

The rebirth of the resurgence belt:
the floodplain as a complex human-water system

Colophon

master thesis project

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Academic Year 2022-2023
November 2023

TU Delft
MSC Architecture, Urbanism and Building Science
Urbanism Track

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Contents

<i>The vocabulary</i>	8
<i>Abstract</i>	10
<i>Motivation</i>	12
<i>Introduction</i>	14
the resurgence belt	16
the anatomy of a resurgence	18
the shapes of resurgences	20
problematization	22
research question(s)	24
<i>Methodology</i>	26
research framework	26
theoretical framework	28
conceptual framework	29
<i>Landscapes of North Italy</i>	30
the natural landscape	31
natural... or artificial landscape?	32
geology	34
the precipitation tragedy	40
late holocene and water management	42
current water management systems	44
the vicious cycle of a system in crisis	46
hydrological risks	48
pressure and impacts on groundwater bodies	50
groundwater bodies' health	51
the urbanization problem and the pollution phenomena	56
droughts through colors	58
the productive landscape	60
<i>Terre d'acqua</i> : the agricultural landscape	65
context of resurgences	66
crops in the Po Valley	68
relation between agriculture and resurgences	72
the cultural landscape	74
the agri-cultural heritage	75
the origin of rice	75
the history of rice in North Italy - Vercelli	78
the architectural and religious heritage	80
the abbeys system	80
monastic communities	80
le grange	80
la cascina a corte: the farmhouse	82
Leri Cavour	83
important characters of ricefields	84
Camillo Benso Cavour, the 2.0 farmer	84

previous change in agricultural practices	84
the ricefields: an open air factory	86
le mondine	87
<i>The life of rice</i>	88
cultivation phases	88
fertilization	88
plowing and leveling	89
the harrowing	89
the submersion	89
difference between sowing in water and sowing in dry conditions	91
dry sowing	92
the biological cycle	94
the final product	96
the harvest	96
drying and storage	96
anatomy of rice	98
rice processing	99
the after-life post production	102
bio-energy production	102
<i>Framing the site</i>	104
resurgences' density and ricefields	104
consortia of Piedmont	105
biodiversity – fauna in Piedmont	106
biodiversity – flora in Piedmont	108
habitat of resurgences	110
la riserva san Massimo	116
what are the main environmental challenges for agriculture?	117
the loss in agrobiodiversity	118
fieldwork	119
la riserva San Massimo	119
the ricefields of Vercelli	123
cultural elements	131
<i>The rebirth of the resurgence belt</i>	138
intention	138
time	139
values of transition	139
strategies	140
the natural landscape in Piedmont	142
the natural water system in Piedmont	144
risks in the resurgence system of Piedmont	146
the productive landscape	148
the sponge strategy	148
the inevitable change in agricultural practices	152
conditions and relations of biodiversity	154
agroforestry	154

coppice	155
constructed wetlands	157
polyculture: ricefields and the agricultural transition	158
an alternative future: lentils	159
lentils (<i>lens culinaris</i>) in dry conditions and permeable soil	159
lentils in bioenergy production	160
lentils (<i>lemna minor</i> L.) in submerged conditions and impermeable soil	161
<i>Designing for the future</i>	162
(un-)existing green infrastructure	163
current situation - monoculture of ricefields	164
current situation - other culture	165
green infrastructure	166
buffer zones of resurgences	167
soil type	168
topography	169
hydrological risk	170
possible disappearance of resurgences by 2030	171
designing for 2030	172
elements of 2030	173
designing for 2040	174
elements of 2040	175
ecological corridors	176
primary corridor	176
secondary corridor	178
tertiary corridor	180
the three landscapes	184
wilderness	187
productive landscape	189
lentils and ricefields . alternative futures for 2040	193
cultural landscape	194
cultural heritage network	196
cultural heritage elements	198
“Galileo Ferraris” – the green factory	203
grangia of Leri Cavour	206
<i>Conclusion</i>	208
<i>Reflection</i>	210
<i>Bibliography</i>	214

Images made by author unless stated otherwise

The vocabulary

agrobiodiversity: The agrobiodiversity is strongly connected to the agro-ecosystems, to all the natural environments modified by humans with the introduction of cultivation for agricultural production. Agrobiodiversity refers to an economic and social value, referring to an artificial context shaped by humans. In the Biodiversity Convention, adopted in Nairobi and signed in Rio de Janeiro in 1992, the concept of agrobiodiversity extends not only to breeds and varieties, but also to the agronomic and zootechnical culture that allow their management and the agricultural landscapes that they generate.

channel: resurgence water which corrodes the soil and creates a network used for irrigation

fontanile (or fontanili, pl): water intake for irrigation purposes, in non-emerging aquifers, which is done with excavations in the ground in the form of pools or even small lakes in which the water boils from the bottom (artificial spring).

grangia (grange, pl): benedictine agrarian community founded on its own economic and administrative organization.

marcite: land, permanently irrigated, which allows the grass protected from the temperature of the water to grow even in the winter months.

mondine: a woman employed to weed Italy's ricefields during the 40-day period of summer known as the monda.

monoculture: particular type of exploitation of agricultural land, which consists in cultivating the land with a single species or variety of plants for several years.

polyculture: type of agriculture characterized by the coexistence of different crops in the same geographical area or even in the same company. Very often it has a purely subsistence purpose, that of covering the food needs of the agricultural population (or family), but it can also take on a technical-agronomic meaning.

resurgence: the area of the resurgences constitutes a transitional zone between the high and low plains, between permeable soils - in which the waters infiltrate, originating underground aquifers - and those more impermeable - in which waters become more superficial. It is an area where the water comes up from the

ground to the surface without human intervention.

resurgence belt: imaginary border that include the area containing all the resurgences.

spring: water moving underground finds an opening to the land surface and emerges, it can also be artificial - called fontanile.

squared sea: the landscape created by submerged ricefields.

Abstract

The Po Valley is a floodplain, also known in the past as the “The Garden of Europe”. It owes its agricultural, industrial and cultural wealth to the rich system of resurgences and to the irrigation network connected to them.

Due to their suitability for agricultural activities, floodplains are preferred areas for human settlements. The fluvial landscape development was altered by the water and land management activities to create cultivable land, while simultaneously protecting communities from the risk of flooding events, which are still the most common natural disasters worldwide.

With the increasing urbanization and climate change, the territory (already densely populated and exploited for agricultural and industrial uses) is facing a difficult water shortage situation.

The focus of the research is the resurgence belt in the Po Basin, more precisely in the Piedmont region, and the understanding of the origin of the water system: the Alps and Apennine, the high plain, the resurgence belt and the low plain.

In the area of the resurgence belt, it is possible to control the mountain floods that flow downstream, causing the severe flooding phenomena that we are seeing more and more often in recent years. These traits also have the pre-eminent function of governing the waters of violent and sudden precipitations that the current rain disposal systems are unable to manage effectively. The slopes of the paths lead the waters towards wetlands and hold them for the time necessary and then gradually release them.

The resurgence belt, in addition to playing an important role in the natural water management and the ecological protection of vegetation and an fauna, is still fundamental today in the economic-agricultural context as it is the basis of the irrigation activities necessary to support production in many meadows and ricefields.

It constitutes a precious and unique natural heritage, which unfortunately has reduced in dimensions due to various factors: economic, social and environmental. It is clear that we will increasingly have to learn to live with the two extremes of long droughts and intense rainfall and consequent floods, which only a more natural territory and hydrographic network can cope with simultaneously.

By studying the area of the resurgence belt, the project seeks to imagine an alternative future for North Italy and explore a strategy to face the retreat of the resurgence belt and the water crisis. Furthermore, the project aims to imagine an alternative future for an area that is highly exploited by monoculture and has a linear economy, based on the consumption of fossil fuels and non-renewable resources.

Key words: resurgence belt, ricefields, monoculture, agrobiodiversity, alternative future



▲
Resurgence. *Source: photography produced and edited by the author*

Motivation

The interest in this research arises from the desire to know and deepen the processes underlying hydrogeology and understand the growing water crisis in the Po Basin, North Italy.

During a hike in the spring of 2021, I visited an area that was part of “the resurgence belt”. It was genuinely fascinating to discover that all the water around me was coming up from the ground aquifers naturally, without human intervention but only because of the stratification of alternating layers of permeable and impermeable soil. After the hike I started to research more about this area and I found out that the 80% of the resurgences are going to disappear by 2040.

The area of resurgences, the Po River, the ice of the Alps, the rains, the springs and the aquifers are all pieces that make up a unique mosaic. A wealth that we risk losing through neglect and shortsightedness.

The floodplain of Po Valley, in fact, is also known in the past as the “The Garden of Europe”. It owes its agricultural, industrial and cultural wealth to the rich system of resurgences* and to the irrigation network connected to them. Due to their suitability for agricultural activities, the floodplain was the preferred area for human settlements. Today, one-third of the Italian population lives in this area (ISTAT, 2019).

The fluvial landscape development was altered by the water and land management activities to create cultivable land, while simultaneously protecting communities from the risk of flooding events, which are still the most common natural disasters worldwide. Despite this, environmental disasters due to climate change are damaging cities and agriculture more and more frequently each year and cultivation is becoming a challenge.

Living in the Po Valley, I have had the opportunity to notice changes in the landscape myself in recent years. The territory, exploited mainly for the agricultural economy, seems to have entered a vicious circle: water is scarce in certain areas and the land, although affected by the drought, is no longer able to absorb the rain, causing floods whenever precipitation happens; meanwhile in other areas water is abundant and is dispersed and wasted.

How to live and organize the system and mitigate, adapt or react to these increasingly frequent disasters is a very discussed topic nowadays.

This research aims at contributing to the belief that the situation can change and the area can be seen less as an open air factory and more as a natural landscape that can be resilient and enjoyed through its historical value.



▲ Ricefields in North Italy. *Source: photography produced and edited by the author*

Introduction

The Po Valley covers a large part of Northern Italy, the area that historically has seen the emergence of capitalist agriculture, industrialization and the large energy industry, which until the middle of the last century was a hydroelectric.

It is the area where the great industrial cities - such as Milan and Turin - are concentrated, alongside intensive agriculture and livestock.

Starting from the Po basin it is therefore possible to cover the entire history of Italian and European economic development, in all its aspects: agricultural, industrial, urban.

Nowadays, it plays a significant role in Italian economy as producing 40% national GDP, consuming 48% of national produced energy, and approx. one-third Italian population living here (ISTAT, 2019).

The Po Basin area is composed of different areas: the Alps, the high plain, the resurgence belt and the low plain.

The area of the resurgences constitutes a transitional zone between the high and low plains, between permeable soils - in which the waters infiltrate, originating underground aquifers - and those more impermeable - in which waters become more superficial. It is an area where the water comes up from the ground to the surface, with or without human intervention.

Their function was essential in the past and responsible for the economic development of agricultural population. They were able to apply its specific qualities in the best possible way, achieving an exemplary balance between the possibility of exploitation and protection of their naturalistic-environmental characteristics.

Resurgences are an extraordinary naturalistic, landscape and cultural element of North Italy but they are decreasing in number and degrading in environmental quality, causing significant problems to the water system.

The agricultural landscape of the Po Valley is the result of a profound evolution of the territory produced by the hard work of man over the centuries.

Initial reclamation work carried out in Roman times has led to the creation of one of the most fascinating countryside in the European territory.

At the base of all this is the great wealth of this land: water. Its abundance is manifested not only by the presence of an intricate and dense network of canals and canals, but also by the fact that linked to them there is an enormous variety of plant and animal species that are often those that characterized the primeval wetlands that they dominated the plain in pre-Roman times (Provincia di Milano, 2002).

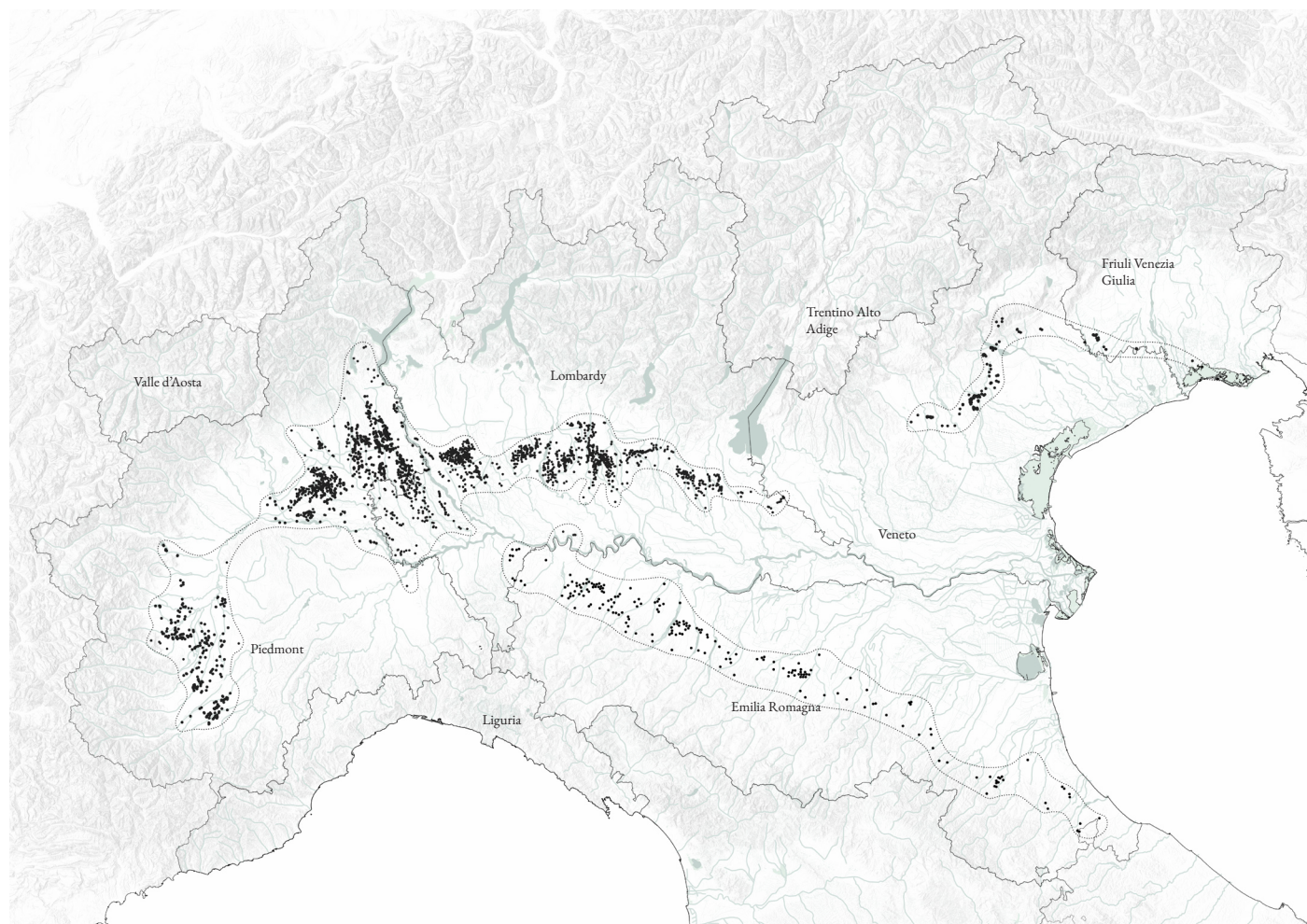
However, the most evident manifestation of this richness is evident from

the presence of the resurgences in the Po Valley, a fascinating microhabitat where unique faunal specimens coexist, in an otherwise unreproducible context, in it the waters coming from the ground aquifers rise spontaneously to the surface.

The resurgences, in addition to playing an important ecological role in the protection of vegetation and an important fauna, is still fundamental today in the economic-agricultural context as it is the basis of the irrigation activities necessary to support production in many meadows and ricefields (Provincia di Milano, 2002).

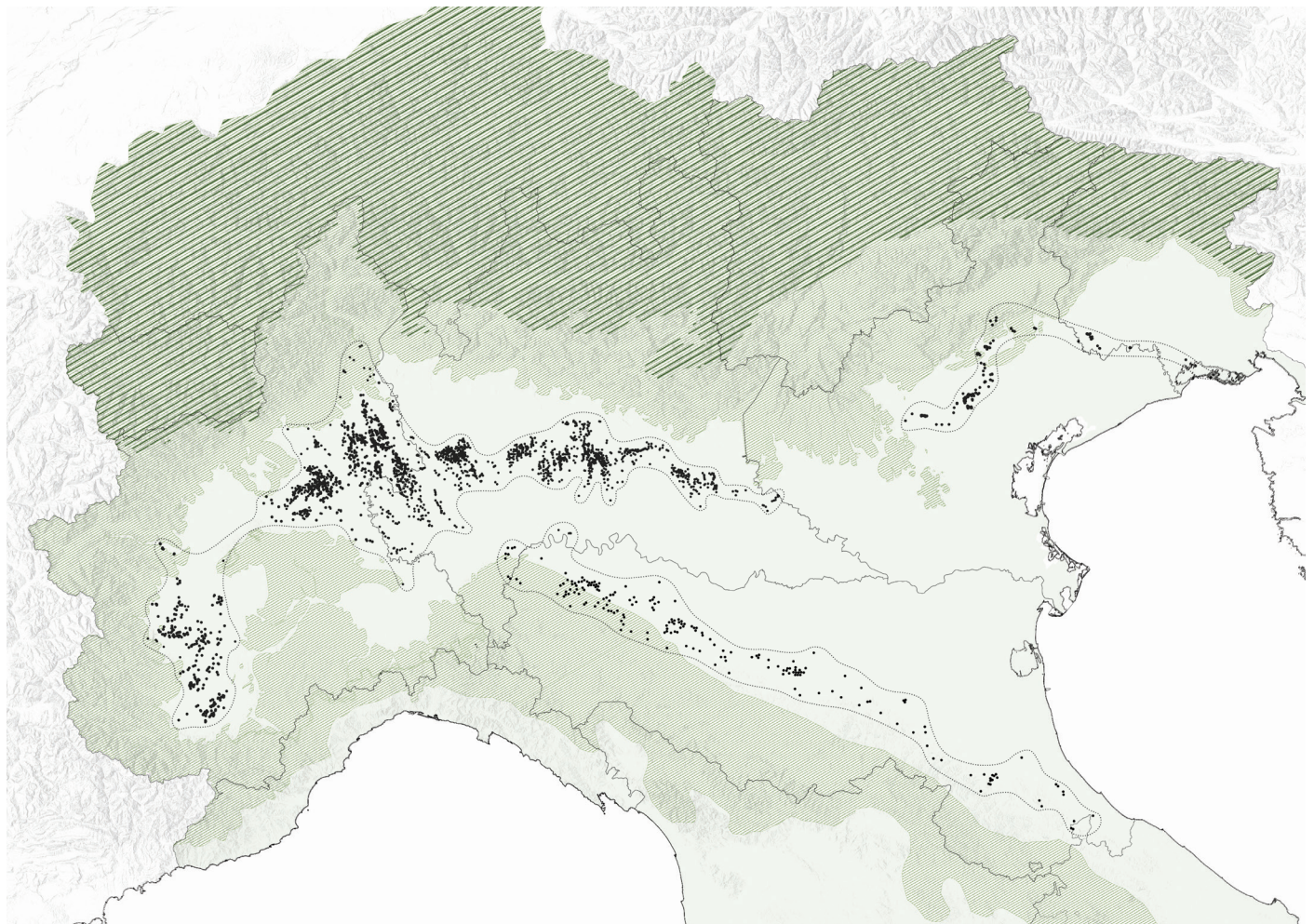
The resurgence belt

16



- water system
- resurgence
- resurgence belt

▲ The resurgence belt. Source: Natura 2000, 2022. ADBPO, 2022. Regione Lombardia, 2022. ARPA Lombardia, 2022. Regione Veneto, 2022. ARPA Veneto, 2022. Regione Piemonte, 2022. ARPA Piemonte, 2022. Regione Emilia Romagna, 2022. ARPA Emilia Romagna, 2022. Regione Friuli Venezia Giulia, 2022. ARPA Friuli Venezia Giulia.



17

-  The Alps
-  Pre Alps and Appennine
-  Po Valley
-  resurgence
-  resurgence belt

▲ The topography of the area. Source: AIPO, 2022. GeoFabrik, 2022. OSM, 2022. Regione Emilia Romagna, 2022. Regione Liguria, 2022. Regione Lombardia, 2022. Regione Piemonte, 2022. Regione Trentino Alto Adige, 2022. Regione Valle D'Aosta, 2022. Regione Veneto, 2022.



The anatomy of a resurgence

18



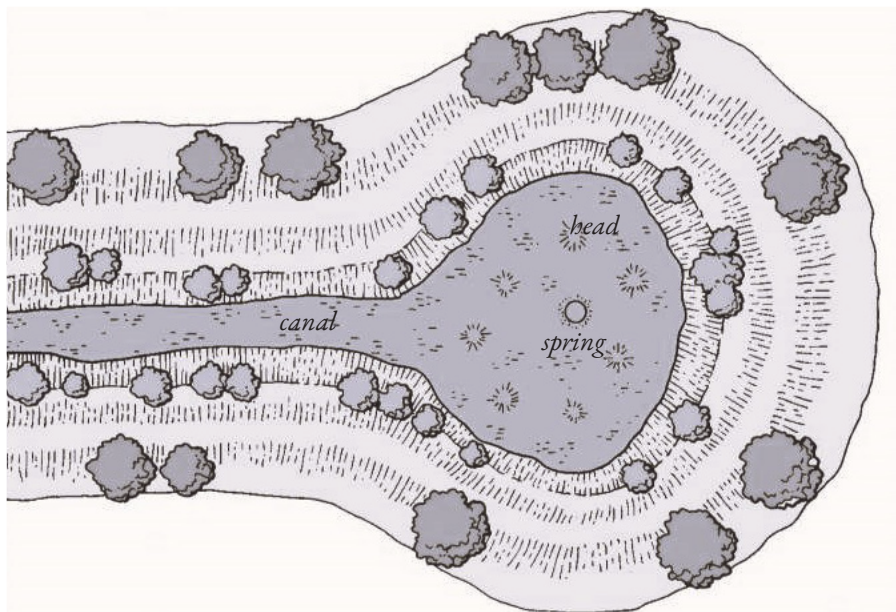
▲ An active resurgence. Source: photography produced and edited by the author

The resurgences in their natural state manifest themselves as clearly visible water emergencies, which tend to erode the surrounding soil, creating an irregularly shaped area.

The important role assumed by these particular resurgences depended above all on the characteristics of their waters.

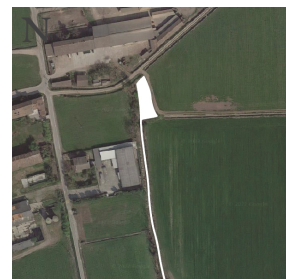
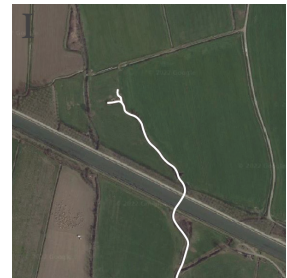
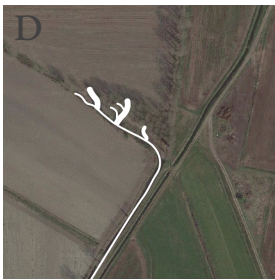
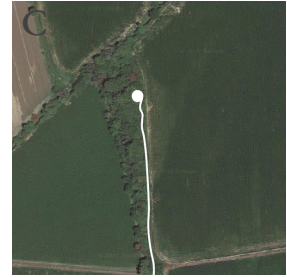
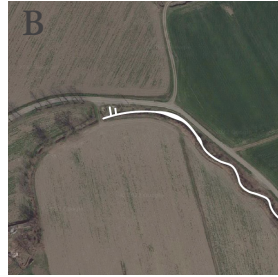
Among the most important ones are: the flow which was not subject to sudden variations, abundant in the hottest and driest periods and reduced in the mild ones (rich in rainfall); the temperature which is more or less constant throughout the year (16-18 degrees in winter and 12-14 days in spring and summer); the quality which is excellent both from the organoleptic point of view and from the chemical-physical point of view (Gomarasca, 2012). On the other hand, the waters present in the other types of canalization, especially those inside the cities, were normally polluted, as these were used as a vehicle for the sewage system where the fluids of the inhabited centers were discharged (Gomarasca, 2012).

19



▲ Anatomy of a resurgence. Source: De Luca, : D. A. (n.d.). *Studio idrogeologico dei Fontanili della Pianura Piemontese*. Aaiga.Org. <https://www.aigaa.org/public/GGA.2005-02.0-55.0081.pdf>

Shapes of resurgences



As stated previously, the water of the resurgences tends to erode the surrounding soil, creating one or more heads in a very irregularly shape.

These shapes have been studied and classified as follow:

- A. elongated
- B. comb
- C. circular
- D. dendritics
- E. elliptical
- F. Falcata
- G. L shape
- H. T shape
- I. Y shape
- L. irregular
- M. square
- N. rectangular
- O. trapezoidal
- P. triangular

21

When the resurgence dries up, human intervention can transform them into *fontanili*, with the aim of reclaiming the surrounding areas and making them suitable for cultivation. The *fontanile* is obtained by widening the natural depressions in the ground to facilitate the flow of water, forming a more or less rounded “head” which can collect multiple outcrops (“heads”). The water thus collected is conveyed into a canal or “channel”. In turn the channels are brought together to form ditches or actual resurgence rivers.

Problematization

22



▲ An inactive resurgence. *Source: photography produced and edited by the author*

Fluvial environments have always played a crucial role in human history. The necessity of fertile land and fresh water for agriculture has led populations to settle in floodplains more frequently than in other environments. Floodplains are complex human–water systems in which the mutual interaction between anthropogenic activities and environment affected the landscape development. The anthropogenic presence on the territory (urbanization, infrastructural networks and intensive cultivation) has increased the fragmentation process, or rather the phenomenon of rupture of natural environments. The process sees the reduction of the surface of natural environments with an increase in their isolation and therefore a loss in biodiversity, leading to a more polluted habitat. In the recent years the Po Valley has been suffering from a water crisis. Large population, vibrant socioeconomic activities lead to water quality degradation, challenging management of water and land resources, increase in hydraulic and hydrogeological risks and loss of biodiversity (PRBA, 2007). Also, because of global warming and high temperatures, the phenomenon of drought and floodings are more and more frequent, damaging not only the territory but also the people and the economy.

The resurgence belt is a fascinating microhabitat which plays an important ecological role in the protection of vegetation and an fauna and it is still fundamental today in the economic-agricultural context as it is the basis of the irrigation activities.

Moreover the resurgence belt is an extraordinary naturalistic, landscape and cultural element of North Italy.

The function of the resurgences was essential in the past and responsible for the economic development of agricultural population.

The area of resurgences represents a real system of completely natural regulation of the level of the underground water reservoir.

The resurgences bring to light the waters of rivers and rains absorbed by the soil of the high plain; they thus represent the natural outcrop of the hydrogeological system, a sort of fill in the large area of Northern Italy (Modena and Zangheri, 2005).

In the last 30 years, in the resurgence belt there has been a progressive lowering of the water level and a consequent reduction in the overall flow of the resurgences.

Many have definitively dried up and many others are facing ever longer periods of drying up. The phenomenon has been causing alarm for long time: over the last 30 years, more than 80% of the resurgences have disappeared and the forecast is that if compensatory initiatives are not implemented, capable of counteracting the slow lowering of the water table, within 20 years we will see drying up of most of the existing resurgences (Life Risorgive, n.d.).

Research question(s)

Main research question

How can the resurgence belt be redesigned and planned in order to preserve its cultural and environmental quality?
How can the Po Valley – through design and planning - become a resilient urbanized alluvial landscape?

Analysis sub-questions

RQ1. What are the impacts of the operational land on the natural systems?

RQ2. What areas will be more influenced by the retreat of the resurgence belt? And what areas are influencing the retreat of the resurgence belt?

RQ3. With the retreat of the resurgence belt, how will the landscape change?

RQ4. How can this areas be thought and designed?
How can the resurgence belt be preserved through the planning of the operational land?

RQ5. How can the resurgence belt preserve its cultural and environmental quality?

Methodology



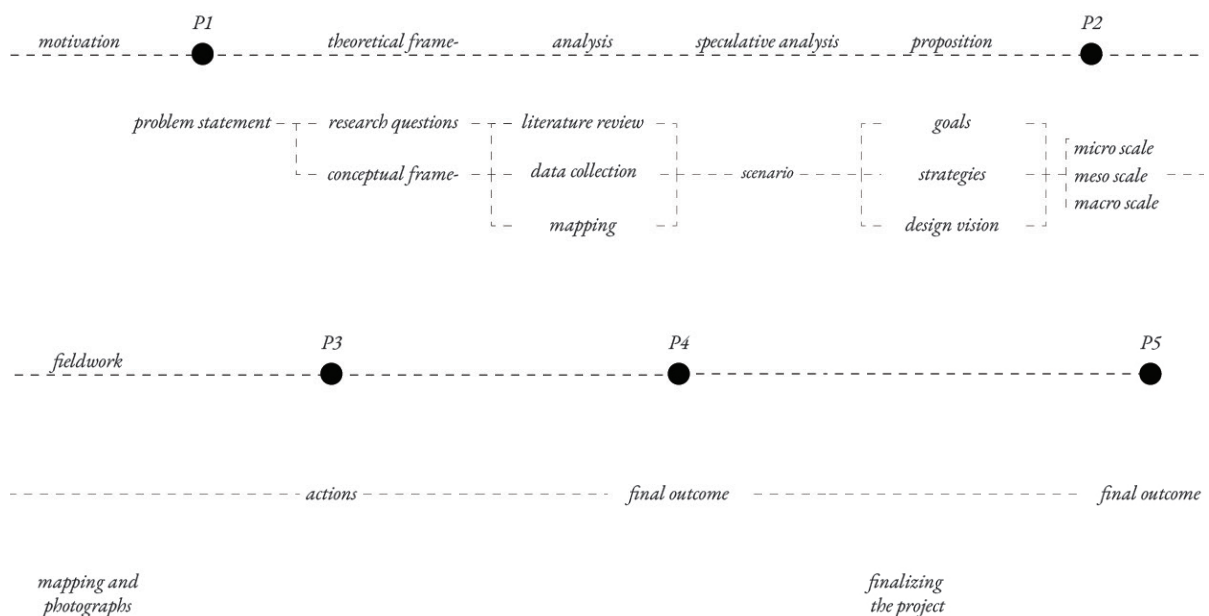
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▲ An active resurgence. *Source: photography produced and edited by the author*

Research framework

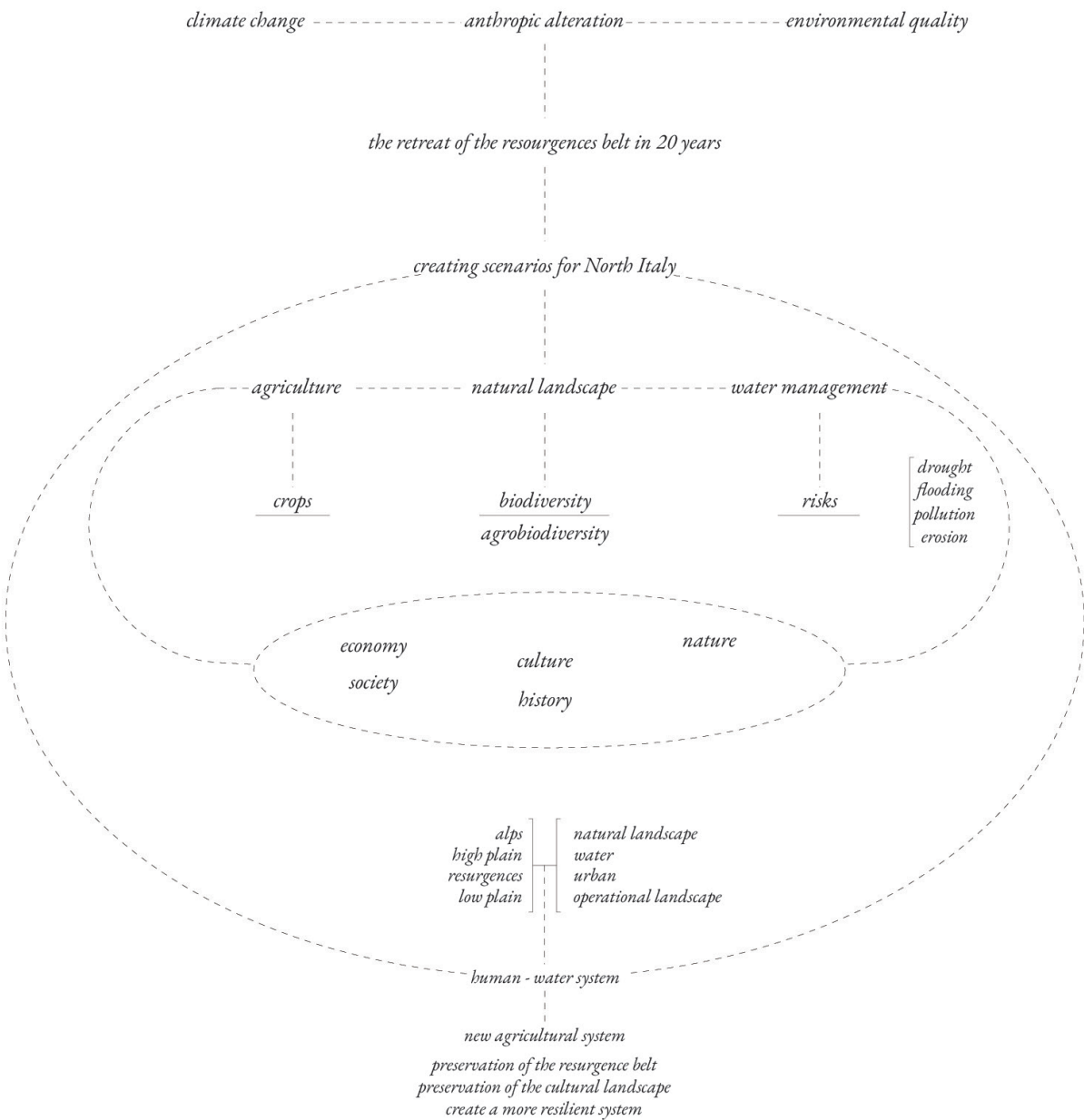
- Literature review (current state, challenges and potentialities)
- Framework to give direction to the project
- Consulting National Databases
- Analytic cartographies
Creation of maps that provide a deep understanding of the current situation and working systems.
- Speculative cartographies
Envisioning new socio-spatial realities, intersecting the physical world and the imagination of the mind.
- Photos and fieldwork
Collection of documentation to show the current situation and understand it from a closer point of view.
- Selection of key study and critical areas
Selection of specific sites that can showcase the current situation and would potentially be suitable for interventions.
- Goal, strategies and vision

26



<i>Domain</i>	<i>I level</i>	<i>II level</i>	<i>III level</i>
----- <i>ecosystem</i>	retreat of resurgences warmer wheather dimish in precipitations frquency and intensity of storms water scarcity	desertification flooding pollution	fauna losses vegetation losses pollinating insects loss aquifers contaminatic soil contamination
----- <i>social system</i>		urbanization degradation health issues	fragmentation loss of public space
----- <i>economic system</i>		loss of agricultural land level of work power operational and management inefficiencies	monopolization crisis and economic uncertainty
----- <i>spatial system</i>		public space losses loss in culture and identity devaluation of the territory	

Theoretical framework



Conceptual framework

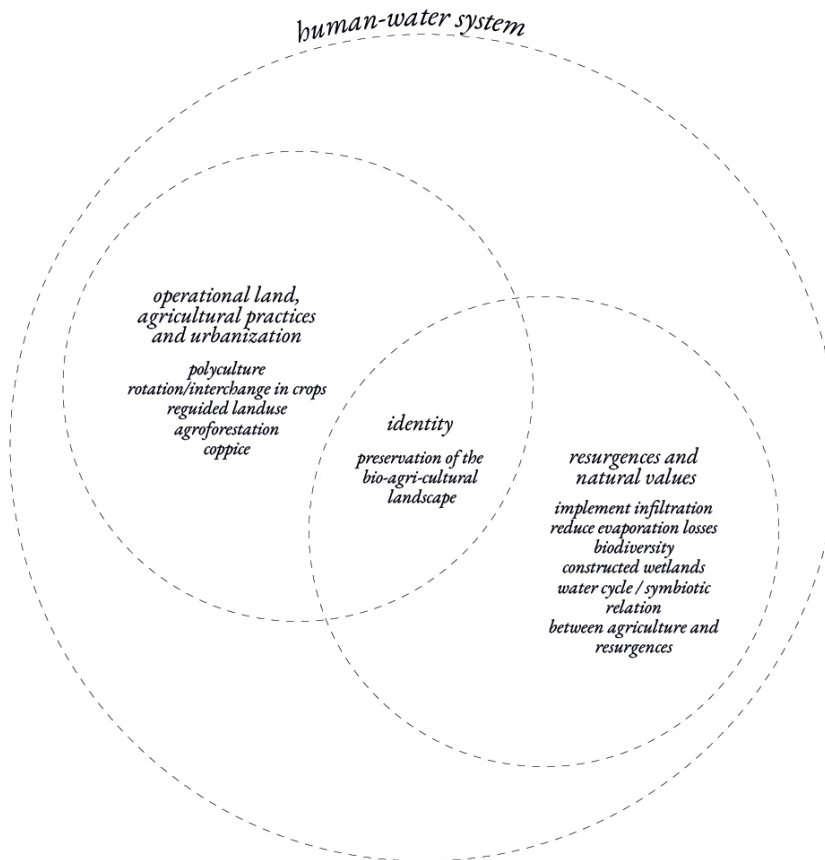
Starting from the problematization, the retreat of the resurgence belt, due to climate change, anthropic alterations and environmental degradation, the theoretical framework divides the study in three main topics: natural water management, landscape and agriculture.

The framework supports the idea that the Po basin is a set of different landscapes that, through a symbiotic relation, can become a more resilient territory.

By the regulation of the water system and the level of the underground water, the resurgence belt and the cultural landscape of North Italy can be preserved.

The conceptual framework brings together all the aspects of the Po Basin, seen as complex human–water systems.

The symbiotic relation between the operational landscape, agricultural practices and urbanization combined with the natural values of the territory can preserve the identity of the land.



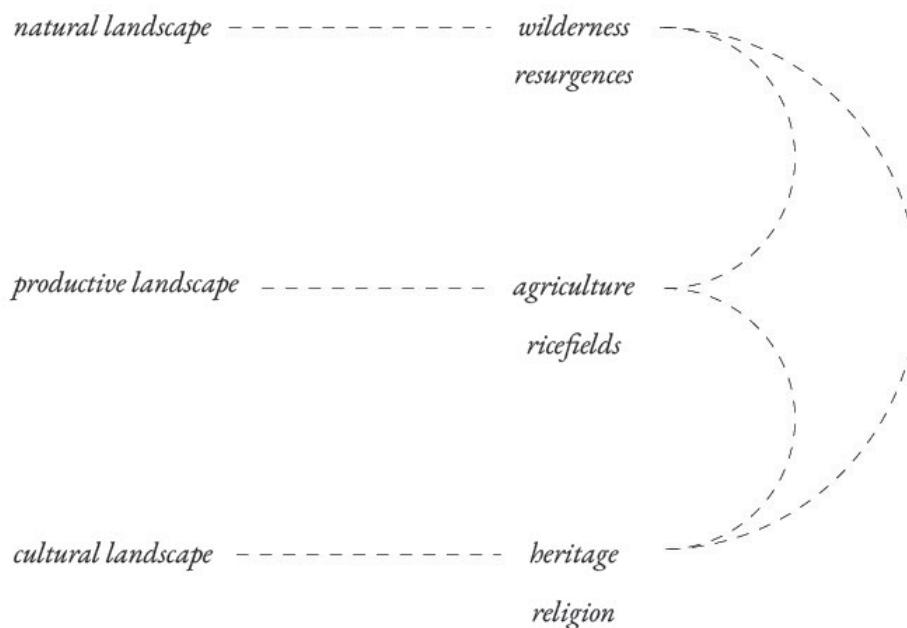
Landscapes of North Italy

North Italy is composed by three main landscapes: natural landscape, productive landscape and cultural landscape.

The three pillars of sustainability are economic viability, environmental protection and social equity

At this moment, the territory is facing a period of crisis which, over time, can lead to the collapse of this subsystems and the disruption of the whole system.

In the next pages these three subsystems, natural landscape, productive landscape and cultural landscape will be analyzed in their complexity and challenges.



The natural landscape

This subchapter will discuss the research analysis that can be divided in different parts:

First, the comparison between natural and artificial.

Going to Po Valley in Summer means having the impression that most of the area is natural, because of the growing crops. With the map of natural areas (natura 2000) it is possible to sense how “small” and fragmented natural areas are and with the map of artificial areas it is possible to perceive how strong the agricultural activity is.

Another important aspect of the landscape is the water system that is either based on natural water management (through different soil types the water crosses the whole area, creating a ground water reservoir - important for North Italy since all the water is extracted from the terrain- and the phenomenon of the resurgences) and the human interventions to control the system.

A map of risks was created to show all the possible droughts, flooding and erosion that can happen in the territory.

The last part of the analysis is about the water quality of the aquifers and superficial water - either chemical and environmental - but also about the urbanization level and pollution.

Natural or...

32

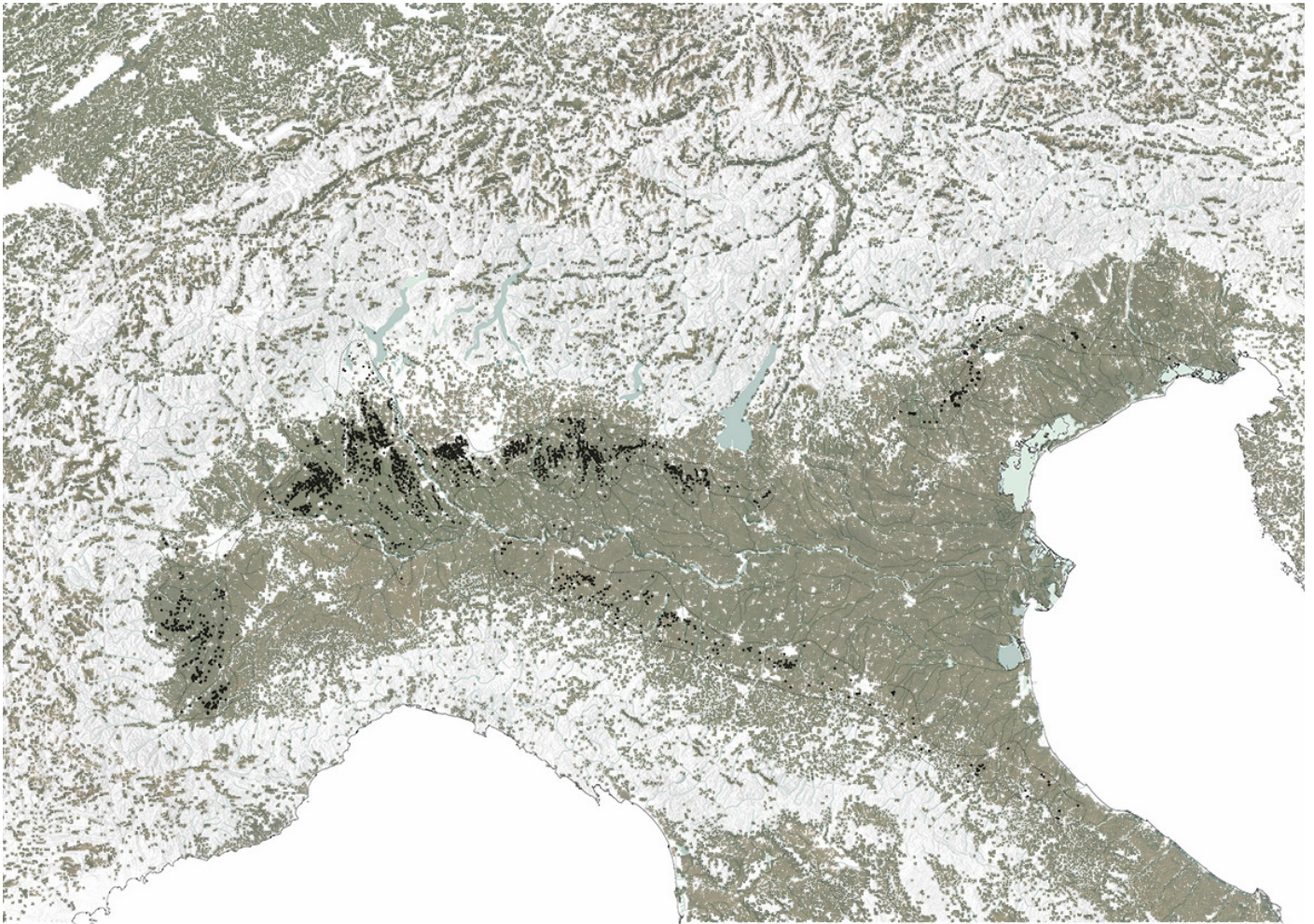


- Natura 2000
- Protected areas
- water system
- resurgence
- ▭ resurgence belt



▲ Natural areas in North Italy. *Source: Natura 2000, 2023*

Artificial landscape?



33

- agricultural areas
- water system
- resurgence
- resurgence belt



▲
Agriculture in North Italy. Source: *Euro crop map, 2018*

Geology

The complexity of the geology of Northern Italy (such that in a relatively small area there is a high diversity of geological characters) together with the presence of numerous active endogenous and exogenous phenomena, has meant that the Italian territory has been the cradle of part of the geological thought, through the work of Italian and foreign scholars who have studied its aspects on the ground.

Geology is used to anticipate natural risks (hydrogeological, seismic, volcanic), e.i. the geomorphological, hydrogeological, slope stability etc. The geological map is also the basis for seismic microzonation studies, fundamental for correct urban planning.

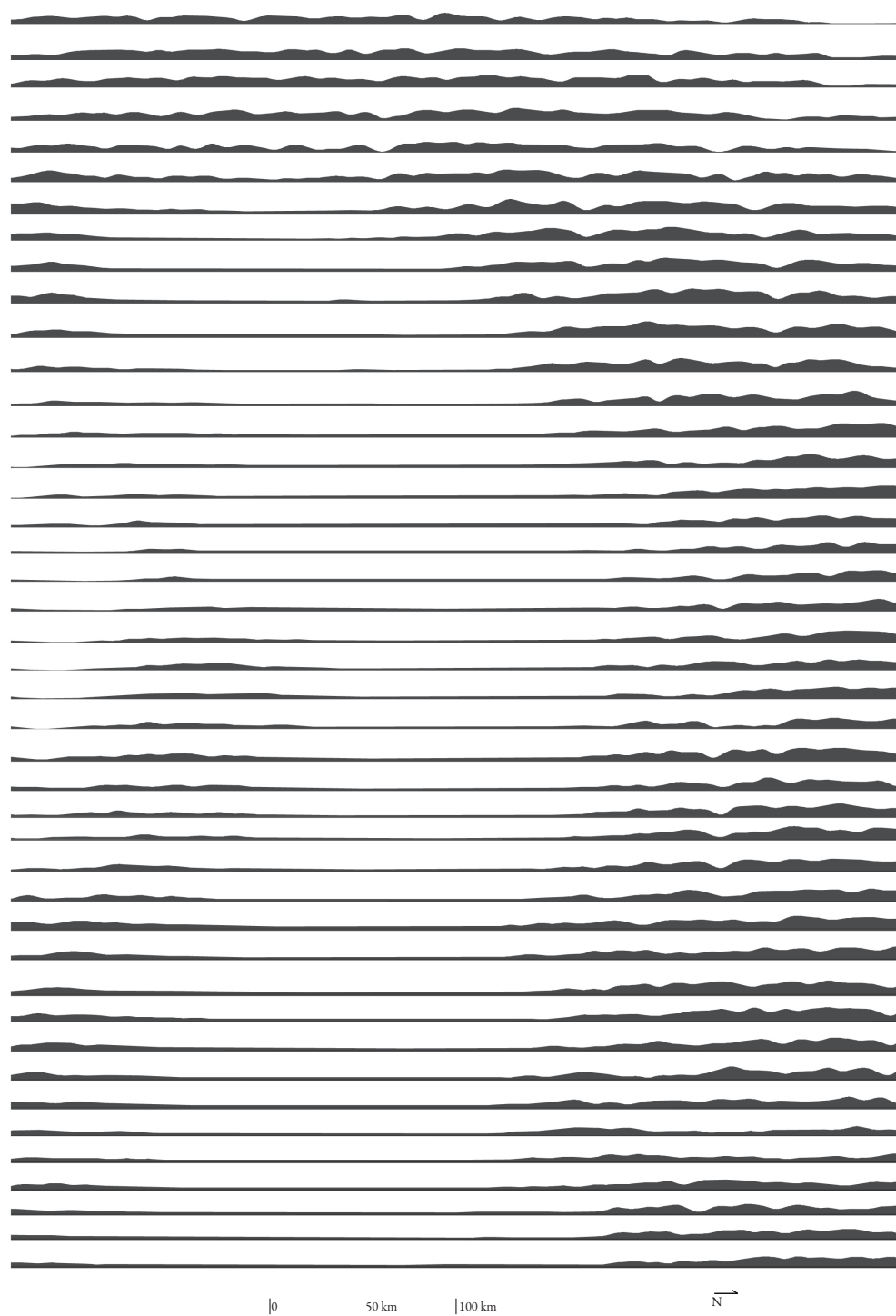
It is equally important geological knowledge:

- to safeguard the environment from the dangers of groundwater pollution water bodies, watercourses, lakes and seas.
- for the defense of the coasts.
- for correct use of natural resources, first of all water.
- for the use of energy sources, in particular of the geothermal energy that our country benefits from rich.
- to the identification of suitable sites for the possible storage of radioactive waste and CO₂.
- to design of infrastructure works; to guarantee the real effectiveness of interventions for soil defense.

It is clear that the amount of data collected, analyzed and interpreted to create a geological and geothematic map and represented on this constitutes an essential knowledge asset for any form of planning activities and of territorial planning and ad support every initiative, intervention and action aimed at environmental protection and defense against natural disasters.

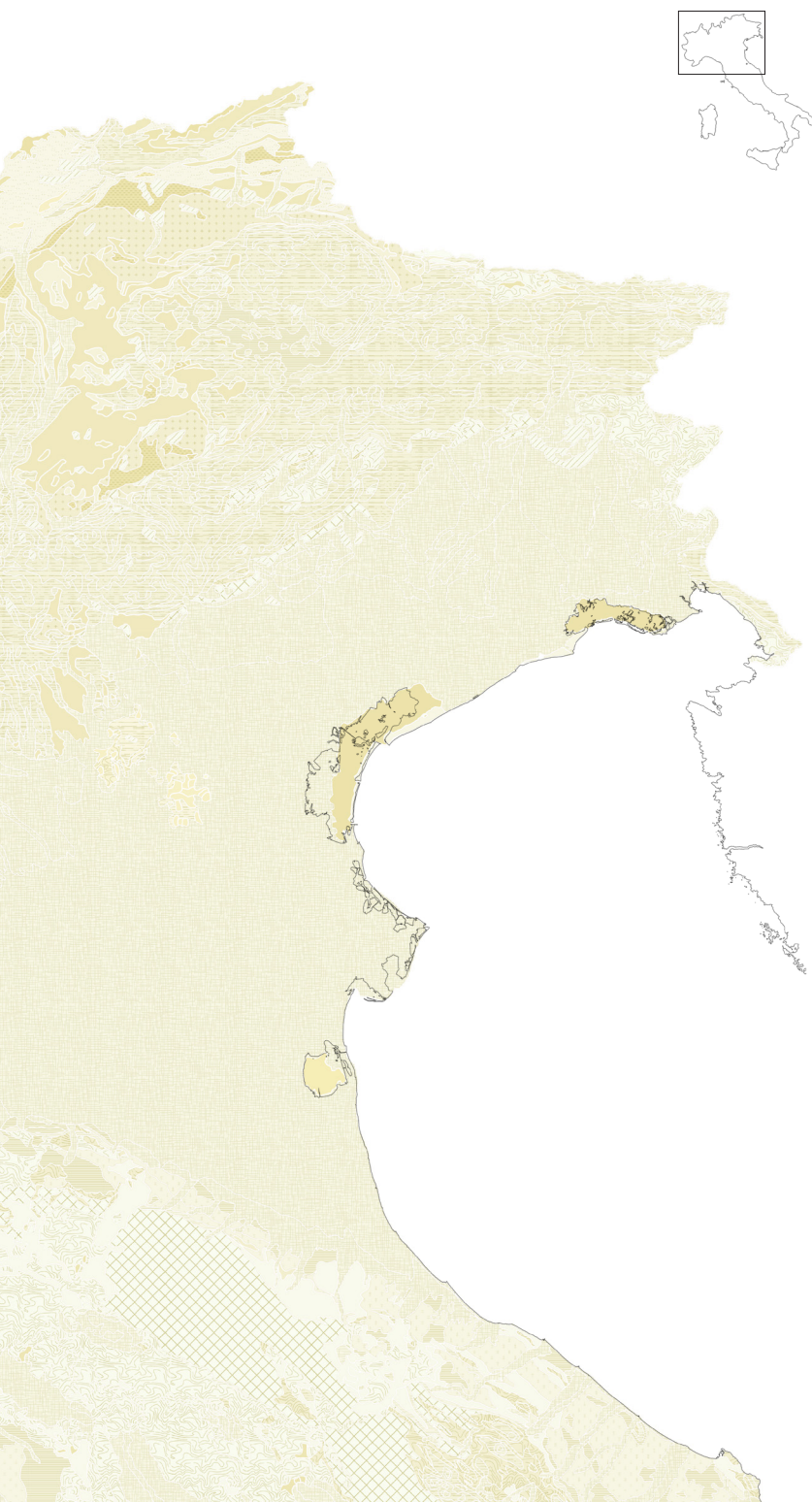
Likewise, it is very important to consider the geomorphological features of the areas. These two elements, morphology and geology, constitute the basis for the creation of the resurgences phenomena.

In the image on the right, it is shown the territory of Northern Italy cut in sections (distance 20 m).



▲
Topography of North Italy.





