 'As integrated systems, green, blue and grey water infrastructure can reduce runoff, increase biodiversity and offer cultural/health benefits through public access to valued natural resources'. (Bacchin et al. 2014)

A greater network of green and blue infrastructure ameliorates the access to natural areas that has being impoverish over time, in order to make room for highly urbanised environments (Bacchin 2015). Therefore, it is crucial to propose spatial interventions that are able to host new functions and new processes for alternative possibilities, thus allowing for flexibility.

As stated by Bacchin (2014): 'Green and blue open spaces as a structurally performing system, is developing new ways to conceive and shape the organization of the human/natural environment for the future transformation of urban regions'. The re–shaping of the territory through green and blue networks is one of the design objectives of this thesis, since not only enables the retrofitting of nature into highly urbanised areas, –or rural towns where nature is disappearing–, but it holds the potential to retrofit and manage stormwater, thus enhancing the ecological and urban performances of the region.

The system of open spaces within the city, such as roads, public squares, gardens, sport fields and parks, are considered to be 'catalysts for urban regeneration', given its potential for delivering hydraulic decentralised functions. (Bacchin et al. 2014: 3). It is worth highlighting the importance of diversity in use and multifunctionality regarding roads or pedestrian paths in order to improve the ecological and urban performance of the site.

Adaptive Capacity

> 'The subject of coexistence – in this case coexistence with flood risk – hence becomes crucial and forces us to reflect on some categories of ecology as design categories; specifically resilience, resistance and adaptation'. (Viganò 2013: 422)

Social–ecological systems function across multiple scales of space, time and social organisation, resulting in a myriad of multi–scalar interactions, which are key elements for understanding the dynamics of a system at any given scale.

Social–ecological systems are comprised by hierarchies and adaptive cycles (Holling 2001). On the one hand, the hierarchical system is used as a method to deal with complexity, which likewise is subdivided in subsystems. On the other hand, adaptive cycles are comprised by change, connectedness and resilience. According to Folke (2010) resilience thinking requires of three main aspects: resilience, adaptability and transformability.

Hierarchies and adaptive cycles form a 'panarchy', which is the hierarchical/gradient structure in which natural, human, and human–nature systems are interlinked in continuous adaptive cycles of growth, accumulation, restructuring and renewal. This never-ending transformative cycles take place in multiple scales. (Holling 2001)

The inherent features of complex adaptive systems are subject to gradual change intertwined with periods of rapid change. This dynamic interaction does not allow to know when such dramatic changes are going to take place (Folke 2016). According to Holling the ultimate understanding of adaptive cycles and their scales would contribute into the identification of their tipping points, as well as 'when' a system can accept positive changes, which will be the cornerstones to 'foster resilience and sustainability within a system'. (Holling 2001: 392)

The following concepts are coined by Folke et al. (2010):

Resilience
Capacity to adapt or transform while facing –unexpected/extreme– change

Adaptability
Refers to human action that sustain, innovate, and improve development on current pathways

Transformability

Capacity to cross thresholds into new development trajectories

> 'Any transformation draws on resilience from multiple scales and diverse sources. It recombines experience and knowledge, learning with change, turning crises into windows of opportunity, and governing transformations for innovative pathways in tune with the resilience of the biosphere'. (Folke 2016)

Integration of Theories

In a way, the first and second part of the theory gives the third part as a result. On the one hand, the first theory –Ecological Principles– is the backbone for the analytical chapter and project design. Its overarching aim is the intertwining of human and ecological dimensions. On the other hand, the second theory – Landscape Infrastructure– focus mainly on ecological, and urban realms and lastly, on the human dimension. Although each theory has a set of specific objectives, both theories aim to achieve a common goal: a system that is able to accommodate change, in other words, an adaptive and robust design that is able to cope with uncertainties. Thus, adaptability is on the core of both theories, taking into consideration the potential for change, degree of connectedness and resilience of the system, thus, allowing for the shift from the conventional and monofunctional infrastructure to infrastructure that performs as landscape (Bacchin 2015: 49).

Implementing green and blue multifunctional infrastructure seeks to understand and re-establish the lost connection of living with water and with the ecological patterns of the region, and see them as an opportunity instead of looking at them as a nuisance or hazard –in case of meteorological events. Furthermore, the new interdependency processes of the social–ecological system aims to explore new possibilities of interaction. As a result, one of the aims of implementing green and blue networks is to create awareness, and making the greater landscape part of the communities' imagination.

Some of the positive results of green and blue infrastructure as a planning and design approach 'are integral & innovative governance, climate adaptive/ active city, stimulate sustainable & resilient solutions, restore ecological flows & habitats for greater liveability , strengthen innovation power (technology/governance/financial/ design/cultural)'. (Bacchin et al. 2017)

Moreover, since 'transformational change at smaller scales enables resilience at larger scales' (Folke 2010) the design multi–scalar approach is a way to foster resilience in more manageable spaces.

Given that one of the aims of this thesis is to be able to spatialise the somehow abstract nature of the aforementioned theories, as a conclusion of this chapter some design principles arise based on the main challenges faced by the region: no relation with waterscapes, deterioration of bio–diversity, unplanned retrofitting management and urban growth. The principles are: connectedness,

multifunctionality, flexibility and adaptability, in order to reduce the cascading effect in the infrastructural system. It is worth noting that, when arriving to the design proposals this principles will be put into more of a local context taking into account the idiosyncrasy and specificity of the place.

Multifunctionality, flexibility and adaptivity are concepts strongly interconnected. Their differences lie mainly on function, time and spatial features. Moreover, the possibility of delivering processes deriving from these three concepts provides the design with higher potential for a water resilience region.

1 Multifunctionality

The term 'multifunctionality' is embedded in the ecological performance of natural landscapes such as the processes that develop in nature such as evapotranspiration, absorption of carbon dioxide, improving mental and physical health of the inhabitants.
Multifunctionality refers to how many functions certain landscape can provide, as well as the diversity of said functions.

From the aforementioned Four Natures reading of the territory, the first nature is the one that posses the highest multifunctionality, the man–made nature is the one the lowest multifunctionality, in the third nature the aim is not to replicate the natural processes but to bring back the high levels of multifunctionality as a way of engineering the landscape to be able to respond to different needs.

2 Flexibility

This concept is related to timeframes and contingency design. In case of need, extreme flooding for example, this spaces can be used for a certain period of time, without damaging other parts of the system.

3 Adaptivity

It is more related to the spatial structure of the system. Throughout a changing circumstances, an adaptive system should be able to maintain its regime as usual if one element collapses –or needs to be intervened–.

4 Connectedness

It can be argued that this concept 'regulates' the elements of the system. From the elemental notion of ecology, without connections such as nourishment and outlet sources the biotic and abiotic elements would not function correctly and would die. The connectedness of existing and proposed patches enables a more robust matrix.

PART 3

Analysis

Governance in Peru | Spatial scales in Governance | Existing plans in Chancay–Lambayeque Basin | Territorial Reading | Territorial Summary | Sub-basin Reading Summary

FIG. 1.37 Political division of water management in the country
Source: Made by author

Governance in Peru

Water Management

Interventions by the national government on water management in the coastal valleys started in the 20th century.

- In 1969, the 'Agrarian Reform' –Reforma Agraria– by the military government of president Velasco Alvarado took control over large agricultural states and water resources.
- In 1989, the 'Board of Users' –Juntas de Usuarios– assumed governmental functions regarding irrigation systems.
- –In 2009, a new Water Law –29338– was promulgated, replacing the General Law on Water from 1969. The new law focus on an Integrated Water Resources Management –IWRM– at catchment scale.

→ Council of basin's hydrological resources [CRHC]

'The new Water Law recognizes the right of native and peasant communities for ancestral traditions and customs of water use, and mentions for the first time environmental and ecological flow. But it does not explicitly define the related management and the right for collective community use'. (Drenkhan et al. 2015: 725)

n:

Chancay–Lambayeque Basin:
Lambayeque

It is under this law that National Water Authority –ANA–, Administrative Water Authorities –AAA–, and Local Water Authorities –ALA–, which functions at national, regional, and local levels, respectively, are created as part of the National Water Resources Management System (SNGRH). The council of the National Water Authority –ANA– functions under the representation of: Ministry of Agriculture and Irrigation, Ministry of the Environment, Ministry of Energy and Mines, Ministry of Health, Ministry of Production, Ministry of Housing, Construction and Sanitation, National Maritime Authority, Regional Governments, Rural Municipalities, Organisation of Agrarian Users, Organisation of Non–Agrarian Users, Local Communities and, Native Communities.

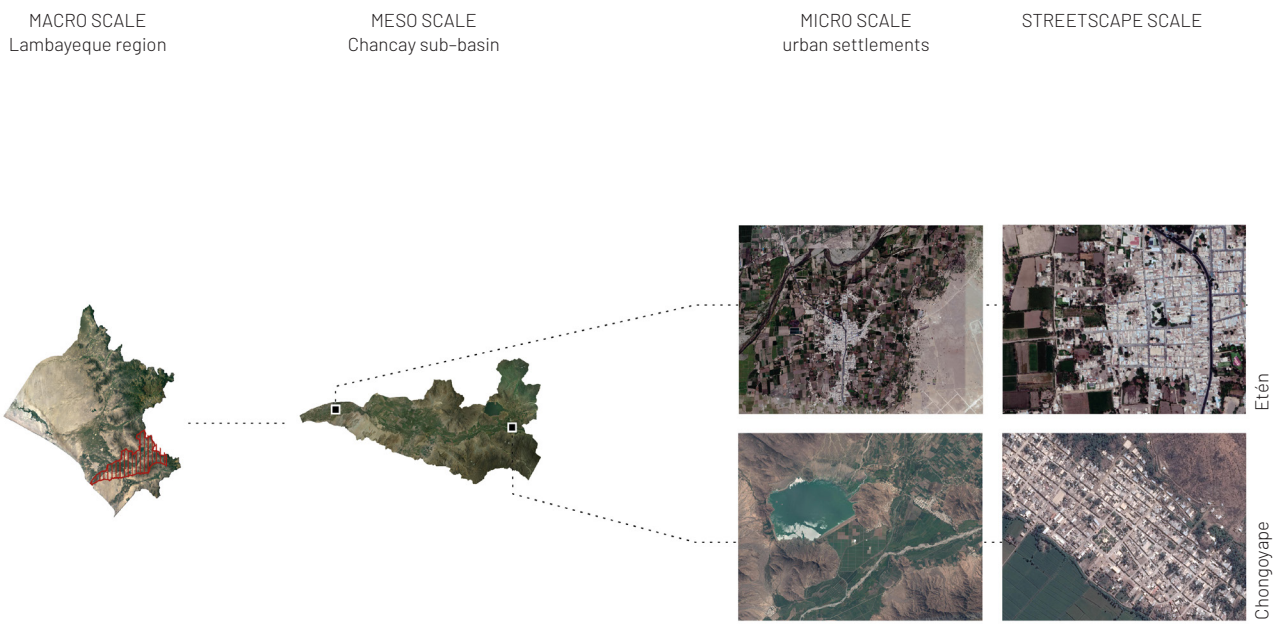


FIG. 1.38 Diagram of spatial scales used in the project.
Source: Made by author

Spatial Scales in Governance

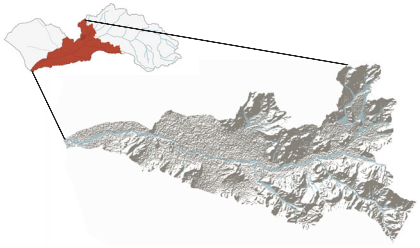


FIG. 1.39 Chancay sub-basin location as part of the Chancay-Lambayeque basin.
Source: Made by author

Spatial Scales

Multiscalarity approach is one of the tools used for to achieve adaptability, since the feasibility on transforming small-scale areas is greater than in the bigger ones. Furthermore, as stated by Hung (2011) even the smallest spatial interventions have an impact on the greater region.

Multiscalarity approach is taken into account from the analysis to the design parts. However, in the third part some of the maps are only presented in the regional scale or in the sub-basin scale since it is more explanatory in either one, such is the case of hydrogeology system only shown in the meso scale.

Working across scales allows for the intertwining of the four main design objectives: Co-existance with water, protection of biodiversity, gradual retrofitting and accommodation of future urban growth. It is worth noting that the use of hierarchy of space-time domains will allow for address an array of different issues in the project. In a way, the two first objectives are more focused -although not completely- into improving the ecological performance of the territory and the last two are more prone to address issues from the built performance.

Furthermore, at the macro-scale the most striking features of the region are presented. At the meso-scale certain particularities start to appear, such as the relation between infrastructure and urban tissue. At the micro-scale and 'streetscape scale' (Bacchin 2015: 33) seasonal patterns of temperature and precipitations are presented. Taking flooding resulting from natural disasters as an example: river floods can be addressed in the first and second scales and, in the third and fourth depending on the location of the site. However, exceedance water resulting from the same natural disaster can only be tackled at the streetscale since stormwater management principles demands for a more detailed view of the system.

The continuous change of scales allows for retrofitting within all the scales, which is illustrated in the regional strategy, sub-basin structural map and spatial interventions. Some design principles appear at the sub-basin scale for example, which requires for the regional strategy and spatial interventions to embrace it therefore, to slightly change the design; however, the principles from the theoretical framework -connectedness, multifunctionality, flexibility, adaptability- and the design objectives -co-existance with water, protection of biodiversity, gradual retrofitting and accommodation of future development- remain the same. Multiscalarity approach provides a broad yet specific scope of the territory.

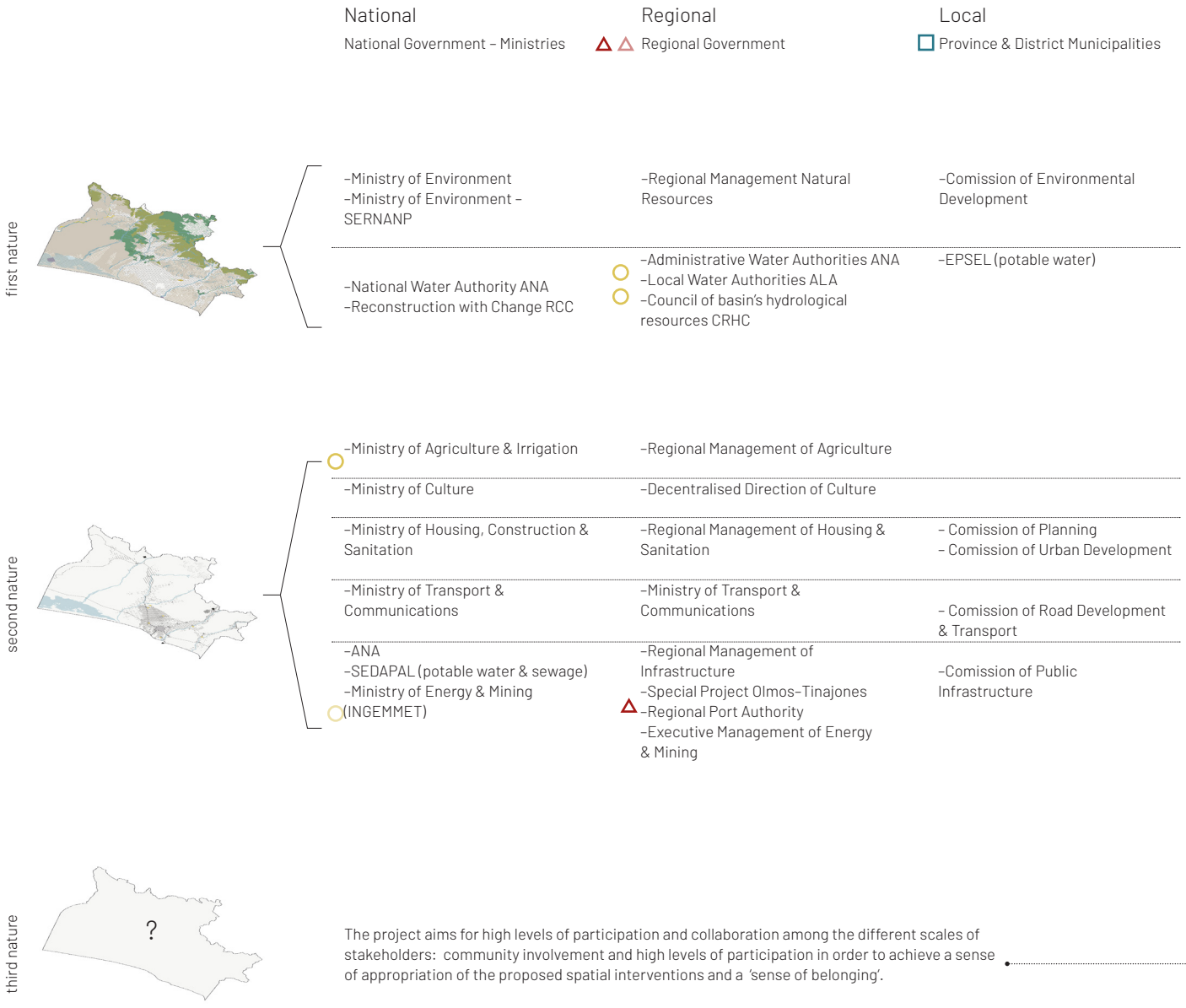
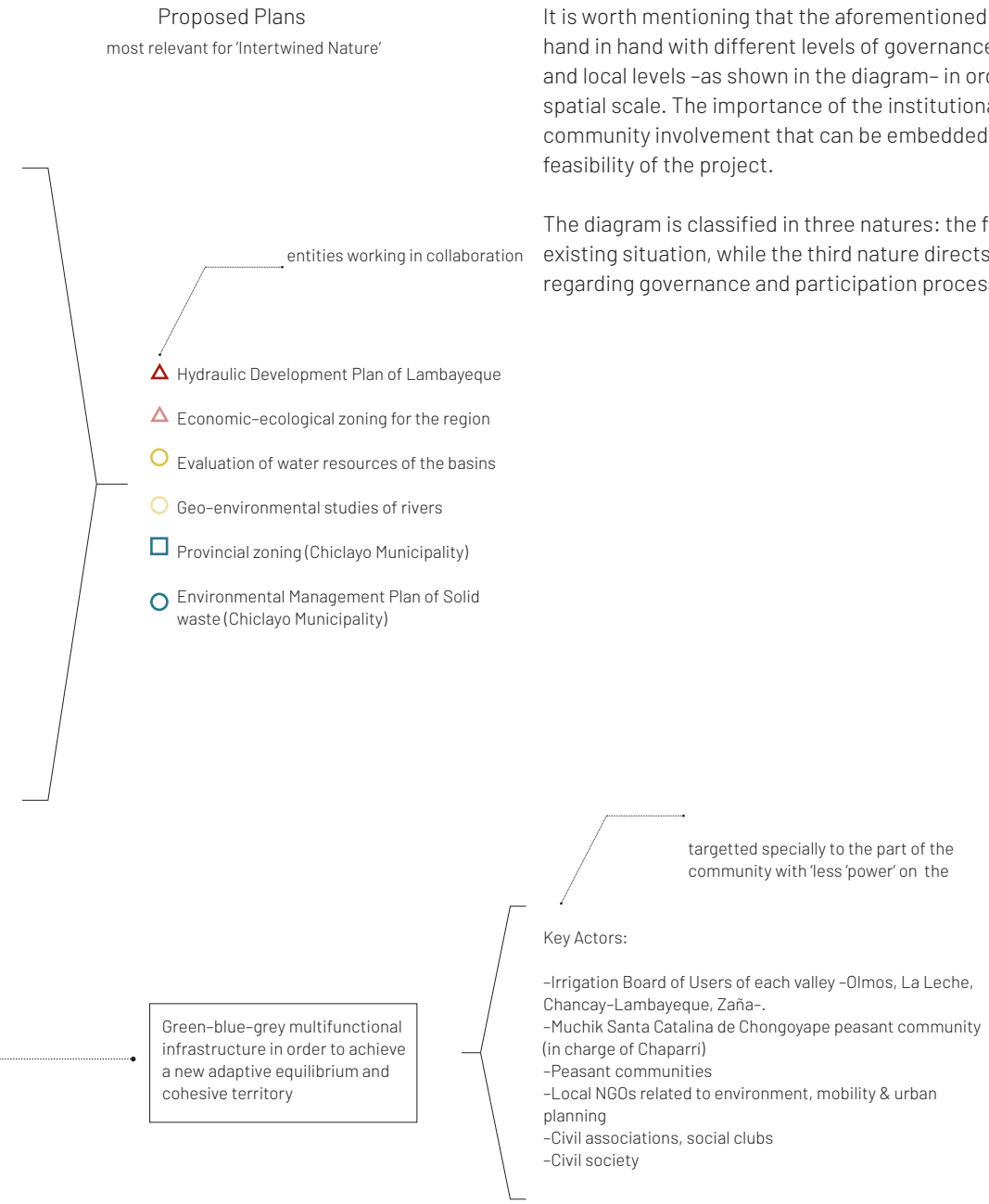


FIG. 1.40 Diagram of spatial scales in governance
Source: Made by author

Spatial Scales in Governance



It is worth mentioning that the aforementioned design scales should be approached hand in hand with different levels of governance, from the national to the regional and local levels –as shown in the diagram– in order to support the strategy in each spatial scale. The importance of the institutional framework lies in the percentage of community involvement that can be embedded with the design, thus increasing the feasibility of the project.

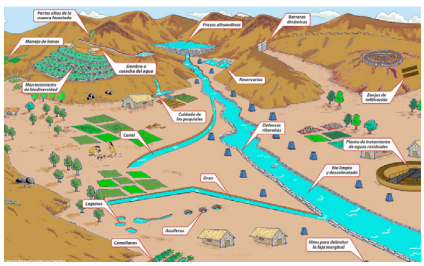
The diagram is classified in three natures: the first and second ones describe the existing situation, while the third nature directs towards the aim of the project regarding governance and participation processes.

Location of Chancay-Lambayeque basin, between Lambayeque and Cajamarca regions.

FIG. 1.41 Existing hydrological plans for the sub-basin re-drawn from Hydrological Development Plan of Lambayeque Region, 2014.
Source: Made by author

1

2



3

FIG. 1.42 [1][2]Cleaning of the bottom part of La Leche river as part of Reconstruction with Change programme.
Source: Author

FIG. 1.43 [3] Integral solution of a basin
Source: Reconstruction with Change, accessed on May 7th 2018

Existing plans in Sub-basin

Existing Plans in Chancay-Lambayeque Basin

Existing plans on the Chancay-Lambayeque can be classified in two fields: On the one hand, the Hydraulic Development Plan of Lambayeque -Plan de Desarrollo Hidráulico- that has traditional infrastructure at its core. On the other hand, the Reconstruction with Change -Reconstrucción con Cambios, RCC-, an entity of exceptional character created in 2017 under the umbrella of the Ministry Presidency, after the severe destruction caused by Coastal El Niño. RCC's plans aimed to propose integral solutions where different levels of stakeholders participate; however, the plan is still at early stages, in other words, data has been recollected, estimated budgets for early works have been presented pending of approval. Moreover, initial work processes include cleaning of riverbeds, construction of houses for people who lost theirs during the phenomenon and, displacement of population -still- living in hazardous zones.

Hydraulic Development Plan of Lambayeque

The Hydraulic Development Plan of Lambayeque considers five main topics: water regulation works, prevention works, agricultural development, hydro-energetic development and actions for social inclusion.

1 Water regulation works
Regulation of 500 mmc for flooding risk management, water supply for irrigation purposes, water supply for population, hydroelectric energy production. 19 dams
2 Prevention programmes
River defense mechanisms and urban waterstorm drainage. cleaning of lower parts of the river and construction of dikes. Implementation of monitoring and rain forecasts systems. Mapping of risks zones, volume flow measurement measuring stations, evaluation and studies.
3 Agricultural development
More than 240 000 productive hectares
4 Hydroenergetic development
Construction of hydro-power plants along the valleys
5 Actions for social inclusion
– Activity 1: Organisation of producers, analysis of the current situation and the socio-economic profile of the users, citizen participation, bases for the conformation of productive alliances
– Activity 2: Organisation of the production, studies for market alternatives, elaboration of production systems and irrigation management , technical assistance programme in marketing and commercialisation, Search for alternatives on agro-industrial and post-harvest techniques.

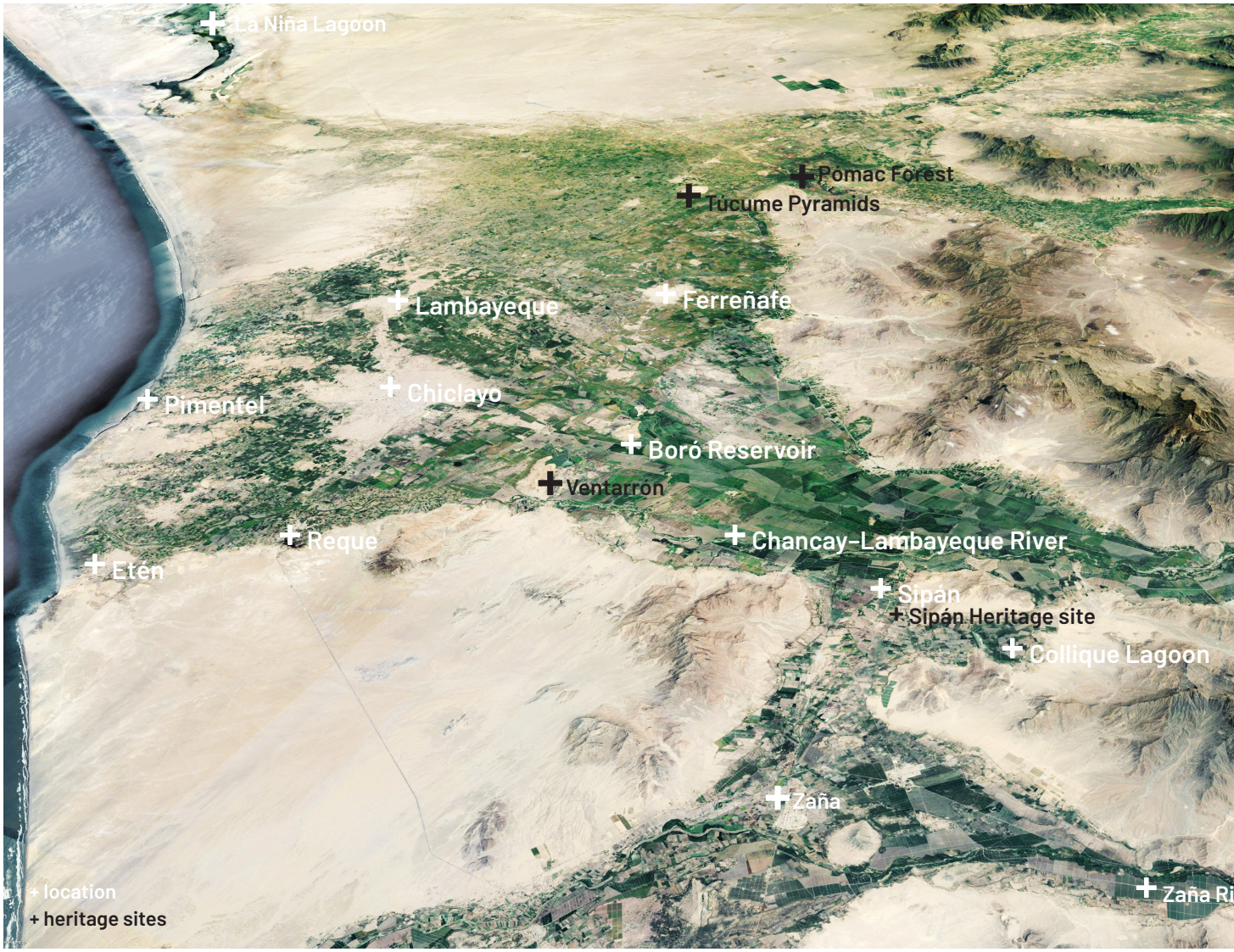


FIG. 1.44 Chancay valley overlooking the region.
Source: Made by author

Territorial Reading

Territorial Reading explores the region in different layers that later on will be part of the suitability map through different spatial scales: water system, geology, hydrogeology, ecological system, ecological system – protected national and regional areas, built system, road system and agricultural system, each of them evaluated in macro and meso scales in a parallel effort in order to understand each feature not as a layer but as a system.

The aim of this exploration is to understand how the regional and local patterns function, as well as to draw relationships that later on will be embedded in the regional strategy.

Territorial Overview

As mentioned before, most of the rivers of the region have their catchment area in the Pacific Ocean and their origins in the Andes. Glacier melting and changes in its nature affect downstream dynamics, some of which are 'hydro- power, population, land use practices, tourism, social relations, urban development, spirituality, and cultural perceptions' (Drenkhan et al. 2015: 720).

Given its location in the middle and downstream parts, the water conflicts from Chancay sub-basin are: on the one hand, resulting from vulnerabilities such as river and coastal floods, and mudslides. On the other hand, water quantity and quality. Water quantity is a challenge during drought seasons. Moreover, conflicts arise when powerful private agricultural groups and the small-scale farmers claim water for irrigation purposes. Regarding the issue of water quality, it is specially affected by intensified mineral extraction in the upper part of the basin –in Cajamarca region–, and poor management once the river enters the region, given that there is no treatment for grey waters or waste solids; the usual way is to redirect the grey waters to rivers, streams or the ocean.

This overall situation triggers socio-environmental conflicts not only in the region, but at national level. In words of Drenkhan er al. (2015: 128) 'these disputes occur between rural and urban areas, upstream and downstream users, as well as on institutional levels' which as a result calls for an integral solution regarding water governance, supply, quality and functionality, in order for communities to thrive in a sustainable way.

Chancay valley's main built patterns are: Etén, Reque, Sipán, Pampa Grande and Chongoyape.

Roads + Built System

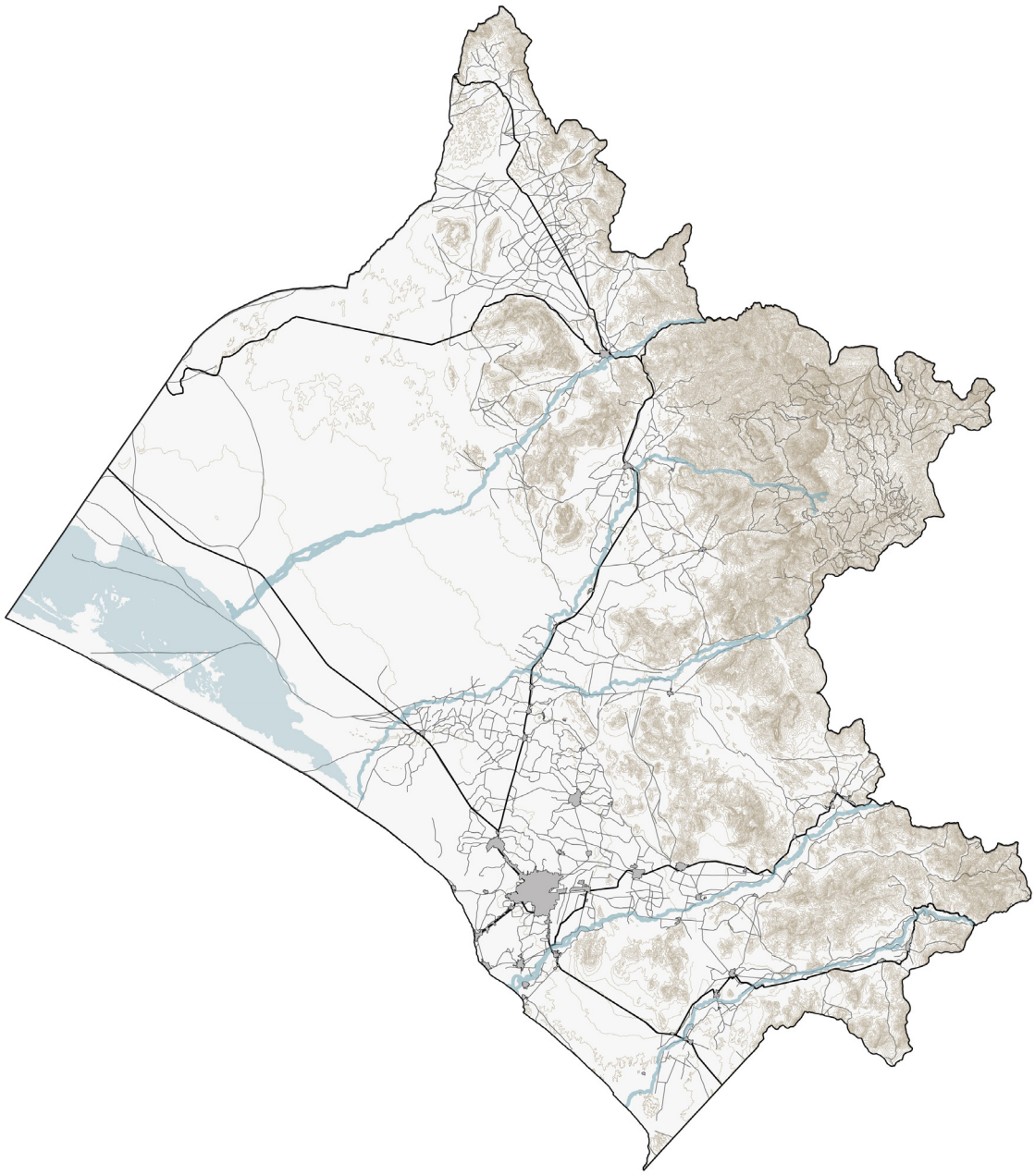


FIG. 1.45 Road system + built tissue
Source: Made by author with data from INGEMMET

Road & Built System

National roads that cross the region are: Panamericana highways, which connects the American continent along the coast, in the case of Peru; the commonly-known as 'Old Panamericana' a highway that connects the small towns in the interior of the region with Piura, the region towards the north. The third national highway connects the Lambayeque with Amazonas region, at the East.

Over centuries, built environment has concentrated along main infrastructure, such as national and regional roads. Chiclayo is one of the main cities in northern Peru and the central node of the region, where all urban functions and services are concentrated.

Main cities of Lambayeque region are listed below:

- Chiclayo, where 70% of the total population is settled, thus were most of the government institutions and services are located.
Moreover, it is one of the main nodes of the country, given its strategic location which allows the city to have thriving commercial relations -and constant immigrating population- with adjacent regions: Piura (north), Cajamarca (east) and La Libertad (south).

-Lambayeque, considered one of the main cities in the region regarding heritage, where museums about Lambayeque or Sipán culture can be found such as Brunning museum and Tumbas Reales museum.
-Ferreñafe, National Museum of Sipán is located in this city.
-Monsefú, this city is known by the making of handcrafts, mainly of wood.
-Reque,from the culture point of view, it is home of notorious musicians.
-Pimentel, coastal town overwhelmed by tourists specially during summer months, from january to march.

It is worth noting that last two cities are located south and west of Chiclayo respectively, and it is where the urban tissue is expanding toward.

FIG. 1.47 Region showing the Chancay sub-basin
Source: Made by author

Region showing the following zoom-in area

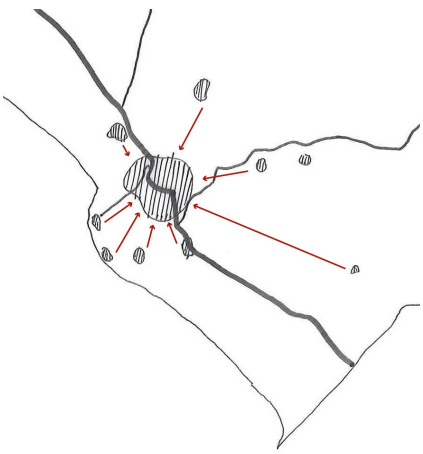


FIG. 1.46 Diagram showing the central location of Chiclayo as the main node of the region.
Source: Made by author

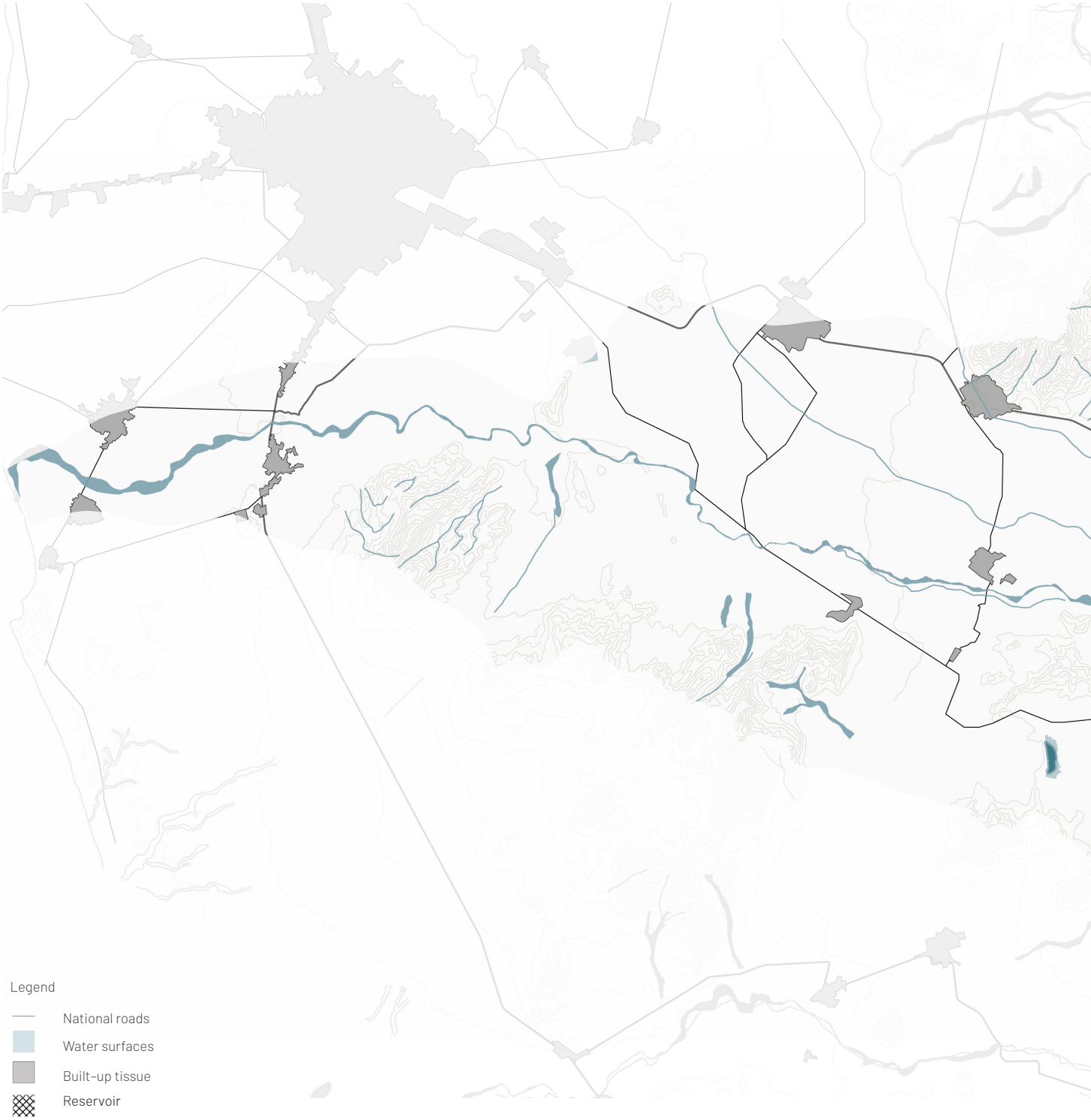
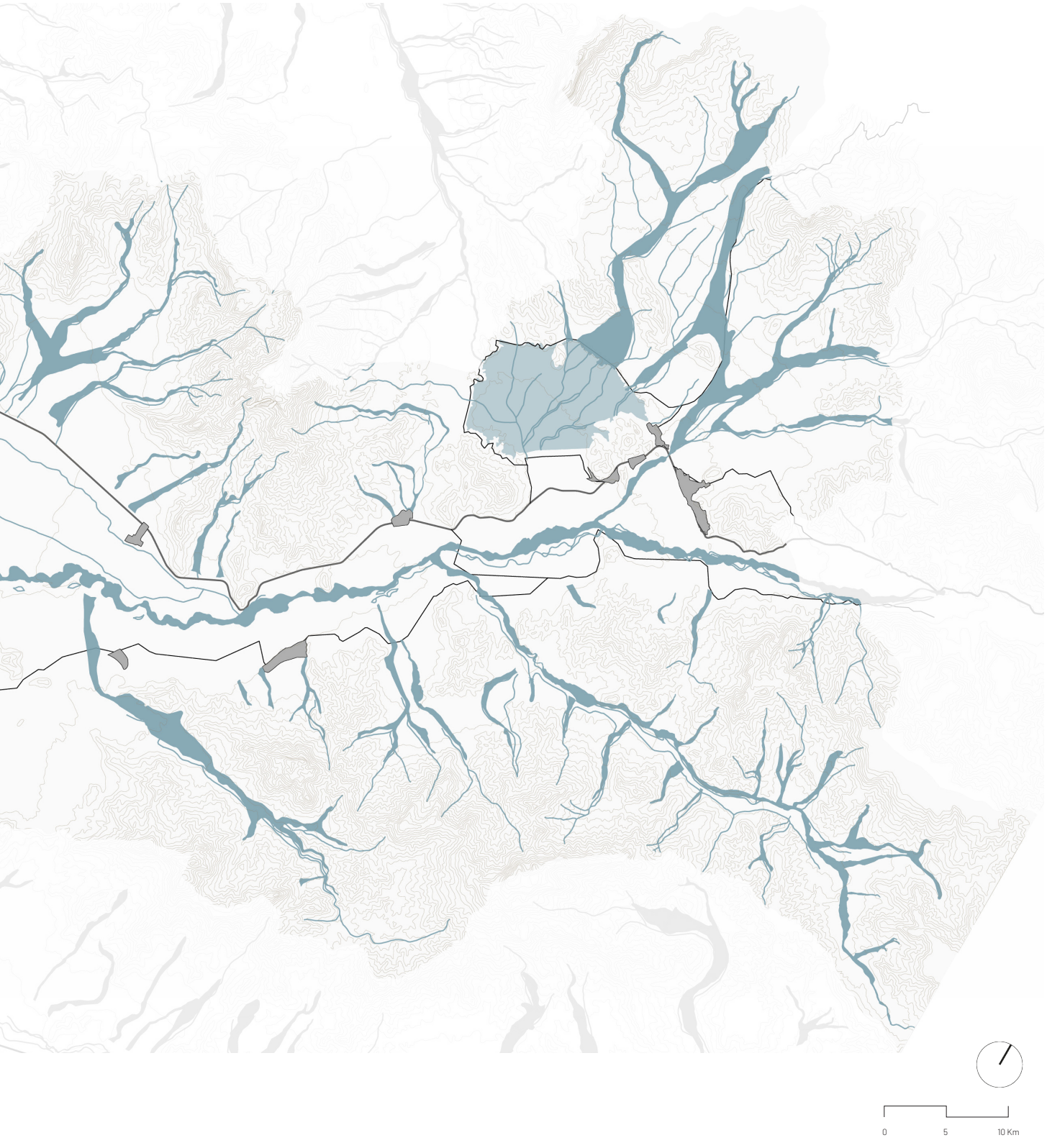


FIG. 1.48 Road system + built pattern map
Source: Made by author with data from INGEMMET


0
5
10 Km

Hydrology System

FIG. 1.49 Water system map
Source: Made by author with data from Geo Servidor MINAM

FIG. 1.50 Irrigation canal passing through the Mórrope desert.
Source: Author

Hydrology System

Regarding water infrastructure the main reservoirs of the region are Collique lagoon, Boró and Tinajones Reservoir, the latter of inter-regional importance given that is the primary source for the hydroelectric plant Carhuaquero, which is the main energy supplier of the north part of the country.

