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Moving horizons, Landscape design praxis through soil transformation

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MOVING HORIZONS
Landscape design praxis through soil transformation

a dissertation presented by
Vittoria Mencarini
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Abstract

This thesis research investigates the relationship between *soil transformations* and *landscape design praxis*, focusing on the mutual effects and potential disciplinary developments aiming at structurally linking the two fields. The starting assumption is that, *soil is a condition of inherent shifting in landscape evolution both in physical and semantic relationship*.

Through a critical reading of the components that contribute to form the common image of the landscape, the sustained hypothesis is that *Landscape itself is intrinsically related to soil alteration*, subject to both anthropogenic and environmental pressures. Thus we can recognize the soil as a fundamental design element identifying actions among different spatial settings - *surface, soil, subsoil* - to find renewed forms of management and planning for contemporary territories.

The aim is to understand if there's a limit to soil transformation – in terms of *soil health* - and how can landscape design encompass or overcome this limit and tackle this challenge.

The interdisciplinary aspects are merged in a transdisciplinary view. For this reason the thesis features an advance named *Moving horizon*, proposed in the form of Landscape Manifesto.

The thesis objective is to develop an approach capable of building a coherent relationship between *planning* and *design scale*. It will be presented through the survey to real case studies – formal and informal practices -, considered paradigmatic examples in a critical understanding of *territorial metabolism* to shape spatial strategies.

Focusing on the general model set up on preliminary considerations, a specific workflow for and operative procedure in processing soil in anthropic contexts will be presented. The research analyses the implementation of this procedure in the framework of the *Climate Change Adaptation Plan 2020* development by the Municipality of Ravenna as a remarkable case study for explaining and testing the model set-up.

The approach aims at assist: designers engaged in landscape design, scholars and professionals involved in territorial transformations, decision-makers in their strategic choices by elaborating and visualizing prospective landscape shifting on several scales.

The research fits into the Italian context. It is therefore assumed that the results of the research can be transferred to different scales and in similar international contexts.

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The work presented here would not have been possible without the help, guidance and support provided by many individuals I have had the pleasure of getting acquainted with over the course of the thesis.
I would like to take this opportunity to thank them and to express my deepest gratitude for all that they have done. Firstly to my colleges in Italy and Albania, to the people at Polis University of Tirana. I would like to thank, in particular, the staff of the various companies and institutions involved in the research for their assistance and cooperation during the course of the work - such as the Municipality of Ravenna, the Consorzio di Bonifica della Romagna (CBR), the CER (Canale Emiliano Romagnolo), CESTHA (Experimental Centre for Habitats Protection).
In particular I would like to extend my gratitude to the following people for their contribution in transferring the results of my research into effective impacts: Dott.ssa Luana Gasparini, responsible of Environment Office in the Municipality of Ravenna; Dott.ssa Laura Prometti, *geologist*, managment staff CBR (Consorzio di Bonifica della Romagna); Dott. Massimiliano Costa, *biologist*, Director of "Delta del Po" Park; Dott. Paolo Mannini, *agronomist*, General Director of CER (Canale Emiliano Romagnolo); Dott. Simone D'Acunto, *biologist*, Director of CESTHA (Centro Sperimentale per la Tutela degli Habitat); Dott. Luciano Vogli, *enviromental scientist*, researcher at CIRI EA (Interdepartmental Centre for Industrial Research on Energy and Environment) University of Bologna.

Vittoria Mencarini

Ravenna, August 2021

Research & publications

Portions of the thesis are derived from previously published or being-published works and professional practice involved in research as implemented case studies.

Relevant publications
/ "SOIL DISPLACEMENT Landscape project as an infrastructure across building geography and grounding metabolism. The case study of Pialassa Piomboni constructed wetland in Ravenna" (2020) , at the national scientific conference "Cultivating the continuity of european landscapes" organized by UNISCAPE, 15-16th October 2020 - to be published by Springer Nature - FULL PAPER SCIENTIFIC REVIEW
/ "LANDSCAPE AND CLIMATE CHANGE. A resilient strategy for the adaption plan of the Ravenna area in Italy", in the international review "Convergencias, Journal of Research and Arts Education", edited by Escola Superior de Artes Aplicadas (Portugal) – published on the 30 of November 2020 – ISSN: 2184-0180 / E-ISSN: 1646-9054 – FULL PAPER ANVUR CLASSE A
/ "MOVING HORIZONS, design praxis through soil transformation. A Landscape manifesto" (2021), in the international review "CPCL Series" within the conference - accepted abstract, paper under submission - FULL PAPER SCIENTIFIC REVIEW

More prominently, the pilot experiences reported in Chapter 4 concerns the *Climate Change Adaptation Plan for the Municipality of Ravenna* drafted in collaboration with Sealine Research Center and CFR (Consorzio Futura in Ricerche) from the University of Ferrara. The document had been adopted by the Municipality of Ravenna in the end of 2020. Meanwhile, the contents of this work had been published on scientific paper and other conference proceedings.
During the course of the research, collaborations were born with public and research institutions, which led to the development of pilot actions, by triggering ecological dinamicity through design action operated on hydrogeological structure. This works are still ongoing and represent a further implementation of research outcome, such as the *EMyS project* (*Equilibrium Mantainance on hYdroSalinity*) partially presented in Chapter 5. This step is considered a moving foreward step, from wich results can be measured in term of biocenosis and phytocenosis habitat protection and implementation.

Question

How can landscape design face the challenge to preserve soil health?

Preposition

Soil is a condition of inherent shifting in landscape evolution, both in physical and semantic relationship.
In this understanding soil transformation is a *primer* in Landscape Design praxis.

With humanity today being Earth's primary geomorphic agent, the quality of human life and the earth's environment had never depended more on soil management than it does today.
The new challenge facing soil science is how to create a policy to address soil health that embraced the whole system instead of a single soil property or process.
The re-thinking of soil shifting as a primer for landscape design praxis towards a more open-ended and dynamic conceptualisation, does not only affect our understanding of landscape on a speculative way. It also calls for a revision of the very methods and procedures, we use to plan and design the territory.

Thesis Structure

The thesis is organized into five different chapters.
In **Chapter 1.** are introduced the main drivers behind the research, as well as the underlying theoretical framework and the operative background upon which the thesis is based. This connection will be questioned through the interdisciplinary lens of the theoretical framework, drawing up a conceptual scope of *landscape*, *soil* and *design*.

In **Chapter 2.** an outline of the main statement and preposition behind the proposed *Moving horizon approach* is provided. It's a critical review of theoretical and design praxis in which are established ten affirmation points in terms of *awareness*, *design* and *attitude* in landscape project. The first outcome is a Landscape Manifesto, in which are condensed the research propositions.

In **Chapter 3.** a compendium of *topological design o*perations to be performed on soil in terms of *shape, cover* and *composition* is reported. The work is proposed as a *taxonomy of interventions*. It is conceived as an overview, organized in ten boards and a final synopsis of contents, presented as matrix with the linkage between *design operations* and *ecosystem services*. The discussion is supported by reporting results of relevant projects and researches.

In **Chapter 4.** is presented a concrete *workflow* for an operative procedure in soil processing approaching *trans-scalarity*. The procedure will be presented in an *analytic* part - decision-oriented - and a *synthetic* part - concerning spatial arrangement in landscape project framework. Thus it will be implemented in a real case study: the *Climate Change Adaptation Plan* in the Municipality of Ravenna (Italy). The case study is useful to explain and to test the limit and opportunity of the procedure.

In **Chapter 5.** are outlined the general discussion and conclusions of the thesis, research follow-ups, the integration with transdisciplinary cross-breeding disciplinary for further implementation on landscape design and territorial planning, pending issues and further research application.

In every phase is due an interdisciplinary approach, through the discussion with specialists working in fields such as geology, environmental sciences, ecology, biology, policy making,

Thesis structure
Chapter & Phases

1 - STUDY
Introduction and theoretical framework

2 - ANALYSIS
Materials & Methods, Statements & Position

3 - METAMODEL DESIGN
Taxonomy of Design Actions

4 - DESIGN
Model development & Operative research

5 - SYNTHESIS
Model implementation to a case study

6 - MONITORING
Analysis of the results, conclusion & dissertation

PHASE	TOPIC	CH.
1. STUDY PHASE	STATE OF ART	1
2. ANALYSIS	MOVING HORIZON APPROACH	2
3. METAMODEL DESIGN	MODEL APPROXIMATION	3
4. DESIGN	MODEL DEVELOPMENT	4
5. SYNTHESIS	MODEL IMPLEMENTATION	
6. MONITORING	RESULTS, DISCUSSION, CONCLUSION	5

CASE STUDY
CLIMATE CHANGE ADAPTATION PLAN within Sustainable Energy and Climate Action Plan (SECAP) 2020 RAVENNA (ITALY)

Tab. 1. Thesis structure: chapter and phases. source: author

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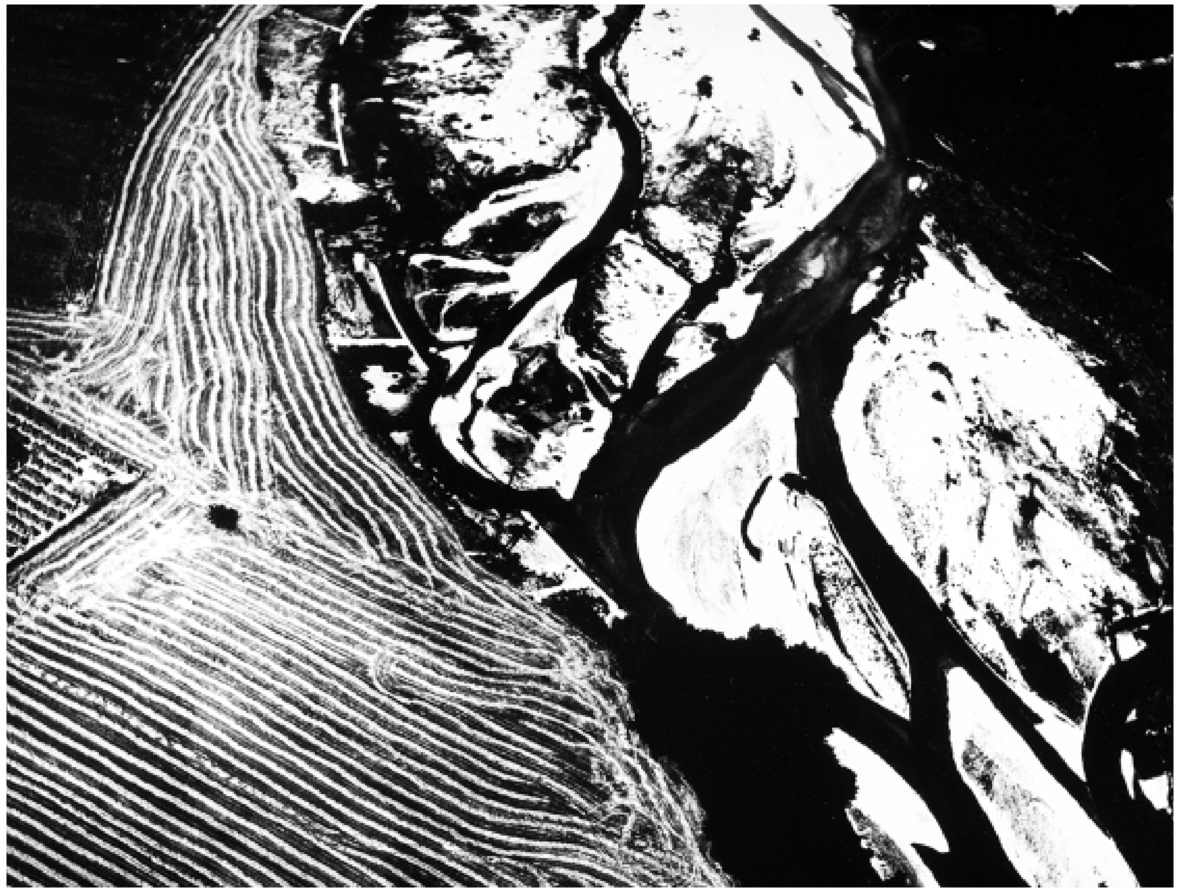


Fig. 1. Rural Landscape in Marche Region (Italy), 80's. source: Mario Giacomelli, On Being Aware of Nature.

A soil was not a thing … It was a web of relationships that stood in a certain state at a certain time

William Bryant Logan
Dirt, the ecstatic skin of the earth

Chapter 1

Introduction

In Chapter 1. are introduced the main drivers behind the research, as well as the underlying theoretical framework and the operative background upon which the thesis is based. Here the methodological approach is detailed, attempting to uncover both the linkage between landscape design and soil transformation, both the relevance of this relationship in orienting spatial planning and design project. This connection will be questioned through the interdisciplinary lens of the theoretical framework, drawing up a conceptual scope of *landscape*, *soil* and *design*.

Chapter 1 / Introduction

The thesis investigates the relationship between *landscape design* and the *transformation of soil* operated by anthropogenic activities. The research's proposal moves from a critical rereading of *soil as design element* that combine to build the scenery of contemporary territories in the will to look for its role in the framework of *landscape resilience*.

The soil is a *non-renewable resource* in reasonable time, able to provide functions and services for local communities. The millennial transformations of the territory have modified *soils structure* and *composition*, threatening some *ecosystem functions* essential for the support of the human habitat.

This awareness influences policies and agreements on a global scale, within new paradigms of development and evolution of anthropic dynamics, in an attempt to limit the negative and irreversible consequences to environment. It drives to a rethinking of the territorial management which is translated into a revision of the planning practice: protecting on one hand the soil resource (*conservation*) and providing strategiesfor resilient adaptation of the territory (*transformation*).

A systemic approach is needed for coordinating the man-made metabolic procedures concerning inevitable phenomena of urban and territorial transformation and ecosystems protection.

The *landscape* gives us an elaborated way of seeing, understanding and shaping environments, by adapting cultural and natural processes to create a new territory. This way, the *landscape design*, can offer precise and contextualized project solutions which can involve large temporal and spatial scales in reference to the extension of the problem.

Through a critical reading of the components that contribute to forming the common image of the landscape, the sustained hypothesis is that we can recognize the *soil as a primer in design praxis* identifying actions among more spatiality - *surface, soil, subsoil* - to find renewed forms of management and planning for contemporary territories.

The research path interweaves several aspects of the discipline of landscape design: interdisciplinarity speculative research, professional practices, legislative framework, paradigmatic cases studies, on-site investigation, applicative case study.

All thing considered the thesis methodology can be described as *deductive process* headed to set a model based on *research by design*. It's a critical review between theoretical and design praxis in which are established three affirmation points in terms of *awareness, design* and *attitude* in landscape project.

Fig. 2. Building site in Barcis Lake, Dolomite (IT), 2020. The barcis lake is generated by an artificial reservoir along the Cellina river, for hydroelecrictal purpose. The construction of a bridge has made necessary the emptying of the lake. This brought out the river-bed morphology and the sedimentology dynamism. source: author

The thesis purposes a potential model grounding on a namend *Moving Horizon approach* applied on *planning process* and *design practice*.

This approach aims at assist designers engaged in landscape design, scholars and professionals involved in territorial transormations, decision-makers in strategic choices phases.

The main outcome is the outline of an operative workflow, useful to orient decision on territorial scale, and to align spatial arrangement in a landscape project. This model will be implemented in a real case study, concerning the plan for adaptation measure in response to climate change in the territorial administration of Ravenna (Italy), with territorial scope. It will be useful to explain and to test the limit of the procedure in the attempt to identify, more specifically, the concrete actions for adaptation to climate change by relating the territorial and planning scale to that of the project. The approach is based on understanding and transforming the soil as a fundamental material of this process.

This approach allows a territorial upgrade to contemporary objective and needed, increasing the level of compatibility between the evolution of the human habitat and the maintenance of natural regeneration times. Other sub-outcomes can be considered, such as a Landscape Manifesto - arranged in ten statements - and a taxonomy of topological operations to be operated on the ground - in terms of *shape, cover* and *composition* shifting.

The research fits into the Italian context. The case studies will be medium-sized cities, but will have a territorial scope. The problems that need to be answered also affect territories of other dimensions both in the national and international context. It is therefore assumed that the results of the research can also be transferred to different scales and in similar international contexts.

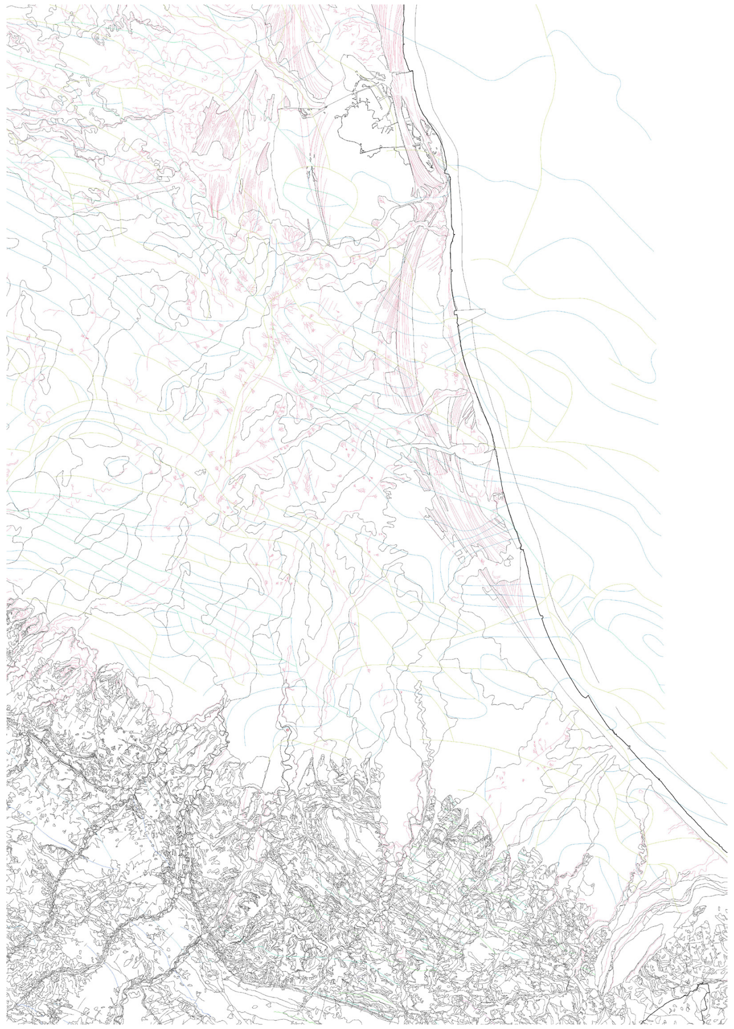
The project is intended as *a series of operations that intentionally and consciously switch spatial arrangement induce spatial alterations with the aim of impress a clear form of evolution in places across a certain time frame*.

This way design can be realized as a driver in *ontogenetic*[1] *generative level*[2] in landscape semantic field. We are not looking for an appreciable formal composition in a *still image*, but the connection and the relationships between the elements that make up the *landscape* by their natural interface with a symbiothic and osmothic relationship with the *ground*.

[1] Ontogeny (also ontogenesis) is the origination and development of an organism. The term can also be used to refer to the study of the entirety of an organism's lifespan.

[2] Ref. Complexity theory and landscape ontogenesis: an epistemological approach. International Journal of Risk Assessment and Management, 2005. Almo Farina.

Landscape is the canvas of multiple successive changes, and present-day modeling relates to this culture of change through sets of conventions and signs that eventualy enable better choices on the terrain.
(Girot, 2013)



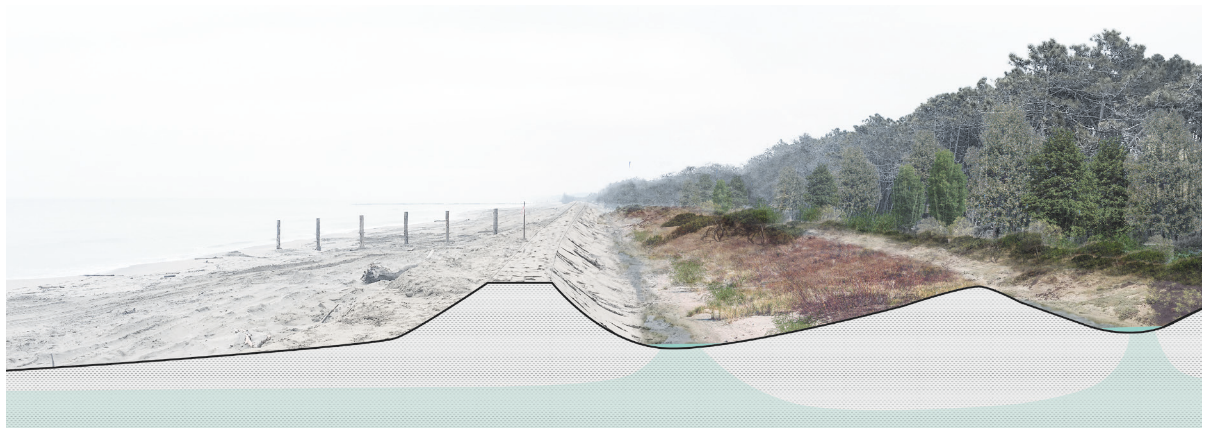


Fig. 3-4. Approaching planning and design scale. From the top: Ravenna geomorphological units and isofreatic; critical coastal area (actual sitaution); design arrangement for dynamic shoreline stabilization. source: author, from SECAP 2020 Ravenna

1.1 Research background & Motivations

As evidenced by numerous studies in the fields of ecology and geology (Naveh, 2000) (Richter, 2007) (Ellis, 2014), the current territorial configuration is subject to further anthropogenic to environmental pressures. Thus territories presents many critical issues in terms of environmental risks and *ecosystem functions* losses.

Meanwhile, cities are called to take *adaptation measures* to respond to global challenges - such as increasing their *resilience* in the face of climate change risk factors and the need to adapt their mobility infrastructures to sustainable parameters - or provide for renewable energy sources facilities.

In this respect unpredictable development trends, altered societal needs, and constantly shifting territorial functions require new thinking. Quoting the provocative words of Pierre Belanger (2014) *"On this bigger canvas, brown is the new green."*

In order to safeguard the *soil resource* and the functions it carries out, this scenario presupposes a process of transformation and upgrade, capable of responding positively to risk forecasts - that represent a factor of vulnerabilities in the near future- by avoiding *soil degradation*[3].

These preliminary thoughts and considerations have formed the starting point for my research work addressing the questions:

How can landscape design face the challenge to preserve soil health[4]?

I find that the possible problematics related to the concrete implementation of landscape projects into *soil preservation* need to be clarified and discussed more thoroughly.

The study of interdisciplinary literary sources combined with the study of practical examples constitutes the basis for elaborating on the research objective and research questions towards an argued formulation, the *Moving Horizon approach*.

Problems-opportunities

Already at the beginning of 2000, Daniel Richter, a prominent soil scientist part of the Anthropocene Working Group[5], argued *"Humanity's expanding systems of food fiber, and water production are now enterly dependent on the management practiced on several billions of hectares of soil."*

[3] *Soil degradation* expresses the *soil unhealth*
[4] *Soil health* is considered as the most important, functional characteristic of any *soil ecosystem service.*
[5] Source: the Mission Board's proposal to the European Commission for a mission in the area of *Soil health and food*. Manuscript completed in September 2020. First edition.

SOME ECOSYSTEM SERVICES PROVIDED BY SOILS INCLUDE[5]:

- producing adequate quantities of nutritious and safe food, feed, fibre and other biomass for industries;
- storing and purifying water, regulating flows, recharging aquifers, and reducing the impact of droughts and floods thereby helping adaptation to climate change;
- capturing carbon from the atmosphere and reducing emission of greenhouse gases from soils, thereby contributing to climate mitigation;
- nutrient cycling supporting crop productivity and reducing contamination;
- preserving and protecting biodiversity by preserving habitats both above and within the soil;
- supporting the quality of our landscapes and greening of our towns and cities.

Fig. 5. China, soil protection system on a large scale. Above, vegetable fibre barriers to stop the sand. source: "The water Atlas", Laureano

Soil definitions in different soil classification systems

The definition of the *soil* is not univocal (FAO, 2015) (ISPRA, 2011).

The *World Reference Base for Soil Resources* (FAO, 2014) classifies as soil *any material within 2 m of the Earth's surface* that is in contact with the atmosphere, but excluding living organisms, areas with continuous ice not covered by other material, and water bodies deeper than 2 m.

In the *United States Soil Taxonomy* (Soil Survey Staff, 1999) soil is considered to be a *natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space*, and is characterized by one or both of the following: (i) *horizons* or layers that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter; and (ii) the ability to support rooted plants in a natural environment.

In the *Russian Classification System* (Shishov et al., 2004), soil is defined as a *solid-phase natural-historical body with a system of inter-related horizons composing a genetic profile* and which derives from the transformation of the uppermost layer of the lithosphere by the integrity of soil-forming agents.

French pedologists put emphasis on the spatial aspects of soil as an '*objet naturel, continu et tridimensionnel*' (a natural, continuous and three dimensional object) (AFES, 2008)[6].

Urban soils including those *sealed* by concrete or asphalt, strata of composts or other fertile materials applied to construct lawns and gardens, superficial layers, mine spoil or garbage heaps are also considered in some soil classification systems (Rossiter, 2007). The concept of soils as natural bodies also includes very thin films in caves or fine earth patches within desquamation cracks of hard rocks as found in Antarctic endolithic soils (Goryachkin et al., 2012) and in underwater soils (Demas, 1993).

Thus, the concept of soil becomes very broad.

According to ISPRA (ISPRA, 2011) in the following pages we will talk about *soil*, meaning the *thin porous and biologically active medium* that represents "*the top layer of the earth's crust, formed by mineral particles, organic matter, water, air and living organisms. It is the interface between earth, air and water and hosts most of the biosphere.*"[7], that is capable of sustaining the life of plants, is characterized by its own flora and fauna and by a particular water economy. It is divided into horizons having their own physical, chemical and biological characteristics[8].

[6] A related variant considers that "*soil in nature is a three-dimensional continuum, temporally dynamic and spatially anisotropic, both vertically and laterally*" (Sposito and Reginato, 1992).
[7] Commissione delle Comunità Europee (2006) - *Strategia tematica per la protezione del suolo*.
[8] Soil Conservation Society of America (1986)

Fig. 6. Embankment in protected wetland areas, Valli di Comacchio (Italy). source: author

Fig. 7. Pedogenesis process at 2500 mt high in Brenta Dolomite (Italy). source: author

Problems-opportunities

Already at the beginning of 2000, Daniel Richter, a prominent soil scientist part of the Anthropocene Working Group[9], argued *"Humanity's expanding systems of food fiber, and water production are now enterly dependent on the management practiced on several billions of hectares of soil."* The importance of *soil protection* is now recognized in international policy programs - such as AGENDA 2030, (SDGs ONU, 2015) or international scientific report, such as the *Special Report on Climate Change and Land* drafted by IPCC (IPCC, 2019) and the *Report of the Mission Board for Soil health and food (COE, 2020)* drawn up by the EU, reported in the next pages.

They identify in *land management* a fundamental tool for safeguarding and protecting the environment by preserving *soil health*, in order to prevent *land degradation* and avoid the related territorial risks.

By the way, currently there is no contextual programs of intervention that in a systematic, coherent and organized manner considers the *soil* as protagonist of changes able to combine *soil protection* (in terms of *soil health conservation*) by adapting the territorial asset that needs to be updated (*transformation*).

Infact, numerous prescriptions and directives are traced which foresee the safeguard of its functions, without concretely expressing the operative steps for making these requests practicable and feasible in design terms.

There is also a large amount of scientific literature produced in recent decades concerning the soil stressing issues, by placing the *soil* in relation to the anthropogenic and environmental pressures exerted. Regrettably, the results of these investigations are placed in a deeply sectorial ambitus, without being permeable with the administrative sphere.

Meanwhile, there are evidence that certain landscape projects have avoided the soil degradation and made soil functions more performing, presented in Ch 3.3.

It is therefore necessary to organize a series of conscious actions that are capable of summarizing the cause-effect relationships in the dynamics studied by one and the objectives pursued by the other.

[9] The Anthropocene Working Group (AWG) is an interdisciplinary research group dedicated to the study of the Anthropocene as a geological time unit -supplementing the Holocene as first suggestes by Paul Crutzen in "Geology of Mankind" (Crutzen, 2000) - in which human activity shapes our planet more than nature itself. It was established in 2009.

Processes affecting the landscape and the soils both feedback mechanisms between soils and landscape though the intricate relation between water flow patterns, soil development, vulnerability to erosion and landscape change (Finke, 2016).

SOIL GEOMORPHOLOGICAL TRACKS LAND TAKE

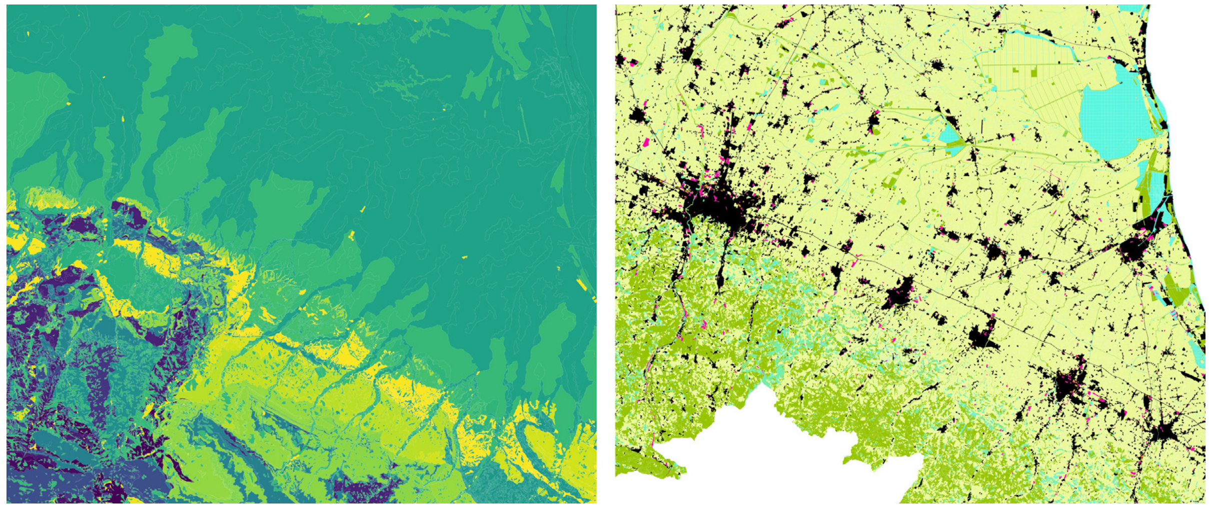


Fig. 8. Critical comparison between the concept of soil and land. Land take is translated in the italian language with "soil consumption". GIS mapping elaboration, 2018. source: author

Fig. 9. Flood in Deltebre (Spain), 2019. Marine ingression reached 3km inland, covering by flood the areas with critical topography. This events caused several damaged and some victims. source: ESA and Copernicus

European Mission 2021-2027

"Caring for soil is caring for life"

Ensure 75% of soils are healthy by 2030 for food, people, nature and climate.

Report of the Mission Board for Soil health and food

This document is the Mission Board's proposal to the European Commission for a mission in the area of Soil health and food. Manuscript completed in September 2020. First edition.

Mission & Aims

Together, all of us will help to design and apply solutions to achieve the main goal of the mission which is: By 2030, at least 75% of soils in each EU Member State are healthy, or show a significant improvement towards meeting accepted thresholds of indicators, to support ecosystem services.

DATAs

The following examples from the EU reflect the gravity of the problem (as referenced in Annex1):

- 2.8 million potentially contaminated sites, but only 24% are inventoried and 65,500 remediated;
- 83% of EU soils with residual pesticides; 21% of agricultural soils with cadmium concentrations above the limit for drinking water; and 6% with heavy metal content potentially unsafe for food production;
- 65-75% of agricultural soils with nutrient inputs at levels risking eutrophication of soils and water and affecting biodiversity;
- 2.4% soil sealed and only 13% urban development on recycled urban land;
- Cropland soils losing carbon at a rate of 0.5% per year and 50% of peatlands drained and losing carbon;
- 24% of land with unsustainable water erosion rates;
- 23% of land with high density subsoil indicating compaction;
- 25% of land at High or Very High risk of desertification in Southern, Central and Eastern Europe in 2017 - and an increase of 11% in desertification in just 10 years;
- the costs associated with soil degradation in the EU exceed 50 billion € per year.

In line with the above goal, the mission aims to achieve the following objectives and targets by 2030

	OBJECTIVE	TARGET
1	**Reduce land degradation,** including desertification and salinization.	1.1: 50% of **degraded land is restored** moving beyond land degradation neutrality.
2	Conserve (e.g. in forests, permanent pastures, wetlands) and increase **soil organic carbon stocks.**	2.1: current **carbon concentration** losses on cultivated land (0.5% per year) are reversed to an increase by 0.1-0.4% per year; 2.2: the area of managed **peatlands** losing carbon is reduced by 30-50%.
3	**No net soil sealing** and increase the **re-use of urban soils** for urban development.	3.1: switch from 2.4% to **no net soil sealing;** 3.2: the current rate of **soil re-use** is increased from current 13% to 50% to help meet the EU target of **no net land take** by 2050.
4	**Reduce soil pollution and enhance restoration**	4.1: at least 25% area of EU farmland under **organic agriculture;** 4.2: a further 5-25% of land with reduced risk from **eutrophication, pesticides, anti-microbials** and other agrochemicals and contaminants; 4.3: a doubling of the rate of **restoration** of polluted sites.
5	**Prevent erosion**	5.1: **stop erosion** on 30-50% of land with unsustainable erosion rates.
6	Improve **soil structure** to enhance habitat quality for soil biota and crops.	6.1: soils with high-density subsoils are reduced by 30 to 50%.
7	Reduce the **EU global footprint on soils.**	7.1: the **impact of EU's food, timber and biomass imports** on land degradation are reduced by 20-40 %.
8	Increase **soil literacy in society across Member States**	8.1: soil health is firmly **embedded in schools** and educational curricula; 8.2: uptake of **soil health training** by land managers and advisors is increased; 8.3: understanding of **impact of consumer choices** on soil health is increased.

Tab. 2. European Mission 2021-27 "Caring for Soil is caring for Life", objectives and target source: European commision, author elaboration

The italian context

In the Italian context the approach to coordinate soil protection is fragmented and lacks of coherent address. This in spite, according to ISPRA (ISPRA, 2018), 91% of Italian municipalities (88% in 2015) and over 3 million households are at risk in these areas of high hydrogeological vulnerability (Fig. 10).

The report on *Hydrogeological instability in the italian context*[10] provided by ISPRA in 2018 shows that overall 16.6% of the national territory is mapped in the most dangerous classes for landslides and floods (50 thousand km2). Furthermore, almost 4% of Italian buildings (over 550 thousand) are located in high and very high landslide hazard areas and more than 9% (over 1 million) in floodalble areas in the medium scenario forecasting.

In italian legislative framework, the *soil* is oulined under three main categories without any interference:

- *Enviroment*: intended as an *environmental matrix* (Testo Unico Ambientale DL 152/06)
- *Geology*: as a *matter* (Normativa ambientale sulla gestione delle terre e rocce da scavo PRD 120/17)
- *Urbanistic*: as a *non-renewable resource* (Disciplina regionale sulla tutela e uso del territorio LR 24/17)

This passage shows a certain inconsistency in the interpretation of *soil* in its complexity, which reflects both a semantic imprecision, both the lack of coherent policies in managing the whole *soil* intricancy.

Through a critical reading of these addresses, it is not clear in what terms the soil - as environmental matrix - is really considered as a territorial planning element. Even though such normative orientations persist somehow in a conservative vision of the landscape evolution, influenced by an *aesthetic* approach[11].

There are conceptual and operative limits in the translation of the objectives into effective planning and design tools. It misses the connection between *pattern* and *process* (expressed in Ch. 3.1), necessary for managing the environmental dynamics between the *soil* and the *ecosystem services* that can provide (deep in Ch. 1.5.1, 1.5.3 and C. 5.2) .

Working on the actual state of *soil health*, the attempt is to start a reflection on a conceptual reform that we consider fundamental for the challenges of *landscape design* and *planning* in the near future, - in which soil properties should become design element.

Within this framework the role of *landscaper* can actually be reconsidered at the light of a decision making process, that needs to address transformation processes, by providing proposal for physical shaping and manipulating the ground.

[10] The report is originally entitled *Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio*
[11] This topic is deeply argumented in Ch. 1.5.1

The process of soil degradation can lead to a collapse of landscapes and ecosystems, making societies more vulnerable to extreme weather events, risks to food security, food safety and even political instability. Land degradation is further exacerbated by the effects of climate change.

European Commission, 2020
Caring for soil is caring for life, Mission Board for Soil health and food

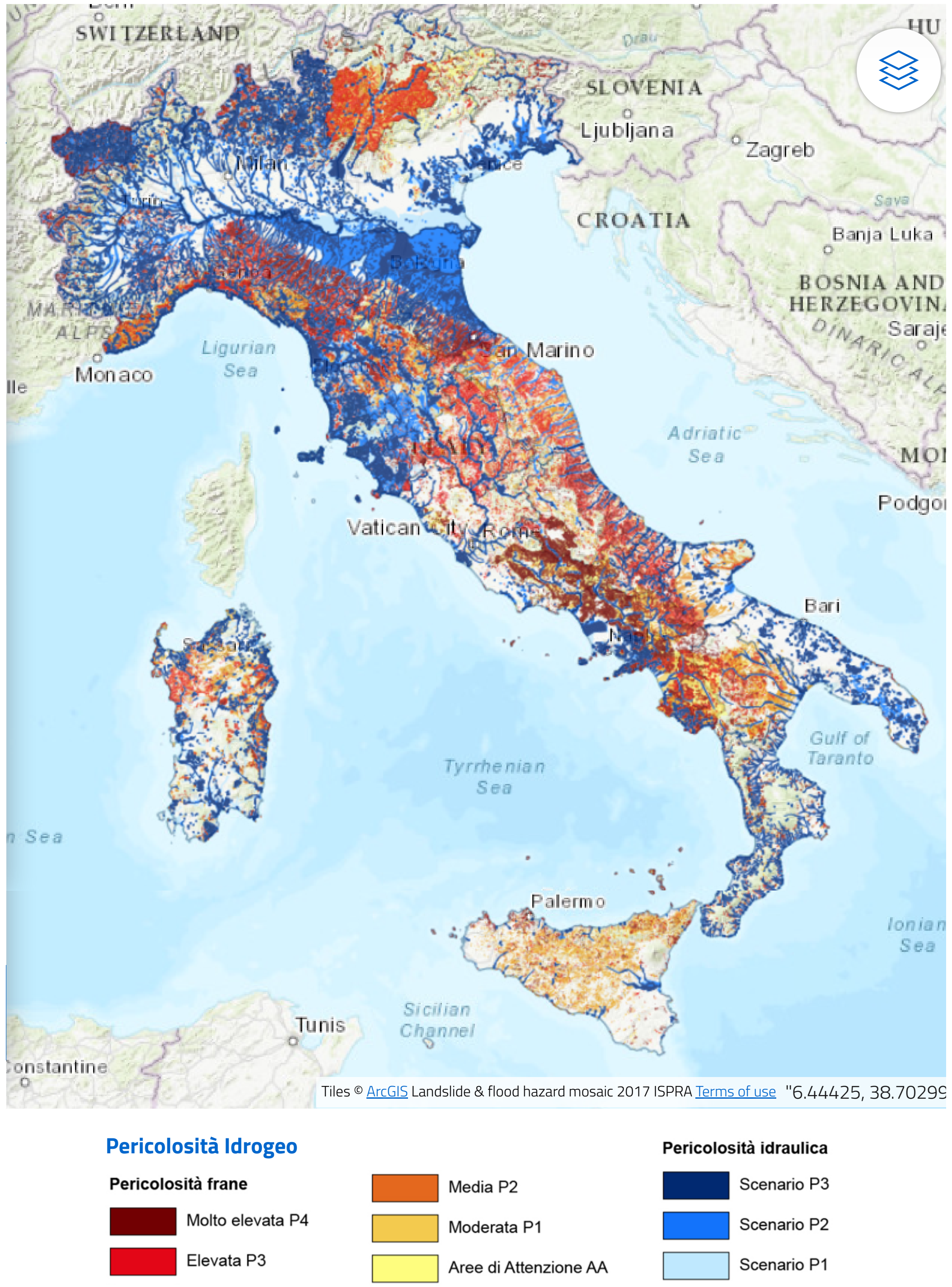


Fig. 10. Cartography of hydrogeological disruption in Italy. source: "Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio", ISPRA 2018

SOIL DEGRADATION IN ITALY 2012-2019[12]

High degradated areas +1.643 Kmq
Medium degradation +14.000 Kmq

DEGRADATION FACTORS

- Hydrogeological erosion; loss of soil: 8,3 ton Ha/anno;
- Organic matter loss;
- Compaction, for use with heavy agricultural vehicles; "medium" or "high" levels in the Po Valley and cultivated areas on the Adriatic coast and larger islands;
- Unsustainable agricultural practicesexcessive use of pesticides, excessive concentration of nitrates, especially in areas with high livestock density (Lombardy plains);
- Salinisation in coastal plains exposed to saline intrusion;
- Landslides, which affect all mountain ranges and related hills;
- Land-take;

SOIL DEGRADATION EXPRESSES SOIL UNHEALT

[12] Source: "L'italia perde terreno. Il consumo di suolo e il degrado del territorio" drafted by ISPRA in december 2020 and SOIL 4LIFE

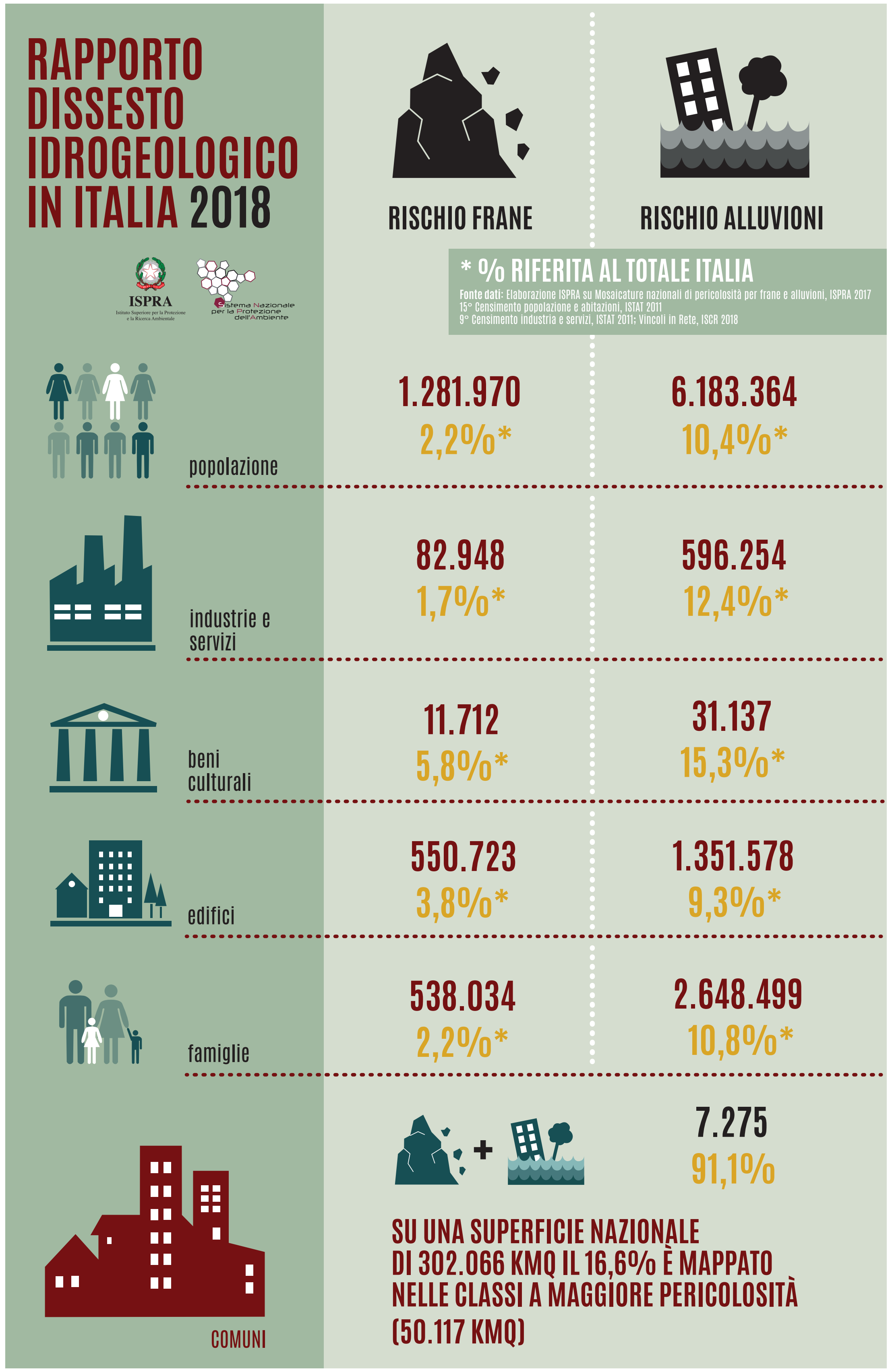


Fig. 11. Datas concerning hydrogeological disruption in Italy. source: "Dissesto idrogeologico in Italia: pericolosità e indicatori di rischio", ISPRA 2018

Overcoming top-down approach

In the top-down approach, the *soil* is often mistakenly confused with the concept of *land*[13].

The risk of a purely quantitative and standardizing approach is to interpret the territory in parceled and abstract shape, without incorporating the contextual environmental specificities that are the basis for maintaining *ecosystem services*. It appears necessary to overcome the geometrical and parcelizing urbanistic logic that characterized industrialized countries in the last decades, which allowed urban settlements to develop by interrupting the natural flow of some cycles supported by soil that are an essential support of human and ecosystem habitat, bringing to the fragmentation of many habitats with high ecological values.

The critical state of urban rigidity had already been traced by Rem Koolhas, in wondering *What Ever Happened to Urbanism?* (Koolhaas, 1995). I take up his words that today appear prophetic *"it will no longer aim for stable configurations but for the creation of enabling fields that accommodate processes that refuse to be crystallized into definitive form".* A decade after, the american landscape James Corner emphasized en emerging discipline, the *landscape-urbanism*. In the essay Terra Fluxus (Corner, 2006) he expressed how the *ground* should become the actual connecting element to be transformed: *"This work must necessarily view the entire metropolis as a living arena of processes and exchanges over time, allowing new forces and relationships to prepare the ground for new activities and patterns of occupancy".* According to Corner, it is, so to speak, the landscape-urbanists' role to nurture and oversee the ground to accommodate unknown future changes and interconnections in urbanized territories. As I see it, this expression reflects the same acceptance of *performative ground* able to provide facilities and guarantee reliability as well as integrate unknown future changes and interconnections, close to environmental features[14].

In addition, the work of Richard Forman (Forman, et al., 1986) (Forman, 2005)[15] should be mentioned He recast the science of landscape ecology (together with Godron) to introduce the basis of ecology into land use management. As a result of the complexity of the factors to be evaluated, planning and urbanism should open up to a rapid update of the concept, assimilating contributions from disciplines such as geology, engineering, landscape ecology and translate them into *design parameters, by* combining urban planning standards with *landscape metrics*, ensuring consistency with the initial objectives.

[13] '*Land*' commonly refers to the planet's surface not covered by seas, lakes or rivers. It includes the total land mass including continents and islands. In more daily use and legal texts, 'land' often refers to a designated piece of land. It consists of rocks, stones, soil, vegetation, animals, ponds, buildings, etc. *Soil* is one of the essential components of land. (EEA, 2019).

[14] Before them, other important urban planners had intercept flexible and pluralistic processes without renouncing to the construction of the city shape. In particular, it refers to the theories articulated by Kevin Lynch (1962), Ian Mc Haarg (1969), Bernardo Secchi (1986, 2020). This topic will be deepened in Ch 1.6 *Soil as a palimpsest in approaching scalarity.*

[15] This aspect will be argued more in deep in Ch. 3.1.

"It will no longer aim for stable configurations but for the creation of enabling fields that accommodate processes that refuse to be crystallized into definitive form."

What Ever Happened to Urbanism? (Koolhaas, 1995)

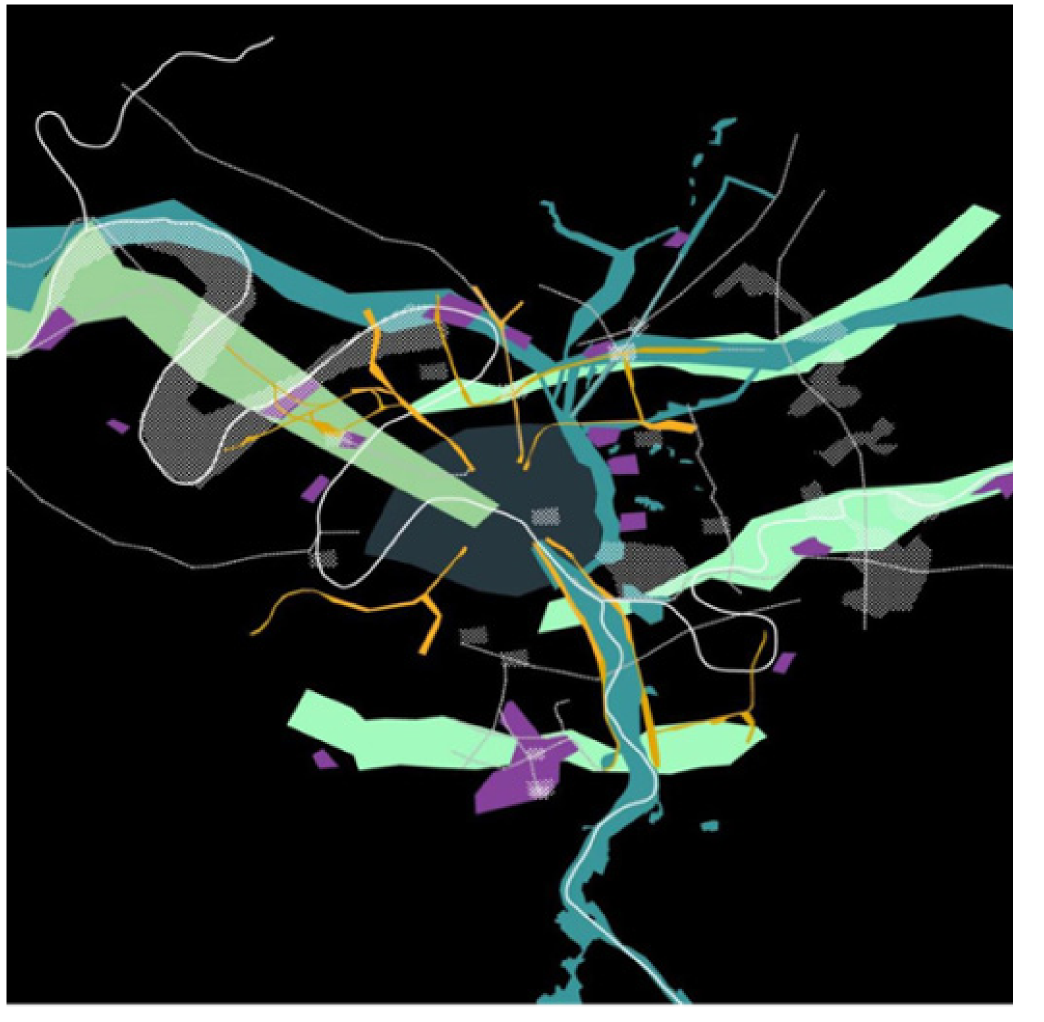


Fig. 12. Le Grand Paris, la "ville poreuse",permeable and connected 2009. The envisioned metropolis is crossed by movements and bodies that find, in urban space, new relationships and possibilities of encounter. The porous city project speaks of filtering soils, inclusive geographies, parks that do not separate, urban-rural fabrics to be reused and stratified, imagining a 100% recycling of gray energy present in places. author: Bernardo Secchi and Paola Viganò

Prominent role of Landscape Architect

The role of the *landscape designer* appears to be prominent in this emerging dialogue, for their competence to translate territorial and environmental parameters in design option that can be reflected on several project scale.

To make this approach effective, it is essential to have a *systemic vision* - made of visible and invisible connections - linked in an osmotic and symbiotic relationship that passes through soil envisioned as: a *diaphram*, an *environmental matrix*, a *project matter*. Cristophe Girot expresses this concept well in the essay *Immanent Landscape*: *Landscape is the canvas of multiple successive changes, and present-day modeling relates to this culture of change through sets of conventions and signs that eventually enable better choices on the terrain.* (Girot, 2013)

Nevertheless, the possibility to shape design actions depends on the ability to translate political intentions into concrete project actions, capable to find an answer to the problem on many *scales of intervention*.

Likewise, the effectiveness of new urban policies depends on the ability to incorporate *environmental parameters* (Lister, 2008) and *ecological dynamism* into *planning* and *design*, so that urban settlements return to having a *physical* and *functional* connection with their local context.

In this renewed relationship with nature, the *landscape* should not be understood as a *passive scene*, but as an active and functional system (Corner, 2005) connected to the human habitat supported by soil.

There is no reference to the formal search for a precise and nostalgic landscape scene. It would be pure anachronism. Rather, a link must be sought with the context and with the *rhythms of nature* that are proper to it (Lister, 2007), identifying new forms of design that can metabolize and synthesize the complexity of the forces involved. This ecological attachment to the landscape do not exclude beauty and poly-sensual experience (Meyer, 2012) (Hellstrom, 2010). In *Sustaining beauty, the performance of appearance: a manifesto* Elisabeth Meyer illustrates *"how immersive, aesthetic experience can lead to recognition, empathy, love, respect and care for environment"* (Meyer, 2012).

The *landscape design* tries to interpret the contemporary needs in updating and adapting the territories to new challenges. The aim is to drive these values into the future by increasing the level of compatibility between the evolution of the human habitat and the maintenance of nature's regeneration times (Corner, 2006) (Belanger, 2014) (Clement, 2015) (Clement, 2013) (Lister, 2015) towards a novel aesthetic (Meyer, 2012) (Hellstrom, 2010).

In this regards numerous examples and references will be reported during the thesis.

In ecology field soil is considered the central processing unit of the earth's environment.

(Sanchez 1994, Richter and Markewitz 1995)

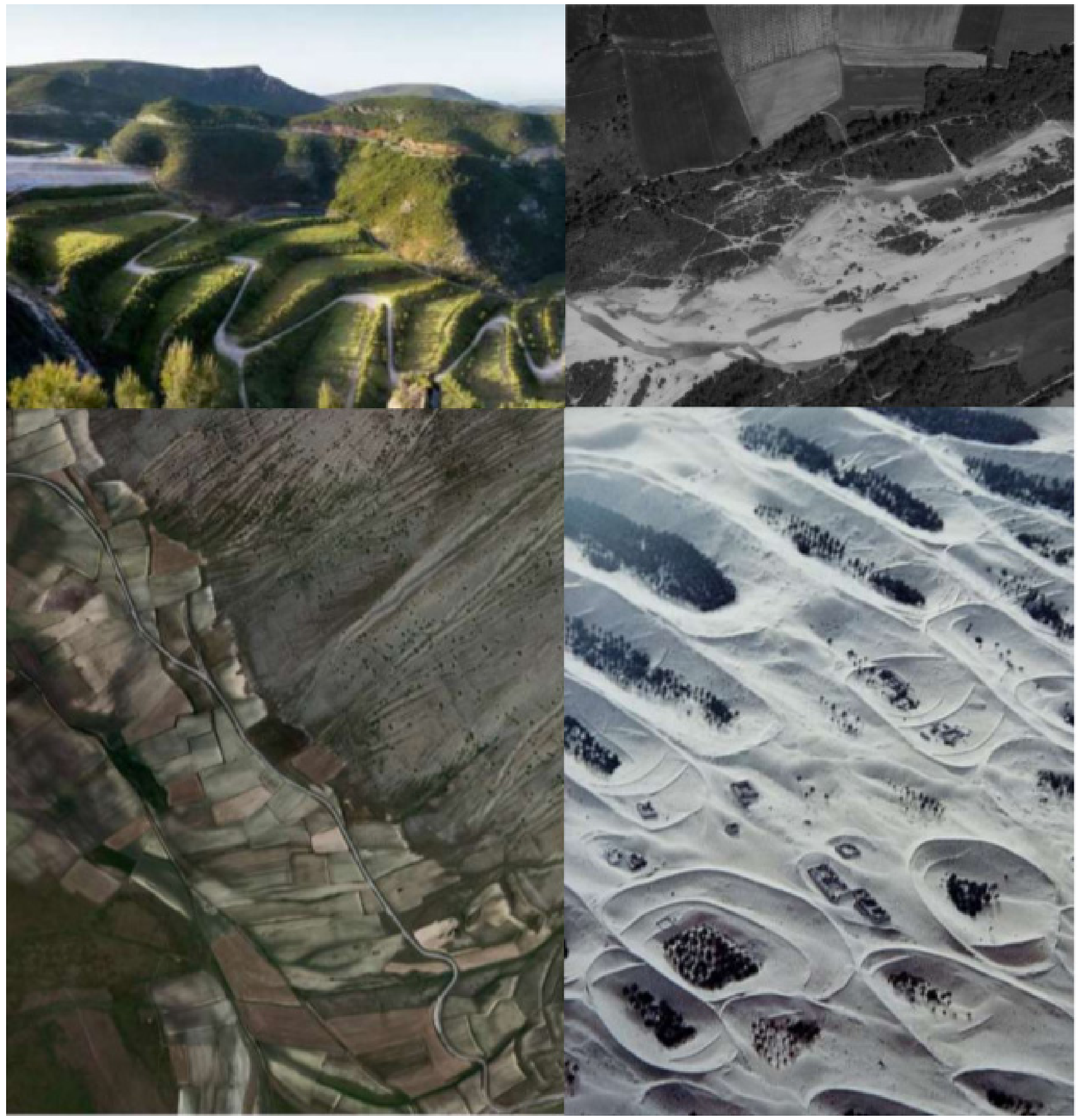


Fig. 13. Operative framework: the making of Landscape along tradition and modernity. Clockwise from the left: Garraf Landfill, Barcellona (Spain), 2007, source: Battle i Roig studio; alpine river Meduna with "braided", Italian Dolomites; (Italy), source: author; satellite view of Castelluccio Plan, source: Google Earth; Erg oases in the Algerian Souf, source: "The water Atlas", Laureano.

1.2 Aims & Objectives

The work focuses on the relationships between soil transformations and landscape design praxis, on the mutual effects and potential disciplinary developments aiming at structurally linking the two fields. The starting assumption is that, *soil is a condition of inherent shifting in landscape evolution*. Along the thesis dissertation will be substantiate how *landscape* in itself is intrinsically related to s*oil alteration*, subject to both anthropogenic and environmental pressures.
The research aim is first to emphasis this *physical* and *semantic* relationship. The *interdisciplinary* aspects are here merged in a *transdisciplinary* overview, in the attempt to provide a ground-breaking approach helpful to assist those scholars and professionals engaged in territorial transformations.
In such a way the role of *soil as fundamental design element* in the landscape project will be reframed, by identifying renewed forms of management and planning for contemporary territories.
For this reason the thesis purposes a potential model grounding on a named *Moving horizon approach* applied on *planning practice* and *design process*.
Thus, even though the main output of this thesis is considered of being the *Moving horizon approach*, other sub-outcomes can be considered, such as a *Lanscape Manifesto* of ten statements and prepositions as well as a synoptic *taxonomy of possible intervention*, intended as an overview on topological operations that can be operated on the ground in terms of *shape*, *cover* and *composition* shift.
With this aim, the thesis investigates, three main kind of frameworks. The first one is featured by exploring non univocal semantic field in landscape concept, relating the linkage that exists between landscape and soil transformations, both in *aesthetic-philosophical manifestation*, both in *environmental* and *material terms*.
The second kind of environment that this work addresses are the most characterized and affected by territorial *risks* and *anthropic pressures*. The third one concerns the reciprocity between *ecological*, *economical* and *energetic* component in evolving landscape. In particular, the thesis reports applicative case-studies located on the Italian and international context, highlighting the potentialities related to the transformation of soil in landscape design praxis as fundamental operation for managing the effects of anthropic process. They can be considered paradigmatic examples in a critical understanding of territorial metabolism to shape spatial strategies.

1.3 Methodology

Approach

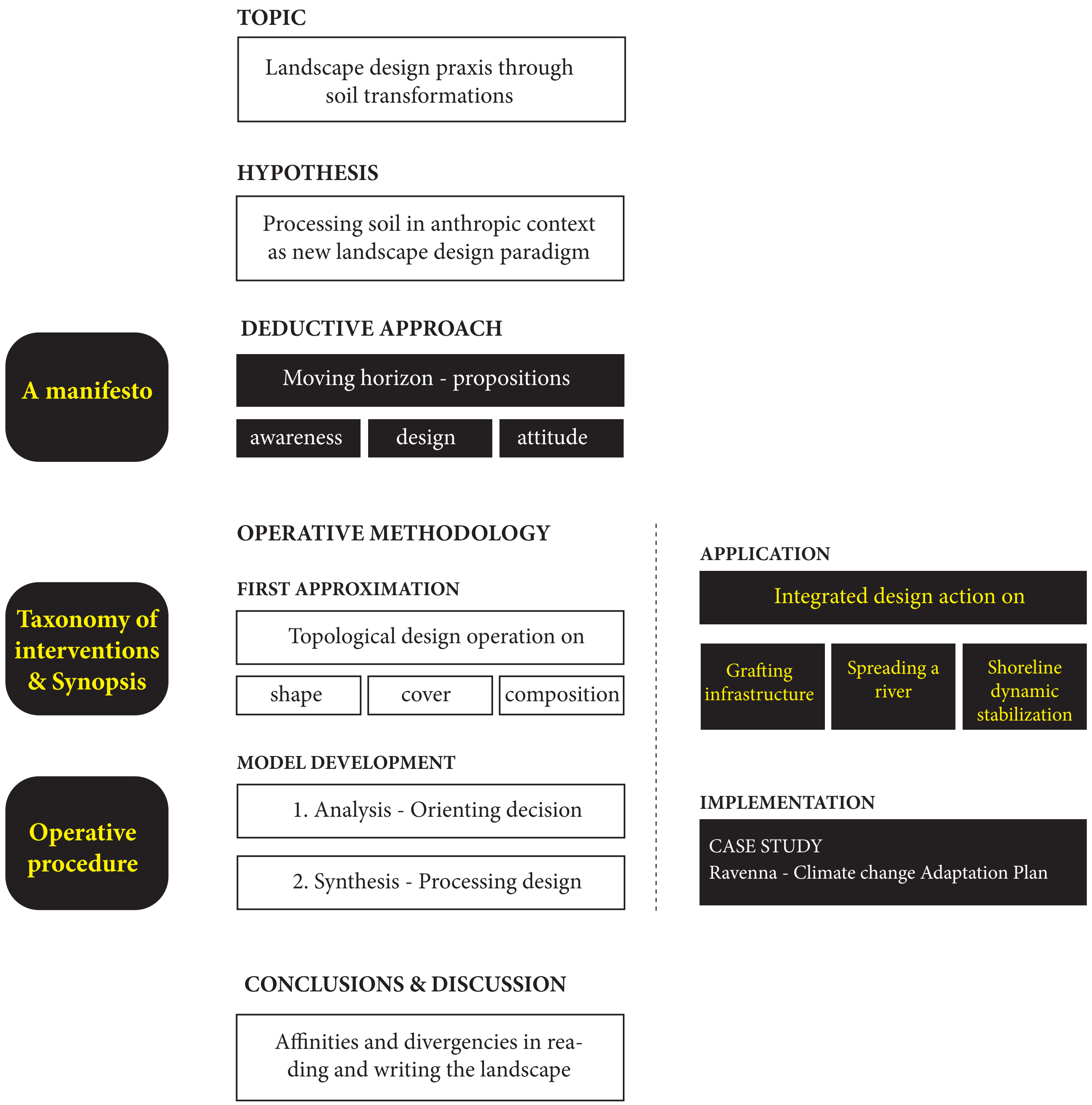
As already stated, the main subject of this thesis is *landscape design praxis over soil transformation*. Specific scientific literature on the matter is not wide spread and is extremly sectoral-specific, separing the field of landscape to that of the *soil, ecology, economy* and *legislation*.
However this work focuses both on theoretical rereading, both on the operative and design-process dimensions. Interpreting the *soil as a design element* lead to conceive the discipline of landscape design through parameters and tools commonly used in other disciplines, such as *geology, ecology* and *environmental engineering*.

As far as projects dealing with landscape transformation require team-work and multidisciplinary skills, here landscape design is intended as:
/ a *transdiciplinary discipline*s able to merge and synthetize speculative and operative aspects, in order to give an organic, integrate and inclusive response in terms of design;
/ an *effective tool to root metabolic processes in the anthropocene era* with its capacity to theorize sites, territories, ecosystems, networks and infrastructures, and to organize large urban fields
/ *human-processing control device* for increasing the level of compatibility between the evolution of the human habitat and the maintenance of nature regeneration times

The study of literary sources combined with the study of concrete practical examples constitutes the basis for elaborating on the research objective and research questions towards an argued approach.
In such perspective, the proposed methodological approach is *research by design*, described by Roggema as *suitable yet necessary approach to plan for the future, especially in projects concerning complex environmental challenges* (Roggema, 2017). In this regard *research* stand as *"development of new knowledge"* and *design* as a *"counterintuitive thinking"* (Roggema, 2017).

The methodological workflow is structured in an almost linear way, even if the development of every work package was not time subsequential.

Thesis structure
Workflow



Tab. 3. Thesis structure workflow. source: author

Steps

The theoretical background of the research has been oriented to clarify the positions grounding the *definition of landscape in itself* and its components (*energetic, ecological* and *economic* ones) -related to design aspects - , in parallel with *soil as hydden layer supporting our daily life* and a resource to be manteined and managed.

The study phase is followed by an analytical stage in which *research by design* should demonstrate - according to Roggema - a question to be addressed.

In the design phase the thesis works out the landscape design-related possibilities - through soil tranformation in the form of *design* and *spatial-planning* applications -, using *non-textual artefacts* to reach the adequate answer to the formulated question.

The final stage, brings forward the outcomes of the research, but also delivers a knowledge transfer and has a wider impact through the implementation of an operative procedure to a real case studies. The applicative case is reached by tha climate change adaptation plan in Ravenna, Italy.

Proposals and research presented in the following chapters are the results of critical and annotated re-reading of interdisciplinary works. It refers reading of interdisciplinary bibliography mainly focusing on the concept of landscape, soil matter, ecosystem, environmental issue, lagislation framework. The themes and topic have been addressed to investigate types of complex and highliy dynamic contexts with high anthropogenic pressures and critical forecasts in evolving landscape dimension .

Research path

The research path interweaves several aspects of the discipline of landscape design:

/ interdisciplinaty speculative research (Fig. 14)

/ professional practices (Fig. 15)

/ legislative framework (Fig. 16)

/ paradigmatic cases studies (Fig. 17)

/ on-site investigation (Fig. 18)

/ applicative case study (Fig. 19)

Research path

INTERDISCIPLINARY SPECULATIVE RESEARCH

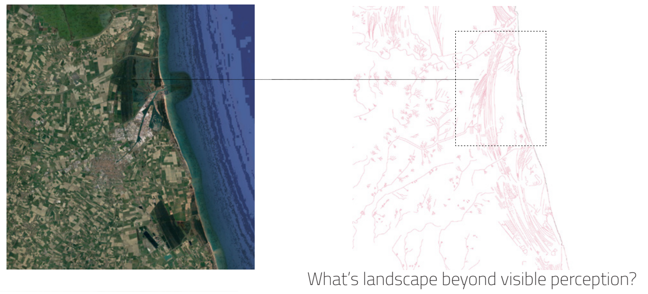


Fig. 14. Relationship between geomorphological traces and satellite view in Ravennna

PROFESSIONAL PRACTICE

Fig. 15. Masteplan of a park, state of art and project

LEGISLATIVE FRAMEWORK

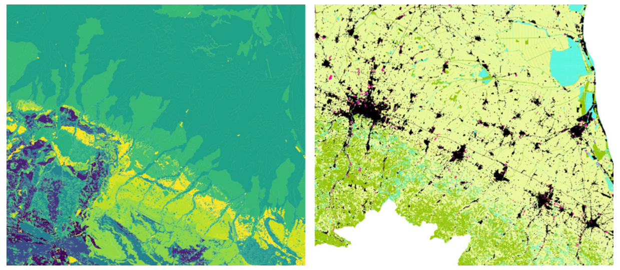


Fig. 16. Comparison among geomorphology and land use in Emilia Romagna Region

PARADIGMATIC CASES STUDIES

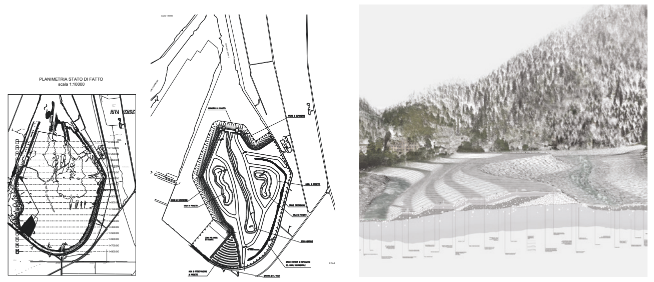


Fig. 17. Pialassa Piomboni in Ravenna constructed wetland and Sigirino topographic modelling

ON-SITE INVESTIGATION

Fig. 18. Coastal erosion barrier in Lido di Spina

APPLICATIVE CASE STUDY

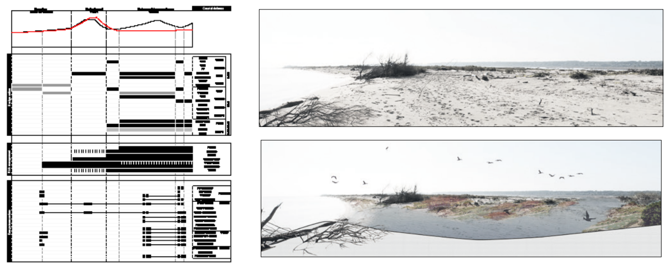


Fig. 19. Dynamic coastline, proposal for SECAP Ravenna 2020

It started from my professional practice in the field of *landscape design*, in which I recognized *the soil as a primer for landscape projects on several scale of intervention*. The practice has always been followed by speculative research on the topic and a huge collection of photographic material highlighting the linkage between soil and landscape evolution under environmental and anthropic pressures. The professional practice was also useful to become closer to legislation upgrade - at regional and national level - and requests, always more focused, on the preservation of soil health.

Phases

In summary, the method applied can be described by the following steps:

1. Study phase – State of art – Chapter 1:

The investigation scope aims to argue how spatial tranformations are involved both in the functions both in the *perception of Landscape*. Thus soil is regarded as the *featuring condition of inherent shiftings*. The study is carried out through the study of specific literature that describes and illustrate the semantic sphere (landscape, soil and their interrelations).

2. Analysis – *Moving Horizon Approach* – Chapter 2

Tha analysis phase provides to outline the main statement and preposition behind the proposed approach, exploring the *horizon* to be moved: *the line of the visible world, one recognizable layer of soil, a time limit*. The analysis will be supported by reporting results of relevant projects and researches that embrace the landscape project.

3. Metamodel design phase – *Taxonomy* of topological operations – Chapter 3:

This section provides both to enumerate datas requirements and availability concerning soil, both to recognize fixed and changing parameters to be trasfered as a design element in the framework of adaptation measures to increase territorial resilience and preserving ecosystem services provided by soil.

4. Design Phase – Model Development – Chapter 4

This section sets out a practical procedure for how design could be used in spatial research. The aim is to identify, the concrete actions whithin the framework of landscape resilience by relating the *territorial* and *planning scale* to that of the *project*, through an approach based on understanding and transforming the soil as a fundamental matter of this process.

5. Synthesis Phase – Model Implementation – Chapter 4

This phase provides for the implementation of the model developed in the previous step into a real case study: the *Climate Change Adaptation Plan* in Ravenna, Italy- developed by the author along the investigation period. The transfer of design proposal to a real case-study is useful to verify the hypothesis above.

6. Monitoring Phase – Results, Discussion and conclusion – Chapter 5

This phase provides to outline the general discussion and conclusions of the thesis. The first part anlyses the results, general conclusions pending and open discussion and research follow-ups of the work, across a comparison between the theoretical and practical aspects in landscape design field.

