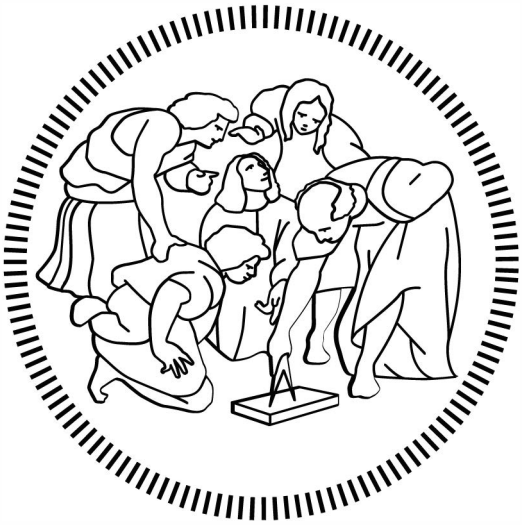
Politecnico di Milano

SCHOOL OF ARCHITECTURE, URBAN PLANNING AND CONSTRUCTION ENGINEERING

Master of Science – Landscape Architecture. Land Landscape Heritage



GREEN INFRASTRUCTURE FOR MULTI-SCALE RESILIENCE

Geo-design method for Ravenna case study

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Here I am finally at the end of my 2-year master's course, in which I have grown a lot as a person and as a citizen.
Thanks to the experiences lived in this area, I have known new aspects of my character that have led me to observe the world with a new mentality, to think and reflect differently than before.
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ABSTRACT (ITALIAN)

Le odierne pratiche di pianificazione soffrono di estrema rigidità e talora si dimostrano impotenti di fronte ad una crescente complessità legata ai sistemi urbani e territoriali.
Si esige la necessità di ottenere informazioni legate alle condizioni del sito in modo tale da fornire una conoscenza che possa essere utilizzata come supporto per la fase strategica e, successivamente, progettuale.
In questi termini le informazioni geografiche computate mediante sistemi GIS (Geographic Information System) e RS (Remote Sensing) sono in grado di fornire dati spaziali e temporali, qualitativi e quantitativi, in forma di mappe tematiche, scenari, modelli, diagrammi e tabelle.
Tale dato, se trattato correttamente, ha per sua natura il potenziale di diventare prima informazione e poi conoscenza.
Il processo di analisi si caratterizza con un approccio multi-scala, in cui la lettura del sito parte da una scala territoriale per giungere ad una più urbana.
In questo modo è possibile determinare scelte strategiche su più livelli che possano coesistere in armonia all'interno di un unico sistema, sino a giungere a scelte progettuali di dettaglio.
Questa metodologia, che può essere integrata nel sistema definito come "Geo-design", viene applicate a due scale differenti, la prima, territoriale, che considera un'estesa area con centro la città di Ravenna, la seconda, urbana, è definita da Ravenna stessa con un piccolo focus sul porto.
Tali estensioni sono state scelte per la presenza di elementi di grande pregio naturalistico, storico-culturale, economico e turistico.
Le informazioni derivate dalla fase analitica sono riassunte nella SWOT e definiscono elementi tutt'ora non riconosciuti che necessitano di essere considerati sia per il loro valore che per la loro potenziale influenza negativa.
Alla pianificazione delle mappe strategiche sulle due scale considerate, si aggiunge una proposta meta-progettuale in riferimento all'area pilota localizzata nella darsena del porto di Ravenna.
Le azioni progettuali adottate sono da considerarsi la ovvia risposta alle fasi precedenti di analisi e strategia.

ABSTRACT (ENGLISH)

Today's planning practices suffer from extreme rigidity and sometimes prove to be powerless in the face of a growing complexity linked to urban and territorial systems.
There is a need to obtain information related to the conditions of the site in order to provide knowledge that can be used as a support for the strategic and, subsequently, design phase.
In these terms, geographic information computed through GIS (Geographic Information System) and RS (Remote Sensing) systems are able to provide qualitative and quantitative spatial and temporal data, in the form of thematic maps, scenarios, models, diagrams and tables.
This data, if worked correctly, by its nature has the potential to become information first and then knowledge.
The analysis process is characterized by a multi-scalar approach, in which the reading of the site starts from a territorial scale to reach a more urban one.
In this way it is possible to determine strategic choices on several levels that can coexist in harmony within a single system, up to reaching detailed design choices.
This methodology, which can be integrated into the system defined as "Geo-design", is applied at two different scales, the first, territorial, which considers an extensive area centered around the city of Ravenna, the second, urban, is defined by Ravenna itself with a small focus on the harbour.
These extensions were chosen for the presence of elements of great naturalistic, historical-cultural, economic and tourist value.
The information derived from the analytical phase is summarized in the SWOT and defines elements still not recognized that need to be considered both for their value and for their potential negative influence.
To the planning of the strategic maps on the two scales considered, a meta-design proposal is added with reference to the pilot area located in the dock of the harbour of Ravenna.
The project actions adopted are to be considered the obvious response to the previous phases of analysis and strategy.

1. THE STARTING POINT

1.1. INITIAL REFLECTIONS

Nowadays impacts of anthropic alterations on environments are more and more visible.
The anthropic impact, that is, the set of effects that human activities have on the environment that surrounds it, has in fact reached a speed and depth of influence unprecedented in natural history in the last century.
The effects are manifold and are literally changing the appearance of our planet with potentially disastrous consequences.
Like all species, man modifies the territory in which it is found to make it more comfortable and bring it closer to its survival needs.
With the development of agriculture, for example, it was constantly looking for land suitable for cultivation.
Intensive cultivation, combined with efforts to procure timber, have also triggered ever faster deforestation.
Ever larger portions of forests have been cleared with tragic consequences for biodiversity.
Another impact considers wetlands destruction, which has increased flood and drought damage, nutrient runoff and water pollution, and shoreline erosion, and triggered a decline in wildlife populations.
Destruction of wetlands is also detrimental to economy: recreation like fishing, hunting, and wildlife watching are decreasing producing economical losses.
All these impacts affects both natural and urban environments providing negative consequences for biodiversity, economy and society.
New sustainable strategies and design principles are needed to direct policies towards a better relationship among agriculture, urban settlements and natural environments (*figure 1*).
The role of policy makers and designers is both to define ways to mitigate anthropic impacts on natural environments, and, in the same time, to protect economy and society.
This is a hard task to achieve, but it is possible.
The way to act can be work with ecosystem services, which are the benefits provided by ecosystems.
A network of healthy ecosystems often provides cost-effective alternatives to traditional “grey”

infrastructure, offering benefits for citizens and biodiversity.

This is why the EU promotes the use of nature-based green and blue infrastructure solutions with the development of the Green Infrastructure Strategy.

It aims to ensure that the protection, restoration, creation and enhancement of green infrastructure become an integral part of spatial planning and territorial development whenever it offers a better alternative, or is complementary, to standard grey choices.

Different approaches are emerging to better orient future decisions and design applications using new technologies.

One of these is the geo-design, which uses geographic information system (GIS) and remote sensing (RS) technologies to provide a deep knowledge of the object under study supporting future decisions [29].

Figure 1: Example of a GI in practice

1.2. SITE DEFINITION AND THE REASON OF THE CHOICE

According to the introductive thoughts, the thesis focuses on the application of geo-design approach in the area of Ravenna in order to provide landscape planning actions at two different scales and some design proposals.

Two scales are considered due to the kind of work that has to be provided.

Different scales define different details of knowledge, it is possible to make comparisons between them providing a strong support for the strategical and design phases.

Both scales have been chosen thank to existing knowledge of their components.

The beginning is Ravenna town which can be described by different compartments (*figure 2*):

» Town centre is the cultural hub of the municipality with several historical buildings;

» The harbour is the economic hub, is the most important harbour for the region and one of the most important for freight traffic in Italy;

» Seaside is the tourism attractor;

» Pialasse represent the natural component of the town.

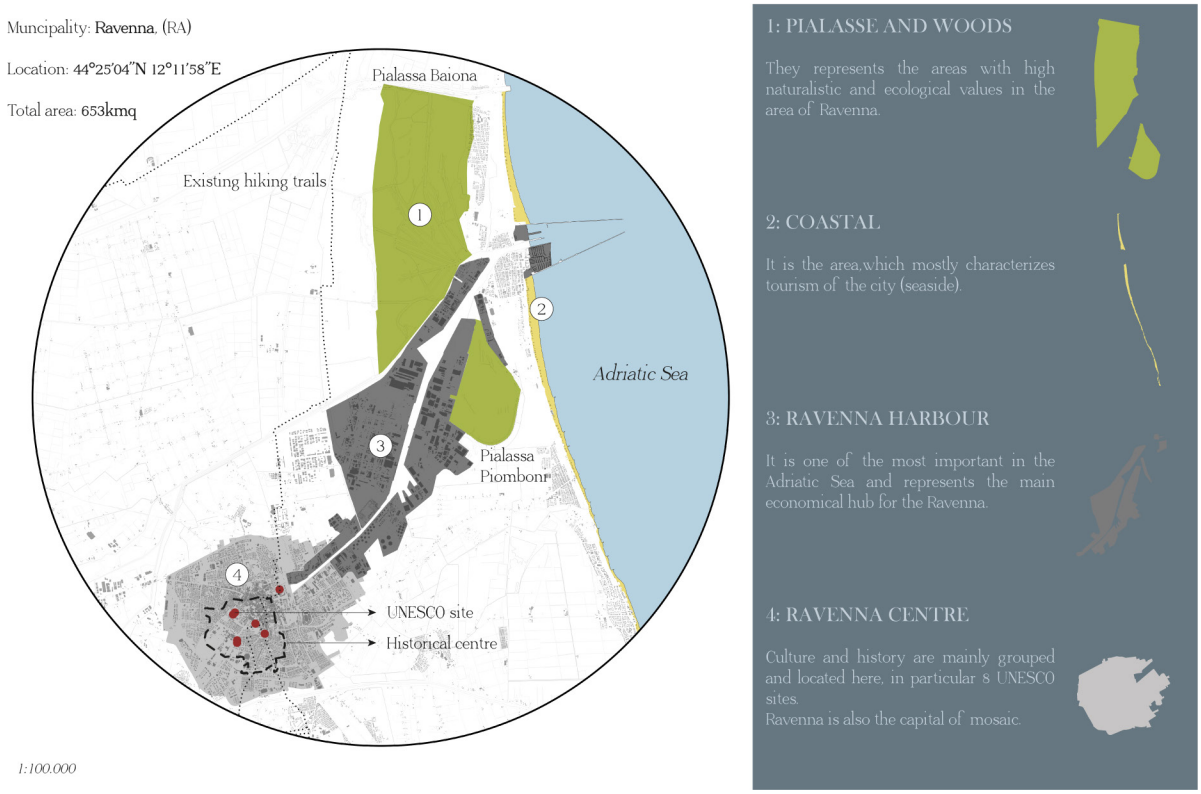


Figure 2: Ravenna compartements

The analytical phase will go deeper in their description understanding their issues and relations among one another.

Thank to it it has been possible to assess and map issues and dynamics which can be used as a support for strategical actions

Observing and mapping risks that Ravenna is and will facing in the future represents a strong base to direct actions towards mitigation processes; flood risk and sea water level scenario shows the importance introduce adaptive green and blu areas in the site.

The cohabitation between different environments, like urban structures, agricultural areas, wetlands and the sea generate a very complex dynamics of relations.

This topic is faced with a technic-scientific method to obtain the necessary knowledge for supporting decisions.

The municipality of Ravenna is not the only site considered in this work.

There is the wait to hook the strategical planning of this scale with a bigger one, which encompass different towns.

The second scale covers an area 29.537,9kmq encompassing 20 municipalities of Emilia-Romagna divided into 3 provinces (Ferrara, Ravenna and Forlì-Cesena).

This such a big area has been taken to create a system of relations at a territorial scale, following the goals of European Green Deal, such as "increasing climate ambition" and "biodiversity and ecosystems", partially "from farm to fork".

Even in this case the choice of the area extension has been done according to the existing knowledge and photointerpretation of the territory, then a brief analytical insight for each of them have been provided.

The territory is defined by several components with different values (naturalistic and historical-cultural), which can be observed in figure 3:

» Po di Volano natural reserve: it is a site of community interest (SIC) inserted in the list of Natura 2000 network (special code IT4060005) according to the European directive 92/43/CEE "Habitat", also classified as ZPS (Special Protection Zone). The site considered is a parcel of a bigger system and it is a salty wetland;

» Valli di Comacchio natural reserve: it is another SIC and ZPS of Natura 2000 network (code IT0460002). It is also a ZSC (Special Conservation zone) area. The site (130kmq) includes what remains of the vast brackish valleys, rich in sandbanks and bumps with halophilous vegetation, which until a century ago characterized the south-eastern part of the province of Ferrara and which still today constitute the largest complex of brackish wetlands in the region. and one of the most important in Southern Europe;

» Ravenna: the town as said before is well known for different things, in particular is known as the capital of mosaic thank to the presence of artworks with this kind of techniques inside the 8 UNESCO sites;

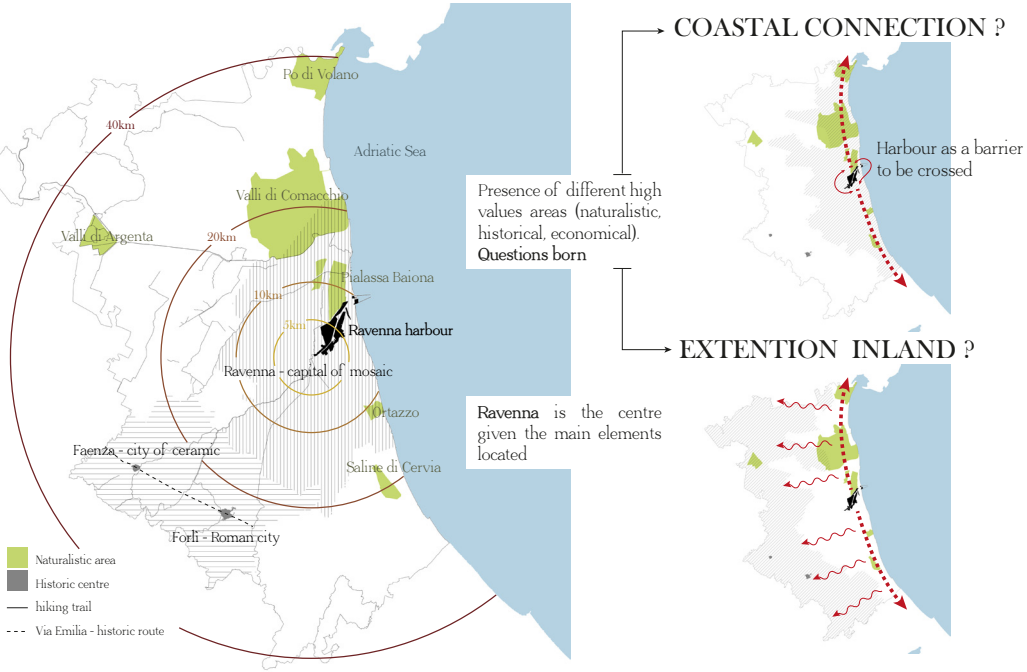
» Classe pinewood natural reserve: another SIC and ZPS inside Natura2000 network, coded as IT4070010. It is the largest pine forest located south of Ravenna, arranged parallel to the coast in a large rectangle, cut by the Fosso Ghiaia and surrounded by arable land and not completely reclaimed land;

» Saline di Cervia natural reserve: another SIC and ZPS inside Natura2000 network, coded as IT4070007. Very ancient saline (probably of Etruscan origin), it is located in a vast depression close to the sub-litorial cordon crossed by the Statal road Adriatica, on this side of the

Pinewood of Cervia and of huge urbanizations;

» Forlì: it is the small chief town of Forlì-Cesena province, which 117.695 inhabitants. Its origins date back to the 188 A.C. with the edification of Forum Livii. It is particular important for its historical buildings and it is located along the Via Emilia, an ancient commercial route which linked Ariminum (Rimini) and Placentia (Piacenza).

» Faenza: it is a small municipality of Ravenna province with 58.250 inhabitants. It is also placed along Via Emilia but is well known as the city of ceramic. Faenza is a wonderful city of art whose fame shone in the Renaissance period to produce exquisite ceramic objects



PO DI VOLANO NATURAL RESERVE

Conservation measures: SIC/ZPS
Natura 2000 code: IT4060005
Institutive measure: D.M. 13-07-77
Surface: 220ha
Type: salty wetland

SALINE DI CERVIA NATURAL RESERVE

Conservation measures: SIC/ZPS
Natura 2000 code: IT4070007
Institutive measure: D.M. 31-01-79
Surface: 765ha
Type: saline

VALLI DI COMACCHIO NATURAL RESERVE

Conservation measures: SIC/ZPS/ZSC
Natura 2000 code: IT4060002
Institutive measure: L. R. n. 44/95
Surface: 130kmq
Type: salty wetland

FORLI'

Origin: 188 A.C.
Roman and renaissance traces
Surface: 130kmq
Located at Via Emilia (historial route)

RAVENNA - CAPITAL OF MOSAIC

Presence of the harbor
Presence of salty wetlands (Pialasse)
8 UNESCO sites
High seaside tourism
Surface: 653kmq
Origin: II century A.C.

FAENZA - CITY OF CERAMIC

Origin: II century A.C.
Presence of the international ceramic museum
Surface: 215,8kmq
Located at Via Emilia (historial route)

CLASSE PINEWOOD NATURAL RESERVE

Conservation measures: SIC/ZPS
Natura 2000 code: IT4070010
Institutive measure: L. R. n. 44/95
Surface: 1.082ha
Type: wetland

ARGENTA VALLEYS NATURAL RESERVE

Conservation measures: ZSC/ZPS
Natura 2000 code: IT4060001
Institutive measure: DGR 512/09
Surface: 3.993ha
Type: pseudo-artificial wetland

Figure 3: High value areas of the territory location and description

exported to many European countries;

» Argenta valleys natural reserve: it is the last SIC and ZPS considered with Natura 2000 code IT4060001. The site is part of a rather large area of the province of Ferrara, the only one wedged beyond the Rhine between the provinces of Bologna and Ravenna and is characterized by wet relict biotopes that survived reclamation.

Even in this case analysis plays a foundamental role in pointing out elements which are not now known, but full of values which deserve to be considered.

An example can be given by all the area located NW to Valli di Comacchio, that was a wetland and now replaced by agricultural fields; it has strong value in term of resilience so the strategy expects to enlarge the Po Delta Park econpassing this piece of land.

Also that area will be totally inundated according to sea rising effect and the scenario provided, so it can be planned to replace fields with better land uses capable to mitigate the issue without totally loosing production.

Considered the two scales, the final goal is to assess a system of actions and strategies to guarantee the sustainable development of the territory linking cultural and natural heritage to enhance resilience, society, economy and new kinds of tourism.

The system will be better faced at the urban scale of Ravenna defining more detailed interventions and possible design due to prove the efficiency of this working method.

1.3. STRUCTURE OF THE THESIS

This thesis paper treats the use of geo-design principles to the planning of a Green Infrastructure for the area of Ravenna and its surroundings.

The following capital represents an introductive part which represents the contextualization of the whole work defining the relationships between landscape architecture and landscape planning, all the legislation at different scales of rules and initiatives related to the thesis objects and finally the definitions of all the important terms used.

Subsequently, it is entered in the real applicative phases of the paper seen.

The first part is the analytical one, which encompasses the detailed descriptions of all the analysis done and the considerations for each of them.

Two scales of analysis have been considered and finally there is a recap to understand the weaknesses and potentialities of the sites.

The second phase is structured by the strategy definition.

Two scales have been considered for analysis, so the same for strategy.

Territorial strategy defines guidelines to provide the sustainable development of the site dividing them into 3 systems (ecological, water and urban ones), the urban one structures detailed intervention according to the characteristics of the compartment in question.

The strategical part also encompasses the description of existing projects, works and other thesis used as references.

Following the third step, the design phase.

Here, one area has been chosen as a pilot area to show the kind of interventions applied in line with the strategical actions.

Even here, a list of landscape projects have been taken and detailed described as references.

The final passage is represented by the conclusion capital, where final considerations are shared with the problems faced all along the course carried out and possible improvements that can be done.

Figure 4 shows the structure

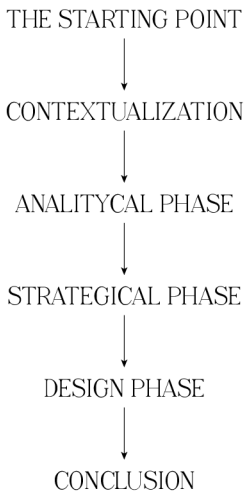


Figure 4: Thesis structure

2. CONTEXTUALIZATION

Before starting to describe the entire process of analysis, strategy and design it is important to clarify all the elements which will be treated.

The starting point is the relationship and differences between landscape architecture and planning, the different principles they support to well define their goals and methodological approaches.

Then a strong description of legislature at different scale must be done, because it is fundamental to frame the reasons of strategical choices.

Particularly attention has been done to the European Green Deal, which represents the main references for this work context.

Other terms will be defined, such as "geo-design" and "Green Infrastructure".

Finally, the main attention will be done for the definition of the word "resilience" due to its variety and complexity of meanings.

2.1. LANDSCAPE ARCHITECTURE AND PLANNING

According to the definition of the IFLA (International Federation for Landscape Architecture), *"Landscape Architects plan, design and manage natural and built environments, applying aesthetic and scientific principles to address ecological sustainability, quality and health of landscapes, collective memory, heritage and culture, and territorial justice. By leading and coordinating other disciplines, landscape architects deal with the interactions between natural and cultural ecosystems, such as adaptation and mitigation related to climate change and the stability of ecosystems, socio-economic improvements, and community health and welfare to create places that anticipate social and economic well-being"* [76].

According to this definition, landscape planning can be considered a branch of landscape architecture.

Typically, landscape planning provides information about the existing qualities of the landscape and nature, which are nature or landscape potentials.

Moreover, defines sensitivity to impacts, the existing and potential impacts on these potentials, and the guidelines for the development of the landscape, upon which proposed measures and development plans can be measured [8].

As said previously no actions, no strategies can be done without a knowledge of the site.

Landscape analysis involves the evaluation of elemental, spatial, and temporal pattern of landscape, as well as dynamics and land-use pattern.

The kind of topics studied can be of all types: land use, climate, geology, topography, infrastructures, built fabric, ecology…

Landscape fragmentation affects habitats and wildlife and causes loss of connectivity.

The detrimental effects of fragmentation can be mitigated by the creation of new habitats or protection of existing ones using connection.

Hence, the growing awareness of the need for connected natural spaces has been reflected in planning approaches such as greenbelts and linked park systems, greenways, ecological networks, green networks and green infrastructure [10].

Landscape planning in englobed in the term of Landscape architecture and it represents only a part of the whole.

landscape architecture defines design and strategical intervention at different scales, from a very small area, which can be a garden, to a site that can encompasses very large areas, regional, national and transnational sites.

Planning considers only a part of both actions and scales, providing generally guidelines and strategies at a scale that can be considered medium to small.

2.2. REGULATORY FRAMEWORK

The first organic law, in Italy, at a national level concerning the protection of natural beauties is L.1497 of 1939, “Norms on the protection of natural beauties”.

The primary function assigned to the competent Ministry, which at the time was that of national education then of the public education, while since 1975 it has been the Ministry of Cultural and Environmental Heritage, was to declare the significant public interest of special categories of landscape heritage, or to “bind” them [75].

This law was based on an essentially aesthetic conception of the landscape object and concerns individual assets or overall beauties.

It was characterized by identifying some categories of Natural Beauties, in particular:

» Individual beauties - immobile things that have conspicuous characters of natural or geological beauty (villas parks or gardens);

» Overall beauties - complexes of immovable things that make up a characteristic appearance with aesthetic and traditional value (panoramic beauties).

The object of protection is in fact essentially the “beauty of nature”.

Therefore, the protected object had to preserve the natural beauty as an asset to protect and preserve.

To this discipline, the provisions of art. 82 of the D.P.R. July 24, 1977, n. 616 attributed to the regions the delegation of the administrative functions exercised by the peripheral bodies of the state for the protection of natural beauties, as regards their identification and protection.

Law 1497/39 also spoke of landscape planning and, in art. 5, delegated to the Ministry for National Education the faculty to arrange a territorial landscape plan for “immovable things and panoramic beauties”: however, these were essentially plans having a conservative function.

Even in the face of the delays in adopting the Landscape Plans, an innovative law was promulgated in 1985, the so-called Galasso Law (Law 431/85).

The law is concerned with classifying the naturalistic beauties based on their peculiar characteristics, dividing them by morphological classes.

The protection action within the areas identified according to the directives of the legislature does not totally exclude building activity but submits it to the approval of the bodies responsible for protection, as well as to the Ministry of Cultural and Environmental Heritage.

The regions are obliged to draw up a landscape plan that protects the territory and its beauties, in particular the plans can also put the total inability to build in:

» Alpine areas above 1.600m;
» Apennine areas above 1.200m;
» 300m from seashores and lakes;
» 150m from rivers banks and streams, on volcanoes, in the Italian wetlands of the Ramsar list, in areas of archaeological interest, agricultural universities (managers of assets for civic use and woods.

All the areas identified by Galasso are subject to state property jurisdiction [67].

During the 90’ the need to define a unique text in environmental matter determined the emanation of d.l.gs 490/1999, which coordinates the matters of law 1497/1939 and law 431/1985.

Important new principles are introduced.

Firstly, it is said that the planning, in the hands of the Regions, is always compulsory referred to the areas protected by law, but, optionally, also to those areas protected by specific decrees.

Secondary, it is states that landscape planning is superordinate to that urban planning.

The most important boost in the matter of “landscape” came from above, from European Commission with the European Landscape Convention

It was adopted by the Committee of Ministers of the Council of Europe in Strasbourg on 19 July 2000 and was opened for signature by the member states of the organization in Florence on 20 October 2000.

It aims to promote protection, management and planning of European landscapes and to foster European cooperation.

The Convention is the first international treaty exclusively dedicated to the European landscape as a whole [51].

The convention defines Landscape as: *"Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors"* [64].

The territory is thus considered in its entirety, as a compound exceptional landscapes, landscapes of everyday life, degraded landscapes, and territorial planning is identified as an essential moment for its protection and management.

For this reason, in May 2004 the d.l.gs n.42 of 2004 came into force bearing the title "Code of Cultural Heritage and Landscape" (so-called Urban Code). It is therefore outside the subject of the Consolidated texts because it is a code, a normative text which, even when it faithfully reproduces the previous TU 490/99, determines an innovative effect of the source.

Among the general principles, an important novelty represented by the Code is constituted by the introduction of the notion of cultural heritage, as the broader genre in which cultural and landscape assets must be brought back.

This new term and, in general, the kind of dispositions were taken from the European Landscape Convention.

Landscape assets, pursuant to d.l.gs 42/2004 and subsequent amendments, are divided into main categories.

The first one are assets bound by ministerial or regional provision of "declaration of notable public interest" (art. 136) consisting of "immovable things that have conspicuous characteristics of natural beauty or geological singularity, villas, gardens and parks that are distinguished by their non-common beauty, the complexes of motionless things that make up a characteristic appearance having an aesthetic and traditional value, the panoramic beauties considered as paintings and also those points of view or belvedere, accessible to the public, from which one can enjoy the spectacle of those beauties";

The second category is represented by assets bound by law (art.142), such as physical and geographical elements (coasts and banks, rivers, reliefs, wetlands), land uses (woods, forests and

civic uses), historical evidence (agricultural universities and archaeological areas), parks and forests.

Pursuant to art. 142 the areas protected by law are:

» *"Coastal territories included in a strip of depth of 300m from the shoreline, also for the elevated land above the sea";*

» *"Territories bordering lakes included in a strip 300m deep from the shoreline, also for the elevated territories on the lakes";*

» *"Rivers, streams, watercourses registered in the lists provided for by the consolidated text of the provisions of the law on water and electrical systems, approved by Royal Decree 11 December 1933, n. 1775, and the relative sides or feet of the embankments for a strip of 150m each";*

» *"Mountains for the part exceeding 1.600 meters above sea level for the Alpine chain and 1.200 meters above sea level for the Apennine chain and the islands;*

» *Glaciers and glacial cirques";*

» *"National or regional parks and reserves, as well as the external protection territories of the parks";*

» *"Territories covered by forests and woods, even if crossed or damaged by fire, and those subject to reforestation restrictions, as defined in article 2, paragraphs 2 and 6, of legislative decree n. 227";*

» *"Areas assigned to agricultural universities and areas burdened by civic uses";*

» *"Wetlands included in the list provided for by Presidential Decree March 13, 1976, n. 448";*

» *"Volcanoes";*

» *"Areas of archaeological interest"* [36].

Regions, to which the competence in the field of landscape planning is transferred, must submit specific rules for the use and enhancement of the protected territory, through the implementation of the Regional Territorial Landscape Plans (PTPR), which provisions are implemented in the Territorial Coordination Plans Provincial (PTCP) and in the municipal plans (PRG).

The plan has the purpose of safeguarding the landscape and environmental values present in their territorial realities.

For the region of Emilia-Romagna it was established with the L.R. n.32/12 an agreement between the Ministry for Cultural Heritage and Activities, the region and the Association of Local Autonomies aimed at the precise definition of some criteria.

These criteria regarded methods for affixing and modify landscape constrains and the modali-

ties for landscape authorizations release (procedure defined by art. 146 d.l.gs 42/2004).

Modalities for landscape authorizations, finally, were modified and simplified with D.P.C.M. 12/12/2005, firstly, and then by D.P.R.n.139/2010 [79].

This short paragraph describes in a very simple way the historical evolution of legislature for landscape protection and valorization (*figure 5*).

Multiple laws and decrees were emanated with a passage of competence from the state to regions and the influence of the European Landscape convention.

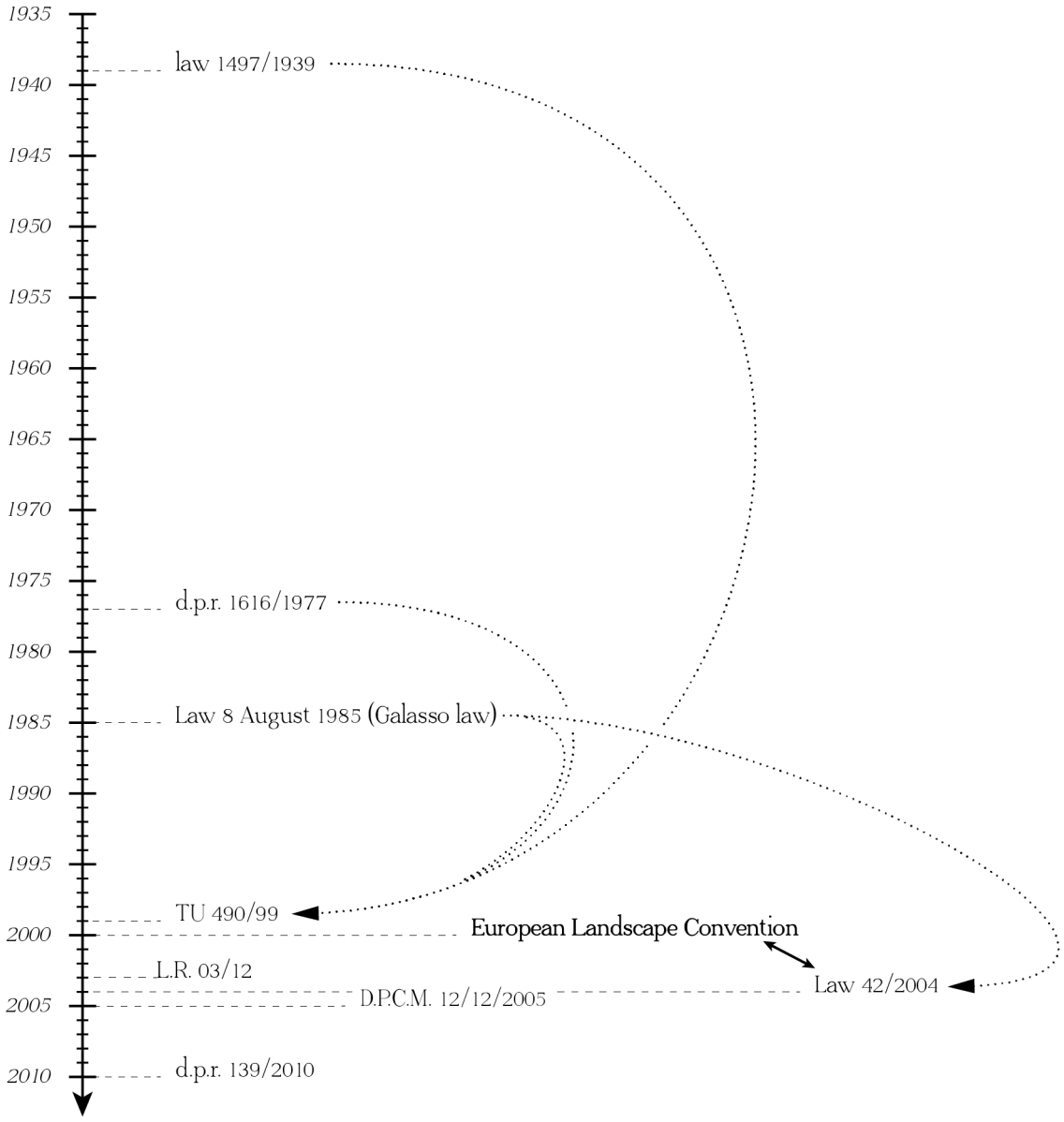


Figure 5: Timeline of landscape legislation

2.3. EUROPEAN GREEN DEAL INITIATIVE

Climate change and environmental degradation are a huge threat to Europe and the world.

To overcome these challenges, Europe needs a new growth strategy that transforms the Union

into a modern, resource-efficient and competitive economy [63].

The main goal is to reach climate neutrality by 2050.

Achieving this will require a transformation of Europe's society and economy, which will need to be cost-effective and fair, as well as socially balanced.

The European Commission has decided on 17 September 2020 to launch a €1 billion call for research and innovation projects that respond to the climate crisis and help protect Europe's unique ecosystems and biodiversity: European Green Deal Call.

The projects funded under this call are expected to deliver results with tangible benefits in ten areas covered by 20 topics:

» Increasing climate ambition: cross sectoral challenges (preventing and fighting extreme wildfires with the integration and demonstration of innovative means, towards climate-neutral and socially innovative cities; climate-resilient innovation packages for EU regions);
» Clean, affordable and secure energy (innovative land-based and offshore renewable energy technologies and their integration into the energy system; develop and demonstrate a 100 MW electrolyser upscaling the link between renewables and industrial applications, accelerating the green transition and energy access partnership with Africa);
» Industry for a clean and circular economy (closing the industrial carbon cycle to combat climate change; demonstration of systemic solutions for the territorial deployment of the circular economy);
» Energy and resource efficient buildings (building and renovating in an energy and resource efficient way);
» Sustainable and smart mobility (green airports and ports as multimodal hubs for sustainable and smart mobility);
» Farm to fork (testing and demonstrating systemic innovations for sustainable food from farm to fork);
» Biodiversity and ecosystems (restoring biodiversity and ecosystem services);
» Zero-pollution, toxic-free environments (innovative, systemic zero-pollution solutions to protect health; environment and natural resources from persistent and mobile chemicals, fostering regulatory science to address chemical and pharmaceutical mixtures: from science to evidence-based policies);
» Strengthening knowledge (European Research Infrastructures' capacities and services to address European Green Deal challenges; developing end-user products and services for all stakeholders and citizens supporting climate adaptation and mitigation; a transparent and

accessible ocean: towards a digital twin of the ocean);

» Empowering citizens (European capacities for citizen deliberation and participation for the Green Deal; behavioural, social and cultural change for the Green Deal, enabling citizens to act on climate change and environmental protection through education, citizen science, observation initiatives, and civic involvement) [62].

The thesis work follows some of these "calls", which represent the cardinal elements of the strategical definitions of guidelines and actions, as well as generators of the idea of Green Infrastructure.

The main area used as starting point is the one related to "biodiversity and ecosystem".

Other important ones are "increasing climate ambition" with a focus on "climate resilient innovation packages" topics.

Also "from farm to fork" has been considered.

These last ones are considered even if the proposal partially encompasses their goals and challenges.

To better understand how the thesis interacts with European Green Deal initiative, it is better to define in a detailed way the topics followed.

2.3.1. BIODIVERSITY AND ECOSYSTEM: RESTORING BIODIVERSITY AND ECOSYSTEM SERVICES

Large-scale ecosystem restoration is urgent.

It needs a systemic approach to deliver tangible benefits on the European Green Deal actions for climate (mitigation, adaptation and disaster risk reduction), biodiversity, zero pollution and sustainable food systems (from farm to fork), health and wellbeing. Actions under this topic should therefore be pivotal in demonstrating and promoting systemic solutions for upscaling urgent restoration to increase biodiversity and support a wide range of ecosystem services, as requested in the Biodiversity Strategy for 2030 for damaged terrestrial, freshwater, coastal and marine ecosystems [43].

This topic responds to the urgent challenge of accelerating transformative change through upscaling restoration of ecosystems at sea or on land.

Actions should:

» Provide large-scale demonstrators of how systemic upscaling and replication of best practice ecosystem restoration can be deployed at multi-scale levels, focusing on degraded ecosystems, responding to relevant restoration goals enhancing biodiversity;

» In line with the EU Biodiversity Strategy for 2030, restore degraded ecosystems, in particular those with high potential to capture and store carbon and to prevent and reduce the impact of natural disasters, and, where relevant, to contribute to the achievement of favourable status for species and habitats of the Birds and Habitats Directives inside and outside the Natura 2000 network of protected areas;
» Adapt, integrate and demonstrate innovative methods (technological, non-technological, social and governance, including sustainable financing) on upscaling ecosystem restoration, also in regions and for communities in transition;
» Support the development of specific demand and supply chains in restoring ecosystems on land or at sea;
» Demonstrate and test how restoration activities and socio-ecological management of ecosystems enable sustainable, climate-neutral and climate-resilient, inclusive, transformative approaches, including across the bioeconomy (agriculture, forestry, marine and innovative bio-based sectors) and as investments in disaster risk reduction;
» Promote scaling up and stepping up of implementation of nature-based solutions;
» Showcase how restoring ecosystems at large scale will also help human communities to adapt to changing conditions at their local level, and how restoration activities can be integrated into economically and socially viable land use practices, enabling a shift of social and behavioural patterns towards increased benefits for biodiversity and strengthening social acceptance and social resilience;
» Demonstrate how to maximise synergies and avoid trade-offs between priorities for restoring biodiversity, mitigating and adapting to climate change;
» Generate knowledge on how large-scale restoration can accelerate transformative change beneficial for biodiversity and climate resilience.

The proposal for the territory in question fits perfectly with this topic providing actions to valorise, protect and develop existing ecosystems which are threatened but in the same time rich in potentialities and fundamental for ES.

2.3.2. INCREASING CLIMATE AMBITION: CLIMATE-RESILIENT INNOVATION PACKAGES FOR EU REGIONS

Every additional half-degree of global warming may inflict a new order of magnitude of harmful consequences on planetary health as well as economic and social cohesion. The failure of economic, financial and industrial policies to sufficiently mitigate and adapt to climate change

is more than ever a primary concern for societies worldwide.

Now, the challenge is to scale up and demonstrate at large scale systemic solutions to trigger behavioural change and new ways of decision-making, while accounting for local and regional contexts.

Multiple disciplines are needed, like technological, digital, business, governance, environmental dimensions, which can cooperate with social innovation.

This will develop adaptation pathways consistent with European Green Deal targets, and tailored to support the regions and communities most exposed to climate change impacts [41].

Proposals should address only one of the following sub-topics:

» Innovation Packages for transformational adaptation of European regions and communities (Innovation Actions): The actions should aim at enabling rapid and far-reaching change through the use of nature-based solutions (NBS), innovative technologies, financing, insurance and governance models, awareness and behavioural change. These packages can propose and implement multiscale and multisectoral regional adaptation pathways in line with national and regional climate objectives. The use of climate services, such as Copernicus Climate Change Service, can be extremely useful to achieve the final goal. They need to implement and test innovations in key systems demonstrating their contribution to improving resilience in the region and/or community. Proposals can take stock from existing good practises and solutions already available from other programmes, such as Horizon 2020, EIT KICs, LIFE+ Programme, Structural Funds programmes the EIB, the EBRD and at national, regional, local and private level.

» Support the design, testing and upscale of Innovation Packages (Coordination and Support Action): The action should support the implementation and wide dissemination of the solutions developed and tested under sub-topic 1. This action is defined by the citizens and region engagement, monitoring and assessment phase and, finally, by portfolio and solutions step.

The thesis work considers partially challenges for this topic, in specific considers the sub-topic 1 trying to adopt a strategy at territorial scale which make use of NBS to provide advance packages.

It is a partial reference due to the fact that the topic deals with exclusively on Climate change basis.

The analysis of the territory studied does not include specific part on it (only flood risk and water sea rising scenarios), but the guidelines proposed can be applied on other topics deeply

considered in this work.

2.3.3. FARM TO FORK: TESTING AND DEMOSTRATING SYSTEMIC INNOVATIONS FOR SUSTAINABLE FOOD FROM FARM TO FORK

European food is recognised as being safe, nutritious and of high quality. It should now also become the global standard for sustainability. Although the transition to more sustainable systems is in its infancy, it remains a big challenge to feed a fast-growing world population and steer food systems within a safe and just operating space - encompassing planetary health, economic viability and social welfare, and including human health. Many current production practices and consumption patterns still result in air, water and soil pollution, contribute to the loss of biodiversity and to climate change, challenge animal welfare and consume excessive amounts of natural resources, including water and energy, while an important part of food is wasted [42].
The topic provides some subtopics which need to be followed for the proposals:

» Subtopic A: achieving climate neutral farms by reducing GHG emissions and by increasing farm-based carbon sequestration and storage;
» Subtopic B: achieving climate neutral food businesses by mitigating climate change, reducing energy use and increasing energy efficiency in processing, distribution, conservation and preparation of food;
» Subtopic C: reducing the dependence on hazardous pesticides; reducing the losses of nutrients from fertilisers, towards zero pollution of water, soil and air;
» Subtopic D: reducing the dependence on the use of antimicrobials in animal production and in aquaculture;
» Subtopic E: reducing food losses and waste at every stage of the food chain including consumption, while also avoiding unsustainable packaging;
» Subtopic F: shifting to sustainable healthy diets, sourced from land, inland water and sea, and accessible to all EU citizens, including the most deprived and vulnerable groups.

This is the last topic that can be used as a reference or a basis model for the proposal of Ravenna and surroundings.
Farm to fork initiative provide a lot of issues to be solved, the proposal can help to achieve the challenge, in particular can work on sub-topic C by proving new kind of land uses and buffer zones to protect water bodies to be polluted.

2.4. GREEN INFRASTRUCTURE

Previous paragraphs have been dedicated to describe the general framework in which the thesis is inserted.

Now, it is time to define the kind of intervention has been planned for the area under study: green infrastructure (GI).

There are different definitions of GI, but in this case, it has been considered the one given by European Union (2013) according to "Building a Green Infrastructure for Europe" initiative: "Green Infrastructure can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. More specifically GI, being a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water." [69]

This is not the only definitions used; following others:

» "...is an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife." [3]: Green infrastructure. Linking Landscapes and Communities;

» "...is a strategically planned network of natural and semi-natural areas with other environmental features designed and man aged to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings.", (German Federal Agency for Nature Conservation (2017): Federal Green Infrastructure Concept).

» "...is the network of natural places and systems in, around and beyond urban areas. It includes trees, parks, gardens, allotments, cemeteries, woodlands, green corridors, rivers and wetlands.";

The European definition introduce an important element, which are ecosystem services (ES).

They are all the "multiple benefits provided by ecosystems to mankind" (Millennium Ecosystem Assessment).

The term is used, because GI can be represented as planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of

ecosystem services.

This network of green and blue spaces can improve environmental conditions and therefore citizens' health and quality of life.

It also supports a green economy, creates job opportunities and enhances biodiversity [70].

It does not include only environments, but it is linked to human wellbeing, society and economy.

The GI planning can provide a good equilibrium among all the elements, where everything is guaranteed the right development and protection (*figure 6*).

The final goal of GI is to endorse a better quality of life, as said before, improve biodiversity (with a connection among high naturalistic areas), protect from natural disasters, such as floods, and climate change impacts and encourage a smarter development and more efficient use and reuse of existing spaces.

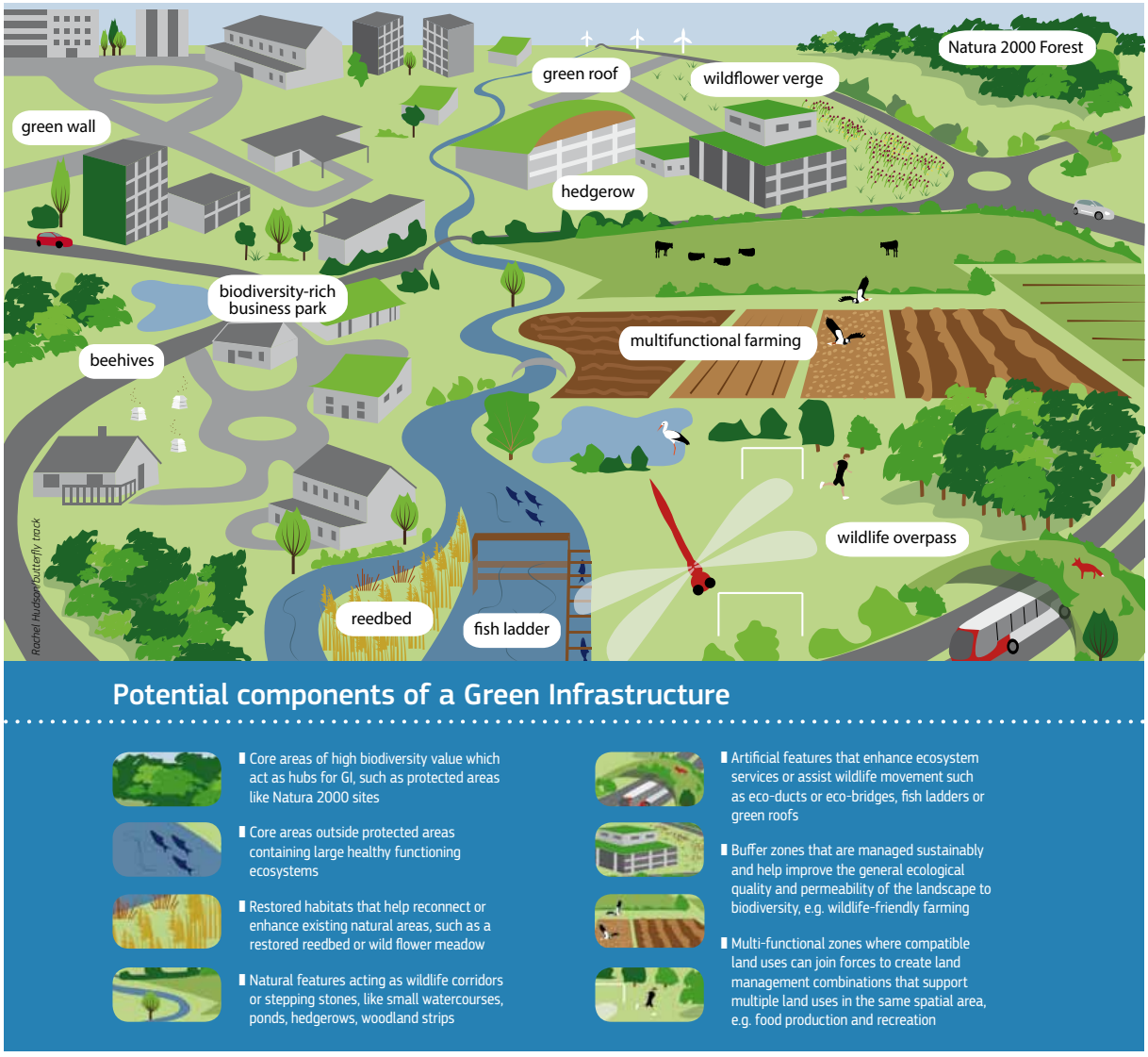


Figure 6: The elements of GI

In May 2011, the European Union adopted a Biodiversity Strategy to halt biodiversity loss in Europe [40].