Chancay river is the main water source for consumption, irrigation and production of energy of the region.

As mentioned before, water flows of Chancay start at 3800 meters above sea level. While in the middle slope, Chancay river gets to Tres Tomas dam, where the river is divided into three: Lambayeque river, used for irrigation purposes in the valley, Taymi canal -which is the main water source of Chiclayo- and Chancay river, also known as Reque river, for its proximity with the city of the same name. Moreover, Taymi canal follows the remains of a pre-Inca irrigation canal and connects the Chancay valley with the adjacent one, La Leche.

Total consumption of the basin is 986.7 million m3 per year and non-consumptive use amounts to 37.3 million m3 in the same period. 95.9% of the total is consumed by the agricultural sector, followed by the 3.4% used by population, the remaining percentage is used by industries and livestock production. Furthermore, the consumption of the basin constitutes 7.6% of the total consumption of the Pacific catchment area and 6.4% of the total national usage. (Quality Diagnosis of Chancay-Lambayeque basin)

Power produced by hydroelectric plants account for the 54% (21,733GWhGW) of the national production. National energy demands increase by about 5.4%/year, mainly due to demographic and economic changes. (Drenkhan et al. 2015: 724)

Region showing the above and following zoom-in area

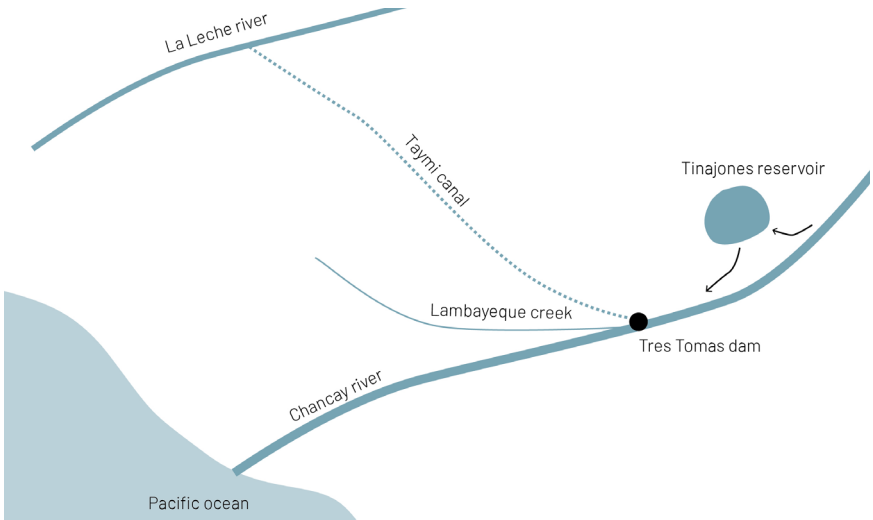


FIG. 1.51 Diagram showing the main water infrastructure related to Chancay river .
Source: Made by author

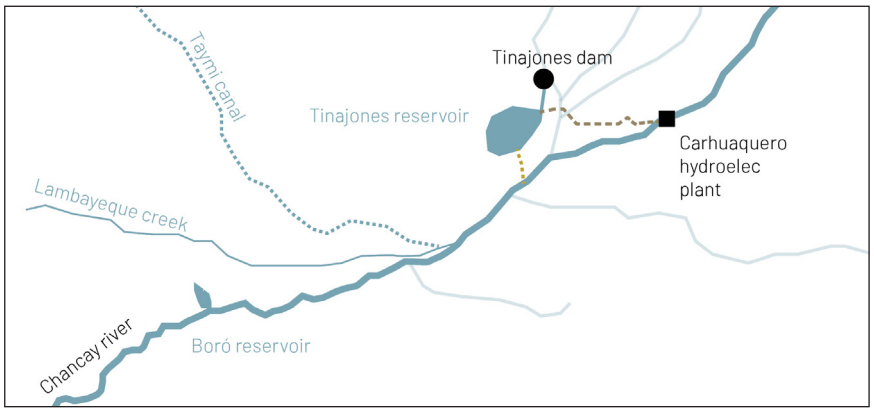


FIG. 1.52 Diagram of the water system in the Chancay-Lambayeuqe basin.
Source: Made by author

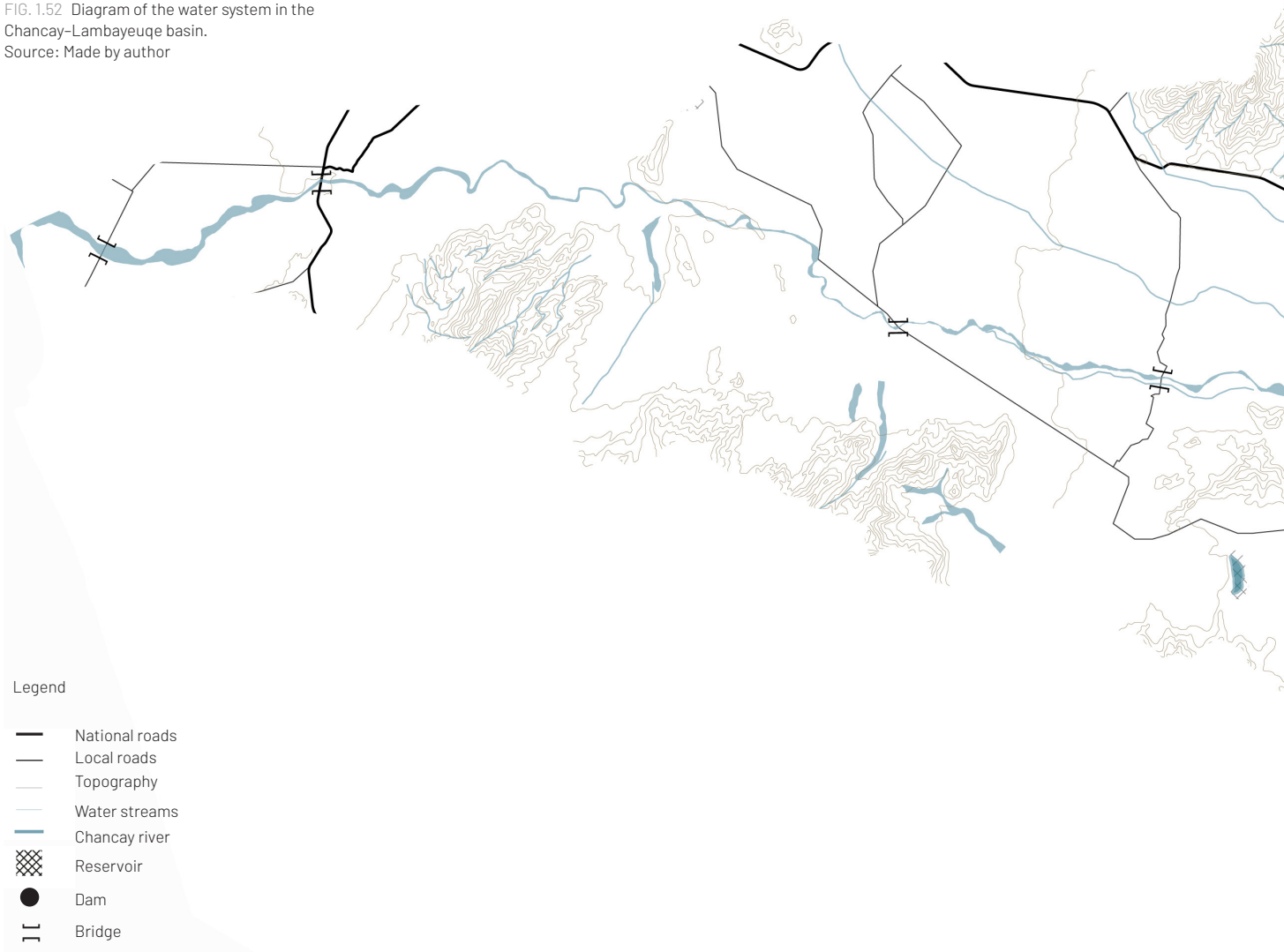


FIG. 1.53 Hydrology system + topographic map
Source: Made by author with
data from Geo Servidor MINAM

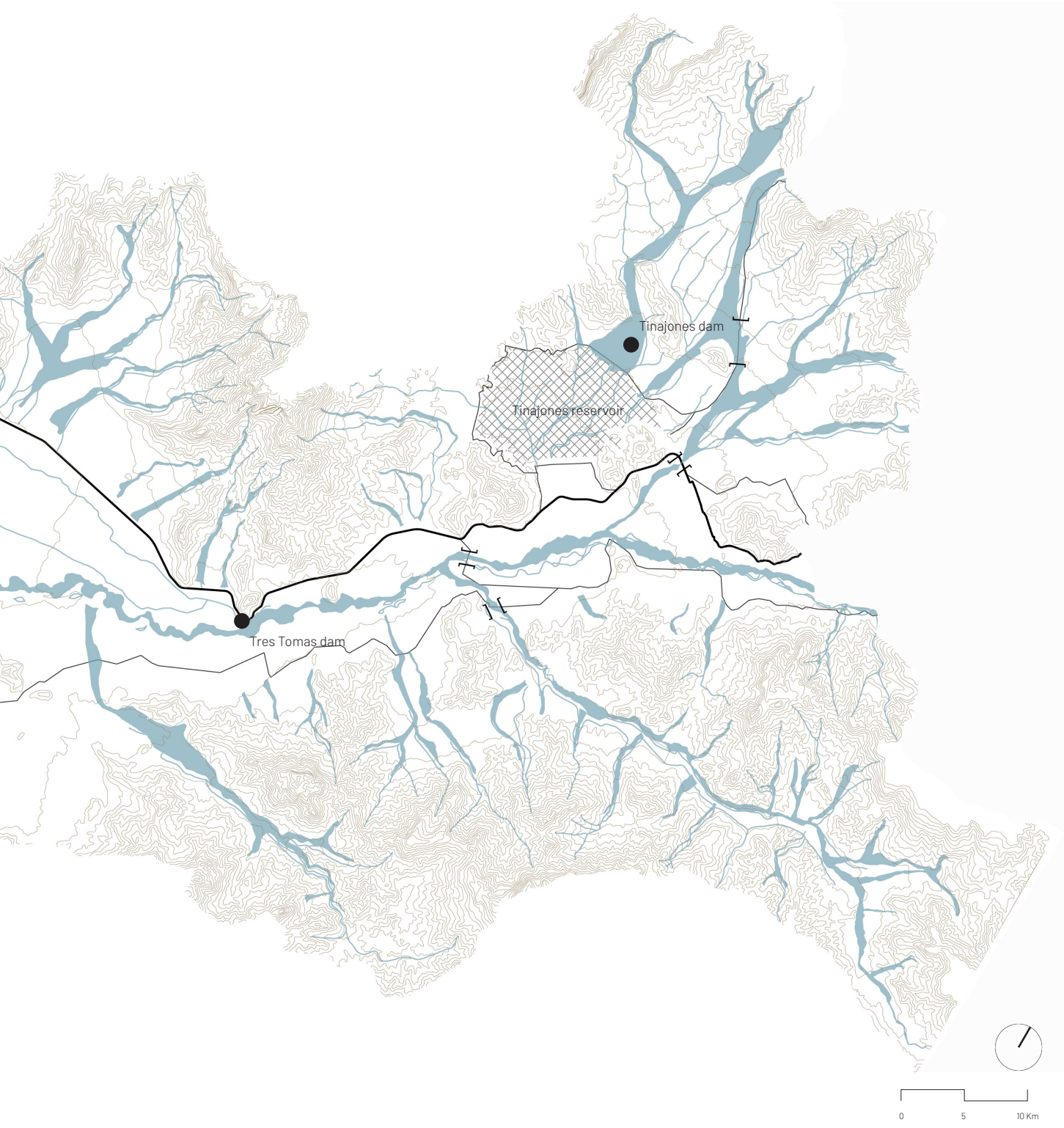

Tinajones dam
Tinajones reservoir
Tres Tomas dam
0
5
10 Km

FIG. 1.55 Irrigation system in Sipán
Source: Made by author with data from Google maps

1

2

FIG. 1.56 Changes in the landscape. The image from 1970 shows the natural course of one of the streams arriving to Chancay river . In the image of 2016 the water course has been canalised.
Source: Google Earth

Attitude towards water: river, canals & ditches

Taymi canal is the one that carries water to Chiclayo from Chancay river. Once inside the city it divides into ditches that run through the city. Cities nearby Chiclayo are part of the same system. Smaller cities in the diffused urban pattern of the region function within their own system, normally around a main canal that runs in the perimeter of the city or rural settlement, usually as part of the irrigation system in the latter case.

The general perception of canals and ditches that run through the built environment is utterly negative, given their dreadful conditions: polluted and smelly water, infrastructure poorly maintained (garbage can be found in the water or in the slopes of the canals and ditches). Due to this conditions adjacent sidewalks are extremely insecure.

Scaling up, the same attitude is found towards the river, which is treated as a threat instead of a resource of pleasure and pride. Built areas settled near rivers or streams do not incorporate the water flows into the urban design instead, the river is used as the back part backside, where the untreated grey water goes.

It is worth highlighting that no Irrigation system map could be found therefore, the retracing of Google Earth maps in this stage is critical.

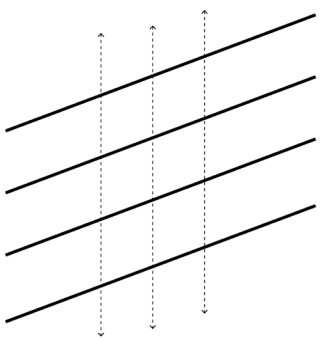


FIG. 1.57 Irrigation system diagram, where the orientation of rivers from the Andes to the Pacific ocean is shown. Dashed lines indicate the direction of main canals in orders to irrigate the valleys.
Source: Made by author

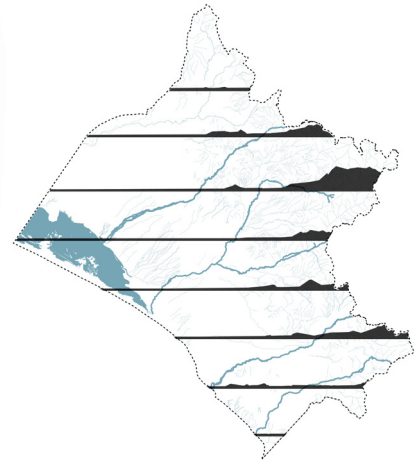
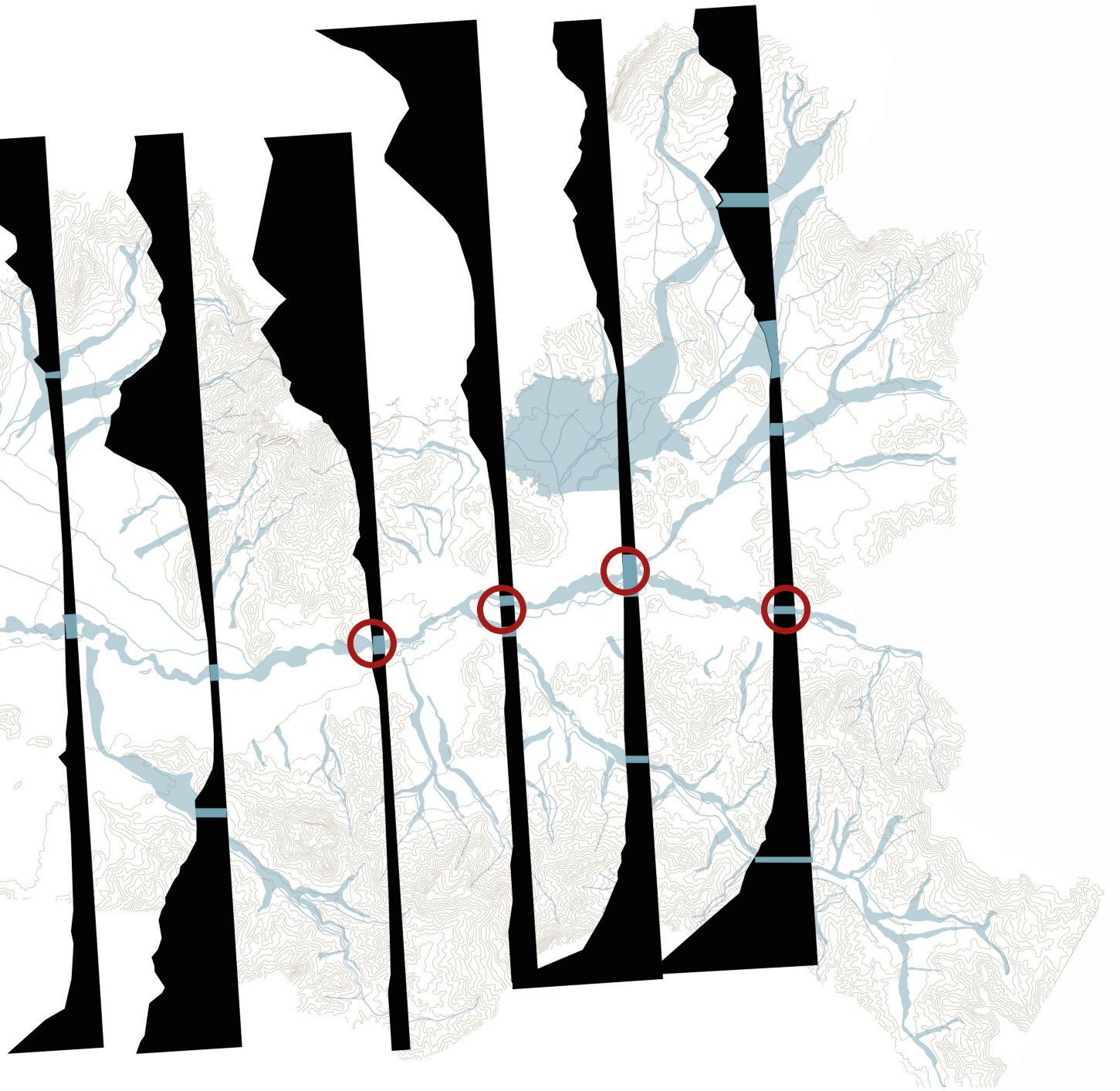


FIG. 1.59 Sections across the territory.
Source: Made by author

FIG. 1.58 Sub-basin topography.
The conclusion of the sub-basin topography relies on the potential for spaces of water in case of flooding. Moreover, it allows to identify the higher vulnerability in the valley and, in consequence if this flood risk affects: communities, infrastructure or productive land.

Major risk regarding river flood are represented with red circles in areas where the adjacent areas to the river are at the same level or lower than the river and the rest of the plain.
Source: Made by author with data from Google Earth


0
5
10 Km

Geology + Hydrogeology System

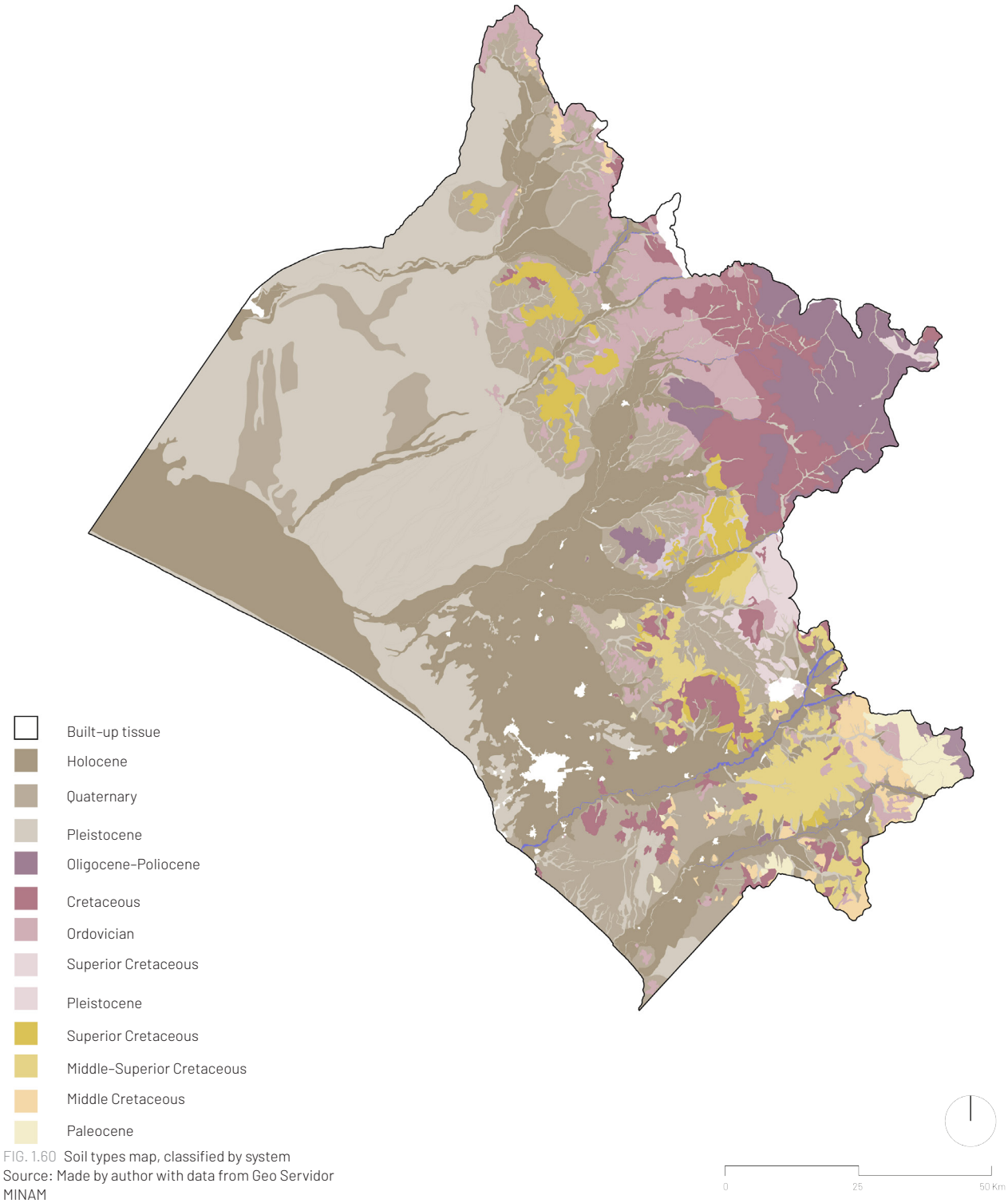


FIG. 1.60 Soil types map, classified by system
Source: Made by author with data from Geo Servidor MINAM

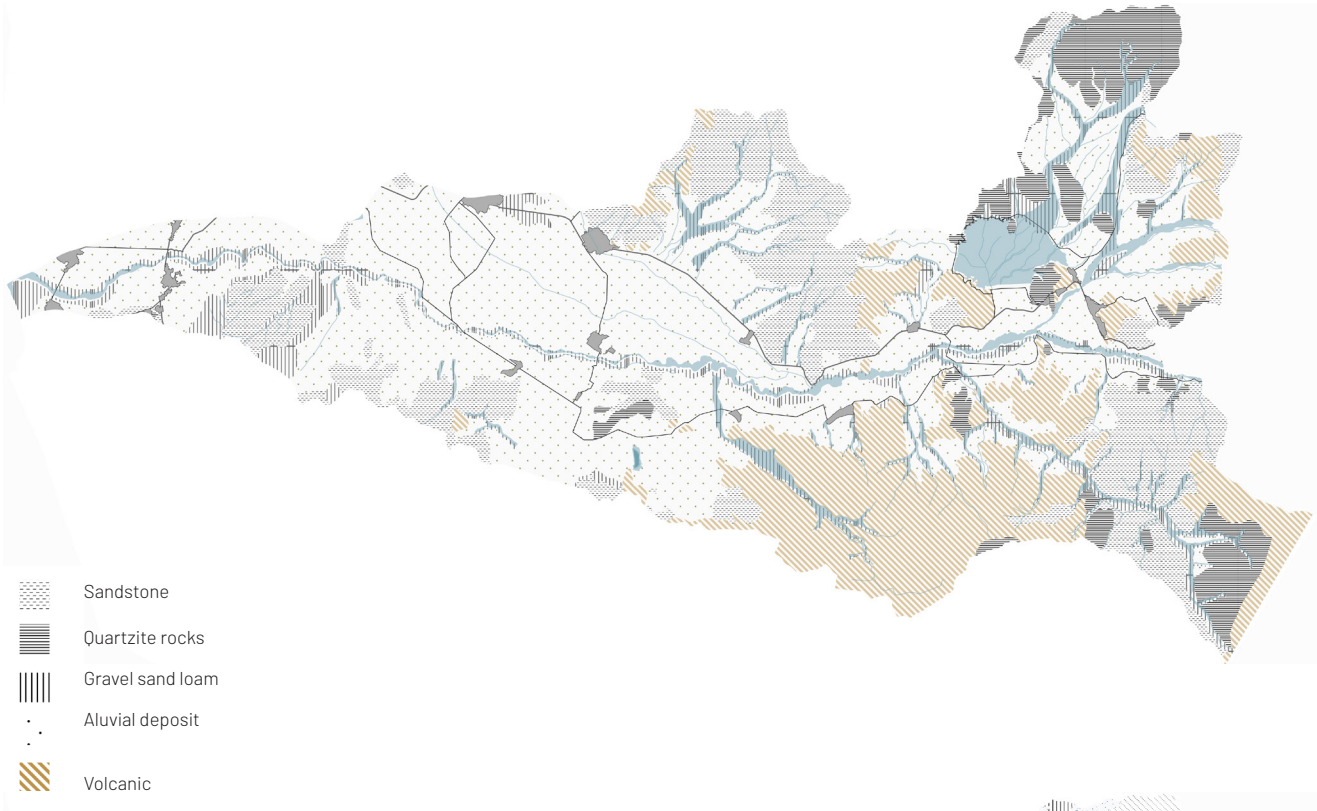


FIG. 1.61 Geology map, classified by stratigraphic units
Source: Made by author with data from INGEMMET

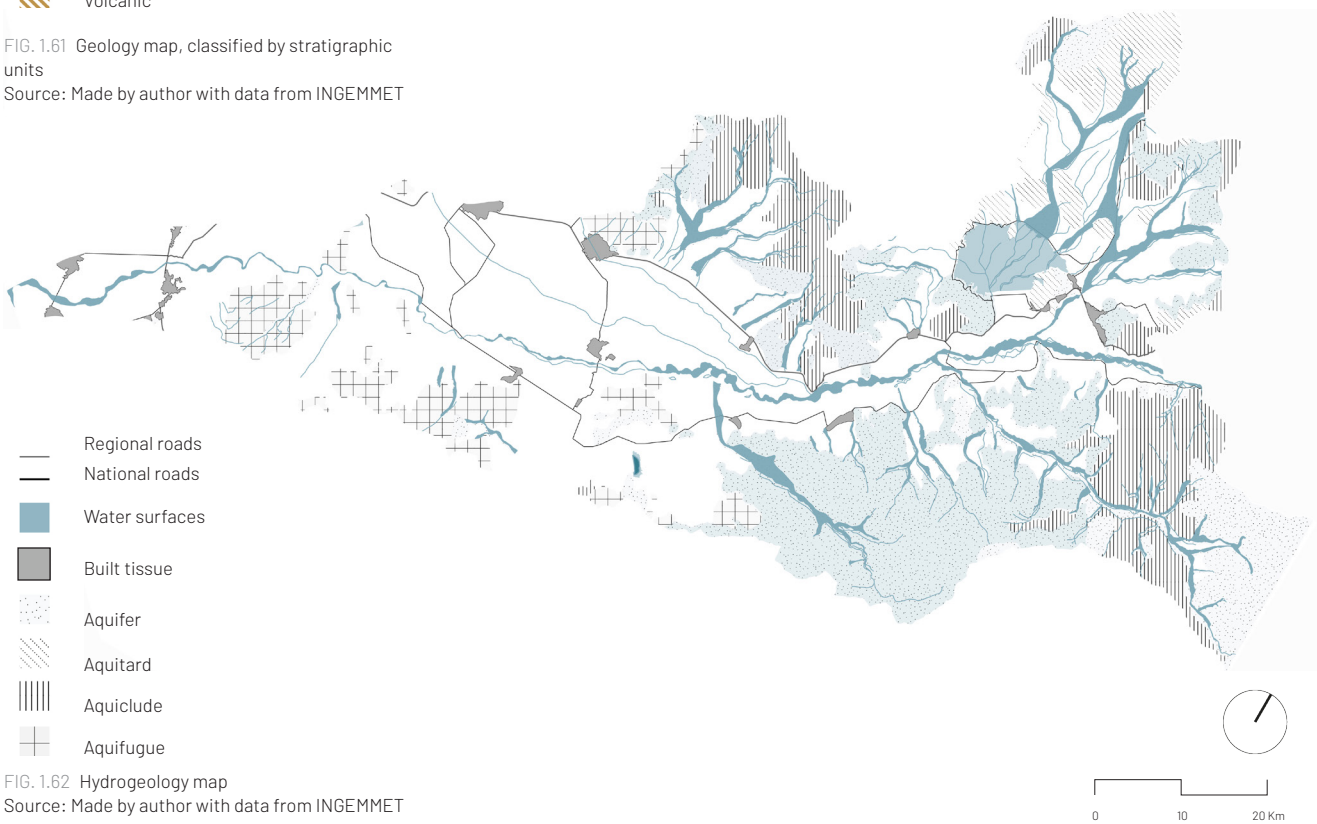
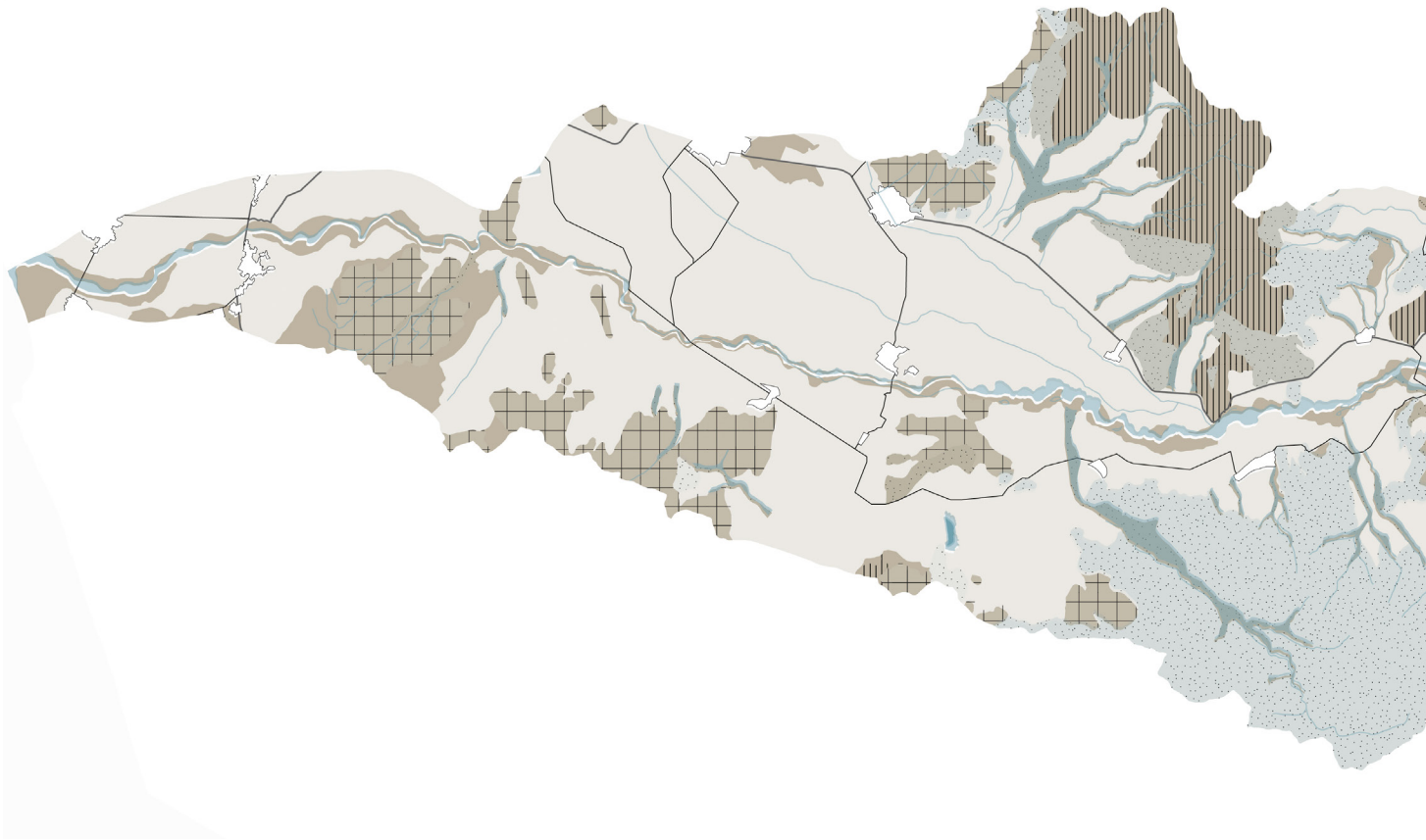


FIG. 1.62 Hydrogeology map
Source: Made by author with data from INGEMMET



High permeability – Low water holding capacity

Medium permeability – Medium water holding capacity

Low permeability – High water holding capacity

FIG. 1.63 Geology + hydrogeology conclusion map
Source: Made by author

Geology & Hydrogeology

According to the stratigraphic units (Geological Survey of Lambayeque, 2013) a classification is made were four hydrogeological formations comprise the following categories:

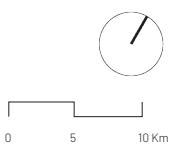
–Aquifer. Facilitates accumulation and circulation of groundwater. Composed by statigraphic units: Volcanic and Goyllarisquizga group.

–Aquitard. Low permeability. Stores and transmits water slowly. Composed by statigraphic units: Tinajones formation.

–Aquiclude. Stores groundwater but does not allow for its circulation. Composed by statigraphic units: Inca and Pariatambo formations.

–Aquifugue. Impermeable, functions as a sealed rock. Composed by statigraphic units: Pulluicana and Quilquiñán group and Pariatambo formation

The map on the left shows the conclusion of overlapping geology and hydrogeology were a classification from high to low permeability is made. High permeability soils are considered potential sites for forest patches foe example, given its low water holding capacity, the recharge and cleaning of the water table would be a result of this use. On the other hand, low permeability soils have high holding capacity, which makes them potential sites for water storage or wetlands.



Ecological system: vegetation cover

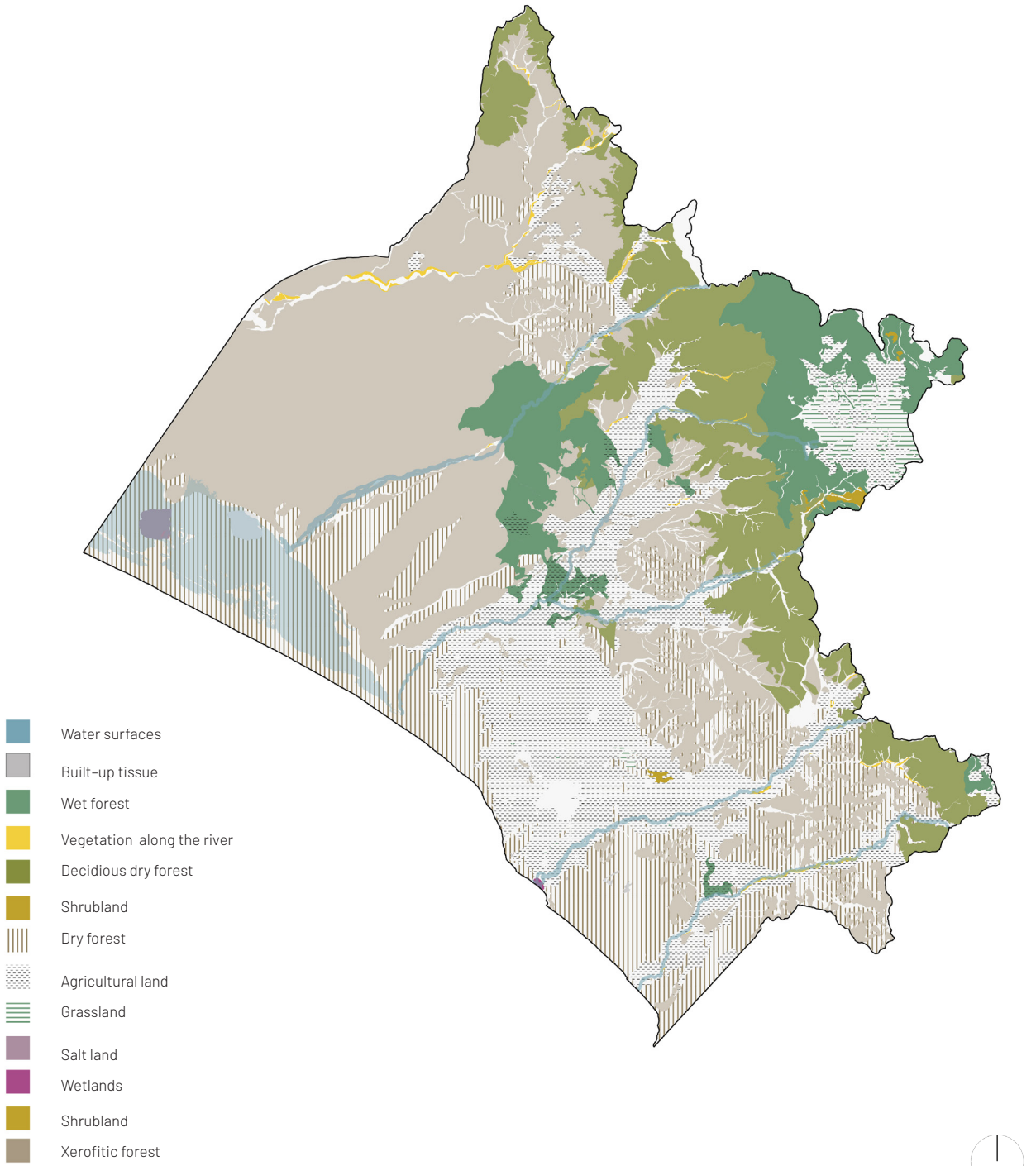
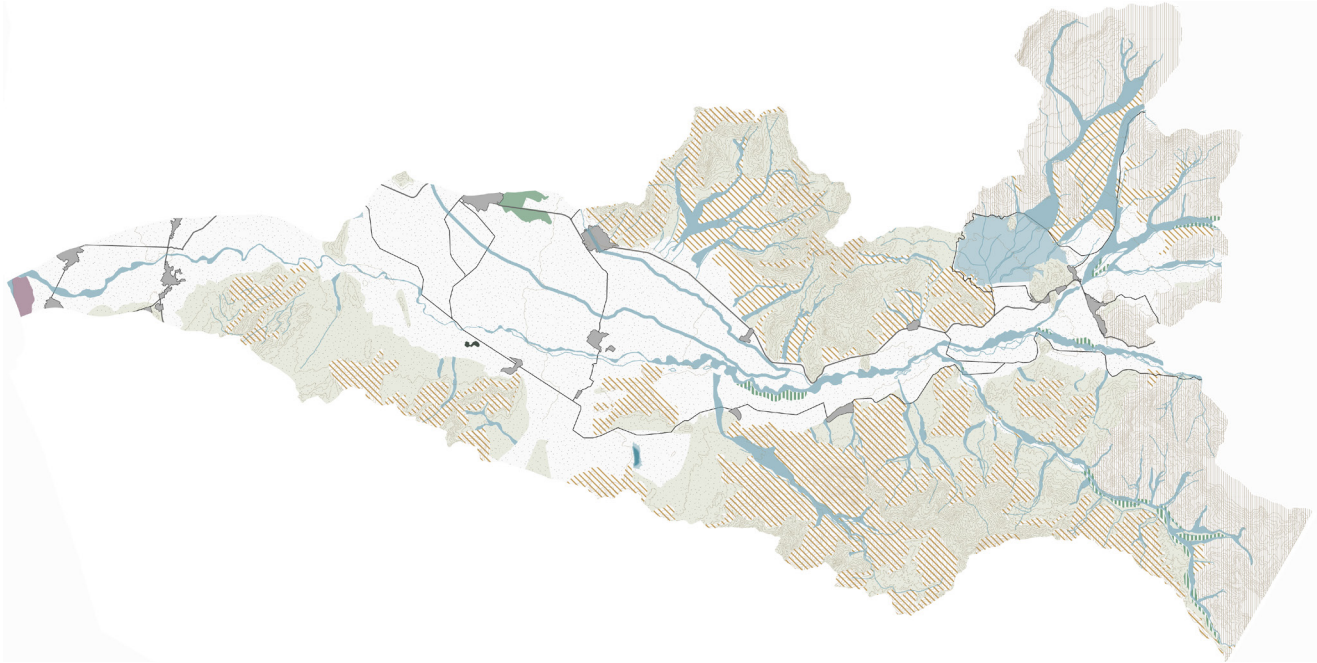


FIG. 1.64 Ecological system map - regional
Source: Made by author with data from Geo Servidor MINAM



Topography
Regional roads
National roads
Water surfaces
Built tissue
Dense decidous dry forest
Scrubs
Riparian vegetation
Grassland
Evergreen xerophile dry forest
Sparsed xerophile dry forest
Wetland
Agriculture land

0 10 20 Km

FIG. 1.65 Vegetation cover map - sub-basin
Source: Made by author with data from Geo Servidor MINAM