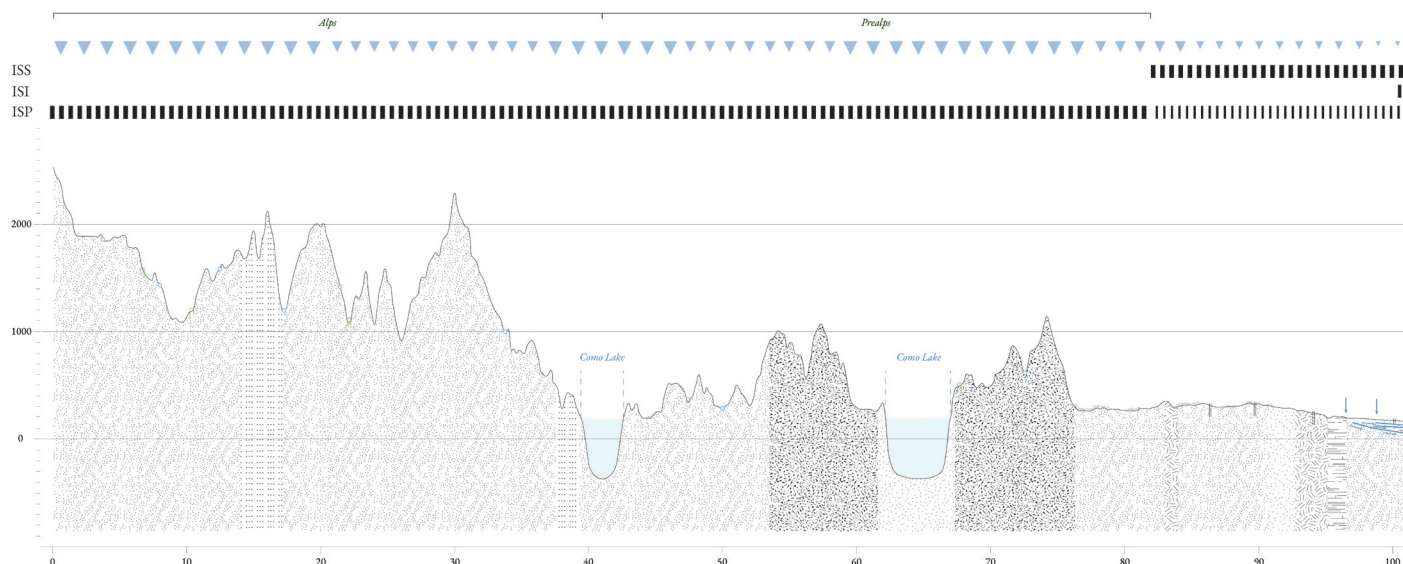
- alluvional and mixed terrain
- clays
- clay shale
- typical detrital limestones
- limestones and dolomites
- sedimentary terrain
- conglomerates and deposits
- wind deposits
- glacial deposits
- mainly sand
- chalky-sulfiferous
- lakes and glaciers
- lavas, pyroclastites, ignimbrite
- calcareous
- high level metamorphites
- low level metamorphites
- medium level metamorphites
- metamorphites various levels
- ophiolites and green stones
- intrusive rocks
- sandy
- travertines
- predominantly flyschaidi unit

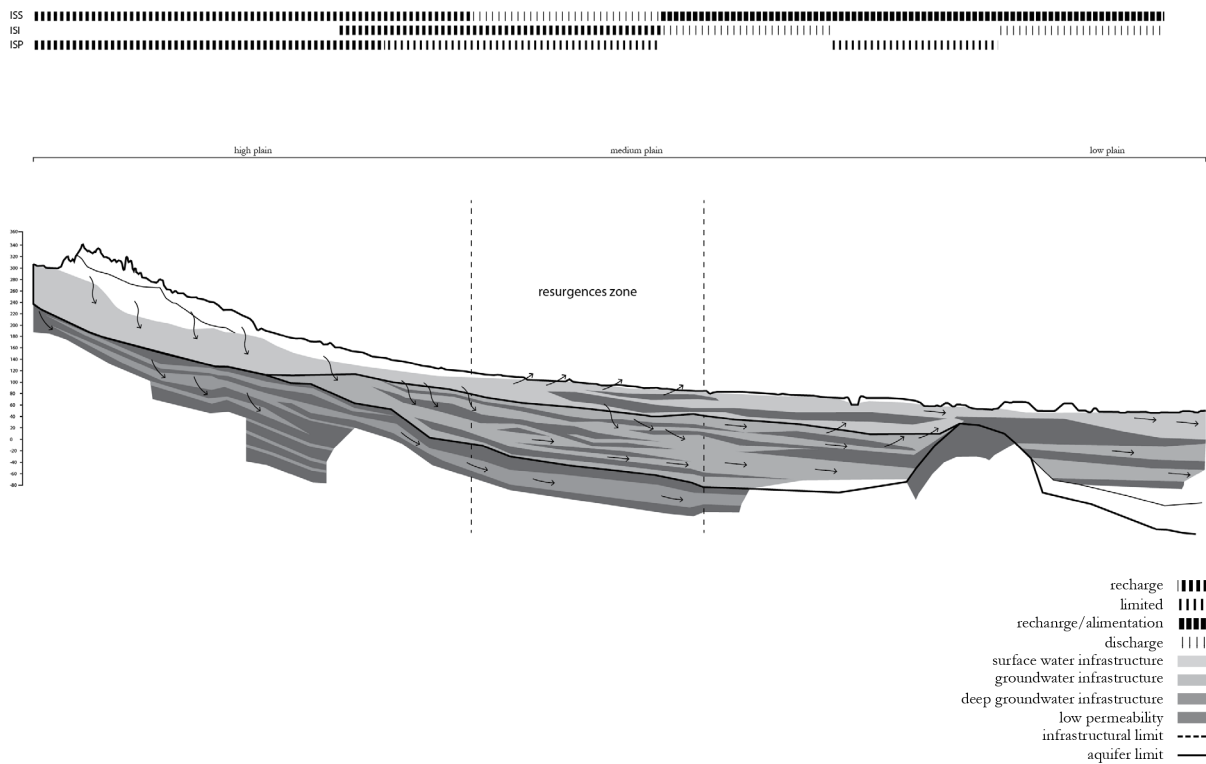
Geologically, what most differentiates the high and low plains is above all the grain size of the substrate, which in the high plain is coarse and inconsistent (extremely permeable) while in the low plain it becomes thinner, being essentially made up of sands and clays.

In this territorial context, the underground waters move therefore from the alpine and pre-alpine zone (very permeable) to those of the lower plain.

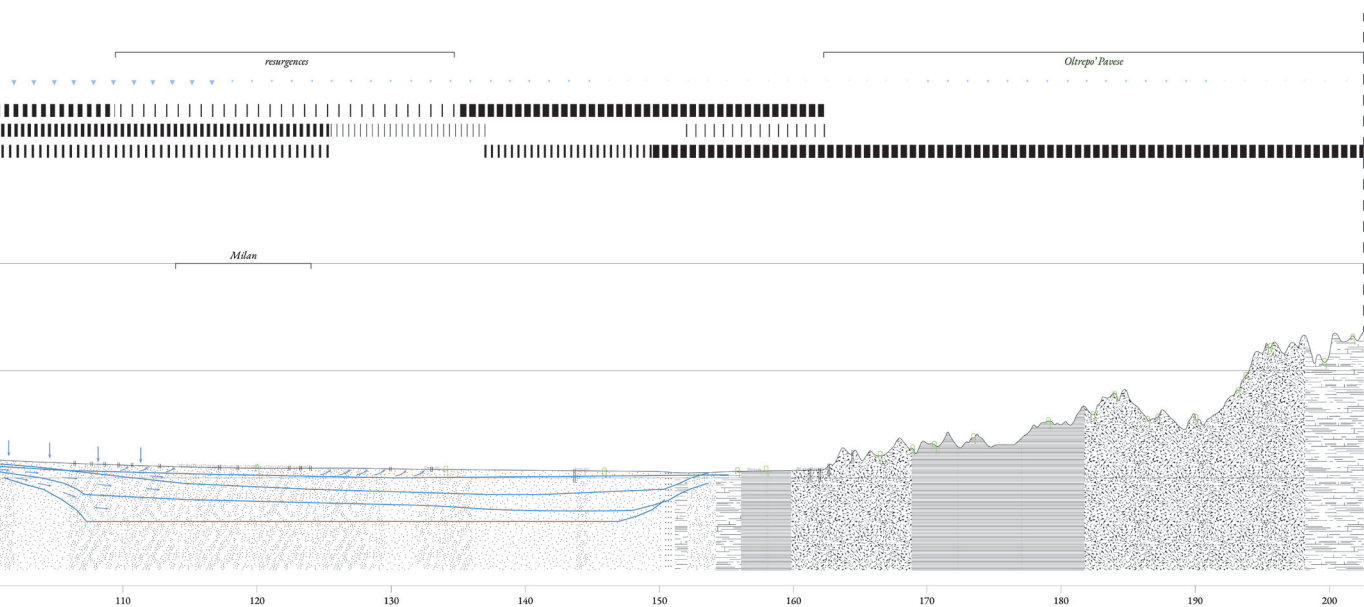
From the Alps and Prealps these flow towards the valley, first meeting the bands of morainic hills and the high plain, both characterized by more or less coarse rocky-stony material. Here the surface water is completely absorbed in the subsoil where it flows along the permeable areas (trapped, they flow slowly between the clays). Once the groundwater reaches the lower plain, they encounter finer substrates of sand and clay and find it difficult to continue underground - in this context the aquifer tends to surface where the water table intersects the topographical one, giving rise to the “phenomenon of the resurgence” (Comitato Risorgive, 2008).

On the Apennine side of the Po Valley the resurgences are rather rare and of modest capacity as the scarcity of coarse deposits (the glaciers were not very extensive) greatly limits the recharge of the aquifer. On the Alpine side, however, the band of resurgences which can be up to 50 kilometers wide, extends almost continuously from Piedmont to Friuli, remaining parallel to the foot of the mountains, interrupted only at the Berici Mountains and the Eugean Hills.





39



The rebirth of the resurgence belt

The precipitation tragedy

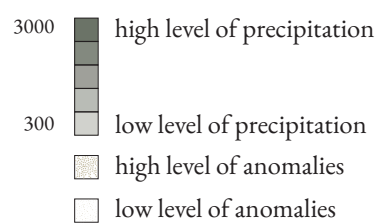
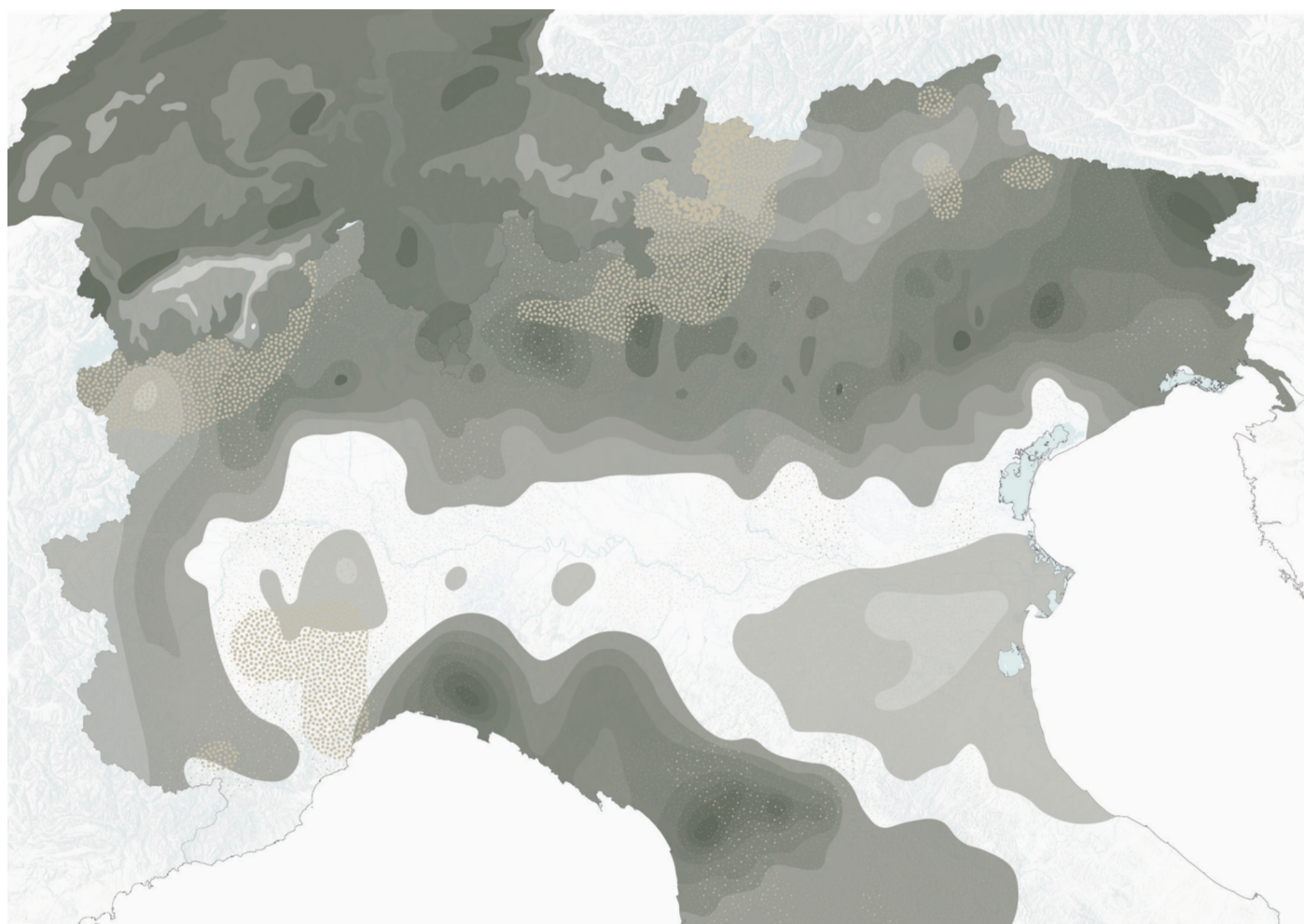
The knowledge of the climatic characteristics of the national territory, in all its different aspects, helps to make decisions in the planning of important sectors of our economy, reducing environmental risks and optimizing economic and social benefits.

Either agriculture, tourism and transport are strongly influenced by trends meteorological reports must be structured in relation to the climatic conditions. Also the production of hydroelectric, wind or solar energy, is directly influenced by the climate, as is the implementation of infrastructure and scientific research itself. Despite this, it is easy nowadays to record the climatic events but still the future is uncertain.

There is no doubt that the management of the territory's resources as a whole, the monitoring of ecosystems and the protection of human health and safety can be better planned if the different climate characteristics.

The image on the right shows the precipitation level in 2022 and its anomalies.

anomalies - year 2021		
	temperature °C	precipitations
Italy	+0,7	-4 %
NW	+0,6	-6 %
NE	+0,5	-17 %
C	+0,7	-15%
S	+0,8	+8 %
Sicily	+0,7	+40%
Sardinia	+0,7	+25%



▲ Precipitation level in North Italy and Switzerland. *Source: Copernicus, 2022*

Late Holocene and water management

Due to their suitability for agriculture activities, floodplains are preferred areas for human settlements. Many studies substantiate the interpretation of floodplains as complex human–water systems.

As a matter of fact, the fluvial landscape development was altered by the water and land management activities to create cultivable land, while simultaneously protecting communities from the risk of flooding events, which are still the most common natural disasters worldwide.

The overall population growth result in the anthropogenic reshaping of the natural environment. Between the X century and the XIII century AD, the urban population in Northern Italy doubled and the demand for cultivated lands increased.

Cereals became a more fundamental component in the diet and in the agrarian regime, leading to the reconfiguration of the medieval natural landscape for agricultural purposes by the population.

In creating new land for cultivation and settlement, a massive landscape transformation was set off by the European communities through woodland clearance, arable intensification, the development of irrigation systems and the drainage of wetlands. Land reclamations works modified many European regions profoundly, such as the alluvial wetlands in the Po Valley (Northern Italy) (Filippo Brandolini et al, 2018).

According to old documents and historical maps the land reclamation of the Central Po Plain reached its peak during the Renaissance (1400–1500th AD) and continued in the Modern Age (1600–1700 AD), with the last marsh areas only being reclaimed in the XX century AD: the drainage system and channels are still active and allow the cultivation and drainage of the Po Valley (Filippo Brandolini et al, 2018).

During the last two centuries, the height of the Po river embankments have been raised

significantly to protect urban areas, and the river has become increasingly controlled, but the debate around future sustainable flood management activities is ongoing. In particular, with steadily increasing embankment heights, the potential flood depth increases, which in turn increases the flood damage if a failure occurs.

The heightening of embankments, indeed, represents an important element of the ‘levee effect’; flood defenses by protecting from regular flooding reduces perceptions of risk and encourages inappropriate development in alluvial floodplains, actually increasing overall vulnerability (Domeneghetti et al, 2015).



43

▲ The wetlands in the Po Valley before the renaissance land reclamation works, 1570 AD. Source: *Library of the Università degli Studi di Bologna*, 2022.

In the case of the Po River, for example, the main embankments are already very tall along large sections of the river, and their further raising is not environmentally sustainable. The environmental evolution of the Central Po Plain and its relationship to human activities has been studied for prehistoric periods and the Roman Era; however, these human–environment interactions in subsequent centuries are less apparent. The post-Roman Era represents a crucial moment in the Late Holocene development of the Po Plain when a large portion of the well-organized Roman countryside turned into vast alluvial wetlands; the Roman drainage system collapsed, and the inhabitants had to deal with living in a waterlogged environment (Filippo Brandolini et al, 2018).

Current water management

The map above shows the embankments and dams of the Po basin.

The raising of the embankments, in fact, represents a component of the so-called “bank effect”; flood defenses actually increase overall vulnerability, as a protection against regular flooding reduces perceptions of risk and encourages inappropriate development in alluvial floodplains (Domeneghetti et al, 2015).

A possible correct strategy to reduce the flood hazard when considering very large or extreme events consists of exploiting areas outside of the main embankments with the ‘Room-for-River’ approach. In the case of the Po River, for example, the main embankments are already very tall along large sections of the river, and their further raising is not environmentally sustainable.



45

0 | 50 km | 100 km | N

- embankments
- ✕ dikes



▲ Water management of the Po Basin, Source: *Elevation/World_Hillshade, 2022. OpenStreetMap, 2022. ADBPO, 2022. Regione Lombardia, 2022. Regione Emilia Romagna, 2022. Regione Piemonte, 2022. Regione VDA, 2022. ARPA Lombardia, 2022*

The vicious cycle of a system in crisis

Northern Italy seems to have entered a vicious cycle that causes the failing of the whole system.

Global warming consequences are high temperature, low precipitations and less green, while population growth is causing high demands, high levels of pollutions and urbanization phenomena.

All of these are facilitating the drought risk that, consequently, causes less soil percolation, loss of habitat and less fertile soil, meaning a loss in agricultural production.

Less soil percolation capacity means that when there is an anomaly in the precipitation and the rain is heavy, the ground is not ready to take into the water and this causes floods. At the same time, loss of habitat means the disruption of the ecosystem and less production means water war.

In North Italy water is managed by consorzio, which means that the land is divided in areas which can include one or more region, and each consorzio decides how to manage the water, often leaving one area with no supply and another with more water than needed.

46

Le piogge danno tregua alla siccità, cresce il livello di laghi e fiumi lombardi

Tornano tutti sopra la media del periodo, tranne il Garda. Per il lago di Como +10 centimetri in 36 ore. Bene il Po. L'inizio della stagione irrigua è...

🕒 11/05/2023

Agricoltura: dopo la siccità, anche la pioggia fa danni

I nubifragi nel mantovano, rovinano le colture ortofrutticole, già messe a dura prova da molti mesi senza acqua

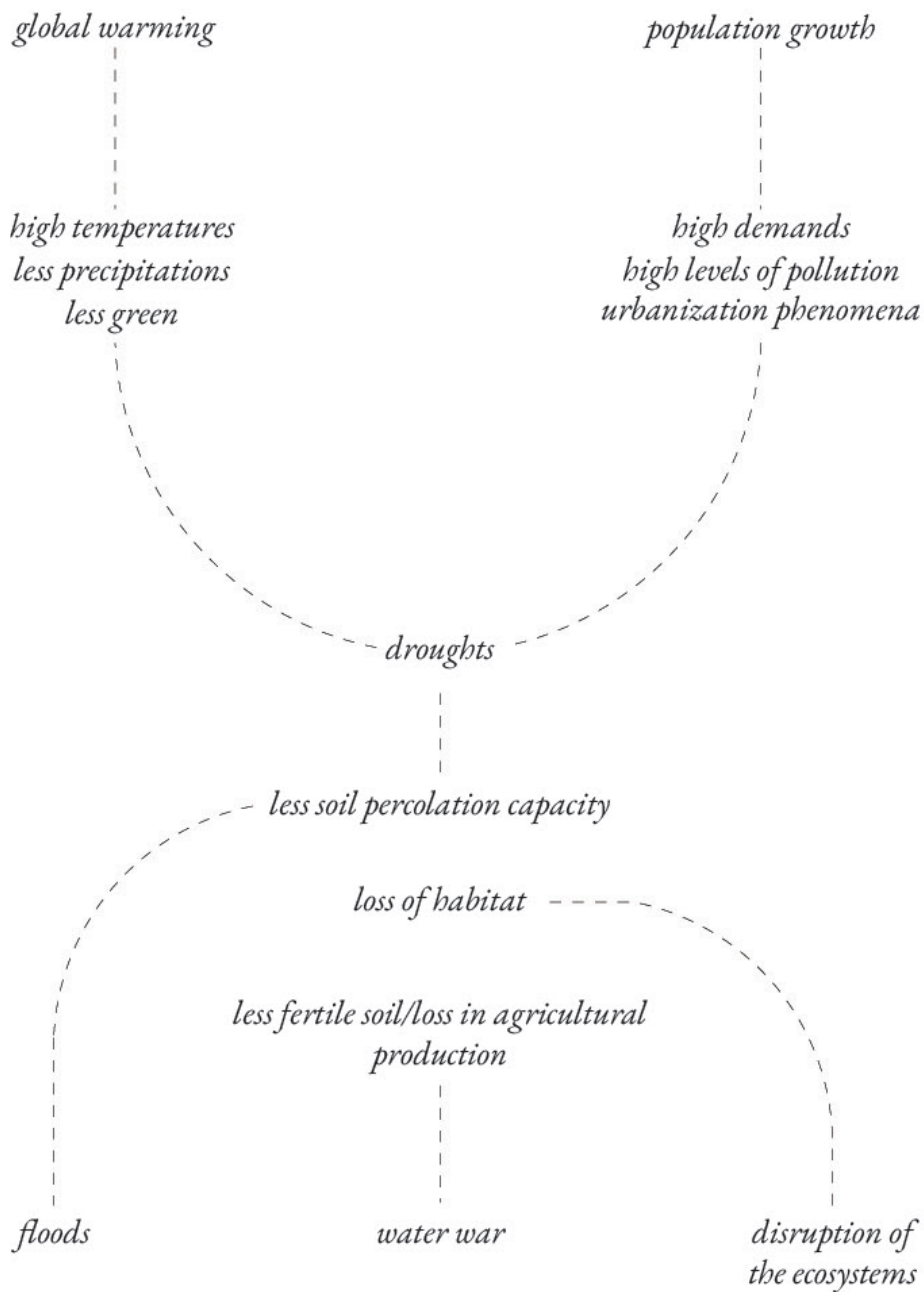
🕒 13/05/2023

L'acqua non basta ancora

Le piogge e la partenza ritardata delle irrigazioni hanno migliorato il bilancio idrico regionale: il deficit idrico è passato dal 60 al 43%. Ma per la...

🕒 04/05/2023

▲
News on hydrological risks in North Italy. Source: Rai News - TGR, 2023. TG la 7, 2022.

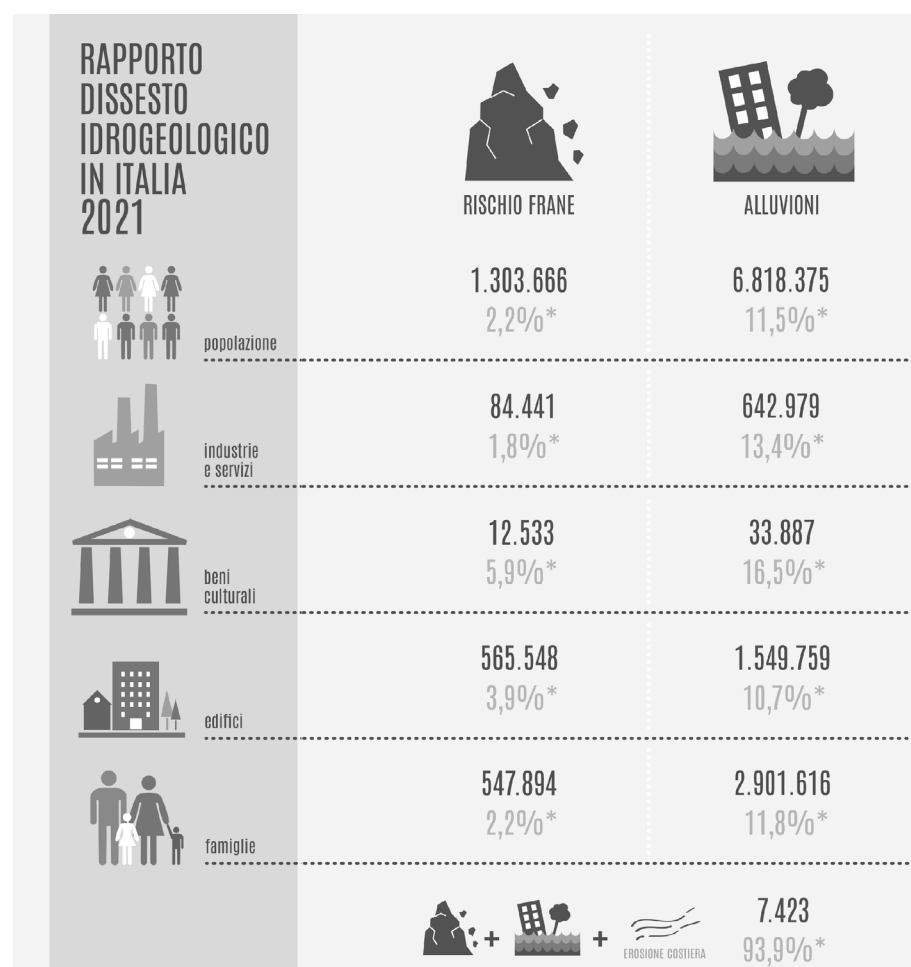


Hydrological risks

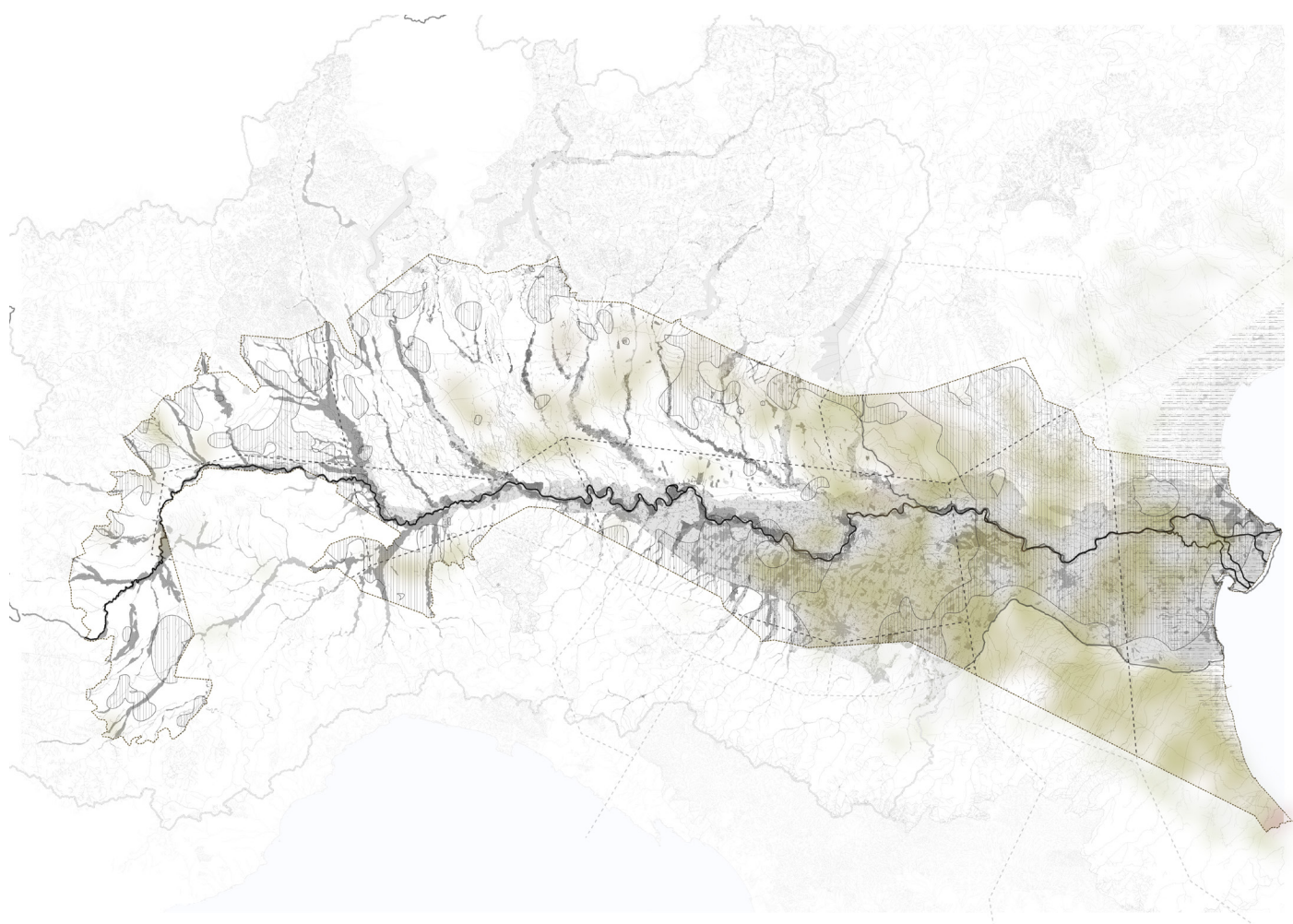
The Environmental Research Letters, which analyzed the 2022 Italian drought stated: “Persistent anticyclonic conditions and anthropogenic global warming played an important role in exacerbating the exceptional drought that affected Western Europe and Italy in 2022 “. The drought has led to an intensification of soil aridification through evapotranspiration, which also causes floods in case of heavy precipitation.

The XDI (The Cross Dependency Initiative) stated how the hydrological risks due to climate are mainly affecting the North and North-West of Italy. In fact, a newly published report indicates that Veneto, Lombardy and Emilia-Romagna are now in fourth, fifth and eighth place in the ranking of the European regions most exposed to extreme weather events and climate change (The Cross Dependency Initiative, 2023).

The image on the rights shows all the hydrological risks in the Po Valley: flood risk, drought risk, saline edge and erosion.



▲ Hydrogeological risks in Italy. Source: ISPRA, 2021.



49

-  saline wedge
-  flooding risk
-  major agriculture
-  drought risk

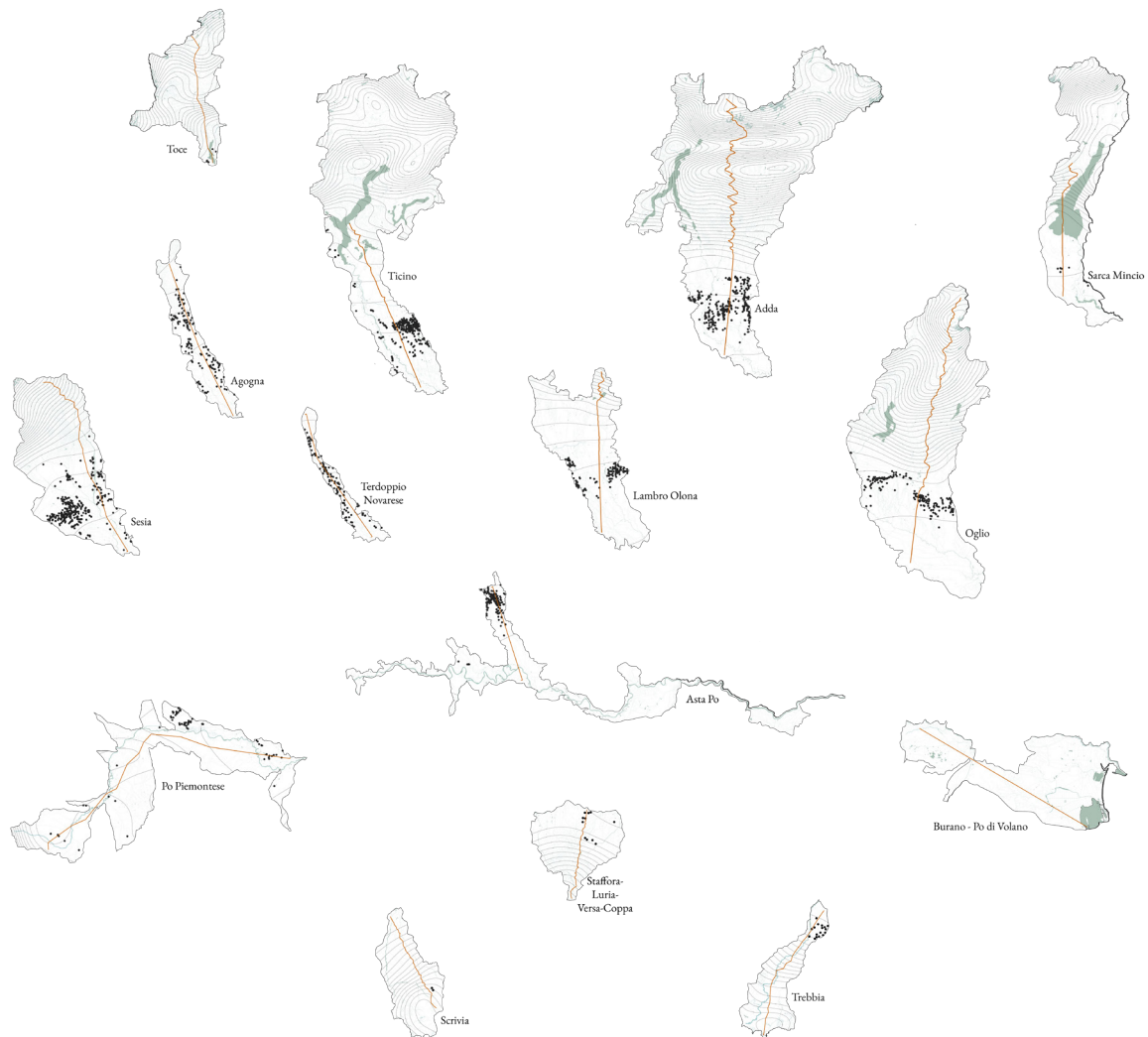


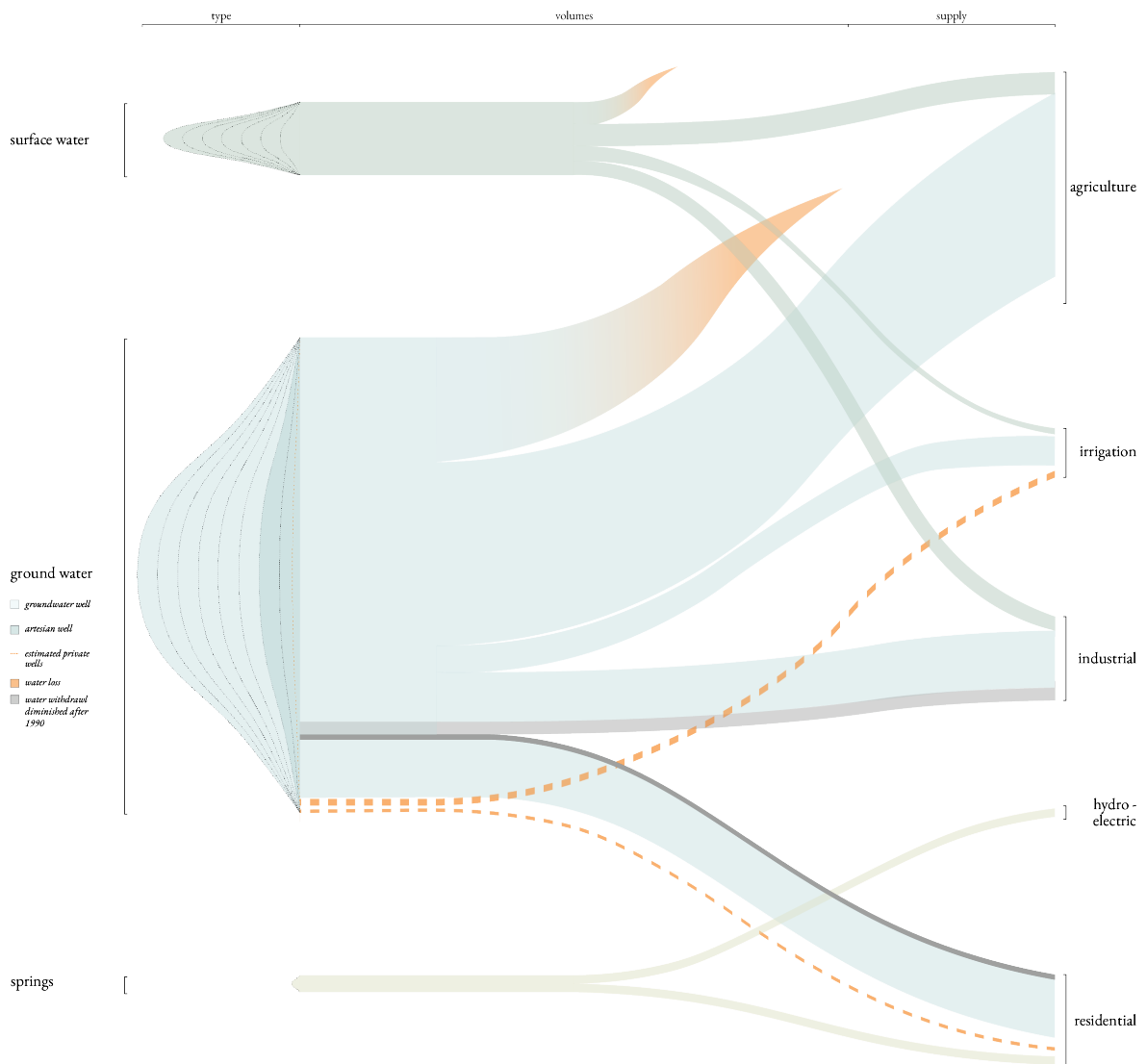
▲ Hydrological risks in North Italy. Source: ADBPO, 2022. Regione Lombardia, 2022. ARPA Lombardia, 2022. ARPA Piemonte, 2023. Regione Piemonte, 2023. Regione Veneto, 2023.

Pressure and impacts on groundwater bodies

The resurgence rivers in addition to having been strongly affected by the progressive loss of flows and the compromise of water quality have also undergone a strong environmental deterioration, mainly due to the lack of traditional care actions of riparian vegetation.

The end result is that those islands of biodiversity that were once resurgences have progressively depleted of wild life. In the worst cases, the loss of flow and practical value of the resurgences has reached the extreme consequences: the head of the resurgences and the initial section of the channel have been buried, leaving a drainage pipe to escape at most in the rare moments in which the aquifer recovers its ancient levels.

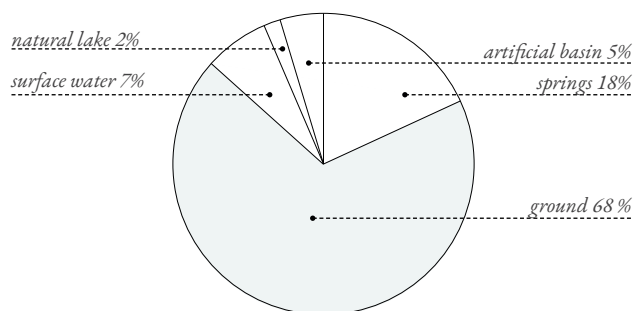
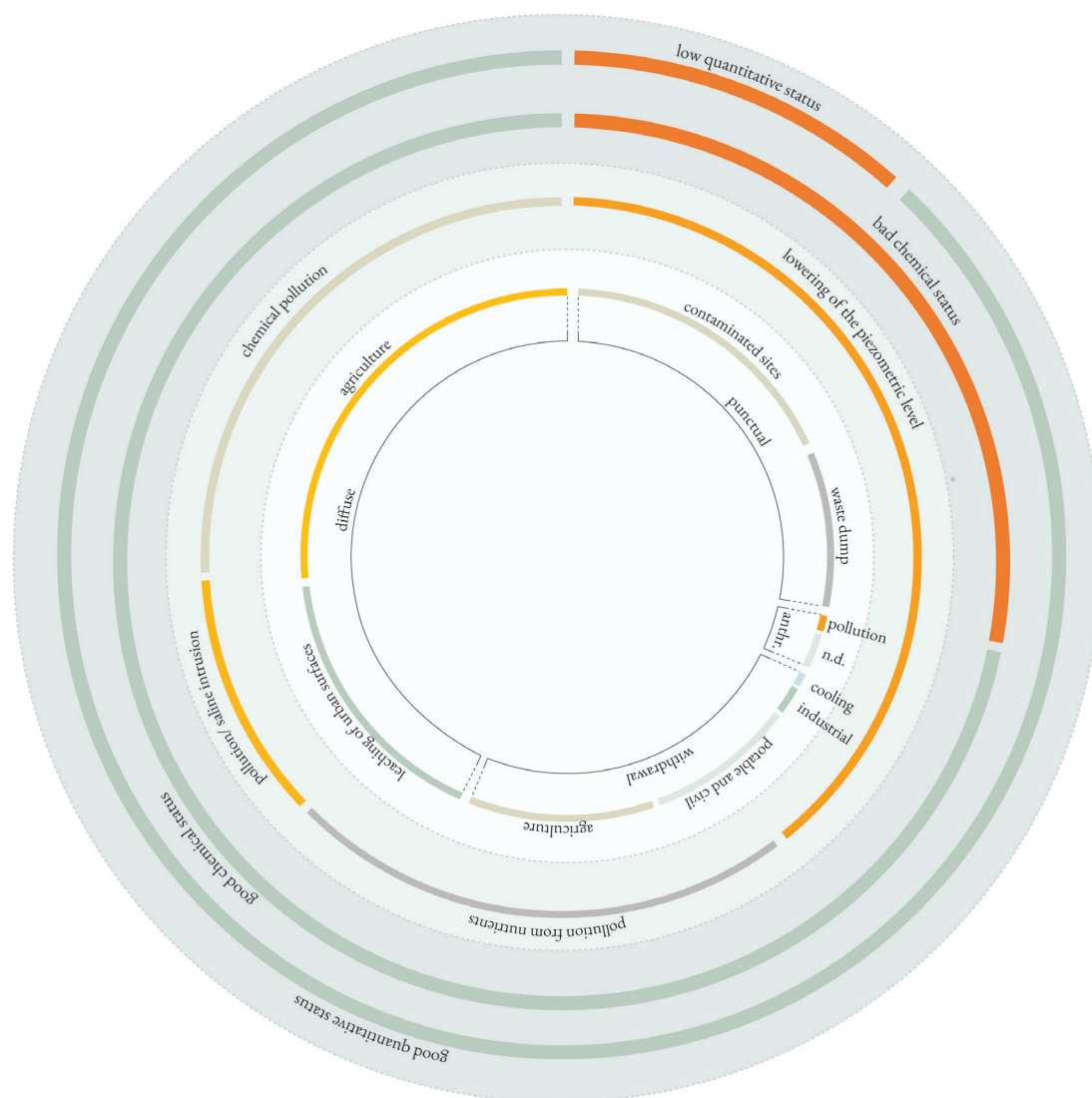




51

	1000 m ³ /y l/per person						
	spring	ground	surface	natural	artificial	sea water	
Po Basin	504,1	1902,1	197,2	44,7	132,7	-	2780,8
Italy	3313,4	4515,9	441,4	47,7	901,3	10,4	9230,2

▲ Utilization and distribution of water in Po Basin. Source: ISTAT, censimento delle acque per uso, 2019.

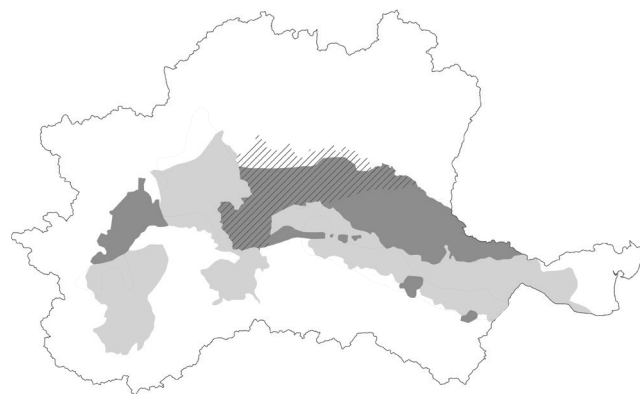


▲ Pressure and impacts on groundwater bodies. Source: ISTAT, 2019. AIPO, 2019.

Groundwater bodies' health



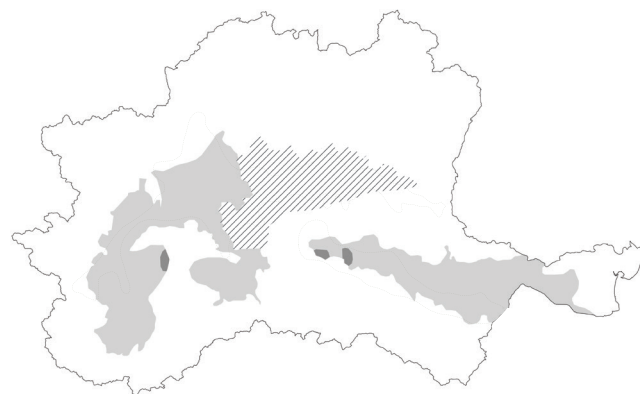
ecological level



ecological level



quantitative level



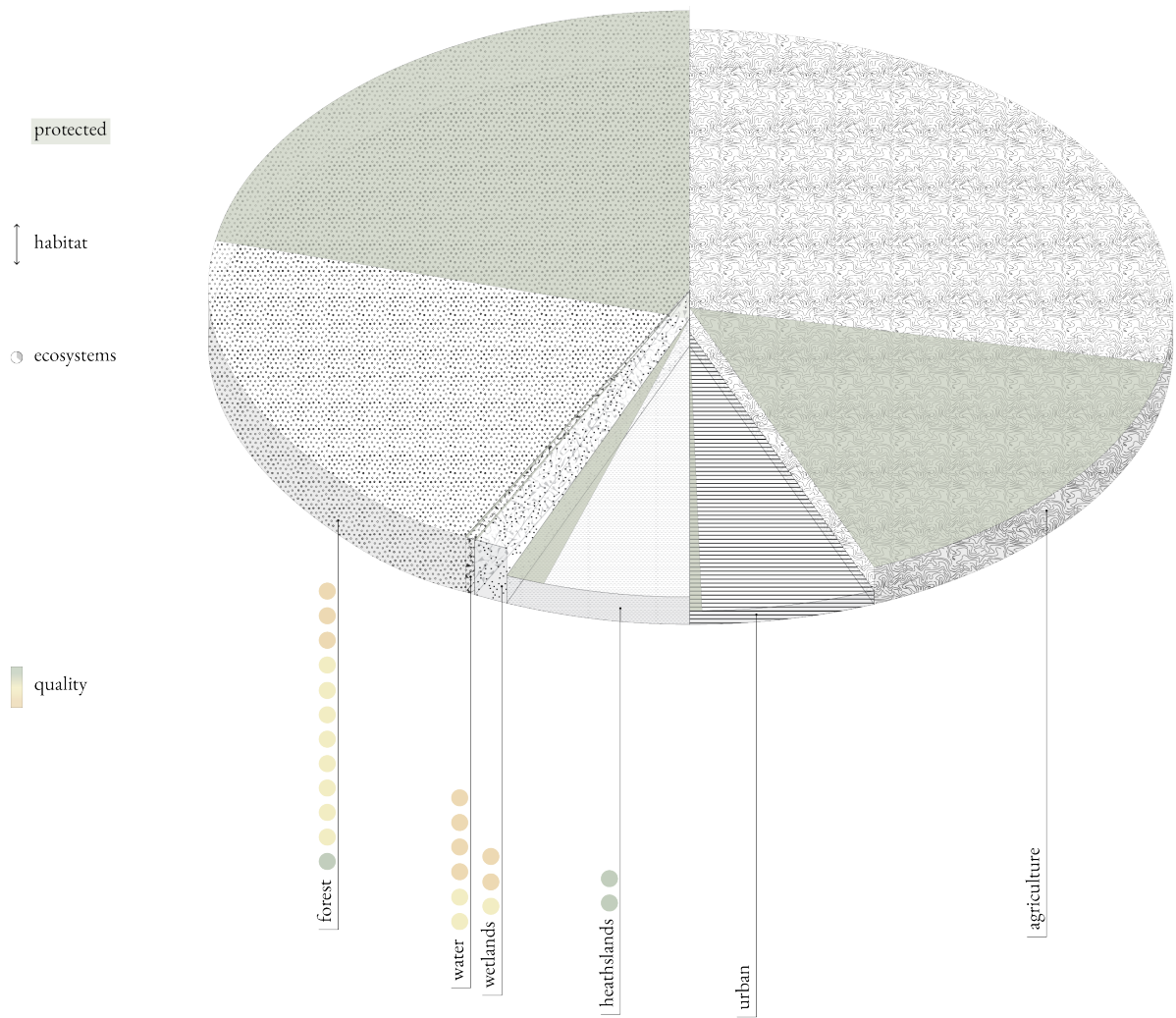
quantitative level

 freatic bodies
 low level/high level

53



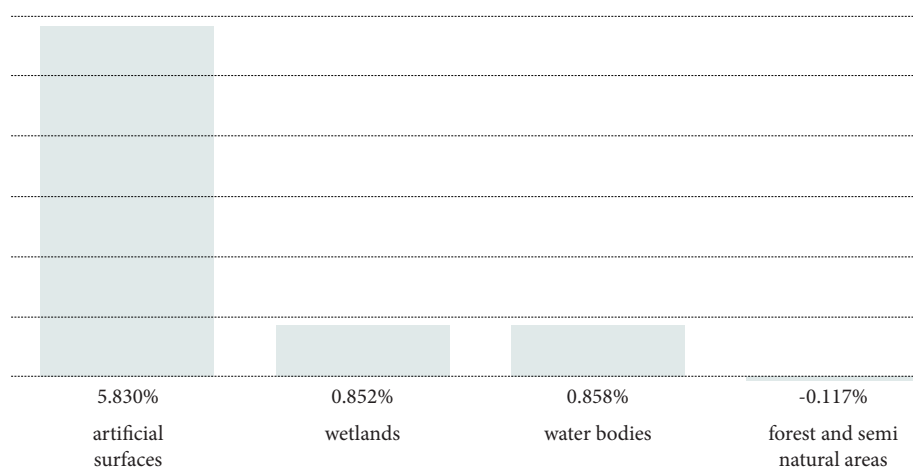
▲ Ground water bodies' health. Source: ISTAT, *utilizzo e qualità della risorsa idrica in Italia*, 2019.



The development of human activities in the high plain in recent decades has generated various risk factors for the protection of groundwater quality:

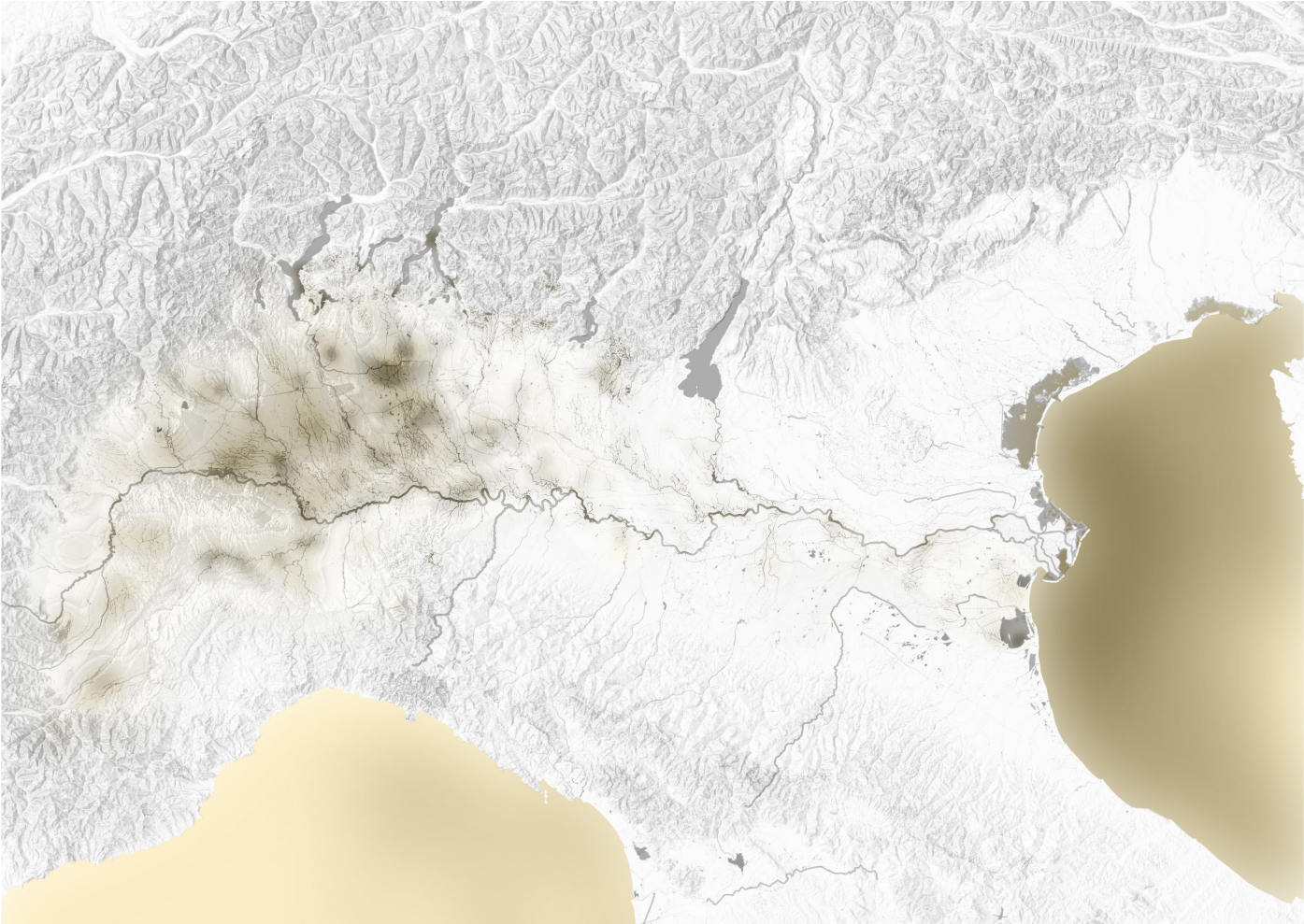
- dispersion of pollutants of industrial origin (heavy metals; solvents; etc.) -
- organic contamination of civil and agricultural (nutrients).

The most polluted areas are in Lombardy and Piemonte (west area) and how this leads also to the contamination of the Po delta and therefore the Adriatic sea. The river Po reaches a level of pollution of class 4 in some areas, and has an average of pollution class 3.



The urbanization problem and the pollution phenomena

56

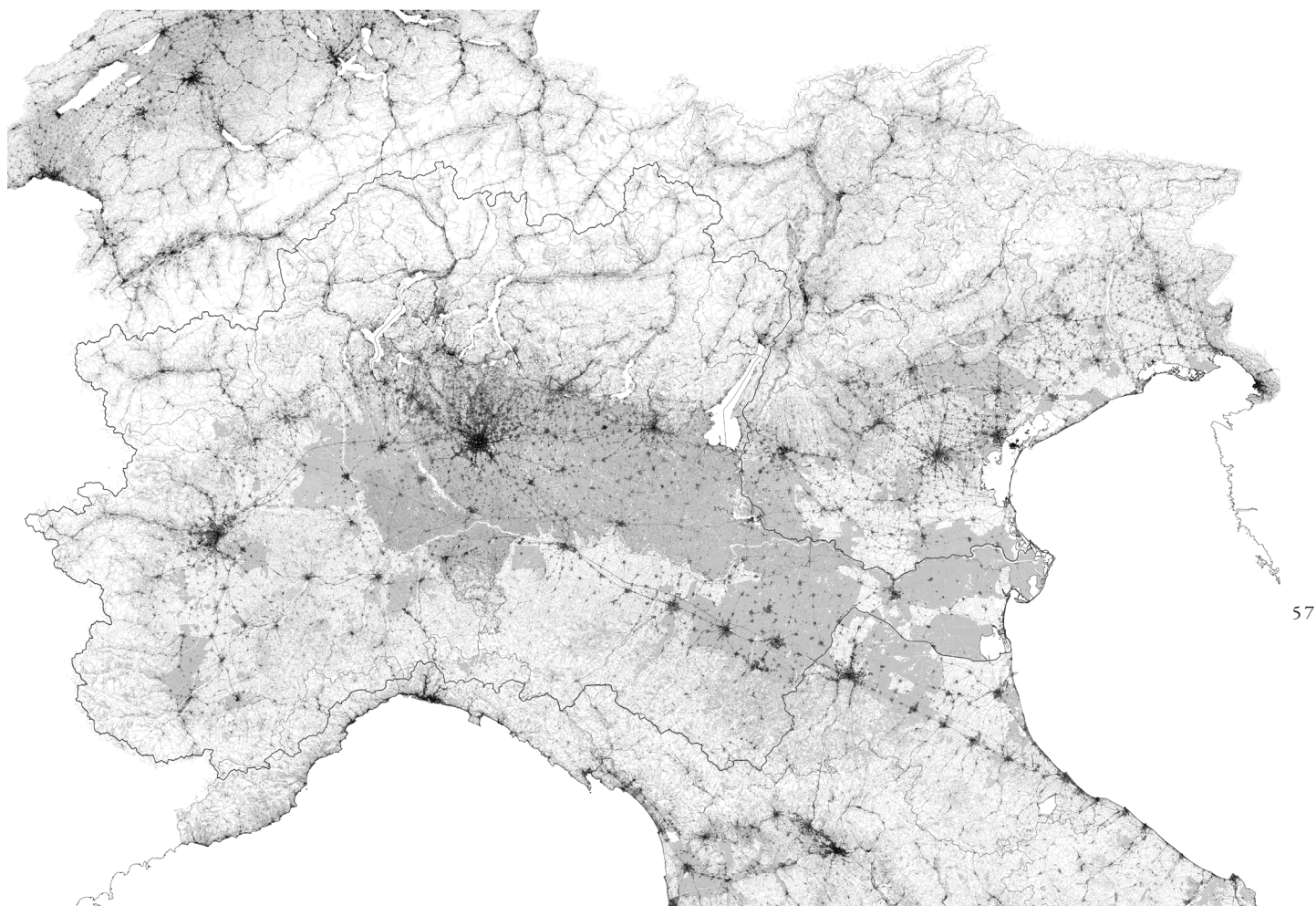


■ pollution level

0 50 km 100 km N



▲ Contamination level of the ground and surface water. Sources: *Elevation/World_Hillsshade, 2022. OpenStreetMap, 2022. ADBPO, 2022. Copernicus Marine Service, 2022.*



57

- 0 50 km 100 km N
- Po basin
 - Network infrastructure
 - intensive agriculture
 - urbanized

▲ Natural areas in North Italy. Source: Natura 2000, 2023

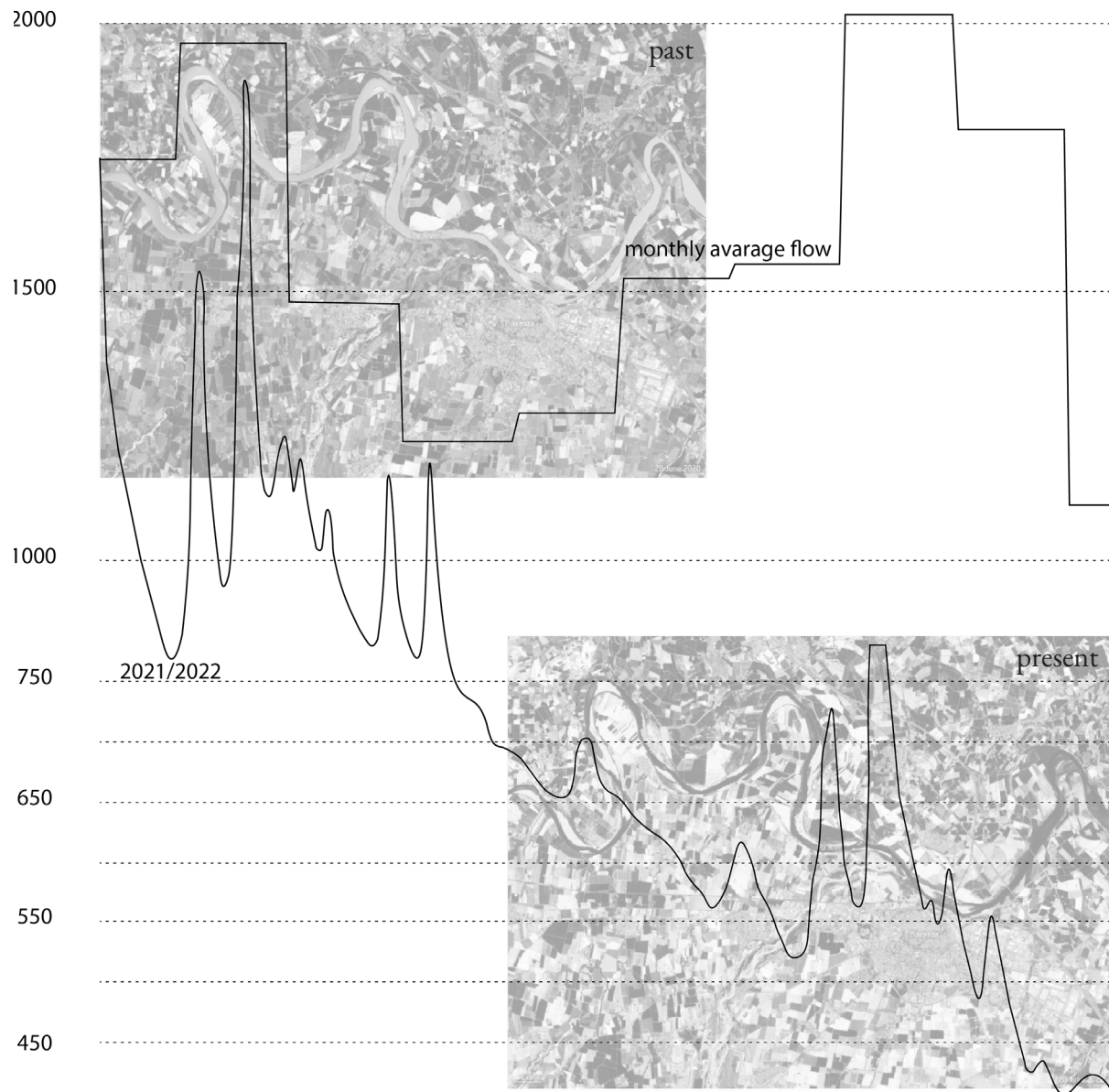


Droughts through colors

In the images on the right, it is shown how the droughts is changing the colors of the landscapes of North Italy.