The initiative is called Building a Green Infrastructure for Europe.

It recognises that GI can make a significant contribution to the effective implementation of a wide range of EU policies where some or all of the desired objectives can be achieved through nature based solutions (NBS)

Here another important concept: nature base solution.

They are a series of actions inspired, supported or literally copied from nature.

It is a relatively recent concept used by the European Commission to identify nature-based strategies, actions, interventions that provide ecosystem services and socio-economic benefits capable to increase the resilience of cities [84].

The question that must be solved is the way in which a GI can be planned, on what basis policymakers can decide.

The most effective ways of building a Green Infrastructure is through spatial planning.

This enables interactions between different land uses to be investigated over a large geographical area.

Databases can be given by the strong analysis of the site considered, it can provide enough data to obtain the knowledge to support decisions.

As said in the first chapter geo-design approach is an innovative way to guarantee this knowledge.

2.5. GEO-DESIGN

The definition of geo-design is derived from two terms, geo and design.

Both of them are subject to a wide variety of interpretations.

The term geo can be simply defined as geographic space, space that is ref¬erenced to the surface of the earth (geo-referenced).

The word design, the second component of geo-design, can be defined as either a noun or a verb. As a noun, design generally refers to some object or other entity.

As a verb, it usually refers to a process or series of activities [21].

According to all of this, the term can be define in an essential way as “design in the geographic space”.

Geodesign is a broad field involving many different types of professionals (scientists, planners,

architects, landscape architects, engineers, agency repre¬sentatives, constructors, sponsors, stakeholders, etc.) working in many different domains, such as GIS, CAD, BIM, RS…

Given this wide spectrum of pro¬fessional activity, there is a correspondingly large number of software programs supporting that activity, each domain having its own cluster of software tools supporting various aspects of the design process.

GeoDesign enhances traditional environmental planning and design activities with the power of modern computing, communications, and collaboration technologies, providing on-demand simulations and impact analyses to provide more effective and more responsible integration of scientific knowledge and societal values into the design of alternative futures [11].

This is a very short description of such a complex method and way of thinking.

The importance is that it fits perfectly with the purposes of the thesis.

Green infrastructure is a complex device to plan.

Geo-design can furnish the right support for decision making and strategical processes.

Obviously, being an academic work, the method has not been followed literally due to some lacks, like data, personnel, communication with stakeholders (also the Sars-Cov2 pandemic have not simply the situation).

2.6. THE CONCEPT OF RESILIENCE ASSOCIATED TO ECOLOGY

Resilience is a very complex term used in many different purviews (psychology, economy, engineering, ecology, sociology and many more).

In the field environment and ecology, it is a two-faced concept.

On the one hand, the concept is used as a descriptive, ecological concept [30] whereas, on the other hand, it represents a boundary object with a rather wide meaning [13].

As a result, the original ecological concept of resilience firstly defined has been transformed considerably.

The descriptive ecological meaning is, in turn, divided into two meanings:

» The first one refers to dynamics close to equilibrium and is defined as the time required for a system to return to an equilibrium point following a disturbance event [16];

» The second meaning of resilience refers to dynamics far from any equilibrium steady state and is defined as the amount of disturbance that a system can absorb before changing to another stable regime, which is controlled by a different set of variables and characterized by a different structure [14].

According to this, 10 different definitions for resilience, grouped in 3 classes, can be found:

» Category 1 (descriptive concept): from definition 1 to 6
» Category 2 (hybrid concept): definitions 7 and 8
» Category 3 (normative concept): definitions 9 and 10

The different definitions are:

» ORIGINAL ECOLOGICAL DEFINITION: Resilience as a "measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" [15];
» EXTENDED ECOLOGICAL DEFINITION: Resilience is defined as "the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behaviour" [13];
» SYSTEMIC-HEURISTIC DEFINITION: Resilience as a "panarchy", divided into 4 adaptive cycles. Resilience represents a quantitative property that changes throughout the adaptive cycle and principally occurs on each level of a system's hierarchy [13];
» OPERATIONAL DEFNITION: Resilience as "the ability of the system to maintain its identity in the face of internal change and external shocks and disturbances" (Cumming et al. 2005);
» SOCIOLOGICAL DEFINITION: Social resilience is defined as "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change"[2];
» ECOLOGIC-ECONOMICAL DEFINITION: Resilience as "the ability of the system to withstand either market or environmental shocks without losing the capacity to allocate resources efficiently" [24];
» ECOSYSTEM-SERVICES RELATED DEFINITION: resilience corresponds to the underlying capacity of an ecosystem to maintain desirable ecosystem services in the face of human use and a fluctuating environment [12];
» SOCIAL-ECOLOGICAL DEFINITION: Resilience is defined as "the capacity of social-ecological systems to absorb recurrent disturbances (...) so as to retain essential structures, processes and feedbacks" [1];
» METAPHORICAL DEFINITION: Resilience means "flexibility over the long term" [25];
» SUSTEINABILITY-RELATED DEFINITION: Resilience refers to the maintenance of natural capital in the long-term to provide ecosystem services that provide instrumental as well as eudemonistic values for human society [23].

The second concept is to define resilience is considering it as a boundary object.
Within the field of science and technology studies, this signifies a term that facilitates communication across disciplinary borders by creating shared vocabulary although the understanding of the parties would differ regarding the precise meaning of the term in question (Star and Griesemer 1989).
Boundary objects can coordinate different groups without a consensus about their aims and interests.
Resilience

2.6.1. RESILIENCE ASSOCIATED WITH ESOSYSTEM SERVICES

A major challenge of the twenty-first century is ensuring an adequate and reliable flow of essential ecosystem services (ES) to meet the needs of a burgeoning world population. All social-ecological systems (SES) produce a "bundle" of ES, including provisioning (e.g., freshwater, crops, meat), regulating (e.g. flood and climate regulation), and cultural services (e.g., recreation, spiritual values).
Extensive and rapid global changes, including urbanization, growing human populations, rising consumption, and increased global connections, have led to a large and growing demand for provisioning services. Meeting these needs has resulted in large-scale conversion of natural ecosystems to cropland, which has eroded the capacity of ecosystems to produce other ES essential to human health and security (e.g. regulating services).
Enhancing ES resilient is fundamental to provide a more efficiency in terms of economy, society and environment.
The method followed by this definition is the one of "resilience of what to what".
What is desired to be resilient and to what.
Resilience of ES is defined as the capacity of the SES to sustain a desired set of ES in the face of disturbance and ongoing changes in SES.
Every SES produces a variety of interacting ES at multiple scales, and it is not possible to increase the resilience of all ES simultaneously, although there are synergies among some services, important trade-offs exist between ES at a particular scale, as well as between ES at different scales.
A growing number of studies provide insight into how the resilience of SES and the ES they produce may be enhanced [4].

Although several studies have proposed general rules for enhancing resilience [31], there is not yet a definitive set of resilience enhancing principles or a synthetic understanding of where and when they have to be applied.

Seven generic principles have been defined [5] for enhancing ES resilience:

1. Maintain diversity and redundancy: Diversity in SES encompasses biodiversity, spatial heterogeneity, livelihood strategies, and institutional diversity. Redundancy is closely related to diversity and is a system property that describes the replication of particular elements or pathways in a system. It is an "insurance" for ES provision by allowing some system elements to compensate for the loss or failure of others. Resilience of ES is maintained by a combination of diversity and redundancy, and low levels of either can lead to brittleness of the SES and compromise resilience. Both diversity and redundancy tend to increase with the number of species or elements in a SES and therefore tend to be correlated. There is wide consensus from a variety of disciplines that diversity and redundancy are important for resilience because they provide options for responding to change and disturbance. The diversity of system elements, such as multiple species, management approaches, and institutions, provides the basis for innovation, learning, and adaptation to slower, ongoing changes;
2. Manage connectivity: Connectivity is defined as the manner by which and extent to which resources, species, or social actors disperse, migrate, or interact across ecological and social "landscapes" [6]. Landscapes may consist of components, such as patches, habitats, or social groupings. These components are referred to as nodes and the connections between them as links, such as ecological corridors. Connectivity in SES facilitates the exchange of material or information necessary for the functioning of ecological and social processes, and hence often directly affects the production of ES. Connectivity also affects the resilience of ES because it affects the spread of disturbances and facilitates recovery after a disturbance [22];
3. Manage slow variables (a variable whose rate of change is slow in relation to the timescales of ES provision and management and is therefore often considered constant) and feedbacks (a mechanism, process, or signal that loops back to influence the SES component emitting the signal or initiating the mechanism or process): Foster an understanding of SES as complex adaptive systems: SES consists of variables that change and interact on a range of timescales. Slow variables determine the underlying structure of SES, whereas the dynamics of the system typically arise from interactions and feedbacks between fast variables that respond to the conditions created by the slow variables. In relation to ES, such as crop

production and drinking water (which represent fast variables), slow variables include, for example, soil composition and phosphorous concentrations in lake sediments. Feedbacks occur when a change in a particular variable r reinforces (positive feedback) or dampens (negative feedback) subsequent changes of the same type. Changes in slow variables and feedbacks can lead to nonlinear changes in SES. Regime shifts usually result from a combination of a shock and gradual changes in slow variables that erode the strength of the dominant feedbacks, generating a reorganization into a new regime. The issue is to strengthen the stabilizing feedbacks in a system, which can help maintain a particular SES regime and associated ES in the face of external stresses;

4. Foster an understanding of social-ecological systems (SES) as complex adaptive systems (CAS): the key of this point is to recognize SES as CAS (a system of interconnected components characterized by emergent behaviour, self-organization, adaptation, and substantial uncertainties about system behaviour). This concept born caused by it is impossible to predict the macroscale SES behaviour from individual system components, the fact that SES are continually evolving and adapting in response to internal system feedbacks. Understanding SES as CAS constitutes a particular mental model, used to interpret and understand the world and decide future decisions. This cognitive framework emphasizes holistic approaches, the management of multiple ES and trade-offs in an integrated way, and the importance of slow variables and feedbacks in SES dynamics;
5. Encourage learning and experimentation: The need for learning is based on the assumptions that knowledge is always incomplete and that uncertainty, change, and surprise are inevitable in complex SES. Hence, there is a constant need to revise existing knowledge to enable adaptation to evolution and change in SES, as well as to maintain ES in the face of disturbance and change. Experimentation, moreover, represents the only way to test new methodologies and approaches and monitoring results.
6. Broaden participation: Participation refers to the active engagement of relevant stakeholders in the management and governance process [28]. Participation can occur in different stages of management process: from identifying problems and goals to implementing policy, monitoring results, and evaluating outcomes. Participation appears central to facilitating the collective action required to respond to disturbance and changes in SES and ES;
7. Promote polycentric governance systems: Polycentricity refers to a governance system with multiple governing authorities at differing scales. Governance is defined as the exercise of deliberation and decision making among groups of people who have various sources of au-

thority to act and may be practiced through a variety of organizational forms (e.g., bureaucratic department, watershed council, non-profit organization). Polycentric structures confer modularity and functional redundancy that can preserve key SES elements in the face of disturbance and change. For example, broader levels of governance can step in when lower levels collapse and fail.

Ensuring an adequate and reliable flow of essential ES to meet the needs of the XXI century is an enormous challenge.

In a world of rapid social-ecological changes, enhancing the resilience of key ES to face increasing levels of disturbances can make an important contribution to increase the quality of spaces. Although a definitive set of principles for enhancing the resilience of SES and the ES they produce does not yet exist, these preliminary set of principles are capable to provide practical guidance for enhancing the resilience of ES.

3. ANALYTICAL PHASE

Landscape architecture, when it is called to produce strategies and design for large areas, requires a deeper knowledge of the site.

The reason is simple: provide a way to understand the elements of the place, to have an overview of potentialities, weaknesses, threats and strengths of the territory.

The analysis phase must cover huge amount of topics, such as environment, ecology, land use, economy, social, tourism, risk, infrastructures etc.

The data has to be used as a support for the decision-making and design processes.

Analysis comprehends the use of thematic maps, models, statistical data, graphs and all the features can help.

A good analysis is not static, it does not consider only existing situation, a good analysis evaluates the processes which generate them, understanding the reasons of changes and non-changes.

Analysis needs a multi-scalar approach; single scale read cannot provide a full understanding of the dynamics and characteristic of the site.

Some issues and, in general, some particularities can arise only from a specific scale, moreover different scale analysis works together achieving the final goal: the creation of knowledge.

Geographic Information System (GIS) and Remote Sensing (RS) represent the fundamental means to the end.

"A geographic information system (GIS) is a framework for gathering, managing, and analysing data. Rooted in the science of geography, GIS integrates many types of data. It analyses spatial location and organizes layers of information into visualizations using maps and 3D scenes.With this unique capability, GIS reveals deeper insights into data, such as patterns, relationships, and situations, helping users make smarter decisions" [61].

"Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth" [97].

For the site two scales presented in the first chapter are used.

Territorial scale has been chosen thank to the presence of high value areas which have been presented before, the analysis will provide a deeper insight understanding if there are other areas deserving to be considered and treated.

The urban scale focuses on a piece of territorial one considering Ravenna that is the main town of the area (presence of Cultural elements, natural areas, the harbour and the seaside).
The analysis will focus on determining characteristics, issues and potentialities of the territory.
Figure 7 shows the kind of analysis provided for different scales.

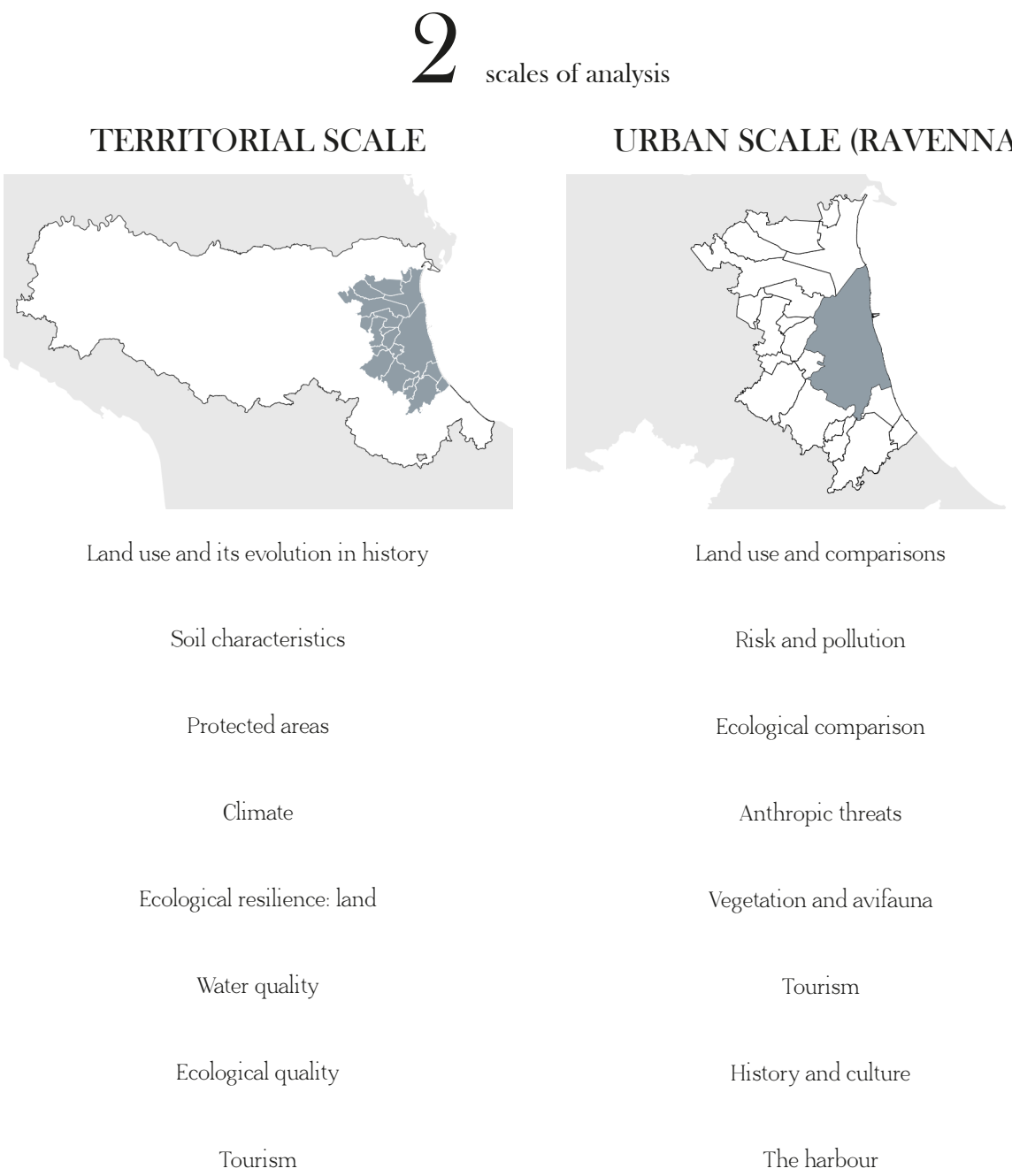


Figure 7: List of the analysis for each scale

This work has considered several datasets of different types coming from several web source. Since data are provided into different format, elaborations must need dedicated software which can easily interact among them.
The following image (*figure 8*) lists datasets sources and softwares used in relation with the

kind of files computed.

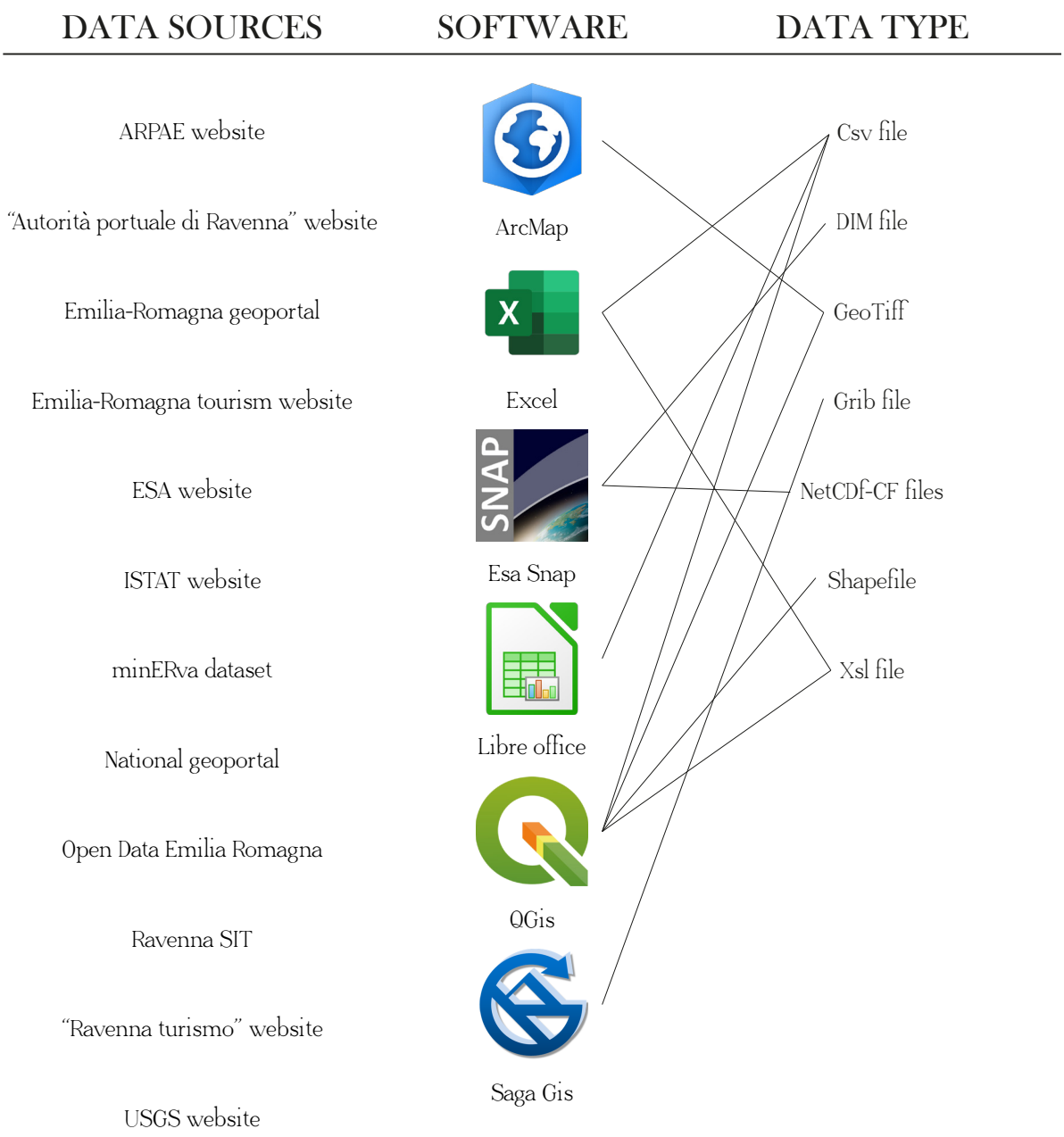


Figure 8: Datasets description and relationship between softwares used and files computed

3.1. TERRITORIAL SCALE ANALYSIS

The first scale considered encompass the whole site.

It is located in Emilia-Romagna, from the Adriatic sea coast to the Apennines feet (44°27'13.8"N 12°03'51.8"E).

Three provinces are partially considered (Ferrara, Ravenna and Forlì-Cesena) and, inside them, 20 municipalities makes up the territorial administrative mosaic (*figure 9*).

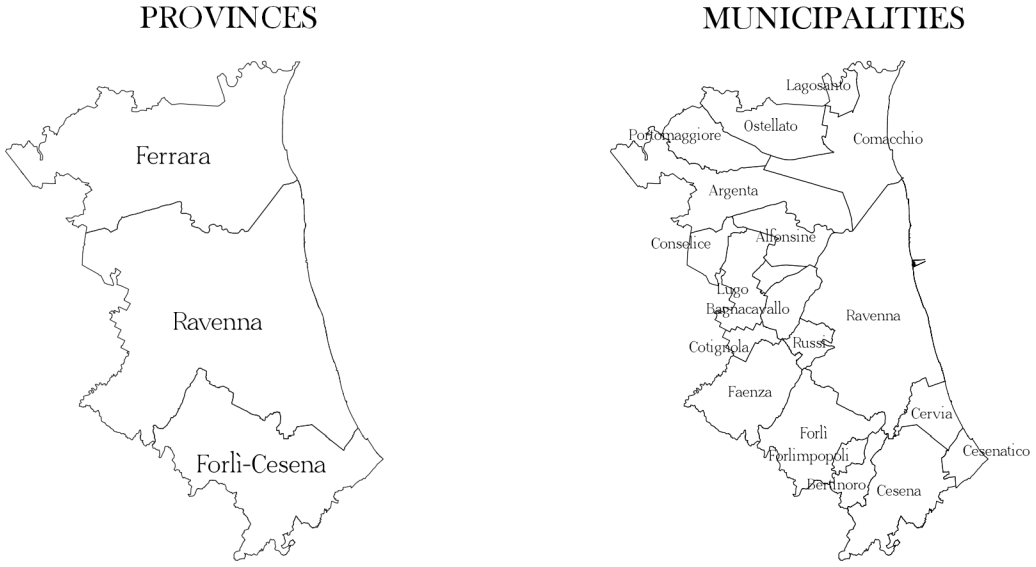


Figure 9: Provinces and municipalities division

Analysis comprehends these topics, previously shown:

» Land use and its evolution in history;

» Soil characteristics;

» Protected areas;

» Climate;

» Ecological resilience: land;

» Water quality;

» Ecological quality;

» Tourism.

This thesis work belongs to landscape planning, so it is essential to analyse the site from an environmental point of view.

For this reason these topics are chosen and they cover several aspects able to provide the knowledge to support future decisions.

3.1.1. TERRITORIAL ANALYSIS: LANDUSE

The first analysis for the territorial scale is the land use and its historical evolution; four times series have been selected (1853, 1994, 2008 and 2017).

Raw data (.shp files) available on Geoportal have been managed to obtain land use maps and statistical comparisons among them (changing matrixes).

Land use data are characterized by different levels of details for classify territory.

The first level of classification introduces the main land uses: urban areas, agricultural areas,

wooded and semi-natural areas, water bodies and wetlands.

The presented analysis considers only the first level of classification because there is the wait to understand the changes along time of main landuses and not their subclassifications (e.g. it is important to understand the trend of urban areas, rather than residential industrial areas, roads etc).

Results are defined by thematic maps, diagrams and change matrixes.

The first process is to cut the land use data with the site borders using basic geoprocessing tools.

Raw data presents several polygons which are characterized by different information like the code related to the first level of classification.

It means that multiple polygons fall in one level.

In order to calculate areas and percentages, it is important to group or “dissolve” all the polygons with the same code in one with another vectorial geoprocessing tool.

Now the file is defined by 5 elements, one for each land use type, then working with attribute table it is possible to calculate areas.

Final maps can be observed in figure 10.

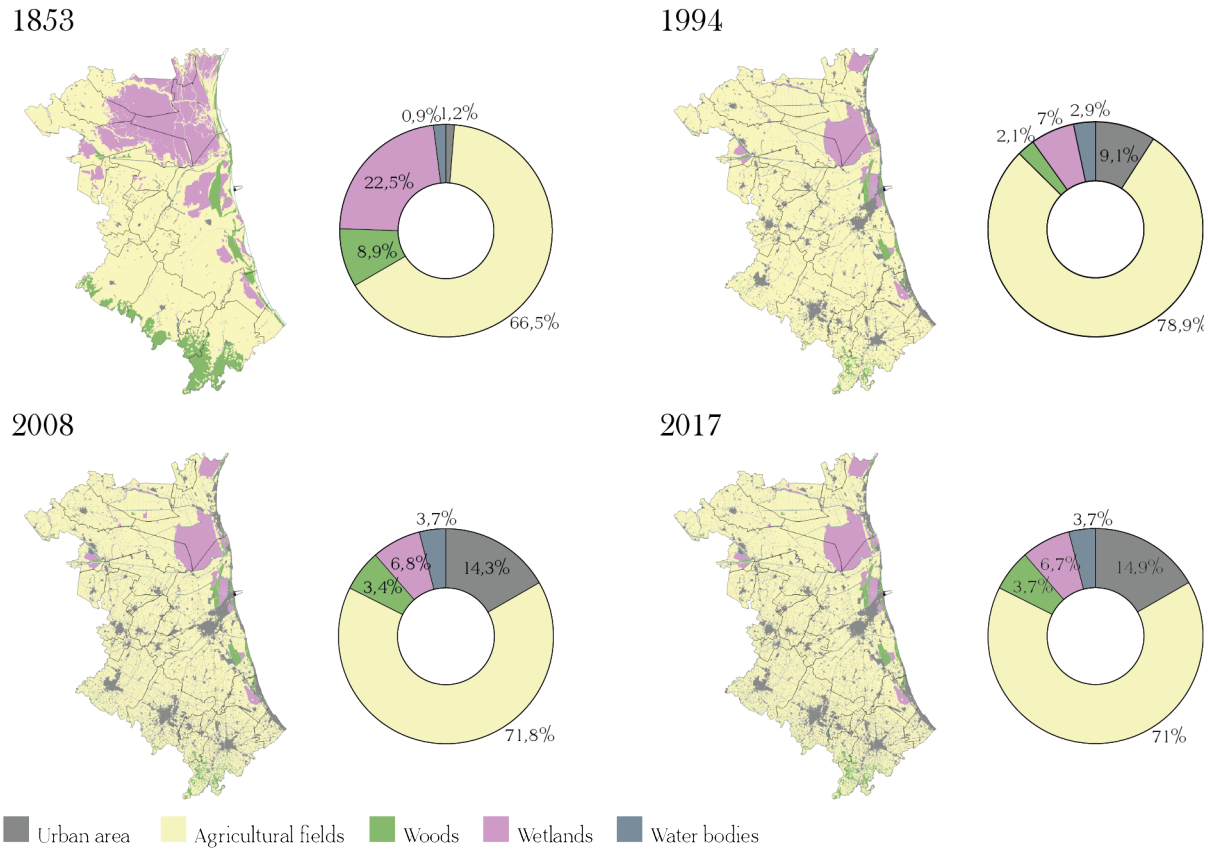


Figure 10: Historical evolution of land use at first level of classification

The second phase regards the production of changing matrixes, which shows how much territory the single land use type has received (columns) and lost (row) after the single time.

In this case two subsequently times need to be considered (1853/1994, 1994/2007 and 2008/2017) and computed by unifying them inside Qgis.

In this way it is possible to study and identify the evolutions from the first time to the second one.

The unification produces the generation of multi polygons determined by attributes of both times used.

This mean that the attribute table of the single element has one field with the code of the land use at first time and one for the second time.

Thank to this changes can be detected by firstly dissolving polygons and then computing percentages as before.

Matrixes are finally created by working with calculated data and results are shown in figure 11.

CHANGING MATRIX 1853 - 1994

1994 \ 1853					
	49,8%	47,8%	0,2%	~0%	2,1%
	9,8%	85,4%	0,5%	1,7%	2,7%
	11,6%	61,7%	22,3%	2,7%	1,9%
	2,3%	70,1%	0,3%	23%	4,4%
	9,2%	56,6%	0,9%	1,8%	31,5%

CHANGING MATRIX 1994 - 2008

2008 \ 1994					
	93,3%	4,9%	0,9%	0,2%	0,7%
	6,8%	90,6%	1,2%	0,4%	1%
	3,5%	5,4%	89%	0,9%	0,9%
	1,1%	0,6%	0,3%	96,2%	1,4%
	3,2%	6,2%	3,2%	1,4%	86%

CHANGING MATRIX 2008 - 2017

2017 \ 2008					
	96,3%	2,9%	0,4%	0,2%	0,2%
	1,6%	97,8%	0,4%	~0%	0,2%
	1,1%	4,4%	93%	0,3%	1%
	0,1%	2,1%	0,3%	97,3%	0,1%
	1,1%	3,1%	0,2%	0,5%	95%

Figure 11: Changing matrixes

With matrixes, it is possible to understand, from one time to the other one, decreases and increases of the single landuses.

Observing maps, urban centres represent islands in a sea of agriculture.

This one, agriculture, covers the majority part of the territory since the first time with 66% and increased its extension till 71% in 2017.

The others land uses, specifically wetlands and secondary woods, describes an opposite trend.

Wetland lost the 70% of its territory to agriculture (reclamation process) from 1853 and 1994, in particular in the north.

Today is it possible to admire its remnants: Valli di Comacchio and Po di Volano.

Woods were, like urban areas, a minor element but, while towns increased along time, woods were mainly replaced by agricultural areas between the first and second times.

The loss of wetlands represent an important issue to be faced, because they are fundamental

to maintain and develop biodiversity, they produce fresh water, food, raw materials and, in the same time, protect the territory from climate change.
Also, the increase of urban areas and the high presence of agricultural activities can generate specific emissions in the atmosphere and chemicals (pesticides and fertilizers) in the soil.

3.1.2. TERRITORIAL ANALYSIS: SOIL CHARACTERISTICS

The second analysis takes into account soil characteristics and geology in order to better understand characteristing of what is under feet.
Elements considers were lithological units overlapped with geological landscapes, soil texture, % of organic carbon in the soil, salinity and WRB classification.
All the raw data were taken from Open Data of Emilia-Romagna website and they are of two kinds of file, vectors (.shp) for geology and WRB and rasters (.GeoTiff) for all the others.
Two different processes are used according if the data is a vector or a raster, anyway the software used has been Qgis.
The workflow is very simple and follows the land use one, it means cutting the data at regional scale to the site considered and unify all the polygons into one to simplify computations of areas and percentages.
The difference between vector process and raster one is made by the file itself.
A vector is set of geometric elements (points, lines or polygons) also of different shapes, which represent a portion of the territory, a position or a set of positions.
A raster set of square (or rectangular) cells, of the same size, named as pixels, which represent a portion of the territory.
Each cell contains a numerical value that quantifies an average characteristic of that area.
Differences are represented only by the kind of tools used because they work in different ways.
These kinds of data are useful to comprehend characteristics that can't be observed directly by human eyes or by photointerpretation, like it could be done for land use (*figure 12*).
Soil texture, which identifies on the basis of the percentage composition of its solid particles distinguished by particle size classes (clay, loam, sand, silt etc), is important to understand soil permeability.
The permeability of the soil is a property that is generally identified with the measurement of the saturated water conductivity and which expresses the capacity of the soil in saturation conditions, to be crossed by a flow of water, in the direction vertical.

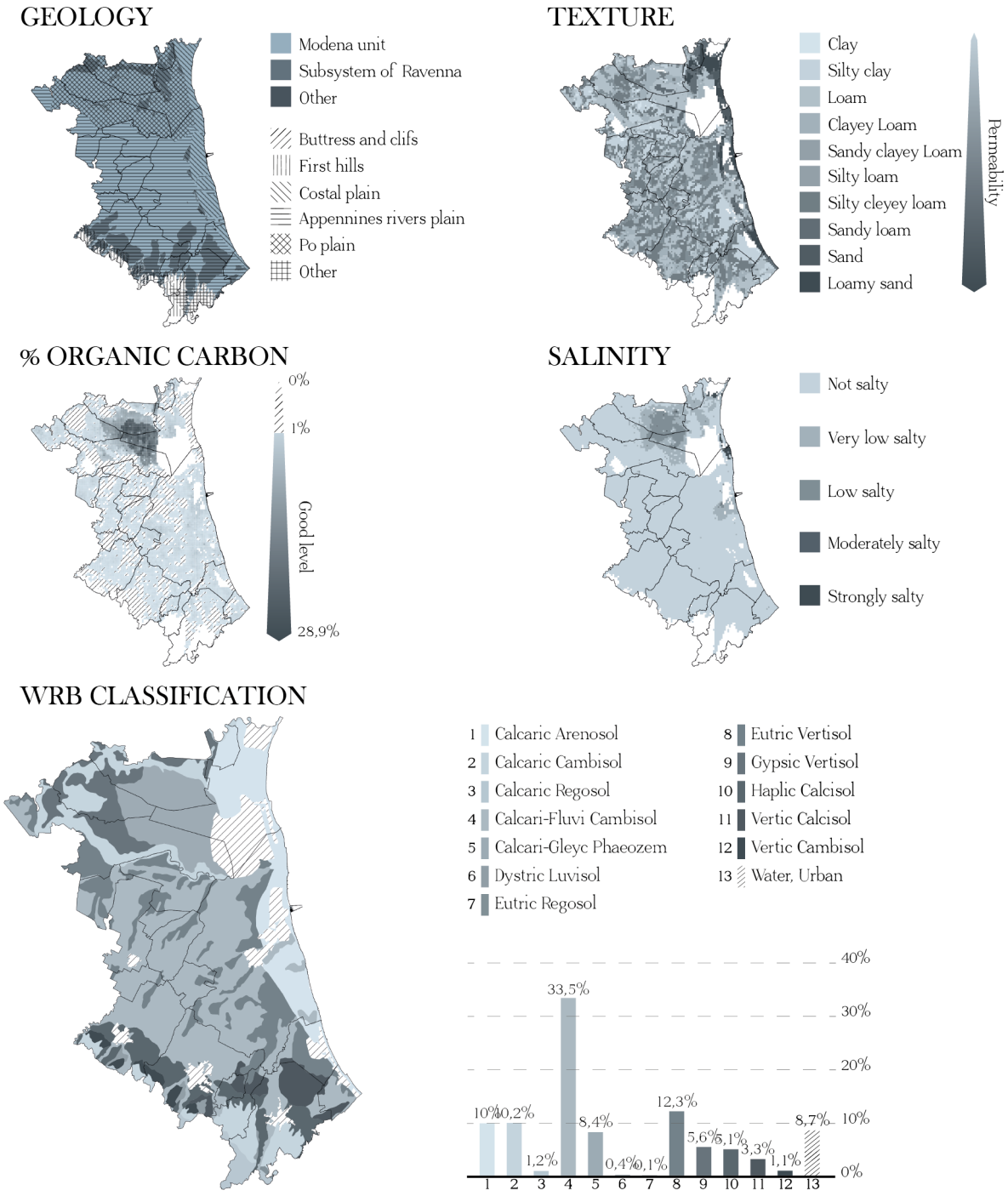


Figure 12: Soil characteristics maps

Very permeable soils facilitate the absorption and movement within them of considerable quantities of water in a short time.

Very permeable soils are therefore protective with respect to erosive phenomena and consequently to the quality of surface water, particularly in sloping conditions, while they are not very protective against groundwater.

The conditions are opposite in the presence of poorly permeable soils characterized by low infiltration and marked surface flow processes.

In this case the territory is characterized by different textures and permeability, mainly by medium permeability with silty loam and silty clayey loam soils; along the coast and Po di Volano area soil is highly permeable caused by loamy sand soils.

Is it possible to notice a linkage between percentages of organic soil, salinity and land use, but firstly is important to give some definitions.

Soil organic carbon (SOC) is a measurable component of soil organic matter and it acts as climate change mitigator.

Small increases of SOC over very large areas in agricultural and pastoral lands will significantly reduce atmospheric carbon dioxide.

Salinity is one of the most important abiotic stress for soil quality.

It is associated with poor soil structure, low water holding capacity and excessive accumulation of sodium, chlorine and carbonates in the soil.

The area near Valli di Comacchio is characterized by high concentration of organic carbon and low-medium present of salinity (almost the whole has no salts in soil).

That area was a wetland during XIV century and was completely replaced by agricultural fields.

The presence of wetland can explain the high amount of organic carbon, while salinity can be related to the presence of an aquifer of salty water which recharged wetlands in the past [91].

The World Reference Base (WRB) is the international standard for soil classification.

At the first level a subdivision is made based on the pedogenetic principle, which is expressed in a morphology of the soil; 32 soil groups are thus obtained, while at the second level the group name is flanked by a qualifier prefix and/suffix.

The site is covered by 13 different soils, but only one rules over all the others: Calcari-Fluvi Cambisols.

It a very deep soil, with Ap - Bw - C profile, non-gravelly, with frank texture to silty frank, slightly to moderately calcareous, in reaction moderately alkaline, very high base saturation, well drained [77].

The soil is the living skin of the earth through which the lithosphere, the hydrosphere, the atmosphere and the biosphere interact and plays a fundamental role for the life of our planet because it regulates the cycles of water, carbon, phosphorus and nitrogen.

Knowing soil characteristics is foundamental to better manage life and all the processes that happen thank to it.

3.1.3. TERRITORIAL ANALYSIS: PROTECTED AREAS

The following analysis encompasses protected areas, considering both their naturalistic values and according to a specific juridical code, D.lgs. n. 42/2004 (Galasso areas - 1985).

All the raw data are vector files and they have been taken from Open data Emilia-Romagna, regional geoportal and minERva dataset.

Protected areas are divided into (*figure 13*):

Figure 13: Example of protected areas

» RER ("Rete Ecologica Regionale") which is the framework of existing naturalistic priority sensitivities, and a design of the supporting elements of the reference ecosystem for the assessment of strengths and weaknesses, opportunities and threats present in the regional territory;

» ZPS (Special Protection Zones) which are protection zones placed along the avifauna migration routes, aimed at the maintenance and arrangement of suitable habitats for the conservation and management of populations of migratory wild birds;

» ZSC (Special Conservation Zone), according to the Habitats Directive of the European Commission, are Sites of Community importance (SIC), in which the conservation measures necessary for the maintenance or restoration of the natural habitats and populations of the species for which the site has been designated by the European Commission;

» RAMSAR areas, which belongs to RAMSAR convention, are those wetlands of international values. The Convention has as its objective the international protection of wetlands through their identification and delimitation, the study of the characteristic aspects, in particular avifauna, and the implementation of programs that allow the conservation of their habitats, flora and fauna [81];

» "Parco del Delta del Po" is a regional park designated by LR 27 2/07/1988 and it is characterized by high number of different habitats, fauna and vegetation types.

Natura2000 is a network of sites of community interest, and of special protection areas created by the European Union for the protection and conservation of habitats and species, animals and plants, identified as priorities by the Member States of the European Union.

Galasso areas comes from L. 431/85 and defines the so-called landscape constrains.

All these are receipted inside the PPTR ("Piano Paesaggistico Territoriale Regionale").

The constrains considers are:

» Art. 17, watercourse protection areas;

» Art.21, archaeological settlements;

» Art.22, historical urban centres;

» Art. 136, landscape assets;

» Art. 142 letter letter a, coastal area;

» Art. 142 letter letter d, woods and forests;

» Art. 142 letter letter i, wetlands.

The process adopted is the same as for land use maps.

A deeper computation has been provided for density maps, in particular for vegetation density map inside Po Delta Park and habitat density map related to Natura 2000 sites.

For the first one, the final map has been calculated starting from the layer of vegetation type distribution and the shapefile of the park.

The only way to obtain necessary element is to create a grid covering all the park polygon, in this case a 500x500m grid has been chosen.

The next step is to identify how many vegetation types are included for single cell.

Intersecting grid and vegetation types, it is possible to provide polygons cut at cell borders (one polygon one vegetal type).

The next step is to convert polygons into points by extracting centroids and then counts their numbers inside each unit with a specific tool ("counts point in the polygon").

Working with symbology it is possible to show different density using a colour gradient.

For Natura2000 habitat density (*figure 15*), it has been used the polygon layer of Natura2000 habitats.

Density maps work with kernel tool, which calculates the density of features in a neighbourhood around those features.

It can use points or lines as inputs.

To obtain them the same passe adopted for vegetation has been used by providing centroids and then apply the kernel density tool to generate the final map.

As before areas and percentages have been calculated.

Looking at all the maps (*figure 14*) is it possible to observe the presence of lots of protected area of different kinds, also same areas are under different protections codes, such as Valli di Comacchio, which is considered in all maps.

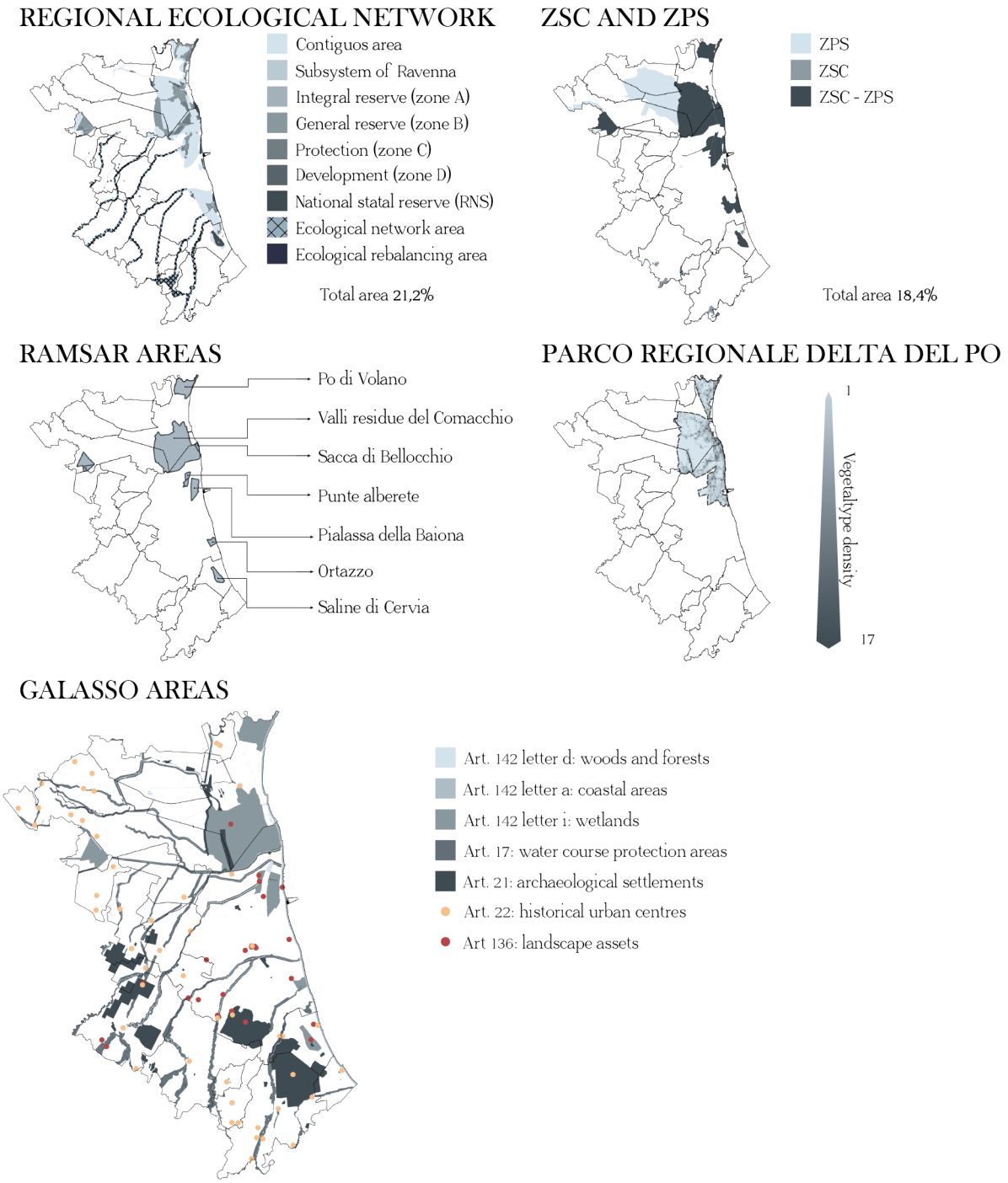


Figure 14: Maps of protected areas classifications

Existing wetland represents the main protected areas in the territory, this is due to their importance for biodiversity and climate change adaptation; governments are expressing the wait to conserve and valorise them knowing the threats they are facing.