Thesis structure
Workpackages

WP1 - STATE OF ART
Theoretical framework, background and position

WP2 - OPERATIVE PROCEDURE
Taxonomy, model development

WP3 - APPLIED RESEARCH
Thesis output on real cas study

WP4 - IMPLEMENTATION
Dissertation and writing activities

TOPIC	2017 / 18				2018 / 19				2019 / 20			
Theoretical framework and literature review												
Materials & Methods												
Statements & Position												
Database & Case history outline												
Data collection & Simulation												
Model approximation												
Model development												
Model implementation												
Drawing results and conclusion												

Tab. 4. Thesis structure workpackages. source: author

Outcomes

OPERATIVE PROCEDURE

TAXONOMY OF INTERVENTIONS & SYNOPSIS

A LANDSCAPE MANIFESTO

EXPLORING NON-UNIVOCAL SEMANTIC FIELD

Tab. 5. Thesis outcomes. source: author

1.4 Contributions & Constraints

The thesis lays the ground for further work to be carried out with regards to the application of the *Moving horizon approach* in landscape design praxis. Specifically, the research has found that a *landscape-based approach integrating soil transformation as fundamental element* is indeed a primer in planning and design procedure. In the process, the thesis has highlighted certain key areas which contribute to the discipline of landscape design:

/ The research work is mainly aimed at support those professionals involved in landscape design and spatial planning which affect both from the field of architecture and from different disciplines but still involved in the fields mentioned. It provides a specultative and operative framework of possibilities for *reading* and *writing* the landscape, by emphasizing the strong relationship between *soil transformation, planning* and *design praxis*

/ *Exploring non-univocal semanthic field in landscape* can be worth in raising the level of awareness in understanding and reading landscape and its components, clarifying the reciprocity and complementariness between the various disciplines that deal with landscape studies such as *geology, ecology, environmental sciences*, being inextricably linked through reciprocal relationships with soil

/ The *Moving Horizon approach* has been exploited into an operative model that contribute to the scientific understanding on the soil and ecosystem services - and their interrelations with transformation operated by design actions- , by clarifying in a quinck and effective way the connection among alteration of soil and its conservation in terms of soil health

/ The research development offers a comprehensive and detailed panoramic on the topic without finalizing the debate on it. It opens for a matter of time and possibilities. The lack of a specific bibliography and the high interdisciplinarity of the topic (*landscape* and *soil*) leads to do the effort to create a first approach, that can add contributions. The argument cannot be completed or ended but can be highly implemented.

/ The model provides a framework within which other specialistic contributions may apply refining the data supply (in terms of quantity and definition), tools and methodology according to a constant updating. This potential development is one of the principal research follow-ups. The main discipline to be involved are geologists, engineer, environmental scientist, agronomists.

1.5 Theoretical Background

The thesis grounds its work on three main *topic* composing the *theoretical background* upon which applicative case studies and the proposal of *Moving horizon approach* have been developed.
The first topic concerns the concept and definition of the *landscape*, *investigating non-univocal semantic fields*. Here, exploring the ambiguous connection between the *scientific* and the *aesthetic* ways of conceiving landscape, the *objective* and *subjective* components that interfere with the threshold of landscape perception are introduced. Through a critical reading, the *landscape meanings* are investigated, by revisiting the elements that contribute to create the common landscape imaginery. Starting from it's *ethimological root* and presenting a brief perspective of paradigmatic examples envisioned as *cultural heritage*, here the intricate connection between *landscape* and *soil transformation* is clarified.
The second topic regards the soil, intended as the *hidden layer supporting our daily life*. The aim is to explain: what actually soil is; its role in supporting ecosystem services; the direct and indirect impacts that anthropic activities exert on it. Furthermore it is emphasised the connection between scientific research and national and international agreements about the importance of supporting soil's health.
The third topic regards the reciprocity between *ecological, economical* and *energetic* components in landscape evolution - tightly closed to their interaction. These relationships are made of *material* and *energy flows.* Along different *space-time scales* they shape our environment, interfacing with geosphere. Thus they should be considered part of landscape design process.

By relating the scientific review on these three topics and by attempting to understand their potential connection with design and planning issues, the present original research aims at specifying, from its very beginning, the main theoretical framework in which the applicative case studies have been carried on.
In fact, we have chosen to recall the specific references concerning the landscape discipline reporting some projects, in order to emphasize their direct effects on the design and applicative research process.
Thus, the following paragraphs tackle mostly that part of the research dealing with those disciplines which contributed to drive our approach towards the possibility of using soil transformation to face the challenge of addressing future landscape evolution affecting the decision-making process of territorial development.

Interference with other scientific realms

different perspectives to interpret the external environment

Landscape design	**Landscape ecology**	**Ecosystem ecology**	**Cognitive landscape**
a series of operations that intentionally induce alterations of space with the aim of giving a clear form of evolution in places	investigates the effect of the spatial arrangement of the objects and related processes into a geographic realm	focuses on the flow of matter and energy throughout organisms, populations and communities	focuses on landscape as semiotic interface between resources and organisms
spatial interpretation & transformation ⟷	**spatial arrangement**	**flow of matter and ener-**	**signs, signals and meaning**

Spatial tranformation are involved both in the functions both in the perception of Landscape

Tab. 6. Interference with other scientific realms on Landscape. The diagram is outilined by the author, through a critical reading of the following papers produced by the ecologist Almo Farina: "Cognitive landscape and information: new perspective to investigate the ecological complexity" (2005); "The Landscape as a Semiotic Interface between Organisms and Resources" (2008); "Ecology, cognition and Landscape" (2012).

1.5.1 Sub-limen, moving along the threshold of landscape perception. Soil as a featuring condition of inherent shifting.

Intro

Moving along the threshold of landscape perception, the supported hypothesis is that s*oil transformations can be recognized as a fundamental condition of inherent shifting*.

Down through the ages, landscape has been subjected to various interpretations and understandings. As argued by the landscape ecologist Almo Farina (2012) *"because the landscape is an expression of complexity, a single celebratory definition cannot suffice"*. According with him we intend to go beyond the semantic presupposition of subjective perception - and revelation - attributed to the landscape in the common sense of the term.

The apparent inconsistency between the numerous landscape interpretations and the practical understanding of soil transformation has formed the focal point of the discussion throughout this thesis.

A new semantics is decisive to re-frame a set of areas through this reduction of formal and functional separation. This advancement aims at re-formulating the concept of landscape in order to manage its dynamism rather than immobilize it in a passive scene.

Through an approach based on the understanding of s*oil as the underlying material of this dynamism*, the Landscape is outlined by the latter as *the result of environmental and anthropogenic processes into a geographic realm in continuous evolution*.

Thereby, the design praxis is configured as the *intention to codify and contextualize these processes, involved as active components in the landscape generative and organizational levels*.

To make this approach effective, it is essential to have a systemic vision, by incorporating principles and methods aimed at *exploring non-univocal semantic fields*.

The proposed approach is not a mere conceptual overcoming in a speculative sphere. It is rather presented as the attempt to concretely express the linkage between *fixity* and *mutability* features, capable of transcending the idea of *still image*.

In this chapter, I present the theoretical setup for the empirical inquiries for the concept of *sub-limen*, expressed at the end of this sub-chapter.

"Beauty can give you a false sense of existential security"

Rem Koolhaas
inteviewed by the journalist Vladimir Pozner, 2018

Fig. 20. Soil salinization in Ravenna, 2020. Salinization is considered a degradation factor in terms of soil health. The visual effect can be suggestive in some light conditions. source: Matilde Stolfa

Exploring non-univocal semantic field

In western culture, the term *landscape* is the subject of numerous semantic discussions and interpretations. The erratic meanings refer to the terms in which is treated by the numerous disciplines that affect the landscape and the aspects that make it up (Antrop, 2000) (Antrop, 2019) (Gibelli, 2008) (Zagari, 2006).

In the common and most widespread terminology it refers to *a portion of territory as it appears embraced by the gaze of a subject*. In this establishment, it assumes an high degree of subjectivity, hence the landscape is perceived as a *phenomenon*. This aesthetic realm is also emphasized by the 1st article of *European Landscape Convention* (COE, 2000)[16], as well as by prominent scholars, such as the theorists Rosario Assunto[17] (1994) and Michael Jakob (2009) - albeit with conceptually different purposes and implications.

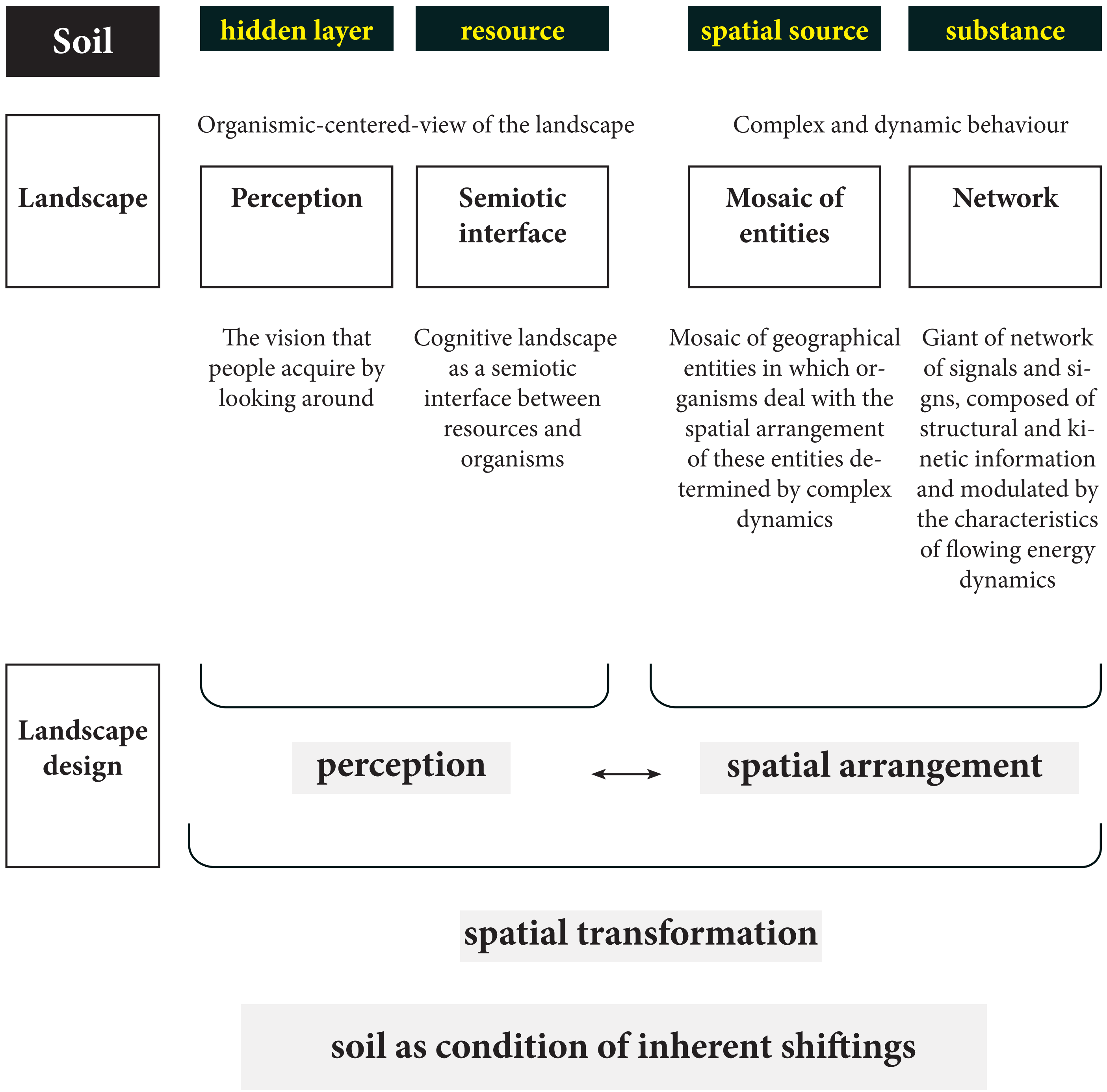
On the other hand, in scientific areas of interest - such as *landscape ecology* (Forman & Godron, 1986) (Naveh & Lieberman, 1990) (Farina, 2008) (Farina, 2012) (Wu, 2013) and *geography* (Antrop, 2000) (Farinelli, 1981) - the study of these interactions and their measurement through techniques and tools tend to an objective description and knowledge-oriented representation. In this context, the landscape is understood as the result of processes between natural and anthropic matrices that materialize in a space. The topic is broadly debated for the social, economic and environmental values connected to the idea of landscape (Gibelli, 2008). The perceived landscape is immediately analysed by the observer, compared and evaluated through the lenses of his knowledge and previous experience (Antrop, 2010), and of the manner in which the information are transmitted from the context of the observer and vice versa (Gibelli, 2008). Since from the interpretation of reality derives both personal choices and territorial decision-making processes, it assumes fundamental importance with regard to the "*destiny*" that a certain landscape may have (Gibelli, 2008).

Nevertheless, every approach is necessary but not sufficient to fully understand and explain the inner landscape complexity. The crucial point is how can this setting be shifted into land design and urban development by involving theories and practices. In this regards each perspective contributed to a new and deeper understanding of the landscape, helpful in make a conscious decision.

[16] Art. 1 European Landscape Convention: «*"Landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors*» (Council of Europe, 2000)
[17] Assunto enhances the identity aspects, Jakob deny them. Jakob in particular speaks of a visual relationship between the observer-subject gaze and a piece of Nature-object from which the experience of the landscape flows.

Interdisciplinary framework

Exploring non-univocal semantic field on Landscape



Tab. 7. Exploring non-univocal semanthic field on Landscpae. The diagram is outilined by the author, through a critical reading of the following papers produced by the ecologist Almo Farina: "Cognitive landscape and information: new perspective to investigate the ecological complexity" (2005); "The Landscape as a Semiotic Interface between Organisms and Resources" (2008); "Ecology, cognition and Landscape" (2012).

Soil as a condition of inherent shifting

Although they cannot give an univocal definition, the various interpretations of the term lead to *the description of a place and to the interaction between the elements – anthropic and environmental - that compose and characterize it*. The sustained hypothesis is that this relationship is *intrinsically linked to the soil shifting, creating ever new landscapes*.

This statement does not deny the approaches described above and finds support in the short essay drafted by the Austrian pedologist Peter Finke. In *Soil and Landscape* Finke affirms *"Soil is the part of the landscape that is less easily observed because it is below the surface. There exist however strong relations between the landscape that we see and the soil below. These relations exist because soil and landscape are affected by the same processes, and also because soils and landscape influence each other"* (Finke, 2016).

In fact, these alterations define the spatial heterogeneity and the peculiarities. Therefore the landscape is perceived in its diversity, even if this does not happen in a conscious way.

The discontinuity of edaphic factors[18] contributes to the intriguing diversity of ecological patterns found in nature. Perception and spatial transformations are mutually linked and related to spatial arrangement in a symbiotic connection with *soil shifting*. They all combine to define the framework in which the discipline of landscape design stands and operates.

Processes affecting the landscape and the soils are highly influenced by processes that redistribute mass on the surface, but also below the surface (*leaching*) (Finke, 2016). Thus there are also feedback mechanisms between soil and landscape though the intricate relation across water flow patterns, soil development, vulnerability to erosion and landscape change (Finke, 2016).

A more technical understanding of soil - in its pedological and geological meaning - will be provided in the next sub-chapter. Here the letter prefers referring to the representation given by the naturalist William Bryant Logan in *Dirt, the ecstatic skin of the earth* (Bryant Logan, 2017), a book across narration and science. Logan shows the interconnection between soil and life and especially with human civilization. He argues *"A soil was not a thing … It was a web of relationships that stood in a certain state at a certain time"*. Starting from the formulation given by the letter in reference to the outline of landscape meaning and terminology, this overview stands in a mutual relationship with the landscape. It is all about the process. We are focusing on the physical support and the main drivers which in turn determine the structure, function, and dynamics of landscapes.

[18] The edaphic factors include the physical, chemical and biological properties of the soil, the result of geological and biological phenomena and of anthropic activities. Physical and chemical soil characteristics greatly influence the ecology and evolution of plants and associated biota.

Fig. 21-22-23. Pedolandscape. Soil development makes a contribution to the spatial heterogeneity of the soil because, together with other agents, soils with different evolutionary pathways participate in forming the soil cover and so contribute to the creation of specific soilscapes. From the top: badlands in lower Marecchia river valley (Italy); mountain in upper Marecchia river valley (Italy); Llobregat rivermouth protected area in Barcelona (Spain). source: author

Back to the origins

This relationship between landscape and soil transformation can also be traced backwards by following the evolutionary trajectory of the term, which ethimologically meant *an action operated on a site - characterizing it – through soil manipulation*[19]. In the Latin matrix *pays- age* the term *pays* derives from the Latin *pango*, with the meaning of *delimiting by sticking pegs*. In the Germanic root, *land-schaft* refers to *land schaffen*, with the meaning of *transforming a terrain*.

Over time, the literal relevance has charged with cultural values, which basically denote *an identifiable tract of land influenced by human activities* (even if it is simply the act of viewing) (Corner, 1999). As such, in this approach, landscape literally describes the state of altered land as distinct from virgin land before human influence, rather than referring to the subject matter of physical transformations operated on the ground.

Yet another interesting aspect to take into consideration is the study of literary sources that traces the historical path along which landscape has been shaped throughout the centuries.

By overviewing key literatures, the most significant reference can be find out in numerous works of: Pietro Laureano - centered on *water management* traditional knowledge (2007, 2013); in Franco Panzini's work *Progettare la natura* (2005) – concerning the main steps in which man has shaped the environment; in the written production of Gilles Clement (2012, 2013).

In a roundabout way, they emphazise the role of soil planning and management behind landscape design praxis from the Neolithic to the contemporary era. Here is reported a brief digression, in chronological order.

The first forms of practices and techniques used in the deliberate modification of space to obtain an advantage are due to food and shelter needs. In particular, the water supply, which is vital for life, has led to the development of knowledge relating to soil management (Laureano, 2013).

Already the first hominids created surfaces and banks for water collection. In the steppes, savannahs and deserts, along karst highlands or the interpluvial plains, human groups exploited favourable marginal areas subject to alternating presence and absence of water through flow control techniques.

Filter techniques for water and canalizations to fertilize the fields were carried by the first neolithic societies, that were spread in nearby areas, in consequence of sedentarization and the related multiplica-

[19] As evidenced by Michael Jakobs in *Landscape and literature,* in neolatin languages the term derives from french word *paysage*, composed to *pays*, that means *land, region* and the suffix *-age* which tends to give the idea of collective, global. *Pays* comes in turn from the Latin *pango* with the meaning of "sticking pegs", "delimiting". In germanic languages it comes form *Land – schaft,* in which *land* stands for *region, farmland clearing land* and *schaffen* means *making up, shaping.*

BACKGROUND

CONTEMPORARY

Fig. 24-25-26-27. Operative framework: the making of Landscape along tradition and modernity. Clockwise from the left: rural landscape in Marche region (Italy), source: Mario Giacomelli archive, On Being Aware of Nature, 1954–2000; Trellborg Viking fortress archeological site; Baronio Park in Ravenna Construction site, 2015, source: Paisà landscape; Garraf Landfill, Barcellona (Spain), 2007, source: Battle i Roig studio.

tion of the agricultural production centers. With the passage of time these methods became more and more elaborated. In the sixth and fifth millennium b.C. - before the development of practices to control the course of large rivers - the so-called *entrenched villages* were surrounded with ditches that drained water and made it usable for feeding and irrigation. Between 5.000-2.000- b.C. in Britain started the development of big environmental modelling of gigantic size, such as Avenbury and Stonehenge holy sites, that maintained the huge circular embankment with the internal trench (Panzini, 2005). In Scandinavia, during the Viking Age, *Trelleborg-type fortresses* were constructed through a giant defence embankment, that still remained in some Denmark archaeological sites.

In the VI millennium b.C., the Mesopotamian societies devised the first techniques of canalization and flow diversion with banks which allowed fort flood irrigation (Laureano, 2013) (Panzini, 2005).

In the same period in Baluchistan (a region between modern Iran and Pakistan) the Harappa's pre-civilization employed underground dams, called gabarband, to hold water flows in the soil and surface dams made by sand accumulation that promoted silt sedimentation combined with the control of alluvial deposits and floods.

The first forms of cultivation with direct sowing on the ground occurred in lands taken from the forests, in turn abandoned when impoverished by the use (Panzini, 2005).

Later, the agricultural widespread technique of terracing combined several uses: slope protection; soils replenishment; clean water supply; animals shelter. In China, Central and South America and Mediterranean basin, the soils have kept their fertility for millennia, thanks to these water control techniques, moisture collection and soil protection (Laureano, 2001).

During the Italian Renaissance the soil is no longer seen as a resource for household food consumption (Panzini, 2005). From this moment onwards the ground is seen as a possible place of investment for the production of food products intended for trade and raw materials for textile or construction industries. So a very large-scale soil manipulation began. Important works of tillage and land reclamation impressed a total change in huge areas of Tuscany and Po Plain.

The implementation of French *royal villas parks* - such as Versailles or Chantilly - are the results of a great territorial redesign, operated by reclamation works and great hydraulic infrastructures (Panzini, 2005). As well as the big urban transformation in the XIX century for the big city park construction is linked to ground modelling as a central element of the design process.

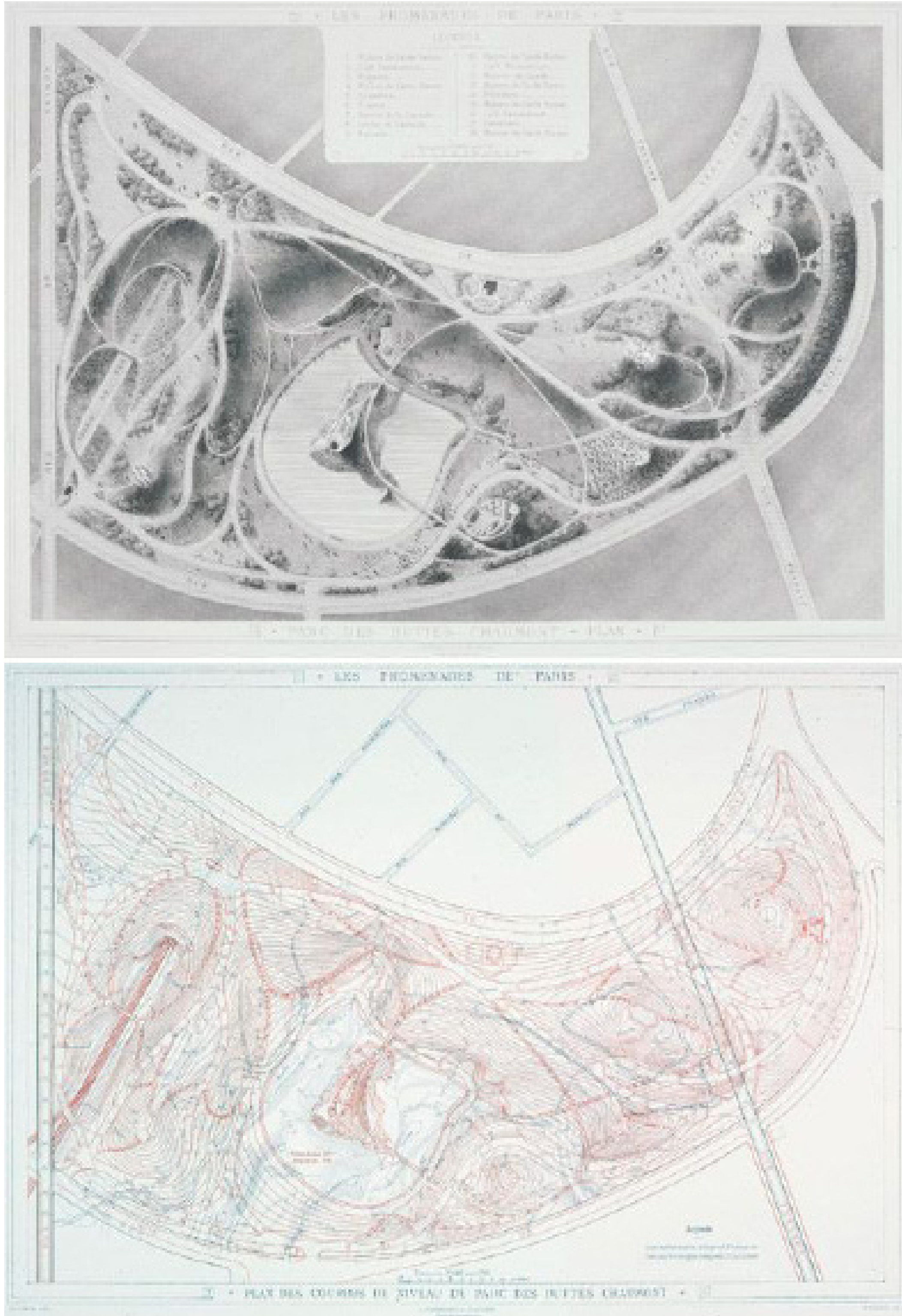


Fig. 28. Two views of the Parc des Buttes Chaumont in Paris by Jean-Charles Adolphe Alphand, 1867-71. A contour drawing illustrates the engineered underpinnings of the landscape, and a shaded relief drawing of the site heightens the topography. The technique of overlaying the before and after contours, with the proposed highlighted in red, shows the dynamic process in a single image. The curviliner design language emerges from the rough site, accentuating and amplifying the existing lanforms, while deliberately leaving rough edges in places. The pair of drawings demonstrate the merger of the technical and aesthetic mastery found in the design.

As an example, engineer and parks director Jean-Charles Adolphe Alphand - under the direction of Georges-Eugène Haussmann - transformed a former quarry and waste dump into a romantic parkland. The pair of drawings in Fig. 28 demonstrate the merger of the technical and aesthetic mastery found in the design (Desimini & Waldheim, 2016). The accompanying engraving uses shadow and texture to fully render the character of the ground plane.

In summary, the agents that modify the landscape, both environmental and anthropic, always deal with a modification of the soil in terms of *morphology, coverage and composition*. This subject will be fully argued in Chapter 3.

All these examples shows that environmental control is a way to protect the valuable assets: agricultural production, animals breeding, the art of living and in general what with the passage of time will seem the best (Clement, 2012). Quoting Gilles Clement (2012) the way to interpret the *best* that - depending on the models of civilization - will determine the *style* of the landscape transformation.

Sub-limen

In these understanding, the *soil processing* can seemingly change status from being '*background*' to '*foreground*' in the *making of landscape* and its perception.

In this framework, the latter chose to title this section sub-limen in reference to the following concept:

/ *sub limen*: the soil is normally under the threshold of common perception because it is the part less observed of landscape but also the main trascendental component

/ *subliminal:* as a feelings that take place below the level of consciousness, - too weak to be felt, but sufficient to influence the unconscious and condition behavior – the soil is not recognized or understood by the conscious mind, but still having an influence on it

/ *sublime*: in rejection of judgment and the concept of beauty and morality, we prefer relate the landscape perception to ecstatic instead of aesthetic

/ *sublimation*: soil, an even transforming matter, changes phase in direct transition from solid to aeriform state without passing through the liquid phase

This new semantic is decisive to re-frame a set of areas through the reduction of formal and functional separation, as re-formulating the concept of landscape in order to manage its dynamism rather than immobilize it.

Fig. 29. Construction site of special waste landfill in Ravenna, 2021. source: author

Soil is the part of the landscape that is less easily observed because it is below the surface. There exist however strong relations between the landscape that we see and the soil below. These relations exist because soil and landscape are affected by the same processes, and also because soils and landscape influence each other. (Finke, 2016)

Fig. 30. Soil in natural condition at 2000mt high, Brenta Dolomite (Italy). source: author

Fig. 31. Soil in anthropization condition at 1500 mt high, Brenta Dolomite (Italy). source: author

1.5.2 Soil, an hidden layer supporting our daily life

Soil as living matter

The *soil* is an *environmental matrix*, formed by *an highly variable mixture of minerals, organic matter, water, gas and microorganisms* that interact with each other (Markewitz & Richter, 2001). Soil is one of the most complex *biomaterials* on Earth (Adhikari & Hartemink, 2016) in continuous exchange with the terrestrial *systems* that together with the *pedosphere* make up our planet: *lithosphere, hydrosphere, atmosphere* and *biosphere* (Adhikari & Hartemink, 2016). It behaves as an open, thermodynamic system highly responsive to inputs and outputs of chemical elements and energy (Markewitz & Richter, 2001). Soil formation, the so-called pedogenesis, is the result of long processes of interaction between the elements that compose and interfere with the soil. As a result we define it a non-renewable resource in reasonable time (Markewitz & Richter, 2001).

Along the *pedogenesis* dynamism, the environmental conditions that determine the development and soil properties are: *climate*, *lithological substrate*, *morphology* and *relief*, *biota*, *time* and also *human activities*. This last is described as the *Sixth Soil-Forming Factor* (Richter, 2012).

Soil-forming processes include *atmospheric deposition* of water, dust, and solutes, mineral weathering, organic decomposition, pedoturbation, plant rooting, redox reactions, fire effects, chemical leaching, and erosion. The combination of all these agents contribute to produce: *soil organic matter*, *organo-mineral complexes*, *secondary minerals*, *aggregates*, *clay skins*, *complex surface areas*, *soil pans*, and *pore networks* (Richter, 2012).

Many substances are stored, filtered and transformed in the soil - including water, nutrients and carbon. Soil also provides a habitat for *soil biota*. The preservation of soil biodiversity - and soil biota - is essential for maintaining soil processes and functions - like nutrient cycling, decomposition, and bioturbation - , thereby for maintaining a flow of ecosystem services (Adhikari & Hartemink, 2016).

In this regard, in ecology field soil is considered the *central processing unit of the Earth's environment*[20] (Sanchez 1994, Richter and Markewitz 1995).

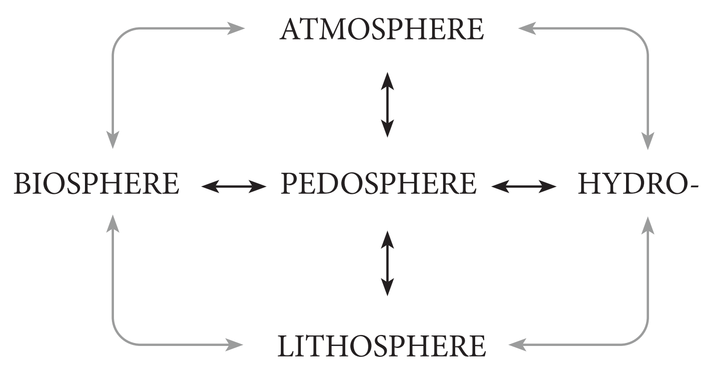
[20]With socio-ecological upscaling - accelerated with the emergence of urban and industrial societies - the Earth is entering the *Anthropocene age*. Confining human influence within the biotic state-factor seems to underestimate humanity's reach over ecosystems and soils worldwide. From the prospect of the Anthropocene age (Crutzen, 2002), humanity has outgrown the biotic factor of soil formation. (Richter, 2007)

SOIL

highly variable mixture of :

- minerals
- organic matter
- organisms
- gas & liquids
- water

Open and complex system in continuous exchange with the other ones



Tab. 8. Exchanges among terrestrial system. Author elaboration

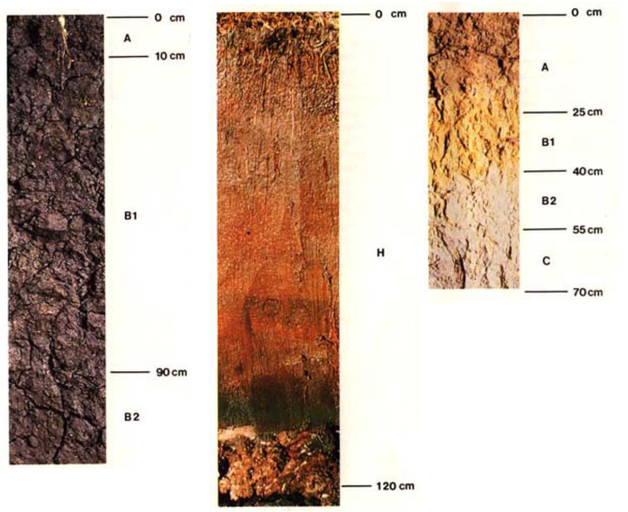


Fig. 32. Soil horizons. source: FAO

Fig. 33. Alluvial Fans in Iran

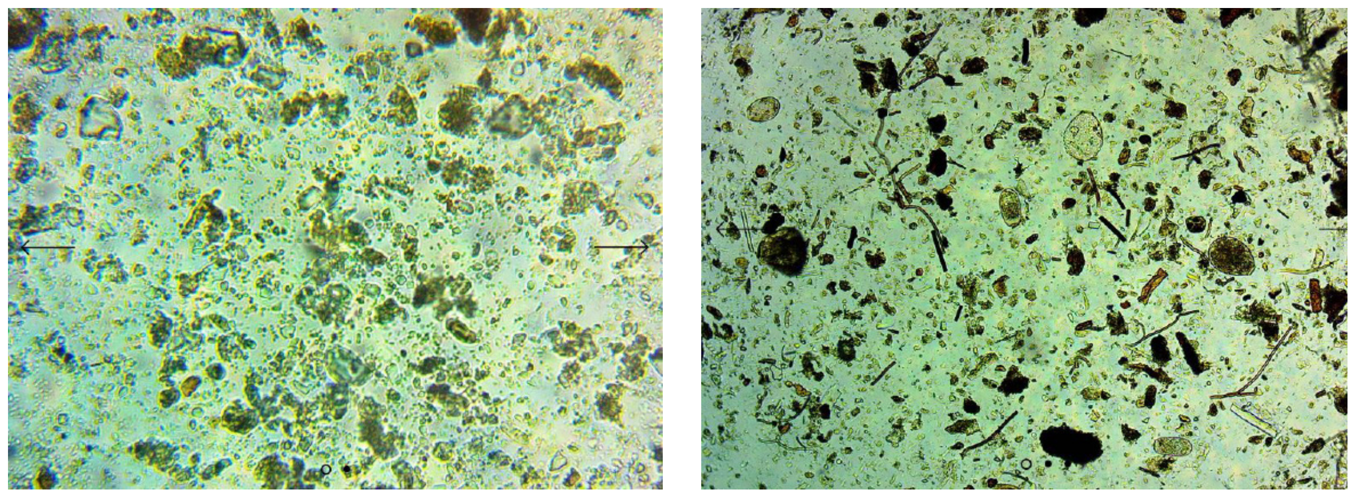


Fig. 34. On the left: Tillages soil. On the right: forest soil.

An hidden layer supporting our daily life

Richter and Markewitz (2012) describe soil as: "*the biomantle of unconsolidated material that makes life possible on planet Earth"*. According to the researchers, soil is the *hidden layer supporting our daily life*. It is a great and extensive connective tissue, through which environmental networks spread and allow us to live our daily life as we imagine it today. The *natural* and the *built environment* are anchored to the ground through very complex relationships. The surface layer and the subsoil exchange matter, energy and information, in a sort of osmotic relation.

Soil features make up environmental and territorial networks - like aquifers and underground canals – in a symbiotic link with the natural ecosystems.

Soil has a role in balancing the material flows that cross it, by operating as the *interface of 'biophysical interactions'* in water and energy exchanges across the land and the atmosphere.

The IPCC's *Reports on Climate Change and Land* (2019) elucidates how these interactions depend on the land surface characteristics, including surface roughness, and soil water access by vegetation[21].

For millennia, humanity has worked hard to domesticate wild soils to meet core human needs[22] (Richter, 2007). Re-tracing the conventional contours of the cities we live in and the spaces we travel through, the diagram on the other page (Fig. 35) illustrates the range of *depths* and dimensions that we have explored, exploited, occupied, and instrumentalized over the course of the past 3,000–5,000 years of human history. Soil is the matter of exploitation and the physical canvas of exerting pressure on the *altitudes of contemporary urban life* organized through different depths and elevations, from logistics to communications, policies to legislations, planetary processes to intertidal cycles, climatic differences to barometric pressures (Belanger, 2016).

Echoing an expression of Pierre Belanger in *Altitude of Urbanization* (2016) *"Altitudinally, change is as much environmental and spatial, as it is political and ecological"*. This longitudinal landscape provides an augmented understanding of where we live in relationship to thermodynamic exchanges, latitudinal variations and hydrological ranges that are associated with vectors of movement to better understand the live, dynamic ecologies under across manyfold depths.

[21] Which depends on: soil characteristics, the amounts of roots, the emissivity of long wave radiation by vegetation and soils.

[22] As evidenced in Ch 1.5.1 and Ch 3.2

33% of world population lives within 100 mt of sea level

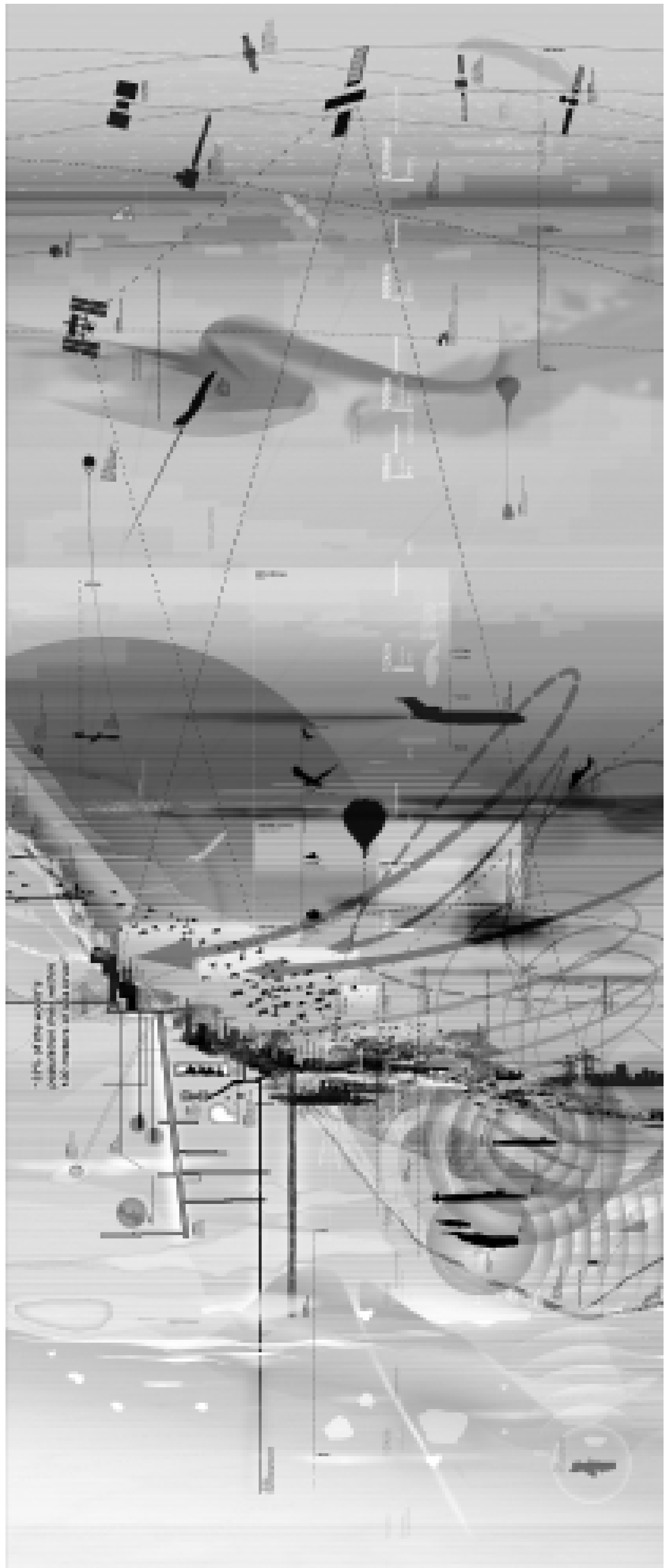


Fig. 35. The altitude of urbanization, Pierre Belanger. Seeing from the side: altitudinal section showing depths of extraction with underground urbanization to the deepest hole in the ground at 10,781 m below sea level to atmospheric urbanization with satellite revolutions at 380,000 km in high earth orbit.
source: Pierre Belanger, in "Altitude of Urbanization" (2016)

Construction of the human niche: antropocene ecologies

As it becomes increasingly clear a complex history of human impact is accruing within soils, as new changes are overlain on those from the past. In the last 50 years, humans have transformed them more rapidly and intensely than in any comparable period of time in human history with the aim of meeting the rapidly growing demands of food, fresh water, soil, raw materials, fuels (Richter, 2012). Along these *great acceleration* (Ellis, 2011), increasing fractions of Earth's soil are: manipulated for residential, industrial, transportation, and recreational development; altered in hydrology; chemically contaminated; and used for waste disposal. As a result, the *human niche* has been expanded far beyond anything that unaltered nature could provide by processes of cultural evolution far more rapid than biological evolution. These unprecedented capabilities for social-ecological upscaling are what have enabled a single species to transform an entire planet *(Ellis, 2014)* with humanity being today *Earth's primary geomorphic agent*[23] (Richter, 2012). Richter argues that: *"Influence on soil formation is much more profound than originally perceived and that human impact occurs across all natural soils not as deviation but as a component part of the genetic soil type"* (2007). Humanity, for example, alters: climate at both microscales and macroscales; biota, by rearranging, promoting, and extinguishing plants and soil biota; parent material and geomorphology by physically mixing, resorting, and rearranging enormous soil volumes in cultivated fields[24], wetlands, riparian zones, cities, suburbs, roads, industrial areas, mine lands, and war zones; and time by greatly accelerating the pace of soil change at both local and global scales.

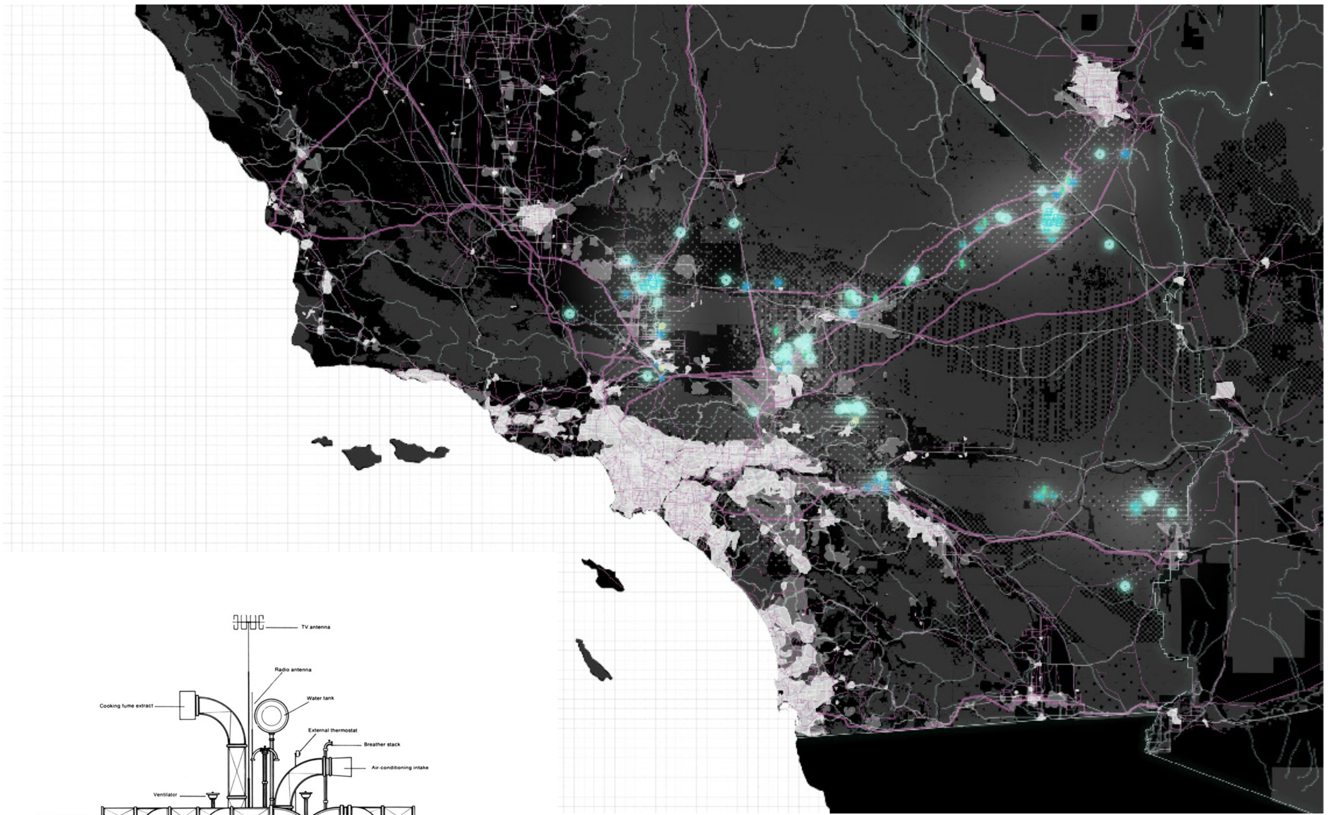
In this sense human driving forces represent a global wave of *soil polygenesis* altering fluxes of matter and energy and transforming the thermodynamics of soils as potentially very deep systems (Richter, 2012).

As a result, some researcher suggested the concept of *soil as a human-natural body*.

Our understanding of soil's role in the great global cycles of chemical elements lag far behind our impact on these cycles (Markewitz & Richter 2001). Humanity's expanding systems of food, fibers and water production are now entirely dependent on the management practiced on several billions of hectares of soil. The quality of human life and the Earth's environment has never depended more on soil management than it does today.

[23] By which derives the concept of *Anthropocene*, a proposed geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change.

[24] Extensive areas of forests that are currently being cleared and converted to agricultural uses, alter Rates of change in soil organic carbon in response to cultivation, manure amendments, reforestation, and other practices contrast with rates of change in soils that are products of natural soil formation. (Richter, 2012) - As tillage frequency and intensity increase and carbon input, especially from roots, decreases, the probability for degradation of soil health increases. (Karlen, et al., 2019)



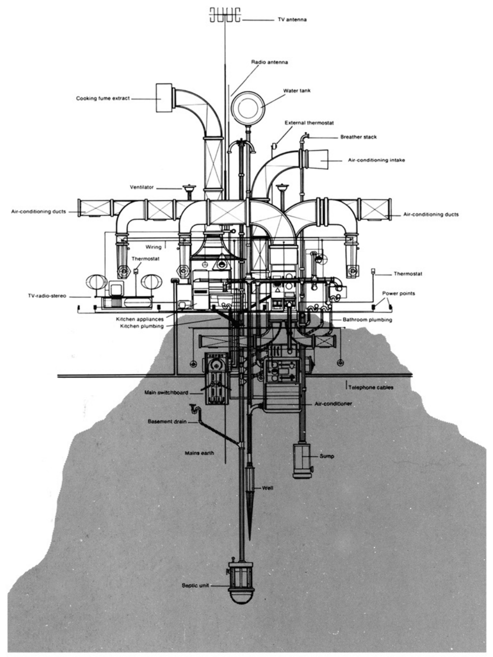
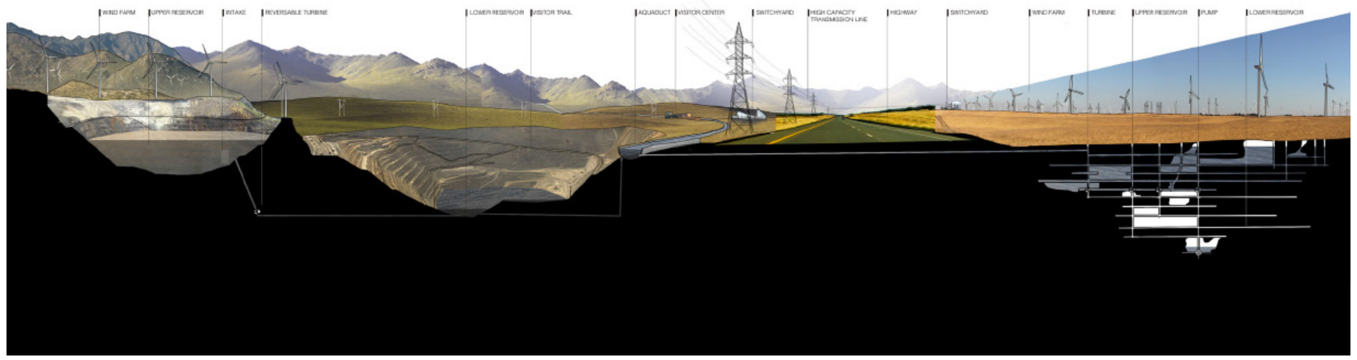


Fig. 36-37-38. From the top: Landscape and energy, by Pierre Belanger; Anathomy of a dwelling, by Reynar Banham; Crossing sectiong along energetic landscape and the impact on soil, by Pierre Belanger



Managing Soil and Ecosystem services

Soil plays a crucial role in *ecosystem functioning*[25] (Adhikari & Hartemink, 2016).

The dynamic nature of ecosystem is primarily due to a key ecosystem component, the soil, which harbours a range of *biota* with diversified roles in soil, role which is key to many processes and functional variations. Furthermore, the impact of human activities and the role of changing climate and land use on soils, coupled with changing demands over time, changes *soil physio-chemical processes* and leads to a different set of functions or services.

The changes made have contributed to substantial net gains for human well-being and the development of the market economy. Nevertheless, these profits have been achieved with rising costs in the form of environmental degradation, that indirectly represents a burden for the community both in financial terms and in unmonetizable forms but with great value for the conservation of natural habitats.

Soil deserves a much greater share of human attention and affection (Markewitz & Richter, 2001) and this can be addressed by incorporating soils into *ecosystem services* framework and linking it to the multitude of functions it provides (Adhikari & Hartemink, 2016).

The aim should be the *soil health* preservation, according to the definitiion given by the US Department of Agriculture: *"the continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans"*. The functions that the soil performs, and the ecosystem services connected to these, vary in *space*, in relation to the *characteristics of the soils*, and over time, in relation to the *boundary conditions* (climate, soil management, etc.): different soils provide different services and/or of different quality. Thus, the *soil health* status reflects multiple decisions regarding *land use* and *management practices* (Karlen, et al., 2019) (Adhikari & Hartemink, 2016).

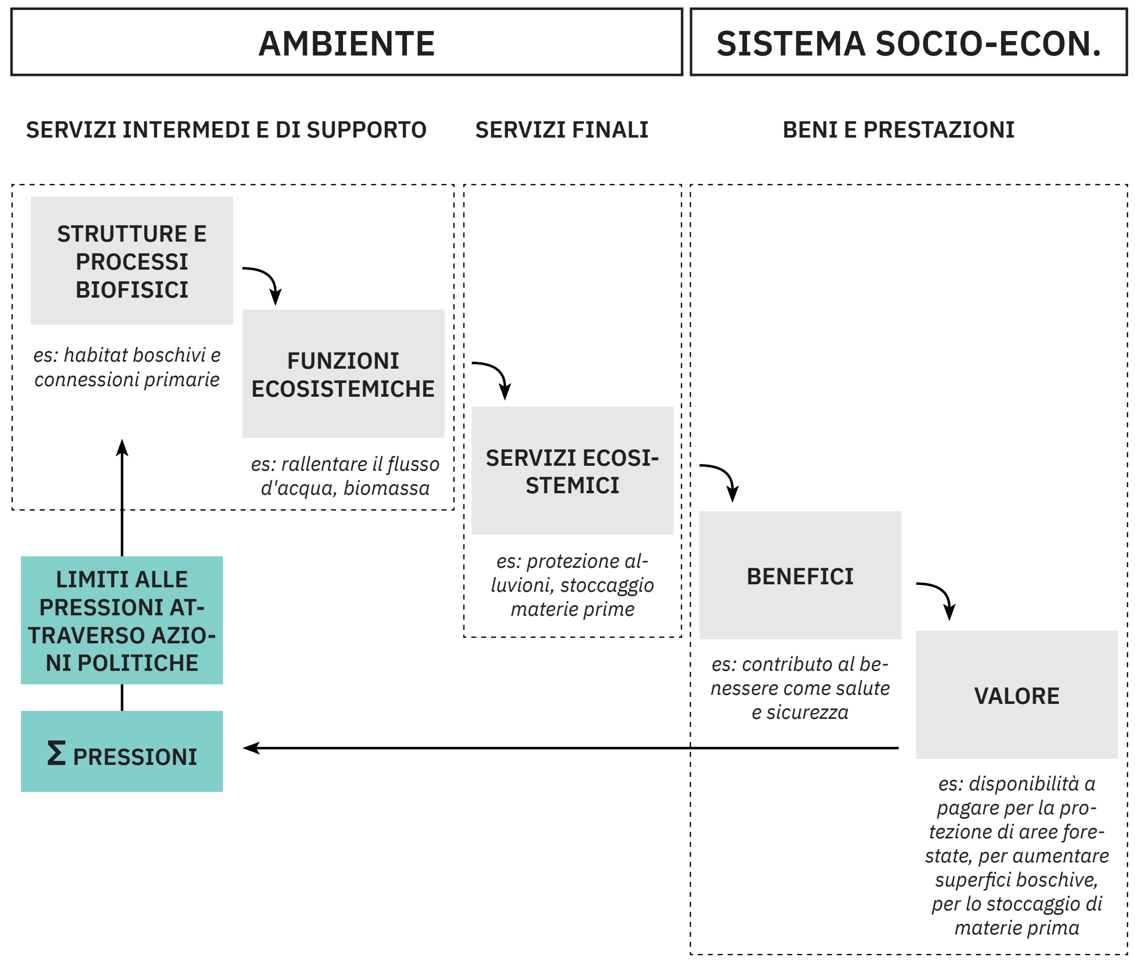
In spite of its importance, most studies (Costanza et al., 1997) (De Groot et al., 2002) (MEA, 2005) have described ecosystem focusing on the ecosystem services only (i.e., *provisioning, supporting, regulating*, and *cultural services*) with little emphasis on soil. We have considerable knowledge about soils, its formation and distribution, but our understanding of its functions and services is incomplete.

The relationship between soil carbon, soil biota, soil nutrient cycling, soil moisture retention and ecosystem services has been well documented. Similarly, the spatial aspects and dynamics of soil properties related to ecosystem services have been studied through mapping or scenario modelling of future changes. Nonetheless only a few studies have directly linked soil properties to ecosystem services[26].

[25] Soil functions support the delivery of ecosystem services, defined as *"the benefits that people receive from ecosystems"* (Millennium Ecosystem Assessment, 2005). The main ecosystem services provided by the soil are: - *life support*, hosting plants, animals and human activities (and with the cycle of the elements of fertility); - *procurement*, producing biomass and raw materials; - *regulation* of the hydrological and bio-geochemical cycles, and with the relative purifying capacity; - *cultural values*, as a historical-archaeological archive and a fundamental part of the landscape.
[26] We'll go more in deep on this concept in the final chapter.

The new challenge facing soil science is how to create a policy to address soil health that embraces the whole system instead of a single soil property or process (Karlen, et al., 2019). This way the anthropic context and urban settlement can return to having a physical and functional connection with its own territorial geomorphological features and attitude, in order to avoid some territorial risks related to land degradation phenomena (such as *acidification*, *contamination, desertification, erosion, salination*), which are related to the loss of *soil health*.

Soil scientists should engage professionals from other disciplines to further promote the study of the contribution of soils to *ecosystem services* delivery and to human well-being. For instance, soil studies could be used in local and national policy development and in programmes on natural resource use and management.



Tab. 9. cascade model of the relationships between five points that define the paradigm of ecosystem services adapted from Potschin and Haines-Young, 2011. Author's reworking and translation.

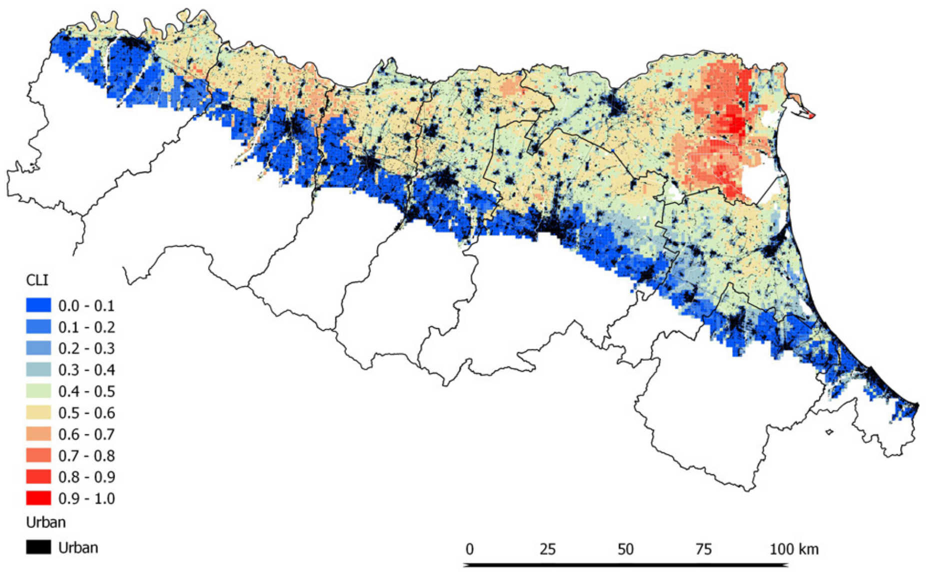
Linking soil to ecosystem services

LIST OF KEY SOIL PROPERTIES RELATED TO ECOSYSTEM SERVICES

Key soil properties		Provisioning services				Regulating services							Cultural services				Supporting services		
		A	B	C	D	E	F	G	H	I	L	M	N	O	P	Q	R	S	T
		Food, fuel, & fiber	Raw materials	Gene pool	Fresh water/ Water retention	Climate & Gas regulation	Water regulation	Erosion & Flood control	Pollination/ Seed dispersal	Pest & disease regulation	Carbon sequestratio n	Water purification	Recreation/ ecotourism	Esthetic/sen se of place	Knowledge/ education/ inspiration	Cultural heritage	Weathering/ soil formation	Nutrient cycling	Provisioning of habitat
1	Soil organic carbon	x	x		x	x	x	x		x	x		x	x			x	x	x
2	Sand, silt, clay, & coarse fragments	x	x		x	x	x	x			x	x				x	x	x	
3	pH	x								x		x					x	x	
4	Depth to bed rock				x	x	x	x				x							
5	Bulk density	x											x	x					
6	Available water capacity	x			x	x	x	x				x							
7	Cation exchange capacity	x										x						x	
8	Electrical conductivity	x																x	
9	Soil porosity & air permeability	x			x	x								x					
10	Hydraulic conductivity & infiltration	x			x	x	x	x				x							
11	Soil biota	x		x		x			x	x	x	x	x				x	x	x
12	Soil structure & aggregation	x			x	x	x	x									x		x
13	Soil temperature	x								x							x	x	
14	Clay mineralogy		x														x	x	
15	Subsoil pans	x			x		x	x											

Tab. 10. Linking soil to ecosystem services. A table linking given ecosystem services to the specific soil attributes was generated by Artemink and Hadikari (2016) through a list of key soil properties related to ecosystem services. This table provided insight into the soil properties and their connection to the defined ecosystem services. Soil properties governing services were grouped into four major classes: soil carbon, physico-chemical properties, hydrological properties, and biological properties. Re-elaboration of the author

CLI - EFFECT ON MICRO-CLIMATE



CSP - CARBON STOCK POTENTIAL

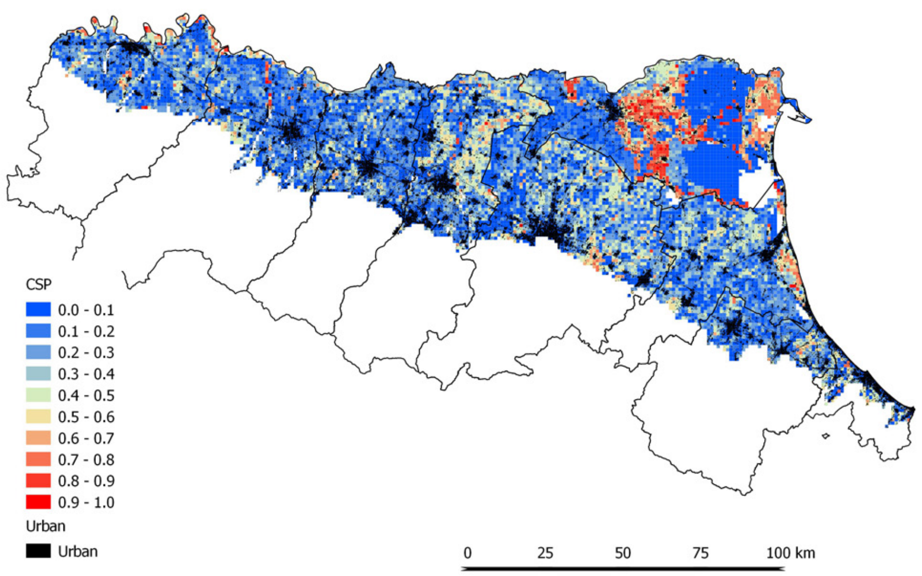


Fig. 39-40. Mapping ecosystem services provided by soil in the proposal given by Emilia Romagna Region (2016).
On the left CLI (Effect on micro-climate), on the left CSP (Carbon stock potential).
The key-soil properties considered are:
- Soil organic carbon (SOC);
- Sand, silt, clay & coarse fragments (Skel.);
- Bulk density;
- Available water capacity (AWC);
- Cation exchange capacity (CEC);
- Soil porosity and air permeability (PSI);
- Hydraulic conductivity & Infiltration / saturated hydraulic conductivity;
- pH;
- Carbon stock;
- Volumetric soil water content (at -33kPa tension and -1500kPa tension);
- Shallow water table content;

1.5.3 Evolving landscape: reciprocity between ecological, economical and energetic component

Evolving landscape: form follows forces, flows, functions

Landscape is always in motion, subjected to evolving process that brings to continuous shift of energies and substances flow in a time-space relationship. As highlighted by IPCC (2019) *"'Biophysical interactions' are exchanges of water and energy between the land and the atmosphere"*.

In addition to environmental factors, landscape modifications are often the result of forces applied on the territory by *drivers* far from the *spontaneous ecological processes* - such as the economy and socio-cultural factors (Farina, 2012). As already stated, humans have become a dominating component after modifying and using approximately 95% of land (Ellis, 2018)[27].

In fact, with the advent of the industrial revolution and the consequent transition to an economy on a global scale, the interactions between man and the territory go beyond the immediate modification of space in the settlement surroundings and the issue becomes of global importance, in the search for resources and energy, and in the movement of products and people. This represents the passage to an Era in which materials and energy are artificially produced, transformed and moved in a sophisticated and articulated way, altering spontaneous dynamic process, as stated in previous sub-chapter focusing on soil related issues.

Talking about heterogeneity and spatial arrangement in an ecological sense, Richard Forman argues that *"Form is the diagram of forces"* (Forman, 1995). From this ecology point of view not only do flows create structure, but structure determines flows. Therefore, the configurations that contemporary territories assume follow the flows pulse regulated by economic processes dealing with the management of resources for commercial purposes (Belanger, 2016). Ecology has highlighted the finiteness of resources.

It's important to understand the logic and the interpretation of evolving landscape, in order to incorporate it in design process, as the results between these *forces, flows* and *functions*.

[27] Phenomenological and physical consequences of human activities are related to the upgrade of tools and technologies that leads to constantly shift the way of shaping landscape and territory in comparison with previous periods. Thus human activities have become the main drivers that can transform and alter the environment (Wu), and can be considered an integral part of environmental dynamics by landscape ecologiest (Farina, 2012).

Forms follow flows, forces and function

Fig. 41. Sandy dust across agricultural field - affected by salination - next to coastal area, Ravenna (Italy),

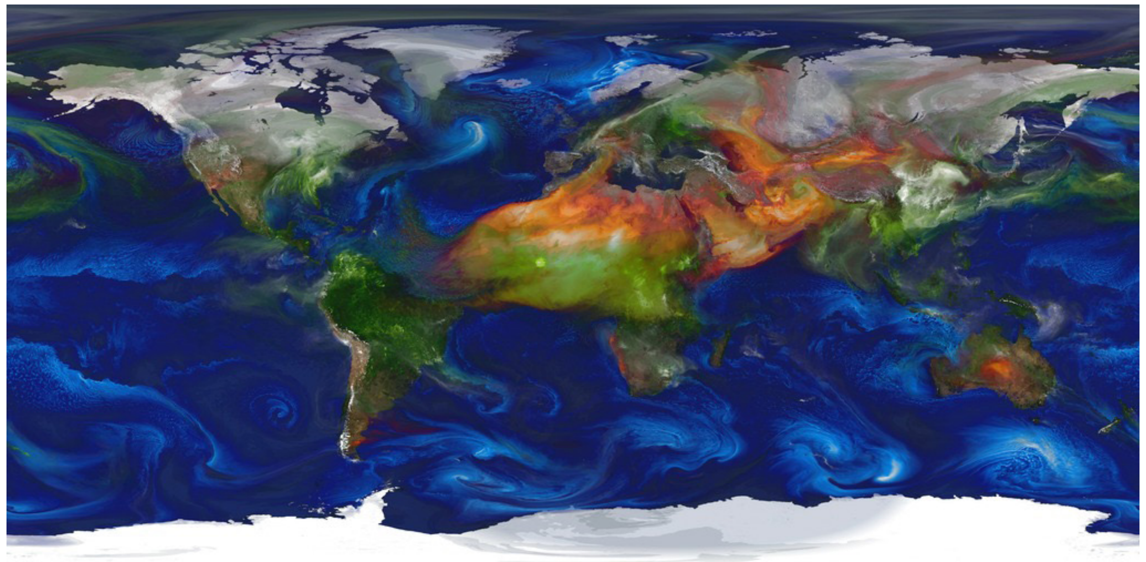


Fig. 42. Portrait of Global Aerosol. source: NASA, 2012

Landscape as a dynamic system: a contextual thinking

Scientific theories and studies envisioned landscape as a dynamic system, anticipating of decades the current debate on landscape design praxis and theoretical speculation.

Starting from the *paradigm of complexity,* the ecologist Almo Farina (2012) argues that "*the landscape is not just a heterogeneous spatial configuration of objects and processes, thus landscape has to be defined as a domain, a system, an unit"*.

A *system* is a *cohesive conglomeration* of interrelated and interdependent parts that is either natural or man-made[28]. Changes in one part affects other parts and the whole system - with predictable patterns of behaviour -, subject matter of the research in *system theory*.

Systems theory[29] is an interdisciplinary field of study between mathematics, physics and natural sciences. Along last decades, several scholars contributed to set out theoretical and comprehensible formulation for describing the principles and the opportunity of *systemic thinking* applied to landscape and ecology. Significant references can be found in the written production of Ramon Margalef, Zed Naveh, Almo Farina, Fritjof Capra.

Although, the higher contributions are due to Howard Odum, an American ecologist celebrated for his pioneering work on *ecosystem ecology*. He's well-known for his provocative proposals for additional laws of thermodynamics, informed by his work on general systems theory which includes the study of landscape and their components. In Odum's outline *landscape* is conceived as an *open, dynamic* and *complex* system, in which part of its elements are organized by a *spontaneous emergence of order*, defined as *self-organization* and *autopoiesis* (Odum, 1971). He synthetized the energy and matter flows in a famous diagram (Fig. xx). The text *Ecology: bases scientists for a new paradigm* (Odum, 1953) influenced an entire generation of ecologists, lately also inspiring landscapers and designers.

[28] Every *system* is: delineated by its spatial and temporal boundaries; surrounded and influenced by its environment; described by its structure and mainly expressed in its functioning. In this regard the *system* resulting from elements aggregation is not merely their addition, but it's something different, with new and emerging properties, because of the interactions between the system's elements.

[29] It was founded during the first half of the 20th century as a result of the *great shock*, in which the scientific sector has realized that systems cannot be understood through *analytical* investigation (Capra, 1996). *Analysis* proceeds isolating to the object of the study in the attempt to understand it. While *systemic thinking* frames this object within of the context of a *higher whole* (Capra, 1996). Thus *systemic thinking* is *contextual*, and opposed to classic analytical approach.

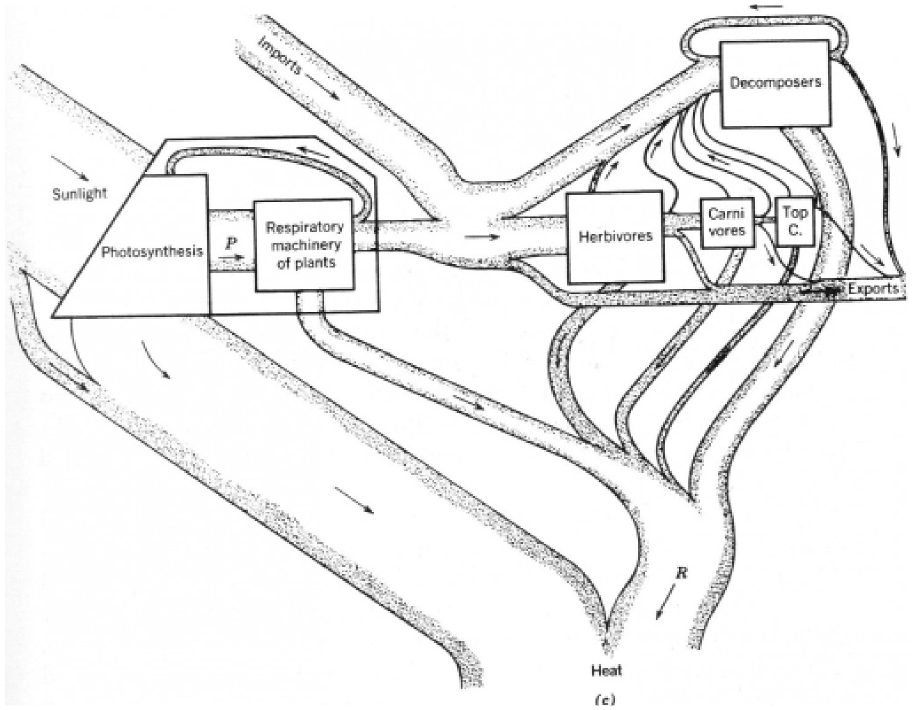


Fig. 43. Energy and Matter Flows Through an Ecosystem, source: Odum, "Environment, Power, and Society", 1971.

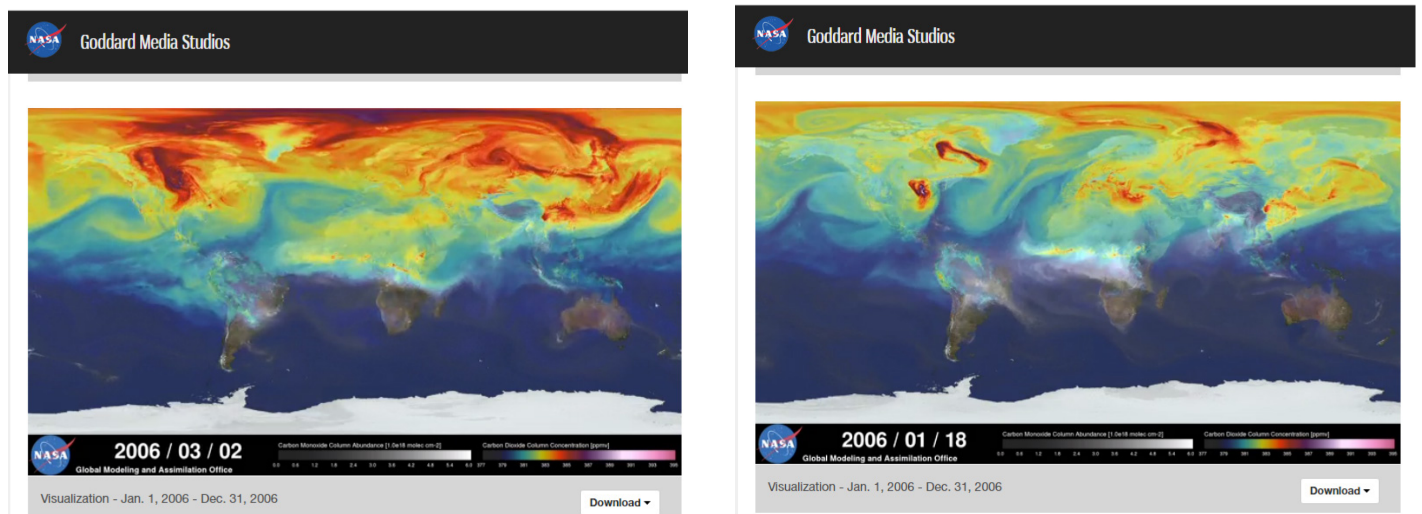


Fig. 44. Global temperature seasonal shift. source: NASA, 2015

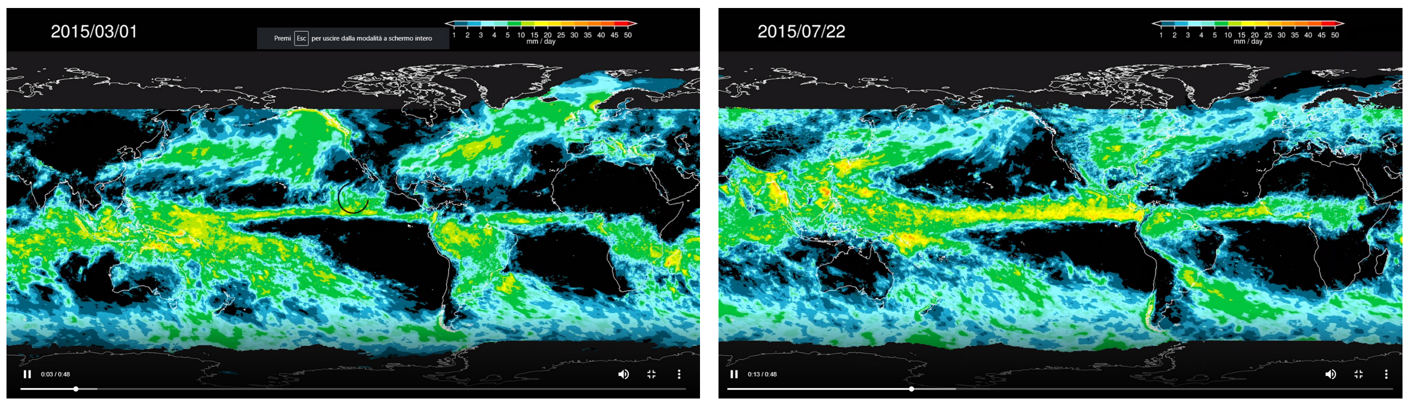


Fig. 45. Global precipitation seasonal shift. source: NASA, 2015

Energy, ecology, economy

H. T. Odum left a large legacy in many fields. By associating the environmental relationship with the energy control of economy, he predicted their social-political implication in a time when this phenomenon was at its very beginning. In 1973, he formulated in a famous essay entitled *"Energy, ecology and economics"*: *"There is a unit of the single system of energy, ecology and economics. The world's leadership, however, is mainly advised by specialists who study only a part of the system at a time".*

In contemporary interdisciplinary debate Odum's theories are taken as reference by prominent authors, such as Nina Marie Lister (Lister & Reed, 2014) and Pierre Belanger (2016)[30], for contextualizing *landscape design praxis* in the framework of *systemic thinking* through ecological models of spatial organization suggested by Odum's *open-system theories*.