Ecological system: protected areas

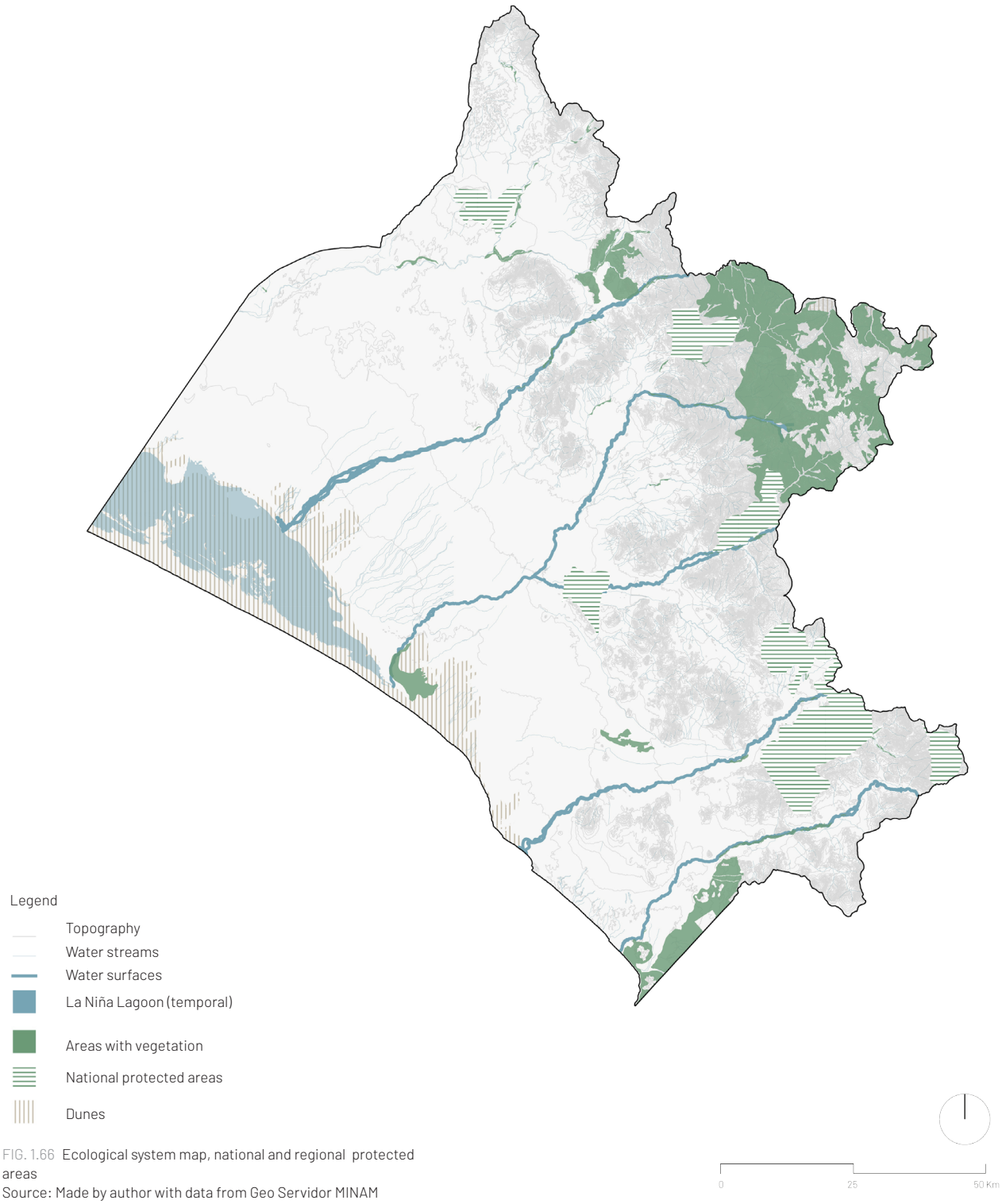


FIG. 1.66 Ecological system map, national and regional protected areas
Source: Made by author with data from Geo Servidor MINAM

Life-zones

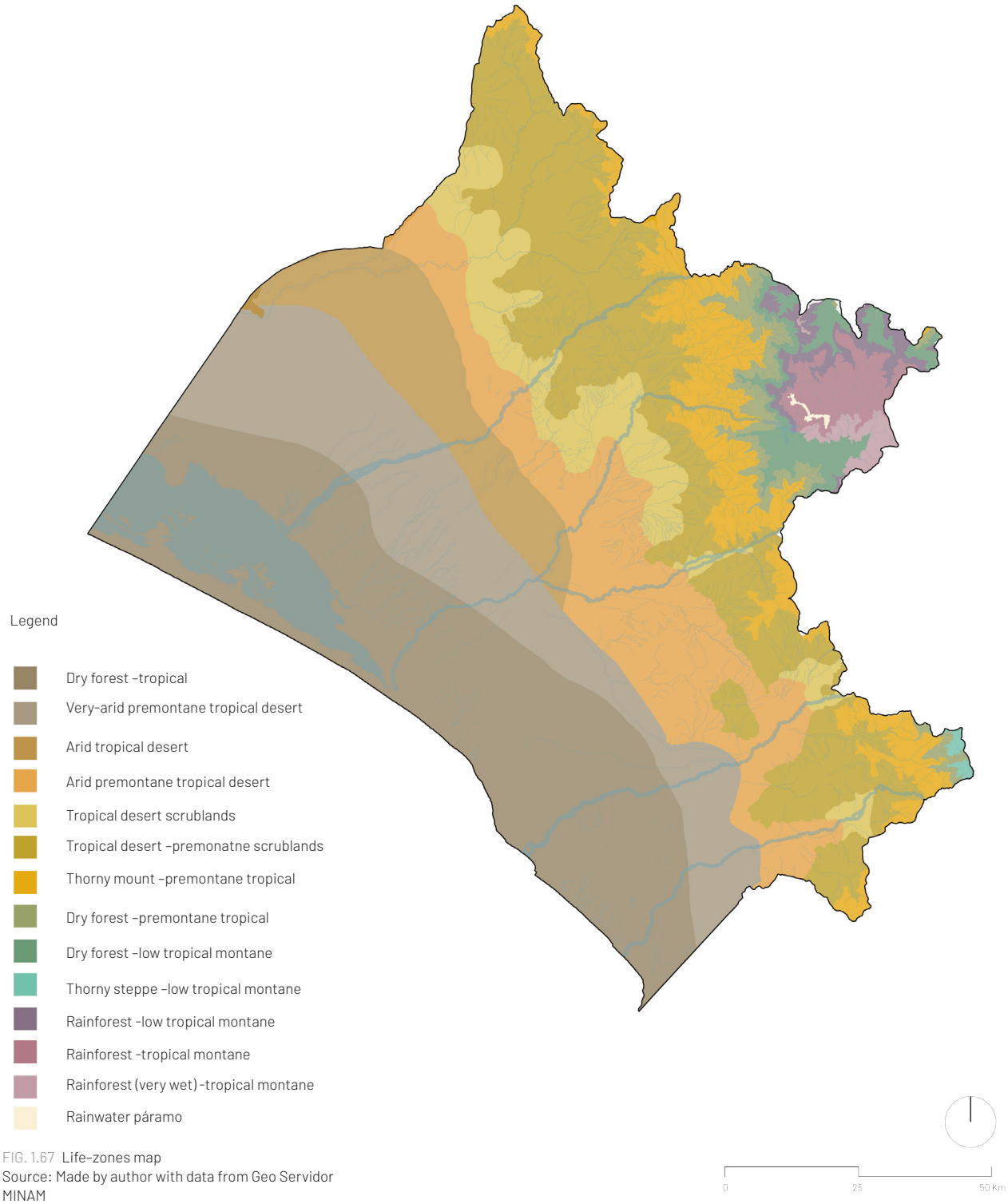


FIG. 1.67 Life-zones map
Source: Made by author with data from Geo Servidor MINAM

Agriculture System

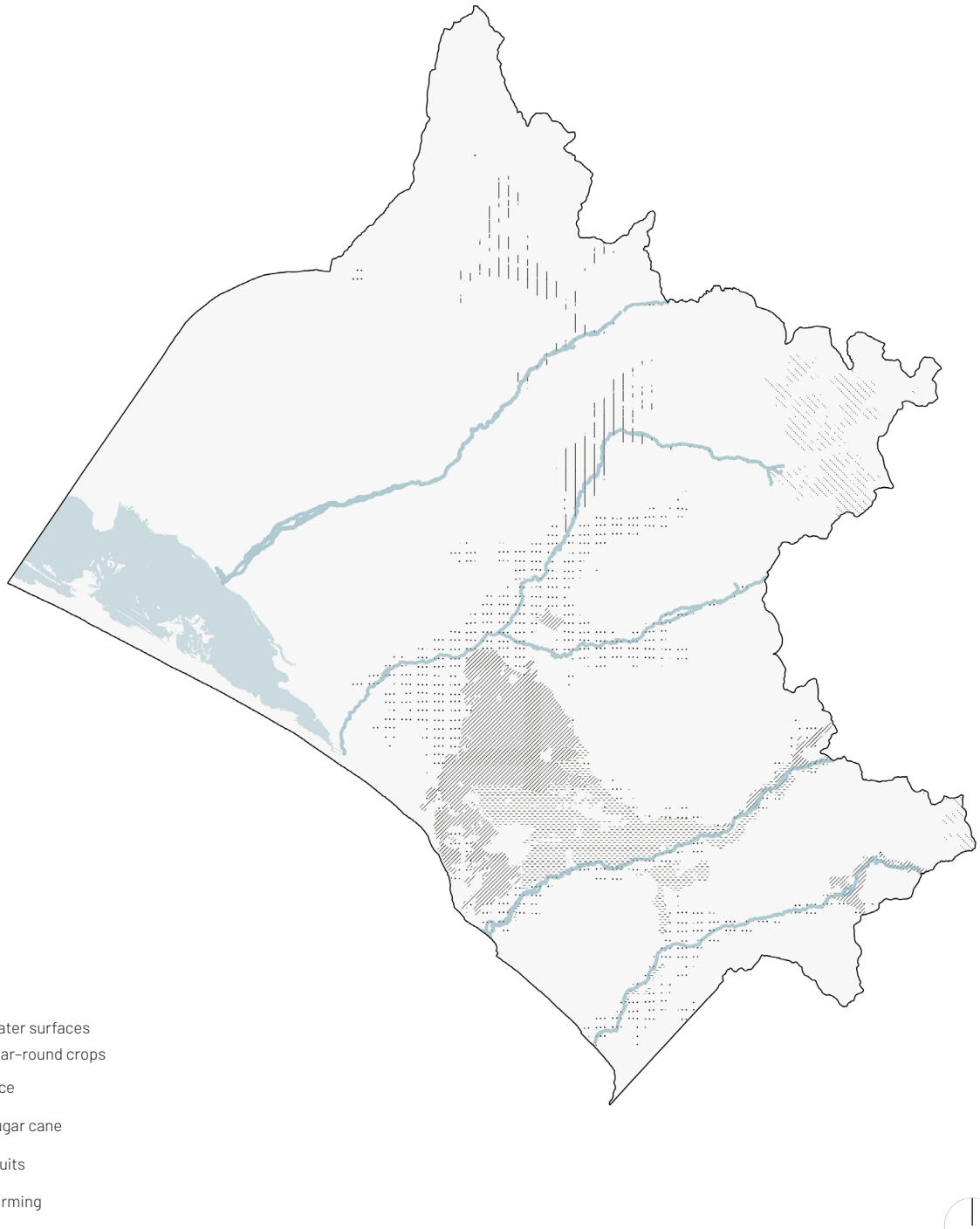


FIG. 1.68 Agricultural system map
Source: Made by author with data from Geo Servidor MINAM

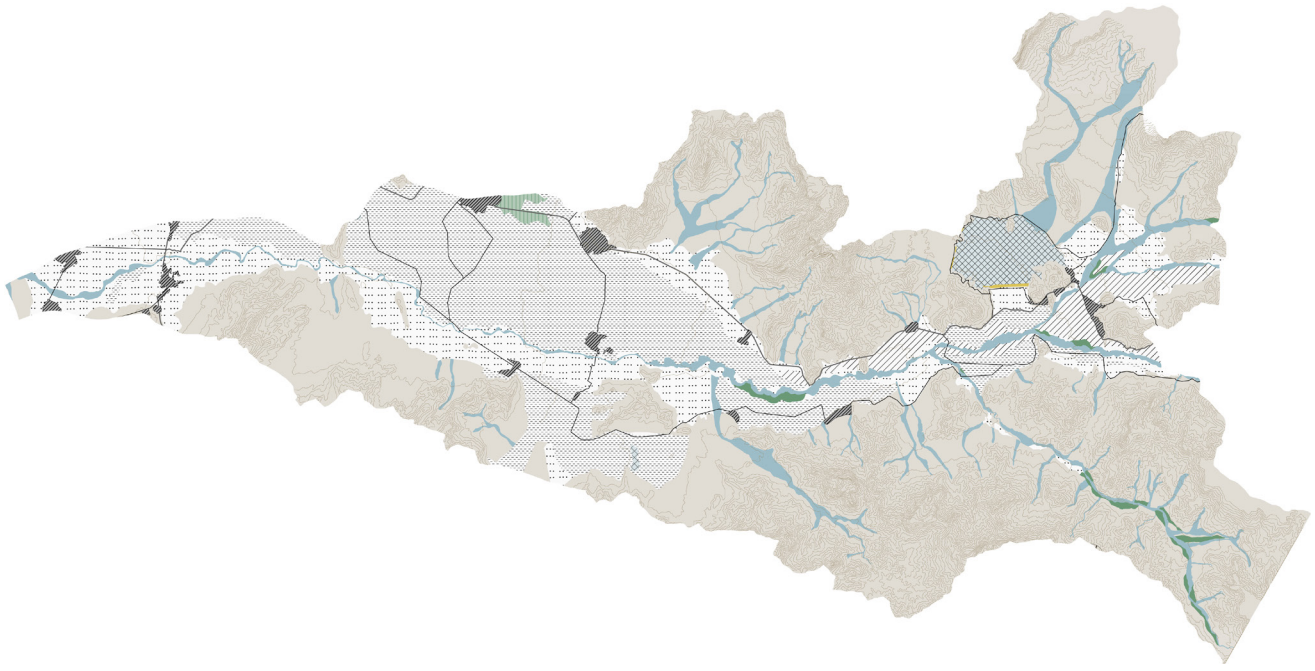


FIG. 1.69 Agricultural & land use system map
Source: Made by author with data from Geo Servidor MINAM

Legend

- Water surfaces
- Year-round crops
- Rice
- Sugar cane
- Fruits
- Farming

Agriculture & Land Use

Agriculture System
In the last two decades, agricultural area in the country has increased by 30%, from 54,770 km2 in 1994 to 71,250 km2 in 2012, where the Pacific coast represents the main site for agricultural development comprising more than 71% of the national market. (Drenkhan et al. 2015: 723).

Agriculture and commerce account for the 72.4% of the regional gross domestic product, where main crops are:

	(in hectares)
Sugar cane	28 930.68
Rice	26 478.50
Yellow Corn	5 781.55
Cotton	2 948.14
Beans & cereals	1 277.55

Other crops: pepper, lemon, mango, passion fruit, sweet potato.
Source: inrena.gob.pe (2012)

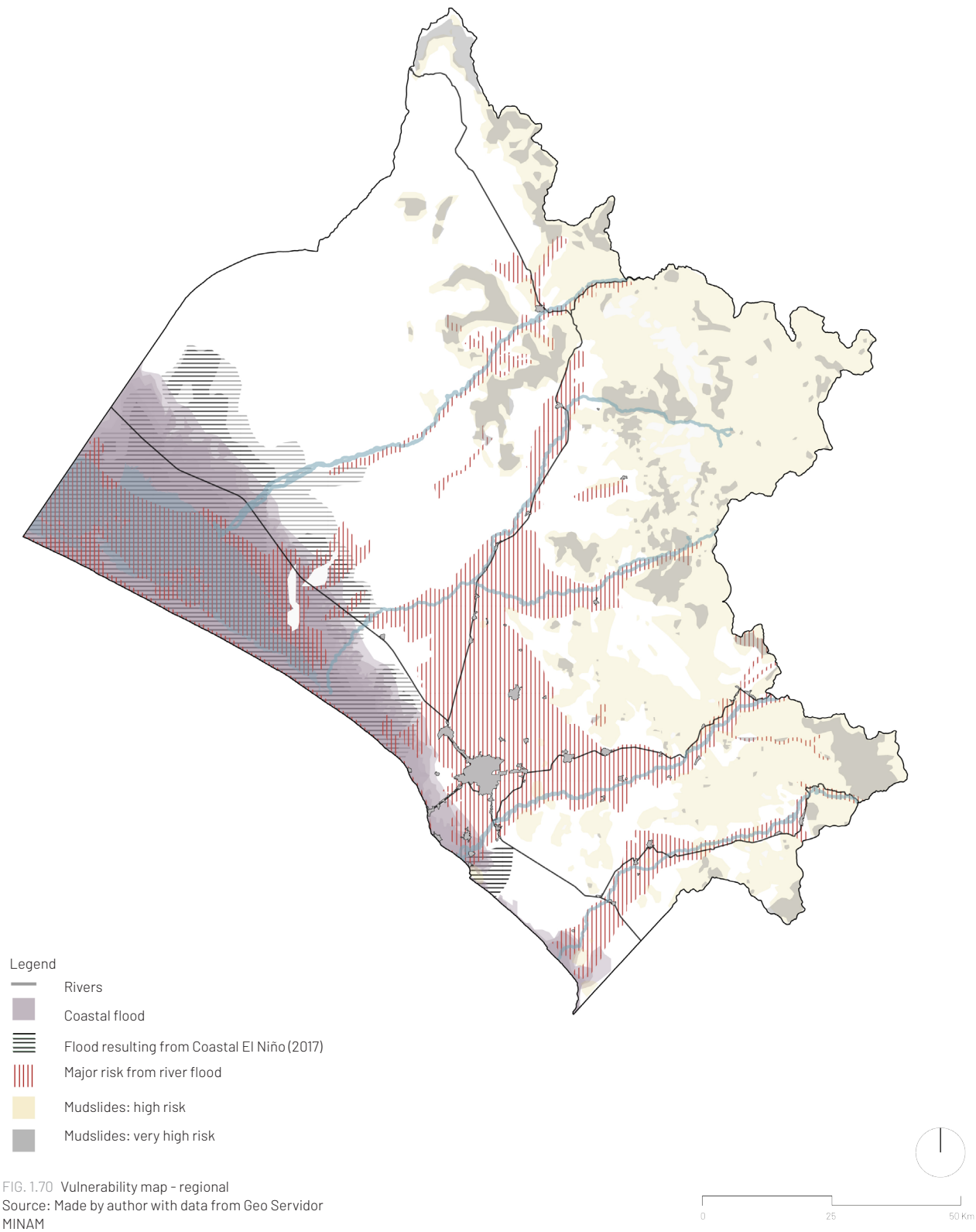
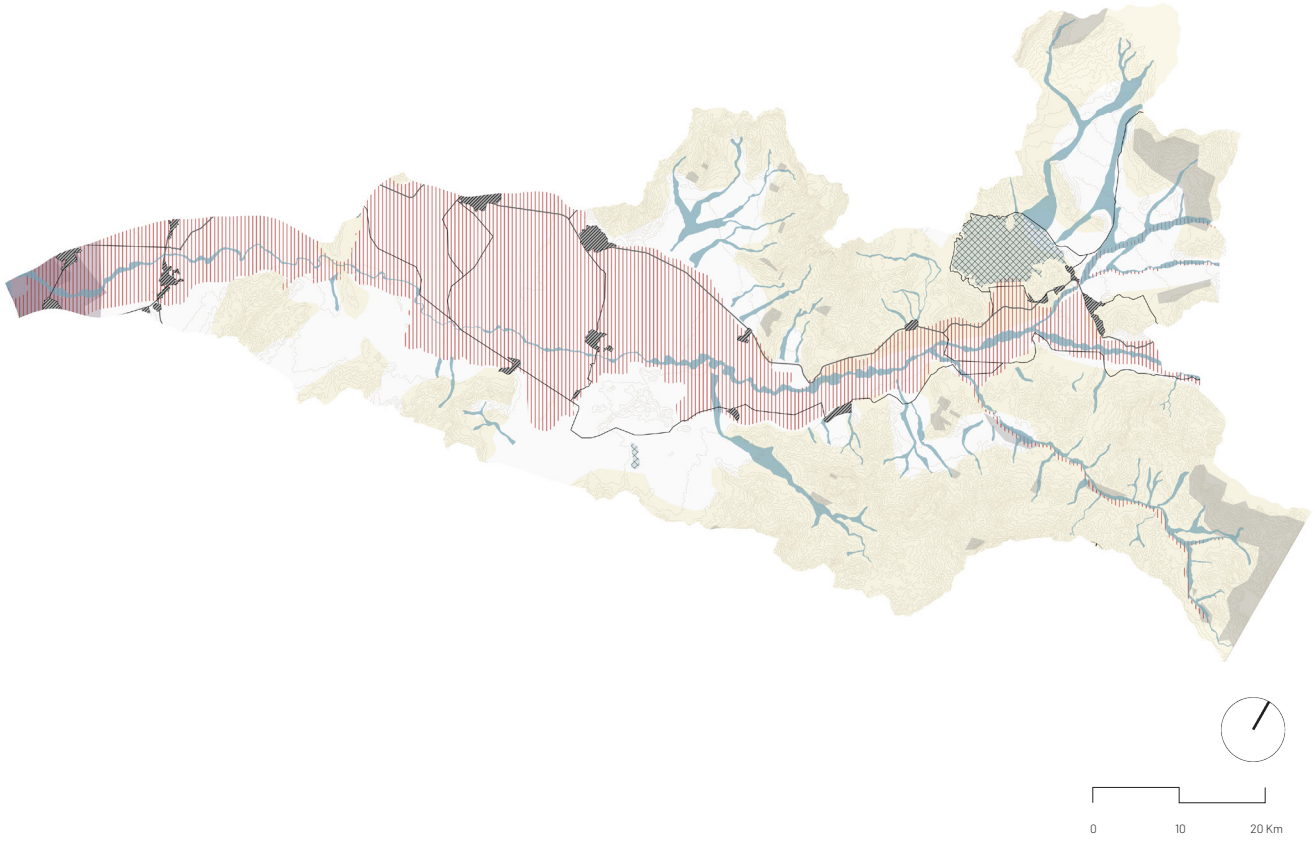


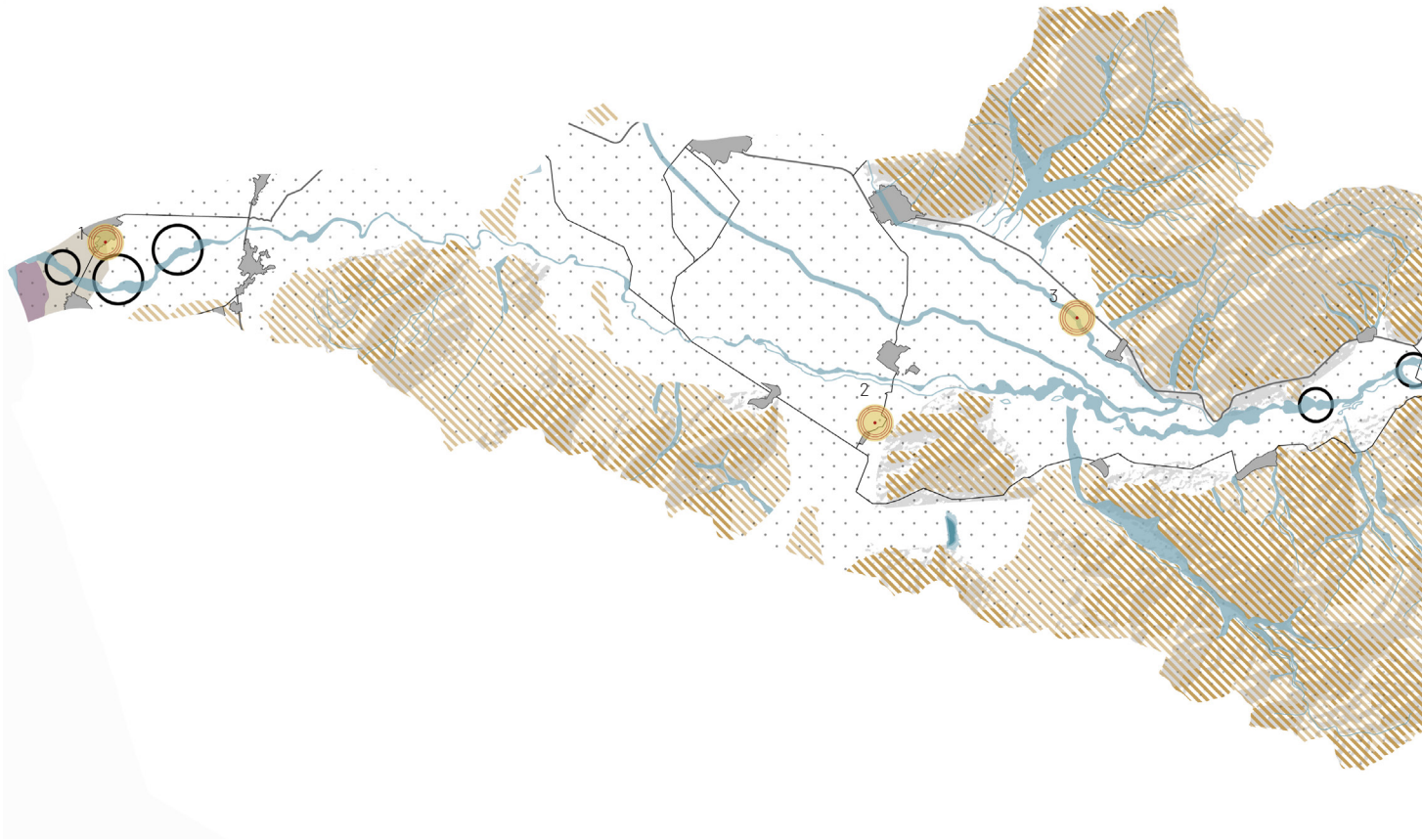
FIG. 1.70 Vulnerability map - regional
Source: Made by author with data from Geo Servidor MINAM



Vulnerabilities

According to Folke et al. (2010) resilience is the 'capacity to adapt or transform while facing –unexpected/extreme– change'. In the case of Lambayeque the unexpected change results from coastal flooding due to rising sea level, natural disasters such as Fenómeno El Niño, which causes extreme precipitations resulting in river floods and mudslides, and finally, seismic movements.

FIG. 1.71 Vulnerability map - sub-basin
Source: Made by author with data from Geo Servidor MINAM



Legend

- Lower areas
- Heritage 1: Monsefú [handcrafts] 2: Huaca Rajada [centre of Moche culture] 3: Old Moche irrigation canal 4: Chaparrí Natural Protected Refuge
- Wetlands
- Dunes
- Highly productive area
- Dry forest – dense evergreen xerophyte vegetation
- Dry forest - sparsed xerophyte vegetation

FIG. 1.72 Site specificity map
Source: Made by author with data from Geo Servidor MINAM

Site Specificity

Site Specificity Map puts in the same level of importance experiences and physical attributes of a certain landscape. As Berrizbetia describes in Re-Placing Process (2007) the term 'site' does not aim to be all-inclusive as 'place' which is 'open-ended, whereas place was singular' (Berrizbetia 2007: 176). 'Site' highlights some of the features of a 'place' -but not the whole array-, which in this case are heritage, dry forest and its native species, and the economy commonly linked to different types of productive land.

The aim of the Site Specificity Map is to produce new modes of engagement and relations to the place, that later on will be intrinsically linked to the design, functioning as a strategic layer in order to create awareness and improve the regional identity.

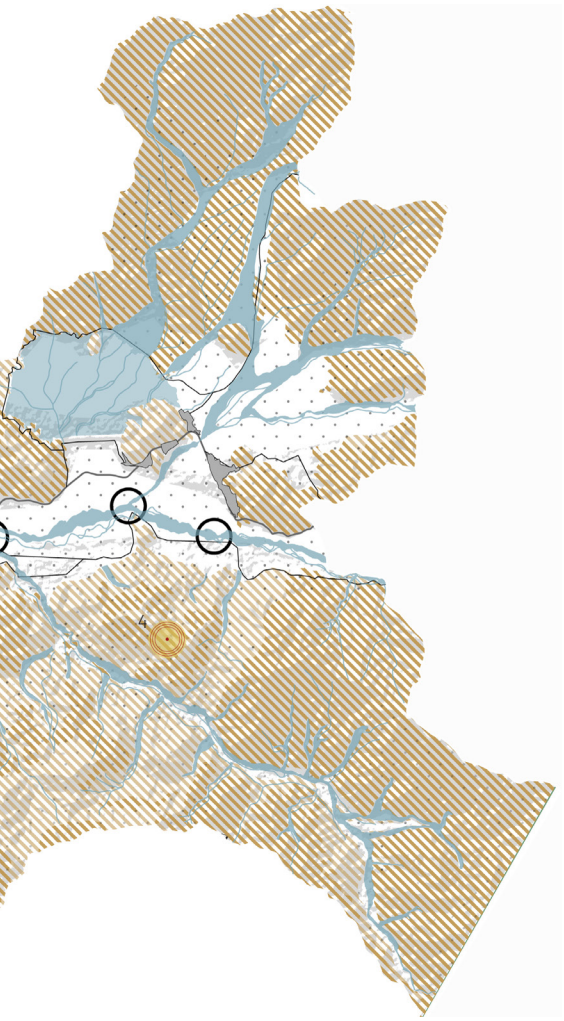
Dry forest is the most striking type of landscape in the region, currently under threat since many of its endemic fauna and flora species are being displaced since the ecosystem is being destroyed in the interest of urbanisation, mostly illegally settled, as is the case of the site considered heritage Chaparrí Natural Protected Refuge.

Lower areas are zones adjacent to the river that need more defence against river flooding given to its lower topography compared to the river stream.

Natural wetlands have gradually disappeared, the only remaining are located next to the coast along with the dunes.

Heritage:

1. Monsefú city is natioally known by the handmade production of utensils and toys, and its handcrafts market.
2. Huaca Rajada is the name of the archeological findings of the centre of Moche culture, settled in the northern part of the country between II and VI century. They were known by their adobe constructions, some of these remains can still be visited nowadays.
3. Old Moche irrigation canal is still used for the same purposes since its early stages many centuries ago.
4. Chaparrí Natural Protected Refuge



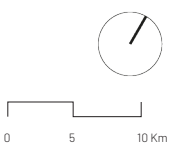
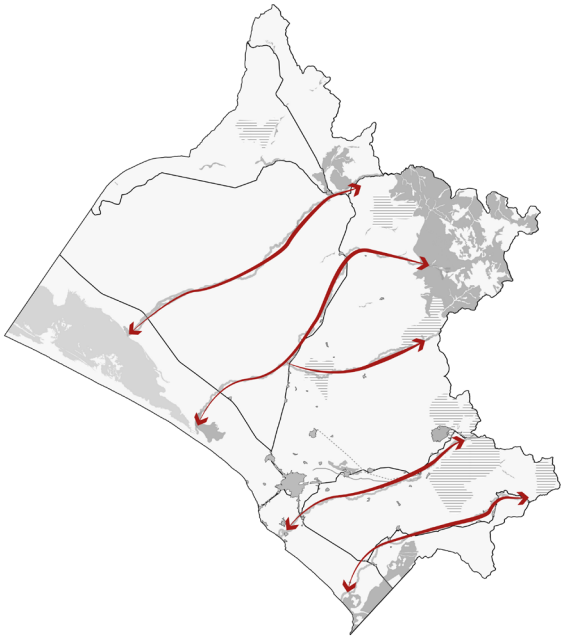


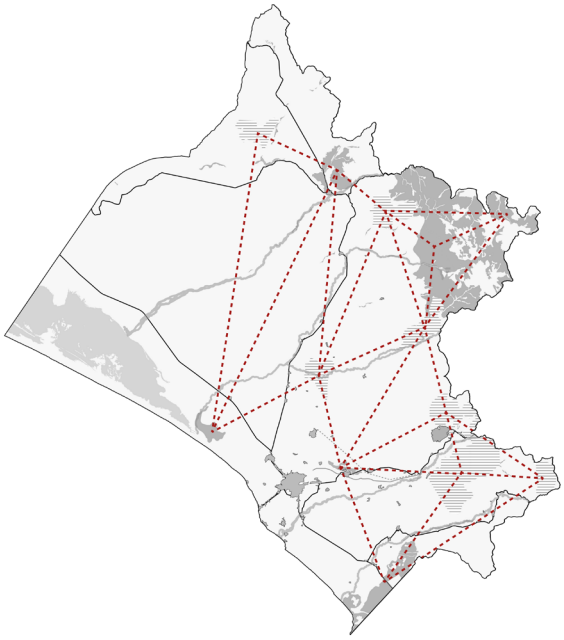
FIG. 1.73 Chaparrí – Regional Private Conservation Area, natural habitat for national and regional native flora and fauna species. Source: www.turismoruralcomunitario.com.pe

FIG. 1.74 Huaca Rajada. Centre of pre-Columbian Moche civilisation. It is worth noting that remains from Moche and Sipán culture can be found throughout the region , such as irrigation canals that are used until present days.
Source: Getty images

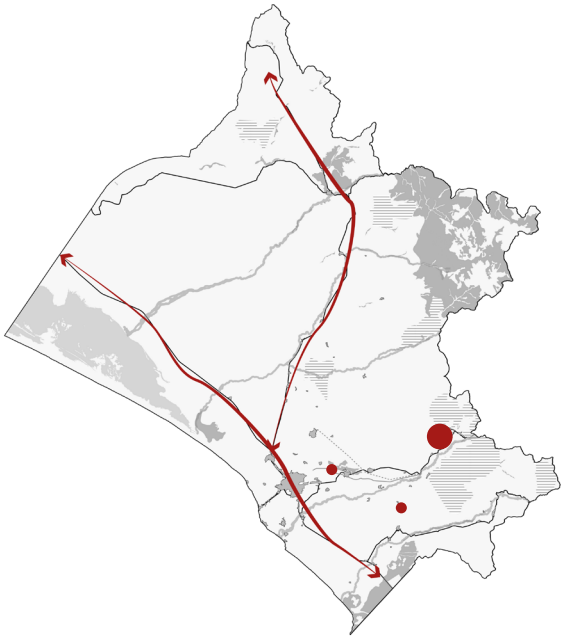
FIG. 1.75 Dry forest, contrasting views
Source: Peru, Kingdom of Forests



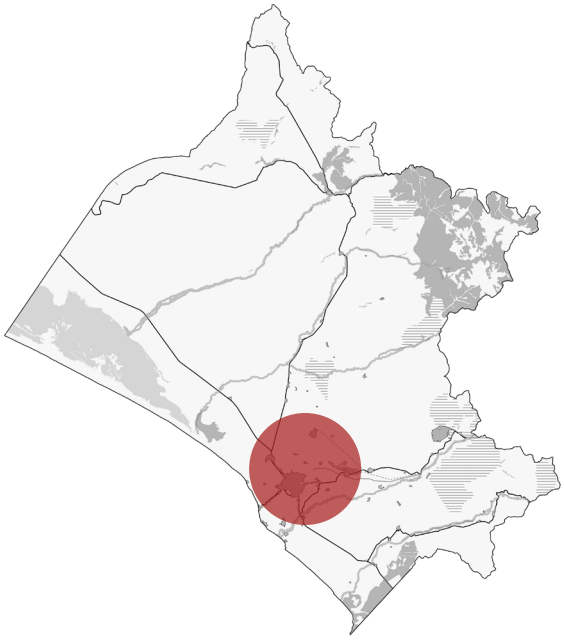
1



2



3



4

FIG. 1.76 [1] River as carrying structure
[2]Geometrical connection of main ecological patches
[3]Infrastructure –main roads and reservoirs– as the 'missing ecological link' & catalysts for change
[4] Major population of the region + major vulnerability to climate related threats
Source: Made by author

Analysis –Summary

Regional Reading Summary

Four main statements arise from the territorial reading in regard from the two major challenges faced by the region: disconnected landscapes and flood risk.

River as carrying structure
The understanding of 'carrying structure' holds the capacity for the design of green and blue multifunctional networks along the main east-west axis of the territory, connecting ecological and built patterns along a regional corridor.

Connection of main ecological patches
Ecological continuity can be achieved through the intertwining of these patches.

Infrastructure as 'missing ecological links' & catalysts for change
The two main highways have the potential to become ecological links in order to achieve a cohesive territory. Moreover, the possibility of the reconfiguration of the relationships among the road system and water, ecological and social systems become the catalyst of change for an adaptive equilibrium.

Taking into consideration the deficit regarding infrastructure in Latin America [4], it seems almost logical to take advantage of the existing one, Panamericana highway, the perpendicular link throughout the Pacific Coast that connects the American continent.

Vulnerability
Almost 90% of the regional population is settled where the red circle is located and in turn, that zone is prone to vulnerabilities resulting from coastal and river floods, and mudslides therefore that is the zone where major risk susceptibility is located.

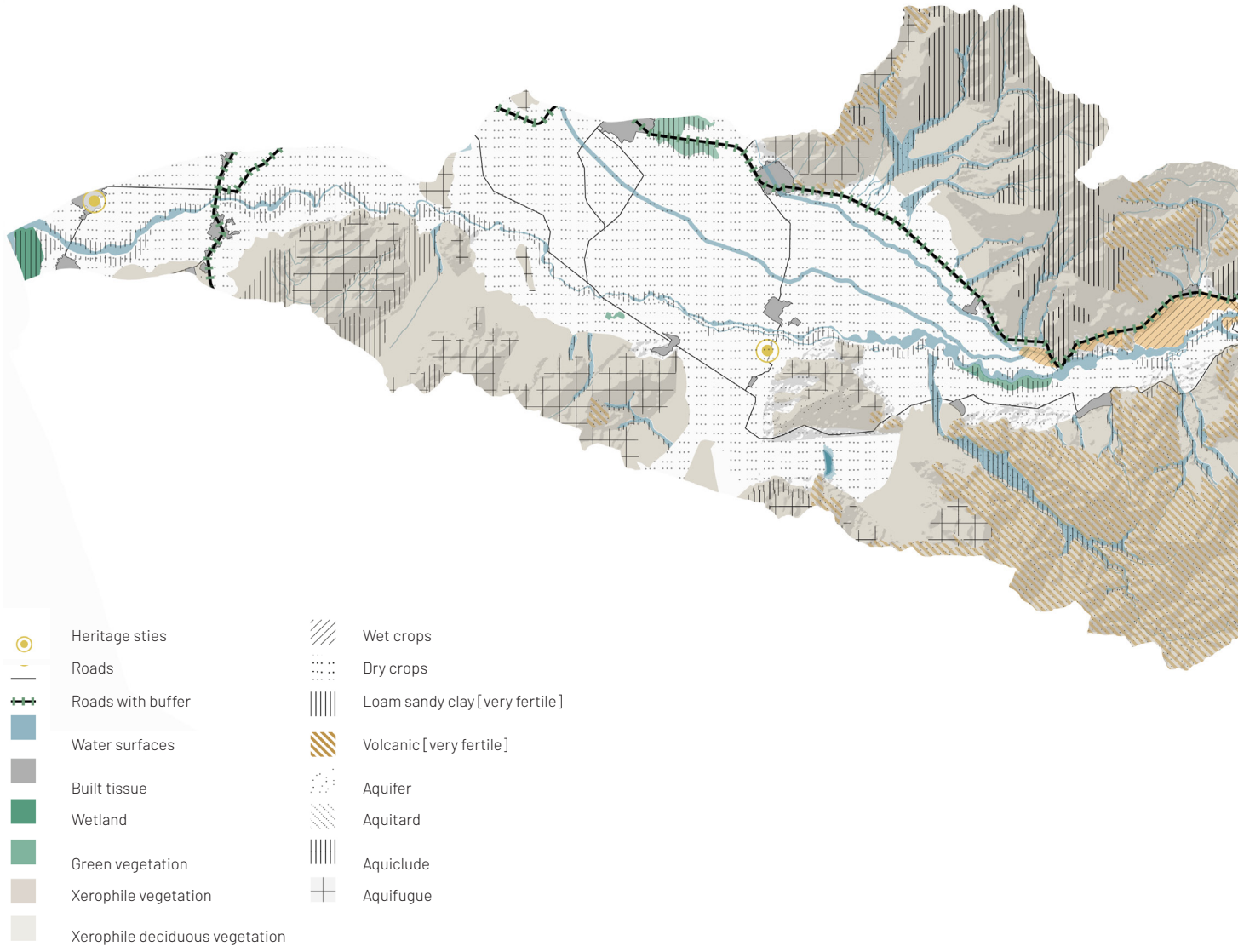
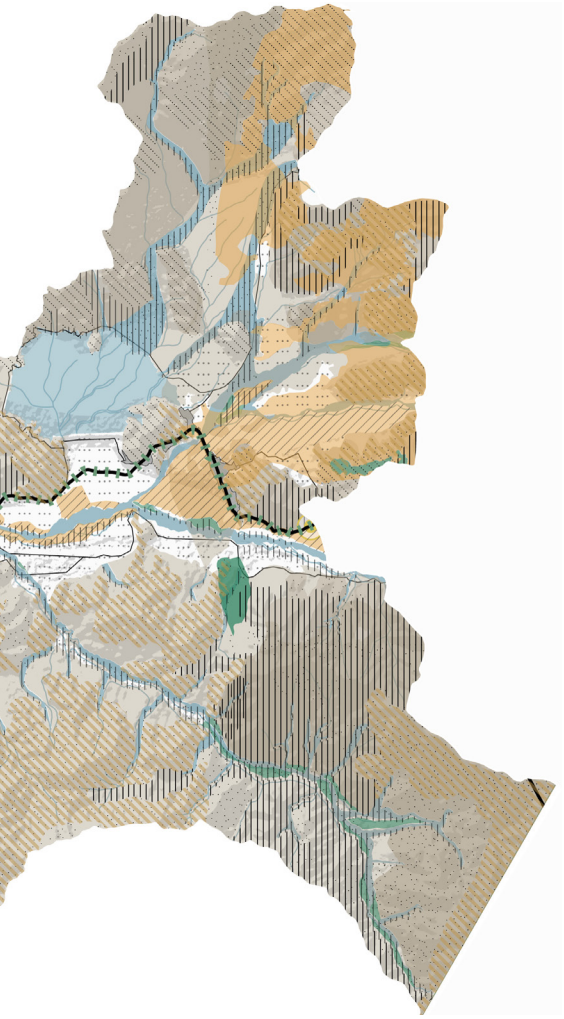


FIG. 1.77 Suitability map made with the most potential areas of the following layers: hydrology, geology, hydrogeology, vegetation cover, risk areas, heritage sites and urban tissue.
Source: Made by author



Sub-basin Reading Summary: Suitability Map

The suitability map shows a cohesive way to urbanise, taking into account the most suitable land use from the overlapping of hydrology, geology, hydrogeology, vegetation cover, risk and built areas layers. It takes into consideration the elements that conform the broader landscape and the configuration of each system. The configuration or 'spatial structure' considers in turn, topography and topology of the system.

Layers are categorised regarding first, second or third nature. It is worth noting that some of the maps overlap between two categories such as 'Infrastructure as landscape' and 'Floodable areas', which overlap the second and the third nature those layers are part of the analysis of the second nature: highways and agriculture land as man-made constructions, however their consequently and almost direct implication in the project is stated in their tittle, thus the need for considering them as part of both natures. Afterwards, the layers utilised for each category are introduced stating the design principle that is more suitable for, and, the direct improvement in the built or natural environment.

Regarding water the challenges are multiple –and in some cases contrasting–: flood, drought, pollution, lack of visibility and connection with built environment, water infrastructure is hidden and finally, no treatment for waste water.

The aim is to design an understanding of water as an ecological, economic and social asset, instead of having negative impressions of destruction about it. Changing the mindset of the population towards water is the overarching aim of 'Co-existance with water'.

In order to achieve this, general design principles are presented in this chapter, taking into consideration the site and the theory from the second part. According to the specificity of each site, more precise strategic tools will appear in the design chapter.

Protection of biodiversity aims for the recovery of important ecological patches that are in constant risk of disappearance. Another important feature of this design principle is the protection of endangered flora and fauna native species. Furthermore, 'Protection of biodiversity' introduces new natural patches at the broader and smaller scale.