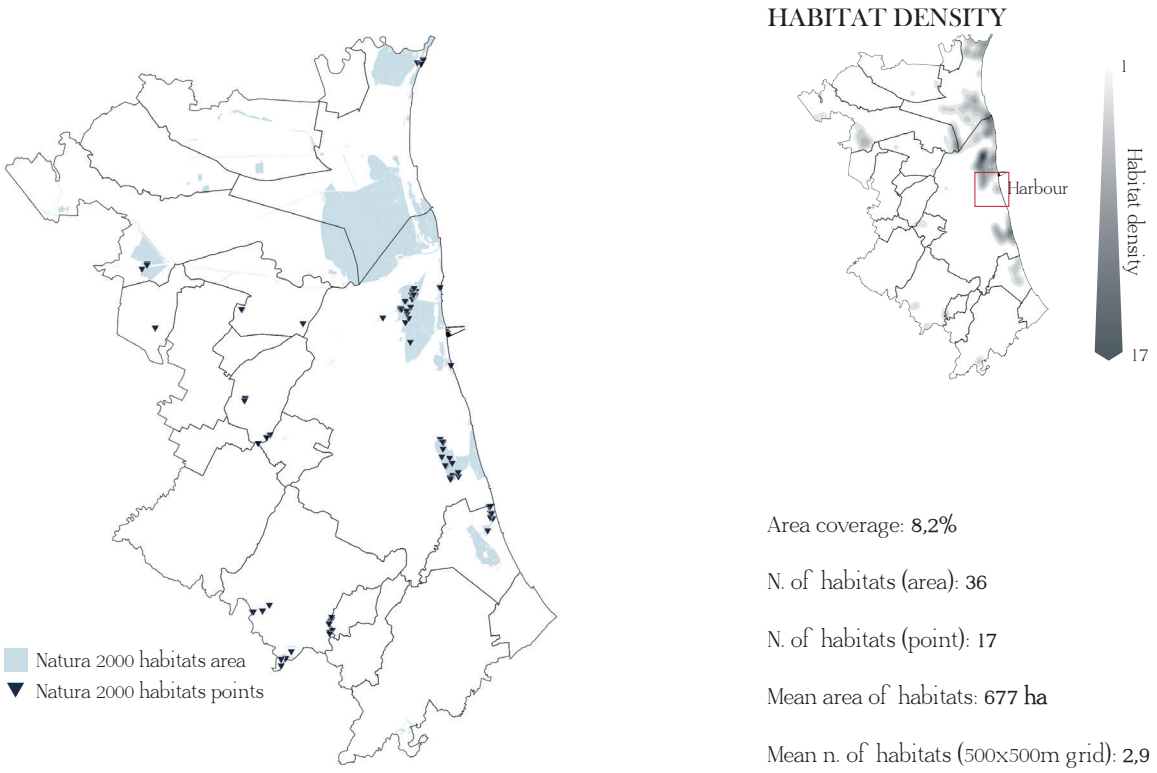


Figure 15: Natura 2000 sites and habitat density

Coastal area and wetlands represent the places where biodiversity can better spread, this data is shown in the two density maps.

Inside the "Parco del Delta del Po" the areas with high vegetation diversity are, starting from north:

» Po di Volano border with sea;

» Valli di Comacchio border with sea;

» Pialassa Baiona and Pineta San Vitale.

While, considering Natura2000 habitats density the main areas are located between the border of Pialassa Baiona and pinewood and between Valli di Comacchio and sea.

A barrier to the continuity of protected area can be observed: the area of Ravenna harbour.

For this reason, Galasso areas try to protect them from some human processes by defining buffers within which man-made activities can be done.

According to all said above, areas with elevated natural values are fundamental to protect and to confer resilience at territorial scale providing space for the development of animals and plants.

3.1.4. TERRITORIAL ANALYSIS: CLIMATE

Climate analysis is divided into two branches, the first one considers climatic data (minimum/maximum temperatures, minimum and maximum temperature variation, mean precipitation,

wind direction and intensity and evapotranspiration) from 1961 to 2015, the second one considers bioclimate and comparisons between ombro-thermal diagrams at territorial scale and Ravenna considering two time series: 1961-1999 and 2000-2018.

Both climatic and bioclimatic data are taken from ARPAE [35] website as vector layers (mean values are already present, so no need to any calculations with field calculator)

As before, the process required is only to cut each single layer with site borders.

In order to generate a clear way to read temperature dynamicity, the variation between minimum and maximum variation has been done.

The workflow is simple and it has been seen previously, unifying the two layers is possible to have both maximum and minimum temperature for the single polygon.

The two information can be easily computed by subtracting the minimum one from the maximum one in the attribute table.

It is better to remind that temperatures are written by a range of values, like 7-8°, and considering that it is impossible to calculate mean values, so it has been decided to consider the mean value of the range, such as 7,5°.

Working manually inside the single fields resulted simple, in this case, due to few values to change.

Final maps can be seen inside figure 16.

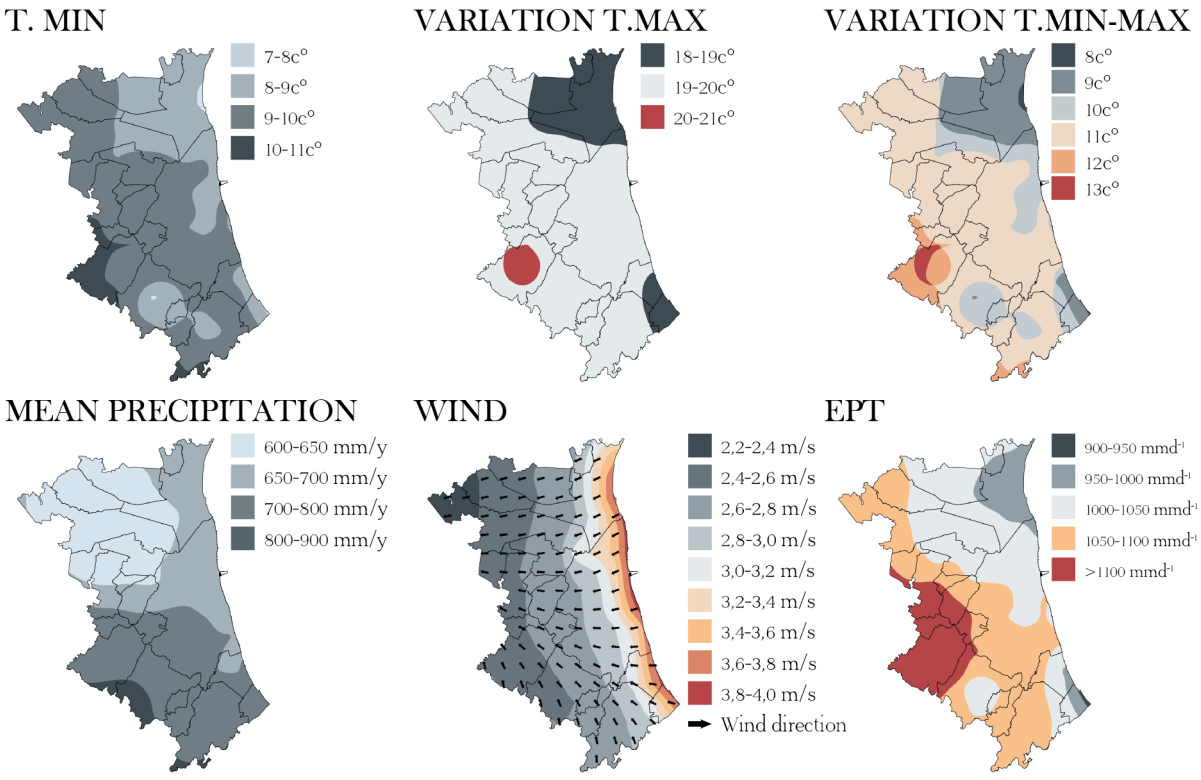


Figure 16: Climatic maps

For the definition of ombro-thermal diagrams, it has been started from daily climatic data (Excel tables) from 1/1/1961 to 31/12/2018 related to the single meteorological station (coded) placed all over Emilia-Romagna and in other parts of Tuscany.

There is another spreadsheet thank to this has been possible to locate the single code to its municipality and region.

There are 3 climatic tables: minimum temperature, maximum temperature and mean precipitation.

Before explaining the process to obtain ombro-thermal diagrams, it is important to define what is it.

Ombro-thermal diagram or Walter-Lieth diagram allows the graphical comparison between the thermal regime and the pluviometric regime relative to a climatological period of reference or to a single year; when the rainfall curve falls below that of the average temperatures ($P < 2T$) the period concerned is considered arid, otherwise with water availability [39].

In this case the process has been computed inside Excel, Qgis and Libreoffice.

The first phase is to eliminate all the codes of useless meteorological stations by controlling codes in the secondary spreadsheet.

For regional diagram eliminate online station outside Emilia-Romagna, for Ravenna diagram consider only codes related to that city.

All the process has been made for the three tables.

After that, calculate daily mean values for both temperatures and precipitation.

It is a simple formula to be applied inside Excel.

In this case for the single day there is only one value, which corresponds to the medium value among all the stations considered.

Due to the fact ombro-thermal diagram requires mean value for precipitation, there is the need to make the mean between minimum and maximum temperatures.

To achieve the goal, the daily maximum and minimum temperature values have been processes in a single spreadsheet.

At this moment there is a table for daily values for precipitation and mean temperatures.

The next passage is to divide each single table by two, the first with data from 1/1/1961 to 31/12/1999 and the second from 1/1/2000 to 31/12/2018 for both region and Ravenna.

Now there is the need to group daily values into monthly ones. The first thing to do is to associate for the single day the relative month.

To do this, the first thing is to separate the field of date (XX/XX/XXXX) into three different

ones (one for date, one for month and one for year) by “text in column” inside data toolbar using “/” as separator.

MONTH	T1960-1999 (°C)	P1960-1999 (mm/y)	T2000-2018 (°C)	P2000-2018 (mm/y)	T VARIATION	P VARIATION
January	1,9	75,39	2,94	65,29	1,04	-10,11
February	3,64	63,70	4,15	82,37	0,51	18,67
March	7,15	77,16	8,13	86,14	0,98	8,97
April	10,78	87,92	12,15	79,41	1,37	-8,51
May	15,36	75,97	16,60	75,03	1,24	-0,94
June	19,07	73,89	20,85	59,05	1,78	-14,84
July	21,81	50,03	23,10	41,46	1,29	-8,57
August	21,50	71,66	22,89	50,39	1,39	-21,27
September	17,83	85,72	18,25	78,81	0,42	-6,91
October	12,80	108,85	13,64	103,06	0,84	-5,79
November	6,99	115,51	8,49	129,86	1,50	14,35
December	2,91	86,07	3,85	79,89	0,94	-6,18

Figure 17: Climatic table after all computations

After that, eliminate the useless fields and put the tables inside QGIS.

The process continues with the use of “Group stats” plug in which is possible to compute some statistical analysis in simple and quickly way.

Inside its interface, it has been possible to calculate monthly mean temperature by making the average of daily ones and then monthly precipitation values by summing daily ones.

The final results are tables with months as rows and values for columns.

After that this tables are firstly opened inside Libreoffice and then inside Excel.

Manage all the tables in Excel to have only one final (*figure 17*), where there are values for total precipitation and total mean temperature associated to every month.

Now is it possible to develop ombro-thermal diagrams, remembering to set precipitation axis value two times temperature one and, after 100mm of precipitation, set it as three times higher (*figure 18*).

Climate is extremely important in this historical period due to the consequences of anthropic action which caused climate change.

Bioclimate, that is the set of climatic conditions seen in terms of their influence on living organisms, is also fundamental to explain possible dynamics and future scenarios related to the territory, and it is influenced by climate change [7].

Climatic and bioclimatic features can represent an alarm bell from environmental point of view. This can be explained by the ombro-thermal diagrams.

Looking at them, they show similar result, there is formation of aridity during summer months with a peak in July, it means that precipitations decrease a lot and temperatures perceived a little increase.

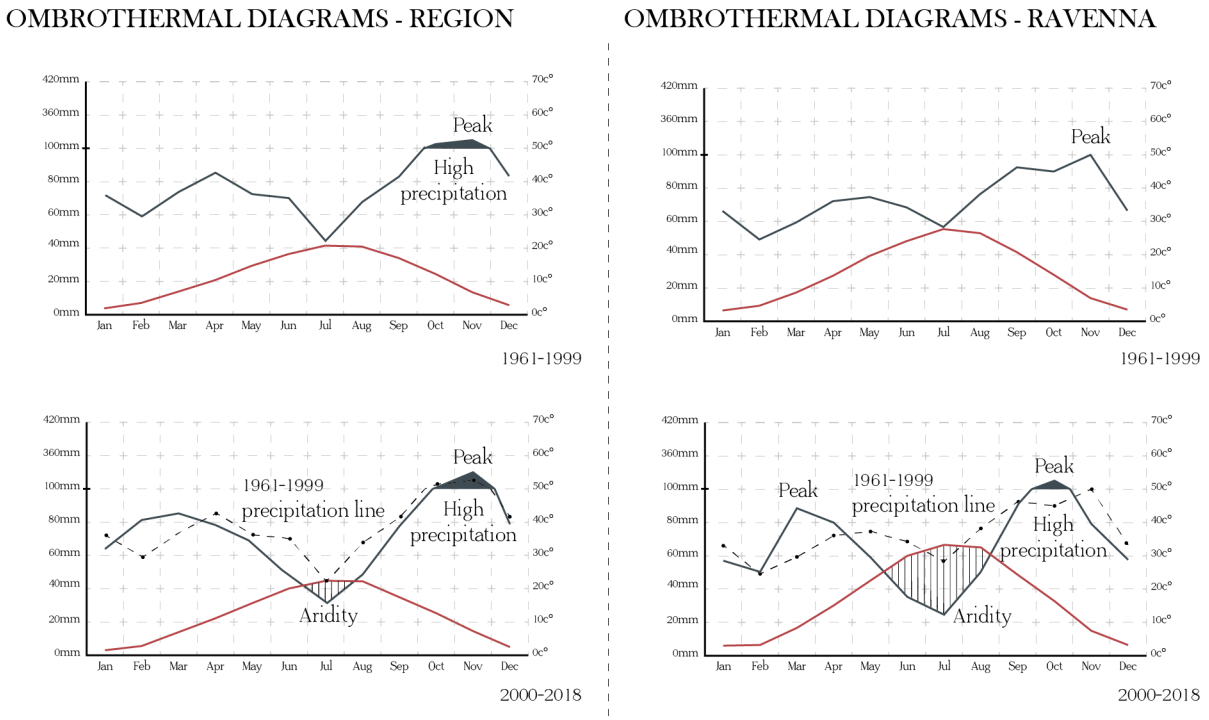


Figure 18: Temporal and scale comparison with obrothermal diagrams

Other stuff is the generation and, in some case a sharpening, of precipitation peaks before and after the arid period.

All these changes affect more negatively the site of Ravenna.

The existing situation provides a non-linear distribution of precipitation of water during the year.

It means a lack in water supply during summer with possible problems for irrigation and other activities, while during peaks water can cause disaster related to floods.

Understanding relationship between temperature and precipitation and their evolution can be a support do understand the possible action to be done to mitigate risks related to this topic.

3.1.5. TERRITORIAL ANALYSIS: ECOLOGICAL RESILIENCE, LAND

DESCRIPTIVE INTRODUCTION

The first complex analysis made is related to the ecological resilience of the territory.

Resilience in ecology is therefore the ability of an area, an ecosystem, a vital community to resist the blows, to cushion the devastating effects, to return to its initial state, after a disturbance that has removed it from that state.

There are different ways to assess resilience, but in this case, it has been followed a scientific paper [32] , suiting input data according to the available ones.

This document defines resilience as the relationship between human needs, environmental sup-

ply and their exchanges

In this case six input data are used to define the result:

» Patch density, that is the density of different land uses inside the territory;

» Biopotentiality (BTC) is an indicator of the state of metabolism energy, measured in Mcal/m3/y, of plant systems and represents the ability of an ecosystem to conserve e maximize the use of energy, able to identify the evolutions / involutions of landscape, in relation to the degree of conservation, recovery or transformation of the mosaic environmental;

» NDVI (Normalized Difference Vegetation Index) is a value, which ranges from -1 to 1 showing the quality of vegetated areas: the higher the value, the better the quality;

» Slope;

» Distance matrix of disturbances, it is a matrix which values get worse approaching disturbances, seen as code 1 of land use classification without code 14 (urban green areas).

» The document considers disturbances only mines, but in this case they are extended to all grey areas;

» Distance matrix of ecological sources; it is a matrix which values get worse stepping away from ecological sources, seen as codes 3 and 5 of land use classification.

For every single input the final output is a normalized raster (30x30 cell dimension), which values range from 0 to 1, where 0 is the worst value and 1 is the best one.

The formula foresees to divide the value of the single layer by the maximum value: “cell value/max. value”.

In order not to have to many values for outputs, it has been decided to aggregate values into ranges shown in the figure 19.

MINIMUM VALUE	MAXIMUM VALUE	CLASS
>0	<=0,2	Low
>0,2	<=0,4	Medium-low
>0,4	<=0,6	Medium
>0,6	<=0,8	Medium-high
>0,8	<=1	High

Figure 19: Classes of values for resilience computation

DATA COMPUTATION

This kind of analysis determines land resilience, for this reason, water bodies have been cut

from all the six input by “cut raster with mask” tool.

Now, each single input has been defined by a specific computation and process, made with Qgis and ArcMap.

The first one is patch density.

The process is like the definition of vegetal type density.

Raw data is defined by 2017 land use classification (in this case it has been used level two of classification); to this one it is unified a 200x200m grid.

As before the single cell of the grid is characterized by some polygons.

To provide the density there is the need to count the number of different elements for each cell by, firstly, extract centroids and then count them with the appropriate tool.

After that, using ArcGis, the vector layer has been rasterized, so the single cell of the grid is converted from a polygon to a raster cell defined by the value related to the number of land uses inside it.

The process finishes by the output normalization using raster calculator and the reclassification of them.

The final map shows that all the territory is characterized by homogeneity of land uses, it means few habitat diversity and it can affects the resilience of the territory

The second input layer is referred to biopotentiality.

Even in this case starting data is the land use classification at second level.

DESCRIPTION	VALUE
Land uses with prevalence of energy subsidized systems (industries, infrastructure, buildings, bare areas, rocky outcrops)	0
Land uses with prevalence of agricultural-technological systems or degraded ecotopes (arable land, scattered buildings, uncultivated herbaceous plants, river corridors)	1,5
Land uses with prevalence of semi-natural agricultural systems (herbaceous arable land, orchards, vineyards, hedges) with medium resistance)	2,5
lLand uses prevalence of natural ecotopes (shrubs, pioneer vegetation, rows, poplar groves, reforestation and arboriculture, urban greenery)	3,5
Land uses with prevalence of natural ecotopes without energy subsidy (coppice woods, woods of the basal and sub-montal plane, wetlands)	5

Figure 20: Classes of values for biopotentiality

For each one it has been attributed a value between 0, the worst value, and 5, the best value (Ingegnioli’,1993) shown in figure 20.

As for patch density the layer has been rasterized normalized and reclassified.

In this case biopotentiality map shows medium values for the majority of the site. It is related

to the presence of a single land use, agriculture, which have a medium value of biopotentiality.
The third input is NDVI, referred to vegetation quality:
Imput are satellite images (.GeoTiff) and they have been taken from USGS website.
12 images, one for month for the same year (2018), from landsat8 mission have been downloaded.
This kind of images are characterised by eleven bands, each band is referred to a specific range of electromagnetic spectrum.
NDVI is defined by a specific formula, that is: "(near infrared band - red band) / (near infrared band + red band)";
12 images are selected, and not only 1, because vegetation quality changes during the year, caused by seasonality, crop rotation and so on.
Inside QGIS, for the single time, has been calculate the NDVI by the equation written before using band 4 for infrared and band 5 for red:

"(B4 – B5) / (B4 + B5)"

At this point 12 NDVIs images are present, now it is time to make the mean value using raster calculator.
The final result is the mean value of NDVI to 2018, the next passage is to normalize the values which range from -0,160139 to 0.470222.
Two calculations are needed to achieve the goal, the first is to convert all the values into positive ones by summing cell values with the lowest value without the symbol "-", the second passage is to divide the new values with the new maximum one.
Then has been possible to reclassify the layer.
Mean annual NDVI shows negative values, the only classes represented are low and medium-low.
Low NDVI values occur in areas with low or no vegetation cover, or where the vegetation present is senescent or suffering, it means low photosynthetic activities and low level of biomass.
The fourth element to add is the slope, the workflow is simple: obtain slope data from the DTM (Digital Terrain Model) of the site.
The first step is to download the DTM from regional geoportal.
The problem is that it is impossible to download a single raster for whole territory of Emilia-Romagna, but the website allows only to download single parcels or sheets, which represen-

ts a portion of the territory.

After obtaining all the necessary sheets, the next part is to unify all of them Ina single raster with ArcMap.

The entire DTM has been cut following site boundaries inside QGIS.

Subsequently, it has been possible to compute slope data from DTM by the appropriate tool.

Finally it is possible to obtain the final layer as all the others.

The slope in the site is almost absent, only in the SW direction terrain starts to corrugate in the correspondence of Apennines feet.

The second-last layer is referred to the distance matrix from disturbances, where the higher the distance, the better the value.

The starting point is land use layer.

The first step is to identify disturbances with take distances from the scientific paper; here they are not only mines, but all the built fabric.

From land use layer it is possible to extract only particular polygons or those areas which are classified as urban areas.

Essentially the second level of classification is determined by a doble digit code, where the first one represent the first level membership (urban areas, agricultural field…), while the second one goes deeper in the classification such as residential areas, roads, industries and so on.

In this case all the codes with first digit 1, apart from code 14 (urban green areas), are selected and exported.

The second passage it to provide the distance matrix.

With multi-buffer plug in, it has been possible to provide multiple buffers from a layer using a prefixed distance, in this case 50m.

Thank to this, it has guaranteed to simulate a real distance matrix.

The next step is to cut this last layer with site boundaries in order to eliminate unnecessary polygons.

The final layer is computed as the others by its rasterization and calculations with raster calculator.

Disturbances in this territory are fragmented and their density changes. The most critical areas are the one of Ravenna, caused by harbour, and near Apennines in SW where there are some important towns.

This is not a high urbanized territory, but the fragmentation of disturbances can cause different problems all over the territory in term of loss of resilience.

The last layer is another distance matrix, but, in this case, from ecological sources.

The process is the same, apart from two differences.

The first is the selection of ecological sources from land use, here codes 3 and 5 (woods and forest and wetlands) have been chosen and not code 1.

The second is related to the addiction of a step before the reclass of normalized values.

If in the previous matrix values near 1 are considered positive because distant from disturbances, here is the opposite, de fact, the higher the distance, the worse the value.

Areas nearer ecological sources are positively affected then distant areas.

To convert values a simple formula has been used to obtain the "negative" value of the single cell.

Opposite to the disturbances, ecological sources are located in few areas, mostly near coast.

Their positive influence is limited.

Matrixes have been generated to understand what areas are positively and negatively affected by disturbances and ecological sources.

Obviously, this kind of influence cannot be applied to an area which is located to much distant from the source, so three different scenarios, with different limits (no limit, 2km and 5km) are considered and applied to the final map of resilience to observe changes (*figure 21*).

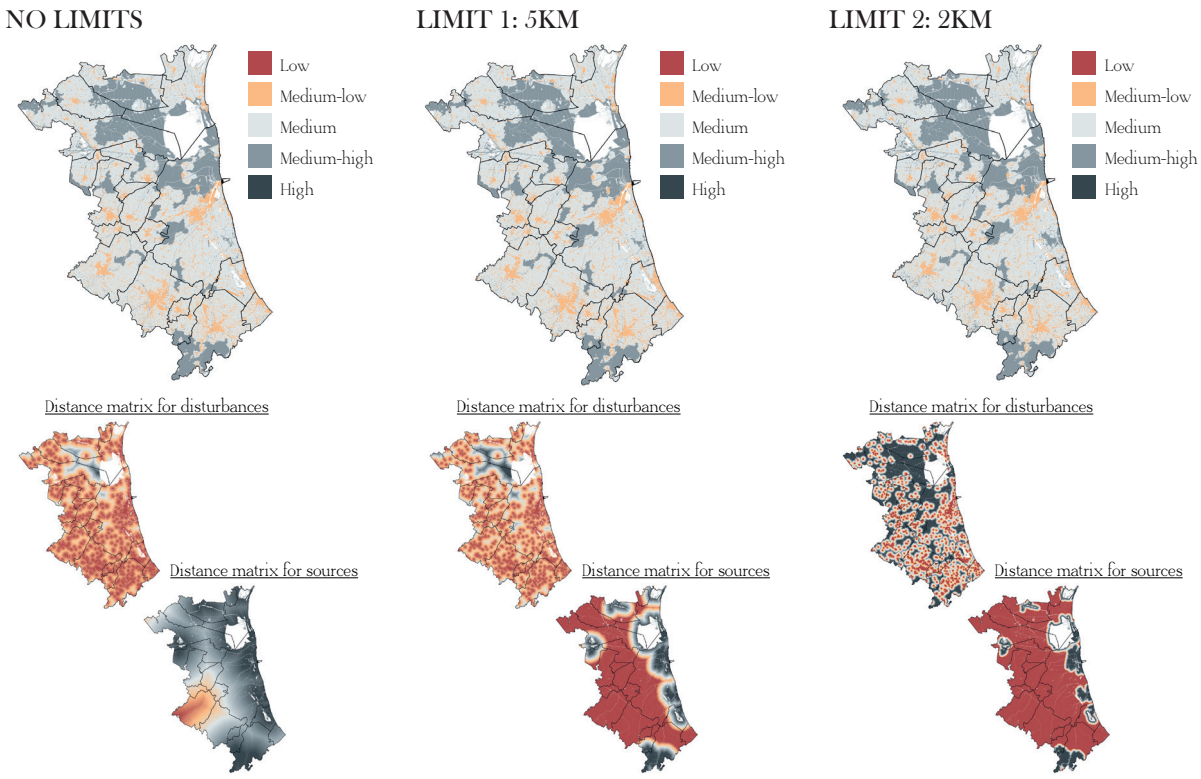


Figure 21: Resilience variation according to different limitations of distance matrixes

The limit represents the distance beyond which there is no influence.

For the main resilience map 2km limit has been chosen.

At this point all the layers are prepared for the final calculation of the resilience value.

The way to do it is the average value between them, but is not the mathematical mean, it is the weighted one, it means that each layer has a specific weight.

Weights are taken from the paper [32]:

» Path density = 0,2142;

» Biopotentiality = 0,3255;

» NDVI = 0,1368;

» Slope = 0,0735;

» Distance matrix from disturbances = 0,1250;

» Distance matrix from ecological sources = 0,1250.

All the elements are ready to computed to generated the final maps by the use of the following formula

"[(patchdensity*0,2142)+(biopotentiality*0,3255)+(NDVI*0,1368)+(slope*0,0735)+(disturbancematrix*0,1250)+(ecological sources matrix*0,1250)]/6"

All the final layers are grouped in the figure 22.

RESULTS DESCRIPTION

The territorial resilience goes from medium-low to medium-high.

Observing the map, there is a big medium-high area, which covers the NO zone of Valli di Comacchio (it was the ancient wetland replaced with agricultural fields).

Urban centre affects differently surrounding, this can observe for the area of Ravenna and it harbour.

The site is characterized by two ecological sources, Pialassa Baiona and Pialassa dei Piomboni separated by the harbour. Pialassa Baiona, in the North, has a medium-high value of resilience, while Pialassa dei Piomboni, in the South, has a medium one.

The reason can be attributed to their intrinsic characteristics, like dimension, water quality, anthropic use and so on.

According to all of this, the resilience analysis is important to understand weaknesses and the way in which operate to solve them increasing territorial resilience.

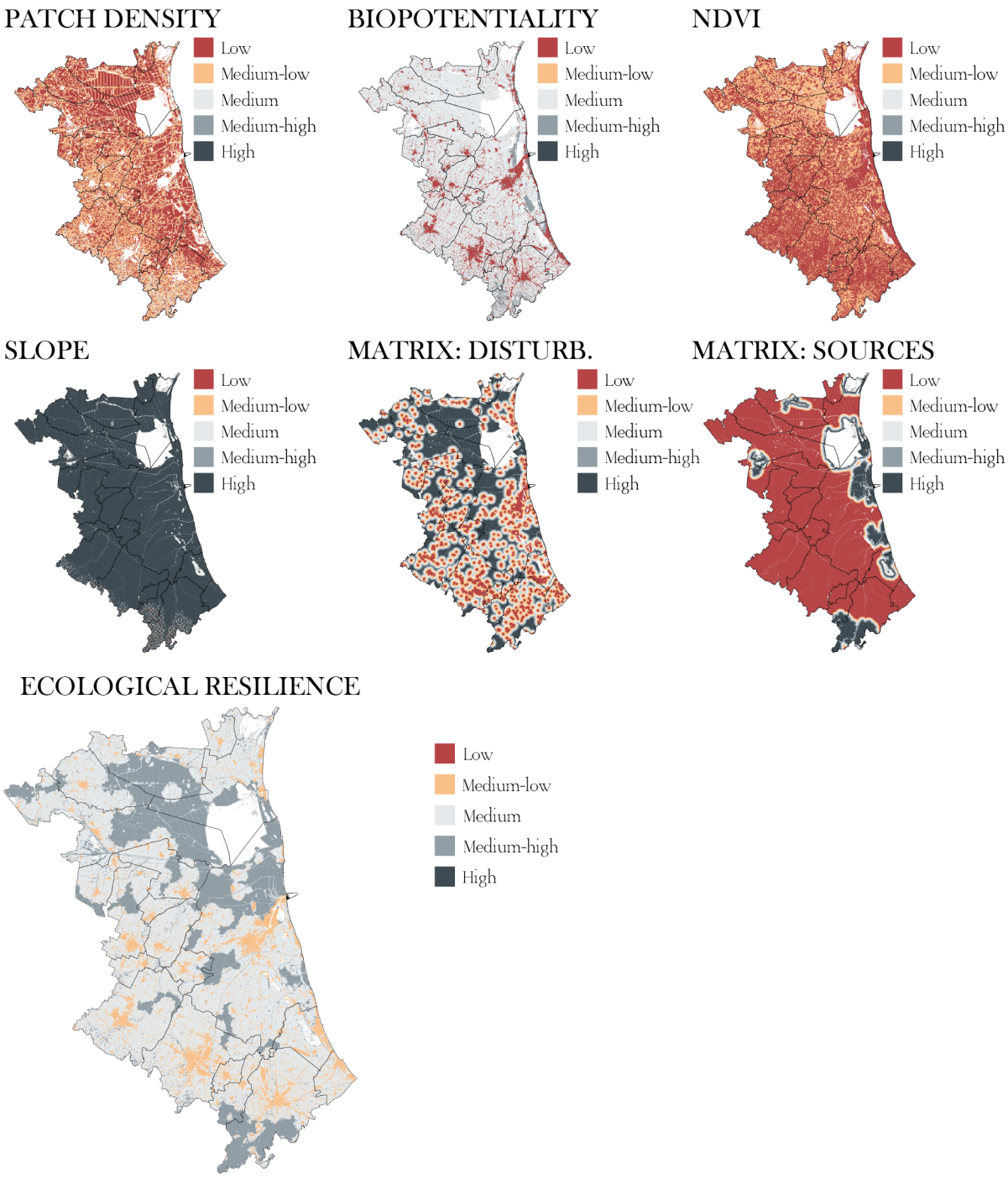


Figure 22: Land ecological resilience inputs and final result

3.1.6. TERRITORIAL ANALYSIS: WATER QUALITY

As said in the previous paragraph, resilience has been analysed only for land.

Now it is time to analyse water quality relative to surface water bodies.

Water quality is one of the most important factors in a healthy ecosystem.

Clean water supports a diversity of plants and wildlife and provides fresh water for people.

This analysis is performed with the use of ESA Snap software, which is a common platform,

funded by ESA (European Space Agency), which contains toolboxes for various Sentinel data and other Earth Observation data processing tools.

Thus, the images used for this kind of computation belongs to Sentinel-2 (.DIM file) and Sentinel-5 (.NC file) satellites.

These data are used to process the C2RCC model (Case-2 Regional CoastColour) following the instruction from an ESA training webinar [59].

The model works with water colour, which is determined by substances in the water.

Measuring the water colour allows a retrieval of the water quality.

Eutrophic waters appear green, while sediment loaded waters get a brown colour.

Highly sensitive multispectral cameras, deployed on satellites, allow a quantification of such water constituents from space, at global scale.

For this study three parameters are used:

» TSM (Total Suspended Matter) which is a parameter used in water quality management and purification. Indicates the quantity of solids present in suspension and which can be separated by energetic mechanical means such as vacuum filtration or centrifugation of a liquid sample;

» CDOM (Coloured/Chromophoric Dissolved Organic Matter), is a naturally occurring dissolved matter that absorbs UV light in water. It's usually made up of tannins that are released from the breakdown of plant material;

» Chl-a (Chlorophyll a) is a measure of the amount of algae growing in a waterbody. It can be used to classify the trophic condition of a waterbody. One of the symptoms of degraded water quality condition is the increase of algae biomass as measured by the concentration of chlorophyll a [58].

The process to obtain the final map is quite complex and it have required the use of ESA Snap and Qgis software.

For like NDVI, the three water parameters change during the year according to seasonality, so for a good assessment 12 images (one for each month of the year) have been download from ESA hub website.

The workflow consists in the application of the model inside ESA Snap and then post produce results inside Qgis to assess the final map.

Satellite images require a pre process to be ready for usage, it is characterized by, firstly, their resampling and then by delimiting or cutting images to site areas to simplify computations.

This step has been done with graph builder which help to write a multi-step process.

The model requires some input data, which are strictly related to the day of the year of images.

Input data are:

» Salinity (PSU);

» Temperature (°C);

» Ozone (DU);

» Air pressure at sea level (hPA);

» Elevation (m).

Salinity and elevation have been taken as constant, so same values for all the images.

Temperature and air pressure are related to the day of the image and they have been consulted on climatic website [47].

Ozone value, measured in Dobson unit (DU) must be obtained from another kind of image, which derive from Sentinel-5 products.

The Sentinel-5 mission focuses on monitoring of trace gas concentrations and aerosols in the atmosphere to support operational services covering air-quality near-real time applications, air-quality protocol monitoring and climate protocol monitoring.

For this reason, inside S-5P OPS webpage of ESA website, 12 images related to the same day, month and year of Sentinel-2 ones are downloaded and imported in ESA Snap as NetCDf-CF files.

Even in this case a pre process is done to prepare images and after that, the band related to the quantification of ozone can be exported as a raster.

The model requires a number for ozone input, so there is the need to calculate the mean value of it on the whole territory considered, by applying raster statistics inside Qgis.

This process has been made for all the 12 images and now the C2RCC model can be applied.

The model provides a new file with several bands, but only three are important for this water quality assessment:

» Absorption coefficient of Gelbstoff at 443nm (iob-agelb) for CDOM;

» Concentration of TSM (conc-TSM) for TSM;

» Chl-a concentration(conc-chla) for Chl-a.

At this point there are 3 rasters (one for each parameter) related to each day of the year considered, so 36 in total.

Now, to assess annual value for them there is the need to provide the average and then classify results to understand the meaning of them

For the single parameter map the reclassification process considers different classes for the

single parameter.

For TSM classification has been fallen a scientific document [7], for Chl-a classification another scientific paper has been considered [44] and, also, a paper for CDOM has been followed [9].

Classification can be seen in figure 23.

TSM RANGE	CLASS	CDOM RANGE	CLASS	CHL-A RANGE	CLASS
0 - 25	Low	0 - 0,2	Low	<3	Low
25 - 50	Medium-low	0,2 - 0,4	Medium-low	3 - 6	Medium-low
51 - 75	Medium	0,4 - 0,6	Medium	6 - 10	Medium
76 - 100	Medium-high	0,6 - 0,8	Medium-high	10 - 25	Medium-high
101 - 125	High	0,8 - 1	High	>25	High

Figure 23: Ranges and relative classes of quality forsingle parameter of water quality

After obtaining single parameter assessment is the time to provide water quality map by computing these ones together.

Since they have classified with three different unit measures they cannot be used without a previous normalization of they values.

After that the average value between them has been done using raster calculator.

The next passage is the reclassification of normalized value, because low values means good water quality and vice-versa, so using the formula "1-cell value" is it possible to obtain the right classification.

Finally, is possible to reclass values and obtain the final map shown in figure 24.

Final maps shows pixel effect.

To mitigate this problem SAGA GIS has been used with the application of majority filter thank to this is possible to attenuate the problem.

TSM map is the only parameter which have good values.

Chl-a has low and medium-low values in the wetlands, this can be caused by the high presence of suspended micro-algae which generate an over production of this kind of chlorophyl.

This fact can provide a eutrophication of water generating problems for existing biodiversity.

CDOM is the worst parameter, not only wetlands but also offshore areas are affected by an over production of CDOM.

Inland CDOM can be explained by the emission from agricultural and industrial activities, whi-

le offshore ones by the gas extraction platform.

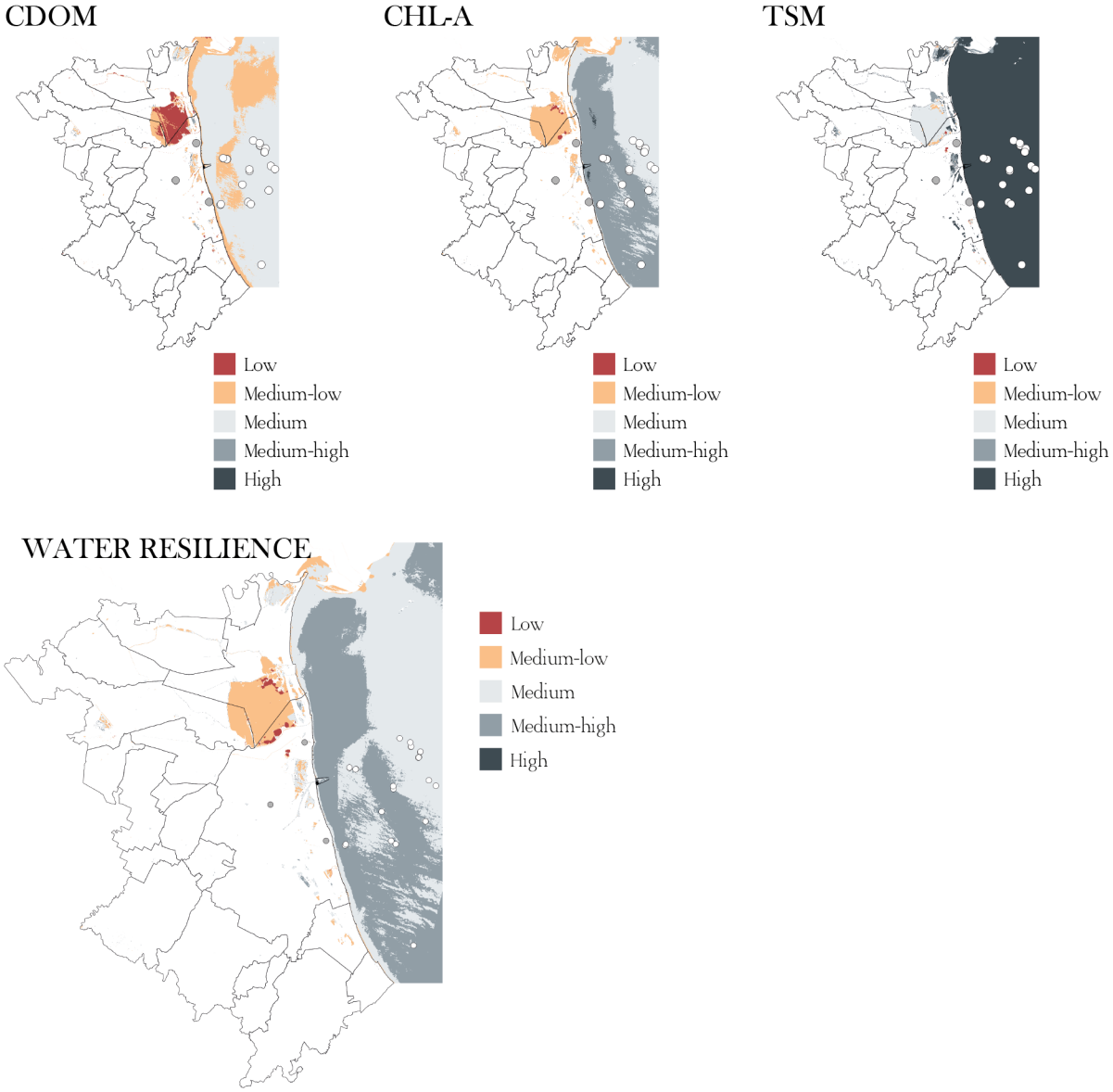


Figure 24: Surface water quality indexes and final reult maps

To better understand these dynamics is useful to produce seasonal maps for the single parameter, using the same process for single parameter annual value but dividing mean values for seasons (*figure 25*).

The worst period is summer, where there is the highest emission of all the parameters in wetlands.

TSM has only bad values for wetlands in summer.

CDOM provides medium-low values in winter and autumn for both inland and offshore.

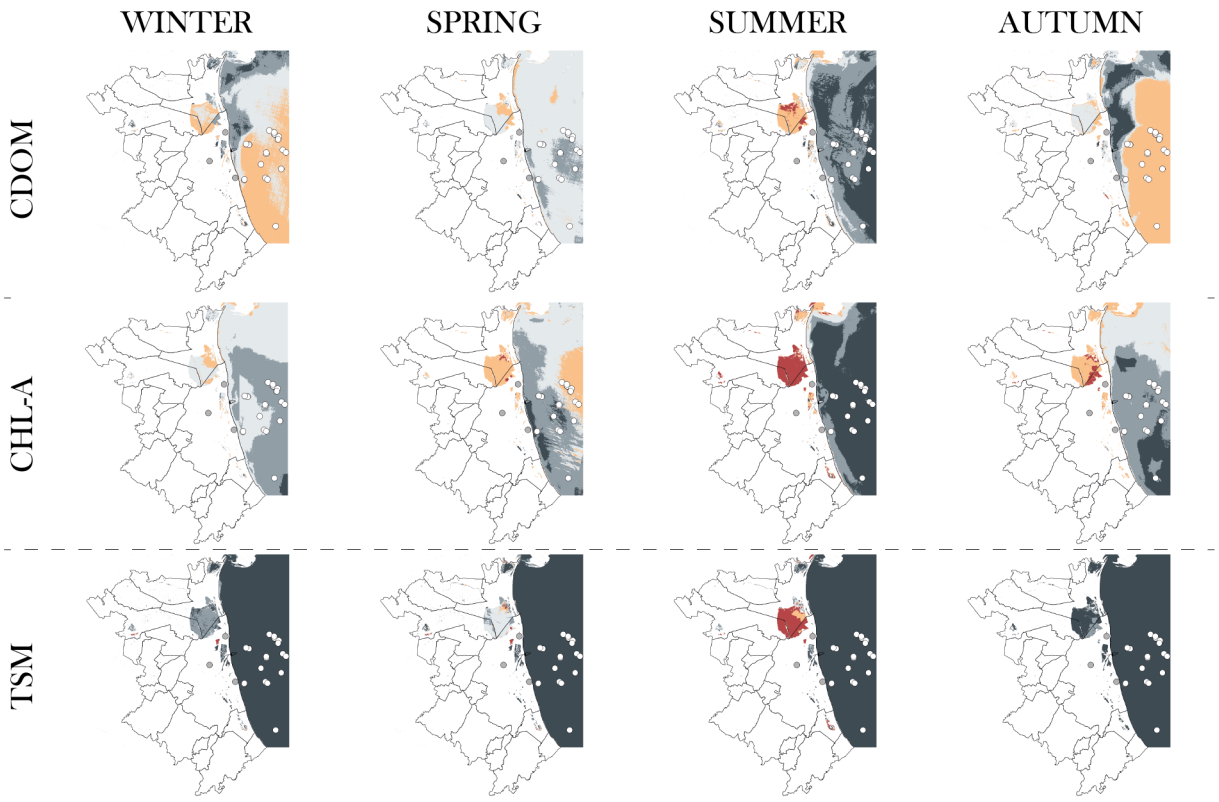


Figure 25: Seasonal inputs variation

3.1.7. TERRITORIAL ANALYSIS: ECOLOGICAL QUALITY

DESCRIPTIVE INTRODUCION

The following analysis belongs to landscape ecology principles.

The ecosystemic analysis is based on ecological indicators and analytical-descriptive methods, already present in the literature and able to highlight the level of ecosystemic balance of a given territory and the level of territorial fragmentation.

The process adopted for the definition of ecological quality follows an already existing work [56].

One of the most used tools to analyse the state of environmental health of a given area and able to return a graphic model that schematically represents the level of ecological connection of a given territory, is the Ecological Graph. It is based on the definition of the environmental system as *"combination of landscape units different in terms of structure and functions, characterized by different degrees of connection and correlated by energy exchanges, with rapid evolutionary processes"* [17].

This model can be represented by a graph consisting of nodes (landscape units), links (energy and material exchanges) and a set of rules governing the relationships between nodes and links. Landscape units are defined as portions of natural landscape consisting of different biotopes

identified and delimited by elements of the anthropic network (roads, railways, settlements) that overlapping the natural network affects it and divides it into units.

While within the individual landscape units the circulation of matter and energy is not hindered by the presence of significant barriers, the circulation between the various units is instead strongly conditioned by the elements of the anthropic network which produce a barrier effect whose greater or lesser permeability depends on the type and configuration characteristics of the ecotone elements.

The evaluation and quantification of territorial dynamics make use of the use of a series of control indices that allow in the first instance to measure the level of organization of the environmental system in question: bioenergy (Mcal/year) and connectivity.

The first is not given by the simple energy developed by the eco-mosaic tile, i.e. the biopotentiality, but also takes into account the ecological specificity; connectivity, on the other hand, represents the dynamic part of the system and estimates the amount of functional exchanges possible between sectors.

In order to assess the level of bioenergy, a formula is required:

$$\text{“}BEj = (BTCmedia * Area)j * (1+k) = Bj * (1+k)\text{”}$$

where:

» Bj (territorial biopontetiality) is the ability of a system to maintain itself in a given biological equilibrium and can be calculated by the weighted average value of the surfaces of eco-patches (land uses) for their specific BTC value;

» K is a synthetic structural index defined by 3 parameters: kf (shape coefficient), kd (permeability coefficient) and kp (Shannon coefficient);

At the same way, the formula to asses fluxes and exchanges among landscape units is:

$$\text{“}Fij = [(BEi + BEj)/2] \,.\, [Lij/(Pi+Pj)] \,.\, p\text{”}$$

where:

» BEi and BEj correspond to the level of bioenergy of landscape units I and j;

» Pi + Pj is the perimeter of adjacent units;

» Lij corresponds to the contact perimeter of units I and j;

» P is the permeability coefficient of the border which separates the two units, it ranges from

0 (highway) to 1 (fluvial border).

The analysis is divided in assessing bioenergy values for dingle sector, fluxes and exchanges among adjacent ones and ecological quality as the medium value of 10 parameters.

DATA COMPUTATION: BIOENERGY AND FLUXES

The first step is to identify landscape units.

As said before landscape units are patches separated by anthropic traces and natural network.

Provincial, statal roads, highways, railways and main rivers are considered the network to be used as unit borders. Road systems and railways have been drawn manually, after the creation of a new linear layer, using OpenStreetMap as base map. After merging all layers, units can be generated by cutting the site with these lines.

Some mistakes can occur, there are some infinitesimal holes between polygons and they would create problems, so they must be filled.

This part regards the creation of a new layer which covers the entire site and with the unification of the site itself, it is possible to generate polygons related to holes.