In this view mankind activities became the main *vector* between forces that are involved in *building and transforming geography*, overcoming and often disrupting the threshold of nature regenerative time, self-organization capability and *autopoiesis*. In Belanger's reinterpretation of Odum's: *"Vectors cause storms that we call economies, across different tides of supply and demand, a morphology of socio-economic ebbs and flows. Infrastructures, fixed or fluid, are their landfalls and landfills."* (2014).

In conclusion, the main difference between these models of spatial organization - made by *networks* and *systems* - demonstrates how the modern concept of networks addresses form and physical space (operationalized through a closed systems of points and lines), compared to how the post-modern concept of systems addresses *fluidity* and *flows* (animated through vectors, flows, fields, inputs, outputs, energies, exchanges, patterns, processes). If *network thinking* characterizes the mid-century approach to urban design, then *open systems thinking* - that is the ecologic optic - is applicable to *complex*, *indeterminate conditions*, *risks* and *hazards* that are typical of contemporary and future *urban patterns*.

[30] In particular Pierre Belanger argues As mutual agents, capitalism and ecology coexist and co-evolve from islands of exclusion toward an open sea of materials, elements, and entities through the opening of resource streams, the weaving of material sheds, the preordination of processes, the generation of ground effects, and superintendence of time. (Belanger, 2014)

Many are beginning to see that there is a unity of the single system of energy, ecology, and economics. The world's leadership, however, is mainly advised by specialists who study only a part of the system at a time.

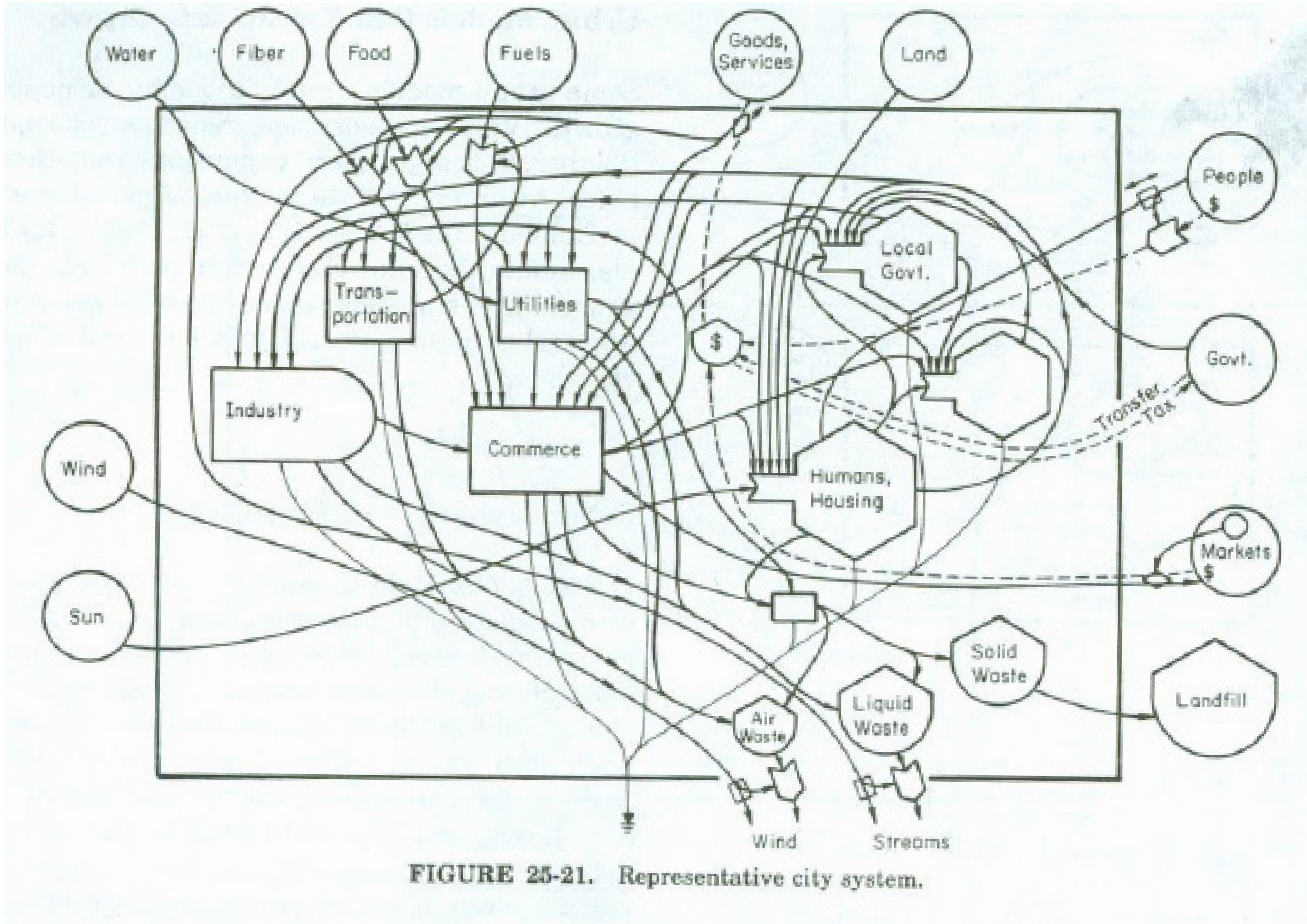


Fig. 46. Ecological and general systems : an introduction to systems ecology / Howard T. Odum T. Odum (Ecological & General Systems, 1966-83)

Resilience as adaptive system across natural and human habitat

According to Zed Naveh (2000), *"In ecology, undisrupted systems have relatively high organizational level that can renew, repair, and replicate themselves as networks of interrelated component producing processes, in which the network is created and re-created in a flow of matter and energy, are called auto-poietic systems (self-creation)."*

In other words, the *energy management* and the capability of a system to *self-organize* define the difference between *human* and *natural habitat.* The *human habitat* can be defined as *the set of areas where the human population lives or is active permanently (also through the contribution of subsidiary energy), limiting the self-regulation capability of natural systems* (Treccani, 2020). Where this capability is not limited, it is in the presence of natural habitat.

A large amount of protected areas have lost their natural features and connections with water and material flows that generated them. Thus, without anthropic works for their maintenance they would face many environmental criticalities. In this regards, common examples are: coastal dune systems, that often have to be restored with human intervention (Img x); numerous wetlands, that need to be provided with fresh water for maintaining their ecological functions; forests, that need management in order to keep them safe from fire and other disruptions.

In this view the contact between human and natural habitats is very profound and close to the idea of *maintenance* and *conservation of nature* at a certain state of *equilibrium*, instead of let natural habitats evolve towards *novel ecosystems*.

The emerging concept of *resilience as adapting system* tries to overcome this limitation.

According to its original definition: "*Resilience is the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning and adaptation"* (Holling 1973, Gunderson & Holling 2002, Walker et al. 2004).

Landscape design praxis involves such systems, where climate, socioeconomic trends, built systems, and riverine processes affect flood hazards and disasters. They operate like both evolving ecosystems (characterized by complex behaviours associated with nonlinearity, emergence, uncertainty, and surprise) and engineering systems that should keep urbanized areas safe.

Fig. 47. Restoration of protected sand dune in Punta Marina, Ravenna (IT) source: author

Fig. 48. Protected area of Valle Mandriole in 2019, during a botox contamination. This summer the wetland protected area resulted contaminated by botox. It's due to the absence of fresh water replacement. In consequence more than 4000 bird died and the area seemed a wet desert. source: author.

Fig. 49. Resilient hybrid system: Bevano river mouth before (1986) and after (2019) intervention source: elicopter flight archive, Municipality of Ravenna (IT)

The paradigmatic difference between *engineering* and *ecological resilience* can be illustrated by the ball-and-cup heuristic (Scheffer et al. 1993, Walker et al. 2004).

The *engineering resilience* concept assumes only *one regime,* hence only one possible basin of attraction; and the very bottom of the basin represents the ideal steady state. The *ecological resilience* concept assumes *multiple regimes*, hence more than one basin of attraction. The system may move about within the basin, never settling at the bottom; it may also overcome a threshold and settle in a new *basin of attraction*. The notion of *engineering resilience* is concerned with whether the system can remain at the bottom of the basin; while the notion of *ecological resilience* is concerned with whether the system can remain within the current basin.

Urbanized floodplains are such systems, where climate, socioeconomic trends, built systems, and riverine processes affect flood hazards and disasters. They operate like evolving ecosystems rather than engineering systems and are characterized by complex behaviours associated with nonlinearity, emergence, uncertainty, and surprise. According to Lister (2014) *"Ecological thinking remains a powerful lens for understanding complex adaptive systems."*

Several solutions proposed in the field of landscape design are an hybridization of these two kind of resilience (Img xx). In the next chapter several cases studies will be presented, in particular the implemented cas studie in Ch. 4.

Fig. 50. Difference between engeneering and ecological resilience The cup represents the region in the state space or "basin of attraction", in which the system tends to remain, and includes all possible values of system variables of interest. The ball represents the state of the system at any given time. source: "A Theory on Urban Resilience to Floods—A Basis for Alternative Planning Practices", Kuei-Hsien Liao, 2012

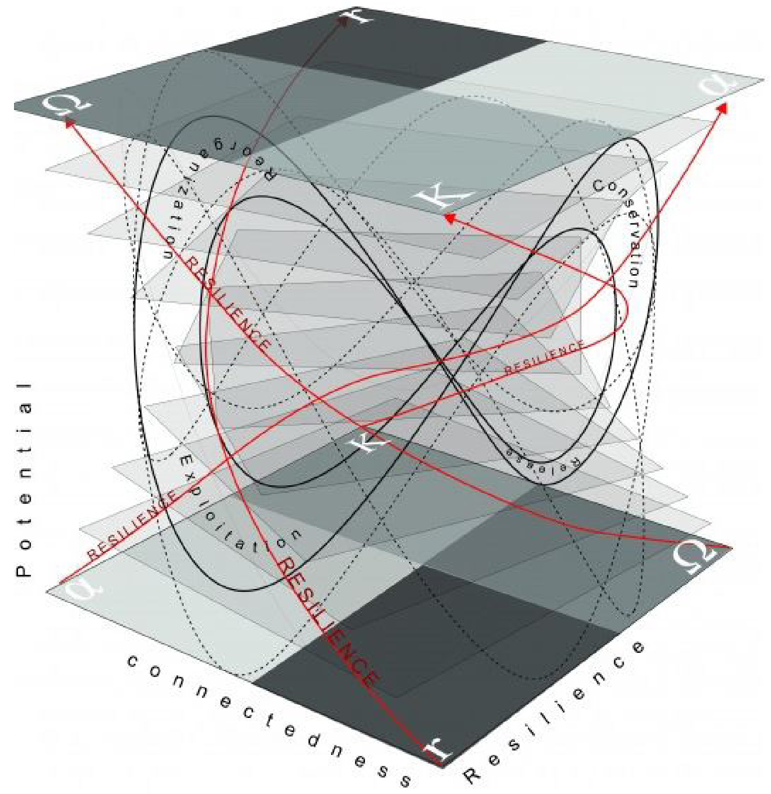


Fig. 51. Resilience visualized as a function of the adaptive cycle source: "Projective Ecologies, Nina Marie Lister, 2014

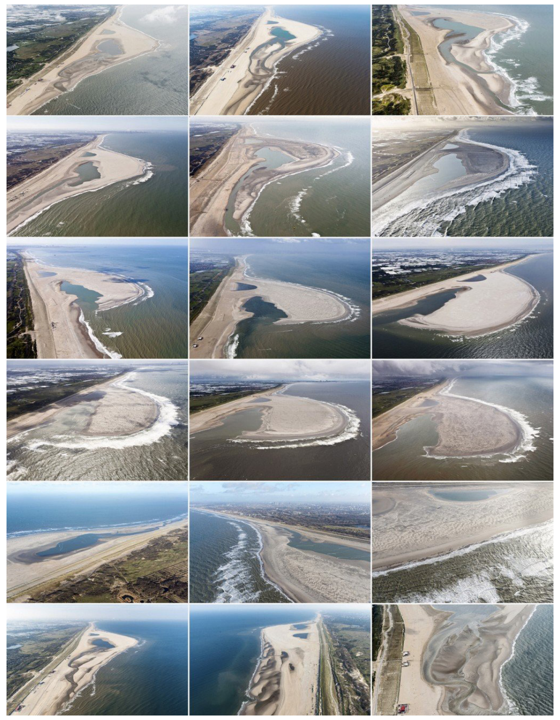


Fig. 52-53. Dynamic and rigid coastline. On left a sand engine in the Netherland. source: "Understanding sediment bypassing processes through analysis of high-frequency observations of Ameland Inlet, the Netherlands", Elias, 2019. On the right coast line defense in Lido di Spina (Italy), source: author

'Biophysical interactions' are exchanges of water and energy between the land and the atmosphere (IPCC, 2019)

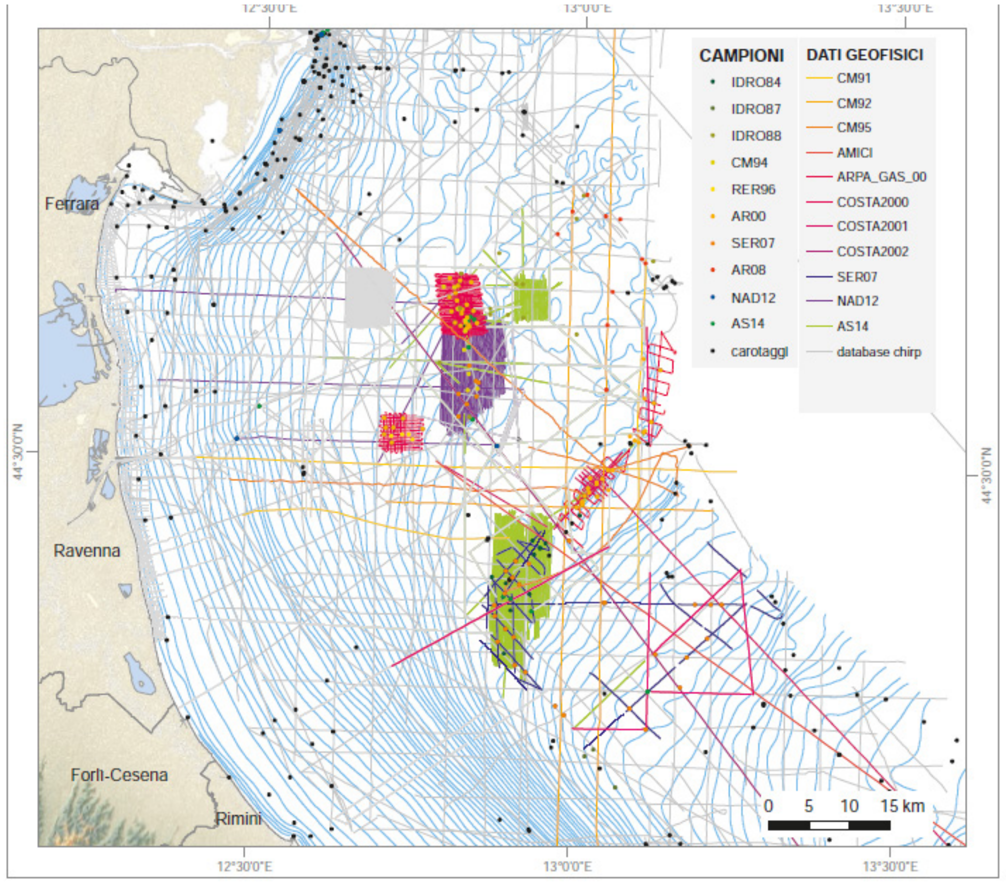


Fig. 54. Adriatic sand quarries, from which the sand is extracted for coastal nourishment in Emilia Romagna.

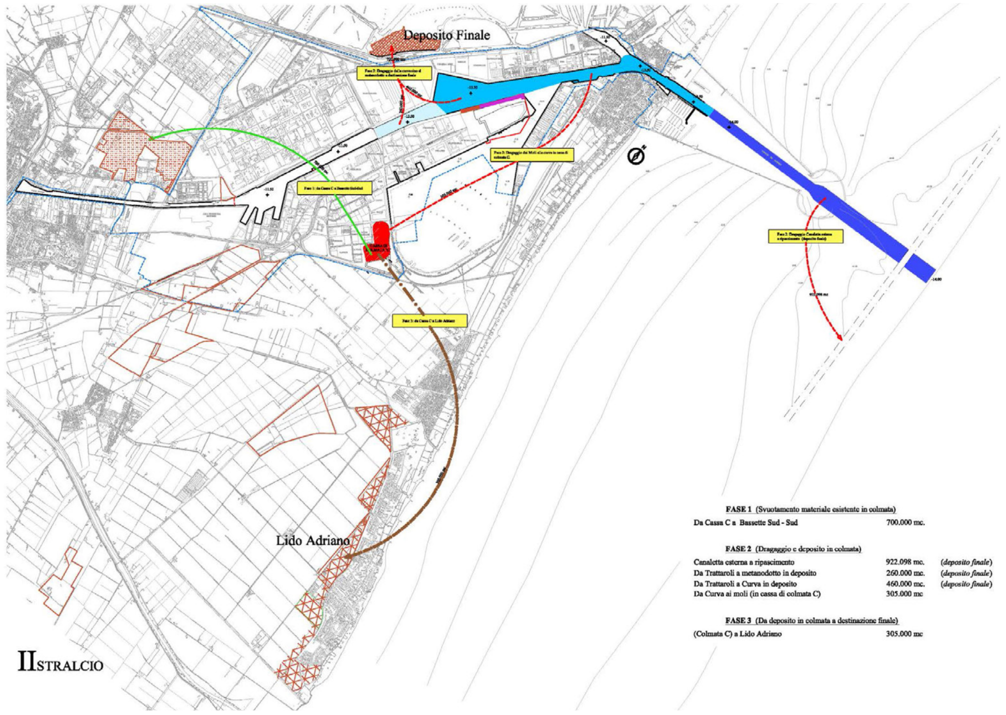
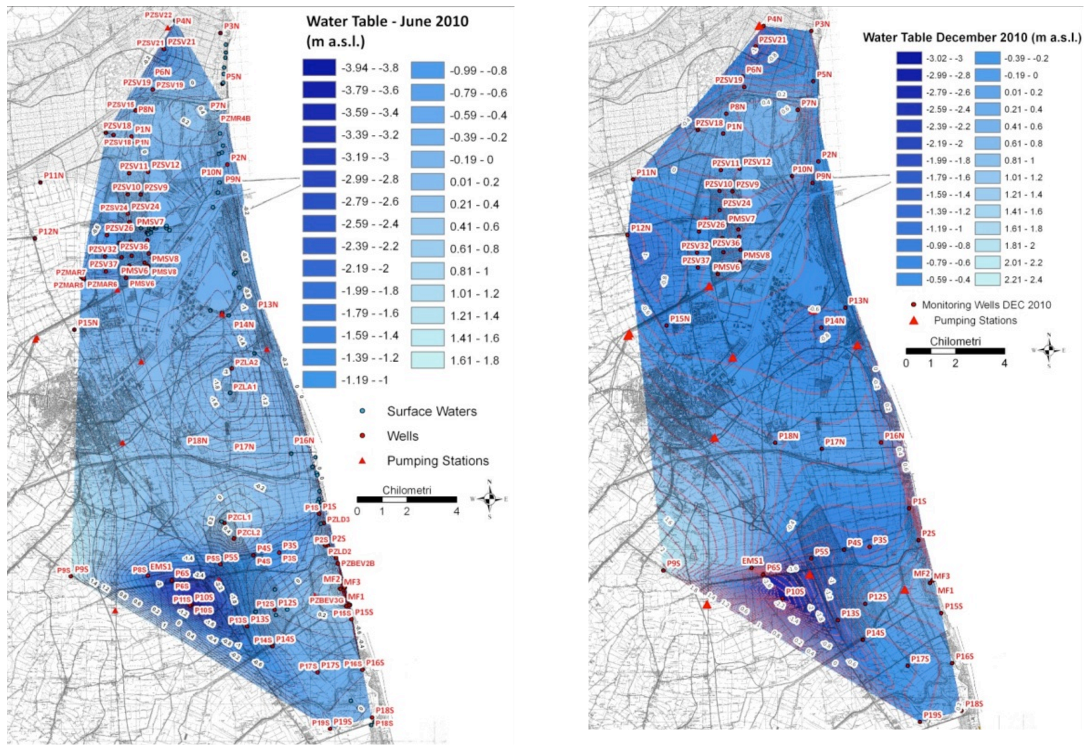


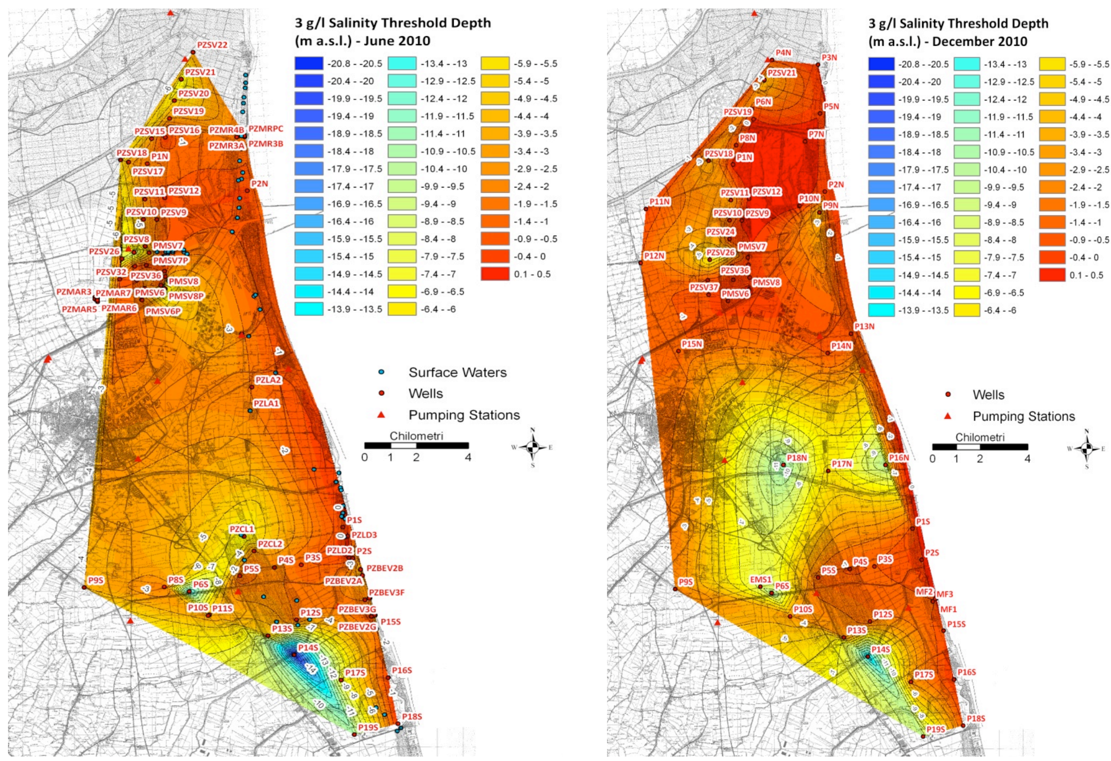
Fig. 55. Layout of dredging material relocation (from Candiano channel) in Ravenna

Ravenna groundwater aquifers



summer winter

Ravenna groundwater salinity



summer winter

Fig. 56. Underground acquifers cartography in the city of Ravenna (IT) source: "Coastal salt intrusion project", Municipality of Ravenna and University of Bologna Department of Environmental Studies, 2009

1.6 First conclusions: the soil as a palimpsest in approaching scalarity

In this section I will propose the interpretation of *soil as a palimpsest in reading and writing the landscape*. By now, the term *palimpsest* is wide-spread diffused in *planning* and *urbanistic* field, since the metaphoric implication proposed by Andrè Corboz in a prominent essay entitled *"Land as a Palimpsest"* (Corboz, 1983). Corboz's suggestion has been employed by others, in reference to environmental and cultural traces embedded in the territorial framework.
In the following paragraph we will retrace the use of the term palimpsest in its meaning – literally and figuratively - and we will propose to incorporate the *soil as a palimpsest in approaching scalarity*.

The value of soil as spatial planning matrix lies in:
/ laying out the physical and spatial relationships at the dimension of a territory, mainly hydrogeological components both on surface both underground
/ situating the parts in relation to the whole

The value of soil as design element lies in:
/ preparing the ground across highly contextualized actions in terms of shape cover and composition
/ handle the physical dynamic matter

By putting the soil at the center of this reinterpreted advance, the fragments become framework components for a structure of connections (Fig. 57-58). The soil is strategically transformed into levels of essential infrastructures for an organic vision of the territory, capable of evolving in the space-time relationship. Thus it aquires a new role following the international focus of adaptation to global challenges.

As a project, the land is semanticized. It can be parsed. It bears a name. Projections of all kinds are attached to it, transforming it into a subject. *(Corboz, 1983)*

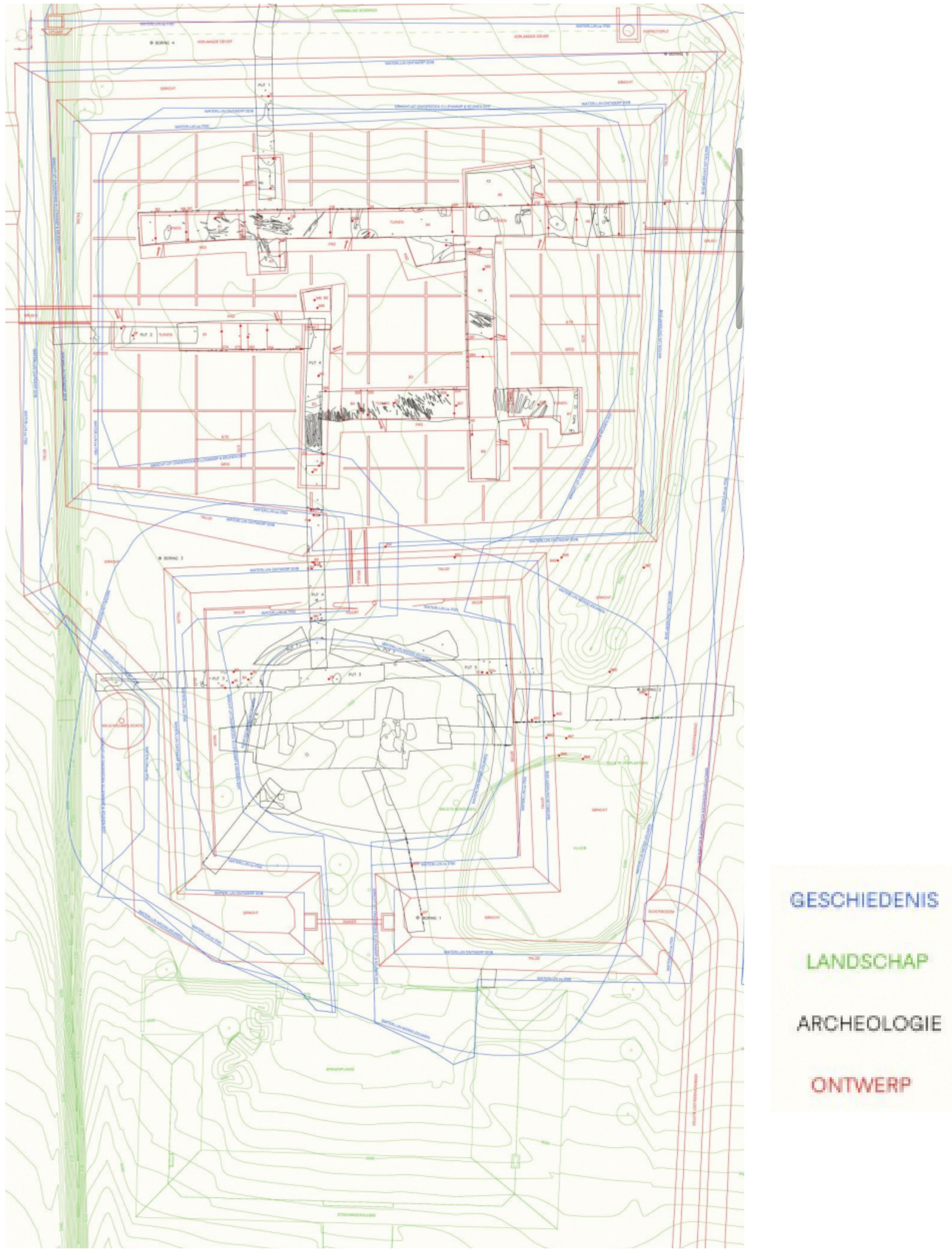


Fig. 57. Introducing History in Etzenrade Castle. The pattern of excavation trenches will be translated into an archaeological garden where interesting finds will be placed as sculptures among the planting of Piet Oudolf. The idea is not to 'reconstruct' the past, but to show the archaeological process in the landscape design and in this way to tell the story of the site. author: Lola Lanscape, 2018.

Overviwieving key literature

Literary a palimpsest is a manuscript or piece of writing material on which later writing has been superimposed on effaced earlier writing. The term comes from the Greek *palin psaomai* and means *scraped again*. This word has been borrowed in other areas to allegorically express the act of *rewriting* and *reprogramming* something. According to Paolà Viganò (2020) *"The metaphor of the palimpsest alludes to the meeting/clash between different times, endless modifications and transformations"*.

By going over some key passages in the key literature on the topic, here we clarify the way of understanding this word and why we argue that *soil is a palimpsest in approaching scalarity.*

There is great convergence on the figure of the palimpsest. Architects, urban planners, landscape de-signers, sociologists and naturally historians of the city allseem to agree on the usefulness of the metaphor of the *territory* (or *land*) *as a palimpsest* (Viganò, 2020).

Any territory is the result of multiple and simultaneous processes; some are taking place spontaneously, others as the direct result of human interventions. (Secchi 1990; Secchi and Viganò 2009). These logics are embodied in the territory itself, making it comparable to a *palimpsest*, in which the traces of recent and ancient modifications *lie* (Corboz, 1983).

In 1983 André Corboz, wrote a prominent essay, entitled *Land as a Palimpsest*. In describing the territory as being the result of slow and long-term processes involving multiple transformations, Corboz implicitly declares the onset of a new paradigm for understanding cities and territories: a new gaze attentive to the chronological dimension of spaces, aware of the long history of places, interested in that ensemble of signs, traces and voids so tangible, and yet ignored by the modernist paradigm of *tabula rasa*. To describe this complexity, Corboz proposes the metaphor of territory as palimpsest. In particular he affirms: *As a project, the land is semanticized. It can be parsed. It bears a name. Projections of all kinds are attached to it, transforming it into a subject.* (Corboz, 1983). This text re-contextualizes the notion of palimpsest—both as a methodological and a theoretical question—in the light of two main conceptual *shifts*: the *territorial turn*, which increased interest among different disciplines, projects, and policies for the dimension of cities as territory, and the *digital turn*, namely the rapid evolution of data recording, archiving, and mapping technologies.

By focusing on a territory "*overhead by tracks and past readings*," "*a text that men have written on the soil*" (Corboz, 1983), Corboz's theories inspire the ideas of the Italian urbanist Bernardo Secchi.

I claim that it is not only a matter of modifying the use of what already exists or of replacing it with new architectures, of filling unfinished parts of cities, but that today it is also about, if not above all, design and avoiding to treat the soil in a trivial, reductive, technical and unarticulated way.
(Secchi, 1986)

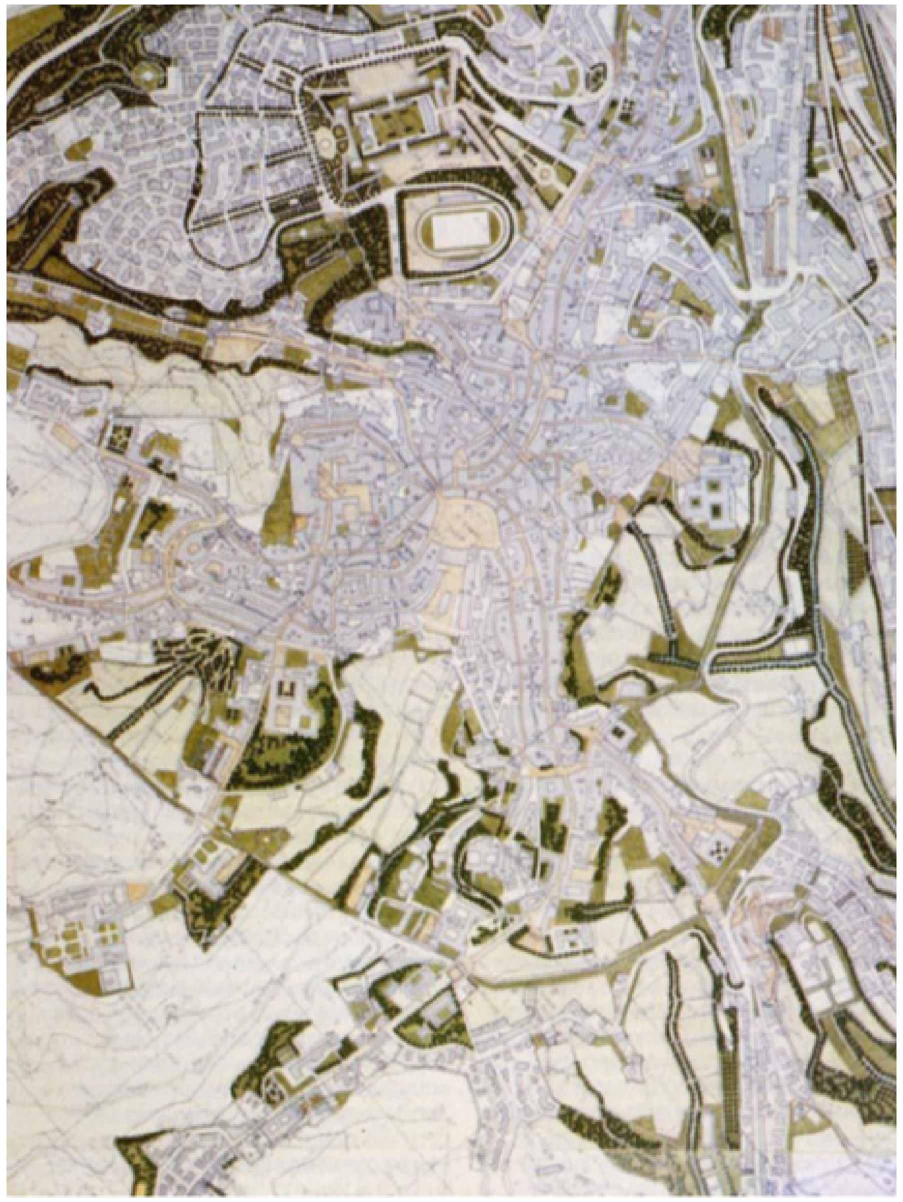


Fig. 58. Siena Urban Planning. The project of the ground and the project of the norm.
author: Bernardo Secchi, 1987-1990

In 1986, Secchi wrote *Project of the ground*[31] - a significant essay - expressing the possibility of working with soil as structural characteristics in urban composition, encountering history and territorial geography. In this understanding , the proposed "*project of the ground*" and the "*settlement principle*" interpret and evaluate phenomena of the contemporary city that manifests itself in the links between urban forms and geomorphological characteristics. This attitude tends to recompose in a coherent framework the effects of individual choices, by relating the surface elements in continuity with territorial matrix. The *project of the ground* therefore indicates a design theme lost in operations originated by the Modern Movement due to a series of simplifications[32-33].
In parallel, Paola Viganò will present projects with a connection to these concepts, from her collaboration with Bernardo Secchi[34]. By recognizigning the soil as *common ground*, they intervenes on the treatment of horizontal surfaces, on the design of equipment, on the works of primary and secondary urbanization, defining form and reciprocal spatial relations.
Secchi found that the design and planning process can be conceived as a *topographic* and *topological* process, which started from the recognition of the soil's three-dimensional and material features, as well as its sense of place: the project crossed the scales of space, time and disciplines.
This interdisciplinar[35] and multidimensional approach to planning had already been proposed in the 1960s in America by Kevin Lynch in *Site Planning* (1962, 1984) and Ian Mc Haarg in a prominent book entitled *Design with Nature*[36] (1969). Both emphasize the need to connect territorial and environmental matrix to spatial planning, with particular emphasis on geological features and pedological factors. Their contribution is still deeply relevant and has marked a turning point in fields such as geography, soil science, engineering, environmental sciences, ecology.
Even without referring directly to the concept of palimpsest, they provide the tools - for the epoch – and the parameters to be incorporate in territorial planning and design.
In particular, in this Anglo-Saxon approach the *soil* (as an environmental matrix) finds its role in planning.

[31] In Italian language *Progetto di suolo*

[32] Simplifications is intended in terms of: quantity, which has distributed the soil through zoning, defining it according to parameters and indices, according to uses, functions and activities; that of the megastructures, which have incorporated in a single building the complexity of urban soil; that of technology, which has reduced the soil to mere support of flows and communication networks

[33] In a recent article entitled *Palimpsest Metaphor: Figures and Spaces of the Contemporary Project* (2020), Paola Viganò clarifies: "*The palimpsest as a figure in the contemporary project is not only a criticism of the modern space, but the expression of a change of direction in the design activity, of its social role and of the theories intended to support it"*.

[34] To be mentioned: Brescia Urban Planning (Italy), the Ville Porose the Great Paris (France), the Horizontal Metropole Brussels 2040 (Belgique)

[35] Early as 1962 the *site planning* is defined by Kevin Lynch as "*The art of arranging structure on the land and shaping the space between; an art linked to architecture, engeneering, landscape architecture and city planning"*.

[36] Environmental impact assessment, new community development, coastal zone management, brownfields restoration, zoo design, river corridor planning, and ideas about sustainability and regenerative design all display the influence of Design with Nature.

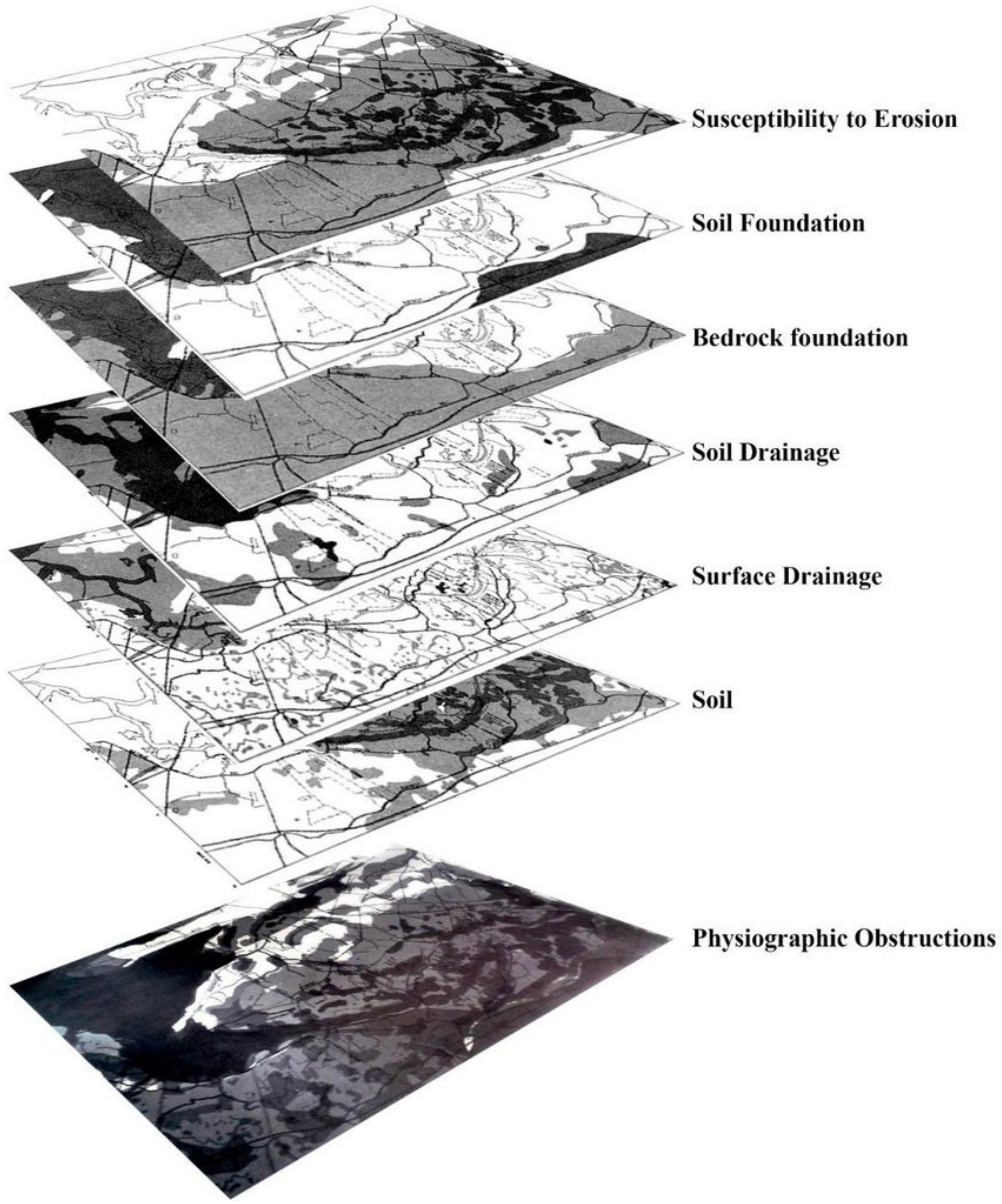


Fig. 59. Composite physiographic obstructions. Almost every geographic information systems (GIS) presentation begins with a depiction of a layer cake, although rarely crediting McHarg and often without his eloquence or insight into how the data should be collected and analyzed. source: Ian McHarg, Design with Nature, 1969

The contribution of Secchi (and Viganò) is very important in the urban discipline. Otherwise, they do not actually consider the *soil* in its intrinsic multidimensionality and dynamism. They rather interpret it as *plastic matter* to be transformed as a connective *common ground* under the thrust of an anthropic direction [37]. More in particular, as soils within cities become widely and increasingly recognised as a fundamental resource that provide a wide range of ecosystem services, and an effective agent to contrast climate change, the *Project of the Ground* suggested by Secchi requires a shift towards a *Project of the Soil* in which the open space, the 'space between things', can no longer be conceptualised as a surface and demands – instead – to be understood as a *living thickness*, a volume in four dimensions.

Accordingly, all soils and their structures and processes are fundamentally diagenetic, formed and changing over time. Pore networks, redoximorphic features, rooting channels, clay mineral suites, nutrient and element distributions, and structural aggregates, all respond to the ebbs and flows of changing environments and biota.

In this shift the soil must be conceived as a *performative medium*. This concept is clearly expressed by Anita Berrizbeitia, of which we propose an extract from *Surface in Depth (2011)*: *"A surface is a living system with its own structure and cycles of production. It is a performative medium that conveys water and support organisms like bacteria, fungi, plants, and animal life. It is the result of processes that take place under it such as the decomposition of rocks and their migration upwards from the depth of the ground. It is also the result of processes that take place over it like erosion caused by wind, water, and human activity. It responds to external system like climatic patterns that evolve in their own composition. In its biological sense, the surface in landscape architecture is less a boundary and more a zone of connectivity. It is a place where vegetational, hydrological, and soil system interact."*

The resolution of local issues - through urban and environmental specificities - is proposed as catalyst elements involved in the renewal process.

The planning scale must include the dynamics of soil evolution and relate to its transformation to a more detailed project scale, embedding knowledge from other disciplines (Fig. 59-60-61). Thus the soil becomes a palimpsest even before it is part of the territory, bringing the project scale closer to that of planning.

[37] «ciò che del suolo è corrugazione volontaria, ma anche vera e propria preparazione e organizzazione tecnico-formale della sua superficie [...]: l'uso del suolo, la sua distribuzione funzionale, ma anche le materie, inclinazioni, ricoprimenti, rialzi, bordi, congiungimenti, scavi, riporti (… insomma:) l'architettura della terra» da B. Secchi, Progetto di suolo, in "Casabella" 520, 1986, ora in Id., Un progetto per l'urbanistica, Einaudi, Torino 1989, pp. 129-136

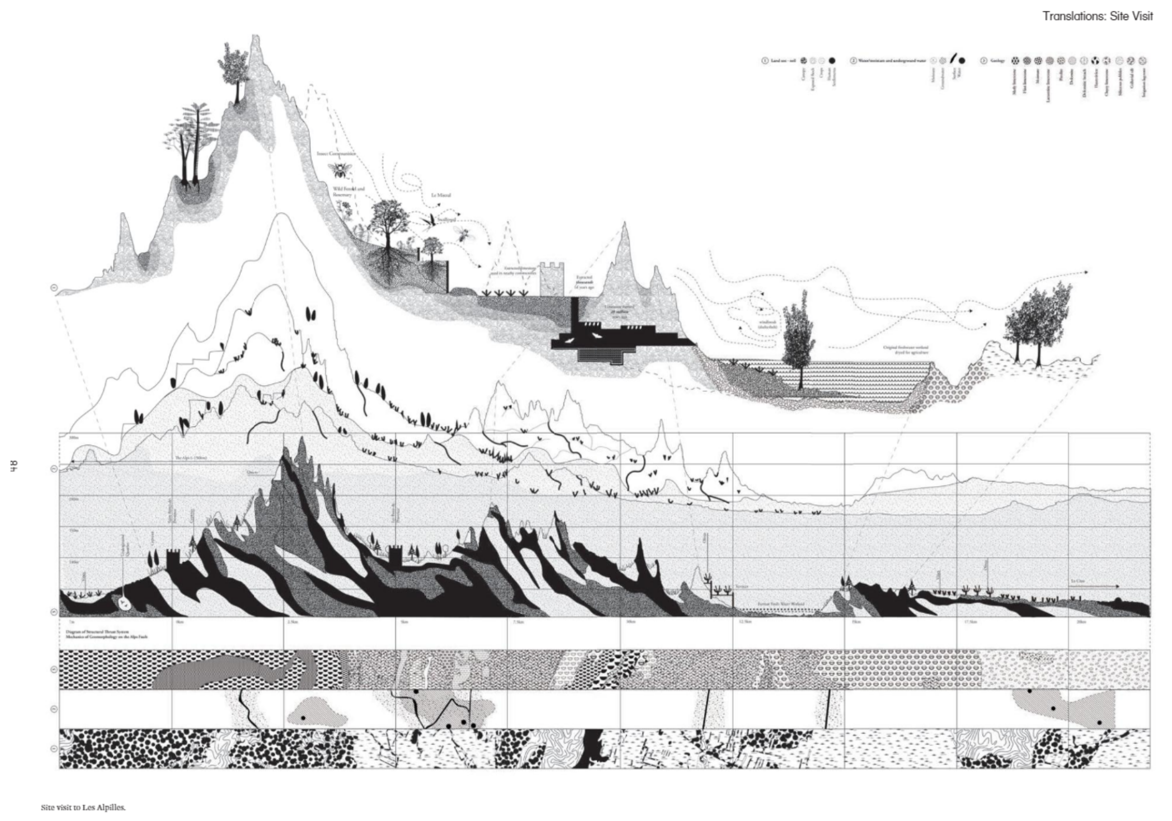


Fig. 60. Site visit to Les Alpilles. source: Regenerative Empathy: Complex Assemblages in a Shared Environment, 2019.

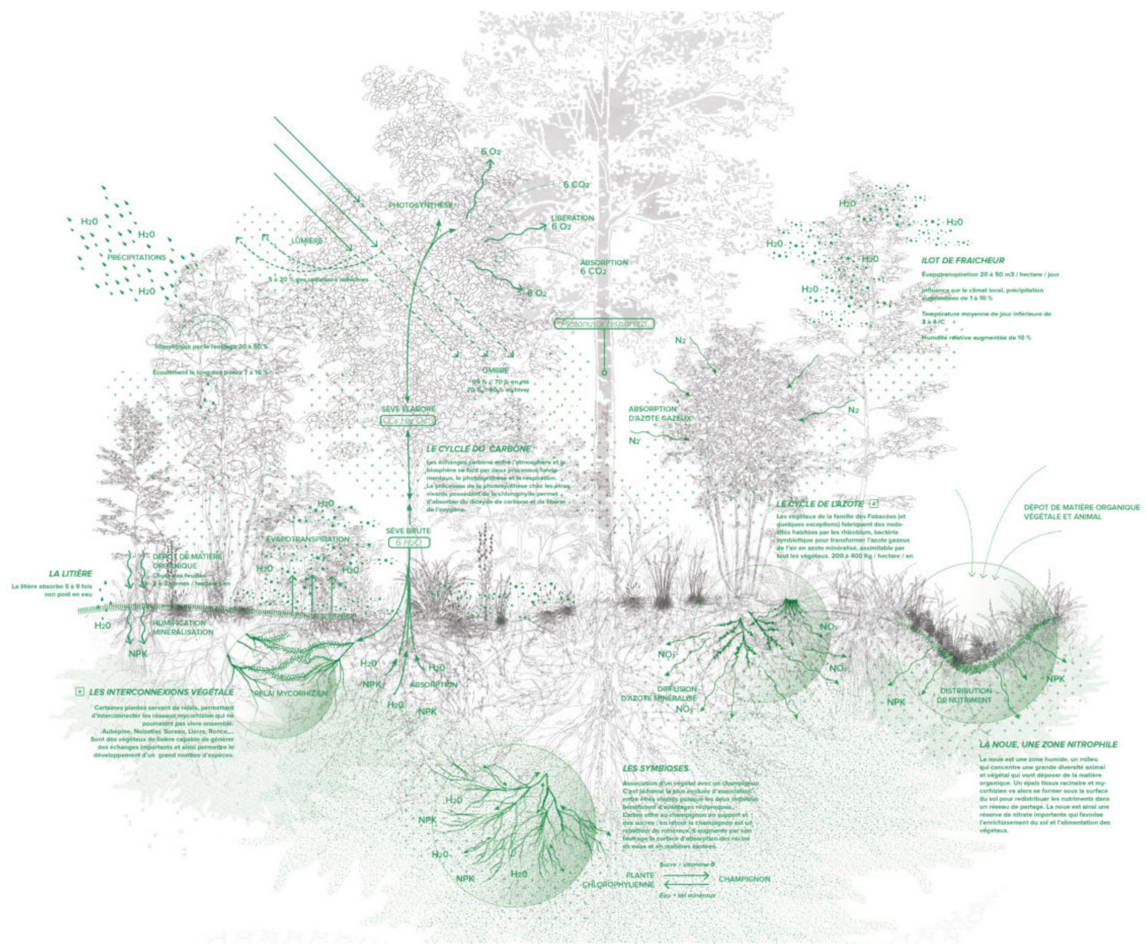


Fig. 61. Palette-ecosysteme. Author: Kevin Michels, Atelier Coloco, V.Mure, 2020

Conclusion

In conclusion, the value of soil as an element of planning and design lies in handling live and dynamic physical matter. From being '*background*' for the built, the soil transformations become the '*foreground*' or primary order both in landscape design praxis and in theoretical implications, by embedding the soil as a palimpsest in *reading* and *writing*[38] the landscape.

As evidenced by Girot on one hand *"This lack of understanding about terrain is quite typical of our modern age and has been detrimental to landscape in general, where it is always assumed that a site can be made flat to assume a program"* (Girot, 2013). On the other hand, Girot continues *"Understanding territorial continuity physically helps to better identify qualitative priorities in a landscape"* (Girot, 2013).

Therefore, the interpretation of soil as a palimpsest requires a critical comparison between:

(1) the pre-existing structural and perceptual hydrogeological arrangement to identify the valuable components and the main issues;

(2) the current planning framework according to their systemic inclusion;

(3) a diachronic and synchronic analysis of the territorial transformations according to plan predictions, to define management, requalification and valorisation criteria starting from the critical points;

(4) understanding about paleo-climates, biota, geomorphology, changes in geologic substrates, and soil residence times;

(5) incorporate ecological dinamicity, connecting biological, hydrological and pedological processes;

Soil is the vibrant matter that we *read* and *write*. Soil is alive and in continuous exchange. On very distant time horizons the soil itself writes and rewrites its history and so ours.

In *Soil in the Anthropocene* (Richter, et al., 2015), the geologist Daniel Richter extend the Corboz's suggestion specifically to the soil.

According to Richter: *Understanding soils as polygenetic palimpsests requires much more understanding about paleo-climates, biota, geomorphology, changes in geologic substrates, and soil residence times. While we can read the basics of many soils, we are far from understanding soil as an archive, and must realize that at some level the soil may always remain at least a bit shrouded in mystery.* (Richter, et al., 2015).

[38] The concept of *reading* e *writing the landscape* will be deepen in Ch. 5, in refernce to James Corner's suggestions expressed in *Landscape imagination* (2011)

Fig. 62. Landscape and soil characteristics, Ravenna (Italy). Processed from Google earth, with highlighted types of soil reported in the next diagram. source: author

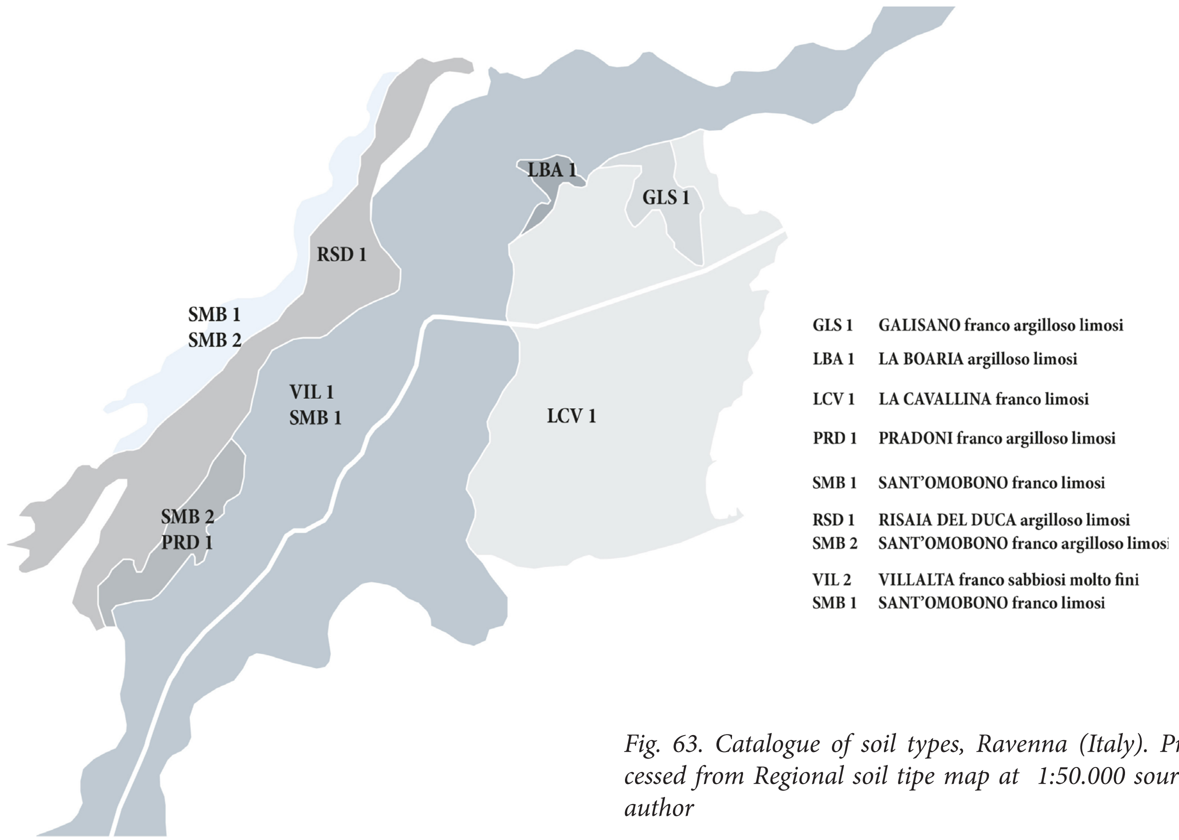


Fig. 63. Catalogue of soil types, Ravenna (Italy). Processed from Regional soil tipe map at 1:50.000 source: author

The diagrams highlight how the soil types maintain features from the original geomorphological features - that still condition the type of transformations possible - highlighted in the diagrams shown. The images show how these characteristics follow the original course of the river, which was diverted at the beginning of the 19th century. These features still characterises the agricultural landscape both in the choice of crops both in programming the water grid. source: author, from the SECAP 2020 of Ravenna

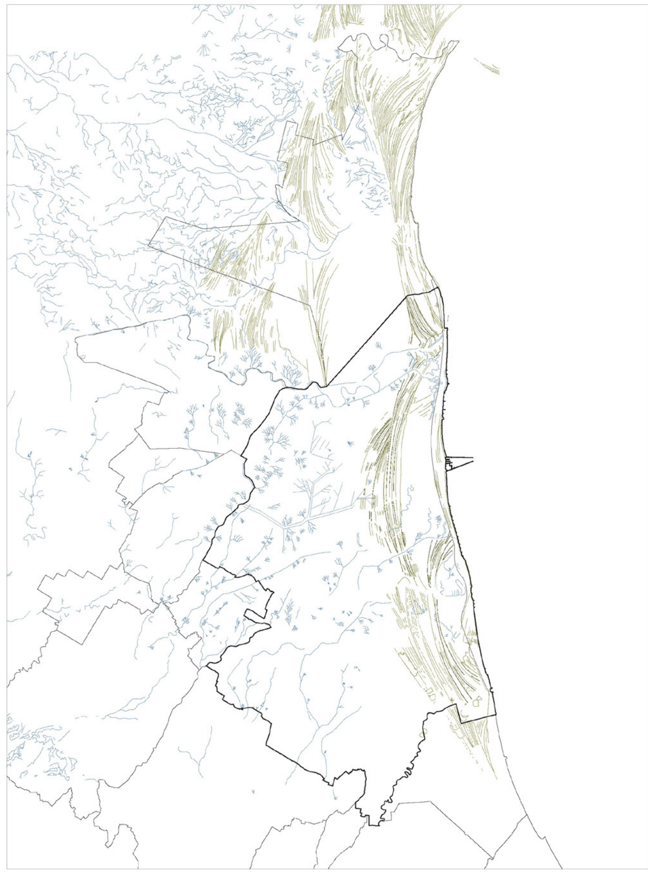
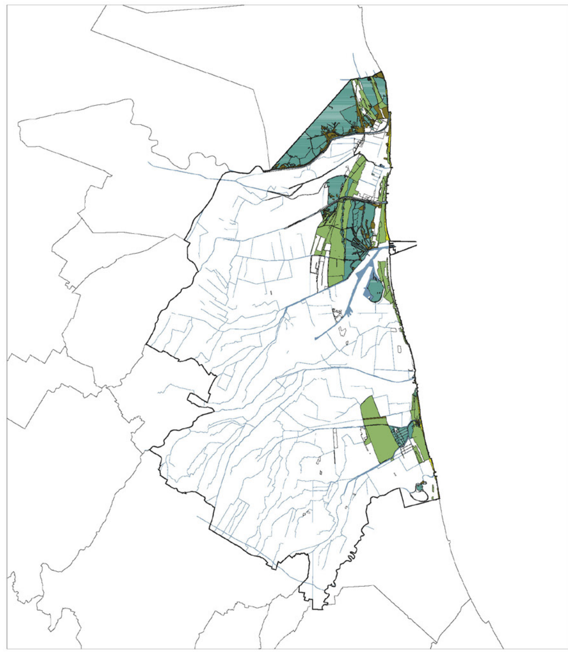


Fig. 64. Clockwise from the left are schematized by GIS processing: geomorphological lines in which are visible bumps, paleodossis, paleoalveos; the protected areas, the system of rivers and canals the drainage network of surface water; an overlay of the two maps with framing from the center of Ravenna city to the sea. source: author , form the SECAP Ravenna 2020



The integration of these maps show the organization of pinewood and wetlands areas in organic relationship with the geomorphological structure of the territory: the first develop on coastal cords and paleodossis, while wetlands occupy depressed and transition areas.
In this logic, the critical dynamism of surface waters is linked to the nature of the places, which, as a result of millennial transformations still retain geomorphological characteristics.
These components must be integrated in a renewed vision of the territory, capturing the characteristics of fixity and changeability, preparing it to evolve towards adaptation scenarios over the long term.

Fig. 65. Pineta di Classe. Pinewood systems arise on paleo-dossi. You can see both from the morphology and the type of vegetation that changes depending on the presence of water in depressed areas. source: author, 2020

This lack of understanding about terrain is quite typical of our modern age and has been detrimental to landscape in general, where it is always assumed that a site can be made flat to assume a program. […] Understanding territorial continuity physically helps better identify qualitative priorities in a landscape. (Girot, 2013)

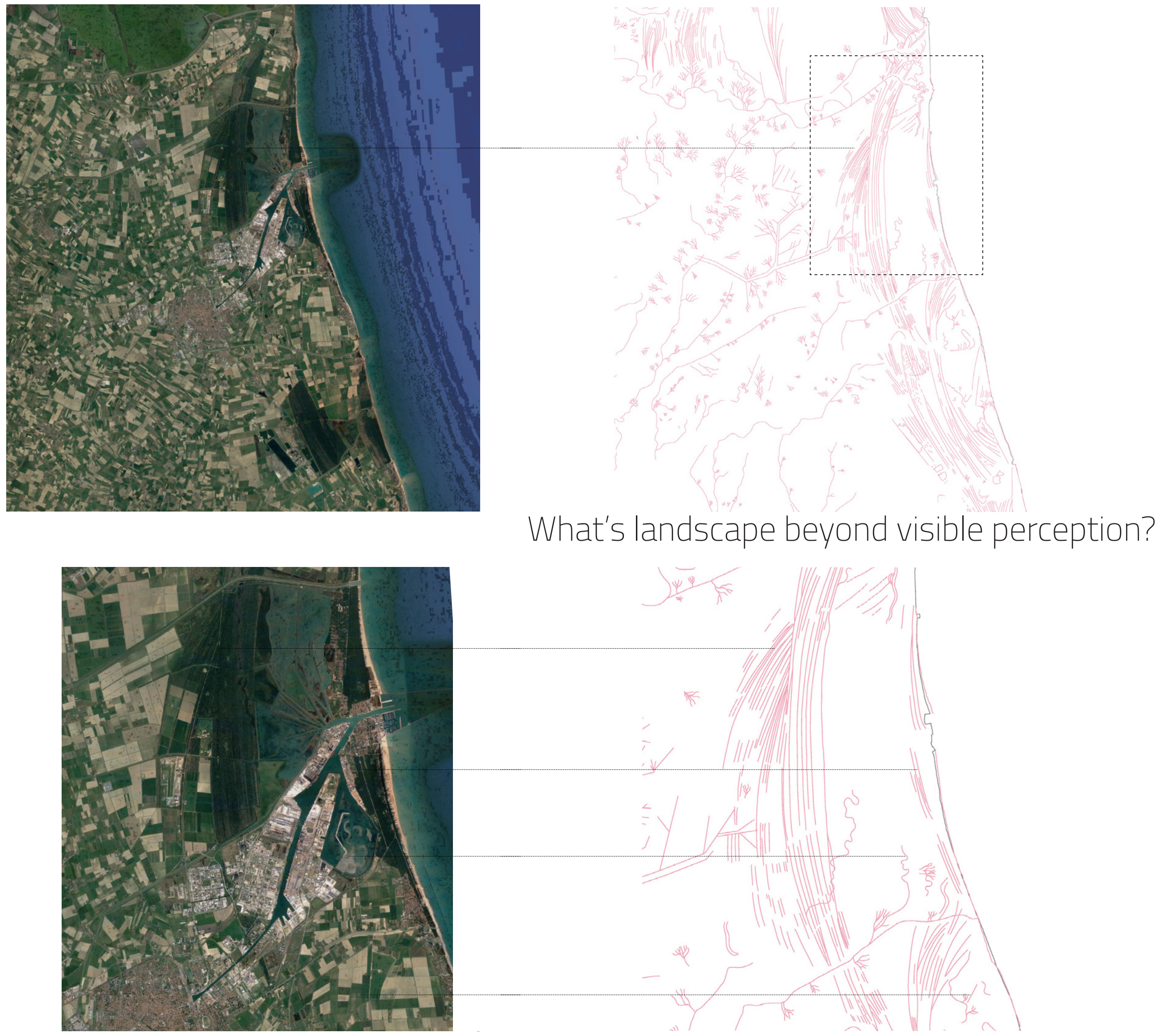


Fig. 66. Relationship among satellite overview and geomorphological featuring traced by GIS in Ravenna, Italy. source: author, 2020

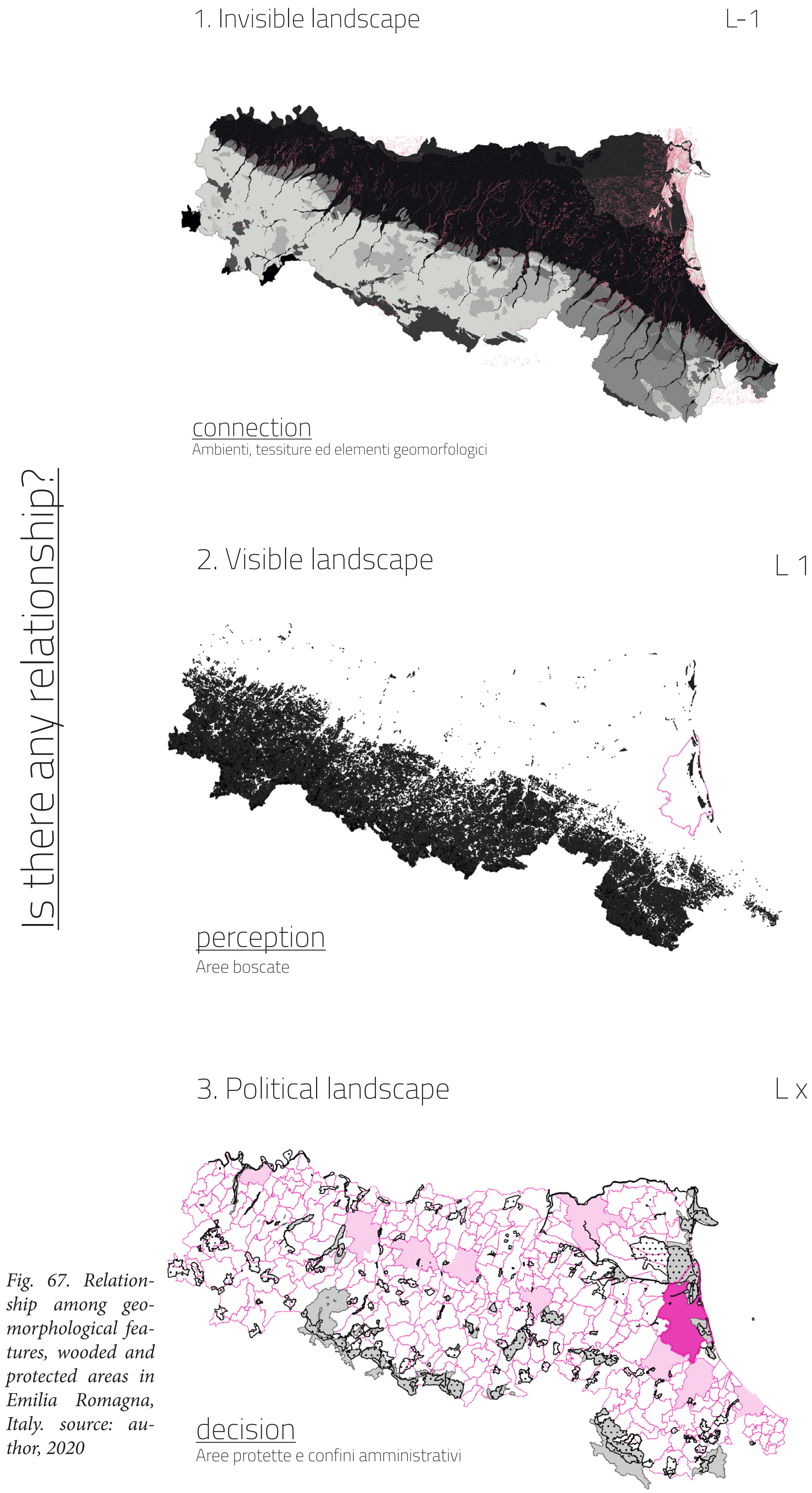


Fig. 67. Relationship among geomorphological features, wooded and protected areas in Emilia Romagna, Italy. source: author, 2020

F. 68. Valli del Mezzano recalamated land, Ferrara, Italy. This sitellite view shows the geomorphological element (ancient alluvial meander) beneath the surface, in contrast with agricultural field pattern, in relationship to different soil texture.

The real voyage of discovery consists not in seeking new landscapes, but in having new eyes.

Marcel Proust
In Search of Lost Time

Chapter 2

Moving Horizon Approach

Chapter 2. provides to outline the main statement and propositions behind the proposed *Moving Horizon Approach*.
It's a critical review between theoretical and design praxis in which are established three affirmation points in terms of *awareness, design* and *attitude* in landscape project. The interdisciplinary aspects are here merged in a transdisciplinary overview. The first outcome is a Landscape Manifesto arranged in 10 points, in which are condensed the research propositions.

2.1 Approach: awareness, design, attitude

Moving horizon was born as an investigation that moves across research and design dimension. It explores the relationship between *landscape design* and *soil transformation*.
In this section I will propose an approach for *mapping*, *manipulating*, and *designing* with *geospatial gaze*, with the goal of transcending the flat, static map into live documents that expand the representation of time and space, in order to better address the dynamic conditions for landscape project.
The *horizon* here is the *line of the visible*, a *recognizable layer of soil*[39], a *time-framed process*[40].
Going beyond the human-centered visible perception, the approach integrates new spaciousness within the landscape design practice. By putting the soil shifting at the center of the design scene, soil becomes a matter that moves over time and space under the action of environmental flows and anthropic agents.

As said in Chapter 1, it is important to discern a key of understanding for landscape in all its dimensions:
/ the *cognitive* one by which *awareness* can be acquired, exceeding human-sight sensing boundary;
/ the *physical* one that can be measured and transformed, across *design* process;
/ the *virtual* one that can be simulated across the time-framed process, along a non-deterministic *attitude*.

The proposed approach is *deductive.* Starting from the proved correspondence between the soil transformation and landscape evolution (Chapter 1 and 3), an approach has been traced for:
/ *Increasing awareness*, by switching perspective and involving new spatialities across overlayed depth
/ *Addressing the design workflow*, in manipulating and transferring matter for performative ground
/ *Orientate the attitude in managing complexity*, through a non-deterministic approach encompassing new parameters

[39] A soil horizon is a layer parallel to the soil surface whose physical, chemical and biological characteristics differ from the layers above and beneath. Horizons are defined in many cases by obvious physical features, mainly colour and texture.
[40] The refernce is to *Moving horizon estimation (MHE),* an optimization approach that uses a series of measurements observed over time, containing noise (random variations) and other inaccuracies, and produces estimates of unknown variables or parameters. Unlike deterministic approaches, MHE requires an iterative approach that relies on linear programming or nonlinear programming solvers to find a solution.