The first one is the landscape in 2019 while the other one is the landscape in 2023. The differences are noticeable, the terrains are becoming more and more dry and the rivers are diminishing in quantity.





The productive landscape

As already stated, the transitional zone between the undifferentiated system to the multi-layered one in the high plain constitutes the “resurgence belt” and has been profoundly affected by the anthropization process which, in a development still underway, is significantly modifying the landscape. Towns are increasingly closer to each other due to local residential needs and the desire to leave increasingly chaotic and polluted cities is rising.

One could say that it was a mistake to favor the urbanization of these small towns, as was common in the past, along the main communication routes rather than selecting sites that had all the services but also were far from the main traffic routes. Today we are witnessing the need to build cycle-pedestrian paths to encourage contacts between different realities and safe travel.

These are difficult to plan and implement due to the presence of many homes scattered here and there built without any real order and with outdated urban development criteria. This evolution has in a certain sense damaged agricultural development, which was once the main activity capable of providing a livelihood for most families, as it has fragmented most of the large countryside into a myriad of small plots of land.

The reduction of the extensive countryside was accompanied by the decrease in the breeding of meat and dairy animals, both due to the difficulty and heaviness of fieldwork, accompanied by an inconsistent income and to the lack of free time that such jobs entailed in a civilization in which this aspect of daily life takes on ever greater importance.

Currently, entrepreneurs who base their work on agriculture, although few, are equipped with expensive, sophisticated machinery, initially to replace the workforce that had moved to the industries and now to optimize and make their work increasingly profitable and less burdensome, in step with the times and demands of the market. However, to work well and make the most of their potential, these machines need space; hence the trees that interspersed the meadows until about 30 years ago are now rarely noticed, having been eliminated to leave more room for manoeuvring for the operating machines. Haymaking, for example, which once required a lot of human resources in the summer periods, can now easily be carried out by a single operator.

Few meadows have survived thanks to a fair number of dairy cow farms which has allowed the fields cultivated for fodder to be preserved.

In similar lowland environments where these farms have disappeared, stable grassland has given way to more profitable crops such as corn and soybeans. Thus the trees typical of the rural civilization have disappeared; interspersed with the meadows you can almost no longer see the rows of mulberry trees, field maples and Italian walnuts which acted both as a support for the vines with which they were associated and for the shade necessary for the work of the fields in the past.

Another example is the so-called ungrafted vines (clinto, clinton, bacò),



▲ Before and after. *Source: Google Earth, 2022.*

which were supported by these trees pruned in a particular way to avoid excessive shading of the ground; the farmers who took advantage of the branches they cut as lumber; the breeding of silkworms thanks to the presence of mulberry trees.

All these cultivation techniques have been abandoned due to the excessive demand for labor and because they were unprofitable.

In this landscape, also existed many ditches that, in addition to acting as drainage for excess water during the rainy period, were used for irrigation. In North Italy, numerous of these ditches were once active resurgences that today have lost their functionality due to the lowering of the water table and to the increasingly massive use of water for civil and industrial purposes.

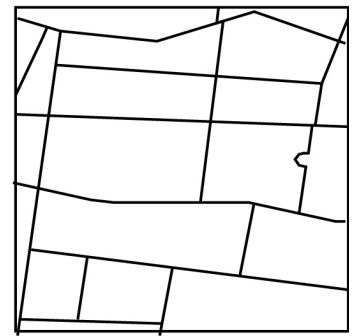
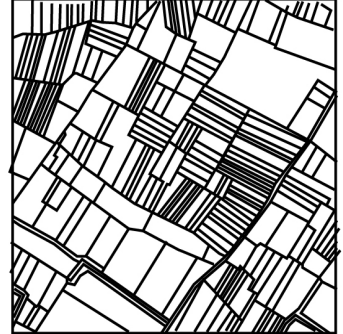
Unfortunately, as it has frequently happened in the recent past, these ditches are closed to facilitate mechanization. Consequently, some resurgences are lost, even permanently, because even if they are no longer active, they could only be reactivated if the environmental conditions of the past were restored. Today the cultivation of fields is increasingly mechanized and aimed at quantitative production and, consequently, even stable meadows are fertilized more to shorten the maturation times of the forage, with an always potentially present risk of pollution of the aquifers and consequently of the resurgences. Many of the ditches once fed the areas where hemp was left to macerate, a crop that is now completely abandoned also because it required an inhumane work effort. The small stables have given way to a few large farms which can be defined as milk and meat industries, which, instead of producing good manure as in the past, due to the modification of breeding procedures, it produces enormous quantities of rich slurry of nitrogen, which is more difficult to dispose, as it is ammoniacal nitrogen with notable fertilizing power. The risk that excess, leached nitrogen reaches the aquifer and pollutes both the water from springs and domestic wells is always potentially present. It is fundamental to act and operate in such a way as to enhance local flora and fauna, to maintain and conserve the reality of the resurgences for a young population who cannot have any memory of them in any other way.

Up until the 1960s, the plots were small and followed local contour lines. The leveling of the land was done with optical instruments in the first preparation and then the same water was used in the annual renovations. By flooding the chamber, both the slope given by the flow and any accumulations of soil to be flattened or depressions to be filled were observed. The landscape of the old ricefields was made of curved lines all intersecting each other. The extension averaged half a hectare. With laser levelers it was possible to move on to average extensions of 3 hectares (which can even reach 8) with higher embankments. With these chambers and with a precise leveling system, water is used better: less is needed because there is a greater guarantee of uniformity of the submersion and it is on average shallower than in the past. The two plans refer to the same rice-growing area, comparing the arrangements of 1950s to today's. The plots today appear more regular and large than in the past. The simplification of the geometry of the paddy is the result of the massive use of flattening and leveling means. In the schemes we can also see the disappearance of many rows of windbreak trees that once characterized the landscape of the lower Vercelli area.

It is noticeable the stemic process which affects entire areas of landscape: it involves the elimination of all those marginal, semi-natural elements, such as hedges, rows of trees, perhaps small puddles, and even dry stone walls, which in agriculture in the past they were much more common, and due to the logic of intensive agriculture they are eliminated, for example to make room for large agricultural machinery, or simply to increase the extension of the cultivated area.



▲ Before and after mechanization. Source: image made by the author



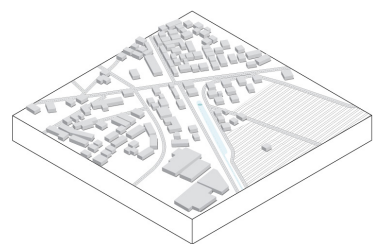
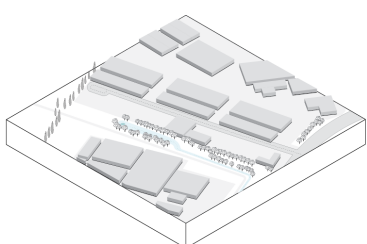
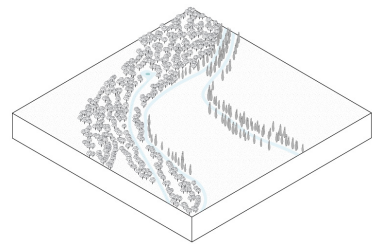
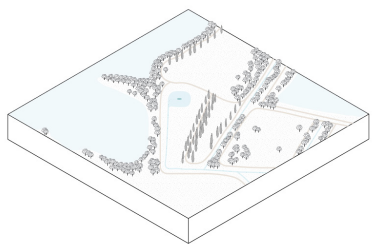
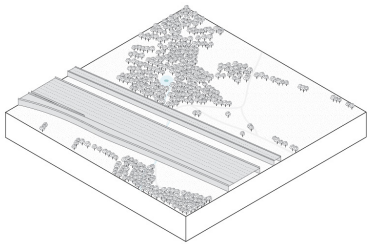
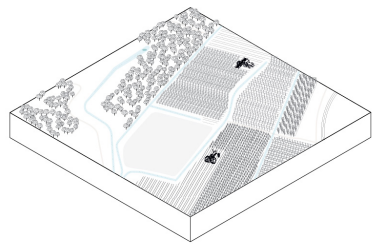
Terre d'acqua: the agricultural landscape - cultivated crops

As already stated, the floodplain of Po Valley is rich in water this helped the evolution of its agricultural landscape. Some parts of the territory (the agricultural area of approximately 82 thousand hectares of land near Vercelli) accommodate the cultivation of rice and it is commonly known as “mare a quadretti” (the squared sea) as these fields are submerged with water in order to grow the crop. The ricefield is “nature” made by man as it is a meticulous engineering work.

The uniqueness of these places lies in the fact that each ‘square’ – called the chamber which is the space of a ricefield - is divided from the other by earthen embankments. These are placed in continuity with each other and not at the same height, so as to allow the slow flow of water. The rice shoots then remain immersed for over a month to protect themselves from temperature changes and give life to the seedlings which will reach maturity at the end of summer.

The mainly cultivated agricultural products are cereals, potatoes, vegetables, sugar beets, fruit, poplars and fodder; viticulture is very strong in the hilly areas. Piedmont is the first Italian region for rice cultivation. Breeding is concentrated on cattle and pigs. The past two years have not been easy for Piedmontese agriculture, faced first and foremost with the gravity of the climate emergency, which manifested itself by causing a strong water crisis which affected all agricultural sectors; From a structural point of view, 36% of the region’s territory is intended for agricultural production, equal to 923,428 hectares of UAA (Used Agricultural Area), historically fragmented both from the farm point of view (an average of 21 ha/farm) and from the sectoral point of view (Regione Piemonte, 2023).

Context of resurgences



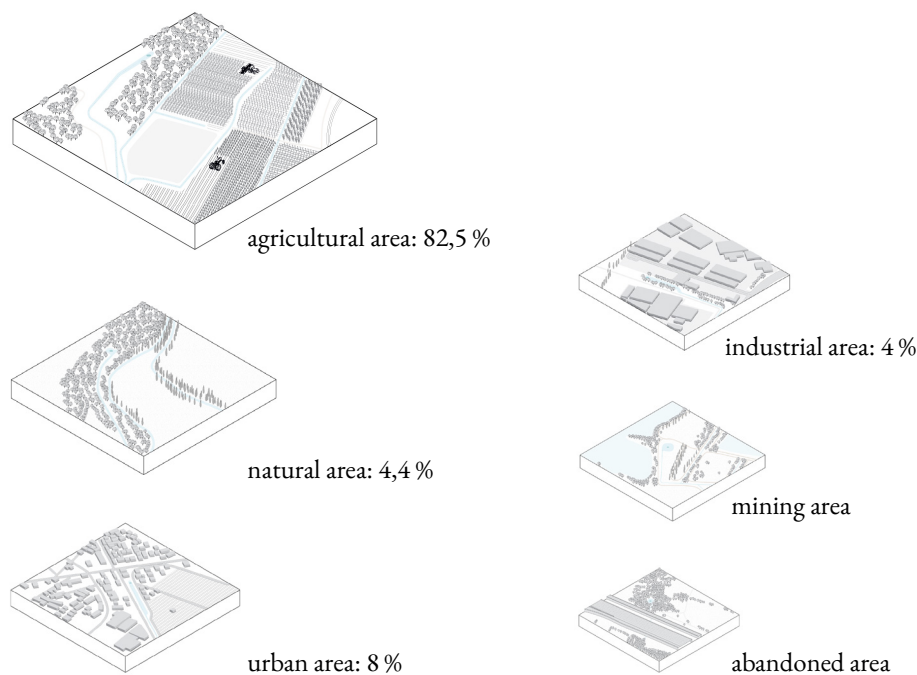
This determines a characteristic of the resurgences which is that of being, from a “functional” point of view, not directly dependent on the environment in which they are located: in other words, a resurgence inserted in an urban context can maintain its irrigation function for the land located in agricultural areas and, on the contrary, a resurgence located in a rural area can see its course interrupted, and therefore its irrigation function, by the construction of settlements and new urbanizations along the course.

In some areas of the Lombardy Region, the flow guaranteed by the resurgences is by no means negligible and allows for the presence of irrigated agriculture, otherwise impossible or subject to withdrawal from the groundwater through wells, with consequent energy expenditure and economic burden.

n

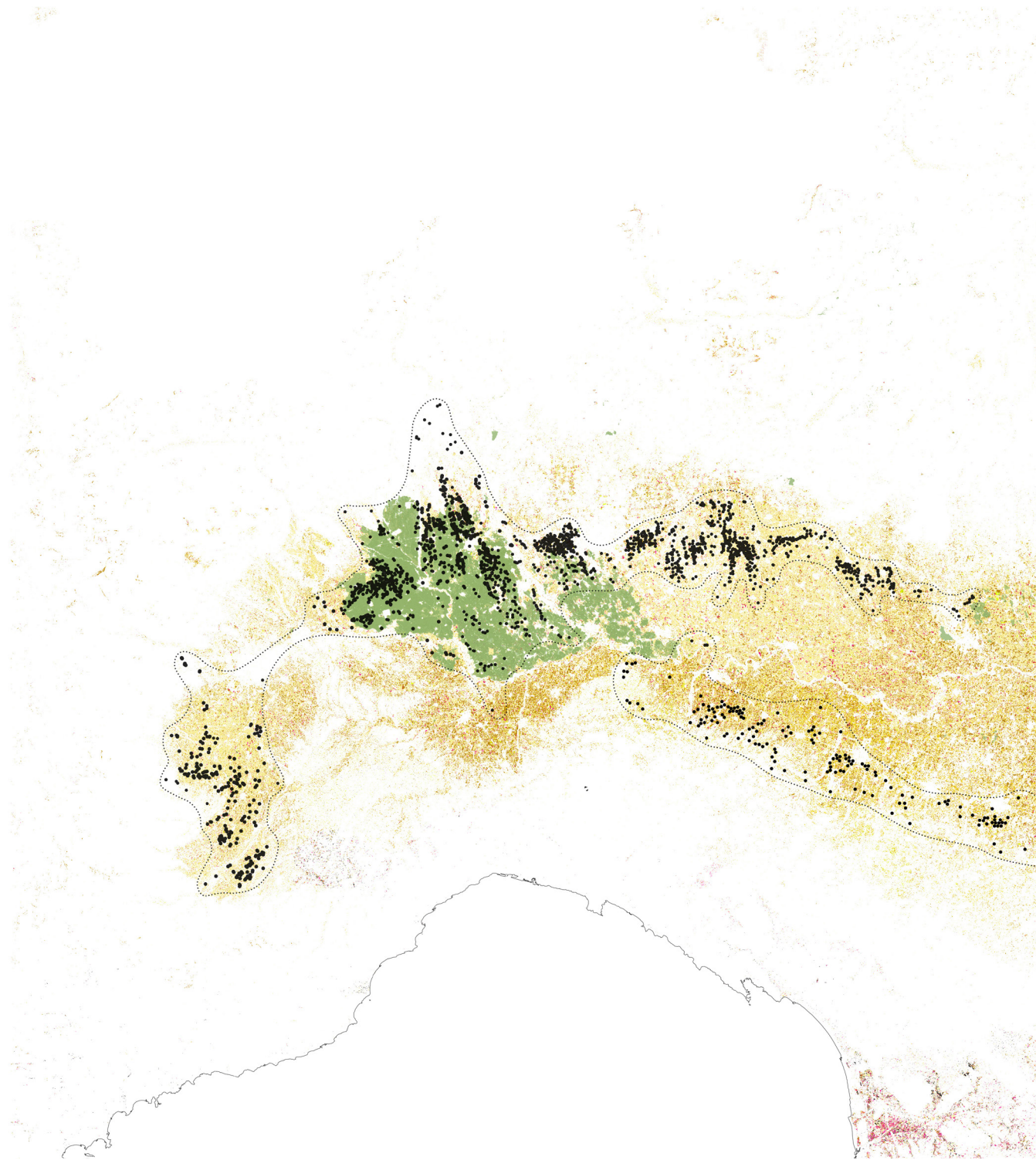
The Plan, approved with DCR n. VII/1179 of 16 February 2005, places, in fact, the underground waters of resurgences among the main irrigation sources (the others being surface waters, by far the most important in terms of quantity, and those extracted through wells).

67



Crops in the Po Valley

68

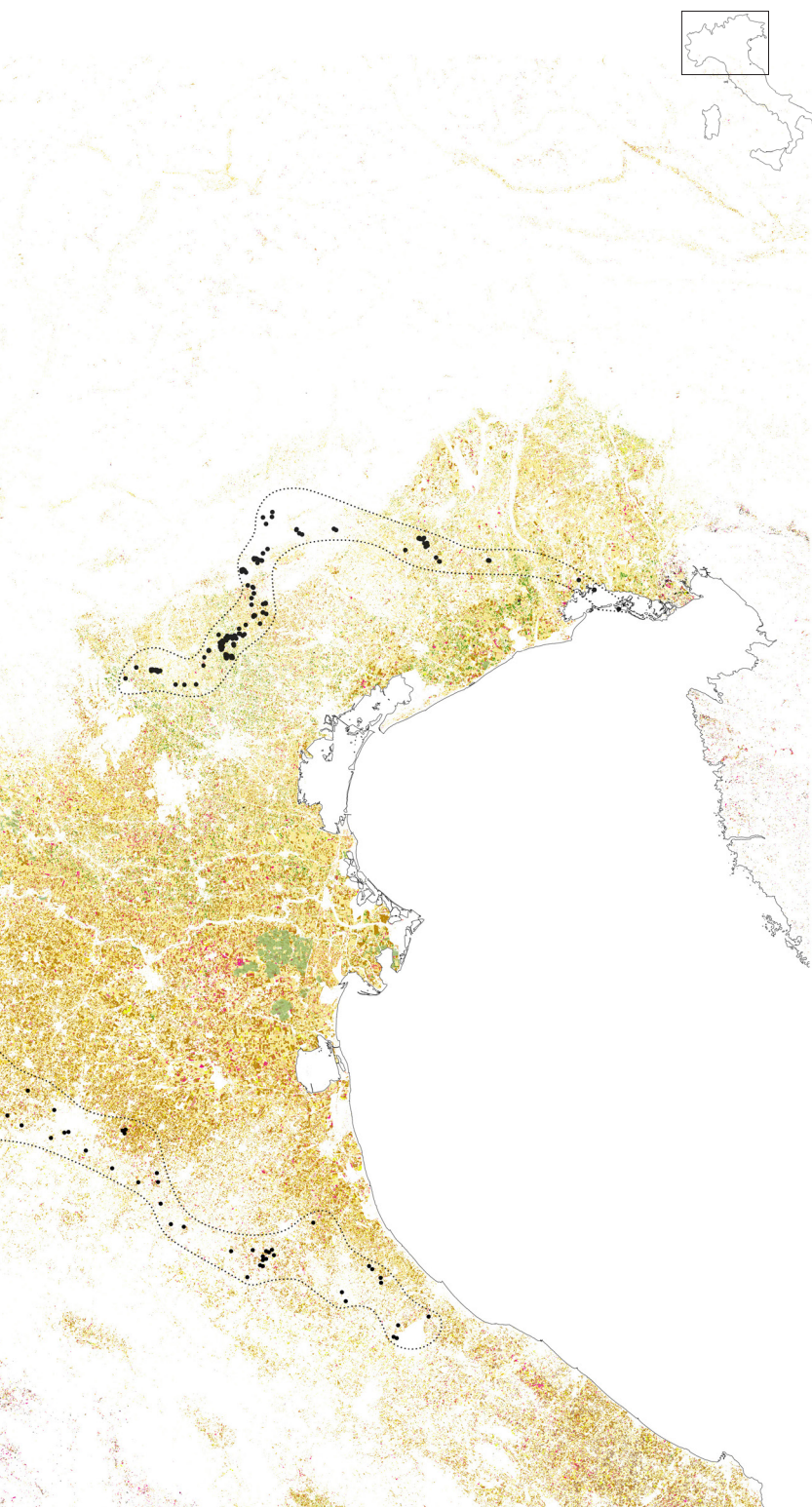


0

50

100

N



- common wheat
- durum wheat
- barley
- rye
- oats
- maize
- rice
- triticale
- other cereals
- potatoes
- sugar beet
- sunflower
- rape and turnip rape
- soya
- dry pulses
- fodder crops
- bare arable land
- bare land
- resurgence
- resurgence belt

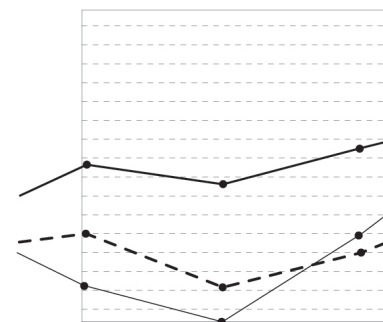
▲ Crops in North Italy. Source: Eurocrop, 2018

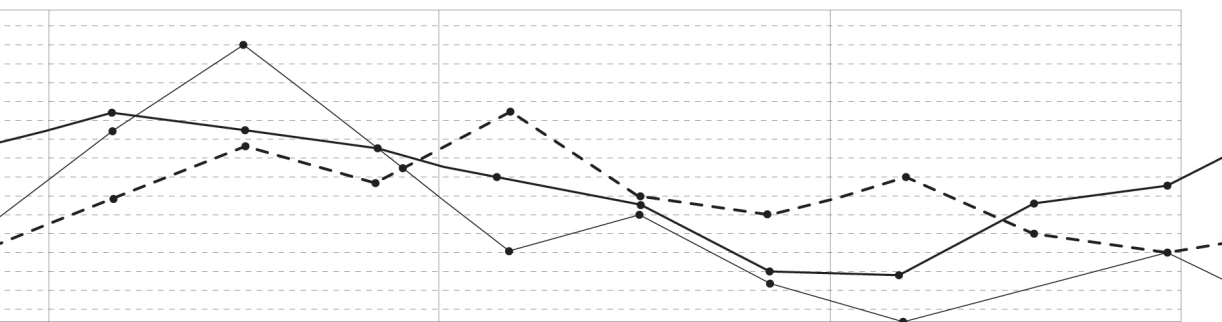
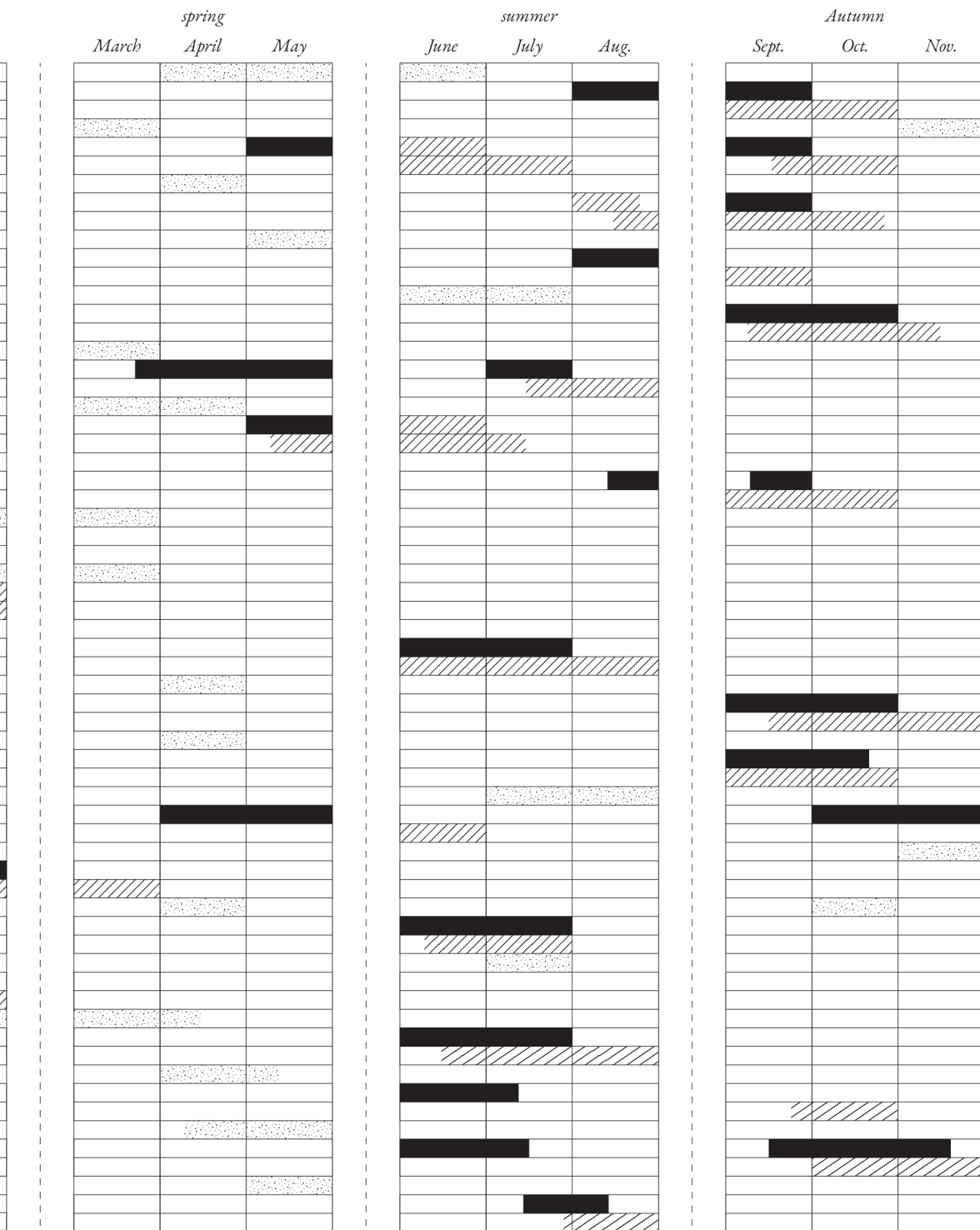
crops	resilience			pattern	irrigation	workers	soil	sun
	water need	f	d					
corn	●●●●●●●●	○ ○	○ ○		surf-sprink	⊙ ⊙	deep fertile sandy	○ ○ ○ ○
pea	●●●●●●●●	○	○ ○		drip	⊙ ⊙ ⊙	silty heavy clay	○ ○
pepper	●●●●●●●●	○	○		surf-drip	⊙ ⊙ ⊙ ⊙	sandy drained	○ ○ ○ ○
sugarbeet	●●●●●●●●	○ ○	○		drip rainfed	⊙ ⊙ ⊙	clay	○ ○ ○ ○
tomato	●●●●●●●●	○	○		surf-drip	⊙ ⊙ ⊙	clay	○ ○ ○ ○
asparagus	●●●●●●●●	∅	○ ○		drip	⊙ ⊙ ⊙ ⊙ ⊙ ⊙		○ ○
beans	●●●●	○	○		surf-drip	⊙ ⊙ ⊙	well drained	○
vineyard	●	○	∅		drip	⊙ ⊙	sandy clay	○ ○
fruit trees	●●●●	○ ○	○ ○		drip	⊙ ⊙	sandy silt	○ ○ ○
olive	●●●●	∅	○ ○		drip	⊙ ⊙	wide range of soil	○ ○ ○
wheat	●●●●	∅	○ ○		drip rainfed	⊙	sandy silt clay	○ ○ ○
nuts	●●●●●●●●	○ ○	○ ○		drip	⊙ ⊙ ⊙	sandy clay	○ ○ ○
red pepper	●●●●●●●●	○	○		surf-drip	⊙ ⊙ ⊙	sandy drained	○ ○ ○ ○
artichoke	●●●●●●●●	∅	○		surf-drip	⊙ ⊙	deep sandy drained	○ ○ ○ ○
lettuce	●●●●●●●●	○ ○	∅		surf-drip	⊙ ⊙	sandy silty	○
alfalfa	●●●	∅	○ ○		sprink	⊙	wide range of soil, deep	○ ○ ○
cauliflowe	●●●●	○ ○	○		surf-drip	⊙ ⊙ ⊙	sandy drained	○
barley	●●●	∅	○ ○		drip rainfed	⊙	gravel limestone	○ ○ ○
cotton	●●●●●●●●	○ ○	∅		surf-sprink	⊙	sandy loam well drained	○ ○ ○
rice	●●●●●●●●	○ ○	∅		surface	⊙ ⊙ ⊙ ⊙ ⊙ ⊙	wide range of soil	○ ○ ○
bamboo	●●●●●●●●	○ ○			surface	⊙ ⊙ ⊙ ⊙ ⊙ ⊙	wide range of soil well drained	○ ○ ○

water flow _____

seeding/harvesting - - - - -

average water need —————





▲ Crops in North Italy. Source: Eurocrop, 2018

Relation between resurgences and ricefields

The spring water comes from the aquifers and it is used for the ricefields' submersion.

Resurgence water is water from precipitation or from surface water systems that percolates into the soil and it is collected in aquifers.

Once this water reaches the ricefield system, where the soil (should be) is permeable, the water stagnates and creates natural microhabitats, both in the actual resurgence and in the ricefields, such as organic carp farming.

The ricefields system represents an accumulation lung for water coming from the Alps which is then returned to agricultural irrigation on its way to the Adriatic. Ricefields constitute an important interconnection between surface and deep waters but unfortunately this balance has been spoiled in recent years with dry cultivation.

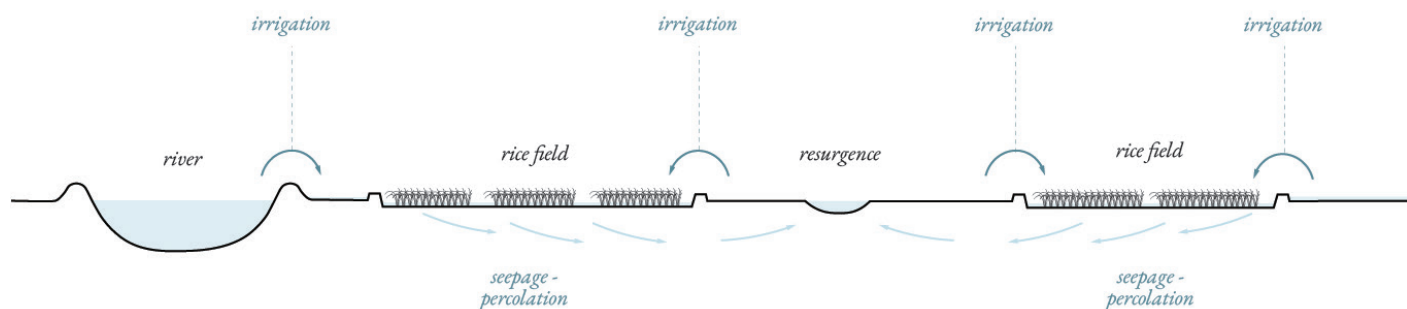
It is common to think that using water for submersion is excessive, in some ways a waste. In reality, the ricefields are part of a vast and complex water system that starts from Lake Maggiore and reaches the river Po. In the last two decades, also due to new sowing techniques such as dry sowing, only apparently more thrifty in water management, the balance that had been created in two centuries of rice development has been altered.

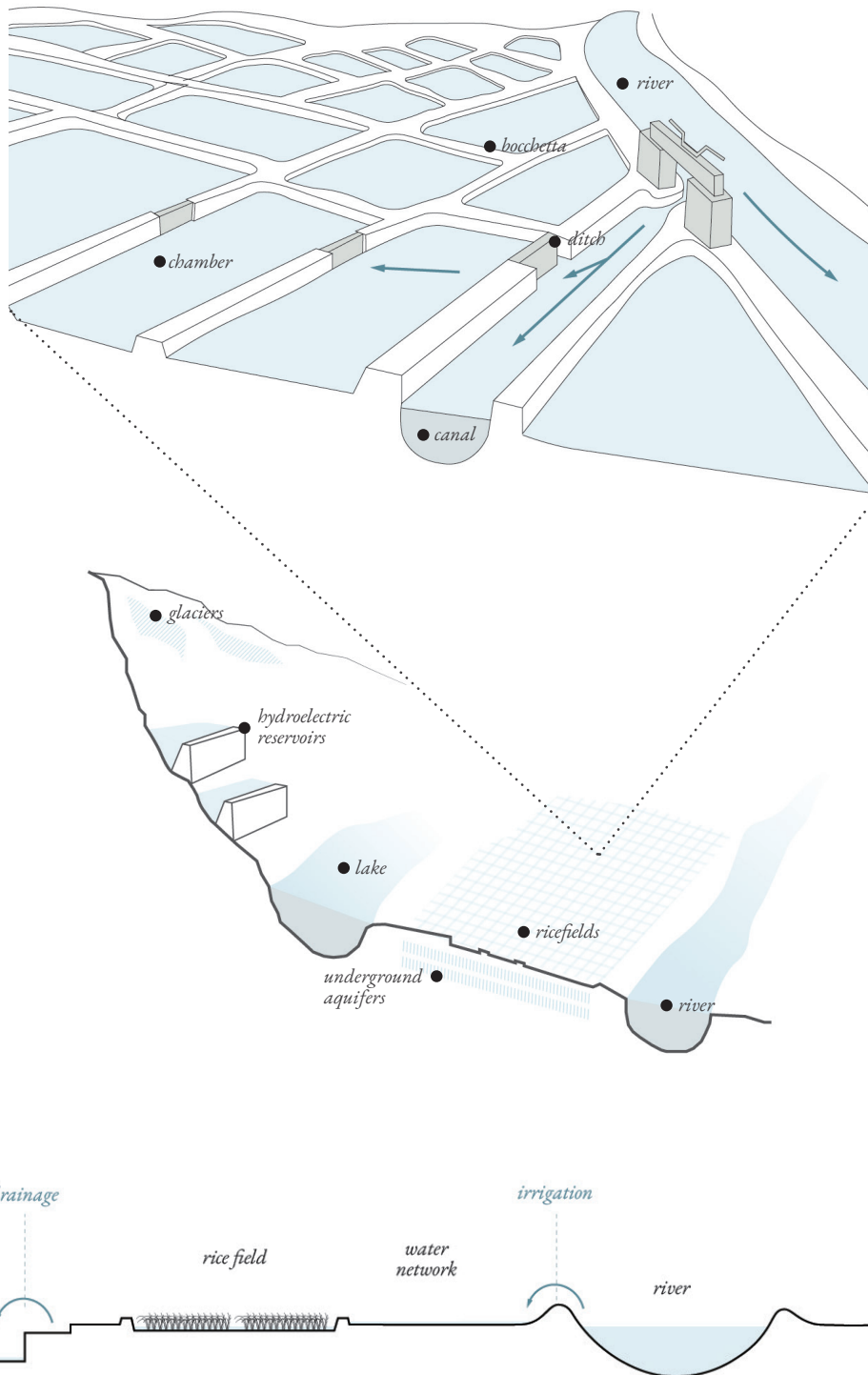
Submersion increases biodiversity, providing habitat for wildlife, and the naturalistic value of the rice-growing landscape.

Today the flow of water introduced into canals, ditches, held back by dams and locks, received by fountains and finally by rivers is very different from the past. When there is water, problems are not seen. With this year's drought, however, the repercussions affect not only the ricefields, but all agriculture in a significant part of the Po Valley.

Italian ricefields, when flooded, are in fact, like a large sponge that retains the water and slowly releases it into the enormous groundwater below.

The water penetrates the permeable ground, passes through the various layers and stops at the impermeable bottom of the aquifer. It flows downstream and is taken up again in canals and wells, reused several times from upstream to downstream, until it is finally returned to the Po river.



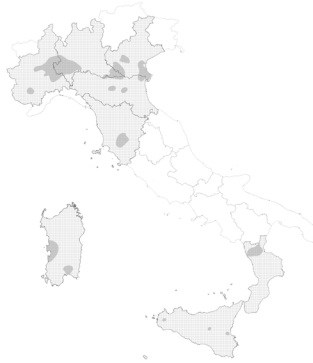


The cultural landscape

As already mentioned before, the landscape of northern Italy is a landscape rich in history that it still retained in its different elements: agricultural landscape, water landscape and architectural landscape.

The water-rich land allowed the agricultural landscape to develop and the fertility of the land was celebrated by building religious monuments nearby those areas.

All these elements are a strong presence in the land of ricefields which is located between Piedmont and Lombardy.



“When we think of ricefields, we usually think of their most poetic moment and their most beautiful aspect: that spring season, between April and May, in which the “lower plain” filled with water and the ricefields all together became a sea, which reflected the stars and the snow-laden Alps. That season lasted just under a month and then, the surface of the water began to be covered in green, and then again, in the space of a few days or a few weeks, only the rice could be seen. The sea transformed into an immense prairie and the prairie began to be populated with frogs.”

(Sebastiano Vassalli, n.d.)

These lands, still cultivated, are facing a period of crisis due to global warming and the presence of pollutants. This area is in fact densely urbanized and the landscape that remains is totally dedicated to agriculture. Although the landscape created by the immersion of rice is suggestive, when this does not happen (as in periods of water shortage in 2022 and 2023) the territory is abandoned. Before going into the problems of monoculture and rice production, it is important to understand its origin and history throughout the centuries.

The agri-cultural heritage

The origin of rice - Rice cultivation has its roots in the Far East in the regions located at the foot of the Himalayas, in China and in the countries of South-East Asia. Asia is precisely the place from which the *Oryza sativa* species originated and was domesticated. Discovered by some communities of proto-farmers as a vegetable from which to draw nourishment, they started a domestication activity through an initial action of collecting its seeds, moving on to the cultivation of spontaneous fields, finally arriving at the sowing of this wild rice. We became aware of their capacity for resistance even when transplanted as young rice plants in fields other than the original one, a characteristic that they had most likely developed in regions particularly subject to intense floods whereby in flooded fields they were uprooted and made to flow into muddy areas located further downstream, this wild species began to be cultivated by proto-farmers in areas that were more easily accessible or in any case closer to the villages. Depending on the climate of the territory in question, the japonica subspecies developed in China, and indica south of the Himalayas. The first, typical of temperate climates, has a small and rounded grain while the second, typical of tropical climates, is characterized by a more elongated and thin grain. The first cultivations in China date back to the period of the Xia dynasty (ca. 2195 BC - 1675 BC) and that of the subsequent Shang (1675 BC - ca. 1046 BC), among the sedentary matriarchal tribes that arose along the Yellow River (called Huang He) and the Yangtze River (known as the Yangtze).

75

However, some archaeological research carried out in 1973 by university professor Wang Zauze would seem to anticipate the history of the practice of rice cultivation to 5000 or 6000 years ago, tracing it back to the period of the Neolithic culture of Yangshao (5000 BC - 3000 BC) in the province of Zhejiang, in Hemudu, in the lower Yangtze River basin. Furthermore in the Hunan region, some rice grains found in bowls and dating back to 8200-7800 BC, would show how this cereal was already known then. Widely cultivated in China, to the point of establishing itself as the main cereal given its important productive yield, rice was not only used as a food but also for the production of alcoholic beverages obtained thanks to its fermentation and this technique was soon widespread in all of Asia reaching navigator, geographer and cartographer who in the service of King Darius of Persia made an exploration trip to India during which, along the Indus river, he discovered this cereal that grew in Pakistani lands; while it was only known in later times, in the 4th century BC, by the Western world thanks to Alexander the Great's expeditions to India.

Widely cited by various Greek and Latin authors, rice was considered a healing spice from the East until the Renaissance, capable of remedying intestinal, digestive and other problems, as reported in some texts from the Roman era. author Dioscorides Pedanio including *De materia medica*,



while in the food field there is no evidence attesting to its use within the normal diet. In the work *Geographica* by the Greek geographer Strabo, this cereal is described and southern Afghanistan, Korea, Japan and the islands of the Pacific Ocean are identified.

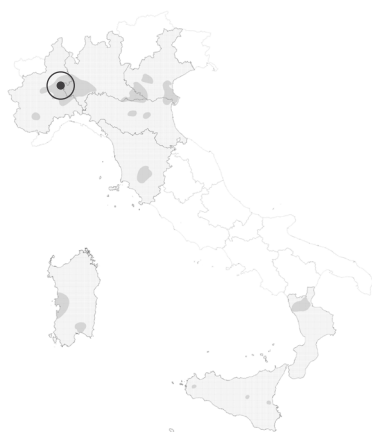
In the "Land of the Rising Sun," rice first arrived on the island of Kyushu in 2000 BC. approximately, brought by the Chinese people when they migrated there from the Shandong peninsula, most likely passing through Korea, or from the delta of the Yangtze River sailing towards the archipelago, and the variety that spread on Japanese soil was mainly the japonica one while the indica one developed only in the southern islands.

In India some Sanskrit texts from 3000 BC. they tell the story of the rice plant through a botanical-agronomic classification and describing its cultivation techniques. Cultivated and used in these places of the Far East as a food, it was first known from the Middle East through the Persian people, as witnessed in some writings dating back to the 6th century BC. of the Greek

Scyllace of Carianda, Northern Iran, lower Syria and the West Bank as the places where it was cultivated. Although rice had already been established in some areas of the Mediterranean already in Roman times, the period in which it began to be cultivated is uncertain, presumably by the Arabs after its probable Indian introduction, in the territories of Palestine, the West Bank, Syria and later also in Egypt. On African territory it is thought that it was most likely the Arab populations who introduced rice cultivation in Algeria and Senegal and then spread it to other western areas of the continent.

In Europe we had to wait until the 8th century AD, with the Arab conquest of Spain on the Visigothic kingdom, to probably ascertain its first cultivation, which certainly occurred later, as described in some documents, in the 12th century in the Spanish cities of Alzira and Xativa. From here, from the 13th century, the cultivation of this cereal began to spread first in Portugal and then in France, in the Camargue region, between the 15th and 16th centuries. In Italy, although we do not have precise information regarding the introduction of rice cultivation, it is assumed that this crop was introduced first in Sicily by the Arabs in the 8th century near the Lentini plain, while in the Po Valley, the hypotheses regarding the introduction of rice are multiple: according to some scholars in the areas of Piedmont and Lombardy it arrived at the time of Charlemagne brought by his soldiers at the end of the battles against the Arabs, while according to others its diffusion in central-northern Italy would have been favored by the commercial affairs of the Venetian merchants with the oriental world. However, the first document certifying the cultivation of rice in Tuscany dates back to 1468 in which a certain Leonardo Colto dei Colti, a landowner, asked to be granted the use of water for the cultivation of rice in some fields near Pisa and in 1475 the two letters from the lord of Milan, Galeazzo Maria Sforza, to Nicolò de' Roberti, in which the duke donated 12 bags of rice for sowing to encourage its cultivation also in the Ferrara territory of the Marquis Ercole I d'Este. This last fact demonstrates how the duke had already started the cultivation of this cereal for some time, in fact according to some studies this cultivation had been experimented in 1470 at the ducal estate of Villanova di Cassolnovo in Lomellina and from here it had then spread to the Sforza farms located in the surroundings of Vigevano, then reaching the Novara area and the whole of Lomellina, finally arriving in the Vercelli area in 1493. Although in the 15th century the kingdom of Naples came under the Spanish dominion of Alfonso of Aragon, starting a small rice business in Paestum, Piedmont and Lombardy.

The history of rice in North Italy - Vercelli -



I-II century AD

First land reclamation (military)

From the first and 2nd century AD vast uncultivated areas were donated to the military to reclaim the land and make it productive; most of these interventions were concentrated for some centuries only in the areas located along the main communication routes or near major urban centres, hence so the marshes and woodlands still dominated a good part of the Vercelli area. In the beginning of the first millennium woods, marshes, forests, thickets and barracks dominated the territory.

XII century AD

Abbazia di Lucedio (monks)

In the beginning of the XII century AD the Cistercian monks of the Abbey of Lucedio thanks to the recovery of areas marshy areas and subsequent construction of channels for water management created the conditions for the introduction XV century rice-growing activity.

1864

Cavour canal

With the nineteenth-century creation of Cavour canal, designed to divert the waters of the Po in order to remedy the problem of summer drought beyond the Sesia river in the Lomellina and lower Novara areas, complex canalization works were started which led to a growth in the irrigation network and a consequent increase in rice paddy area.

XX century AD

World War I

During the First World War there had been a significant increase in the rice-growing area due to a growing demand for this cereal, which occupied 40% of the agricultural landscape Vercelli, once the war was over the rice sector suffered a profound crisis due to importation of rice from Asia. The Fascism tried to support the national rice production establishing in 1931 the Ente Nazionale Risi and with the which undertaken programs for example research on new rice varieties, supports financial aid to rice growers and setting the price at a national level.

1960

World War II and the agricultural mechanization

In the period following the Second War, new ones were cultivated worldwide varieties such as Carnaroli, Vialone nano, il Baldo and the S. Andrea; The agricultural mechanization and the introduction of chemical herbicides meant that the laborers until then present in rice field like the one represented by figure of the rice weeder would disappear in the early 60s. From this moment on, the agricultural technologies and techniques became increasingly innovative that the work in the rice fields became simpler and quicker.

XV century AD

Primordial irrigation system

The system of natural streams and fountains was revolutionized thanks to the fifteenth-century creation of secondary canals such as the Canale del Rotto and the Naviglio d'Ivrea which, taking the necessary water from the Dora Baltea, a tributary of the Po, allowed the start of a primordial irrigation system in the Vercelli area based on canals and the first cultivation of this cereal, without however allowing it to establish itself as a reference crop. Lucanian monks, being owners of two thirds of the work, were able to exploit the water from the canal for the irrigation of the first ricefields, used initially for medical purpose.

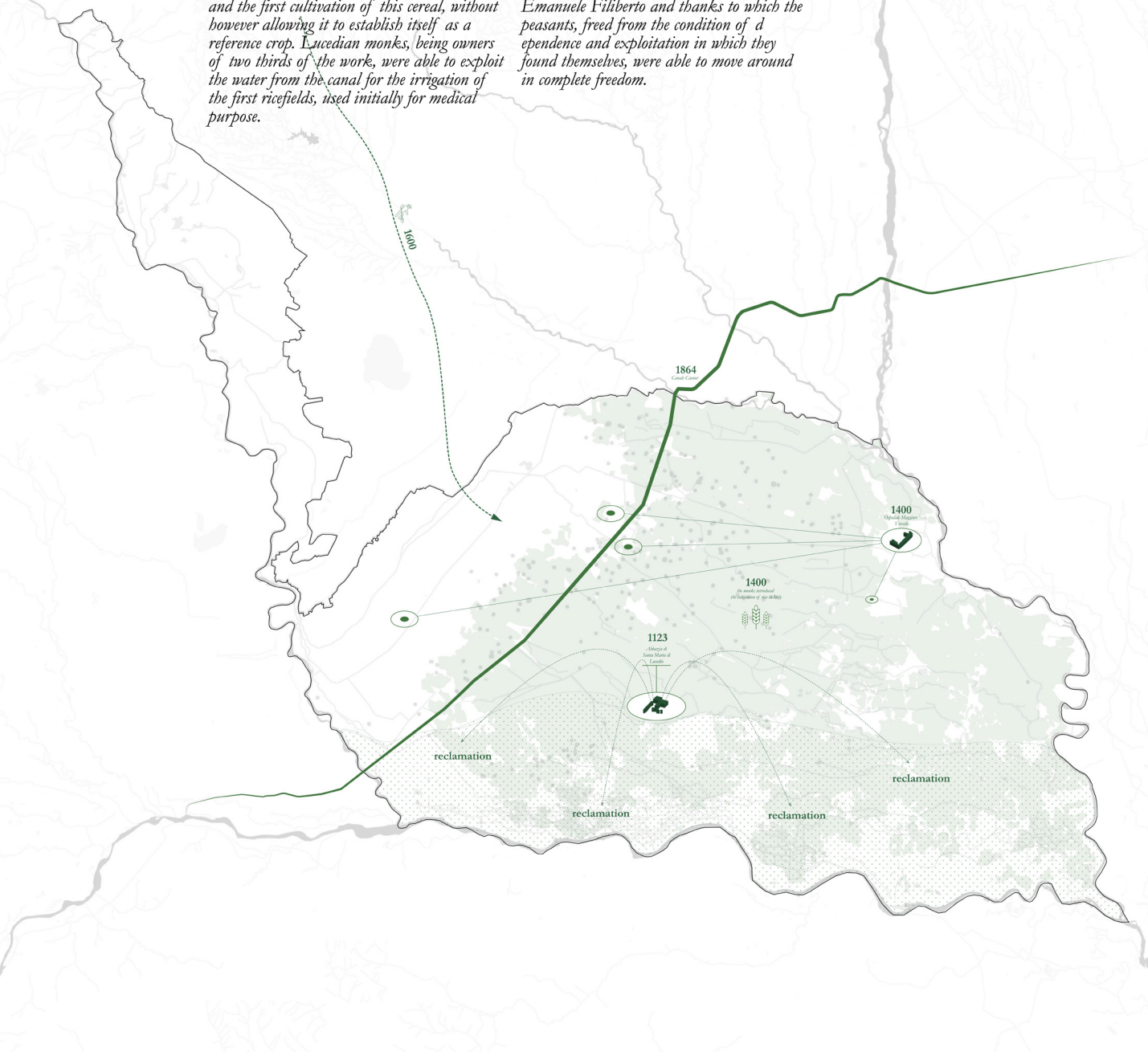
Job opportunities

The introduction of this new crop offered new job opportunities especially among the inhabitants of mountainous or poor areas who saw working in the rice field as a real turning point. Their influx into these places was further favored in the second half of the sixteenth century with the abolition of serfdom, at the behest of the Savoyard duke Emanuele Filiberto and thanks to which the peasants, freed from the condition of dependence and exploitation in which they found themselves, were able to move around in complete freedom.

XVII - XVIII century AD

Wars, French and Spanish domination

The XVII century was a historical period marked by wars, plagues and French and Spanish domination. In the XVIII century the Vercelli area was affected by the War of Spanish Succession that ended in 1714, after 13 years of european conflicts, it profoundly marked the countryside.



The architectural and religious heritage

The abbeys' system - The agricultural, industrial and cultural wealth of the Po Valley owes a lot both to the rich system of resurgences and to the irrigation network connected to them. Surely the abundance of water, the fertility and the richness of the soils were the decisive elements to start a virtuous mechanism that saw its peak in architectural works such as abbeys, parish churches and fortified farmhouses.

The conspicuous difference between the characteristics of the flowing waters and those of the resurgences, led many Cretical orders to build churches, sanctuaries and abbeys. The religious found in these waters some of the most important prerogatives of positivity that are the basis of the Christian concept of life.

The purity and clarity of the waters were interpreted as the washing of the impurities of sin, their abundance and regularity of flow were conceived as symbols capable of opposing the impetuosity that overwhelms and destroys everything. The transparency, the sparkle and the gurgling of the waters emerging from the subsoil led the religious to meditation.

Over time, this led to the definition of the low irrigated plain not only as the "Garden of Europe" but also as the "Garden of Christianity" (Provincia di Milano, 2002).

Monastic communities - The monastic community, coming from Burgundy, settled in the Vercelli area, now known for the cultivation of rice, in the first half of the 12th century (1123).

The monks reclaimed the territory and were the first to cultivate rice in the humid areas of Piedmont. This cereal was initially used as a medicine, for a soothing and anti-inflammatory effect. The monks also began the first works on the construction of canals for the agricultural system of the area.

Le grange - In order to take care of and make the most of the Order's numerous land holdings, the monks introduced the granges: a sort of monastic agricultural settlements, which combined the advantages of central planning with local autonomy. Born initially as simple granaries, i.e. warehouses for the storage and drying of cereals, hence the term grange, over time they underwent expansions and transformations on an architectural level with the addition of stables, sheds and houses aimed at housing animals, tools, lay brothers, shepherds and laborers.

These were real agricultural management centers representing early Cistercian agriculture and which originally could not have been more than a day's journey from the monastery both because their proximity facilitated their control by the abbey and because the monks were able to return to the same place for the night and because the lay brothers could participate in the Sunday religious offices that were held at the abbey. The management of the granges was entrusted to the abbot, while the cultivation of the lands was placed in the hands of monks and lay brothers. Work was in fact, an essential



piece in the existence of the white monks, since from this derived both their very survival and the salvation of their soul, which occurred through prayer, manual labor and physical sacrifice; consequently, they personally took care of the management of their land holdings. During the plowing or harvesting period, external labor was very often used, but the multiplication of the granges and their excessive distance from the abbey made it necessary to increasingly resort to the help of inhabitants of nearby villages to support the lay brothers in their work.

The figures that could therefore be found within the “abbey-grange system” were multiple starting from that of the abbot, a figure who assumed the most important function since he played the role of owner, entrepreneur, worker and manager of the lands, of personnel and animals; the cellarius, i.e. the monk who took care of the economic resources of the abbey; the grangiarus, a figure with the task of organizing and supervising the work inside the grangia; the lay brothers, lay people who carried out agricultural activities and who took on greater responsibilities within the companies from the moment in which the monks were not allowed to stay overnight outside the abbey; and finally the familiaris who occupied the last place within the hierarchical scale and were servants who worked alongside the lay brothers and who lived inside the granges.

La cascina a corte: the farm house - Starting from the 12th century, with the frequent attacks and looting in the countryside, the granges began to be equipped with a defensive system, towers and sometimes ditches were built along their perimeter. The arrangement of the various buildings on the four sides of a courtyard and leaning against each other, from the oratory to the homes of the grangiere, the lay brothers, the familias and the salaried workers; from stables and closed sheds for animals to cellars, dairies and granaries; from open spaces such as porticoes for the storage of carts and tools to rooms for carpentry, workshop and weaving activities; it gave the granges an architectural layout that followed a sort of “closed courtyard” scheme. The idea of limiting and closing large square and rectangular courtyards, equipped with threshing floors, can still be seen today in the large companies of the Piedmont and Lombardy plains.

The Cistercian foundation of Lucedio certainly played an important role in the rural reorganization of the local territory. Nowadays, the six first granges (Castelmerlino, Darola, Montarucco, Leri Cavour, Montarolo, Ramezzana) show very little of their ancient medieval face, certainly retaining the name of origin still traceable in historical documents, but almost all of them renovated over the centuries, now presenting themselves as nuclei with stratified architectural characteristics as they belong to different eras. The years between the XVII and XVIII centuries were the first to see an initial general renovation of these granges and the provision of each with a

religious building. Without a doubt, however, it is the transformations that occurred between the nineteenth and early twentieth centuries that had a more significant impact on the original structure due to the enlargement of the farms with the consequent addition, very often, of a second courtyard. From a functional point of view, most of these have retained their original agricultural production activity and among them, some also host new functions aimed at the public, others instead find themselves in conditions of total abandonment.