After the selection of these polygons by observing their area (it is almost nil), it is possible to merge them with one of the adjacent sector according to some rules (in this case it has been decide to aggregate it with the biggest adjacent polygon).

Next compute the area of the single sector and then associate to each sector a specific identification number.

Now 217 landscape units are ready.

The formula used requires calculating some indexes and parameters.

Each of them have been measured separately in different ways and finally unified with tabular join with sectors.

Attribute table will be characterized by several fields, one for single parameter and indexes so that it is possible to apply the formula using the field calculator.

The first parameter is BTC values, which are already assigned.

This step has been done for ecological resilience.

Sequent index is territorial biopotentiality or Bj, which is computed unifying sectors and BTC values and then working with attribute table assessing areas and areas weighted with BTC values (to each polygon has been multiplied the relative value of biopotentiality).

Average values of weighted BTC for single sector is calculated using group stats plug in, which generates a .csv file.

After the correction inside Libre office the table has been joined with sectors and Bj can be

measured by dividing this last value with sector area.

The second index to assess is k defined by the sum of three parameters (kf, kp and kd)

Each single parameter must be calculated separately.

Kf is assessed with the formula: "1- (PCj/Pj)", where PCj represents the perimeter of the circle, expressed in meters, having an area equal to that of sector j, while Pj, is the perimeter, expressed in meters, of sector j. Two new fields are created inside landscape units or sectors layer, one measures the perimeter of single unit (Pj) and the other is filled with the formula to assess PCj ("2π x √[(unit area)/π])".

Kf can be measured with the formula shown above.

The second parameter is Kp, calculated following the formula:

$$\text{“}kp = [\Sigma (Lij * p)] / Pj\text{”}$$

where the numerator is calculated by summing the length of the barriers that separate the sector from the others by the permeability coefficient "p" of each element of the barriers.

To obtain the numerator, the method is a sequential and use some Qgis and Arcmap tools to separate every side of each sector and finally assess length weighted with permeability values, taken from the book "Paesaggio, Pianificazione, Sostenibilità" (Fabbri P., Alinea Editrice, Firenze 2003) and shown in figure 26.

TYPE	VALUE
Highway	0,1
Provincial road	0,2
Railways	0,5
Natural rivers	1

Figure 26: Permeability values for infrastructural type

At this time the numerator can be calculated using group stats.

Import the new table, join it with landscape unit layer (polygons) and then apply the kf formula.

The last parameter is kd which is computed by the following formula:

$$\text{“}kd=[\Sigma (ni/n)\log10(ni/n)]/\log10(1/5)\text{”}$$

The number of elements with BTC = 0 are divided by the total number of elements present in each sector by the logarithm of the same ratio are calculated in the numerator, added to the same ratio for the other classes of BTC, (1,5, 2,5, 3,5 and 5).
The logarithm of 1 divided by the total number of classes of BTC is calculated instead.
Using group stats is possible to count the number of BTC polygons for each unit filtering results according to single biopotentiality value (0/2,5/3,5/5) and total count.
After the tabular join with landscape units, it is possible to apply kd formula :

"[(BTC0/BTC)*log10(BTC0/BTC) + (BTC2,5/BTC)*log10(BTC2,5/BTC) + "(BTC3,5/BTC)*log10(BTC3,5/BTC) + "(BTC5/BTC)*log10(BTC5/BTC)]/log10(1/5)"

Finally, all the parameters are ready and they can be summed to assess k index.
The second part of the analysis deals with fluxes measurement, here the workflow is quite complex due to the several passages and steps to be done.
At now bioenergy is characterized by a point relative to single sector, the task is to generate a line that connect two points which represent two adjacent sectors.
The creation of this linear layer has been done using Qgis, ArcMap and Excel.
With the distance matrix tool inside Qgis is it possible to generate lines from points (centroids of units), but the tool provides all connection possible, not only among adjacent ones.
The next step is to eliminate all useless associations from the matrix.
A particular query creates a field inside the attribute table filled with all the codes relative to adjacent units of target one.
Following the query:

"aggregate (layer:= 'landscape unit', aggregate:= 'concatenate', expression:= 'ID', concatenator:= ',', filter:=intersects($geometry, geometry(@parent)))"

A new field is generated and populated with all the adjacent units ID (e.g. 1, 3, 70, 112…).
Written like this they are useless, so the step is to create a field for single adjacent unit using Excel separating the single field in as many as there are adjacent units.
These fields are called "NEAR1", "NEAR2", "NEAR3"…
Import inside QGIS and tabular join with landscape units layer. At this point is it possible to eli-

minate all the useless associations by giving code 1 for right associations and code 0 for wrong one using “CASE WHEN…” query:

“CASE WHEN target=NEAR1 THEN 1 WHEN target=NEAR2 THEN 1… ELSE 0 END”

When the machine finds that the target related to a specific ID is equal to a “NEAR” unit it fills the new field with code 1, it means that that target is an adjacent to that ID, otherwise it gives 0. Selecting all the 0 values it is possible to eliminate non-adjacent targets.

At this moment every single element is defined by an input and a target, respectively two adjacent sectors.

To do this there is the need to provide coordinates (X and Y) for each input and target.

X and Y can be found and measured with simple formulas inside field calculator (“$x” and “$y”).

Now, double tabular join with the distance matrix table, one for input and one for target.

Each input/target as coordinates for both start and end stroke.

To draw a line between the input and relative target has been done with “XY to line” tool (ArcMap).

Lines are ready but they are empty, such as a white sheet.

All the parameters used for the formula require to be associated to this layer.

BEi and BEj have been already calculated.

For Fij the process is longer.

The layer which has measured the length of each unit side multiplied for permeability coefficient is already present, the problem is to associate for the single side the relative association input/target.

To do this, it is important to create a buffer along all the lines, so that the new polygons fall, contemporaneously, on both adjacent units.

Then, unifying these layers it is possible to provide the unification of both input and target ID to the same element.

Useless rows can be eliminated, such as the ones which have ID field=-1, ID_1= 0 and ID=ID_1 (if ID and ID_1 are the same, it means that input and target are the same, so they have to be eliminated).

The final problem is to find a way to associate this attribute table to the one of linear layer.

The solution is to create a field which unify input and target and use it as primary and secon-

dary key for the tabular join (the process of fields unification has been done in Excel with this formula:

"CONCATANATE("ID"; "_"; "ID_1")"

Now Fij can be calculated and normalized as for bioenergy part.

Fluxes are graphically represented by lines with different thickness, the higher the thickness the higher the fluxes.

The overall value of each individual unit is expressed both by the bioenergy value of the unit itself (allocated resources), and by the possibility of exchange with neighbouring units.

This value is expressed by the formula "VUPi = BEj (∑ Fij1 + Fij2 + .. + Fijn) log N".

The process is the following:

Using tabular join and group stats plug in it has been possible to assess the VUPi value for each sector.

RESULTS DESCRIPTION

The final map of bioenergy and fluxes provide a complex situation (figure 27).

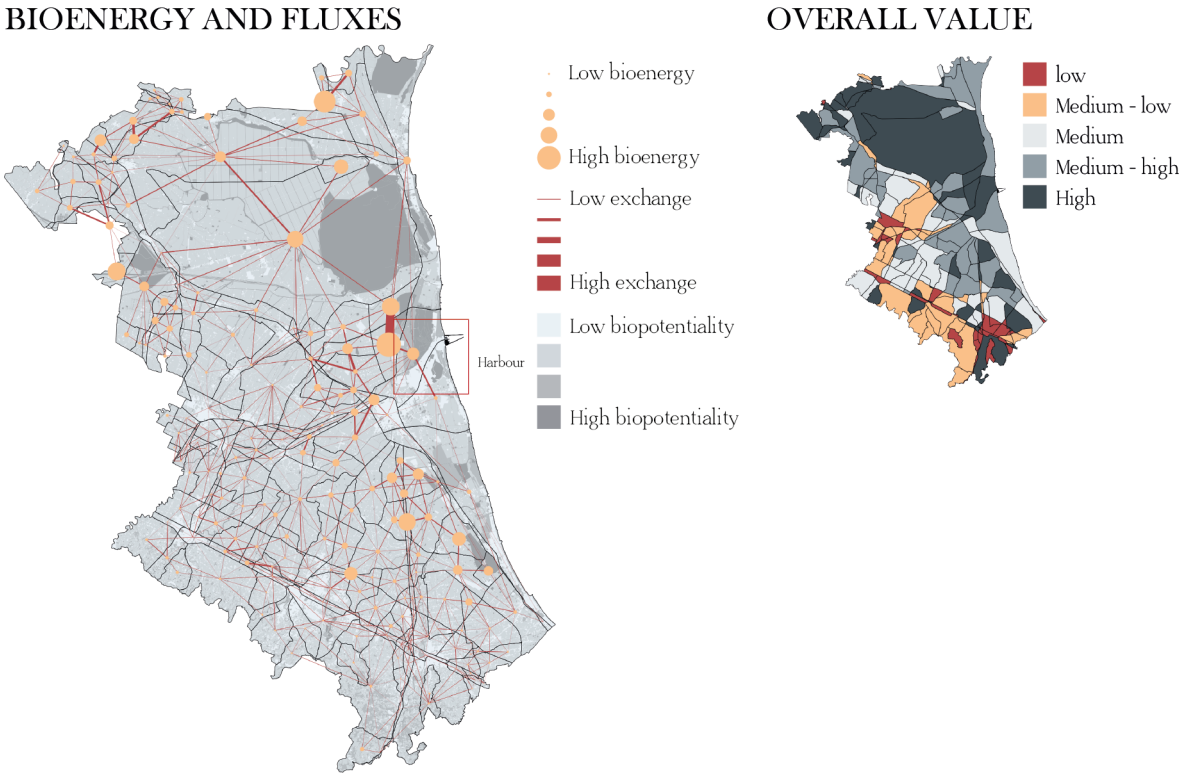


Figure 27: Bioenergy and fluxes map with VUPi result

Level of bioenergy are high in specific location, the main one is related to Pineta San Vitale, near Pialassa Baiona.

Essentially these high values are associated to the presence of high naturalistic area in the landscape unit.

Fluxes in the area shows a negative trend, only few of them can be considered good, like the one of Pineta San Vitale.

The worst situation is located in the agricultural area in the south where both bioenergy level and fluxes are very low.

This is caused by the presence of agricultural activities and fluxes are affected by the presence of highways and the complex system of provincial roads.

Values are affected by different indicators, like the sector area, shape and length of the perimeter, the kind of perimeter (is it is a highway, river, railway...) the contact perimeter between two adjacent sector and so on.

DATA COMPUTATION: ECOLOGICAL QUALITY

Ecological analysis is not finished yet, the next phase is to provide information relating to the environmental system analyzed to define and evaluate the starting ecological structure.

For this purpose, the data relating to the analyzed territory are collected and standardized through an assessment of ecological quality capable of outlining the initial ecological structure and providing the ecological value of the individual sectors.

The latter is constructed considering the applied ecological indices and the aspects concerning the structure and intrinsic functions of the sectors and their relationship with the environmental mosaic.

To evaluate the territory from an ecological point of view, each sector has been analyzed under 10 parameters.

For each one has been given a score between 0 and 1; each zone was judged for each attribute not in an absolute way, but in relation to the other zones, so that the maximum score was attributed to the zone that, compared to the others, has the best conditions in that parameter.

The judgment, therefore, does not represent an absolute value of the quality of the sectors, but a value referring to the precise conditions in which the territorial reality studied finds itself.

The parameters are taken from the source, but modified according to available data:

» Disturbances;

» Functional coherence;

» Level of urbanization;

» Sector health state;

» Infrastructures;

» Naturalistic interest;
» REC (Municipal Ecological Network) presence;
» River banks quality;
» Underwater quality;
» Eco-fabric location.

The first five of indicators deals with the analysis of land use and anthropogenic characteristic of the sectors.

The second part of indicators deals with environmental characteristic of the sectors (water, natural areas...).

For each indicator, a specific process for the evaluation has been done.

For disturbances, land use classification at the second level has been considered.

Values are assigned considering the type of land use and their rate with landscape unit dimension, values are classified in the following figure 28.

DESCRIPTION	VALUE
If a sector has areas classified with code 131 (caves) and 132 (landfills)	0
If the cover % of code 134 is higher (degraded areas not used and not vegetated) than 40%	0,3
If the highest % is code 2 (agricultural areas)	0,5
If the highest % is code 141 (urban green areas)	0,7
If cover % of code 3 (woods and forests) is higher than 40% and code 4 (wetlands) is higher than 20%	1

Figure 28: Table sectors classification according to disturbances

For the attribution of the value, it has been taken the worst value possible (e.g. if in a sector are present some areas coded ad 131 and the agricultural activities cover 70% the value attributed is 0).

The process to achieve the goal is to unify landscape units layer and land use classification and measure percentage after that assess values.

Disturbances are present all over the territory, de fact there are a lot of sectors with value 0 and few areas without them, like the one relative to Valli di Comacchio and Pialassa Baiona.

The functional coherence of the sector has been assessed on the basis of the elements that compose it and their functional aptitude: too many functions of different types within a single area can lead to a dissipation of energy and materials and to excessive fragmentation internal.

The score was divided as figure 29 shows.

DESCRIPTION	VALUE
If there is a high heterogeneity of land uses	0
If there are more than one prevalence land uses	0,5
If the there is a prevalent land use	1

Figure 29: Table sectors classification according to functional coherence

This topic has been processed according to land use classification at first level.

Functional coherence is very good all over the site due to the high presence of agricultural fields.

The third element is level of urbanization.

Values are attributed according to percentages of urban areas for each unit (*figure 30*).

DESCRIPTION	VALUE
90% < urbanization <= 100%	0,1
80% < urbanization <= 90%	0,2
70% < urbanization <= 80%	0,3
60% < urbanization <= 70%	0,4
50% < urbanization <= 60%	0,5
40% < urbanization <= 50%	0,6
30% < urbanization <= 40%	0,7
20% < urbanization <= 30%	0,8
10% < urbanization <= 20%	0,9
0% < urbanization <= 10%	1

Figure 30: Table sectors classification according to urbanization

Also, the level of urbanization shows good values, indeed urban areas, according to land use analysis, cover a low percentage of the territory; only two sectors have bad values, one is Ravenna center.

The feature four is the sector health state, which has been assessed the level of air pollution considering PM_{10}, $PM_{2,5}$ and O_3, based on normalized weighted values, and the presence of pollution sources (*figire 31*).

For the attribution of the value, it has been taken the worst value possible.

In order to achieve this goal a specific process has been applied:

Raw data are rasters relative to air pollutants.

NORMALIZED WEIGHTED MEAN RANGE	VALUE
0 - 0,1	0,1
0,1 - 0,2	0,2
0,2 - 0,3	0,3
0,3 - 0,4	0,4
0,4 - 0,5	0,5
0,5 - 0,6	0,6
0,6 - 0,7	0,7
0,7 - 0,8	0,8
0,8 - 0,9	0,9
0,9 - 1	1
If there are the presence of pollution sources (landfills, caves and industries at risk)	0

Figure 31: Table sectors classification according to health state

With raster calculator is possible to all layers and compute the mean value among the three input data.

To obtain the normalized weitghted value there is the need to use group stats, but it works only with vector files.

For this reason each single raster has been vectorized with ArcMap.

Unifying this last one with sector layer it is possible to divide the new polygons (former raster cells) following units borders.

Finally, it is possible to use the plug in to assess the required value and after a second normalization classess can be done

The final map shows some areas with low value, due to the presence of pollutants sources, while the value of whole territory can be considered medium.

The last element for anthropic part is characterized by human infrastructures.

The layer of networks is already present and defines sectors borders (*figure 32*).

DESCRIPTION	VALUE
If a border is a highway	0
If a border is a provincial or statal road	0,5
If the border is a railway	0,7

Figure 32: Table sectors classification according to infrastructural borders

Considering the fact that this site is covered by a complex system of provincial roads, the most present value is medium; the south part of the territory has low values due to highways.

The first element for environmental characteristic is naturalistic interest.

Areas have been classified according to their ecological value and shown in figure 33.

DESCRIPTION	VALUE
0ther areas	0
If there is a presence of code 2 (agricultural fields) areas with a coverage higher than 50%	0,2
If there is a presence of code 141 (urban green areas) areas with a coverage higher than 10%	0,6
Presence of protected areas and woods with a coverage higher than 30%	1

Figure 33: Table sectors classification according to ecological value

The process is the same, unify layers with landscape units layer and then measure areas and percentagess.

From naturalistic interest, obviously, the most diffused value is 0,2 about agriculture.

The second feature is the presence of ecological network for each sector.

The process, as before, is the same.

The values attributed are shown in figure 34.

DESCRIPTION	VALUE
0ther areas	0
If there are corridors in landscape units	0,5
If there are core and buffer zones in landscape units	1

Figure 34: Table sectors classification according to RER presence

As showed in maps, higher values are located in the coastal areas, where wetlands are placed.

Rivers banks quality is the third element.

For this one a descriptive approach has been used; values are attributed considering some factor:

» Vegetation density along the banks and the kind of it (meadows, shrublands, trees…);

» Channelization;

» Shape of the river the kind of meanders, the width of the cross section;

» Consideration both banks;

» The level of urbanization along the banks.

Due to the presence of agricultural canals, most of the territory presents low values due to bad quality of banks.

The second last feature is underwater quality.

Raw data has been characterized by a point layer about chemical status of underwater quality, taken from ARPAE website.

A value is attributed to each point (0= not assessable; 2=good status; 3=medium status; 4=bad status).

To guarantee the right assignment for each unit, there is the need to transform points into polygons.

The first step is to manage values to fit with the scale values (0=0,4; 2=0,8; 3=0,6; 4=0,2), after that, points are transformed into a raster using "IDW interpolation" with ArcMap.

After vectorization, percentage of the single value has been calculated for each unit and then, the weighted value has been computed like previous analysis.

The results show a medium and medium low quality of underwater.

This can be caused, mainly, by agricultural activities, which release chemicals and pollutants in the soil, they are absorbed and reach aquifers.

The last element considered is the eco-fabric location.

The ecological role of the area within the eco-fabric was assessed based on the position compared to other areas functionally related to the one considered.

The river is considered the most important element of the eco-textile, so values are assigned according to rivers position and distances from units.

The first part of the workflow regards to use multi-buffer plug on rivers (buffer width 200m, limit 5km) to correlate landscape units and distances from rivers ("union" tool between these two layers)

subsequently it is necessary to normalize distances by diving all with the highest value, which is 5km.

The final step foresees to calculate the weighted medium distances for each unit by computing areas for the single buffer relative to each unit, multiply them with distance values and then compute weighted values with group stats plug in.

Rivers innervate in the territory like a net and almost all units are characterized by a natural river.

To assess the ecological quality of the different landscape units, the final step is to provide an arithmetic average between all the ten elements considered using field calculator.

The formula applied is:

"(E1+ E2+ E3+ E4+ E5+ E6+ E7+ E8+ E9+ E10)/10"

where E means the element analyzed, like naturalistic interest, level of urbanization etc.

RESULTS DESCRIPTION

Figure 35 shows all the maps and the final assessment.

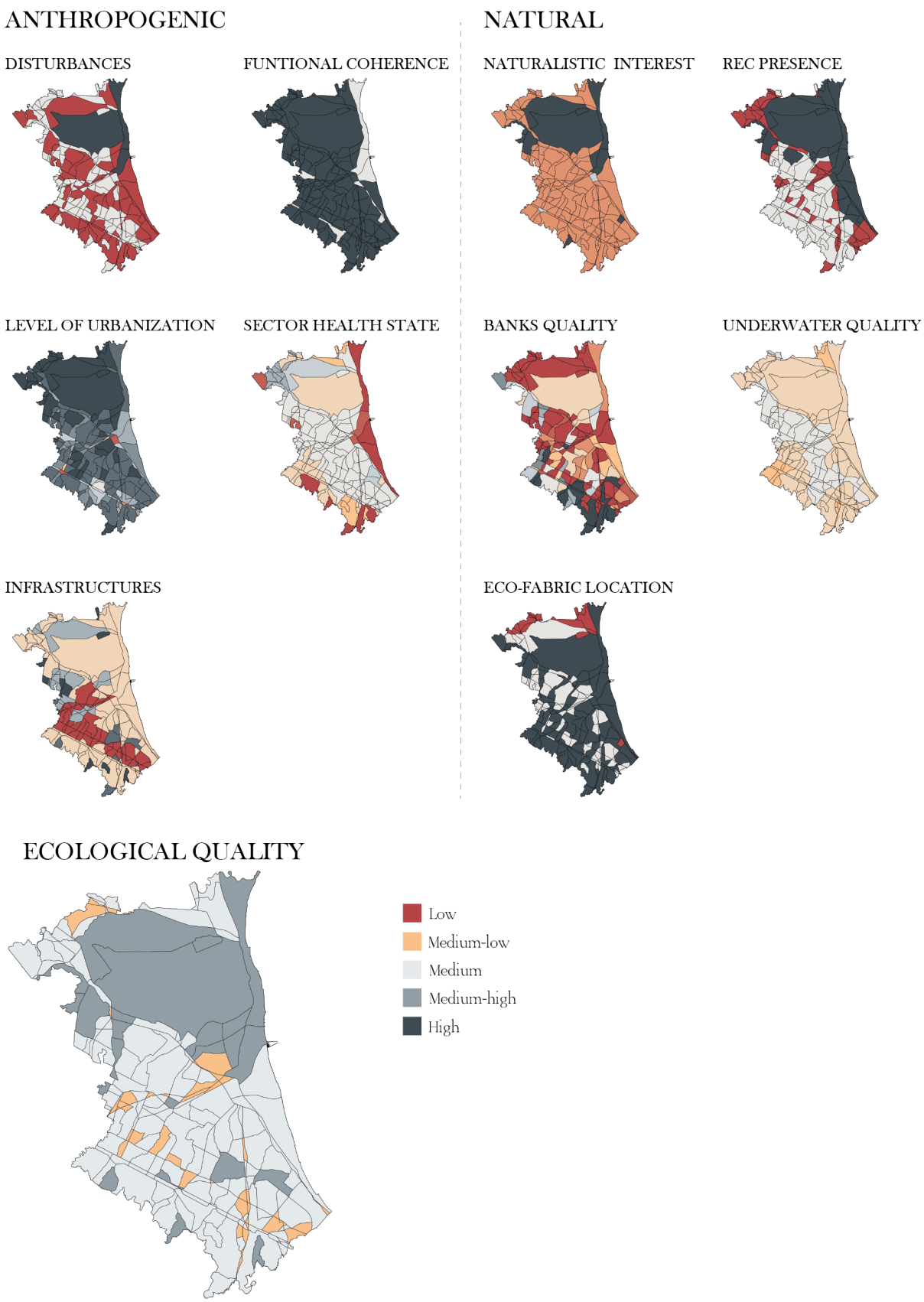


Figure 35: Ecological quality indicators and final result

According to the results, ecological quality ranges from medium-low to medium-high values, but medium-low ones are limited in few areas.

The area of the harbour is characterized by a medium and medium-high ecological quality, thank to the presence of wetland.

The presence of the harbour itself is negatively influencing the southern sector.

This fact is caused by the same reasons written in the resilience analysis, specifically, the intrinsic characteristic of wetlands.

Ecological quality, bioenergy and fluxes assessment allow, through the application of landscape-structural and biological-functional criteria, to identify the elements of the existing ecological system, to understand its possible future scenarios and to be able to offer development guidelines more appropriate to the safeguarding and redevelopment of urban natural areas. Knowledge of the state of health of the territories and their connections is a fundamental condition for guiding redevelopment interventions.

3.1.8. TERRITORIAL ANALYSIS: TOURISM

The next analysis is focused on tourism.

Raw data are divided into georeferenced data and tables for statistical data.

Shapefiles are:

» Hiking trials from geoportal;

» Camper station, touristic events, touristic attractions and beaches are added manually in a new layer, the source has been taken from Emilia-Romagna tourism website.

Statistical tables refer to data from 2016 to 2019 grouped inside the “Rapporto Annuale Turismo in Emilia-Romagna” for regional and provincial data.

Municipality data are taken from “data and periodic elaboration” of tourist section inside regional geoportal.

A first part of tourism analysis comprehends data at territorial and provincial scales, focusing on:

» Mapping different kind of touristic elements;

» Histogram for annual number of tourists at provincial scale;

» Histogram of the ten best municipalities for Emilia-Romagna in terms of annual number of tourists;

» Diagram for seasonal variation at regional scale dividing Italians and foreigners.

The map is a thematic representation of the different touristic elements in the site (*figure 36*).

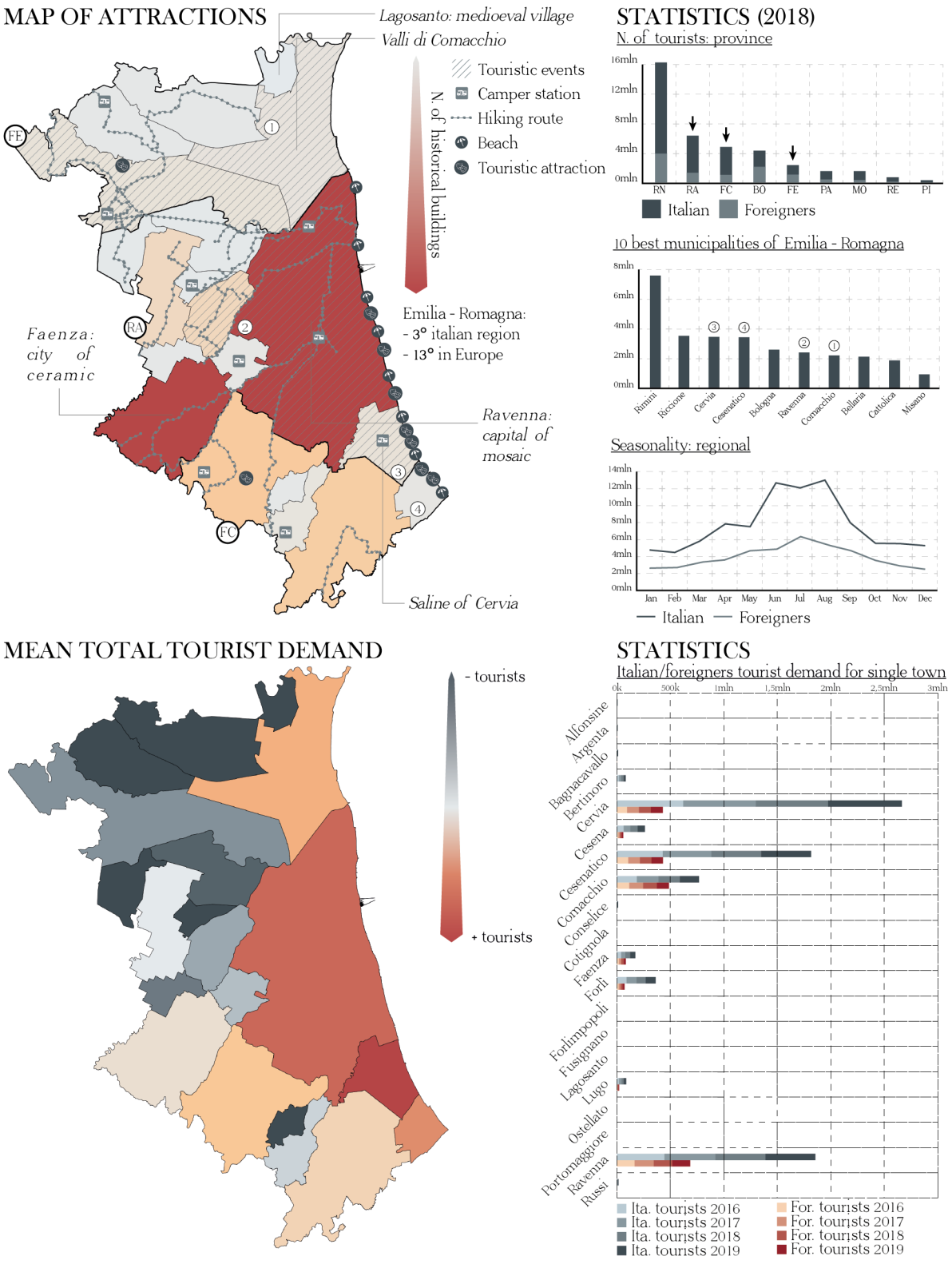


Figure 36: Turism maps and statistics

The territory provide a strong component of tourism, but located in few areas, main attractions are locate along seaside, while culture represents something only in few municipalities (Ravenna and Faenza).

The territory is characterized by some touristic attractors, like Valli di Comacchio, Pialassa Baiona, the medieval villa of Lagosanto, Faenza “the city of mosaic”.
From the naturalistic tourism the territory provides some events in Ravenna, Comacchio and Argenta, while hiking trials cross mostly all the towns.
The province of Ravenna and Forlì-Cesena are respectively the second and third provinces for annual tourists.
Focusing on comparisons between towns, there are four municipalities inside the first 10 city for annual tourists (Cervia, Cesenativo, Ravenna and Comacchio).
Considering the variation of tourists along the year, is it possible to observe the period May-August is the one with high increase of Italian tourists, while foreigners increase gentler.
The second part of the analysis consists in a deeper comparison between municipalities of the site considered.
The map and the histogram are made after an elaboration of the existing data taken from tables.
As said before Cervia is the best location for tourists, while Ravenna is position second.
Focusing on the histogram, differences between Italians and foreigners are shown, also data are divided yearly.
Essentially is it possible to say that the main attractors are coastal towns, although the territory presents several potentialities, both cultural and naturalistic.
Analyse tourism can help to understand people flows in the territory, better understanding their preferences and main attractors.
This information can help to understand in what direction converge the strategy, enhance the existing attractors or provide actions to develop new ones.

3.2. URBAN SCALE ANALYSIS

Territorial scale analysis provides a deep overview of the whole territory according to the different topics considered.
Strengths and weaknesses have been arisen and they will be used as a support for the strategy phase.
Something has needed a specific attention: Ravenna and the harbour.
Looking at the final maps, the town of Ravenna results a centrality both positively and negatively.
It is the main city of the homonymous province, it is an important historical centre (capital of

mosaic), touristic attraction and economical hub due to the harbour.

This last one plays also a very impacting affection to the surroundings; de fact represents a barrier to the ecological continuity of protected areas.

For these reasons, a second scale analysis has been developed at urban scale focusing on it.

Deeper analysis can show new element which will help for the design phase.

Topic treated are the sequent:

» Land use and comparisons;
» Risk and pollution;
» Ecological comparison;
» Anthropic threats;
» Vegetation and avifauna;
» Tourism;
» History and culture;
» The harbour.

Deeper analysis at urban scale and comparisons with the territorial one provides a better knowledge of this parcel of site.

Multiscalarity approach is necessary in order to provide more detailed information, which cannot be showd and studied at territorial scale.

Territorial analysis is useful to obtain data and guarantee the definition of guidelines and general actions, but to provide design proposals there is the need to focus the attention on a smaller portion of the site introducing different analysis.

They support the outline of weaknesses or potentialities in well defined areas, that areas designated for designs.

Design works with spaces, so they need to be defined with a certain level of details and specific scales can do it.

3.2.1. URBAN ANALYSIS: LAND USE COMPARISON

The first analysis at urban scale is, as territorial one, land use.

In this case, it has been gone deeper by providing a comparison between the two scales and observe if the trends are similar.

The process to obtain data is the same, the only difference is about the site borders.

For the territorial analysis, the selections from municipals borders have been considered diffe-

rent towns, now only Ravenna city has been selected and use as the base for every cut for all the analysis.

After that, using Excel, comparison histograms have been done, they can be read in two ways: comparison between territorial and urban scale at the same time series or among all the times series according to Ravenna.

The time chose are 1953, 1994, 2008 and 2017.

Ravenna follows the same changes as the whole territory, although with few differences:

» Urban areas increased higher inside Ravenna than all the site, but there is only 2% of difference at the existing situation;

» At the starting time Ravenna has more agricultural, but from the second time the trends changed;

» The most important changes is relative to wetlands, histograms shows that the whole territory have lost more wetlands than Ravenna, looking at first territorial analysis maps is it possible to observe where this lost happened: at Valli di Comacchio;

» Ravenna has a bigger presence of forests, in this case pinewoods, than the whole territory, also, there was a little process of "afforestation" can be observed from 1994 (5,4%) to 2008 (6,2%), with an increase of 0,8%.

The second part of land use analysis is the provisioning of a thematic maps representing the third level of land use classification (*figure 37*).

This kind of map shows deeper information about the kind of crops cultivated, the kind of forests present and the kind of urban areas.

This last one presents a "strange" data, residential tissue covers smaller area than service one.

This can be caused by the fact that Ravenna is a touristic city, so services are the most important urban requirements.

Also, if agriculture rules over all the other land uses, inside them there is a kind of cultivation which rules over the others: arable lands.

"Land affected by crops herbaceous plants subject to rotation or monoculture (excluding permanent meadows and pastures), as well as fallow land. The land of the specialized horticultural and flower companies are not included" (Corine Land Cover).

This class has been characterized by a surface occupied by almost 80% annual crops with fields bordered by ditches or channels mostly devoid of vegetation.

Apart from arable lands the other crops present are orchards with a coverage of 6,9%, the class called "cultural systems", ("mosaic of plots that cannot be mapped individually with various

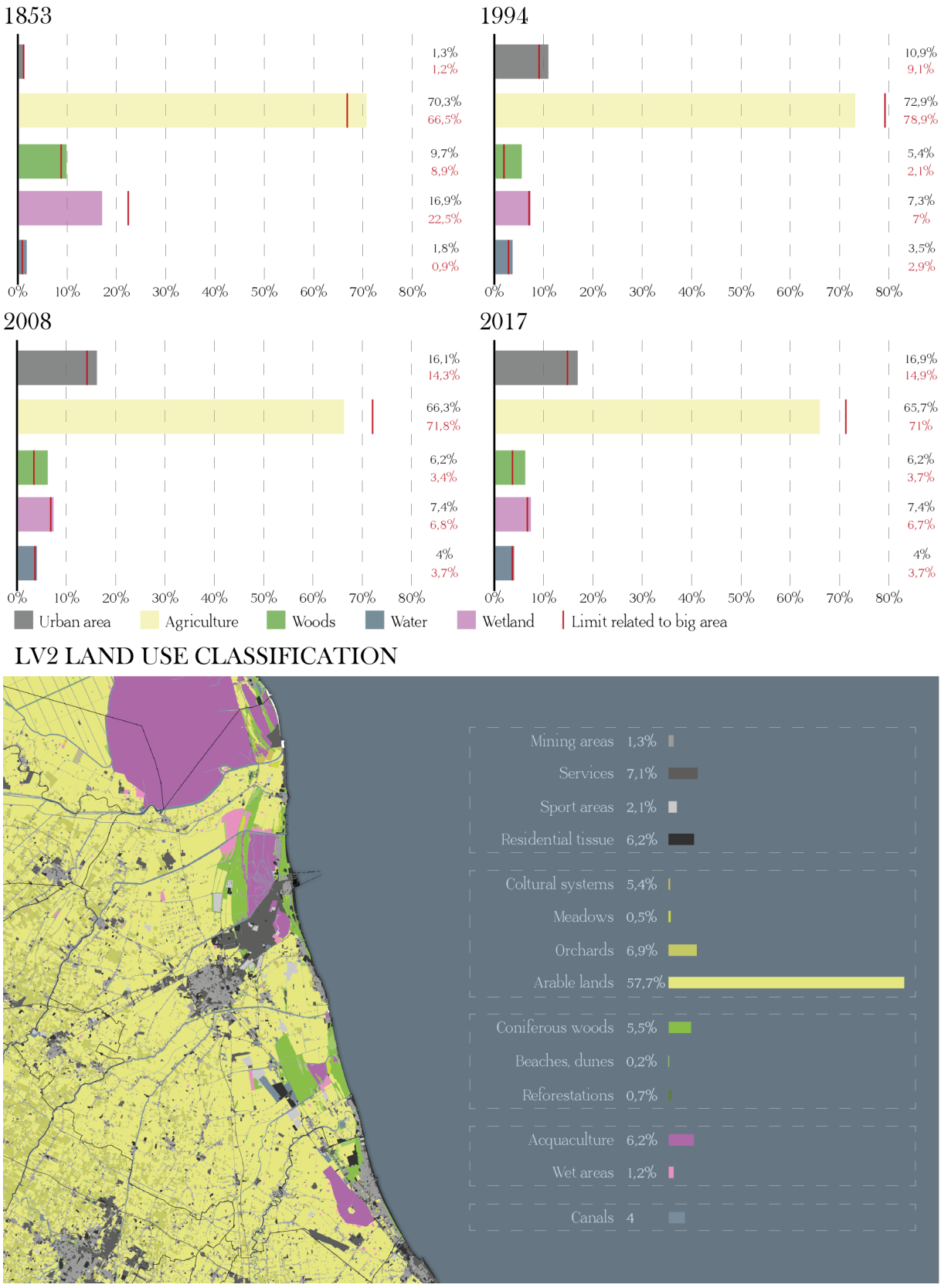


Figure 37: Land use comparison between territorial and urban scale; land use classification at second level

temporary crops, stable lawns and permanent crops, each occupying less than 75% of the total area" - Corine Land Cover.) with a coverage of 5,4% and meadows with 0,5%.

The 5,5% of coniferous forest is explained by the pinewoods (San Vitale and Punta marina

pinewoods).

The first documentary evidence in which we begin to speak of "pine forest" dates to the description of war events that occurred towards the end of the 5th century (clash between Odoacer and Romolo Augustolo in 476 and siege placed from Theodoric to the city of Ravenna from 491 to 493).

It is thought that pinewoods were built to provide raw material for ship production.

At the end wetlands, they mostly be used for aquaculture (6,2%).

3.2.2. URBAN ANALYSIS: WATER RELATED RISK AND POLLUTION

The second analysis regards the topic of risk and pollution.

This step has been divided into classes of risk and pollution.

The first one is air pollution, which is meant the presence in the air of one or more substances that alter the composition e the balance of the atmosphere, causing harmful effects on humans, animals, plants and the environment.

The substances considered are PM_{10}, $PM_{2,5}$ and O_3

PM or particulate matter refers to solids and liquid particles dissolved in the atmosphere, the subscript "10" and "2,5" defines the diameter of single particles in nm units (nano-meters).

PMs sources can be both naturally, like volcanoes eruption or particles produced by fire and anthropic activities, those with fossil fuels.

O3 (ozone) is an allotropic version of oxygen (O2).

It is present in the higher layers of atmosphere (ozonosphere) at 25km above Earth surface and filter solar rays coming from sun.

This element can be found also in the low atmosphere as secondary or photochemical pollutant.

Responsible are nitrogen oxides (NOx) and volatile organic compounds (VOCs) from which, under the influence of sunlight, ozone is formed.

Emissions from motorized traffic, industry, crafts, as well as solvents are the main cause of these pollutants.

Ozone, also, is strictly related to agricultural activities, de fact, ozonated water is used to irrigate crops and eliminate bacteria and microorganisms, which can damage the plant right from its germination stage.

Raw data are taken from ARPAE website, and they are present in ascii format (.asc), which are classified as raster.

Available data considers a time range of 7 years, from 2009 to 2015 for each pollutant.

The process is quite simple and it has been done only with QGIS.

The first step is to provide the mean values for each emission, so, after importing all the files, raster calculator can be used to assess them with the following formula, exemplified for PM_{10}:

"(PM_{10}_2009+ PM_{10}_2010+ PM_{10}_2011+ PM_{10}_2012+ PM_{10}_2013+ PM_{10}_2014+ PM_{10}_2015)/7"

For all the new rasters the format has been changed into .GeoTiff and cell size dimensioned to 30x30m (this has been done to provide the possibility to related these rasteres).

The final step is to assess data, which consider all pollutants used.

Each air pollutant has its own unit measure, so they cannot be compared without a normalization of their values.

After that, the total average value can be assessed with the following formula:

"($PM_{2,5}$_total+ O_3_total+ PM_{10}_total)/3"

No classes of values are done in this case.

The final results are shown in figure 38.

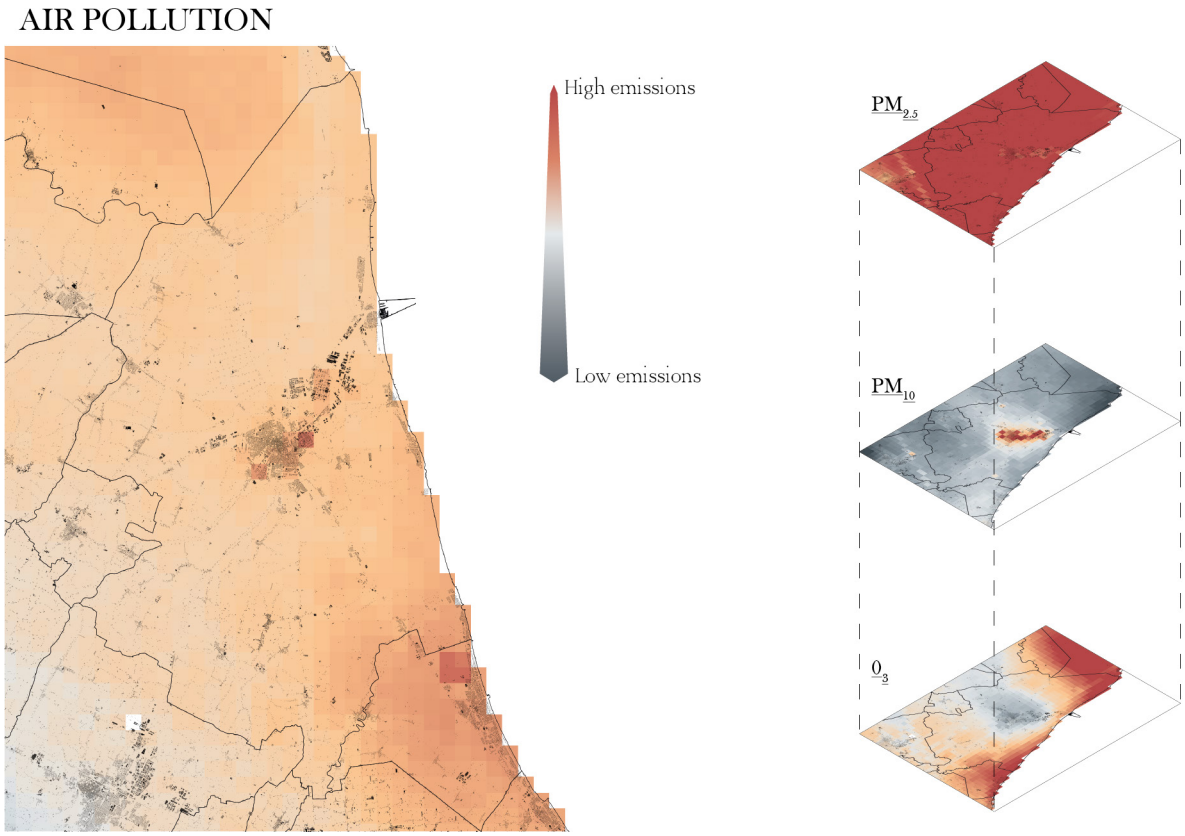


Figure 38: Air pollution assessment

According to results, Ravenna has a medium quality of the air.

Is it possible to observe, for example, that the city centre is characterized by an high emission of PM_{10} (due to traffic), ozone emissions has the opposite trend, they are high in agricultural field, while $PM_{2,5}$ emission is high everywhere.

Is it possible to state that air pollution is related to land uses and the kind of anthropic activity done.

The second phase is characterized by the analysis of soil pollution.

It indicates the alteration of the chemical-physical and biological balance of the soil, as well as the predisposition to erosion, landslides and the entry of harmful substances into the food chain up to man.

In this case some pollutants have been analysed (source: "Natural-Anthorpic background Card") [44]: chrome (Cr), nickel (Ni), lead (Pb), copper (Cu) and zinc (Zc).

All these are metals and they can represent a possible source of pollution for top-soil layer (20-30cm deep) and, consequently, generates environmental problems.

The standard classification provides a range of values for each metal divided into 4 classes (significantly below, below, above and significantly above) [45][82].

The process is similar to the one explained above, the only difference is that raw data, taken from Open data Emilia-Romagna, are vector files (.shp), relative to 2018, and not rasters.

As seen a lot of times before, the input data have been cut along site bordersto eliminate useless areas and the merged to have only one polygon for each risk class.

Single maps are ready, now the step, as air pollution analysis, is to create a general assessment of soil pollution considering all inputs.

The task is done by merging all the layers.

As for air pollution each single parameter has different unit measure, so that it is important to rasterize them and finally normalize cell values and compute the average value in the raster calculator interface with the following formula:

"(Cr+Ni+Pb+Cu+Zc)/5"

The map can be observed in figure 39.

The soil of Ravenna has a good quality, apart from a small area in the near Valli di Comacchio (the area is outside Ravenna administrative borders).

The only metal which can generate a threat is chrome.

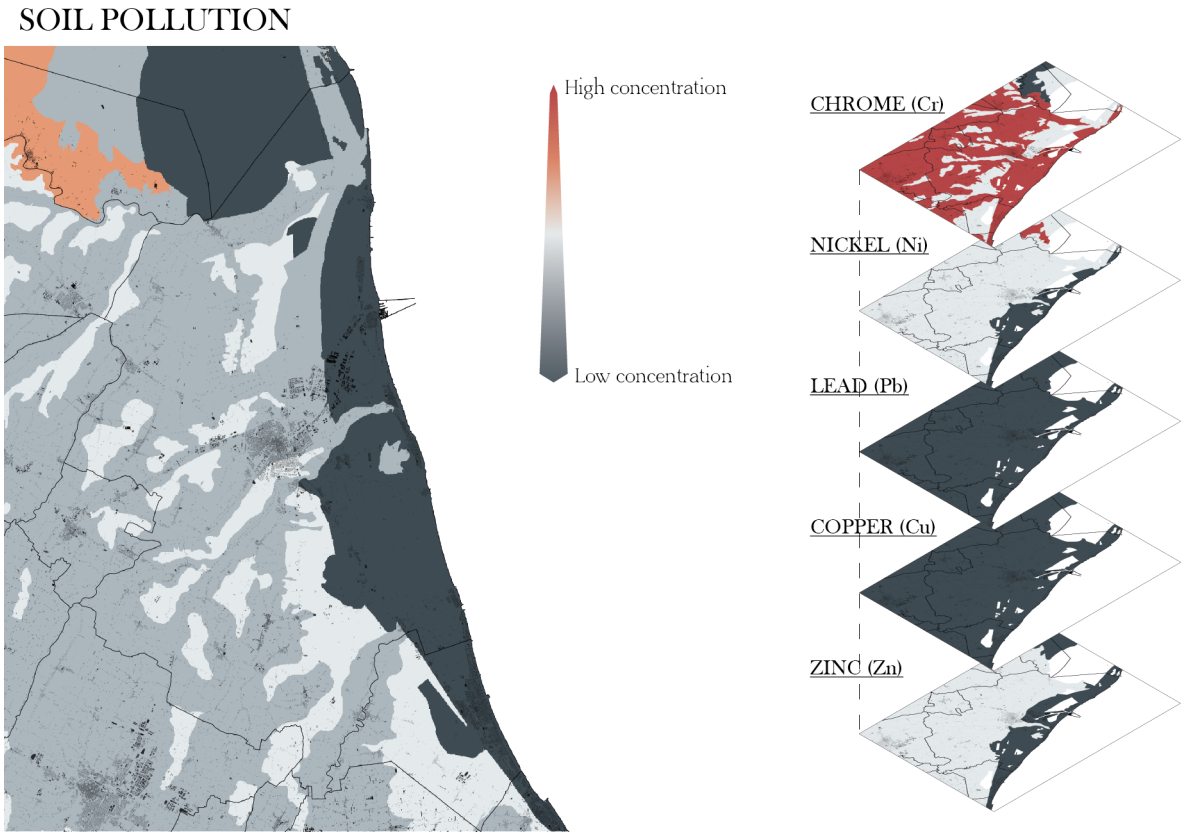


Figure 39: Soil pollution assessment

It is partly attributable to natural degradation processes of the geological substrates, from which the soils themselves originate; in part it is a function of the use on the soil of substances containing heavy metals used for pesticide defence or for fertilization.