Moving horizon approach **DEDUCTIVE**

SOIL **HORIZON**

Awareness

new spatiality
switching perspective

Apparent line of the sight

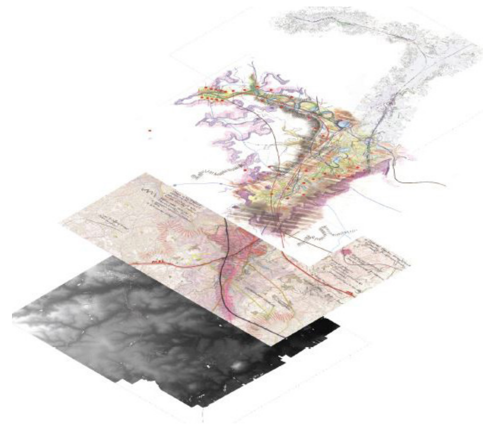


Fig. 69. Layering overlapping about landscape components by Kathrine Moore. source: Is Landscape...? Philosophy drafted by Moore

Design

project matter
transferring substance

Recognizable layer of soil

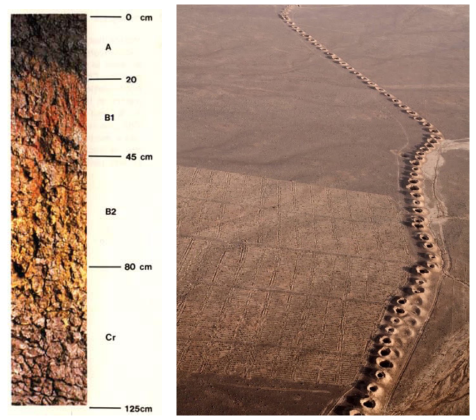


Fig. 70-71. On the left, photograph soil horizon. source: FAO. On the right, Iranian Qanat. source: "The water Atlas", Laureano.

Attitude

new parameters
non deterministic approach

MHE - Moving horizon estimation

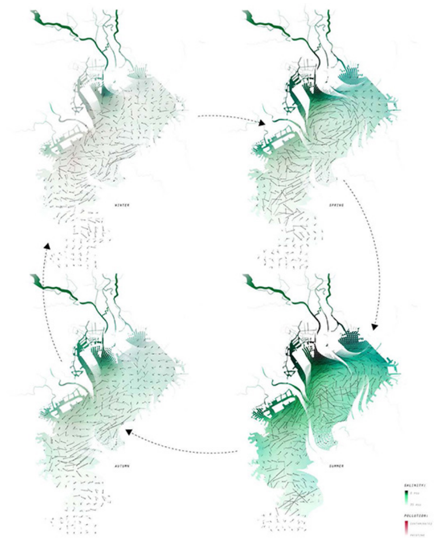


Fig. 72. Salt water wedge along seasonal tide. source: Scenario Journal.

Fig. 73. Green corridor for Cerdanyola directional Center, competition 2010. General Plan. author: Anna Zahonero landscaper

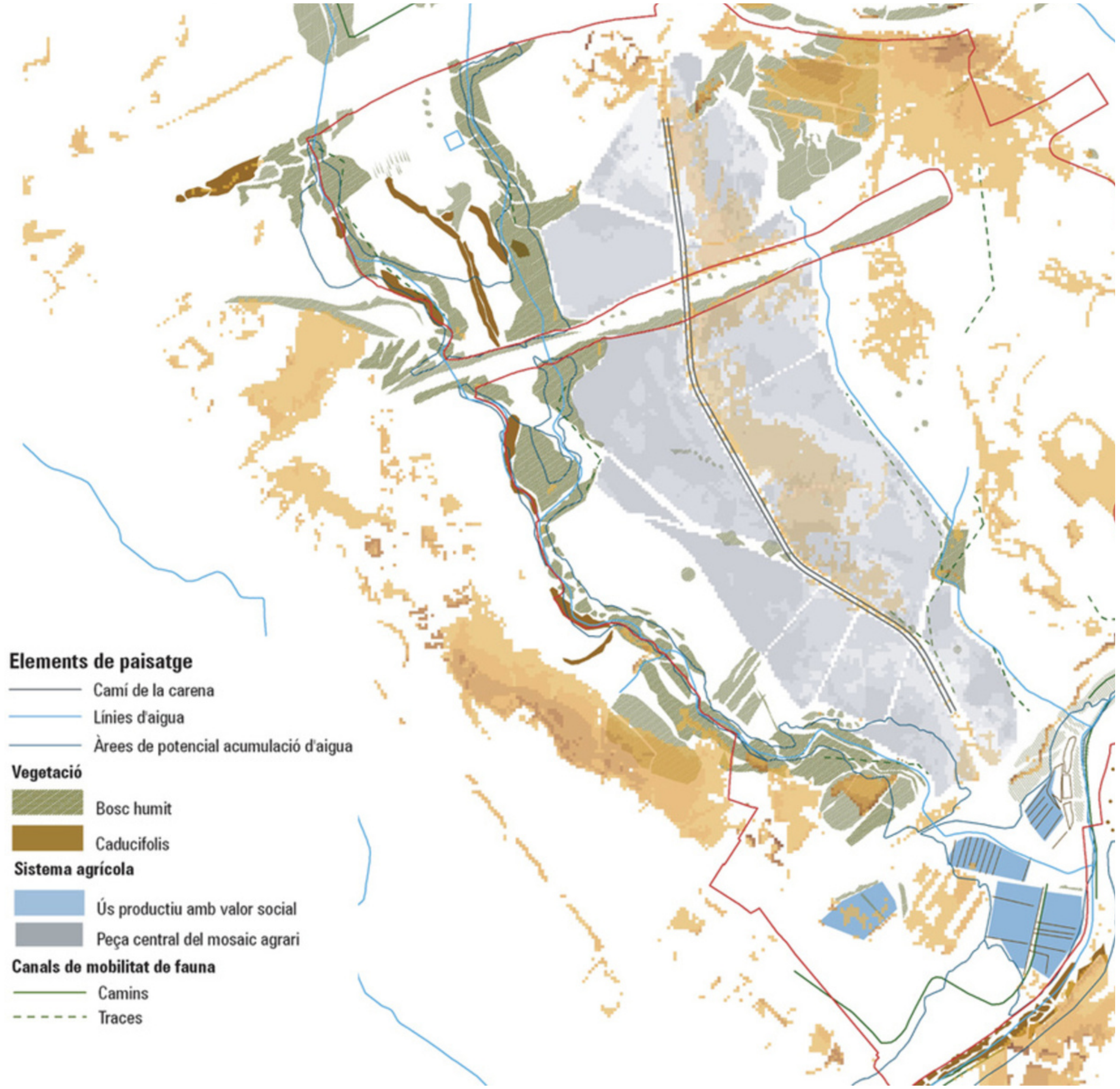


Fig. 74. Green corridor for Cerdanyola directional Center, competition 2010. Landscape elements. author: Anna Zahonero landscaper

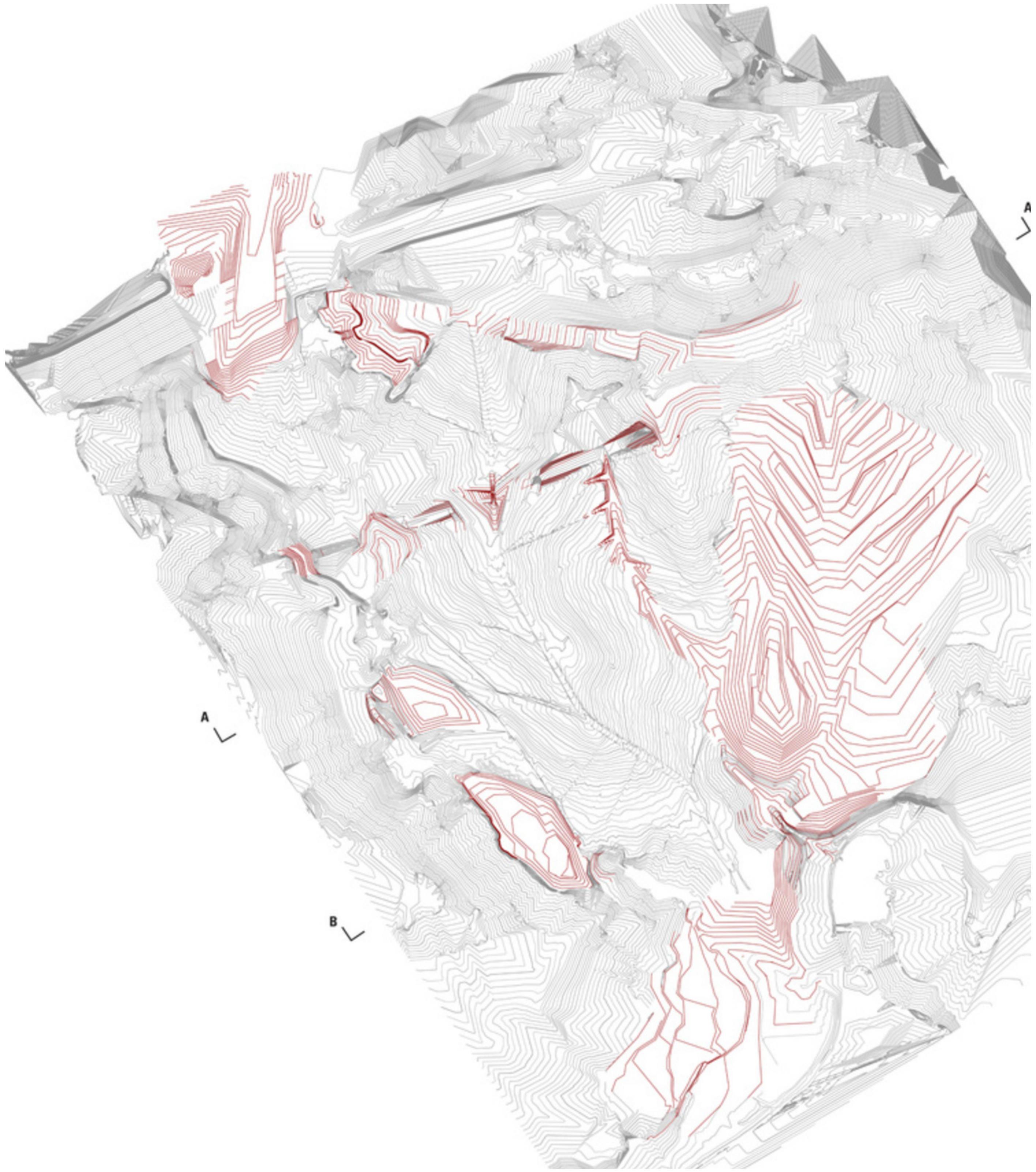


Fig. 75. Green corridor for Cerdanyola directional Center, competition 2010. Proposed topography. author: Anna Zahonero landscaper

2.2 A Landscape Manifesto, 10 propositions

The framework produced by this assessement has been condensed in 10 propositions, collected in form of a *Landscape Manifesto*. The strategy that we have utilized in outlining the Manifesto is the result of an effort to describe in a simplified and understandable way the soil as an emerging component of landscape complexity towards design praxis. This passage is inspired by the critical reading of transdisciplinary literature of prominent authors that are reported for each related point of the Manifesto.

A Landscape Manifesto

1. Screening the Landscape imaginery

2. Crossing layer

3. Crossing time

4. Crossing scale

Awareness

switching perspective
new spatiality

5. Building geography

6. Grounding metabolism

7. Resetting spatiality

8. Shaping action

Design

transferring substance
project matter

9. From fragment to framework

10. Processing possible reality

Attitude

non deterministic approach
new parameters

Screening the landscape imaginery, Landscape is not a passive scene anymore, but is in fact an active working system connected to the human habitat, which it also supports.

The territorial structure is subject to a constant evolution, and so the aspect we perceive. The relations of fixity and dynamism of its components are related to the vision and sharing of values that redefine the relationships between the parts in a logic of necessity. Visions that change in time and with them the conformation that the territory assumes in an ongoing adaptation process that passes through the soil.

FARINA *Cognitive Landscape* (2010) - GIROT *Immanent Landscape* (2013) - FINKE *Soil and Landscape* (2016) - DOHERTY & WALDHEIM *Is Landscape….? Essay on Landscape Identity* (2014) – LAUREANO *The water Atlas* (2010) – PANZINI *Progettare la Natura* (2005)

Crossing layer refers to sharing information among manifold depths.

Landscape evolution does not proceed with regular continuity but is presented as a series of steps in height, age, value, size. The ability to driving decisions passes through the comprehension, codification and contextualization of those signs, signals and related meaning. Therefore, the model implies a series of steps that should bring to outline compressed and decompressed information that crosses the ground depths.

Design with Nature (1969) - CORBOZ *The Land as a Palimpsest* (1983) - GUSTAVSON *Is Landscape Philosophy* (2014) – BELANGER *Altitudes of Urbanization* (2016)

Crossing time

Crossing time refers to a diachronic and synchronic analysis of the territorial transformations according to plan predictions.

In dynamic systems we can only study and predict some behaviours of this process, but the real consequence can only be forecasted. The predictability is sensitive to initial condi tions and beyond a certain time it can no longer be predictable.
Complexity of a system is not an internal characteristic, and it can only be analyzed and represented across *time horizons*.

BELANGER *Out of Time* (2014) – CAPRA *The Web of Life* (2001)

Crossing scale

Because Landscape themselves are spatially heterogeneous entities, their structure, function and dynamics are scale-dependent.

Scale generally refers to the spatial-temporal dimensions in which organisms, patterns or processes are recognizable. A worthwhile perspective can represent these different scales not as a nested hierarchy, but assuming the concept of multiscale. In this concept the global scale is not placed above the the local one, but rather each scale is present and operates at the same time.

CORNER & MAC LEAN *Taking measure across the american landscape* (1996) – CORNER *Terra Fluxus* (2006) - FARINA *Principles and Methods in Landscape Eclogy* (1988)

Grounding metabolism suggests the need for a more explicit and systematical exploration of the geographical imprint of metabolic processes.

It interprets urban metabolism as an inherently geographic condition, investigating the possibility for a redefinition of the design context in a manner that can grasp both the fluidity of metabolic processes and their geographical engraving on the earth and soil, reshaping landscape. It builds upon an understanding of a contemporary design context that is not merely being upscaled but is in constant circulation through the weaving together of a multiplicity of variegated geographies.

IBANES & KATSIKIS *Grounding Metabolism* (2014) – BELANGER *Landscape as Infrastructure* (2016) – LAUREANO *La Piramide Rovesciata. Il modello Oasi per il Pianeta Terra* (2013)

We should interpret design as a geographic agent that is still focused on the physical configuration of human occupation of the ground.

The proposed approach foresees to first understand how natural processes and peculiarities, coupled with mankind activities, have contributed to mutually building geography, in terms of shaping territory and landscape, as the effects between these two forces, although reflexive to the spatially transcendent systems of flows and processes. Landscape design presupposes a reliable level of awareness in managing the aforementioned agents and a certain care about the consequences of the transformation impressed in a specific site by anthropic activities.

BELANGER *Out of Time* (2014) - IBANES & KATSIKIS *Grounding Metabolism* (2014) - FARINELLI *L'invenzione della Terra* (2007) - ODUM Environment, Power, and Society (1971)

Every spatial arrangement is the product of structural information.

Information has been considered as a basic property of the universe like energy and matter. Information refers to order, structure and organization. Moving materials and debris from one place to another for maintaining the status of human habitat, means reshaping topography and creating new processes that lead to the creation of new patterns of topology and ecology.

HOBBES *Novel Ecosystem (2006)* – ERLE C. ELLIS *Ecologies of the Anthropocene: Global Upscaling of Social-Ecological Infrastructures* (2014) - CLEMENT *Piccola pedagogia dell'erba. Riflessioni sul giardino planetario* (2015) – FARINA *The Landscape as a Semiotic Interface between Organisms and Resources (2008)*

Design is envisioned as a series of actions that intentionally induce spatial alterations with the aim of putting in place a clear form of evolution.

The project is intended as a precise and sophisticated tool able to synthesize agents and complexities generating an al teration of place, and which the place itself will be able to metabolize through time and space. One has not to look for an appreciable formal composition in a still image, but rather has to seek the connections and relationships between the elements that make up the landscape, made of visible and invisible components. Soil is the physical dynamic matter that influences these transformations.

CORNER *Terra Fluxus* (2006) –GIROT *The elegance of Topology* (2013) - LISTER & REED *Ecology and Design, a parallael Genealogy* (2014)

From fragment to framework

Starting from the resolution of local issues through environmental specificities, soil is proposed as catalyst elements involved in situating the parts in relation with the whole.

The spatial configuration of contemporary territories is pervaded by the figure of the fragment and the dispersion. Reframing the soil as a palimpsest provides to detect the matrix of structural transformation approaching territorial scale to neighborhood unit. Thus the fragments become framework components for a structure of connections, strategically transformed into levels of essential infrastructures as a qualification for an organic vision of the territory, capable of evolving in the space-time relationship by defining a direction of change.

GIROT Immanent Landscape (2013) – CORNER Terra Fluxus (2006) – CORNER Recovering Landscape (1999)

Processing possible reality

Processing possible reality affords the greater proximity to what exists and what is yet to come.

In replacing natural dynamism and features, landscape design praxis should be addressed to take care of the impact of moving materials and energy flows, and to analyse the design effects through several assessement scenarios. Simulating a field of possibilities offers the greatest closeness to the manifestation and manipulation of the ground itself, making the landscape present and vivid, as it exists and as it could be.

Buffering *Simulating surface water flows and vegetation spread with the use of Rhinecerous and Grasshopper plugin*

GIROT Robotic Landscape (2019) – DI GIULIO, EMANUELI, LOBOSCO *Scenario Evaluation by Design* (2018) – WALDHEIM & DESIMINI *Cartographic Ground* (2016)

2.3 Soil handling, landscape project across building geography and grounding metabolism

Manage the effects of anthropic process

In current circumstances, man has the great responsibility of better managing effects and products of those intense anthropic processes - such as waste disposal, excavation materials, etc - which cannot be assimilated in reasonable time by spontaneous renewal cycles (Sijmons, et al., 2014) (Belanger, 2016) (Tilly, et al., 2014). The millennial transformations of the territory, have modified environmental structure and soil composition, threatening some ecosystem functions and ecological processes[41].

Some changes in environmental matrix (air, water, soil) are present but invisible and untouchable, even if they play a big role in global balance, such as pollution, greenhouse gases in atmosphere, water and soil (Ellis, 2014). Others are visible and physically consists in movement of huge quantity of materials of certain size, from a certain point to another, changing bodily spaces and landscapes.

Moving materials and debris from one place to another for maintaining the status of human habitat, means reshaping topography and creating new processes that lead to the creation of new patterns and topology (Ellis, 2014) (Clement, 2015).

The time for regenerating and metabolize the artificial switches are longer than the time to achive this change, undermining the ability of *self-regulation* and *autopoiesis* present in natural systems (Naveh, 2000). In this condition the maintenance of some areas and the preservation of its natural and ecological peculiarities, is possible only through the man-made maintenance of precise features that simulate and reproduce morphological situation in which can be developed natural processes.

This synthesis is important, given that global trends in urbanization, population growth, climate change, energy use, and water availability finding integration of different scales of planning and design and the establishment of long-term monitoring and adaptive management (Tilly, et al., 2014).

A systemic approach is needed for coordinating the man-made metabolic procedures concerning inevitable phenomena of urban and territorial transformation and ecosystems protection, admitting that one can be consequent and functional to the other (Belanger, 2016) as integral part of a novel enviosened ecology (Belanger, 2014).

[41]As stated in Ch. 1, Landscape modifications are often the result of forces applied on the territory by drivers often far from spontaneous ecological processes, such as the economy and socio-cultural processes (Farina, 2012). The configurations that the contemporary territories assume follow the flows regulated by the economy that deals with the management of resources for commercial purposes. Ecology has highlighted the finiteness of resources.

Increasing the compatibility between the human habitat and regeneration times of nature

Man should start thinking in *metabolizing* the effects of its impact on the ground, through several tools involving *natural dynamism* and feature in the design process (Harg, 1969) (Lister, 2015) (Ibañez & Katsikis, 2014) (Naveh, 2007). This attitude should be addressed to take in care the impact of moving materials and energy flow and analyse the effect through several scenarios evaluation (Lyle, 1999) (Lobosco, 2017).

Assuming complexity as refential state (Naveh, 2000) (Farina, 2008) (Belanger, 2016) the conventional disciplinary reductionistic and mechanistic approaches should be replaced by integrative and systemic approaches, that leads to transdisciplinarity (Naveh, 2000) and alignement of disciplines - such as landscape architecture, civil engeenering and urban planning (Belanger, 2016), by considering other paradigms that interfere with the same epistemological area incorporating ecology and economy as part of this speculative framework (Farina, 2012) (Naveh, 2000) (Clement, 2013) (Belanger, 2016).

This perspective allows a territorial upgrade to contemporary objective and needed, increasing the level of compatibility between the evolution of the human habitat and the maintenance of regeneration times of nature, necessary for preserving ecosystem services (Naveh, 2007) (Ellis, 2014).

Natural processes and ecological dynamic have to be transformed in project parameters involved in design process (Lister & Reed, 2014). The aim is to provide precise and sophisticated tools able to synthesize the agents and the complexities of the forces involved in the transformation of the territory. As a result, any valuable interpretation of context needs to be connected to this specific operation.

The emerging sustainability culture offers new perspectives on creative spatial practice, as an expanded field of aesthetic and political agency. Such articulation, however, requires a reconsideration of landscape aesthetics be-yond the consoling and beautiful, as well as a fundamental shift in landscape thinking from representation to agency.

Landscape project as an infrastructure across building geography and grounding metabolism

The landscape design can offer precise and contextualized project solutions which can involve large temporal and spatial scales in reference to the extension of the problem.

The proposed approach is first understand how natural process and peculiarities coupled with man kind activities have contributed to mutually building geography, in terms of shaping territory and landscape, as the effects between this two forces (Fig. 77). We should interprets *design* as a *geographic agent* that, is still focused on the physical configuration of human occupation "*on the ground*" (Ibañez & Katsikis, 2014).

Design is conceived as a tool for *grounding metabolism*. According to Ibañez & Katsikis (2014) *metabolism* is here intended as an *highly asymmetric effort to coordinate social and environemntal systems* and nor does it aim to reintroduce any sort of geographical determinism in which the organization of metabolic processes is derived from the specificities of natural geography (Fig. 76).

It builds toward an understanding of a contemporary design context that is not merely being upscaled but is in constant circulation through the weaving together of a multiplicity of variegated geographies. As a prelimirary synthesis the project is here envisioned as a series of operations that intentionally induce alterations of space with the aim of giving a clear form of evolution in places. We are not looking for an appreciable formal composition in a still image, but the connection and the relationships between the elements that make up the landscape, made of visible and invisible components. Corner says that in working landscapes (or, as he calls them, *Terra Fluxus*) "operational logic is employed, over compositional design" (Corner, 2006). Through this reading landscape is not a passive scene anymore, but is in fact an active working system connected to the human habitat, which it also supports.

The result will be the design of renewed and highly contextualized landscapes, as consequence of conscious and sophisticated actions, integrating landscape and infrastructure.

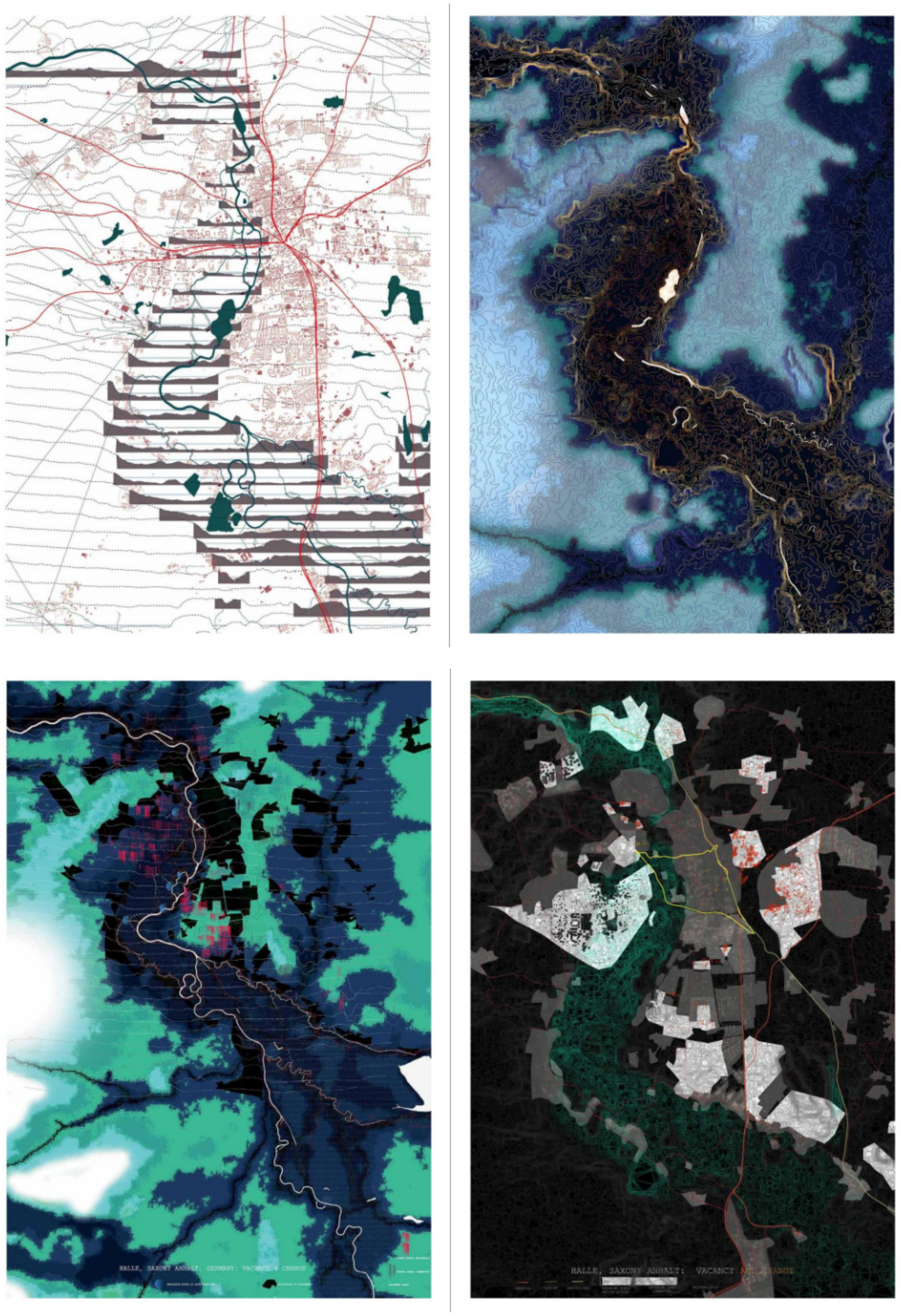


Fig. 76. Cartogenesys and design proposal for floodable areas in the city of Halle, Germany. These areas mostly lie in the floodplain of the river and become the project site for flooding and creation of landform that can be put to use of inundation, water storage and agriculture. source: "Ecology without nature, Shrinking Cities & Floodplains", Architectural Association, 2015

Nor is infrastructure neutral. It excludes as much as it integrates. (Belanger, 2016)

Fig. 77. Fogolana lagoon. Ongoing. source: Google Earth.

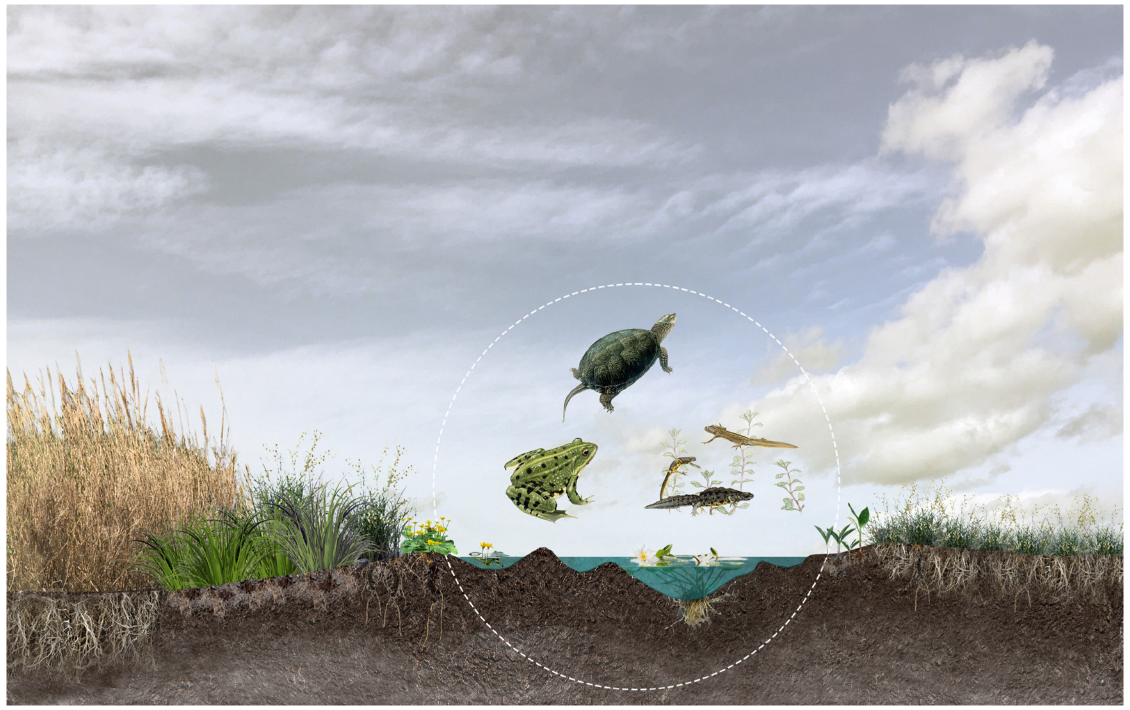


Fig. 78-79. Ecological dynamic featuring in abandoned agricultural field in Ravenna, Italy. In construction. source: author.

Fig. 80. Countryside, Ravenna (IT). source: author

We spend our lives hurrying away from the real, as though it were deadly to us. 'It must be up there somewhere on the horizon,' we think. And all the time it is in the soil, right beneath our feet.

William Bryant Logan
Dirt, the ecstatic skin of the earth

Chapter 3

Field of possibilities

Chapter 3. Reports a compendium of topological design operations to be performed on soil in terms of *shape, cover* and *composition.* The work is proposed in form *Taxonomy of interventions* organized in ten boards. By following the research by design method, it is conceived as a general overview in exploring the field of possibilities offered by processing soil in landscape design praxis. The taxonomy is supported by a brief perspective of significant examples, emphasiszing their relationship with soil transformation.
Finally an illustrative survey is provided, through the examination of factual case-studies that represent significant examples of contemporary landscape design projects.
In this respect, this chapter can be regarded as the first process of meta-projective abstraction. The aim is to provide a framework of possibilities for actions to those involved in landscape design.

Field of possibilities

Below, the thesis reports a research work presented as a *Taxonomy* of interventions, organized in ten boards dedicated to every proposed design category and subcategories (Ch. 3.2).

It's conceived as the attempt to represent the main possible actions to be performed *on the ground* considering its alteration in terms of *shape, cover* and *composition*.

The *taxonomy* development represents an effort to represent the suitable design operations in a synthetic and organized way. This passage passes through inevitable simplifications in dealing with such a vast and interdisciplinary topic, while still ensuring a level of precision that can be of practical use to those working in the field of landscape.

It is devised as an overview, results from a first process of metaprojective abstraction, inspired by reported cases studies - engaging tradition and modernity - and a critical interpretation of scientific literature review in terms of impact on *ecosystem services* provided by soil in the linkage between impressed tranformation actions and *soil properties* argumented in Ch. 1.5.2.

Finally a final synopsis of contents is outlined, by developing a matrix with the linkage between *taxonomic categories*, *risks management*, *ecosystem services*.

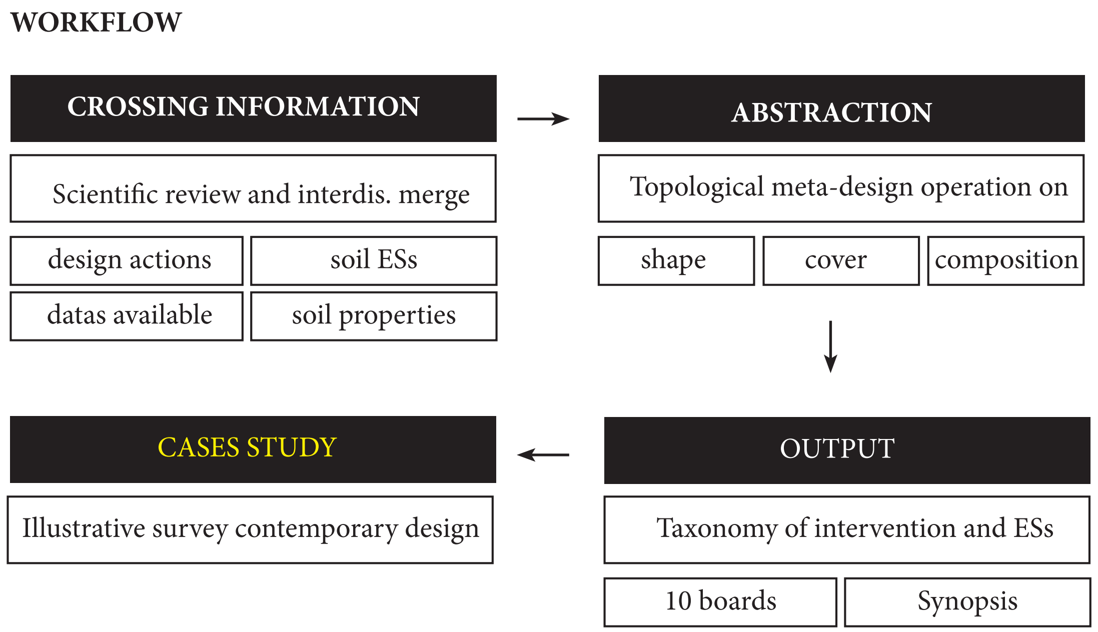
The overall objectives of this research step is:

(i) to raise the level of awareness in understanding and reading landscape and it's components, by emphasizing the strong relationship between *soil transformation* and *landscape design praxis;*

(ii) to clarify in a quinck and effective way the connection among soil alteration and its conservation in terms of *ecosystem services;*

(iii) to provide a framework of possibilities for action to those involved in landscape design in an operative and synthetic way.

As follows, this passage provides to show briefly how the soil is the protagonist of changes that have as its purpose *protection* but also an *alteration* to adapt the territorial structure in persitent updates.



Tab. 11. Chapter workflow. source: author

Fig. 81-82. Right: Yemen. Above, at the bottom of the marbid the stone walls which organize the terraced slope and collect humidity. source: The water Atlas, Laureano.

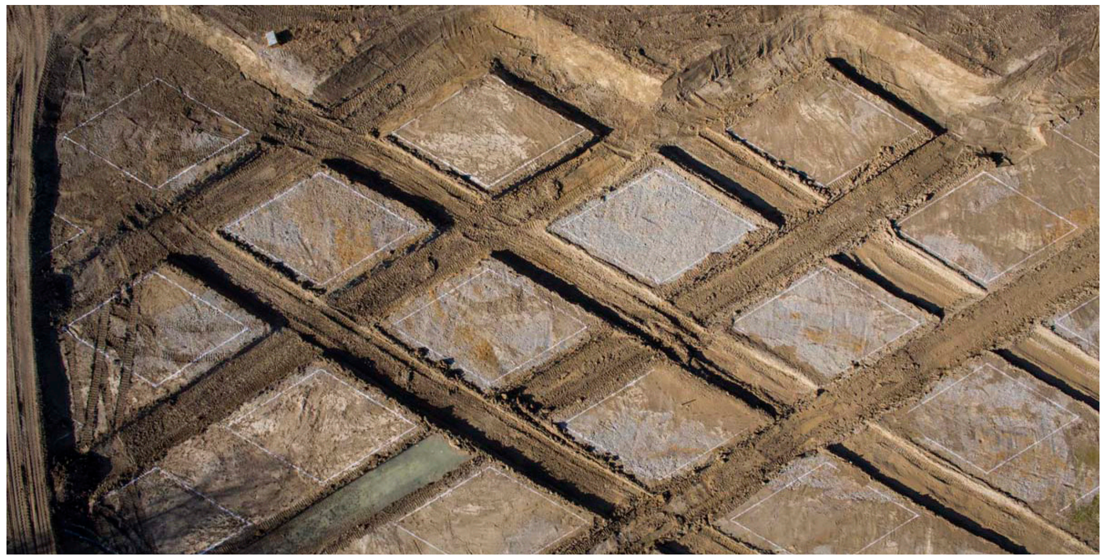


Fig. 83. River Aire renaturation building site, Geneve (Switzerland). The design process involves the excavation of diamond mesh to create a pattern that creates the conditions of naturalness in which the transport of water and sediments takes place source: Atelier Rampini Descombes.

3.1 Topological operations on soil: shape - cover - composition

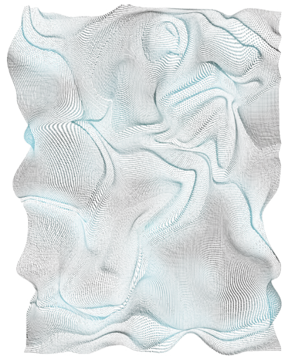
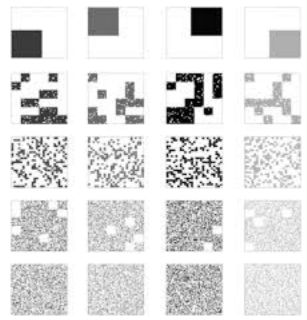
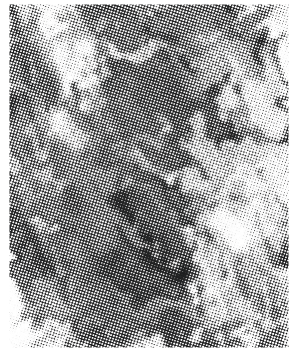
The framework produced by this analysis is neither uniform nor homogeneous, reflecting the gaps in research and the diversity between conceptual and operative approaches and must be considered only as a simple introduction. In the following paragraphs the main topological operations on soil are presented, identified as three main categories - *shape, cover* and *composition* - and ten related sub categories (Tab. 12):

Shape: Digging / Excavation / Adding / Moulding
Cover: Water / Vegetation / Agriculture / Impervious
Composition: Structure / Improver

They are presented individually, through the conceptual description and the main practical-theoretical references traceable within each topic.
Each type of action significantly affects the others, contributing to the construction and transformation of the landscape in both traditional and contemporary practices.
As a general introduction it is considered important to present two paradigmatic cases studies distant in time and in the use of different technologies, but with a similar approach and both located in the extreme climate of the desert.
A sophisticated and successful model based on the sequence of the presented topological operation through traditional knowledge is the *oasis model*[42] widely described by Pietro Laureano (Laureano, 2013) (Laureano, 2001).
A landmark for such contemporary projects is the *Jade Eco Park* in Taiwan, a new 70-hectares park on the site of the old airport, with leisure, sport, family and tourist activities, a 3000 m2 visitor center, a maintenance center, and the urban regulation for a new museum and the Taiwan tower. The winning competition proposal has been developed by the international team lead by the French landscape architects Cathrine Mosbach and Philipe Rahm[43].

[42] The model will be described through the definition given by Laureano himself in *The Water Atlas, traditional knowledge to combat desertification* (Laureano, 2001).
[43] The following is the description made by Desimini and Waldheim in *Cartographic Ground* (Desinimi and Waldheim, 2016).

TAXONOMY OF DESIGN ACTIONS OPERATED

Shape	**Cover**	**Composition**
grounding morphology	pattern superposition	behaviour under trace
		
Topology, Girot 2013 Cartographic Ground, Waldheim 2016 Terra fluxus, Corner 2006	Pattern and Process, Turner 1989 Landscape metrics, Wu 2000 Spatial Ecology, Forman 1986	Oasis model, Laureano 2001 Soil & Landscape, Finke 2016 Soil change, Richter 2011
DESIGN & REPRESENTATION	LANDSCAPE ECOLOGY & PLANNING	SOIL SCIENCE, PEDOLOGY & HYDROGEOLOGY

Digging	Channel Pond	Water	Permanent Temporary	Structure	Size & Texture Water & Organic
Excavation	Qarry Pit	Vegetation	Grass Tree and brushes	Improver	Biological Mineral
Adding	Embankment Microtopography	Agriculture	Intensive Conservative		
Moulding	Terraces Slide and smooth	Impervious	Urbanization Infrastructure		
TOPOGRAPHY DTM CLOUD POINT		GIS Corine Land Cover Land take		Soil structure Aquifers	

Tab. 12. Taxonomy of design actions operated on soil. source: author

TRADITIONAL OASIS MODEL

Fig. 84. The erg oases in the Algerian Souf region with artificial craters (bur) dug out and protected by barriers of leaves, regulate the dune movements and shape the great sandy desert landscape. source: "The water Atlas", Laureano.

The first synthesis of complexity is the oasis intended as an artificial accomplishment deriving from a perfect knowledge of the environment. In the desert, dryness is interrupted by singular situations that give rise to niches and microenvironments contrasting with the overall cycle. A slight depression collects humidity, a stone provides shade and a seed flourishes. Thus, favourable dynamics develop: the plant generates its protection from the sun's rays, concentrates water vapour, attracts insects, produces biological material and the soil from which it subsequently draws its nourishment. [...]They often originate from a single palm tree, planted in a hollow in the ground and surrounded by dry branches, which protect it from the sand. As the time goes by, large tilled fields develop along terraced canyons or on green archipelagos among the dunes, thanks to complex and diversified techniques of water production, land organisation and microclimate formation.

(Laureano, 2001)

CONTEMPORARY OASIS MODEL

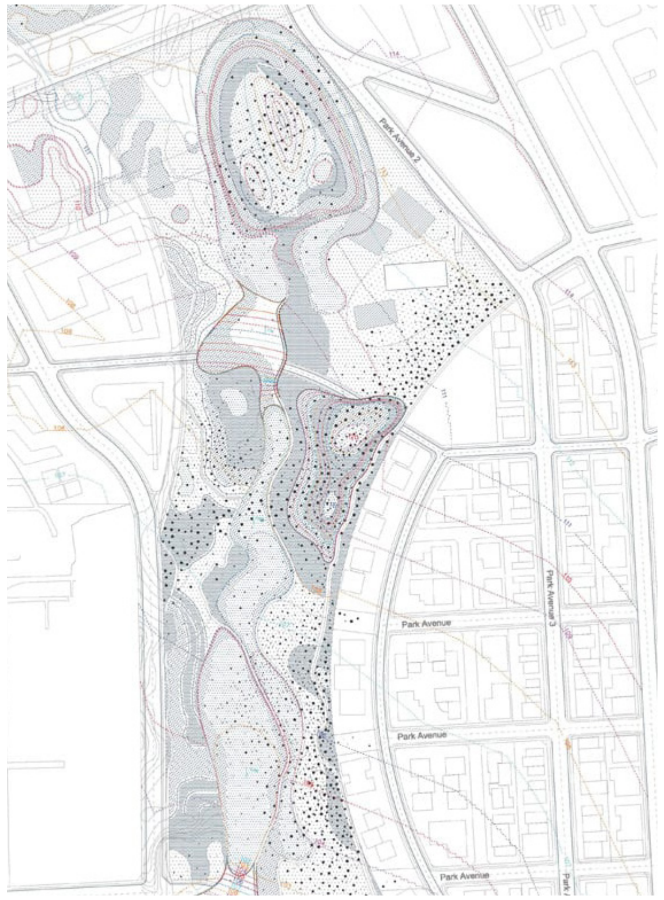


Fig. 85. Mosbach Paysagistes's plan for the Taichung Jade Ecopark appears as a lithospheric painting, revealing stratigraphic gradients between wet and dry and high to low. source: Philippe Rahm studio

Taichung Jade Ecopark focuses on microclimate as a way to organize design. Hydogeological conditions drive topographic manipulation. The ground surface and depth are altered to promote groundwater infiltration, take advantage of potential cooling breezes, and address adjacent sources of noise and air pollution. The park comprises layers of porous materials designed to hold, absorb, release, and celebrate water. Topography, vegetation, dehumidifiers, and fountains changes the ambient temperature throughout the park, promoting biodiversity and accomodating a wide range of human activity in both the wet and dry season. The plan drawing represents the project as a series of layers, highlighting the stratigraphy present in the designed lithosphere.

(Desimini & Waldheim, 2016)

TRADITIONAL OASIS MODEL

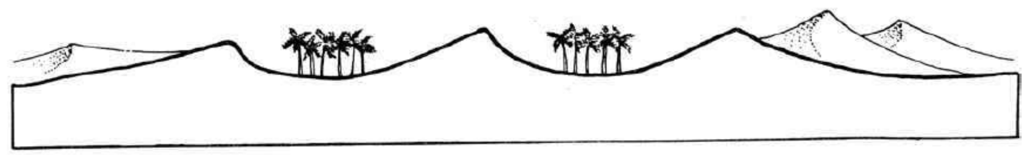


Fig. 86. Erg oases situated in artificial sandy craters (bur) typical of the Algerian Souf region. The dunes protect the oases at the perimeter and the palm trees, which directly soak up water form the subsoil, create a microclimate suitable for horticulture. source: "The water Atlas", Laureano.

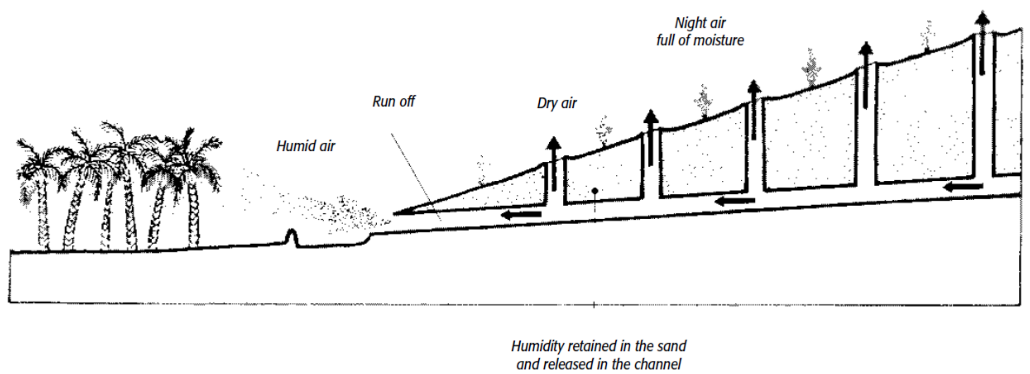


Fig. 87. Humidity water supply to the foggara. The air full of moisture of the palm grove is sucked out by the foggara in the opposite direction to the water run-off; it condenses in the tunnel and comes out of the shafts as dry air. During the night the temperature decreases and determines a further moisture condensation on the soil surface that is absorbed by the shafts and the tunnel. source: "The water Atlas", Laureano.

CONTEMPORARY OASIS MODEL

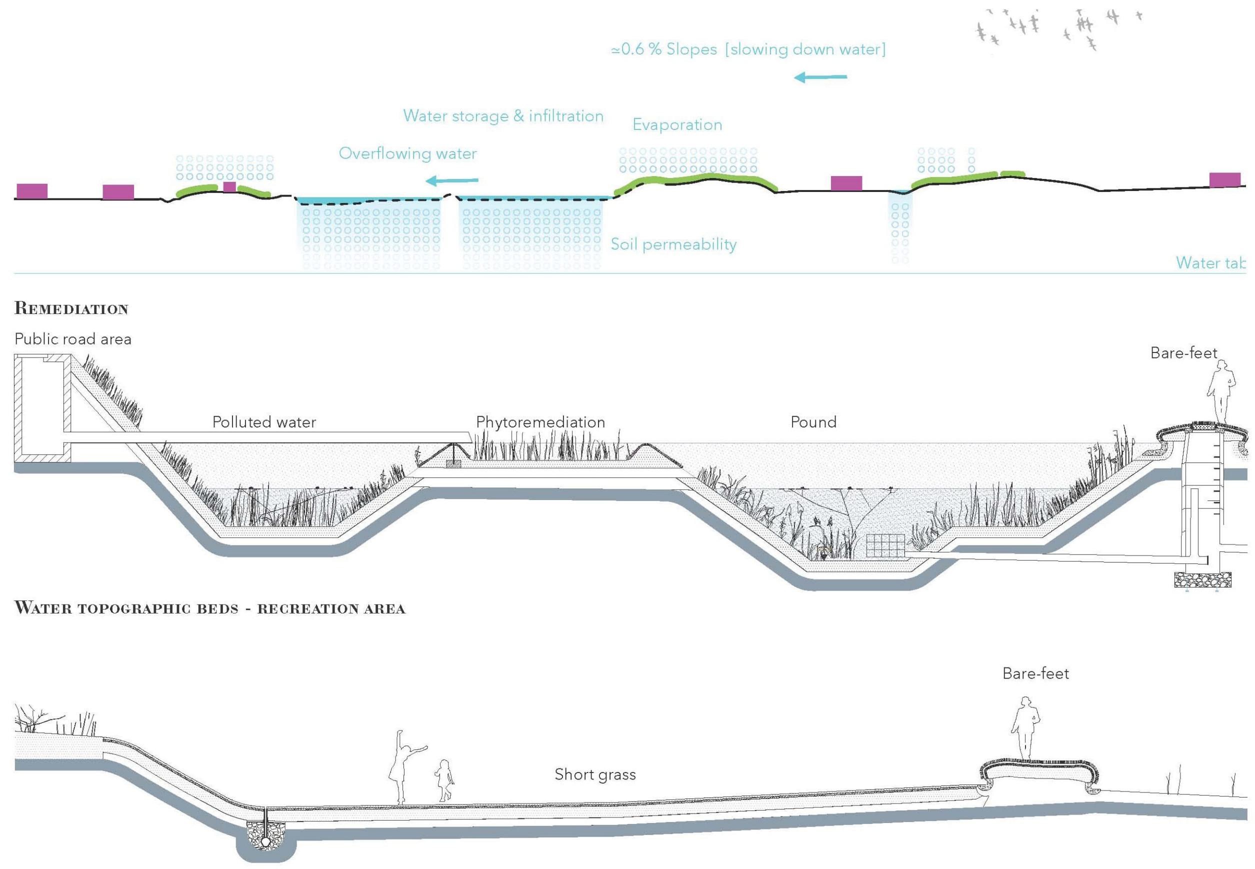
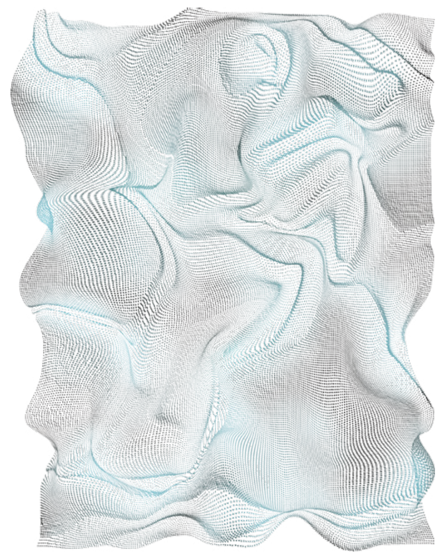


Fig. 88. Mosbach Paysagistes's plan for the Taichung Jade Ecopark appears as a lithospheric painting, revealing stratigraphic gradients between wet and dry and high to low. source: Philippe Rahm studio

As formulated by Pietro Laureano (Laureano, 2001) *oasis* are typical of the desert, but can also be assumed as a general model. Thus a theory of the *oasis* can be drawn up: the study of closely linked processes between man and nature that, under the hardest living conditions, can create vital cycles and *autopoietic* ecosystems which are able to continuously regenerate and perpetuate themselves. The environmental features of the desert can be ascribed to the conditions of high aridity of the soil and to the sparse vegetation. It is the soil, which is the surface layer produced by the continuous action of *chemical, physical* and above all *biological* factors, that makes plant life possible, which in turn protects the soil and ensures its constant regeneration. In the face of epochal involvement of technology and techniques used in territorial changing, the presented cases studies bring forward analogies in landscape transformation. They both embed several consequential actions operated on soil in a symbiotic resulting of types and forms, driving inspiration for landscape design praxis through soil transformations.

shape grounding morphology

Digging	Channel Pond
Excavation	Qarry Pit
Adding	Embankment Microtopography
Moulding	Terraces Slide and smooth



Watershed simulation through parametric tools along a curvilinear surface

Shape is the spatial organization of a substance. Its changing is the first asset in *grounding morphology.* It generates a field of spatial heterogeneity and discontinuity. In fact physical configuration conditions the opportunity to control energy and matter flows, and the attitude of a substance to self-organization (Ch. 1.5.2). This is related to the auxiliary energy involved in keeping a certain state of things.

The organization of matter in space influences its features. The soil can assume plastic or elastic behaviour, depending on: its own properties, the type of applied transformation, the scale and the time of observation. Over time the landscape appreciation has evolved. As we have seen through several examples from Corner (1999, 2006), Belanger (2016), Sjimons (2017) and many others, contemporary landscape design approach is moving away from the ancient, controlled and Arcadian image and it's embracing this new process-framework of design. The concept of grounding morphology emerges as the foreground, and the shaping praxis comes to define a common denominator between fundamental design aspects on several scales approaching territory to design.

The most influential practitioners and theorists - in articulating and spreading the ideas of shaping landscape as a fundamental practice - are Charles Walheim, James Corner, Cristophe Girot.

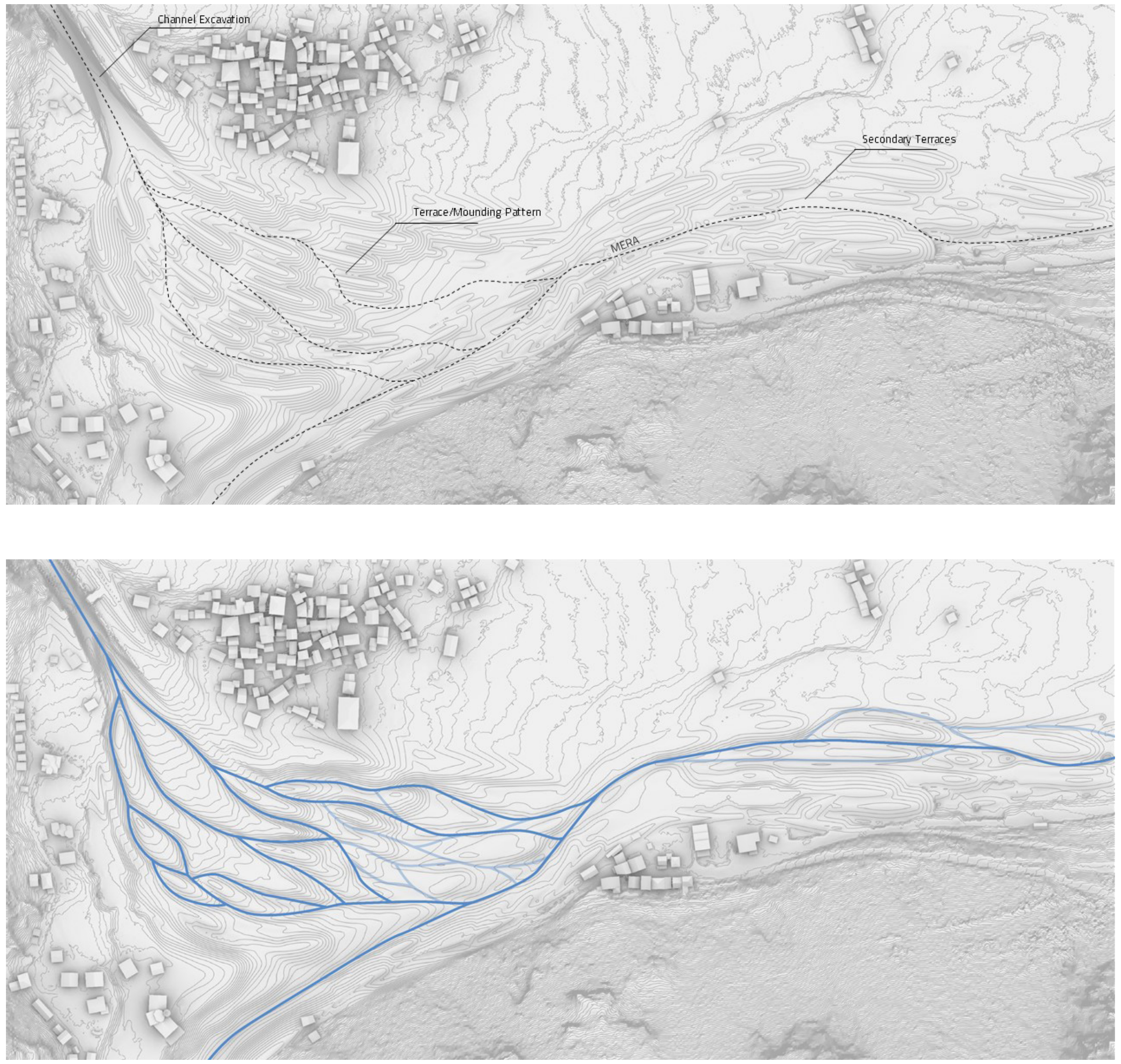


Fig. 89. Systematic investigation undertaken over the Design Studio Robotic Landscapes II in designing a dynamic alpine landscape in Bondo (CH). source: Robotic Landscape, Christophe Girot

They do not directly refer to the word soil. They rather use *terrain* (Girot, 2013), *ground* (Corner, 2006) (Desimini & Waldheim, 2016), *canvas* (Girot, 2013), that for extension the letter refers to *soil* in its multi-faced features clarified along the investigation. In many ways, these three concepts represent an extract of the original proposed research themes. Corner's input reflects the attempt to approach the design scales in the framework of *landscape urbanism* and flow-function ratio. Girot suggests to using a formal mathematical concept to think and design the landscape. Waldheim relates the theme of translating three-dimensional information into a two-dimensional surface (topology). Their contributions, briefly reported below, has supported the concurrent discussion on landscape architecture in the interface between academia and practice.

Overviewing key literature

James Corner in the essay *Terra Fluxus* (2006) provides a convincing explanation for the linkage between the design praxis and the physical trans-formation of the environment under anthropic pressures.

The American landscaper invites to "*preparing ground*" in space arrangement "*flexible and open*". In this understanding Corner argues *"The designation terra firma (firm, not changing; fixed and definite) gives way in favour of the shifting processes coursing through and across the urban field: terra fluxus"* (Corner, 2006).

Yet Cristophe Girot introduces another interesting aspect. He associates the concept of *shape* for identifying both the *operational tools* and the *semantic framework* with which to conceive landscape design, using the term *topology*[44]. Intuitively, what characterises a *topological space* is its *shape,* not the distance between its points, which can be undefined. As he outlines in its work *The elegance of Topology "Although topology is generally understood as a mathematical construct relating to the continuity and connectivity of surfaces, it can also incorporate a more general understanding about the genealogy of a constructed landscape"* (Girot, 2013). Within this approach Girot's theory is the attempt to overcome the ecological view and understanding of *layering* different parameters in the design of landscape proposed by Ian Mac Harg (Mc Harg, 1969). In this respect he proposes the use of *point-cloud models "to recapture the precise, local, and cultural specific character of the landscape.[…] The design is nestled into the existing topography, representationally set apart – as a separate overlapping surface full of points - but physically responsive and cohesive"* (Desimini & Waldheim, 2016). (Img. 89-91).

The trajectory of representation – of concept and context – has moved from the material and physical description of the ground toward the depiction of unseen and often immaterial fields, forces and flows. In the book *Cartographic Grounds, projecting the landscape imaginary,* Charles Waldheim and Jill Desimini (2016) revisit the depiction of geographic morphology as grounds of and for design through a series of foundational representational techniques associated with the two-dimensional depiction of three-dimensional conditions. *Cartographic Grounds* reimagines the projective potential of cartographic practices that afford greater proximity to the manifestation and manipulation of the ground itself, making present and vivid the landscape as it exists and as it could be.

Overviewing Corner, Waldheim and Girot specifications for shaping landscape, it appears that all the described approaches have a distinct focus on systemic and holistic thinking with different specific contributions on the topic useful for designers involved on several intervention scales.

[44] Topological space may be defined as a set of points, along with a set of neighbourhoods for each point, satisfying a set of axioms relating points and neighbourhoods through mathematical structure that allows the formal definition of concepts such as convergence, connectivity, continuity, neighborhood, using subsets of a given points.

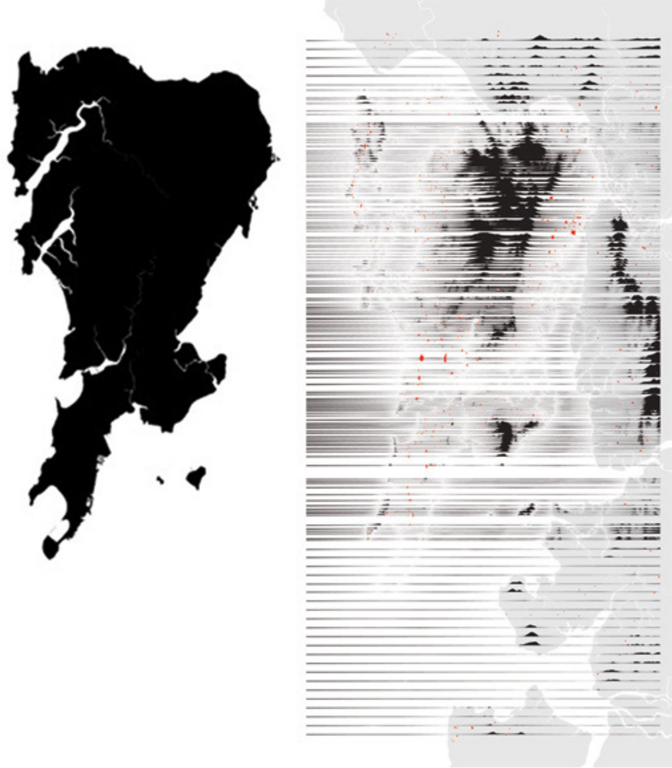


Fig. 90. Mumbai sections, 2009. source: Anuradha Mathur and Dilip da Cunha

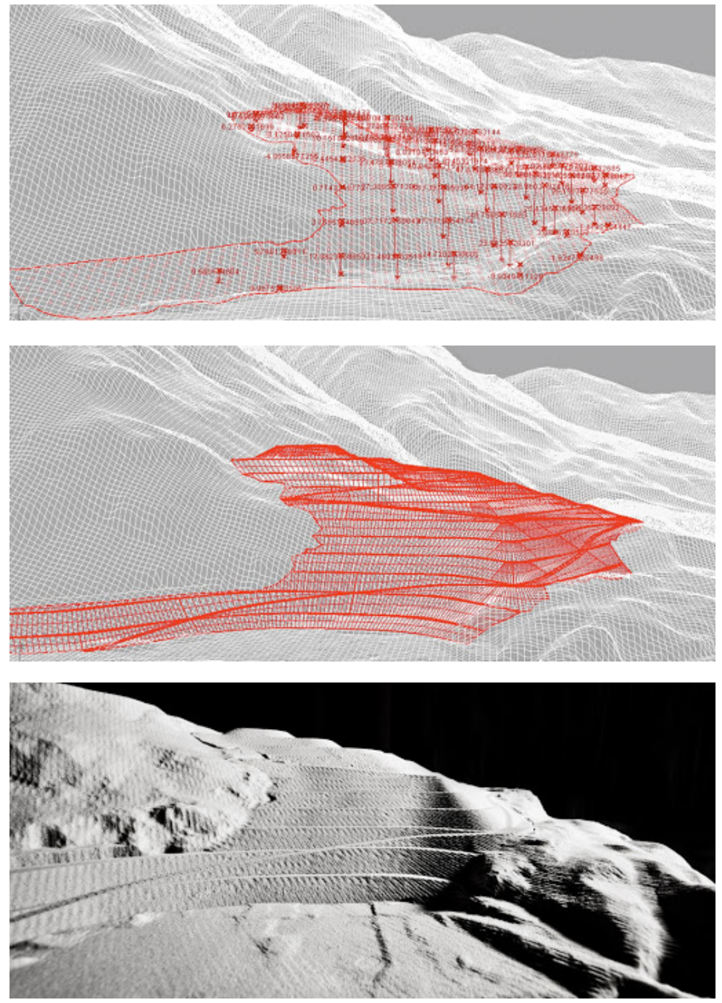


Fig. 91. The Sigirino Depot (CH), point cloud visualization of existing and constructed hillside in the Sotto Ceneri mountain range. Source: Atelier Crhistophe Girot

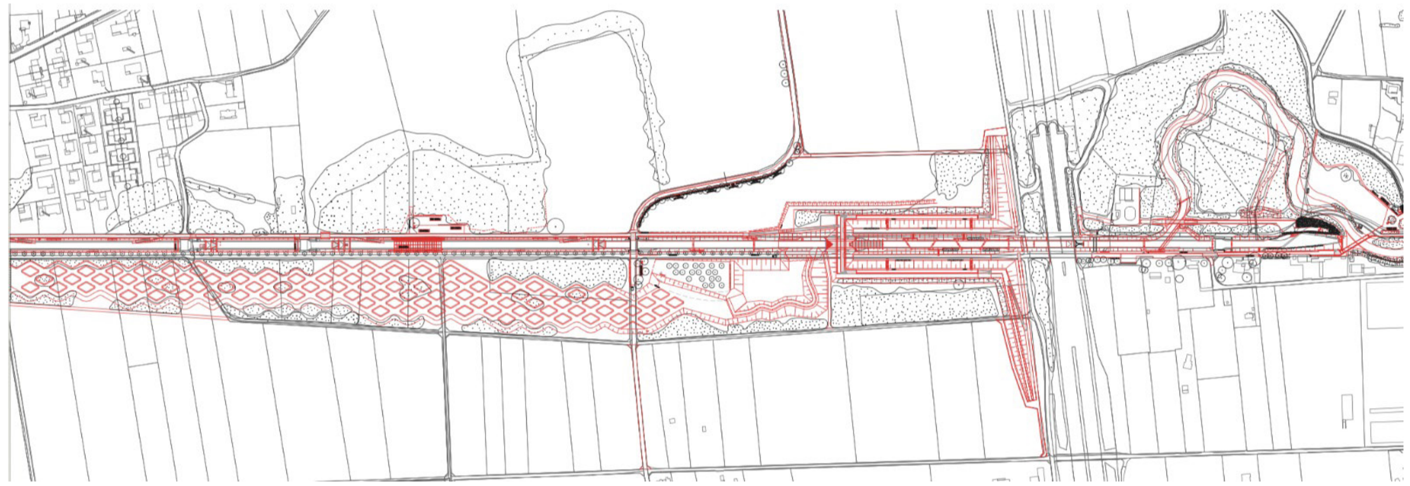
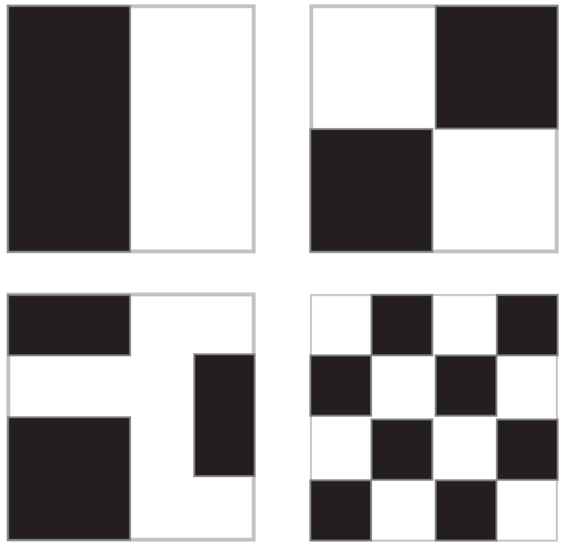


Fig. 92. Renaturation of River Aire (CH), the excavation project overlaps the existing site of intervention. Source: Atelier Descombes Rampini

cover pattern superposition

Water	Permanent Occasionaly
Vegetation	Grass Tree and brushes
Agriculture	Intensive Conservative
Impervious	Urbanization Infrastructure



Example of four landscapes with the same percentage of two land covers but spatialy arranged according to different values of decreasing connectedness (Farina)

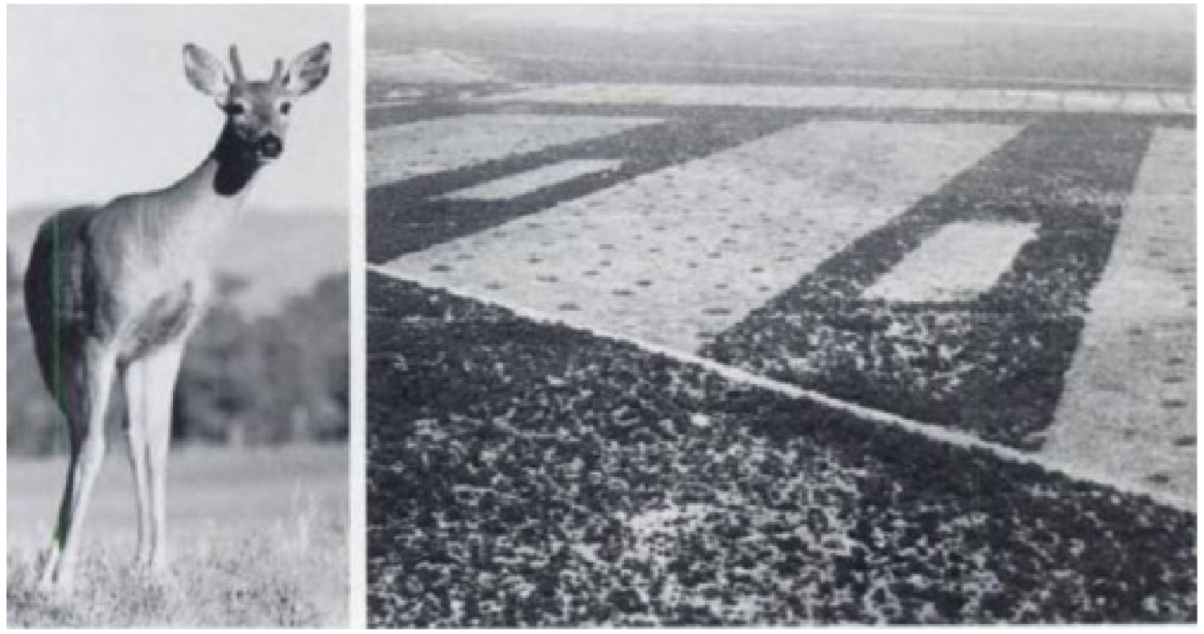


Fig. 93. High contrast and varied grain size in a wildlife management area. Large 250-meter-wide clearing and intervening shrubland strips provide browse and cover for deer, quail, peccary, and wild hogs. in Land Mosaic. source: The Ecology of Landscapes and Regions, Richard Forman, 1995

Cover is the surface overlay. Soil is normally covered both in its natural condition, and in its anthropized status. The *soil coverage* is substantial in the visual perception of the landscape. Simultaneously, the elements that lie on soil surface play a big role in terms of soil functions, such as carbon and gases exchange, water infiltration capacity, nutrient cycle.

In fact, as evidenced by numerous studies (IPCC, 2019), the way in which soil surface is covered influences the exchange with atmosphere, hydrosphere and biosphere. Soil coverage deeply affects the *pedogenesis process* and the ecosystem characteristics. Furthermore the habitat continuity is a key research topic in landscape ecology, dealing with the study of ecological flows in *landscape mosaics*, *land use* and *land cover change* (Wu, 2013).

The Italian expression *copertura del suolo*[45] (ISPRA, 2018) – literally *soil coverage* - actually refers to the English terms "*land cover*" , that here can be considered equivalent. Operating an oversimplification - in accordance with the classification of *Corine Land Cover*[46] - the coverage types proposed along this section are: *water, vegetation, agriculture, impervious*.

[44] *Copertura del suolo* (literally *land cover*) means the biophysical cover of the land surface, including artificial surfaces, agricultural areas, forests and forests, semi-natural areas, wetlands, water bodies, as defined by the Directive 2007/2/CE (ISPRA, 2018). Hereafter is proposed a categorization of *soil coverage* equivalent to *land cover*, but we are focusing on the *soil*, intended as environmental matrix.

[46] The CORINE Land Cover (CLC) inventory in managed by *Copernicus*, an European Union's Earth observation programme, that offers information services that draw from satellite Earth Observation and in-situ (non-space) data. (CLC) inventory was initiated in 1985 (reference year 1990). Updates have been produced in 2000, 2006, 2012, and 2018. It consists of an inventory of land cover in 44 classes. (COPERNICUS, 2021)

In situations of data scarcity, *Land use* and *Land Cover* (LULC) standard are very useful proxies for soil information. LULC usage allows to produce those spatially distributed biophysical parameter values needed for mapping production or scenario modelling of future changes. Changing land cover strongly impact shifting in soil composition and so il shape. This spatial aspects allows to link the dynamism of soil properties to *ecosystem services* (Adhikari & Hartemink, 2016).

As reported by the landscape ecologist Jangle Wu *"Socioeconomic processes are the primary drivers for land use and land cover change which in turn determines the structure, function, and dynamics of most landscapes."* (Wu, 2013). In this section the author associate the *coverage of soil* with the concept of *pattern superposition*. From the definition given by Wu (Wu, 2013), in landscape ecology *pattern* literally refers to *"The composition (diversity and relative abundances) and configuration (shape, size, and spatial arrangement) of landscape elements, including both spatial patchiness and gradients."* Operating an approximation, *cover* is considered a *casing of soil and the linkage between them in a cause-effect relation*. This way coverage is not intended only as a simple *overlapping layer*, but rather a *key driver* in landscape processes. Taking an example suggested by Richard Forman *"Substrate heterogeneity, such as hills, wet spots, and different soil types, causes vegetation patchiness"* (Forman, 1995).