Leri Cavour - In November 1179 the grange was purchased by the monastery of San Genuario, to which it already partially belonged, and in the deed reference was made to a *castrum et villa de loco Alerii*, which therefore shows us that a centre was present at the time fortified, of which today however there are no visible and tangible testimonies.

At the beginning of the nineteenth century the grangia became the property of the Cavour family who transformed it into a truly modern agricultural company, eliminating and re-adapting some ancient buildings, and thanks to the cooperative work between Count Camillo and his friend Giacinto Corio the grangia played an important role in agricultural progress. Nowadays, Leri Cavour is unfortunately in a state of abandonment and degradation.

83



▲
Leri Cavour. *Source:*

Important characters of ricefields

Camillo Benso Cavour, the 2.0 farmer - Second son of the Marquis Michele di Cavour and Adele de Sellon, Camillo was born in Turin on 10 August 1810, in the midst of the Napoleonic period. Camillo had to decide whether to undertake the military or ecclesiastical career. He opted for the first and at the age of 10 he was admitted to the Regia Military Academy. After graduation, in 1825, Camillo began his military life and but he retired in 1831.

While travelling Cavour matured his political growth, strengthening his liberal ideas and the concept of democracy. Once he returned to Piedmont, his brother entrusted him with the Leri farm with the intention of helping him find a job. In 1835, Camillo dedicated himself to the management of Vercellese territory. From this new occupation he had a lot of satisfying achievements. In his activity as a “farmer” Camillo was always a skilled self-taught. When he approached the management of family estates, he had no training neither theoretical nor practical, but his tendency to want to know led him to document himself, to research soon to expand his knowledge. The numerous trips abroad were moments of important training for Camillo and above all England played an important role. Here he studied agriculture with the aim of drawing useful lessons, especially in field of livestock farming, fertilizers, drainage and machinery. Thanks to the meeting with Giacinto Corio, a farmer from Livorno Ferraris and tenant of an estate in San Genuario (1843) and his subsequent entry, in 1849, as a partner in the management of the estates of Leri, Montarucco and Torrone, the latter then purchased by Camillo in 1836, Cavour was able to improve not only these family properties in Vercelli but also initiate important experiments in the agricultural, zootechnical, mechanical, chemist and plumber who had a significant impact both on his companies and on Piedmontese agriculture (Rosario Romeo, 2012).

Previous change in agricultural practices - Throughout the centuries, the agricultural practices have changed.

Camillo Cavour was one of the main characters for the introduction of new practices for ricefields. He studies crops rotation, new crops, machinery, fertilizers and drainage system.

While managing the vast Vercelli property, Camillo Cavour immediately noticed the advantages of the crop rotation in the area, especially in the practice of rice cultivation. Contrary to what his father had started in previous years, with the reduction of ricefields in favor of meadows to increase the production of forage useful for livestock farming, Camillo extended rice cultivation.

The crop rotation present in the Vercelli area, with the disappearance of the rest-year (the year where land was not cultivated), had led to important progress compared to the early years of the century. This five-year rotation was based on the cultivation of dry crops for two years: corn the first year

and wheat the second, before moving on to the cultivation of rice in the following three years. It therefore opened with a first year of renewal crops, such as corn and in some cases also oats, on heavily fertilized land and then ended with three years of paddy fields without any further fertilization of the soil.

As a consequence of this crop rotation system introduced in Leri, they witnessed the gradual disappearance of the problem linked to the scarcity of manure and the reduction in the fertility and productivity of the soils. It was noticed how the sowing of rice for five consecutive years was causing a gradual decline in product yield.

The main innovation brought by Cavour was the experimentation with the cultivation of sugar beet. In France and in Germany, between 1836 and 1837, there was a revival in the production of sugar from beetroot, Cavour decided to attempt the cultivation of this herbaceous plant on the Leri area, although already in 1835 had started a cultivation of fodder beet on the Grinzane area. If the experiment carried out in Leri had been successful, the count's next intention would have been to build a sugar factory on the property to process the product on site and consequently start a sugar factory in Piedmont. In fact, studying the French situation, Cavour stated that Piedmontese farmers could produce raw sugar at a better market than the French and enjoy the same profits despite a price difference between the two countries; however, Camillo abandoned this project and dedicate himself to the cultivation of fodder beet.

Regarding rice cultivation, in addition to the attention that Camillo paid to the improvement and care of the fields through their leveling, the removal of non-essential banks and the rectification of the irrigation channels, he experimented with different varieties of rice including the Bertone, which came from America and spread very quickly throughout Piedmont due to its cycling qualities short cultivation, allowing the subsequent sowing of other crops, and resistance to the brusone (rice fungus) attack. However, the discovery of some negative aspects such as its tendency to impoverish the soil and to vary its productivity depending on the fertility of the soil, led many farmers to abandon the production of this rice variety. To deal with the health problems caused by rice cultivation, with water stagnation and the consequent spread of malaria, Cavour attempted to sow a rice from Nicaragua, suitable for dry cultivation and therefore suitable for cultivation on his Montarucco estates. and Torrone where there was a water shortage.

Today, rotation remains a proposal explained by agronomy texts and experts which only sporadically finds application in rice farming. Rotation is a constant cycle in which the same crops alternate in the field at equal time intervals. The interchange is a succession of different crops at unequal time

intervals. Among the crops used for interchange in rice cultivation, soybean is having a certain diffusion as it is an improving species capable of fixing nitrogen. Rotation and interchange are accompanied by intercrops which, within the same agricultural year, succeed the main crop: this is the case of grassland and fodder which can sometimes be used for green manure. The benefits are undeniable from an agronomic point of view, but having to manage different crops can force the rice grower to use a contractor, complicating business management.

The strong soils of the Vercelli and Novara areas do not allow the cultivation of corn after rice: in order to obtain acceptable yields it is preferable to switch to an intermediate crop such as barley.

The ricefields: an open air factory - Looking at the ricefields as a whole: the land, the means used, the working methods, it is possible to discover a production system that for each operation organizes and exploits every minute of the working time of a mass made flexible and adaptable to the needs of production.

86

Comparing the ricefields and the factory, which in Italy has been experimenting with new structures and organizational models since the second half of the nineteenth century, it is possible to state that in the ricefield area the capitalist revolution has already taken place and finds a limit only in the cycle of the seasons.

It is the cycle of nature that prevents the exploitation of labor from reaching total saturation; at the same time, this rigidity of the cycle becomes a stimulus for the agricultural entrepreneur to make the most of the workforce when it is used. But in turn the exasperated exploitation and the rigidity with which the work is used will be the elements at the basis of the social protest when a cultural gap will make the mass of labourers, workers and pickers perceive the unbearable injustice of their condition.



Le mondine - *Le mondine* had an important influence on the history of the ricefields and the economic development and they are still part of the nation's popular imagination. Tens of thousands of women fowed into these areas every year for transplanting and rice-mopping, the weed-cleaning, which took place in a lean position, in a linear array that advanced slowly with legs and arms immersed in water, underneath large straw hats that protected from the sun and insects: a hard work that began at dawn and ended at sunset, in a defined time and space, characterized by female exploitation, by first labor

unions of women, by the resiliency to this dramatic condition throw the expression of the song.

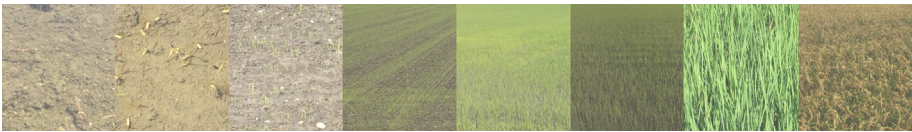
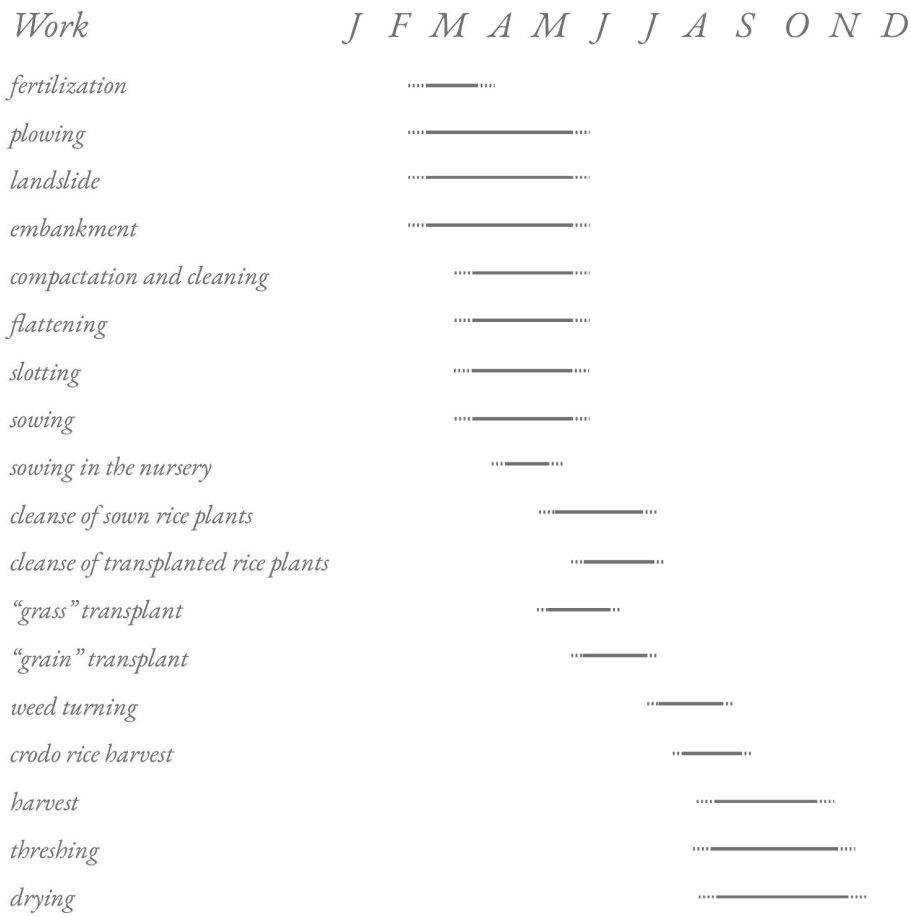
Mondine's choirs, sometimes poignant, which rose liberating in the days of the rice feld and marked the time of work, protest and nostalgia for the distant home, has become part of the history not only of these places, but of all of us.

Other important characters of the ricefields and resurgences where weeders, agricultural labourers, fishermen, boatmen and washerwomen.

*"E lotteremo per il lavoro, per la pace, il pane e per la libertà,
e creeremo un mondo nuovo di giustizia e di nuova civiltà"*

The life of rice

Cultivation phases



Fertilization - In the basic fertilization, which is carried out at the end of March, organic and mineral fertilizers are distributed to provide nitrogen, phosphorus and potassium to the extent that the soil and the plant require. The objectives of this fertilization are multiple: 1) to modify any state of soil deficiency, with reference to the individual nutritional elements necessary for the growth of a healthy and vigorous plant; 2) increase the fertility potential of the soil; 3) compensate for the removal of elements resulting from the production and harvesting of

rice, taking into account the inevitable losses; 4) restore, between the different elements of fertility, a relationship proportionate to that of their use by the plant; 5) increase the commodity value, as well as the biological one, of rice.

Plowing and leveling - Between winter and spring, the soil is turned over. The tractors tow equipment equipped with large steel blades into the field that cut the soil, work it and turn it over. Turning the soil with the plow serves to aerate the soil, facilitate the incorporation of fertilizer, sink organic elements and clean the soil of spontaneous adventitious or weedy grasses. Once plowing has been carried out, the ground must be levelled, to obtain a perfectly flat “chamber”, without unevenness or holes which would be an obstacle to meticulous water control. One of the first conditions for achieving a superior technical-economic result in rice cultivation is to prepare a seedbed that is as flat as possible. Reliefs and lowlands, in fact, do not allow accurate water maneuvers, do not allow the fertilizing elements supplied to be used uniformly and prevent the plant from being able to tiller regularly.

Years ago, water was introduced into the ricefield which, acting as a level, made it possible to identify reliefs and lowlands, which were then chopped up by women with mattocks, while a horseman leveled the ground with the leveller, or passed by with a towed wooden plank. from a horse. This operation was rather tiring, as it was performed barefoot in the still cold water of early spring.

Today, leveling takes place on dry ground using a laser level: a stand equipped with a transmitter is positioned in the field which sends the laser signal to a receiver positioned on the tractor. Consequently, the level rises and lowers automatically to perfectly level the ground.

In this phase it is important to consolidate the banks to avoid landslides and it is essential to carefully clean the ditches and canals, as well as arrange the locks that allow the passage of running water and the regulation of the difference in height between the various ricefields.

The harrowing - It is a process that consists in breaking the surface crust of the soil formed following leveling. In the past, it was carried out both by using a fixed harrow, pulled by a horse led by a rider, and by hoeing (sliding) which was entrusted to women. Nowadays, however, the harrow towed by a tractor is used. Harrowing is a fundamental process for aerating and oxygenating the soil and is essential both to allow the incorporation of fertilizers distributed into the soil and to facilitate the sowing of rice.

The submersion - The function of submersion, which takes place immediately after harrowing and levelling, is to protect the future seed

and seedling from temperature changes and keep them at a constant temperature; it occurs by filling the ricefield with running, clear and crystalline water.

The presence of rice is therefore favored by the abundance of water. The Piedmont region is widely cultivated with ricefields thanks to the large quantity of water available both due to the presence of springs and the presence of artificial canals, the most important of which is the Canal Cavour, an 80 m long water highway km, which starts straight, curves where needed and passes under the rivers. It is a capillary network that dates back to the 15th century: some sections were designed by Leonardo.

The main axis, the Cavour Canal, takes its name from Count Camillo Benso di Cavour, at the time President of the Council of Ministers of the Piedmontese Government and who was one of the promoters of this great work, whose works began in 1863 and ended in 1866: 14,000 men in less than three years created, with bricks and natural stone, a complex system that would allow the irrigation of the land and which is, still today, considered the flagship of Italian and European hydraulic engineering : a colossal irrigation project that laid the foundations for the future “golden triangle of rice”. The Cavour Canal originates from the Po river in Chivasso (entrance key), is integrated with the waters of the Dora Baltea, crosses the Vercelli plain, passes under the Sesia river and runs through the Novara plain and then ends in Ticino. The Sesia river (literally “La Sesia”) originates at 2,500 m on Monte Rosa, from the glacier of the same name and, descending along the Valsesia, receives the waters of numerous streams until it acts as a natural border line between the provinces of Novara and Vercelli. It is approximately 140 km long and is one of the longest rivers in Piedmont.

The Canal, which draws water mainly from the Po, Sesia and Lake Maggiore, with its branches, serves an irrigation network of 20 thousand km, under the control of the East and West Sesia Irrigation Associations through the water carriers who regulate the channels at millimeter and are able to provide each farmer with the necessary quantity of water. Thanks to flow and submersion, Est and Ovest Sesia take water from the rivers, make it travel through the network and bring it back to the rivers without wasting even a drop.

Men have conveyed the water with a network of ditches and canals that dive into each other to slide into the ricefields to create a rational irrigation system: the submergence of the fields is organized with small locks, dams or embankments that divide the ricefields into various compartments.

In this way it is always possible to have running water in the ricefields and not stagnant water, to avoid the formation of the so-called “cream” on the surface.

The lands flood and it's all a flow of water: first you see the *squared sea* and then the plants that emerge.

Difference between sowing in water and sowing in dry conditions

In a not very distant time, up to about 40 years ago, rice was grown in small plots, called seedbeds, and then transplanted by hand by rice weeder: while a man or boy threw the bunches of rice into the water, the weeder planted the rice plants with their finger into the soft soil (because it was submerged in water), walking backwards, always one next to the other. The seedling ended up in the ricefield only after having passed its first growth phase.

This system, which had become too burdensome, was abandoned; currently, direct sowing is practically the only rice cultivation method in Italy. Today sowing takes place directly in the paddy field chambers, already submerged in water.

It is sown in April, immediately after the ricefields are flooded.

The choice of the moment of sowing is fundamental: if you sow too early you run the risk of the climatic trend of the month of April which can still reserve days with temperatures that are too low. Furthermore, the water used for submerging the ricefields is largely derived from the Dora Baltea and in the canals derived from this nivo-glacial river, in April, temperatures are around 10 degrees. The water in the ricefield has an essential thermoregulatory function in the first weeks of the seedling's development: it avoids excessive temperature changes from day to night, releasing the heat accumulated with the spring sun in the still cool night hours. It can be introduced or removed promptly due to changing climatic conditions, to counteract the development of algae and infesting aquatic vegetation, to kill parasites or to promote the ripening of rice.

Today, for all varieties of rice, we know precisely the time that passes from sowing to harvest and, usually, even for the later varieties, sowing does not continue beyond the first ten days of May, to avoid harvesting at late autumn, with the risks associated with rain and bad weather. To combat the weed variety of "crodo rice", in recent years the technique of late sowing has become widespread, from the second to the third ten days of May, the diffusion of which is also suggested by the growing rationalization of the use of water according to a "gradual distribution" in the territory. Late sowing also allows for the implementation of "false sowing", an ancient agronomic technique which consists in preparing the soil and irrigating it, as if normal sowing were carried out, but, in reality, the seed is not distributed on the ground. In this way, the germination of the seeds of weeds present in the paddy field, such as crodo, is stimulated, which are subsequently eliminated with a mechanical operation using the harrow.

Before proceeding with sowing, the paddy seeds are left in water beforehand to revitalize them and give them weight, so that they do not float on the water, but settle to the bottom: in this way, the risk of seed fluctuation is reduced which would have difficulty taking root and a homogeneous distribution of future seedlings is guaranteed. Sowing in water is called "broadcasting", because it is carried out by spreading the seed in bulk with

a rotating mechanical plate. Nowadays the “spreading” is carried out via a GPS satellite system, which allows for greater precision and less waste of seed.

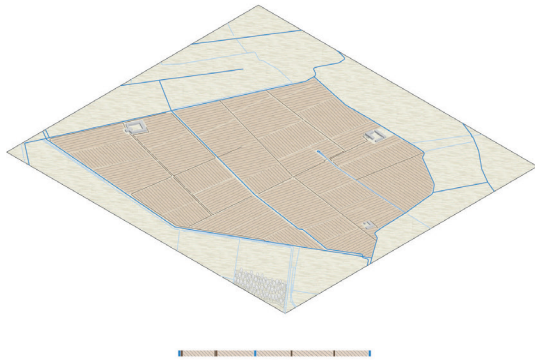
The rice seed is an embryo that contains all the minerals the plant needs in the first growth phase; the seed in water, after about 8 days, swells and emits a “radicle” that extends downwards and a stem that extends upwards: at this point the paddy field dries out to allow the rice plant to take root well in the soil. Subsequently, the field is flooded again: from this moment on, the ricefield is periodically and expertly drained and then irrigated.

Dry sowing - an alternative to traditional water sowing is “dry” sowing. A machine connected to the tractor is used, which creates space for the seed and, at the same time, lets it fall to the ground in long rows; subsequently the “rolling” is carried out thanks to which the seed is buried. By dry sowing, the seed is allowed to emit a “radicle” that extends downwards and a stem that extends upwards. After about a month of drying (approximate time based on the variety of rice and weather conditions), water is let into the ricefield; from this moment on, the ricefield is periodically and expertly drained and then irrigated.

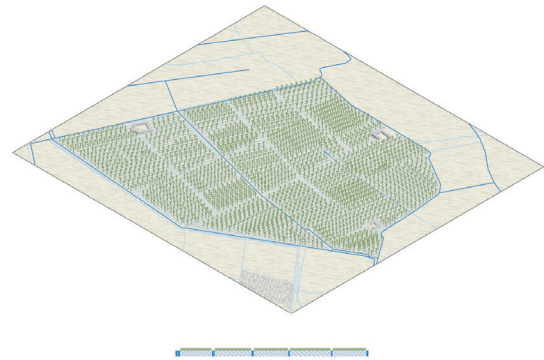
Dry sowing rice, unfortunately, favors an exponential increase in the weed “crodo rice”, a plant very similar to rice. The main characteristic of the “crodo” is the tendency of the kernels to detach from the cob and fall to the ground before the rice is harvested. The crodo plant is recognized because it is taller than the rice plant and the grain is reddish in colour; when it matures, the grain does not remain in the ear but falls to the ground, making it impossible to harvest. Its danger lies in the fact that it matures before the rice and the grain, called *crodata*, which is very resistant and capable of reproducing for years, falls to the ground, uncontrollably infesting the ricefield. This leads to a loss of production which, in the event of a large spread of the weed in the ricefield, can cause a drastic quantitative and qualitative reduction in the harvest.

However, dry sowing allows you to obtain good results in ricefields where there are fermentation problems due to the decomposition of the organic substance, as well as excessive presence of algae, cups or aquatic weevils; furthermore, it limits or delays the development of aquatic weeds (e.g. *Alisma*, *Cyperus difformis*, *Heteranthera*, algae, *giavoni*...), limits the emission of water vapor into the atmosphere and reduces the lodging of tall varieties (such as Carnaroli rice, which reaches higher heights than normal).

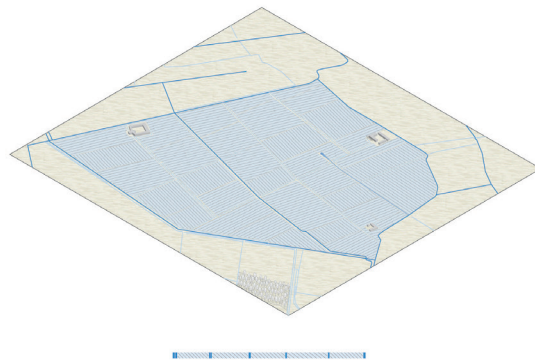
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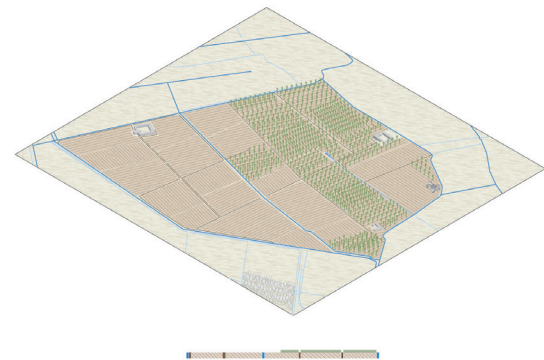
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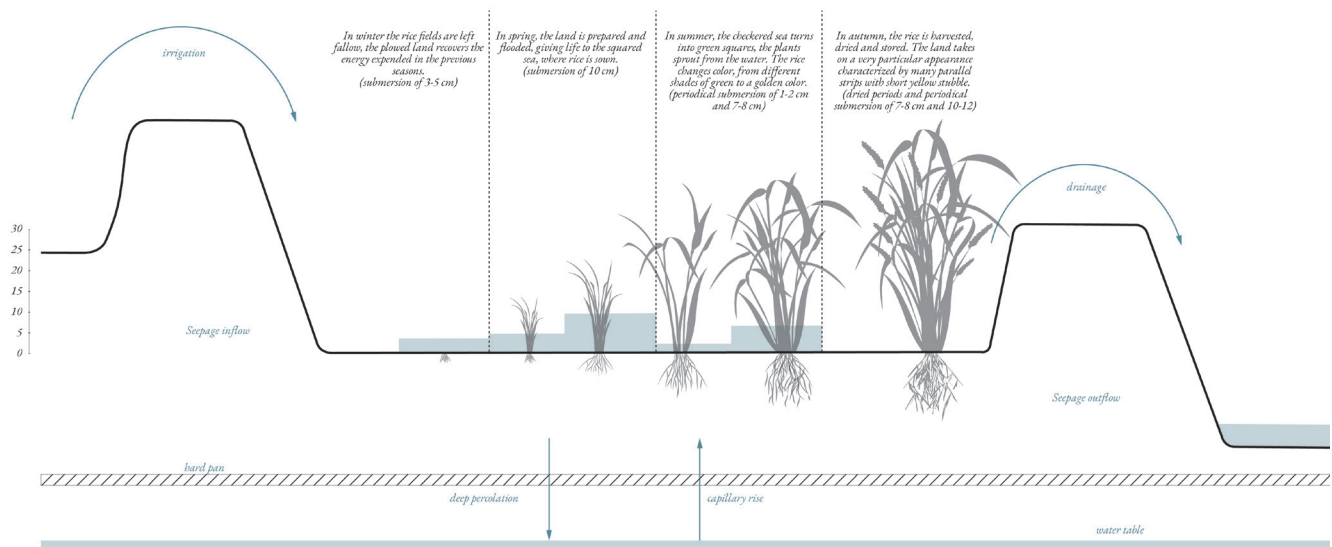
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submerged | summer



93



The biological cycle

Rice is very demanding in terms of heat and water: the temperature must be high and constant to avoid serious damage caused by temperature changes. In the equatorial regions, where the temperature is constantly high, there are also 2-3 harvests per year. In temperate climates the only possible growing season is the spring-summer season and with the aid of irrigation done with systems that also perform important thermoregulatory functions. The life cycle, from sowing to maturation, is 150-180 days.

The biological cycle of rice takes place through different phases: germination, tillering, rising, flowering, fertilization and maturation.

The seed germinates only in optimal temperature and oxygenation conditions; during the *germination phase* the important factors are the quantity of available oxygen and the temperature, which must not fall below 12°C. When sowing in water, the seed is in conditions of poor oxygenation, with water flowing inside the chamber; for this reason, after the formation of the plumage the first drying of the chamber is necessary, so that the primary root binds to the soil and germination can continue. The rooting dryness thus determines the strengthening and elongation of the roots, the best nutrition of the plant and superior vegetative development.

This is perhaps the most delicate phase of the whole year: the seed is in fact still poorly anchored to the ground and at the mercy of waves and currents inside the chamber. Many factors can detach it from the ground and take it elsewhere: the wind, the masses of moving algae and the tiny crustaceans present on the bottom. This phase is considered completed when the plant has formed the second/third leaf.

The next phase is called *treating* and is characterized by the formation of secondary appendages: in a period of 40/70 days from germination, we witness the progressive appearance of secondary shoots and adventitious roots and the ricefield stops resembling a lake, to become a very green lawn. During this phase the culms develop first from the buds located at the base of the leaves and, subsequently, from the buds placed on the already developed culms. The number of culms that develops varies depending on the rice variety, but is also affected by cultivation practices and, in particular, by sowing density and fertilization.

Coinciding with this period - in June - there is the beginning of the *raising* phase during which the internodes of the culm lengthen, the leaves grow and the inflorescence develops.

Rice, in addition to being demanding in terms of temperatures, is very sensitive to daily temperature variations. In this period, the partial submersion of the plant proves to be very useful, as, during the night, the water returns part of the heat accumulated during the day, thus performing the function of a "thermal flywheel", particularly important in our latitudes, for guarantee the fertility of the spikelets and, consequently, good production.

The budding phase ends with the formation of the first inflorescences and the beginning of the plant's reproductive period.

fertilization occurs mainly through self-pollination in the months of July and August. The flowering and pollination process starts from the top of the spikelet and proceeds downwards. The rice flower opens 90-100 days after the germination of the seed, in July, and is protected by the glumes and husks; the flower contains 6 styles which carry the anthers (male organ) which contain the pollen; at the base of the flower there is the pistil (female organ) formed by the ovary and the stigma on which the pollen falls. Fertilization lasts from 5 to 60 minutes: the pollen is collected from the ovule with the help of the feathers and from then (in August) the caryopsis begins to form which matures, depending on the variety, between September and October. During the period in which fertilization occurs, the temperature and humidity of the air are very important.

The last phase is that of *maturation*, during which the ovary transforms into a coated caryopsis: the grain thus begins to receive and accumulate nutrients, passing from a milky consistency to a waxy and finally glassy one. The maturation of the cob also proceeds from top to bottom and ends, depending on the variety, in the months of September/October.

The final product

The harvest - Choosing the right moment for cutting has a certain importance and the difficulties are linked to the fact that the speed and uniformity of rice maturation vary according to numerous components, starting from the varieties.

During the ripening process, the starch, essentially accumulated in the last two leaves, is transferred to the caryopses (dried fruits). The progressive accumulation ends with the complete formation of the grain. The maximum length of the caryopsis is reached 25-30 days after flowering, from September to October; the width and thickness, however, have a rapid increase about 30 days after fertilization.

Until 1950 the harvest was done manually with a sickle. The first successes in mechanization were achieved in the 1950s with the advent of self-propelled combine harvesters by the Ente Nazionale Risi. Currently the harvest is carried out exclusively through the use of combine harvesters, whose technological progress has reached very high levels of perfection in recent years. In Italy, rice harvesting operations mostly take place in the months of September-October.

Freshly harvested rice is called paddy or rough rice and is covered in husks, rigid and inedible shells.

Drying and storage - Freshly harvested rice always contains high humidity and must therefore be subjected to drying to minimize microbial activity and respiration, as well as to stabilize the product.

Once the drying took place in the farmyards, filling, with the flood of rice grains still covered by the husk, all the spaces in the farmyard exposed to the warm early autumn sun: the rice was moved manually every day to avoid fermentation and promote the reduction of the humidity percentage.

Nowadays, dryers are used that introduce hot air at variable temperatures; dryers are differentiated between static ones (with a daily or prolonged cycle) and dynamic ones, i.e. with intermittent or continuous movement of the product.

The freshly harvested rice is taken to the spaces provided under the porch, where it is unloaded and stored, but it is not possible to accumulate large quantities, since the rice has a high moisture content which could cause it to ferment. Consequently, drying is carried out immediately after harvesting and, in any case, no later than 15-20 hours after this, under penalty of fermentation.

Before entering the dryer, the rice passes through sieves and screens which serve to separate and eliminate straw residues, weed seeds, empty grain and impurities from the grain; subsequently, the rice is transmitted to the actual drying body which, with the introduction of hot air and the continuous movement of the product, favors the lowering of the humidity percentage in a uniform way.

The methods with which the rice is dried are very important, since they influence the quality of the product: excessively rapid losses of humidity can in fact cause unwanted cracks or breakages of the kernels.

Once drying is complete, the rice is subjected to a controlled cooling cycle, in order to bring the product to room temperature without the grain undergoing stress.

Once cooling is complete, the rice is ready to be stored; during this phase it is subjected to further cleaning by ventilation and screening, in order to eliminate drying residues.

Subsequently the rice is stored in silos.

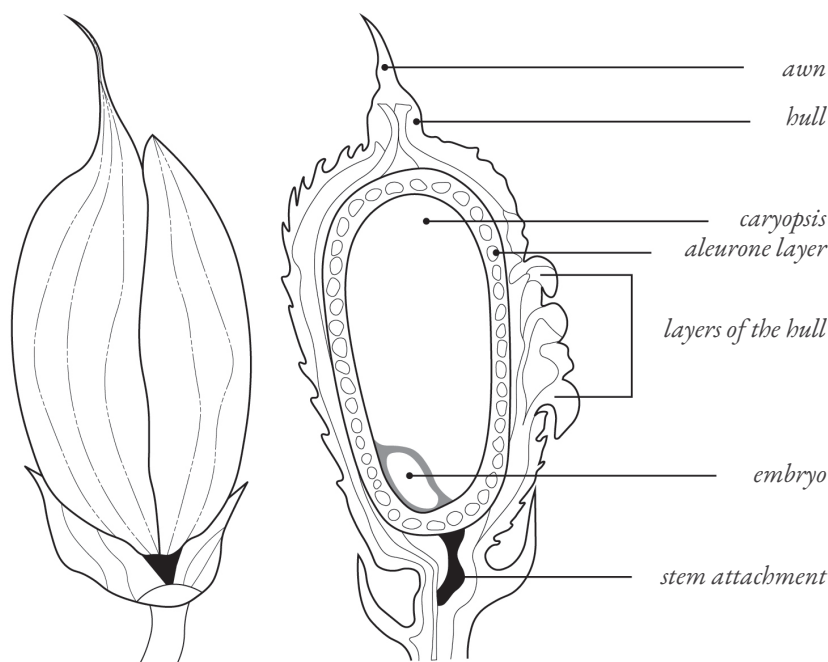
The dried and stored grain of rice is not yet edible due to the presence of the external coverings of the caryopsis. These coatings have different names depending on whether reference is made to botanical terms or to others of a more commodity nature. Thus the external glumes are also called husk; the outermost part of the caryopsis, made up of the pericarp and the aleurone layers, is respectively referred to as chaff and flour, while the germ is commercially called bud and the endosperm is the processed rice grain.

Once dried, the grains of raw rice (commonly called paddy) are still surrounded by the husks, which are hard, woody and rich in silicic acid (hence the name “dressed rice”). At this point in the process, the embryo is still capable of germinating, so the grains are also suitable for sowing. However, they cannot yet be used for culinary purposes.

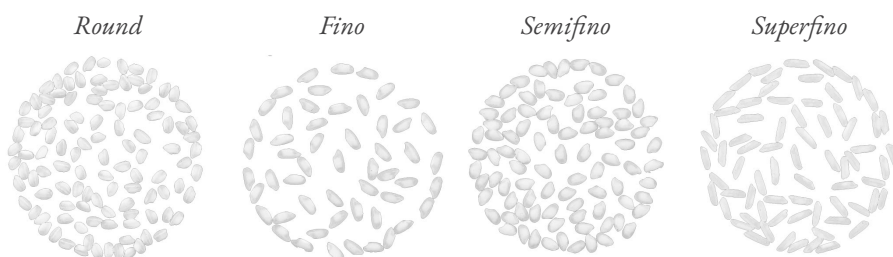
Anatomy of rice

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98



Rice processing is an important variable that determines the quality of the product.

If we look closely at a paddy grain, we realize that it is covered by a rough and hard shell: the husk, a tissue that must be removed to make the rice edible. The husk represents 20% of the weight of the grain. The goal is to remove the outermost cell layers with minimal breakage. The paddy rice is unloaded into the pit and subsequently sent to the storage silos and then passes to another silo called “processing stock”. Thus begins the actual processing.

The paddy rice is sent to the cleaner, called *tararara*, to remove, through a vibrating sieve, all the impurities still present. The machine is equipped with a vibratory movement and is equipped with two overlapping and inclined perforated frames to facilitate the advancement of the product. The first frame has holes larger than the grains, to allow the rice to pass through and fall into the frame below, while all larger foreign bodies, such as straw, remain above and are thus separated. The holes in the underlying frame are smaller than the grains of rice and do not allow them to pass through; the rice remains above the frame and continues its journey, while all the smaller foreign bodies (earth, pebbles and weed seeds including javoni) fall from the holes and are thus separated. The entire system is crossed by a counter-current air flow, which sucks up the lighter parts such as dust, fragments of husk and empty paddy grains.

Subsequently the rice enters the *roller sheeter*, which manages to peel approximately 90% of the paddy rice, removing 90% of the husk. The husker is a device made up of a cylindrical container containing two rollers, of equal diameter, coaxial and kept at an adjustable distance, close to the size of the kernel. The kernels enter from above, in a central position and pass through the two rollers, which rotate in the opposite direction at different speeds, thus creating a condition of friction or tearing, which manages to detach the husk. The husk, being very light, is separated with a flow of suction air and sent to the storage silos, to then be used as a bed for stables or poultry and to produce energy.

The product then enters the *fan* which works in suction: the fan sucks in the husk and lets the rice fall.

During husking, the pressure of the rollers must not be too strong so as not to break the beans but, in doing so, not all the beans are shelled; once approximately 90% of the husk has been removed, 10% of “dressed rice” still remains.

The separation of the still dressed beans takes place with a machine called *grains separator*. The rice is fed into the paddy separator, which exploits the difference in specific weight between the shelled rice and the paddy rice; the paddy is a machine equipped with special zig-zags and a lateral oscillation movement: the clean rice descends downwards as it is more slippery, while the still dressed rice rises to enter the *second sheeter*, made of stone and

rubber.

The brown rice thus enters the *bonarde* or *calibrated separator* which, exploiting the different thickness of the grains, separates the beautiful rice from the less beautiful one. The bonarde is in fact made up of cylinders, slightly inclined forward, which rotate around their own axis and have cuts of different widths; while the cylinder rotates, the rice grains advance inside it: normal rice grains do not pass through the slits and continue their journey until the exit, while the immature, thinner ones pass through the slits and are thus separated (to be intended for animal use). Since the thickness of the grains is different for each variety, cylinders with slits suitable for each type of rice are needed.

The result is “raw brown rice”. The rice finally enters the stone remover which removes the residual pebbles through a vibrating sieve; the result is brown rice: the grain, composed of rice starch and germ, has been husked, that is, freed from the external layer of the husks, but retains its gem and is still wrapped in the precious silver film (pericarp).

To obtain white rice, we must proceed with processing. Smoothing occurs by abrasion and is the further mechanical operation to which the rice is subjected: it is a refining that has the aim of removing the external integuments of the grains, i.e. the “pericarp”. Since ancient times, rice processing has taken place in the classic mortar. By sinking the pestle into the center of the mortar, the grains were forced to move and create an upward flow.

This movement induced the beans to rub together, creating an abrasive action that slowly eliminated the external part.

At the end of the 19th century, the *hamburg mechanism* was created, which we still use today because we believe it to be the best and which revolutionized the way of smoothing rice: instead of turning the rice against the abrasive wall, the abrasive stone was turned against the rice. A special mixture of abrasive materials coats a truncated cone, thus creating an emery wheel; the grinding wheels are mounted on a central shaft which rotates them and is surrounded, 2/3 cm away, by a perforated basket. As the cone rotates, the rice enters the space between the cone and the perforated basket and tends to fall downwards, but the rotation of the cone, with its centrifugal force, manages to drag it, making it make several turns, before exiting the bottom. In this way the emery surface of the cone “scratches” the beans, removing the external part. To prevent the abrasion of the cone from always acting on the same beans, i.e. those that are close to its surface, a protruding rubber strip is inserted between one frame and another which forces the beans to pass forcibly against the cone and mix, thus obtaining a homogeneous processing, the same for all the beans.

As the external parts are removed, the rice becomes increasingly fragile and therefore the grain size of the abrasive must be increasingly finer in order to reduce its aggressiveness and make processing more delicate. As you continue

to work, the abrasive surface of the cones tends to become smooth and lose its incisiveness; it is therefore necessary to revive it and make it scratchy again, carrying out manual maintenance. This maintenance consumes and reduces the external thickness of the emery which, once it reaches a certain limit, must be reconstituted.

The rubbing operation tends to break the beans, so it must be performed delicately, with several light passes: normally 3/4 passes are used. With this calibrated process we try to keep a part of the gem intact. The brown rice enters the *first smoothing machine* formed by a stone cone: the rice falls outside the cone and is scratched. In the first step, the outermost part of the pericarp, made up of a film of cellulose, and the first part of the aleurone, as well as 50% of the gem, are removed.

Subsequently the rice enters the *second smoothing machine*, also made up of a stone cone, but which differs from the first smoothing machine because the dimensions of the cone become increasingly smaller and the grain of the emery becomes increasingly finer. In the second step, a large part of the aleurone and another part of the bud are removed.

The substance removed in the first two steps is in the form of a hazelnut-honey colored flour called “chaff”, rich in crude fiber and with a good content of fats, vitamins, mineral salts and proteins; the chaff is sucked through small perforated frames, by a suction system which transports it to the storage silos.

Finally the rice enters the *third smoothing machine* which removes the other aleurone cells, a part of the endosperm and a further part of the bud. Only very hard and resistant rices, such as Thaibonnet, also pass through a fourth grinder, while for more delicate rices such as Carnaroli, the passages are limited to three. The third and fourth sanders eliminate the rice flour, which is sucked through small perforated frames by a suction system which transports it to the storage silos; the flour has a light cream color and has a lower content of crude fibre, proteins and lipids than the chaff. Both chaff and flour are used as animal feed.

At this point the processing is finished.

In this way, the stained grains, any foreign seeds, pieces of husk and other foreign bodies that have overcome all the barriers set up for their capture during the manufacturing process and have reached the bottom together with the rice are eliminated. Until a few years ago, the rice processing process ended with the elimination of the breakage. With the evolution of technology, in modern rice mills, further steps have been added with which it is possible to guarantee the total absence of foreign bodies in the product.

The after - life post production

The agri-food industry produces a significant amount of waste and in many sectors recycling is minimal and disposal is sometimes a real headache, often with serious consequences for the environment. This is the case of rice, of which Italy is one of the major European producers and for which the disposal of waste resulting from the production cycle has represented a real problem for decades. For one ton of white rice, 1.3 tons of straw are produced, 200 kilos of husk, the “husk” that encloses the grain, and 70 kilos of chaff, the residue obtained from bleaching the product. Disposing of this waste has always been the big problem in the sector. If burned, straw causes polluting fumes. If it is buried, in the event of flooding of the fields, it emits methane gas which increases the greenhouse effect. And it is difficult to reuse: the recycling percentage does not exceed 6%. At least so far. Thanks to applied research, technology and the principles of the circular economy, rice straw has become a raw material in green building and green architecture. New bricks for building buildings are made from straw, and are much cheaper than traditional ones, have strong insulating properties and at the same time are breathable. They call them sustainable bricks because they are biodegradable, easy to handle and therefore transportable to the construction site at reduced costs.

102

Pharmacology also feeds on rice waste: the chaff, the floury residue rich in fats obtained from bleaching, until now was used only for animal feed but recently pharmacology uses it to produce substances useful for reducing cholesterol, while recent tests have ascertained its anti-tumor properties.

As can be seen, the virtuous circle of rice allows many applications capable of ensuring the economic circularity of many wastes and by-products which become raw and secondary materials in other and very different production chains. But what few could imagine is that a waste/waste of rice could then return to being as it was before, that is, rice once again.

Bioenergy production - The term “biomass” indicates the predominantly vegetal organic matter, both spontaneous and cultivated by man, terrestrial and marine, produced as a result of the process of chlorophyll photosynthesis with the contribution of the energy of solar radiation, water and various nutrients.

The most abundant types of biomass that can be used energetically can be traced back to the following categories:

- Forestry and wood industry biomass, deriving from forest cutting and maintenance, from sawmill operations, from the transformation of wood products;
- Agricultural by-products, such as straw, stalks, vine shoots, pruning

branches, etc.;

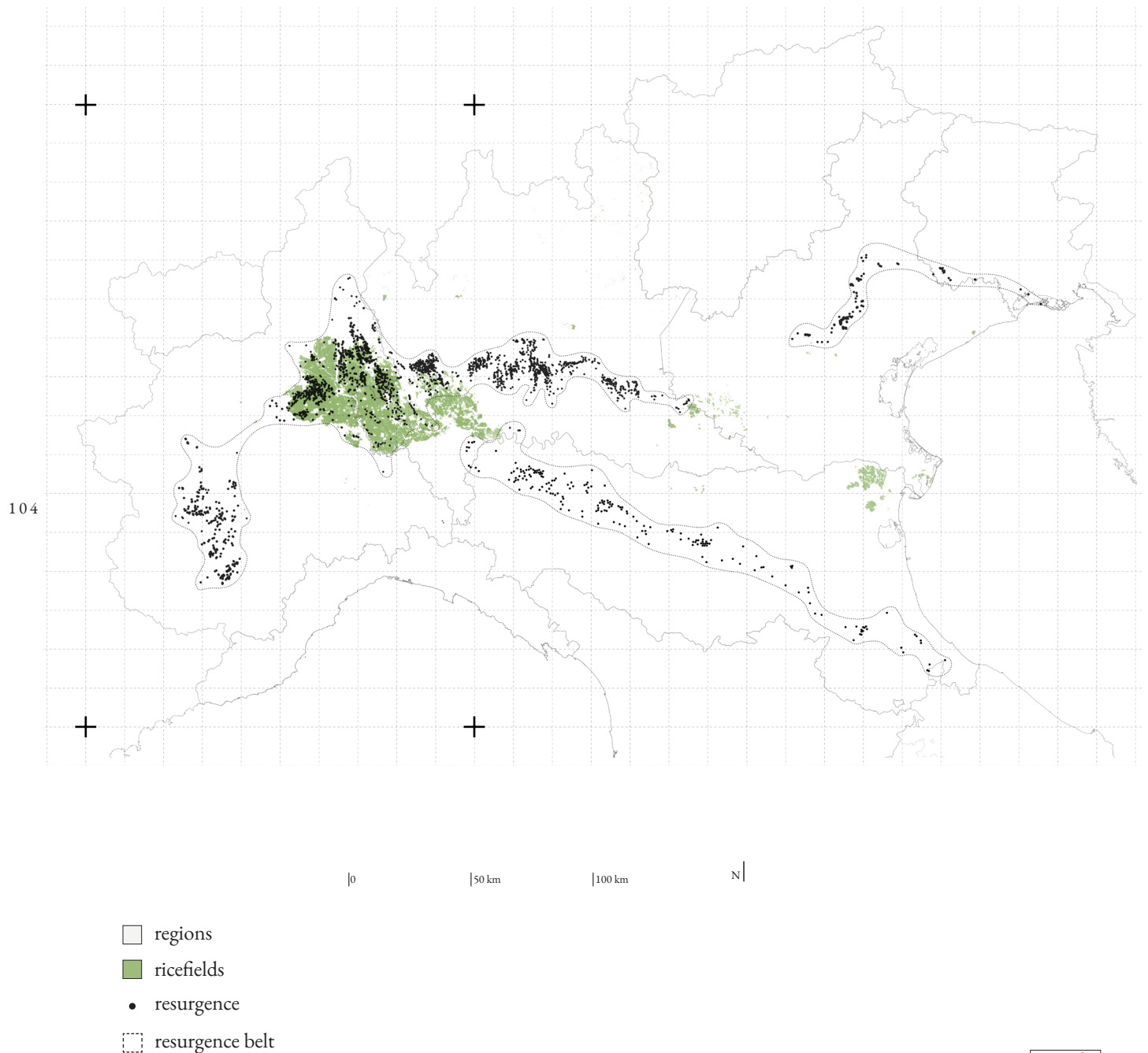
- Agroindustrial residues, consisting of pomace, pomace, stones, rice husk, etc. coming from the food industry (rice mills, distilleries, oil mills);
- Energy crops aimed at the production of herbaceous or woody biomass for direct exploitation (combustion) or for the production of biofuels (short rotation forestry, oilseeds and sugars).
- The organic fraction of urban waste, coming from separate collection from which biogas can be produced
- The potential energy contained in biomass can be released directly as thermal energy in the combustion process (traditional and dominant use), or concentrated in a variety of solid, liquid or gaseous fuels, making transport and final use easier. , through thermochemical or biochemical processes.

The plant solutions vary by type of biomass, technology used and final product (electricity only, combined with heat production, thermal energy only). For example, direct combustion of biomass in special suspended ovens, on a fixed or mobile grate, on a fluidized bed, are consolidated technologies; gasification, pyrolysis and carbonization which allow solid, liquid and gaseous intermediate fuels to be obtained; the production of biogas through anaerobic fermentation. The project “Energy recovery through gasification of rice husk and other agricultural waste” was developed within the VIDA project funded by the European Union, and was developed by ESE – Engineering Services for Energy, with the aim of optimizing the food supply chain by reusing agricultural waste for self-production of energy.

Rice husk has characteristics that make it ideal for gasification: thanks to its chemical composition, the production of tar is reduced and it is possible to recover large quantities of silica from the ashes. This by-product can be resold on the market. Furthermore, husk is an agricultural waste available in quantity at rice processing plants and whose disposal can represent a problem, although in certain periods and in certain geographical areas the husk can be sold (e.g. for the production of bedding for animals).

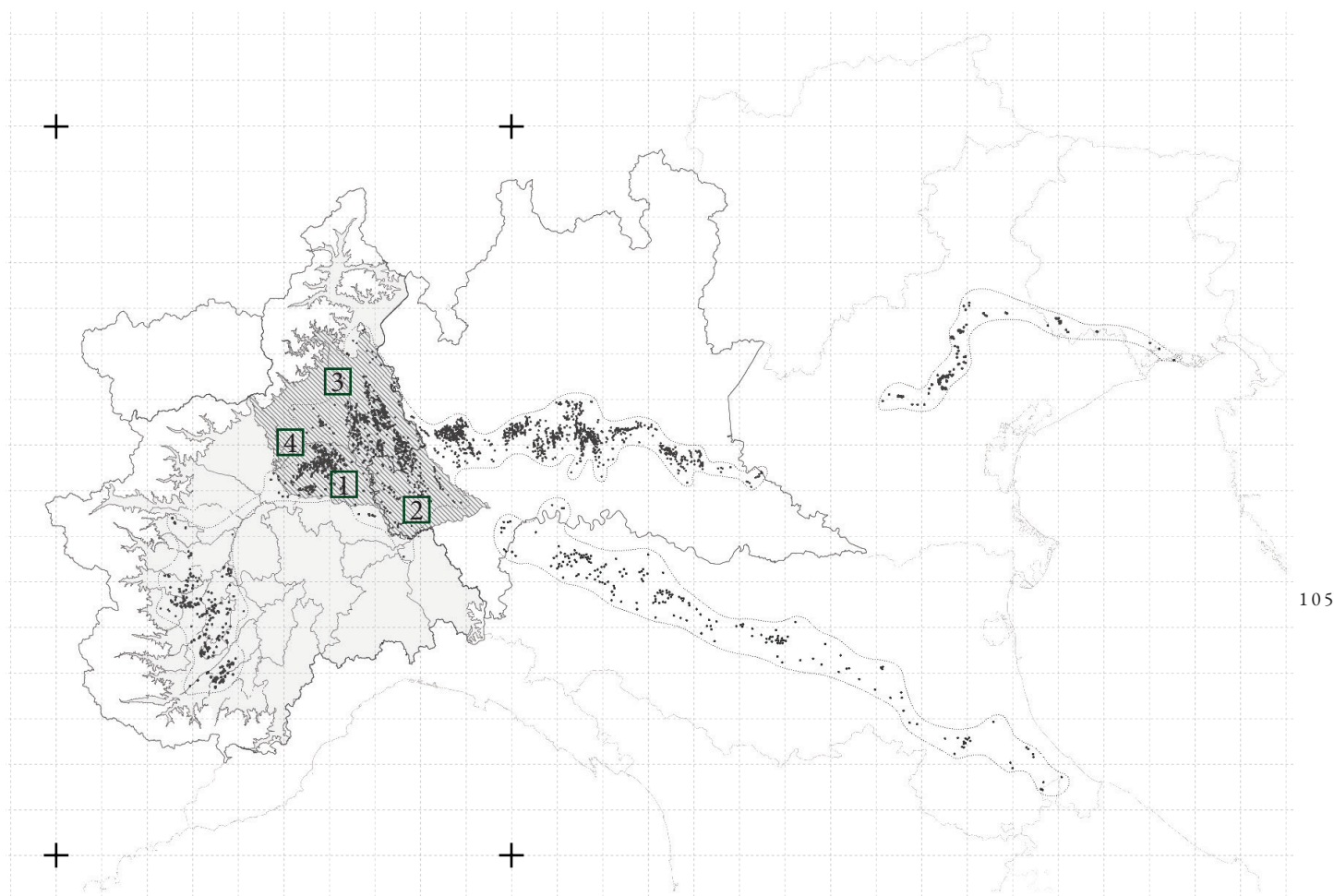
Framing the site

Resurgences' density and ricefields



▲ Ricefields and resurgences. Source: *Regione Lombardia, 2023. Regione Piemonte, 2023.*

Consortia of Piedmont



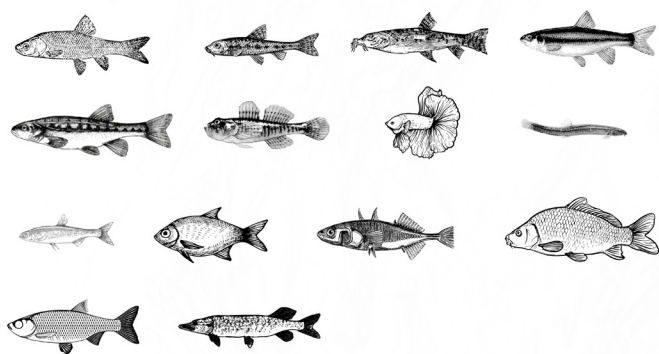
105

- consortia
- ▨ consortia area of project
- resurgence
- resurgence belt
- 1 Pianura Vercellese
- 2 Pianura Novarese
- 3 Baraggia
- 4 Angiono Foglietti

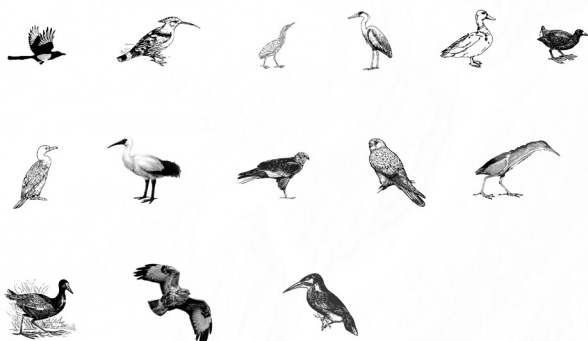
▲ Frame of the project. Source: *Regione Lombardia, 2023. Regione Piemonte, 2023.*



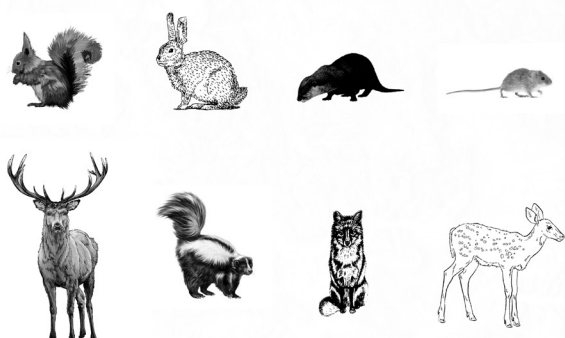
Fishes 60+ species



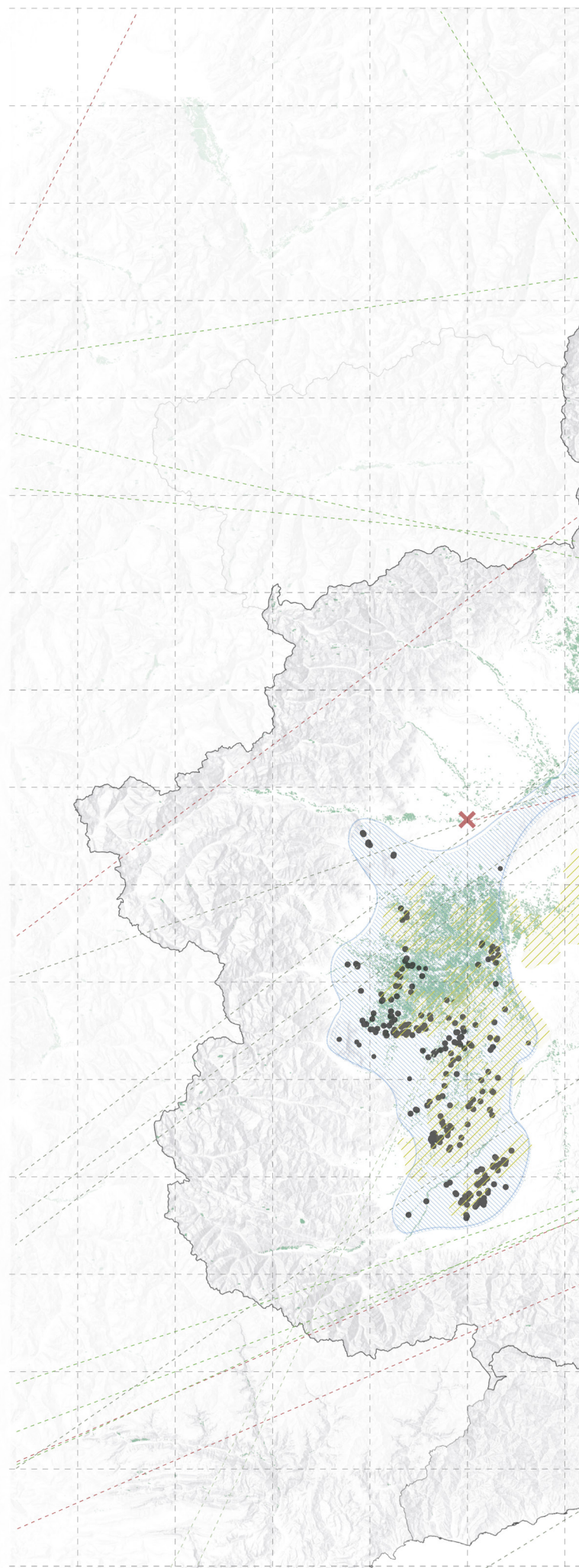
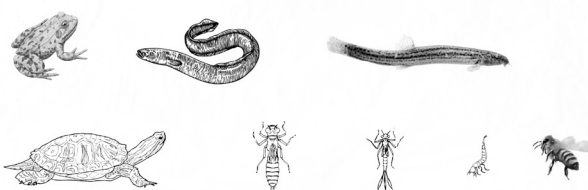
Birds 95+ species