After that, an overlapping between air and soil pollution has been done to assess a general overview about pollution risk.

To do It, the two risk maps, which have normalized values, can be computed together and measure the mean value between them (*figure 40*).

According to it, Ravenna has a risk pending from medium to medium-high values.

Next the analysis focuses on flood risk.

Flood is a caused by the overflow of rivers (or other running waters) and torrential rains.

This term also indicates a catastrophic event caused by atmospheric conditions such as rains and thunderstorms that last for days or weeks.

Flood risk assessment, in Italy is managed by the PGRA.

Flood risk management plan (PGRA) is the operational tool provided for by Italian law, in particular by D.lgs. n. 49 of 2010, which implements the European Directive 2007/60 / EC (Seveso directive), to identify and plan the actions necessary to reduce the negative consequences of floods for human health, for the territory, for goods, for the environment, for the cultural heritage and for economic and social activities.

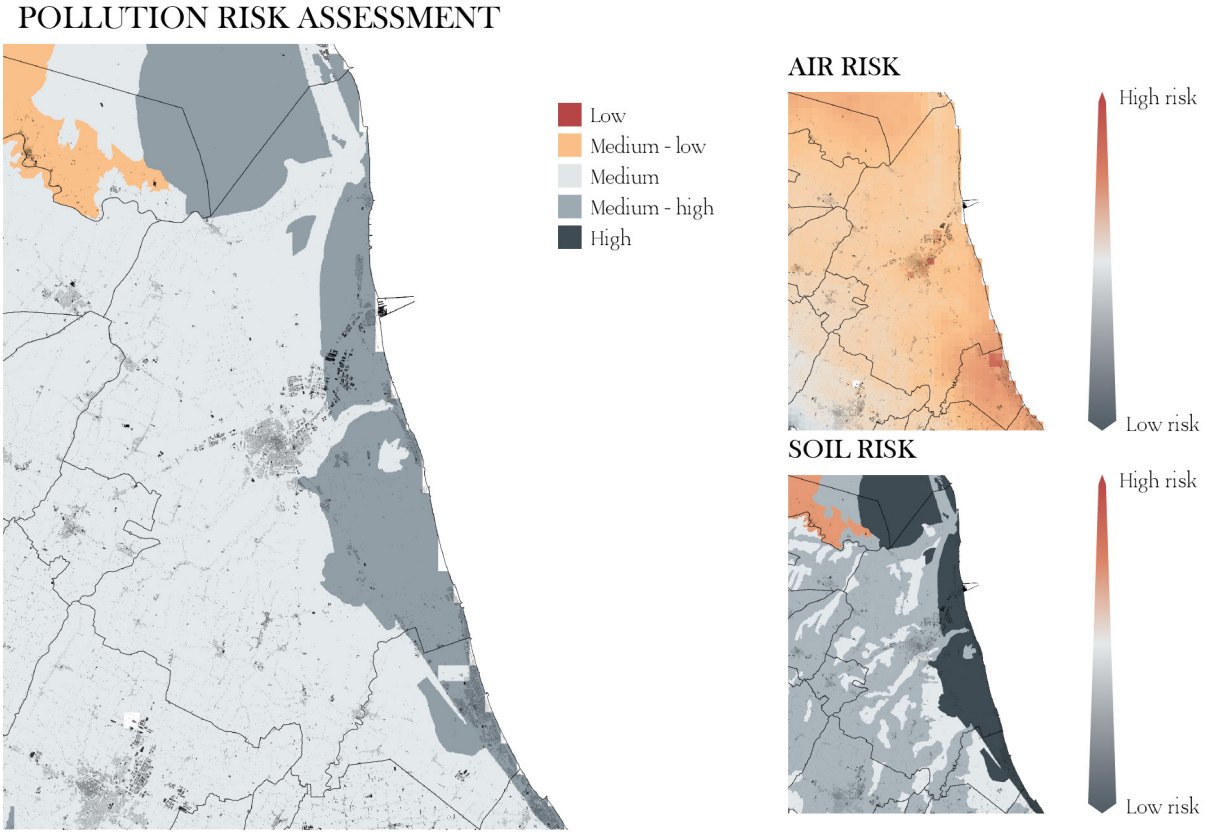


Figure 40: Pollution risk assessment

It must be established at the river basin district level; the one considered here is Padano district. This plan map territory according to 4 classes of risk (risk is defined by three parameters, hazard, vulnerability and exposition):

» R1 (moderate or zero risk): for which the social, economic and environmental damages are negligible or null;

» R2 (medium risk): for which minor damage to buildings, infrastructure and all environmental heritage that does not affect the safety of people, the usability of buildings and the functionality of economic activities;

» R3 (high risk): for which there are possible problems for the safety of people, functional damage to buildings and infrastructures with consequent unavailability of the same, the interruption of the functionality of socio-economic activities and damage to environmental assets;

» R4 (very high risk): for which loss of life and serious injuries are possible to people, serious damage to buildings, infrastructures and environmental heritage, the destruction of socio-economic activities.

No computation has been done for raw data, because water district authorities furnish data at municipal and regional scale.

The only process made is the management of risk layers:

The problem occurs when it tries to give a graphic look to this thematic map, polygons of different risk classes overlap together (e.g. a polygon with R2 risk partially covers a R1 one).

The issue is simply avoided extracting single risk polygons and unified together.

In this way polygons

The new layer has an attribute table populated by polygons which have a field for the single risk class.

Overlapped polygons can be seen observing attribute tables, if two fields relative to the same polygon have values, it means that the polygon is overlapping between those two classes.

For those polygons the value chosen is the worst possible (e.g. is a polygons overlaps R2 and R4 risk class, R2 is not considered).

Subsequently areas and percentages are computed with field calculator (figure 41).

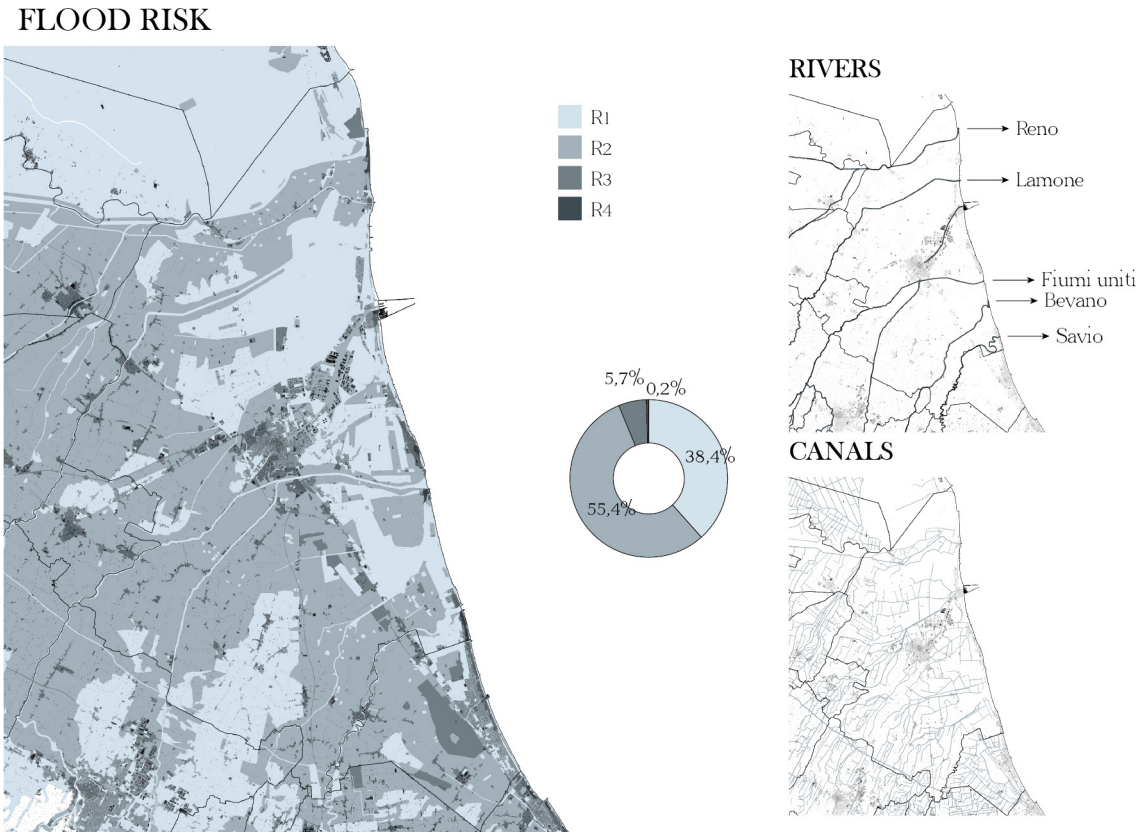


Figure 41: Flood rissk assessment

The entire town of Ravenna is under the risk of flood divided into:

» R1 with 38,4% coverage;

» R2 with 55,4% coverage;

» R3 with 5,7% coverage;

» R4 with 0,2% coverage.

Most of the area analysed is relative to R2 risk class, which is a medium risk, and it covers the half of the site.

Looking at map, town centre and the harbour are under R2 and R3 classes, so this can be caused by the high urbanization.

In a following paragraph this kind of information will be overlapped to cultural heritage buildings in order study the exposition to this risk.

The last part of risk analysis encompasses another time water topic, but in this case sea water rising.

"Sea level is the base level for measuring elevation and depth on Earth. Hence, sea-level rise is a climate change phenomenon through which the ocean water volume increases, mostly as a consequence of ice-sheets and glaciers melting and water thermal expansion" [92].

The Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) finds that global mean sea levels will most likely rise between 20cm and 110cm by the end of this century. These are the direst sea level rise projections ever made by the IPCC [76][93].

The analysis focuses on the provisioning of some predictive models of the possible future of the area.

The main question to respond is "how much will territory be covered by water?".

The scenario considered is at the year 2100, according to IPCC prediction.

Three models have been considered, two are relative to the thresholds of IPCC (+20cm and +110cm) and one considering a medium value, in this case +50cm.

The base data for the scenario is the DTM (Digital Terrain Model) obtained from regional geoportal as a raster.

DTM refers to existing topography, but in 2100 it can change due to a phenomenon which affects this site: land subsidence.

"Land subsidence is a gradual settling or sudden sinking of the Earth's surface due to removal or displacement of subsurface earth materials. The principal causes include: aquifer-system compaction, drainage of organic soils, underground mining, natural compaction or collapse, such as with sinkholes or thawing permafrost." [78].

Land subsidence data have been taken from ARPAE website as vector files (.shp).

The available data correspond to three time series, the first from 1992 to 2000, the second from 2000 to 2006 and the third from 2006 to 2011 (another time series was available, but something wrong occurred when trying to download it).

Every time series is presented with some polygons, each one corresponds a range of values which references to the mean values of subsidence in the time series considered.
The workflow is simply, generate the 2100 DTM model interpolating land subsidence and existing terrain model, then provide the models selecting all the areas which will be inundated.
It means selecting cells which have values minor than the thresholds provided by IPCC.
The initial step is to manage land subsidence data in order to provide a medium value that can be used to generate the future model.
For each range of values of subsidence, the mean value is considered (e.g. if the range is -5mm/-2,5mm, the value considered in -3,75) to guarantee the possibility of computation between time series and it has been signed in a new field of the attribute table.
Then, the next phase is related to solve a problem of approximation, indeed land subsidence data divides territory in strips of values, but each point of them has its own value which falls in the range given (e.g. according to the previous range, not all that polygon has a mean value of -3,75mm, but they have others values between -5mm and -2,5mm). to solve this problem a 1x1km punctual grid has been created, the mean value of the polygon over which the point of the grid falls is assigned by the use of "join attributes by location".
After that with the IDW interpolation is it possible to create a raster which may better represent the phenomenon.
The three new rasters are used to calculate the mean value for the entire time series, sum of the three considered with the formula:

$$(T1+T2+T3)/3$$

where T is time series.
The mean value of the totally land use observation time period is ready (almost 20 years).
To calculate the land subsidence for 2100 there is the need to multiply this value for as many years as the difference to reach 2100: 82 in this case.
Now summing this raster with the existing DTM the model can be assessed.
After that, the three scenarios can be easily done by selecting the areas which will be inundated.
Technically these areas are represented by those cells of the raster that have a value minor than the threshold considered.
Formulas used are "DTM 2100 scenario <0,2m" for the best scenario, "DTM 2100 scenario < 1,1m" for the worst scenario and "DTM 2100 scenario < 0,5m" for the medium scenario.

Results show that predicted feature is a threat for everything and everyone (*figure 42*).

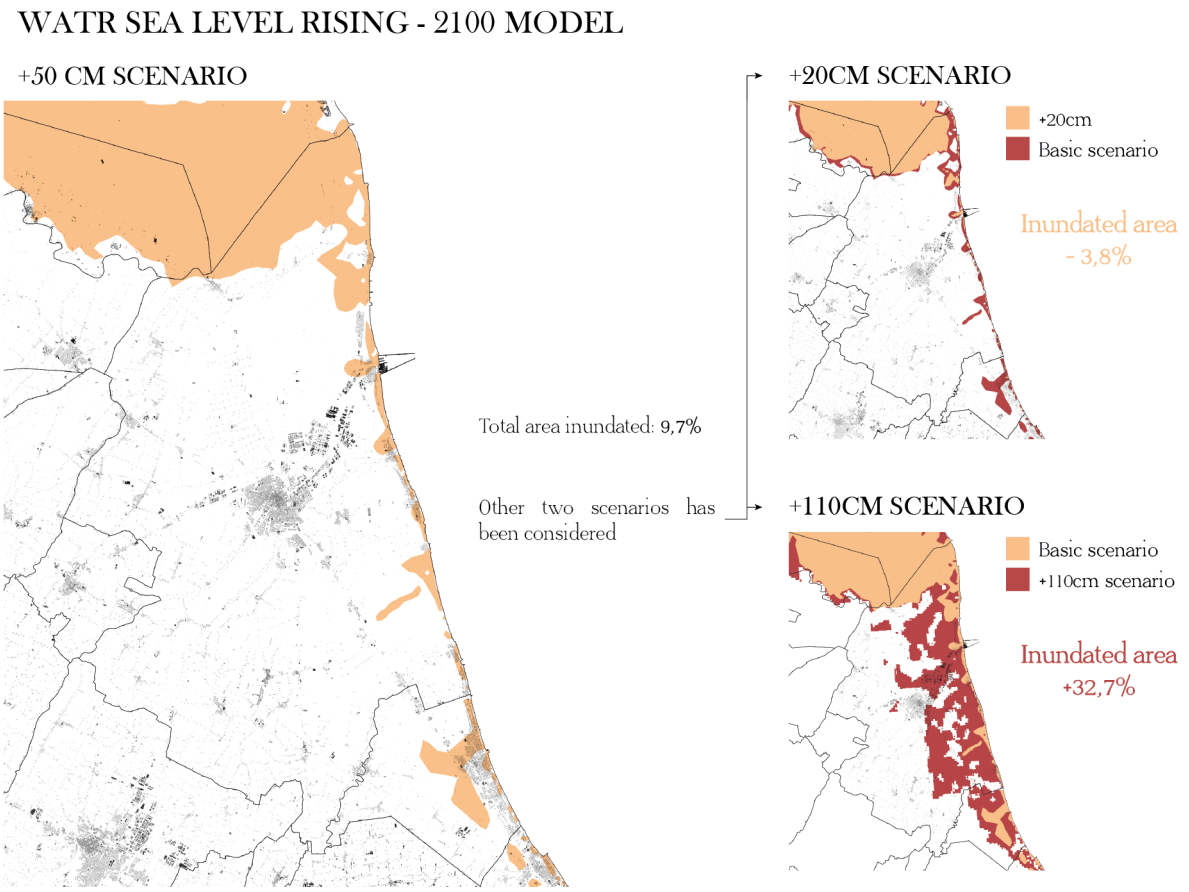


Figure 42: Water sea level rising scenarios

There is the need to avoid the worst scenario, essentially it will be almost complete loss of the town.

Also, considering only the best scenario, it can cause problems.

The consequences of these scenarios are tragic.

Economy, society and environment will be endured high impacts.

All the existing coasts will be inundated with an increase of erosion processes and a change in the chemical status (increase the salinity concentration) of aquifers near the sea, causing the inactivity of wells nearby.

With the loss of seaside, Ravenna will lose the main touristic attraction with an enormous impact on economy and tourist flows during the year.

With the worst scenario, the harbour will totally under water, Ravenna economy will be destroyed.

The entire analysis completed for the topic of risk and pollution can give an overview of the possible threats Ravenna is challenging and will challenge.

Air pollution is “visible” and people are facing directly, so, mitigation action are needed.

For water sea rising something can be done to avoid the possible problems or, at list, limit them as much as possible.

All these risks are also linked, de fact the increase of water sea level will generate an increase of possible floods.

All the risks are not concentrated in small areas, but regards the entire territory, this is a prove that interventions need a strategy which encompass the entire territory and no single locations.

3.2.3. URBAN ANALYSIS: ECOLOGICAL COMPARISON

Ecological analysis at urban scale recalls the territorial one.

Ecological quality, fluxes and bioenergy for landscape units are provided exactly as before.

This analysis wants to stress the dynamicity and the capability to change at change of conditions around., de fact, if the inputs change, the output values change to.

Ravenna landscape units are different from the same at territorial scale, administrative limits cut previous units, and this generates new inputs which confer new values.

Also the biggest change done is relative to the harbour and Pialasse.

At territorial scale, Candiano canal has been used as a border dividing the area into two landscape units, the harbour belongs to both units.

At urban scale, the need is to try to change units shape and dimension and observe possible changes.

Now this area has been divided into 3 landscape units separating Pialasse from the harbour, but, if from one side Pialassa Baiona has been separated, it was not possible to divide Pialassa dei Piomboni from Ravenna harbour due to site conditions.

With these new inputs, the results show a change for all the elements considered.

Ecological quality defines how the harbour interferes and influence the unit.

Previous values are 0,61 for Pialassa Baiona and 0,42 for Pialassa dei Piomboni and agricultural fields, the new sectors show an increase for both Baiona and agricultural fields, respectively 0,72 and 0,61.

Particularly attention has to be done for Piala dei Piomboni, it cannot be divided by the harbour and the new value is 0,39, a medium-low value.

The harbour has a stronger influence on Pialassa than the wetland influence on the harbour itself.

This is a proof of the instability of this Pialassa.

According to bioenergy and fluxes, the new sectors provide a new mosaic.

Without the harbour, Pialassa Baiona acquires the second highest value of bioenergy at urban scale (the first one is related to Classe pinewoods), but fluxes for this area are extremely good caused by the non-presence of hard human infrastructures.

All the coast is characterized by a good quality of bioenergy and fluxes, apart from the harbour unit, while agricultural areas in the inland provides low bioenergy and fluxes.

All this is an example of what has been spoken about in the initial part of the chapter, the importance of multi-scalarity.

All this stuff can be observed in figure 43.

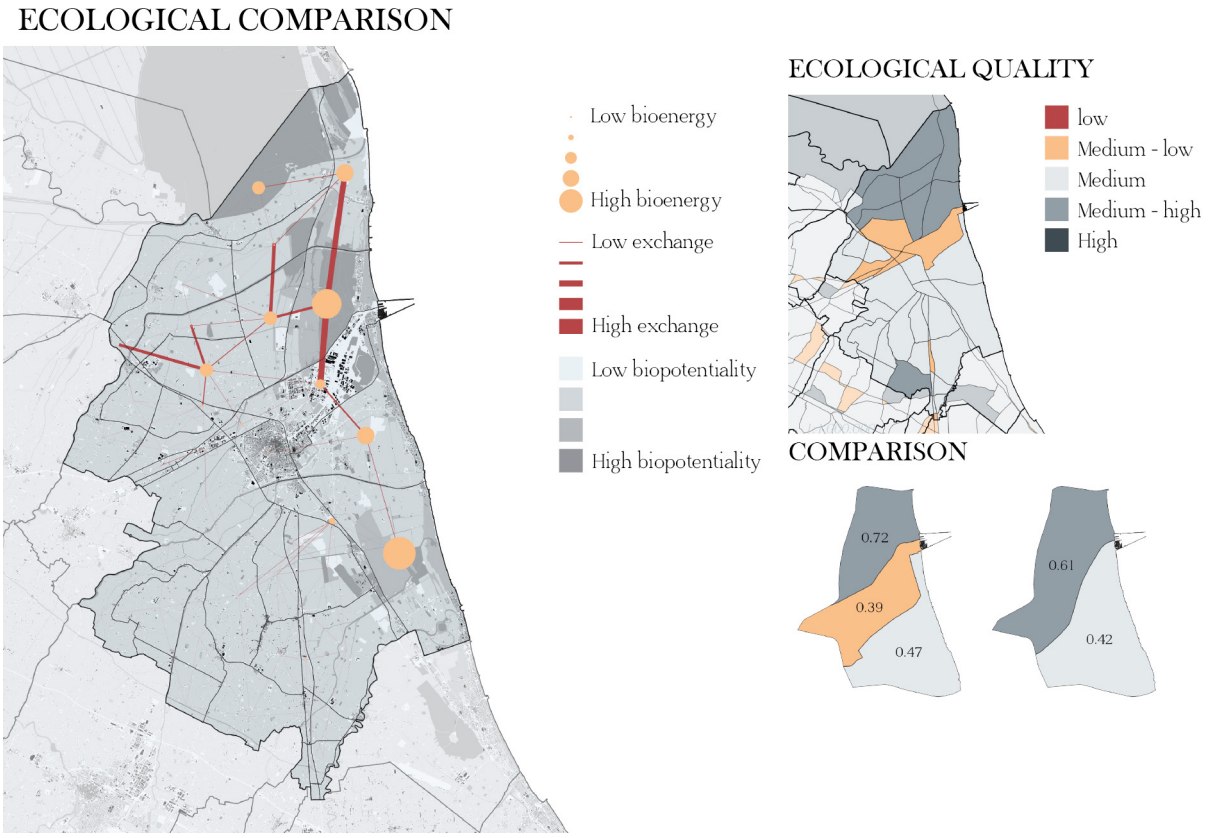


Figure 43: Comparison between territorial shapes and the new ones provided for urban scale

This analysis is fundamental to understand ecological dynamics, understand the potentialities and the weaknesses of Ravenna from ecological point of view, de fact this shows how negative the presence of the harbour is for the ecological equilibrium of coastal landscape and how a certain kind of agricultural activities flatten ecological values.

3.2.4. URBAN ANALYSIS: ANTHROPIC THREATS

From ecological analysis the urban weaknesses have been arisen, caused mainly by anthropic activities.

This paragraph goes deeply in the definitions of the consequences of them defining the threats to environments, in particular for protected areas (*figure 44*).

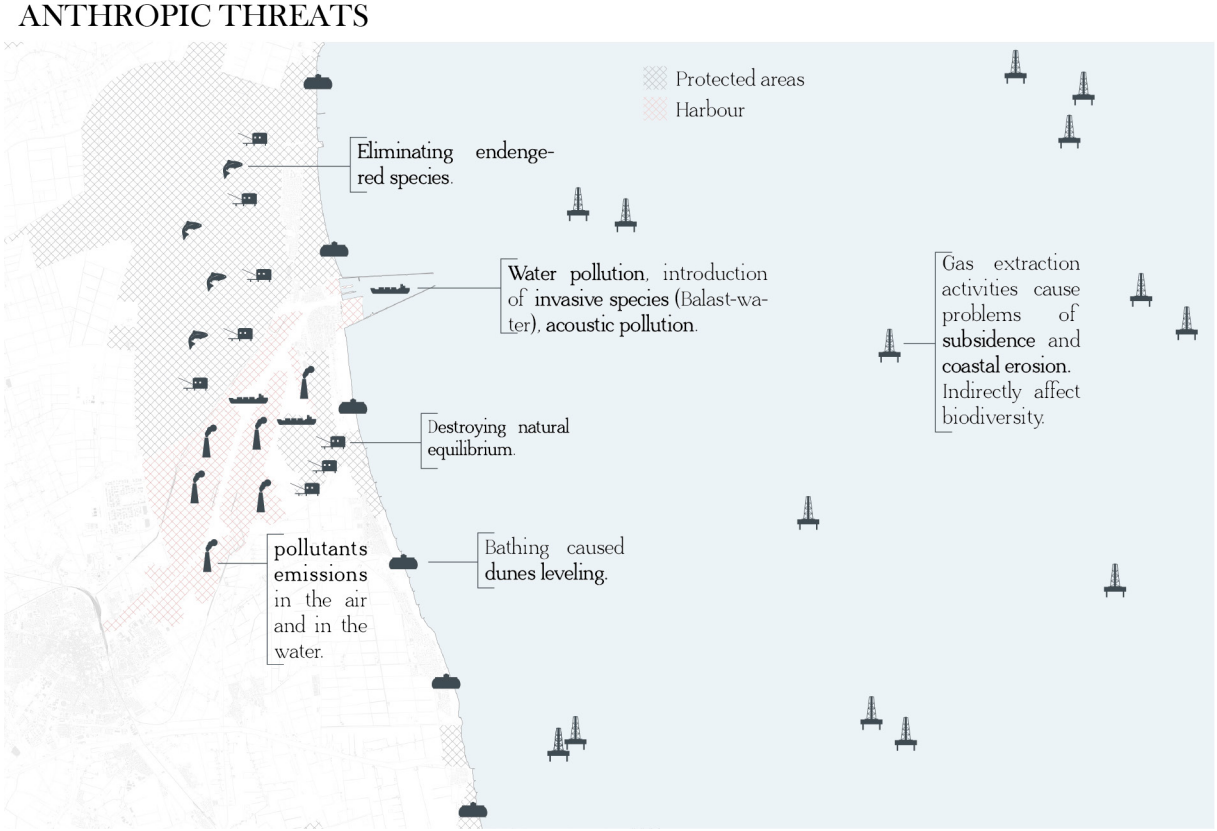


Figure 44: Map and description of the anthropic threats to natural environment

The first threat described arrives from the sea: gas extraction platform.

The are 47 offshore platforms which operates along Emilia-Romagna coasts and some of them are located within 2km from seaside, like Angela Angelina platform near Lido di Dante.

The impacts caused by these activities affects environment.

Extraction and soil perforation enhance land subsidence phenomenon.

The extraction of gas off the coast, even if it is not the only cause of this phenomenon, remains the main anthropogenic cause of loss of volume of the sediment in the subsoil, with the effect of lowering the topographical surface [68].

According to some studies, the reduction of 1cm per year involves, in the same period, a loss of sand volumes, which represent an economic loss for administration in terms of erosion proces-ses, loss of seaside areas which impact on tourism [27].

Another threat relative to sea and harbour are ships, their action can impact on air, water, sound and biodiversity.

Transport by container ships is considered sustainable, as the ships emit low levels of carbon dioxide (CO2) per T/km.

However, this does not exhaust the problem, as, a globally, the shipping sector emits enormous quantities of air pollutants, which cause severe environmental damage and accelerate climate change.

Pollutants emitted are:

» Sulfur oxides (SOx). They are partially responsible for acid rain and damage vegetation;
» Nitrogen oxides (NOx). They acidify the soil and waters. They also cause the eutrophication of lakes, soil and coastal areas;
» Ground-level ozone (O3) harms human health and vegetation, and contributes significantly to climate change;
» Particulate matter (PM) and carbonaceous particulate matter (BC) can cause heart and lung disease, chronic bronchitis and asthma. Furthermore, carbon dioxide emissions are the second largest cause of climate change, after carbon dioxide [37].

Ships can produce water pollution in different way [88]:

» Oil can come out of the engines and machines or from the bilges, the lower part of the hull, where the various drains are collected. Oil, petrol and the by-products of the biological decomposition of petroleum are harmful to fish and fauna in general, but also to humans if ingested. The effects may not be fatal, but organisms are still harmed by these substances;
» The waste water comes from sinks, showers, galley, laundries and all other cleaning activities. They can contain a large amount of pollutants, such as detergents, oils, fats, metals, organic compounds, hydrocarbons, food scraps, or bacteria such as faecal coliforms;
» Solid waste produced by a ship includes glass, paper, cardboard, plastic, and aluminium and metal cans. Solid waste entering the ocean can be transported to the coasts and can threaten marine and human organisms, coastal communities, and even industries that use seawater.

Also, heavy noise produced by ships is considered an environmental pollutant.

Noise can both affects humans and animals, it can provide acute ailments relative to a heavy noise exposition for a short period or chronic ailments relative to a long exposition to a noise source.

Unwanted sounds can compromise physical and mental well-being even at low levels.

Noise pollution represents a threat also for biodiversity and both terrestrial and aquatic ecosy-

stems, which is caused a decrease in the wild population in the world.

Impacts are hearing loss or damage, “mask” process causing inability to listen to environmental signals, physiological non-auditory effects and behavioural effects.

The last impact is the correlation with alien species spread by the ballast water effect.

Ballast water is one of the major pathways for the introduction of nonindigenous marine species. Ballast water is fresh or saltwater held in the ballast tanks and cargo holds of ships. It is used to provide stability and manoeuvrability during a voyage when ships are not carrying cargo, not carrying heavy enough cargo, or when more stability is required due to rough seas. Ballast water may also be used to add weight so that a ship sinks low enough in the water to pass under bridges and other structures.

When water fills tanks, some living organisms, both in the larval or mature state, can be captured.

The release of ballast water may introduce non-native organisms into the port of discharge. These introduced species, or bio-invaders, are also referred to as exotic species, alien species, and nonindigenous species [38].

The following source of anthropic threat is located at the coasts of the site.

Erosion processes are caused by the demolition of coastal dunes to be replaced by seaside for tourism.

The loss of them generates a lot of environmental problems, linked to erosion, as said before, and protection of in land ecosystems.

Ravenna wetlands, as observed in land use analysis, are characterized by aquaculture and fishing activities.

Legal Fishing activities cause impacts on biodiversity and ecosystem due to the illegal artifacts and different kind of water.

Worse are activities of fish poaching [66] are causing serious damages to marine ecosystem by eliminating endangered species and destroying habitats with the use of illegal fishing systems.

The last, but not the least the harbour, which only its presence represents an impact to the existing ecological system of the territory.

Port activities cause pollutants emissions in the air and in the water, which affects climate change and at the same time generate problems for surroundings environments.

All this paragraph is important, because it has been possible to have a detail analysis not on the results of impact, but on the sources, which cause impacts.

Knowing the kind of impact is important to understand what kind of action and strategy must

be done but knowing impacts sources can let understand where to act.

3.2.5. URBAN ANALYSIS: VEGETATION AND AVIFAUNA

The following analysis is focused on the description of existing vegetation and avifauna.
Plants are extremely precious organisms because they release oxygen into the air, a fundamental gas because it is the guarantor of the life of all living beings, including humans [48].
Ravenna has characterized by different environments, each of them is defined by different characteristics, such as soil moisture, presence of water, altitude, human influences and so on…
The analysis stresses the attention to the vegetation of protected areas, which belongs to Parco del Delta del Po.
In the site 4 environments are highlighted: dunes, wetlands, shrublands and woods and urban environments.
As said before different environments are covered by different flora and vegetation.
The thematic map (*figure 45*) has been done by cutting the vegetation classes of the park using Ravenna borders, then attribute for each one the relative environments, "sand and dunes", "salty wetlands", "shrublands and arboreal" and "urban environment".

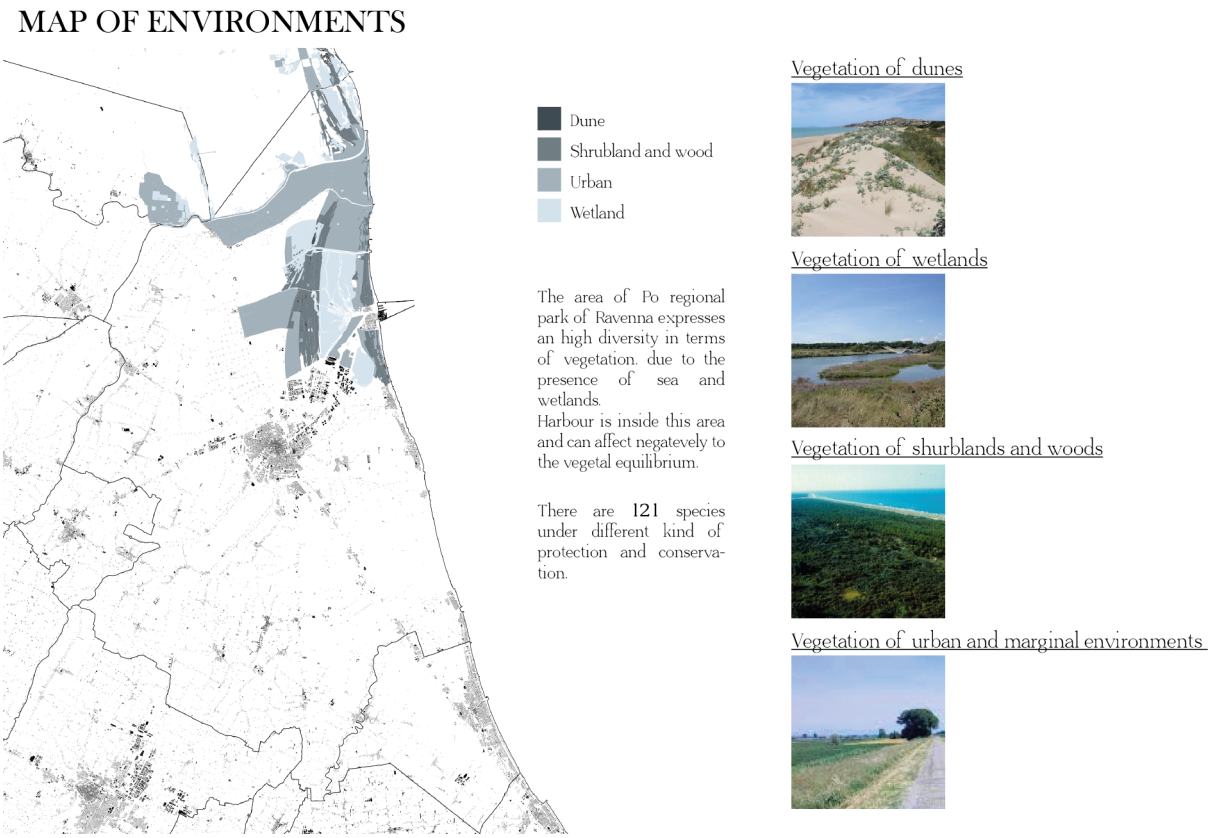


Figure 45: Map of environments of Parco del Delta Po for vegetation analysis

Vegetation classes have codes, thy are decoded by the use of "Base Dati della Carta della Vegetazione della Regione Emilia-Romagna Scala 1: 10.000/25.000" document from regional geoportal.

Values are attributed following official documents relative to cognitive frames about ZSC and ZPS areas, "SIC/ZPS IT4070004: Pialassa Baiona Pineta di San vitale" and "SIC/ZPS IT4070006: Pialassa dei Piomboni, Pineta di Punta Marina" [49][50].

After the production of Thematic map it has been possible to provide a deep research and description of the characteristic of the single vegetation and flora for each environments using two websites:

» Acta plantarum website for flora information [33];

» Podromo della vegetazione d'Italia for data about vegetation and comunities [87].

The first environment analysed is "sand and dunes" (*figure 46*) [54].

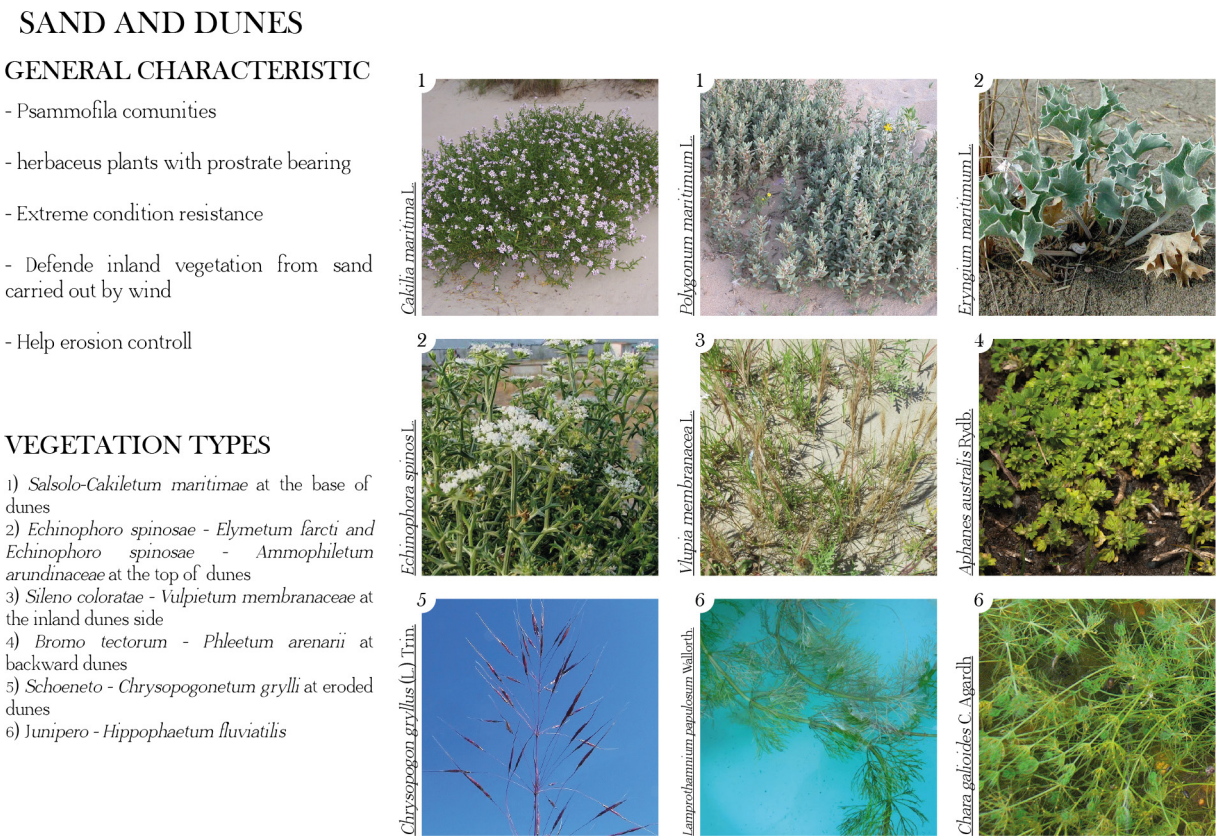


Figure 46: "Sand and dunes" vegetation description

The coastal environment of the sands (beaches and dunes) is an exemplary case of "extreme environment". The wind carries very small droplets of sea water together with large quantities of tiny grains of sand creating a real "aerosol" that grinds and encrusts of salt in everything it encounters, rapidly submerging the branches and leaves of the plants. In addition to this, due to both the excessive drainage of rainwater in the sandy soil that washed away the mineral nu-

trients and the intense evaporation caused by the sun and the wind, the sandy soil and subsoil are “physiologically” arid.

The intensity of these extreme factors and their resultants in any case gradually decreases with the increase in distance from the shoreline, giving rise to progressively more permissive situations and allowing an increase in specific diversity as one proceeds inland.

Finally, because this substrate is also physically very unstable and mobile, it follows that the formation of plant communities is often very difficult and only a few highly specialized plant species can live there.

These are the “psammophilous” plants, which have adopted particular and very specific morphological and physiological adaptations:

» Adapted to physiologically arid but unsalted environments, they always live at a level much higher than that of high tide, so as to be flooded with salty waters only occasionally and for very short periods;
» Some have very developed roots to be able to reach deep water, fresh, which is scarce in surfaces, others instead horizontally in order to collect as much rainwater as possible;
» They have a remarkable resistance to the salty air environment, that is to the tiny salt crystals carried by the winds that can grind the buds and leaves of plants.;
» Generally they are low or have a prostrate posture to oppose the wind with limited resistance;
» They produce shoots at different heights to avoid complete burial by the wind blown sand;
» They have leaves with a light colour to protect themselves from the sun’s rays;
» The surface of the leaves reduced to a minimum covered with a light hair to avoid excessive transpiration;
» They have water accumulation systems in the leaves;
» They have reduced transpiration, to avoid excessive evaporation caused by strong solar radiation.

This environment is populated by some vegetation type:

» Salsolo-Cakiletum maritimae behind the aphitoic area of the shoreline;
» Echinophoro spinosae - Elymetum farcti and Echinophoro spinosae - Ammophiletum arundinaceae at the top of dunes;
» Sileno coloratae - Vulpietum membranaceae at the inland dunes side;
» Bromo tectorum - Phleetum arenarii at backward dunes;
» Schoeneto - Chrysopogonetum grylli at eroded dunes;

» Junipero - Hippophaetum fluviatilis.

The second environment can be observed in figure 47 an is related to salty wetlands.

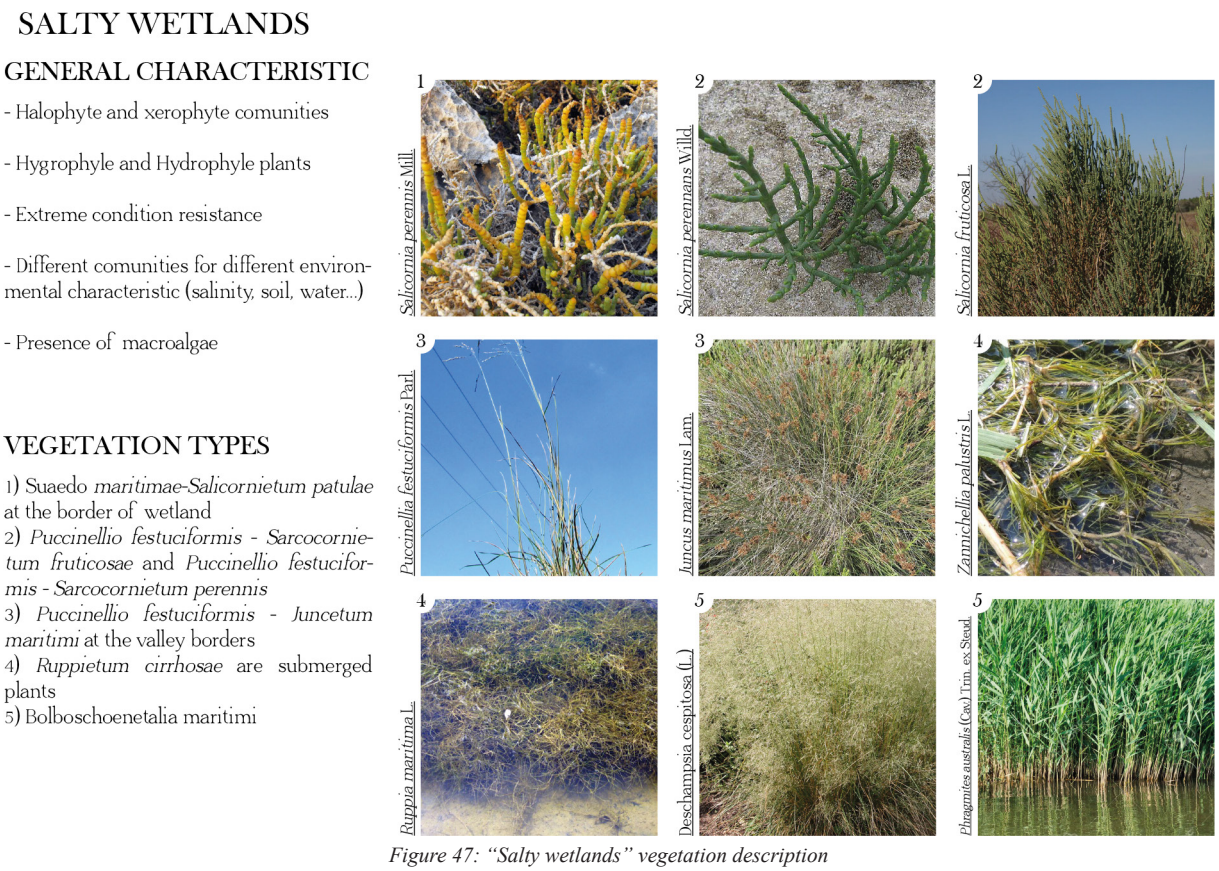


Figure 47: "Salty wetlands" vegetation description

Wetlands have been defined as "marshy, marshy or peaty areas or in any case bodies of water, natural or artificial, permanent or temporary, with still or running water, fresh, brackish or salty, including stretches of sea whose depth does not exceed 6 meters at low tide" (International Conference in Ramsar, Iran, 1971).

The brackish wetlands include all coastal water bodies in which continental freshwater and marine salty waters are mixed in which, depending on the tides and the flow of the rivers, the salinity assumes different intermediate salinity values from time to time.

The emerged brackish coastal territories are characterized by the presence of circulating waters which have, due to the inputs of sea water and intense evaporation, a higher salt concentration than that of sea water.

These salty soils, physiologically arid as the high concentration of salts gives rise to an osmotic pressure that prevents most plants from absorbing fresh water, are called allomorphic soils.

Even in this case only plats with specific adaptation behaviour can live and reproduce in these environments: halophytes and xerophytes communities, they can resist to soils rich in salts and arid soils.

Depending on the different environmental conditions such as the type of soil, the average duration of emergence from the water, the saline concentration of the circulating water, different halophytes communities can be born, divided if they are submerged by water and terrestrial vegetation of wetlands.

Vegetation types presented are:

» Suaedo maritimae-Salicornietum patulae at theborder of wetland;

» Puccinellio festuciformis - Sarcocornietum fruticosae and Puccinellio festuciformis – Sarcocornietum perennis;

» Puccinellio festuciformis - Juncetum maritimi at the valley borders;

» Ruppietum cirrhosae are submerged plants;

» Bolboschoenetalia maritime.

The third environment, shown in figure 48, is referred to shrublands and woods associated to the coastal pinewoods, near wetlands [18].