Pattern and ecological process

The relationship between *pattern* and *ecological processes* has been introduced in the interdisciplinary field of *Landscape Ecology*, since the '80s[47]. LULC have a significant role in pattern analysis, outlined by Wu as "The procedures with which landscape pattern is quantified, primarily, using synoptic indices and spatial statistical methods" (Wu, 2013). This assestsment is related to quantitative - i.e. percentage of coverage - and qualitative data – i.e. kind of land cover and spatial arrangement - as described by the image on page 134 ri-elaborated by the author from Almo Farina's book *Principles and Methods in Landscape Ecology* (Farina, 1998).

These theories have played an important role in: a) describing and comparing the spatial patterns of landscapes; b) monitoring and predicting changes in landscape patterns; c) relating spatial pattern to ecological processes at a particular scale or across a range of scales (Cardille & Turner, 2017) (Wu, 2013) (Farina, 1998). Along three decades landscape ecology has developed a suite of *pattern metrics* and *indicators* which can be used for quantifying sustainability in a geospatially explicit manner (Fig. 94)[48]. This way, categorical maps of patterns can be developed using Geographic iInformation Systems (GIS), through the *overlay* and *interpolation* of diverse sorts of spatially explicit information stored both in vector and in raster form, both in raster form, i.e. *cell by cell* (pixel by pixel) in a grid.

Looking towards more descriptive writings on the practical aspects of pattern and process, some works in the written production of Richard Forman should be mentioned, in particular *Land Mosaic. The Ecology of Landscapes and Regions* (Forman, 1995) and *Urban Region, Ecology and planning beyond the city* (Forman, 2008). Here is reported an example offered by Forman concerning our hypothesis taken from *Landscape Ecology*: *"superimposing maps of soil types, tree communities, and herbivorous mammal communities for a landscape may show several places where boundaries coincide and many places where they do not. The degree of congruity in space among the units of different components is useful in mapping, land use planning, and analyses of landscape structure"* (Forman & Godron, 1981).

Having said that this chapter still remains to answer as *approximation*, in the *Taxonomy* boards some examples will be presented more in detail. This paragraph integrates a brief introduction to the *landscape ecology* concepts permeable with to design and planning concerning this topic.

Landscapae ecology in fact explores the ecology of heterogeneous land areas, where - quoting Foreman - *"natural processes and human activities interact to produce an ever changing mosaic"* (Forman, 1995).

In this terms, given their experience with *landscape pattern analysis,* landscape ecologists have much to offer to *planners* and *landscape designers* in exploring and testing different landscape-based scenarios for sustainability planning and decision-making (Wu, 2013).

[47] According to its key-literature, the origins of relating landscape pattern and ecological processes can be traced back in the academic paper *The Effect of Pattern on Process* drafted by Monica Goigel Turner in 1989, that still raemains one prominent researcher on thise topic.
[48] A number of *landscape metrics* and *spatial statistical* methods have been developed through algorithms that quantify specific spatial characteristics of *patches, classes of patches,* or entire *landscape mosaics.*

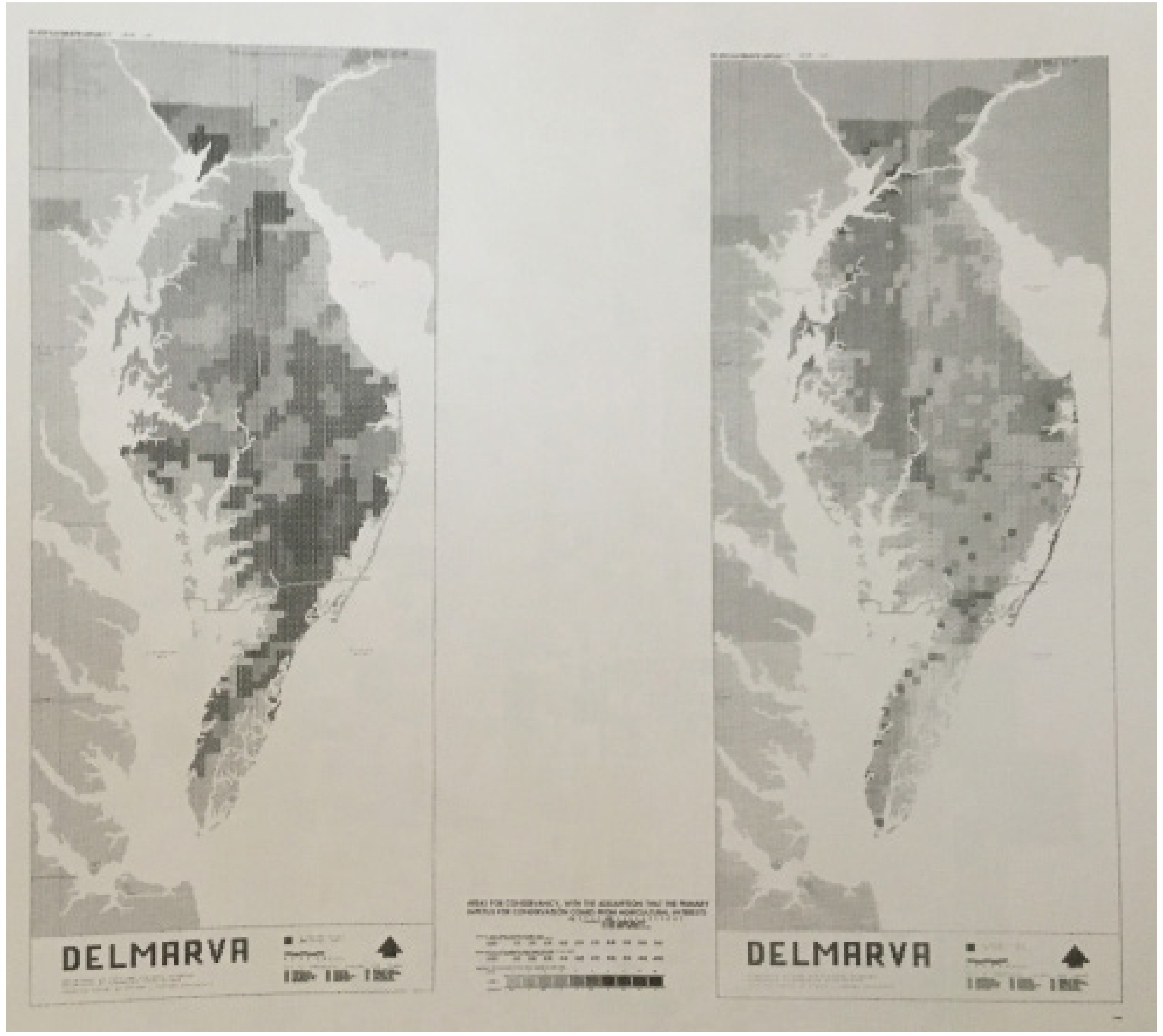
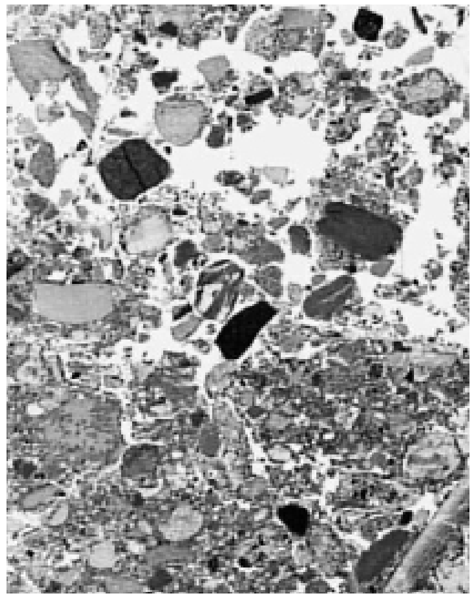


Fig. 94. Computer mapping and the Regional Landscape, A forest Density; B Area for conservancy. The maps present an exercise made by the student of Harvard University to determine locations suitable for development in Delmarva Peninsula, though geographical dats and code infromation. The first map shows forest density; the second one presents an aggregation of multiple types of data mapped with different weighted values - high soil quality (+3), high wildlife potential (+1), high forest density (+1), and high shoreline indentation (+1), to yeld optimum areas for conservation. source: Carl Steinitz, 1967. In Cartographic Grounds (Desmini and Waldheim 2016)

composition behaviour under trace

Structure	Size & Texture Water & Organic matter
Improver	Biological Mineral



Aggregation of soil elements through microscopic analysis

The term *composition* generally refers to the combination of elements in a structure, in terms of *arrangement, quality, properties* and *mutual relationship*. The *components of a substance* influence its *under trace behaviour* subjected to inner and external inputs. This attitude is connected to those subterranean relationships that influence the *soil properties* and display on the visible surface.

In fact, as pointed by Peter Finke *"The development of both soils and landscape is highly influenced by processes that redistribute mass at the surface, but also below the surface (leaching)"* (Finke, 2016).

The basic components of *soil* are *minerals, organic matter, water* and *air* arranged in different percentages. These elements can change in time, space and in response to external and inner dynamics. Being soil an highly variable *mixture* of these components, changes in each part dynamically affect the others.

Anthropogenic factors deeply and rapidly change soil composition. In particular, the increasing use of *mineral improvers* affect the presence of organic matter and water, whose occurrence is crucial to maintain the soil healthy. This shift can be directly linked or consequent to other activities associated with changes in *land cover* and *land use*, such as agricultural practice, urbanization, artificial snow, air pollution, etc.

This section deals with the subject of soil transformations associated to its *composition*, starting from studies related to the field of geology and pedology. These sciences study soil, its characteristics and changes.

Fig. 95. Saline wedge in different season, along a coastal lagoon in Lido di Spina (Italy). source: Google Earth.

Being an extremely specific and specialized topic, a general framework is provided through the simplification in two macro categories: Texture – *Size & Structure / Water & Organic matter* – and Improver – *Organic / Mineral*. To deepen this topic, please refer to a more specific bibliography, in which should be mentioned the written production of Peter Finke, Daniel Richter, Douglas L. Karlen , Alfred E. Hartemink.

Structure

Soil structure is one of the most important properties affecting crop production because it determines: a) the depth that roots can penetrate; b) the amount of water that can be stored in the soil and the movement of air, water and soil fauna (Pagliai, et al., 2004). Quantifying soil structure modifications allows to understand the impact of management practices on the soil environment (Pagliai, et al., 2004).

Specifically, soil structure is the arrangement of *granulometric particles* in aggregates that have distinctive shapes easily distinguishable. It is it is influenced both by intrinsic characteristics- such as *chemical composition* - and by external environmental factors - such as alternation of *freezing and thawing* -, *moisture content*, as well as by the activity of *microorganisms* and the *cementation* carried out by clay, organic substance and metal compounds.

It influences the *physical* and *chemical* behaviour of soils and is deeply affected by *texture* and content of *clay, water, soil organic matter* (SOM) and *soil organic carbon* (SOC).
Water is the element at the base of every dynamic process: *biological*, concerning the presence of microorganisms; *chemical*, with reference to matter transformation and exchange; *physical,* in relation with mechanical actions of substance flows and movement.
Texture refers to the distribution of particles size. The particles that make up the soil can be divided into size categories named *particle size fractions*. The different combinations of sand, silt and clay are grouped into *textural classes*. Shape and continuity of pores affect many important processes in soils (Pagliai, et al., 2004).
Soil organic matter (SOM) refers to the large source of carbon-based compounds. This in turn is composed of *living* and *dead organisms*: plant roots and animals, their remains in various stages of decomposition, cells or tissues and substances produced or reworked by the roots of plants, and micro-organisms.
As evidenced by numerous studies (Pagliai, et al., 2004) (Finke, 2016) (Karlen, et al., 2019) (ER, 2016) organic matter and clay content keep soil particles together in form of stable aggregates. These factors have positive effects on *soil health* by: a) strengthening soils resistance to wind and water erosion; b) preventing soil crust formation; increasing the rate of water infiltration and decreasing the runoff effect by reducing the surface flow and facilitating the penetration of plant roots; improving water retention capacity and thus enhancing resistance to droughts; c) retaining nutrients, due to its cation and anion exchange capacity.

FOREST SOIL | *MECHANICAL PRESSURE* | *AGRICULTURAL TILLAGE SOIL* | *AGRICULTURAL NON TILLAGED-SOIL*

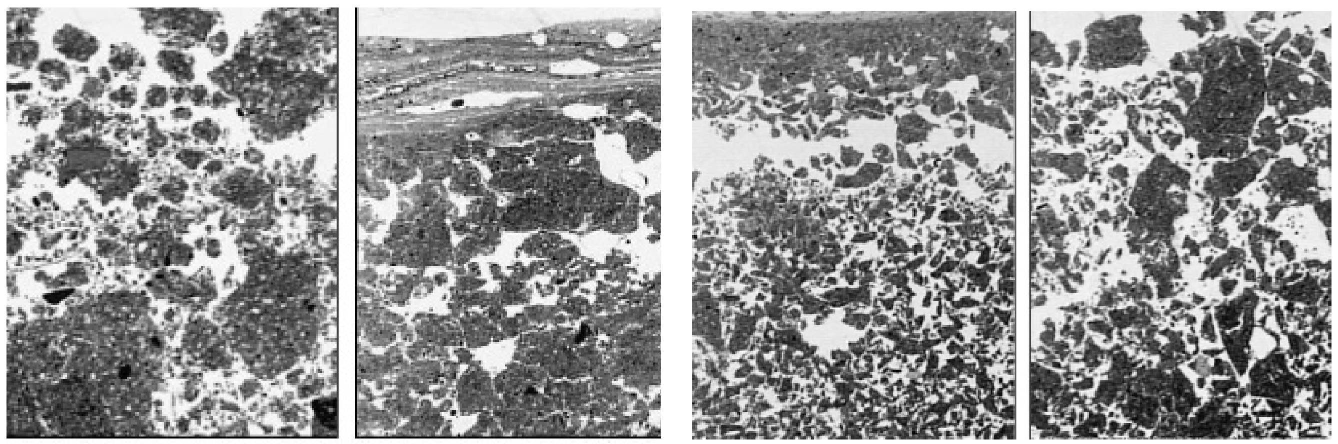


Fig. 96. Example of soil structure changing in natural and anthropization condition.

Improver

Soil characteristics are often manipulated by man through the addition of substances that increase soil performance in terms of both *physical* and *chemical properties* - primarily its *fertility*, the ability to provide nutrition for plants - and its *mechanical features.* These products are generally called *improvers*, *conditioners* or *amendments*. They include a wide range of *fertilizers*, and can be made of *non-organic substance* originated by chemical synthesis processes, or of organic materials[49]. Given the worldwide diffusion of agricultural activity, the massive use of soil improvers has a very strong impact both on the soil health, and on the environmental equilibrium at the global scale.
During the 1990s, 100 million tonnes of fertilizers were used worldwide every year, following an increase in soil inputs of N, P, and K from 3- to 8-fold between 1960 and 1995 (Markewitz & Richter, 2001).

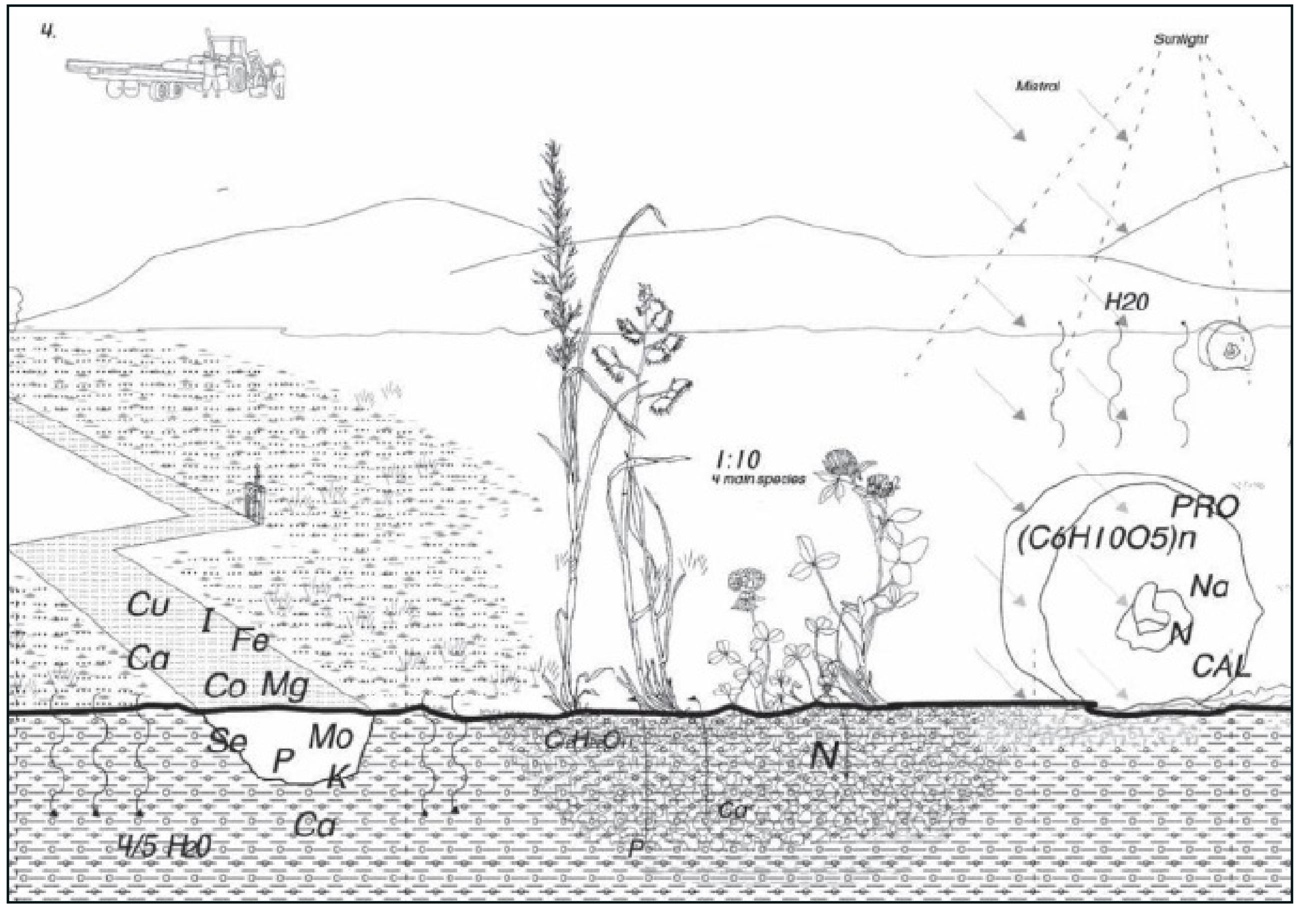


Fig. 97. Land recovery device. source: Regenerative Empathy_ Complex Assemblages in a Shared Environment by Harvard GSD.

[49] Typologies and characterization is presented in the concerning schedule on page 160-161-162-163.

According to *IPCC Special Report on Climate Change and Land* (IPCC, 2019) the use of nitrogen fertilizers increased by 800% between 1961 and 2019, representing a *key driver* of *global warming* due to both direct and indirect *greenhouse gases* emissions.

Inappropriate manure or mineral fertilizer management, can either deplete or increase the fertility status well-beyond levels needed to support plant growth and development (Karlen, et al., 2019).

Excessive soil fertility levels can then contribute to eutrophication, expansion of hypoxic dead zones, drinking water pollution, groundwater contamination, algal blooms, impaired recreation on lakes, reservoirs, and streams, etc. due to nutrient runoff (e.g. P) or leaching (i.e., NO3-N) (Karlen, et al., 2019).

Furthermore consequence of long-term intensive cultivation is the degradation of soil structure, which can reduce the effect of chemical fertilizers (Pagliai, et al., 2004).

Vice versa, as anticipated in the previous paragraph, the conscious and careful application of compost and manure improved the soil porosity and the soil aggregation (Pagliai, et al., 2004).

The use of *biochar* - a carbonaceous material obtained from the transformation of biomass at high temperature in anaerobic conditions - can jointly tackle the problems of *global warming* and of boosting sustainable agricultural intensification, "closing the nutrient loops" at the farm or regional level (Tonini et al., 2019). In fact, it is supported by the UNDP and the IPCC as both a climate change *mitigation* and *adaptation* measure (IPCC, 2019): *mitigation* through CO2 sequestration in soils – indeed is also considered a negative emission technology – and *adaptation* through the improvement of *soil health* quality, in terms of productivity and reduction of vulnerability to climate change. *Biochar* shows interesting properties for agricultural purposes: a) high *cation exchange capacity* (CEC) (Marshall et al., 2017), which enhances nutrients adsorption and retention and prevents their leaching; b) high specific surface, i.e. porosity, which promotes water and gases retention in soil, thus enhancing soil resistance to drought and reducing need for irrigation and gaseous ammonia emissions (Janczak et al., 2017).

The presence of big mammals in wild condition - such as horses and cattles - provide *soil eutrophication* (adding *nitrogen* and *phosphorus*), that in context of *oligotrophic soil* - such as those affected by salination - can have a positive impact on soil health (Fig. 98. Also intensive animal industries often produce large quantities of wastewater and nutrients. Regretfully, given the widespread extent of this practice, eutrophication concerning industrial and intensive agriculture has and continues to pose a serious threat to potable drinking water sources, fisheries, and recreational water bodies.

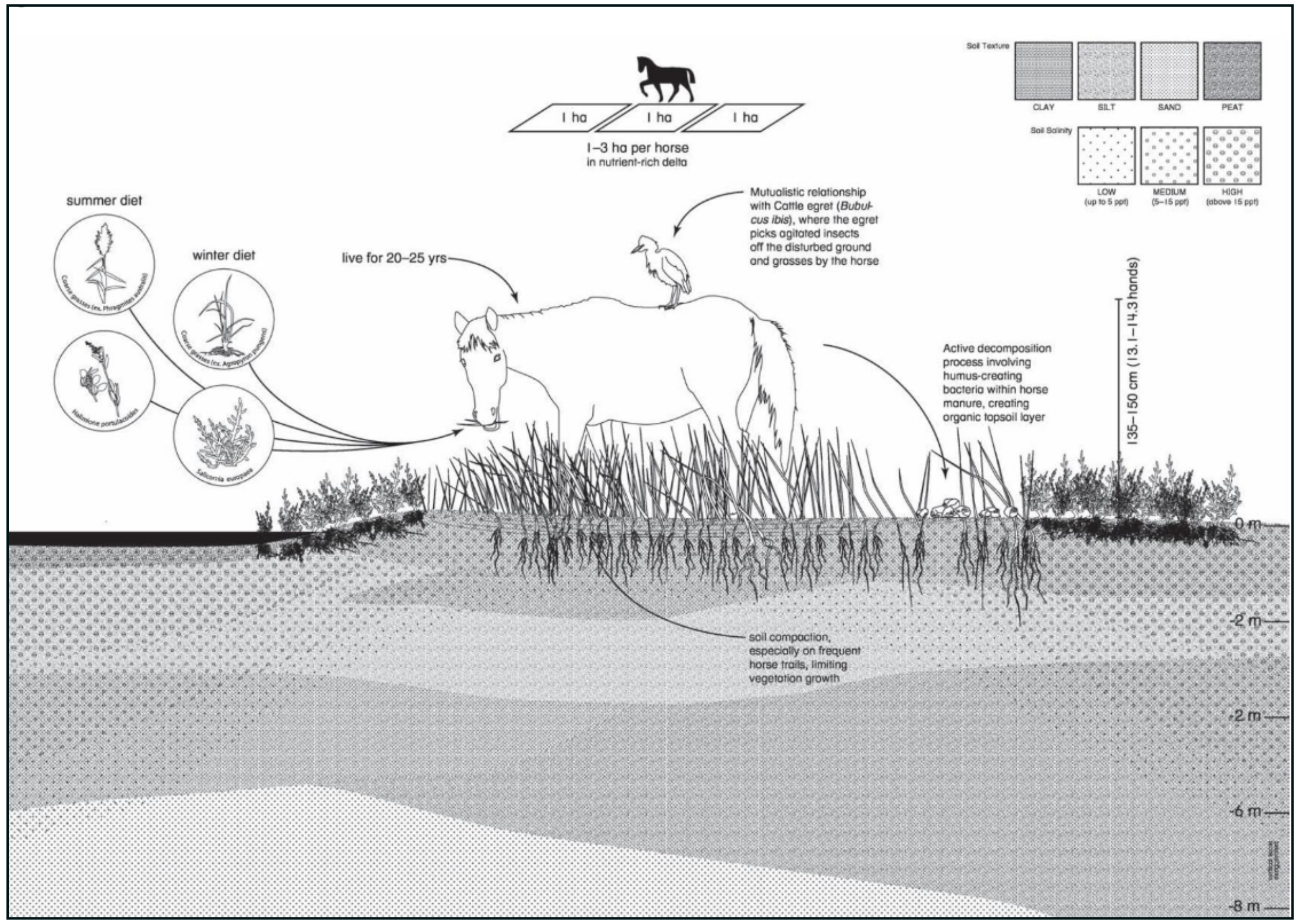


Fig. 98. Land recovery device. source: Regenerative Empathy_ Complex Assemblages in a Shared Environment by Harvard GSD

3.2 Taxonomy of design actions

Criterion, matherials and methods

This research step presents the results of the intersection of information from multiple disciplinary fields, dealing with *historical survey, pedology, hydrogeology, ecology, ecosystem services* provided by soil.

The field is vast and with great difficulty in finding specific information. The choice of information and sources from which to start is based on principles of consistency and pragmaticity, so that the disclosure processed is meaningful, verified, complete and usable.

This section has been developed in three operational steps. The methodological criteria followed in the analysis and information to take into consideration are illustrated in the working steps reported below and clearly expressed in the following schedule.

1. Crossing information – selection and abstraction

The first part concerns the choice of information to be crossed, with the aim of finding a significant way of transmitting them in a complete and concise way the linkage between design operations, soil properties and ESs provided by soil. Sources comes from different disciplinary fields, with their related expressive languages.

2. Abstraction and approximation – Taxonomy in 10 boards

The crossed information is first collected and summarized in three macro-categories of interventions on the soil: *shape, cover, composition.* They are associated with the intention to study and control the behavior of the soil according to the transformations impressed. These will be analyzed in a coincident manner, in association with 10 taxonomic sub-categories presented in the form of summary sheets.

3. Output – synopsis and schedule

The last part of the research concerns an illustrative survey of significant case studies that represent examples of conscious actions related to contemporary landscape design that improve the ecosystem functions of the soils.

Field of possibilities						
	1. Crossing information – selection and abstraction					
Sources	Anthropogenic soil transformation	Ecosystem services provided by soil	Soil properties	Datas available	Literature review	
Sources	Laureano (2007, 2011)	(Adhikari & Hartemink, 2016)	(Adhikari & Hartemink, 2016)	Morphology, cover, composition	. Scientific paper and studies related with soil . Legislation, standard addresses on soil protection	
Criterion	. Conventional actions on territorial use and managament along the history and nowadays	---	---	Usable as design parameters with GIS ecc Photos and general datas	Related with ecosystem services and soil properties set out by Adhikari and Hartemink	
Effect	2. Abstraction and Taxonomy					
Effect	**Metamodel design:** Topological operations on soil in terms of shape, cover, composition					
Effect	Grounding morphology		Pattern superposition		Under trace behaviour	
Effect	Shape		Cover		Composition	
10 Boards	Digging	Channel Pond	Water	Permanent Temporary	Texture	Size & Texture Water & Organic matter
10 Boards	Excavation	Quarry Pit	Vegetation	Grass Bushes&trees		
10 Boards	Adding	Embankment Microtopograp.	Agriculture	Intensive Conservative	Improver	Organic Mineral
10 Boards	Molding	Terraces Slides&Smooth	Impervious	Urbanization Infrastructure		
Information	**Photography** of relevant example with highlihted the soil operation **Examples** of common practices **Examples** of paradigmatic LD projects with good impact on ESs **Impact on soi**l through scientific references					
Valori	3. Output - synopsis					
Valori	**Synopsis:** Taxonomy of intervention: linking soil transformations to ecosystem services					
Valori	Linking design to soil transformation			Linking design operation to ESs provided by soil		
Valori	1-3 impact positive/ negative					

Tab. 13. Field of possibilities. source: author

shape Digging Channel Pond

Fig. 99. Po rivermouth protected area, Veneto (Italy), characterized by a series of canalization works that allow the agricultural exploitation and the permanence of wetlands regulated by canals and ponds. source: Google Earth

1.1	Channel	Pond
	Potential application	
Tipology	Agriculture, defence, civil and underground infrastructure, water flood management and distribution, riverbed, reclamation, agricultural fields, navigation, water drainage, water refill in natural ecosystem, flooding risk reduction	Agriculture, water management, phytoremediation, pool, water storage (artificial snow and agriculture), implementation wetland ecosystems, aquifers recharge, urban stormwater, flooding risk reduction
	Examples	
Traditional	Stonehenge, Agriculture, Wetland areas, percolation/infiltration trenches, Diversion systems on a large scale and use of floods (Nile, etc)	Saltworks, Pools, phytoremediation, , SUDS (Sustainable Urban Drainage Sysyems), infiltration/percolation/detention basins, Bioswales
Contemporay		Minghu Wetland Park, Liupanshui City, Guizhou Province (China) Turenscape; Parco Baronio Ravenna (Italy) Paisà and Land;
	Potential implication on hydro-geological mechanism[1]	
Opportunities	Water drainage, water storage, water regulation	Water drainage, water storage, water infiltration
Pressures	Soil loss, change in soil cover and texture, loss of ecological dinamism	Soil loss, change in soil cover and texture
	Impact on Soil properties and ESs provided by soil	
Soil Properties *3: high – 2: medium - 1: low – N: neutral*	3: Sand, silt, clay & coarse fragment - Soil porosity & air permeability - Hydraulic conductivity & infiltration - Soil structure & aggregation 1: Soil organic carbon - Bulk density - Soil Biota - Clay mineralogy	3: Soil organic carbon - Sand, silt, clay & coarse fragment - Soil porosity & air permeability - Hydraulic conductivity & infiltration - Soil Biota - Soil temperature 2: Cation exchange capacity - Electrical conductivity - Soil structure & aggregation - Clay mineralogy - Subsoil pans 1: Bulk density - Available water capacity
Ecosystem Services *D: direct – P: proxy – C: collateral – N: neutral*	D: Fresh water - Water retention / Water regulation / Erosion &Flood control / Recreation - Ecotourism C: Gene pool / Water purification / Climate & Gas regulation / Pest & Disease regulation / Pollination - Seed dispersal / Cultural Heritage / Nutrient cycling / Provisioning of habitat	D: Fresh water - Water retention / Water regulation / Erosion & Flood control / Climate & Gas Regulation / Carbon sequestration / Provisioning of habitat P: Gene pool / Pest & Disease regulation / Recreation - ecotourism / Aesthetic value - Sense of place / Knowledge - education - inspiration / Nutrient cycling C: Pollination - Seed dispersal / Cultural Heritage / Weathering - Soil formation

Tab. 14. Crossed information. source: author.

Digging is the intervention operated on soil that presupposes its removal, in order to create an hollow and/or a plane surface. It is a basic action operated in human settlements in order to shape the site so that it matches anthropic necessity to manage and control the environment and its resources, mainly water. The dimension and capacity of digging depends on the development of technologies. To this operation are associated two main design action: *channel* and *pond*, which are normally involved in water management practice such as caption, storage and infiltration (pond) and distribution (channel). This kind of operation is generally very helpful in soil management, in case of both water scarcity (dryness), and water excess (flooding) (Pietramellara & Arfaioli, 2014). The capability to operate this kind of soil-transformation allowed human to become sedentary in the Mediterranean area, enabling the origin of agricultural landscape and settled-society, especially in those areas with extreme weather condition, such as deserts, as very well reported by Pietro Laureano (2001, 2007, 2013) and Franco Panzini (2005).

Fig. 100. Cesarea Park, Ravenna (Italy). Construction site in a urban expansion area in Ravenna, where a green zone able to maintain the hydraulic invariance following the urbanization is built. Inside the park is created a 9-meters-deep lake that allows to keep a water surface while collecting rainwater and reloading the aquifers.

source: Vittoria Mencarini

Fig. 101. The Neolithic ditch of Murgia Timone, Matera (Italy). The thicker vegetation makes the ditch visible. On the right the double ring mausoleum of the Bronze Age is evident. Aerial photographs of the village of Murgia Timone reveal its perimeter, now covered with vegetation that grows thicker than in the surroundings thanks to the higher moisture content in the ditch, showing that on these limestone plateaux one of the purposes of digging trenches was to collect water.

source: The water Atlas, Laureano

shape Excavation Qarry Pit

Fig. 103. Extraction site in Marche Region (Italy). The excavation site involves top soil and vegetation removal. source: Google maps

1.2	Quarry	Pit
	Potential application	
Typology	Sand reserves, minimg (metal, stone, rare-earths elements), gravel cave	Undergroung facility, basement, bunker, cementery, storage, sewer, hypogean structure
	Examples	
Traditional	Mines, cave, urban settlement	Qanat, Pit courtyards and Pit Hypogeum, Pit cisterns, Pit houses
Contemporay	River Aire renaturation, Geneve (Switzerland) Atelier Descombes; Pialassa Piombone Ravenna (Italy) MED Ingegneria	LTH (Lund Institute of Technology) Campus Park, Lund (Sweden), Thorbjörn Andersson
	Potential implication on hydro-geological mechanism[2]	
Opportunities	Water storage	Water storage
Pressures	Soil loss	Soil loss
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: Depth to bed rock N: Soil organic carbon (II) / Bulk density (I) / Available water capacity (II)	3: Sand, silt, clay & coarse fragment / Hydraulic conductivity & infiltration / Soil temperature 2: Available water capacity / Soil porosity & air permeability 1: Depth to bedrock / Cation exchange capacity / Soil structure & aggregation N: Soil biota (I) / Clay minerealogy (I) / Subsoil pans (III)
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Food, fuel& fiber / Raw materials N: Gene pool (I) / Water regulation (II) / Climate & Gas regulation (III) / Carbon sequestration (II) / Pollination – Seed dispersal (III) / Esthetic - sense of place (III) / Knowledge / education / inspiration (I) / Cultural heritage (I) / Weathering – Soil formation (III) / Nutrient cycling (II) / Provisioning of habitat (III)	D: Fresh water - Water retention P: Water regulation C: / Erosion & Flood control N: Weathering – Soil formation (II) / Nutrient cycling (II) / Provisioning of habitat (III)

Tab. 15. Crossed information. source: author.

Excavation is a work in which soil is removed from one site generating an hollow and a void. In a *pit* the generation of an hollow is functional to other purpose for which an empty space is required. In a *quarry* site the bare and void cavity is generated as a consequence of stock and reserve soil is took away from one place to another in order to be reused.

In ancient time pit-courtyard could acts as an impluvium and provided an open-air sunny space, surrounded by walls, which could be used for agricultural work and food preparation. Some of these courtyards were used for waste collection and humus production, and to form gardens carved out of the rock. This technique solved the problem of soil infertility and the need to protect plants. Therefore, excavation praxis was multipurpose: it was used to drain water micro-infiltrations and capillary moisture from rock, making it salubrious for living or for grain storage; it was also used to provide material for the building of external terraced wall; finally, it was used to condense atmospheric moisture and collect water. Alack, excavation can represent a big issue in soil loss and degradation in contemporary uses and practices, related to the rapid increase of techniques far away from those metabolic processes that marked the traditional approach in soil health preservation.

Fig. 104. Val di Fassa (Italy) Controlled snow-making system and reservoir in case of snow lacking. The need to have artificial snow basins requires the excavation of large waterproofed areas with material repositioning on site. The levelling of slopes allows water to be conveyed into the excavated basin.

source: Google maps

Fig. 105. Matmata (Tunisia). Dwelling consisting of a pit courtyard dug out of clayey soil. The rooms overlooking the courtyard have underground connections with others of the same kind. A pit-courtyard acts as an impluvium and provides an open-air sunny space, surrounded by walls. Some of these courtyards are used for collecting waste and produce humus, and form gardens carved out of the rock. This technique solves the problem of soil infertility and the need to protect plants.

source: The water Atlas, Laureano

shape Adding Embankment Microtopography

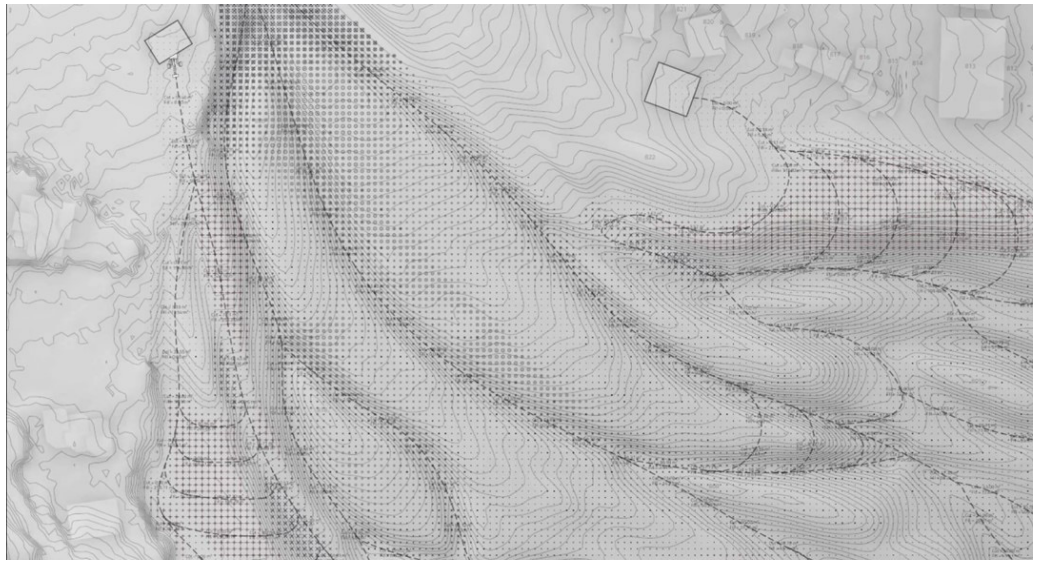


Fig. 106. Robotic landscape simulation in Bondo (Switzerland). The addition of larger rocks and boulders enables them to create various surface conditions that can respond and withstand the large forces of water and debris flows. source: Prof. Christophe Girot, ETH Chair of Landscape Architecture

1.3	Embankment	Microtopography
	Potential application	
Tipology	Soil stabilization, barrier, defense, infrastructure, water management and distribution, dune reconstruction, landfill, mound, rampart, levee, reclamation, Infrastructure ground, Landfill, Snow park, reinforced soil	Water management and regulation, biodiversity habitat, mound and sacred settlement, saline, garden, park, urbanization, Biodiversity habitat reconstruction, natural based solutions, green infrastructure
	Examples	
Traditional	Ha-ha wall, viking castle, Royal Mounds of Gamla Uppsala, Tumulo del Principe Etrusco, Royal garden (Versailles)	Saline, Rujm el-Hiri, Agriculture
Contemporay	Amsterdam's Schiphol Airport Park (Netherlands) Dirk Sijmons; Mota acustica, Abrera (Spain) Battle I Roig	River Aire renaturation, Geneve (Switzerland) Atelier Descombes; Pialassa Piombone Ravenna (Italy) MED Ingegneria
	Potential implication on hydro-geological mechanism[3]	
Opportunities	Water drainage, water storage, Erosion & flood control	Water drainage, humidity capture, water retention, CO2 capture, Soil biota
Pressures	Loss in soil formation mechanism	----
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: Sand, silt, clay & coarse fragment / Soil temperature 2: Soil porosity & air permeability / Hydraulic conductivity & infiltration / Soil Biota 1: Soil organic carbon / pH / Available water capacity / Soil structure & aggregation / Clay minerealogy	3: Soil organic carbon / Hydraulic conductivity & infiltration / Soil Biota 2: pH / Cation exchange capacity / Soil porosity & air permeability / Soil structure & aggregation / Soil temperature / Subsoil pans 1: Available water capacity / Electrical conductivity
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: / Fresh water - Water retention / Water regulation / Erosion & Flood control P: Gene pool / Pest & desease regulation / Recreation - ecotourism / Esthetic - sense of place / Cultural heritage C: Water purification / Polination - Seed dispersal / Knowledge - education – inspiration / Nutrient cycling / Provisioning of habitat N: Weathering – Soil formation (I)	D: Food - fuel&fiber / Gene pool / Fresh water - Water retention / Water regulation / Erosion & Flood control / Esthetic - sense of place / Provisioning of habitat M: Water purification / Pest & desease regulation / Pollination - Seed dispersal / Recreation - ecotourism / Knowledge - education – inspiration / Cultural heritage / Weathering - soil formation / Nutrient cycling C: Raw materials / Climate & Gas regulation / Carbon sequestration

Tab. 16. Crossed information. source: author.

Adding soil is an operation useful to shape an environment for human habitat. This action is normally used in order to reach the optimal level for a site. It is very common in reclamation works and urbanization processes, related to the need to prevent damage caused by flooding , obtained by raising the floor. At building sites, the costs of excavated earthen material transportation can be avoided, by replacing the soil in a site close to the building site in combination with *digging* and *excavation* practice.

Embankments are infrastructural works, related to *soil shaping* in a rigorous and performing configuration that incorporate inner reinforced structure that ensure the work stability.

Microtopography is a crucial *ground-modelling* process in reaching the appropriate gradients and slope to fulfil water management and soil handling. Embracing several level of project intervention, it is a fundamental operation in designing nature-based solutions, such as parks, gardens, green infrastructures and in re-naturalization of sites.

Fig. 107. Ravenna (Italy). Construction site of the right bank of the Bevanella canal by the Romagna Reclamation Con- sortium. The embankment increases protection from hydraulic risk, in an area where it is already high and also increasing due to climate change effects. In depressed areas it is necessary to regulate the water flow with surface works.

source: Vittoria Mencarini

Fig. 108. Ravenna (Italy). Dune setting re-naturalization in Lido di Classe in a protected area. Topographical conditions are created with the help of wooden piles so that the sand spontaneously settles along the damaged dune belt. The process is slow but follows the course of nature in the sand deposit that is shaped by wind and vegetation.

source: Vittoria Mencarini

shape Moulding Terraces
Slides and smooths

Fig. 109. Vall d'en Joan landfill restoration, Garraff, (Spain) The restoration project defines a pattern of topographic configuration with terraces, side slopes, drainage system, pathways and plantation by phases. source: Google maps

1.4	Terraces	Slide & Smooth
	Potential application	
Tipology	Soil stabilization, soil fertility, agriculture, infrastructure, water management, landfill	Water management and regulation, biodiversity habitat, snowparks
	Examples	
Traditional	Terracing system (e.g. Hababa, Petra, Matera)	Squares (e.g. Piazza del Campo in Siena),
Contemporay	Garraf Landfill restoration, Catalunya (Spain) Battle I Roig; King Hussein Memorial Competition Amman	Avalanche protection barrier & Saxhóll Crater Stairway (Iceland) Landslag, Tejo and Trancão park, Lisbon (Portugal) PROAP
	Potential implication on hydro-geological mechanism[4]	
Opportunities	Soil stability, soil fertility, Water drainage, hydrogenesis	Water drainage, soil stability
Pressures	---	Soil compaction
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: Soil organic carbon / Available water capacity / Soil porosity & air permeability / Hydraulic conductivity & infiltration / Soil structure & aggregation / Soil temperature 2: pH / Cation exchange capacity / Soil Biota / Subsoil pans 1: Sand, silt, clay & coarse fragment / Clay minerealogy	1: Soil temperature
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Food - fuel&fiber / Water regulation / Erosion & Flood control / Recreation - ecotourism / Esthetic - sense of place / Knowledge - education – inspiration / Cultural heritage / Nutrient cycling P: / Fresh water - Water retention / Water purification / Climate & Gas regulation / Carbon sequestration / Pest & desease regulation / Pollination - Seed dispersal / Weathering - soil formation C: Raw materials / Gene pool Water purification / Provisioning of habitat	D: Water regulation / Erosion & Flood control P: Recreation - ecotourism / Knowledge - education – inspiration / Cultural heritage / Weathering - soil formation / Nutrient cycling N: Nutrient cycling (I), Provisioning of habitat (I)

Tab. 17. Crossed information. source: author.

Moulding soil presuppose setting-up a new topographic profile, arranging *terracing, sliding and smooths*. This practice has been used since ancient times for settle and make-up productive places with high altitude development, after a process of total or partial deforestation, or in context with extreme climate conditions and lack of water. This operation actually changed the site's morphological peculiarity, preserving a certain respect of the original context. The main consequence in terms of shape is the watershed shifting, which in turn implies the simultaneous implementation of other actions - such as *channelization* and *embankment*, - in order to generate a performative topographic field in water management and erosion control.
These practices are normally combined with reinforced wall construction and the shaped profile is highly performing for keeping safe the geostatic attitude. In traditional practices these procedures allowed a control of the hydrogeological system also maintaining a high quality of soil. In fact agricultural practice on terraces - spread worldwide - allowed to keep soil fertility and the hydrogenesis phenomenon (Laureano, 2013).

Fig. 110. Matera (Italy). Massive dry stone walls protect from the effects of the rainfalls and create the space for cultivations organised on artificial terraces along the slopes of the Palomba of Matera. Matera boasts the Sassi, a primeval ancient site where the Neolithic ditches and the agro-pastoral terracing system attest to the ways of inhabiting the caves and mana- ging the soils.

source: The water Atlas, Laureano

Fig. 111. Andalo (Italy). The development of ski facilities has completely re-designed the morphology of the mountain sides to make these areas accessible to tourists. This involved in addition to massive deforestation, the reshaping of slopes using reinforced soil walls and slope reinforcement.

source: Vittoria Mencarini

cover Water Permanent Temporary

Fig. 112. Meduna Stream, Pordenone (Italy) In this stretch of the river you can see how territorial patterns are linked to the presence of water in a permanent and occasional (agricultural fields, meanders, flooding areas). source: Google maps

2.1	Permanent	Occasionly
	Potential application	
Tipology	Peatland and wetland, lake, river, basin and channel, cave renaturation, dikes, phytodepuration basin	Irrigation, flooding areas, artificial snow, river banks, rain garden, SUDs, lamination basin
	Examples	
Traditional	Oasis , Alluvial fan, river, Diversion of rivers,	Alluvial fan, Water intakes and creation of gardens on the sides of the riverbed, flooding river areas (e.g Nile & Euphrate valley)
Contemporay	Living Breakwaters, Staten Island, NY, SCAPE; River Aire Geneve Ch Atelier Descombes; Tianjin Qiaoyuan Wetland Park, Tianjin (China) Turenscape	Yanweizhou Park Jinhua and Puyangjiang River Corridor (China) Turenscape; Bishan Park, Singapore, Ramboll Studio Dreiseitl; Corktown Common, Toronto, Canada, Michael Van Valkenburgh Associates
	Potential implication on hydro-geological mechanism[7]	
Opportunities	Water storage, environmental preservation,	Contrasting saline wedge, fertility, organic process
Pressures	Anoxia and roots asphixia, ecosystem shifting, soil productivity loss	Anoxia, soil composition alteration
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: Soil organic carbon / pH / Electrical condictivity / Soil porosity & air permeability / Soil temperarure 2: Subsoil pans 1: Sand, silt, clay & coarse fragment /Available water capacity / Cation exchange capacity / Hydraulic conductivity & infiltration / Soil biota / Soil structure & aggregation / Clay minerealogy	3: Soil organic carbon / pH / Bulk density / Cation exchange capacity / Electrical condictivity / Hydraulic conductivity & infiltration / Soil biota / Soil structure & aggregation / Subsoil pans 2: Sand, silt, clay & coarse fragment /Available water capacity / Available water capacity / Soil porosity & air permeability / Soil temperature 1: Clay mineralogy
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Gene pool / Fresh water - Water retention / Water regulation / Weathering - soil formation / Provisioning of habitat P: Erosion & Flood control / Climate & Gas regulation / Pest & desease regulation / Pollination - Seed dispersal / Recreation - ecotourism / Esthetic - sense of place / Knowledge - education – inspiration / Cultural heritage C: Water purification / Carbon sequestration /Nutrient cycling	D: Gene pool / Fresh water - Water retention / Water regulation / Water purification / Erosion & Flood control / Pest & desease regulation / Pollination - Seed dispersal / Recreation - ecotourism / Weathering - soil formation / Nutrient cycling / Provisioning of habitat P: Food - fuel&fiber / Raw materials / Climate & Gas regulation / Carbon sequestration / Esthetic - sense of place / Knowledge - education – inspiration / Cultural heritage

Tab. 18. Crossed information. source: author.

The presence of *water* has a deep impact on soil. In fact water strongly regulate ecosystems preservation in terms of phytocenosis and biotic communities maintenance. Furthermore, water is a fundamental element in the *carbon cycle* and in the spontaneous processes of organic matter decomposition. Thus it plays a crucial role in *soil organic carbon (SOC)* content, a basic marker in soil health determination. The lack of water inhibits vegetation and, indirectly, soil cohesion, related to the capacity of organic matter to keep soil particles bound together. The dry soil, no longer protected by vegetation and incoherent, disintegrates and feeds the sandstorms (Laureano, 2001) trigging desertification and erosion phenomena.
The *permanent water* coverage of soil (such as in wetlands and in peatlands) inhibits oxygen exchange between soil and atmosphere, leading to the genesis of *H horizon* with organic carbon top level. The *temporary* presence is fundamental in ecological features maintenance and biodiversity balancing.

Fig. 113. Ridracoli Lake (Italy). The dam of Ridracoli is a large hydraulic work. It forms a basin with a capacity of 30 million cubic meters of water. The creation of the basin in a previously wooded area changed the vegetation cover, now absent in the water collection areas creating an extremely artificial scenario in a natural context.

source: Vittoria Mencarini

Fig. 114. Sebkha of Timimoun (Algerian Sahara). The natural dynamics of the sebkha are used by desert people who are able to create the oases and the soil by intercepting the smallest quantities of water, thus reversing the desertification.

source: The water Atlas, Laureano

cover Vegetation Grass / Bushes and trees

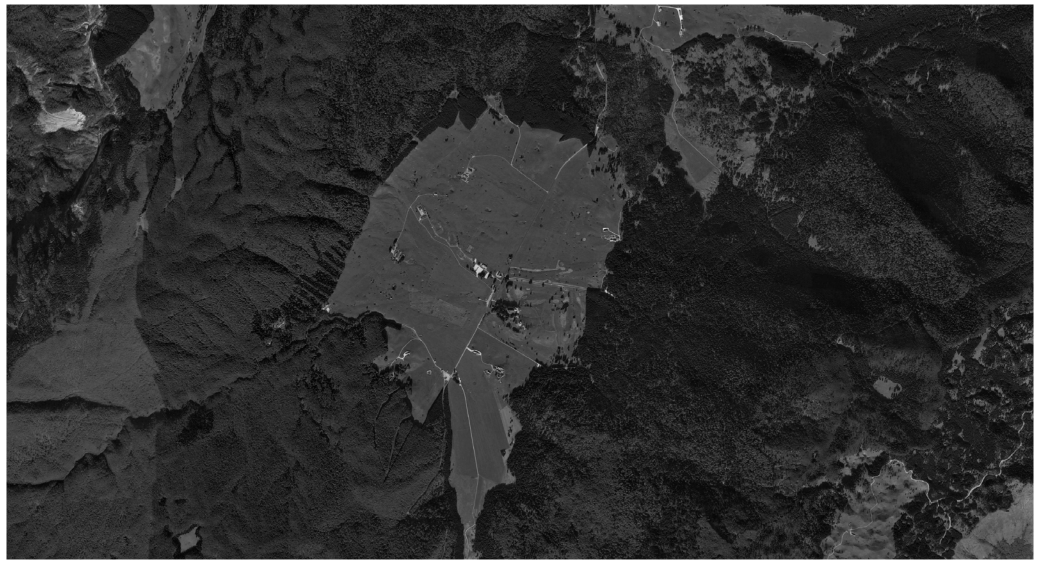


Fig. 115. Pasture in Piancansiglio, Alpine region (Italy). Deforestation to create pasture space has been widespread for centuries throughout the Mediterranean basin. These practices have generated patterns that have entered the common imagination of a pastoral landscape, the result of well-defined anthropogenic practices. source: Google maps

2.2	Grass	Bushes & Trees
	Potential application	
Tipology	Peatland, pasture, parks and green public spaces, garden	Reforestation, Compensation & mitigation works, Renaturation, parks 6 green public spaces, garden
	Examples	
Traditional	Ha-ha wall, viking castle Trelleborg, cistern-well in the Great Dahlac, Royal Garden, Rinasence garden, Exploitation of open areas in the forests for farming	Oasis, Bastions, Forestation (coastal Pinewood); Walled garden
Contemporay	Jardin du tiers Paysage, Saint Nazarè (France) Gilles Clement & Coloco & The garden in motion Parc Citroen, Paris;	The Metro Forest, Bangkok, (Thailand) LAB Landscape Architects; Forested infiltration area, Bosco limite, Veneto (Italy) Etifor;
	Potential implication on hydro-geological mechanism[10]	
Opportunities	Water drainage; biodiversity	Maintaining soil stability, CO2 storage, regulation and purification of the water cycle, fertility, Soil formation, protection and quality, biodiversity
Pressures	Soil desertification and pollution (artificial medow); soil erosion; soil acidification (intensive pasture)	Soil desertification (e.g. Pine, eucaliptus); soil erosion (forestry non conservative)
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: pH / Soil temperature 2: Soil organic carbon / Sand, silt, clay & coarse fragment / Hydraulic conductivity & infiltration / Soil biota / Subsoil pans 1: Available water capacity / Cation exchange capacity / Soil porosity & Air permeability / Soil structure & aggregation / Clay minerealogy	3: Soil organic carbon / pH / Available water capacity / Cation exchange capacity / Hydraulic conductivity & infiltration / Soil biota / Soil structure & aggregation / Soil temperature / Subsoil pans 2: Sand, silt, clay & coarse fragment / Depth to the bed rock / Soil porosity & Air permeability / 1: Electrical condictivity / Clay mineralogy
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Gene pool / Pest & desease regulation / Pollination - Seed dispersal P: Raw materials / Water regulation / Water purification / Climate & Gas regulation / Provisioning of habitat C: Food - fuel&fiber / Fresh water - Water retention / Erosion & Flood control / Carbon sequestration / Recreation - ecotourism / Esthetic - sense of place / Knowledge - education – inspiration / Cultural heritage / Weathering - soil formation / Nutrient cycling	D: Gene pool / Water purification / Erosion & Flood control / Climate & Gas regulation / Carbon sequestration / Pest & desease regulation / Pollination - Seed dispersal / Esthetic - sense of place / Knowledge - education – inspiration / Weathering - soil formation / Provisioning of habitat P: Food - fuel&fiber / Raw materials / Recreation – ecotourism / Esthetic - sense of place / Nutrient cycling

Tab. 19. Crossed information. source: author.

Soil diversity plays a fundamental role in determining vegetation patterns (Farina, 2005). The vegetated coverage of soil is one of the pedogenesis factors, very important also in terms of soil protection and soil health.
Vegetation change will also affect the organic matter input to the topsoil and thus its stability or erodibility (Finke, 2016). The presence of vegetation is extremely dynamic and susceptible to natural and anthropic perturbations.
Soil quality has a close relationship with wooded areas covered by *bushes* and *trees*. Woods have a symbiotic link with the soil and they mutually regulate important ecosystem processes supporting local and anthropic habitats. Soil quality has a close relationship with forestry-related operations, such as site preparation, species selection and maintenance type. The forests management should include practices that also involve the regulation of hydrogeological phenomena, with the aim of maintaining *soil stability, CO2 storage, water cycle regulation* and *water purification, soil fertility. Grassland* can be either a natural ecosystem, such as prairie, or an artificial one, originated by process of deforestation for obtaining place for pasture and grazing. We can also have herbaceous coverage in urbanized areas, such as parks and gardens. The maintenance of this condition can have a big impact in terms of soil quality and water resource use for irrigation, related to local climate conditions.

Fig. 116. Monte Fumaiolo (Italy). Ridge with single-species reforestation, which was partly felled by gusts of wind. Areas not protected by arboreal vegetation are subject to soil erosion and runoff. These areas are spontaneously repopulated by the herbaceous vegetation that is distributed according to the morphology, the presence of water and humidity and the soil texture.

source: Vittoria Mencarini

Fig. 117. Brazil, the remains of the Atlantic Mata, the original rainforest on the coast almost disappeared.The clearance of the plant cover leaves the soil without humus and exposes it to the agents of dissolution and unable to recover.

source: The water Atlas, Laureano

cover Agriculture Intensive Conservative

Fig. 118. Nevallan (Australia). Nevallan in summer, you can see the wetter areas well thanks to the "keyline". If you look closely you will notice that the wettest point is not necessarily the valley. source: www.permacultu-raincorso.it Keyline design is a landscaping technique of maximizing the beneficial use of the water resources of a tract of land. The "keyline" denominates a specific topographic feature related to the natural flow of water on the tract. Keyline design is a system of principles and techniques of developing rural and urban landscapes to optimize use of their water resources.

2.3	Intensive	Conservative
	Potential application	
Tipology	Conventional agricultural praxis, extensive agriculture	Keyline, permaculture, organic agruculture
	Examples	
Traditional	Diversion systems on alarge scale and use of floods	Terraces, Oasis model, Hedomite and Nabatean Hydroagriculture, Integrated use of marginal areas (marshlands, karstification and forests), Terracing systems
Contemporay		Navallan farm (Australia) Keyline project, Yeomans; Bosco limite Forested Infiltration Area, Veneto (Italy) Etifor
	Potential implication on hydro-geological mechanism[13]	
Opportunities	Water drainage and infiltration	Maintaining soil stability, CO2 storage, regulation and purification of the water cycle, fertility, soil formation
Pressures	Soil erosion and degradation, pollution, acidification, loss of fertility, loss of organic matter	---
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	2: Hydraulic conductivity & infiltration / Soil structure & aggregation N: Soil organic carbon (II) / Sand, silt, clay & coarse fragment (II) / pH (II) / Available water capacity (I) / Soil temperature (III) / Subsoil pans (I)	3: Soil organic carbon / pH / Cation exchange capacity / Hydraulic conductivity & infiltration / Soil biota / Soil structure & aggregation / Subsoil pans 2: Available water capacity / Soil porosity & Air permeability / Soil structure & aggregation / Soil temperature / 1: Sand, silt, clay & coarse fragment / Clay minerealogy
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Food - fuel&fiber / C: Raw materials / Gene pool / Water regulation N: Fresh water - Water retention (I) / Water purification (III) / Erosion & Flood control (I) / Climate & Gas regulation (II) / Carbon sequestration (II) / Pest & desease regulation (I) / Pollination - Seed dispersal (II) / Esthetic - sense of place (I) / Cultural heritage (I) / Weathering - soil formation (I) / Nutrient cycling (I) / Provisioning of habitat (I)	D: Raw materials / Water regulation / Water purification / Erosion & Flood control / Knowledge - education – inspiration / Cultural heritage / Nutrient cycling P: Food - fuel&fiber / Gene pool / Fresh water - Water retention / Pollination - Seed dispersal / Recreation - ecotourism / Esthetic - sense of place / Weathering - soil formation / Provisioning of habitat C: Water purification / / Climate & Gas regulation / Carbon sequestration / Pest & desease regulation

Tab. 20. Crossed information. source: author.

Agriculture is a human activity which consists in the cultivation of plant species, and which is related to a continuous manipulation of *topsoil*. The main purpose of agriculture is to obtain products from plants to be used mainly for food, textile industry, energy production. Agriculture is an ancient practice that started the process of becoming sedentary of human civilization (Panzini, 2005) (Laureano, 2001). The early forms of agriculture were practised on soils which where naturally irrigated (Laureano, 2001) . The history and evolution of agricultural practices went step by step with human technological development and the cultivation knowledge evolution. The sites occupied for agricultural practice are obtained through deforestation, fire , reclamation, shaping of mountain reliefs. This is enabled by morphological and ecological changes with respect to the original features of a territory, combined with a widespread infrastructural network for water resources management, made up of canals, dams, wells for water extraction from aquifers .

Intensive praxis aims to maximise the production, without caring about the impact that the practice can exert on soil and environment. The consequences of this approach can be manifested through the following phenomena: water erosion; soil fertility loss; soil salinization; humus destruction; plant cover disappearance; depletion of aquifers and drought; slopes failure and landslides (Laureano, 2001). *Conservative* agriculture concerns the preservation of ecosystem integrity and soil fertility, through devices and practices that take care of the context of intervention, such as tillage reduction, topsoil protection and crop rotation.

Fig. 119. Isla Cristina (Spain). Agricultural practices in Mediterranean countries have often led to intensive land use and soil overexploitation. The arid soils impoverished due to the continuous ploughing by mechanical equipment. The lack of forest vegetation makes the contrast between geomorphological components and traces of agricultural processing extremely evident.

source: Google maps

Fig. 120. Yemen. Ploughing the soil enables the field to absorb the humidity from the atmosphere. Traditional and local knowledge does not suggest miraculous solutions, which would mean to follow the modernity logic, but puts forward a method that can be also reproposed with modern technologies.

source: The water Atlas, Laureano

cover Impervious Urbanization Infrastructure

Fig. 121. Barcelona (Spain). The metropolitan area of Barcelona touching the present reliefs and it interrupts the urbanization in which it is found the difference between permeabilized surfaces from those trees. source: Google maps

2.4	Urbanization	Infrastructure
	Potential application	
Tipology	Urban settlement	Landfill and contaminated sites, storage water basin, mobility infrastructures
	Examples	
Traditional	Plastered floors for water storage and also keep away humidity (e.g. Beida vestige, cisterns of Aden, cistern in the Sasso Barisano of Matera), Urban settlement	Saline, Ditch, Water basin storage, sewer
Contemporay	Plaza de les Glories Catalanes, Barcelona (Spain), Agence Ter; Cesarea new Urban settlement, Ravenna (Italy) Paisà Cino Zucchi	Garraf Landfill, Catalunya (Spain) Bttle I Roig
	Potential implication on hydro-geological mechanism[16]	
Opportunities	Flooding management	Soil insulation in contaminated sites, protecting erosion and flooding
Pressures	Soil loss and degradation, failure in infiltration	Soil loss, failure to provide debris and sediment, failure in infiltration
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	N: Soil organic carbon (II) / pH (II) / Available water capacity (III) / Cation exchange capacity (III) / Soil porosity & Air permeability / Hydraulic conductivity & infiltration (III) / Soil biota (II) / Soil structure & aggregation (III) / Soil temperature (III) / Clay mineralogy (II) / Subsoil pans (II)	N: Soil organic carbon (II) / Sand, silt, clay & coarse fragment (III) / pH (II) / / Hydraulic conductivity & infiltration (III) / Soil biota (II) / Soil temperature (III)
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Fresh water – Water retention C: Water regulation / Erosion & Flood control N: Raw materials (I) / Gene pool (II) / Water purification (III) / Climate & Gas regulation (II) / Carbon sequestration (III) / Pest & desease regulation (I) / Pollination - Seed dispersal (II) / Weathering - soil formation (III) / Nutrient cycling (II) / Provisioning of habitat (II)	D: Water regulation / Erosion & Flood control P: Fresh water - Water retention N: Gene pool (II) / Water purification (I) / Recreation – ecotourism (I) / Esthetic - sense of place (I) / Knowledge - education – inspiration (I) / Cultural heritage (I) / Weathering - soil formation (I) / Nutrient cycling (I) / Provisioning of habitat (I)

Tab. 21. Crossed information. source: author.

Soil sealing is the waterproofing coverage of the soil surface with impervious materials, through the transformation of land in a natural or semi-natural state into land in an artificial state, ready to be *urbanized* and *infrastructured*. Depending on the permeability degree, soil sealing reduces or most likely completely prevents natural soil functions and ecosystem services on the concerned area. It deeply affects the natural watershed and the water management. In terms of *urbanization*, here we refer to *sealed* surface. Anyway, urbanized soils, even if not sealed, present criticalities in terms of ecosystem services, because they are detached from natural, dynamic processes that normally regulate soil function. For example these soils present lack of organic matter and can present critical issues in terms of contamination. Bringing this concept to extremes, we can say that the urban areas contribute both directly and indirectly to the desertification process. Directly, because the massive urbanization itself may be considered as a form of desertification due to the spread of concrete over large natural surfaces; indirectly, through the exploitation of the soil natural resources and their destruction in the areas with a high demographic concentration (Laureano, 2001).

Fig. 122. Ravenna (Italy). Landfill in wooded area. In a urban landfill waste is stored and isolated from the ground through soil sealing works. At these sites the soil is impermeable even if the landfill is coated with earth and plant material in order not to disperse polluting materials in the soil. Anyway they are considered effective land take.

source: Vittoria Mencarini

Fig. 123. Lalibela (Ethiopia). Deep ditches surround the underground monumental complexes of Lalibela. Their water drainage and harvesting function is proved by the reservoirs for conserving the precious liquid in the dry seasons. Urbanization progresses according to this hydro-agricultural pattern by saturating the sloping terraces with constructions or turning the fields in the valleys irrigated by stream-roads into squares surrounded by buildings.

source: The water Atlas, Laureano

composition Structure Size & Texture Water & Organic matter

Fig. 124. Plan de Corones (Italy). Snow-covered slopes with controlled snow during the summer season, in which is evident how the use of artificial snow changes the structure of topsoil. source: Google maps

3.1	Size & Texture	Water & Organic matter
	Potential application	
Tipology	Drainage trench, urban settlement, land reclamation, topsoil	Topsoil, wooded areas, conservative agriculture, wetland and peatland, terracing system
	Examples	
Traditional	Reclamation (e.g. Marib Dam, Pianura padana polderization), Oasis model	Pit-courtyard hummus preparation, terracing systems (e.g. Murgia Timone, Maya & Inca's terracing agriculture), Compost made out of droppings, ash and plants (e.g. oasis); Integrated cycle of organic wastes
Contemporay	Agriculture, urbanization	Territorial green & blue infrastructures, conservative agriculture, pasture
	Potential implication on hydro-geological mechanism[18]	
Opportunities	Water drainage and infiltration, water storage, ecosystem support	CO2 storage, regulation and purification of the water cycle, fertility, Soil formation, protection and quality, water retention
Pressures	Loss of soil formation mechanism	PH alteration, acidification
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: Sand, silt, clay & coarse fragment / pH / Available water capacity / Cation exchange capacity / Electrical conductivity / Soil porosity & Air permeability / Hydraulic conductivity & infiltration / Soil structure & aggregation 2: Soil organic carbon / Soil biota / Clay minerealogy 1: Soil temperature	3: Soil organic carbon / pH / Available water capacity / Cation exchange capacity / Hydraulic conductivity & infiltration / Soil biota 2: Electrical conductivity / Soil porosity & Air permeability 1: Soil structure & Aggregation / Soil temperature
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Gene pool / Fresh water - Water retention / Water regulation / Erosion & Flood control / Nutrient cycling / Provisioning of habitat P: Raw materials / Wathering – soil formation C: Water purification / Climate & Gas regulation /	D: Gene pool / Fresh water - Water retention / Water regulation / Water purification / Weathering - soil formation / Nutrient cycling / Provisioning of habitat P: Raw materials / Climate & Gas regulation / Carbon sequestration C: Erosion & Flood control / Weathering - soil formation / Nutrient cycling / Provisioning of habitat

Tab. 22. Crossed information. source: author.

The basic components of soil are *minerals, organic matter, water* and *air*. The percentage and the presence of these components condition the *structure of soil* and the possible usage, in a mutual relationship.
The relationship between the soil components, in terms of soil texture, is the basis for the development of soil structure, that sets out the level of soil *inner porosity*. Soil structure influences both exchange flows of substances (such as water and gases) through the terrain, and the capability to store and spread them in the subsurface stratum (Pietramellara & Arfaioli, 2014). *Organic matter* allows to aggregate mineral components and to keep water in soil, thus supporting soil fertility. *Texture* is one of the most important soil characteristics since it strongly affects many soil functions and mechanical properties, such as water and nutrient retention, water and gases infiltration, drainage, aeration, SOC content, pH buffering and soil porosity (Hartemink & Minasny, 2014) . These parameters are quite sensitive to external disturbance, such as land use and environmental changes, that constantly affects the composition of soil. In highly anthropized contexts - such as urbanized and intensive agriculture sites - the percentage of organic matter is very low and the level of additional components, such as pollutants and soil conditioners is very high. The presence of some minerals such as NaCL over a certain threshold can become critical in terms of soil degradation, because they lead to acidification, salinization, pollution. It is also important to know these minerals combined effects.

Fig. 125. Ravenna (Italy). Cultivation of sun- flowers on ancient paleodoxes sandy soil. In areas formerly crossed by the sea the agronomic conditions are not naturally of high quality. Sand is in fact an inert soil poor in organic matter and is maintained productive with large mechanical processing, high quantity of water and addiction of synthetic conditioners.

source: Vittoria Mencarini

Fig. 126. Apulia (Italy). The dry stone walls and the "specchie" of the Apulian countryside constitute a titanic landscape-organizing work, useful for catching moisture and maintaining the hydromorphic capacity of soil.

source: The water Atlas, Laureano

composition Improver Biological / Mineral

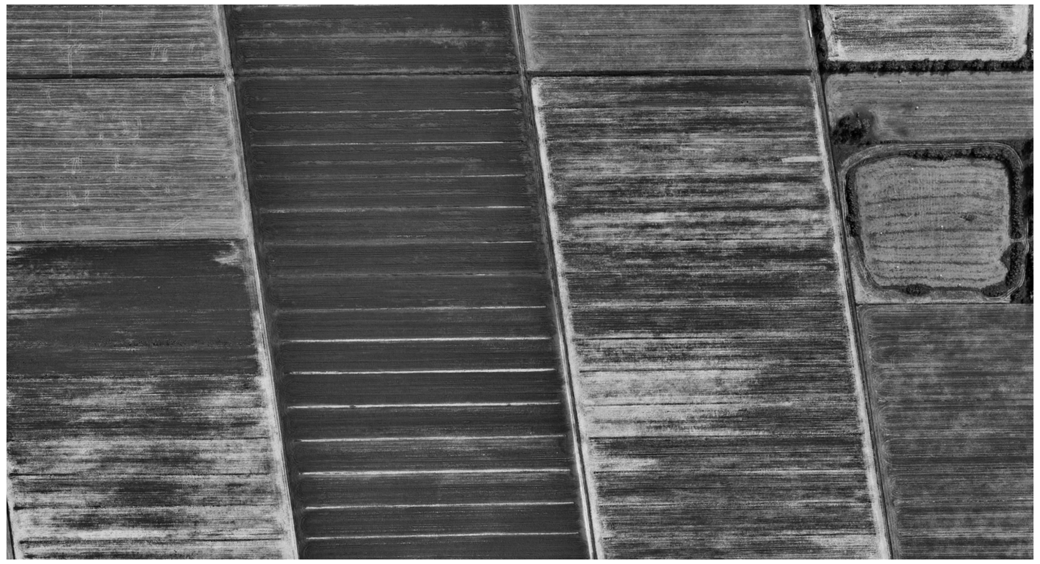


Fig. 127. Ravenna (Italy). Fields intensively cultivated, subject to the ascent of the saline wedge. These lands are located in reclaimed areas, originally occupied by the sea and valley areas. source: Google maps

3.2	Biological	Mineral
	Potential application	
Tipology	Biochar, bone meal, blood meal, coffee grounds, compost, compost tea, coir, manure, straw, peat, sphagnum moss, vermiculite, sulfur, lime, hydroabsorbant polymers and biosolids	Fertilizer (non organic materials) typically provide in varying proportions: Nitrogen (N),Phosphorus (P), Potassium (K) (main macronutrients); calcium (Ca), magnesium (Mg), and sulfur (S) (secondary macronutrients)
	Examples	
Traditional	humus created by irrigation, urban excrement and cultivated fields Devices for the creation of humus (e.g. grabiglioni, oasis) The use of wood ash as a field treatment became widespread; guano in South America and Africa	Egyptians, Romans, Babylonians, and early Germans all are recorded as using minerals and/or manure to enhance the productivity of their farms. But the wide spread use of fertilizer started in the beginning of XXIX century in intensive agricultural field in Europe and USA
Contemporay	Permaculture, conservative agriculture	Intensive agriculture, gardening, disinfection on urban scale
	Potential implication on hydro-geological mechanism[20]	
Opportunities	CO2 storage, fertility preservation, soil formation	Fertility, soil reclamation
Pressures	Water and soil euthrofization	Soil loss and degradation, acidification, pollution
	Potential Impacts on soil	
Soil Properties *3: high –* *2: medium -* *1: low -* *N: neutral*	3: Soil organic carbon / pH / Soil biota 2: Soil structure & aggregation	3: pH / Cation exchange capacity N: Soil organic carbon (I) / Soil biota (I)
Ecosystem Services *D: direct –* *P: proxy –* *C: collateral -* *N: neutral*	D: Gene pool / Fresh water - Water retention / Climate & gas regulation / Pollination - Seed dispersal / Esthetic - sense of place / Knowledge - education – inspiration / Nutrient cycling P: Food, fuel & fiber / Water regulation / Water purification / Carbon sequestration / Pest & desease regulation / Recreation - ecotourism / Cultural heritage / Provisioning of habitat C: Raw materials / Weathering - soil formation	D: Food, fuel & fiber C: Raw materials N: Gene pool (III) / Water purification (III) / Climate & gas regulation (III) / Pest & desease regulation (I) / Pollination - Seed dispersal (I) / Nutrien cycling (III) / Provisioning of habitat (III)

Tab. 23. Crossed information. source: author.