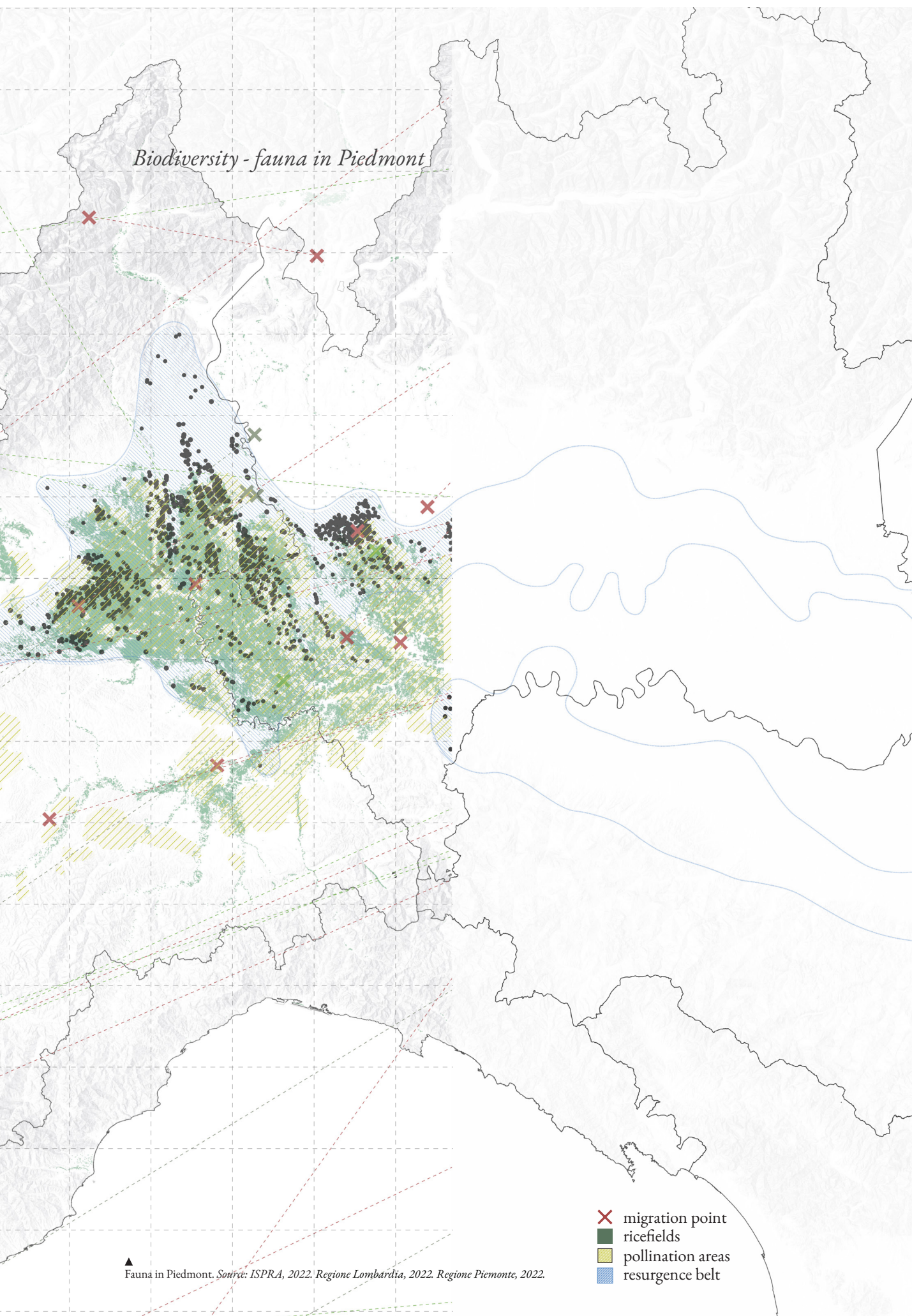


Mammals 50+ species



Amphibians, reptiles and insects 90+ species







Fagus sylvatica



Euonymus latifolius



Buxus sempervirens



Berberis vulgaris



Erica arborea



Cytisus scoparius



Crataegus monogyna



Amelanchier ovalis
Medicus



Cotinus coggygria



Corylus avellana



Coronilla emerus



Cornus sanguinea/mas



Betula pubescens/pendula



Colutea arborescens



Celtis australis



Castanea sativa



Carpinus betulus



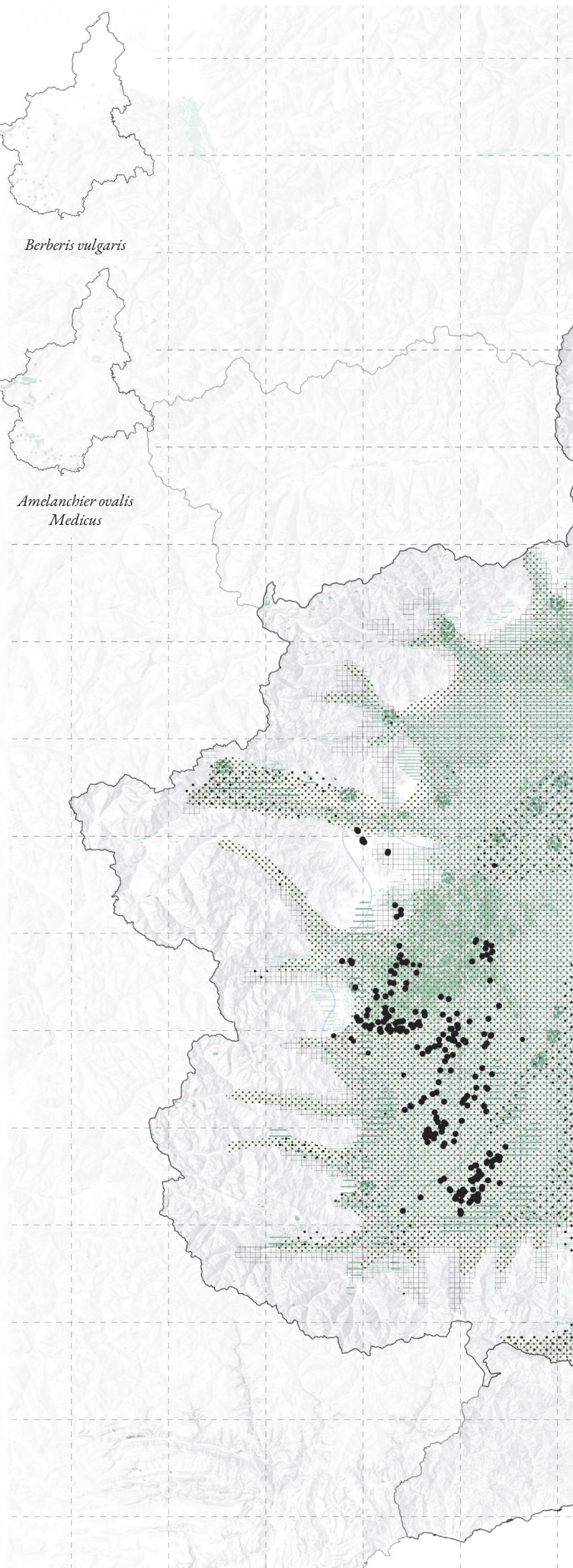
Abies alba



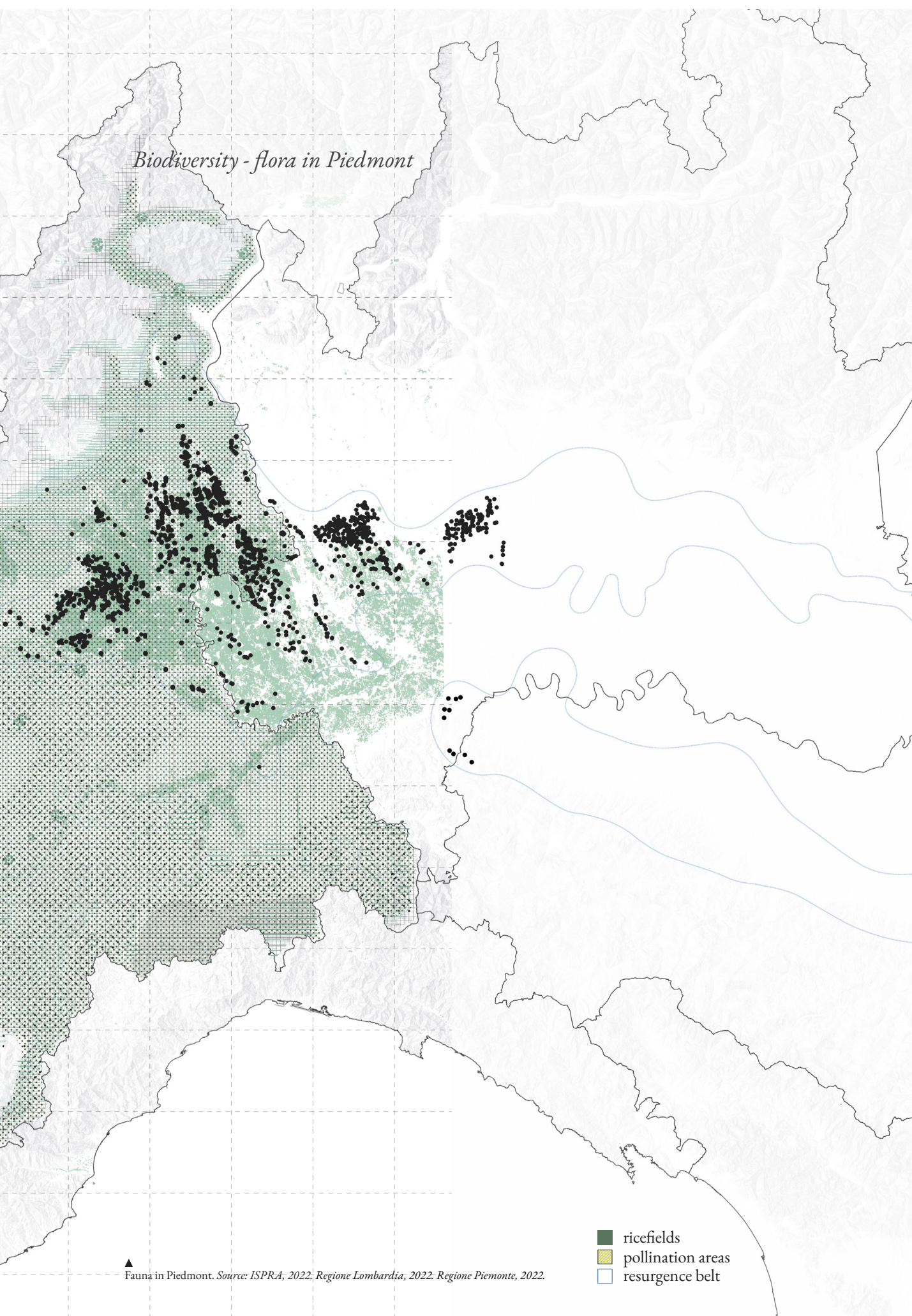
Acer pseudoplatanus/
platanoides/opulifolium/
campestre



Alnus viridis/incana/
glutinosa



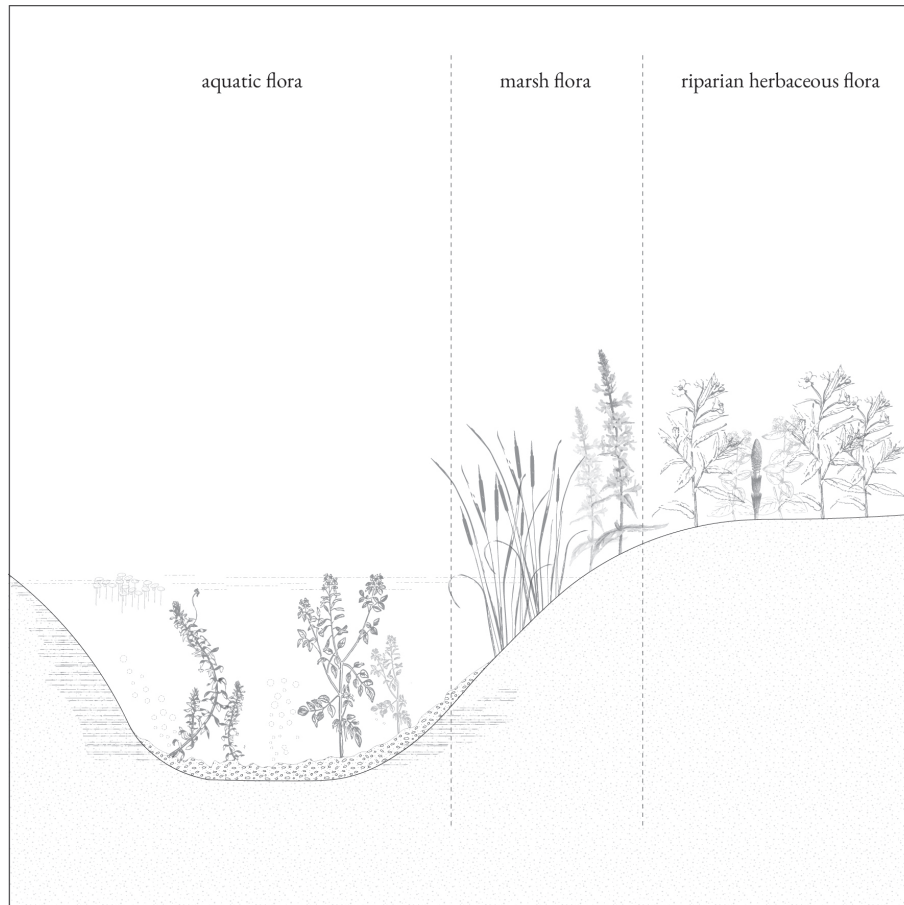
Biodiversity - flora in Piedmont



▲ Fauna in Piedmont. Source: ISPRA, 2022. Regione Lombardia, 2022. Regione Piemonte, 2022.

ricefields
pollination areas
resurgence belt

Habitat of resurgences



▲ Vegetation of resurgences. Source: *image made by the author.*

Considering the river bed, starting from the submerged areas going towards the shore, three vegetation bands can be distinguished:

- Aquatic flora occupying the submerged area and the free surface some water (lemnato and potameto);
- Marsh flora that characterizes the areas close to the banks where the water is shallower;
- Riparian herbaceous flora typical of the emerged bank area (herbaceous flora)

Before human settlements, the territory of the resurgence belt was in all probability occupied by marshland environments and humid meadows surrounded by dense hygrophilous woods of willows, black alders and poplars and, in the areas with more raised and less humid terrain, forests dominated by oaks, the large oaks that characterized the forest vegetation of the prehistoric Po Valley. It is only the subsequent and progressive reclamation intervention carried out at the time of the ancient Romans and then in the Middle Ages that created a system of headwaters and canals having the dual function of draining the wetter lands in order to put them under cultivation and guarantee transport of water for irrigation when necessary.

Traces of the original vegetation remain in the hedges and trees which in many cases surround the headwaters and border the canals, and in the hygrophilous riparian herbaceous vegetation or hydrophytes linked to the water flowing in the system

of canalizations in the Vicenza countryside.

The vegetal landscape was further conditioned by the farmers' interventions, such as the low or high pollard cutting of willows, poplars, alders and plane trees, aimed at obtaining firewood, poles, thin branches to be used as ties (the 'strobe') or for making baskets. Over time, various alien species have been added to the autochthonous species, i.e. those originating in the territory considered since ancient times, which were deliberately imported from other geographical areas or spread spontaneously thanks to their ability to colonize lowland environments. For example, mulberries (*Morus nigra* and *Morus alba*) imported from the East to allow the breeding of silkworms, or black locust (*Robinia pseudacacia*), a tree of North American origin with a great capacity for colonization in different environmental conditions; Turkish grape *cremesina* has recently become widespread in herbaceous vegetation

(*Phytolacca Americana*), coming from North America. Exotic tree species are often planted near homes or herbaceous species foreign to the original plant population of the gardens spread from the gardens.

resurgence environments, and yet these environments still retain significant evidence of the ancient flora that characterized them in ancient times, and for this reason they must be protected.

Where the resurgences meet today there was once a lush broad-leaved forest, interrupted only by the course of the large rivers. With a little imagination you can imagine an amphibious environment, continually remodeled by the wandering of the rivers where stretches of dry forest (on raised bumps) alternated with areas of semi-flooded forest. Only rarely did the forest cover open up to make room for temporary swamps and ponds. The familiar images of today's Amazon can in some way be taken as an example of the landscape of the resurgence belt before human colonization.

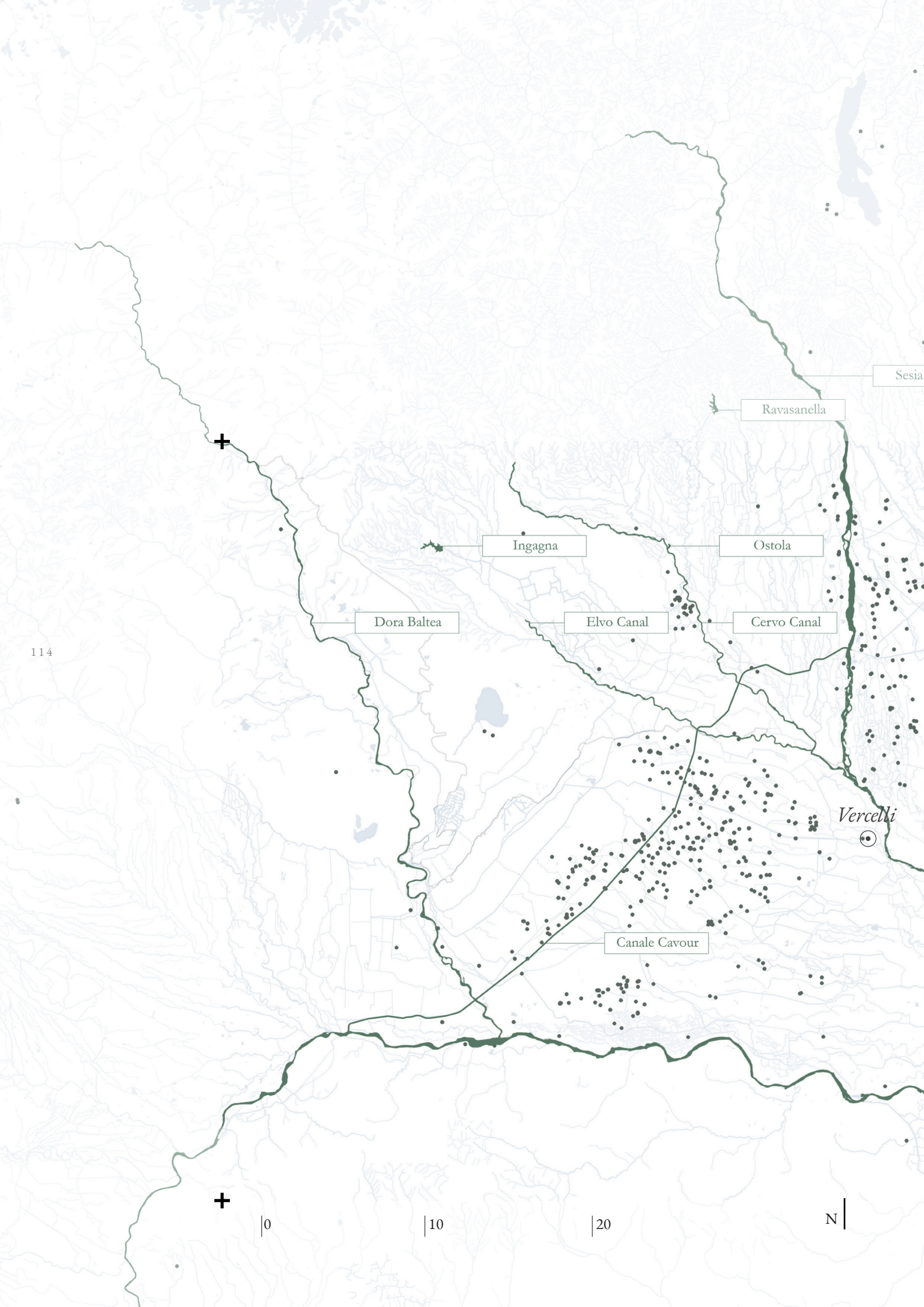
In the drier areas, the forests of English oak (*Quercus robur*) dominated, the mighty oak capable of raising the top of its foliage to above 40 meters in height. Numerous other tree species were mixed with it, such as field maple (*Acer campestre*), white hornbeam (*Carpinus betulus*), lime (*Tilia cordata*), common ash (*Fraxinus excelsior*), black ash (*Fraxinus oxycarpa*), field elm (*Ulmus campestris*) and shrubs, such as Hawthorn (*Crataegus monogyna*), Hazel (*Corylus avellana*), Elder (*Sambucus nigra*), Dogwood (*Cornus sanguinea*), Priest's cap (*Euonymus europaeus*), Blackthorn (*Prunus spinosa*), Dog rose (*Rosa canina*), Ligustrello (*Ligustrum vulgare*).

112

In the more humid and semi-flooded areas, however, the tree layer, in addition to English oak and osseophyllo ash, was made up of black alder (*Alnus glutinosa*), white willow (*Salix alba*), black poplar (*Populus nigra*) while in the more open areas some shrub species dominated, such as Gray willow (*Salix cinerea*), Buckthorn (*Frangula alnus*), May Viburnum (*Viburnum opulus*).

The arrival of mechanization at the turn of the Second World War first brought about a crisis and then, in a very short space of time, around the 1960s, decreed the death of the centuries-old balance between agriculture, trees and territory.

Today only disordered vestiges remain of the ancient agro-forestry systems of the resurgence belt: the plants and landscapes have completely disappeared; rarely do any stretches of road remain; a large part of the main and secondary hydrographic network is devoid of riparian vegetation.



114

Sesia

Ravasanella

Ingagna

Ostola

Dora Baltea

Elvo Canal

Cervo Canal

Vercelli

Canale Cavour

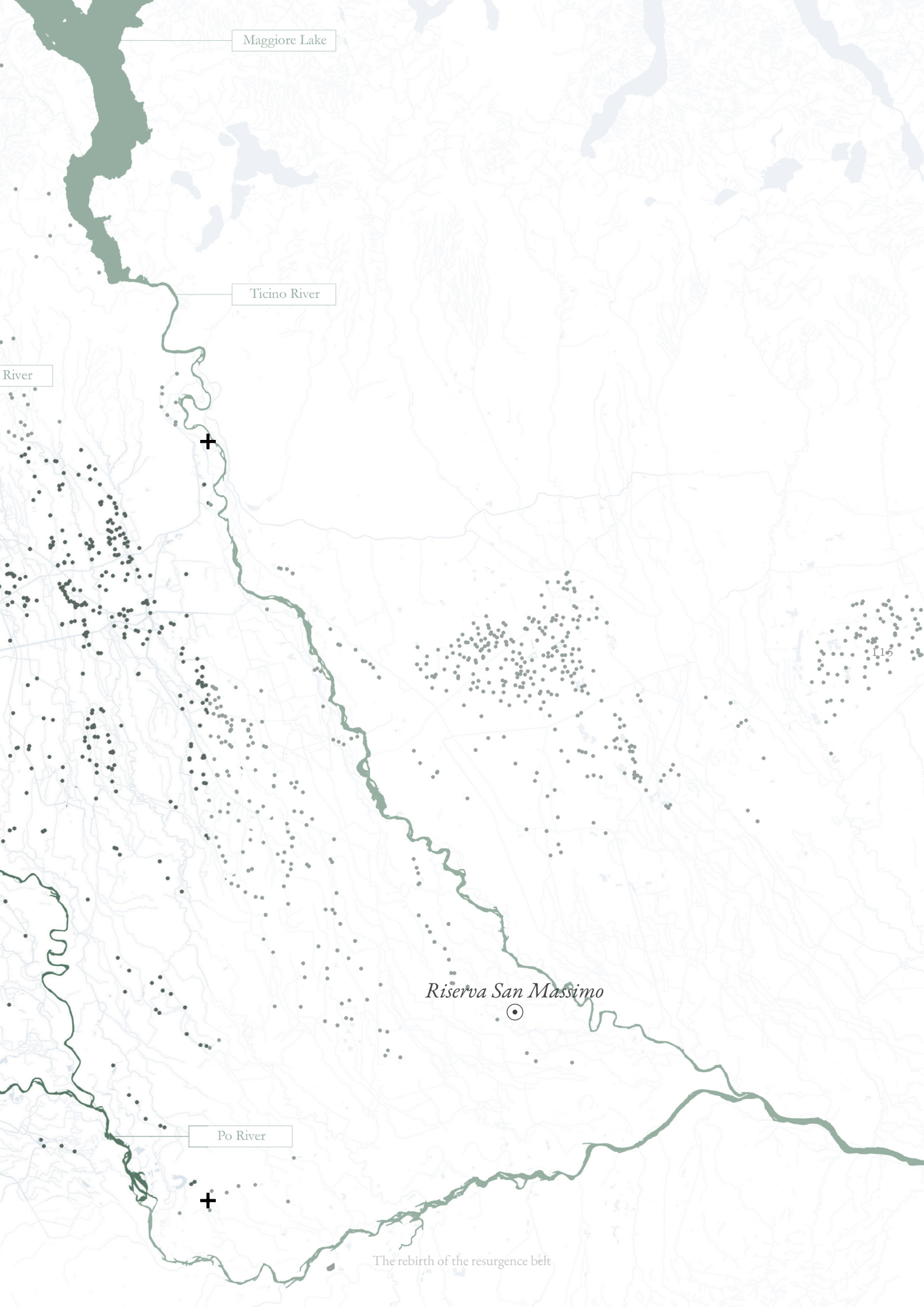


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20

N



Maggiore Lake

Ticino River

River



115

Riserva San Massimo



Po River



The rebirth of the resurgence belt

La riserva San Massimo



Dino Massignani
Manager of Riserva San Massimo

Riserva San Massimo is located in the consortium of Pianura Novarese.

In San Massimo the fields have a morphology that has never been changed over the years: each has its own name and their surface is limited and delimited by rows of fruit trees and woods.

There are 44 springs in the Reserve. The water flows very pure, clear and rich in mineral salts. This water, which is enriched by the organic substances it encounters crossing the 400 hectares of forest and the rich peat soil of the San Massimo Reserve, ends its journey by flooding the ricefields in a natural way.

The company enjoys total water self-sufficiency. The water supplies all the fields, reaching every cultivated land directly, and therefore always equally pure and rich in organic substances.

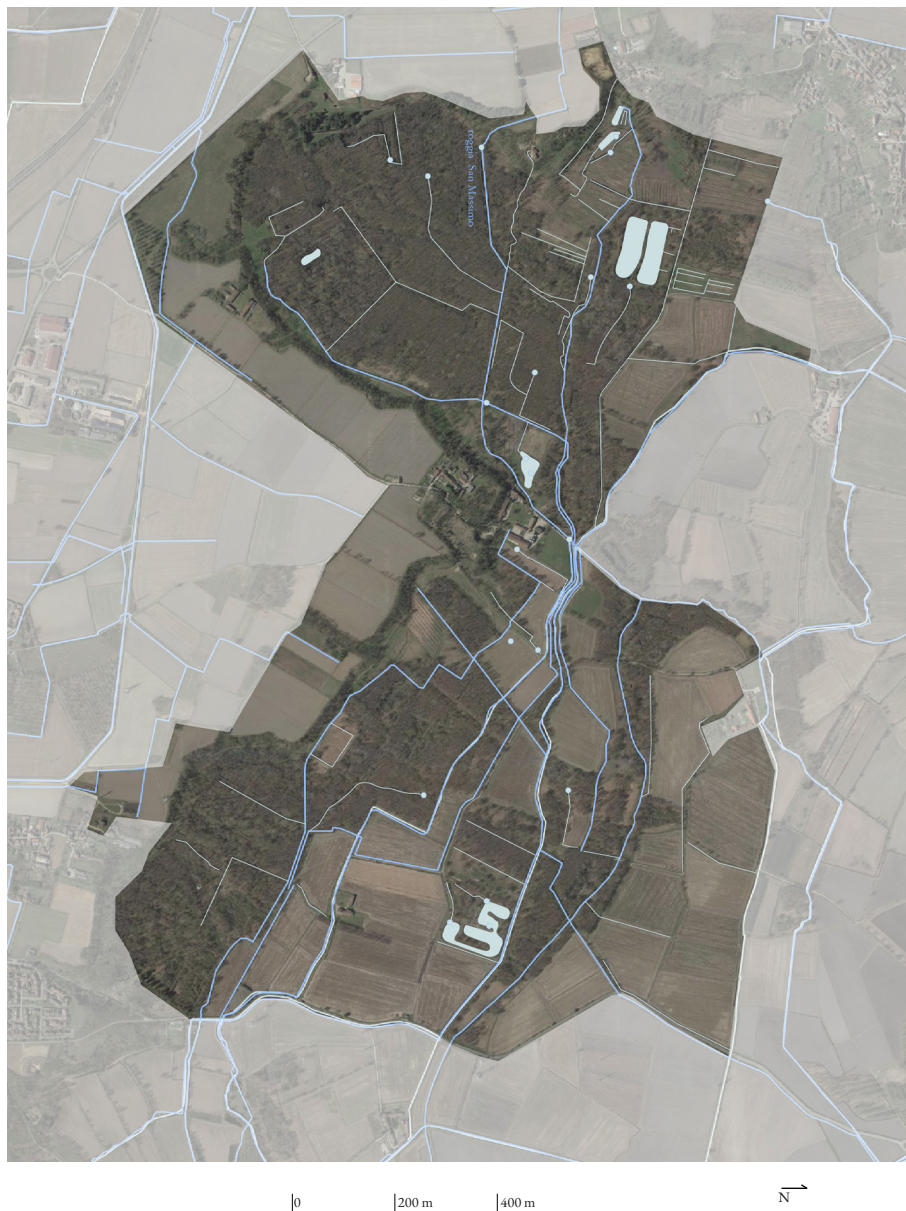
Recently, the San Massimo Agricultural Company carried out a planting project of 5,000 bacciferous plants on the edge of ricefields: *Rosa canina*, *Viburnum opulus*, *Prunus spinosa*, *Crataegus monogina*, *Rhamnus catharticus*, *Cornus sanguinea*, *Ligustrum vulgare*.

Furthermore, with its biodiversity, the Reserve is the ideal context for the organic production of Acacia and Wildflower honey. The process is totally natural and the bees are not exploited: the ivy honey is left in the hives for them to feed on during the winter and only 70% of the acacia and wildflower honey is taken.

In this unique environmental alternation, wildlife finds ideal conditions to complete its life cycle, satisfying all its needs in that state of natural freedom that characterizes it, that is, without depending on direct human management.

What are the main environmental challenges of agriculture?

- mitigation and adaptation to climate change
- the protection of biodiversity
- the reduction of soil degradation and impoverishment
- the reduction of pesticides and fertilizers
- rationalization in the use of water resources
- the conservation of genetic diversity
- the maintenance of pollinators
- environmental risks such as fires, floods
- the reduction of water and air pollution



▲ Source: AIPO, 2022. Google Earth, 2022. OSM, 2022. Regione Lombardia, 2022.

The loss in agrobiodiversity

The loss in the landscape diversity is mainly due to monoculture. The cultivation of rice became fundamental for the economy of the territory, to the point that the landscape changed in order to accommodate its cultivation.

Biodiversity relates to the different living being in the various ecosystem that host them, therefore it refers to all the animals, vegetation and microorganisms that live in an dynamic equilibrium in their own natural environment. Usually, the presence of high biodiversity refers to a more resilient environment, less compromise by the anthropic activities. Therefore, biodiversity refers to an ecological and environmental natural context. It is more complex when we refer to agrobiodiversity, which relates to all the components of the biological diversity that are relevant for agriculture and the agro-ecosystem, including the different cultivations, the animals of zootechnical interest and insects (such as bees) and useful microorganisms (Treccani, 2023).

The agrobiodiversity is strongly connected to the agro-ecosystems, to all the natural environments modified by humans with the introduction of cultivation for agricultural production. (Linee guida per la conservazione e la caratterizzazione della biodiversità di interesse per l'agricoltura, 2012). Agrobiodiversity refers to an economic and social value, referring to an artificial context shaped by humans. In the Biodiversity Convention, adopted in Nairobi and signed in Rio de Janeiro in 1992, the concept of agrobiodiversity extends not only to breeds and varieties, but also to the agronomic and zootechnical culture that allow their management and the agricultural landscapes that they generate.

Shifting the paradigm

compete with nature $\longrightarrow$ *partner with nature*

disturb soil $\longrightarrow$ *protect soil*

monoculture $\longrightarrow$ *polyculture*

reductionist $\longrightarrow$ *holistic*

Fieldwork

La riserva San Massimo



119

▲ Biodiversity in Riserva San Massimo. Source: *Dino Massignani, 2022.*





▲ Biodiversity in Riserva San Massimo. *Source: photography produced and edited by the author*



Ricefields of Vercelli



123

▲ The ricefields of Vercelli. Source: photography produced and edited by the author



▲ The ricefields of Vercelli. *Source: photography produced and edited by the author*



▲ The ricefields of Vercelli. *Source: photography produced and edited by the author*



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▲ The ricefields of Vercelli. *Source: photography produced and edited by the author*

Cultural elements



131

▲ Pertengo, Santuario della Madonna d'Oropa. Source: photography produced and edited by the author



▲ Principato di Lucedio. *Source: photography produced and edited by the author*



▲ Leri Cavour. Source: photography produced and edited by the author



▲ Chiesa della natività di Maria, Leri Cavour. *Source: photography produced and edited by the author*



▲ Tenuta Colombara. Source: photography produced and edited by the author





Fauna of ricefields



The sanctuary of the Madonna delle Vigne
in Sorti della Partecipanza



Grangia di Darola



Submerged ricefields and Bosco delle
Sorti della Partecipanza



Wheat spikes

▲ Suggestive landscape of Vercelli. *Source: image made by the author*

The rebirth and design of the resurgence belt

Intention

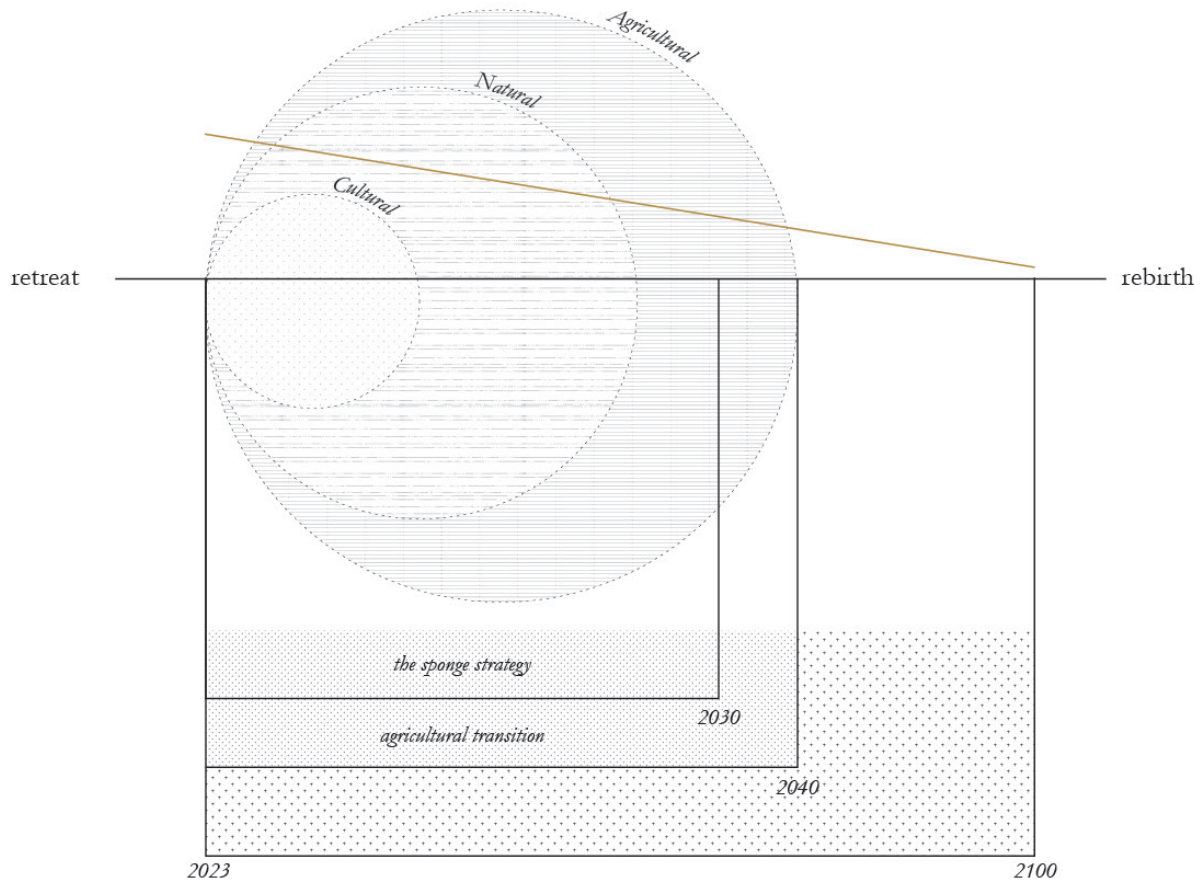
The intention of the project is to reverse the process of disappearance of the resurgences, creating an alternative future for the area of Vercelli.

The first two phases, which run from 2023 to 2030 and then from 2030 to 2040, are the phases of mitigation, while the third phase, which concerns a more distant future, 2100, is the phase of adaptation.

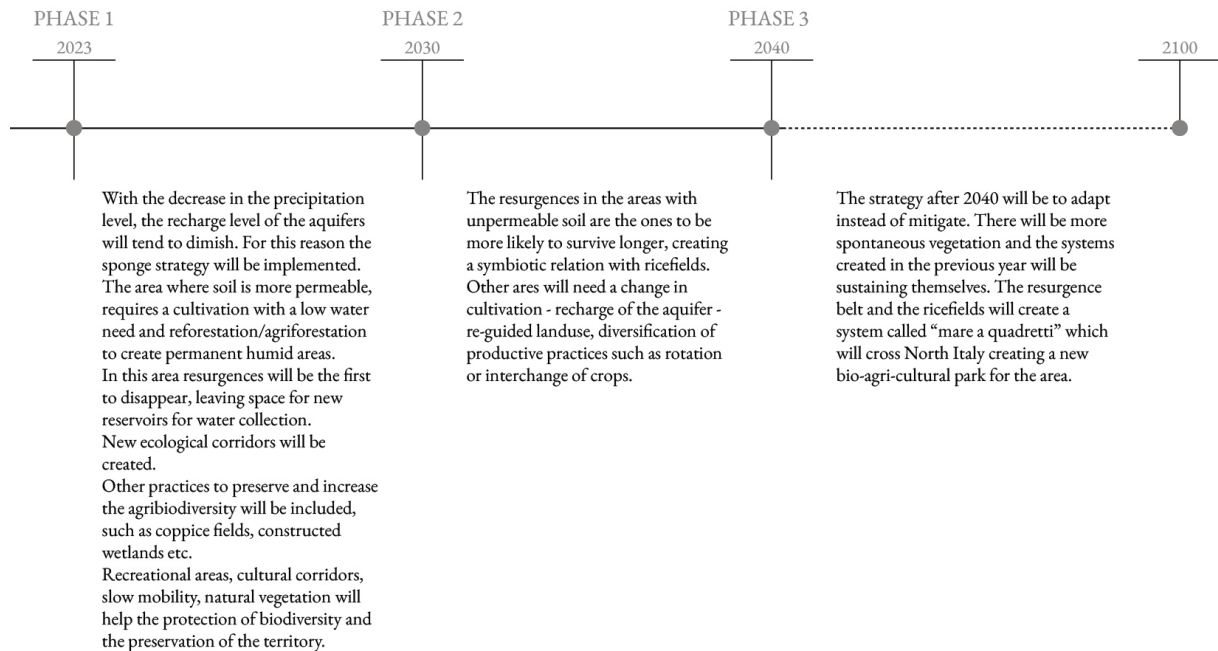
The project is also divided in three main aspects: agricultural, natural and cultural.

The agricultural transition is a challenging topic and this project will discuss and focus on one of the possible alternatives.

138



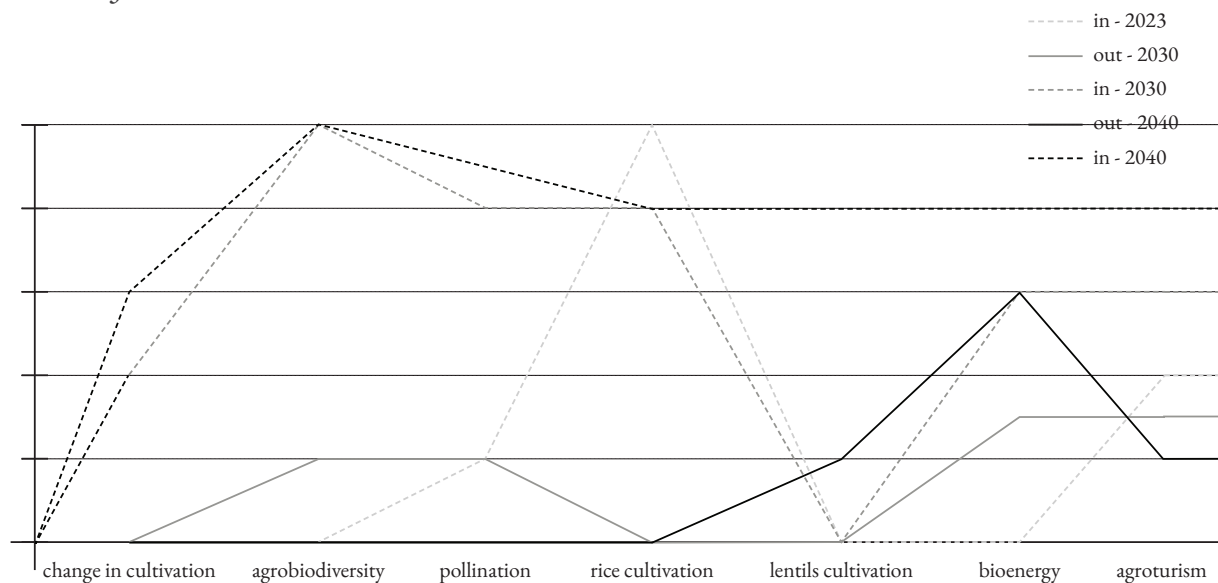
Time

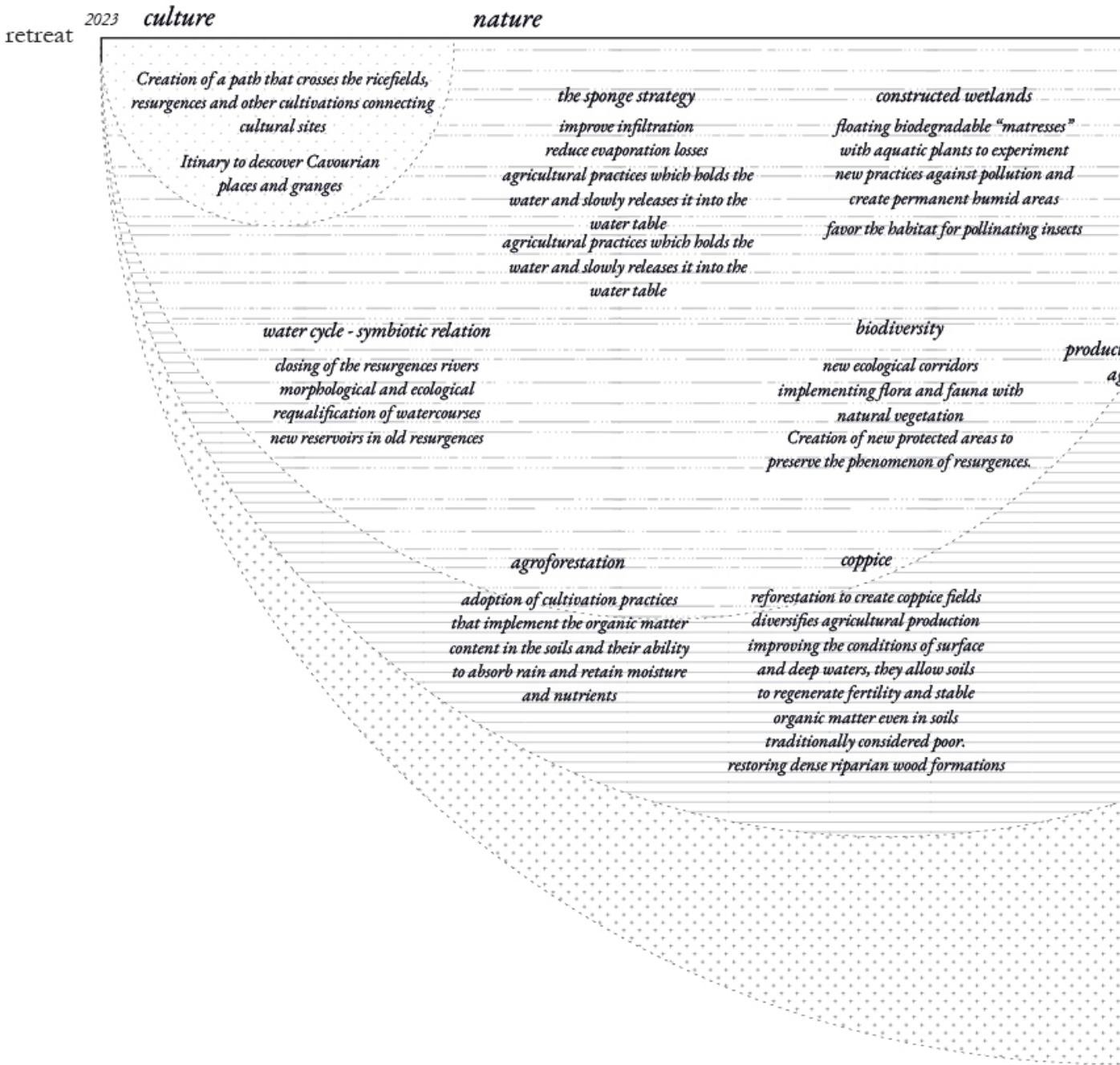


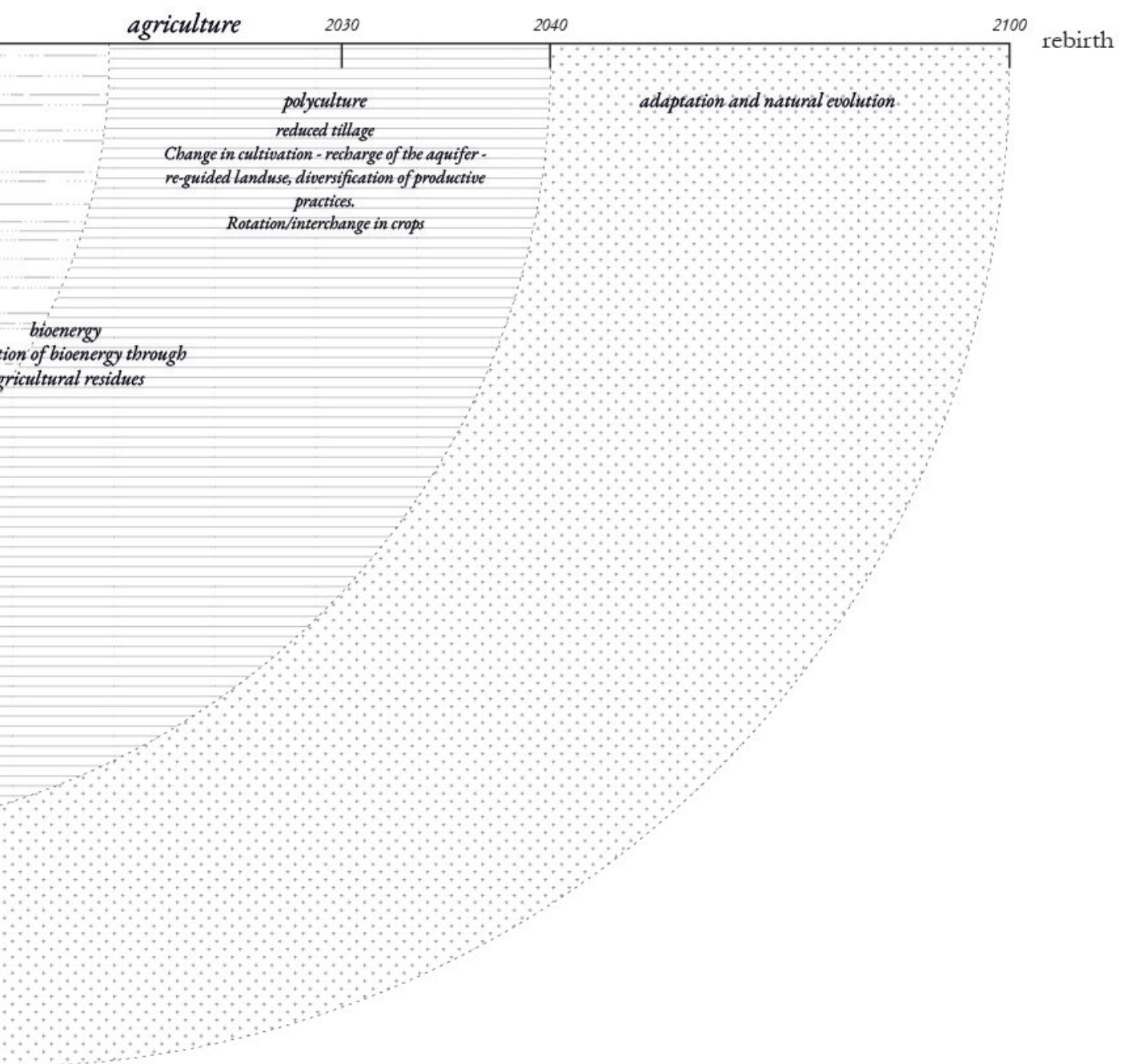
These three phases are interconnected and are essential to avoid the seasonality and fragmentation of the territory. Moreover, this area has a high percentage of abandoned land and buildings and therefore a lot of potentiality to revitalise the territory.

139

values of transition





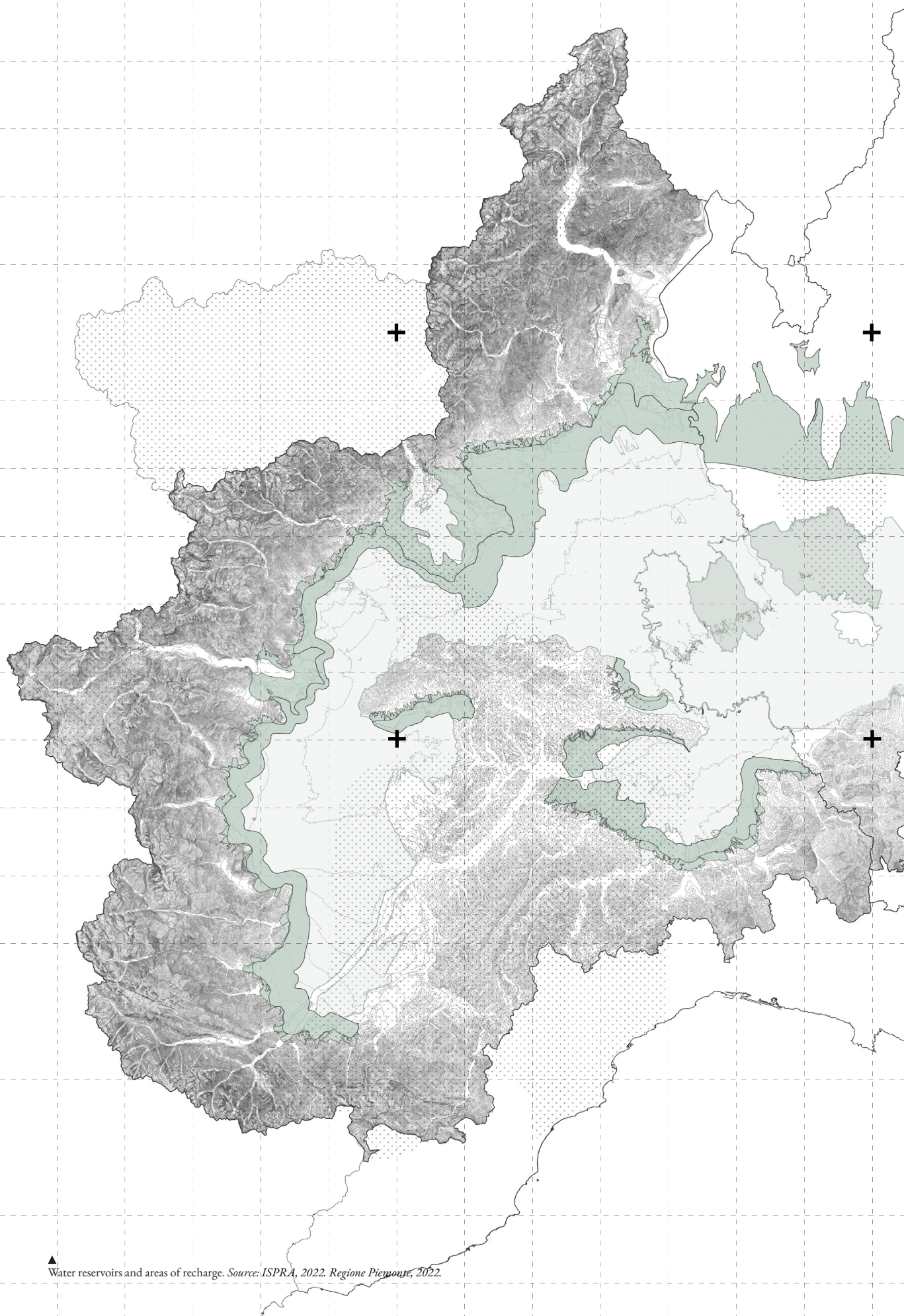


The natural landscape in Piedmont

In the image on the right it is shown how the groundwater system works in the region of Piedmont.
The dark green indicates the areas where the natural transition of the water infiltrating in the ground happens. The light green indicates the area where the reservoir of ground water is.

- recharge area
- reservoir
- optimal reservoir area





143

▲ Water reservoirs and areas of recharge. Source: ISPRA, 2022. Regione Piemonte, 2022.

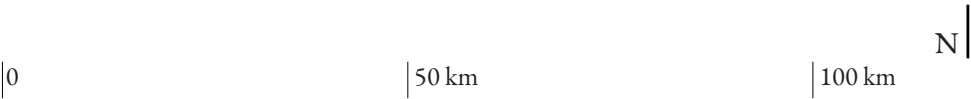
The natural water system in Piedmont

In the image on the right it is shown how the groundwater system works in the region of Piedmont.

The dark green indicates the areas where the natural transition of the water infiltrating in the ground happens. The light green indicates the area where the reservoir of ground water is.

144

- impermeable area
- permeable area
- resurgences
- piezometric level



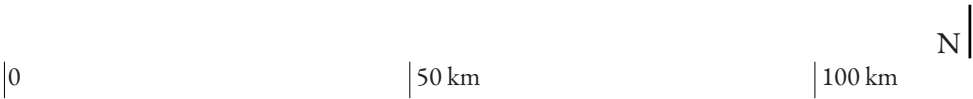
▲ Water reservoirs and areas of recharge. Source: ISPRA, 2022. Regione Piemonte, 2022.

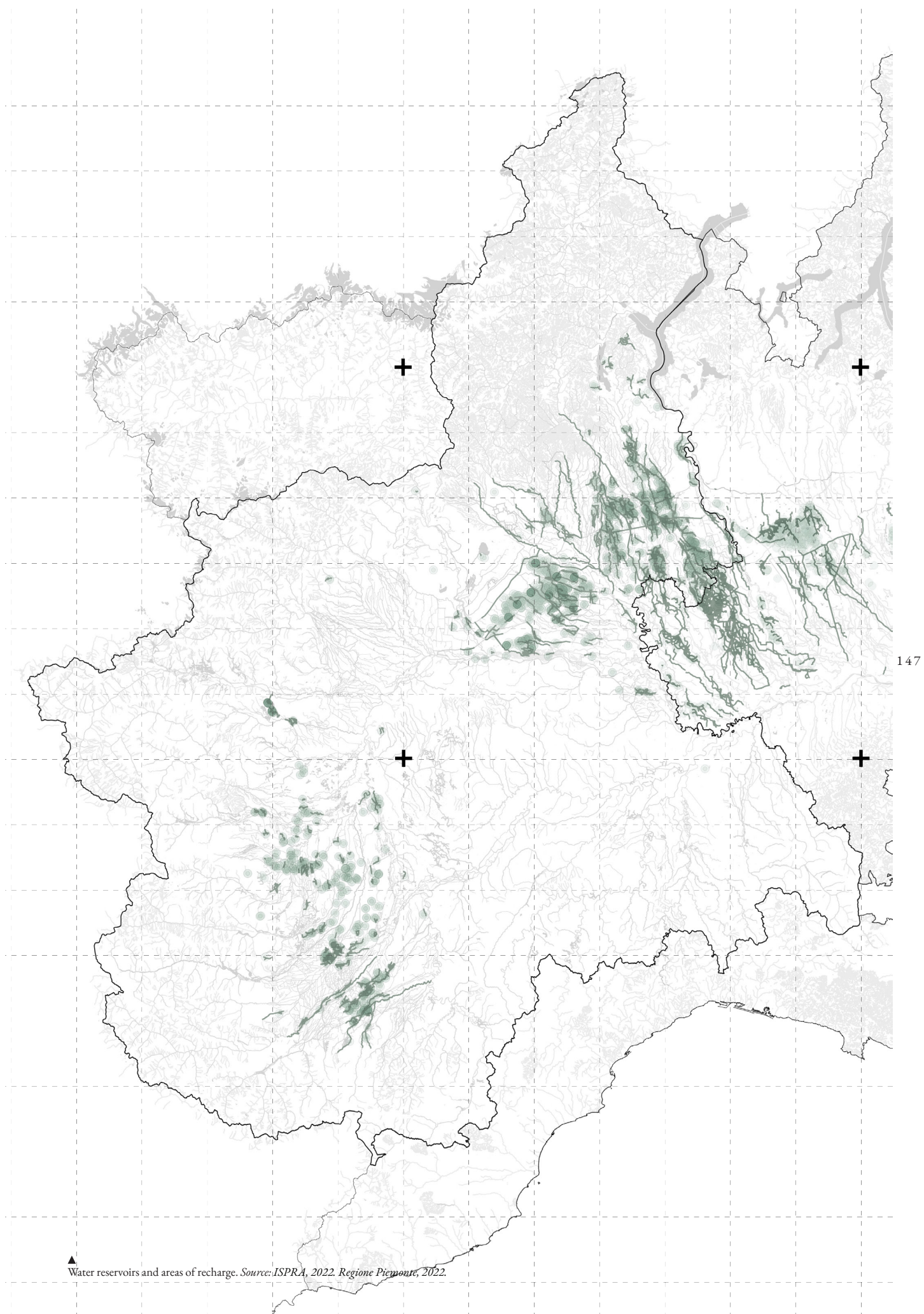
Risks in the resurgences system of Piedmont

In the image on the right it is shown how the groundwater system works in the region of Piedmont.