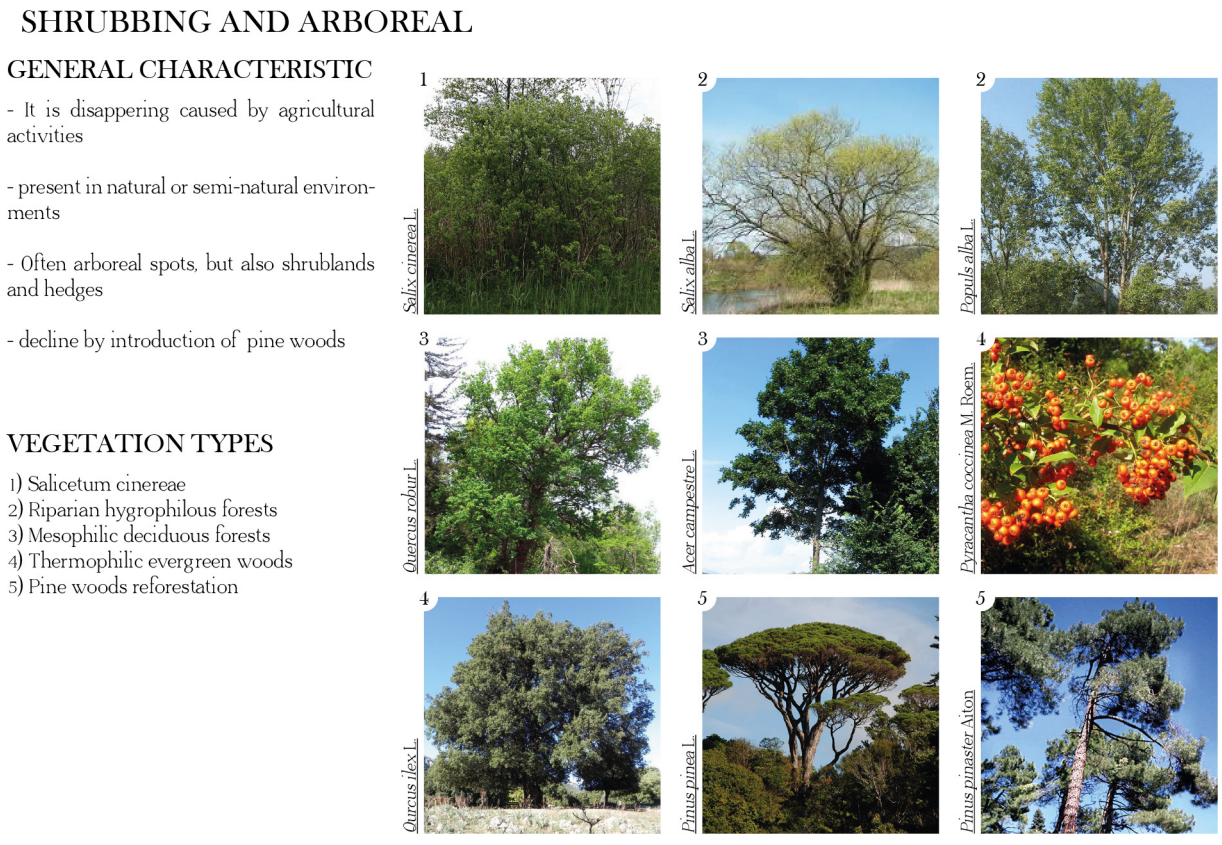


Figure 48: "Shrubbing and arboreal" vegetation description

The shrubby vegetation presents conditions of decline because of the progressive disappearance of the hedges linked to the agricultural landscape and the massive reforestation behind the dunes.

Dense thickets of Salicetum cinereae, invasive in the territories of Punte Alberete and Valle

della Canna.

Coastal woods are hardly traceable to primeval forests, the reorganization of the territory by man has led to a drastic reduction of wooded areas dominated by broadleaf trees, both heat-loving and hygrophilous; on the other hand, pines were introduced, as mentioned in the chapter on the vegetation of the sands. Currently, in natural or semi-natural areas there are three different wood types:

» Riparian hygrophilous forests;

» Mesophilic deciduous forests;

» Thermophilic evergreen woods.

The last environment considered is the one relative to urban environment (*figure 49*).

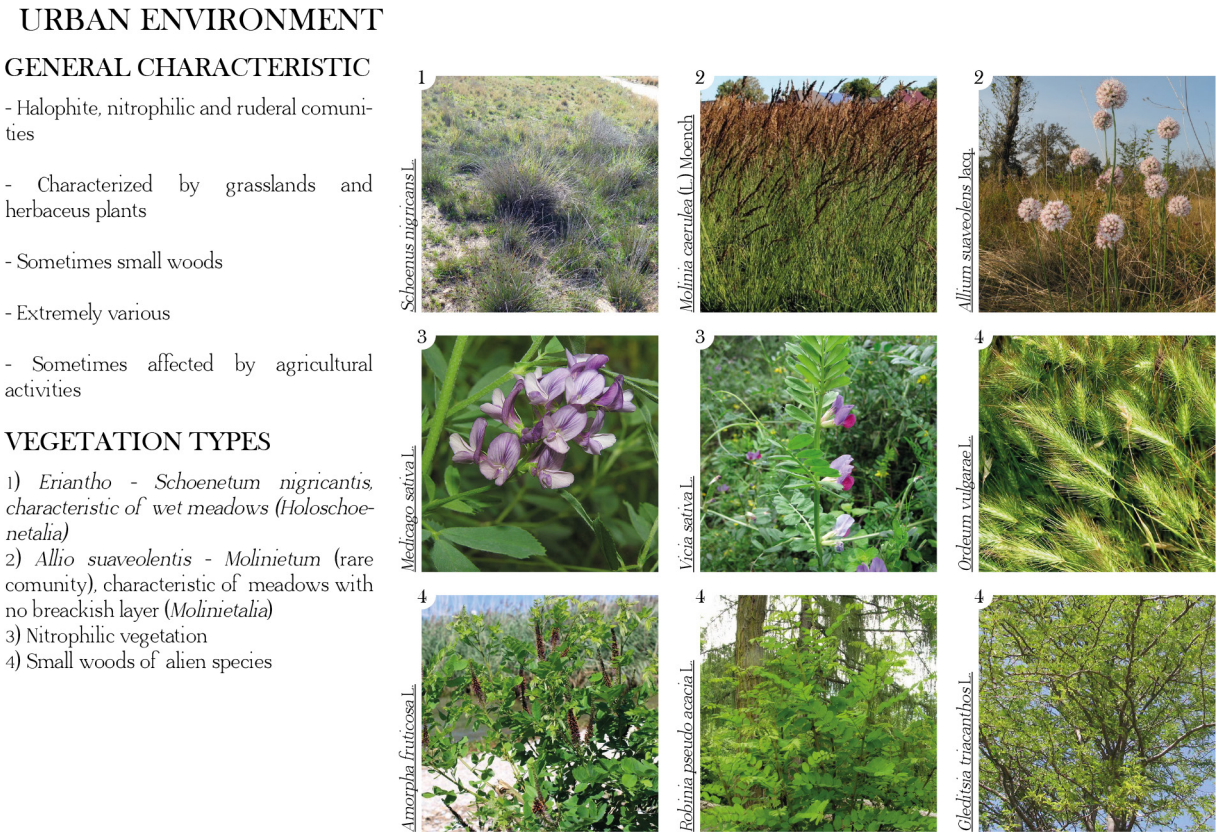


Figure 49: "Urban environment" vegetation description

This environment is obviously affected by human action, which cause the proliferation of specific communities and plants.

Vegetation are defined by halophytes, nitrophilic and ruderal communities characterized by grasslands and herbaceous plants, sometimes small woods.

The nitrophilous and ruderal vegetation form communities of rapid expansion in places where there are ruins, deposits of inert materials, or simply drains; the most frequent species are

exponents of the genera Ranunculus, Malva, Geranium, forage legumes such as Medicago, Trifolium, Vicia, grasses of the genera Avena, Hordeum, Bromus, Poa.

At the edge of the cultivated fields, the vegetation is affected by the disturbance due to agricultural activity, and as a rule it fails to structure itself beyond types of rapidly developing herbaceous communities, rich in native or naturalized weed species.

Locally there are bushes or even spots and thickets of species imported in recent times and which they subsequently colonized with success the marginal areas; among these the most important is undoubtedly Robinia pseudoacacia L., but two other North American shrub legumes are also expanding rapidly in semi-natural areas, Amorpha fruticosa L. and Gleditsia triacanthos L.

The main vegetation types of this kind of environment are:

» Eriantho - Schoenetum nigricantis, characteristic of wet meadows (Holoschoenetalia);

» Allio suaveolentis - Molinietum (rare community), characteristic of meadows with no brackish layer (Molinietalia).

All the environments present different invasive species [19], which are introduced into a natural environment where they are not normally found with impacts to existing habitats (*figure 50*).

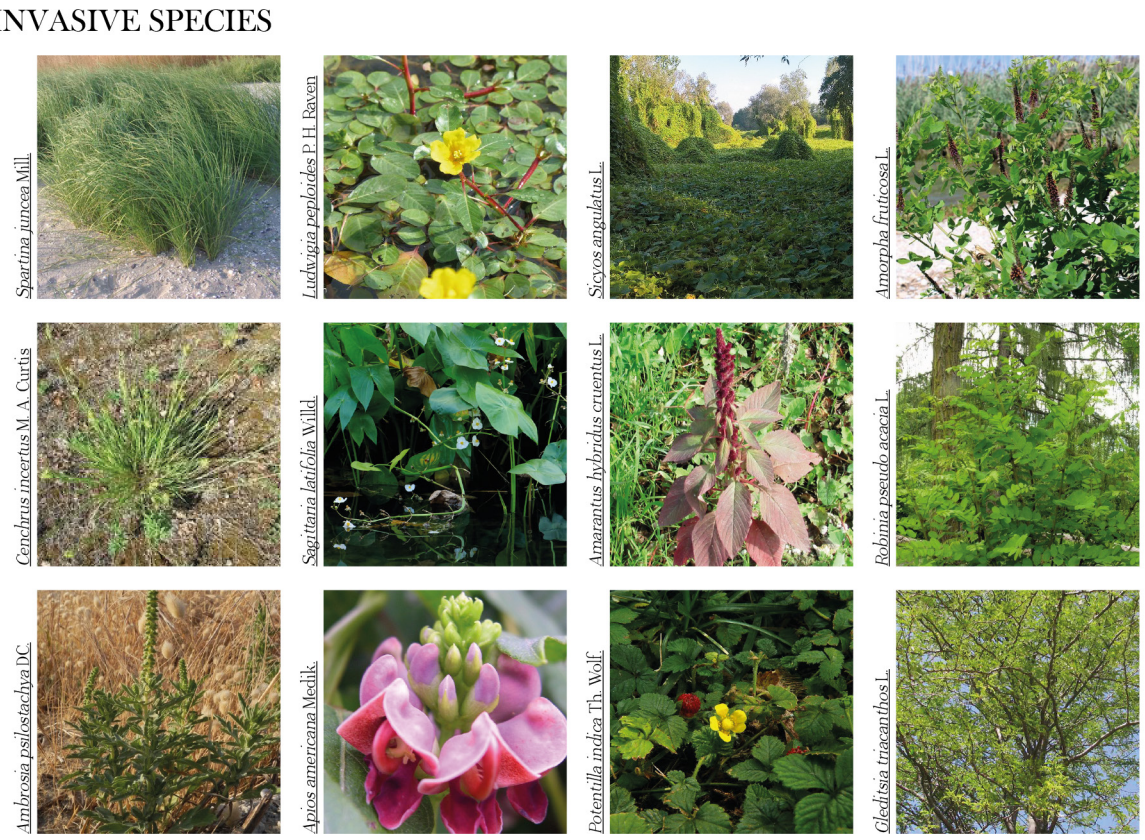


Figure 50: Examples of invasive species for each environment (one column for environment)

So, grasses, meadows, shrubs and trees, as said before, are important because they support life by proving oxygen.

Vegetation is also important because represent the habitat for animal kingdom from microorganisms to big mammals.

Due to Ravenna is famous for wetlands and these represents the habitats for a lot of bird species, so fauna analysis is focused on avifauna.

The first part is the provisioning of the thematic map of sites of important for birdlife (data taken from Annex B8 – panel A7 of Territorial Plan of the Po Delta Regional Park).

The need to map bird areas comes from European Council which the directive 79/409/CEE or Birds Directive.

"The Birds Directive concerns the conservation of all species of naturally living birds in the wild state in the European territory of the Member States to which the Treaty applies. To this end, the directive provides for the maintenance, through the creation, conservation and / or restoration of an adequate surface area of the habitats of the bird species, as well as the establishment of protection areas" [86].

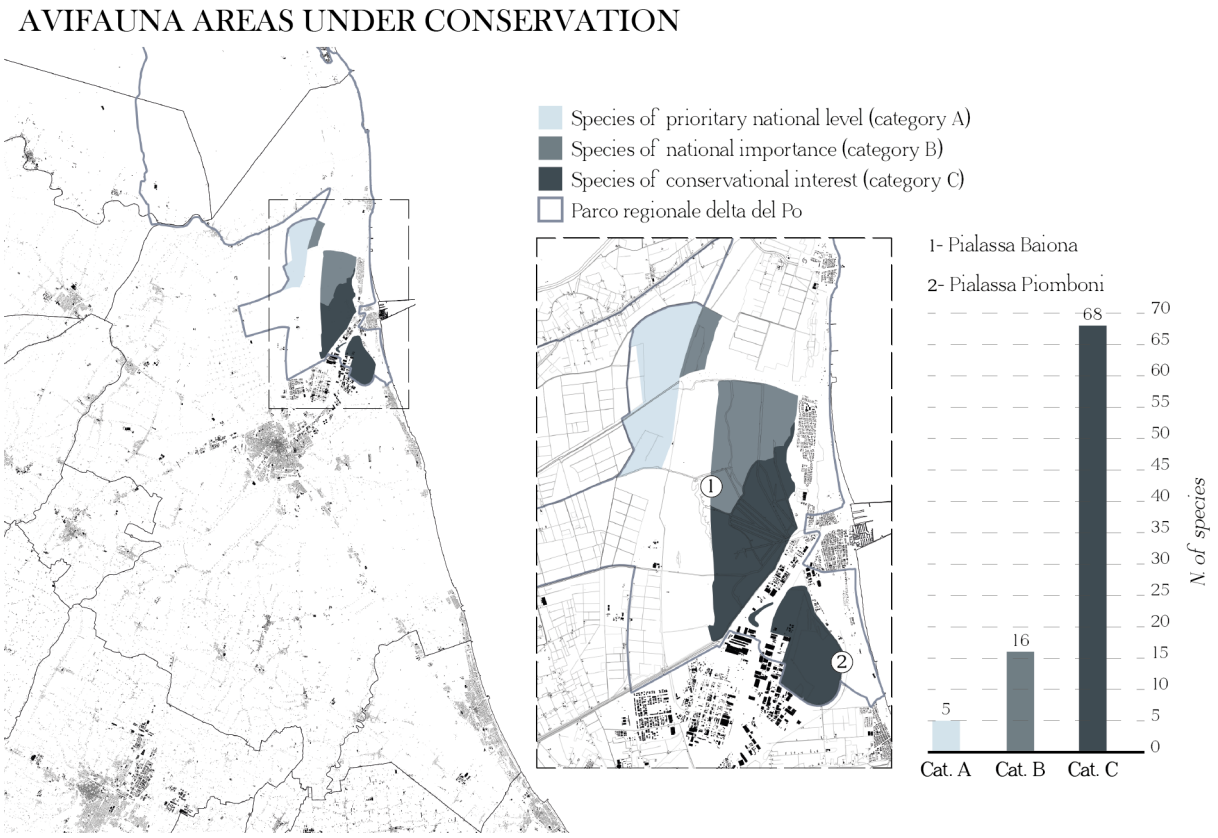


Figure 51: Map of avifauna areas under conservation

The map (*figure 51*) defines three areas with three different levels of conservation:

» Species of priority national level (category A), for this category there are 5 species inside the park;

» Species of national importance (category B), for this category there are 16 species inside the park;

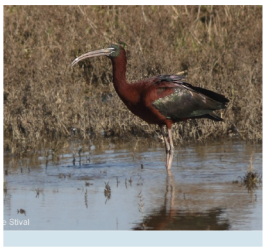
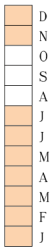
» Species of conservational interest (category C), for this category there are 68 species inside the park.

Casmerodis albus (Airone bianco maggiore)

Habitat: Plain and hygrophylous woods
Reproduction: April - June
Food: Fishes, aquatic invertebrates, amphibians
Fenology: Sedentary, nesting, wintering, migratory

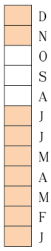

Plegadis falcinellus (Mignattaio)

Habitat: Plain and hygrophylous woods, reeds
Reproduction: May - July
Food: Aquatic invertebrates
Fenology: Nesting, migratory

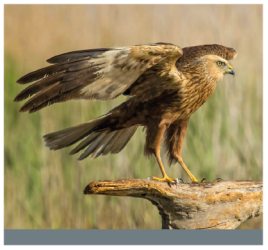
Ardea purpurea (Airone rosso)

Habitat: Reeds
Reproduction: April - June
Food: Fishes, aquatic invertebrates, amphibians
Fenology: Nesting, migratory

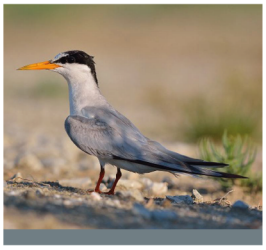
Circus aeruginosus (Falco di palude)

Habitat: Wetlands with reeds
Reproduction: April - June
Food: Small mammals, insects, birds, amphibians
Fenology: Sedentary, nesting, wintering, migratory



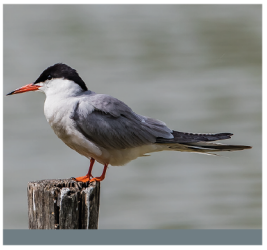
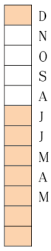

Sternula albifrons (Fraticello)

Habitat: wetlands, dunes, beaches, muddy areas
Reproduction: May - August
Food: Fishes
Fenology: Nesting, migratory



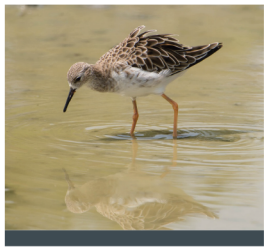

Sterna hirundo (Sterna comune)

Habitat: Dunes of wetlands, muddy areas
Reproduction: May - July
Food: Fishes, crustaceans
Fenology: Nesting, migratory

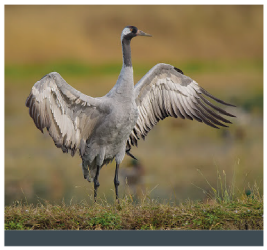
Philomacus pugnax (Combattente)

Habitat: Coastal wetlands, muddy areas, swamps
Reproduction: April - June
Food: Invertebrates
Fenology: Sedentary, migratory



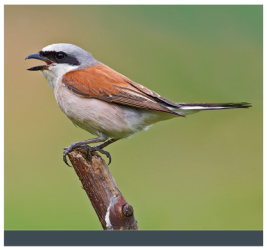

Grus gru (Gru)

Habitat: Wetlands
Reproduction: June - July
Food: Fishes, insects, cereals
Fenology: Wintering, migratory



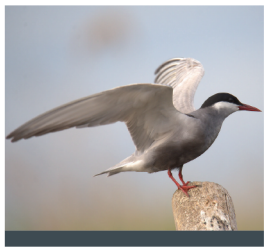

Lanius collurio (Averla piccola)

Habitat: Agricultural fields, borders of woods
Reproduction: May - June
Food: Insects, reptilians, small mammals, birds
Fenology: Nesting, migratory



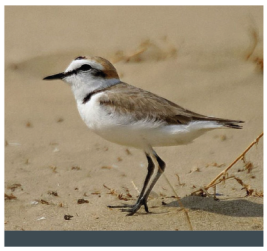
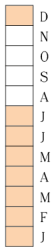

Chlidonias hybrida (Mignattino piombato)

Habitat: Wetlands, reeds, quarries
Reproduction: May - July
Food: Fishes, aquatic invertebrates, amphibians
Fenology: Nesting, migratory




Charadrius alexandrinus (Fratino)

Habitat: Dunes, beaches, muddy areas
Reproduction: April - June
Food: Invertebrates
Fenology: Sedentary, nesting, migratory

Cyrcus pigargus (Albanella minore)

Habitat: Agricultural fields, reeds, meadows
Reproduction: May - July
Food: Small mammals, birds, anphibians, insects
Fenology: Nesting, migratory


Figure 52: Some protected avifauna species description

The analysis goes deeply in the analysis of single species, de fact to better understand the possible actions for strategy and design, it is important to know birds behaviour [96].

For the single species the information are shown in figure 52 and they are:

» The habitat in which they live;

» Reproduction period;

» What they eat;

» Fenology, which, in ornithology, indicates the possible presence on the territory of various bird species during the different periods of the year.

So vegetation and avifauna analysis are fundamental for landscape architecture and planning.

Know the kind of biodiversity which lives and reproduces in the site consider influence the kind of intervention the project must face.

The use of right species can increase the value of the strategy and the design enhancing ecosystem services and developed and mend the tear caused by natural and anthropic interactions.

The study of existing endangered fauna, avifauna in this case, can be useful to understand the actions to promote the reintroduction and conservation of them.

On the other side, the use of wrong species causes a negative impact on environments, such as the proliferation of invasive species with high economical costs to solve the new problem.

3.2.6. URBAN ANALYSIS: TOURISM

Here another analysis which has been treated in the territorial one: tourism.

If the previous study focuses on statistical data about the whole site proving information at territorial and provincial scales, now the analysis stresses the attention to Ravenna (*figure 53*).

Data compares tourist demand flows divided for Italian and foreigners [94], analyse seasonal variability between the period from 2016 to 2019 (data available inside regional geoportal, tourism section), 2020 has not been included because data are influenced by SarsCoV-2 pandemic.

Final diagrams are the results of elaboration from raw data.

The first histogram compares seasonal variability flows between Italians and foreigners in the period considered checking result with regional trends.

Considering seasonality, tourism reaches peaks during summer moths with a low decrease in July, annual variability can be not considered due to similarity in values, there is a very little decrease from 2017.

Italian line has a sharper increase than foreigners.

Comparing with regional trend, line shapes are similar to Ravenna ones, but they have bigger values.

RAVENNA TOURISM

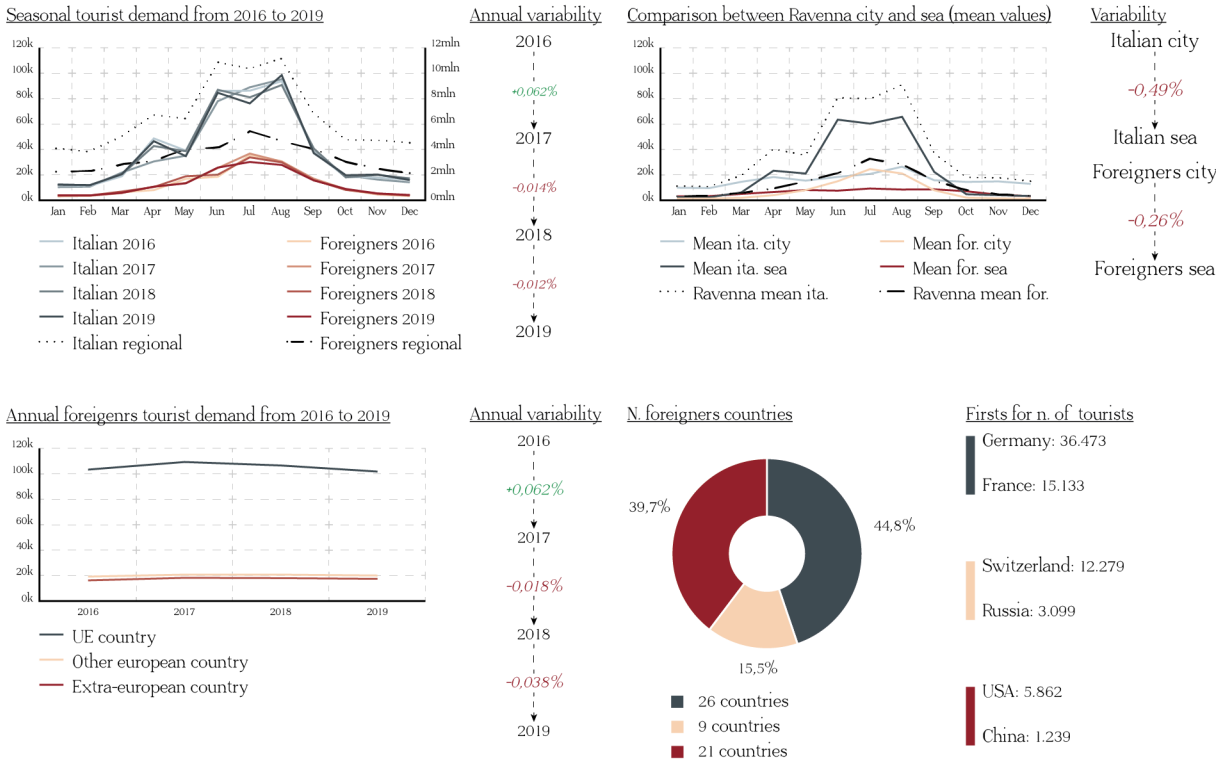


Figure 53: Ravenna tourism statistics

The comparison goes deeper analysis movements inside the town itself.

Ravenna has been divided into “city” related to the centre of culture and “sea” related to seaside tourism.

Here a change can be observed for both Italians and foreigners.

Essentially Italians prefer going to seaside, while foreigners define an opposite trend, they prefer to go in the town centre than seaside.

The variability, in this case, has been computed between “city” and “sea” for both Italians and foreigners.

The last part of the analysis is a focus on foreigners’ demand and flows.

The histogram compares annual variability between provenance divided by UE countries (26), other European countries (9) and extra-European country (21): UE rules over the other two, showing a little continues decrease after an increase from 2016 to 2017.

Among all the foreigners country Germany and France (36.473 and 15.133) are the best tourists exporter for UE countries, Switzerland and Russia for other-European countries and USA and China (5.862 and 1.239) for non-European countries.

Analysis tourists demand and flows for both entire site and internal sectors can be useful to

comprehend people behaviour.
Knowing this, it can be modified towards less impactive locations or places with new attractions providing a more naturalistic and cultural tourism.

3.2.7. URBAN ANALYSIS: HISTORY AND CULTURE

The following paragraph analyses one element which characterise Ravenna: history and culture.
The name Ravenna contains the root rav which means “flowing of water” and the city owes its fortunes to water.
It was water that made it inaccessible to enemies, but it was still water that projected it into history, first as a Roman military port and later as a merchant port that is still one of the largest on the Adriatic.
Although the origin of Ravenna is very ancient (it must be sought at least in the third millennium before Christ), it was with Julius Caesar, as the historian Augusto Torre writes, “that Ravenna had the triumphal entry into history”, an entrance that sees Ravenna the undisputed protagonist for almost five centuries.
In Ravenna Cesare used to spend the winter and it was from there that he would leave for the conquest of Rome.
The city, after roman period, was declared the capital of West empire by Onofrio in 402; after that, it was under the dominion of various population and dynasties, like Goths, Byzantines, Lomgobards and Napoleon.
The Risorgimento period found fertile ground in Ravenna and in these years, thanks also to the work of the poet George Byron, Carboneria spread.
Ravenna is also decisive in the event that allowed Giuseppe Garibaldi to escape from the Austrians.
Forced to leave Rome in July 1849, Garibaldi found refuge in August of the same year in a hut hidden among pinewoods.
After a period of crisis during which the city struggles with serious political and economic problems, Ravenna begins its rise which will pass through reclamation and agricultural work, but above all through the sea [20].
The history of Ravenna was troubled by strife, destruction and conquest under many flags, all this forged the existing Ravenna where, culture and history echoes everywhere.
It is a strong component of the territory which need to be discovered and developed.

Before thinking about strategy and actions, the first step is to find and map all the historical sites present, locations are found inside Ravenna tourism official website [90], then they are manually placed in an appropriate punctual vector layer inside QGIS.
The attribute table has characterized by a field with the name of the building and another one with the belonging class.

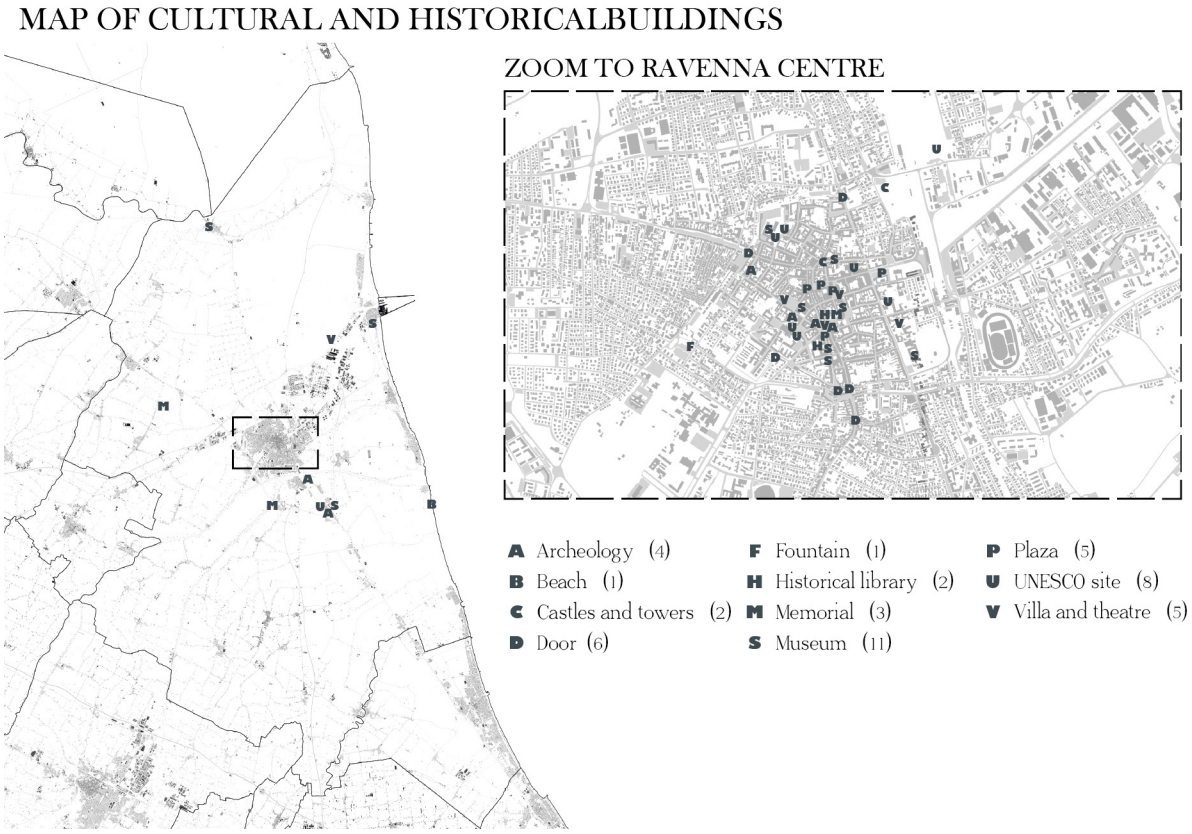


Figure 54: Map of all cultural and historical buildings at Ravenna

The town of Ravenna presents 47 cultural and historical buildings divided into 11 categories:

» Archaeology with 4 buildings (Cripta Rasponi, Giardini Rasponi e delle Terre Dimenticat,- Domus dei Tappeti di Pietra, Ex zuccherificio di Classe, ;
» Beach with 1 building (Spiaggia della Bassona);
» Castle and tower with 2 buildings Rocca Brancaleone, Torre Civica);
» Door with 6 buildings (Adriana, Gaza Nuova, Ravegnana, S. Mamante, Serrata, Sisi);
» Fountain with 1 building (Ardea Purpurea);
» Historical library with 2 buildings (Biblioteca classense, Biblioteca di storia contemporanea);
» Memorial with 3 buildings (Cimitero di guerra di Ravenna, Colonna dei Francesi, Tomba di Dante);
» Museum with 11 buildings (Classis Ravenna, MAR, MAS, Museo arcivescovile, dantesco,

del risorgimento, delle Marionette, Nazionale, TAMO, NaTura, PiccoloMuseo di Bambole e altri Balocchi);

» Plaza with 5 buildings (Anita Garibaldi, Caduti per Labibertà, del Popolo, dell'Acquila, Giuseppe Garibaldi);

» UNESCO site with 8 buildings;

» Villa and theatre with 5 buildings (CapannoGaribaldi, Casa di Giuseppe Mazzini, Palazzo Rasponi, Teatro Dante Alighieri, Teatro Rasi).

The thematic map (*figure 54*) shows a big concentration of them in the historical centre of Ravenna, while few buildings are scattered over the rest of municipality.

One category deserves to be better describe, the one related to UNESCO sites defined by the "Convention Concerning the Protection of World Cultural and Natural Heritage" (1972).

It encourages member countries to identify and protect their heritage whether it is on the World Heritage List.

The difference between a World Heritage Site and a National Heritage Site lies in the concept of "outstanding universal value".

8 sites of Ravenna (*figure 55*) are under the World Heritage List, the description available in

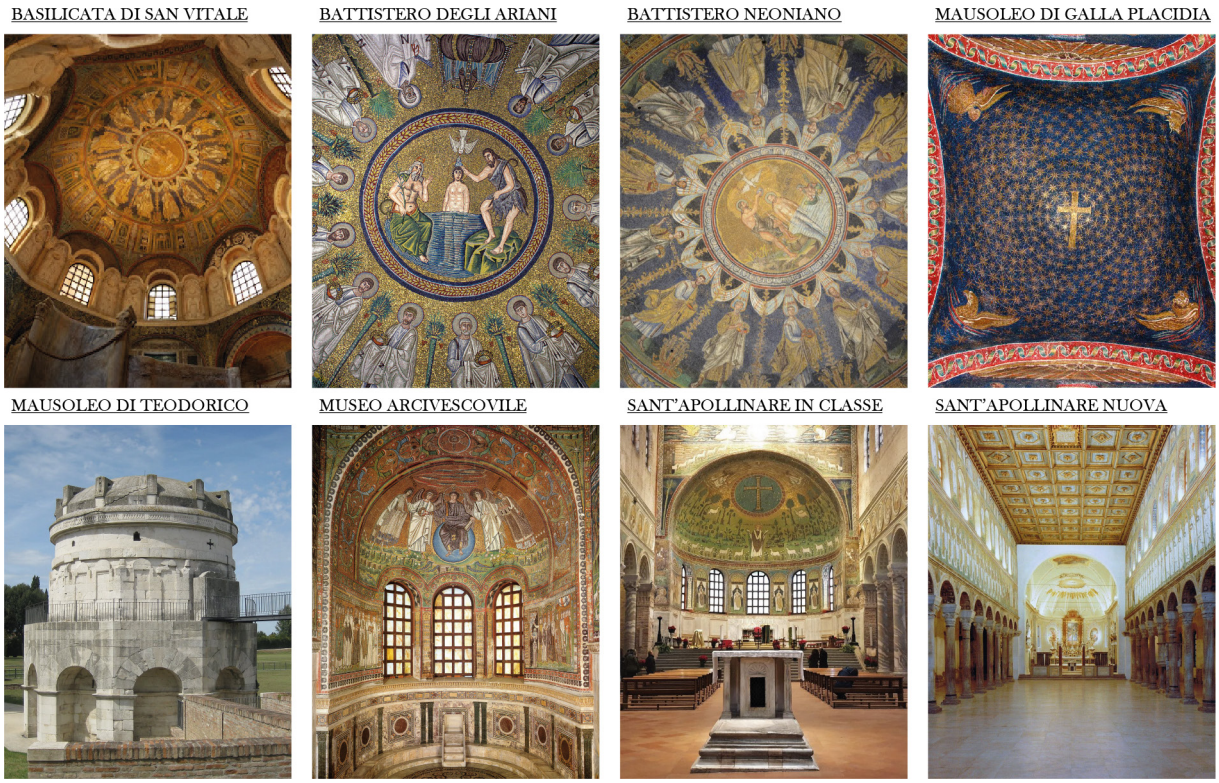


Figure 55: The 8 UNESCO sites

the UNESCO website says: "Ravenna was the seat of the Roman Empire in the 5th century and then of Byzantine Italy until the 8th century. It has a unique collection of early Christian mosai-

cs and monuments. All eight buildings – the Mausoleum of Galla Placidia, the Neonian Baptistery, the Basilica of Sant'Apollinare Nuovo, the Arian Baptistery, the Archiepiscopal Chapel, the Mausoleum of Theodoric, the Church of San Vitale and the Basilica of Sant'Apollinare in Classe – were constructed in the 5th and 6th centuries. They show great artistic skill, including a wonderful blend of Graeco-Roman tradition, Christian iconography and oriental and Western styles".

All the sites are decorated by some artistic elements using mosaic techniques.

The mosaics of Ravenna are truly fantastic and of inestimable historical and cultural value, but they are above all an incredible testimony of the ingenuity and artistic ability of the many masters who over the centuries have designed and created them with precision and infinite patience, giving life to works that define extraordinary still seems too simplistic.

As said before, Ravenna is a concentration of history and culture, which need to be conserved and protected.

For this reason, the analysis goes deeper trying to understand their relationship with locations and risks, in particular flood risk.

For each building has defined the flood risk class in which it falls, if they are inside a protected area and its location in the town (city centre, Classe harbour, outside city centre and Ravenna beach).

RISK AND CULTURE/HISTORY

NAME	COD	FLOOD R.	NATURAL AREA LOC.	RAVENNA LOC.
Basilica di S. Vitale	U	R2	/	City centre
B. di Santa Apolinnare in Classe	U	R3	Ecological Network	Classe harbour
B. di Santa Apolinnare Nuova	U	R2	/	City centre
Battistero degli Ariani	U	R2	/	City centre
Battistero Neoniano	U	R2	/	City centre
Biblioteca Classense	V	R2	/	City centre
Biblioteca di storia contemp.	V	R2	/	City centre
Capanno di Gaibaldi	V	R2	Ecological Network/Po park	Outside centre
Casa Giuseppe Mazzini	V	R2	/	City centre
Cimitero di guerra di Ravenna	M	R2	/	Outside centre
Classis Ravenna	V	R3	Ecological Network	Classe harbour
Colonna dei Francesi	M	R2	Ecological Network	Outside centre

Figure 56: Extract of risks and culture/history table, buildings are, also, assessed for their location inside the town

The risk class has been assessed using QGIS.

Only one passage is needed.

Using the tool “join attributes by location” is it possible to associate the risk class to the point which falls in that polygon.

Results can be observed in figure 56 and it shows:

» 1 building is under low flood risk (2,2%), 43 buildings (91,4%) are under medium risk and 3 buildings under high risk (6,4%);

» 7 buildings are located inside protected areas, of which 3 are placed inside Classe harbour, the ancient roman harbour.

Landscape architecture is not only the design of the green material of the site, but is strictly linked with art, culture and history.

These elements must be considered for the strategy and design to guarantee a discover of them by the future users, both tourists and residents.

The analysis provides the basis to know the features, their disposal in the territory and their characteristic.

All this make simpler to understand the future decisions in terms of both what and where to place actions and strategies.

3.2.8. URBAN ANALYSIS: THE HARBOUR

As previous different analysis has highlighted, harbour is a centrality for Ravenna.

It is the economical hub producing the highest income and providing lots of work opportunities, but at the same time, its location and characteristics define it has a barrier for the ecological continuity.

A study in deep focused on the harbour can be helpful to better direct decisions towards the goal to mitigate issues and develop a greener harbour.

Analysis concerns accessibility, zoning and activities and statistics about passenger and freight traffic.

Accessibility (*figure 57*) analysis regards the entire municipality to better understand relationships between the harbour and main transport infrastructures, such as highways, provincial and statal road system, railways and airports.

After that there is a focus only on the harbour highlighting public transport infrastructures.

Maps are done by drawing layers manually using OpenStreetMap as base map, the only com-

putation has been made for isochrones from bus stations with ORS plug in.

ACCESSIBILITY

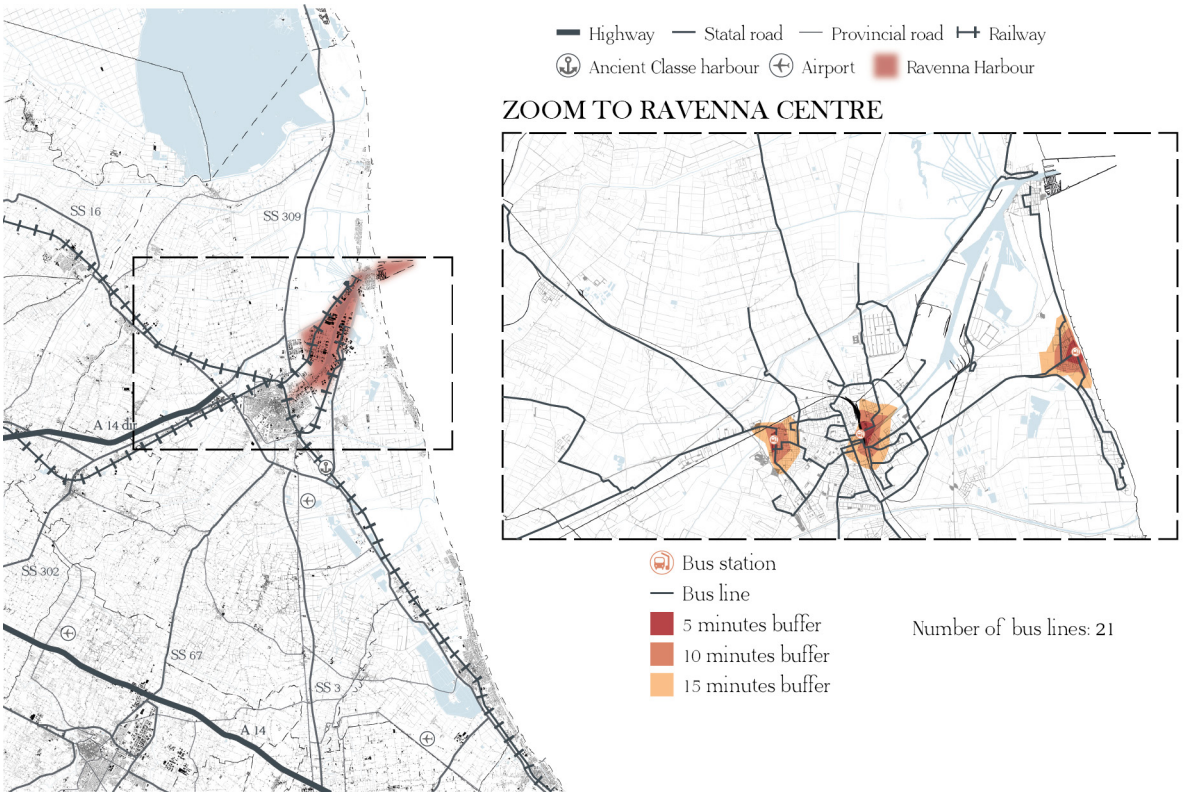


Figure 57: The accessibility to the harbour

The harbour is well connected with the surroundings in particular with two railways branches; the system of provincial and statal roads allows the freight transportation to other municipalities and with highways, which connects the national territory.

Obviously, the road system allows workers and passengers to reach the harbour.

In the area 3 airports are present, the nearest is "Gastone Novelli" airport, which is only 6km from the harbour.

About public transportation, there are 21 bus lines which run near the hub and connects Ravenna centre, the harbour, seaside and surroundings.

There are 3 bus stations strategically located at seaside, the border city-harbour and inside the city centre.

The second analysis (*figure 58*) focuses on the harbour and the description of the different activities provided, the flows of passengers and freights.

"Ravenna harbour, which penetrates the city and extends for over 11km in length from Porto Corsini up to the city dock has been transformed over time from an industrial port to a port mainly commercial, distinguishing itself in the development of shipbuilding and in the transport of solid bulk, which constitute about 66% of port traffic.

HARBOUR ACTIVITIES

Figure 58: Map of the activities inside the harbour

It is a canal port with 22 private terminals, 14km of operational quays and depths currently of -10.50m., which, in area up to largo Trattaroli, they already reach -11.50m.

As for the infrastructural equipment of the port, the overall capacity of the warehouses is 602.258mq, for the yards it is 1.323.922mq and in relation to tanks/silos it is over 1.256.298 cubic meters" [53].

The area is divided into 9 zones, but two of them rules over the other, the first industrial area with a coverage of 43,9%, the second is the one related to industrial activities with a coverage of 40,3% [73].

Other zones are:

» Dock for cruise ship;

» Port authorities, the old one is located near the sea, while the new buildings are located near the darsena at the border with the town centre;

» Monumental cemetery;

» Trattaroli peninsula;

» Touristic harbour.

Among these zones several activities are done:

» Handling and processing of inert substances;

» Storing processes, the most practiced;

» Loading goods;
» Handling containers;
» Loading and unloading goods;
» Shipyards and offshore works;
» Recreational shipyard.

The final part of the study regards the statistical analysis (data are taken from the website of port authority of Ravenna considering a period from 2011 to 2017) about passengers and freight traffic.

Passengers flows are divided into cruises and ferries.

These last ones has five outputs: Bari, Brindisi and Catania for Italy and Igoumenitzia and Patras for extra-Italian countries [65].

Statistics show that the trend is descend from 2011, although a strange peak in 2014 with more than double of flows than the expected; if the trend goes on like this, within few years, ferries can disappear from Ravenna harbour [57].

For cruises the situation is a little bit different [52].

At now there are more than 20 routes which pass through this town, 2011 was the best year of the time considered, but after 2015, the worst one with 39.982 tourists (-116.377 from 2011), the trend is ascendant.

Freight traffic has a totally different values and trends, which main goods transported are:

» Liquid bulk;
» Solid bulk;
» Goods inside containers;
» RO - RO goods (wheeled vehicles with embarkation and disembarkation methods, and loads, arranged on platforms or in containers, loaded and unloaded by means of vehicles equipped with wheels independently and without the aid of external mechanical means);
» Various goods.

Statistics show an opposite trend in comparison with passengers, annual freights moved passed from ~ 15.000.000t during 2011 to ~ 26.500.000t during 2017 (a descendant period occurs from 2005, the best year with ~ 27.000.000t, to 2009 with ~ 18.000.000t).

According to this value Ravenna harbour is the 1° in Italy for handling various goods, 2° in Italy for handling solid bulk and 7° in Italy for total handling.

Recapping all the study done for the harbour it can be say that it is high specified for several activities and there are few spaces for passengers with a lack of public areas (parks, gardens,

plazas…).

Statistical data confirms the possibility to have a complete disappear of passengers, in particular ferries, in few years.

Figure 59 synthesizes all this data.