Soil improvers (or *conditioners*) are substrates and/or products which are added to soil to improve the soil's physical qualities, usually its fertility (ability to provide nutrition for plants) and sometimes its structure. In common usage, the term *soil conditioner* is often thought of as a subset of the category *soil amendments,* which is more often used to include a wide range of fertilizers and non-organic materials, of both *biological* and *mineral* origin. Soil conditioners can be used to improve poor soils, or to rebuild soils which have been damaged by improper soil management and they may be applied in a number of ways. Some are worked into the soil with a tiller before planting. Others are applied after planting, or periodically during the growing season. Soil testing should be performed prior to applying a soil conditioner to learn more about the composition and structure of the soil. Adding a soil conditioner to crops or a garden can be thought of as a great way to get healthier plants, but over-application of some amendments can cause ecological problems, leading to eutrophication phenomena. For example, salts, nitrogen, metals and other nutrients that are present in many soil amendments are not productive when added in excess, and can actually be detrimental to soil and plant health. Runoff of excess nutrients into waterways also occurs, causing harm to water and environmental quality.

Fig. 128. Argenta (Italy). Cultivated field on the sediments of an ancient wetland. In order to maintain this type of land use and the intensive exploitation of these fields, it is necessary to use soil improvers. The nutrients end up in the draining network, creating problems of water eutrophication in surface water and groundwater.

source: Vittoria Mencarini

Fig. 129. Shibam (Yemen). Drainage and soil preparation for humus creation.

*source: Laureano, Agricoltura e uso razionale dell'acqua**

3.3 Comparative case studies: soil as underlying materials in landscape design praxis

In the following sub-chapter, an illustrative survey is put in place, through the examination of factual case-studies that represent significant examples of contemporary landscape design projects. This steps aims at understanding how soil shifting plays a crucial role in the making of landscape dealing with environmental functions improvement in highly anthropized contexts.

They will be outlined through a designated comparative matrix that aims at specifying the design operations listed in the *Taxonomy of design actions* (Ch 3.2), in connection with territorial *risk management* and *Ecosystem Services* provided by soil - within the definition given by Adhikari & Hartemink (2016) introduced in Ch 1.5.3.

The matrix implementation can be assested on more case studies in order to develop a wider and more comprehensive relationship with other case studies.

PARADIGMATIC CASE STUDIES

MOUNTAIN	*The elegance of topology* - SWITZERLAND Designign a dynamic alpine landscape in Bondo
HILLS	*Waste architecture* - SPAIN Vall D'en Joan Landfill Riqualification
WETLAND	*Constructed wetland* - ITALY Piallassa's renaturation
RIVER	*Space divagation* - SWITZERLAND Renaturation of River Aire
AGRICULTURE	*Forested Infiltration Area* - ITALY Bosco Limite

COMPARATIVE MATRIX ILLUSTRATION

SECTION BEFORE / AFTER INTERVEN-

LAND

ECOSYSTEM SERVICES provided by soil

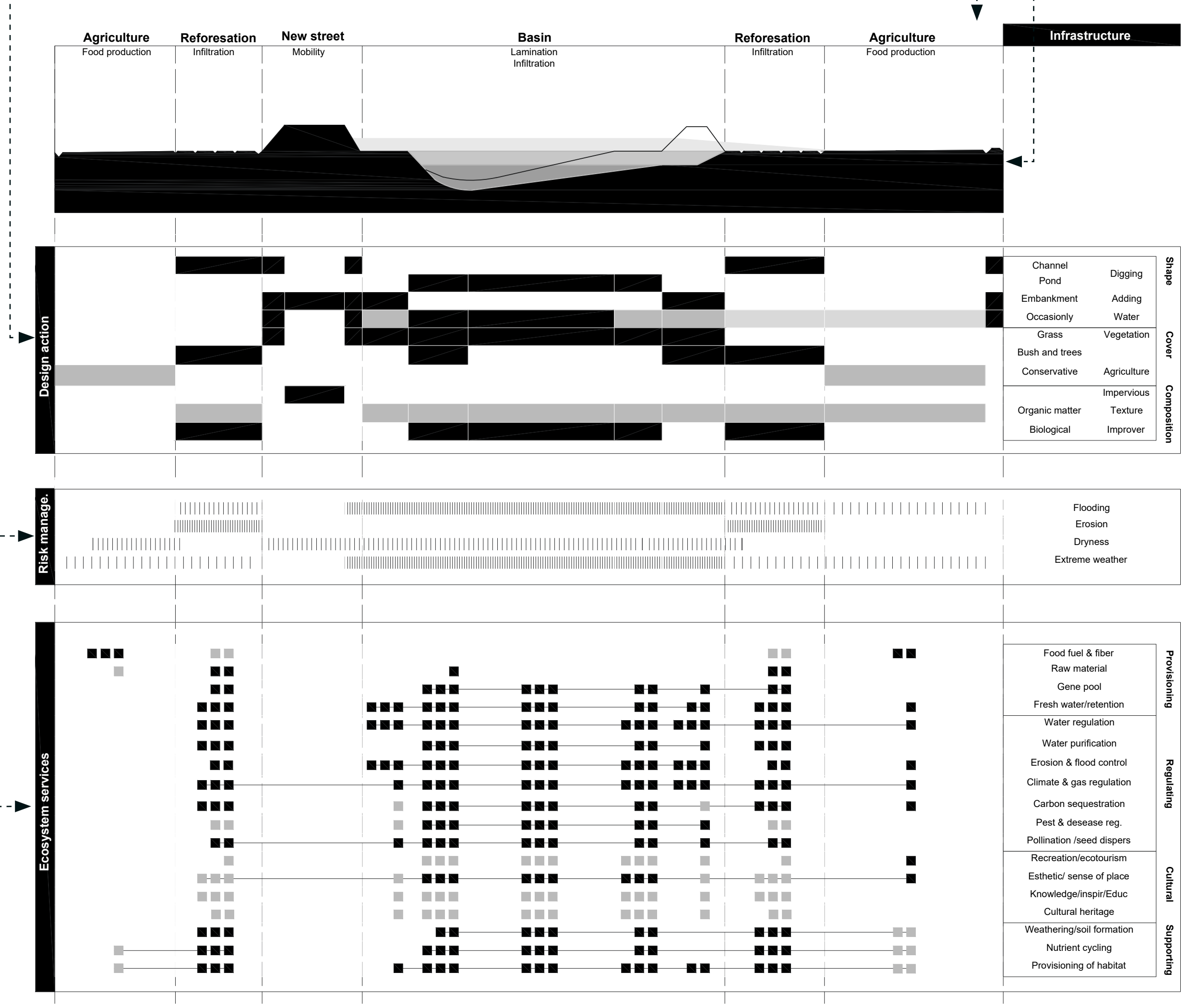
■ *direct* □□□ *high* □ *low*
■ *collateral* □□ *medium*

RISK MANAGEMENT

high *medium* *low*

TAXONOMY OF DESIGN shape / cover / composition

■ *direct* ■ *proxy* ■ *collateral*



Tab. 24. Comparative matrix illustration. source: author

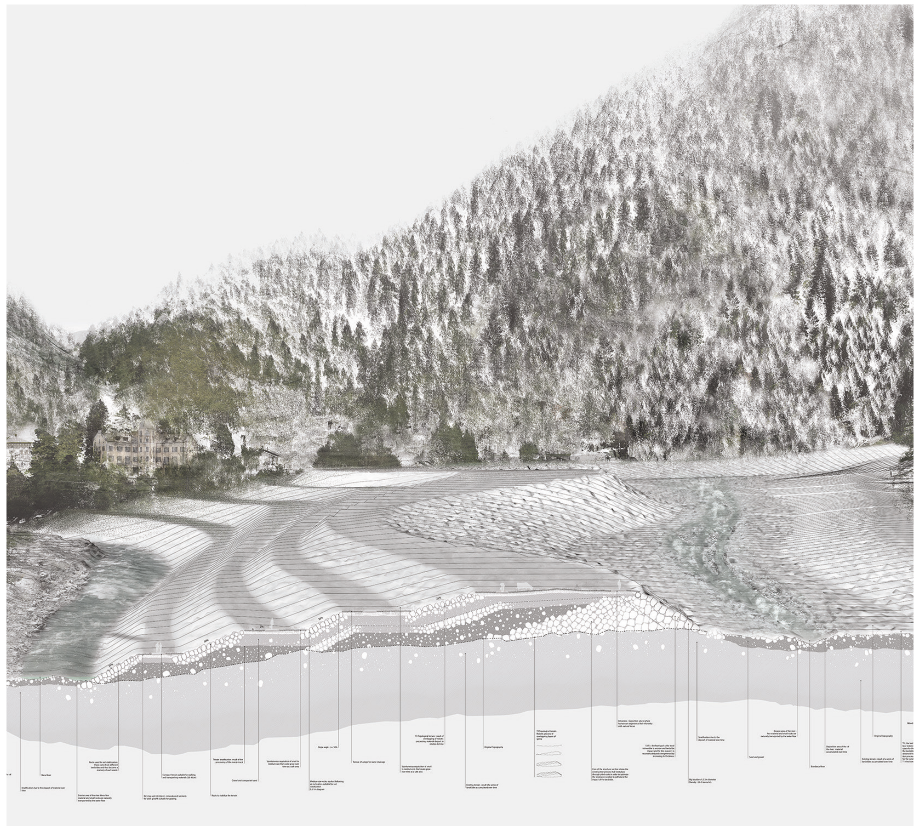
The elegance of topology
Designing a Dynamic Alpine Landscape in Bondo

The *HS 2018 Robotic Landscapes II studio*, held by Christophe Girot and Fabio Gramazio at ETH, investigates the potential of on-site robotic construction and grading methods in landscape architecture. Large-scale topographic modelling through the robotic manipulation of soil and rocks will be creatively investigated to produce a resilient landscape project at the landslide site of Bondo in the Grisons, Switzerland.

During the Design Studio every group studied the three strategic design phases (2015 – 2019 – future) in order to respond to the many debris flows arriving in Bondo. Starting from the original valley state in 2015, the topography in Bondo has been prepared to allow for the arrival of 400'000 m3 of material in summer 2017. After this first landslide, clean-up activities of the riverbed took place and the construction of a promenade and belvedere was designed. At the same time, the design of a strategic topographic structure allowed future landslide events to happen without any risk of destruction for houses, bridges and roads. This means that further clean-up and terrain modelling works has been planned for this last phase as well. The robotic modelling in the first weeks has informed the smaller scale and the robotic construction method with experiments on the UR10 Robotic Arm. This conceptual work was translated to a thesis on robotic construction for the new landscape topology on the site. Based on dynamic landscape modelling principles, the studio will use the facilities of the ETH Landscape Modeling and Visualizing Lab (LVML) and the ITA Arch-Tec-Lab to establish a procedural and iterative design approach. There will be workshops in robotic modelling using sand and gravel, 3D landscape modelling, and 3D prototype printing to help conceive 3D landscape models (using Rhino and Grasshopper plugins).

The processing of shapeless materials such as sand and gravel through digitally controlled machines equipped with sensors allows students to implement feedback-driven formation processes into their landscape designs. The addition of larger rocks and boulders enables them to create various surface conditions that can respond and withstand the large forces of water and debris flows. These robotic modelling processes will be simulated in model scale using a small scale robotic arm. The main objective of these investigations is not the materialization of a predefined landscape condition, but rather the precise analysis and documentation of specific material properties and aggregation processes during the simulations.

Location: Bondo (Ch)
Client: Systematic investigation undertaken over the Design Studio Robotic Landscapes II ETH Zurich
Authors: Design Studio Robotic Landscape II – Prof. Cristophe Girot and Prof. Gramazio-Kohler
Year: 2018
Chronology: every group studied the three strategic design phases (2015 – 2019 – future)
Costs: ////
Images: © Prof. Christophe Girot, ETH Chair of Landscape Architecture, final presentation extract
Dimension: the topography in Bondo has been prepared to allow for the 400'000 m3
Credit: Prof. Christophe Girot, ETH Chair of Landscape Architecture https://girot.arch.ethz.ch/courses/design-studios/design-studio-hs2018-robotic-landscapesii



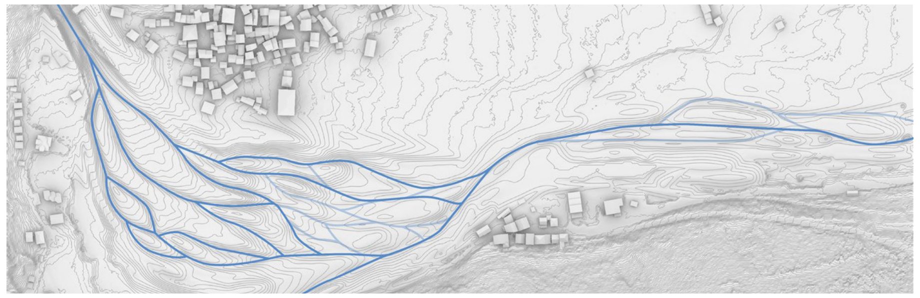
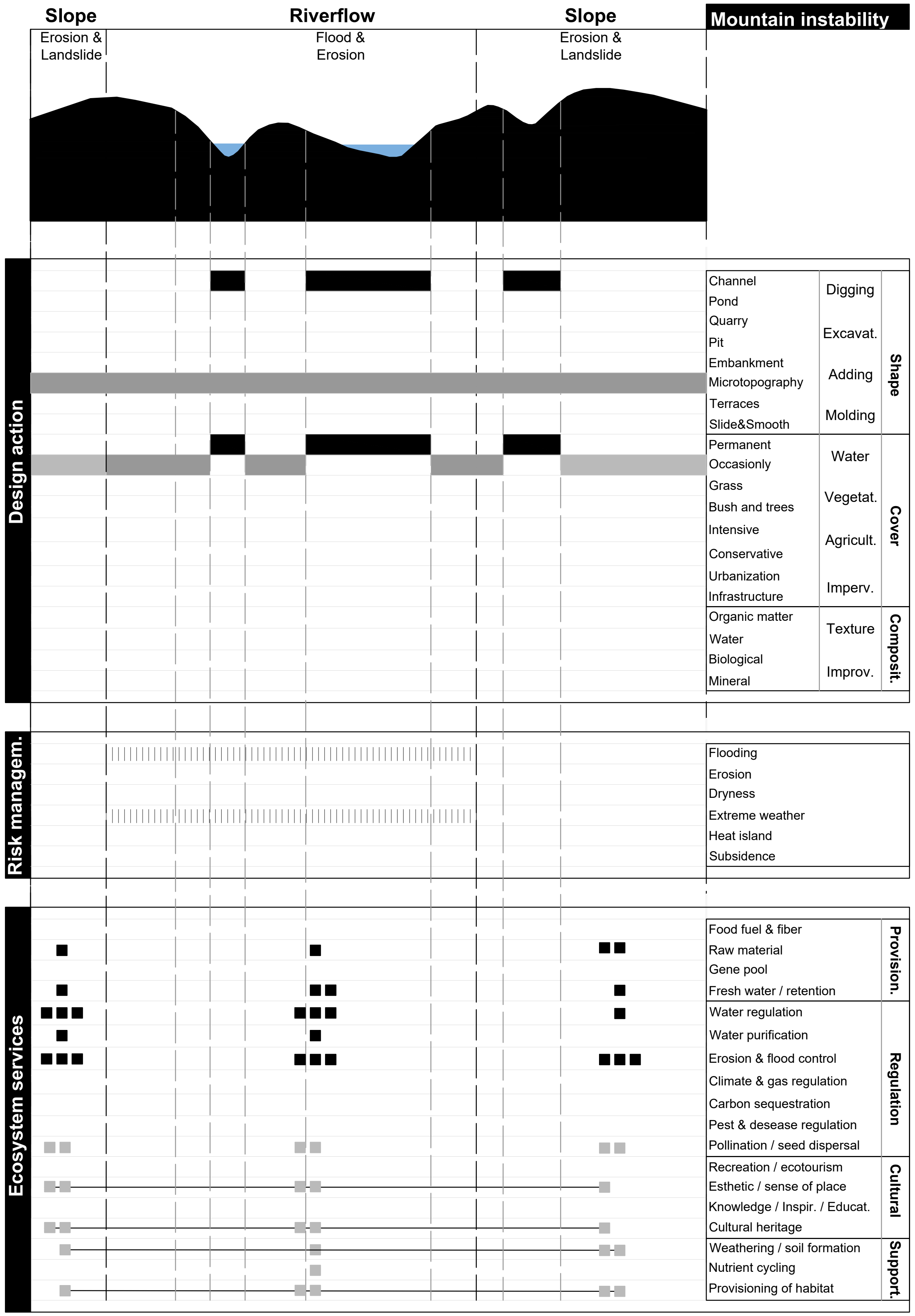


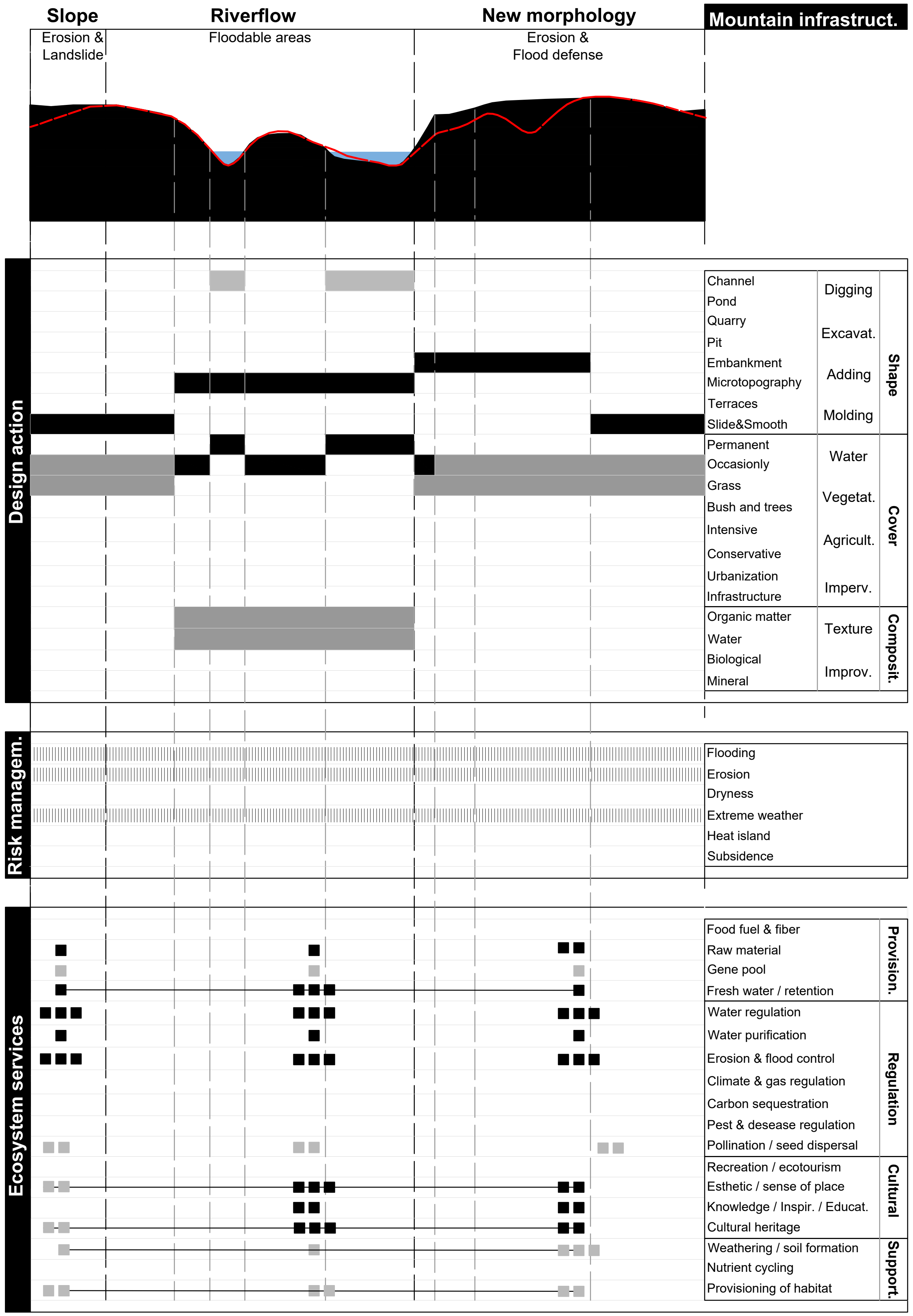
Fig. 130-131-132. From the top: section through Bondo by some students's work; simulation; water and debris flow simulation; Point Cloud Model of Bondo. source: ETH Chair Cristophe Girot

before intervention



Tab. 25. Before intervention. source: author

after intervention



Tab. 26. After intervention. source: author

Waste architecture
Vall D'en Joan Landfill Riqualification, Barcellona

The landscape restoration carried out by Enric Batlle and Joan Roig involved a series of different but integrated actions on a waste landfill site North-East of the city of Barcelona. These actions aimed at transforming its essence from a dump into an open space worth to be visited and full of natural importance. Batlle i Roig's project employs strategic creativity, inspired by the natural orography of the terraces and the agricultural park, to combine the artificial elements and give the city a new, symbolic gateway.
The Vall d'en Joan landfill site was opened in 1974 in a valley in the limestone massif of the Garraf and since then, for about thirty years, it served the city of Barcelona and the surrounding municipalities, reaching a depth of around 70 metres. The decision to redevelop the site, which in the meantime had been incorporated into the Garraf Nature Reserve, was taken in 2002. The restoration project defines a pattern of topographic configuration with terraces, side slopes, drainage system of leachate (separated from the external drainage net), biogas extraction net, pathways and plantation by phases. The whole restoration project goal is to make Parc Del Garraf absorb the dump by using the local forest tissue and by supporting the establishment of primary succession and its development over the years will change and adapt to the specific environmental situation of the former dump site. The plantation process is being done through strong local species with limited water needs and already adapted to the place environment. The vegetal structure planned with different local types of shrubs (such as bardissa, brolla or mediterranian màquia) and trees organizes the plantation project. The authors designed an exploration route that also included a car park and restored an old building to make it an information centre. The urgent task of isolating waste and consolidating the terrain was achieved by designing a series of terraces, embankments, pathways and irrigation canals that combine cultivations, woodland areas, native plants and specific plantations to consolidate the terrain.
The studio decided to create a system of terraces and a path running through them to rationally resolve all the technical problems. The choice of terraces reduced the slope of the terrains, helping to stop erosion and collecting rainwater for irrigation. There was little infiltration, reducing the need to treat the leachate by using barriers and strapping. The biogas extraction network that is part of the site meets the annual need for electricity of over 10,000 people. The introduced agricultural system constitutes a landscape in itself, a logical system for restoring life in a place that had lost it. Changing the topography to form terraces and collecting rainwater for irrigation, planting scrub vegetation and growing native plants and herbs, all this speeds up the process of restoring the original landscape. Choosing local rustic species that require minimal irrigation and are already suitable for this environment (like burdock, aromatic plants or Mediterranean scrubland) means that the park grows spontaneously.



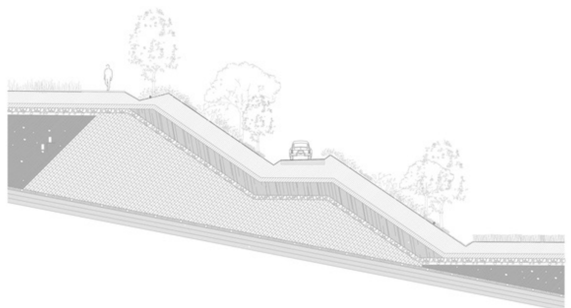
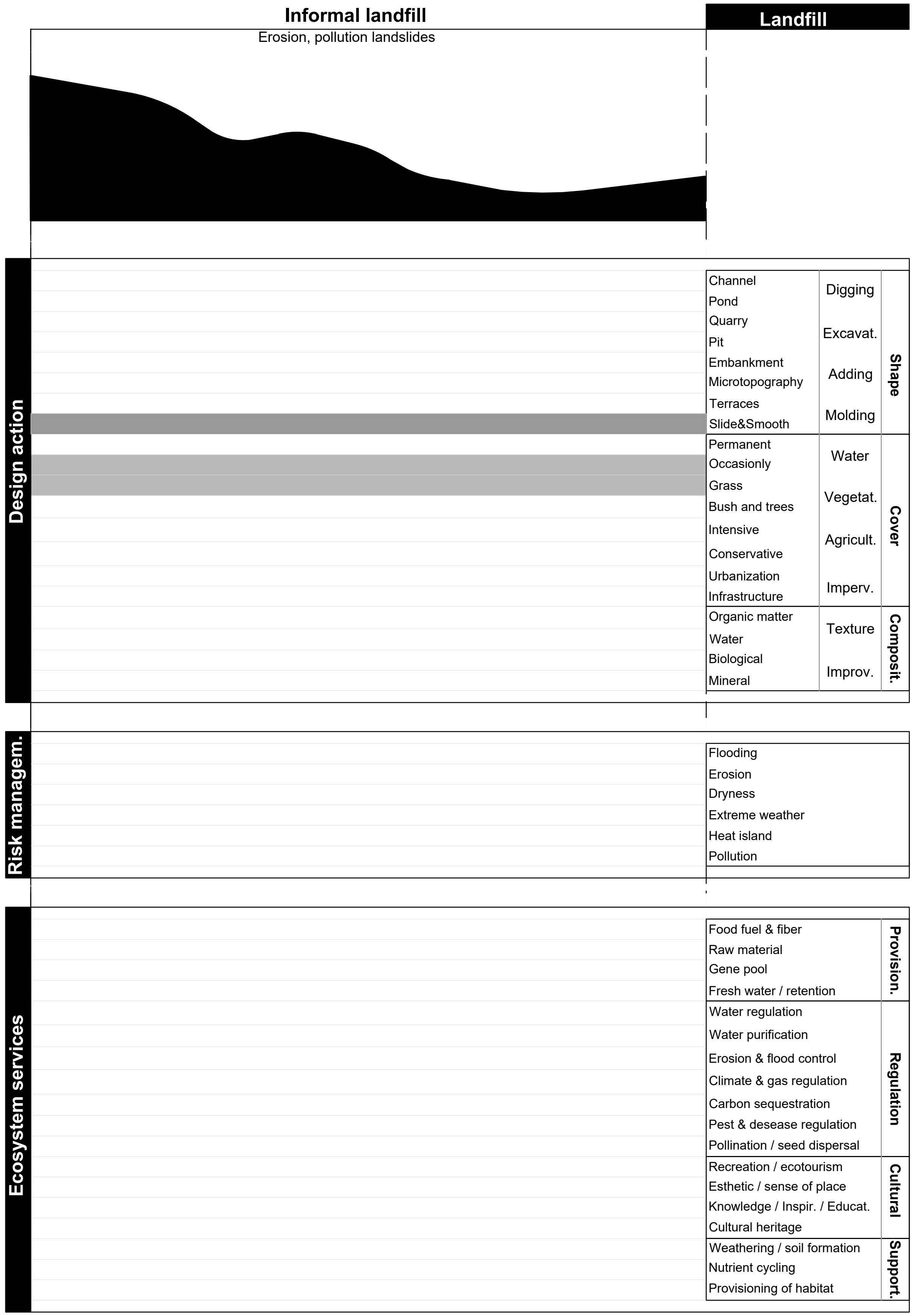




Fig. 133-134-135-136-137. From the top: Garraf landfill in construction; planning; landfill photograph; technical section; water pond. source: Battle i Roig studio.

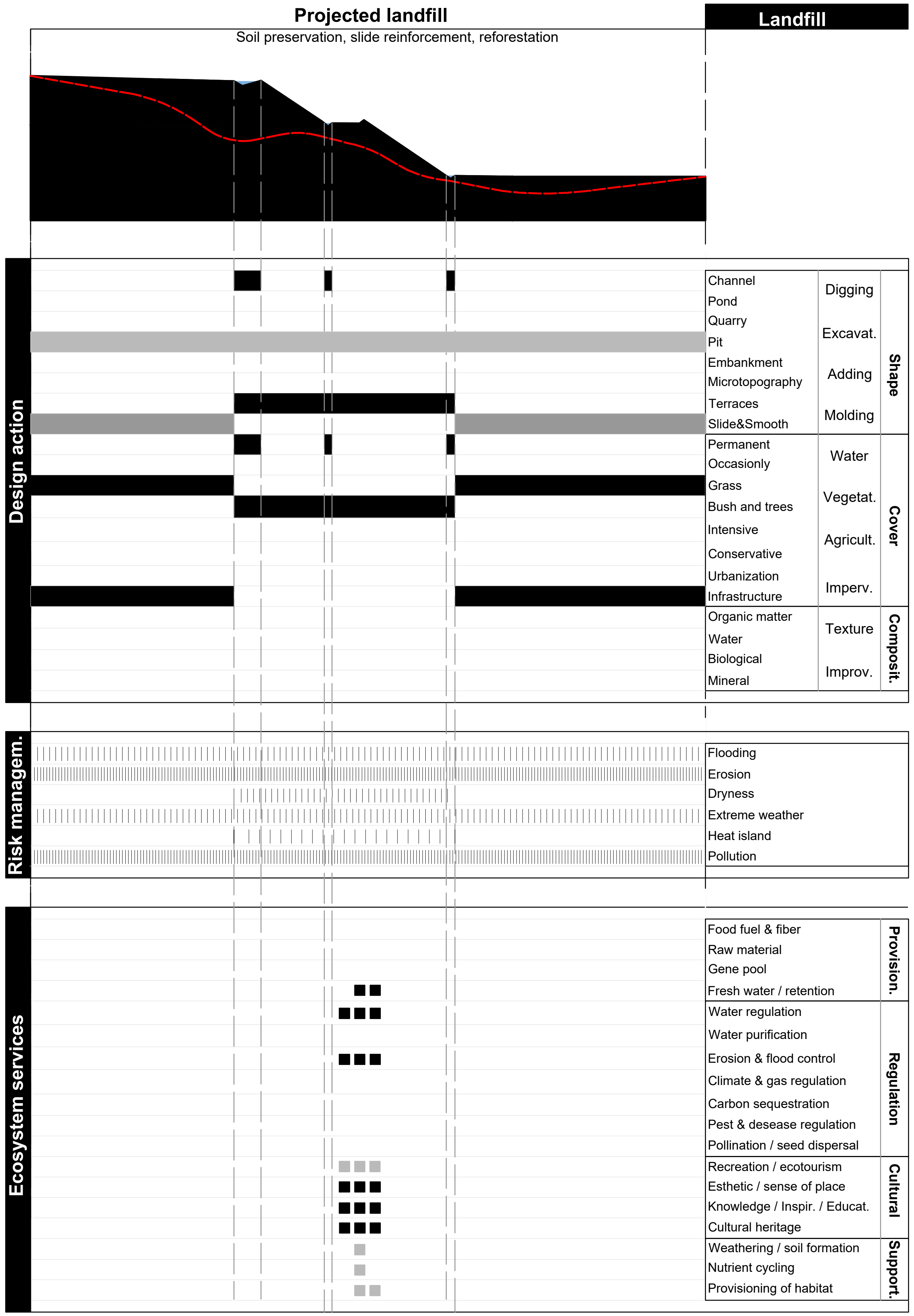
Location: Garraf, Barcelona (Spain)
Client: Amb / Diputació Bcn / Metropolitan Entity Of Hydraulic Services And Waste Treatment
Authors: Architecture, Batlle i Roig (Enric Batlle, Joan Roig); Agricultural Engineer: Teresa Galí-Izard; Agricultural Engineers / Landscape Architects: Jordi Nebot, Xavier Ramoneda, Mario Suñer, Elena Mostazo, Dolors Feu; ZS Ingénieurs civils; Biology: Biotec SA
Year: Construction period Started in 2003 and it is still ongoing
Chronology: 20.000 sqm + 38.885 sqm Phase 1 + 85.993 Phase 2 + 199.720 sqm Phase 3 + 377.723 sqm Phase 4
Costs: Phase 1: 1'500'000 Fr. Phase 2: 25'000'000 Fr Phase 3: 33'000'000 Fr
Images: Photographs © Jordi Surroca, Drawing Battle y Roig
Dimension: 722.321 total sqm (20.000 sqm + 38.885 sqm Phase 1 + 85.993 Phase 2 + 199.720 sqm Phase 3 + 377.723 sqm Phase 4)

before intervention



Tab. 27. Before intervention. source: author.

after intervention



Tab. 28. After intervention. source: author

Constructed wetland
Pialassa's renaturation, Ravenna, Italy

The Ravenna's *Piallassas* – Baiona and Piombone - are brackish coastal lagoons that occupy vast depressed areas parallel to the coast, consisting of semi-submerged areas and shallow waters bordered by artificial banks and a dense network of main and minor canals. The presence of a heavily polluted industrial site in communication with the piallassa leads to the need for reframing the relationship and the exchange processes between them, in order to make them working as better as possible, and with the aim to maintain and preserve the ecological functions and natural processes in the wetland. The renaturation was started by reshaping the morphology and the bathymetric configuration by dredging the harbour channel, and making use of sediments coming from the industrial harbour, isolated and then covered with organic topsoil layer. This channelization network already existed in 1954, but in 1968 it started changing. In 2004 the site presented a critical bathymetry. This is mainly due to the hard infrastructure of the harbour docks, with consequence on reduction of hydrodynamic flows and exchanges. The morphological modification of the piallassa was accompanied by a progressive depletion of its environmental conditions. The absence of emerged areas has reduced the presence of avifauna. Over time the outflows of agricultural and civil origin dumped large quantities of nutrients in the piallassa. In 2000 the site was declared protected area and the project of the wetland restoration and physical separation from the harbour channel started with the bathymetric reorganization of the area of high environmental value. The main works designed in order to create the best conditions for a resumption of the area's bird populations are the construction of: a perimeter bank creating a physical separation between the port area and the natural area; a series of internal tide channels to facilitate the entry of the tidal wave; four buildings, called *"Venetian doors"*, which allow the flow of water in only one direction; a navigable Vincian port for the boats transit at the entrance of the navigable district canal; some islands and internal sandbanks with a form suitable for favouring the settlement of bird populations; resetting the district canal; a phytoremediation area located near the outlet of the S. Vitale drain pump.
All these interventions have been planned to maximize the reuse of in-situ dredging materials and to accommodate a portion of the dredging volumes coming from the port channel maintenance. The emerged areas designed inside the Piallassa require 247.750 m3 of soil entirely taken from the 240.500 m3 made available by the dredging of inner channel. The other interventions concerning the perimeter bank and the areas of re-naturalization were supposed to use the remaining 7.250 m3 and the dredging material of the port channel.
In 2014 the construction of the separation embankment was interrupted because of a change in ministerial parameters concerning the placement of dredging materials. The construction site has been running for 7 years, instead of the foreseen 30 months, and it's still ongoing. As of now the perimeter bank has not been realized yet, so the Pialassa still has physical continuity with the harbour channel, and it's getting filled with sediments.

Loction: Ravenna (Italy)
Client: Harbour Authority
Authors: MED Ingegneria (Definitve project); Piacentini group and Nautilus building construction
Construction period: Start and finish date: 2003 - Ongoing
Chronology: 11 main executive phases planned and the works should be completed in 30 months
Costs: 32.000.000 €
Images: Piacentini website (source)
Dimension: 30 Ha
Credit: MED Ingegneria

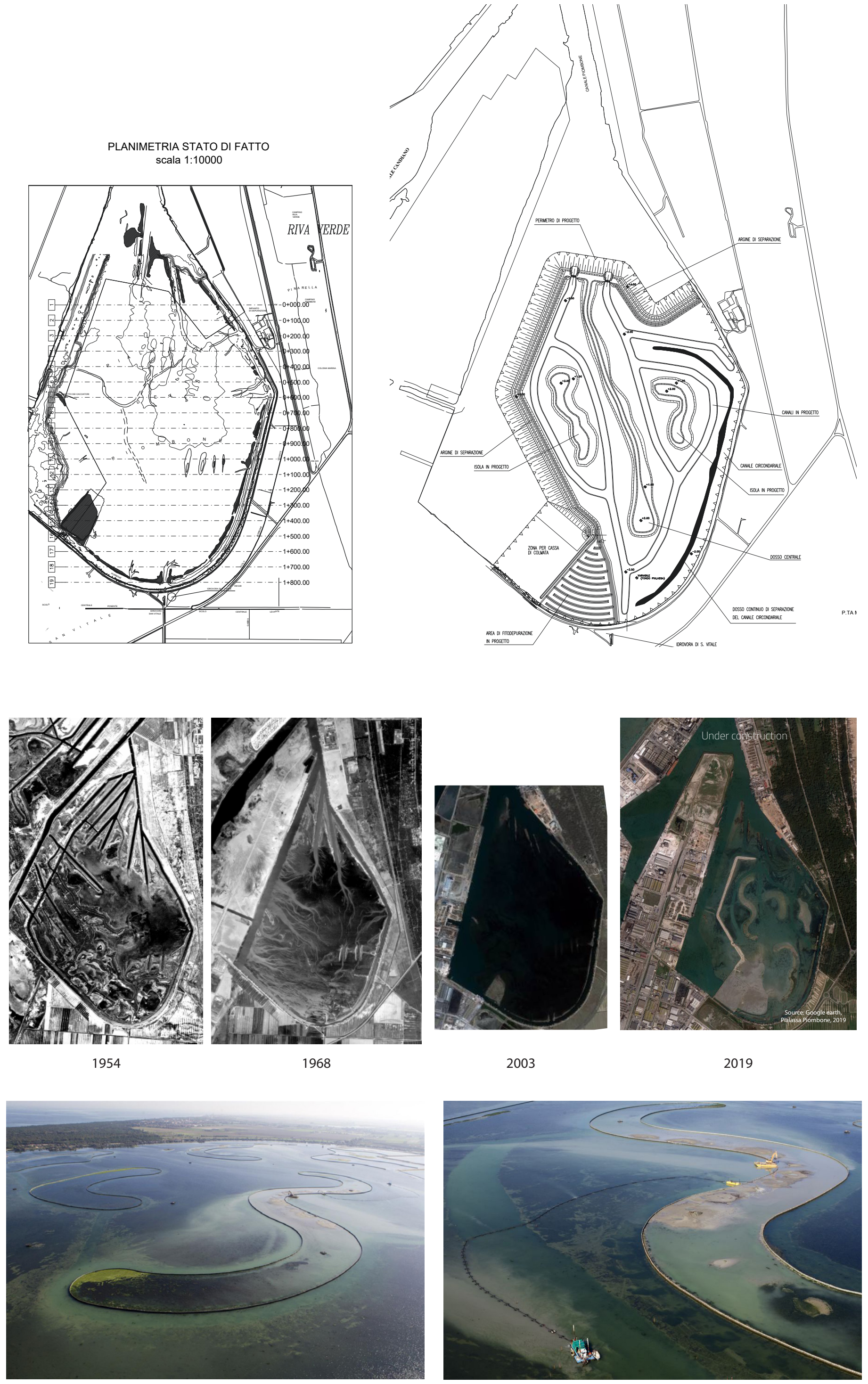
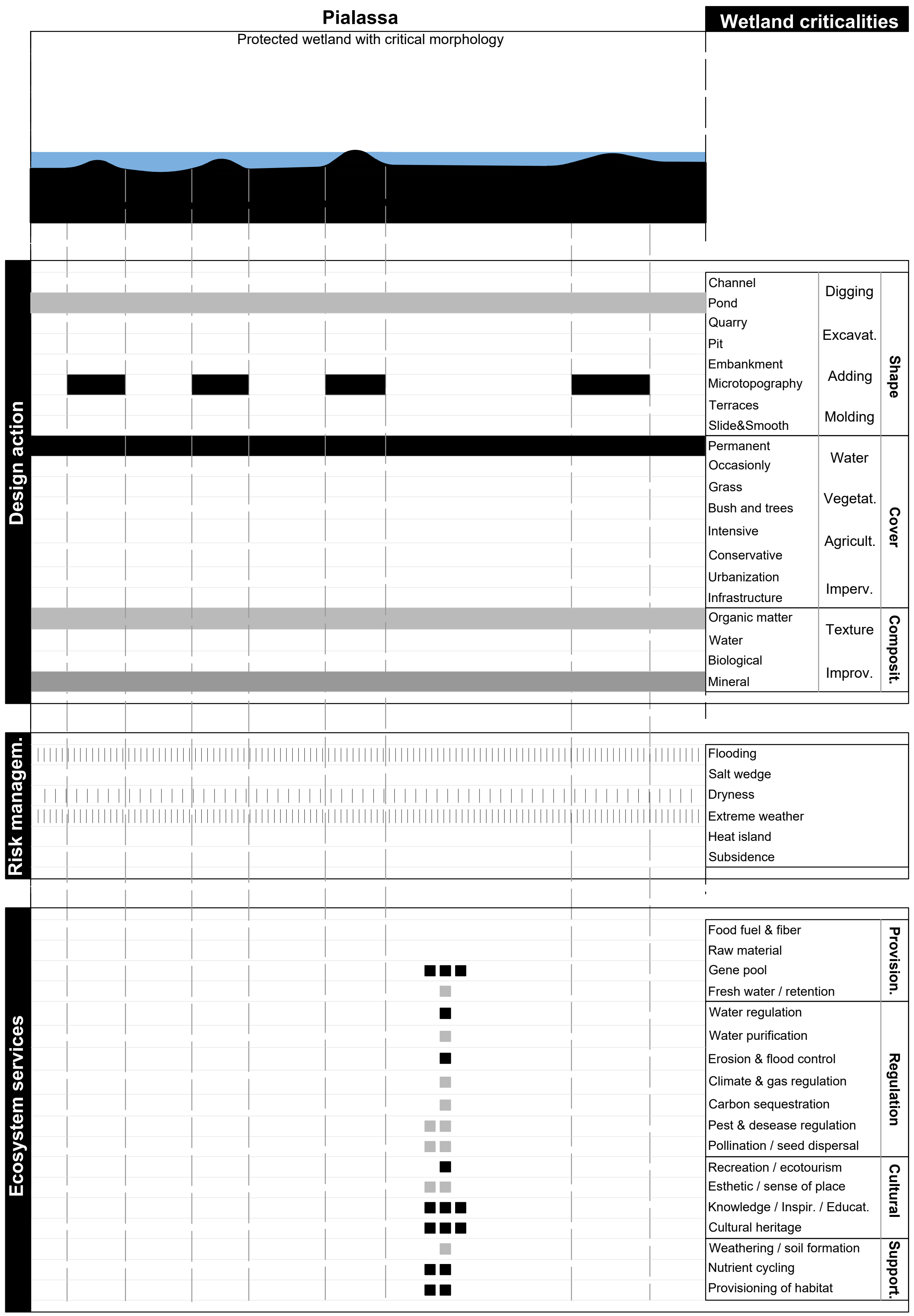


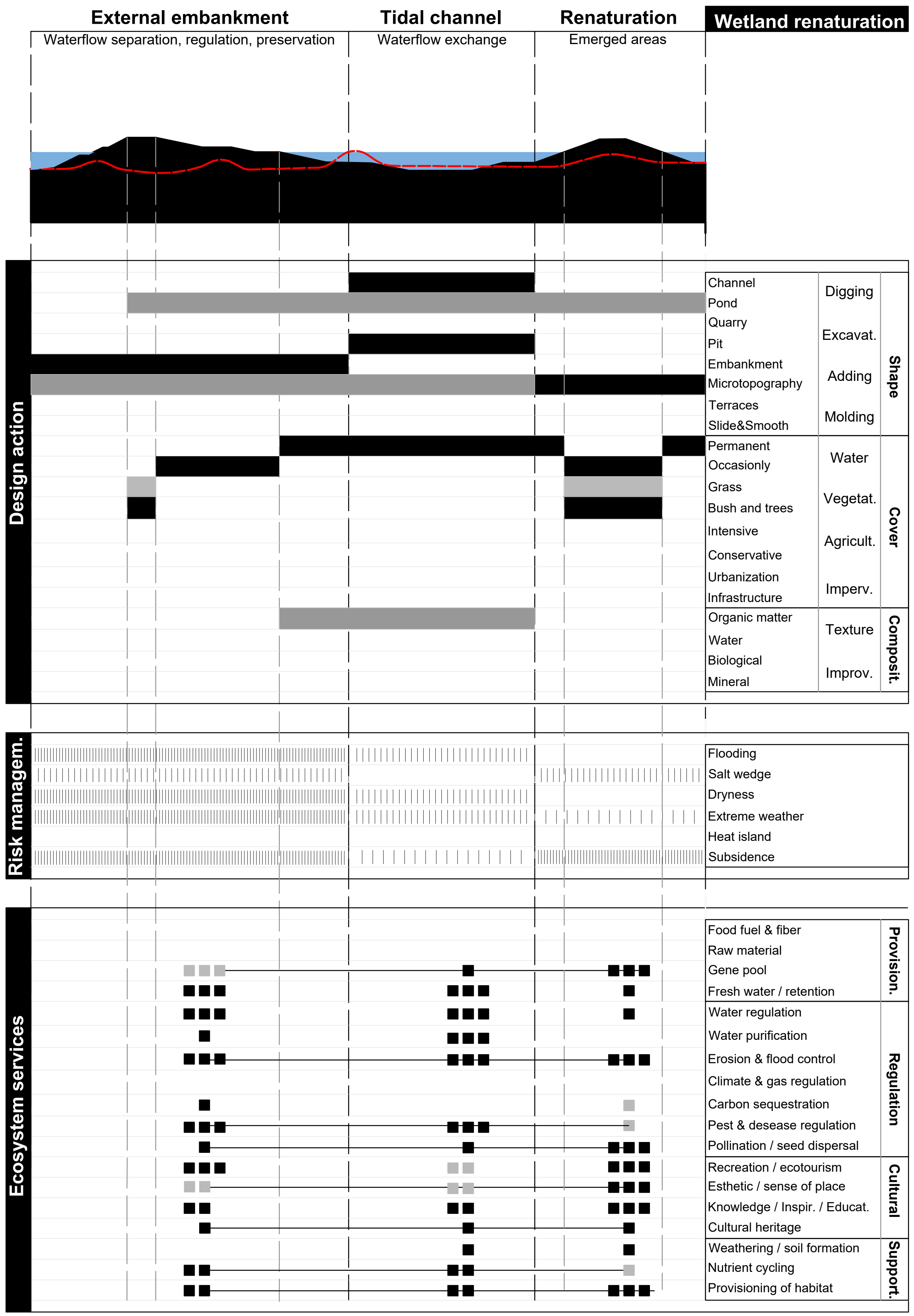
Fig. 138-139-140-141-142. Piallassa's evolution. From the top: bathymetry before intervention; restoration project; piallassa's evolution from 1954 to 2019; building site. source: MED ingegneria; Google Earth; Gruppo Nautilus.

before intervention



Tab. 29. Before intervention. source: author

after intervention



Tab. 30. After intervention. source: author

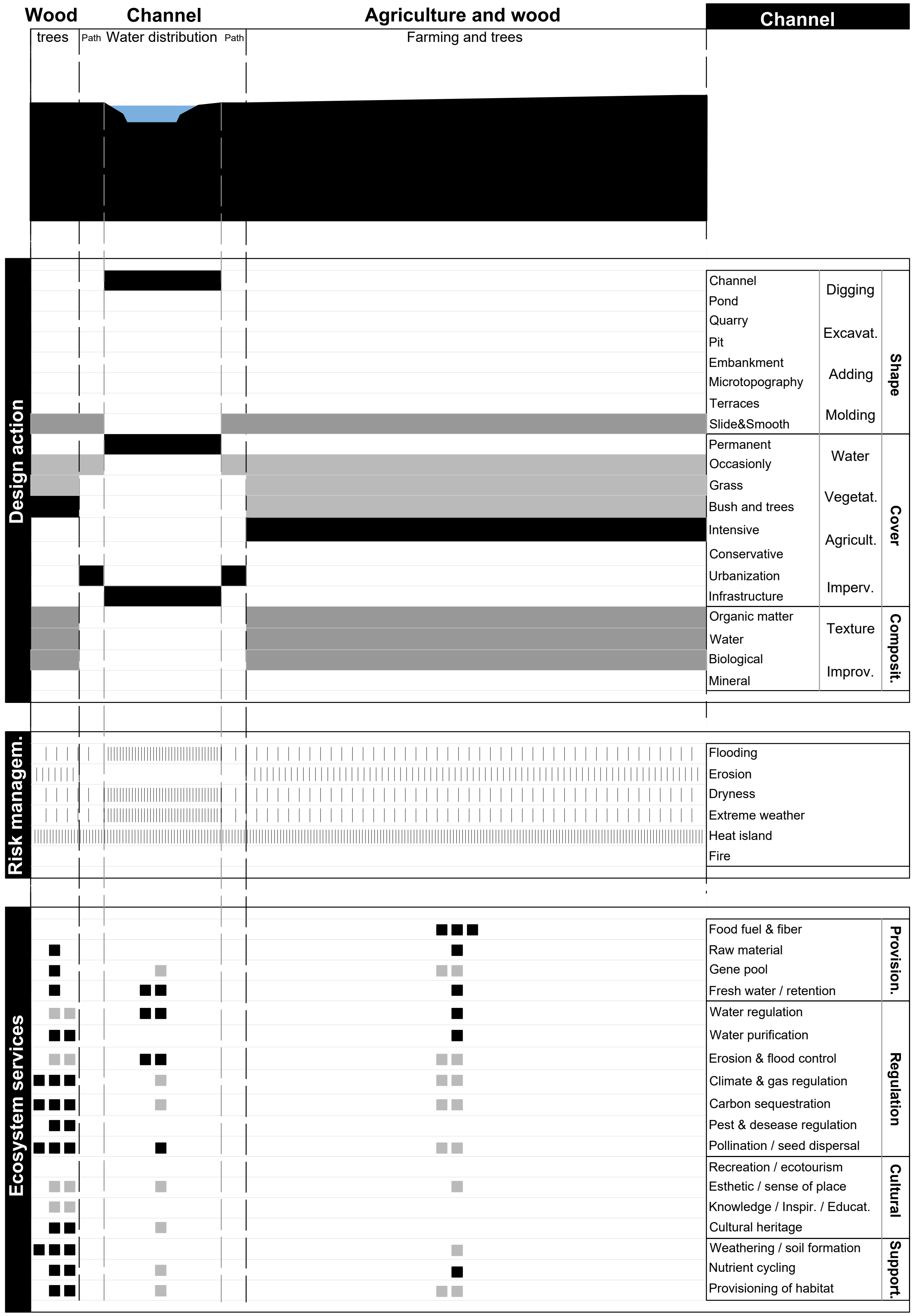
Space divagation
Renaturation of River Aire, Geneve, Switzerland

The Aire river flows through valleys historically devoted to farming. From late 19th century it was progressively canalized. In 2001 the Canton of Geneva opened a project competition bearing in mind the idea of restoring the river to its original shape by destroying the canal. Atelier Descombes proposed instead to combine the canal with a vast divagation space for the river. In the process the canal becomes the cornerstone for the transformations, a reference line which gives the possibility to understand the before and after. A becoming which superimposes on both situations. The project attempts to propose an alternative path, where the urgent ecological shifts are incorporated into a larger cultural change. The complex organization of the design associates the new river space with a linear series of gardens in the former canal. In reality the whole design becomes a linear garden. Looking at the whole watershed, the original morphology of the mountains and the traces of human modifications, this long river garden organises the situations, views, confrontations, presences, aiming at introducing into this fragile and precious territory questions, worries, hopes.
The footprint of the canal is a key device for building the necessary calm and inwardness without which there is no real garden. It is a permanent trace which introduces a complex temporality, both past and future, memory and desire.For the drawing of the river itself – conscious of the useless effort to design a fixed river bed and aware that a river usually loves to freely design itself – the designer proposed a starting pattern whose form addresses the play between the river flow and the prepared terrain.
This diamond-shaped pattern opens a complex series of undetermined channels for the river flow. These channels were excavated along the entire new riverbed by removing the humus layer, maintaining a precise control of the longitudinal profile of the river. The dimensions of these lozenges islands were configured to be able to «accept» the general sizes of the former meanders. The result is spectacular and suggests the devices of most land artists, effecting clearly artificial interventions into a natural situation, thereafter left to the mercy of natural forces. One year after the opening of the new river space, the results are beyond expectations: the river flow, by displacing diverse materials, gravels, sand, significantly modified the geometrical matrix of lozenges. We must accept this paradox: the more defined the grid given to the river, the more the river will be free to design.

Location: Geneve (Switzerland)
Client: République et Canton de Genève (State of Geneva)
Architecture: Group Superpositions
Architects: Georges Descombes and Atelier Descombes & Rampini
Engineers: B+C Ingénieurs
ZS Ingénieurs civils
Biology: Biotec SA
Construction period:
Chronology: Phase 1 2002 – 2006, Phase 2 2009 – 2011, Phase 3 2012 – 2015, Phase 4 Ongoing
Costs: Phase 1: 1'500'000 Fr. Phase 2: 25'000'000 Fr Phase 3: 33'000'000 Fr
Photography: © Superposition
Lentgh: 5km
Surface: 50 Ha

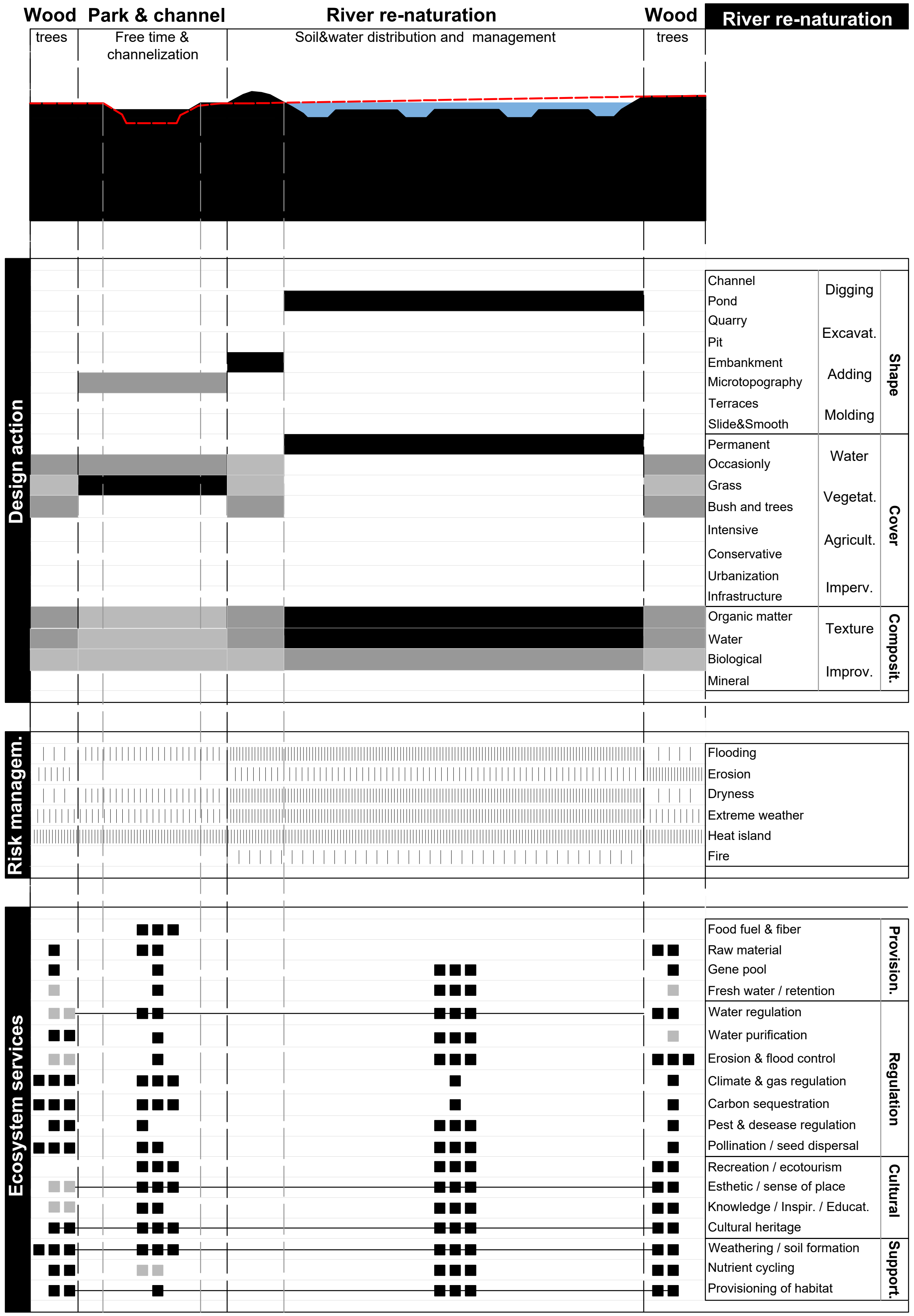
Fig. 143-144-145-146-147. From the top: flooding events; the area just finished the construction site and after some months; sections; aerial photo. source: Atelier Descombes Rampini

before intervention



Tab. 31. Before intervention. source: author

after intervention



Tab. 32. After intervention. source: author

Forested Infiltration Area
Bosco Limite, Veneto, Italy

The *forested infiltration* area system was conceived and developed for the first time in 2007 by Veneto Agricoltura, the Veneto Region Authority responsible for aspects related to agricultural, forestry and agri-food development. Bosco Limite is the result of a research and development experiment in the forestry field: Etifor, in collaboration with the farm owner of the land, wanted to investigate the opportunities offered by the creation of a perpetual forest.

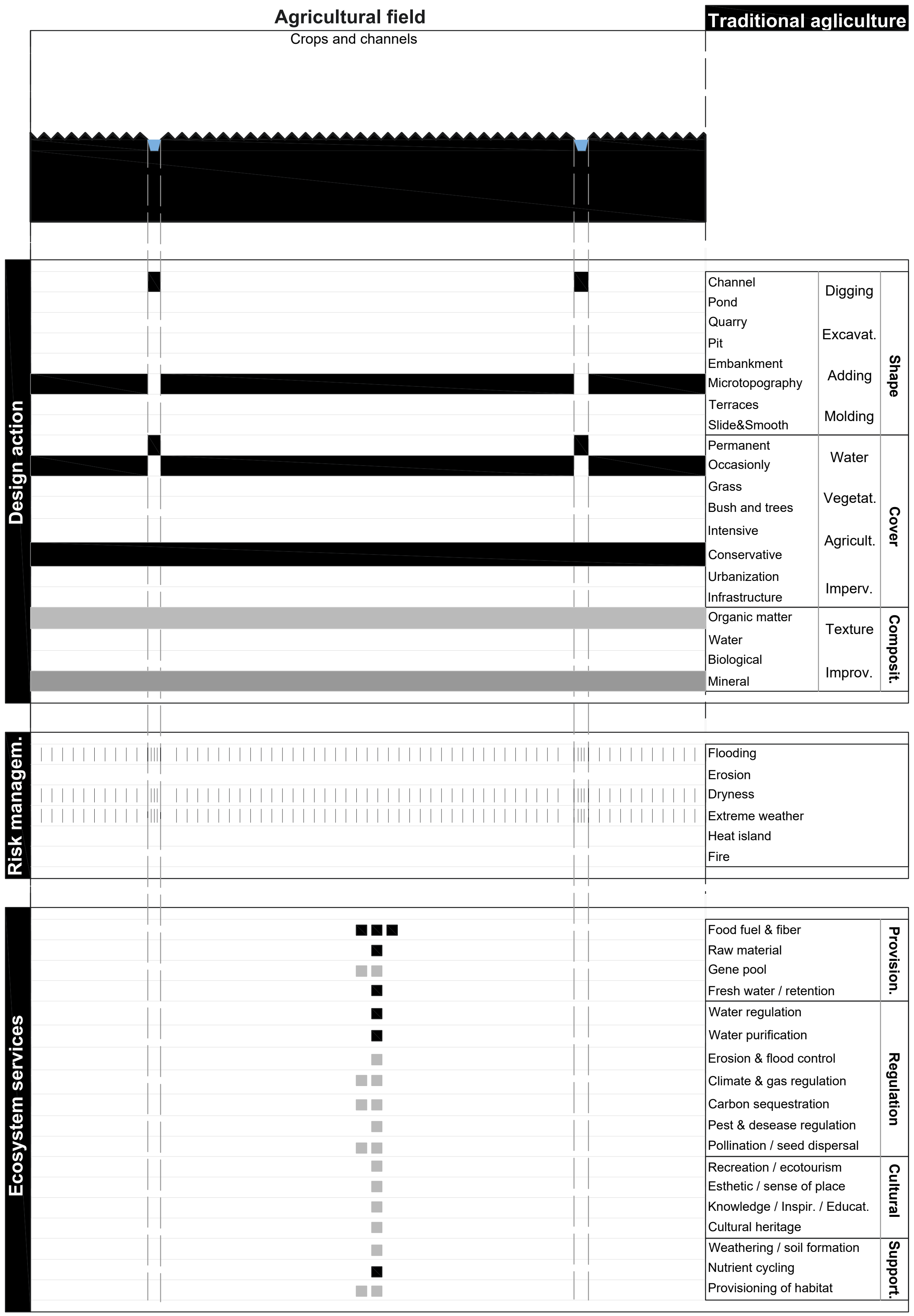
The project was also born from the need to find alternative solutions to various problems present in the Po Valley territory: the excessive exploitation of land, the intensive use of groundwater, the loss of biodiversity and the increase of pollutants in the air. In 2013, it was decided to convert 2.5 hectares of land where maize was being planted for 20 years (creating many problems to the owners due to the effort required for the fields management and the fluctuation of market prices) into a perpetual forest. Today Bosco Limite is economically viable and hosts 2,300 trees, whose species have been selected to recreate the forest environment typical of the Po Valley, and more than 20 different animal species. Together with the commitment to biodiversity and environmental awareness activities, the project provided for the creation of the largest Forest Infiltration Area (AFI) of Veneto, with 1,200 meters of water paths that allow for the infiltration of 1 million cubic meters of water per year. The innovative method consists in exploiting in a positive way the high infiltration rate of soils above the resurgence belt, allocating their surface to the cultivation of a forest that allows to maximize the infiltration rate. The solutions consist in infiltration areas that feature a total of 10 longitudinal infiltration channels having a sinusoidal shape with wide curves. Each channel has a length of approximately 93 meters and are spaced about 14 meters apart (inter-axial). Four of these channels run East-West (first area) and six run North-South (second area). Water is evenly distributed in the recharge area by means of a water level regulation system, which divides the available flow equally among the individual infiltration channels. Each infiltration channel has water level control structures that are spaced 30 meters apart. These structures enable the system to form a 'reservoir', which improves the efficacy of the infiltration.

Environmental and social objectives of the Forested Infiltration Area of Bosco Limite are: promote water conservation by saving it; improving adaptation to droughts and water scarcity; increase the biodiversity by encouraging the settlement of autochthonous plants and animals of the region; protect the landscape by introducing a new oak-hornbeam forest; re-establishing a historic landscape that has almost disappeared; capture 50 t of carbon dioxide per year in 30 years; introduce a new source of renewable energy provided by wood biomass for domestic use; improve the area by restoring its natural value and offering environmental education initiatives to schools and local associations; improve the quality of life for the local population through the creation of new green areas.

Fig. 148-149-150. From the top: 2Has rewooded; an internal channel; aerial view. source: Etifor

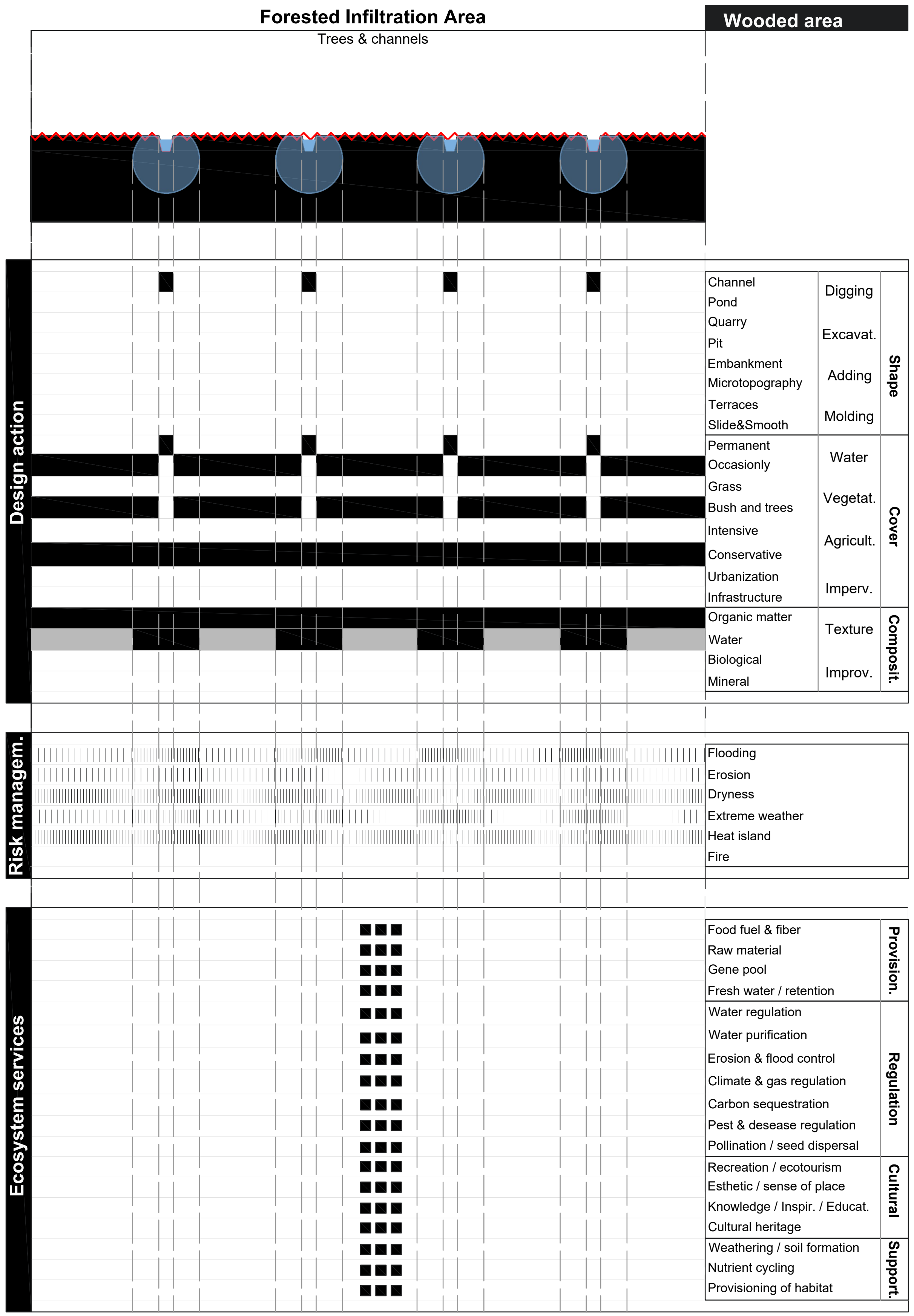
Location: Northern of Italy, Veneto Region (Italy)
Client: Veneto Agricoltura
Projec: ETIFOR
Construction period: from 2011 to 2013) including the design and the implementation of the aquifer recharge mechanism
Costs: confidential
Photography: © Superposition
Surface: 2,5 Ha

before intervention



Tab. 33. Before intervention. source: author

after intervention



Tab. 34. After intervention. source: author

Fig. 151. Cover of the volume "Resilience and adaptation to the effect of climate change", SECAP Ravenna 2020. source: author

Soil is a crucial link between global environmental problems such as climate change, water management and biodiversity loss

José Luis Rubio,
President of the European Society for Soil Conservation

Chapter 4

Processing soil in anthropic con-

Chapter 4. This section deals with an operative workflow for mediation strategies able to reinterpret the *soil* as element of territorial changes experimentation in the *landscape resilience* framework. The functional workflow is finalised at processing soil in anthropic context, by refraiming soil as a palimpsest for approaching scalarity across planning and design process. The procedure will be presented in an *analytic* part - useful to *orienting decision* - and a *synthetic* part - concerning *spatial arrangemen*t in landscape projects. This model will be implemented in a real case study with territorial scope, concerning the *Plan for adaptation measure in response to climate change* set on the territorial administration of Ravenna (Italy).

Landscape resilience in the framework of climate change adaptation

By referring to the propositions discussed in Chapter 2 and the tools developed in Chapter 3 here is presented a formulation for approaching the *planning* and *design* scale.

On this basis the thesis elaborates a model, i.e. the *'Moving Horizon Approach',* establishing an efficient workflow to *process soil in anthropic context* in the form of an operative methodology proper of landscape design praxis. The aim is to highlight the functional role of *soil* as complex environmental matrix as well as complementary providers of ecosystem services and physical transformations matter, treating its potential at different scales.

This allows to recognize the gaps in governance tools involving *soil* as a structural element of *planning*, and to discuss the integration of the appropriate top-down and bottom-up approaches to adapt existing design resources and best management practices.

The following paragraphs present the procedure organized in two logical passages: an *analytic phase* - useful to *orient decisions* taken on a large and wide-view scale - and a *synthetic step* - concerning *spatial arrangement* in a landscape project.

It is grounded on the main assumption that an intervention workflow is required for implementing the project strategies in place, able to transform the existing soil environmental matrix both at the design and territorial scale. In fact, the model implies a series of steps that should bring to *guide choices* through strategic outlines and *processing design*, leading to an effective praxis of *soil handling*.

The proposed research analyses the implementation of this procedure along the *Planning Adaptation measure of Ravenna 2020* as a remarkable case study. The methodological development section will be sup- ported by the mentioned case study, helpful in visualizing the abstraction process underlying the proposed approach.

The model aims at assisting designers engaged in landscape design, scholars and professionals involved in territorial transformations, decision-makers in their strategic choices by visualizing and elaborating prospective landscape shifting at several scales.

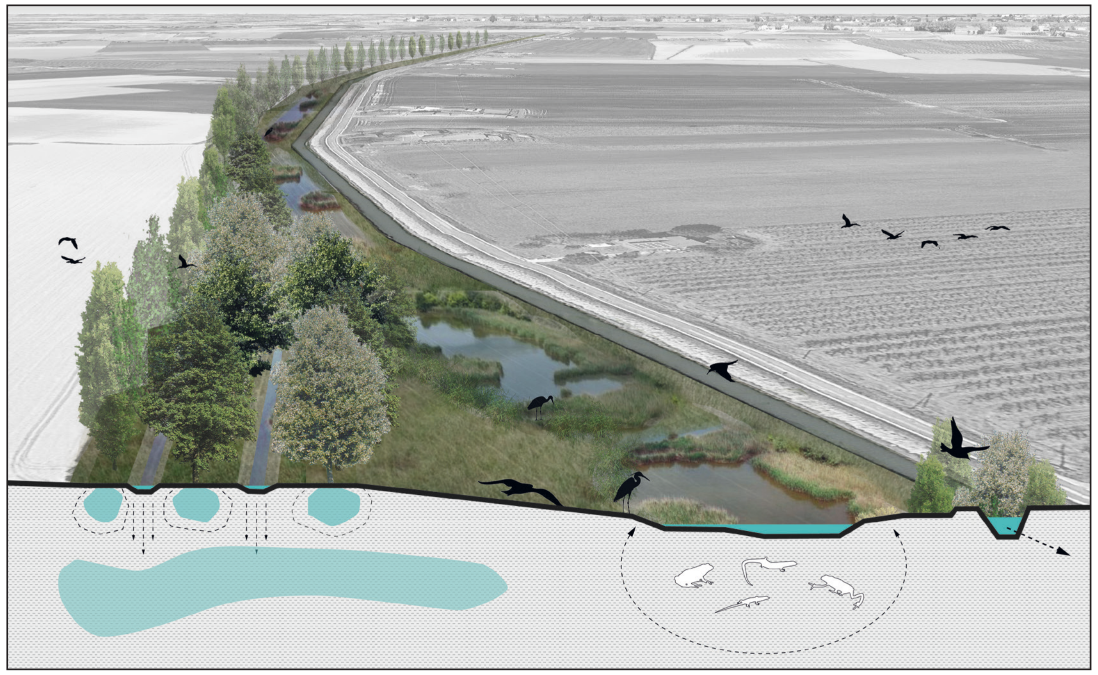
Finally, the results concerning the proposed procedure are drawn in terms of achievements, limitations and potential advancements.