The dark green indicates the areas where the natural transition of the water infiltrating in the ground happens. The light green indicates the area where the reservoir of ground water is.

- water system
- buffer areas - resurgences
- water system at risk





▲ Water reservoirs and areas of recharge. Source: ISPRA, 2022. Regione Piemonte, 2022.

Productive landscape

The sponge strategy - The ricefields system represents an accumulation lung for water coming from the Alps which is then returned to agricultural irrigation on its way to the Adriatic. Ricefields constitute an important interconnection between surface and deep waters but unfortunately this balance has been spoiled in recent years with dry cultivation.

It is common to think that using water for submersion is excessive, in some ways a waste. In reality, the ricefields are part of a vast and complex water system that starts from Lake Maggiore and reaches the river Po. In the last two decades, also due to new sowing techniques such as dry sowing, only apparently more thrifty in water management, the balance that had been created in two centuries of rice development has been altered.

Submersion increases biodiversity, providing habitat for wildlife, and the naturalistic value of the rice-growing landscape.

Today the flow of water introduced into canals, ditches, held back by dams and locks, received by fountains and finally by rivers is very different from the past. When there is water, problems are not seen. With this year's drought, however, the repercussions affect not only the ricefields, but all agriculture in a significant part of the Po Valley.

Italian ricefields, when flooded, are in fact, like a large sponge that retains the water and slowly releases it into the enormous groundwater below.

The water penetrates the permeable ground, passes through the various layers and stops at the impermeable bottom of the aquifer. It flows downstream and is taken up again in canals and wells, reused several times from upstream to downstream, until it is finally returned to the Po river. «The water table is the largest regulated reservoir in Europe and contains around one billion cubic meters of water», explains Alberto Lasagna, director of Confagricoltura Pavia. «The water in the ricefields between Vercelli, Novara, Pavia and Milan is not lost or wasted, on the contrary, it serves to maintain an essential balance which today is instead altered by drought and poor planning».

Among the cultivation techniques mentioned by Romans, which among its benefits highlights an important efficiency in the use of water, there is that of winter submersion. This agronomic practice, which consists in submerging the plots at the end of the growing season for a period that goes from autumn-winter until the beginning of the following spring, allows the level of the water table to be recharged in a season in which the water is abundant since it is not necessary for other crops, such as corn or soybeans.



▲
Zoom in, ricefields. Sources: Google Earth, 2022. Regione Lombardia, 2022. ARPA Lombardia, 2022.

Another positive effect of winter submersion is found on the degradation of crop residues which, on the one hand releases valuable nutrients for the crop into the soil and, on the other hand, reduces methane emissions into the atmosphere.

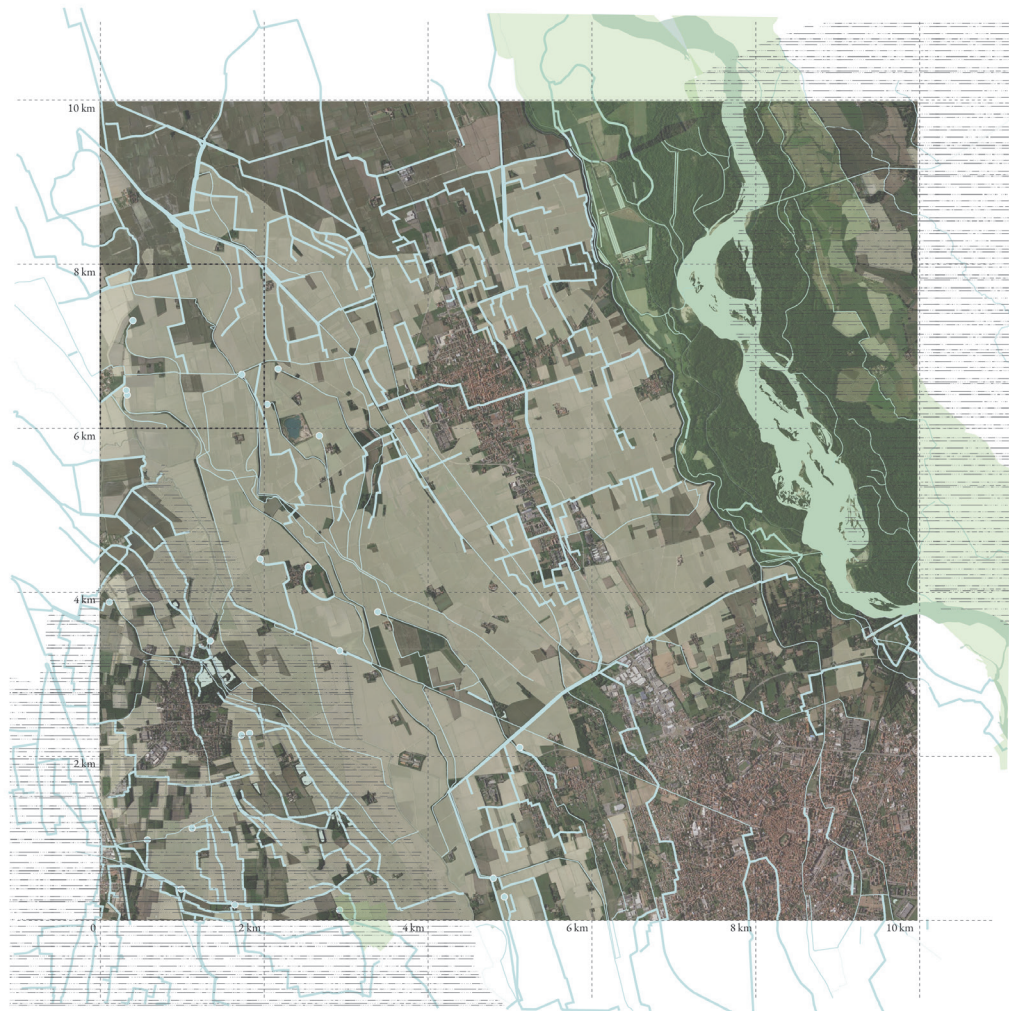
The national rice body, within the Ristec project with the Universities of Milan and Turin, has launched an experiment of winter submersion in the plots of the Center research on Castello d'Agogna rice.

The level reached by the water table at the beginning of the growing season depends on the moment in which the water is drained from the paddy fields in winter. Conversely, if winter flooding is applied only from January, it will most likely be insufficient in many areas to ensure an increase in the groundwater level in April and May.

The best place to store water is the groundwater, whenever there is one. The artificial reservoirs are substantially monofunctional interventions. The controlled recharge of the aquifer determines a wide range of benefits beyond that of storage: higher aquifers support numerous indispensable humid, lentic and lotic habitats; subsidence induced by the lowering of the water table is prevented; higher aquifers slowly release water into the hydrographic network, supporting low flow rates; high groundwater levels counteract the intrusion of the salt wedge.

In the immediate future, we cannot control the trend of rainfall and temperatures (although it has been conditioned over the decades by anthropic activity) but we can certainly act (with short-term response prospects) to ensure that the ever smaller and more concentrated precipitation stays longer on land instead of flowing quickly downstream to the sea.

To achieve this, it is necessary to implement a major redevelopment work that includes: the morphological and ecological redevelopment of watercourses, decanalizing them and recovering the strong incisions suffered in recent decades, reconnecting the alluvial plains, restoring dense riparian wooded formations; the reconstruction of the network of farm hedges and the small hydraulic network; the generalized adoption of cultivation practices that implement the organic matter content in the soil and their ability to absorb rain and retain moisture and nutrients (a 1% increase in the organic matter content can guarantee up to 300 m³/ha of accumulation of water in the soil, available for vegetation); the de-sealing of urban areas. These are measures included in the "Biodiversity 2030" and "From farm to fork" strategies under the EU's New Green Deal. And taken from the recent regulatory proposal (the "Nature Package") presented on 22 June by the European Commission. The proposals currently under discussion in Italy



- protected areas
- reservoir
- other
- secondary
- primary
- ricefields
- resurgences

▲
Zoom in, ricefields. Sources: Google Earth, 2022. Regione Lombardia, 2022. ARPA Lombardia, 2022.

go in exactly the opposite direction.

Another area in which there is much to do before hypothesizing further withdrawals from the water network is that of the reuse of waste water in the irrigation sector. The Italian legislation is excessively restrictive, it does not contemplate the importance of the recovery of nutrients associated with the recovery of waste water, we therefore recommend a rapid transposition of the new EU Regulation 741/2020 (which will enter into force in June 2023). According to a 2017 JRC report, around 47% of Italian irrigation demand could be satisfied from this source. There appears to be no recent data on the volume currently reused, but based on existing estimates it appears that no more than 4% of water is directly reused in agriculture.

In conclusion, it is clear that we will increasingly have to learn to live with the two extremes of long droughts and intense rainfall and consequent floods, which only a more natural territory and hydrographic network can cope with at the same time.

The inevitable change in agricultural practices - As shown in the diagram below, the productive landscape for the alternative future will shift from monoculture to polycultures, including either rice and other crops. New agricultural techniques will be implemented, e.g. crops rotation with the cultivation of rapeseed and barley or other cereals. The cultivation of lentils, explained more in depth in the next chapter, will become increasingly important for the area.

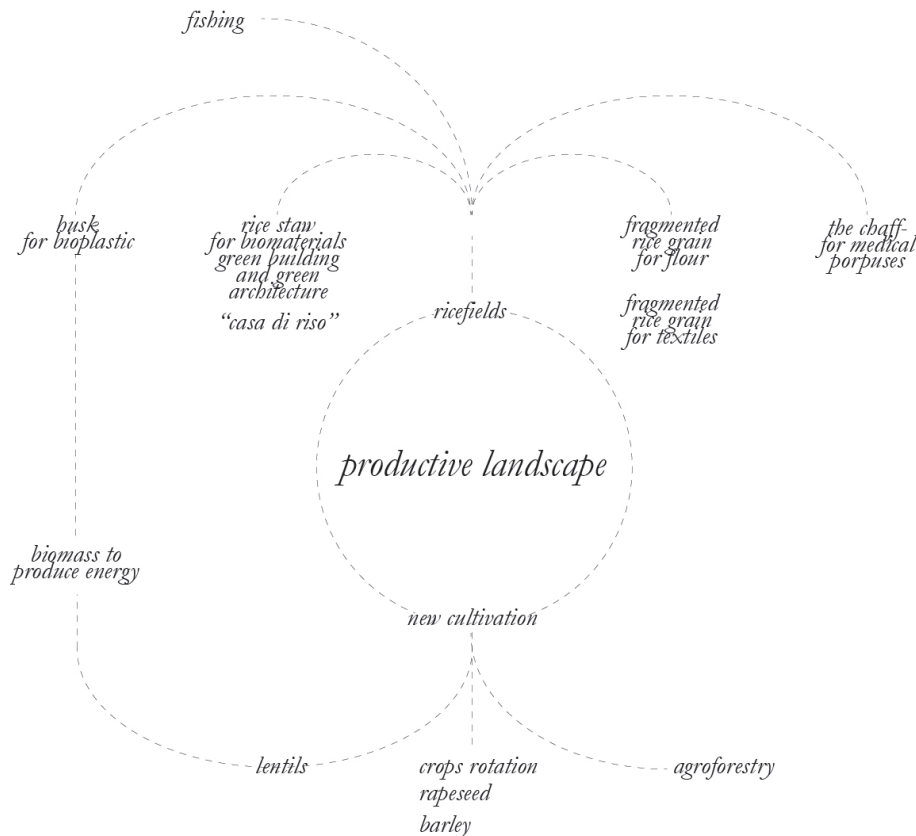
Lentils cultivation is just one of the alternatives: this crop does not represent the agricultural transition in its whole. To shift from monoculture to polyculture more crops needs to be included in the agroeconomical system.

The productive landscape will not be only for food production but also for bio-energy production. As explained in the previous chapters, rice has many lives thanks to its residues, same as the lentils. Rice residues can be used for bio-plastic production, for bio-materials in green buildings and green architecture, fragmented rice grains can be used for flour and textiles while the chaff can be used for medical purposes.

The productive landscape has not only the goal to produce food and other products but also to sustain the agrobiodiversity that it creates. Including new cultivation, it is not only possible to implement the biodiversity in the area but also to maintain the soil healthy, increasing its percolation capacity and its store capacity where needed.

Agroforestry will be explained more in depth in the next chapters, but it is

important to understand how the consequence of good agronomic practices combined with environmental recovery through planting, distributed on the cultivation land, allows biodiversity to develop undisturbed in our fields. It is important to limit damage to amphibians and other aquatic species deriving from alternating water and dry conditions, they create permanent wetlands. Thanks to this, the biofarming of carps can also take place. This system allows you to save 90% of water compared to traditional cultivation on the ground or in a greenhouse. The fish in their tanks produce waste substances; the water containing these substances is pumped and passed through a bio-filter (constructed wetlands) which transforms these 'waste' into useful and nutritious substances essential for the life of plants housed on panels floating in water.



Condition and relations of biodiversity

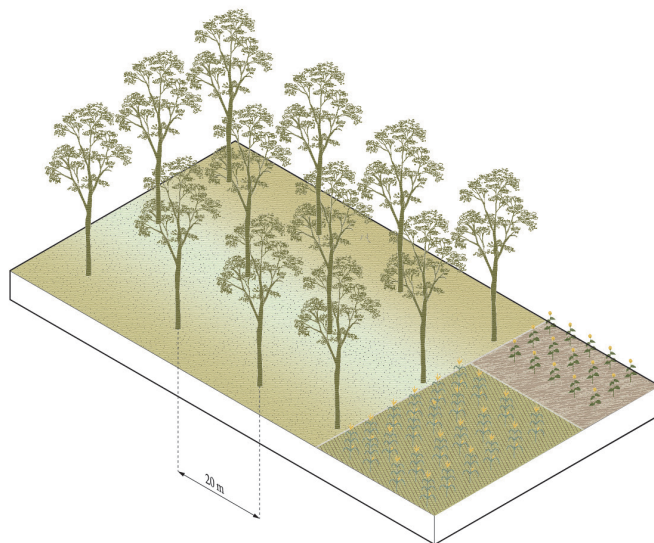
Agroforestry - This practice includes agricultural systems that see the cultivation of tree and/or shrub species, associated with arable land and/or pastures, in the same surface unit. This obviously means not over-exploiting the soil, avoiding monocultures and increasing the yield of crops thanks to the combinations and relationships between the different crops, while respecting the ground.

To complete this technique, farmers implement agroforestry interventions that increase biodiversity and improve the landscape: to limit damage to amphibians and other aquatic species deriving from alternating water and dry conditions, they create permanent wetlands.

Agroforestry for this territory includes hornbeams, alders, birches, dog roses, willows and general plants that tolerate heavy soils and water stagnation more.

The consequence of good agronomic practices combined with environmental recovery through planting, distributed every 20 meters on the cultivation land, allows biodiversity to develop undisturbed in our fields.

The increasingly abundant presence of mixed vegetation, including herbaceous, allows many different species of insects and amphibians to live and reproduce; an example is that of the rare butterfly *Lycaena dispar*, extinct in England and registered in the European Red List of species at high risk of extinction.



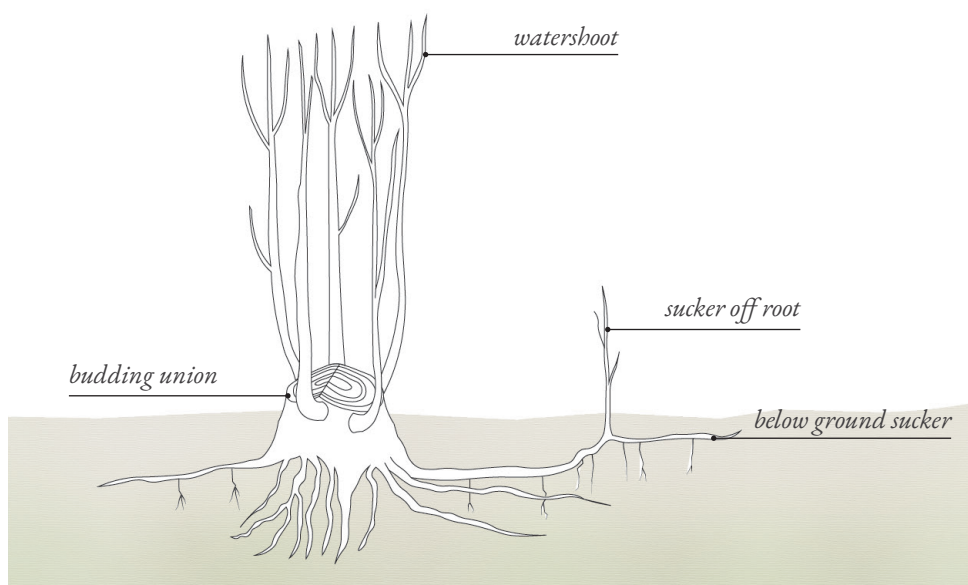
Coppice - The conciliation of food production with that of biomass is a practice that somehow diversifies agricultural production at its foundation and has been the most crucial challenge for the territory. The protection of the soil from the erosion of the fertile layers and from pollution is an emergency to be considered a priority throughout the world;

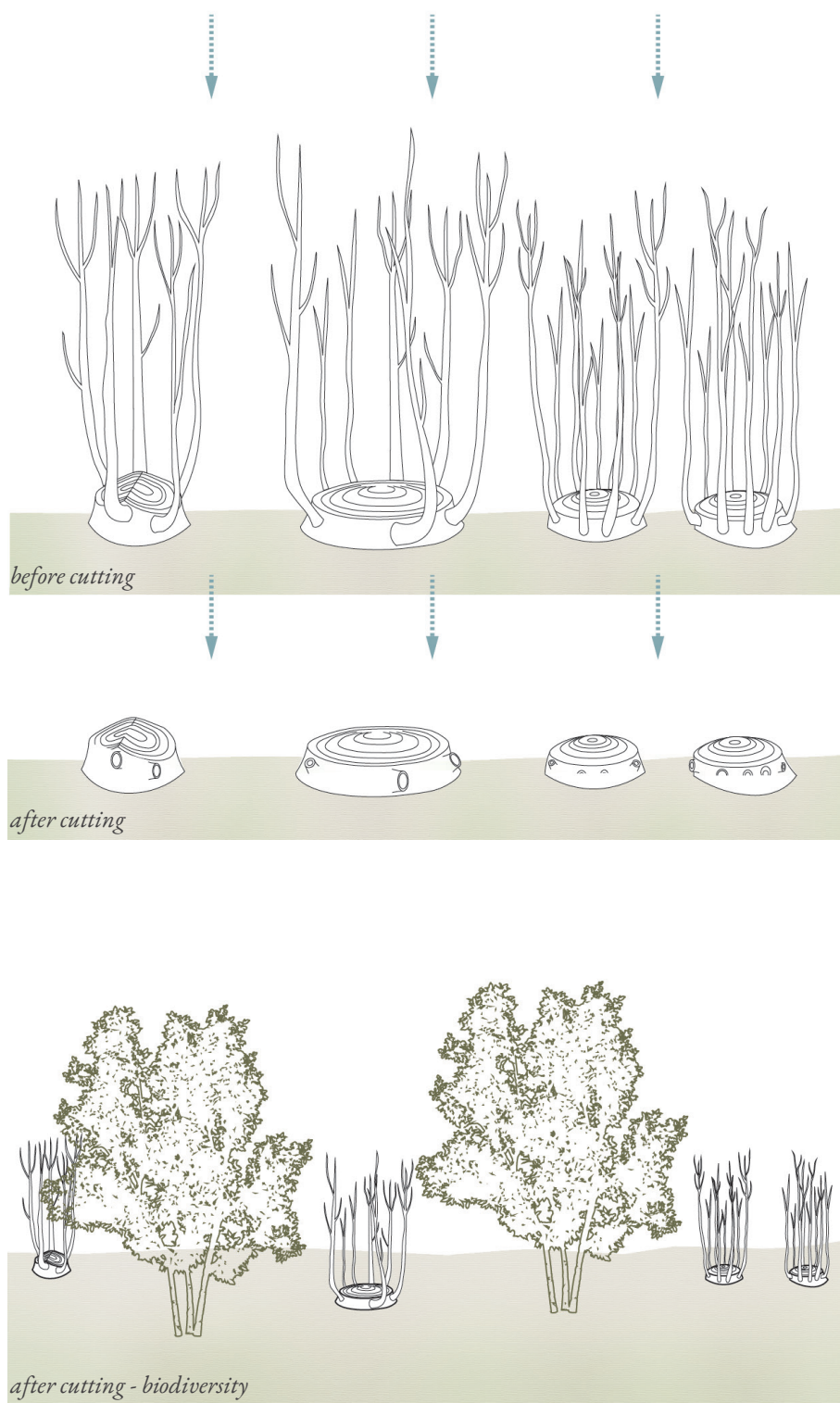
In fact, hundreds of scientific studies have demonstrated that agroforestry systems have many beneficial effects on the environment and evident consequences of climate changes; in addition to improving the conditions of surface and deep waters, they allow soils to regenerate fertility and stable organic matter even in soils traditionally considered poor.

The practice of sub-plantation consists of planting nuclei of young plants of valuable species within a sparse forest population to improve its composition.

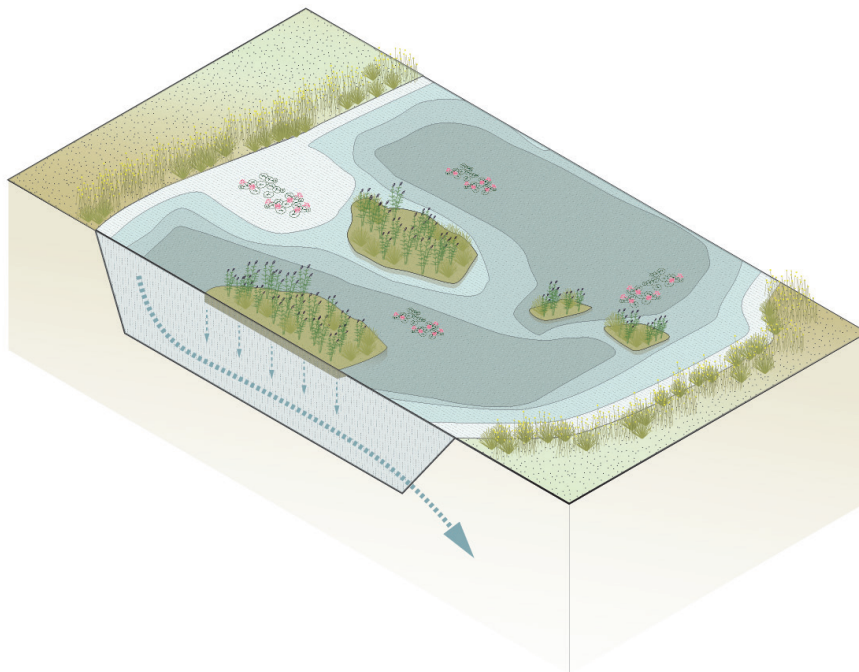
The cut of coppice fields can happen every 16/30 years. Moreover, the coppice fields after a period of time (40 years) can become high forest and produce more income for the economy of the land (Istituto Agrario Sarto, 2023).

155





Constructed wetlands - To contain the circulation of contaminated water, native aquatic plants are inserted floating on biodegradable “mattresses” in order to experiment new practices against pollution. The microorganisms present in the root system allow part of the polluting load to be reduced and form permanent humid habitats. The re-colonization of the banks by native hygrophilous floral species is promoted, which constitute a favourable habitat for pollinating insects.



157

▲
Constructed wetlands. *Source: image produced by the author*

Polyculture: ricefields and agricultural transition

Several studies agree in considering the monoculture technique dangerous for the biodiversity of the area and for the fertility of the soil. Furthermore, the presence of a single cultivated plant favours the spread of insect pests and fungal diseases.

Within intensive monocultures there is a strong impact on bird communities, while diversified agricultural areas manage to buffer the effects almost as well as forest environments. Birds are good indicators of habitat quality, so researchers think that an environment capable of supporting bird populations may prove suitable for hosting other classes of species.

As stated before, the intensification of meadows and vineyards operates on two levels: the first one is local, because it acts right in the field: it is the use of synthetic chemical products, such as fertilizers and herbicides, to which is added the contribution of external inputs, such as intensive irrigation. The second one is a more systemic process which affects entire areas of landscape: it involves the elimination of all those marginal, semi-natural elements, such as hedges, rows of trees, perhaps small puddles, and even dry stone walls, which in agriculture in the past they were much more common, and due to the logic of intensive agriculture they are eliminated, for example to make room for large agricultural machinery, or simply to increase the extension of the cultivated area.

The conclusion is the need to sustain biodiversity by diversifying crops, including natural or semi-natural elements and diminish the use of chemical composts.

Imagining an alternative future to shift the agriculture from mono to polyculture is difficult. Already, the lack of water is changing agricultural choices in the northern region. Even corn, the main food for cattle breeding, gives way to soy, sorghum, barley and sunflower. The lack of rainfall has significantly influenced the sowing choices of farms. According to Coldiretti, there are around 300 thousand agricultural businesses in central-northern Italy which are located in the areas most affected by the drought emergency (Giorgio Vincenzi, 2023).

The most dramatic situation is in the Po Valley where the Po water flow is at the levels of August last year rather than spring. The consequence is that the river is unable to counteract the salt water from the sea which is already penetrating the hinterland for kilometers, burning the crops in the fields, preventing irrigation and posing serious questions to agricultural businesses in the Po delta.

“Last year the drought literally burned 23 thousand hectares of ricefields in Lomellina and 3 thousand in the Novara area. This year we still don’t have

certain data, but the Risi Authority's survey on sowing intentions indicates a further contraction of the areas planted with rice by 7,421 hectares", says Ercole Zuccaro, agricultural technician. "Some farmers have already sown wheat in autumn instead of rice and others will opt for the cultivation of soya, but there are those who, trusting in rain and the release of greater quantities of water from mountain basins, will insist on rice".

"The water crisis will also have inevitable repercussions on this sector with a further increase in production costs due to the scarcity of corn and fodder," continues Boschetti. "The water shortage will have disruptive effects on livestock farming and will trigger inevitable conflicts between farmers and rice growers to control the little available water." Concern and uncertainty are common among farmers because it is difficult to change the company organization in a short time, while fixed costs remain: rent, mortgages, irrigation fees. This is why farmers wait until the last moment to sow, but then we will sow anyway, hoping for rain.

An alternative future: lentils

Lentils (*lens culinaris*) in dry conditions and permeable soil - Lentils peculiar characteristics are resistance to drought and cold. Furthermore, its high rusticity makes it possible not to use herbicides and agrochemicals in the cultivation process, except in particular cases. A non-negligible element that further qualifies it in the eye of the consumer.

The soil where we grow lentils is clay-loam, rich in organic substance and phosphorus. The cultivation technique involves plowing at the beginning of spring, possible harrowing and sowing from mid-March to mid-May (to avoid the danger of low night temperatures). The threshing takes place by August, and then the harvested product is left to rest for several weeks to prepare it for consumption.

Regarding water and irrigation, lentils tolerate drought well and have medium water requirements. The most critical periods, however, are those between flowering and the beginning of maturation and midsummer, especially in the presence of a particularly dry season. Be careful not to wet the plants directly: the flowers and shoots are in fact quite delicate and can be damaged by falling water and suffer burns or scalds.

Lentil in Italy today has a trade balance that is very unbalanced towards imports: approximately three quarters consumed in our peninsula are imported from other countries. In 2015, 1,844 quintals of lentils were exported while 34,145 quintals were imported (Ismea, n.d.).

Lentils in bioenergy production - As rice, lentils residues can be used to produce bio-energy. Other than this, there are some experimentation on how to include the agrovoltatics techniques in the lentils fields to produce renewable energy.

Agrovoltatics is one of the most promising applications for accelerating the development of renewable energy. In fact, it exploits agricultural land to produce solar energy, but without competing with food production and without consuming land.

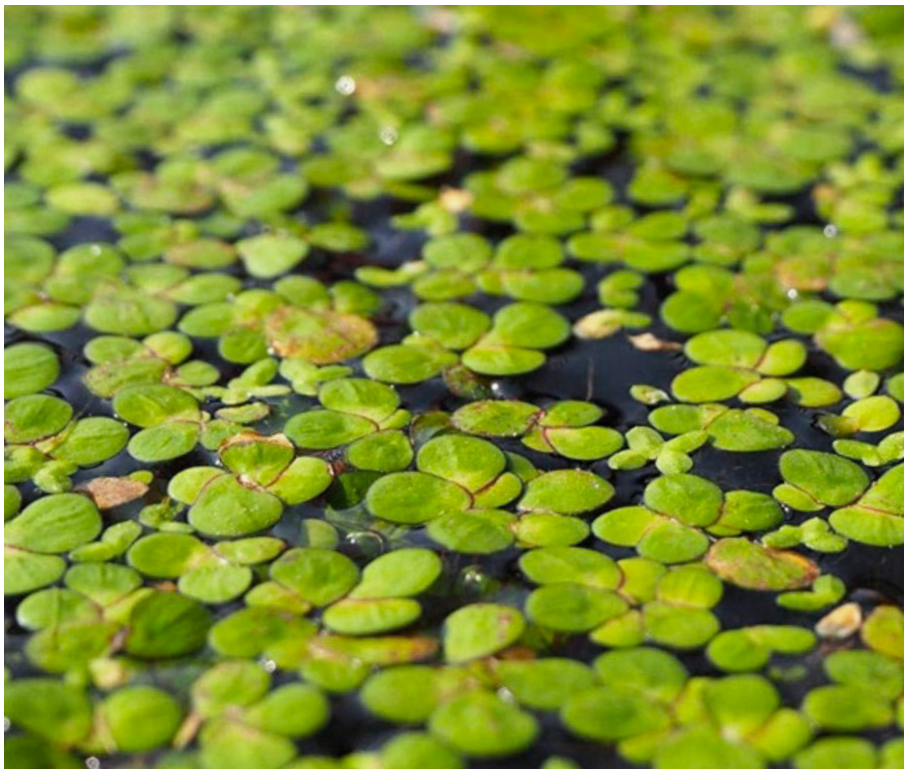
There is an interesting case study relating to the cultivation of lentils and saffron in Colfiorito in Umbria, at the La Valletta farm, where the first of five demonstration sites that are part of the Italian “Agrivoltaic Open Labs” initiative was launched by Enel Green Power. The objective of the project is to create, on Italian territory, open-air laboratories to test, in collaboration with scientific partners, research institutions, startups and agricultural companies, the integration between solar energy production, agriculture and the protection of biodiversity.



Lentils (*Lemna minor* L.) in submerged conditions and impermeable soil - It does not belong to the legume family, this must be made clear immediately. Its name can rather be traced back to its shape; similar, in fact, to that of lentils. This plant contains a high quantity of proteins and which facilitates the control of blood sugar levels after the consumption of carbohydrates. The scholars at the Israeli university had greater glycemic control and also felt fuller. Duckweed also contains many amino acids, the quantity is almost the same as eggs and, in the plant world, this represents a more unique than rare case. Furthermore, this plant is rich in polyphenols, fibre, minerals (primarily iron and zinc), vitamin A and group B vitamins.

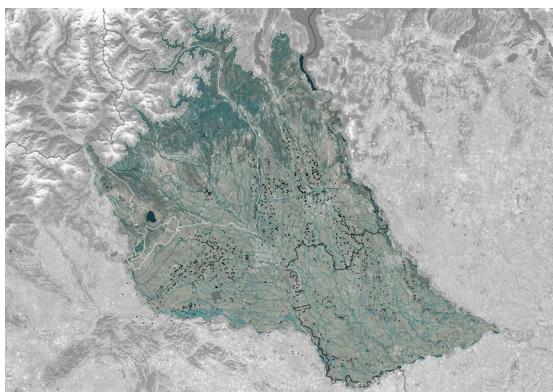
Duckweed is a plant native to all temperate climate zones. Its structure is composed of very small green, rounded and oval leaves, capable of reaching a maximum diameter of approximately 4/5 centimeters. Each leaf is a small plant as it has autonomous roots. During the spring season it is possible to enjoy the beauty of very small inflorescences, which anticipate the development of fruits containing a seed. The main characteristic of these specimens is that they grow on water, and can sometimes be very invasive. They develop quickly, so much so that in three days they manage to multiply their structure, furthermore, they are able to absorb the nitrogen present in the water and the carbon released into the atmosphere.

161



▲
Lentils. Source: Hort Americas, n.d. <https://hortamericas.com/blog/news/could-duckweed-be-the-next-big-vertical-farm-crop/>

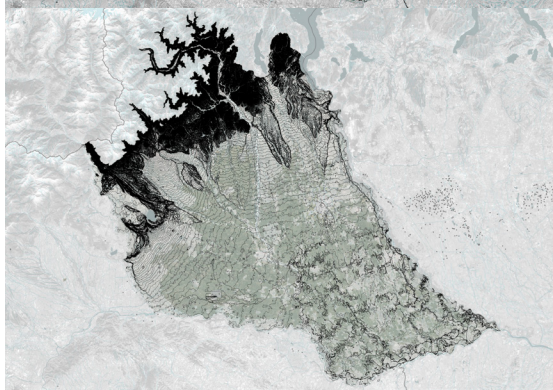
Designing for the future



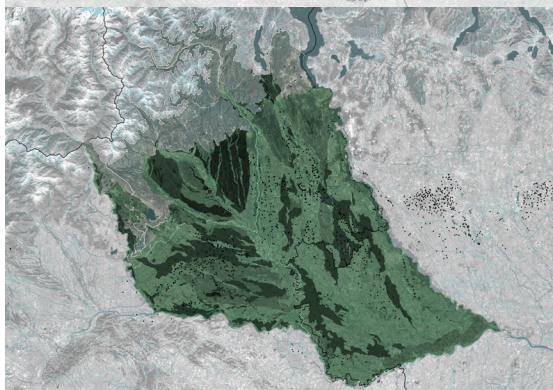
water system - resurgences



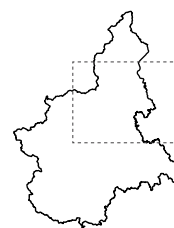
ricefields



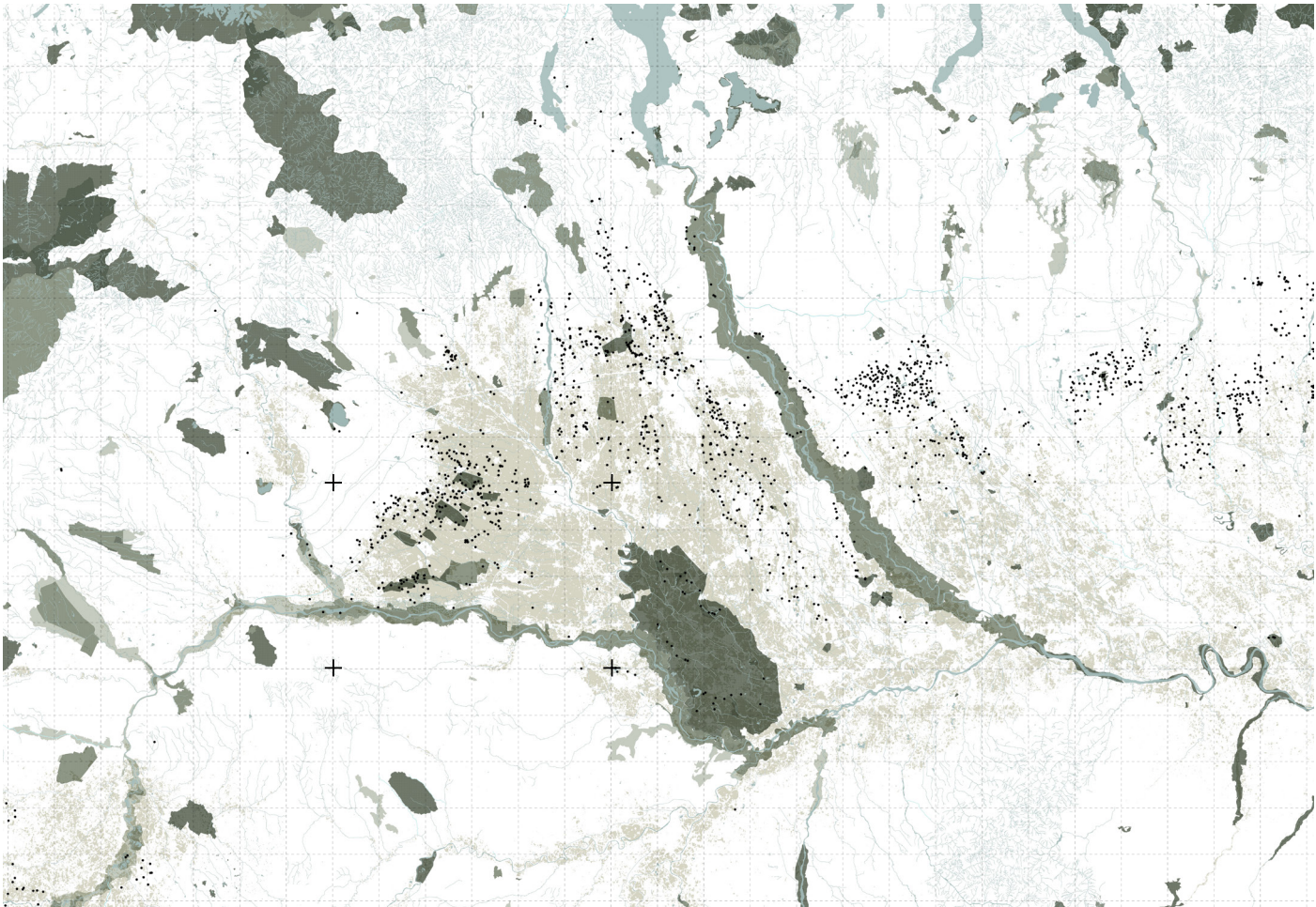
topography



soil type



(Un-)existing green infrastructure

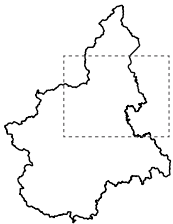


163

N

0 | 15 km | 30 km

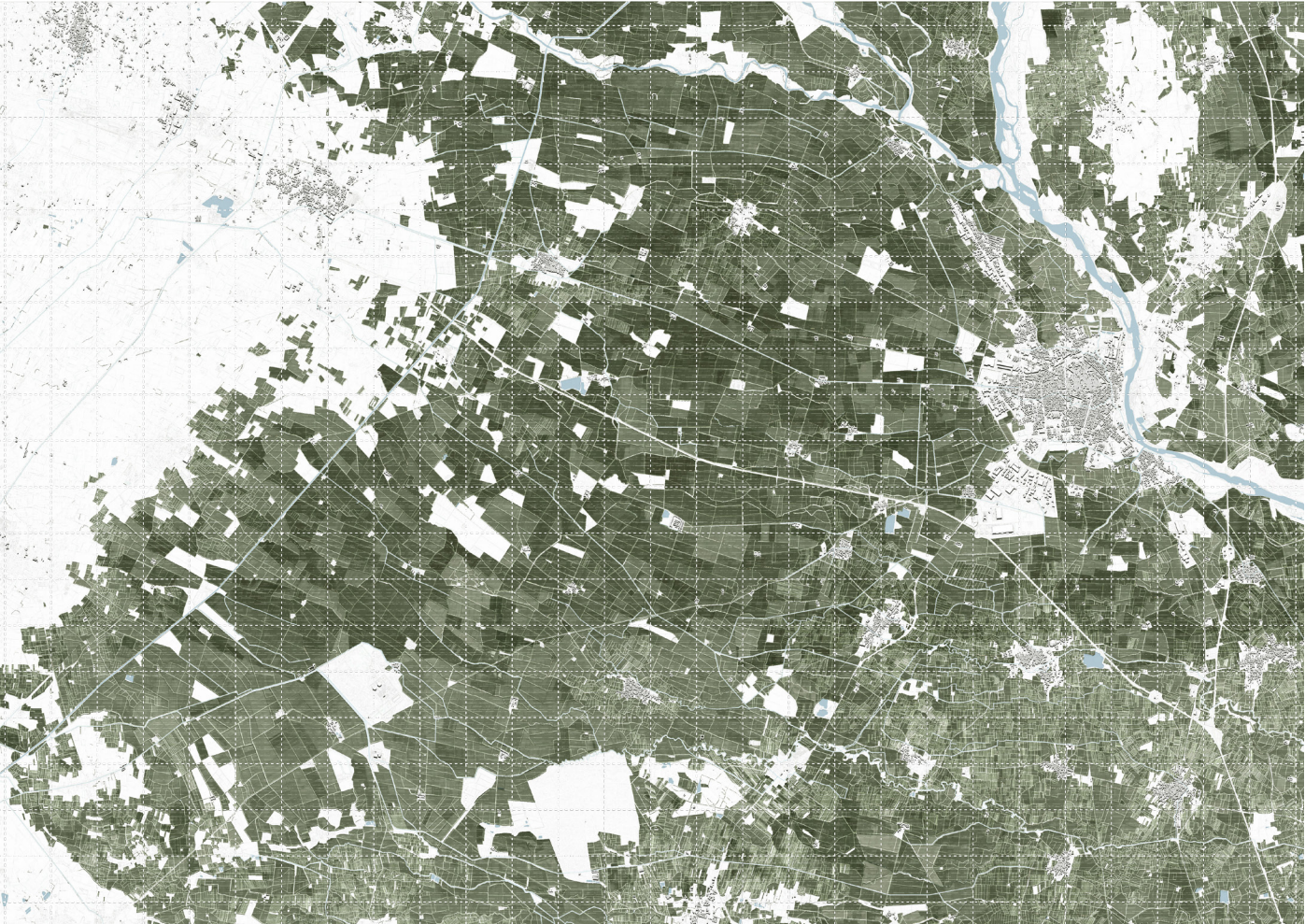
- ricefields
- natura 2000
- resurgence
- water system



▲ Frame of the project. Source: Natura 2000, 2022. Regione Lombardia, 2023. Regione Piemonte, 2023.

Current situation - monoculture ricefields

164



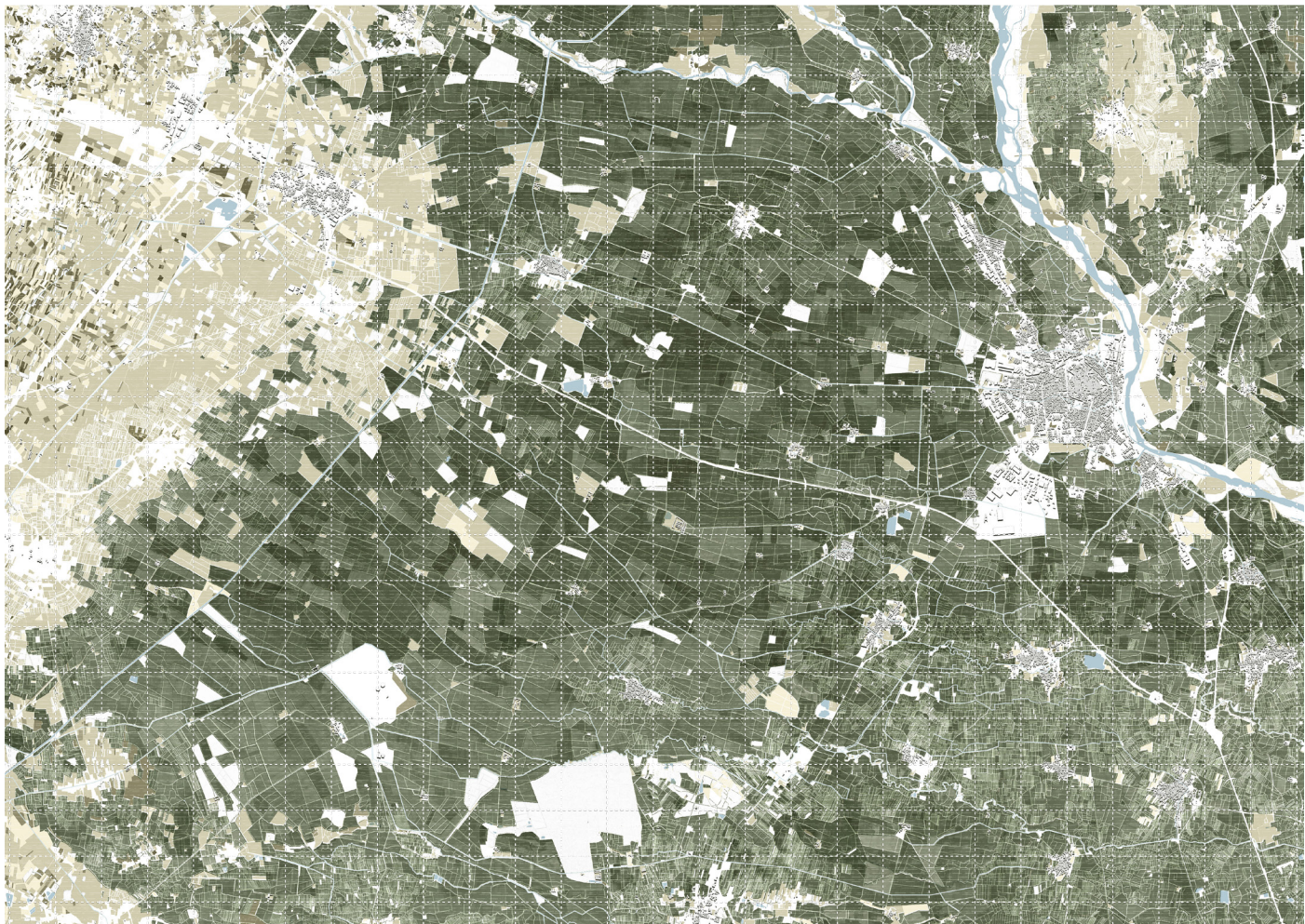
N

|0 | 2 km | 4 km

■ ricefields

▲ Ricefields in Vercelli's area. Source: Regione Piemonte, 2023.

Current situation - other coltures



165

N

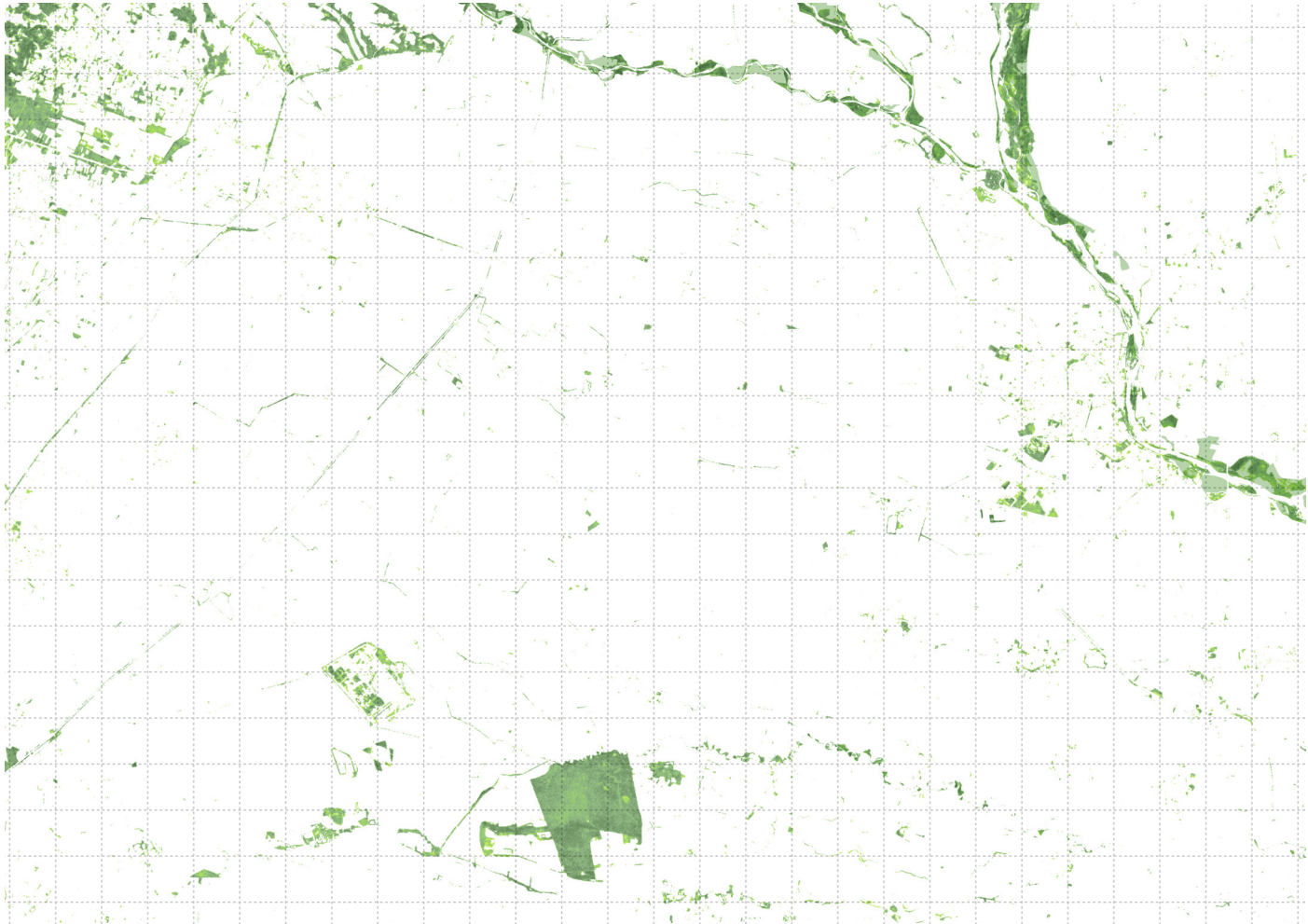
|0 | 2 km | 4 km

ricefields
other crops

▲
Crops in Vercelli's area. Source: Regione Piemonte, 2023.

Green infrastructure

166

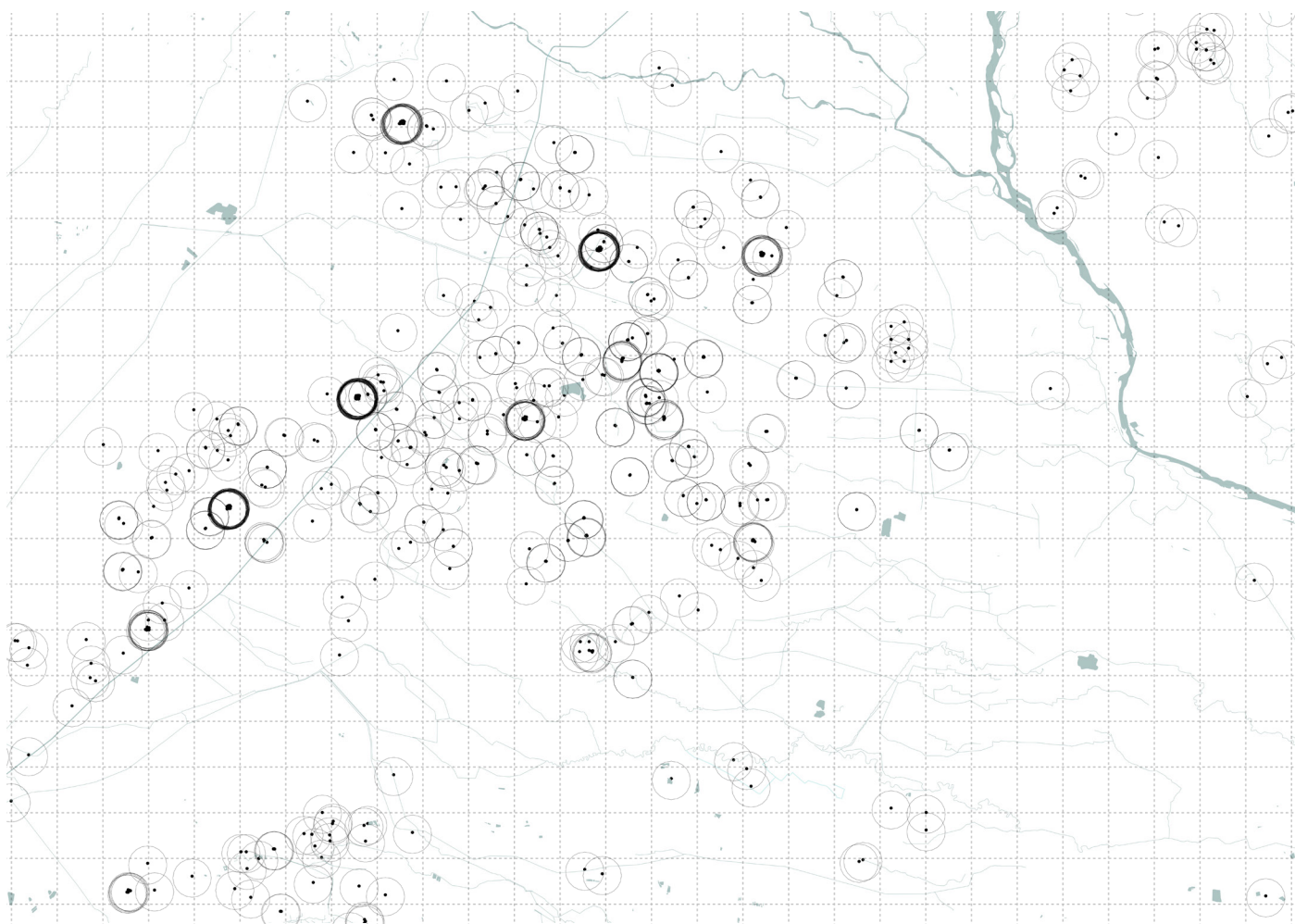


N

0 2 km 4 km

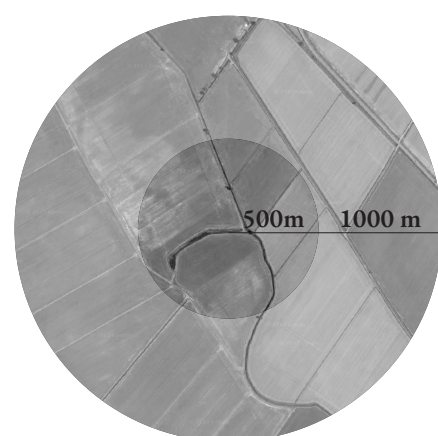
■ nature

▲ Ricefields in Vercelli's area. Source: Regione Piemonte, 2023.