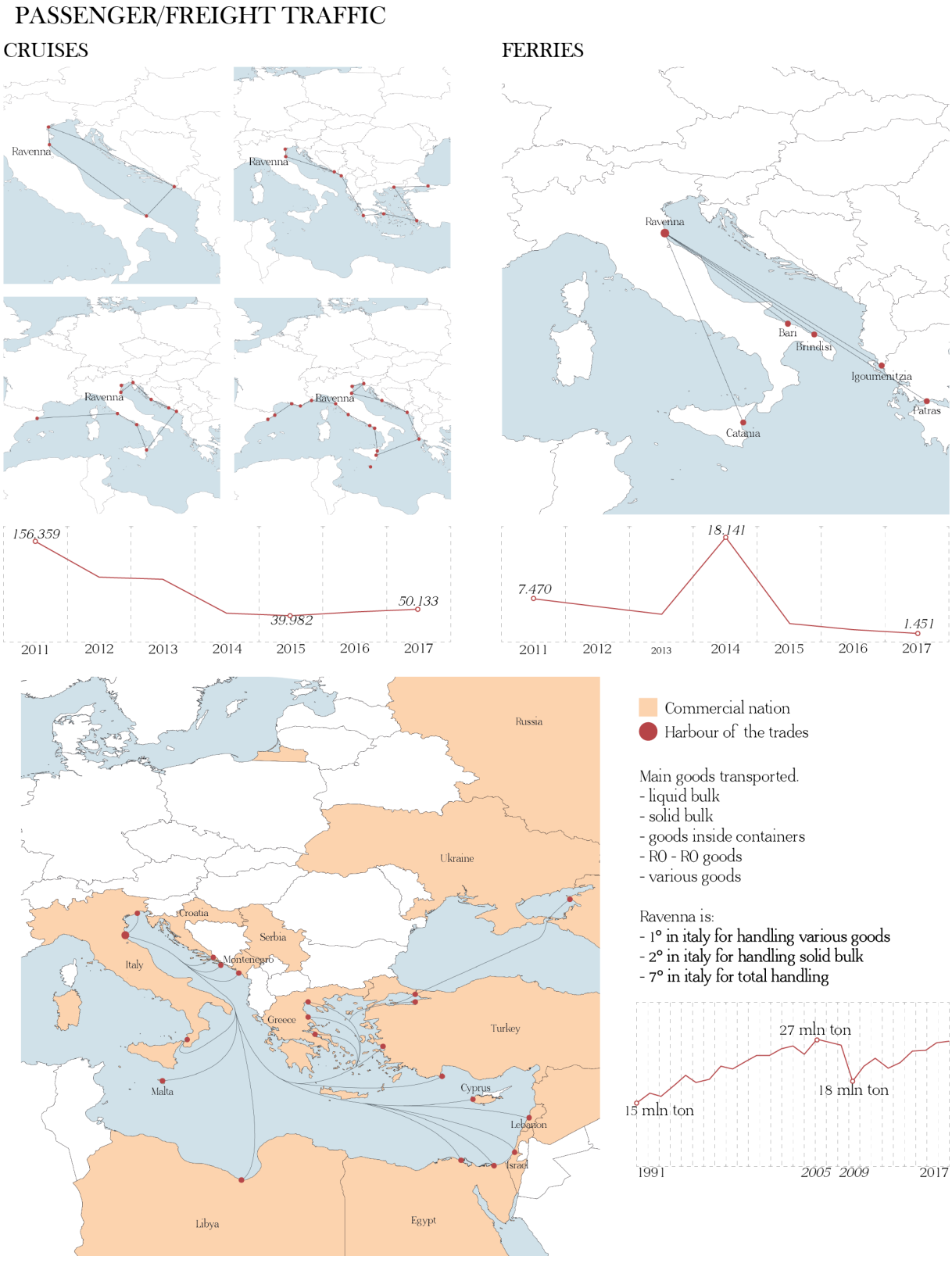


Figure 59: Statistics and map of passenger and freight traffic

Now, as the last element described, Ravenna harbour is also famous for the so called “cemetery of abandoned ships.

These ships abandoned for about ten years in the Piallassa dei Piomboni, an area of the Port of Ravenna, are three river ships dating back to the Eighties, around 110m long, owned by the Russian giant Gazprom.

They are now reduced to wrecks.

It is a story of ships abandoned in Ravenna, due to the shipowner’s debts and legal issues.

The three caravels arrived in 2006 from Sibenik with a load of limestone stones bound for the Fassa Bortolo terminal.

Stopped for security reasons, they have never moved because over time debts have accumulated and sequestrations have taken place.

Even this specific event has to be taken into account, due to the environmental impact these ships are generating on Pialassa.

Following some images of these ships (*figure 60*).

Figure 60: Images ofthe abandoned ships inside Pialassa dei Piomboni

3.3. FINAL CONSIDERATIONS

The entire analysis, divided into territorial and urban scale, provides an overview of the characteristics of the site, a deep knowledge of visible and invisible elements.

Topics addressed depend on the scale used and furnishes different results, which can be the basis for the strategy definition.

The territorial site has seen a high reduction of wetlands, replaced by agriculture, which is the main activity.

Wetland loss is a threat to the ecological equilibrium, because they provide fundamental ecosystem services and sustain biodiversity.

These areas, in addiction with other high naturalistic value areas, such as pinewoods, define the natural capital of the site, which is protected from multi-scale legislations (international, national and regional).

Protection means, in addition to their naturalistic value, that these areas were and still now threatening by anthropic alterations may cause their disappear.

The weakness, in this case, is made by spatial relation among protected areas and between them and surroundings, they are separated and, in some cases, they are negatively affected by human activities.

These last ones don not affect only land and soil, but impact on climate too.

The increase of aridity and precipitation peaks are signals to consider and think about, due to the importance for human well-being both healthy and socio economical.

Land transformation by human provides the destruction of existing equilibrium, this affects the resilience, that is the ability of a material to repair itself after damage or of a community to return to its initial state after being subjected to a disturbance.

Urban areas define the worst value of resilience, that is medium-low, and it affects their surroundings, but it is in land water, which need for care.

Water of wetland is suffering from over intakes of pollutants and human activities, like fishing.

This level of resilience is influenced by ecological quality, a deep analysis on bioenergy and fluxes show the importance to have heterogeneity in terms of land uses, agricultural activities (different crops) and biodiversity.

The presence of hard infrastructures and homogeneity determine low fluxes all over the site, in particular in the SO area.

Bioenergy and fluxes are fundamental for the exchange of biomass and energy, which are strictly related to the general health of the territory considered.

The last thing about territorial scale refers to an element that is highly present in the site. But it can be developed: tourism.

The are has characterized by existing hiking trials, camper station, naturalistic events and lots

of cultural areas which can be discovered.
The problem is that tourism is concentrated along the seaside, while the other attractors remain secondary.
This can be the basis for the construction of something new, more related to nature and culture than seaside.
Wetland loss does not occur so much as at territorial scale, but here, the problem is related to the relationship with urban areas and, in particular, Ravenna harbour.
This last one is affecting on surrounding Pialasse, more than others Pialassa dei Piomboni.
Also, urban environment in addiction to agricultural activities have generated emissions which now a decrease in the urban quality.
The site has to face to different risks related to man-made actions, such as air pollution and flood risk; another one is water sea rising due to climate change (process worsen by humanity) which may cause in the future problems of all kinds (environmental, economical, social…).
Essentially, Ravenna suffers from a bad relationship between environment and people, this problem is a result of reckless actions due to little knowledge of the impacts and / or the tendency to favor economic development rather than environmental protection.
But there is the need to think about these issues, because Ravenna owns a huge amount of diversity in terms of vegetation and avifauna, due to the presence of several environments which own features.
Is it possible to consider another kind of "biodiversity" for Ravenna linked to all historical events which determine the existing epithet of "capital of mosaic" with the presence of 8 UNESCO sites.
This is a strong potentiality which is not valorized and it can be observed by touristic statistics which confirms the primacy of seaside.
Then, the harbour is the main economical source of the city and it the same time is the element which impact higher in the site.
Knowing urban features, movements of passengers and freight, the kind of activities provided can be useful to provide the mitigation of its impacts.
The harbour presents a bad situation according to environmental characteristics, no designed green and blue areas are present, also no public areas are present, no soft infrastructures connect it with the city centre.
The analytical phase is not concluded and the knowlegde is enogh to think about the strategical actions.

3.4. SWOT ANALYSIS

Thank to the analytical phase, the SWOT analysis can be assessed with the definition of strengths, weaknesses, opportunities and threats.

Essentially, this process deals with a summarization a summary of all the analysis provided till now, identifying existing positive (strengths) and negative (weaknesses) elements and future positive (opportunities) and negative (threats) ones.

The diagnosis of these elements aims at a better understanding and knowledge of the current state of the site, considering both scales, and the possibility to the definition and planning of a GI in a sustainable way.

Figure 61 shows SWOT results

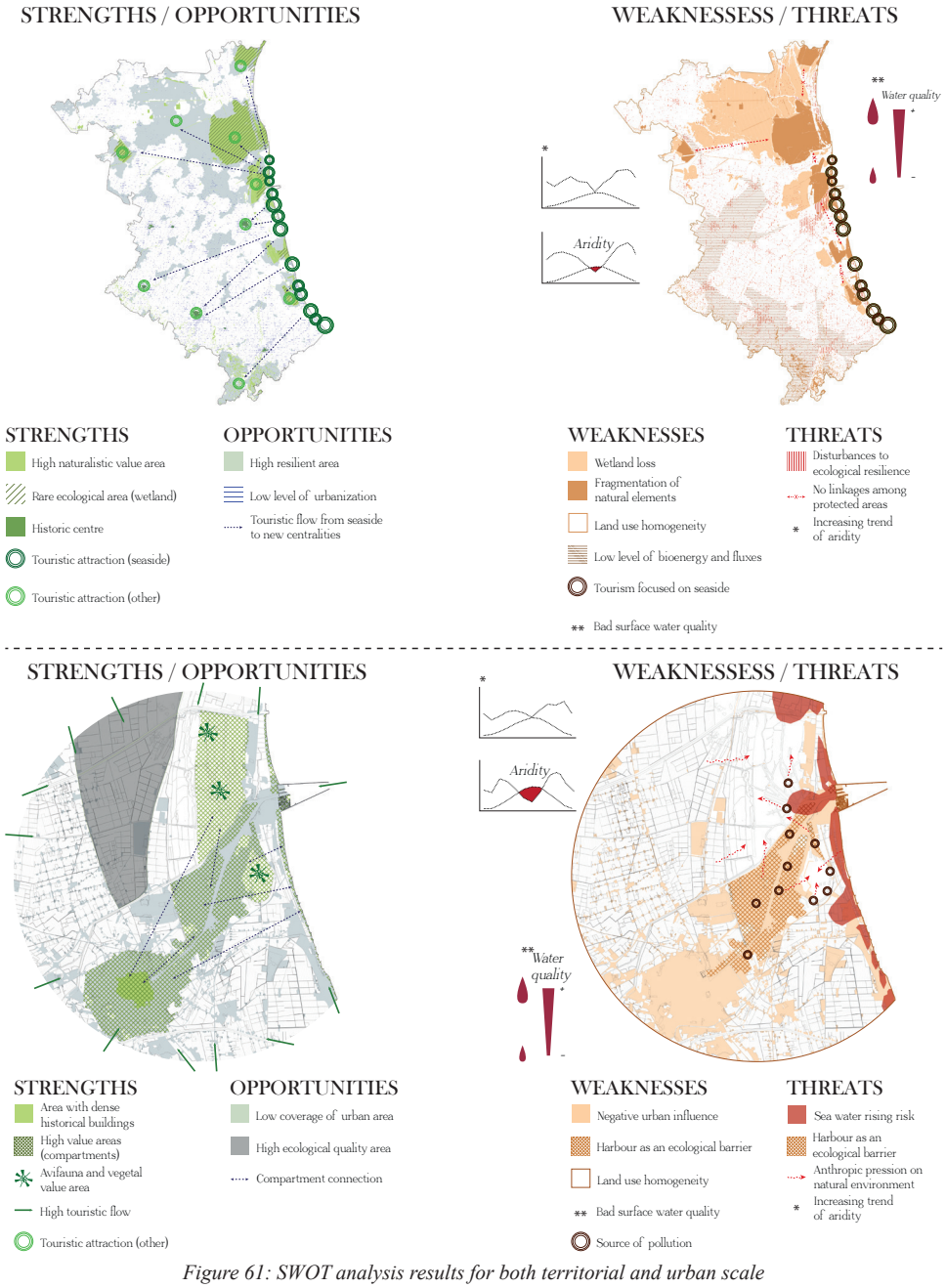


Figure 61: SWOT analysis results for both territorial and urban scale

4. STRATEGICAL PHASE

The next step to the analysis phase is the definition of a strategy that is consistent with what was developed previously.

After a careful reflection on the results of the analytical phase and a bibliographic research on the possible development options, it was decided to operate following the analysis scales.

In this sense, it will be a strategy on a territorial scale that covers the entire area in question and, subsequently, one will be determined on a municipal scale with greater detail on processes and solutions.

According to the urban scale analysis the second scale strategy considers Ravenna, in particular the area of the harbour and its surroundings.

4.1. TERRITORIAL SCALE STRATEGY

The strategy on a territorial scale is structured on the planning of a green infrastructure based on 3 different systems (*figure 62*) [95]:

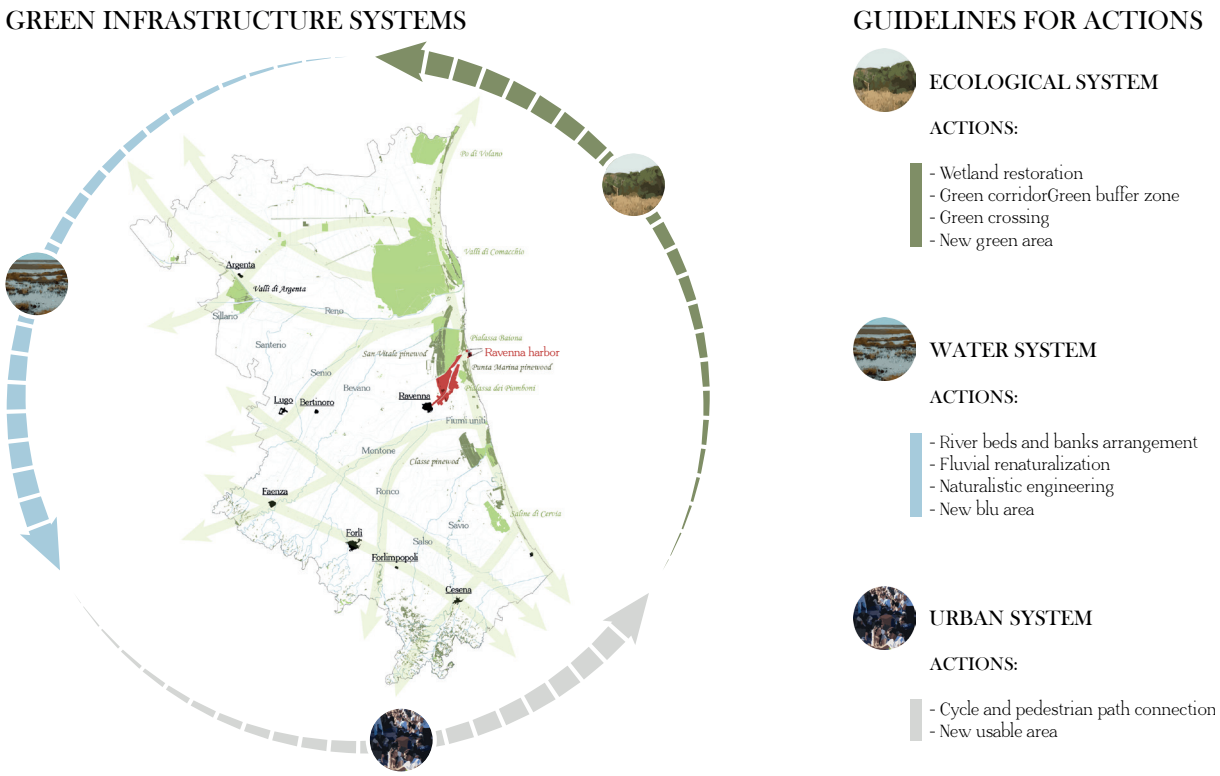


Figure 62: GI concept and actions for single system

» Ecological system: the goal is to obtain an ecological connection between the areas affected by the proposal through multiple ecological corridors, thus obtaining an enhancement on

a territorial scale. Actions vary from the development of riparian areas along waterways, edges and vegetated crossings along road axes and the inclusion of new green areas (parks, wetlands or dunes);

» Water system: the goal is to ensure an increase in water quality, mitigating negative effects (pollution, floods, rising sea waters). The actions vary from the re-naturalization and cleaning of banks and river beds and the construction of multifunctional controlled flooded areas (buffer between source of pollution and output, drainage basins, water collection basins);

» Urban system: the goal is to generate new attractions with both ecological and history-cultural functions that can be reached through gentle and sustainable mobility. In this way it is possible to encourage naturalistic and history-cultural tourism even towards those areas that are now less attractive. The actions vary from the improvement, expansion and connection of existing cycle-pedestrian services and the design of a network of extra-urban cycle-pedestrian infrastructures, thus favoring the rediscovery of local areas and the increase of existing activities.

These solutions are basic guidelines for the definition of the GI, they respond as solutions to the problems identified in the analysis phase (*figure 63*).

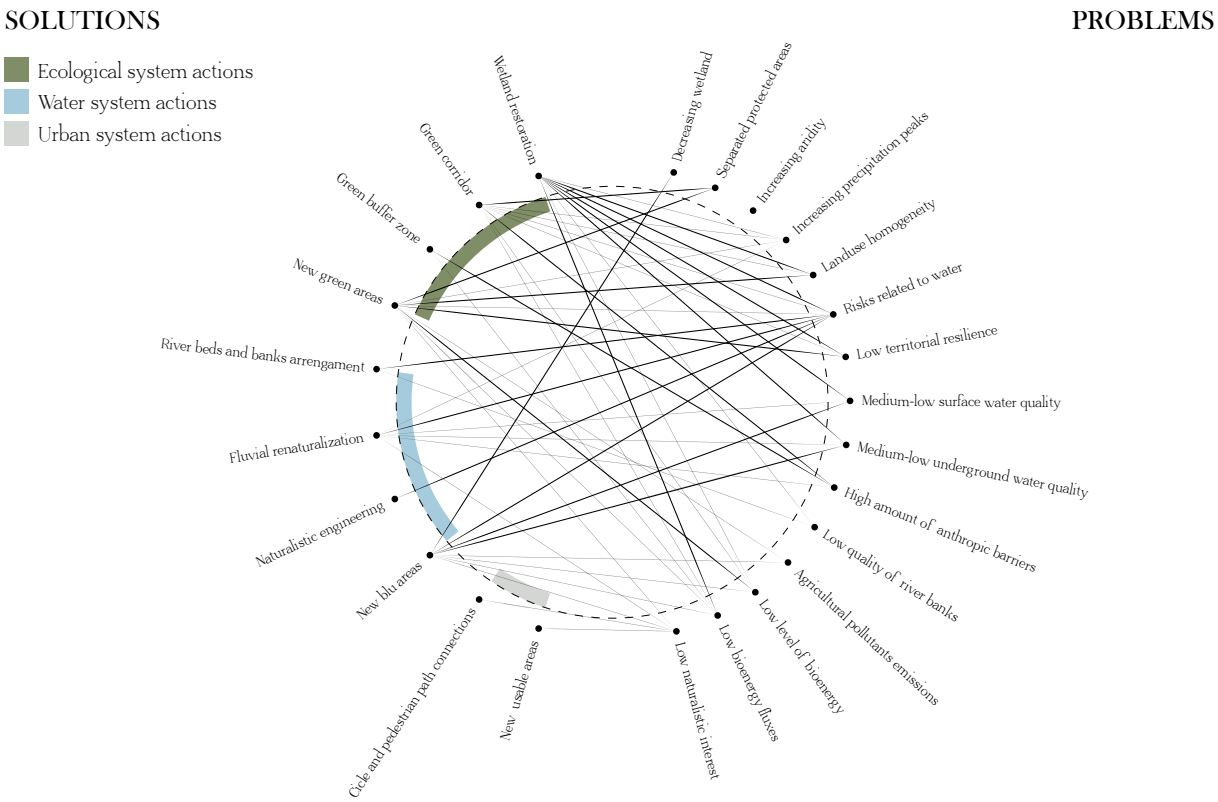


Figure 63: Diagram expressing relationships between solution guidelines and issues revealed from analysis

For the planning phase, the prestigious areas of the site were taken into account.

The analysis carried out show the presence of elements that are recognized as having a value:

» Historic centers: they represent the historic heart of some cities (Argenta, Ravenna, Forlì, Faenza, Bertinoro, Cesena and Lugo). They are recognized with values concerning their history, importance in some periods, the presence of ancient buildings, positioning along historical nerve axes (Via Emilia);
» RAMSAR areas: wetlands recognized internationally by the RAMSAR convention in Iraq on February 2, 1971;
» Areas recognized at European level by the Natura2000 initiative. They are natural areas defined as sites of community interest (SIC) with significant characteristics that require specific protection and safeguarding regulations;
» Protected forests: these are all those areas used as forest or woods that fall under the Galasso law, art. 142, letter d. It is not possible to build within a 150m band of these areas;
» Watercourse protection zones: represents a strip that runs along rivers and canals protected under Article 17 of the Galasso law. It is not possible to build within a 150m band of these areas;
» Protected coastal area: according to art. 142, letter a, of the Galasso law, it is not allowed to build within a 300m strip of the highlighted coastal area.
» Elements of the regional ecological network (RER): it consists of those areas that fall within the definition of the regional ecological network of Emilia-Romagna shown in the PTR (Regional Territorial Plan).

These represent the elements that are still recognized, at different levels of scale (regional, national, European and international) as areas with natural and/or history-cultural values.

From the various analysis carried out, however, areas have been highlighted that have characteristics that are worthy of being recognized and considered:

» High resilience areas: are those areas that have a high resilience, seen as the relationship between human needs, environmental supply and their exchanges (Wu at all.2020). A striking example concerns the whole area located NW of the Valli di Comacchio, that was once part of the immense wetland area, which has been reclaimed;
» High bioenergy areas: the ecological analysis shows that some sectors enjoy a high amount of bioenergy (sum of the actual energy produced in relation to the ecological specificities of the sector itself);
» Areas with high bio-potentiality: always from the ecological analysis it is possible to extract those areas that produce a more than modest amount of energy.

After mapping the recognized and unrecognized areas, which are equipped with one or more values, it is possible to define the main action strategy.

It, as defined above, is the planning of a green infrastructure (GI) that can enhance the entire study area through the recognition of new protected areas.

The latter will be put in contact with the areas of existing historical-cultural value (historical centers) through the extension or new planning of ecological corridors (*figure 64*).

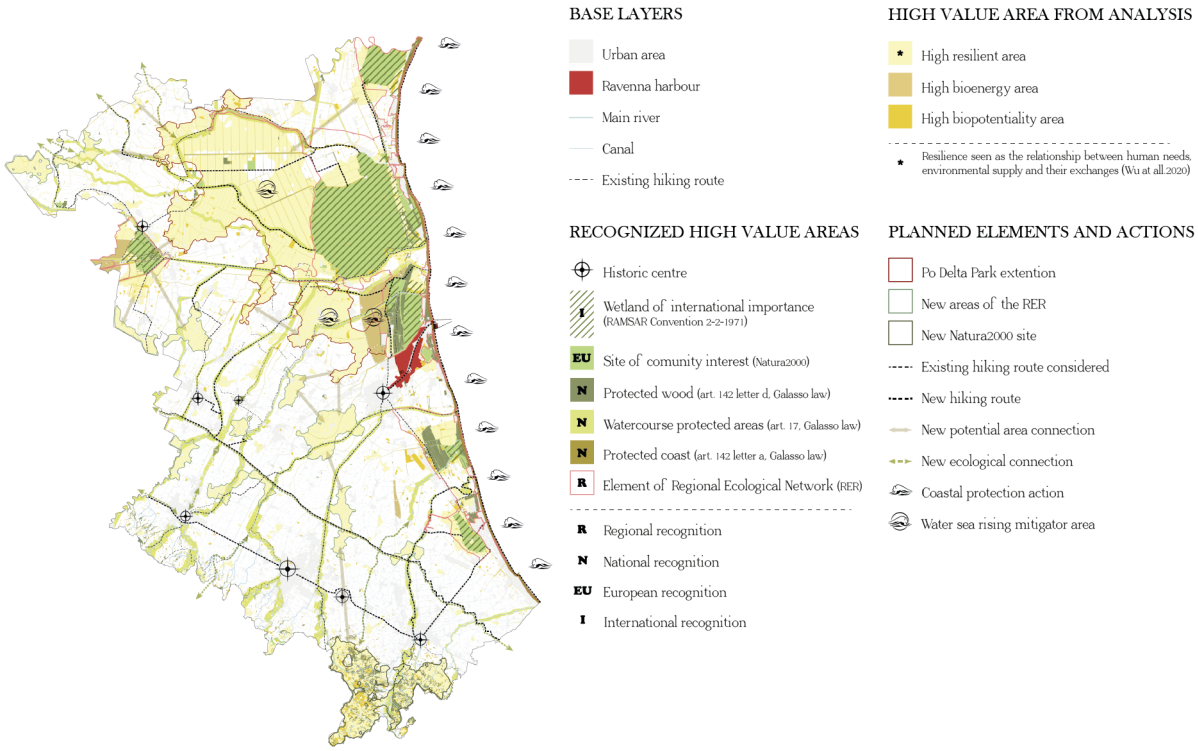


Figure 64: The Green Infrastruture planning map

The entire system will then be crossed by a network of hiking routes to have a public use of the entire structure (links will be added to the existing routes where necessary).

The Po Delta park will be extended to include that area with a high resilience value.

Such is made up of those cultivated fields that once represented a huge wetland area.

The idea is to partially restore it with a gradual process by linking it to appropriate and sustainable agricultural activities.

This proposal can also provide enormous help in mitigating the sea water rising effect (the entire Po Valley will be subject to this type of problem) by constituting a huge controlled flooded area.

The area located to the South, on the other hand, will be proposed as a new Natura 2000 site thanks to the presence of forests of great importance and areas with a high value of bioenergy and bio-potentiality.

The other high resilience areas and sectors of value will be proposed as an extension of the Regional Ecological Network

The planning of the green infrastructure, in addition to enhancing the valuable elements (increasing the ecosystem services provided), will mitigate the problems identified previously.

As regards the protected areas, there will be an increase of 16.3%, passing from a coverage of 33,3% (97.733,4ha) to 46,3% (145.985ha).

Figure 65 shows the final assessment of planned protected areas system.

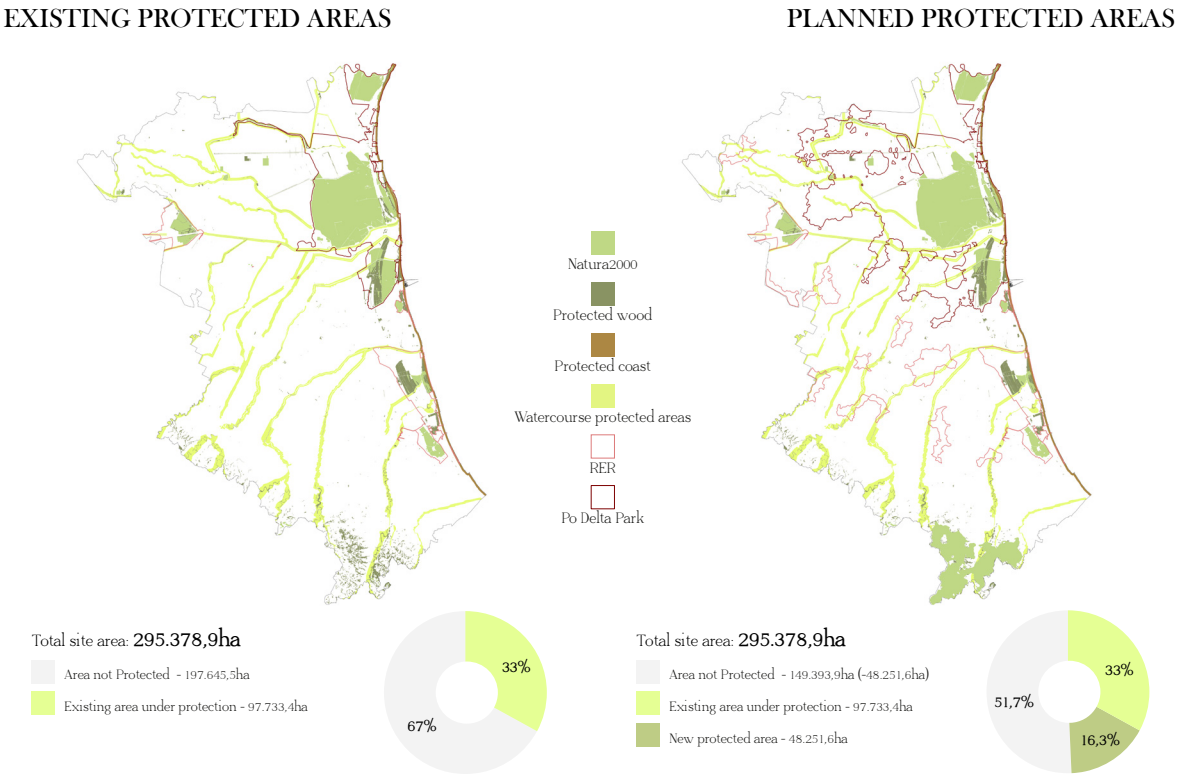


Figure 65: Before and after maps ofprotected areas

4.2. URBAN SCALE STRATEGY

Following the territorial strategy, one will be developed on a municipal scale, particularly focused on Ravenna.

The choice was determined by the analysis carried out, thanks to which it was possible to ascertain the importance of the town from a tourist, historiy-cultural, naturalistic and economic point of view.

The port represents the crucial element for the city's economy, but at the same time causes an obstruction to the ecological continuity of the territory.

The main objective is to identify a system that is able to determine a connection in the N-NW / S-SE direction between the areas of naturalistic value (Pialassa Baiona, Pialassa dei Piomboni

and pine forests) and one in the N -NE / S-SO direction between the sectors of the municipality of Ravenna (seaside area, port and city center, that is between tourism, economy and culture).
This system must then be able to integrate with that on a territorial scale described above.
The goal will be achieved with the planning of a green belt that encompasses all the elements to be joined by inserting new green and blue areas and links that integrate with the existing and newly designed gray elements.
For each sector the functions and ecosystem services produced, the problems due to them are defined and, finally, the objectives to be achieved with the relative solutions to be adopted.

4.2.1. COMPARTEMENT 1: PIALASSE AND PINEWOODS

The areas considered by these sectors are the two wetlands, namely Pialassa Baioni and Pialassa dei Piomboni, and the related pinewoods, San Vitale and Punta Marina [26].
The state of conservation of the humid areas is poor due to the atrophy of the water caused by anoxia (total or almost total absence of oxygen).
The issues related to these areas are:

» Intense fishing activity;
» High tourist load;
» Dredging;
» Increased inputs of organic material due to fishing activities;
» Immission of alien animal species;
» Injection of pollutants due to industrial and agricultural activities.

For pine forests, it can be said that, due to the adverse conditions that have plagued the habitat for some time, they vegetate overall in a state of biological and mechanical stability that can be defined as problematic.
The issues related to these areas are:

» Lowering of the aquifer due to extraction activities;
» Marine aerosol loaded with pollutants;
» Excessive anthropogenic attendance caused by wrong design;
» Spread of invasive alien species.

The main ecosystem functions related to pialasse and pine forests are mainly related to regulation and secondarily to production and culture.
The ecosystem services most performed are carbon sequestration, wastewater treatment, miti-

gation of the effects of climate change, production of drinking water and food, nature tourism and aesthetic value [100].

These are all services that wetlands can potentially provide, but suffer due to the poor conditions in which these areas are.

Considering the identified problems, functions and potential ecological services it is possible to determine their main objectives.

The goal is to restore more resilient habitats, increasing the ecosystem services produced and decreasing the anthropogenic impacts on them.

The actions are [72][98]:

» Re-naturalization and regeneration of wetlands and pinewoods with their possible extension (reintroducing animal and plant species at risk);

» Replacement of impactful activities with more sustainable ones (aquaculture) by promoting eco-sustainable tourism through an appropriate design of spaces;

» Promote buffer strips of constructed wetlands of waste water and/or agricultural practices with low environmental impact.

Figure 66 synthesizes what has been described above.

Figure 66: Compartement 1 description, issues, potential and real ES

4.2.2. COMPARTMENT 2: SEASIDE

Of the approximately 38 km of coastline in the municipality of Ravenna, 28 km are controlled for bathing purposes.

The remaining part, permanently forbidden to bathing, consists of river mouths (Bellocchio canal, Destra Reno canal, Bevano, Lamone, Savio and Fiumi Uniti) for 3.3km, by structures of the Ravenna harbour canal for 1.2km and from the area of the firing range of the Italian Navy near the mouth of the Reno river for 5.2km.

Over time, the area has undergone an almost total elimination of the dunes which confer eco-systemic services both to the coast itself and to the hinterland such as the mitigation of erosion and the protection of inland areas from marine aerosol.

The problems relating to this sector are [55]:

» Demolition and leveling actions to obtain space for establishments and seaside activities;
» Compaction of the soil in the strip parallel to the dune alignments due to foot traffic or the transit of motorized vehicles (mechanical cleaning of the beaches);
» Erosion at the foot of the dune resulting from the retreat of the shore line caused by phenomena of subsidence;
» Erosion at the top and in the body of the dune caused by the presence of paths that cut it perpendicularly to the pine forests behind it, favoring the erosive action of the wind.

As for the coastal area, including the beach and dunes, the ecosystem function of greatest importance is represented by that of regulation, in particular the microclimate and protection from erosion and extreme events such as non-exceptional storm surges.

The cultural function determined by the aesthetic value and the possibility of favoring a certain type of naturalistic tourism plays a lesser importance [60].

As previously mentioned for wetlands, they are potential, in fact, in this specific case they remain so due to human intervention.

For this sector, the goal is to ensure a fair compromise between bathing activities and the regeneration of the highly threatened habitat of the dunes.

The actions are [80]:

» Reproduction of dunes in free areas through naturalistic engineering processes;
» Ensure usability without damaging the dunes and that they connect with the entire system;
» Design of tools for erosion control and sea level rise through NBS (if possible).

All this information are presented in figure 67.

Figure 67: Compartement 2 description, issues, potential and real ES

4.2.3. COMPARTEMENT 3: RAVENNA HARBOUR

The port of Ravenna is an infrastructure located along the entire state-owned area of the Candiano Canal, including the breakwaters and part of the Piomboni valley.

There are activities related to the transport of goods, tourism and nautical pleasure.

It is the only commercial port in Emilia-Romagna and one of the main ports of the Adriatic Sea for freight traffic.

The main problems related to the activities and characteristics of the port are:

» Pollution of various kinds (air, soil, water, sound);

» Ballast-water process, spillage of waters rich in alien species;

» Absence of spaces for public use;

» Presence of abandoned buildings in disuse;

» Architectural barrier between the areas of high ecological-natural value and between the beach and the city center.

Given the fact that the port area is almost totally artificial with few green areas, moreover with a poor level of design and no space for public use, it is possible to say that there are no functions or ecosystem services produced.

The main objective for this sector is the mitigation of the architectural barrier effect and all the

negative impacts on external areas due to its peculiar characteristics.

In order to achieve this, the actions are:

» Introductions of green and blue areas that determine the distribution of new ecosystem services;

» Insertion of spaces for public use using the abandoned and disused buildings along the Candiano canal;

» Green and gray infrastructural connections (cycle-pedestrian paths) that connect the external areas with the new design ones.

Figure 68 synthesizes what has been described above.

Figure 68: Compartement 3 description, issues, potential and real ES

4.2.4. COMPARTEMENT 4: RAVENNA CENTRE

The city center of Ravenna is known for the presence of a large number of buildings of historical and cultural value, in particular there are 8 UNESCO sites.

On an ecological level, the municipality has planned a green belt, which, however, is linked only to this sector and is still not fully completed [71].

The problems, which in this case are partial, reveal:

» Absence of blue areas;

» High emissions of PM_{10} and $PM_{2.5}$;

» Tourism that focuses on the seaside area;

» Few soft infrastructural connections with other sectors and their internal fragmentation;

» R2 and R3 flood risk on the entire sector which represents a serious threat to buildings of historical and cultural value.

The city center of the city of Ravenna, thanks to the presence of a partial green belt, produces a series of ecosystem services also linked to regulation functions (climate adaptation, carbon sequestration, mitigation of catastrophic events), culture (value aesthetic, tourism and recreational value) and secondarily of supply (food).

The primary objective is to continue to develop and implement the green belt while also reconnecting to elements of historical and cultural value by providing:

» Insert new green and blue areas with more or less dense vegetation capable of mitigating atmospheric pollution and flood risk;

» Connect, as far as possible, the existing cycle and pedestrian paths and extend them to the other compartments;

» Insert new green and blue connections (bio-retention areas, rain gardens ...) to unify the urban system of natural areas by constituting a sponge city.

Data are shown in figure 69.

Figure 69: Compartement 4 description, issues, potential and real ES

4.2.5. STRATEGICAL MAPS

The planning of the urban strategic system is based on 3 different levels:

» Development of the natural environment (*figure 70*): mainly the green belt will consider a series of land use changes in some areas. There will be a transition from agricultural fields used for simple arable land to areas for forestry and others used for new usable green areas. Some areas devoid of vegetation will be transformed into new areas for forestry and new parks (an example is the Trattaroli peninsula). Others will be used as reforestation of existing pine forests, while a renaturalization process will be adopted for the lagoon vegetation of the canals (change of sections with the use of naturalistic engineering technologies). A part of these selected areas will identify two different buffer or protection areas (one in relation to the wetlands and the other as a shield to the urban expansion around the city center and the port). The proposals for these buffers will concern the design of systems for water purification before placing it in canals or wetlands. The second buffer, relating to urban areas, will define usable vegetated areas and agricultural activities in wooded areas so as to form a block to urban expansion through NBS. To these areas will be added green / blue ecological connections that extend beyond the site considered, so as to unify urban and territorial scale. The last element to consider is the beach area where the proposal defines the reconstruction of dunes using naturalistic engineering systems. This process will ensure greater defense against soil erosion and protection of internal natural environments from marine aerosol;

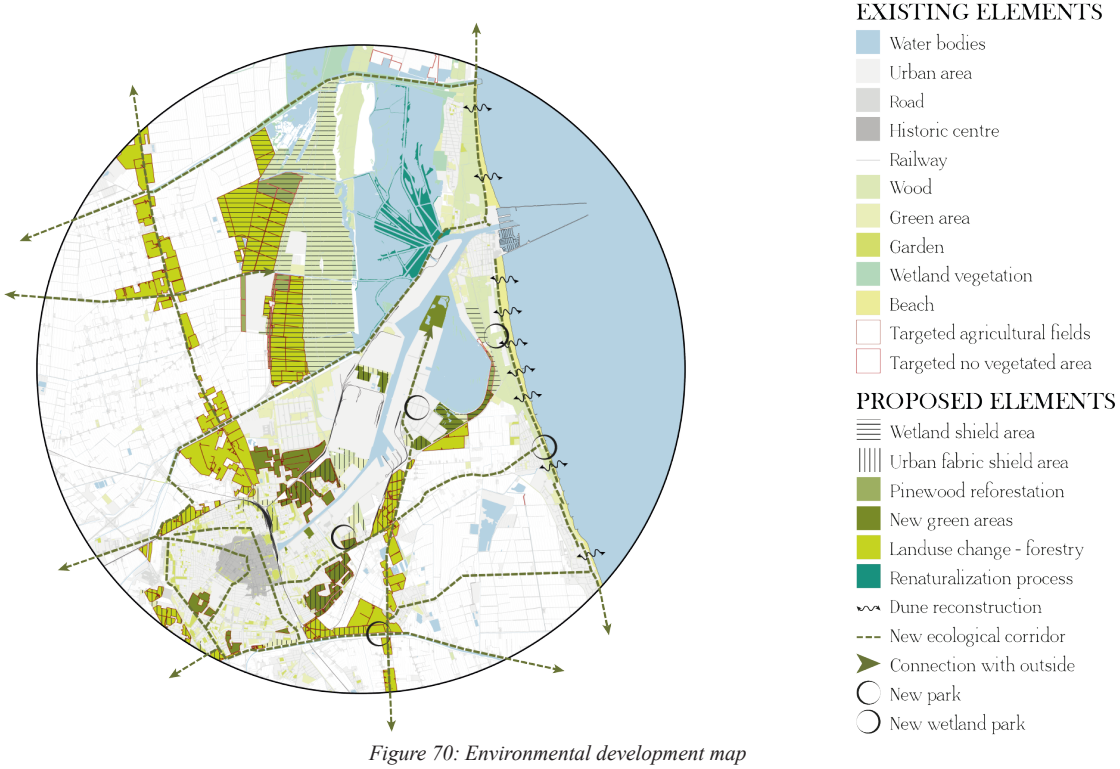


Figure 70: Environmental development map

» Sustainable mobility (*figure 71*): the second level of the strategy concerns soft connections. The existing cycle-pedestrian routes do not guarantee a correct connection between the highlighted sections. For this reason, the proposal provides for the planning the extensions of some of them in such a way as to ensure a complex system aimed at a safe movement over the entire territory in question. As for the ecological connections, the new paths will extend towards the outside of the site to ensure continuity. Additional elements provided by this level are the inclusion of new bus stops at the NW border of the port, in conjunction with the idea of a new park and on the edge of the San Vitale pine forest. Finally, some car parks were also considered both in the city center and in the port, they will have to be redeveloped for a design more suited to the planned plan with the inclusion of bike sharing facilities. The new darsena will be of importance (the focal point of contact between the center and the port) where a public pedestrian area will be developed with the reuse of abandoned buildings with new functions (art center, bar, houses...);

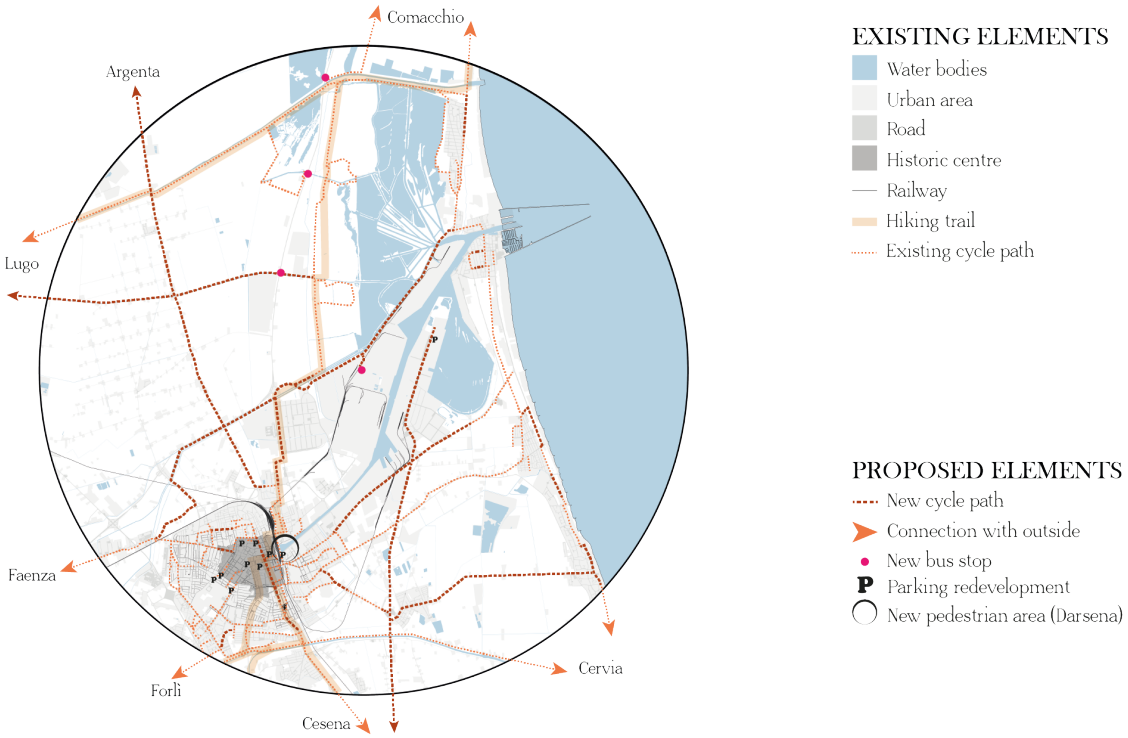


Figure 71: Sustainable mobility map

» Sustainable tourism (*figure 72*): the third and final level concerns the flows of tourists and more generally the formulation of new attractions that can push visitors and residents off the beaches to other places (naturalistic and cultural tourism). In order to do this, there is a need to enhance those new places. In particular, with the renaturalization and insertion of buffer areas as protection, the Pialasse can become new centralities for different activities

(tourism, educational, leisure, physical activity ...). The design of green areas inside the port connected by cycle and pedestrian paths with the other sectors will be able to redefine the relationship between port and city, favoring permeability between the elements. As for the history-cultural aspect, the city center is the master, although sporadic elements have been identified in areas outside them. Part of the strategy envisages the enhancement of these through projects for improving public spaces and adding links. An example is the Garibaldi hut which has an important historical value and is located on the edge of the Pialassa Baiona. The addition of a cycle / pedestrian path that connects the city and Pialassa and the inclusion of a new park will ensure a better flow of visitors and a greater enhancement of the building.

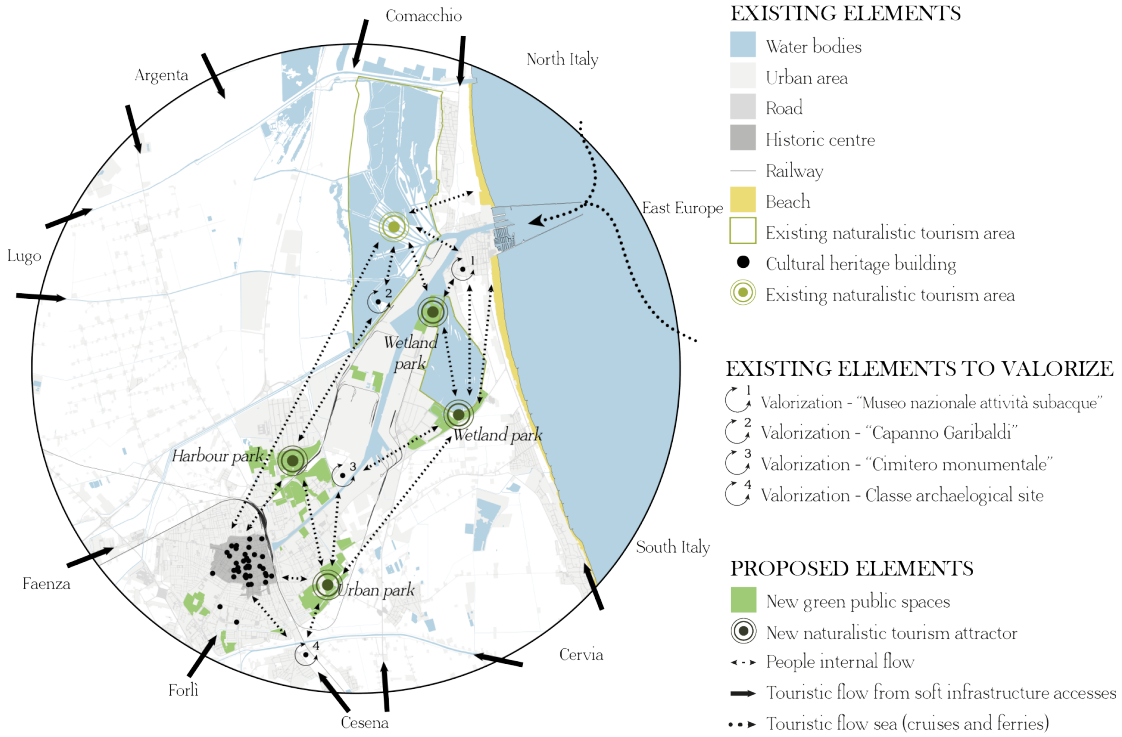


Figure 72: Sustainable tourism flow map

Taking into account the 3 levels described above, the strategy will be able to guarantee an improvement of the ecosystem services provided by the various sectors.