Adaptation

Process of *physical transformations* to be carried out on the ground, with the aim to update to current and future risk scenarios in the framework of territorial

Grafting infrastructure

CURRENT STATE AFFECTED BY FLOOD, DRYNESS AND SALINE WEDGE

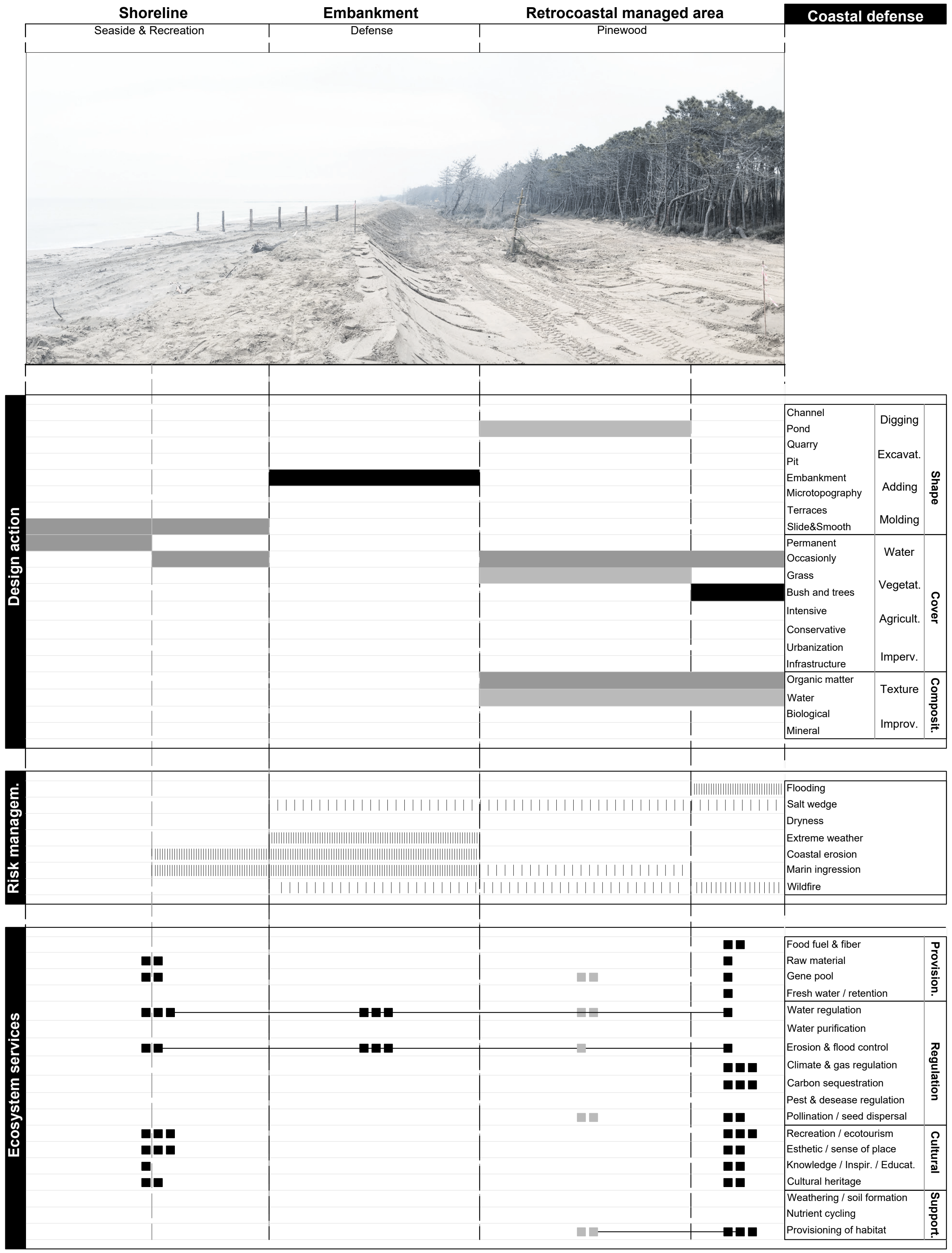


PROPOSED ADAPATATION MEASURES - *HYBRID APPROACH*

Fig. 152-153. Proposal of adaptation measures along an irrigation channel in Ravenna, through an hybrid approach that combines "hard" and "soft" intervention. Source: SECAP RAVENNA 2020

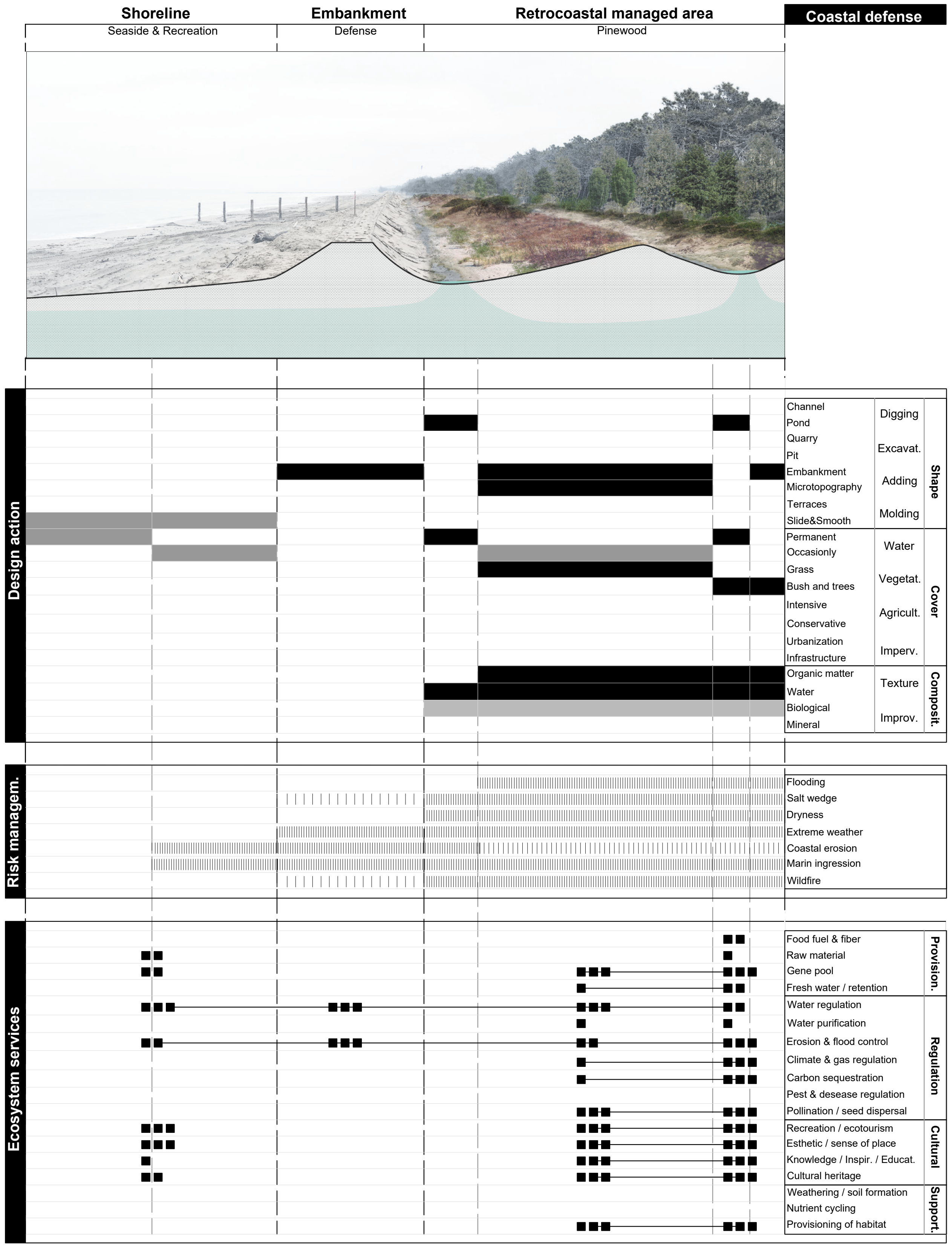
Shoreline dynamic stabilization

CURRENT STATE AFFECTED BY EROSION, FLOOD, DRYNESS, SALINE WEDGE, MARINE INGRESSION



Tab. 35-36. Proposal of adaptation measures for shoreline dynamic stabilization, through an hybrid approach that combines "hard" and "soft" intervention. The current situation is compared with that of the project, through the matrix used in chapter 3, linking proposed interventions in taxonomy, risk management, ecosystem services provided by soil. source: SECAP RAVENNA 2020

PROPOSED ADAPATATION MEASURES - *HYBRID APPROACH*



4.1 Operative workflow, analysis & synthesis

The approach here proposed is relied on an *analysis-synthesis* approach intended as a model of creative process in research by design technique. As illustrated by Roggema (2017): *"During the analysis the way things currently are (the truth) is researched […] In the final stage of the research, the synthesis is concerned with how things will be (the real)*.

It is grounded on the main assumption that by placing these two concepts in relation to each other, they designate two complementary and opposing moments of reflection, performing a destructuration and composition process that brings to knowledge and to the high level of awareness necessary in driving choices.

Analysis consist in *recognizing fixed and changing parameters* and in transforming them into a design element. In the proposed workflow this analysis is based on studies on the geomorphology of sites, soil texture, water management, on the ecological and settlement endowments of a given context. A set of planning and design tools (such as GIS cartography, parametric design tools, investigation on site) is needed to perform this stage.

The aim is to understand the relations between the various components depending on their ability to react to a certain external stress, and to trace the opportunities of participation translated in the form of strategic outline. By superimposing this information, a *reference pattern* was defined on which to set up works compatible with the use and type of soils.

Synthesis moves forward the integration of spatial transformation, by combining the analysed elements to make a whole that is new and different from the same items as separately considered. In this phase we trace the concrete integrated actions in soil processing in terms of *shape, coverage* and *composition*.

Operative workflow

These studies are extremely useful to understand the interaction between human and environmental systems and how spatial aspects are a direct consequence of this interdependence.

PLANNING ⟷ **PROJECT**

ORIENTING DECISION

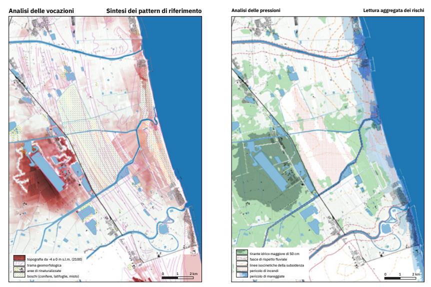
ANALYSIS	MAPPING OVERLAY & INTERPOLATION
1. ATTITUDE	Linking soil to vocation and susceptibility
2. PRESSURE	Linking soil to risks, stresses and hazards
3. OPPORTUNITY	Linking soil to possibilities and limits

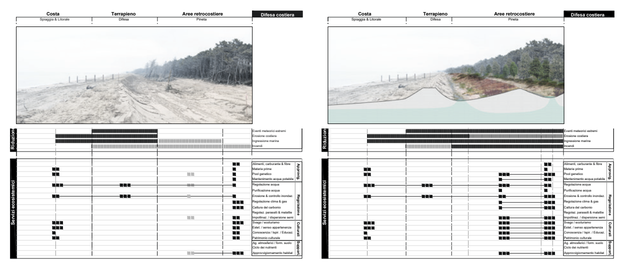
INPUT

OUTPUT

PROCESSING DESIGN

SYNTHESIS	SPATIAL CONFIGURATION
4. OPERATION	Linking soil to topological design operations
5. DESIGN	Linking soil to integrated design actions
6. UPSCALING	Linking soil to Landscape design praxis





STRATEGIC OUTLINES

POSSIBILITIES AND LIMITS

CARTOGRAPHIC GROUNDS

HANDLING SOIL

DESIGN PRAXIS

SOIL TRANSFORMATIONS

Tab. 37. Operative workflow. source: author

INPUT

ORIENTING DECISION

1. ANALYSIS | **MAPPING OVERLAY & INTERPOLATION**

1.ATTITUDE
Linking soil to vocation and susceptibility

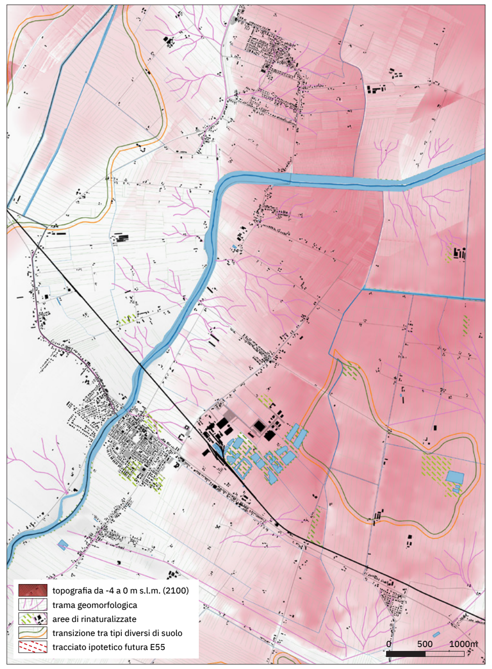


Fig. 184. *Reference patterns outline*

2. PRESSURE
Linking soil to risks, stress and hazards

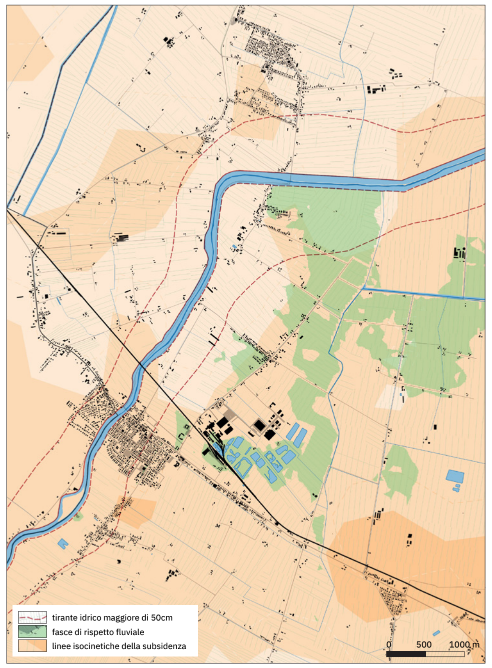


Fig. 185. Integrated risks and pressures outline

PROCESSING DESIGN

2. SYNTHESIS | SPATIAL CONFIGURATION

4. OPERATION
Linking soil to topological design operation

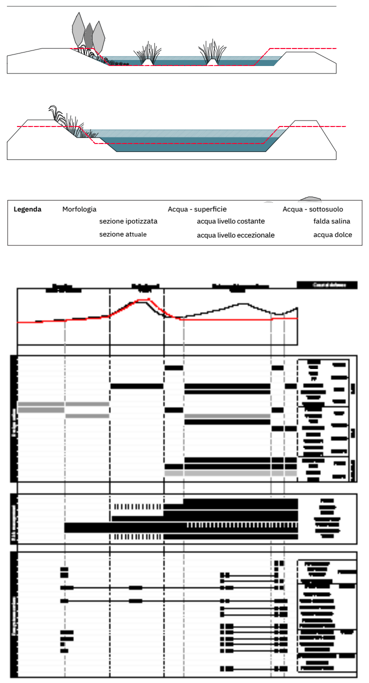


Fig. 187-188. Topological operations

5. DESIGN
Linking soil to integrated design actions

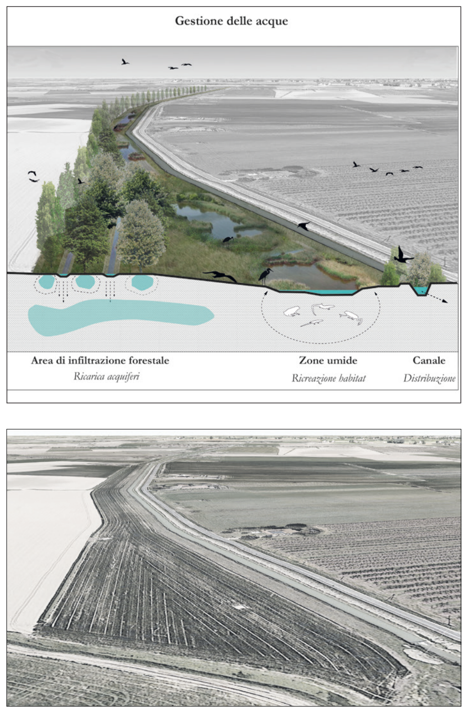


Fig. 189. Design actions

OUTPUT

STRATEGIC OUTLINES

POSSIBILITIES AND LIMITS

3. OPPORTUNITY
Linking soil to possibilities and limits

Fig. 186. Strategic outline

ANALYSIS

Starting from the analysis of risks and geomorphological characteristic at the territorial dimension, here are outilined *attitudes* and *pressures* through the study of the main cartographic references examined. The results are condensed into two aggregated readings that describe the territorial *patterns* - *across* critical factors and opportunities - for the definition of limits of intervention possibilities at planning scale.

SOIL HANDLING

DESIGN PRAXIS

6. UPSCALING
Linking soil to Landscape design praxis

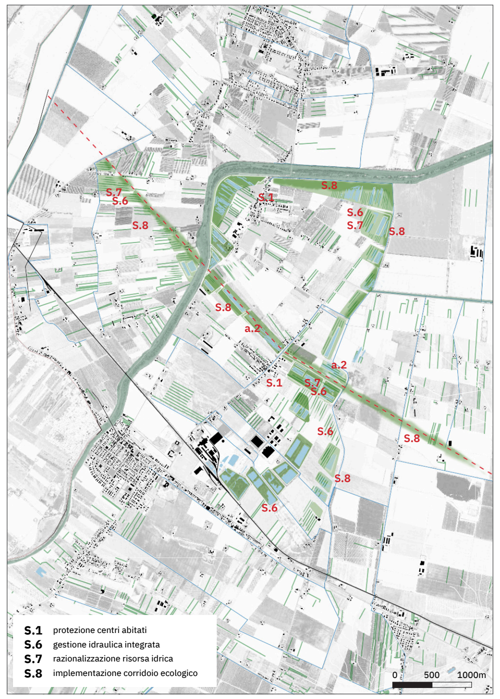


Fig. 189. Proposal

SYNTHESIS

On the basis of territorial studies, in this phase is figured out the landscape design to which the adaptation project actions correspond. On this hypothesis, the project operations are summarized by assuming their potential impact on the reduction of risk and environmental degradation phenomena with a multidimensional approach and aimed at improving ecosystem services.

4.2 Model implementation: supporting the Climate Change Adaptation Plan in Ravenna, Italy

In April 2019, the Municipality of Ravenna signed the commitments set to join the European initiative *"Covenant of Mayors for Energy and Climate"*, launched in 2015 and translated in the wider *"Strategy of mitigation and adaptation to climate change"* of the Emilia-Romagna Region, adopted in December 12th, 2018, and elaborated in compliance with the *"National Strategy of Adaptation to Climate Change"* (SNAC, 2015)[50] approved in 2015.

This is the context of the *SECAP (Sustainable Energy and Climate Action Plan)* drafting - set out in a document on *mitigation* and *adaptation* actions - through the implementation of local climate and energy policies. The contribution presented in this chapter is an extract of the document *"Resilience and adaptation to the effects of climate change"*[51], developed following a study carried out together with *Sealine* - a departmental research center - and the *CFR (Consorzio Futura in Ricerche)*, of the University of Ferrara. The document outlines possible solutions that can reduce the causes and/or mitigate the effects with respect to the identified criticalities and through the creation of specific meta-design scenarios and focus on thematic areas.

The aim is to identify, more specifically, the concrete actions of adaptation to climate change by relating the territorial and planning scale with that of the project through the understanding and transformation of the soil as the underlying material of this process.

The research bases its hypotheses and proposals on a critical reading of the components that characterize the *soil,* both on the *surface* and in *depth*. It seeks in the interaction between environmental infrastructure and soil attitudes the main responses to the consistency and sustainability of project actions. To understand the factors to be taken into account in defining the project strategies and actions, several cartographies have been examined, tracing both a description of the current state and the present risks, and a series of directions and prescriptions of interest on a municipal and regional scale.

These studies are extremely useful to understand both the interactions between human and environmental systems and how spatial aspects are a direct consequence of this interdependence. The study allows to increase awareness of how and how much you will have to rethink the territory and the landscape in the coming years, in the framework of landscape resilience.

[50] "Strategia Nazionale di Adattamento ai Cambiamenti Climatici"
[51] "Resilienza e adattamento agli effetti del cambiamento climatico"

ASSUMPTION

APPROACH to territorial *adaptation* presupposes two kind of behaviour

1. DYNAMIC: embrace the perturbation
Ecological resilience: tolerance + reorganization
Multiple regime: dynamic equilibrium
Unpredictability and uncertainty
Disturbances as learning opportunities

2. RIGID: reject the perturbation
Engeneering resilience: resistance + recovery
One regime: Static equilibrium
Predictability
Disturbances as threats

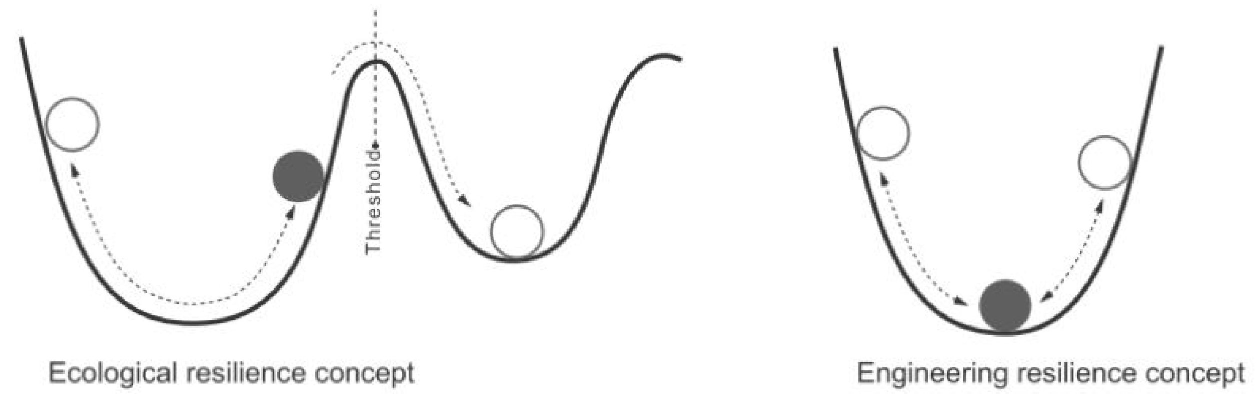


Fig. 50. Difference between engeneering and ecological resilience The cup represents the region in the state space or "basin of attraction", in which the system tends to remain, and includes all possible values of system variables of interest. The ball represents the state of the system at any given time. source: "A Theory on Urban Resilience to Floods—A Basis for Alternative Planning Practices", Kuei-Hsien Liao, 2012

Fig. 190-191. Two example of soft and hard infrastructure in Ravenna (Italy). Left: Sand protection embankment in winter season. Right: suspended riverbed. source: author

Reference

Climate change projections can only be described in probabilistic terms and over long time horizons. Extreme events linked to climate change sometimes evolve at a speed that is difficult to manage with the current tools of planning. This may require anticipating the complexity of uncertainty by imagining the future through scenarios, relied on the comparative analysis of exploratory meta-projects stage.

To carry out this operation, the method of the *"Scenarios' Evaluation by Design"* (Sebd) (Di Giulio, et al., 2018) has been applied. *Sebd* is a technique of planning of territorial and infrastructural systems related to the modification of the landscape and the environment. Its main objective is the *ex ante* evaluation of strategic guidelines in order to influence choices in contexts with a high degree of uncertainty related to medium to long-term time horizons (respectively 2050 and 2100 in the featured case studies).

In doing so, firstly the risks to which the territory is subject, mostly hydro-geological, have been analyzed. Subsequently, a summary framework has been developed, referring both to the current condition and to a future scenario, and based on forecasts of climate change phenomena based on RCP8.5 (IPCC; 2015). Therefore three strategic hypotheses of territorial planning are delineated - one *extremely dynamic (2100)*, the other *extremely rigid (2100)* and an *intermediate between the two (2050)* - to propose possible structural responses to the need of the territory to adapt to risks and pressures to which it is and will be subjected.[52]

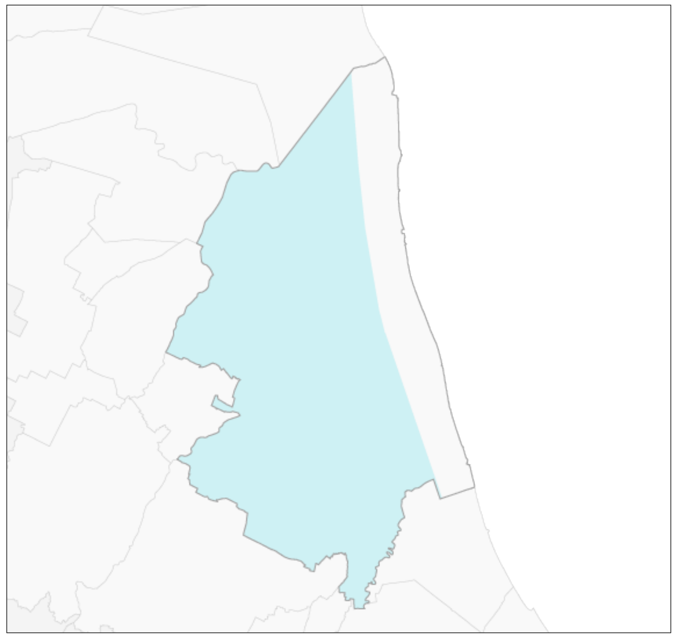
Referring to the guidelines formulated in the general strategy to 2050, this methodology addresses the *adaptation strategies* at territorial scale. For global sea level rise forecasts, reference data shall be based on studies from the *Fifth IPCC Assessment Report* (2015) with time reference to 2100. These forecasts have been translated at a regional scale by ENEA (ENEA, 2018), which estimated how many and which areas will be below sea level and which are at risk of sea ingression (Perini, et al., 2018) (Antonioli, 2016) (Presti, 2018).

For climate data, *Climate Projection Data Sheets 2021-2050* (Tab. 37) have been produced for homogeneous areas in the Emilia-Romagna Region as part of the *Regional Strategy for Mitigation and Adaptation to Climate Change*, together with the *ARPAE Climate Observatory* and *ART-ER*.

The scientific landmark on hydrogeological context referes to research developed by I.G.R.G. (Integrated Geoscience Research Group) of University of Bologna set in Ravenna (Mollema, et al., 2010) (Antonellini, et al., 2010) (Barbarella, et al., 2012) (Greggio, et al., 2012) (Cozzolino, et al., 2017) (Antonellini, et al., 2019), as well as Umberto Simeoni (Simeoni, et al. 2002) (Simeoni, 2004) and Alessandro Bondesan (Bondesan, 2019).

[52] Thereafter, specific adaptation measures are elaborated in in areas more circumscribed by the dimensional or thematic point: northern coastal site, southern coastal and retro-coastal ambitus, rural inner area.

PIANURA EST



INDICATORE	DEFINIZIONE	VALORE CLIMATICO DI RIFERIMENTO	VALORE CLIMATICO FUTURO
TEMPERATURA MEDIA ANNUA	Media annua delle temperature medie giornaliere	12.9 C°	14.5 C°
TEMPERATURA MASSIMA ESTIVA	Valore medio delle temperature massime giornaliere registrate durante la stagione estiva	28.2 C°	31 C°
TEMPERATURA MINIMA INVERNALE	Valore medio delle temperature minime giornaliere registrate durante la stagione invernale	-0.3 C°	1.3 C°
NOTTI TROPICALI ESTIVE	Numero di notti con temperatura minima maggiore di 20 °C, registrate nella stagione estiva	8	18
ONDATE DI CALORE ESTIVE	Numero massimo di giorni consecutivi registrato durante l'estate, con temperatura massima giornaliera maggiore del 90° percentile giornaliero locale (calcolato sul periodo di riferimento 1961-1990)	3	7
PRECIPITAZIONE ANNUALE	Quantità totale di precipitazione annua	710 mm	650 mm
GIORNI SENZA PRECIPITAZIONE ESTATE	Numero massimo di giorni consecutivi senza precipitazioni durante l'estate	21	28

Tab. 37. Climate Projection Data Sheets 2021-2050 produced for homogeneous areas in the Emilia-Romagna Region as part of the Regional Strategy for Mitigation and Adaptation to Climate Change, together with the ARPAE Climate Observatory and ART-ER. In evidence the Inner rural sector. Source: Emilia Romagna Region, author reinterpretetion

Scenario's Reference
Preserving land use or accomodating geomorphological characteristics?

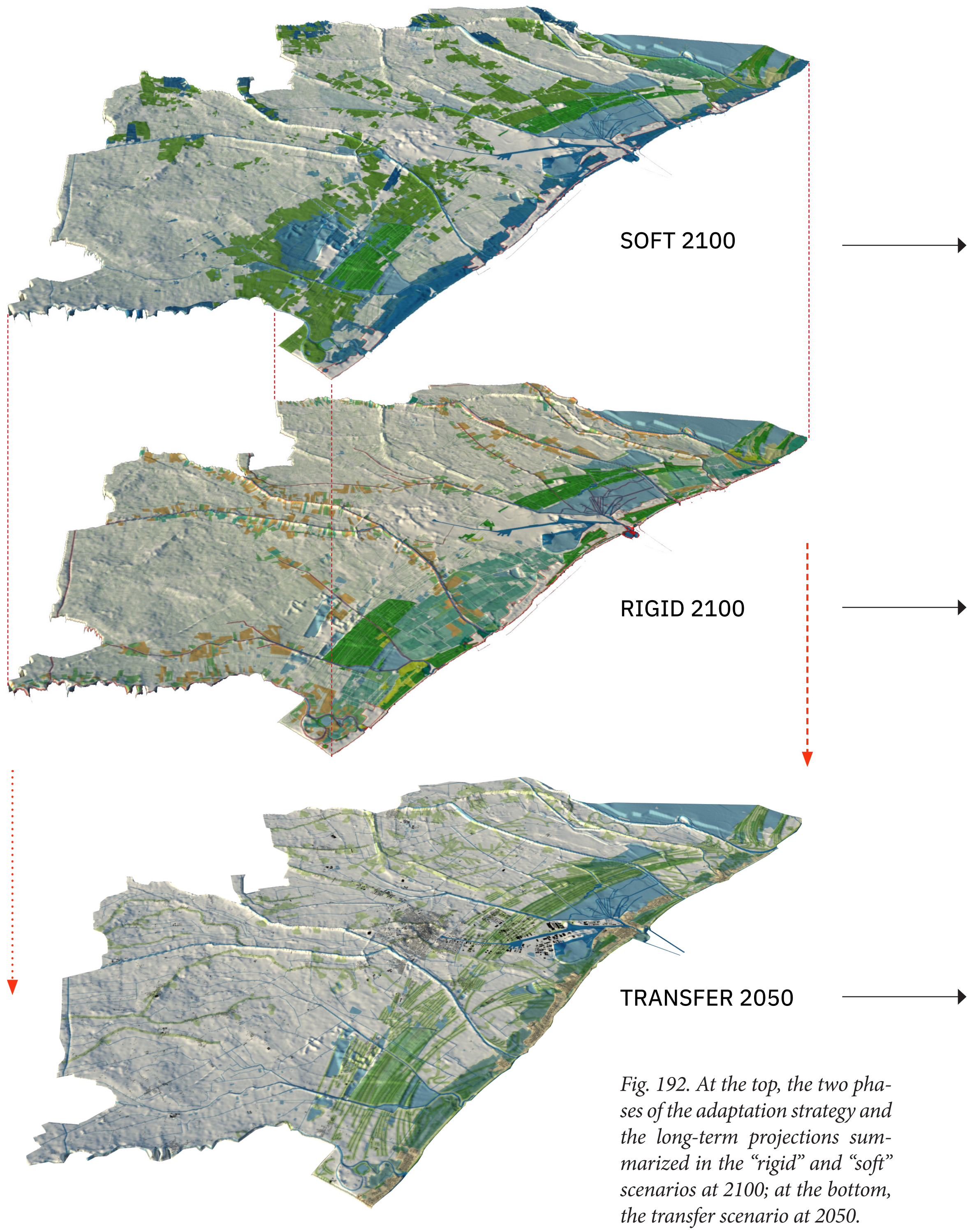
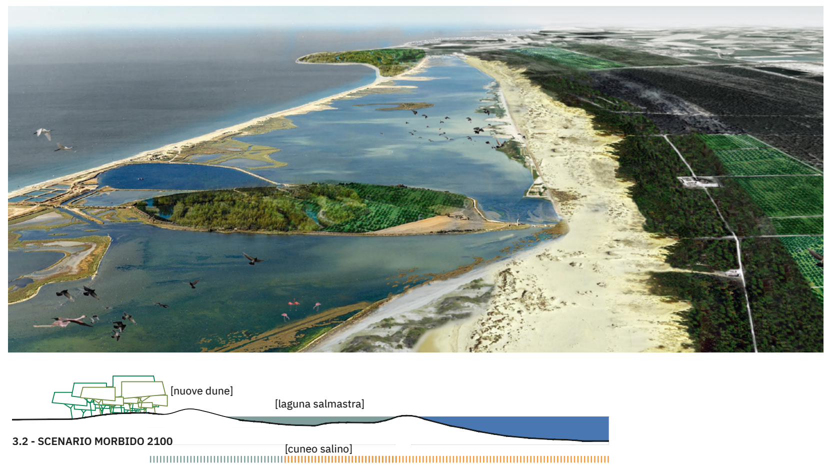
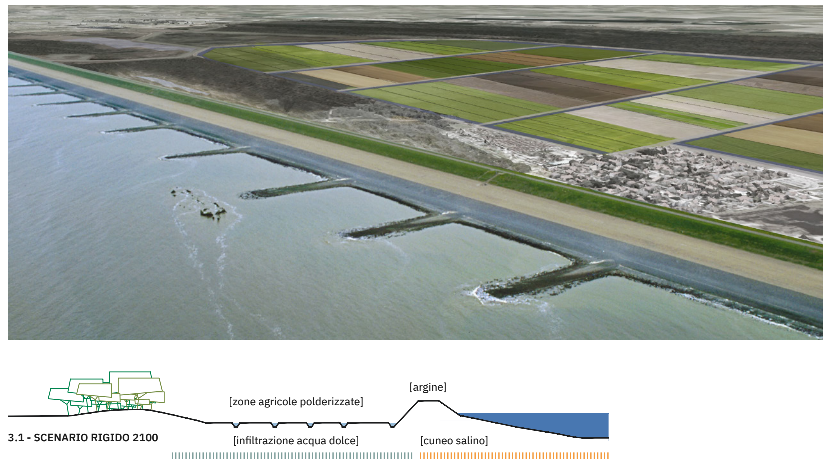


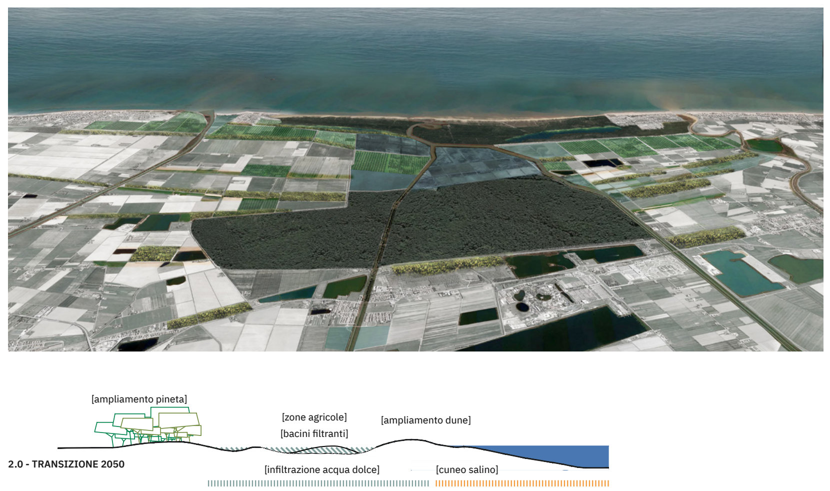
Fig. 192. At the top, the two phases of the adaptation strategy and the long-term projections summarized in the "rigid" and "soft" scenarios at 2100; at the bottom, the transfer scenario at 2050.

RIGID The priority to defend inhabited and productive areas while maintaining soil use and functionality

DYNAMIC The landscape transformations are functional to establish a new balance between human and environmental systems, by assuming geomorphology as a referential







SCENARIOS APPROACH compares the different proposals, with the main objective of making an ex ante evaluation of strategic guidelines using an approach that includes uncertainty and complexity as a design parameter.

RIGID & SOFT SCENARIOS – 2100 - allow to identify the most resilient design possibilities, for example by studying their reversibility, adaptability or the possibility of occurring in succession.

SCENARIO TRANSFER - 2050 - translates the indications that come from the comparative analysis of the single scenarios in possible planning actions and programmatic choices to develop in the short term.

THE RESULTANT SYNTHESIS allows to represent in a more direct and better communicable way to the outside the consequences and the presuppositions of some actions on the territory.

Fig. 193-194-195. Representation of the transition from transformation scenarios to local actions on study areas, here south coast. At the top, the two phases of the adaptation strategy and the long-term projections summarized in the "rigid" and "soft" scenarios at 2100; at the bottom, the transfer scenario at 2050 (south coastal focus design).

Contextual background

Ravenna is a medium-size italian city located in the east side of Emilia-Romagna region, in the Po Plain area, mostly marked by a fragile territory resulting from centuries of land reclamation and water management[53].

The territory of Ravenna is the result of a continuous process of adaptation and modification of its morphological and landscape structures through continuous soil manipulation activities. Its current configuration reflects the interaction between the natural attitude of the area to be a wetland and the anthropic transformations made along centuries by important and intense land reclamation process and infrastructural works. Over time, the achieved land reclamation led to the loss of wetlands and transitional ecosystems (reducing their dimension and morphological structure), while suffering from multiple levels of hydrogeological risks related to more common and severe climatic hazards – such as *subsidence, coastal erosion, rising of the saline wedge, hydraulic risks, woodfire*.

The most critical situation is found on the coastal strip representing the place of highest concentration of different, sometimes synchronous phenomena. Here the particularly delicate environmental and ecosystem characteristics contribute to increase the level of territorial vulnerability, which is also increased by the presence of infrastructures related to the productive sector of tourism, extremely important for the local economy.

Inland, the highest risk factors are related to the combined action of *floods* and *subsidence*, that act on the level of safety of urban areas close to waterways and on the agricultural production system. The latter, in particular, faces a series of problems that depend on the intensification of *drought* trends, and that result in serious imbalances in crop planning. Over the centuries, the progressive shift of the coast line has been matched by major hydraulic works which have involved regimentation and diversion of rivers.

The physical interpenetration between water and earth is articulated in a multitude of variations that testify as the action of the man has always been able to generate new forms of the territory, which in turn have triggered a response of continuous adaptation in the ecosystems looking for a temporary stability. Through a critical and disenchanted reading of the territory it is evident how both the aspect and the structure of this territory are subject to a constant evolution. So the relations of fixity and dynamism of its components are related to the vision and sharing of values that redefine the relationships between the parties in a logic of necessity. Visions that change in time, and with them the conformation that the territory assumes in a continuously ongoing adaptation process.

[53] With an administrative surface of 653,82 km2 Ravenna has the second largest Municipality area in Italy. Currently, this region is primarily dedicated to agriculture and industrial production, and spotted with small but densely populated urban areas, for a total of 160,000 inhabitants.

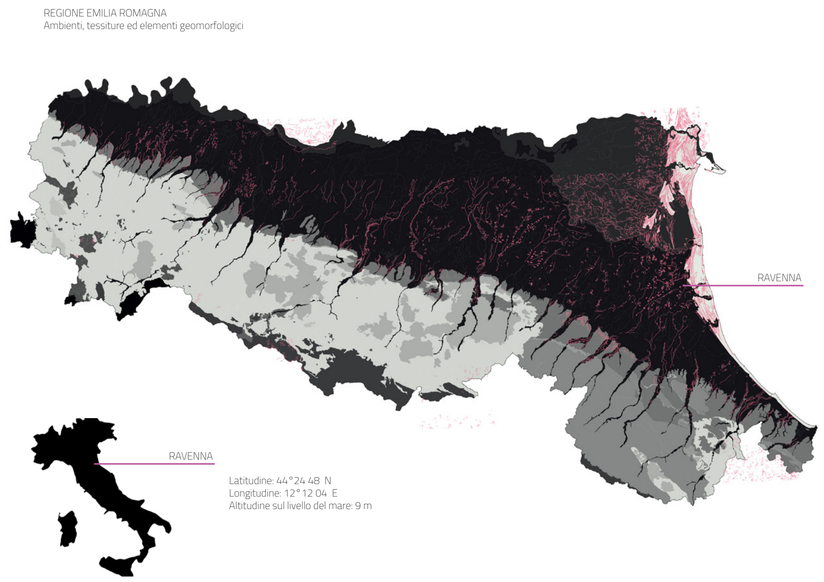
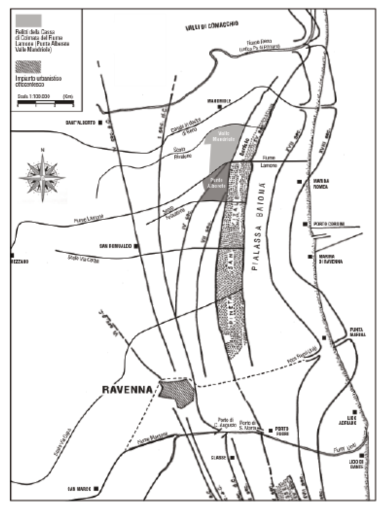
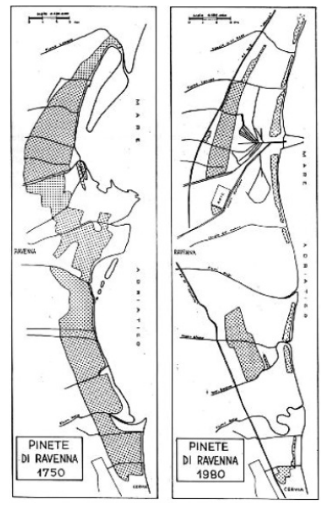


Fig. 196-197-198-199-200 In the following pages have been collected maps and historical images that trace, schematically and for exemplary cases, the evolution of the territory of Ravenna. From the top: geomorphological trace in Emilia Romagna Region drafted by the author; aerial view of Ravenna drafted by the author; pinewood evolution and agricultural transformation from 1951-2019.





Key to understanding

Infrastructure and *land use policies* are the most significative agents of landscape organisation. They have led to a re-arrangement of the whole hydrogeological system, which is reflected in a major transformation of soil. This situation determines the establishing of some environmental degradation dynamics caused by the mismatch between *soil aptitude* and *land use*.

On one hand the control and maintenance works of these systems make up a complex infrastructure framework that determines the forms of the territory and ensures its functionality. On the other hand, the development of new techniques of reclamation and water management has led to a progressive *crystallization* of the landscape according to agriculture and urban growth also linked to tourism.

What used to be an extremely dynamic landscape - in which the different ecosystems penetrated generating areas of particular instability - in a short time has undergone a very clear subdivision accentuated by the *conservation policies* and the *territorial zoning*. In this way, it was possible to preserve many of the ancient systems, but they have lost much of the resilience inherent in their being dynamic and changing environments. Traces of these dynamics remain in the territory and can be read through the lens of *geomorphology* (Fig. 204-206). Geomorphology constrains the water gravitational behaviour, in relationship with *topographic asset* and *soil texture*. Paradoxically, this tendency to the stiffening of the territory – which is consequent to make cultivable and productive areas lie on ancient river beds or ancient coastal areas – brings to the lack of correspondence between *soil attitudes* and *land use*.

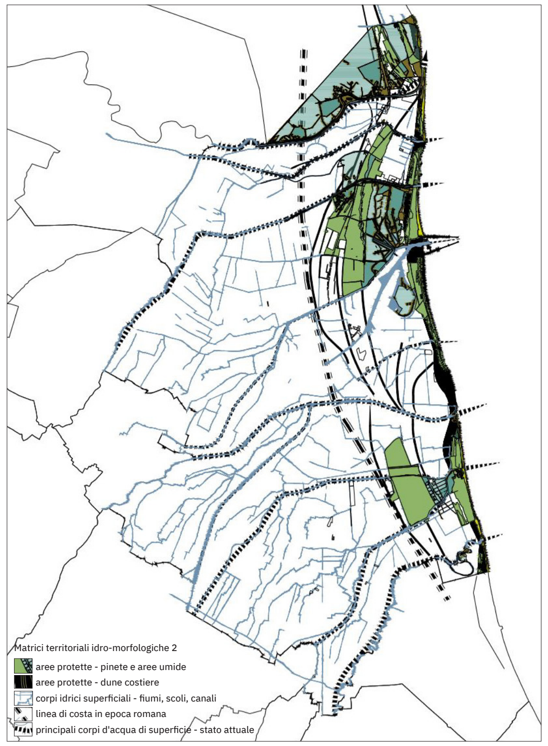
The result is a real increase in the risk and fragility of the landscape, a greater exposure to extreme events and a growing difficulty in reconciling the productive activities that have shaped this territory with the climate changes that affect its future layout. In this regard, the research bases its hypotheses and proposals on a critical reading of the components characterizing the *soil*, both on *surface* and in *depth*, seeking in the interaction between environmental infrastructure and land attitudes the main responses to the consistency or sustainability of project actions.

By referring to soil as a palimpsest, hydrogeological and geomorphological territorial matrix represents a *key of understanding* for a vision of coexistence with natural phenomena in anthropic context. For the definition of strategies on a large scale, two transformational hypotheses have been imagined that refer respectively to a very rigid and very dynamic set-up (Fig. 202-205). In the medium term and for more localized strategies a combination of the two was found, presented in the next paragraph.

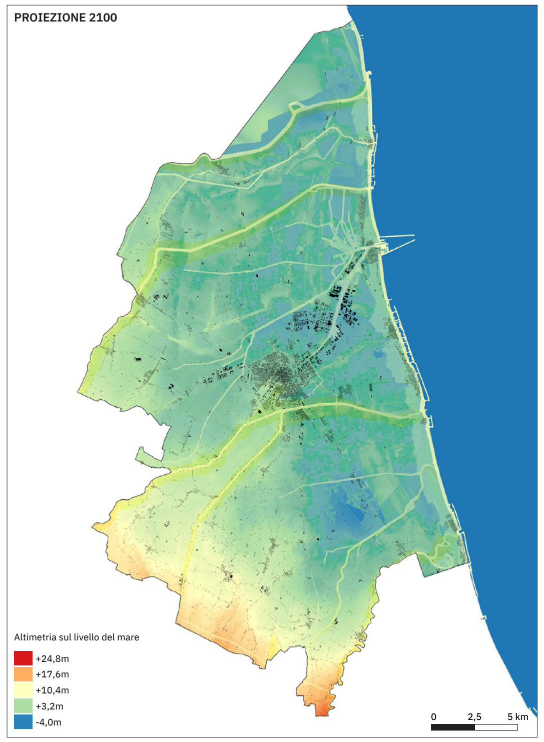
Key to understanding

HYDROGEOLOGICAL AND GEOMORPHOLOGICAL TERRITORIAL MATRICES

REFERENCE RIGID SCENARIO



HYDROGEO. EVOLUTION
- SURFACE -



DTM 2100
- RIGID-

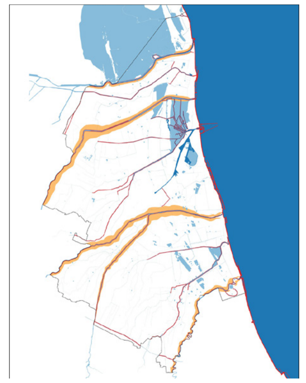
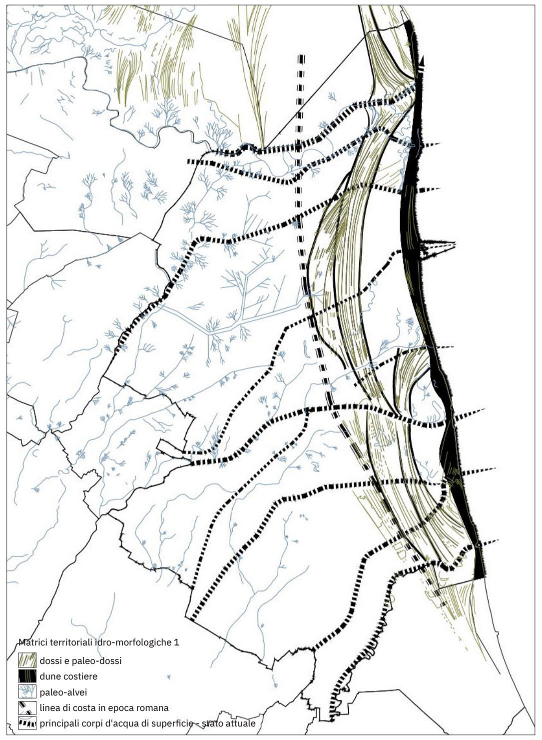
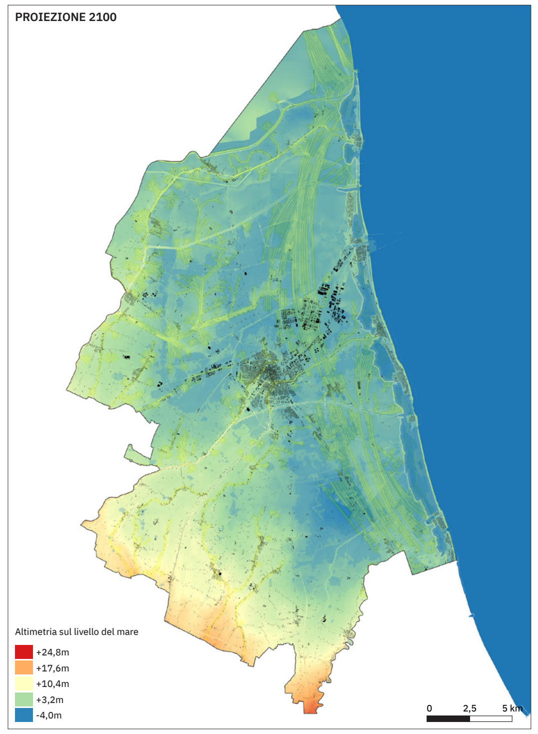


Fig. 201-202-203. In evidence surface water bodies (rivers, drains, canals), protected areas (pine forests, dunes, wetlands) falling within the main areas of geomorphological evolution, the coastline in Roman times. source: SECAP Ravenna 2020

REFERENCE DYNAMIC SCENARIO



HYDROGEO. EVOLUTION
- UNDERGROUND -



DTM 2100
- DYAMIC-

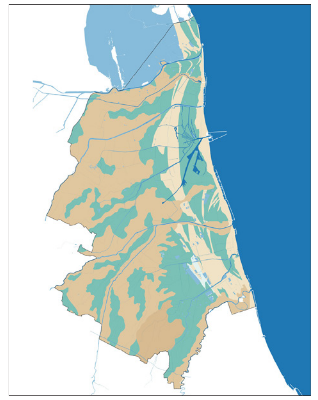


Fig. 204-205-206. In evidence geomorphological carachteristics, topography and soil texture. source: SECAP Ravenna 2020

RCP8.5 EFFECTS SIMULATION +57cm SEA L. RISE

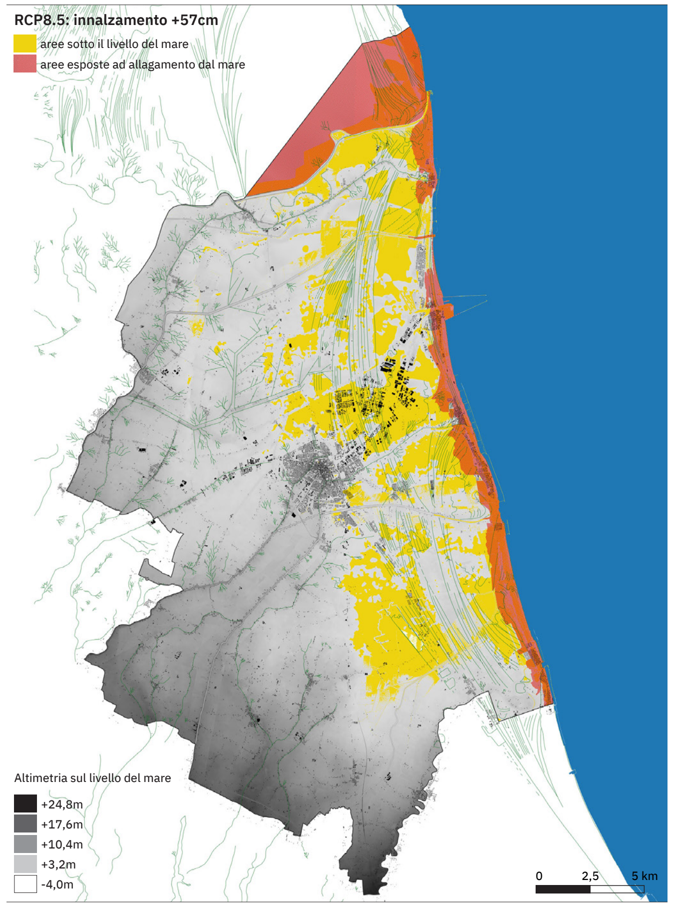


Fig. 207. Sea level rise +57 cm effect simulation, RCP 8.5.

224 SqKm of territory will be depressed compared to the current 72 Sqmq

Estimated coastline regression between 500m and 1km

SCENARIO 2100 - RIGID / CONSERVATIVE

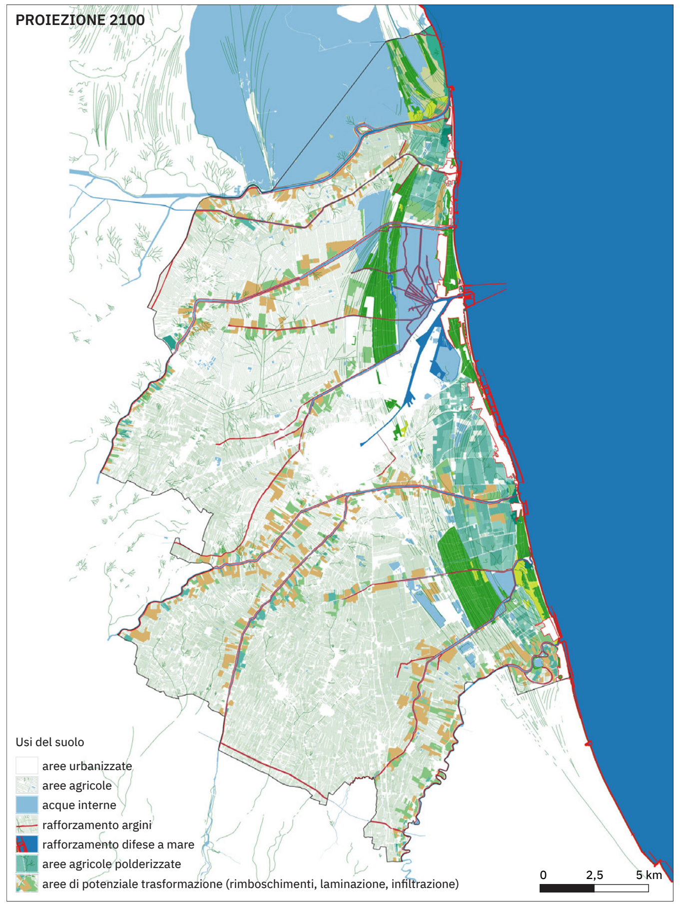


Fig. 208. Rigid-conservative Scenario 2100, territorial plan.

Maintaining current use and functionality of the soil

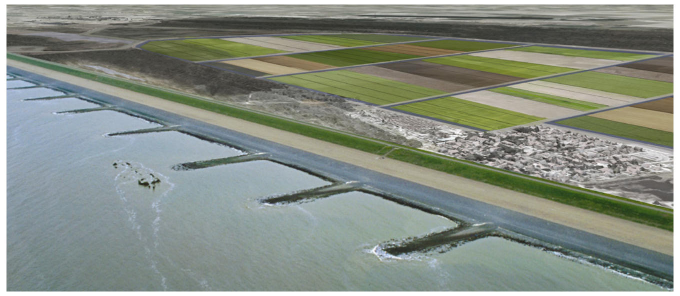


Fig. 193. Rigid-conservative Scenario 2100, south coastal design focus.

Fig. 211. Rigid-conservative Scenario 2100, northern coastal design focus.

SCENARIO 2100 - DYNAMIC / EVOLUTIVE

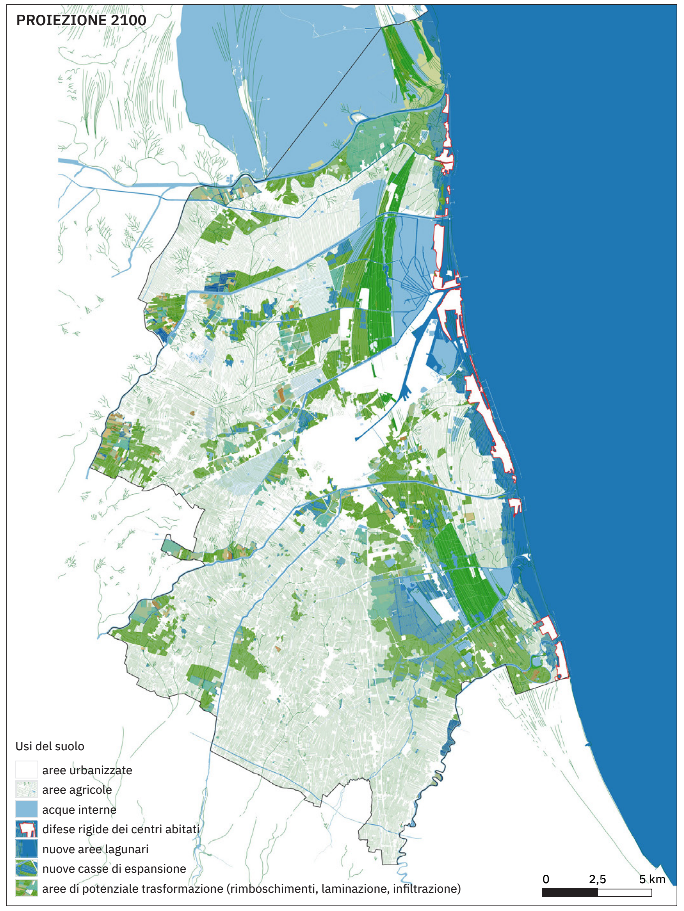


Fig. 209. Dynamic-evolutive Scenario 2100, territorial plan.

Establish a new balance without conservation restrictions

Fig. 194. Dynamic-evolutive Scenario 2100, south coastal design focus.

Fig. 212. Dynamic-evolutive Scenario 2100, northern coastal design focus.

SCENARIO 2050 - TRANSFER

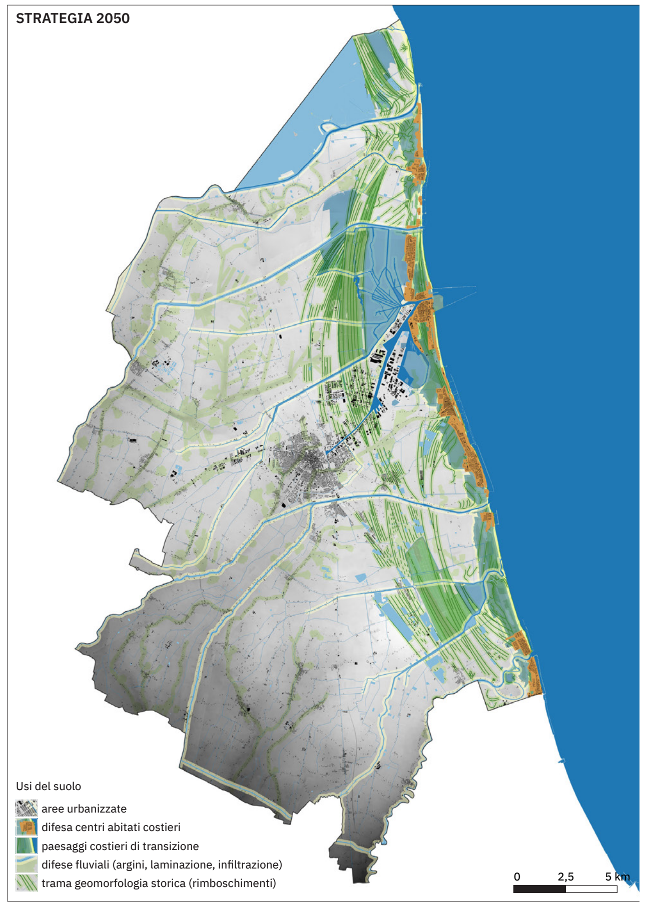


Fig. 210. Scenario transfer 2050, territorial plan.

Two active defensive systems placed on geomorphological

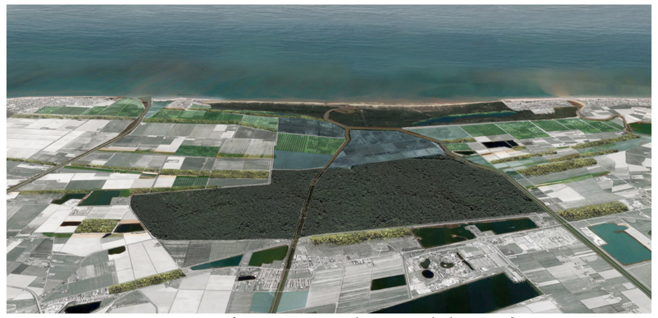


Fig. 195. Scenario transfer 2050, south coastal design focus.

Fig. 213. Scenario transfer 2050, northern coastal design focus.

Scenarios and forecasting

In order to visualize climate change effects in the territory of Ravenna, a cartographic GIS simulation has been drafted. It is based on the IPCC forecast RCP8.5 wich foresees a raise in the sea level of +57cm projected at 2100 (Fig. 207). As we have seen also from the cartography presented in the previous pages, the realization of this forecast will imply the exacerbation of a series of risks to which the territory is already exposed:

1. The *floods frequency* and impact on the coast will seriously endanger the inhabited areas and tourist activities;
2. The pine forests, naturalistic protected areas and backwater agricultural fields will be greatly affected by the *saline wedge intrusion*, accentuated by the greater difference between the level of ground deposits and that of the raised sea level:
3. The sea level rise will reduce the water gradient and consequently the outflow of fresh water to the sea will be more difficult - seriously affecting the rivers, drainage channels and dynamic water exchange systems with the sea;
4. In case of heavy rainfall, the drainage capacity of the water system will be much lower and will result in a higher probability of flooding in the agricultural and inhabited areas of the hinterland;

In the light of these considerations, another variable taken into account to generate scenarios concerns the outlook for landscape and territorial planning towards which Ravenna could potentially aim in the future. Two alternatives have been identified which synthesize very different approaches to adaptation. The interaction of these two alternatives with RCP8.5 forecasts generated the two reference scenarios to 2100 which are set out in detail below.

DYNAMIC 2100 - In the dynamic / evolutionary scenario (Fig. 193-208-211), the transformation of the landscape serves to establish a new balance between human and environmental systems without conservative limitations. The proposed structure is based on the selection of areas with the greatest potential problems in terms of flooding, salinisation and subsidence. Along these areas is suggested an incremental coastal retreat, which can progress towards low impact agricultural and hydrocultural production combined with extensive wetland and wooded ecosystems. Through such operations, territory resilience with respect to the risks is reached relying on the historical structures of the landscape geomorphology, minimizing the intervention on the anthropogenic infrastructures of defence. The protection of the inhabited centers exposed to the storm surges or floods is obtained through the development of buffer zones able to absorb the impact functioning like defence ecosystems and transition between urbanized and rural territory. Depending on the composition of the soil and the topography, these areas will assume the function of infiltration and recharge of the aquifers, or rolling basins.

RIGID 2100 - In the rigid / conservative scenario (Fig. 194-209-212) the priority is to defend the inhabited centers and the productive areas, while maintaining *use* and *anthropic functionality* of the soil. This objective can be achieved by concentrating adaptation actions in the proximity of defence systems. This will result in the strengthening and raising of sea barriers and river banks, and in the strengthening of the reclamation water mechanical drainage system. The hydraulic section of rivers should be increased and integrated with adjacent water storage areas. Along the coast line, it will be necessary to develop a defence system - from *storm surges, floods* and the *saline wedge intrusion* - composed of dams and a network of channels interconnected with artificially drained areas according to the classic *polder* pattern. By preserving the agricultural use, the retro-coastal areas will need a water system able to provide fresh water against the salt wedge and to drain the depressed areas by means of water-pumps.

In order to face the risk of flooding, some featured areas have been identified. In the hinterland, they have been located within the river buffer strips on which it will be necessary to intervene with new embankments and lamination basins. It's a very energy-intensive scenario.

TRANSFER 2050 – The 2050 landscape scenario (Fig. 195-210-213) is an intermediate step, that envisions the reduction of risks and at once prepare the field for further adaptation actions that can equally evolve in both directions - *rigid* and *dynamic* - at 2100. This operation involves the isolation of areas most sensitive to the phenomena of degradation related to climate change. For these sites, the assumptions made in the two scenarios at 2100 are in some cases coincident (such as the defence of inhabited centers), while in others totally opposite (i.e. the management of coastal farming areas and coastal environmental systems, such as pine forests, are implemented differently). Concretely, this approach is realized in the territory of Ravenna with the location of two main systems that we could define as actively defensive. The former corresponds to the first coastal strip in respect to the areas directly affected by the *sea level rise* and the *salt wedge intrusion*. Here the primary need is to strengthen dune systems and bring fresh water close to the coast to stop *soil desertification* and *habitat degradation*. This solution, in perspective, is functional both to the formation of wetland systems advocated by the dynamic scenario, and to the polderization assumed in the rigid one. The *second defensive device,* more backward, leans to the topography articulating in part along the existing water network and in part along the traces of the ancient coastal cords or reclamation works by filling carried out in the past centuries. The result is a plot within which the areas of *water storage*, *lamination* and *infiltration* can then be implemented alternatively in the form of particularly depressed zone, less productive agriculture field, or of naturalistic and ecosystems protection areas - depending on whether you decide to tend towards, the rigid or dynamic scenario respectively.

Crossing scale

Crossing layers

ORIENTING DECISION → **STRATEGIC OUTLINES**

1. ANALYSIS | MAPPING OVERLAY & INTERPOLATION | POSSIBILITIES AND LIMITS

Reference patterns outline This analysis is based on studies on the geomorphology of sites, soil, water management, on the ecological and settlement endowments of a given context to understand the relations between the various components depending on its ability to react to a certain external stress with the objective to trace of the opportunities of participation translated in the form of a project proposal.

Integrated risks and pressures outline To understand the factors to be taken into account in defining strategies and actions project, have been examined several cartographies that they trace both a description of the current state and the present risks, and a series of addresses and prescriptions that interest you on a municipal and regional scale.

S1. Inhabited areas protection
S3. Dune system extension
S4. Geomorphological matrix reinforcement
S5. Hydraulic connection upgrading

ANALYSIS
- to a description of the areas follows the analysis of risks and geomorphological characteristics;
- the main cartographic references examined are identified and then condensed into two aggregated readings that describe the territorial patterns and critical factors;

SYNTHESIS
- on the basis of these analysis, is deepen the transition landscape to 2050 to which short-term adaptation actions correspond;
- finally it is suggested the potential impact of these on the reduction of risk and of environmental degradation phenomena through a renewd spatial arrangement.

1. VOCATION

Linking soil to vocation and susceptibility

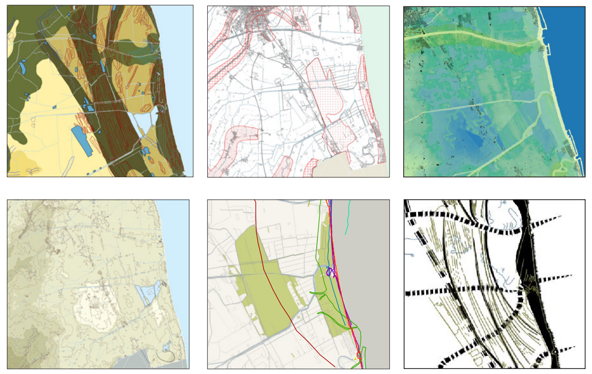


Fig. 214. Soil vocation, cartographic survey.

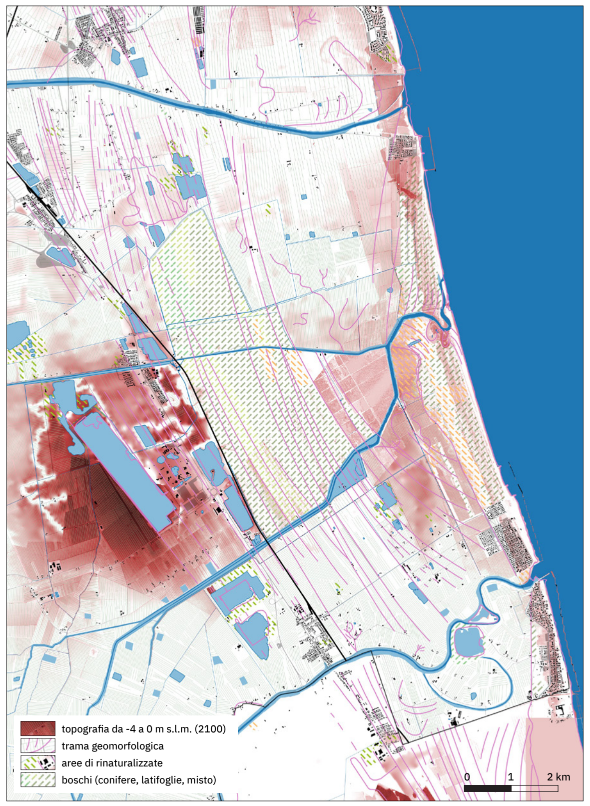


Fig. 215. Soil vocation analysis, "Reference pattern sysnthesis".

2. PRESSURES

Linking soil to risks, stress and hazards

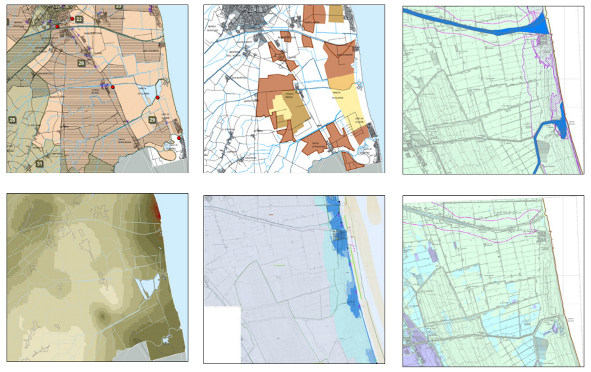


Fig. 216. Soil pressures, cartographic survey.

Fig. 217. Soil pressure analysis, "Integrated risks interpretation".

3. OPPORTUNITY

Linking soil to possibilities and limits

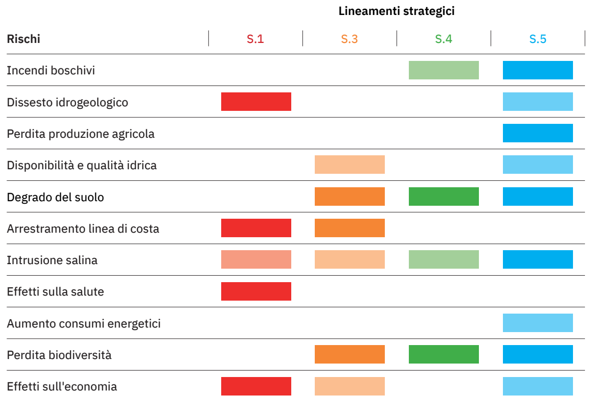


Fig. 218. Scenario transfer 2050, strategic outline.

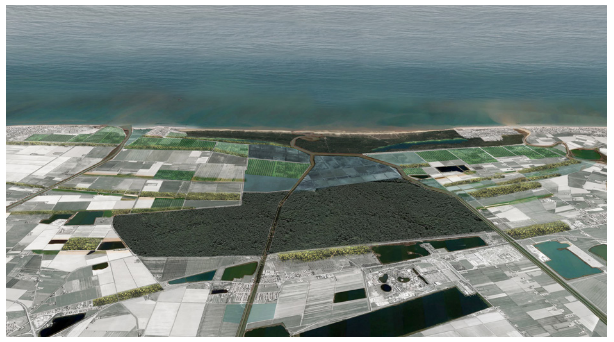


Fig. 195. Scenario transfer 2050, south coastal design focus.

Fig. 219. Scenario transfer 2050, south coastal design focus.

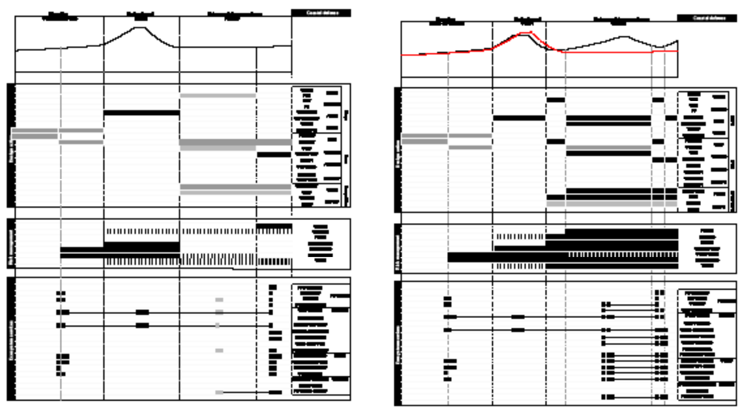
Resetting spatiality

TRANSITION LANDSCAPE 2050

The short-to-medium-term strategy foresees 4 types of strategic outlines that can be credibly developed in the next 30 years in order to contrast the climate trends already in agoing and to prepare the territory for the successive adaptations measures.