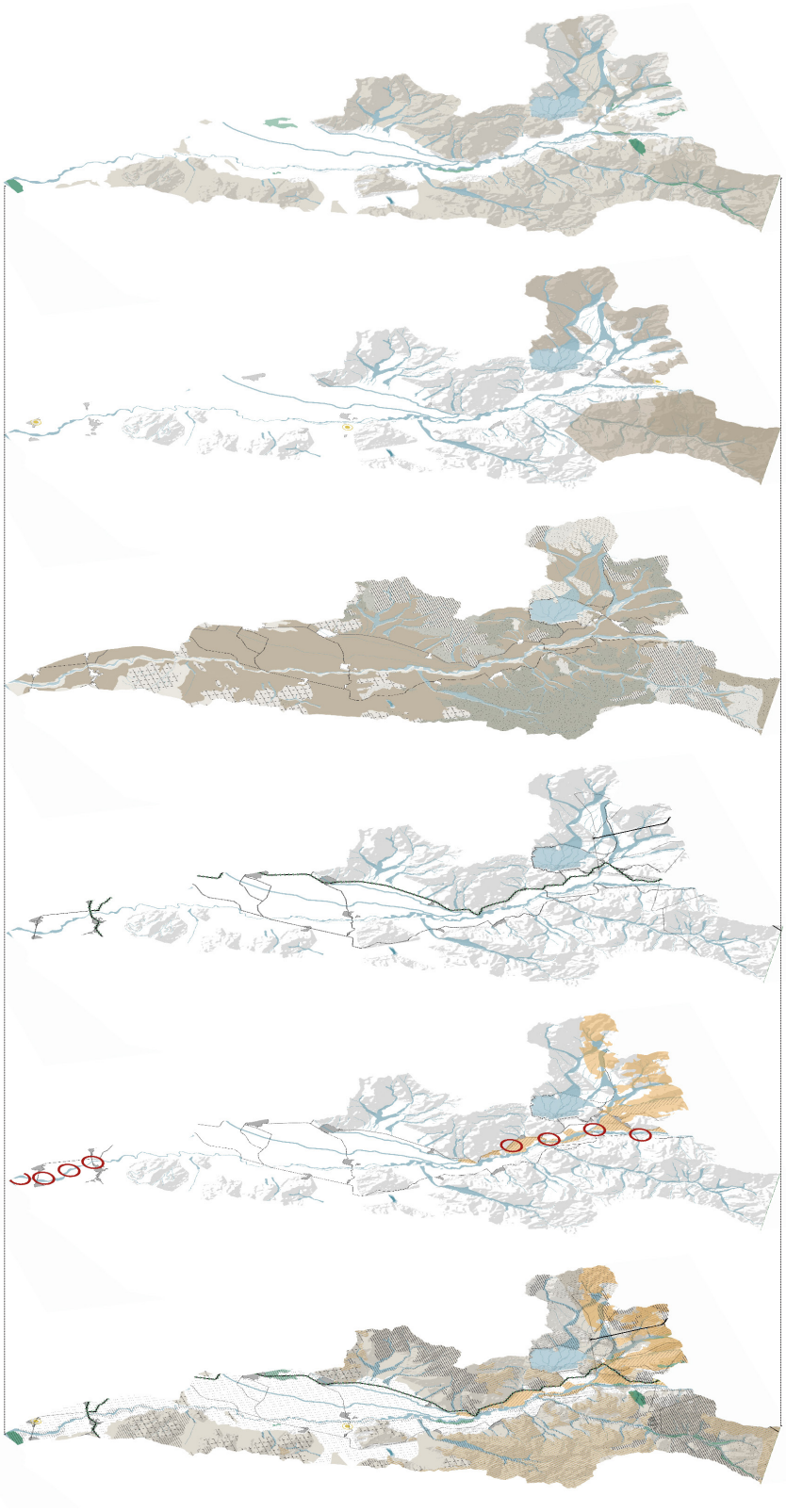
Gradual retrofitting addresses the issue of stormwater management and exceedance water at the third and fourth scale, which is the beginning of the exploration of the urban dimension.

As the name of the fourth principle implies, Accommodation of future development the potential areas where future urban growth can be accommodate to avoid occupation of hazardous or private areas, as well as to start a more regulated and organised urban planning in the region.

first nature

second nature

third nature



Vegetation cover

Heritage

Hydrogeology

Infrastructure as landscape

Floodable areas

Suitability map

FIG. 1.78 Suitability layers resulting in suitability map
Source: Made by author


Potential for:
Improvement of conditions regarding:
Water surfaces
Existing wetland
Decidious (green) vegetation
Xerophile vegetation [dry forest]
Dry forest
Wetland network as part of coastal defence
Flood areas + Water pollution
Region as a inter-connected network/system
Disconnected territory + regional identity
Protection of biodiversity
Shrinking of ecological patches
Monsefú
Huaca Rajada
Huaca Rajada -Sipán Museum
Chaparri Ecological Reserve
Heritage as part of the green-blue-gray infrastructure
Disconnected territory + regional identity
Aquifer
Aquitard
Aquiclude
Aquifugue
Gravel sandy loam
Volcanic
Water table renewal and recharge
Flood areas + Water pollution
Constructed wetlands + terraced vegetation [use of topography]
Use of existing topography
Panamericana highway
Regional highway 6A
Tinajones reservoir
Infrastructure as public space
Monofunctional road infrastructure
Monofunctional and hidden water infrastructure
Topographical lower areas
Wet crops (rice)
Floodable areas -space for the river
Floodable areas in emergency situations
Flood risk
Hydrology + vegetation cover
Heritage sites
Hydrogeology + geology
Infrastructure as landscape
Floodable areas
Intertwining of natures

PART 4

Regional strategy & Chancay Sub–basin Interventions

Design Methodology | Regional Strategy | Sub–basin Strategies | Sub–basin Structural Map | Design Principles | Design interventions along sub–Basin

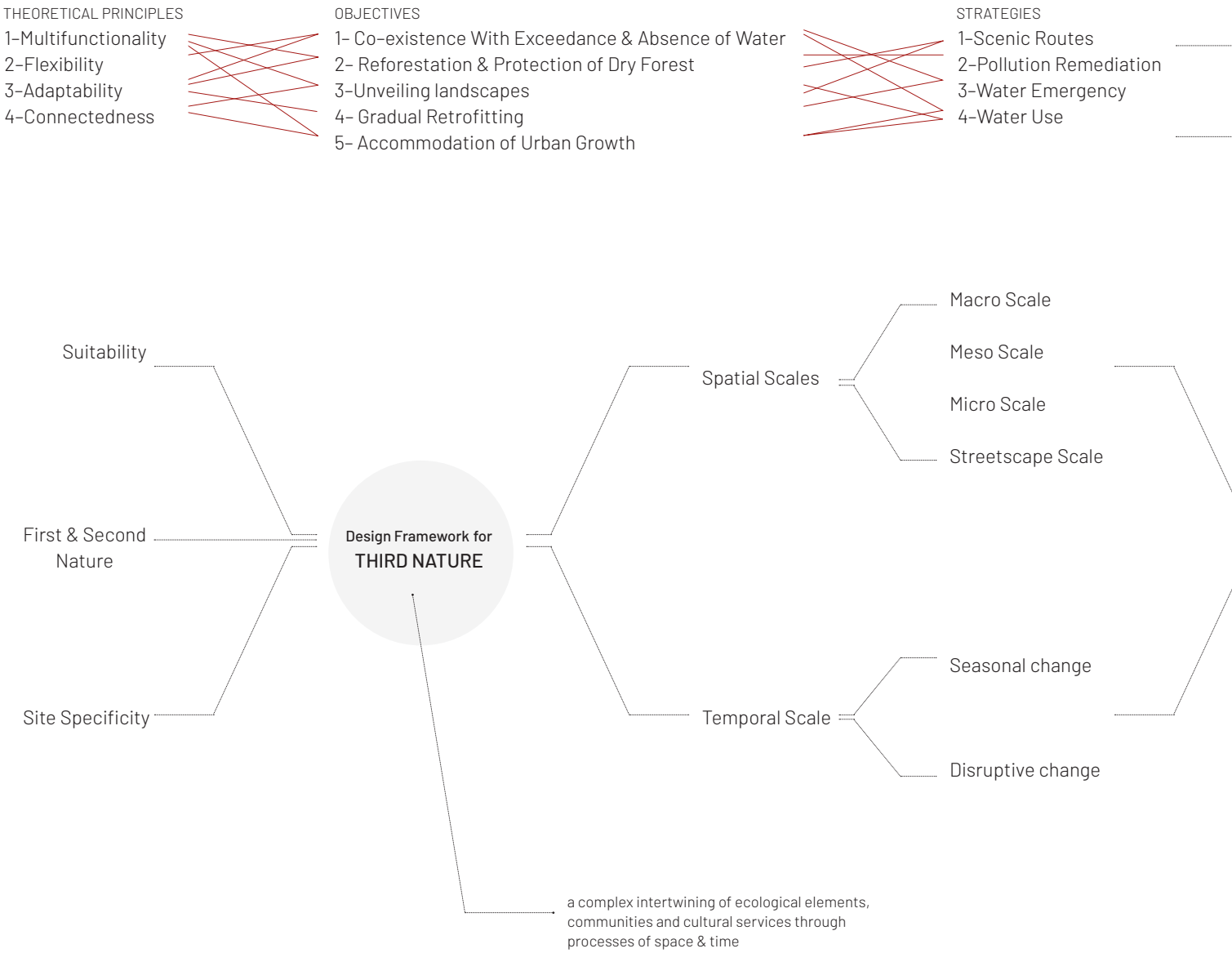
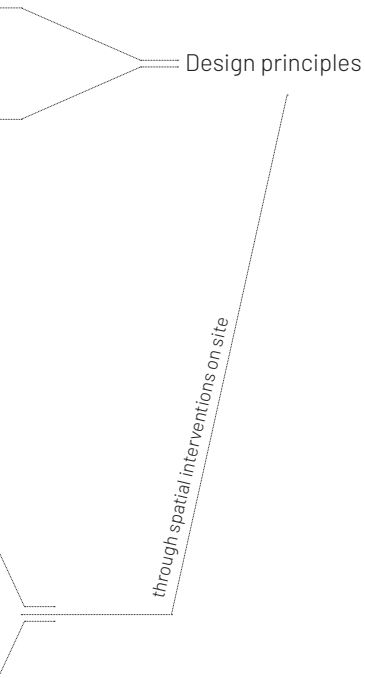


FIG. 1.79 Design framework
Source: Made by author

Design Methodology



The project –third nature– is understood as a complex intertwining of ecological elements, communities, cultural services and waste flows through processes of space & time.

The design method for the Third Nature is fed by three main categories: first, the outcome from the Analysis part: suitability maps; second, the existing natures: wilderness and man–made landscapes; and finally, site specificity, which aims to produce new modes of engagement and relations to the place, that later on will be intrinsically linked to the design.

The multiscalar approach is made trhough two categories: spatial and temporal scales. The spatial scale is comprised by macro, meso, micro and streetscape scale. Regional strategy as a result from the macro scale and Sub–basin structural map as a result of the meso scale are the intial point of the proposed four strategies, which in turn are composed by design principles, which are going to be tested on site with spatial interventions at the micro and streetscape scales.

The temporal scale is explored through seasonal changes and disruptive changes, which in the particular case of Lambayeque is mainly comprised by the threat of natural disasters mainly related to floods and sea level rise.

The constant relation among theoretical principles, objectives and design principles enables the Third Nature of a more robust framework.

In order to explain the inter–relations among theoretical principles, objectives and strategies the following narrative takes the strategies as the starting point drawing the relations with the theoretical principles and objectives.

Scenic Routes

This strategy aims for linking the disconnected landscapes and unveiling new landscapes through green & blue networks, and through soft mobility networks. Connectedness is clearly embedded in the strategy since the theoretical principle is related to the creation of networks in order to create a cohesive landscape as a response to the disconnected green –large and small– patches of the region. Awareness and legibility of the sites will be achieved with this strategy helping to the protection of biodiversity of the dry forest.

Pollution Remediation

Pollution remediation responds to the poor quality of water and the negative mentality of the population towards water surfaces, specially the ones inside the urban tissue. This strategy is fed by multifunctionality, adaptability and flexibility, and directly linked to Co–existence With Exceedance & Absence of Water and Reforestation & Protection of Dry Forest.

Cleaning of water and soil takes as the main design principles afforestation and reforestation, constructed wetlands network and waste water treatment. To put an example, constructed wetlands function as a filtering water system, floodable areas –in case of extreme rainfall– and water storage –in case of drought –. Taking into consideration multifunctionality aims for a certain landscape to accommodate multiple functions, constructed wetlands fall into this category, while the flexibility is embedded in the response of the design regarding temporalities and uncertainties, in this case extreme or lack of rainfall. Constructed wetlands are proposed along with forest patches, river vegetation, green buffers and waste water treatment plants, which means that in case of a changing regime the cleaning of water and soil can still be achieved. Finally, by creating a network, wetlands are part of the 'regulated nature' of connectedness.

Water Emergency

This strategy aims mainly for making space for water in case of need or an emergency as the recurrent case of El Niño Phenomenon, which causes extreme rainfalls, river floods and mudslides.

Proposed spaces on the second strategy are considered the first line of defence against flood risk. In case of extreme river flood, spaces along the river are part of the Water emergency system, enabling the concept of multifunctionality in the aforementioned spaces. Flexibility and adaptability concepts are also embedded in this strategy since the use of spatial–temporal scales is critical when designing for hydrological risk. The objective tackled by this strategy is Co–existence with water, either exceedance or lack of water.

Water Use

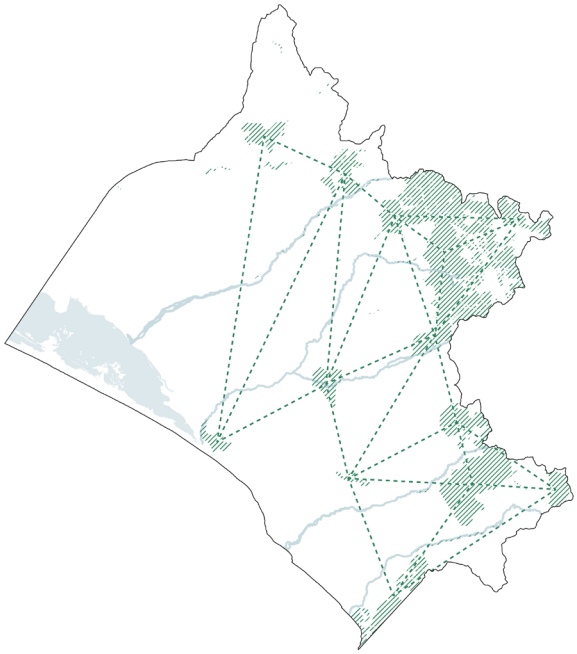
As mentioned before, multifunctional spaces aim for delivering an array of uses to different users

Unveiling new landscapes, is complemented with this strategy as is the case of the first strategy with the proposal of the green & blue network, which in other words functions as the integrator among the different landscapes along the corridor.

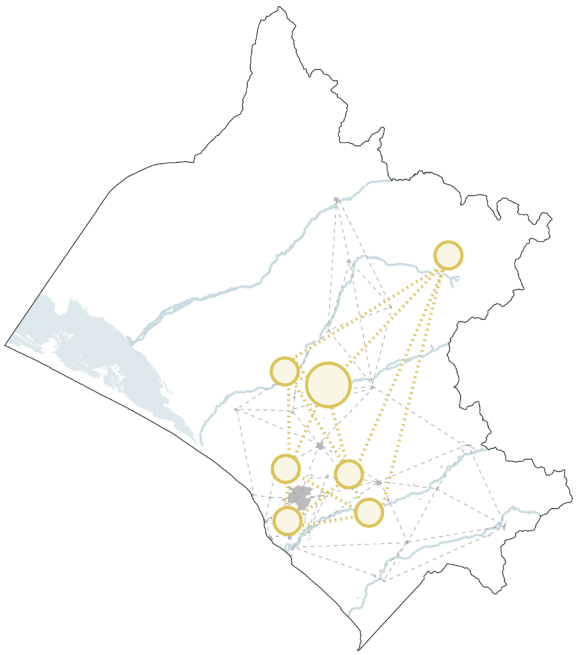
Gradual retrofitting refers to the improvement of existing water infrastructure, highlighting the importance of retrofitting the stormwater drainage and its subsequent treatment, as well as run–off retention and attenuation of peak discharge.

Accommodation of new urban growth aims for a more organised urban growth in areas that are designed and planned to accommodate said development.

Use of water for recreation purposes aims for achieving socio–ecological integration, through a sense of place and belonging. Theoretical principles embedded in this strategy are multifunctionality, flexibility, adaptability and connectedness.

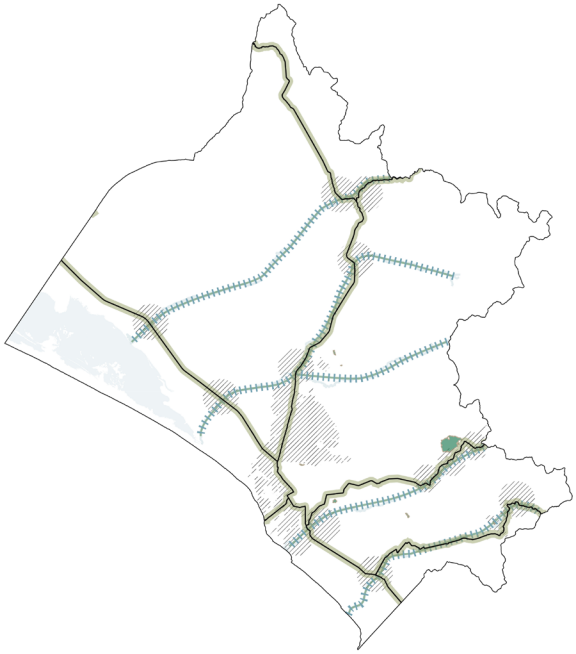


1 First nature: existing green patches and rivers



2 Second nature: heritage sites as a network + built tissue + waste infrastructure

3 Second nature: Irrigation canals and ditches + waste outlets



4 Third Nature: Potential for infrastructure as landscape + floodable areas

FIG. 1.80 Composing 'natures' for the regional strategy
Source: Made by author

Regional Strategy

'The central interest is the fundamental manner in which the entire site is treated as a large-scale landscape, as kind of tissue and bonding agent that ties all disparate parts together. Corridors, patches, mosaics, bridges, pathways, landforms, & matrices create a fabric within which the city can grow new roots'. (Corner, 2014)

In the first part, the introduction of the territory was made in four natures: wilderness landscapes, man-made landscapes, highly designed landscapes and finally, 'waste-flows' landscapes. This four natures are taken as the base for the spatial vision of the region: Towards Territorial Cohesion & Flood Risk Adaptation'.

– First Nature
Existing natural landscapes: four main rivers, main green patches of the region

– Second Nature
Heritage sites and, urban and rural tissue

Given that agriculture is one of the main economic flows of the region, improving the capillarity of the territory is one of the aims of the strategy, which is achieved by adding the water drainage system into the design layers, making it part of the water system in order to make the most out of existing irrigation canals and ditches running through the valleys.

Regarding waste, the implementation of treatment plants that are able to improve the ecological environment around/ them and avoid the dumping of grey waters into the ocean and similarly, avoid keeping solid waste in the open. Furthermore, the integration of waste water into the hydrological system in order to reuse a percentage of grey water for irrigation purposes, specially taking into consideration the 'dry' nature of most of the region.

– Third Nature
Potential of main infrastructure to function as landscape, such as highways and reservoir . This nature will be further explored in the following pages.

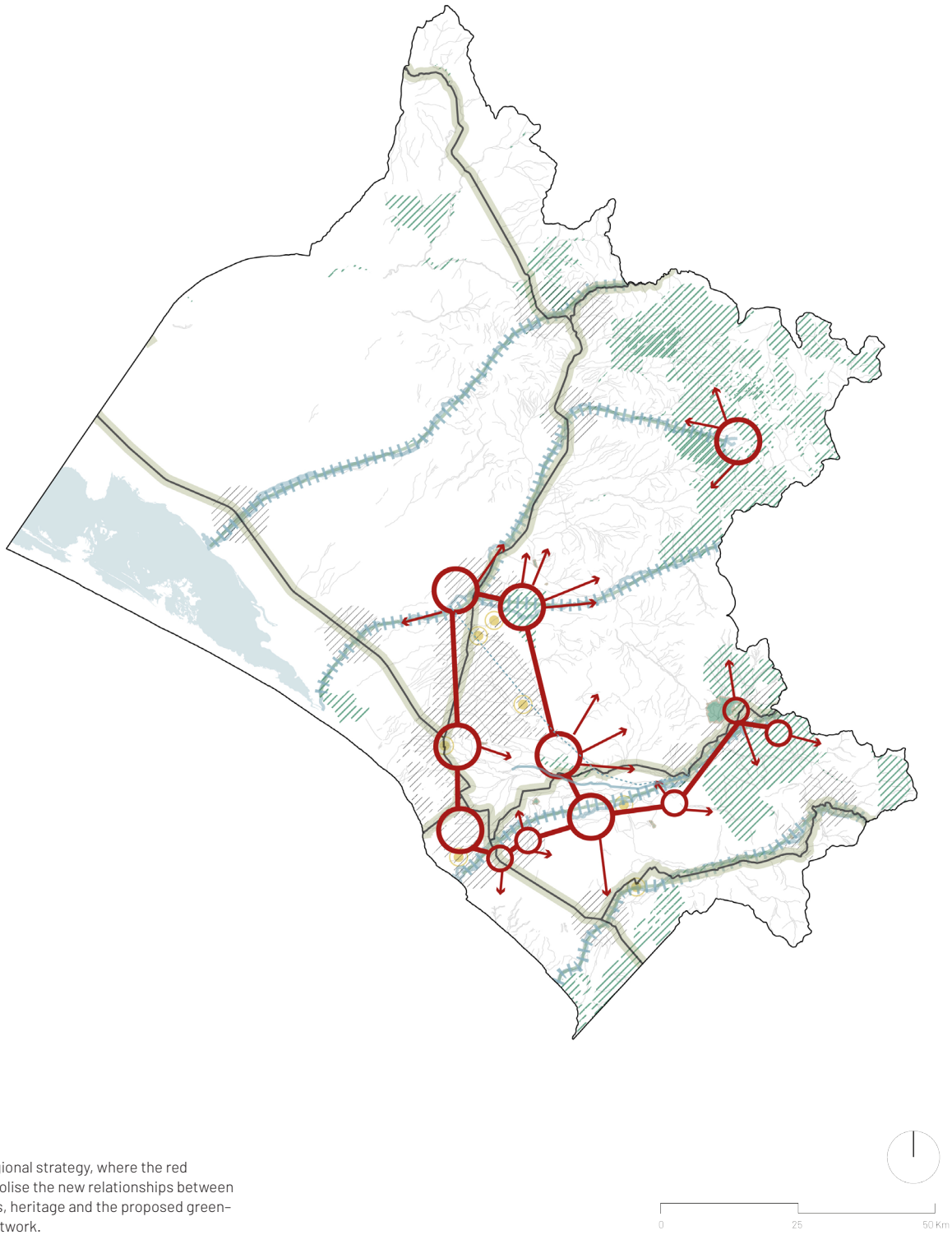


FIG. 1.81 Regional strategy, where the red arrows symbolise the new relationships between communities, heritage and the proposed green-blue-grey network.
Source: Made by author

The term 'cohesion' is understood as the union between different elements, which will result in an integrated and well connected region, rather than the existing dispersed pattern.

Implementing green and blue multifunctional infrastructure seeks to re-establish the lost connection of living with water and ecological patterns of the region, and see them as a opportunity, instead of looking at them as a nuisance or hazard -in case of meteorological events. Furthermore, the new interdependency processes of the social-ecological system aims to explore new possibilities of interaction.

Some of the positive results of green and blue infrastructure as a planning and design approach/tool are integral & innovative governance, climate adaptive/ active city, stimulate sustainable & resilient solutions, restore ecological flows & habitats for greater liveability , strengthen innovation power (technology/governance/ financial/design/cultural). (Bacchin et al. 2017)

In order for infrastructural systems to perform as landscape, connectedness, multifunctionality and diversity need to be embedded in the system, as mentioned before. Furthermore, the shift from 'conventional'/monofunctional infrastructure takes the adaptive cycles into consideration, embedding potential for change, degree of connectedness and resilience of the system. (Bacchin 2015: 49)

The expected result of implementing a land-mosaic plan is to design a 'a spatial arrangement so nature and people both thrive long term' (Forman 2008: 18).

Finally, since 'transformational change at smaller scales enables resilience at larger scales' (Folke 2010) the design multi-scalar approach is a way to foster resilience in more manageable spaces.

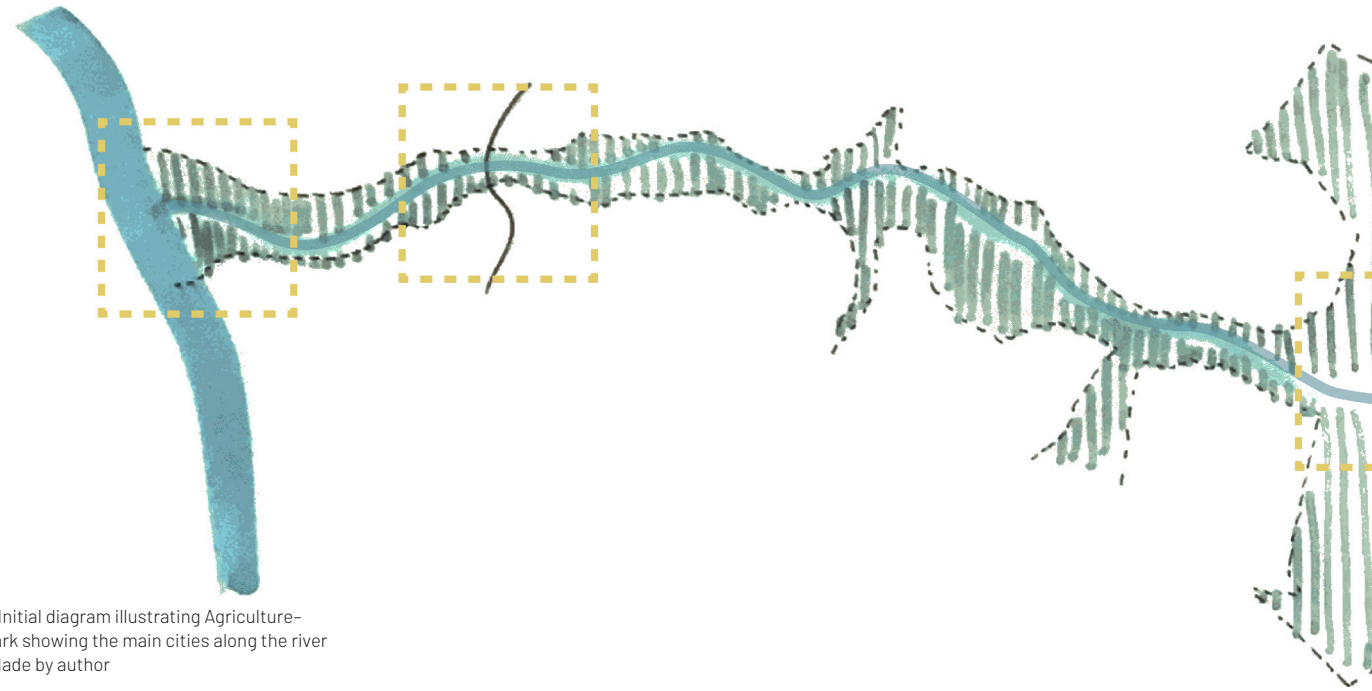


FIG. 1.82 Initial diagram illustrating Agriculture–natural Park showing the main cities along the river
Source: Made by author

Chancay Sub-Basin Structural Map

The structural map of the Chancay sub-basin is comprised by four strategies:

1. Scenic Routes
2. Pollution Remediation
3. Co-existence with water
4. Use/Recreation water

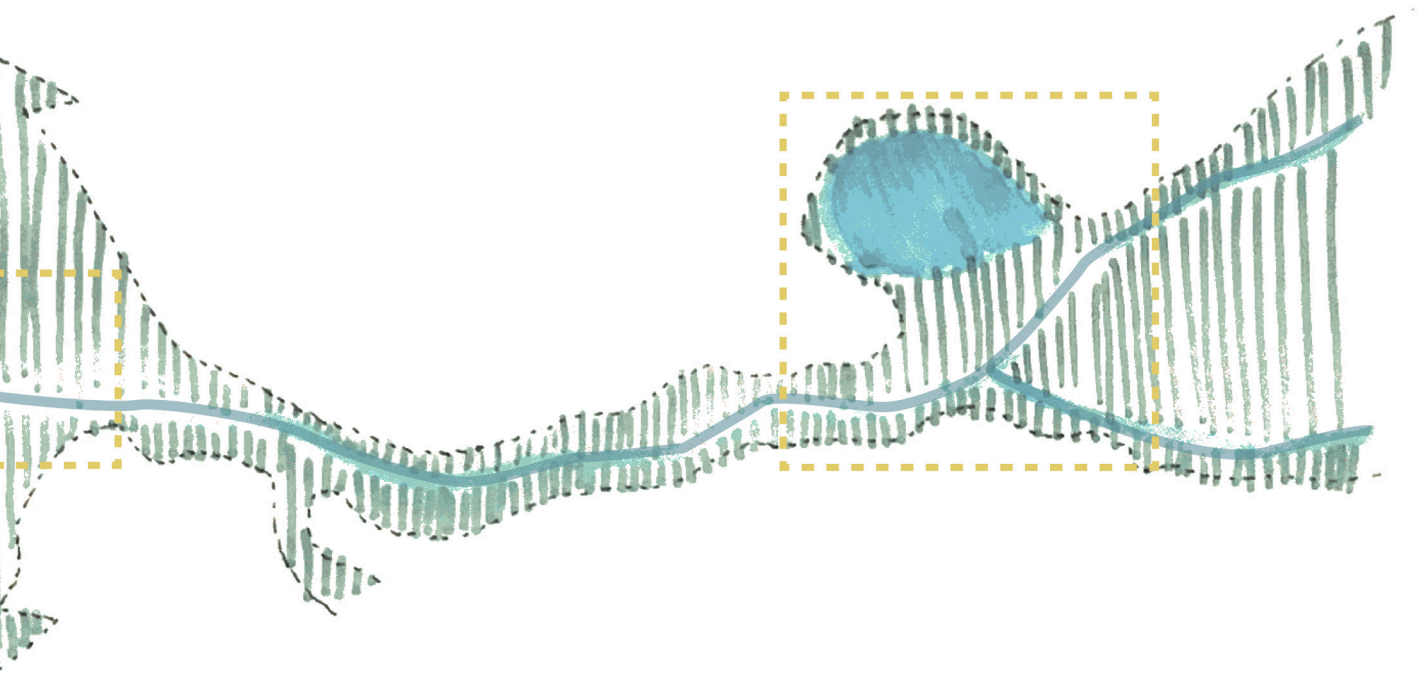
These strategies, in turn, are composed by spatial interventions that are tested in sites along the river corridor, which functions as the linking element at the meso and macro scale, initiating the proposal of an Agriculture-natural park, where an array of landscapes and natures intertwine, profiting and retrofitting among each other achieving a new equilibrium of coexistence.

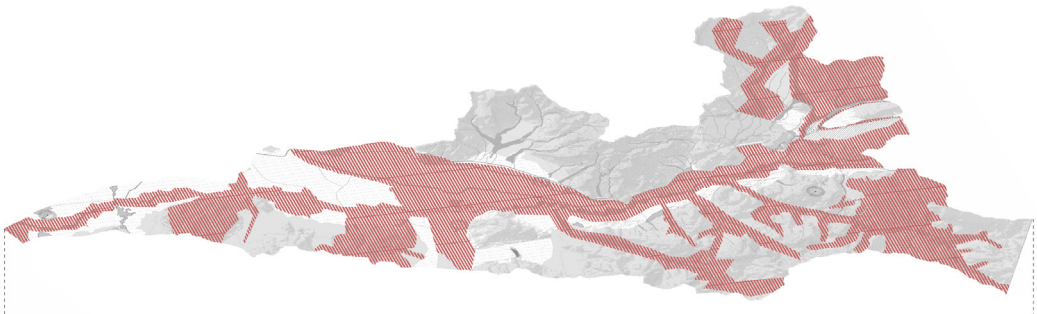
Agriculture-Natural Park

The proposal of the Agriculture-natural park takes the parcels close by to the river axis, turning them into a protected area, which does not mean that the agricultural parcels adjacent to the river will be expropriated since a great percentage of the agricultural land will remain productive in the same location. However, giving the status of regional park to this river corridor will make easier to oblige farmers adjacent to the river to use natural pesticides and fertilisers, improving the soil next to the river, which in turn, will improve the water condition. In return, the products will have an ecological label valued much higher than the resulting from 'regular' practices.

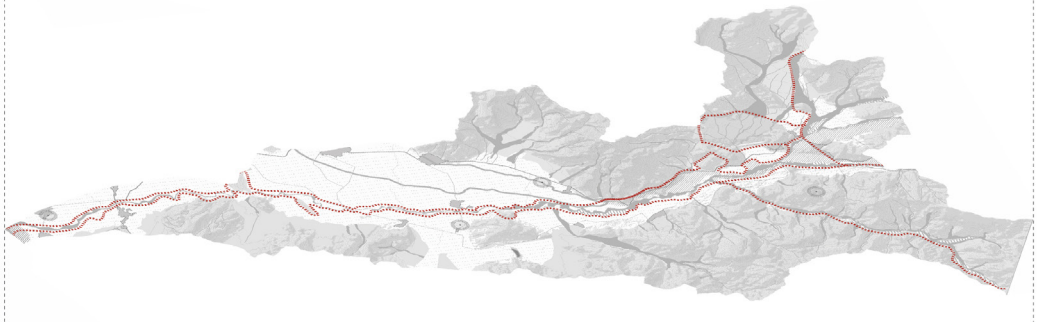
Furthermore, rice producers next to the river will improve its crops by having regular water flow into their parcels, however, in case of natural disaster emergency their crops can be used as part of the floodable emergency water system, that incorporates the aforementioned space for river overflow.

The overarching aim of the Agriculture-Natural Park is to facilitate movement through the valley and to be the integrator among natural and man-made landscapes -while protecting biodiversity- into the expansion of existing growing cities. Moreover, it becomes the link that rural communities need in order to economically thrive.

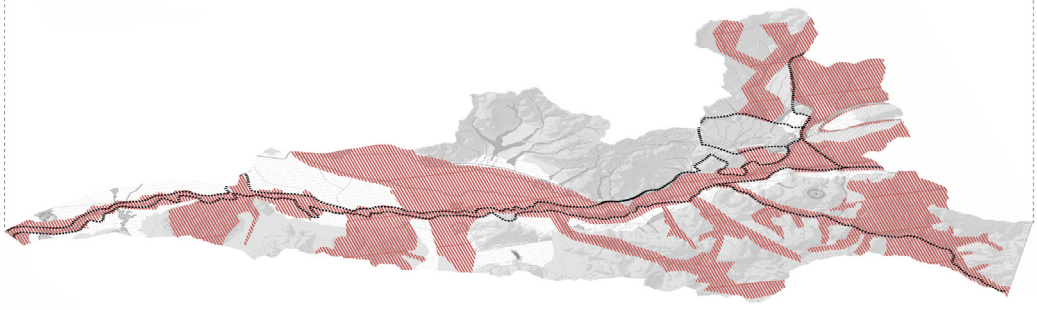




Layers: Agriculture–natural Park + green & blue network



Layers: soft mobility network



Strategy: Scenic Routes

Strategy 1: Scenic Routes

Scenic routes strategy starts form the view of landscape as scenery, 'as a contemplative object for the eye' (Shannon 2010: 126). As Shannon explains in The Landscape of Contemporary Infrastructure this term is closely related to the 'tourist gaze' coined by John Urry, which is explained by the constant movement and the quest for panoramic views and unknown landscapes that take them apart –spatially and mentally– from their everyday lifes. The overarching theoretical principles to take into account in this strategy is connectedness, since it highlights the creation of networks, giving cohesion to the site, while facilitating the introduction of an array of spacial interventions and programmes at a local scale.

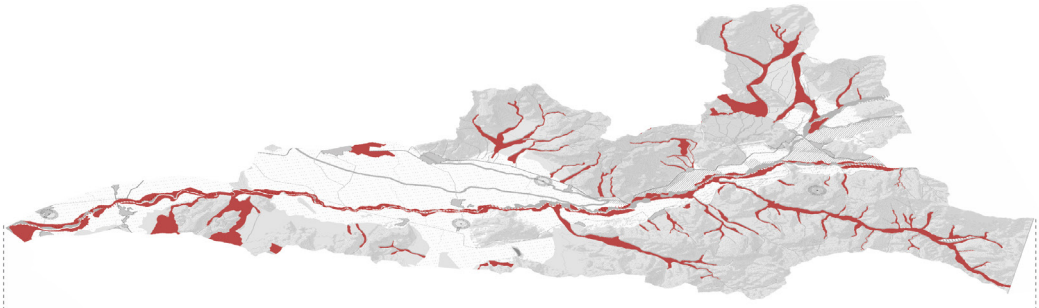
Main parts of this strategy are the aforementioned Agriculture–natural Park –green&blue network– and soft mobility network, which aims to increase the legibility of the regional matrix it crosses, while creating awareness of the existence of the disconnected and unknown landscapes patches, while enhancing the local identity of the places it passes through, putting them in the collective imaginary of the communities.

The view of Scenic routes strategy shows the space for pedestrian and bike paths along waters surfaces, in this case an irrigation ditch. Given its highly productive soil the Agriculture–natural Park allows for agriculture fields to be part of the 'Third nature', interrelating recreation with everyday field work.

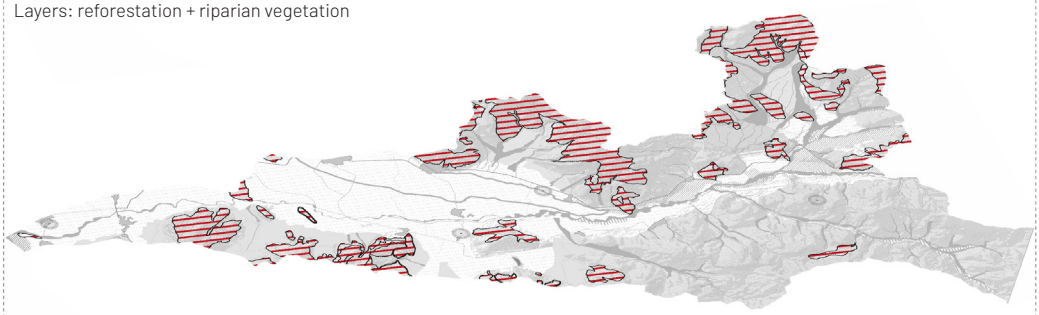
Native species, such as Palo Santo shown in the collage is proposed to be plant along ditches and soft mobility paths in order to cleaning of surface and sub-surface water, as well as soil. Afterwards, palo santo can be responsibly harvested and used for medicinal uses.

A great part of the productive regional territory is cover by sugar cane, which is seed once every 10 to 20 years, and can be harvested every year after the first two or three years. Introducing an agroforestry system, pairing said crop with asparagus, for example, can benefit not just the ecological performance of the site –soil and water systems– but the farmers economy, since they can have more than one harvest per year and, save great quantities of water since asparagus can resist drought, unlike sugar cane that needs great amounts of water. Moreover, an added value to this agroforestry initiative is that the slush and burn technique to harvest sugar cane, that highly pollutes the environment would be avoided. It is worth noting that Peru is one of the main exporters of asparagus worldwide (Agriculture Ministry, 2018) however, excess water –as during the first semester of 2017 with Coastal El Niño– significantly reduces its growth.

Key actors that participate in this Scenic Routes are: Ministry of Agriculture & Irrigation, Ministry of Environment, National Water Authority, Regional and Municipal governments, Irrigation Board of Users of each district of the valley, Muchik Santa Catalina community –in charge of Chaparrí– , peasant communities, civil associations some of them trying to promoting safety for pedestrian and cyclists –Bici and Peatón Cix–.

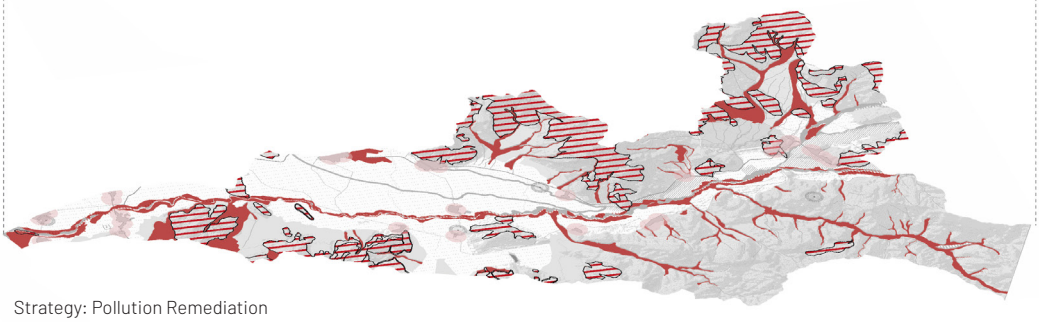


Layers: reforestation + riparian vegetation



Layers: constructed wetlands network

Layers: waster water treatment + green buffer



Strategy: Pollution Remediation

Strategy 2: Pollution Remediation

As mentioned before this strategy has the following theoretical principles embedded in it: multifunctionality, adaptability and connectedness and addresses the issue of water quality, since the upper part of the Chancay basin is located in Cajamarca region, which is caracterised by intensified mineral extraction. Moreover, grey waters of small towns in the river axis are overcharged into the river, without any kind of treatment.

Proposed constructed wetlands networks, forest patches of endemic species and the recover of riparian vegetation aim for cleaning of the water and soil, while recharging the water table, currently under threat due to the use of illegal wells.

Constructed wetlands are proposed specially taking into account geology and hydrogeology suitability reading. In case of drought, wetlands function as storage while in case of flood function as filtering of stormwater as well as water from the river river water. Existing wetlands located near the coast are proposed to be restored, given their current poor conditions.

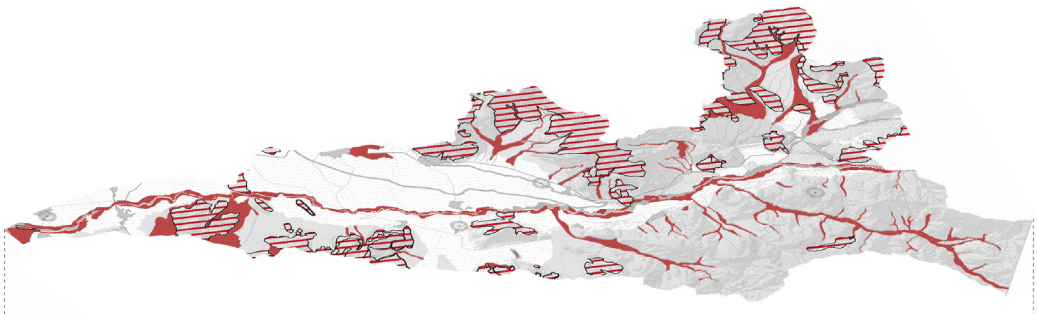
Halophytes plant in constructed wetlands and along the river are totora and barley, to name a few. Totora is the raw material from which 'caballitos de totora' are made, these are hand-weaved boats used for fishing –and recently recreational purposes– for over than 3000 years ago, and are traditional from the region. On the other hand, barley is a highly nutritious cereal that can be part of the National Plan for Reduction of Anemia 2017-2021 (Ministry of Health 2017), which according to the World Health Organization is a public health concern in the country.