167

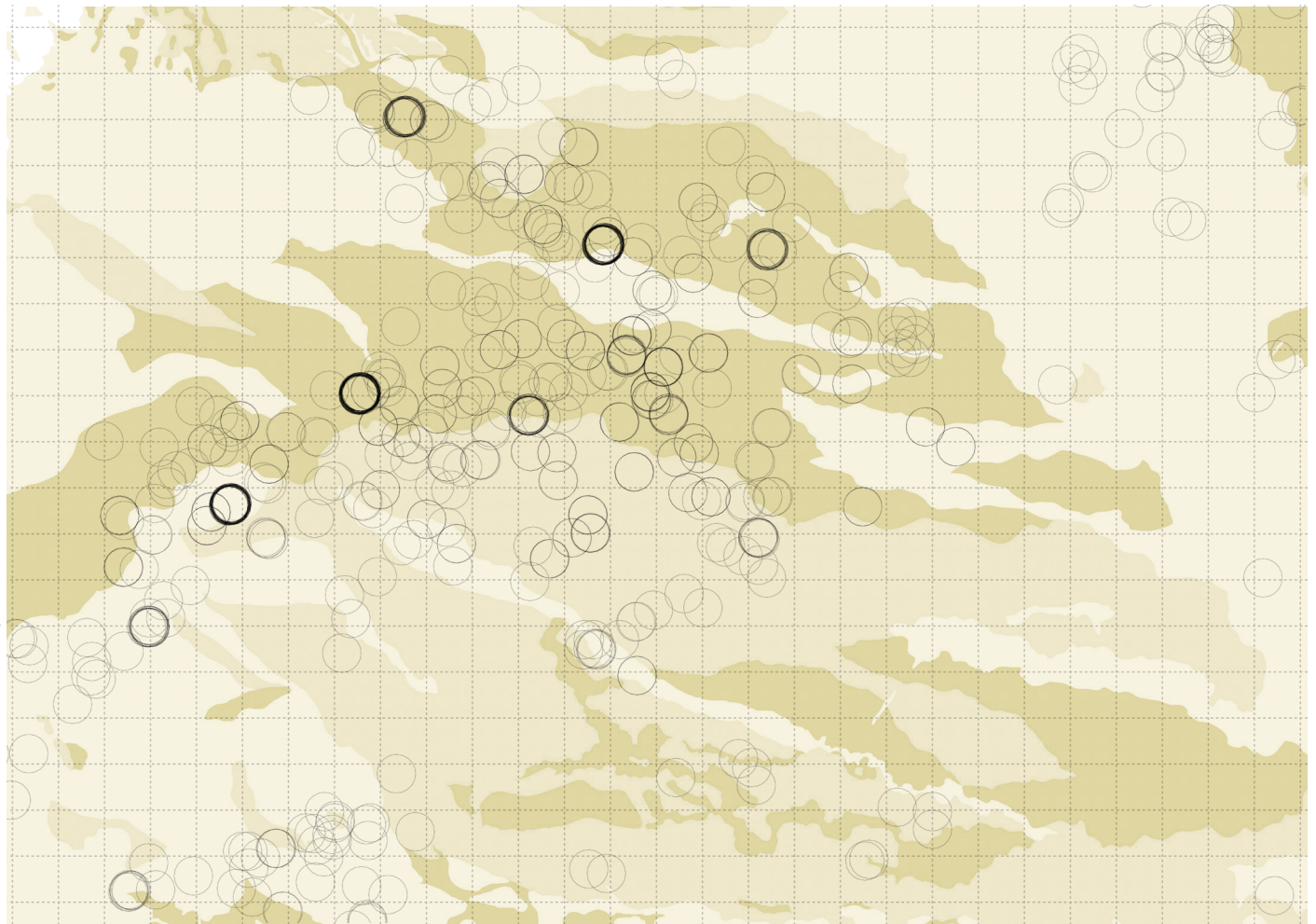
- water elements
- resurgence



▲ Ricefields in Vercelli's area. Source: Regione Piemonte, 2023.

Soil typology

168



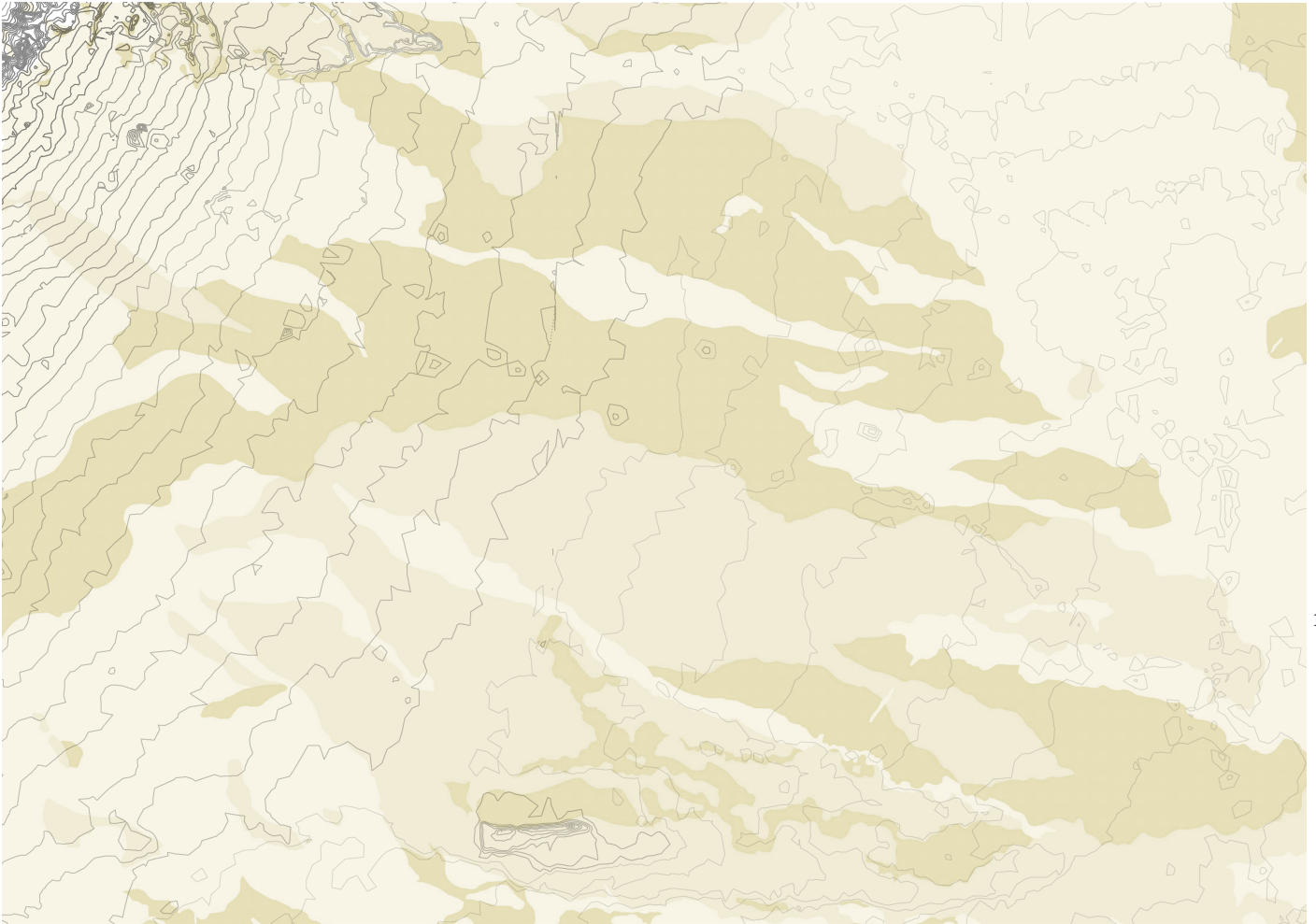
N

0 2 km 4 km

- clayey soil
- silty and clayey soil
- sandy soil

▲ Soil typology. Source: Regione Piemonte, 2022.

Topography



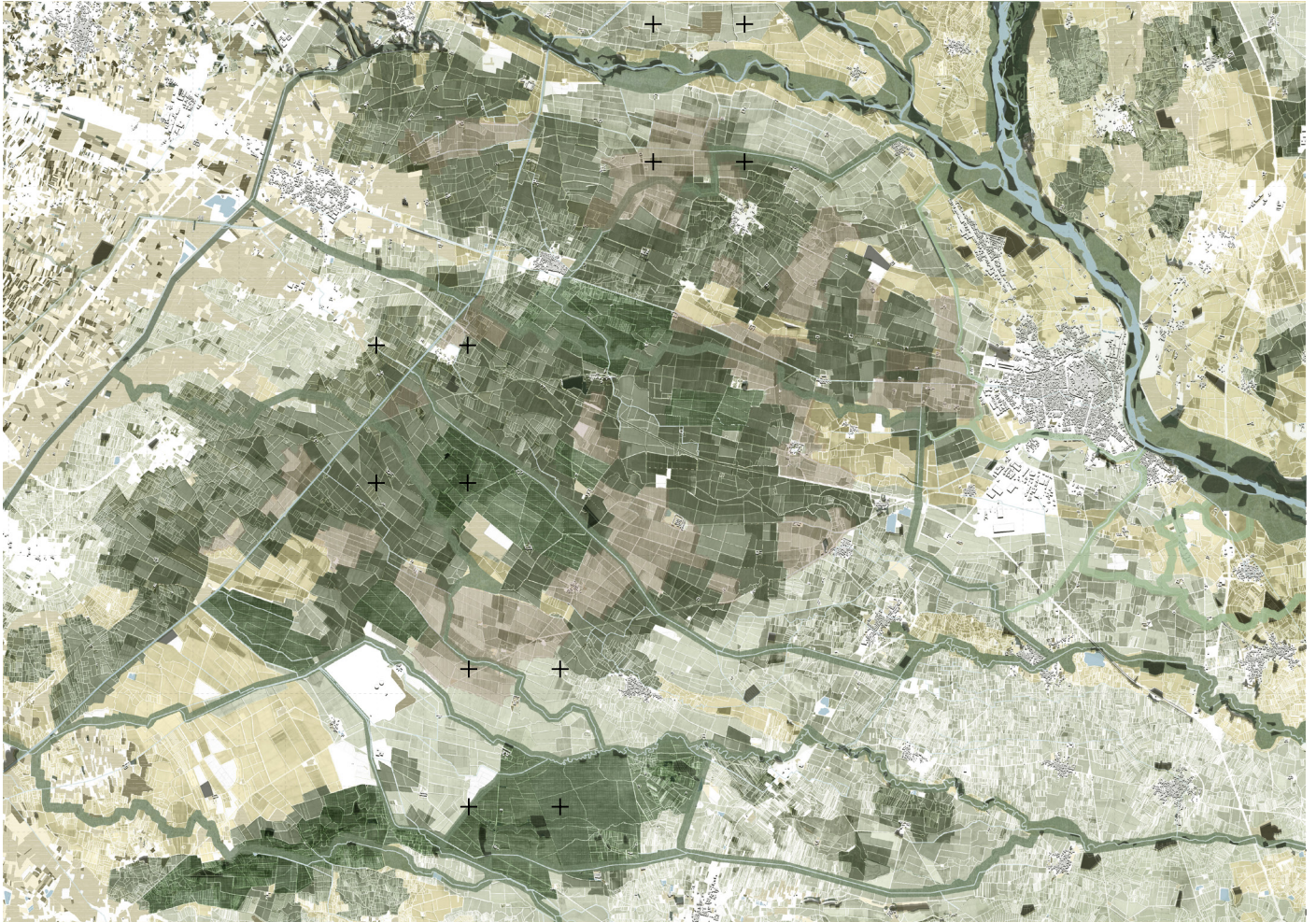
169

▲
Soil typology. Source: Regione Piemonte, 2022.

hydrological risks



▲ Soil typology. Source: Regione Piemonte, 2022.



172

N

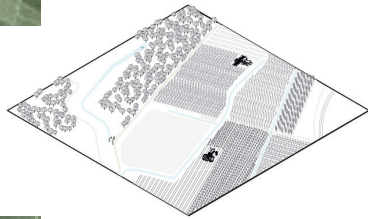
|0 |2 km |4 km

▲
Scenario for 2030. Source: image made by the author.

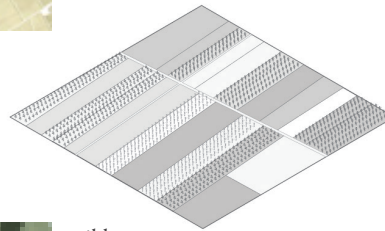
Elements of 2030



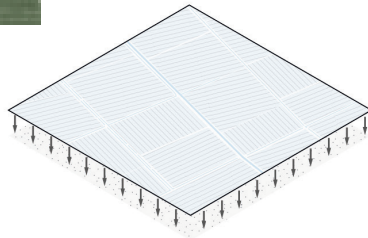
reserve



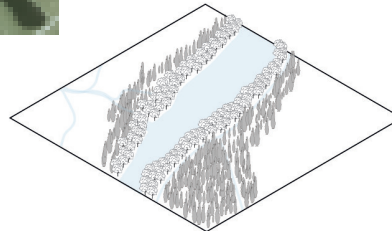
change in cultivation



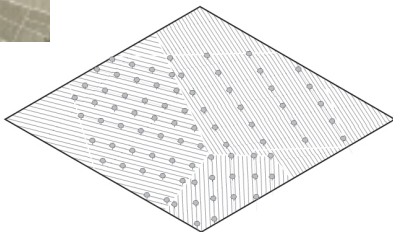
ricefields/winter submersion



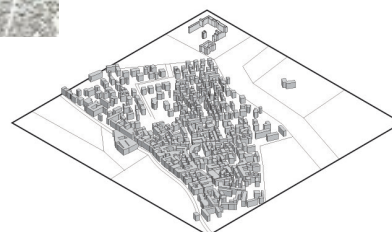
wilderness



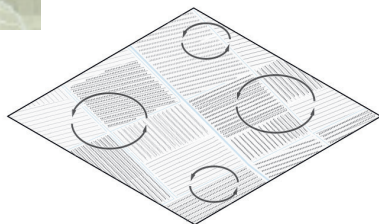
ricefields and agroforestry



urban



crops rotation



Designing for 2040



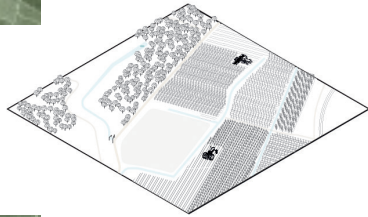
| 0 | 2 km | 4 km

▲
Scenario for 2040. Source: image made by the author.

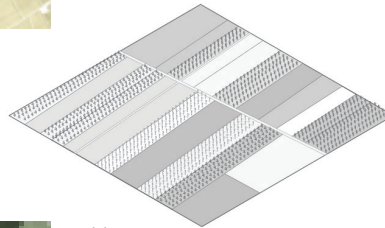
Elements of 2040



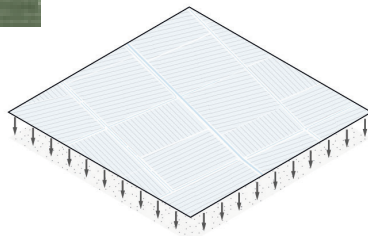
reserve



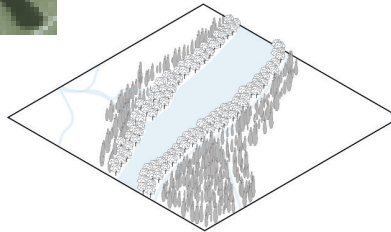
change in cultivation



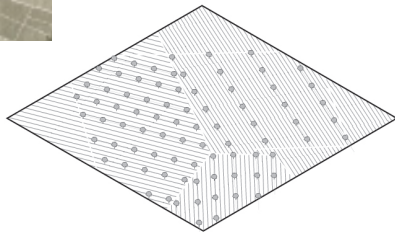
ricefields/winter submersion



wilderness



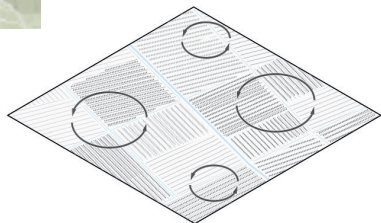
ricefields and agroforestry



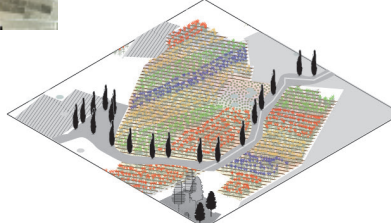
urban



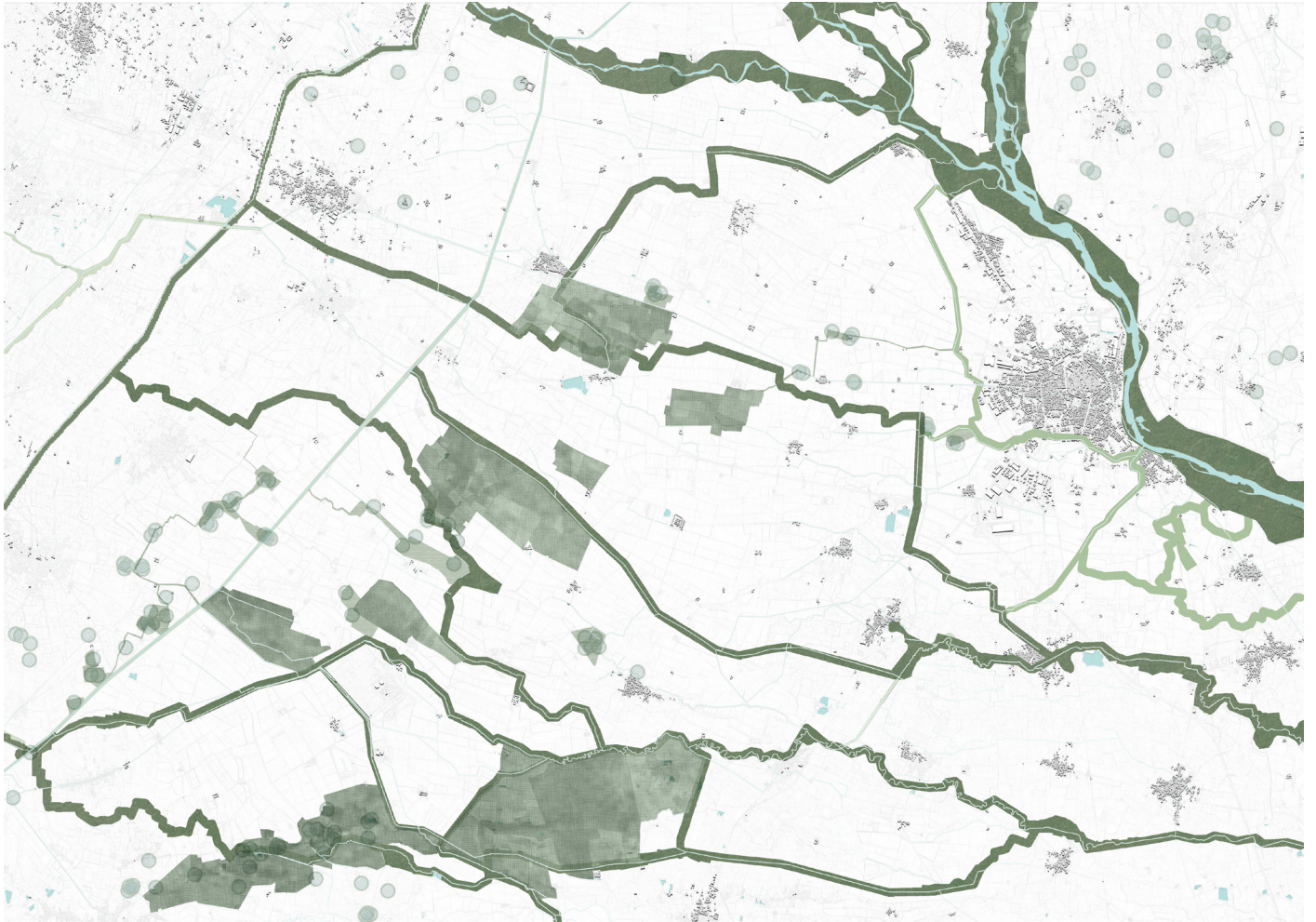
crops rotation



lentils cultivation



Ecological corridors



176

|0 |2 km |4 km

▲
Scenario for 2040. Source: image made by the author.

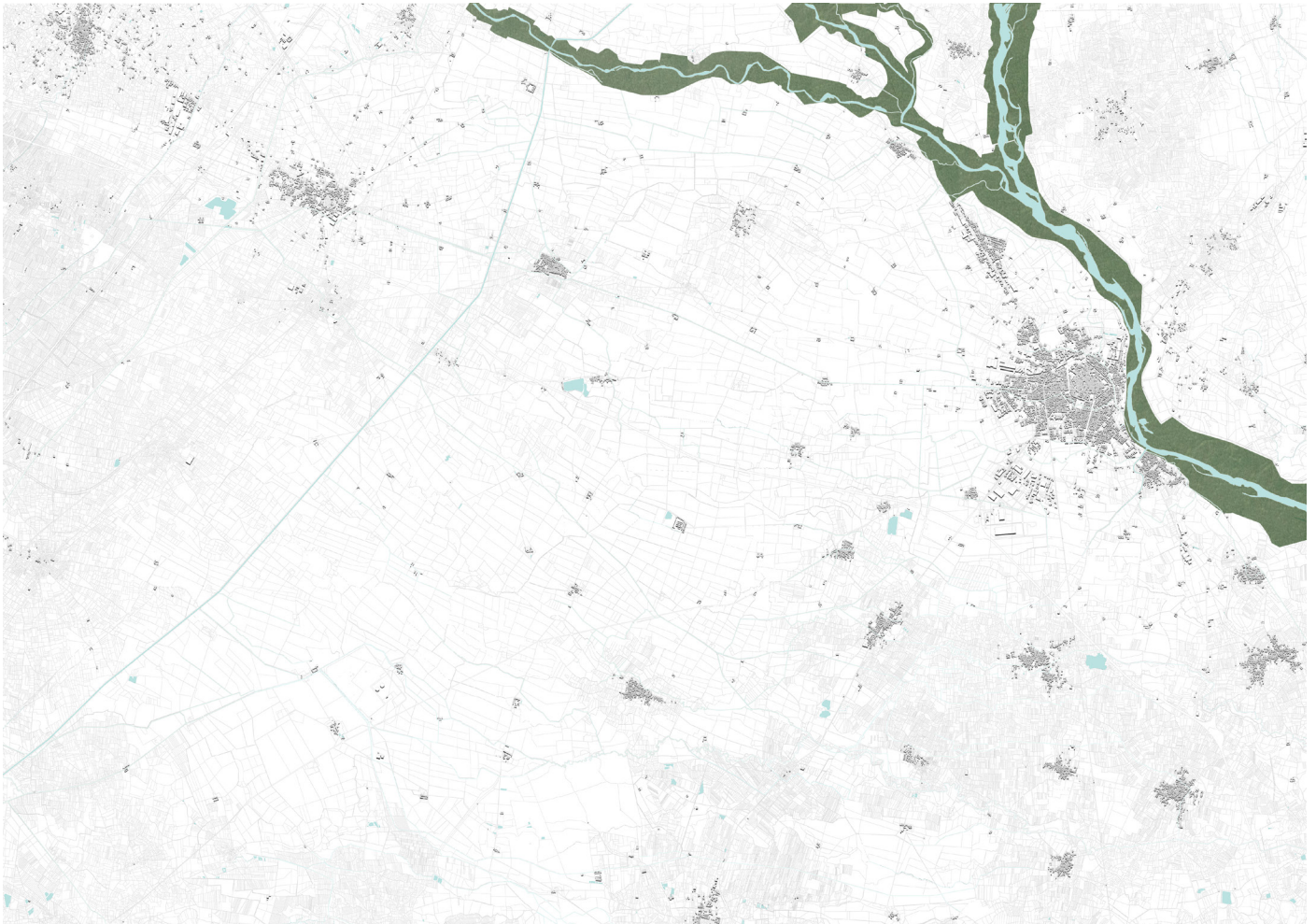
FAO has estimated that from 1990 to 2020, approximately 186 million hectares of forests and woodlands have been destroyed (out of a total of 4.06 billion hectares, approximately 31% of the earth's surface), due to the construction of roads and buildings.

The fragmentation of natural areas puts biodiversity at risk. In this context, ecological corridors are a very effective solution, also with a view to adapting to climate change.

The ecological network arises from a central area, called core area, a natural area already subject to a protection regime, such as natural parks or reserves. The central areas are delimited by protection bands, or buffer zones, which guarantee the slight progression from natural habitat to artificial habitat and which are connected to each other via ecological corridors, fundamental elements that define the movements of animals from a central area to another one.

The corridors, in addition to allowing the passage between core areas, also favor the transit of species in other areas of small surfaces, also called stepping stones, such as ponds or lakes, which can be fundamental for the survival of some species. In this way, the corridors determine the protection of biodiversity in areas where man has built and divided natural ecosystems.

Ecological corridors - primary



178

|0 |2 km |4 km

■ primary corridor

▲
Ecological corridors. *Source: image made by the author.*

Primary corridor - existing

The diagram illustrates a cross-section of a landscape with the following zones from left to right: fallow land, grass, aquatic (Sesia River - 70 m), vegetation, ricefields, and ricefields. Below the diagram, icons represent the vegetation types: *Salix*, *Robinia*, and *Oryza sativa*.

The diagram illustrates a cross-section of a river landscape with various vegetation and animal species. The landscape is divided into five main sections, each with a specific color-coded background and a list of associated species.

Sesia River - 70 m

Vegetation and Animal Species:

- Coppice:** *Alnus glutinosa*, *Robinia*, *Robinia pseudoacacia*, *Fagus sylvatica*, *Castanea sativa*.
- Vegetation:** *Pica pica*, *Upupa epops*, *Turdus merula*, *Egretta garzetta*, *Glaucidium*.
- Aquatic:** *Ibis sacro*, *Falco di palude*, *Buteo buto*, *Alcedo Atthis*, *Buteo stellaris*.
- Vegetation:** *Quercus*, *Ulmus*, *Fraxinus*, *Salix*, *Carpinus betulus*, *Robinia pseudoacacia*.
- New Cultivation:** *Lepus europaeus*, *Trachymys scripta elegans*, *Aura*, *oat*, *black emmer*, *millet*.

Scale: 0 | 50 m | 100 m

Ecological corridors - secondary/connection to core areas

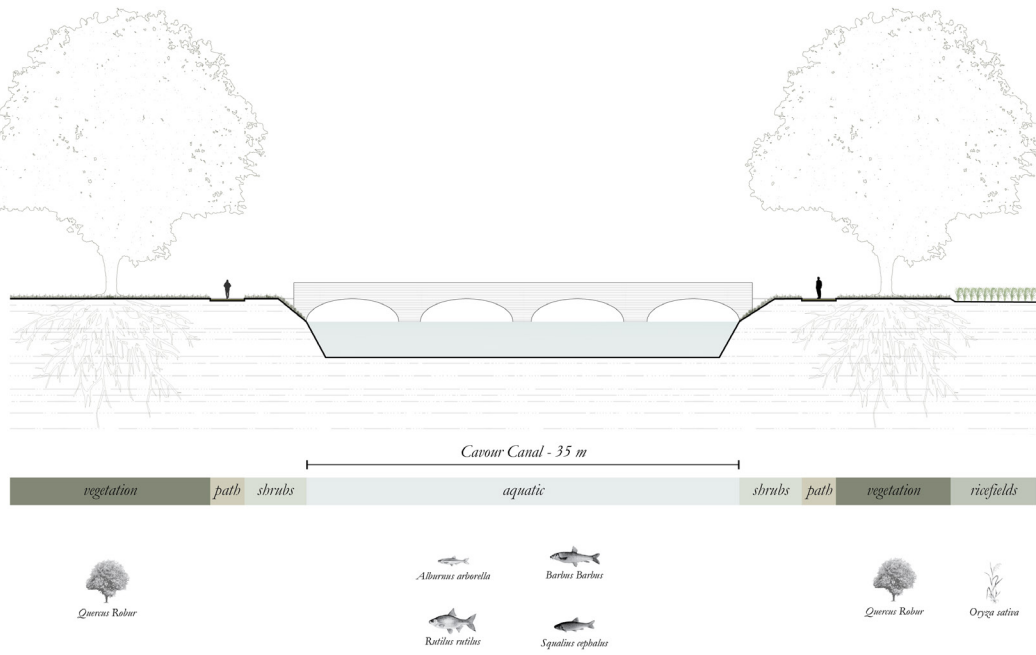


|0 |2 km |4 km

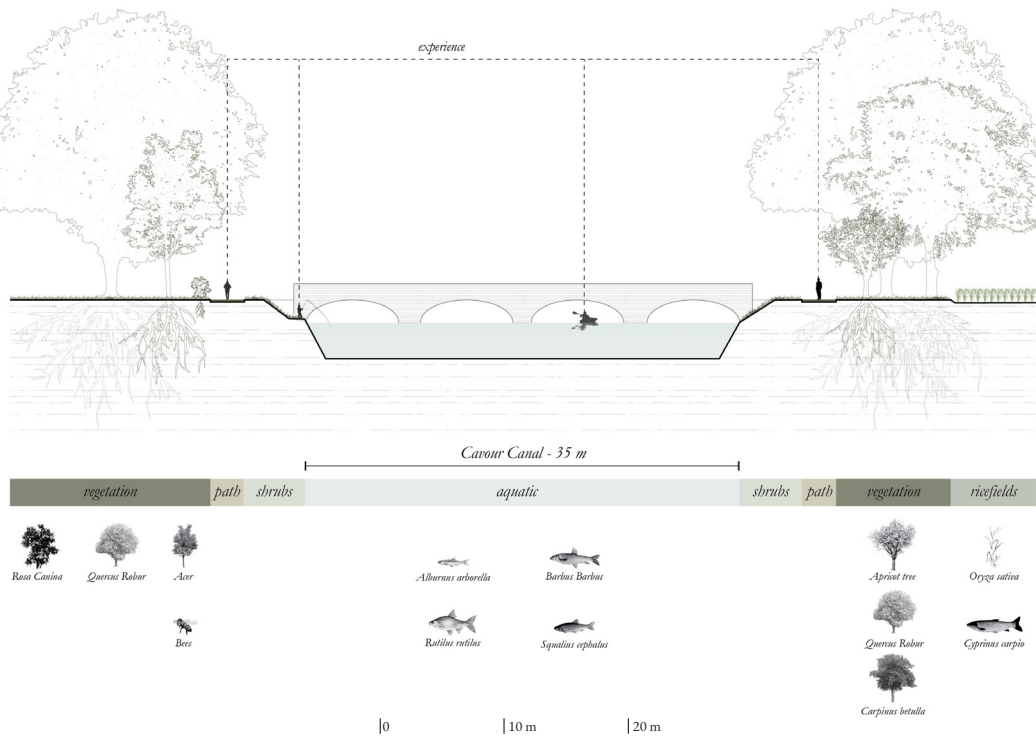
primary corridor
secondary corridor

▲
Ecological corridors. Source: image made by the author.

Secondary corridor - existing



Secondary corridor - alternative future



Ecological corridors - secondary



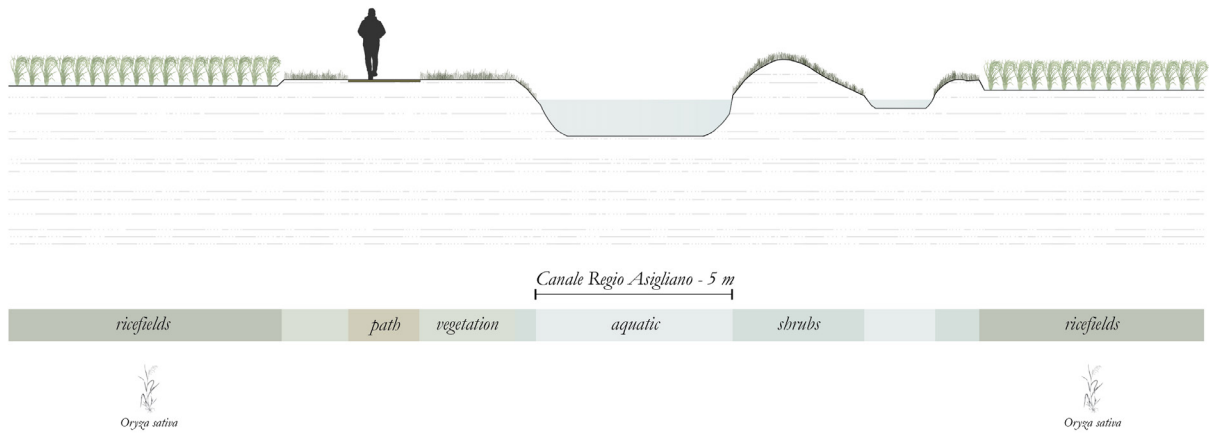
182

|0 |2 km |4 km

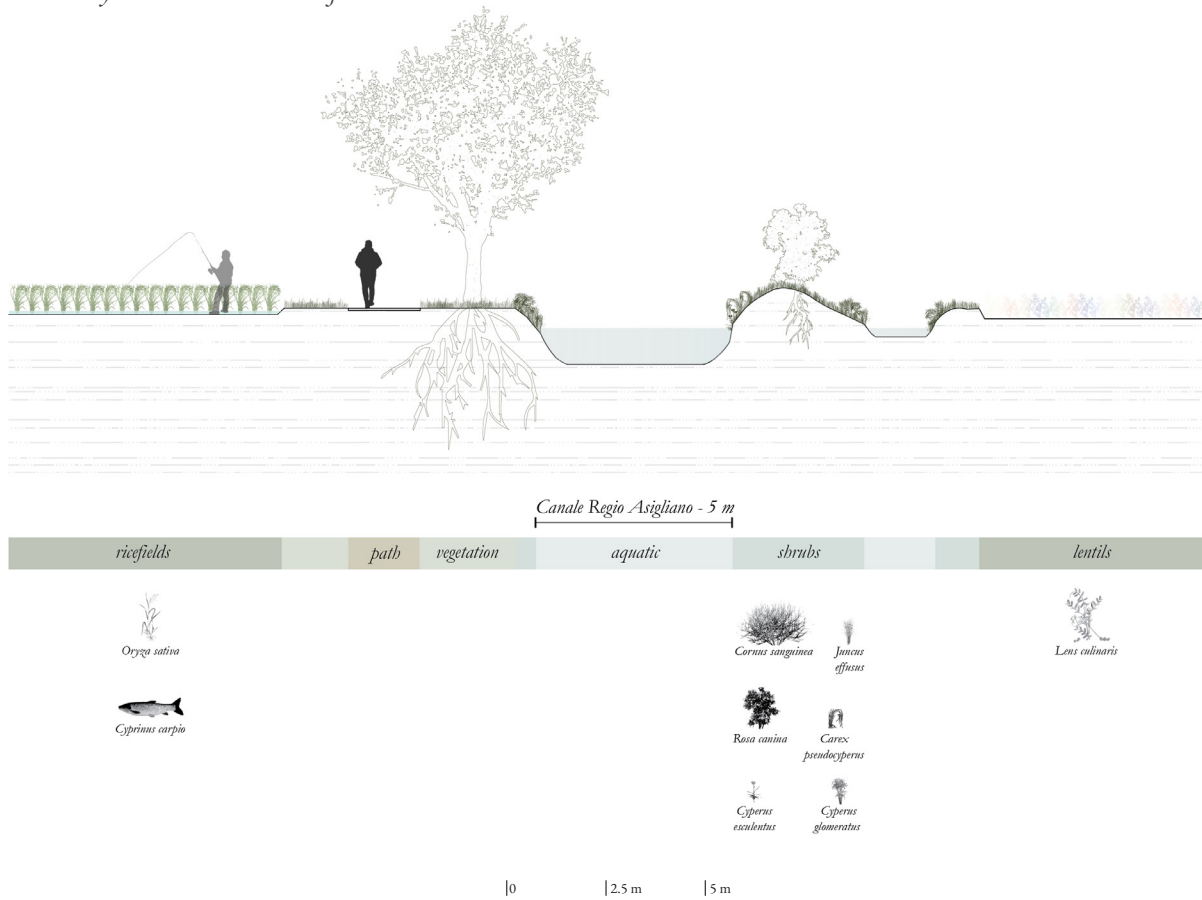
■ primary corridor
■ secondary corridor

▲
Ecological corridors. *Source: image made by the author.*

Tertiary corridor - existing



Tertiary corridor - alternative future



Ecological corridors - tertiary



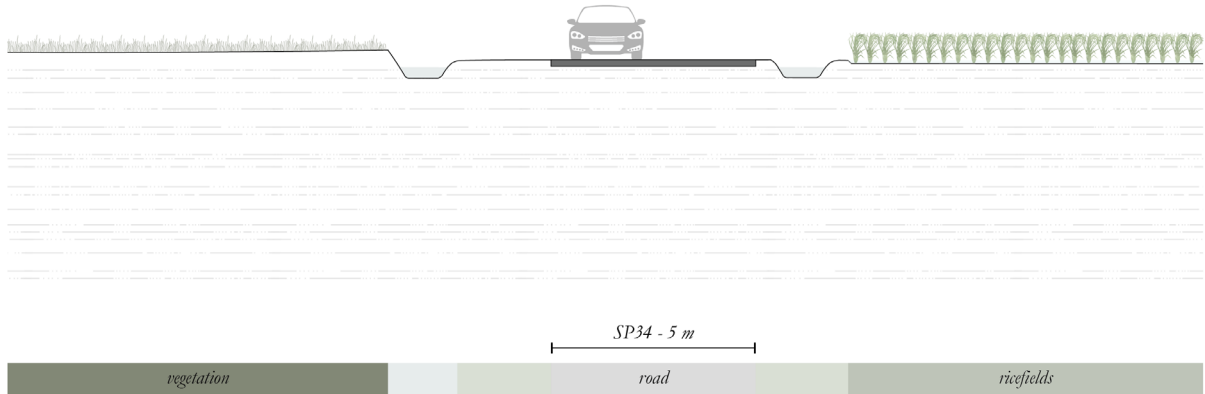
184

|0 |2 km |4 km

- primary corridor
- secondary corridor
- tertiary corridor

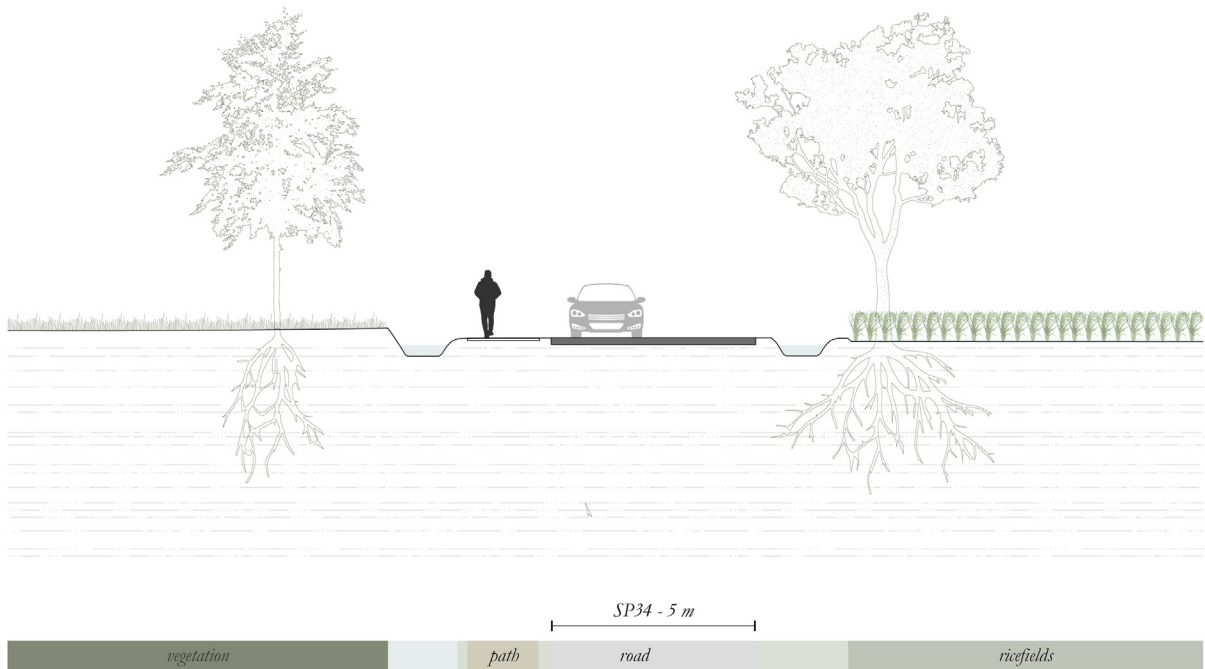
▲
Ecological corridors. *Source: image made by the author.*

Tertiary corridor - existing



Oryza sativa

Tertiary corridor - alternative future



Oryza sativa

Cyprinus carpio

|0 |2.5 m |5 m

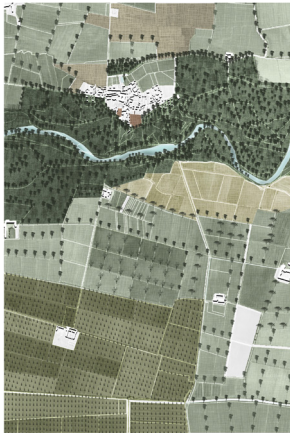
The three landscapes

Wilderness

2023



2030



2040



Productive landscape

2023



2030



2040



Culture

2023

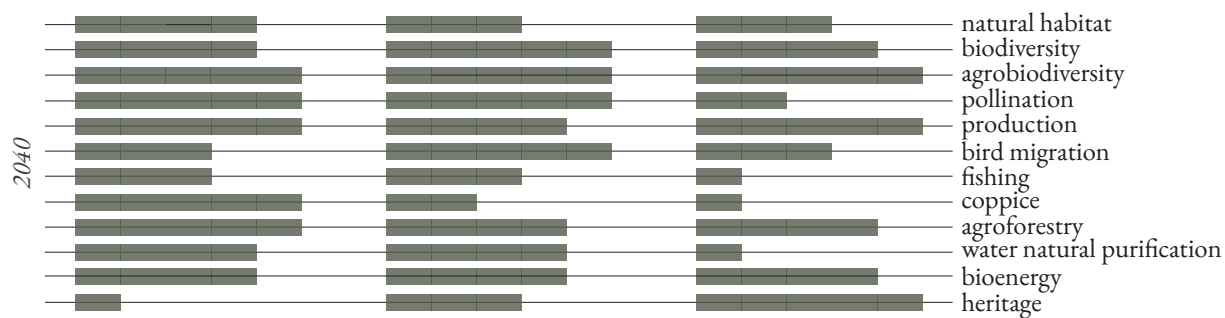
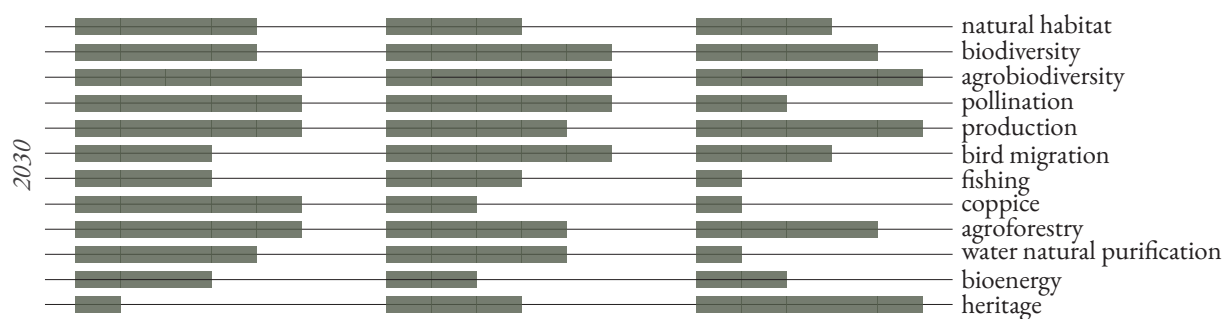
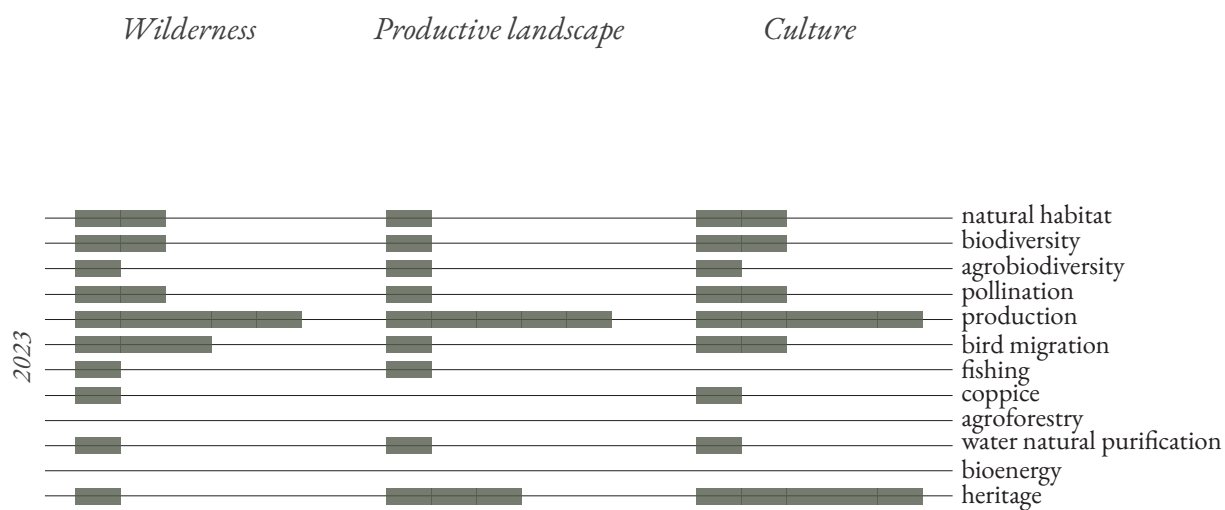


2030

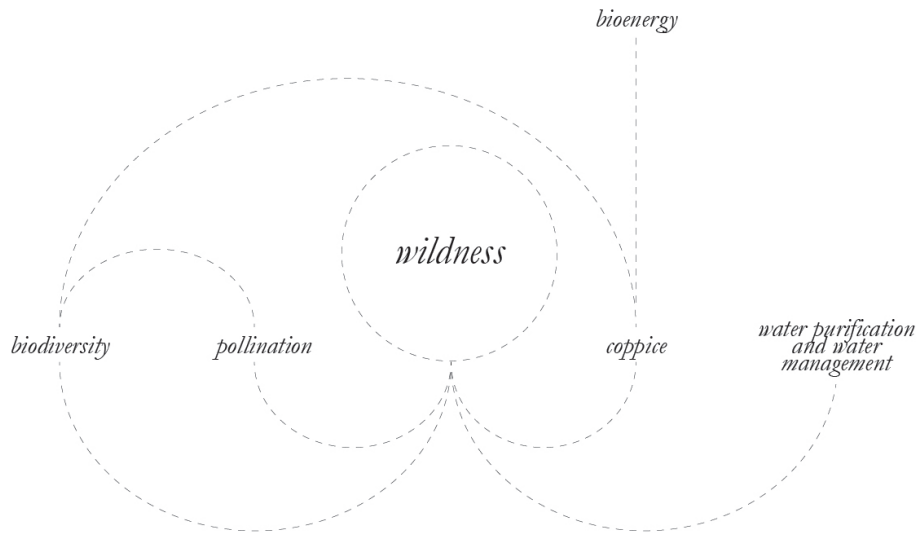


2040





Wilderness



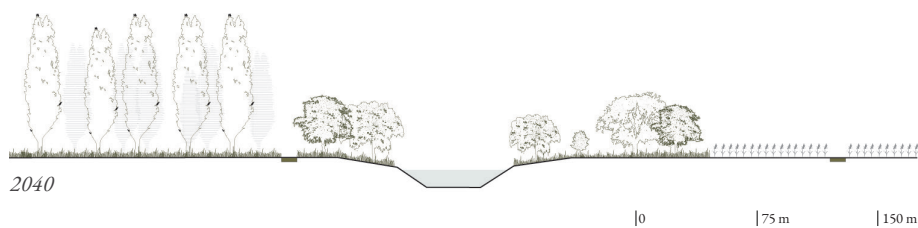
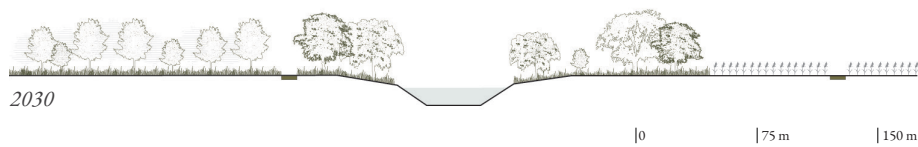
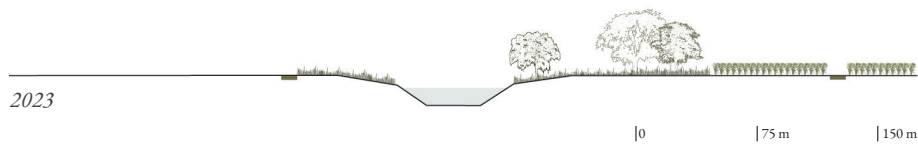
188

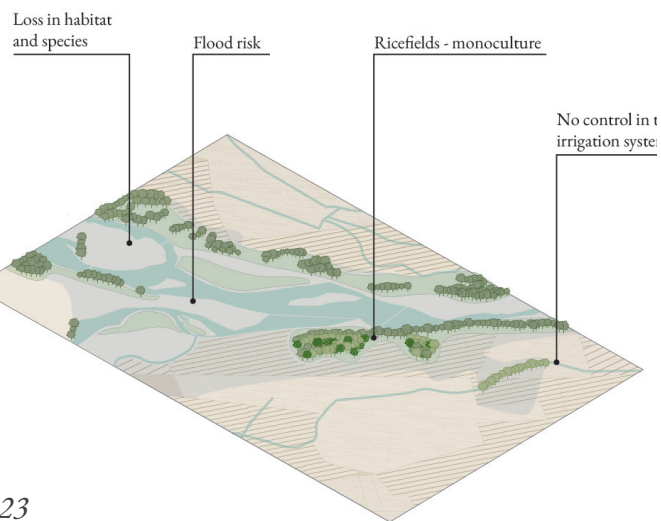
As explained in the previous chapters, the mechanization process changed the landscape of Vercelli. Today the plots today appear more regular and large than in the past. The simplification of the geometry of the paddy is the result of the massive use of flattening and leveling means. Also, the disappearance of many rows of windbreak trees that once characterized the landscape of the lower Vercelli area.

For the future, it is important to restore some areas of wilderness, either for biodiversity, coppice production (bioenergy) and water management. The risk of floods in some areas is really high and it is frightening the human-nature system.

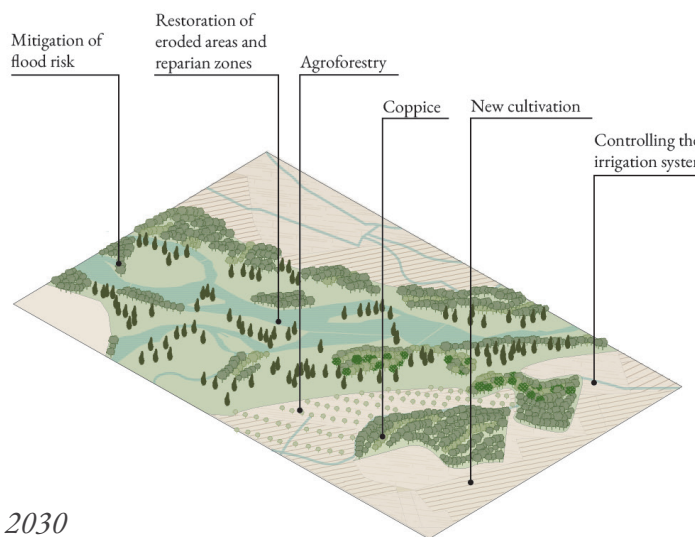
To invert the systemic which affected the entire areas of landscape, the addition of all those marginal, semi-natural elements, such as hedges, rows of trees, perhaps small puddles, and even dry stone walls, which in agriculture in the past they were much more common, and due to the logic of intensive agriculture they are eliminated, for example to make room for large agricultural machinery, or simply to increase the extension of the cultivated area.

Wilderness also needs to be implemented next to the Sesia River, which is facing alternating periods of drought and periods of flood risk. The deforestation that happened in that area is increases these risks and also the loss of biodiversity.

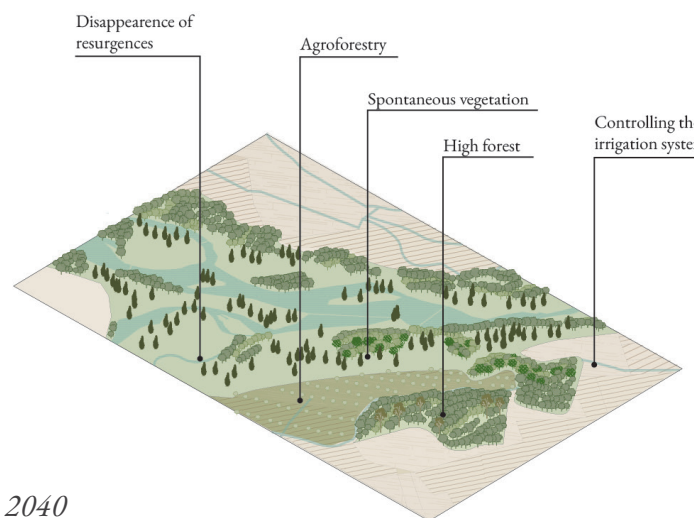




2023

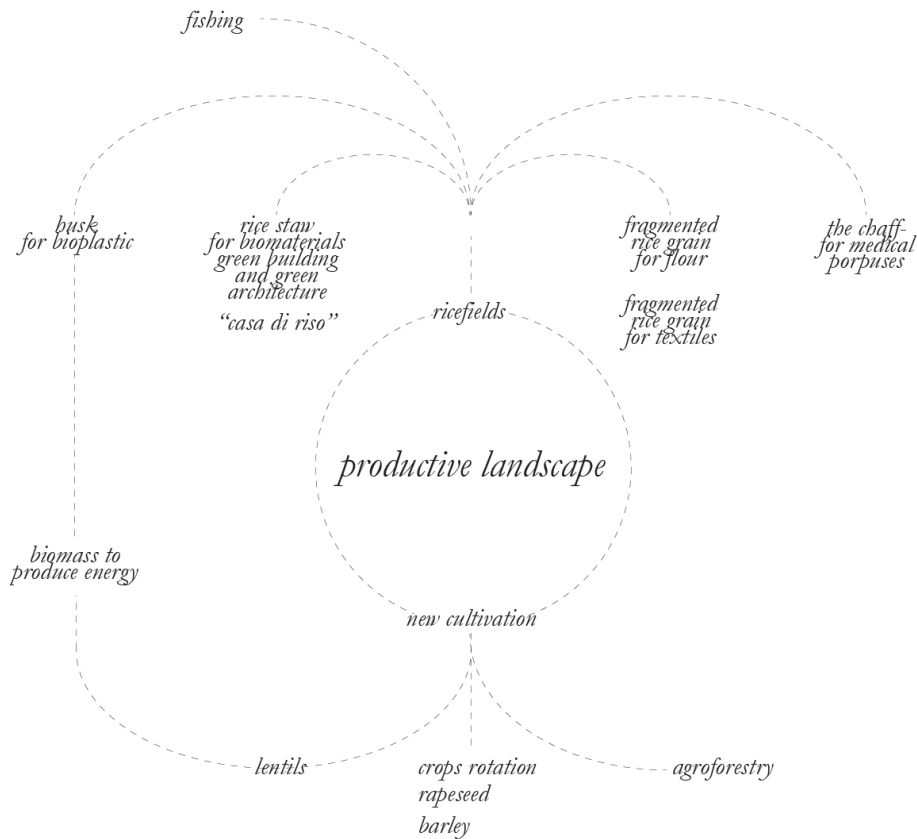


2030



2040

Productive landscape



191

As shown in the diagram above, the productive landscape for the alternative future will shift from monoculture to polycultures, including either rice and other crops.

New agricultural techniques will be implemented, e.g. crops rotation with the cultivation of rapeseed and barley or other cereals. The cultivation of lentils, explained more in depth in the next chapter, will become increasingly important for the area.

Lentils cultivation is just one of the alternatives: this crop does not represent the agricultural transition in its whole. To shift from monoculture to polyculture more crops needs to be included in the agroeconomical system.

The productive landscape will not be only for food production but also for bio-energy production. As explained in the previous chapters, rice has many lives thanks to its residues, same as the lentils. Rice residues can be used for bio-plastic production, for bio-materials in green buildings and green architecture, fragmented rice grains can be used for flour and rextils while

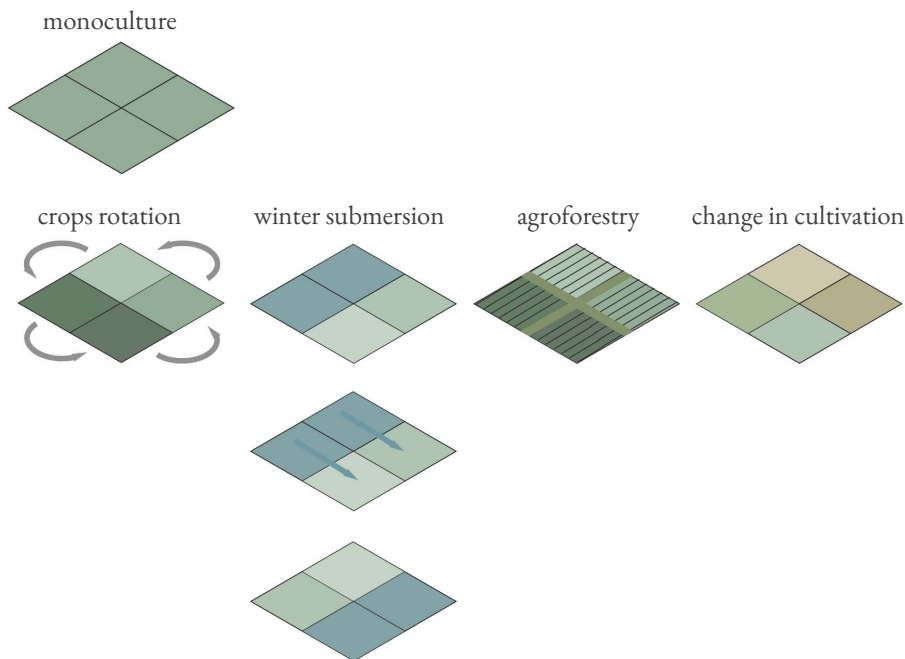
the chaff can be used for medical purposes.