The result will be the planning of a green, sustainable and resilient city (resilience linked to ES) able to adapt to natural and anthropogenic changes.

There will be a shift in tourism towards the new naturalistic and cultural centralities, a greater integration of the port into the complex system in which it is inserted, it will no longer be a disturbing element, but a part of the system.

The naturalistic areas will be enhanced and protected by providing places for a more sustainable relationship between man and nature.

4.2.6. FINAL CONSIDERATIONS

The benefits brought will not only affect the ecology of the area, but will positively influence also all anthropic activities (both agricule, tourism and industry).

The planning of a green infrastructure, integrated with the "nature-base solutions", will guarantee the acquisition of the goal only if it follows some basic principles:

» The ability of the GI to connect existing green spaces;
» The ability of the GI to guarantee multifunctionality of spaces and functions (ecological, socio-cultural, economic ...);
» The ability to ensure the integration between green / blue and gray elements;
» The ability to think and plan GI on multiple scales.

Based on the last point, it was decided to also build a strategy on an urban scale, always defined in the previous paragraphs.

In this case, the planning and management interventions to be developed have been better defined.

NBS are fundamental, as they guarantee multiscalar benefits.

For example, NBS can improve air quality (environmental benefit), which it allows a decrease in diseases related to air pollution (health benefit), which in turn it allows savings in health care (economic advantage).

NBSs provide benefits on a local scale such as disaster risk reduction and increase resilience.

Obviously, these solutions are not without problems, such as the introduction of trees in cities bring benefits such as carbon sequestration and the reduction of the island effect of heat, but, at the same time, it can create VOC emissions, allergic reactions and risks fire.

4.3. EXAMPLE OF GI: LIVERPOOL CASE STUDY

The last part of the strategical capital deals with the description of a Green Infrastructure planning.

The case study chosen regards the one of Liverpool.

All the data are taken from Action Plan document for Liverpool GI [34] and it sets out the actions that are recommended to deliver the Liverpool Green Infrastructure vision that:

"Green infrastructure is planned in Liverpool to support a safe, more inclusive, sustainable and enjoyable city; to provide essential life support functions for a world class city, that is adapted to climate change and where healthy living is a natural choice".

Specifically, the actions help to support five priorities that have been identified for the city.
Four of these have a spatial dimension whilst the cross-cutting fifth deals with design and quality:

» A sustainable city, which supports business, regeneration and housing growth within environmental limits;
» A city providing natural choices for health, which supports improved physical and mental health;
» A cool city adaptable to projected climate change;
» A green and biodiverse city supporting good quality of life for all;
» A city where green infrastructure is well-planned where green infrastructure is a critical infrastructure.

The actions focus on influencing the planning and health sector in particular.
There is a further aim to embed the actions more widely, within the Local Strategic Partnership for example, in order to achieve the scale of change that is required.
Mapping process is extremely helpful to understand trends and dynamics inside Liverpool, so that data are used to support decision making.
Strategy is based on a model that describes green infrastructure in terms of types, functions and benefits Type is the description of the elements that make up Liverpool's green infrastructure.
For each green infrastructure type a range of functions can be identified.
They describe what the green infrastructure type does; it could range from intercepting water to reducing noise.
28 functions have been identified for Liverpool GI.
Multiple functions can be provided by a single green infrastructure type and one of the aims of green infrastructure planning is to achieve high levels of multi-functionality where possible.
Green infrastructure planning is set firmly in the context of public benefit.
There are many ways of identifying and categorising benefits. The Natural Economy Northwest6 project developed a model of eleven benefits that has now been taken up by a range of organisations in the region and across the country.
This is used in this strategy.
Essentially this case study has been taken as a reference to structure Ravenna strategy suiting with the data available and the limits given by this is a stand alone academic work.
In the following image (figure 73) Liverpool GI map is shown.

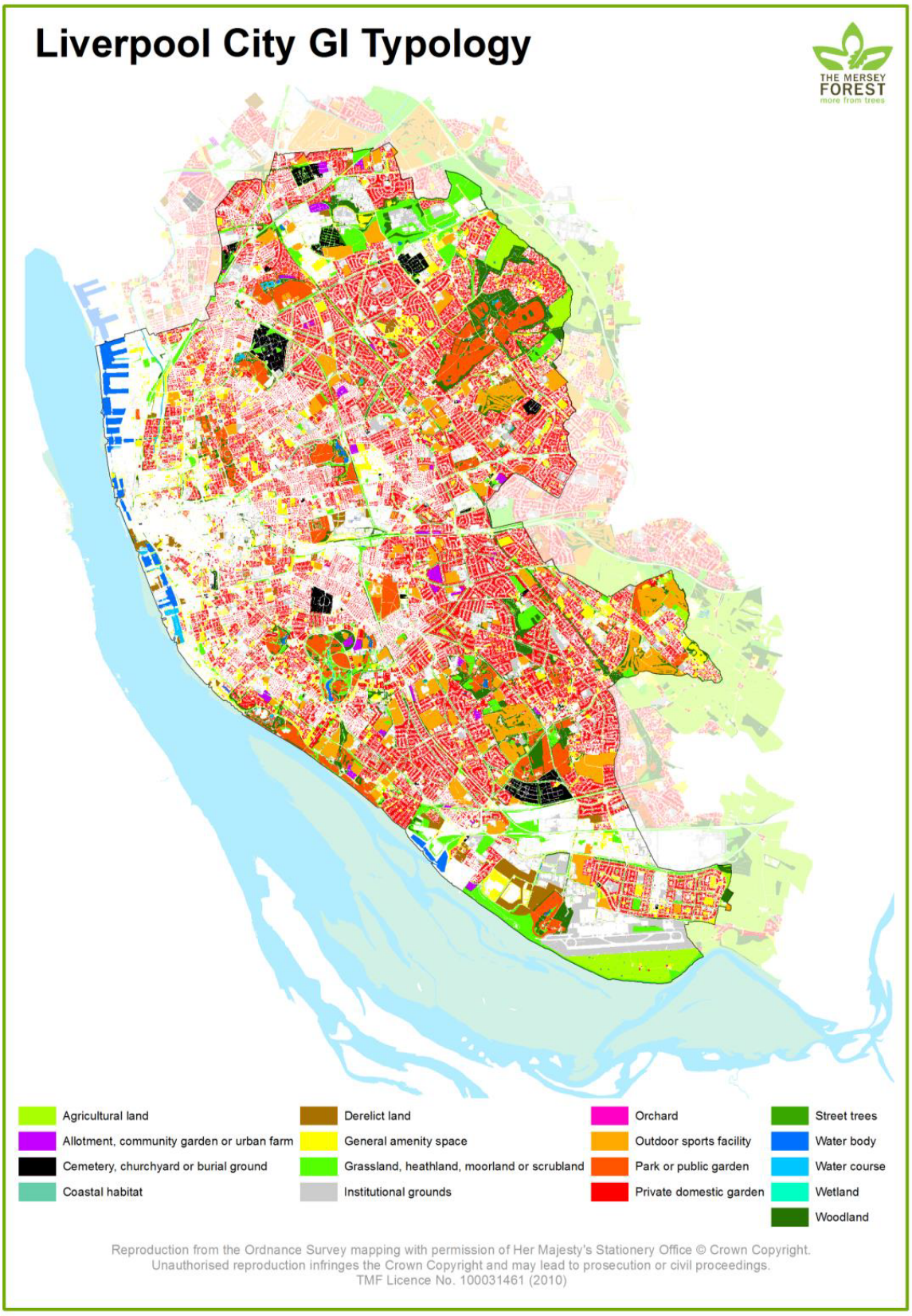


Figure 73: Liverpool GI map

5. DESIGN PHASE

The strategical phase furnishes the planning tools, actions and directions towards the final goal, which is the creation of a resilient system able to increase the quality of spaces for a better environment for both biodiversity and humans.

These strategical actions need to be transformed in practice with landscape architectural designs.

Before focusing on the real spaces designed inside Ravenna it is better to show projects references from which interventions are taken as inspiration.

5.1. HAIKOU EAST & DONGZHAI PORT MANGROVE RESERVE

The masterplan for the Jiangdong New District in the Chinese tropical island of Hainan restores the coastal water network and preserves a particularly sensitive gem, China's largest mangrove forest.

Decades of large-scale, often unplanned urban development and agricultural activities have degraded beaches, coastal wetlands and riverfront areas across the island's capital city, Haikou. Pollution, seasonal flooding and vanishing biodiversity are all challenges for this expanding city facing sea-level rise.

The proposal (*figure 74*) reconnects Jiangdong's waterways into five major water corridors, bringing wetlands into the city and managing urban flood discharge from the city to the farmland and into restored coastal lagoons.

These corridors will become waterfront destinations, with a coastal wetland park and an eco-village to actively conserve and restore wildlife habitats and accessible tourism areas beyond the sensitive mangrove reserve [99].

Following some information about the project:

» Client: Leading group of Jiangdong new area, Haikou, China (Hainan) free trade zone;

» Location: Haikou, Hainan Island, China;

» Status: In progress;

» Year: 2018;

» Area: 300 kmq;

» Author: Hassel studio

Figure 74: Masterpplan of the proposal for the Mangrove reserve

5.2. RESTORATION OF THE DUNAL ECOSYSTEMS WITH TECNIQUES OF NATURAL ENGINEERING

The beaches and coastal sand dunes, often associated with wetlands behind dunes, are among the most vulnerable and threatened ecosystems worldwide.

Despite their dynamic structure and high resilience of their biotic communities, these ecosystems are fragile for the general fragmentation, limited extensions and excessive anthropogenic pressure.

With naturalistic engineering it is possible to intervene to protect and restore the dune system, or intervene to rebuild it where it was destroyed.

The best redevelopment work is always obtained reconstituting beaches and dunes as similar as possible to the original ones and using strictly for the their phytostabilization only indigenous herbaceous and shrub plant species [83].

Among the intervention, which can be applied there are:

» Windbreak barriers (*figure 75*);

» Basal barriers in wicker;

» Checkerboard windbreak screens;

» Construction of dunes through vegetation.

Figure 75: Interventions of dunes reconstruction carried out in the Circeo National Park (Lazio), 2008

5.3. SUSTAINABLE CITY - THE COPENHAGEN WAY

Future environmental challenges must be solved through a sustainable approach to city planning.

The transformation of Nordhavn (North Harbour) continues Copenhagen's historic strategy of a step-by-step expansion into the surrounding sea.

The new Nordhavn is conceived as an urban archipelago (*figure 76*) or a series of dense neighborhoods on the water.

Planning one island at a time, the Nordhavn master plan is not an ideal city vision, specifying every last detail, but rather a robust and flexible guideline intended to inspire future generations of urban planners.

It is a way of addressing one of the great challenges of city planning: designing for the needs and demands of today while trying to predict and address the major environmental challenges shaping our future.

The main structural concept is to break the harbour space up into intersecting canals and basins by creating islets of various sizes.

This layout respects and interprets Nordhavn's past, in which reclaimed land areas created an easily recognizable, rational structure.

Nordhavn will be surrounded and intersected by water, which will lend the district a distinctive character and subdivide it into local districts.

The planning of Nordhavn incorporates the necessary and the extraordinary in the long-standing coexistence between old and new and allows the existing potential to become a launch pad for the area's future architectural identity [89].

Figure 76: Copenhagen Nordhavn transformation

5.4. OLD CENTRAL RAILWAY TRANSFORMED INTO SOCIALLY SUSTAINABLE URBAN DEVELOPMENT IN PARIS

The proposal regards the design of the old central railway station Ordener-Poissonniers in Paris The project is the result of the transformation of the railways and heavy industry into a new 3,7ha carbon neutral "ecosystem neighborhood" based on nature-based design solutions, strengthened social cohesion and on-site renewable energy production (*figure 77*) [85].

Figure 77: Render of Ordener-Poissonniers railway station in Paris

5.5. THE SOUL OF NØRREBRO, COPENHAGEN

The Soul of Nørrebro addresses this issue through a new Nordic Model for city development. It is a highly scalable model based on co-creation, dialogue and humanistic nature-based design solutions.

The project uses nature to solve some of today's hardest urban challenges while increasing the life quality of people (*figure 78*).

This new Nordic Model is based on co-creation, dialogue and a humanistic and nature-based design approach to the shared public space in our cities.

It supports and strengthens the intricate urban systems that define the character of Nørrebro:

» The hydrological circuit;

» The biological circuit;

» The social circuit.

By founding all solutions in a strong city nature, the project amplifies the synergy between the different circuits.

The result is a project that solves a host of urban challenges while at the same time creating new possibilities for social co-existence [46].

Following some information about the project:

» Location: Nørrebro, Copenhagen;

» Year: 2016;

» Author: SLA architects.

Figure 78: Hans Tavsens Park render of Norrebro neighborhood of Copenhagen

5.6. DESIGN PILOT AREA: RAVENNA DARSENA

All the analysis and the strategy definition have been brought to the final part, which is the design proposals.

In this case a pilot area has been chosen to introduce interventions in line with the entire study explained before.

The area is related to the border between harbour and the city centre, where Candiano canal ends in the Darsena (*figure 79*).

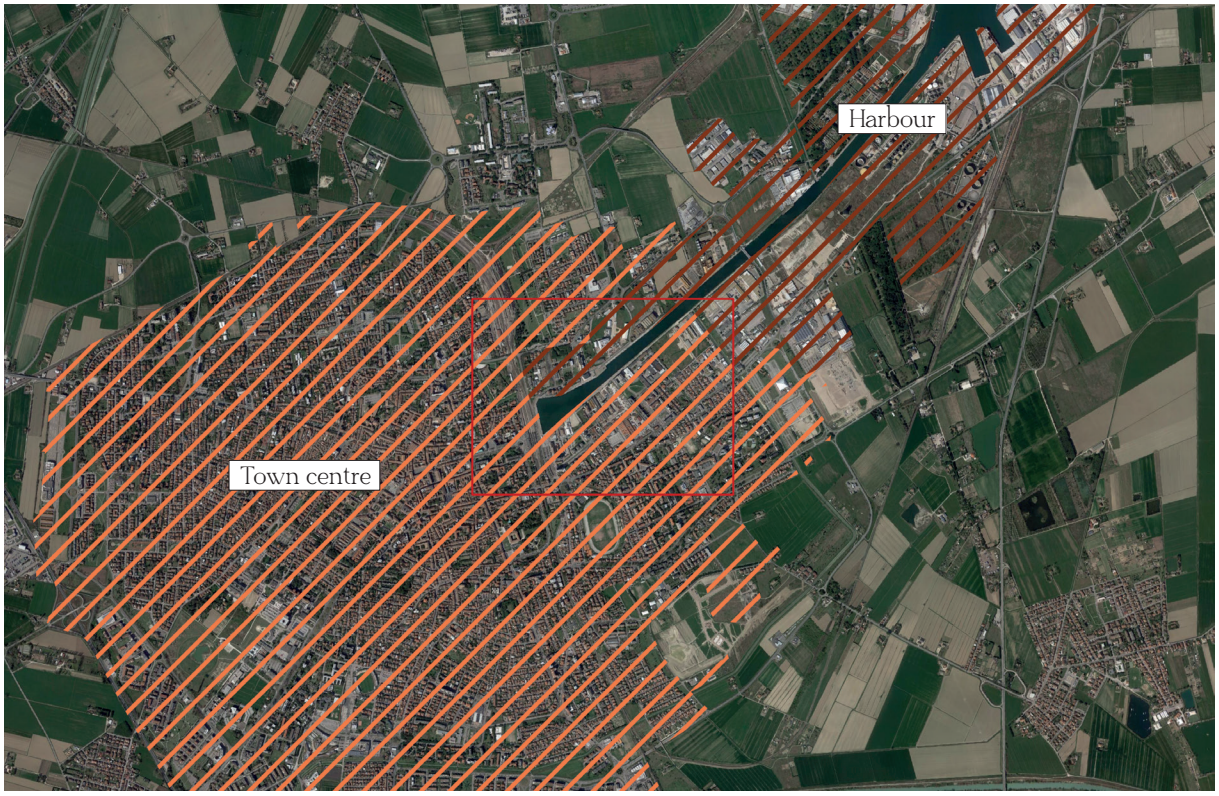


Figure 79: Territorial context of the design proposal

The area is highly urbanized and the railways divides the two compartements.

The exiting situation reveals that the zone is characterized by some important cultural elements, such as Teodorico mausoleum, Sant'Apollinare Nuova church and Brancaleone fortress.

The green areas and linear green elements present are not located along Candiano canal which define it as the barrier spoken about previously.

Also, existing bikelanes and pedestrian paths are located but the they don't intersect with the Darsena and surroundings.

Degraded areas, abandoned buildings, poor design, no public spaces describe the existing situation of the site.

Figure 80 shows images of existing situation

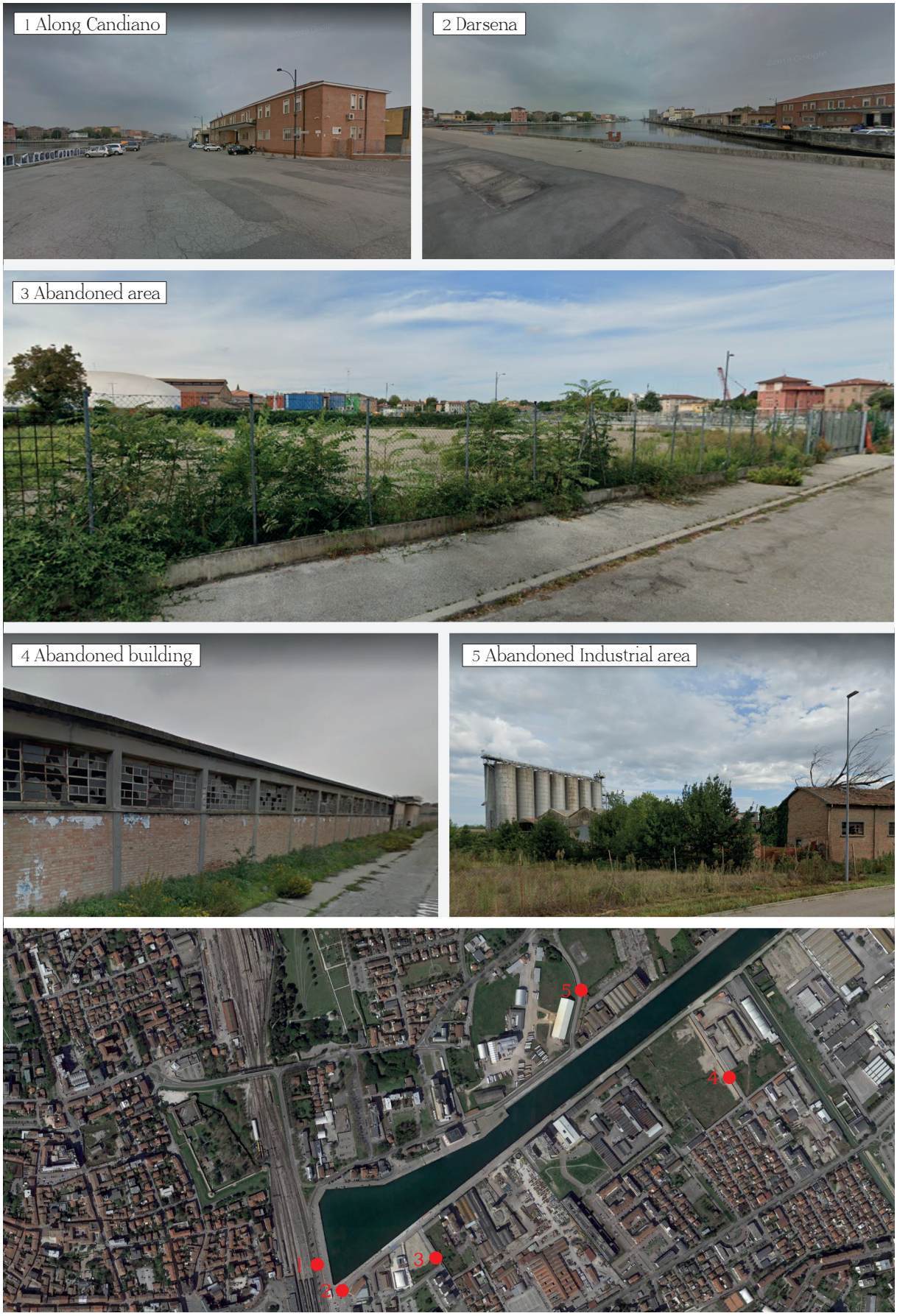


Figure 80: Existing situation of the area along Candiano canal

According to the existing situation and the guidelines provided by the strategy, four actions have been defined (figure 81):

» Cross Candiano canal: as said before, the canal provides an artificial barrier for both nature and people. Proposals will deal with the design of spaces in order to avoid this issues by the usage of both green/blue and grey elements. A N-S connection will be obtained;

» Follow Candiano canal: another kind of connection (W-E) is needed. If the first action considers crossing the canal, this one wants to design spaces along it to provide the possibility to perceive the harbour linking the dock with seaside and the other new design proposals in the harbour;

» Reuse degraded areas and abandoned buildings: due to the area is highly urbanized and there are no "free" areas to be used, the projects want to reuse degraded areas and abandoned buildings as new design sites. This choice will provide multiple benefits. These areas, now, represents pollution sources, spread of invasive species, illegal open landfills, but they are sites with high potentialities. Adding green, blue and soft elements it is possible to bring people and animals there representing new attractors for a different kind of activities more related to sustainability and education. Also they will represents stepping stones for the connection purposes described above.

» Enhance cultural heritage: the last but not the least element is the enhancement of high historical value buildings located in the area. Taking them singularly, most of them do not require any intervention, others are living in the anonymity. One is the darsena itself which is has no value, no one is attracted to visit it. The second one is Moro di Venezia, the Italian challenger boat for the 1992 edition of the America's Cup. It has a strong value in terms of sport but is not well valorised at the moment. The action predicts, using the ones before, to generate a system in which all these elements can be connected and become centralities.

Bringing to fruition these challenges requires the use of NBS or Nature Base Solutions, which are intervention using natural materials such as SUDs (Sustainable Urban Drainage Systems), tree lines, woods, green roofs and walls.

NBS are intended to support the achievement of society's development goals and safeguard human well-being in ways that reflect cultural and social values by improving the resilience of ecosystems, their capacity to renew themselves and the provision of services.

This kind of intervention provides the right interconnection among green, blue and grey structures for a better-quality life for both human and animals.

The new system created will valorise the harbour and the surroundings as a place for people

whose will perceive the site in different ways in a closer contact with nature.

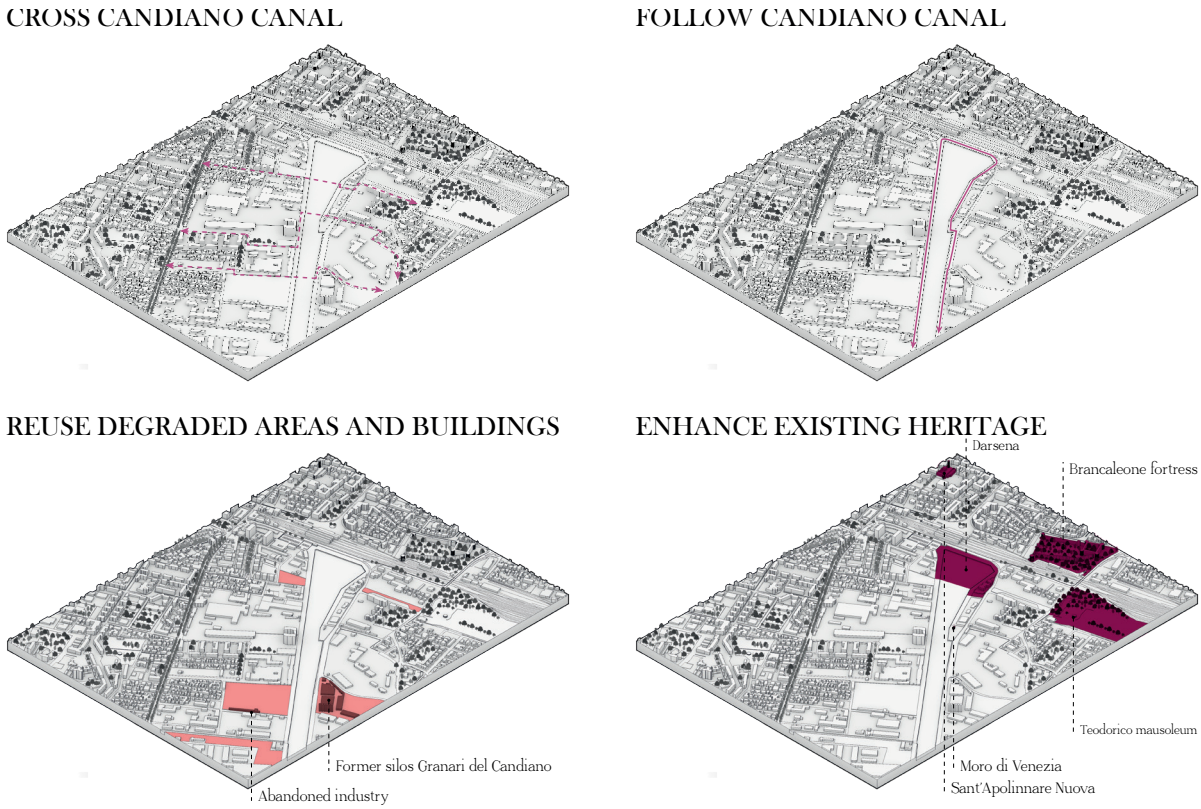


Figure 81: azioni.pdf

Going deeper in the proposal description, the projects foresees the construction of green/blue new areas, usable by people (apart from one) and where possible the reuse of abandoned buildings.

All these sites will be connected with a new boulevard and which help the crossing of Candiano canal and a new way to follow it.

The darsena will be characterised by a floating garden and a pedestrian bridge.

Essentially sevens designs are defined:

» The first is the floating garden, essentially artificial movable floating islands are located and they represents a strong touristic attractors and possible stepping stones for avifauna. They can be design in several ways, with trees, shrubs, only grass or leafless. Different activities can be provided, people can swim near them, they can use boats to reach them and have a rest and sunbathe, or they can be used for cultivation or for energy provisioning. They can be assembled to create a big island for concerts or other kind of activities. Possibilities are infinite;

» The second is the connection of the dock with Teodorico mausoleum introducing a bicycle and pedestrian path with new trees and shrubs;

» The third part is characterised by a former industrial area. The project foresees the creation of a new space for both people and wildlife enhancing existing architecture with NBS like green roofs and walls providing public spaces in relation with blue and green areas. Silos represent a landmark of the site and they can be use to provide an observatory from with visitors can admire a 360° landscape. The area will become an industrial park;
» The fourth element is a non-usable area with only grass, which will be turned into a new green/blue area capable to retain rainfalls or flooded water, the new vegetation cover can provide new ecosystems and habitats for wildlife. It represent a green lung;
» The fifth part is represented by the new boulevard. It is composed by a 4m wide bicycle and pedestrian path and a green corridor defined by trees shrubs and grass. The path envelops the entire darsena from Moro di Venezia to all the other side of Candiano taken into account. It represents an important element to enhance the entire harbour and its perceptions by people, also it represents a green corridor for wildlife which can move from the harbour to the other elements of the new and existing system of green areas;
» The second-last one is represented by a degraded area with an abandoned building. The proposal wants to transform the site into an ecological lung where green, blue and grey elements coexist in a perfect balance. The buildings can be integrated with the use of green roof and walls to become a vertical extension of the new park; different activities can be introduced inside it, such as pubs, cafes, greenhouses, hydroponics and so on. Outdoor activities are strictly related to nature, education to nature can be enhance in this place. Obviously all the benefits expressed in the previous part are provided here. From a “devastated land” a new beatyfull area will be designed and for this reason it will be called “Reborn as a park”;
» The last site is very similar to the previous one, but it is smaller and without any abandoned building. The proposal wants to generate a garden rich in vegetation cover to create a space far from a harbour, a private place where people can feel different emotions and perceive the close contact with nature. It is a Romantic garden

Figure 82 highlights design proposals.

As spoken in the strategical part, actions and designs are used to provide a new relation among compartments that lead to the enhancement of resilience which is relative to the Ecosystem servises provisioning and defence from anthropic and natural alterations.

Each single areas due to their characteristics and materials used will provide different ES, that are linked to functions based on their purpuses.

For example the new harbour boulevard has as main goals to provide soft infrastructural con-

nection along Candiano canal, so the main ES placed are related to cultural one and secondary to regulation.

Figure 82: Parallel perspective and masterplan of the site highlighting new designs

Another example can be given by the two areas with abandoned buildings (also floating park)

which are the only one can provide provisioning services (food) due to the installation of greenhouses, hydroponics and cultivation (floating park).

The romantic garden wants to create a particular place so important is to provide sound protection.

Some ecosystem services can be provided by most of the sites, in particular regulating services, such as climate control, extreme events mitigation, water purification and carbon storage.

Figure 83 tabulars ecosystem services and their intensity for single design area.

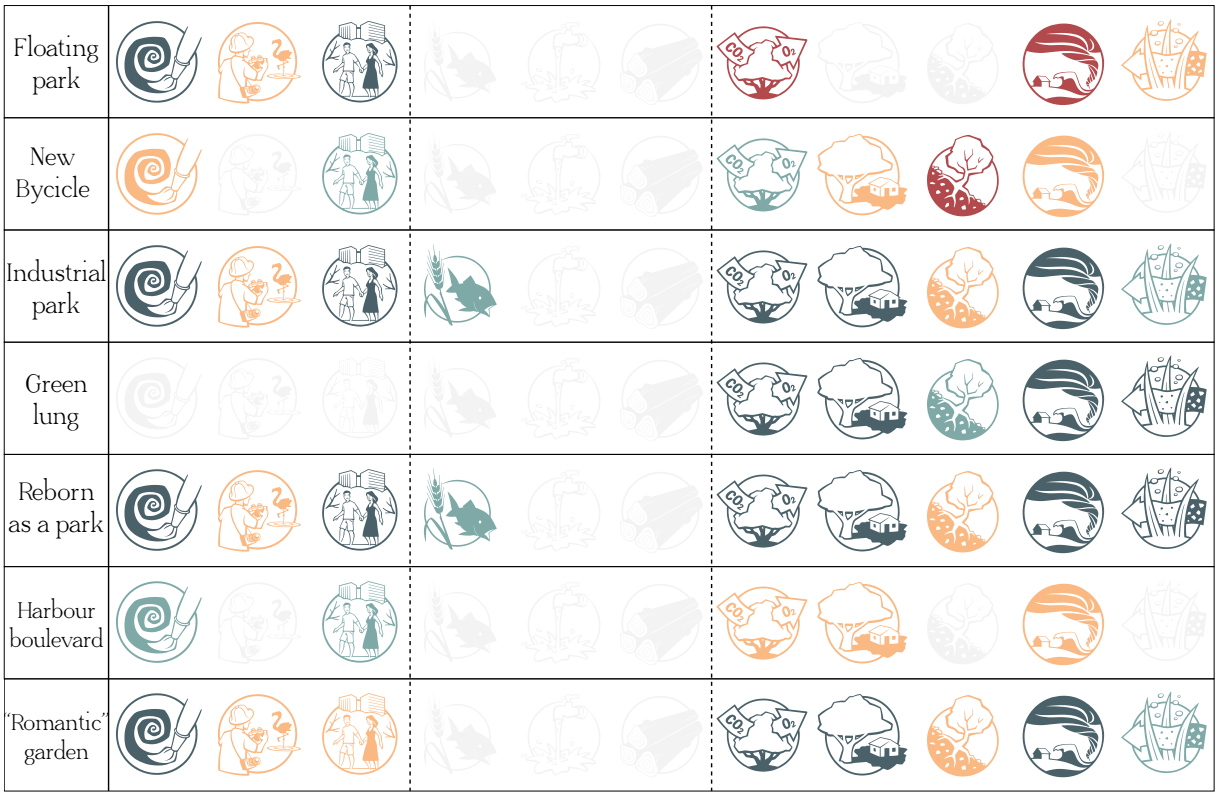


Figure 83: Table of ES provisioning of single design area

5.6.1. DETAILS OF DESIGN PROPOSALS

The last part part of design chapter deals with the descriptionof some detailsabout design proposals, like views and section.

Three sites have been decided:

» Floating garden (area 1);

» Reborn as a park (area 5);

» Harbour boulevard (area 6).

The first one is the floating garden (*figure 84*) and the image is taken from a boat which is browsing in the dock.

This one will be a new public space characterized by floating islands which can be usedin dif-

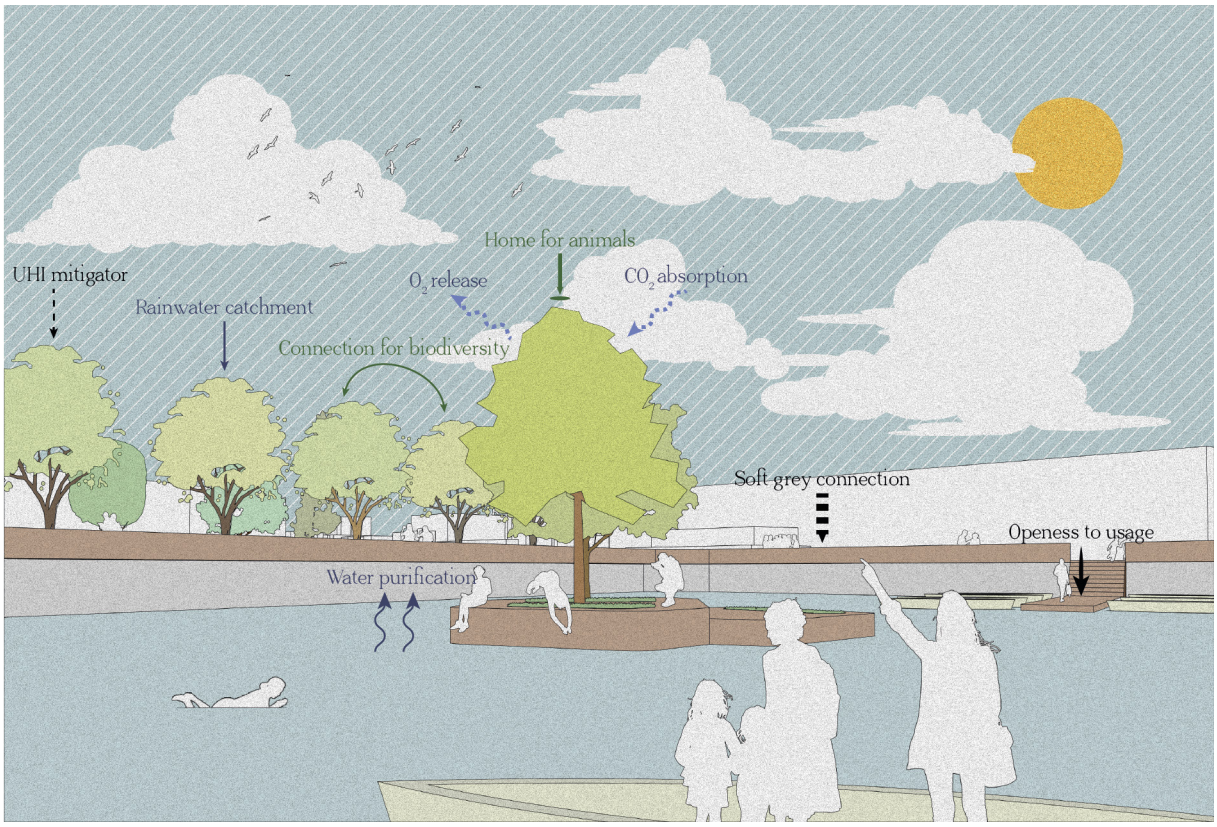


Figure 84: View to the floating garden

ferent ways by people, such as a place to have a rest, to take photos, appreciate the panorama, swimming etc.

Figure 85: View from the "Reborn as a park" site

In the background the new boulevard with the new tree line, used to generate a relationship between green and grey solutions.

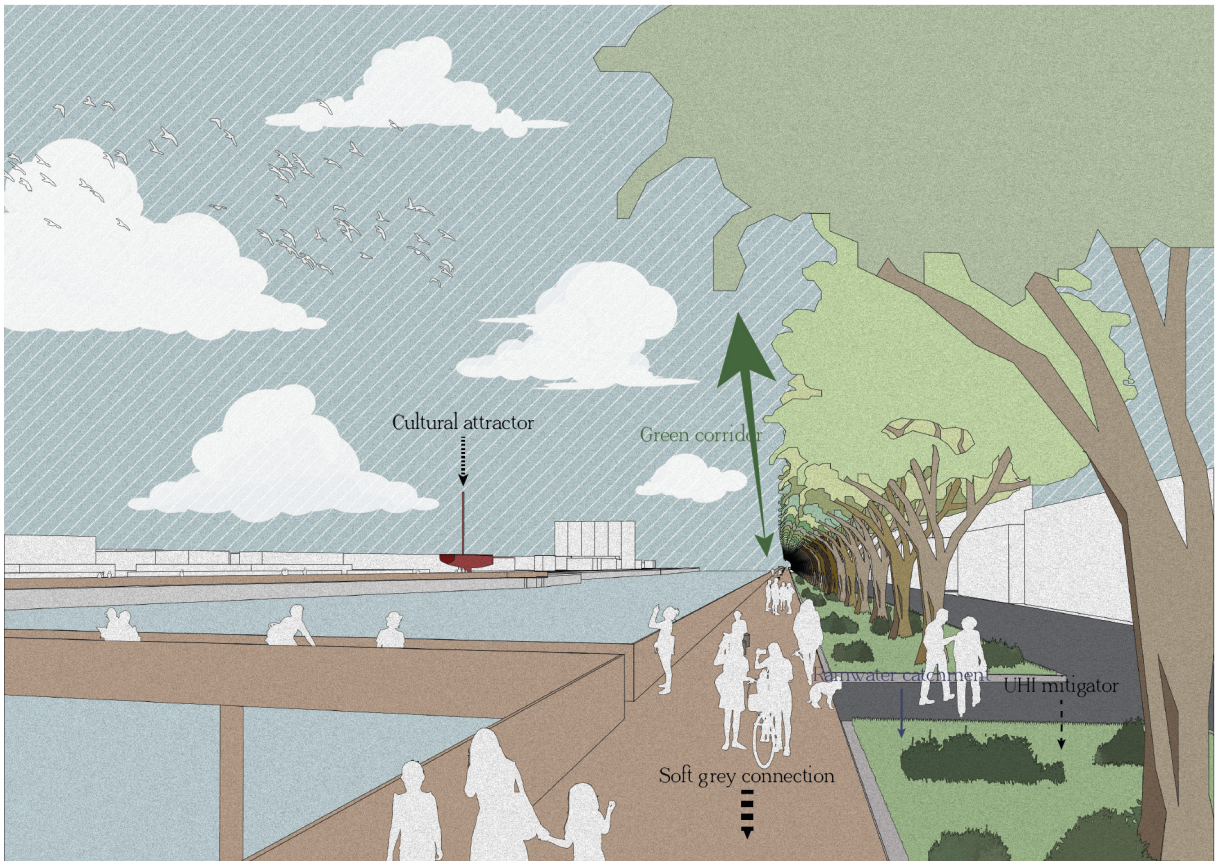


Figure 86: View from the new harbour boulevard

The second site is relative to the so called “Reborn as a park”, which is the retraining of a degraded area and abandoned buildings.

The design will focus on the creation of a place where green, blue and grey structures work together to define a place for both wildlife and people.

It favor the passage towards a climate adaptive harbour thank to the new water reservoirs will help in the miyigation of risks relative to water.

Figure 85 shows a view from this area.

The last site showed is the new harbour boulevard.

The image (*figure 86*) is taken closer to the path where the pedestrian bridge can be seen.

Here several people will use this elemnt as the main connector between harbour and the city and between the two extremes of Candiano canal which forms the harbour.

As said before new green areas will be placed generating also a Nature Base Solution corridor for wildlife able to link all the new sites designed.

Particular attention has been done to the path.

In order to better define spaces a section has been made (*figure 87*)

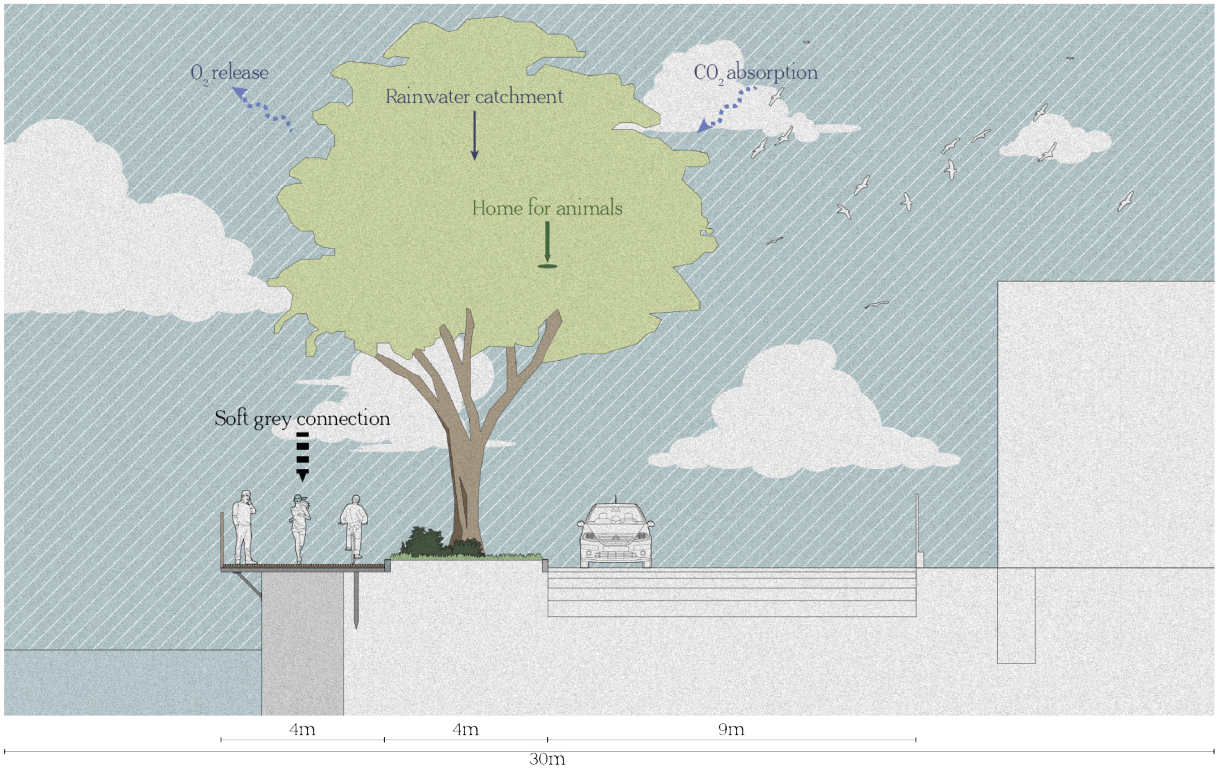


Figure 87: Section of the new harbour boulevard

The boulevard width is 8m diveded into 4m for people and 4m for green space leaving 9m for road.

9m is considered enough to let all king of vehicles, like trucks, to circulate without any problems.

Materials used for the path are stainless stell for the main structure and wood for the pavement in order to give “naturalness” to it.

6. CONCLUSION AND FUTURE DEVELOPMENTS

In this last part of the document the goal is to retrace all the steps taken and the results obtained in order to reach an adequate conclusion by also introducing the possible future developments of what has been done.

The work is divided into several parts.

The first one starts describing negative consequences of anthropic alteration on the environments such as deforestation, loss of biodiversity and climate change and then it introduces briefly the main thematic which consists in the usage of Geographic Information System and Remote Sensing data as a support for the definition of landscape planning strategies and designs (geo-design approach).

After that the phase continues defining the site and the different scales of application of geo-design.

Two scales have been selected, the first considers Ravenna town, located at Adriatic coast of Italy (Emilia-Romagna), the second comprehends a bigger territory from Delta Po River in the North to Saline di Cervia in the South.

The second part of the work outlines the legislative context (European, national and regional) in which the thesis approaches such as describing the regulatory process in the conservation of landscapes and the European Green Deal initiative.

This phase, also, introduces the definitions of the main terms used in the work, such as green infrastructure, geo-design and resilience.

The central part of the document is characterised by the analysis, strategical definition and design proposals.

Analytical component has interested the biggest effort of the work in term of data collection, computation and reading of the results.

Two different strands have been used, one for each scale, computing sometimes different topics, sometimes same ones for comparisons.

Thank to them it has been possible to obtain a wide knowledge of the territory summarized in the SWOT analysis which is extremely useful to build a bridge from data computed to strategy definition.

According to SWOT results the strategy has been divided into the two scales considered, but they are not separated, they belong to the same system.

Territorial strategy wants to define general guidelines of intervention, like connecting protected areas, defining new ones and expand existing Po Delta Park.

Urban one focuses on generating a Green Belt able to connect the four compartments identified (pialasse, seaside, harbour and town centre) among them and with the system highlighted at territorial scale with the usage of Nature Base Solutions (reforestation, forestry, new green and blue areas, new soft grey infrastructure etc).

Finally, a pilot area has been chosen to show the possible design which reflects all the work done before.

The site is located at the border between harbour and the city and the design proposals want to enhance connectivity among neuralgic areas, like historical buildings, new usable areas able to provide several ecosystem services, the re-use of degraded areas and abandoned buildings.

The work described in detail above serves to demonstrate the importance of geographic data to generate a cognitive frame of the target area as the base for future decisions and then design proposals.

Obviously, the process adopted can be fully implemented.

The analytical phase can be enriched introducing different kind of analysis, diffrent topics providing the increase of the knowledge.

For example it can be studied in a better way sociality and people fluxes divided by types (tourists, inhabitants, foreigners etc…) around the two scales considered in order to have a precise information about people movement and then define new strategical actions and design proposals.

New scales can be introduced relative to design sites used as pilot areas to measure Ecosystem Services before and after the project so that the improvement can be scientifically proved and demonstrated.

For particular areas, like Pialasse, a deeper study can be done for biodiversity: for birds can be analysed in a better way their life cycle trying to define possible processes of their protection, conservation and spread.

Another example is given by the analysis of new kind of risks and develop more detailed maps about hazard, vulnerability and exposure. This will help to plan actions for territorial protection.

Design phase, obviously, need to be implemented with details, renders, sections, masterplan and so on.

There is a lack, also, in the strategy definition which is cause from the fact that this study is purely academic: there is the need to have several focus groups with all the entities and sta-

keholders potentially involved.

The point is that landscape planning considers huge areas which cross different levels of administrative limits (municipalities, provinces, regions, catchment areas etc…), so the coordination among all of them results fundamental to divert actions in the right direction.

The conclusion of the work ends with the words of Jack Dangermond, Esri president:

"Geodesign is a vision for using geographic knowledge to actively and thoughtfully design... It will link and build the next generation of both geography and design. It finds the common ground between the science of geography and the methods of design."

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