The use of proposed halophytes is mainly to create a sense of belonging to the place, in order for the community to take care of the plants, because its part of their economy and everyday use, creating the added value of beautiful scenery given that the site is maintained by appropriation.

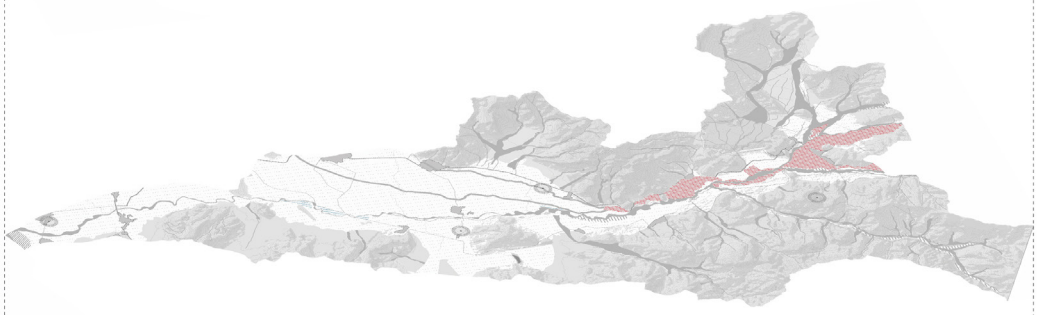
Reforestation and afforestation aim for the protection –and reintroduction– of endangered species endemic of the dry forest ecosystem, some of the are: carob, palo santo, gualtaco, caruaquero and sapote trees, and, an array of regional cacti species (Gobierno Regional de Lambayeque 2013). This design principle can work together with the National Reforestation Plan 2005–2024 lead by the Ministry of Environment.

It is worth noting that the design principles embedded in the four strategies must function in an intertwined way in order to thrive, this is the case of showing a pedestrian bridge –part of the Scenic Routes strategy– crossing the Zaña river given that most of the bridges are just for cars and freight.

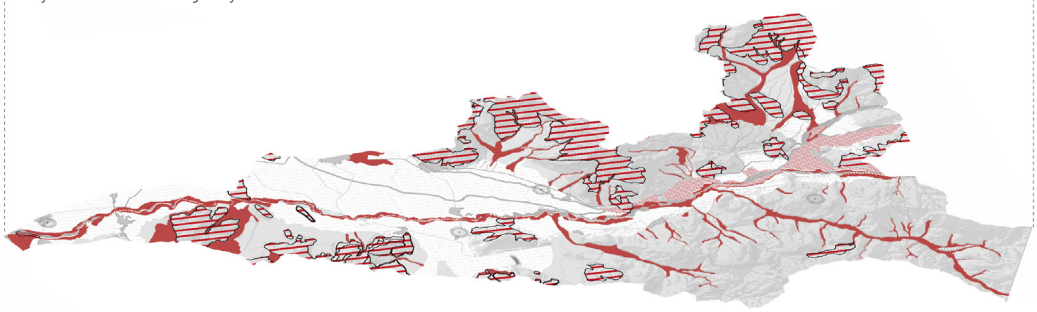
Stakeholders that take part in this strategy are: Ministry of Agriculture & Irrigation, Ministry of Environment, National Conservation Forests Programme –under the umbrella of Ministry of Environment–, National Water Authority, Lambayeque and Cajamarca regional governments since the basin is shared by this two entities,, Municipal governments, Irrigation Board of Users of each district of the valley, Muchik Santa Catalina community –in charge of Chaparrí–, peasant communities, civil associations committed to ecological improvement.



Layer: Constructed wetlands network + proposed forest



Layer: Extreme emergency floodable areas



Strategy: Water Emergency

Strategy 3: Water Emergency

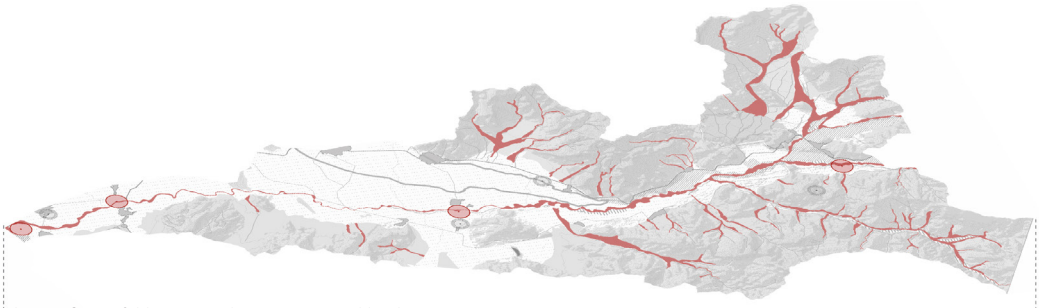
The second strategy functions as the pollution remediation and first line of defence against water threats. This strategy acts as the second line of defence, having embedded multifunctionality, flexibility and adaptability in its design given that rice crops function as a wetland these crops are proposed to be part of the emergency system in case of extreme rainfall thus overflowing the river and the first line of defence. Depending on the position of the city, ditches might be used for conduction of exceedance stormwater towards storage areas.

It is worth highlighting that the emergency flooding system is intrinsically linked to the second strategy, since constructed wetlands and proposed forest patches are the first defence mechanism against hazard from floods. Water emergency is the second line of defence and its only activated in case of extreme emergency, such El Niño Phenomenon for example. Emergency floodable areas allow for temporary flooding which, by being connected to constructed wetlands, exceedance water can be stored for drought season.

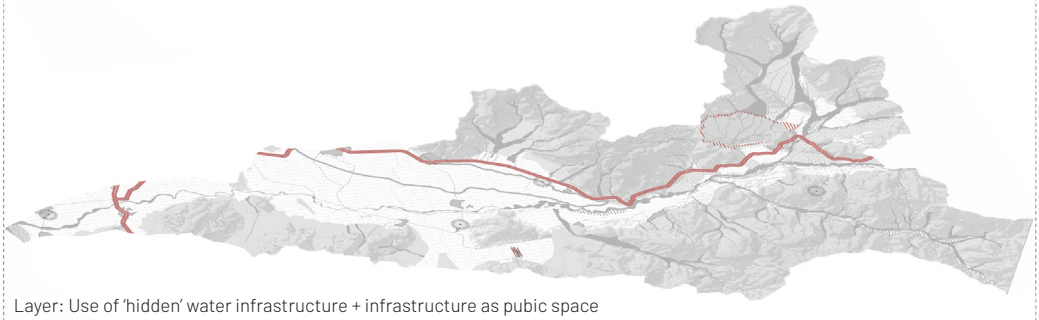
The floodable emergency water system incorporates the aforementioned spaces for river overflow along with the accommodation of evacuation routes and shelters in the higher areas where help can come by air, in extreme situations. It is worth noting that an agreement has to be made between farmers and the regional government regarding the flooding of said parcels, ensuring community participation in the decision making process.

Furthermore, at city and streetscape scale the aim is to take into account stormwater management into account when designing for urban growth, thus becoming a fundamental element of the infrastructural landscape. (Shannon 2010)

Given that Water Emergency needs to temporally appropriate private property it is specially important in this strategy to encourage a transparent and continuous dialogue among the different stakeholders, taking into account that this new equilibrium will be economically prosperous for both parts: the national and regional governments would have to spend less funds to repair the damage after the catastrophe, while farmers can still harvest the crops that are not adjacent to the river, and finally, the most important justification is that many lifes can be saved by prevention and implementation works. Key actors to take in consideration are: Ministry of Agriculture & Irrigation, Ministry of Environment, Rebuilding with Change –under the umbrella of Prime Ministry–, National Water Authority, Lambayeque and Cajamarca regional and municipal governments, Irrigation Board of Users of each district of the valley highlighting the importance to create dialogue among multination corporations and small-scale farmers, Muchik Santa Catalina community, peasant communities, civil associations, social clubs that usually help victims after the disaster might be able to help the communities in the negotiations. Given that some of the peasant communities lack of education, partnerships among local universities can be of some help during conflict resolution, particularly with the specialties of architecture, sociology and psychology, to name a few.

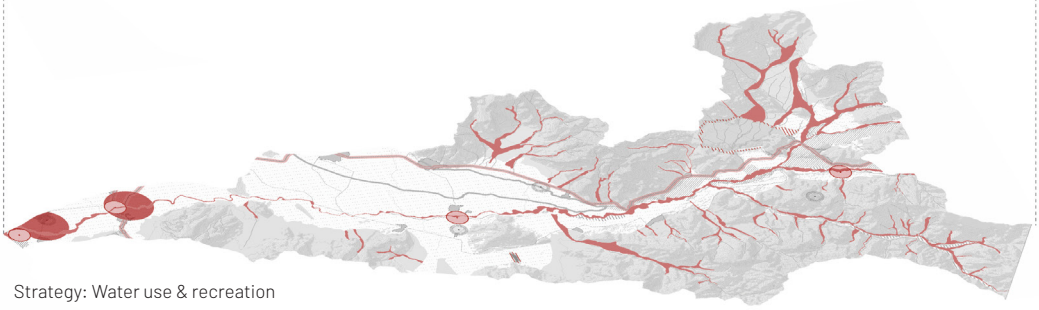


Layer: Green & blue network + strategic parklands



Layer: Use of 'hidden' water infrastructure + infrastructure as pubic space

Layer: Accommodation of urban growth



Strategy: Water use & recreation

Strategy 4: Water Use & Recreation

The fourth strategy aims for using the many water assets of the region , instead of looking water as a nuisance or hazard, changing the mentality and looking at it as an opportunity for economic, social and environment related opportunities, achieving through the spatial–temporal scales the co-existence with water, the unveiling of unknown landscapes, gradual retrofitting and accommodation of urban growth.

Green & blue network proposes to take advantage of the natural water surfaces and subsurfaces on the landscape and create a system intertwining green areas such as constructed wetlands, forest patches, water squares and strategic parklands located in the main nodes throughout the river axis. Given that the Chancay sub-basin is treated as the generator of synergies among the valleys of the region, strategic parklands are adjacent to main cities of the sub-basin: Etén, Reque, Sipán and Chongoyape. Each location highlights different landscape and built patterns: Etén is small city close to the coast, dunes and natural wetlands; Reque's urban pattern is disrupted by Panamericana highway, and its where the Chancay river gains prominence as Reque bridge is one of the most nationally travelled; Sipán is a small rural town containing a heritage site of national relevance; and finally, Chongoyape is a small city adjacent to Tinajones reservoir and wildlife refuge of Chaparrí. Use of 'hidden' and mono-functional water infrastructure such as reservoirs is one of the main spatial strategies. The openness and accessibility to infrastructure enables to treat it as public spaces attached to the greater social ecological network, the Agriculture–natural Park.

Accommodation of urban growth is concentrated on the west part of the sub-basin since its where current trends target development. By planning and designing waterfront development areas not only the historical relationship with water might be recovered but it improves the quality of life of the inhabitants by living in a planned city, instead of organically-grown and chaotic cities. Furthermore, these newly designed areas approach water as a system, from the beginning to end-basis, that is to say from stormwater management to waste treatment plants and its possible reuse into irrigation purposes.

One of the main challenges to be addressed by this strategy is the negative mentality towards surface water inside the urban tissue. Canals and ditches are not really incorporated into everyday life given to polluted water and the use of some ditches as garbage dumps, general population avoids them as much as posible. The design proposes the improvement of water quality with the aforementioned second strategy. Moreover, the changing of the negative mentality towards water will be achieve by cleaning of the slopes and creating not only soft mobility paths around it, but by planting vegetation that become part of social and educational programmes in order to maintain said areas. Canal slopes and adjacent areas can be part of the proposed communal orchards that aim for the reactivation of local economy.

Stakeholders to take into consideration are the ones from the second strategy adding provincial municipalities as well as their local entities such as Commission of Environmental Development, Commission of Planning and urban development and Commission of public infrastructure. This new layer of 'local' stakeholders is added in this strategy given that is the most explored at the streetscape scale.

Chancay Sub-basin Structural Map

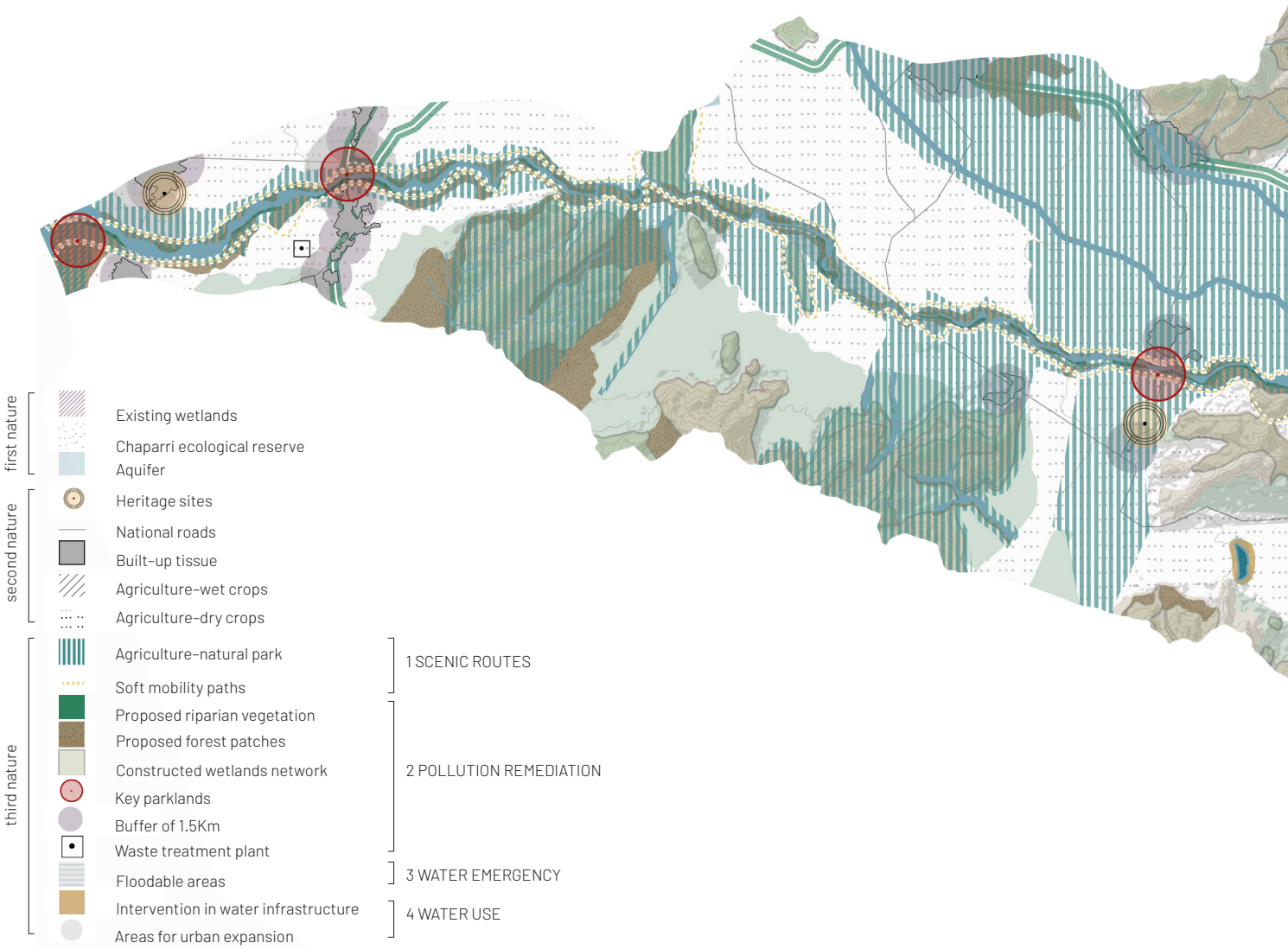
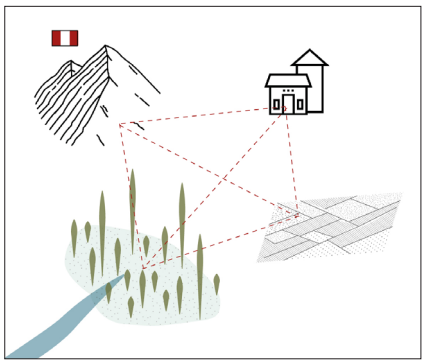
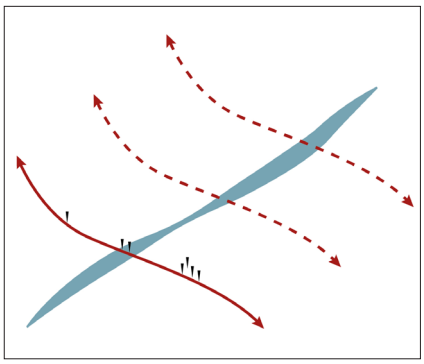


FIG. 1.83 Chancay Sub-basin Structural Map
Source: Made by author


0
5
10 Km

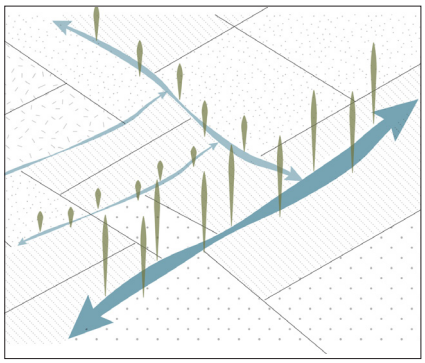


1 Soft mobility network connecting ecological + agricultural + urban + heritage systems

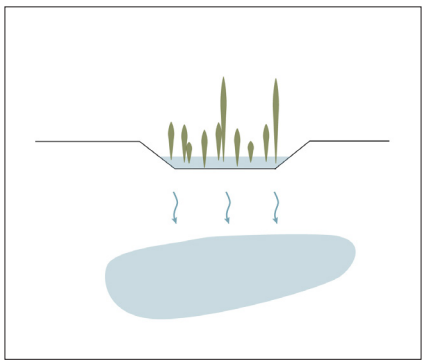


2 River as permeable edge, not a barrier

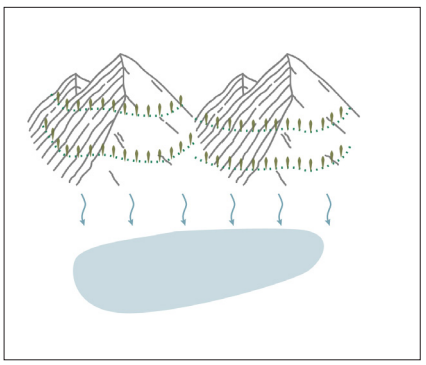
3 Soft mobility along water surfaces



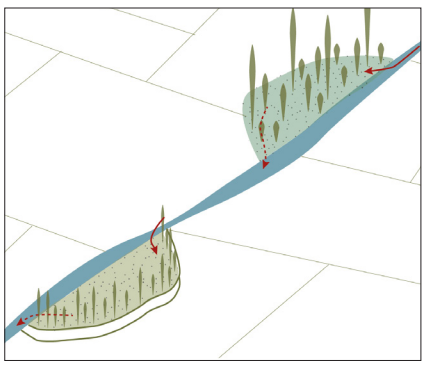
4 Water purification system



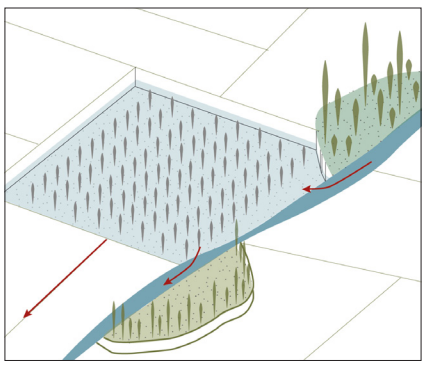
5 Pollution remediation through constructed wetlands network to purify & recharge aquifers.



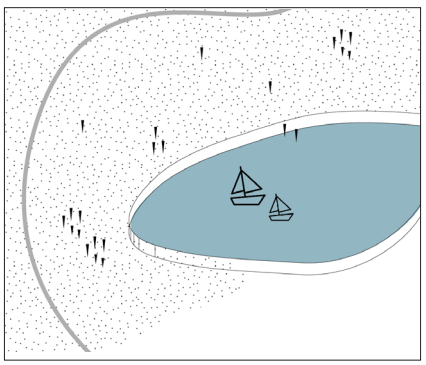
6 Terraced vegetation to recharge aquifers



7 Floodable spaces - wetlands, forest patches, floodable/water squares



8 Floodable spaces in case of emergency - rice crops & ditches and ditches



9 Use of infrastructure and water surfaces for recreational purposes

FIG. 1.84 Design principles
Source: Made by author

Design Principles

The four strategies are comprised by design principles, which are going to be testes on site. These design principles are interrelated with the thesis' objectives and with the theoretical principles.

– Scenic Routes
Soft mobility network embedded in the greater matrix aiming for a connected teritory through hiking and biking paths, and pedestrian bridges. The most remarkable principles are illustrated in images 1, 2, 3 to the left.

– Pollution Remediation
Terraced vegetation, constructed wetlands, wood patches + buffers strips + hedgerows.
Renew of water table by refilling aquifers. Principles are illustrated in images 4, 5, 6 to the left.

– Water Emergency
Floodable & floodable space in emergency case. Principles are illustrated in images 7, 8 to the left.

– Use/Recreation water
This strategy aims for the recreational use of infrastructure such as reservoirs. Moreover, use of canals and ditches for leisure and relaxation activities.
Principles are illustrated in image 9 on the left side of the spread.

It is worth noting that these are the main design principles, but not the only ones used in the design part, which will be tested and implemented in two locations: Chongoyape located in the upper part of the sub–basin, and Reque located in the lower part, near to the catchment area in the Pacific ocean.

Design Principles on Site – Examples

Example A

Design principles: Terraced Vegetation + Reforestion

According to the vegetation cover information, this area is categorised as evergreen and sparsed vegetation in dry forest, however poor conditions are encountered in the area. Existing vegetation in the hills function as the reference to propose terraced vegetation. Most of the hills are located on volcanic soil, which in hydrogeologic terms mean that aquifers are found in the subsurface; thus, the proposal of terraced vegetation is mainly to recharge the aquifers, that are currently threatened by the over use of illegal wells.

meters above sea level

Example B

Design principles: Pollution remediation system + floodable areas + aforestation

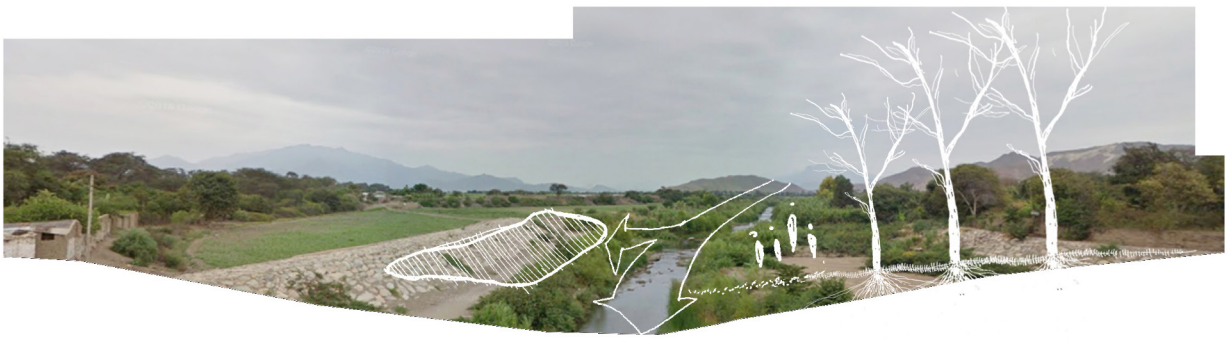
Constructed wetlands network, proposed forest patches and trees along rural road.

FIG. 1.85 Diagrammatic sections showing the implementation of design principles on site. Source: Made by author with photos from Google Maps and Google Earth elevation profiles, accessed on June 9th, 2018

Example C

Design principles: Soft mobility along water surfaces & use of water infrastructure

Use of roads not just for car–based mobility but for pedestrian and bikers as well. Furthermore, use of secondary reservoirs of the region, such as Laguna Boró, shown on the picture above.

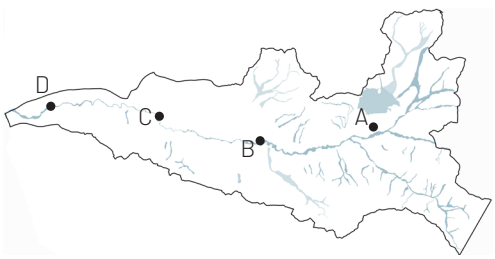


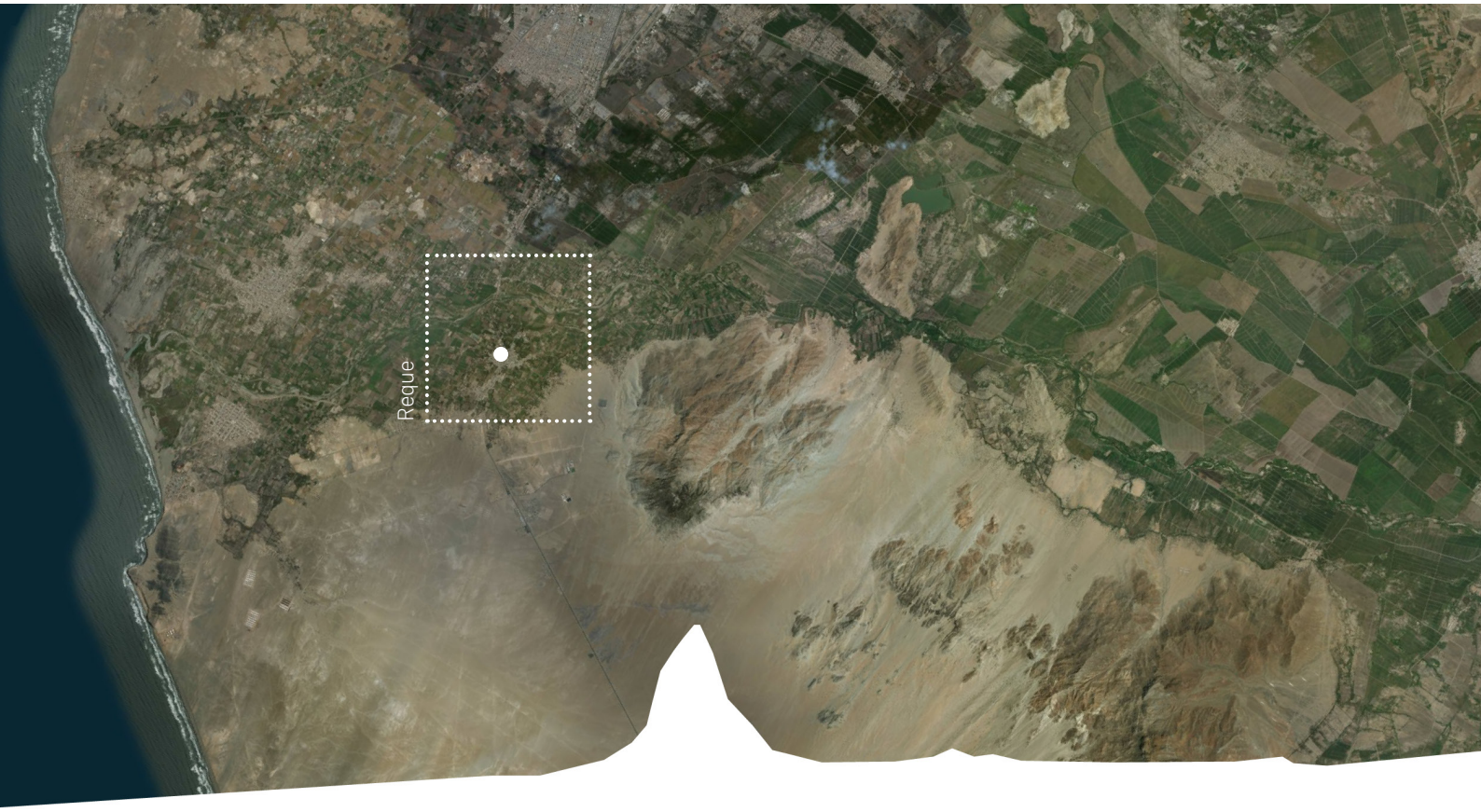
meters above sea level

Example D

Design principles: Floodable space in case of emergency + aforestation

As it name indicates, these areas are part of the protection plan just in case of extreme risk. These spaces are located mainly in the upper and middle slope to avoid greater damage in the lower slope, where most of the population is settled.

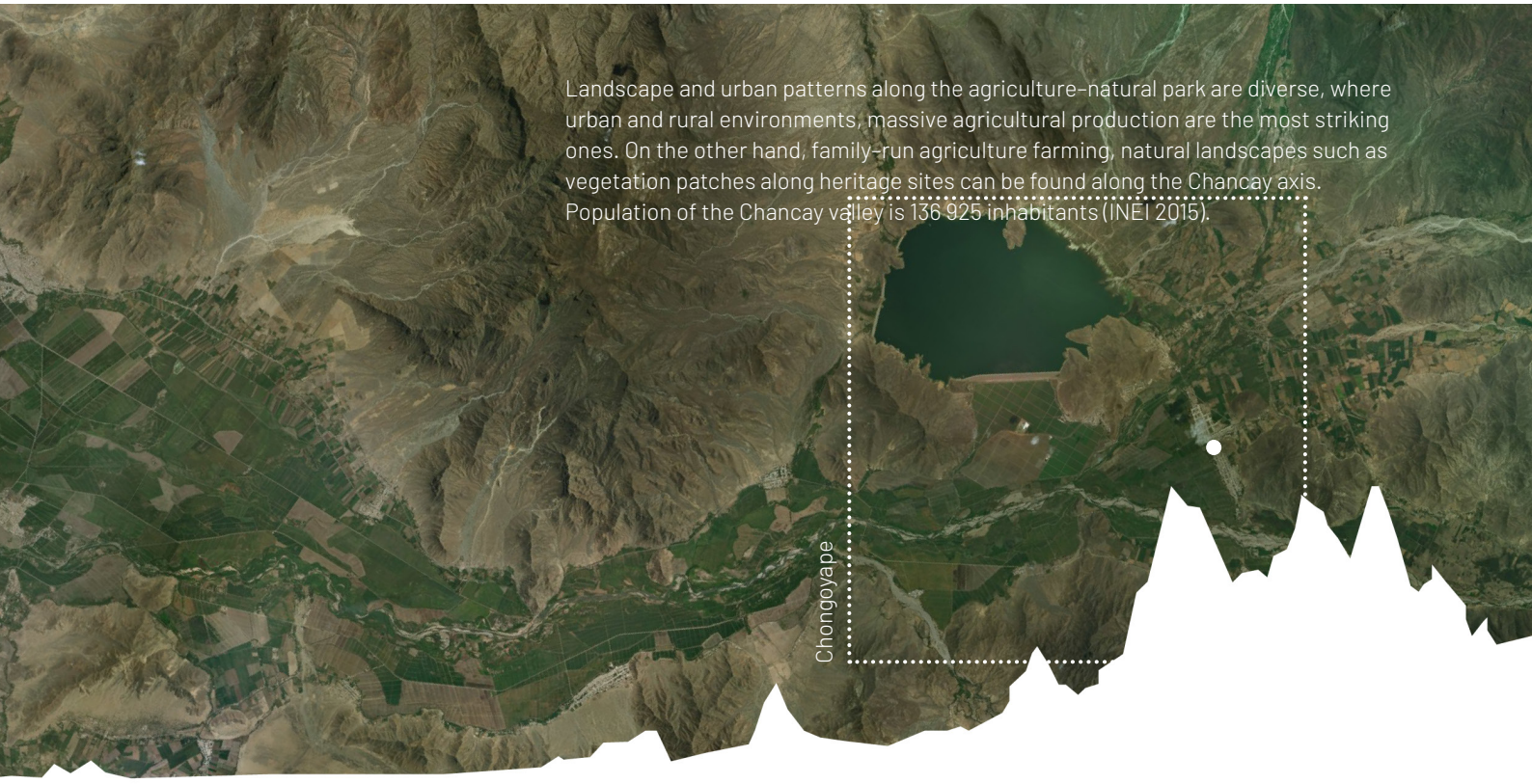




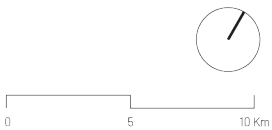
Reque
-Altitud of 24m
-Population 7 200 inhabitants
-Disruption by Panamericana highway
-Prone to river flooding and mudslides
-Given its topographic location main water principles to take into account are conveyance and storage.

FIG. 1.87 Location of interventions in Chancay sub-basin, with exaggerated section.
Source: Made by author with data from Google Earth

Design Interventions Along Sub-basin



Chongoyape
-Altitud of 209m
-Population 25 400 inhabitants
-Prone to river flooding and mudslides
-Closeness to Tinajones reservoir and Carhuaquero hydro-power plant
-Given its topographic location main water principles to take into account is infiltration and conveyance.



Chongoyape

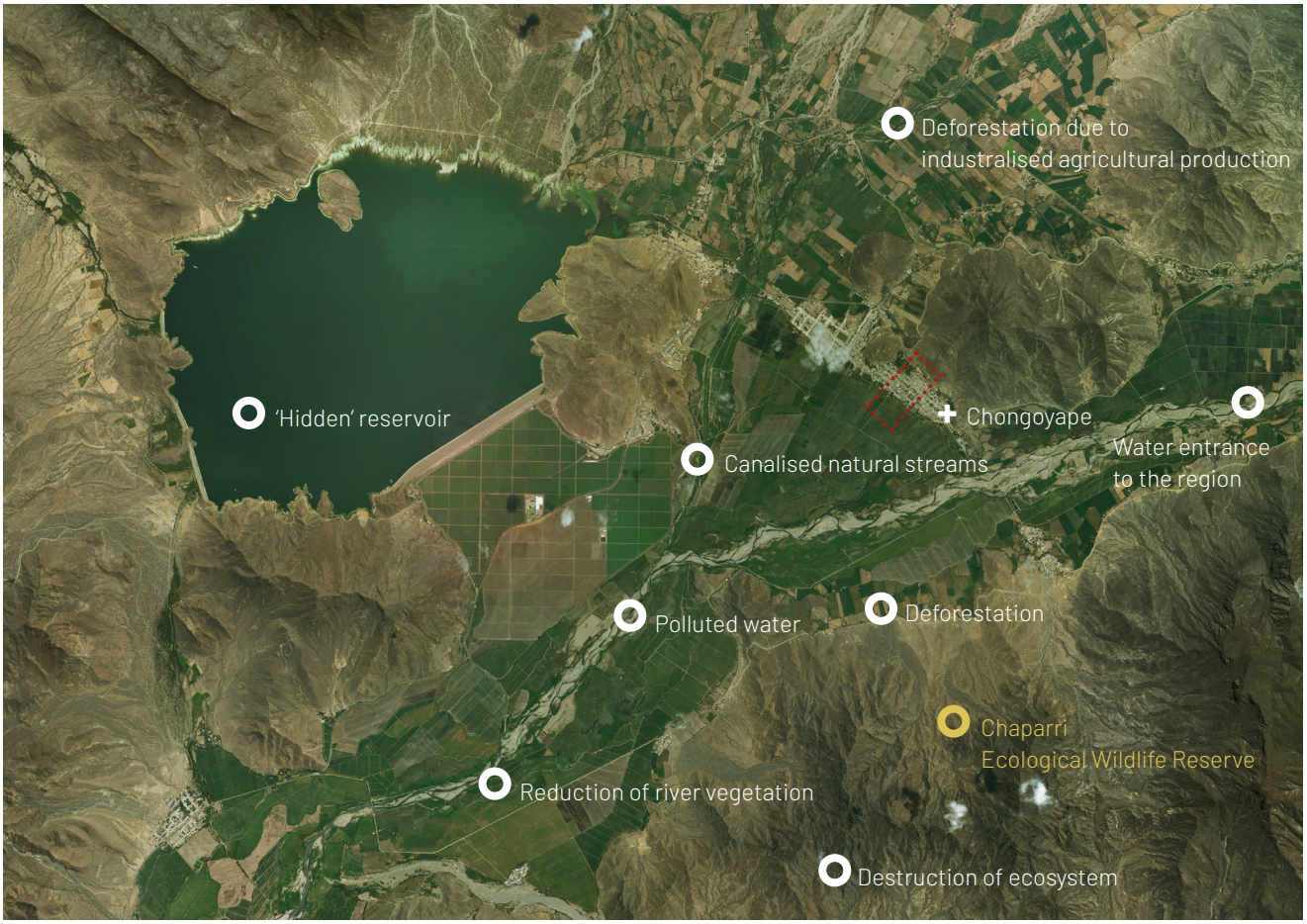


FIG. 1.88 Chongoyape: challenges. Red rectangle shows the streescape scale
Source: Made by author with data from Google Earth

1 Chaparrí Ecological Wildlife Reserve, natural habitat of spectacled bears

2 Tinajones reservoir, 'hidden' infrastructure

3 Main square

4 Deforestation and destruction of ecosystem in protected areas due to land traficking

5 Empty lots in the centre

6 Under-used ditches and poor maintenance

FIG. 1.89 Potentials & challenges of Chongoyape
Sources:
1 www.absolutviajes.com
2 www.elcomercio.pe
3 www.climate-data.org
4 www.esdotmongabay.com
5 & 6 Google Street View, accessed on May 2018

Chongoyape | Suitability Analysis

At this stage of the design, a suitability analysis is made by a similar process as with the Territorial Reading –Part 3–. The layers taken into account for this analysis are: topography, topology, landform, soil, groundwater, natural and semi natural landscapes as well as the urban tissue.

The result of the suitability analysis is the types of species that can be plant in different parts of the site, depending of its specificity.

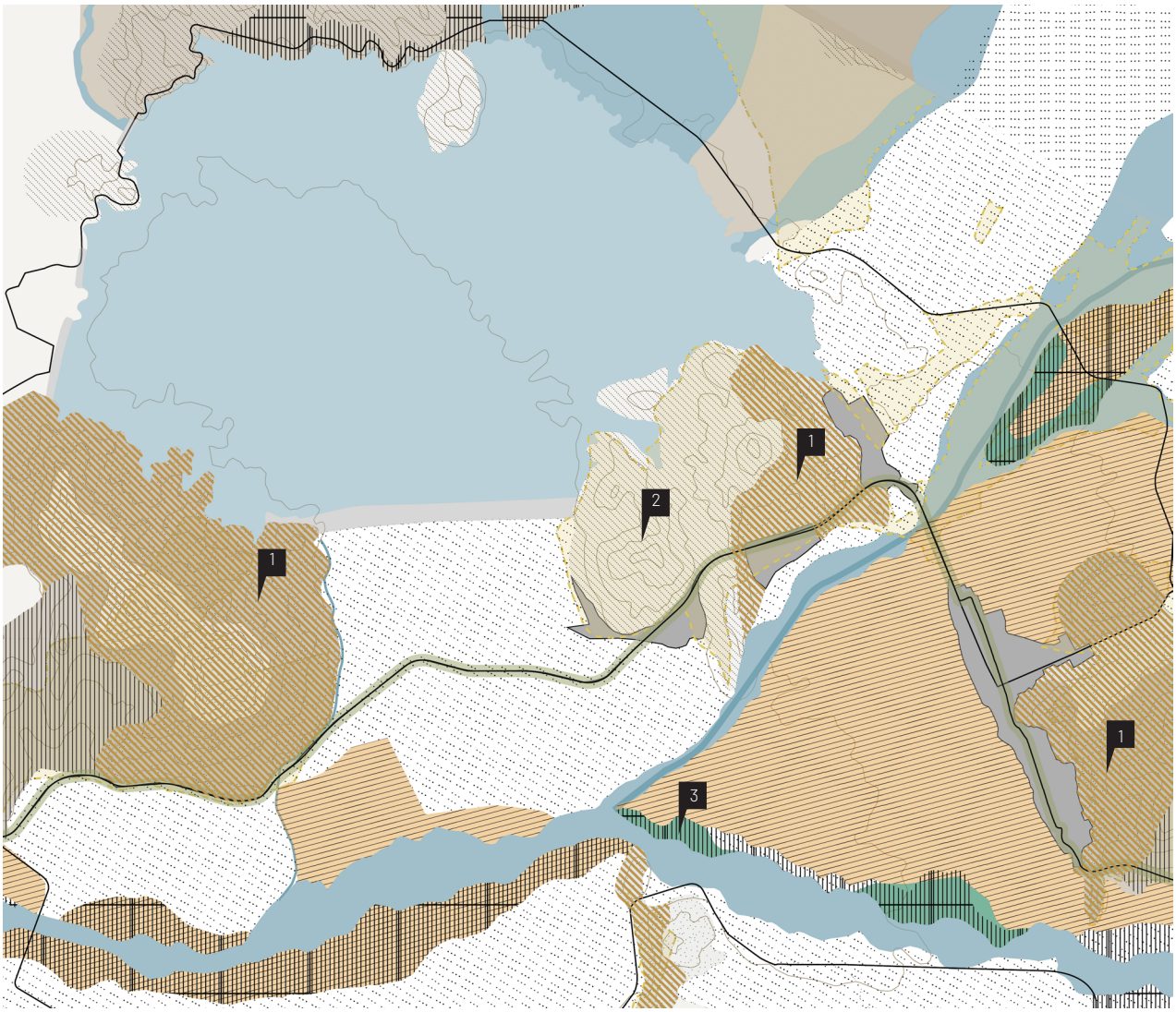
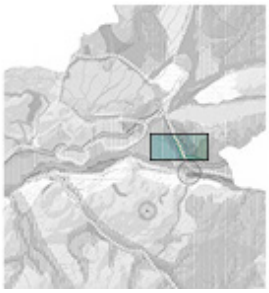


FIG. 1.90 Suitability layers resulting in suitability map
Source: Made by author

Chancay sub-basin scale – meso scale

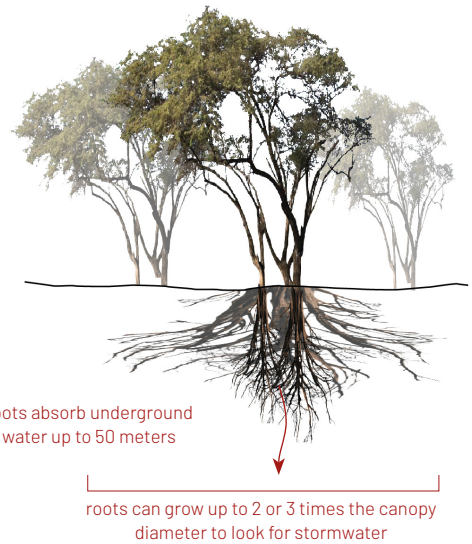


Chongoyape scale – micro scale

Chongoyape – streetscape scale

FIG. 1.91 Multiscalar approach
Source: Made by author

FIG. 1.92 Árbol milenario –millennial tree– is one of the landmarks of Pómac forest.
Source: Made by author



Carob tree was once the reigning native specie in the coastal dry forest, however nowadays is threatened by deforestation in order to make room for unplanned cities.
Moreover, natural disaster resulting in floods endanger

carob tree

porotillo tree

ceibo tree

san pedro cactus

cactus

totora

Most suitable vegetation

1 Sparsed xerophile dry forest + non-fertile soil

2 Sparsed xerophile dry forest + fertile soil

3 Riparian vegetation

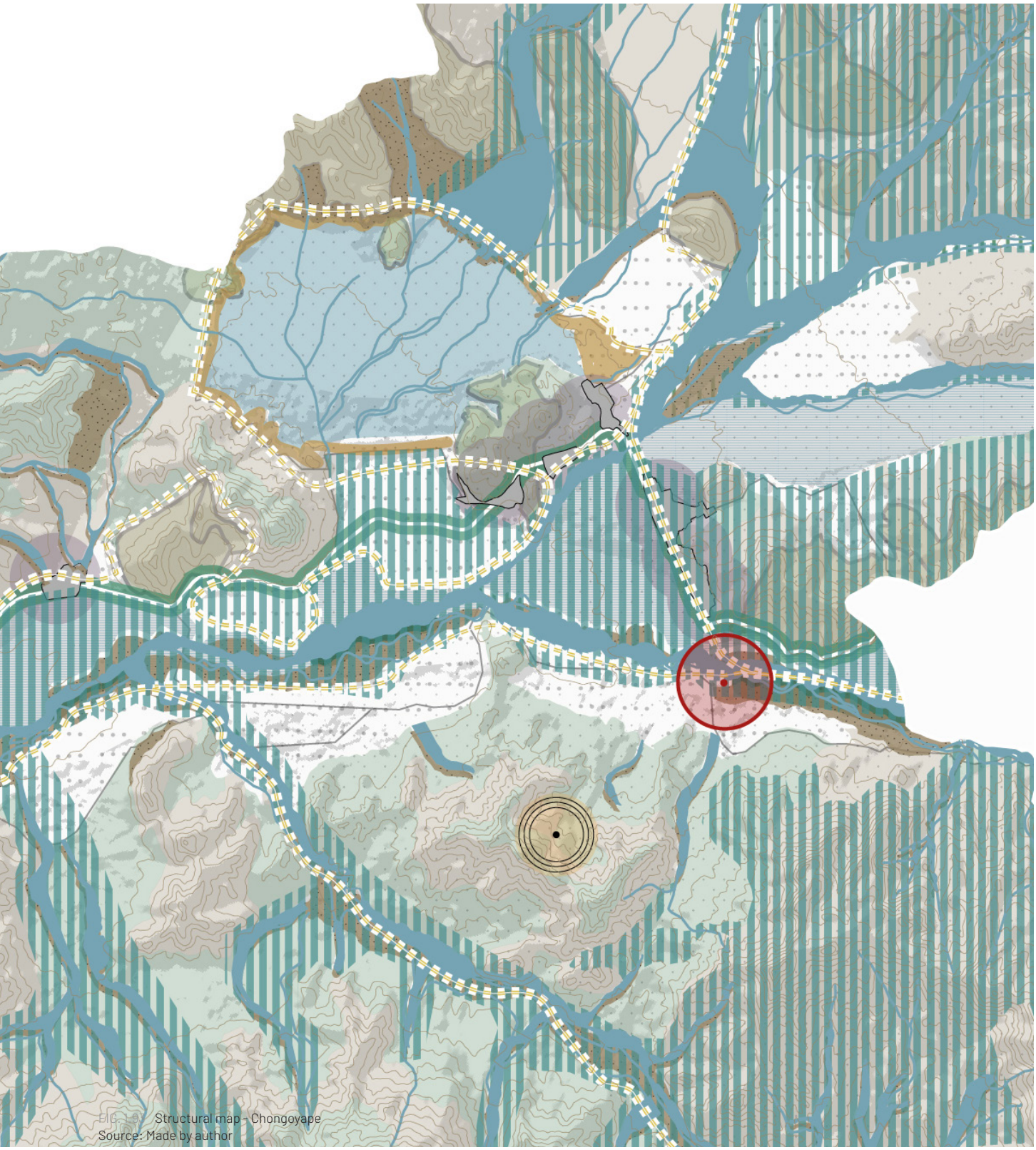


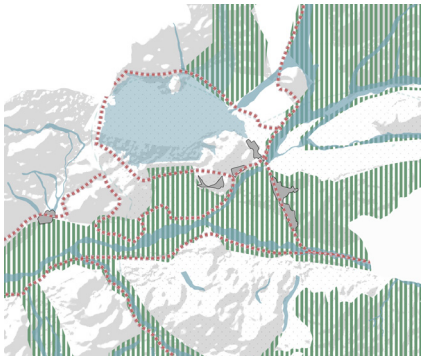
FIG. 137 Structural map - Chongoyape
Source: Made by author

Chongoyape as a Pollution Remediation System

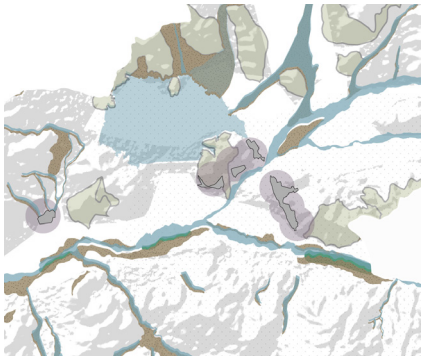
Given that Chancay river enters the region nearby Chongoyape, this project's main aim is to become a Pollution Remediation System, while responding to sudden floods and droughts. This is the highest and starting point of the regional Agriculture-natural park.