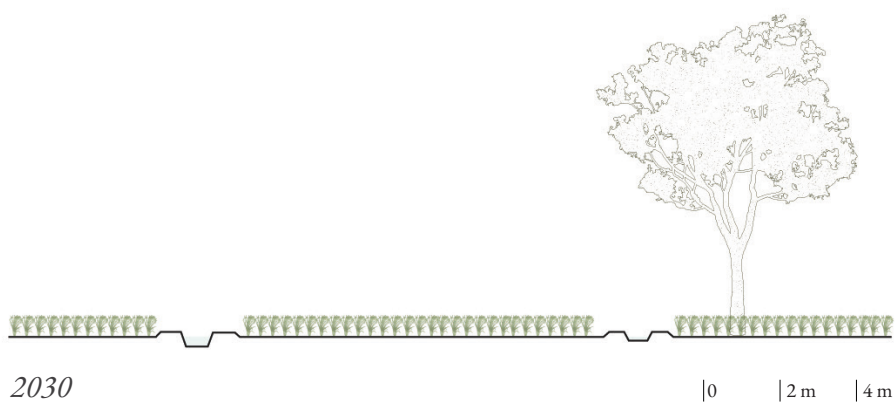
The productive landscape has not only the goal to produce food and other products but also to sustain the agrobiodiversity that it creates.

Including new cultivation, it is not only possible to implement the biodiversity in the area but also to maintain the soil healthy, increasing its percolation capacity and its store capacity where needed.

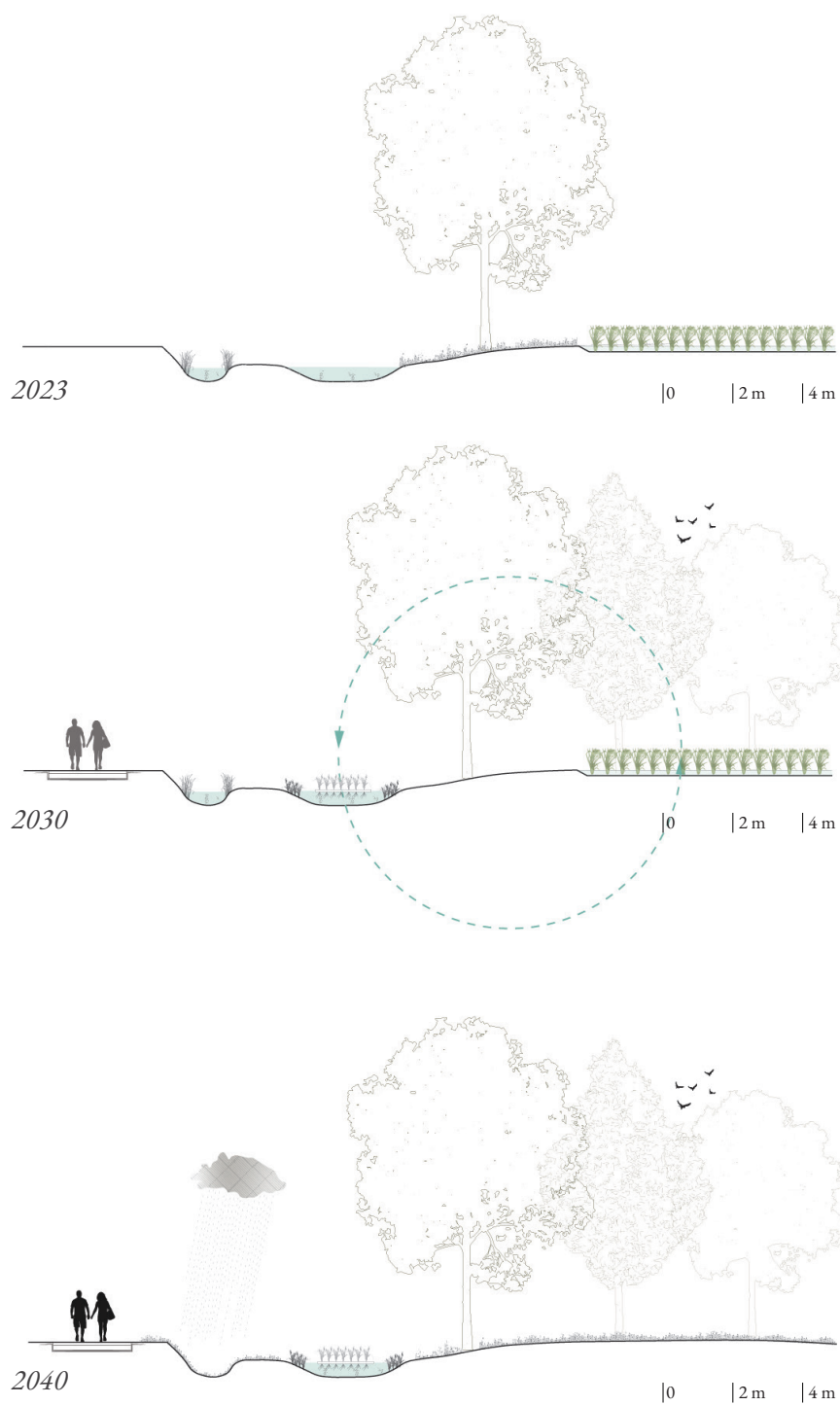
Agroforestry will be explained more in depth in the next chapters, but it is important to understand how the consequence of good agronomic practices combined with environmental recovery through planting, distributed on the cultivation land, allows biodiversity to develop undisturbed in our fields. It is important to limit damage to amphibians and other aquatic species deriving from alternating water and dry conditions, they create permanent wetlands. Thanks to this, the biofarming of carps can also take place. This system allows you to save 90% of water compared to traditional cultivation on the ground or in a greenhouse. The fish in their tanks produce waste substances; the water containing these substances is pumped and passed through a bio-filter (constructed wetlands) which transforms these 'waste' into useful and nutritious substances essential for the life of plants housed on panels floating in water.

192





▲ Transition from monoculture to polyculture. *Source: image made by the author.*

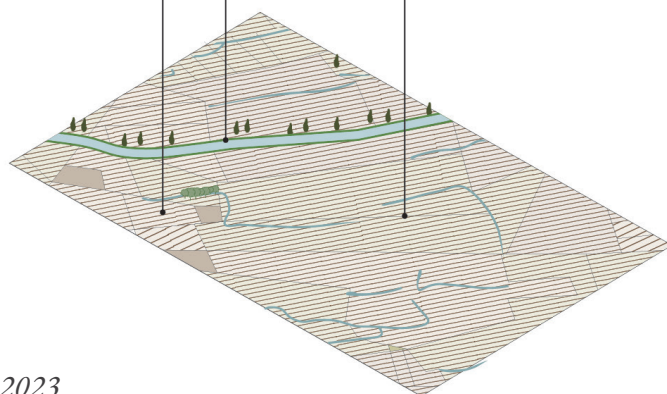


▲ Possible disappearance of resurgences. *Source: image made by the author.*

Loss in habitat and species

Exploitation of the superficial and ground water system

Ricefields - monoculture



2023

Agroforestation

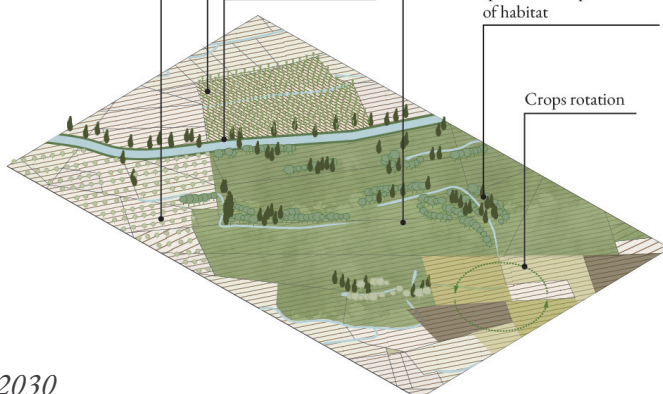
Introduction of new cultivation

Reserve and water flow regulation

Ecological corridor

Reintroduction of species and improvement of habitat

Crops rotation



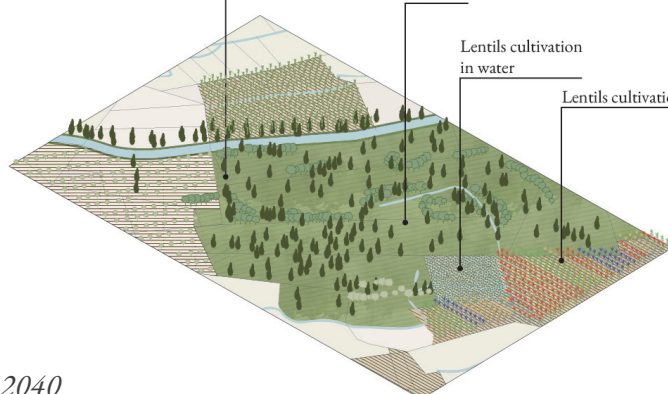
2030

Spontaneous vegetation

Reserve

Lentils cultivation in water

Lentils cultivation



2040

Lentils and ricefields - alternative future for 2040



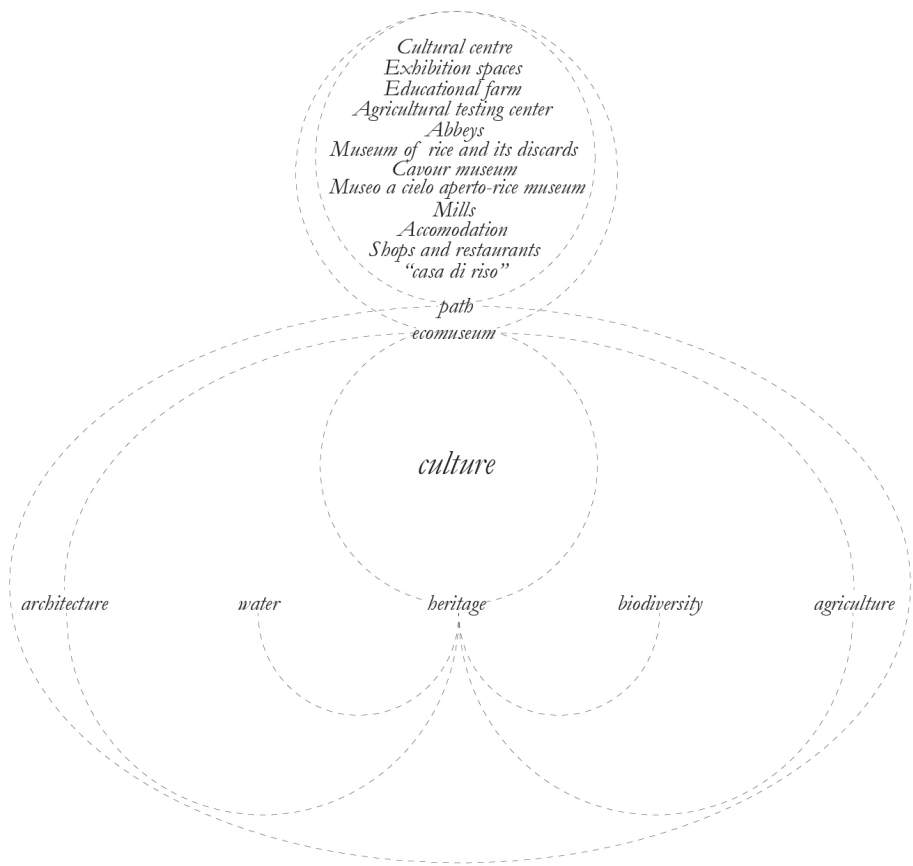
197

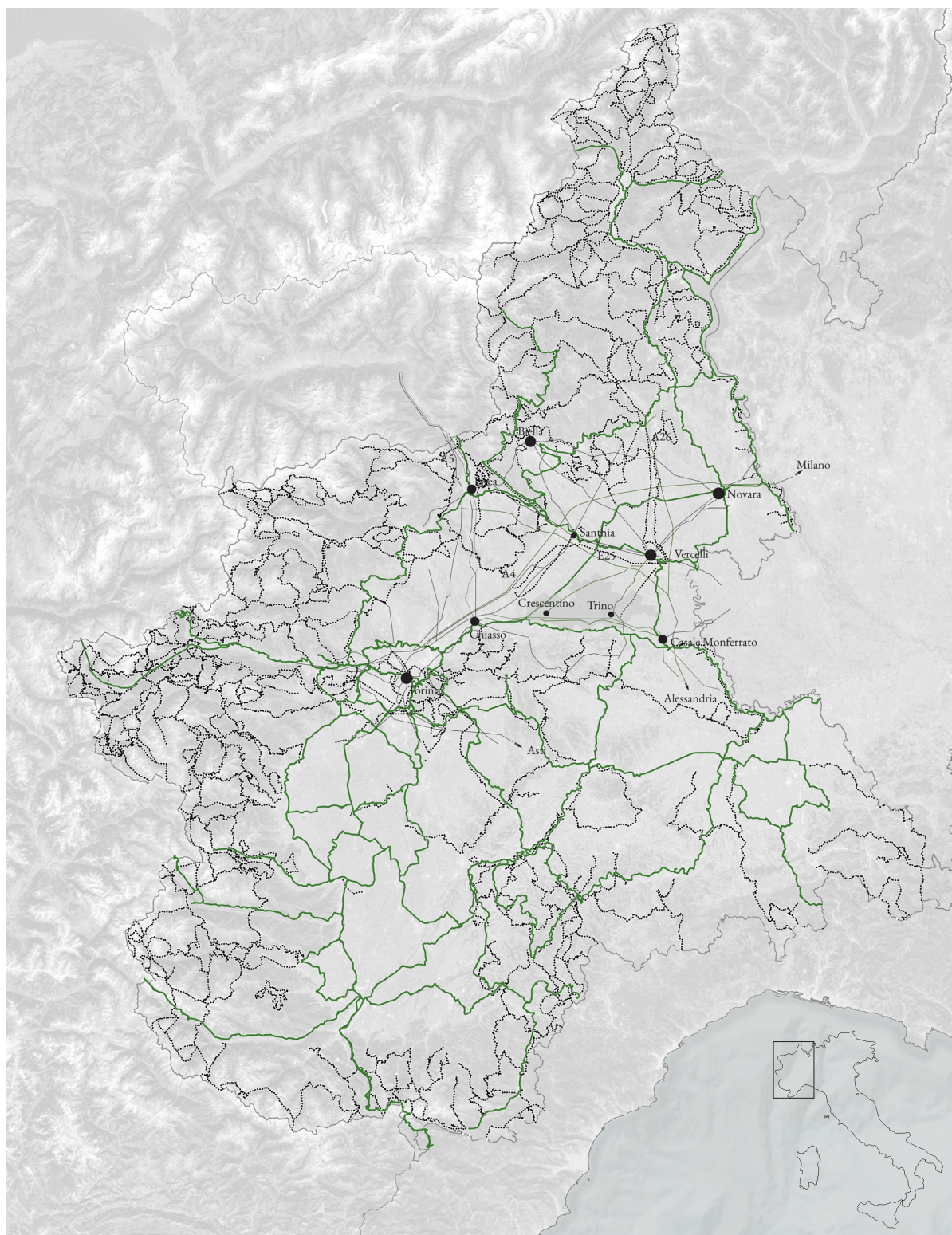


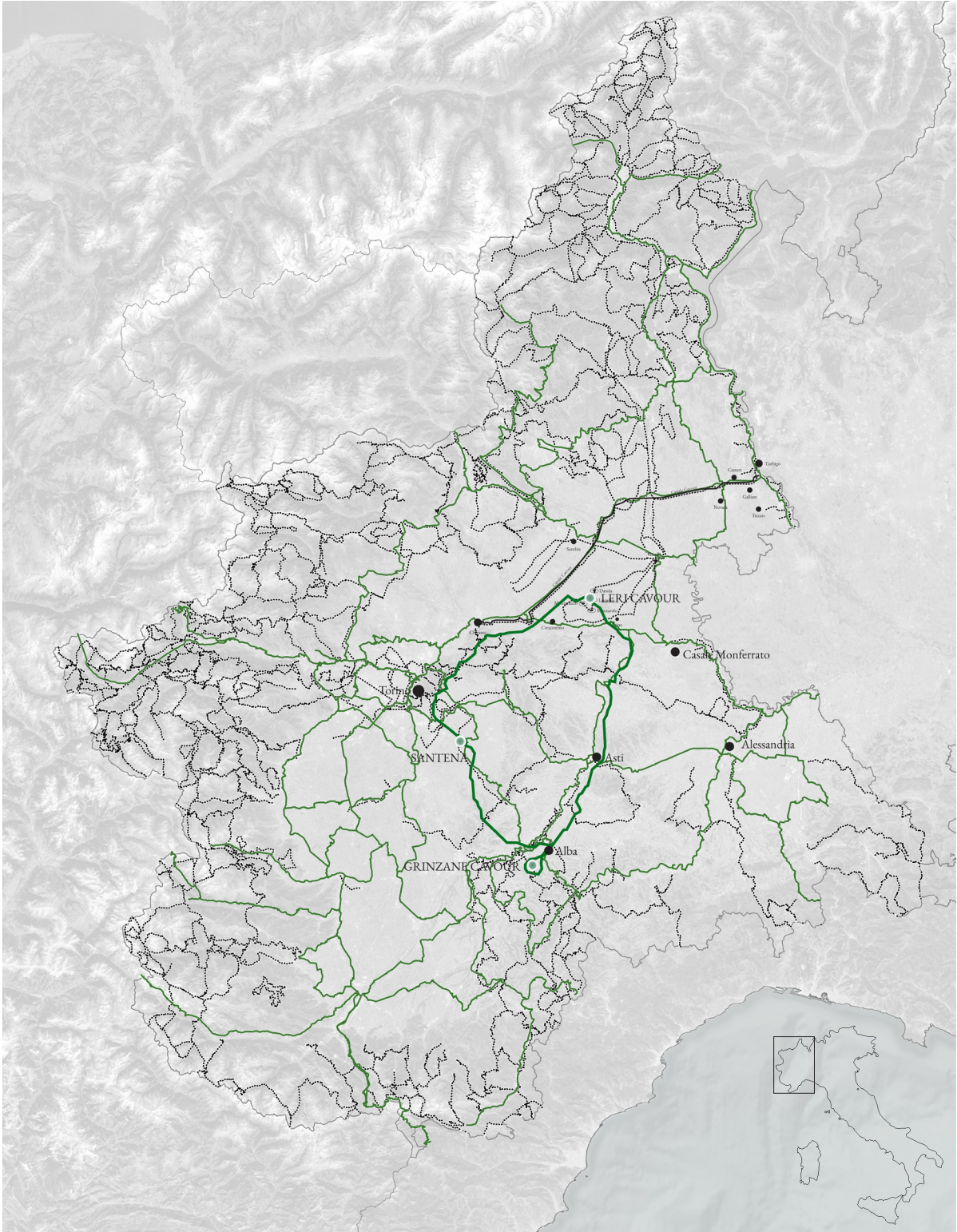


Historic connection route between Northern Europe and Rome born in the medieval period and along which merchants, pilgrims and armies passed, took on a more significant role in the period between the first and second millennium when the ever-growing importance of religious pilgrimages towards the three holy cities: Rome, Jerusalem and Santiago de Compostela ensured that it became a central hub of the great paths of faith. The first description of the ancient route, dating back to the 10th century, is given to us by the travel diary of Sigeric, bishop of Canterbury, who wrote it during his return journey across the Channel from Rome. He had in fact gone to the papal city to receive the ancient liturgical vestment called pallium as a gift from Pope John. Since this diary is considered today as the most accredited itinerary source, we very often talk about the Via Francigena according to Sigeric's itinerary. Since 1994, with its nomination as a "Cultural Route of the Council of Europe", the Via Francigena has acquired importance

on an international level. There are five states crossed (England, France, Switzerland, Italy and the Vatican), 16 regions touched, for a total of 3268 km of mountain paths, mule tracks, country roads and minor roads, which from Canterbury lead to Rome and continue up to in Santa Maria di Leuca, all accessible on foot or by bicycle.

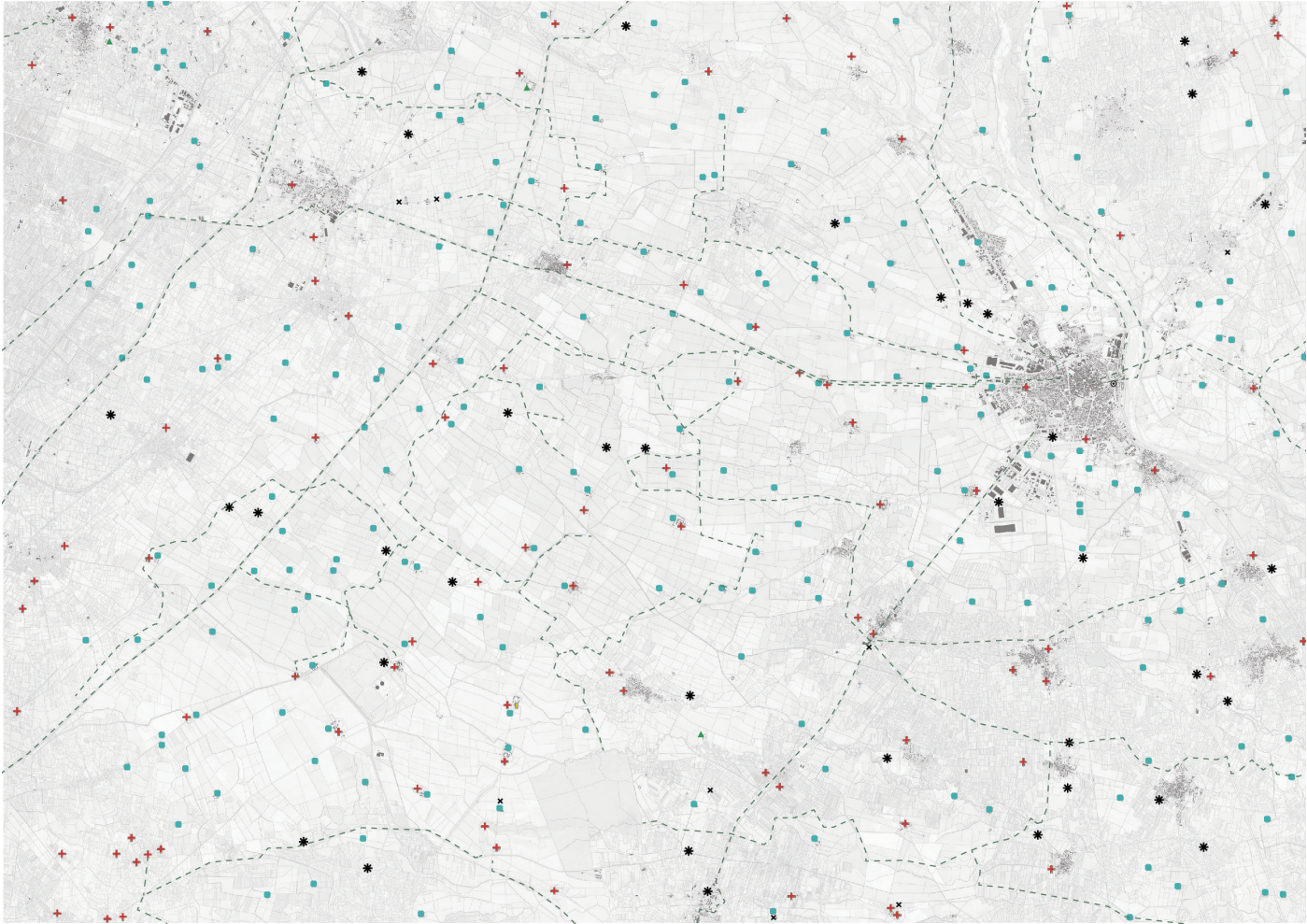






cultural heritage

202

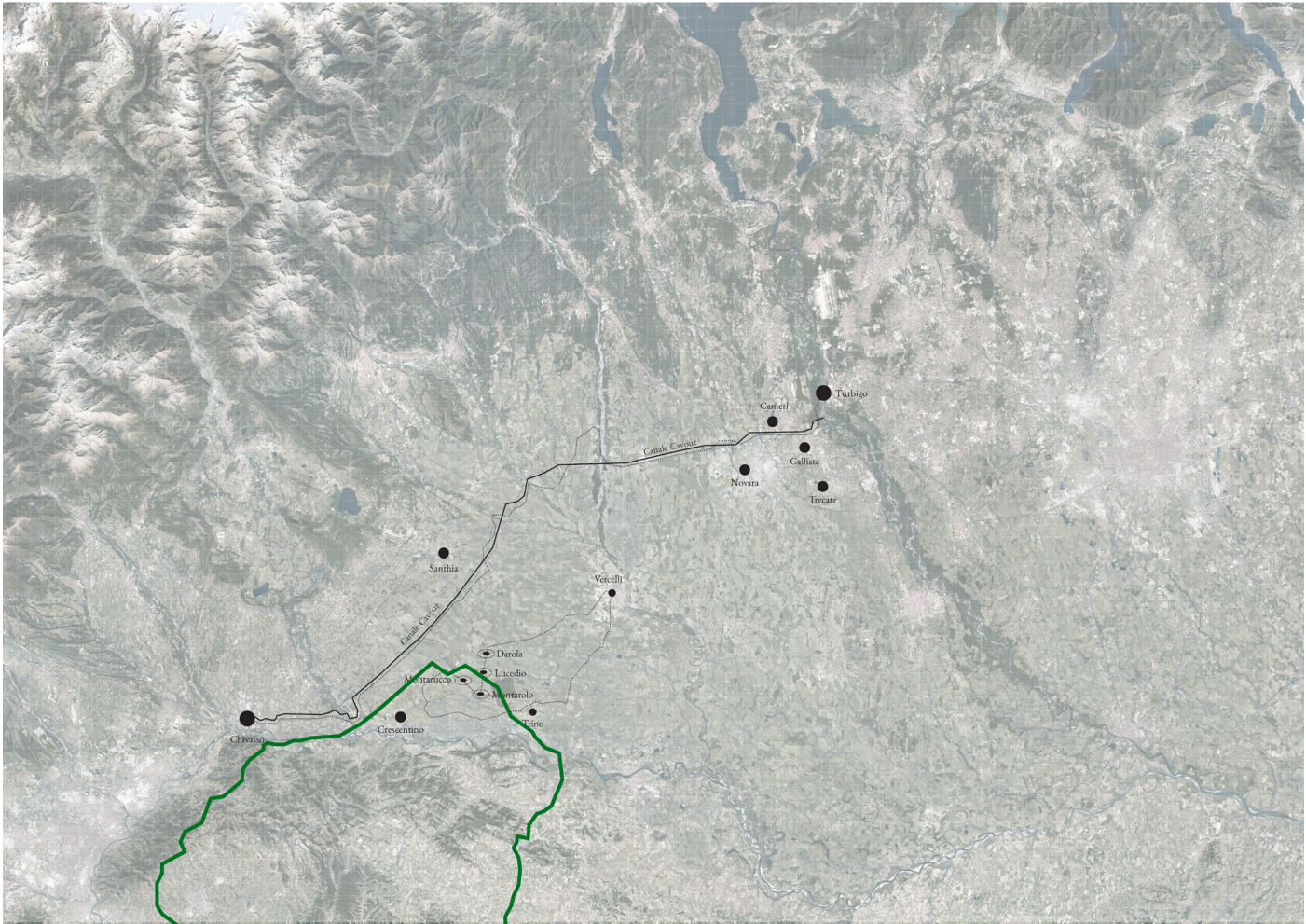


N

|0 |2 km |4 km

- ✚ churches and abbeys
- ▴ belvedere
- courtyard farmhouse
- * mill
- ▲ castle
- ✕ ruin
- △ palace
- ▮ tower
- ⊙ roman city

Cultural elements. Source: Regione Piemonte, 2022.

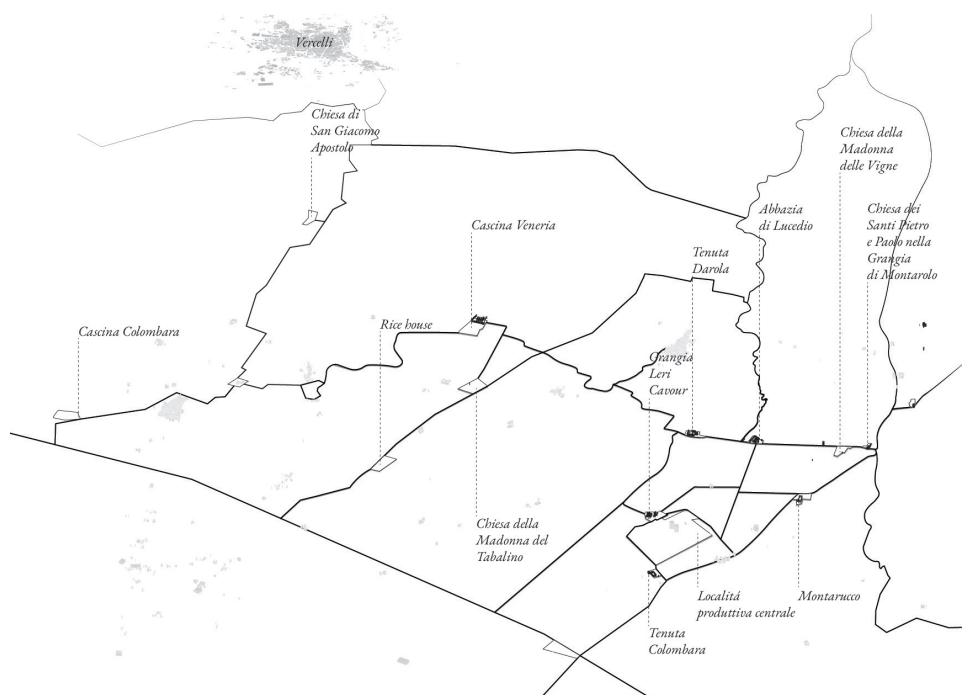


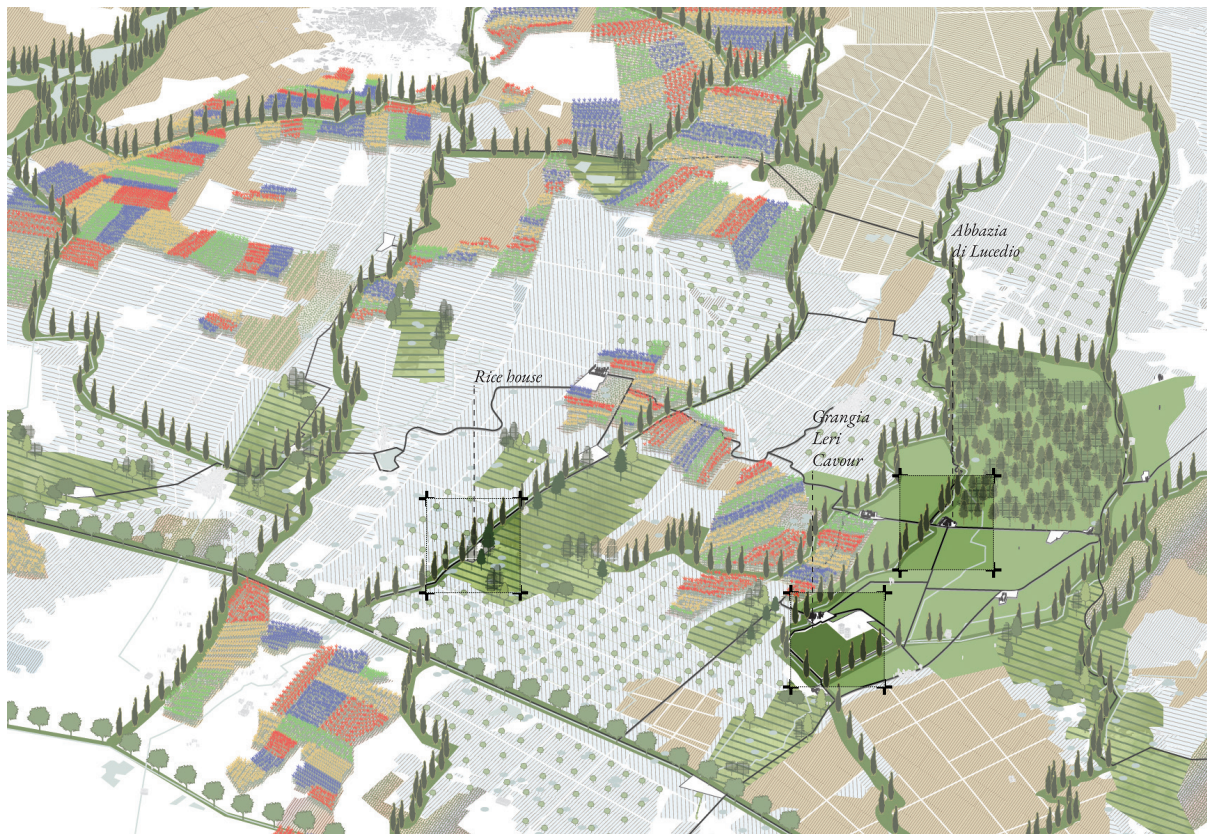
SANTENA

GRINZANE CAVOUR

▲
New path. *Source: image made by the author*

cultural heritage network







▲ Abbey of Lucedio and rice house. Source: images made by the author.

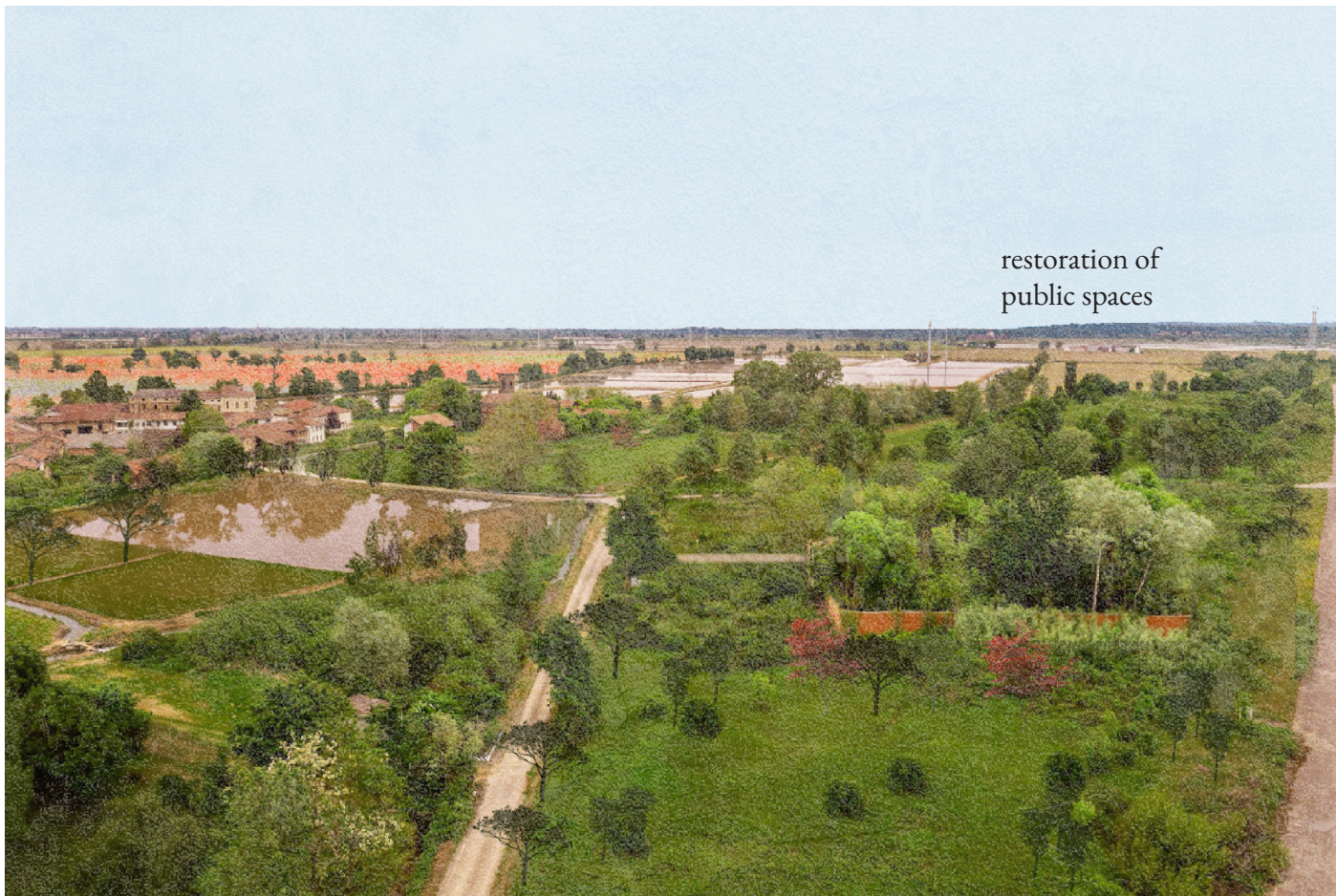
“Galileo Ferraris” - the green factory



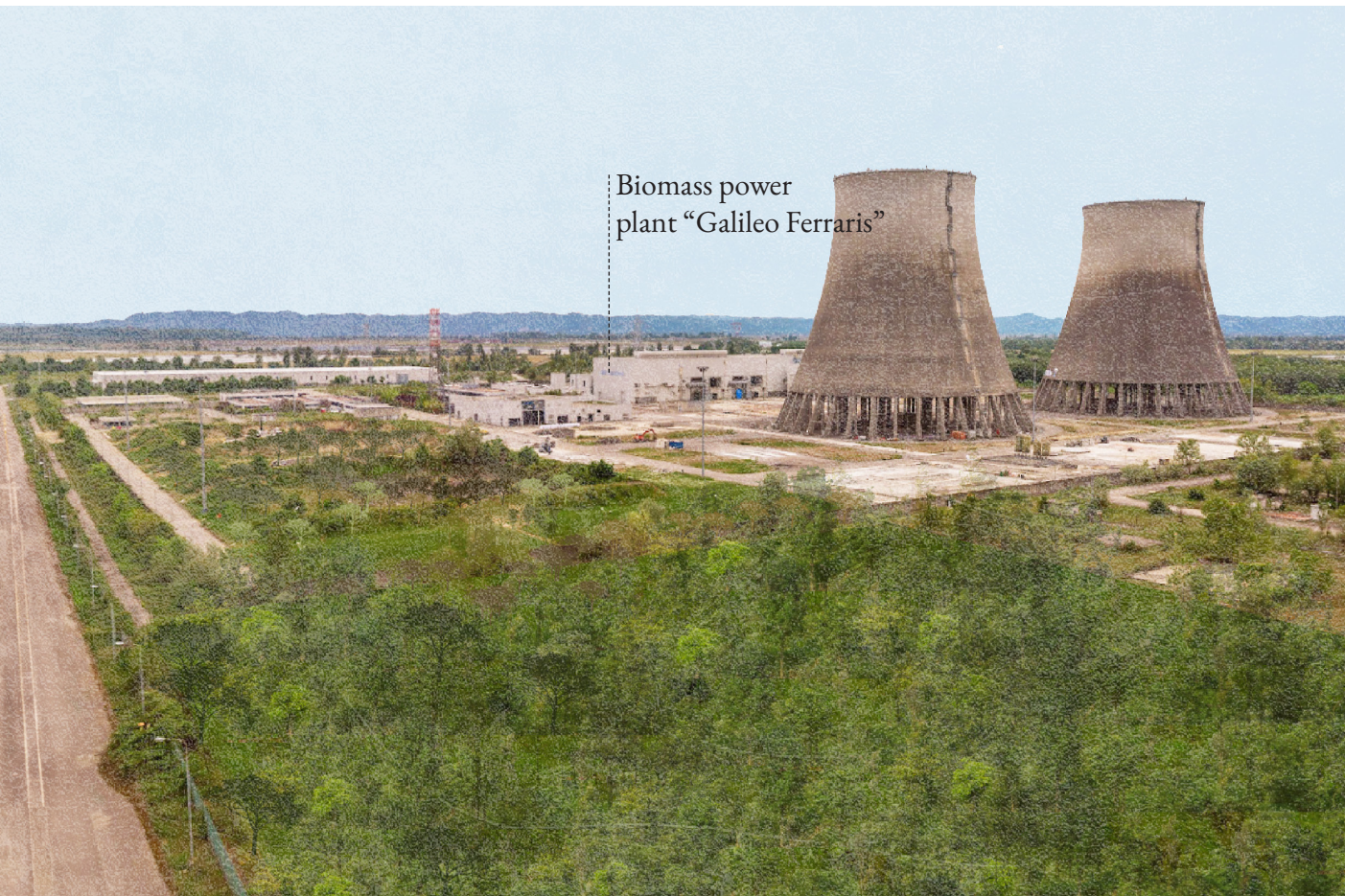
|0 |250 m |500 m N|

207

▲
Località Produttiva Centrale “Galileo Ferraris”. Source: Google Earth, 2022. Regione Piemonte, 2022.



restoration of
public spaces



Biomass power
plant "Galileo Ferraris"

Grangia of Leri Cavour

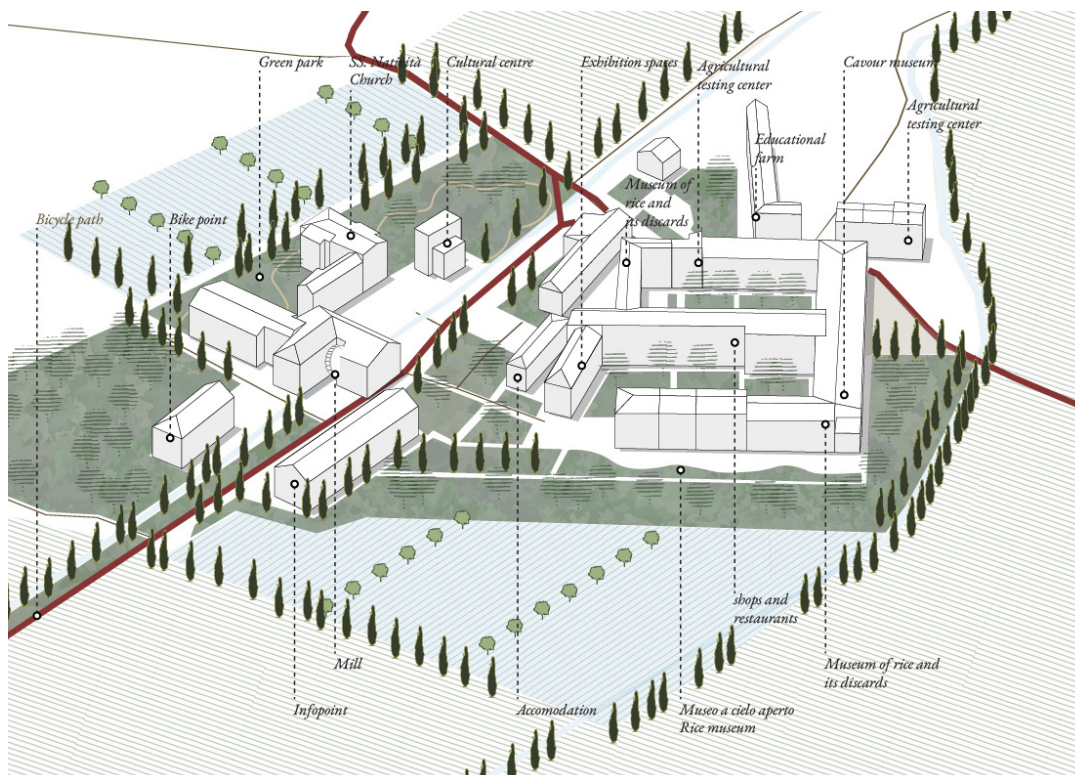
The cultural heritage network aims at connecting the most important cultural elements of the area using a path, which will be either pedestrian and bicycle.

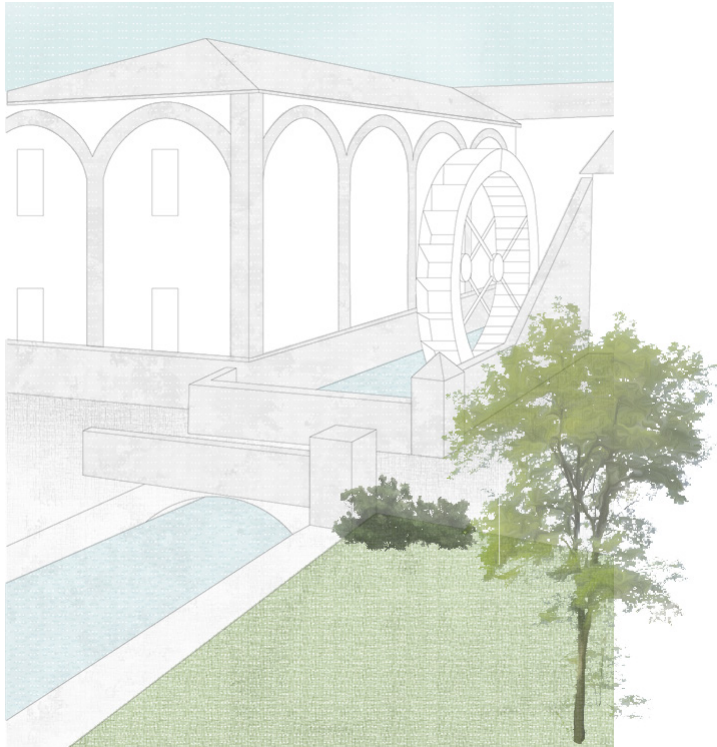
The area of Vercelli is already rich in monuments and buildings with an history. Some of them, for exapple the Grange of Leri Cavour, are now abandoned.

An alternative scenario for 2040 is to recover these historic buildings and reuse them in a way suited to the scenario created for that period. In 2040, thanks to polyculture and a more circular economy, it will be possible to experiment with new agricultural production techniques. The Leri Cavour grange could become a meeting place for these studies and events regarding agriculture, its production and the afterlife of the crops, which could be used to produce bio energy or other materials.

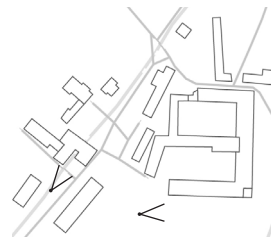
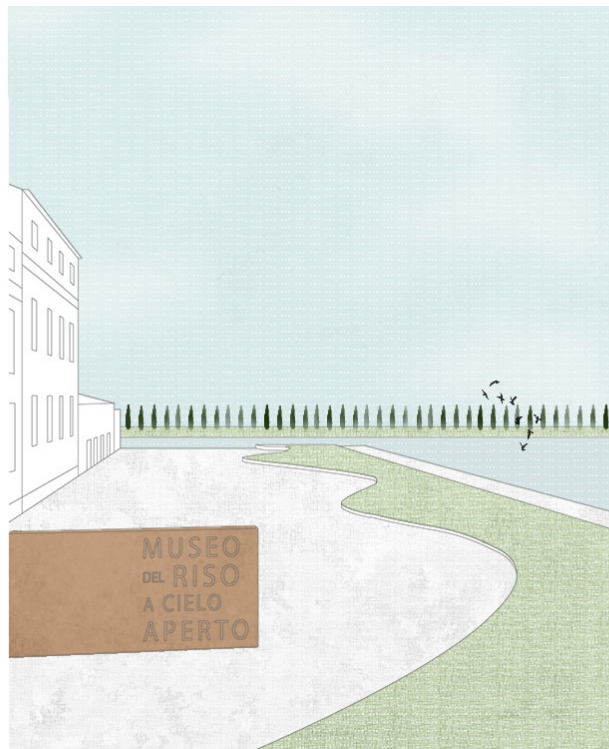
The Grange is a benedictine agrarian community founded on its own economic and administrative organization, it is therefore a really important pillar for Po Valley's agricultural heritage and must be preserved.

In the image below it is possible to see the new uses for the Grangia of Leri Cavour.





211



▲ Leri Cavour's grange. *Source: image produced by the author*

Conclusion

The main research question for the project was “how can the resurgence belt be redesigned and planned in order to preserve its cultural and environmental quality? How can the Po Valley – through design and planning - become a resilient urbanized alluvial landscape?”

Starting with the analysis, it was possible to understand what areas would be more influenced by the retreat of the resurgence belt. Considering the strong relation between agriculture and resurgences but also the density, the area including Pianura Vercellese, Pianura Novarese, Baraggia and Angiono foglietti (consortia of Piedmont) was taken into consideration.

Focusing on Vercelli's area, which is one of the most dense zones for resurgences, it was possible to imagine a future scenario. To preserve the resurgence belt, it is important to take into considerations all the different landscapes. Resurgences, in this historic period, are an important asset for agriculture and, therefore, for the economy. Although this, it is important to respect their natural habitat and needs, in order to preserve their ecological state and therefore their presence.

212

The project, considering the strong relation between resurgences and agriculture but also the need of ricefields in the area of Po Valley, which function as a sponge that helps maintaining the soil wet and fertile, aims at creating a symbiotic relation between resurgences and ricefields. With monoculture it is impossible to sustain their relation, the water of resurgences is not enough to cultivate the extended area of ricefields and get lost in the soil. Also, in some parts of the area, the presence of sandy soil makes the cultivation of ricefields counterproductive: there is a higher need of water, which percolates easier in the terrain and therefore gets lost without submerging the area and can not be used several times before flowing downstream, as it happens in areas where soil is clayey.

The productive landscape for the alternative future will shift from monoculture to polycultures, including either rice and other crops. New agricultural techniques will be implemented, e.g. crops rotation with the cultivation of rapeseed and barley or other cereals. The cultivation of lentils, will become increasingly important for the area. But, lentils cultivation is just one of the alternatives: this crop does not represent the agricultural transition in its whole. To shift from monoculture to polyculture more crops needs to be included in the agroeconomical system.

The productive landscape will not be only for food production but also for bio-energy production. This strong agricultural production also produces many residues and they can be used for bio-plastic production, for bio-materials in green buildings and green architecture, for flour and textiles or

medical purposes.

For this reason, the area of Località Produttiva Centrale “Galileo Ferraris”, which until 2013 has been a thermoelectric power plant, will become an area for bio-energy production and, thanks to purifiers and industrial synergies, can become a green factory.

The productive landscape has not only the goal to produce food and other products but also to sustain the agrobiodiversity that it creates.

In the future scenarios, presented, the practice of winter submersion is back in use: this practice helps with the degradation of crop residues which, on the one hand releases valuable nutrients for the crop into the soil and, on the other hand, reduces methane emissions into the atmosphere.

Other than rice, with the inclusion of new cultivation, it is not only possible to implement the biodiversity in the area but also to maintain the soil healthy, increasing its percolation capacity and its store capacity where needed.

The consequence of good agronomic practices combined with environmental recovery through planting, distributed on the cultivation land, allows biodiversity to develop undisturbed in the fields.

It is important to limit damage to amphibians and other aquatic species deriving from alternating water and dry conditions, they create permanent wetlands.

213



Reflection

1. What is the relation between your graduation project topic, your master track (Ar, Ur, BT, LA, MBE), and your master programme (MSc AUBS)?

The project The rebirth of the resurgence belt aims at studying the floodplain as a complex human-water system.

My interest in this research is driven by the desire to know and deepen the processes underlying hydrogeology, to understand the cultural-landscape identity of the resurgence belt and how it helped creating the identity and history of the Po Valley.

The Po basin, which covers a large part of Northern Italy, is the area that has seen the emergence of capitalist agriculture, industrialization and the large energy industry, which until the middle of the last century was hydroelectric. It is the area where the great industrial cities, such as Milan, are concentrated, alongside intensive agriculture and livestock. Starting from the Po basin it is therefore possible to cover the entire history of the Italian and European economic development, in all its aspects: agricultural, industrial, urban.

Fluvial environments have always played a crucial role in human history. The necessity of fertile land and fresh water for agriculture has led populations to settle in floodplains more frequently than in other environments. Floodplains are complex human–water systems in which interaction between anthropogenic activities and environment affected the landscape development. The anthropogenic presence on the territory (urbanization, infrastructural networks and intensive cultivation) has increased the fragmentation process, or rather the phenomenon of rupture of natural environments. The process sees the reduction of the surface of natural environments with an increase in their isolation and therefore a loss in biodiversity.

In the recent years the Po Valley has been suffering from a water crisis. Because of global warming and high temperatures, the phenomenon of draughts and floodings are more and more frequent, damaging not only the territory but also the people and the economy.

The resurgences bring to light the waters of rivers and rains absorbed by the soil of the high plain; they thus represent the natural outcrop of the hydrogeological system, a sort of fill in the large area of Northern Italy (Modena and Zangheri, 2005).

The resurgence belt is a fascinating microhabitat which plays an important ecological role in the protection of vegetation and an fauna and it is still fundamental today in the economic-agricultural context as it is the basis of the irrigation activities.

The area of resurgences represents a real system of completely natural regulation of the level of the underground water reservoir.

In the area of the resurgence belt, it is possible to control the mountain floods that flow downstream, causing the severe flooding phenomena that we are seeing more and more often in recent years. These traits also have the pre-eminent function of governing the waters of violent and sudden precipitations that the current rain disposal systems are unable to manage effectively. The slopes of the paths lead the waters towards wetlands and hold them for the time necessary and then gradually release them.

They constitute a precious and unique natural heritage, which unfortunately has reduced in dimensions due to various factors: economic, social and environmental. In the last 30 years, in fact, there has been a progressive lowering of the water level and a consequent reduction in the overall flow of the resurgences.

Many have definitively dried up and many others are facing ever longer periods of drying up. The phenomenon has been causing alarm for long time: over the last 30 years, more than 80% of the resurgences have disappeared and the forecast is that if compensatory.

Initiatives are not implemented, capable of counteracting the slow lowering of the water table, within 20 years we will see drying up. of most of the existing resurgences.

While the phenomenon of resurgences has been studied deeply in the East area of North Italy, it has not been fully researched in the area of the West. The focus of the project will be natural and human systems, taking water system as main driver for change. The project, which is located in a highly dynamic, but also fragile and critical environment, would explore alternative forms of coexistence and care.

As an urbanist, I strive to give my project a plurality of voices and diversity, human and non-human, to create possible future scenarios and provide a critical analysis that could be the start of a conversation or a new point of view.

In my opinion, this is the most important thing that urbanists can do. The world needs to see things through others' eyes: providing new points of view, developing a critical thinking and bringing to light some important issues that are not commonly thought of to challenge our professional and personal worldviews. The project will analyze the territory through the studio's approach, using different lenses (social, environmental and political), which I believe is the best approach to frame a complex territory such as a floodplain.

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

The research of this project includes different aspects. The first one is the study of the water system, which is not only assessing the surface water but also the ground water. The second one is geology; during the process it was really important for me to understand the type of ground I was working on, different soil types creates different landscapes. The third one is the topography and the fourth one is about agricultural studies and crops. The project aims at creating a landscape that can sustain itself while being operational but also preserving its history and culture. During the process it was important to use the research to guide the design but at the same time it was necessary to continuously reflect and revise the research while creating the design to make it more coherent.

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

I would define the approach to this project as circular. I started from the main issue, the retreat of the resurgence belt, and focused on the literature review to understand the main principles of the water system in Italy. I decided a framework to give a direction to the project and started collecting data from National Databases. The production of analytic cartographies helped me to understand the current situation and the working systems while the speculative cartographies helped me to envision the socio-spatial realities, intersecting the physical world and the imagination of the mind. While producing these materials, my

perspective on the territory kept shifting and it was only after the fieldwork, when I had the opportunity to understand the territory from a closer point of view, that it was possible for me to position myself and the project.

The excursions and the people I met on site gave me a realistic understanding of the territory and therefore it was easier for me to select some key study and critical areas. After the exploration, I went back to my research and I developed it more – and from there I started creating my design.

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

Social

West of Italy is the most dense in population, the most polluted and also the region where the great industrial cities are concentrated, alongside intensive agriculture and livestock.

It is important for the people, but also for the economy to understand the value of the area of resurgences and how it can be essential in case of high temperatures, low precipitation level and draughts. Also, they are a cultural-landscape, that must be preserved to maintain the identity and history of the Po Valley.

There is a gap in knowledge and recognition of the different systems – human and non-human – their interdependence, vulnerability and limits.

Scientific

While the phenomenon of resurgences has been studied deeply in the East area of North Italy, it has not been fully researched in the area of the West. It is a difficult topic to study and map, but I would like to collect the knowledge and investigate/develop new ideas on how to enhance and preserve these fragile yet powerful territories.

Professional

In my thesis I want to illustrate how urbanism can also mean an action of comprehension, clearance and adaptation of different systems spatially. And again, I strive to give to my project a plurality of voices and diversity, human and non-human, to create possible scenarios for the future and provide a critical analysis or simply a new point of view for this fragile territory.

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

As said before, while the phenomenon of resurgences has been studied deeply in the East area of North Italy, it has not been fully researched in the area of the West. It is a difficult topic to study and map, but I would like to collect the knowledge and investigate/develop new ideas on how to enhance and preserve these fragile yet powerful territories. It must be said that, even though all the data collected came from National databases and the papers cited were relevant, the study of a transitional territories such as ground water is either difficult to map and unpredictable. Moreover, my knowledge on resurgences and ricefields at the beginning of the project were not deep enough to create a urban and landscape design. I did contact some locals and some experts to deepen my knowledge, but inevitably some errors may occur in some parts of the project.

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