The sub-basin structural map is taken as the starting point for this part of the design, by changing the scale from the river axis to the city and surroundings of Chongoyape, more detailed spatial interventions are proposed at this stage.

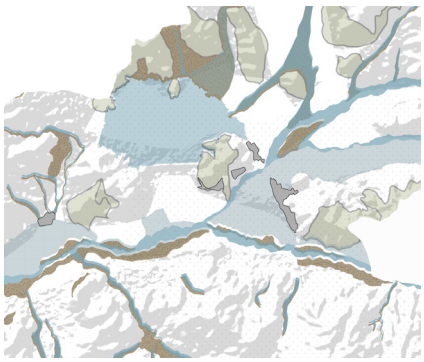
More spatial explorations can be found in the following pages.



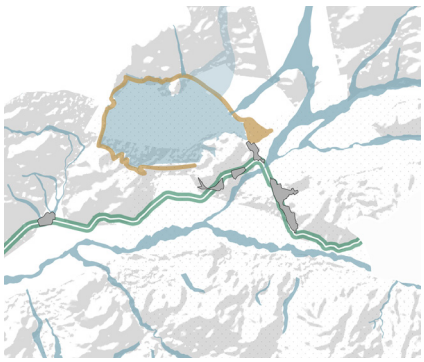
Strategy 1: Scenic Routes



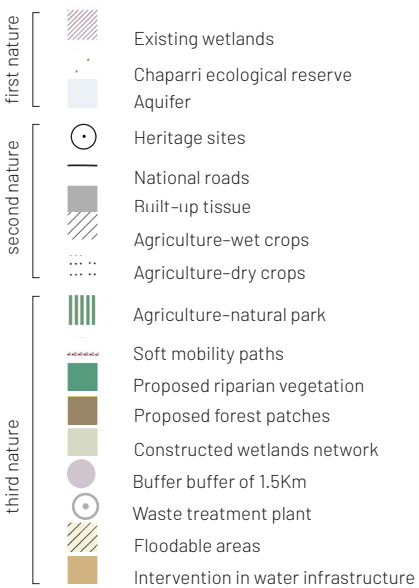
Strategy 2: Pollution Remediation

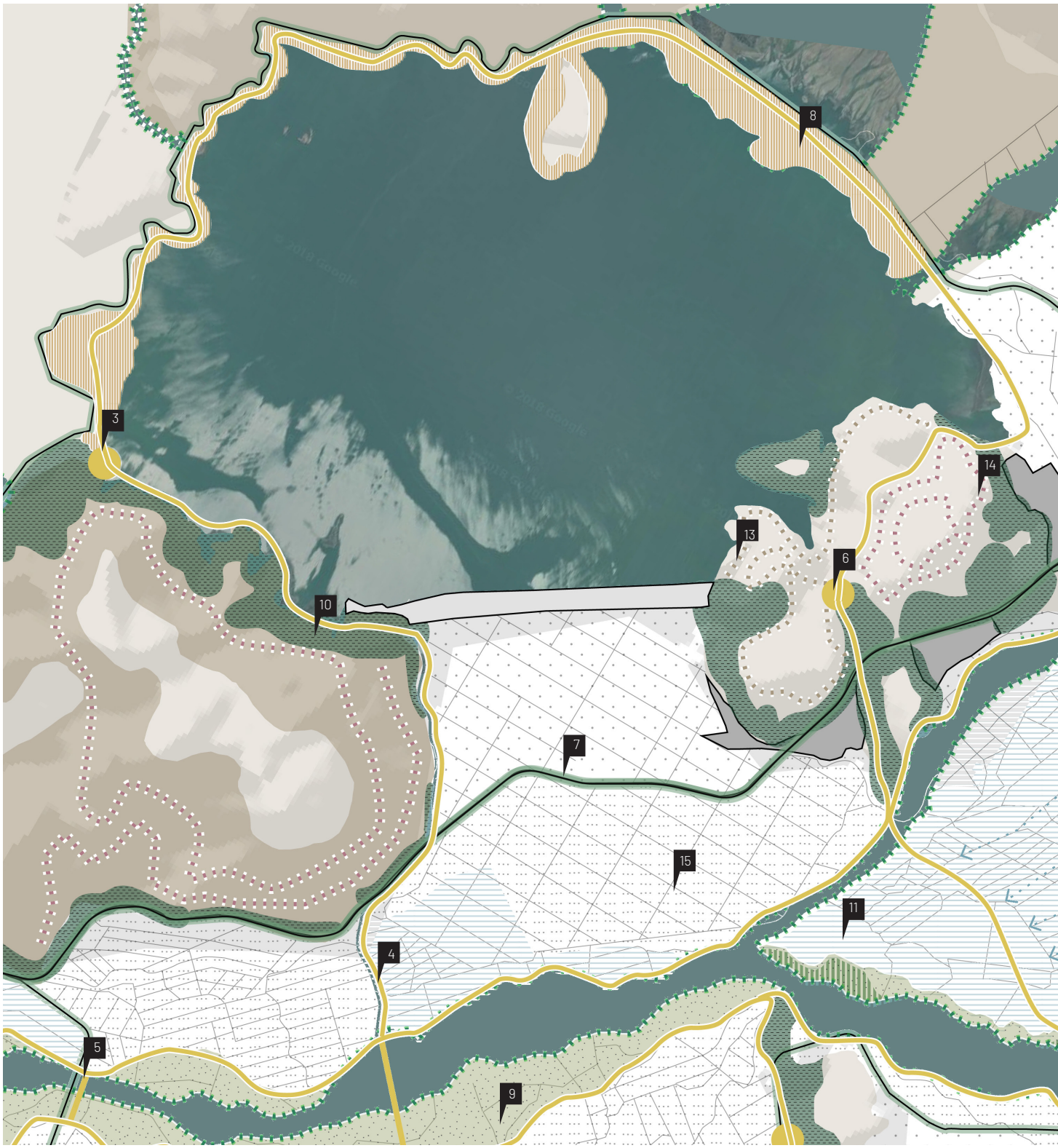


Strategy 3: Water during Emergency



Strategy 4: Water Use & Recreation





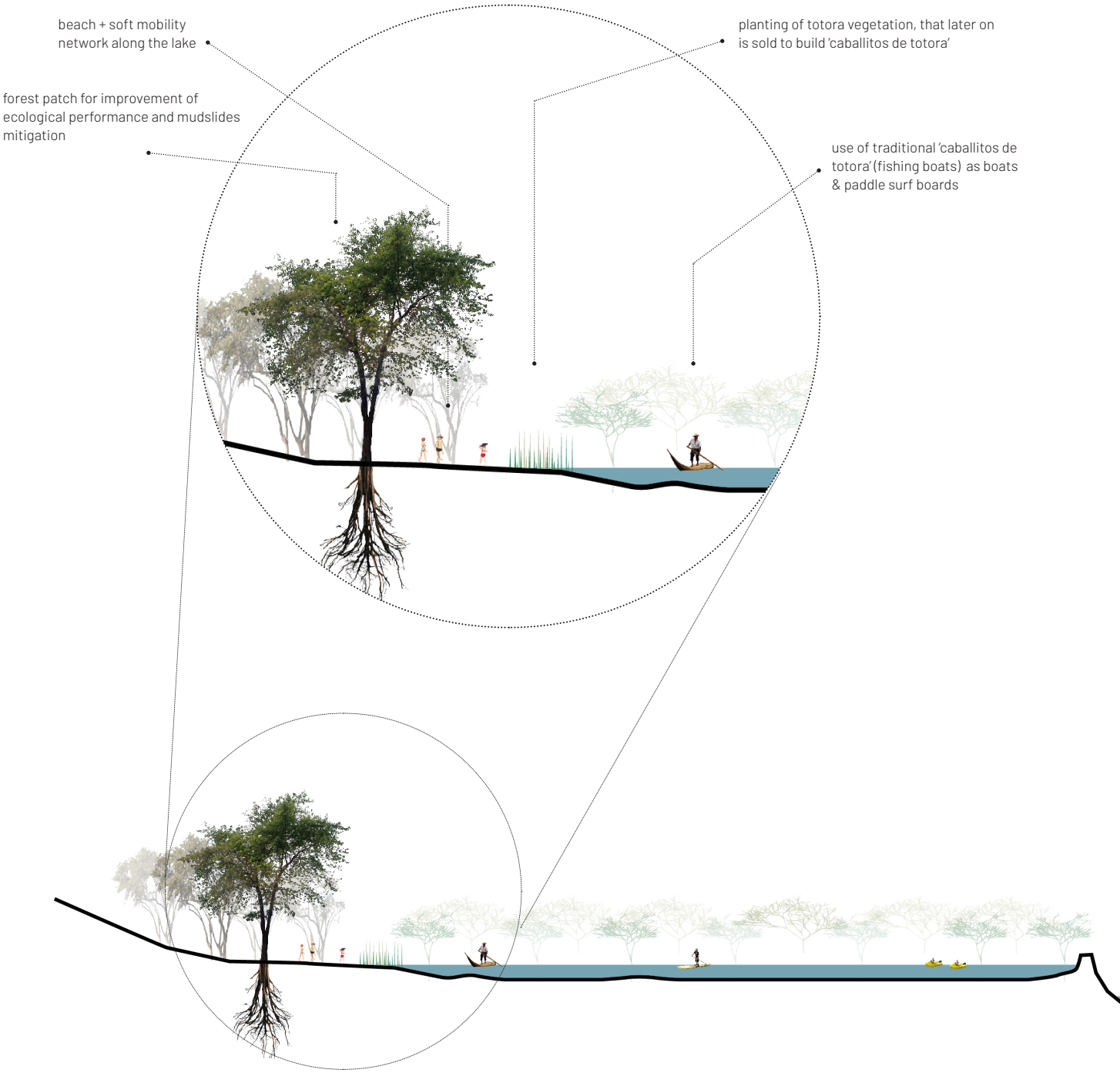
Chongoyape – Design at city scale

1 Recover forest
2 Recover riparian vegetation
3 Starting point of Tinajones scenic route
4 Soft mobility along water surfaces
5 New pedestrian bridges
6 Look-out point for bird-watching
7 Green buffer along highways
8 Beach
9 Constructed wetlands
10 Aforestation
11 Floodable areas in case of emergency
12 Directions water exceedance
13 Terraced vegetation - carob trees
14 Terraced vegetation - carob trees & cacti
15 Diversification of crops

Existing roads
Built tissue
Dry forest
Water surfaces

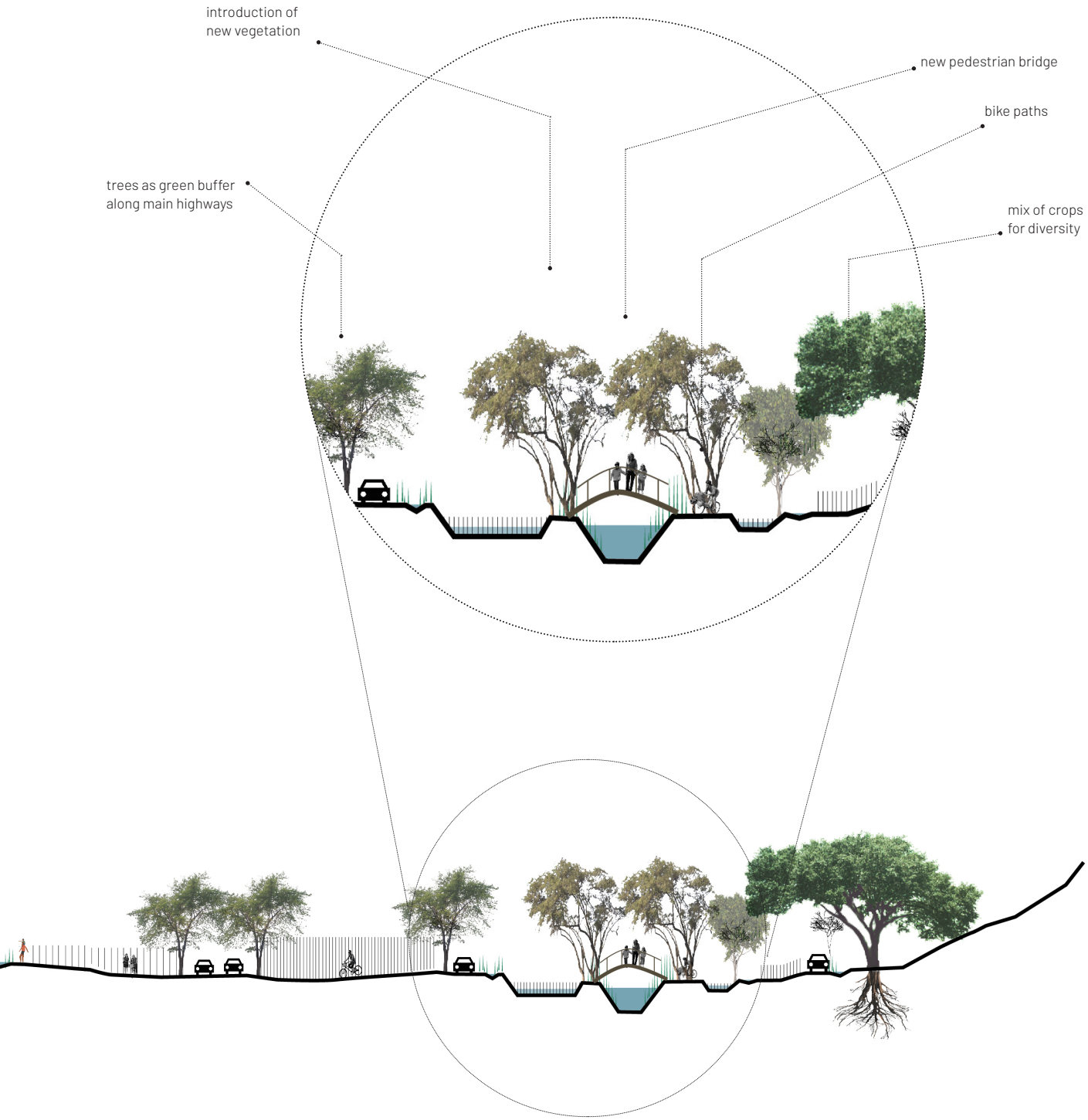
0 1 2 Km

Openness of Reservoir for Recreational Purposes



Chongoyape – Section design at city scale

New Soft Mobility Network



Flexibility in design: dry condition

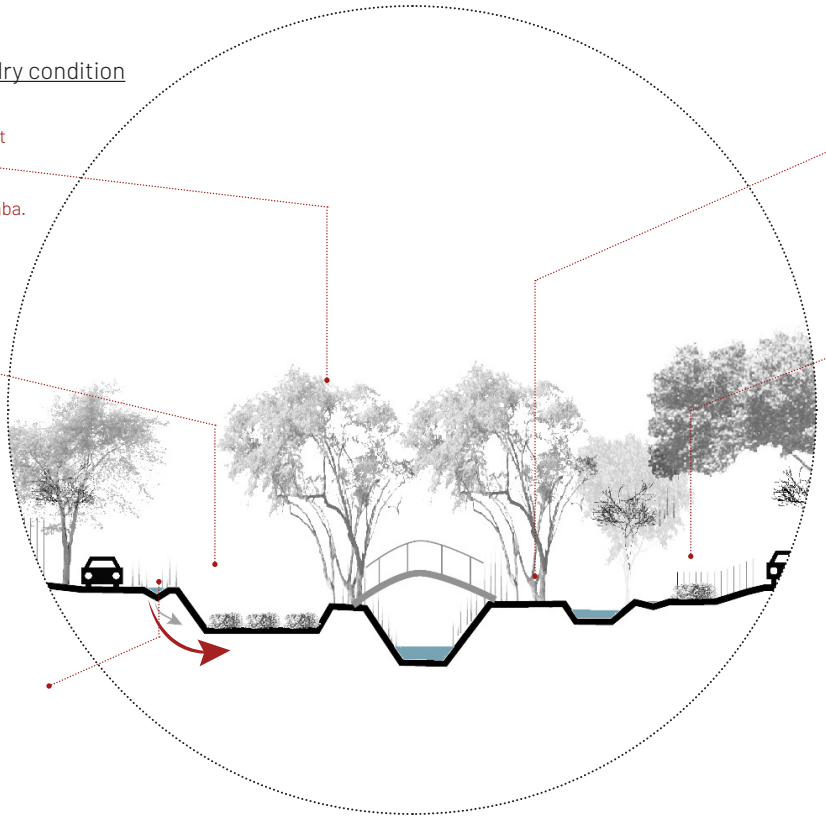
introduce drought-resistant fruit trees along water surfaces, such as mango, passion fruit, guayaba.

crops that need less water such as sweet potatoes, arracacha, strawberries, pineapple, to name a few

use of rice crops or proposed wetlands as water storage

gradual change to crops that require less water unlike the current ones: sugar cane & rice

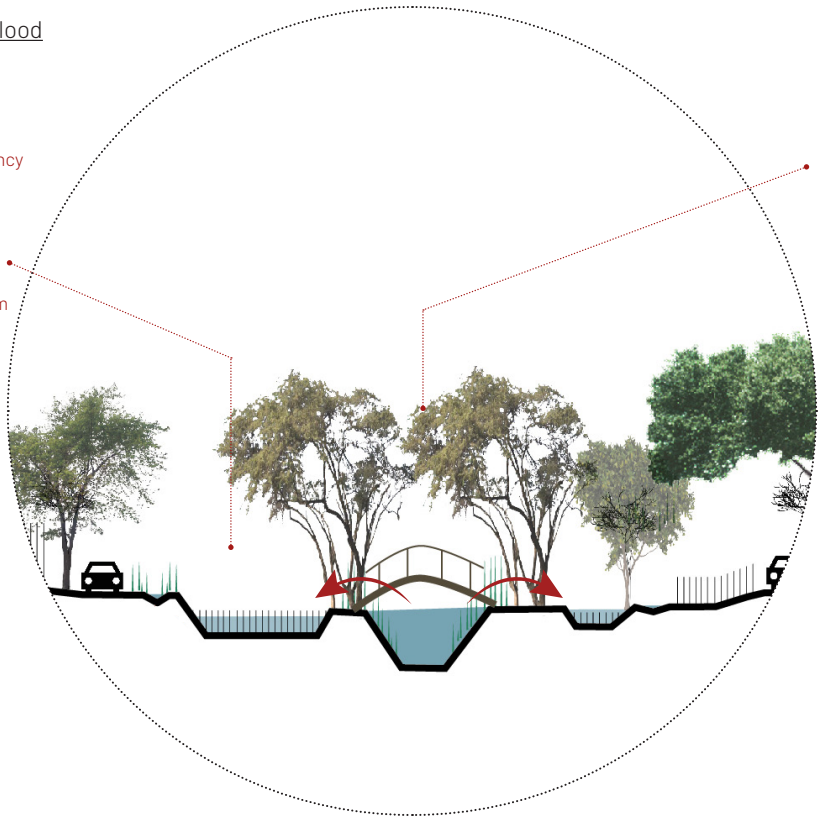
some of the ditches are recharged by strategic water storage across the territory

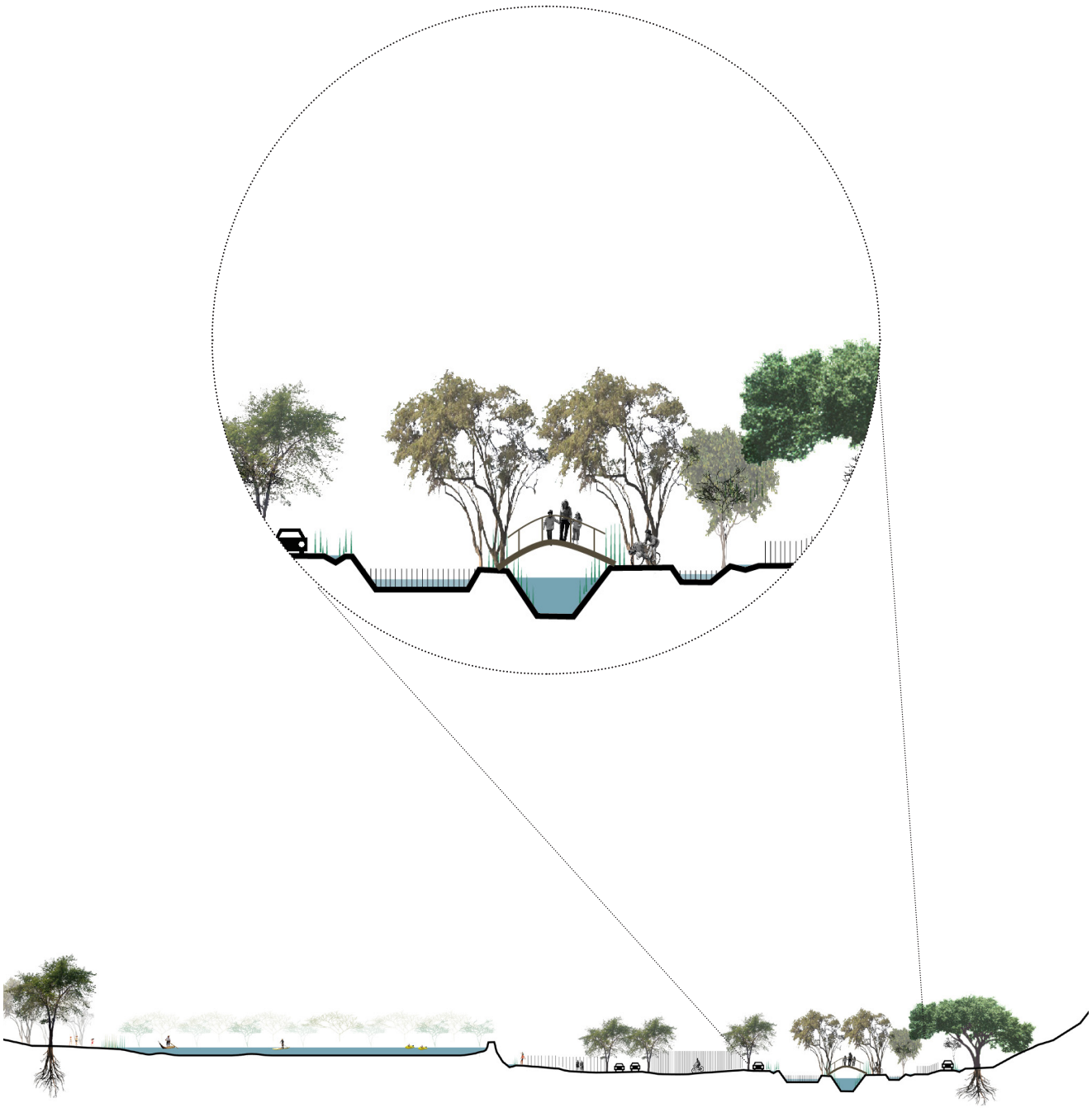


Flexibility in design: flood

In case of extreme emergency rice crops adjacent to the river might be flooded. Policies and continuous involvement of the community is necessary to achieve a new equilibrium

exceedance water runs towards the space designed for it, such as wetlands, forest patches or water squares (while in urban environments)





Chongoyape | Analysis of Streetscape Scale

Continuing with multi-scalar design approach, the analysis of the streescape scale will be presented highlighting the main findings: gravity, structure of the site, affordability and ecological gradient.

Gravity

Taking into consideration that Chongoyape is the highest part of the Agriculture–natural Park, the city has benefited from gravity, since exceedance water can naturally overflow through the streets until its arrival to the main canal. Moreover, the main irrigation ditches are located in the same direction.

Two structures: City & productive land

Diagram shows the city's structures: both are perpendicular to the main canal that runs through the city, however, just two streets connect both structures, being the stornger flow the one connecting the prodcutive land with the market.

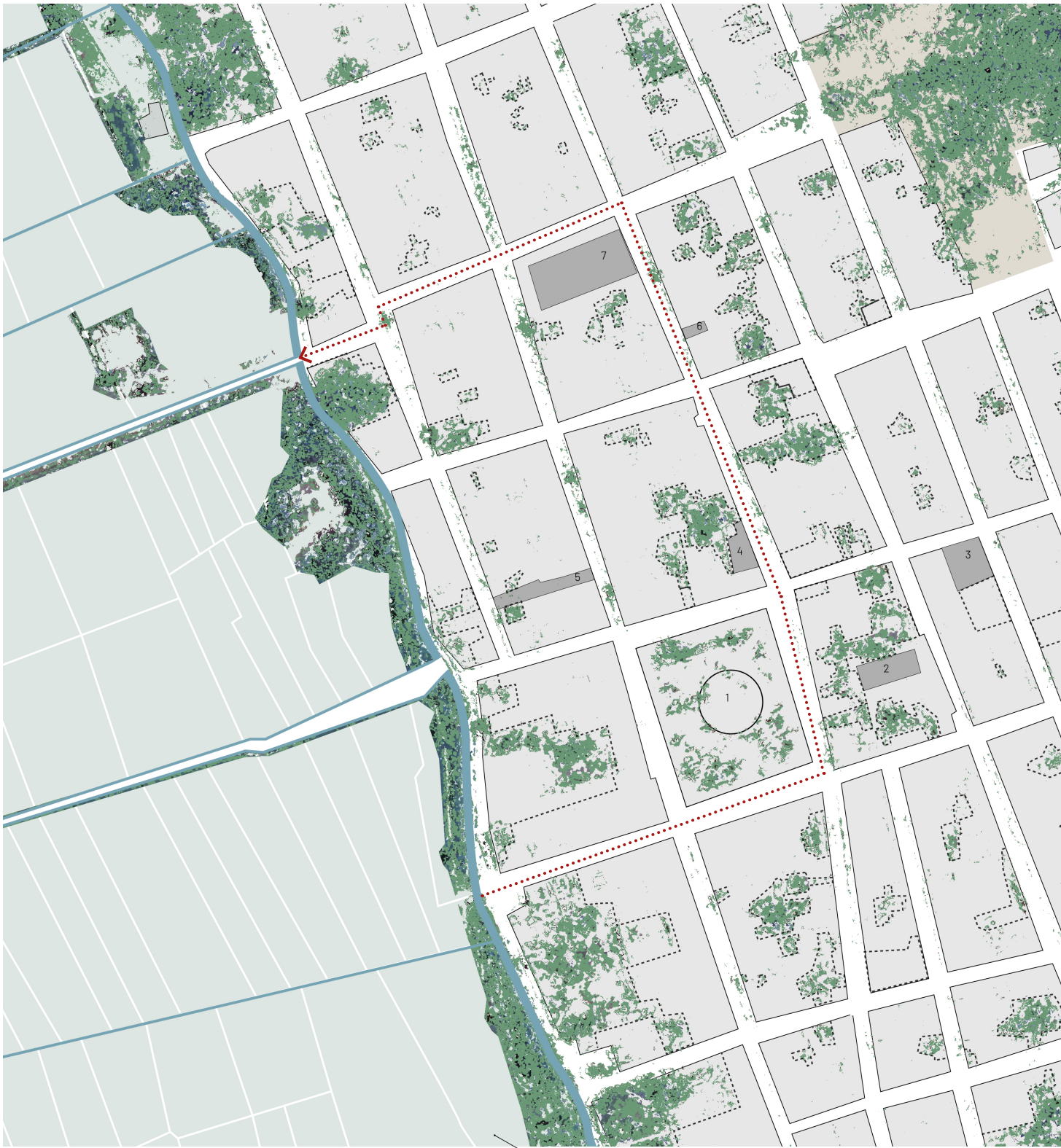
The central core of the city can be seen in red.

Affordability

Existing orchards and vacant lots are illustrated in this diagram, highlighting its affordability. Moreover, this spaces hold the potential to be part of the co-existence water system.

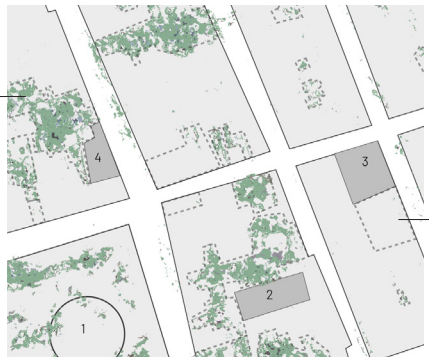
Ecological gradient

There is a gradient form the dry forest, city, canal and agricultural land. Within the built tissue, existing orchards function as the linking elements between the natural, built and productive realms.



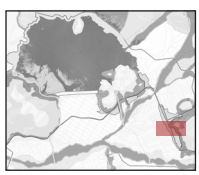
Chongoyape | Analysis – streetscape scale

Although this area is categorised as dry forest and it has existing vegetation, it is in very bad conditions, thus holds the potential for reforestation with indigenous species



Affordability
The diagram shows in detail existing orchards and available lots adjacent to important built tissue.

1 Main square
2 Church
3 Hospital
4 School
5 Transportation agency to Chaparrí
6 Comission of Irrigators
7 Market
Existing roads
Existing tissue
Vacant lots
Existing orchards
Existing green areas
Dry forest
Canal
Ditch
Central core



Chongoyape | Water Related Strategies

Diagrams above show water-related strategies through the process of time and disruptive changes such as El Niño Phenomenon, specially highlighting the flexibility and adaptability of the design.

Existing condition
As explained before in the case of Chongoyape gravity is directed towards west-south.

Dry condition
During dry condition two main strategies assure water flow in the city: First, aforestation at the base of the hill is proposed in parallel with a retention pond, given that volcanic soil acts as a sealing rock, which holds the potential for water storage, from where water can overflow towards underground reservoirs located in certain public buildings, positioned in main streets.

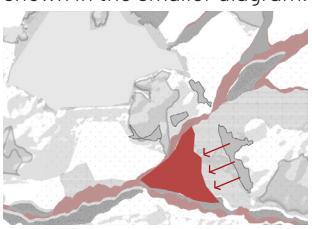
On the other hand, the network of constructed wetlands recharge irrigation ditches. Policies that promote the diversification of crops towards not as water demanding crops as sugar cane and rice are needed in order for the community to survive in every condition.

Light rainfall

This is an opportunity to infiltrate and retain water in constructed wetlands, retention pond and in rain-gardens.

Extreme rainfall

In this acute scenario all the above strategies are put in to action, adding the available lots and proposed orchards stressing the areas on the circles given their hydrological linkage and topology to infiltrate water into the water table. Moreover, ditches are used for the conduction of exceedance water into emergency floodable spaces as its shown in the smaller diagram.

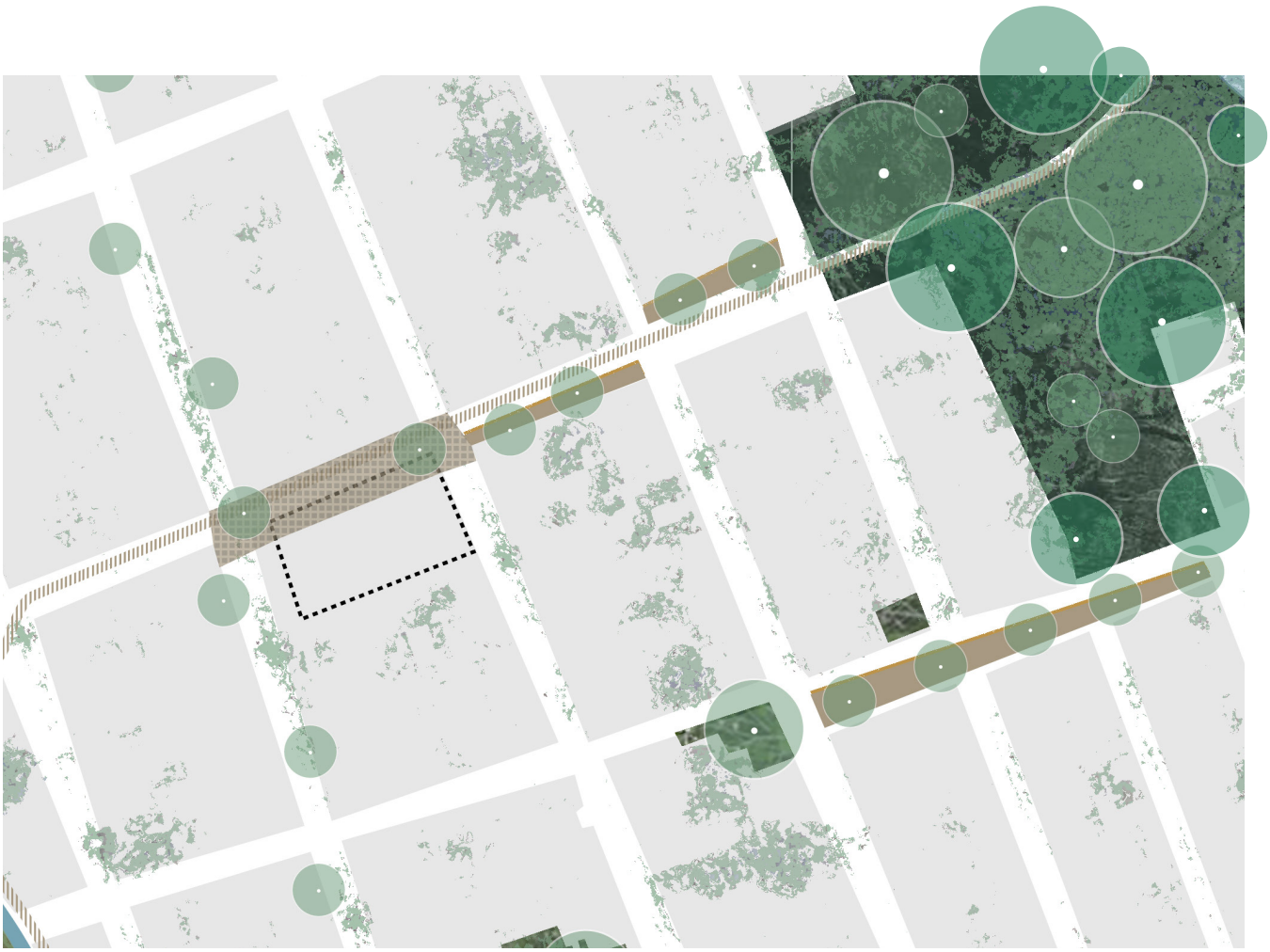


Chongoyape | design at streetscape scale

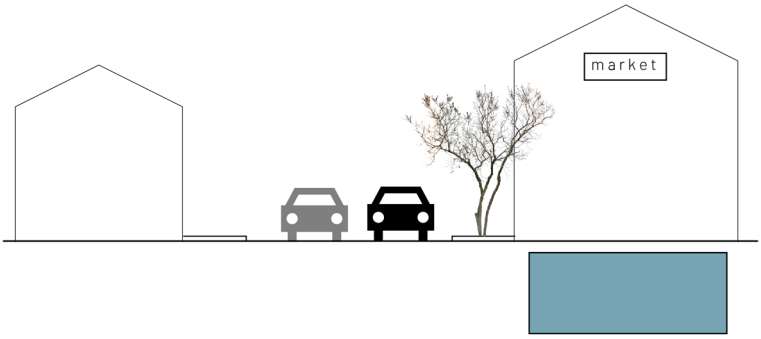
1 Recover forest
2 Recover riparian vegetation
3 Starting point of Tinajones scenic route
4 Soft mobility along water surfaces
5 New pedestrian bridges
6 Look-out point for bird-watching
7 Green buffer along highways
8 Beach
9 Constructed wetlands (functions as water storage during drought season)
10 Aforestation
11 Floodable areas in case of emergency
12 Directions water exceedance
13 Terraced vegetation - carob trees
14 Terraced vegetation - carob trees & cacti
15 Diversification of crops
16 Rain garden
17 Pluvial drainage (retrofit)
18 Pedestrian area
19 'Seeding' projects – communal orchards
20 Underground reservoir
21 Retention pond

1 Main square
2 Church
3 Hospital
4 School
5 Transportation agency to Chaparrí
6 Comission of Irrigators
7 Market
Existing roads
Existing tissue
Existing green areas
Dry forest
Canal
Ditch

0 1 2 Km



Chongoyape | Peatonalisation of the market street

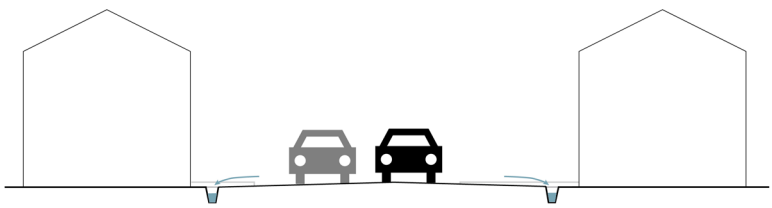


Diagrammatic sections of multifunctionality & flexibility embedded in the streetscape scale:

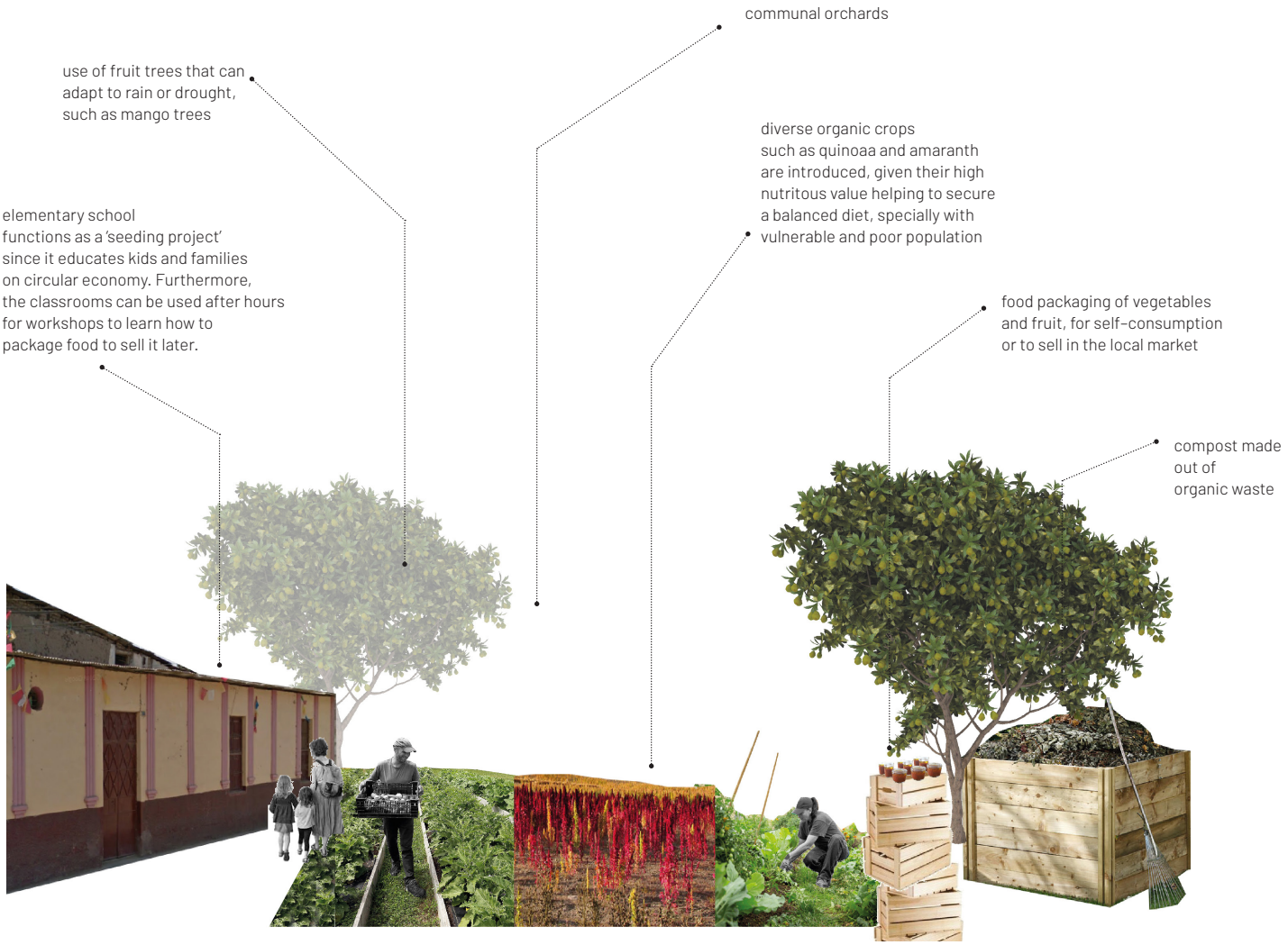
Slow & store
Underground storage beneath public buildings, such as the market, in order to ensure water supply even in case of extreme drought.

Temporal phasing
Pedestrianisation of the market street on weekends in order to create a new public space, since the market is the main reference and gathering point in small cities, such as Chongoyape.

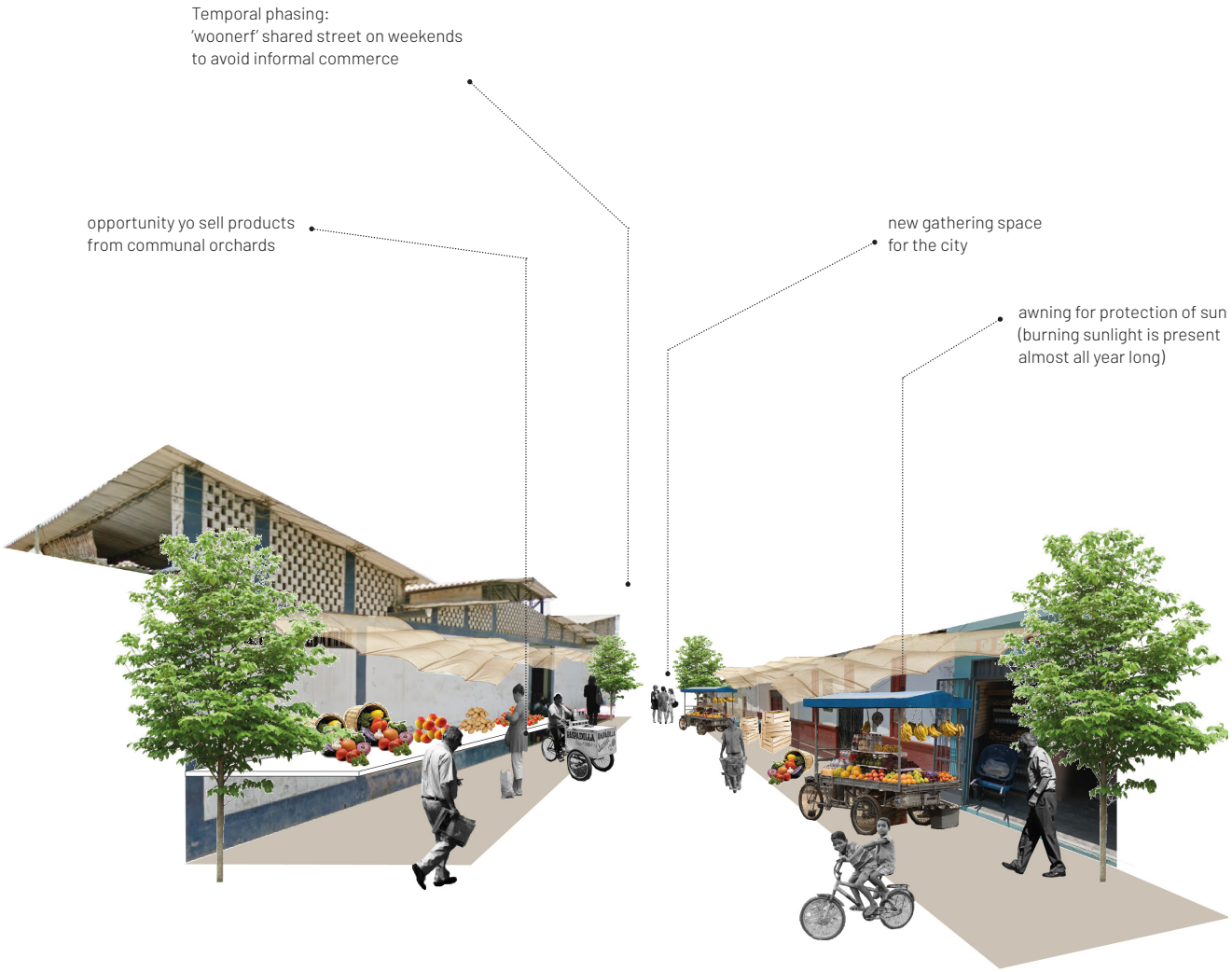
Rain-garden
When the morphology allows for it, introduction of rain garden in order to slowly infiltrate water towards the subsurface.



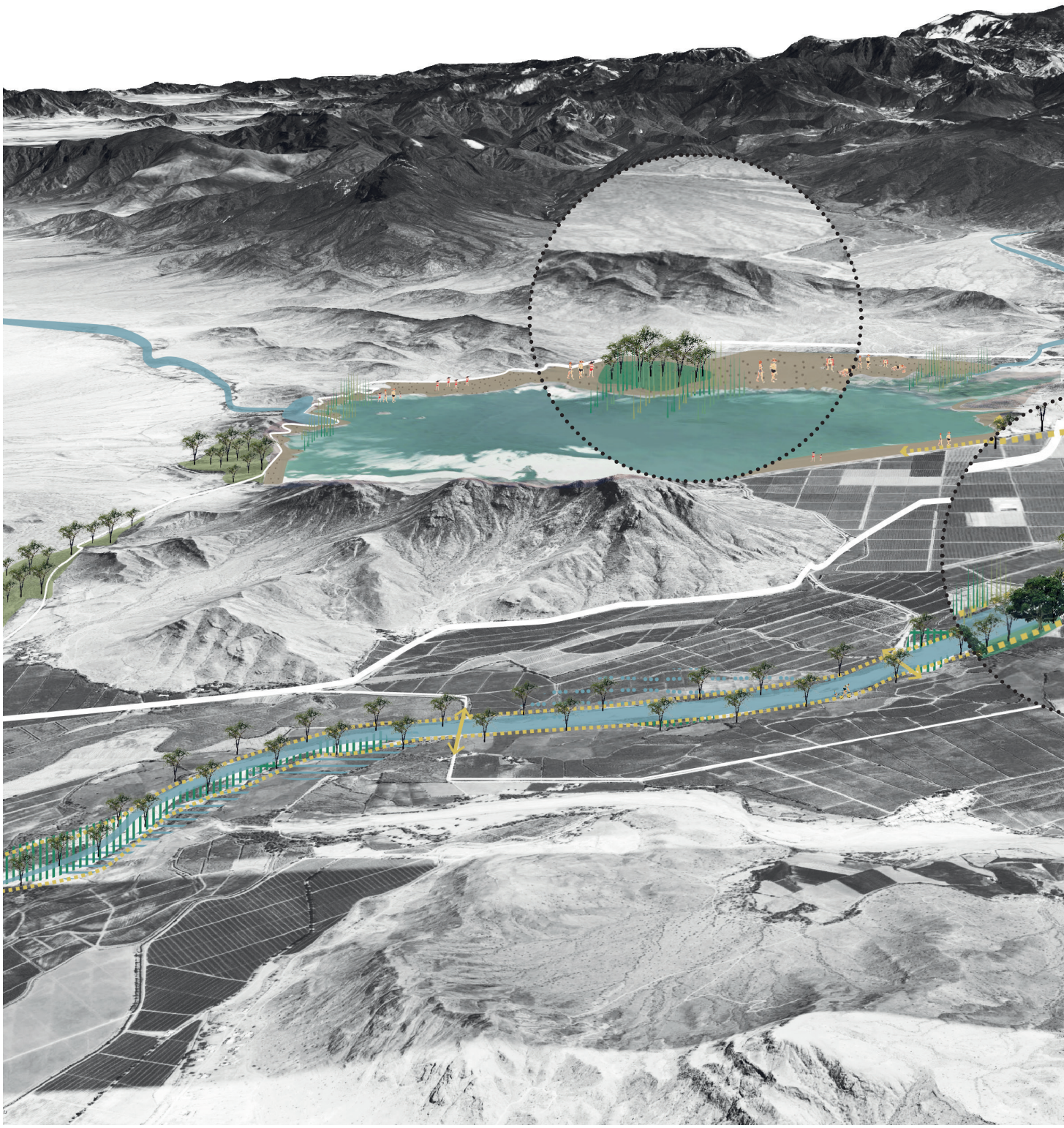
Small-scale retrofit
Underground gutters are proposed in interceptor streets in order to function as pluvial drainage in case of extreme precipitations.

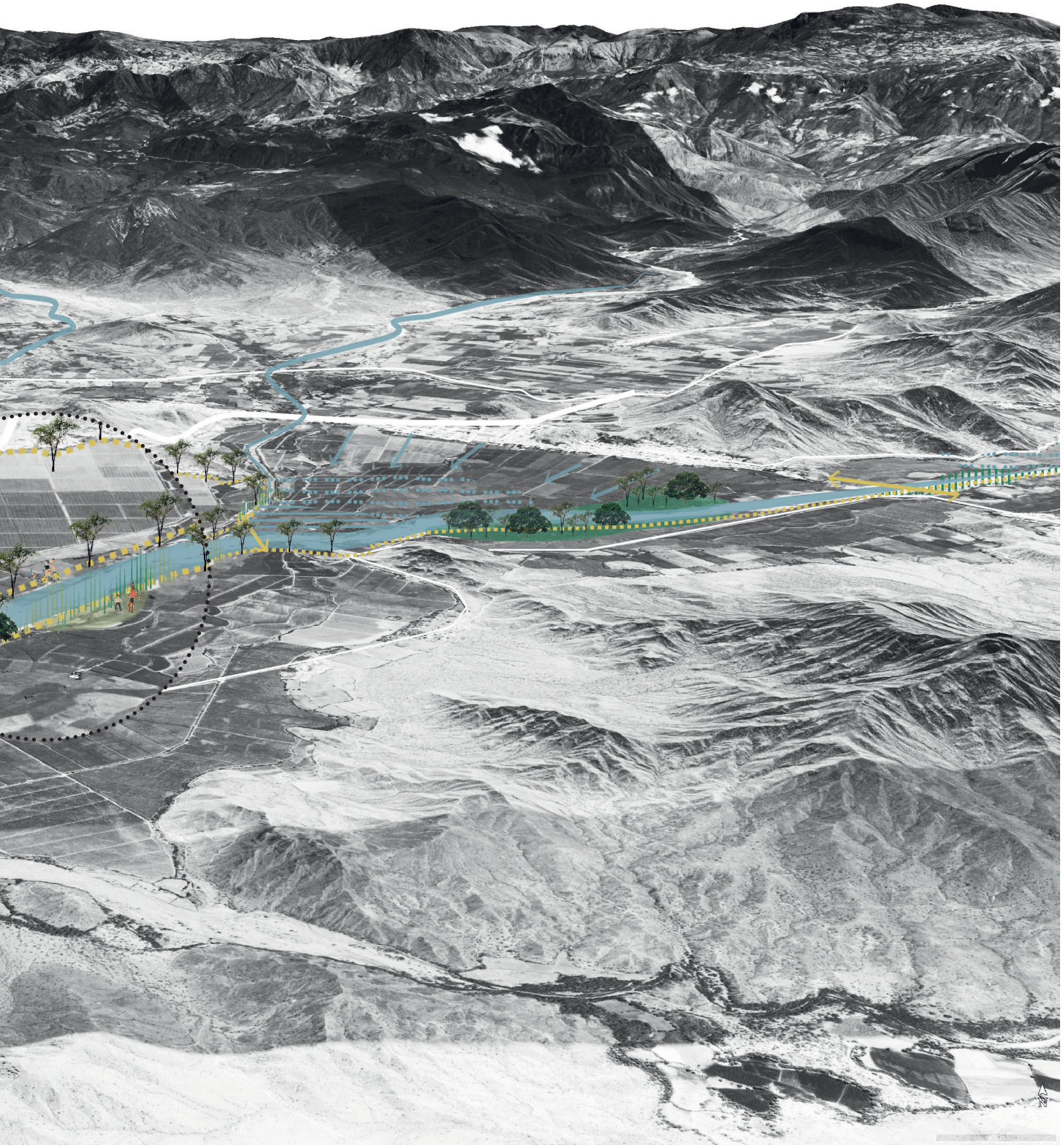


Chongoyape | 'seeding project': communal orchards



Chongoyape | 'seeding project': peatonalisation of market street - temporal phasing





Reque

FIG. 1.94 Reque: challenges
Source: Made by author with data from Google Earth

1 Reque bridge is the most legible bridge of the region

2 Ecological potential of Chancay river near the city

3 Potential for soft mobility paths

4 Occupation of river flood plain by agriculture fields

5 Garbage dump and posterior incineration in the open

6 City is divided by Panamericana highway

Potentials & challenges of Reque

Sources:
1, 2 & 3 Author
4 & 6 Google Street View, accessed on June 2018
5 www.democraciaadolescente.blogspot.com

FIG. 1.95 Landscape along Panamericana highway
Source: Author

FIG. 1.96 Panamericana highway
Source: Author

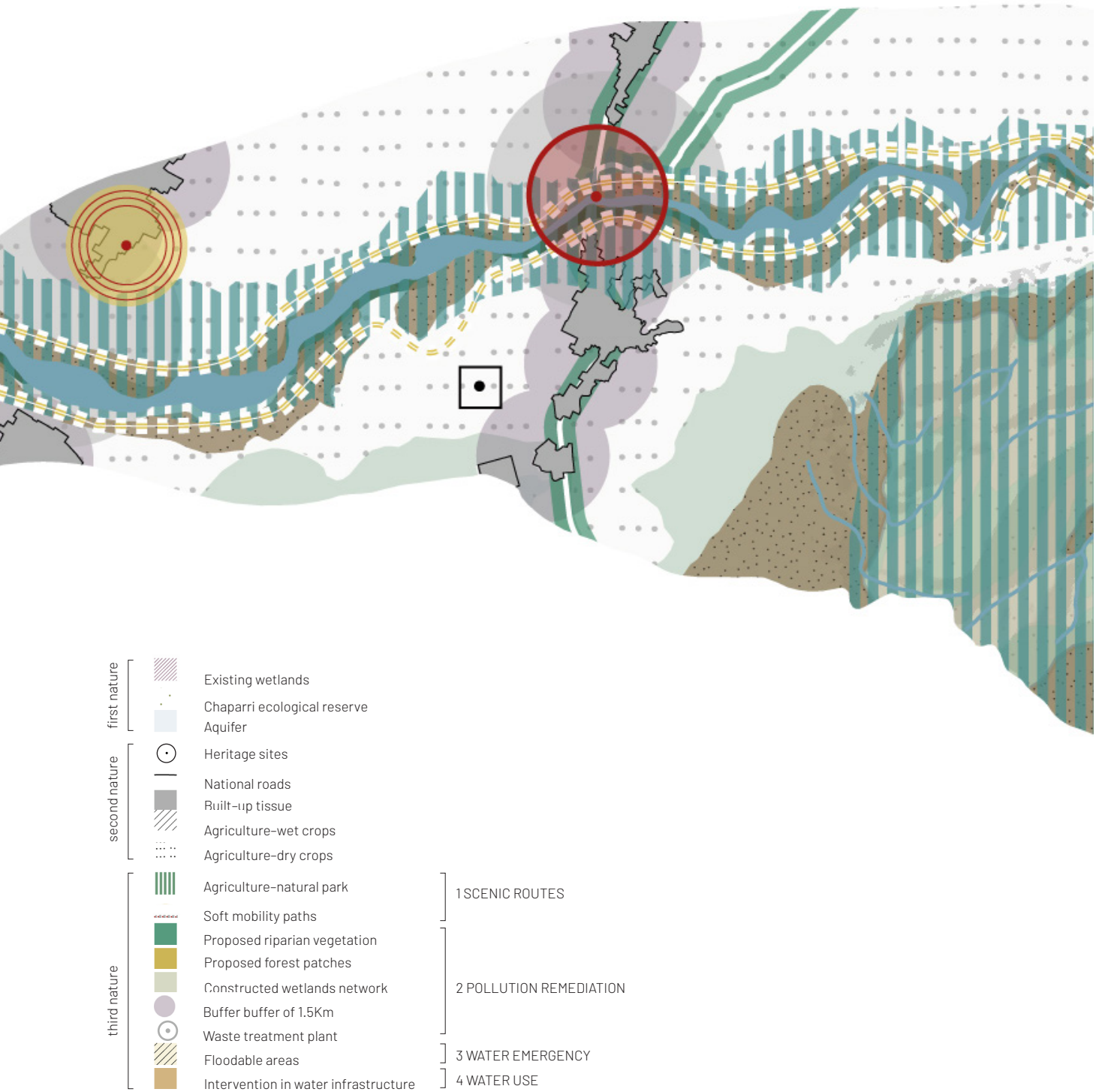


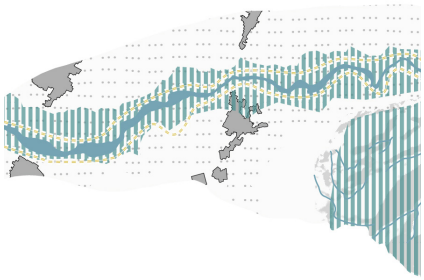
FIG. 1.97 Structural map - Reque
Source: Made by author

Reque: Accommodation for Urban Growth

Historically, most of Chiclayo –main city of the region– was once part of Reque. Throughout the years this tendency and interconnection between the two cities has continued.

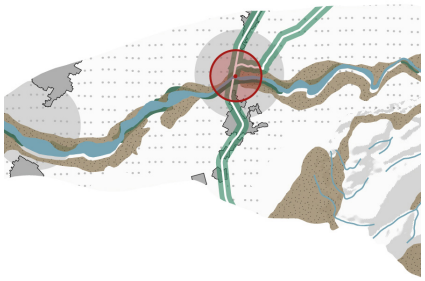
Given lack of public spaces within cities, restaurants in country settings are the main recreation source for the population of most cities in the region. These country–restaurants are comprised by open green spaces and swimming pools, filling the lack of public, recreational and sports spaces within the city.

Economic development is mainly comprised in Chiclayo, thus its the city where most of the urban growth is currently taking place, however due to the aforementioned economic development prices have gone up, which has caused a a new trend: population, specially young people are starting to move towards what can be understand as the 'suburbs' which is mainly in the direction of Pimentel –towards the coast– and to Reque, following the Panamericana highway. Reque as the main area for planned accommodation for urban growth aims to fill the gap that most peruvian –and Latin-American– cities suffer from: sporadic and unplanned growth.

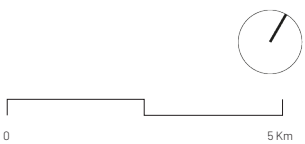


Strategy 1: Scenic Routes

Strategy 2: Pollution Remediation



Strategy 4: Water Use & Recreation



Reque | Suitability Analysis

At this stage of the design, a suitability analysis is made by a similar process as with the Territorial Reading –Part 3–. The layers taken into account for this analysis are: topography, topology, landform, soil, groundwater, natural and semi natural landscapes as well as the urban tissue.

The result of the suitability analysis is the potential sites for urban growth and its complementary functions.

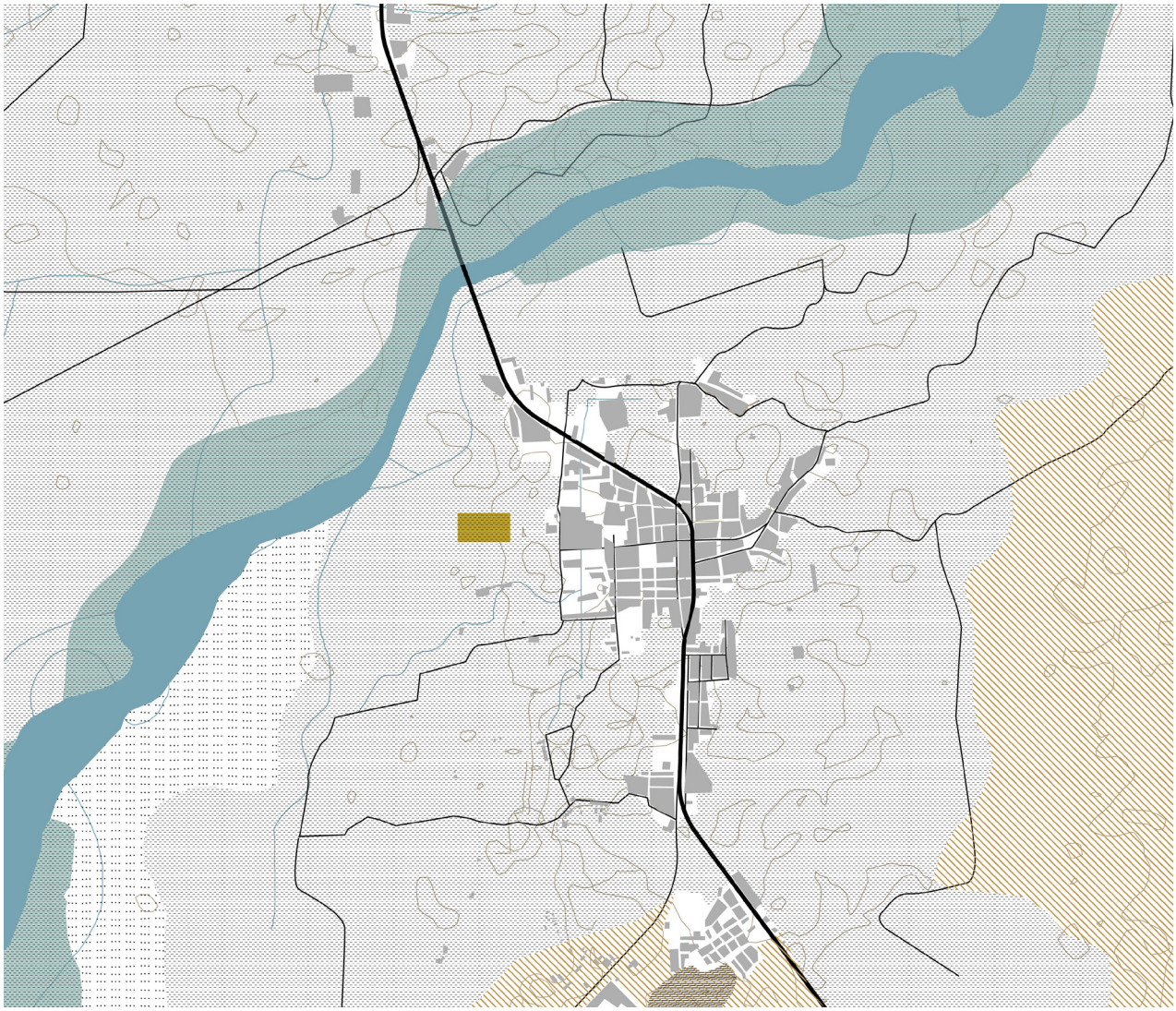
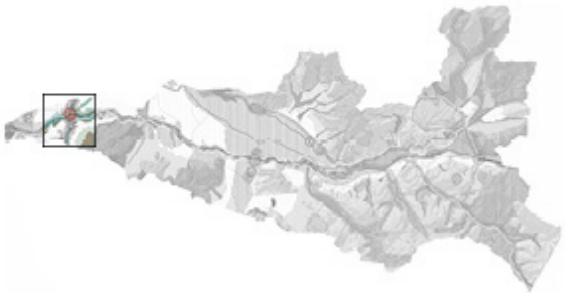
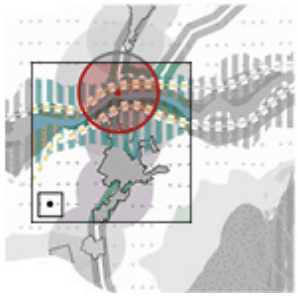


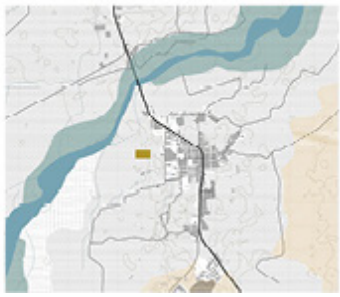
FIG. 1.98 Suitability layers resulting in suitability map
Source: Made by author



Chancay sub-basin scale – meso scale

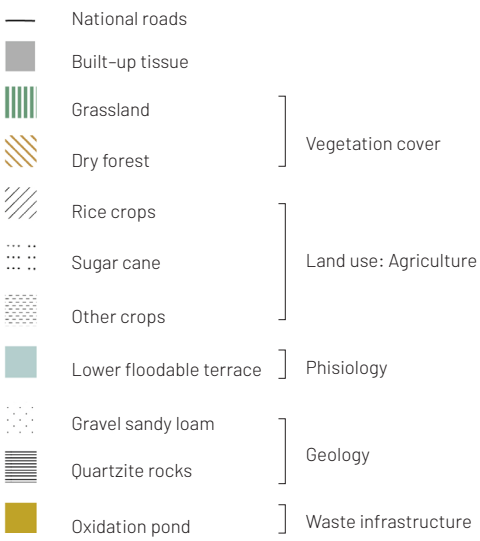


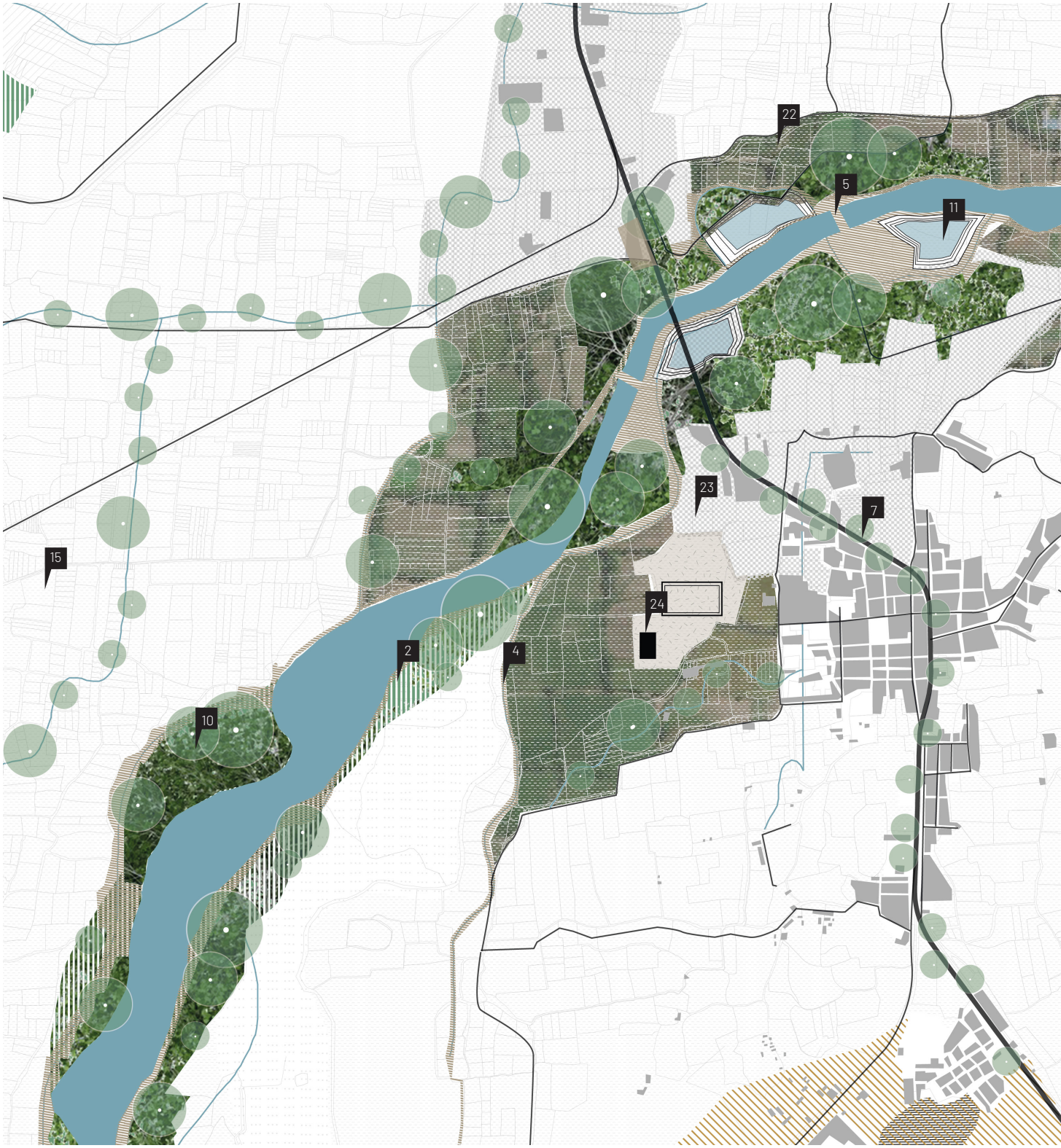
Reque scale – micro scale



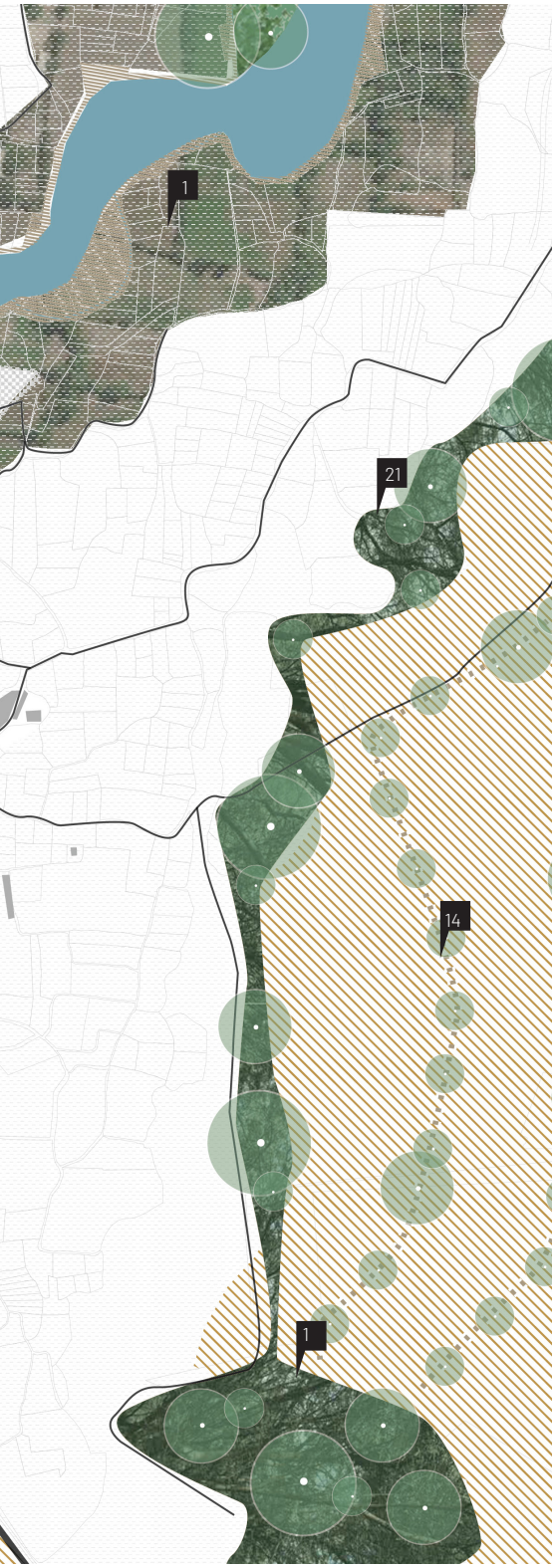
Reque – streetscape scale

FIG. 1.99 Multiscalar approach
Source: Made by author





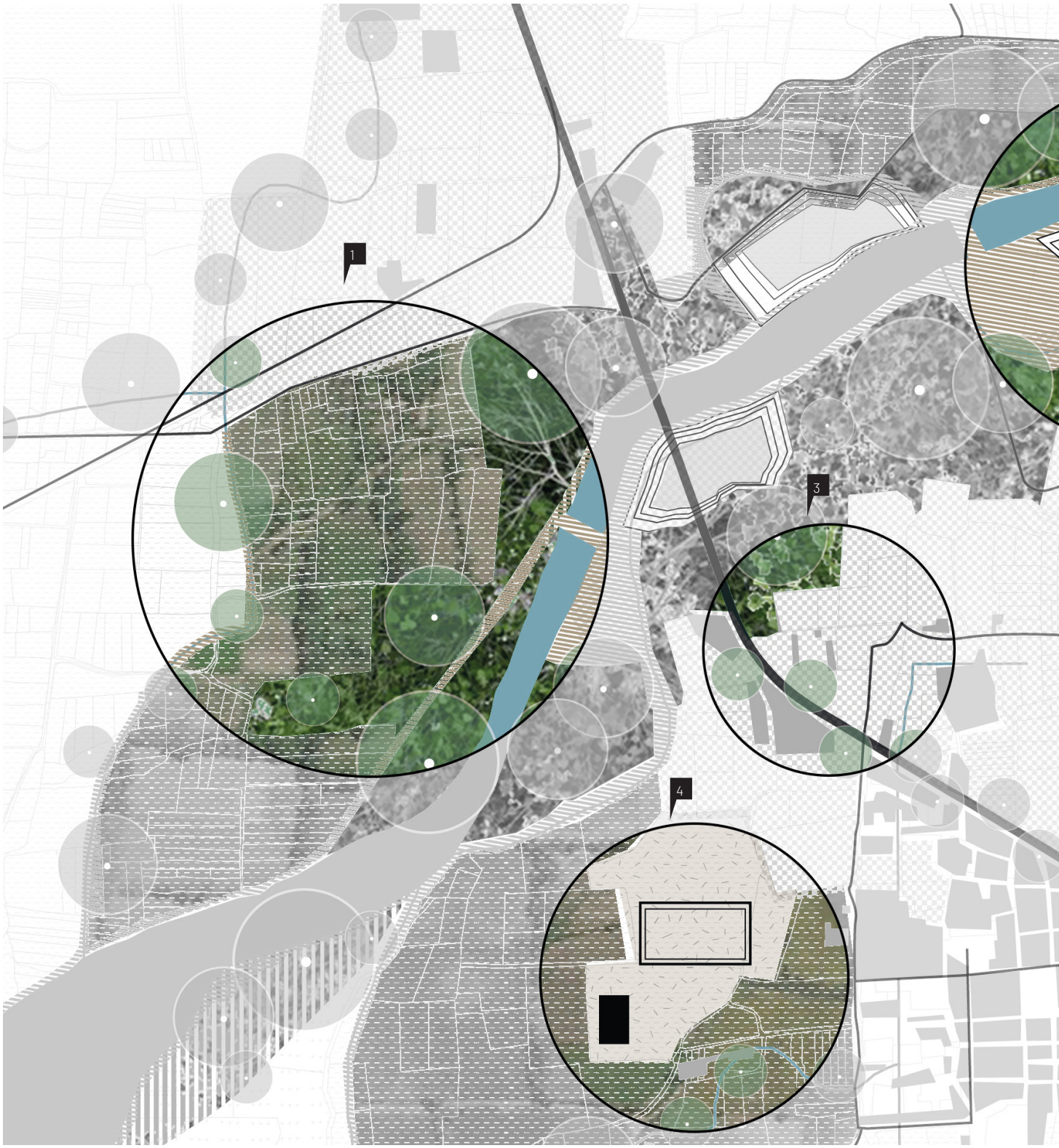
Reque | design



1 Recover forest
2 Recover riparian vegetation
3 Starting point of Tinajones scenic route
4 Soft mobility along water surfaces
5 New pedestrian bridges
6 Look-out point for bird-watching
7 Green buffer along highways
8 Beach
9 Constructed wetlands (functions as water storage during drought season)
10 Aforestation
11 Floodable areas in case of emergency - water squares
12 Directions water exceedance
13 Terraced vegetation - carob trees
14 Terraced vegetation - carob trees & cacti
15 Diversification of crops
16 Rain garden
17 Pluvial drainage (retrofit)
18 Pedestrian area
19 'Seeding' projects – communal orchards
20 Underground reservoir
21 Retention pond
22 Strategic Parkland
23 New development area
24 Waste treatment plant

Panamericana highway
Local roads
Existing tissue
Dry forest
River
Ditch

0 1 2 Km



Reque | design

1 Agriculture–natural Park

Due to the importance of agriculture not just in the economic dimension, but in the regional idiosyncrasy, productive lots are integrated into the river corridor park resulting in the Agriculture–natural Park, which aims for the integration of the first, second and third natures in order to achieve its maximum ecological, social and economic potential.

The created patchwork re–draws the inherent connection between wilderness – comprised by the river and existing vegetated patches– and, man–made landscapes –constituted by agriculture, roads, built tissue and infrastructure– focusing in gathering spaces were excercise, outdoor activities and exchange among social and ecological systems is achieved.

2 Strategic parklands

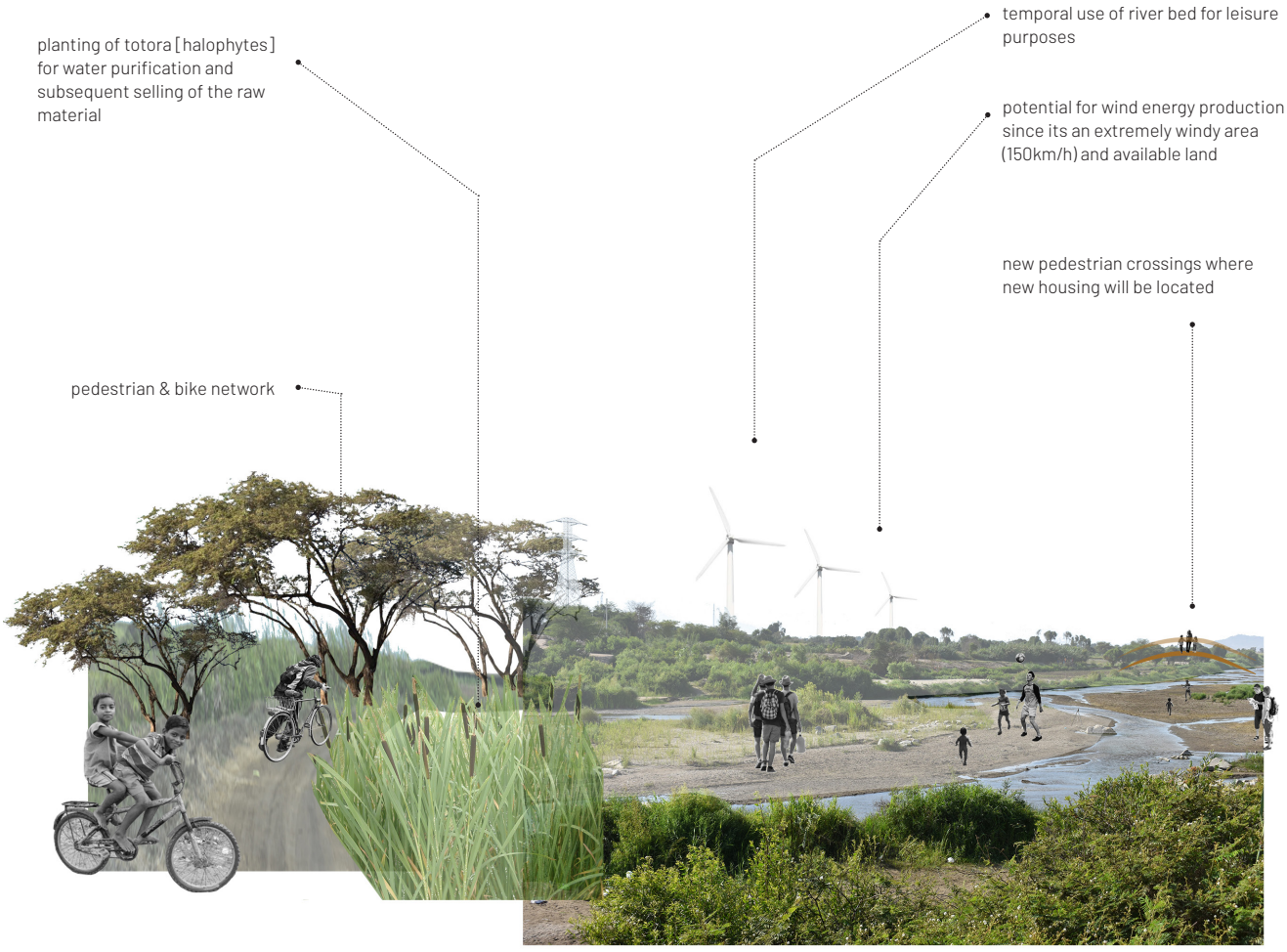
In the case of Reque the strategic parkland is comprised by water squares that in case of extreme rainfall or river flood can be inundated, being part of the first line of water emergency defence. Water squares have embedded multifunctionality, flexibility and adaptivity in their design: as it name indicates it can also be used for leisure and sports activities and, at the same time it responds to contingency design against future uncertainties, responding to flexiblity. Moreover,being part of the green & blue system ensures its performance –being the defence function the main one– even if one of the water squares –or all– stop operating.

3 New development areas

New urban growth of the region will be directed into this new development area in front of the river with high density of housing and commerce. As mentioned before, main highways are the drivers for –unplanned– current development, specially this one connecting Chiclayo and Reque.

4 Waste treatment plant

Taking as a starting point the oxidation ponds that currently do not meet their objectives, a grey water treatment plant is proposed in that site. Surface water pollution is a challenge taken into account in the making of this project, but untreated sewage water causes great damage as well, not only to the environment but for the overall population



Reque: river development proposal

retention pond in the direction where drainage sewage converge. water storage in affordable space next to the church and 'gained' lane

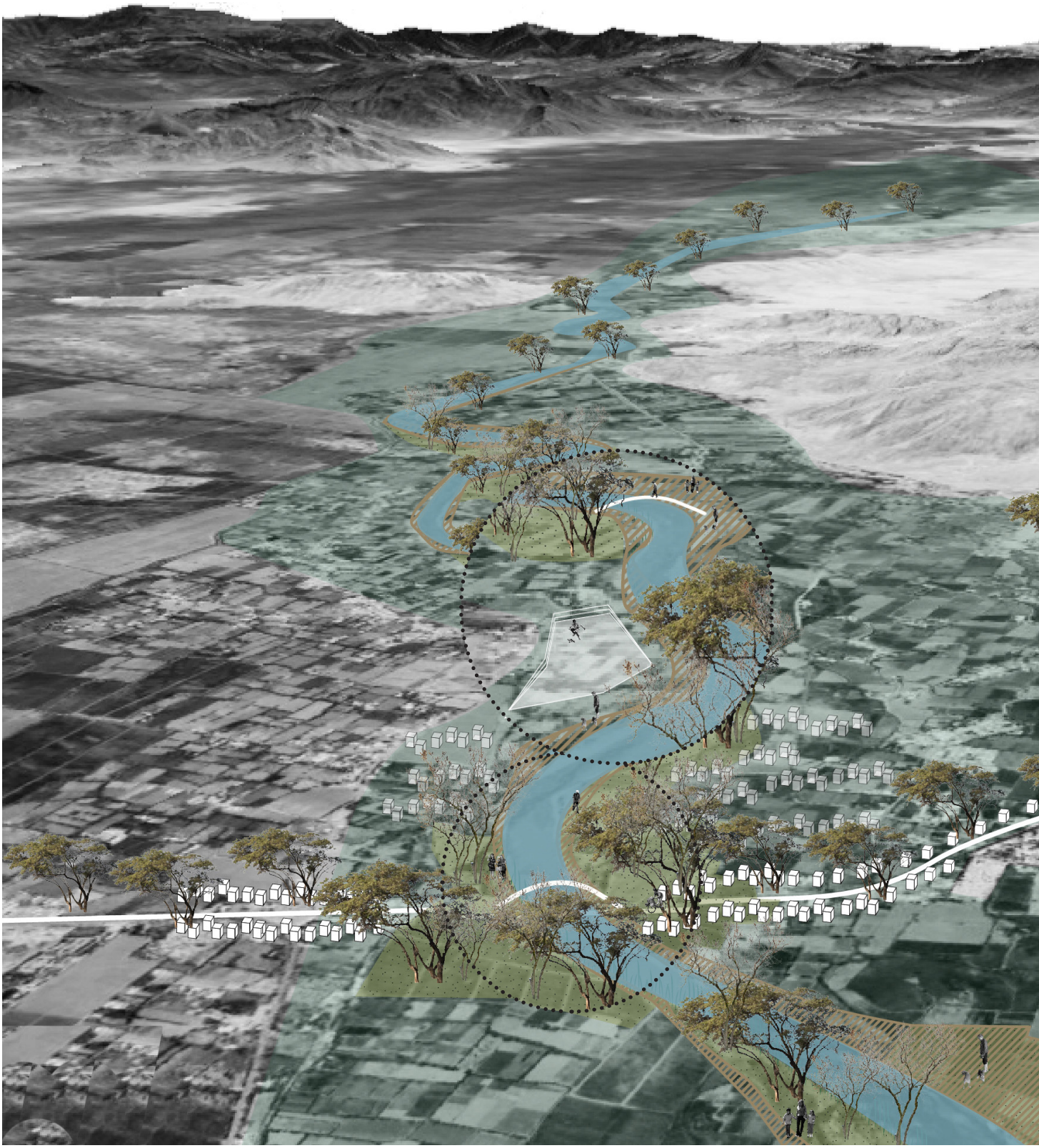
permeable pavement for slow water infiltration

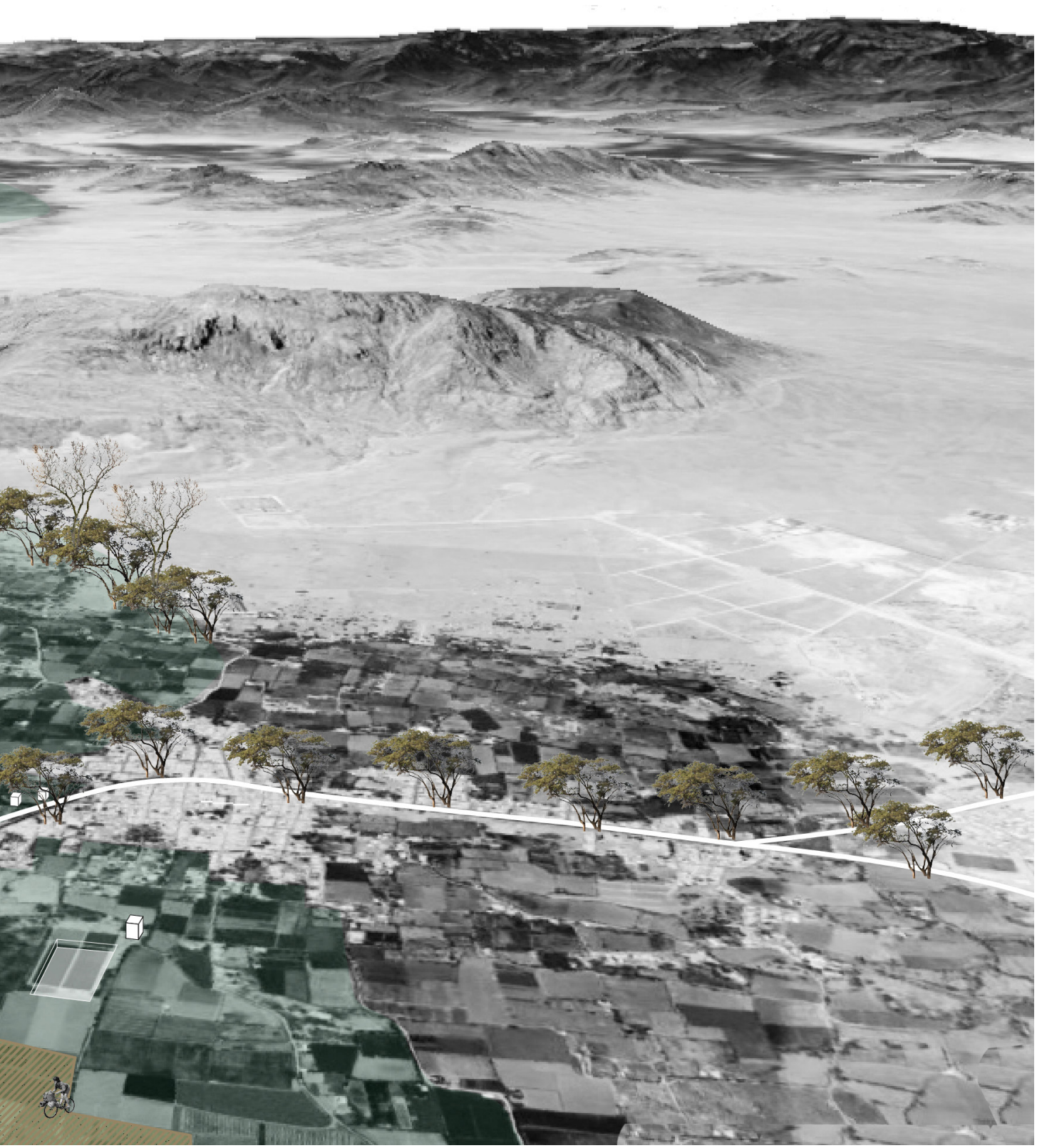
transformation of two lanes street into one in order to gain area for public space

plant of endangered native species such as sapote and carob trees

new gathering space. In the future the sidewalk can disappear and the whole space can become a shared street, 'woonerf.'

Reque: Proposed retention pond & bioswale





PART 5

Evaluation & Reflection

Project Evaluation | Reflection

Evaluation

Evaluation of the project explores, as it name indicates, the assessment of the 'Intertwined Natures', understanding the different types of landscapes and the different grading of manipulation that can be embedded in each of them. Phasing and Implementation of the project will be the start of this chapter, in order to place the project in a more realistic context.

Phasing & Implementation

Evaluation starts with the phasing of the project, in order to understand which are the spatial interventions and policies that might be implemented first, and which interventions are concatenated with others.

Taking Chongoyape as an example, the phasing of the project 'Chongoyape as a Pollution Remediation System' is composed by four stages:

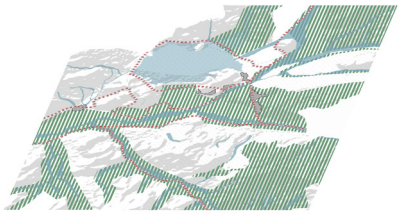
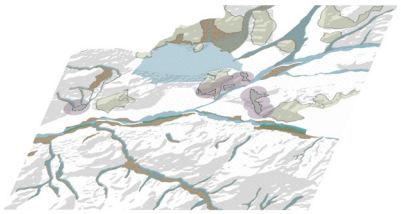
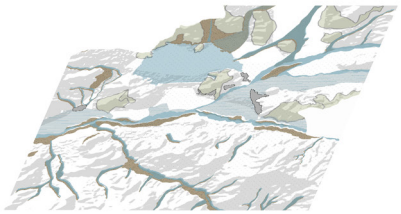
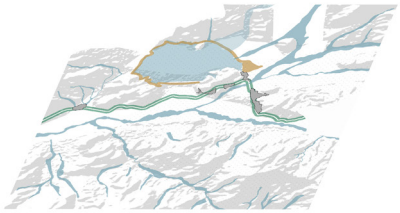
Phase 1: 'Seeding'
Restoration of riparian vegetation and the community's historic relationship with water in order to recover the carrying capacity of the natural landscapes. As it name indicates, the 'Seeding' phase is the first set of action to restore nature and its the starting point of some spatial interventions and functions as the spark that aims for further development and community involvement once the first or second phase of the 'seeding' project started.

Phase 2: Connection
As part of the Agriculture-natural Park Chongoyape & Tinajones reservoir become two important points of the proposed regional ecological–cultural system, creating awareness of this 'disconnected landscape'. Furthermore, the 'connect' phase aims for the creation of networks.

Phase 3: Transformation & Programming
Transformation of infrastructure in order to improve its ecological and economic performance. Also, giving functions and programmes to some unknown landscapes improves the sites legibility.

PHASE 4: CONSTRUCTION & ADAPTATION
The proposed intertwined system allows for flexibility and adaptability in case of future threats. In this phase the new part of the design starts, having as a base the aforementioned phases and seeding projects.

It is worth noting that monitoring and maintenance must function parallel to the aforementioned stages. In order to create a 'sense of belonging' the community must be involved from the initial part of the project, that is the decision making process. Moreover, the everyday use of the proposed spaces is an imperative part of appropriation, considering that by making use of said spaces, maintenance might be done by the community.

STRATEGIES	PHASE 1 - 'SEEDING'	PHASE 2 - CONNECT
Scenic Routes 		-Pedestrian & bike paths connec 'unknown' landscapes
Pollution Remediation 	-Restore riparian vegetation -Recover native species dry forest -Restore hedgerows -Planting of halophytes [totora& barley] -Terraced vegetation -Introduction of new crops	-Green & blue network: plant new native vegetation
Water Emergency 	-Initial discussions with the different stakeholders regarding the areas that might be inundated in case of extreme urgency	-Constructed wetlands network -Policies and laws in place for Water emergency network
Water Use 	-Seeding projects: communal orchards	

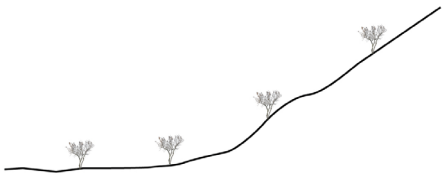


FIG. 1.100 Phasing diagram
Source: Author

PHASE 3 - TRANSFORMATION & PROGRAMMING

PHASE 4 - CONSTRUCTION& ADAPTATION

cting

-New pedestrian bridges, named after the closest settlement.

-New forest patches

-Harvest of totora & barley

-Some wetlands are use as communal orchards [halophytes]
-Pluvial drainage

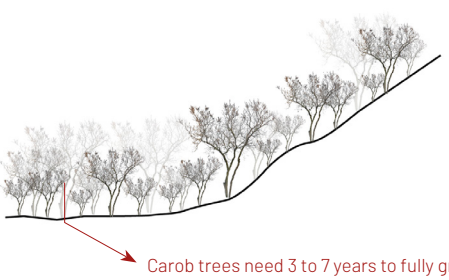
-Retention ponds
-Rice crops can be inundated in case of need

-Openness of reservoirs

-Harvest of communal orchards products [pickling and canning]

With the harvesting from the 'seed projects', the circular economy process reaches the stage of selling

-Rain gardens
-Underground water storage



Carob trees need 3 to 7 years to fully grow

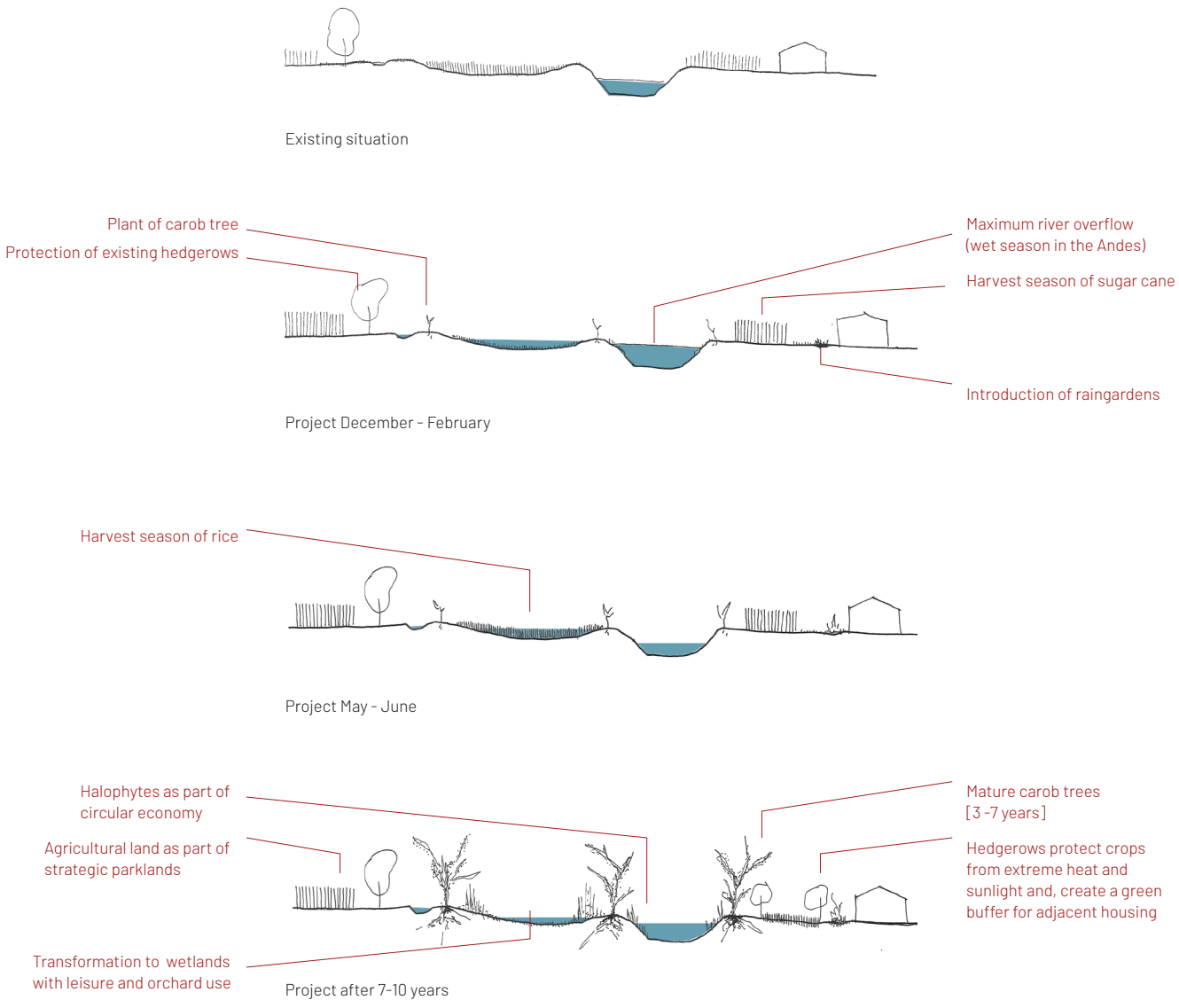
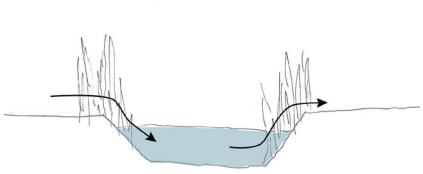
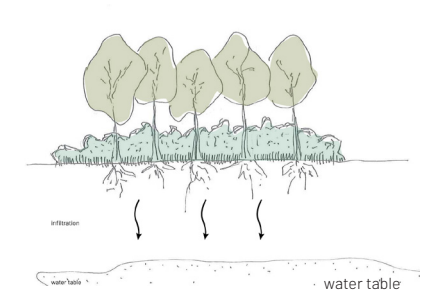


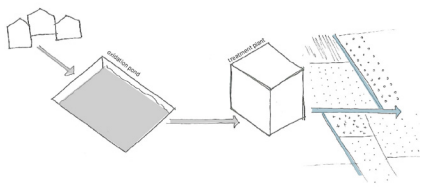
FIG. 1.101 Diagrammatic sections showing how the project evolves, according to the temporal approach
Source: Author



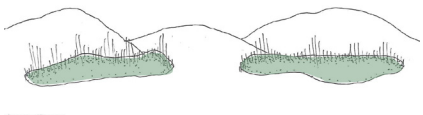
Constructed wetlands network



Proposed forest patches of native species



Grey water treatment plant



Restored wetlands + dunes

Water as a System

As a way to corroborate the effectiveness of the design and the theoretical principles embedded in it, multifunctionality, flexibility, adaptivity and connectedness are going to be addresses throughout the case of targeting water as a system, from beginning to end.

Strategies are comprised by two main topics: spatial interventions and policies. The evaluation of Water as a system will take said parts for its further exploration and corroboration.

According to the latitude, two parts can be identified in the sub-basin: middle and low slope, comprising 136 925 inhabitants (INEI, 2015) along its 80 kilometres. Water functioning as a system, from its entry to the region, where the main challenge is to purify it given that mining companies and small towns along the river discharge their untreated drainage waste into Chancay-Lambayeque river. The system is comprised by water storage for consumption and irrigation purposes, pollution remediation, waste water treatment, coastal defence and, along the Agriculture-natural Park river flood protection.

Pollution Remediation

Constructed wetlands network, vegetation strips along water streams and terraced vegetation are crucially important in the upper part of the sub-basin for the aforementioned reason. Constructed wetlands are the main mechanism to remediate the pollution in the upper part of the sub-basin, and water storage in case of drought.

Forest patches are the main source of restoration of the water table, currently in danger for the construction of illegal wells.

Diversification of crops: Main crops of the region are rice and sugar cane, which need plenty of water. One of the strategies is to slowly change to crops that do not need much water to sustain themselves, such as sweet potato, arracacha, strawberries -root crops- and, fruit trees such as mango and passion fruit to name a few.

Stakeholders that take part in this strategy are: Ministry of Agriculture & Irrigation, Ministry of Environment, National Conservation Forests Programme -under the umbrella of Ministry of Environment-, National Water Authority, Lambayeque and Cajamarca regional governments since the basin is shared by this two entities,, Municipal governments, Irrigation Board of Users of each district of the valley, Muchik Santa Catalina community -in charge of Chaparrí-, peasant communities and, civil associations committed to ecological improvement.

Waste Water Treatment

Grey water treatment plant, makes use of existing oxidation ponds, which currently work just as a pond where sewage flows without any kind of treatment, which later on will discharge on the river. The project proposes the implementation of a treatment plant, where organic matter can be recycled in order to be use as natural fertilisers for the Agriculture-natural Park or for biomass energy in the future. Also, treated water can be used for irrigation purposes. In the national context, Reque is

a medium–small size city, where growth from Chiclayo is already being redirected; moreover, the proximity to said oxidation pond and to the garbage landfill –at open air– makes it one of the most polluted –regarding air– cities of the country.

Coastal Protection

Restored wetlands + dunes. The few natural wetlands found in the sub–basin are near the coast, along the dunes. Taking this as the initial part of the design, a network of wetlands and dunes is proposed as defence from coastal flooding and, at the same time proposed wetlands function as water storage. Halophytes planted in wetlands might be totora and barley, which later on become part of the circular economy chain.

All the principles just mentioned work as a system in order to purify, restore the water table as well as improve the overall conditions of the ecosystem: soil, air, water and liveability of the population.

Policies must work hand in hand with the design part since the adaptability of the plan requires to do so, in order to thrive.

Main stakeholders while targeting 'Water as a system' are at national level: Ministry of Agriculture & Irrigation, Ministry of Environment, National Conservation Forests Programme –under the umbrella of Ministry of Environment–, National Water Authority: at regional level: Lambayeque and Cajamarca regional governments since the basin is shared by this two entities and, at local level: municipal governments, Irrigation Board of Users of each district of the valley, Muchik Santa Catalina community –in charge of Chaparrí–, peasant communities and civil associations.

To be more specific, Pollution Remediation & Waste Treatment Plant are taken as an example where the key actors to take into consideration are: District and Municipal Governments from Reque and Chiclayo, respectively; Irrigation Board of Users of the lower part of the sub–basin, smaller farmers settled in the nearby areas to Reque, peasant communities and civil associations as 'Centro Esperanza Chiclayo', which has environmental justice at its core. For decades, there has being ongoing discussions about pollution resulting from waste flows in Chiclayo and surrounding cities of the region, and the importance of –at least– proposing a place for landfill sites where solid waste overflows and its further treated however, the apathy from people in charge of Chiclayo municipality –in this case the main entity– and its constant slow process has lead to no real improvement. One of the ideas to put forward in this research by design thesis is the necessity to target governance in a simpler way, where bureaucratic obstacles are overcome through participation, given that by making the process more transparent and giving the opportunity for citizens to hold authorities accountable for their actions helps to maintain them controlled and in track of the objectives for the city and its population to thrive.

Furthermore, in the case of Water Emergency a transparent and continuous dialogue is needed from the upper power ladder to the smaller farmer in peasant communities, since this strategy aims for temporally appropriate private property in case of extreme urgency, taking into account that this new equilibrium will be economically prosperous for both parts: the national and regional governments would have to spend less funds to repair the damage after the catastrophe, while

farmers can still harvest the crops that are not adjacent to the river, and finally, the most important justification is that many lifes can be saved by prevention and implementation jobs. Moreover, incentives resulting in reduction of taxes according to the amount of hectares that one farmer is able to 'inundate' in case of extreme need would be one viable solution.

It is worth noting that some of the governance entities are trying to be more transparent, inviting for dialogue even on online platforms such is the case of Rebuild with Change, which offers to show the improvements made by the programme once the web page is loaded. Moreover, Agriculture and Irrigation Ministry has a pop-up window that allows for submitting expressions of interest; while the National Conservation Forests Programme has a very strong digital presence in social networks, which helps attracting younger population, therefore, educating and making them aware of the challenges and opportunities of the programme. Being Peru a centralised country, an improvement needed in the region is to be able to access digitally to the same amount of information that is available form the Ministries at a municipal and district levels.

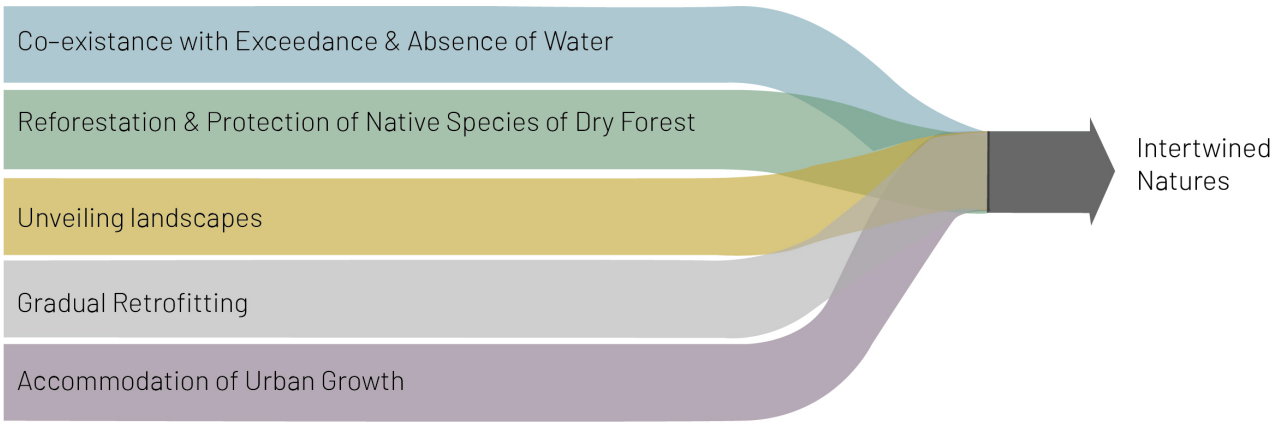


FIG. 1.102 Scheme of objectives feeding the reseach by design: Intertwined Natures
Source: Author

Reflection

Stakeholders Synergy

Regarding the current state of affairs in the country it is safe to say that the current national government has had a more agile and conducive response regarding natural phenomenons. However, the lack of an approach that tackles urban, ecological, water and governance dimensions as a whole is missing. Taking into consideration the government period is 5 years, their aim is to find a quick solution. This situation plus the slow decision making process, are the biggest obstacles found in the current way of disaster response plans.

Hydraulic Plan of the Lambayeque (2014) highlights the reading of the territory as mainly surface water, which leads to the future implementation of hard infrastructure across the territory as several dams and hydroelectric plants. The main challenge to be faced with the Hydraulic Plan is the design of closed-water-system, where no room for adaptability is given in case of the collapsing of one of the elements.

It is worth noting that, current systems operate separated from each other, without ever closing the cycle, such is the case of the hydrological system where the sub-systems -rivers and streams, drinking water and grey water- are not inter-related, which means a considerable amount of water is not repurposed and recycled for another activity. One of the lessons learned from this thesis is the necessity to design an integrated water systems, where all the elements retrofit within each other, from the beginning of the water cycle till the end, that is waste flows.

It is argued by Kato & Ahern (2008: 553) that, one of the key factors to achieve adaptive planning is the early involvement of the whole array of stakeholders, being part of the process from the beginning gives them a sense of ownership; on the other hand, integrating ecological, economic and social values create a sense of ownership, which one the project is done, will allow for appropriation of spaces and the community to be an strategic part of the monitoring and maintenance processes. As mentioned before, one of the ideas to put forward in this research by design thesis is the necessity to target governance in a simpler way, where bureaucratic obstacles are overcome through participation, given that by making the process more transparent and giving the opportunity for citizens to hold authorities accountable for their actions helps to maintain them controlled and in track of the objectives for the city and its population to thrive.

The aforementioned research suggests that an integrative long-term water management plan is needed, which should be not necessarily linked to the 5-year central government, in order to allow for continuation of the plans disregarding changes in the national cabinet, given that this is one of the most important constraints at the time of implementation.

Future Work

Regarding the stakeholder synergy, one of the next steps should be to have some input from government agencies, citizen associations focused on urbanism and environment, and communities where the spatial interventions are located to authentically reflect their aspirations and concerns, since the research and design of this project was made taking into account communities from reading of papers and from previous knowledge of the site, not from direct contact with the communities of Reque and Chongoyape. Given that appropriation of the site is one of the main tools to maintain the designed areas, the constant involvement from the community from the beginning is imperative.

Protection Status

Protection status for natural refuges and parks at both the broader region and inside the built environment is a matter of vital urgency. As mentioned before, land traficking is a problem even in Chaparrí, designated as a Conservation area and ecological refuge by the Ministry of Environment. Although it seems conflicting, aiming for a protection status plus the involvement of not just nearby communities, but from population from all over the region will help to create awareness of the protected ecosystem, creating a 'surveillance' method that in turn, combined with activities to improve the economy of the household with the 'seeding projects' for example, will achieve appropriation of said landscapes.

Protection status for wetlands and bofedales (peat bogs) in the upper catchment is proposed since the basin is located among two regions. Collaboration efforts can be made since ANA can function as a 'mediator', given its higher ranking in the water governance ladder.

Intertwined Natures

Taking this situation as a stating point, it can be strongly argued that an integrative approach that tackles urban, ecological, water and governance dimensions as a whole intertwined system is of extreme urgency, given that this interdependancy will allow to achieve a more resilient and adaptive region, able to cope with future uncertainties. The intertwined natures approach is reflected with the proposed Agriculture–natural park that works as a backbone for the green and blue multifunctional infrastructure that would –eventually– run throughout the whole region due to the importance of agriculture not just in the economic dimension, but in the regional idiosyncrasy, productive land is integrated into the river corridor park, aiming for the integration of the first, second and third natures in order to achieve its maximum ecological, social and economic performance. In other words, water as a mean for multifunctionality, flexibility, adaptability and connectedness. Water as an integrating element that shapes land over time and functions as a natural connector between different landscapes (Kato & Ahern 2008: 553).

It is worth noting that the objectives, theoretical principles –connectedness, multifunctionality, flexibility and adaptivity– and design strategies worked in a intertwined and collaborative way in order to achieve cohesion and flood risk adaptation in the territory, where the main lesson learned is the importance of a multi–temporal scalar and multi–systematic approach, from which the lessons learned from are the following: space for water, integration of river for a cohesive

territory, pollution remediation system, integrated water system, openness of –water– infrastructure, planting of new vegetation, afforestation areas, introduction of innovative ways of using the land, improvement of water image, use of policies and community involvement.

Theory, design strategies and objectives embedded in the project aimed for giving an answer to the research question: How can green and blue spatial strategies be used in Lambayeque to reduce flood risk and improve landscape quality and connection? In order to face this question, the four theoretical principles are used as a backbone:

Multifunctionality responds to different needs of an array of actors in different timeframes, such is the case of the 'seeding projects' as the elementary school in Chongoyape where classrooms and open spaces can be used for their usual purpose and in the afternoons can hold workshops for the process of circular economy, from the planting of vegetables or grains or growing the fruit trees, to harvest them, to learn how to canned and pickled the surplus product, to sell it in the local market, to use the organic waste as fertiliser for the communal orchards. This initiatives aim to deliver a multi–process oriented scope, where the 'seed projects' might start a spark to lead this opportunity into a larger scale, where 'the synergy of multiple uses helps build a broad coalition of support from diverse user groups' (Kato & Ahern 2009: 804).

Flexibility responds to abrupt and gradual uncertainties and its directly related to time, such is the case of a design that is compatible for flood as well as for drought. Moreover, temporal phasing of uses such as the pedestrianisation of the street in front of the market allows for pedestrians, bicyclists and rollerbladers during daytime of weekends, while on weekdays and nights is open for cars.

Adaptability aims for the stability of the system, while one element is on distress or affected by an external threat the system can maintain its current state, in this particular case the floodable spaces of the Agriculture–natural Park can be used as forest patches, constructed wetlands, stormwater parks or communal orchards. Thus, the elements of the 'emergency–water system' has the capacity to influence resilience in the system. As mentioned before with a few examples, multifunctionality, flexibility and adaptability are embedded in the design, the synergy of these three principles delivers resilience capacity in the design and makes the whole region a robust and adaptive socio–ecological system able to transform and self–organise along a different trajectory in case of need.

Finally, the term connectedness refers to the regulation, linking and intertwining of the elements within the system, as well as the designing of networks –soft mobility, constructed wetlands–.

Lessons Learned from Intertwined Natures Approach

As said before, the constant retrofitting among theoretical principles, objectives and strategies is one of the innovative aspects of this research by design thesis. Objectives are the a direct consequence from the initial reading and problem field: flood risk and disconnected landscapes as the main ones, but taking into account

drought, water pollution, lack of connection and visibility of water streams in the greater region, negative mentality towards canals and ditches due to its unpleasant view within the urban tissue, hidden water infrastructure and finally, no treatment for waste water, as well.

It is worth noting the the five objectives are also fed by the features of the four theoretical principles such is the case of:

1 The objective of 'Co-existence with exceedance & absence of water' responds to the dichotomy of flood risk, mainly resulting from natural disasters which leave not only devastated productive land highly impacting the national GDP, but some casualties and thousands of damaged and injured people. This objective is strongly interconnected with 'Water Emergency', 'Water use' and 'Pollution remediation' strategies, the latter one in a lower value since some design principles of pollution remediation compile multiple functions one being the first line of defence, such is the case of constructed wetlands network. These objectives and strategies are related to multifunctionality, flexibility and adaptability since according to Bacchin (2015) the use of these terms –interconnected– provides the design with a higher potential for a water resilience region. Furthermore, by including the constructed wetlands network as part of this new interdependence, the theoretical principle of connectedness enters as part of it, as well.

2 The objective of 'Reforestation & protection of dry forest' responds to the poor treatment that this unique ecosystem is facing in the region, a great part of the coastal dry forest, only found in 3 out of the 25 regions in the country is being destroyed in pursuit of vacant land, which subsequently is urbanised. Also, this objective aims for ecological habitat restoration and movement of species, since indigenous flora and fauna is being threaten. This objective is linked to 'Scenic routes', 'Pollution remediation' and 'Water use' strategies, which in turn, are linked to multifunctionality, adaptability and connectedness. 'Soft mobility network connecting ecological, agricultural, urban and heritage systems' is taken as an example as one of the design principles from the first strategy, the main theoretical principle in this case is 'connectedness' since it highlights the creation of networks, giving cohesion to the site, while facilitating the introduction of an array of spacial interventions and programmes at a local scale. Similarly, the same theoretical principles is the main one of the following objective: unveiling landscapes.

3 The objective of 'Unveiling landscapes' responds to the one of the main challenges described at the beginning: disconnected landscapes, given that almost half of the region is cover by un-built areas with mixed ecological value, this broader landscape holds great opportunity as a linking element with the urban tissue, holding the capacity for creating symbiotic relations through green and blue multifunctional infrastructure. Furthermore, its main objective is to create awareness, creating a sense of identity and belonging by the use of said landscapes. This third objective is put in spatial terms in the following strategies: 'Scenic routes' and 'Water use'. To provide an example, the Agriculture-Natural Park is one of the main features of the Scenic routes strategy since it interrelates and integrates recreation with everyday field work –connectedness theoretical principles– and, taking into consideration

that the park has embedded the four theoretical principles it can be implied that this objective has them embedded as well. In other words, the Park integrated the sub-basin corridor through multifunctional –able to be inundated in case of emergency, or for recreational purposes to name a few– green and blue infrastructure, while responding to flexibility in the case of the contingency planning which might be adapted to performing the same in case of natural disaster, such as El Niño Phenomenon.

4 The objective of 'gradual retrofitting' aims mainly, for run-off retention and attenuation of peak discharge, which responds to one of the main challenges resulting from water-related natural disasters: flooding within the urban tissue –bigger to smaller cities suffer from the same causes– regarding the poor or inexistent conditions of pluvial drainage and water management planning. This objective is directly related to 'Water use' strategy and it has the following theoretical principles embedded in it: multifunctionality and adaptability. In the case of making space in the road for pluvial drainage, for example, multifunctionality principles holds the potential for leave some free space to propose rain gardens, that can absorb part of the exceedance water and subsequently, filter it into the soil; furthermore, adaptability puts forward the idea of having available space adjacent to the road, that might be inundated in the form of a bio-swale for example, in order to reduce the risk resulting from flooding.

5 The objective 'Accommodation of Urban Growth' responds to the lack of planning on Peruvian cities, where the current trend is to let cities organically grow without any kind of proper structuring. Strategies related to this objective are: 'Scenic routes', 'Water Emergency' and 'Water Use', while the theoretical principles embedded in it are multifunctionality, flexibility and connectedness. One example to take into account is the use the whole array of ditches and canals across the territory, since it will improve the negative perception of urban water. By improving urban water collectiveness the accommodation of future urban growth can follow current trends such in the case of Reque, but facing the Chancay river improving quality of life for the growing population while improving ecological performance by the design of green & blue infrastructure. Moreover, economic gains can arise from this situation by investing in strategic areas as the aforementioned. This objective has embedded multifunctionality and connectedness theoretical principles given that the accommodation of future urban growth is directly linked to key parklands, which in turn is linked to said theoretical principles since they are part of the Agricultural-natural Park.

This new interdependencies have an array of degrees regarding the main strategy they are addressing. It should be emphasised that one of the initial objectives of this research was to put the otherwise theoretical terms into a more spatial framework, having achieved this with the aforementioned intertwining and retrofitting of theoretical principles, objectives and strategies, being the latter the spatial part of the interrelation of theory and objectives.

Theoretical principles, objectives and strategies might not be instantly replicable in another context given that the result of said interdependency has its roots on site specificity, however the methodology used to achieve this research by design project might be replicable at a national or international context, since by taking the

most remarkable features and processes of the site, new modes of engagement and relations to the place can be produced, that later on will be intrinsically linked to the design.

An aspect of novelty to put forward with this thesis is first, the notion of using the existing landscapes –first and second natures– plus the site specificity as the canvas where not just new landscapes are designed but new 'codependency of relationships and link to its surroundings' are drawn, as stated by Corner (2014). Second, the capacity of natures ––with certain degree of manipulation– to become the stitching element throughout a dispersed territory, in the form of green and blue networks running across the region, as part of an integral urban planning.

Intertwined Natures is an opportunity to explore and use various landscapes re–drawing the inherent connection between wilderness and, man–made landscapes thus connecting urban, infrastructure and natural dimensions through processes evoked from the site specificity and its historical relationship with water and the agrarian land. Furthermore, the two natures that started as an introductory reading of the territory played a vital role in the design part since they were considered the canvas for the highly–designed landscapes, where design 'with' and 'for' water instead of against is at the core of the research by design, since water surfaces are the integrative element across Lambayeque, achieving at the end, the connectedness of dispersed landscapes and a cohesive and adaptive territory. To conclude, I would like to finish with a quote from Marcel Proust, which throughout this experience has been extremely pertinent: 'The real voyage of discovery consists not in seeking new landscapes, but in having new eyes'.

Bibliography

Dramstad, W., Olson, J., & Forman, R. (1996). Landscape ecology principles in landscape architecture and land-use planning. Cambridge, Mass.: Harvard University, Graduate School of Design etc.

Corner, J. (1999). Recovering landscape : Essays in contemporary landscape architecture. New York: Princeton Architectural Press.

Hunt, John Dixon (2000). Greater Perfections : The Practice of Garden Theory. London: Thames & Hudson.

Waldheim, C. (2006). The landscape urbanism reader. New York: Princeton Architectural Press.

Berrizbetia, A. (2007) Re-Placing Process in Large Parks (ed. Czeriak, J, & Hargreaves, G.) Princeton Architectural Press, Nueva York, 2007

Forman, R. (2008). Urban regions : Ecology and planning beyond the city. Cambridge, UK: Cambridge University Press.

Kato, S., Ahern, J. (2009). 'Learning by Doing': Adaptive Planning as a Strategy to Address Uncertainty in Planning, Journal of Environmental Planning and Management, 51:4, 543 — 559

Kato, S., Ahern, J. (2009). Multifunctional Landscapes as a Basis for Sustainable Landscape Development. Journal of The Japanese Institute of Landscape ArchitectureVolume 72 (2009) Issue 5.

Tucci, C. (2009) 'Mitigating of water related natural disasters in developing countries' in Feyen, J., Shannon, K., Neville, M., & International Urban Water Conference International Urban Water Conference (2008 : Heverlee, Belgium). Water and urban development paradigms : Towards an integration of engineering, design and management approaches : Proceedings of the international urban water conference, Heverlee, Belgium, 2008. Boca Raton, Fla: CRC

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T., Rockström, J. (2010). Resilience thinking: Integrating resilience, adaptability and transformability. Ecology and Society, 15(4), 20-20. doi:10.5751/es-03610-150420

Hung Y. Y., Aquino, G. & Waldheim, C. (2011). Landscape infrastructure : Case studies by SWA. Basel: Birkhäuser.

Viganò, P. Urbanism and Ecological Rationality in Pickett, S., Cadenasso, M., & McGrath, B. (2013). Resilience in ecology and urban design : Linking theory

and practice for sustainable cities(Future city, v. 3). Dordrecht: Springer. doi:10.1007/978-94-007-5341-9

Barthel, S., J. Colding, H. Erixon, S. Grahn, C. Kärsten, L. Marcus & J. Torsvall (2013). Principles of Social-Ecological Urbanism - Case Study: Albano Campus, Stockholm. Trita-ARK Forskningspublikationer.

Gobierno Regional de Lambayeque (2013) Estudio Geológico del Departamento de Lambayeque – Geological Survey of Lambayeque

Gobierno Regional de Lambayeque (2013) Memoria Descriptiva del Mapa de Vegetación – Descriptive Memory of Vegetation Map

Gobierno Regional de Lambayeque (2013) Estudio de Biodiversidad: Flora – Biodiversity Survey: Flora

Bacchin, T., Ashley, R., Sijmons, D., Zevenbergen, C., van Timmeren, A. (2014). Green-blue multifunctional infrastructure: An urban landscape system design new approach. 13th International Conference on Urban Drainage, Sarawak, Malaysia.

Corner, J., & Hirsch, A. B. (2014). The landscape imagination: collected essays of James Corner, 1990-2010. New York: Princeton Architectural Press

Ministerio del Ambiente (2014) Perú, Kingdom of Forests. Biblioteca Nacional del Perú : Lima

Gobierno Regional de Lambayeque & Proyecto Especial Olmos Tinajones (2014) Plan de Desarrollo Hidráulico – Hydraulic Development Plan of Lambayeque

Bacchin, T. (2015) Performative nature; urban landscape infrastructure design in water sensitive cities. Delft University of Technology, Unesco–IHE Institute for Water Education

Meyer, H., Bregt, A., Dammers, E., Edelenbos, J. (Eds.). (2015). New perspectives for urbanizing deltas: A complex adaptive systems approach to planning and design : Integrated Planning and Design in the Delta (IPDD).

Folke, C. (2016). Resilience (Republished). Ecology and Society, 21(4). doi:10.5751/ES-09088-210444

Shannon, K., & Smets, M. (2016). The landscape of contemporary infrastructure. Rotterdam: Nai010.

List of Abbreviations

ANA - National Water Authority

AAA - Administrative Water Authorities

ALA - Local Water Authorities

CRHC - Council of basin's hydrological resources

INEI - National Institute of Statistics and TICs [Instituto Nacional de Estadística e Informática]

INGEMMET - Geological, Mining and Metallurgical Institute [Instituto Geológico, Minero y Metalúrgico]

MINAM - Environment Ministry of Environment [Ministerio del Ambiente]

PNCB - National Conservation Forests Programme [Programa Nacional de Conservación de Bosques]

RCC - Rebuilding with Change [Reconstrucción con Cambios]

SERNANP - Service of National Natural Protected Areas [Servicio Nacional de Áreas Naturales Protegidas por el Estado]