STRATEGIC OUTLINE

S1. Inhabited areas protection o
S3. Dune system extension
S4. Geomorphological matrix reinforce
S5. Hydraulic connection upgrading



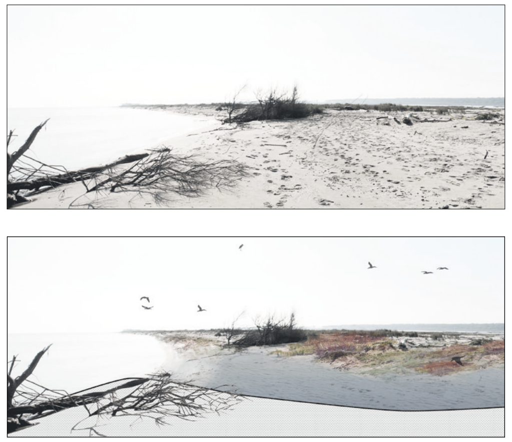


Fig. 221-222. Spreading a river, actual state and design simulation.

Fig. 223-224. Dynamic shoreline stabilization, actual state and design simulation.

Fig. 152-153. Grafting infrastructure, actual state and design simulation.

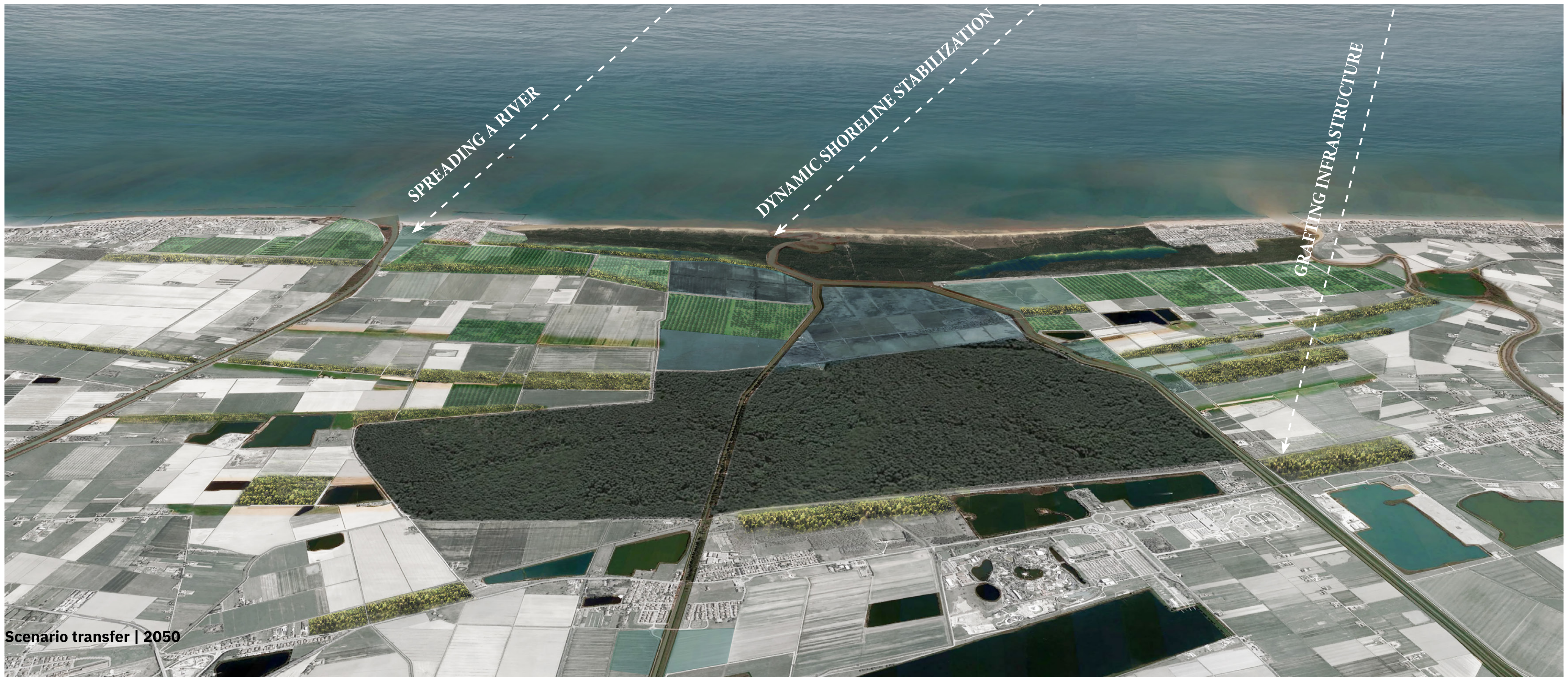


Fig. 195. Scenario transfer 2050, south coastal design focus.

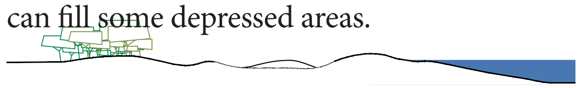
Shaping actions

S1. Inhabited areas protection — inhabited areas will be made safe from the phenomena of coastal retreat and from the river flooding risk connected with the sea level rise. It will be necessary to progressively develop around inhabited areas a new topography able to effectively function as a barrier against extreme events.

S3. Dune system extension - it provides a resilient protection against storm surges and to contrast saline intrusion taking advantage of the intrinsic ability of the dune system to encourage the formation of fresh water lenses. In order to effectively restore these dynamics, it is necessary to increase the thickness of the dune cord by providing for the retreat of the coastal pine forest, especially in the most degraded areas, which are also more exposed to fire.

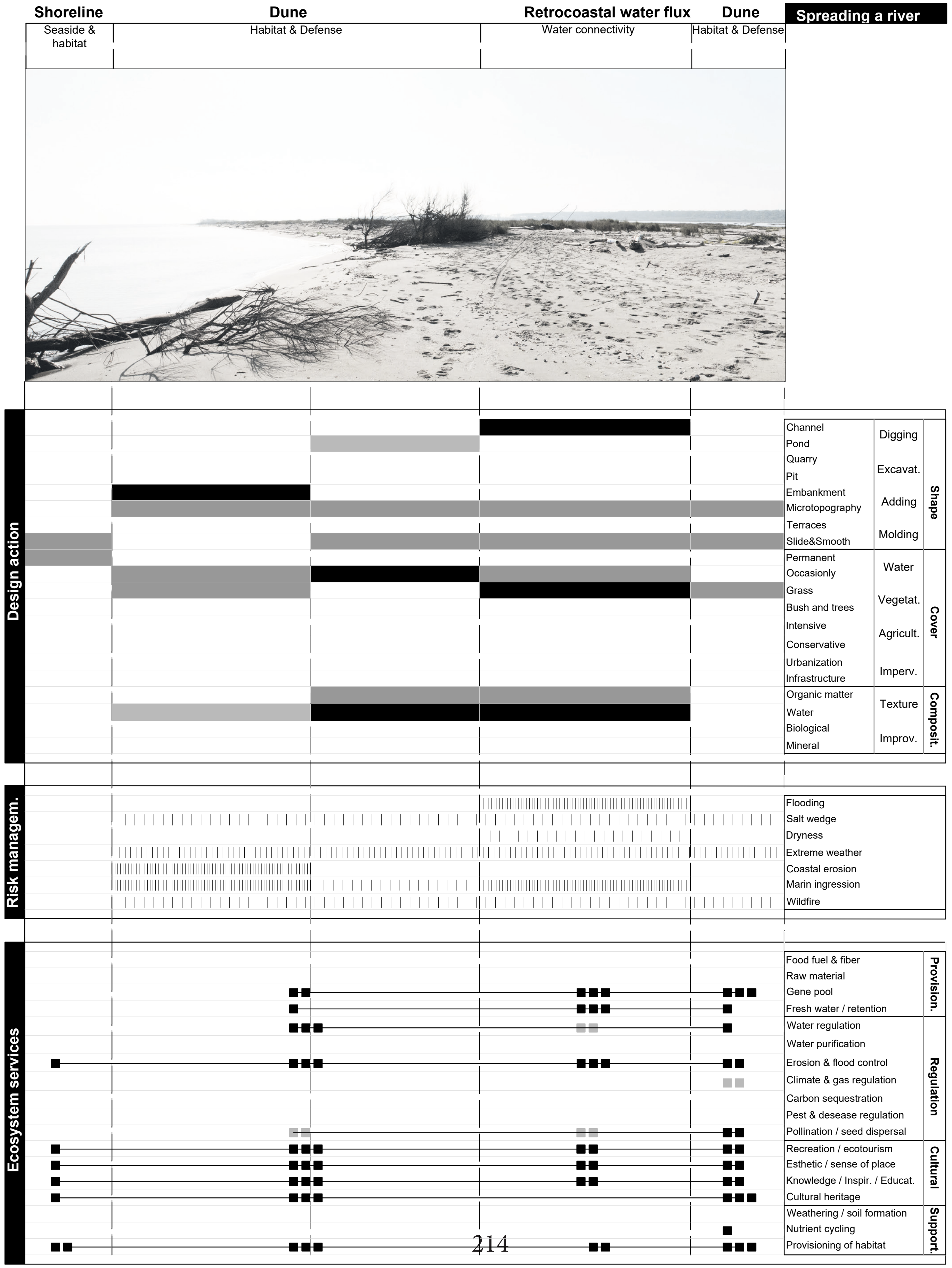
S4. Geomorphological matrix reinforce — consolidate the main geomorphological structures focusing on the ancient coastal cords and paleodunes that underlie the inner pinewoods and other areas currently occupied by agriculture. The development of less erosive farming practices, topographical reconstruction and targeted afforestation, brings to the creation of a new large-scale environmental infrastructure which, in addition to serving as an ecological network, lays the groundwork for implementing a second defensive line further inland.

S5. Hydraulic connection upgrading — buffer zone between the pinewood and the coastal strip, developing a system of temporary fresh water accumulation and infiltration zones. It works as a barrier against saline intrusion and as a lamination zone in case of floods, reducing related risks by improving soil health and surface aquifer recharge. Through the implementation of canals network, the water excess will flow towards further floodable areas that - depending on the permeability of the soil - may evolve towards different ecosystems and productive zones. The solid material carried by rivers can fill some depressed areas.



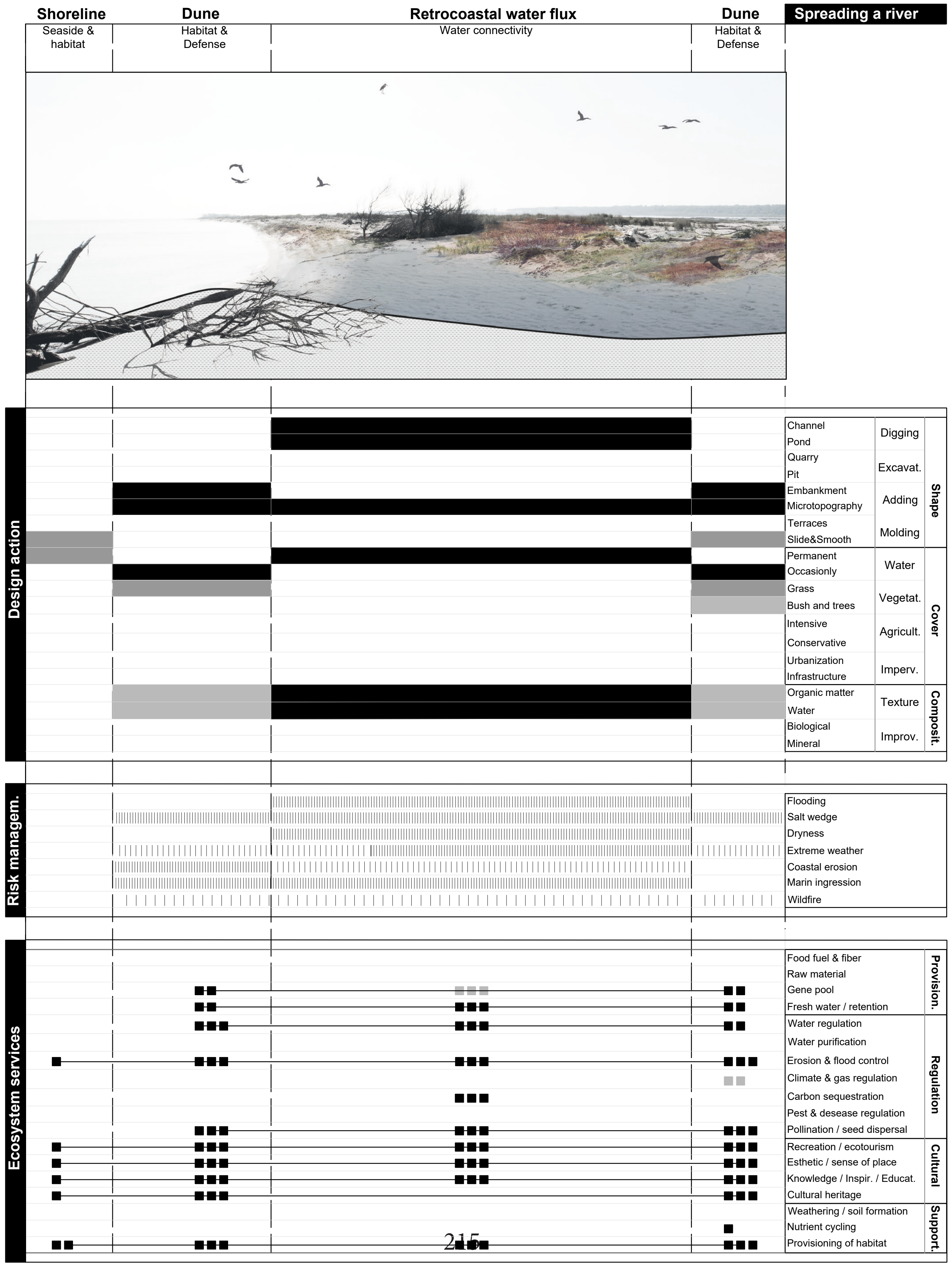
Spreading a river

CURRENT STATE AFFECTED BY EROSION, FLOOD, DRYNESS, SALINE WEDGE, MARINE INGRESSION



Tab. 38-39. Proposal of adaptation measures for spreading a river mouth in a protected area, through an hybrid approach that combines "hard" and "soft" intervention. The current situation is compared with that of the project, through the matrix used in chapter 3, linking proposed interventions in taxonomy, risk management, ecosystem services provided by soil. Source: SECAP RAVENNA 2020

PROPOSED ADAPATATION MEASURES - *HYBRID APPROACH*

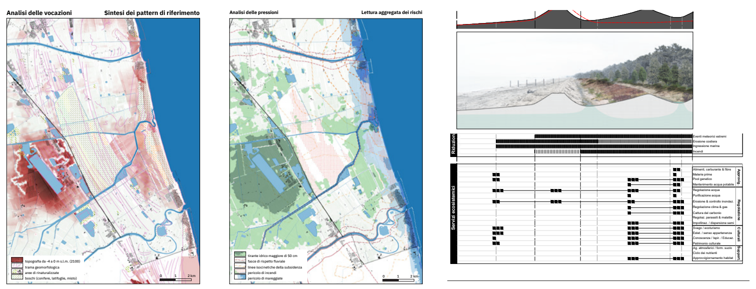


4.3 Drawing results: achievements, boundary, advancements

The operative design procedure undertaken by the proposed case studies underlines the potentials of applying soil as a palimpsest as the most suitable medium to order complex territorial processes over time and scale. With this in mind, SECAP's strategy represents an important step in the articulation of soil transformations as a primer in landscape design praxis.
From every point of view it represents an advanced model for the experimentation and application of an approach transferable and applicable to similar contexts.
Furthermore, the re-thinking and re-framing of soil as palimpsest – starting from the adaptation of existing conditions and policies - can contribute to the debate on territorial resilience strategies by combining anthropic and environmental dynamic processes with (a) the territorial's structure reformulation and its necessity to be upgraded facing risks and criticalities, (b) the requirement of sustainable land management and (c) the demand for infrastructures supporting human activities.

ACHIEVEMENT	
1. DESIGN & PLANNING	Replicability in similar context Connecting territorial & design scale Soil as design & planning element
2. METHOD	Replicability in similar context Connecting territorial & design scale Soil as design & planning element Useful step-path
3. THRESHOLD	Overcoming the zenithal & cartesian approach New design parameters

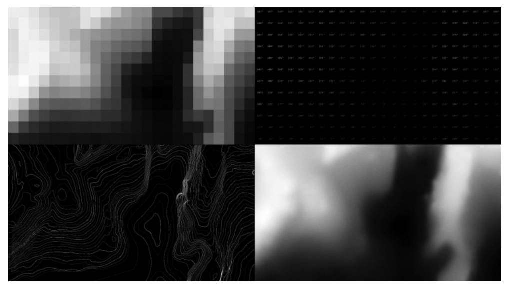
Tab. 40. Achievements. source: author



The method has to be set up through its implementation on more case studies in order to develop a wider and more comprehensive relationship with other disciplines and the evolving legislative framework. On the other hand, a limitation is represented by the lack of sufficiently clear definition about soil data resolution in order to deepen the level of design.
Such a requirement did not occur mostly because data concerning soil are not yet widespread and open at a sufficiently detailed scale.
In order to be able to carry out concrete actions in this case study, it is necessary to have a more detailed and localized study on topography, soil composition and ecosystems. In combination with parametric programs, the interpolation of data could bring to design implementation and more effective and realistic forecasting in territorial transformation.

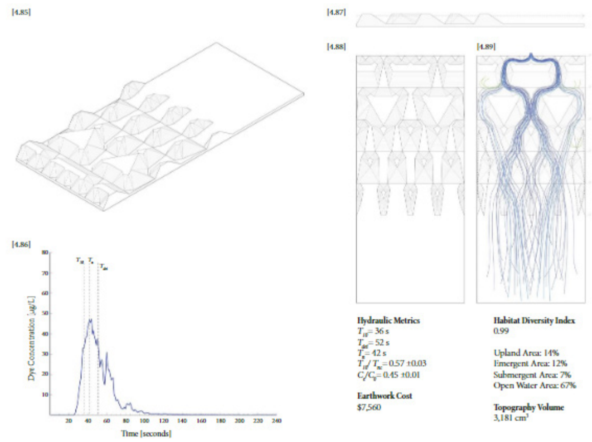
BOUNDARY	
1. DESIGN & PLANNING	Required a good level-experienced in landscape design & planning Capability to relate with other disciplines
2. METHOD	Verification on more case studies Necessity to be wider and more comprehensive Implementation in data collection
3. THRESHOLD	Datas resolution Datas collection Tools & Skills

Tab. 41. Boundary. source: author



ADVANCEMENT	
1. DESIGN & PLANNING	Parametric & Modelling Interpolation
2. METHOD	Implementation in data collection More integration with tools, softwares & disciplines
3. THRESHOLD	Datas resolution Datas collection Tools & Skills

Tab. 42. Advancement, source: author



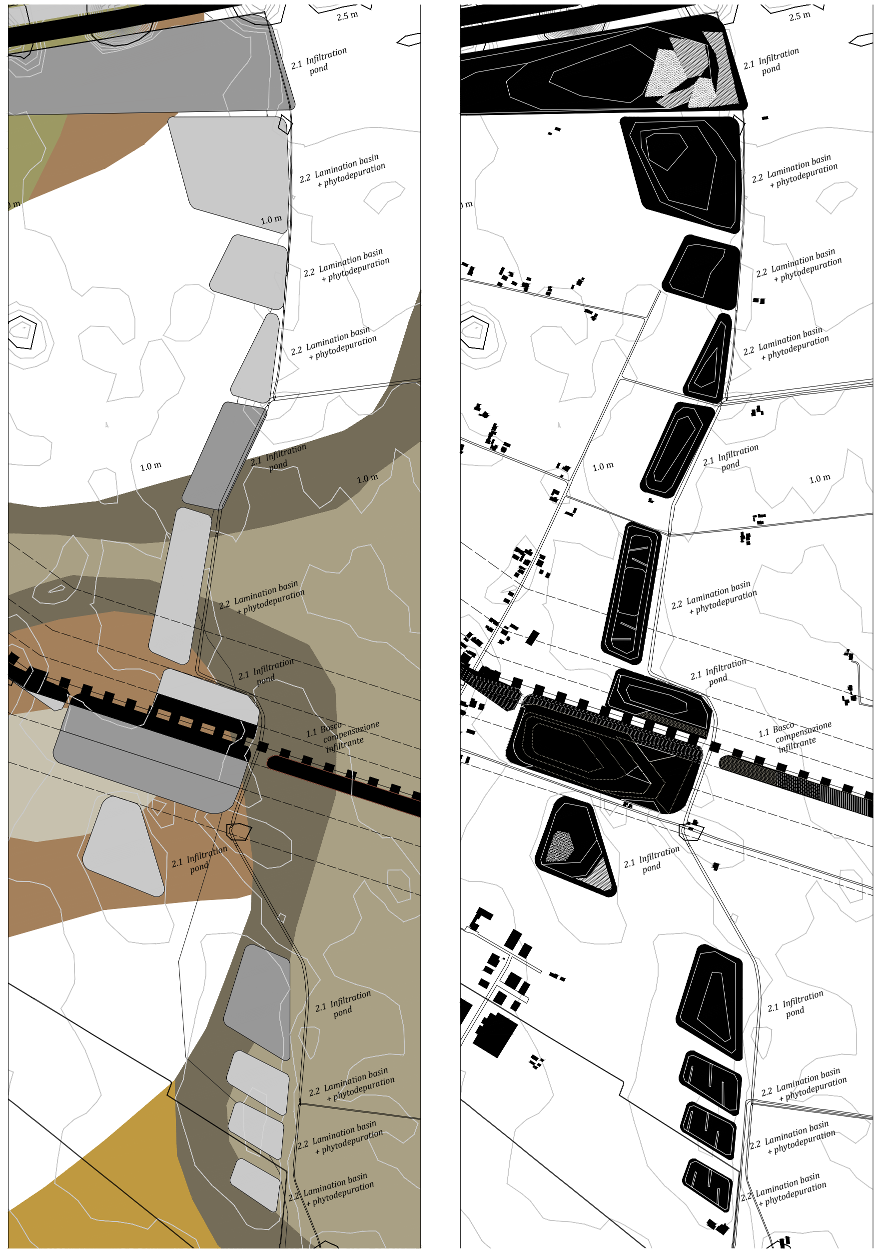


Fig. 220. Grafting infrastructure, studies for the integrate water management ponds along a water channel in rural context, Mezzano, Ravenna. source: author

The main question is how research could emerge through design and new knowledge can be harvested using methodologies and processes of designing.

(Roggema, 2017)

Chapter 5

Discussion and conclusion

Chapter 5. provides an outline of the general discussion and conclusions of the thesis. This final chapter thus breaks the debate down into several sections. The first part analyses the results, general conclusions, open discussion and research follow-up of the work, through a comparison between the *theoretical* and *practical* aspects in landscape design field. The second section examines the integration with cross-breeding transdisciplinarity for its further implementation on landscape design and territorial planning. Finally, last section moves forward perspective, pending issues and further research applications which have been carried out in the last period. In the light of these experiences, it outlines the research development.

5.1 Affinities and divergencies: discussion, results, conclusions

Discussion, the "reading" and "writing" of the landscape

The study of literary sources combined with the study of concrete practical examples constitutes the basis for elaborating on the research objective and research questions towards an argued theory, which is not based on rigid consistency but on *correspondances*.

The result is not the proof of a theorem but the discovery of an unexpected point of view.

By involving *theories* and *practices*, which have so far been either juxtaposed or isolated from one another, the proposed approach breaks down the traditional dualism between *soil transformations* and the *making of landscape*.

In this sense, the *Moving Horizon approach* implicitly criticises traditional landscape practice's seemingly uncritical reproduction of stereotypical 'aestheticised' images. It is not a question of rejecting or abandoning a formal and compositional language, but rather of encouraging a view that favours investigation and observation of reality in its different stratifications offered by embedding the soil as a palimpsest in *"reading"* and *"writing"* the landscape.

Overviewing contemporary landscape design's key literature, with its abundance of imagery and voluminous language, the speculative background for advancing design, creativity, and cultural ideas in landscape architecture is most figuratively explained by the American landscaper James Corner.

Corner's theoretical and professional activities consistently negotiate between poetic imagination in landscape architecture as *cultural practice* and *ecological performance* in landscape architecture as an instrumental medium (Corner, 2011).

In the preface of *Landscape Imagination* – a collection of essays – Corner (2011) clarifies the relationship between theoretical arguments and cultural foundations with the practice of making of landscape: *"Landscape remains a profoundly imaginative project, requiring both a creative "reading" and "writing" of sites. [...] Here one might cite a movement from theory to practice, but it is more precise to recognize that both the writings and the designed works are in themselves projects, and they therefore share the same impulse: to project new possibilities for the field."*

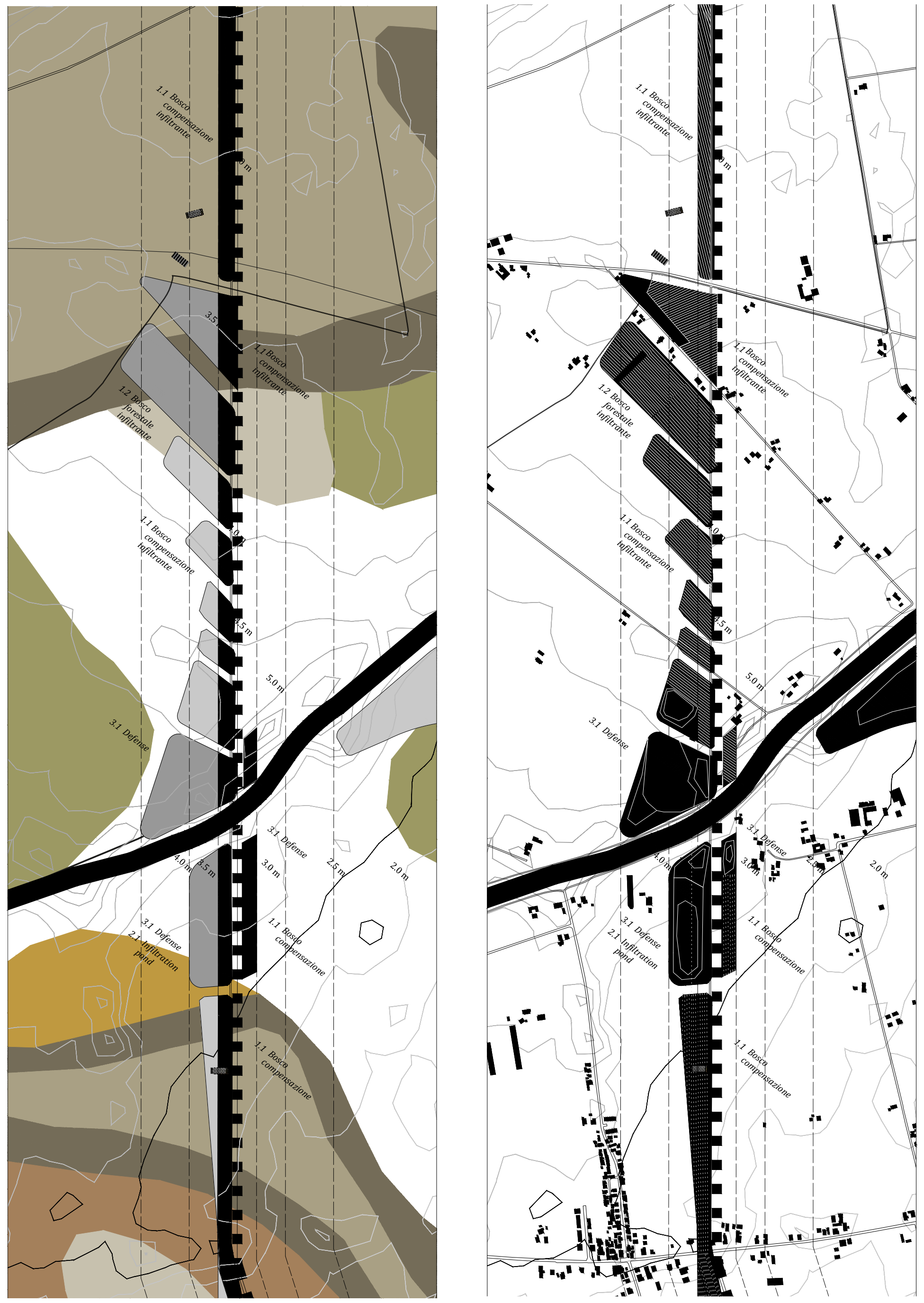


Fig. 221. Grafting infrastructure, studies for the integrate water management ponds along an high speed road in rural context, Mezzano, Ravenna. source: author

How one "images" the world literally conditions how reality is both conceptualized and shaped

James Corner
Eidetic Operations and New Landscapes

Corner's assumption evidences the gap between the speculative discipline and the professional activity – as a distortion of principles – and the defectiveness of shared cultural tools concerning the processes of landscape design praxis. For these reasons, Corner's statements seem to accommodate the inherent *affinities* and *divergencies* in a comparison between theories and practices.
Below is reported a significant passage summarizing this conceptual switch.

Most obvious might be the shift from a representational interest (how landscape mean and signify) to more instrumental practice (what landscape do and how they perform). […]
The shift towards instrumentality and pragmatism does not preclude any concern for meaning and representation, but instead suggests that meaning will best derive from use and work as opposed to some kind of passive, distance reading - the inhabited "landschaft" as distinct from the more objectified and painterly "landskip". From a design perspective, this means paying more attention to the productive and performative aspects of design, to the consequences and effects of what a design might do, and to what its agency might be in and on the world. At the same time, while earlier essays seem to be overly critical of the scenic landscape (landskip), more recent work attempts to reconcile the scenic with the performative, favouring a theatrical, stage-set approach toward the design of setting for action. Indeed, it may well be the interplay between how a setting looks and is figured in relation to the action it supports that creates the most engaging and meaningful landscape architecture.

This shift requires verious skills and a different attitude towards collaboration with other disciplines and social actors. It requires co-design methods that enable participants to contribute optimally from a disciplinary perspective as well as from a collaborative, transdisciplinary perspective, and a new *repertoire* regarding planning and design techniques, such as the representation of concepts and the use of information and communication technology (Fig. 222-223-224).
In this understanding, the connection between representation and implementation is then inseparable from the interrelation between what is given – *topography* – and what is yet to come – *design* (Fig. 222).
The mapping and visualization of data in design culture has changed both in relationship with the advancement of technology - in bringing about the possibility of greater proximity between the real and its representation – and in the way of building landscape idea. The trajectory of representation – of concept and context – has moved from the material and physical description of the *ground* toward the depiction of unseen and often immaterial fields, forces and flows (Fig. 223-224).

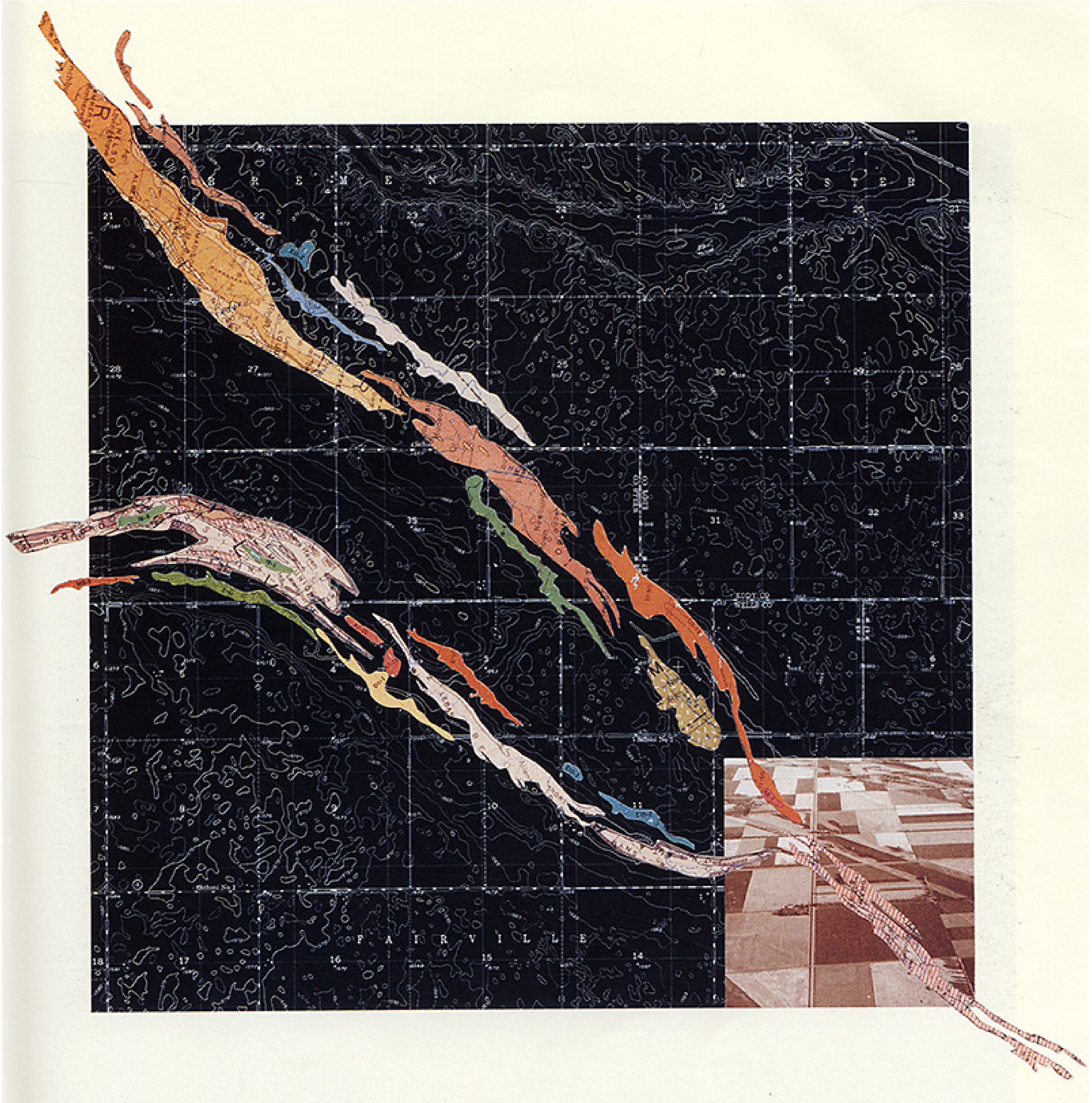


Fig. 222. Pedological Drift, Fairville, North Dakota, from "Taking measure across the American Landscape (1996)". This work best represents the essence of this shift by dissecting the form and the appearance of the American landscape as a wholly pragmatic instrumental creation, but an instrumentality that at the same time harbors poetic and significant content. author: James Corner and Alex Mac Lean.

Corner's contribution is extremely remarkable in the establishment of a reconciliation of the scenic and the performative values inherent in landscape design that involves also its depiction and representation.
I conclude with a significant passage argued in the essay *Eidetic Operations and New Landscapes* (Corner, 2011), that expresses the idea to exceed the *"retinal impression"* in landscape thinking: "*How one "images" the world literally conditions how reality is both conceptualized and shaped".*
His words applied to the subject of the present research sounds as a suggestion to conceive the soil as the medium with which to experience, understand and project the reality.

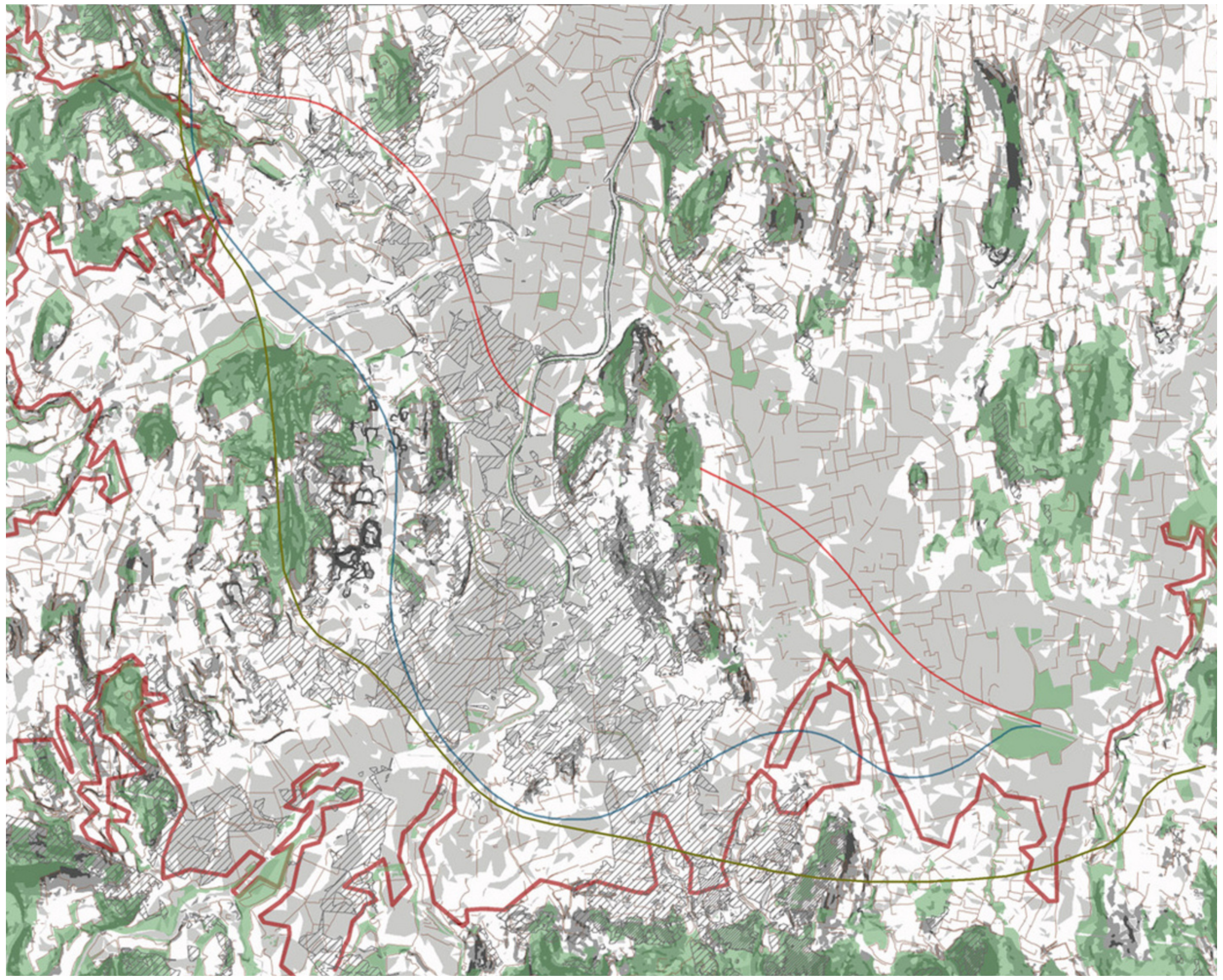


Fig. 223. Landscape attributes. Preliminary studies fora a road variant project in La Bisbal D'Empordà (Spain). author: AZ paisatge, Anna Zahonero landscaper

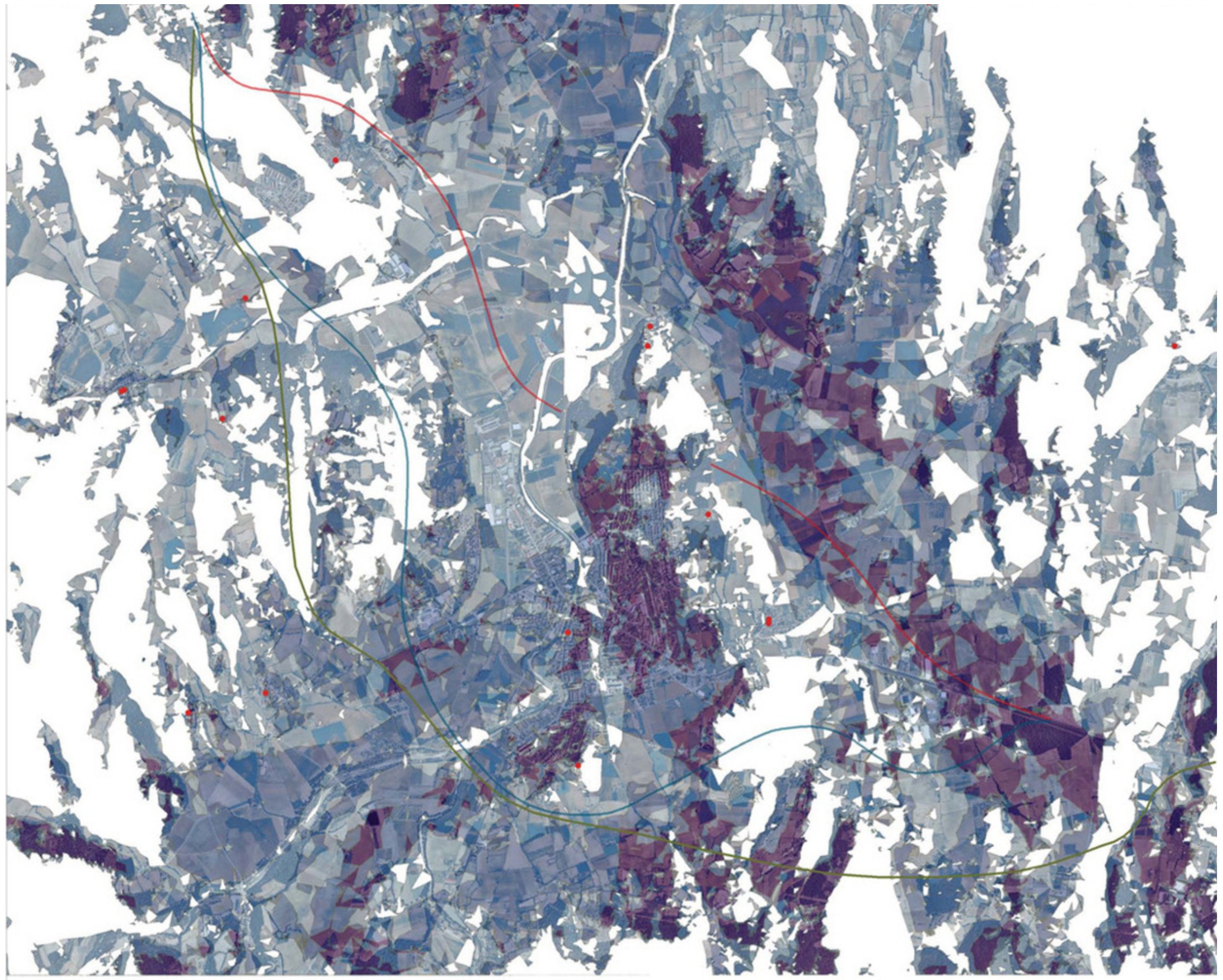


Fig. 224. Heritage elements visible areas. Preliminary studies fora a road variant project in La Bisbal D'Empordà (Spain). author: AZ paisatge, Anna Zahonero landscaper

General results

By retracing the comprehensive structure and the overall employed methodology, in this section I provide to outline the general conclusions of the thesis.

As stated in Chapter 1, I used the *'research by design'* method, which I had refined based on the existing literature within the suggestions offered by Rob Roggema (2017) in *Research by Design: Proposition for a Methodological Approach*.

In Roggema's work is very well-formulated the potential of this investigation technique, which proved to be worthwhile for the scope of the present research. Hereafter I report a short passage that expresses the approach relevance *"The main question is how research could emerge through design and new knowledge can be harvested using methodologies and processes of designing."* (Roggema, 2017).

In this sense, in my *research by design* it was possible to generate scientifically informed design hypotheses and implement these with simulation tools for different cases, thus conforming to the scientific criteria of reliability, hypothesis testing and reproducibility. So, *research by design* as a method to generate new design knowledge has proved to be feasible within landscape architecture and urban design. The results of the empirical approach complement each other and provide the landscape architect or urban designer working in the *making of landscape* context with a new body of easily applicable design knowledge, involving *soil shifting* in design praxis. Coherently with *research by design* method, the structure of the document has been organized for summarizing in every chapter a conceptual step of this research. This structure creates a linear and arranged path that makes it easy to read such a complex and transdisciplinary subject. I retrace the steps through the reading of the chapters with the aim of pointing out the general results emerged along the dissertation work.

Chapter 1 - Interference with other scientific realms. Chapter 1 presents the prerequisite (paradigm) for the research process that will be discussed and, in part, advocated, along the research path. By interfering with other disciplinary realms, the research follow-ups investigate the landscape meaning for being cross-referenced with other epistemological framework and thus opened up to be updated with soil shifting and pedological parameters. The course throughout landscape brings you beyond the wide-spread definition and known paradigms based on its *aesthetic dimension*. In this understanding soil transformation is presented as *the essence of landscape evolution* and discloses its authentic vocation to support and sustain human life and natural habitat. This is the basic concept for bringing about renewed forms of management and planning for contemporary territories. Thus exploring non-univocal

semantic field in landscape, this chapter can be effective in raising the level of awareness about the need for a more thoroughly understanding and reading of landscape and its components, by clarifying the relationships of reciprocity and complementarity between the various disciplines that deal with landscape studies – such as geology, ecology, environmental sciences - being inextricably linked through reciprocal relationships with soil.

Chapter 2- A Landscape Manifesto. In Chapter 2 I propose an approach for mapping, manipulating, and designing with geospatial gaze, with a goal of transcending the flat, static map into live documents that expand the representation of time and space — in order to better address the dynamic conditions for landscape project. This section contributes to the discussion on different solutions for integrating and observing the nature-regenerative time in the design process and the *soil handling* in the spatial planning, activating new *metabolic processes* in its replacement into the environment.

The framework produced by this assessment has been condensed in ten propositions, collected in form of a Landscape Manifesto. It provides a speculative and operative framework of possibilities for interpretation and actions emphasizing the strong relationship between soil transformation, planning and design praxis.

Chapter 3 - Taxonomy of Interventions. In Chapter 3 the research work starts from an *excursus* of informal practices that have been able to organize the territory over the centuries creating the basis for human settlements and the development of civilizations through the alteration of *morphology, coverage* and *composition* of the soil. This journey back in time, inspired by archaeology, helps us to understand the vocations and the hidden elements of a territory, with the aim of identifying design operations that will enable contemporary values to be transferred into the future. The study of literary sources combined with the study of concrete practical examples constitutes the basis for elaborating on the research objective and research questions towards an argued approach. Contemporary, case studies at the end of the chapter allow to express this approach, through graphic representation and crossing interdisciplinary information, arranged in the matrix with the linkage between design operations and ecosystem services, and related to a scientific review on the topic and data available. This basic tool can be helpful in opening the dialogue between disciplines.

Chapter 4 – Operative workflow. In Chapter 4 I introduced an *operative workflow* in the field of landscape design and territorial planning. In this *research by design* phase, the deductions from the first speculative and analytical phases – namely that tight relations exist between landscape design praxis and soil transformations – are justified and enforced to an applicative case study: the *Plan for Adaptation Measure in Response to Climate Change (SECAP)* in the Municipality of Ravenna (Italy).

The empirical research thus supported the theoretical model of these interactions that were also specified in the introduction, by referring – and illustrating - to the propositions argued in Chapter 2 and the tools developed in Chapter 3. It has been useful to explain and to test the limit and opportunity of the research. In this perspective, the concrete actions for adaptation to climate change have been identified, by relating the territorial and planning scale to that of the project, through an approach based on understanding and transforming the soil as a fundamental material of this process.

By reframing *soil as a palimpsest* for approaching scalarity across planning and design process, the implementation model has substantiate the workflow finalised at processing soil in anthropic context. In fact, the presented work involves several scales of intervention. This step brings out the interdependence between spatial, anthropogenic, environmental and ecosystem aspects of the context, and how from these relationships arises the complexity of the city-territory system to which it refers, considering soil as an element of reading and writing the territory. By analysing this information through the cartographic study of biophysical and geospatial systems (geomorphology, topography, soil composition, etc.), they have been reworked in the maps presented in the research and synthesized in some cartographies through mapping overlay process.

The evidence of this process lies in the identification of the transformation bands suitable to host interventions to increase resilient infrastructures and naturalness in those zone of friction between risks exposure and soil vocation and pressures, pointed out in the reference pattern outlined in the analytical phase. After that we traced the concrete integrated actions in processing soil in terms of *shape, coverage* and *composition*. Certain actions include the control of *hydro-superficial lamination*, the increase in *water infiltration* related to *soil permeability*, and the enclosure of vegetation with an ecological function, to adapt the territory to the effects of climate change.

The reported studies are extremely useful to understand the interaction between human and environmental systems and how the current and future spatial aspects are a direct consequence of this interdependence, focusing on the prominent role that soil transformation has in landscape design praxis.

General conclusions

The research provides a speculative and operative framework of possibilities for interpretation and actions planning and design praxis, by emphasizing the strong relationship between soil transformation. I thought this workflow could be very useful for a research concerning the development of specific and contextualized design actions within territorial scope. I would recommend this method for approaching both the planning scale, for which is useful to *orienting decisions* - and the *design scale*, for which it helps in the spatial arrangement in landscape projects.

For instance, the present work has been used for drafting the strategic objectives of the *General Urban Plan*[53] of Ravenna - that provides a vision of a *resilient adaptive city* - contributing to an overall adaptation of its territory compatible with its urban vocation, production and environment.

Otherwise, the study proposes a working methodology that remains at a definition scale linked to the quality of available data and time. At the territorial level there are data which have been dropped in the design dimension, but that could have had a greater degree of deepening, even if this was not within scope of this work.

The achievement of discussed and disseminated targets within a platform of shared experiences can trigger processes of virtuous plan proposals, supported by public administration, and reward, facilitation or incentive systems of private interests in effecting interventions.

Likewise, the development of a collective strategy requires a method of approach, investigation and analysis with flexible tools based on wide-area spatial planning that combine integrated design proposals. Quoting Roggema (2017), the purpose of this work lays in *"Spatial design is no longer just a plan, but at the same time has become a tool for the exploration of the potentials of the site and a means of communication and negotiation between parties involved"*.

Nevertheless, the *Moving Horizon approach* implemented through the SECAP case study has been deployed into an operative model that contribute to the scientific understanding of soil and *ecosystem services* and their interrelations with transformation operated by design actions, clarifying in a quick and effective way the connection among alteration of soil and its conservation in terms of *soil health*.

[53] literally Piano Urbanistico Generale (PUG)

5.2 Cross-breeding: further implementations and transdisciplinarity

Further implementations on planning and design

The growing need to support decision makers with information about the flows of *ecosystem services* has lead in the last decade to the development of more integrated analytical frameworks of the trade-offs between the environmental, economic, social and cultural outcomes of land planning.

Only recently the role of soil has been explicitly put at the core of such theoretical frameworks.

Through this vision, the soil must assume a new centrality, becoming the subject of design and a reference for spatial planning as a support of networks, relationships and integration of components that have to coexist in the city-territory system, with the aim of tracing the opportunities of intervention translated into the form of strategic outlines and concrete design impacts.

The vision offered by SECAP provides a framework within which other specialistic contributions may apply refining data availability (in terms of quantity and resolution), tools and methodology, according to a constant updating. Interpreting *soil as a design element* means conceiving the discipline of landscape design through parameters and tools commonly used in other disciplines.

This potential development is one of the principal research outcomes.

For designers this implies that soil handling and transformation has to be taken much more seriously into account in landscape design. The identification of multiple *soil function areas* and the understanding of their *spatial patterns* and connectivity can provide a further strong basis to support land planning and management. In this respect, for further implementation on planning and design praxis, landscaper should contemplate significant interactions and soil data by means of measurement and indicators worked up by scientific realms involved in pedometric and geological investigations (Fig. 225-226).

In the spatial context, *ecosystem services* assessment can benefit from *pedometric* research for the dynamic spatial-temporal modelling of soil properties and processes.

Many on-site experiments have been conducted to evaluate the effects of conservation management on soil properties, yet there has been little effort to evaluate which indicators should be measured to consistently quantify resulting improvements in *soil health*.

WATER INFILTRATION CAPACITY

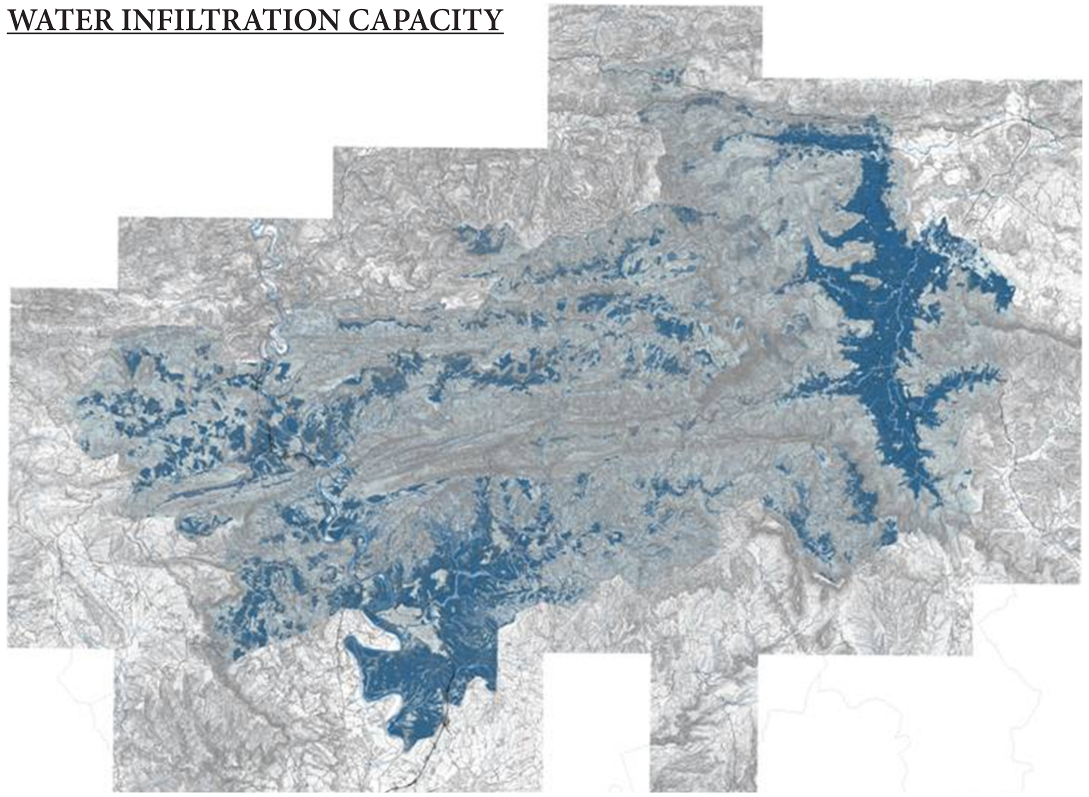


Fig. 225. Environmental analysis, Water infiltration capacity- Vall d'en Bas, del Ges i Bisaura. author: AZ office, Anna Zahonero landscaper.

SOIL RETENTION

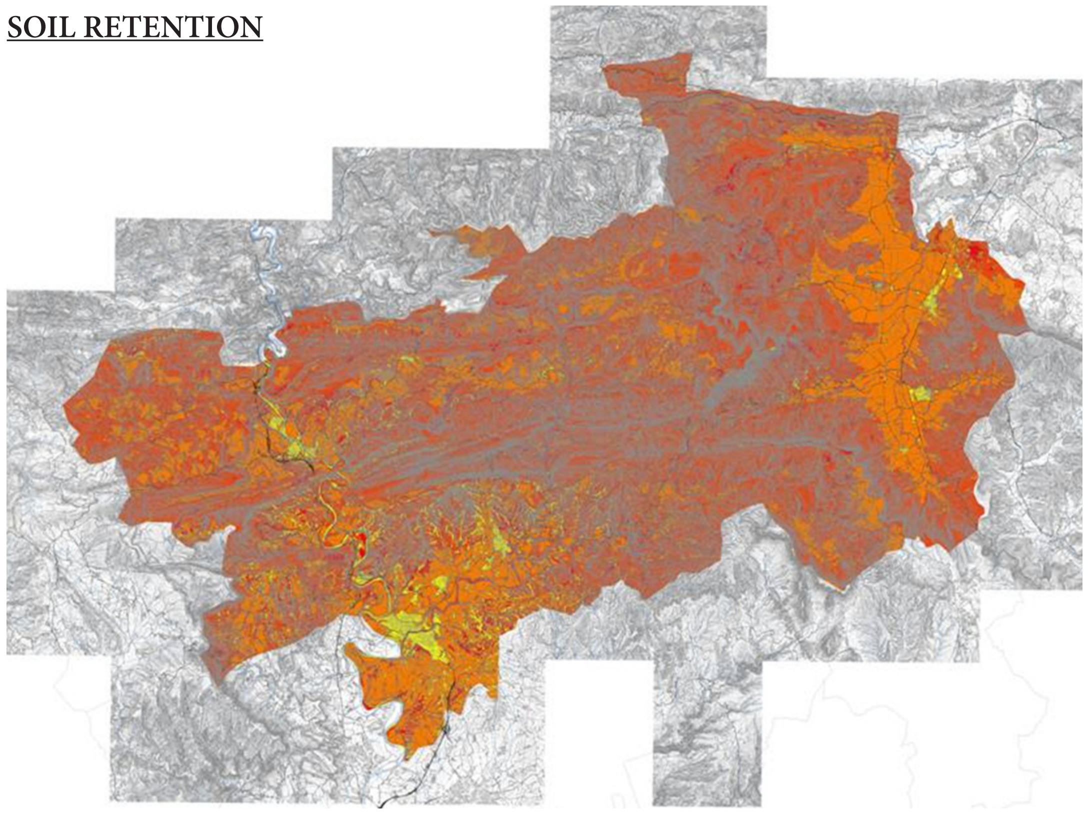


Fig. 226. Environmental analysis, Soil retention - Vall d'en Bas, del Ges i Bisaura. author: AZ office, Anna Zahonero landscaper.

The relationship between soil properties such as *organic carbon, biota, nutrient cycling, moisture retention,* and *ecosystem services* has been well documented (Tab. 40).

Nevertheless, only a few studies have quantitatively linked soil properties to *ecosystem services*.

Similarly, the spatial aspects and dynamics of soil properties related to ecosystem services have been studied through *mapping* or *scenario modelling* of future changes. Instead of using soil information directly, some of the *mapping* and modelling exercises use environmental variables as a proxy to soil information, such as *Land use*, *Land cover* and other *environmental markers* (Tab. 41).

In this regard, here is reported a pair of very detailed research that have been taken as the basis for translating the value of soil in terms of ecosystem services, starting from soil characteristics. Both studies are addressed to be used in local and national policy development in terms of land management. We mention in particular the bibliographic studies of Kabindra Adhikari and Alfred E. Hartemink (2016) collected in a paper entitled *Linking soils to ecosystem services — A global review*.

The second research – with applicative scope – concerns the cartographic maps processing on a regional scale, elaborating *soil properties* with GIS interpolation algorithm. It has been carried out by the Emilia Romagna Region geological service[55] (Italy) - within the SOS4LIFE (Save Our Soil) project - at different levels of decision making and policy support. This research has a very important role to play in raising awareness among technicians and citizens about the enormous importance of soil in the lives of all of us. Since March 2020 the Emilian plain maps are available. These maps can also be processed at a large or municipal scale to support the drafting of urban planning tools. The Ravenna SECAP could be cross-referenced with this cartographic information.

This study will be presented more in detail in the next paragraph.

Below is reported a compendium of the input data proposed by the mentioned researches linking soil properties to ecosystem services.

[54] The study reviews the literature on the relationship between soils and *ecosystem services* and aims to contribute to the scientific understanding on soil and *ecosystem services* and their interrelations.
[55] Servizio Geologico sismico e dei suoli (SGSS) della Regione Emilia Romagna.

INPUT DATA

outlining ecosystem services provided by soil

KEY SOIL PROPERTIES - VARIABLE	ER Region	Hartemik
Soil organic carbon (SOC)	□	□
Sand, Silt, Clay & coarse fragments (Skel.)	□	□
Bulk density	□	□
Available water capacity (AWC)	□	□
Cation exchange capacity (CEC)	□	□
Soil porosity and air permeability (PSI)	□	□
Hydraulic conductivity & Infiltration / saturated hydraulic conductivity	□	□
pH	□	□
Carbon stock	□	
Volumetric soil water content (at–33 kPa tension and -1500 kPa tension)	□	
Shallow water table depth (WT)	□	
Depth to bedrock		□
Electrical conductivity		□
Soil biota		□
Soil structure & aggregation		□
Soil temperature		□
Clay minerology		□
Subsoil pans		□

Examples of ecosystem services (ES) mapping and modeling studies at different spatial resolutions using a range of different input data.
Land use data
Land cover data
Topographic and administrative information
Digital elevation model
Water quality
Vegetation types
Soil types
Slope angle
Rainfall
Land capability

Tab. 40-41. Table of necessary inputs data in outlining ecosystem services provided by soil. Author's critical re-elaboration concerning Emilia Romagna Region's proposal and the overview offered by Kabindra Adhikari and Alfred E. Hartemink in "Linking soils to ecosystem services — A global review", reported in Ch.1.

Evaluation scheme for the Emilia-Romagna plain

The Emilia-Romagna Region has been working for years to promote knowledge of the soil by addressing those who cultivate the soil, such as farmers, and the technicians and administrators who have a duty to protect it. The Institute of Bioeconomy of the National Research Council of Italy (CNR-IBE) based in Florence, in collaboration with the Geological, Seismic and Soil Service of the Emilia-Romagna Region, has prepared a scheme for the evaluation of soil functions at the basis of ecosystem services for the entire Emilia-Romagna plain in Northern Italy for the purposes of urban planning. Therefore, an indicator-based approach has been adopted to assess and map the multiple contributions of soil to providing ecosystem services, based on soil functions derived from available soil data for the 0-100 cm layer.

The methodology consists of:

(i) definition of soil-based ecosystem services, based on available and derived soil data and on societal demands;

(ii) definition of appropriate indicators for the functions underpinning the services, and coding;

(iii) assessment and mapping of soil potential contribution to multiple ecosystem services.

Through *geostatistical simulations* conditioned on the map of the soils in scale 1:50.000 and on the maps of land use spatial data have been used to characterise and model the *spatial heterogeneity* of soil functions in the case study area of alluvial plain of Emilia-Romagna (Fig. 227-228-229).

This has allowed to explicitly take into account the spatial variability of soil properties and the related uncertainty, and to exploit at best the available information. Within this structure, different functions can be treated and mapped together, providing an efficient tool to model the heterogeneity of the different soil functions, both at regional and local scale.

Eight soil functions have been considered as the basis of ecosystem services (Tab. 43):

Habitat for soil organisms (BIO); Filtering and buffering (BUF); Local (micro)climate regulation (CLI); Carbon sequestration potential (CSP); Food provision (PRO); Support for human infrastructures (SUP); Water regulation (WAR); Water storage (WAS).

Table 3
Ecosystem services (ESs), underpinning soil functions and indicators.

ESs categories[a]	Soil contribution to ESs[b]	Soil function[c]	Indicator	Input data	Code
Supporting	Habitat for soil organisms	Biodiversity pool	Potential habitat for soil organisms	Land use Bulk density Organic C	BIO
Regulation	Nutrient and pollutants retention and release; Natural attenuation (potential)	Storing filtering and transforming nutrient, substances and water	Cation exchange capacity Soil reaction Rooting depth	Organic C Clay content pH (0–30) Average shallow groundwater depth	BUF
Regulation	Microclimate regulation (potential)	Storing filtering and transforming nutrient, substances and water	Soil evaporation potential	Available water capacity Average shallow groundwater depth	CLI
Regulation	Carbon sequestration (potential)	Carbon pool	Carbon sequestration potential	Organic C and bulk density (0–30 cm)	CSP
Provisioning	Food provision (potential)	Biomass production	Land capability (LC) map	LC classes and intergrades	PRO
Provisioning (supporting)	Supporting human activities and infrastructures (potential)	Physical and cultural environment	Soil bearing capacity	Sand content Clay content Hydraulic saturated conductivity Peat presence	SUP
Regulation	Water regulation/runoff-flood control (potential)	Storing filtering and transforming nutrient, substances and water	Infiltration capacity	Hydraulic saturated conductivity Air entry point	WAR
Regulation (provisioning)	Water regulation–Water storage (potential)	Storing filtering and transforming nutrient, substances and water	Water content at field capacity Presence of water table	Field Capacity (−33 kPa) Average shallow groundwater depth	WAS

Tab. 43. Eight soil functions have been considered as the basis of ecosystem services: Habitat for soil organisms (BIO), Filtering and buffering (BUF), Local (micro)climate regulation (CLI), Carbon sequestration potential (CSP), Food provision (PRO), Support for human infrastructures (SUP), Water regulation (WAR), Water storage (WAS)

<u>**BIO - BIODIVERSITY**</u>

Interpolation with GIS, input data: Land use, Bulk density, Organic C

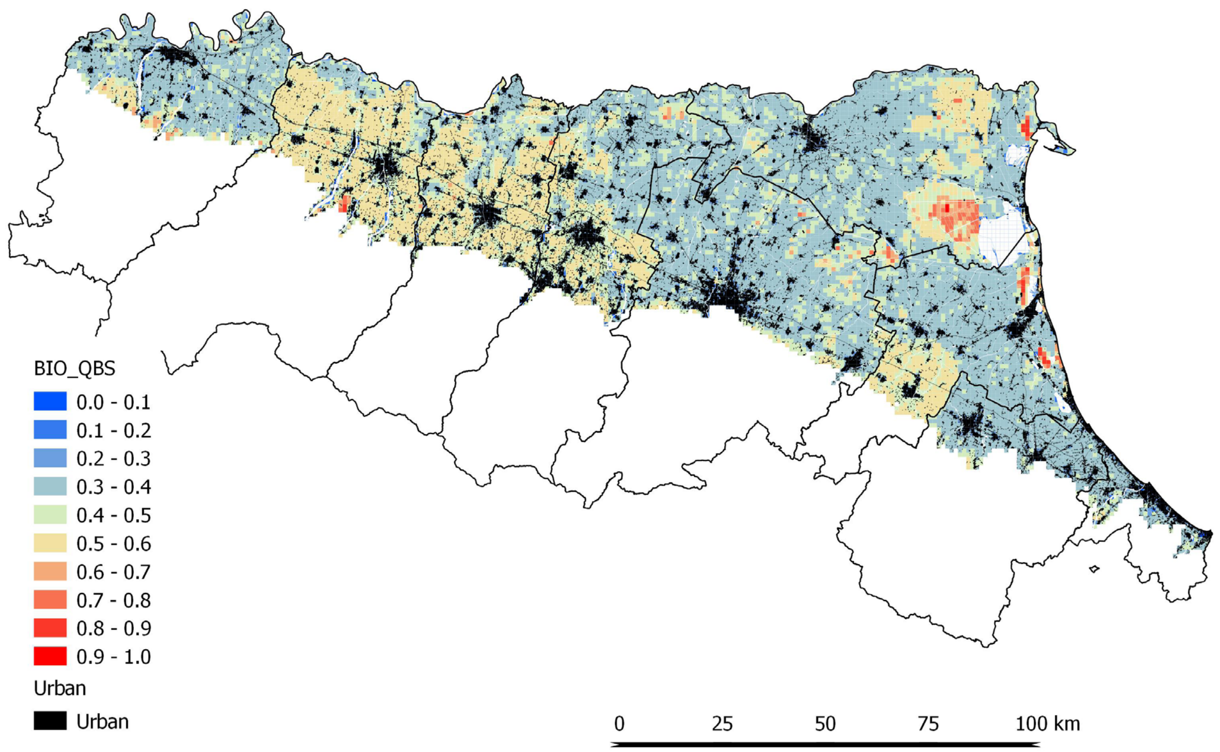


Fig. 227. Habitat for soil organisms (BIO). Interpolation with GIS, input soil data: Land use, Bulk density, Organic C. source: Geological, Seismic and Soil Service of the Emilia-Romagna Region.

The method allows to establish clear links between decisions and *ecosystem services*, allowing to assess the risk of services loss or the possibility to maintain or exploit specific services under different policy and management options. Results provide new insights about the composition and interrelation of multiple soil functions and potential services in the region and highlight the difference between soils in terms of joint functions provision.

Water storage and water regulation, an example in detail

Among the regulating soil functions, those affecting the water cycle contribute in providing fundamental ecosystem services, such as the control of floods and droughts.

As indicator of the potential of soil in storing water - *Water Storage (WAS)* (Fig. 229) - the volumetric soil *water content* at field capacity WC_{FC} (−33 kPa tension), WC_{FC} (m3*m−3), was considered. WC_{FC} was calculated using a locally calibrated point PTF (Ungaro et al., 2005), whose inputs are *soil texture, organic carbon content* and *bulk density*, for a reference depth of 100 cm. The estimated value was then linearly decreased by the coarse fragments of volumetric fraction (sk, vol*vol−1). In case of presence of the shallow water table in the first 100 cm of soil, its average depth, WT (cm), was taken into account for further decreasing the overall soil potential of storing water.

Soil regulates the fraction of precipitation water which infiltrates, thus regulating both runoff and transport of nutrients, pollutants and sediments, and contributing to groundwater recharge. Soil infiltration depends on various factors, such as *moisture conditions*, *soil structure characteristics* (included artificially created tillage clods) and *stability*, besides *soil cover* and *precipitation characteristics*, *duration* and *intensity*. The infiltration process depends mainly on three parameters: *saturated hydraulic conductivity*, *net capillary drive*, and *soil saturation conditions*. At the beginning of a storm and before ponding conditions, the infiltration rate is equal to the precipitation rate. When the ponding conditions are reached, soil reaches the maximum infiltration capacity, which equals the saturated hydraulic conductivity when the whole soil profile is saturated. The maximum rate at which water can enter the soil, or infiltration capacity, fc (mm*h−1) is described by Smith and Parlange (1978), as reported in Morgan et al. (1998).

WAR - WATER INFILTRATION CAPACITY

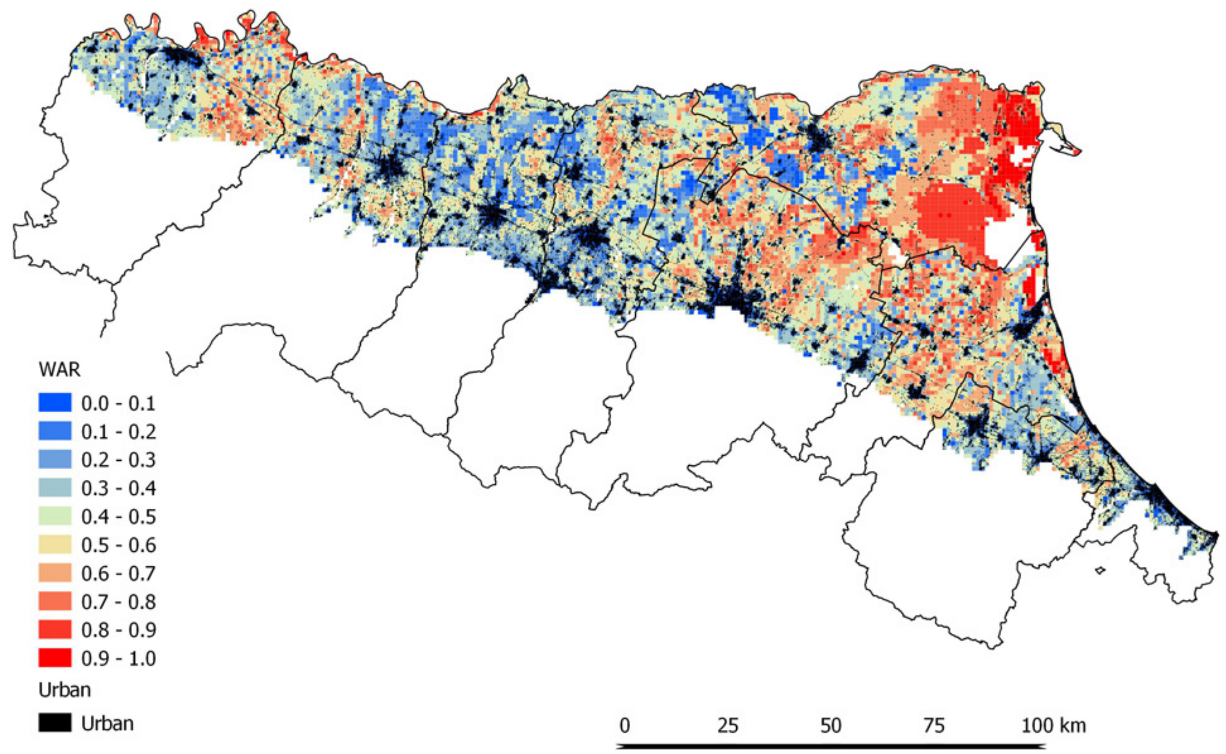


Fig. 228. Water infiltration capacity (WAR). Interpolation with GIS, input soil data: Hydraulic saturated canductivity, Air entry point. source: Geological, Seismic and Soil Service of the Emilia-Romagna Region.

WAS - WATER STORAGE

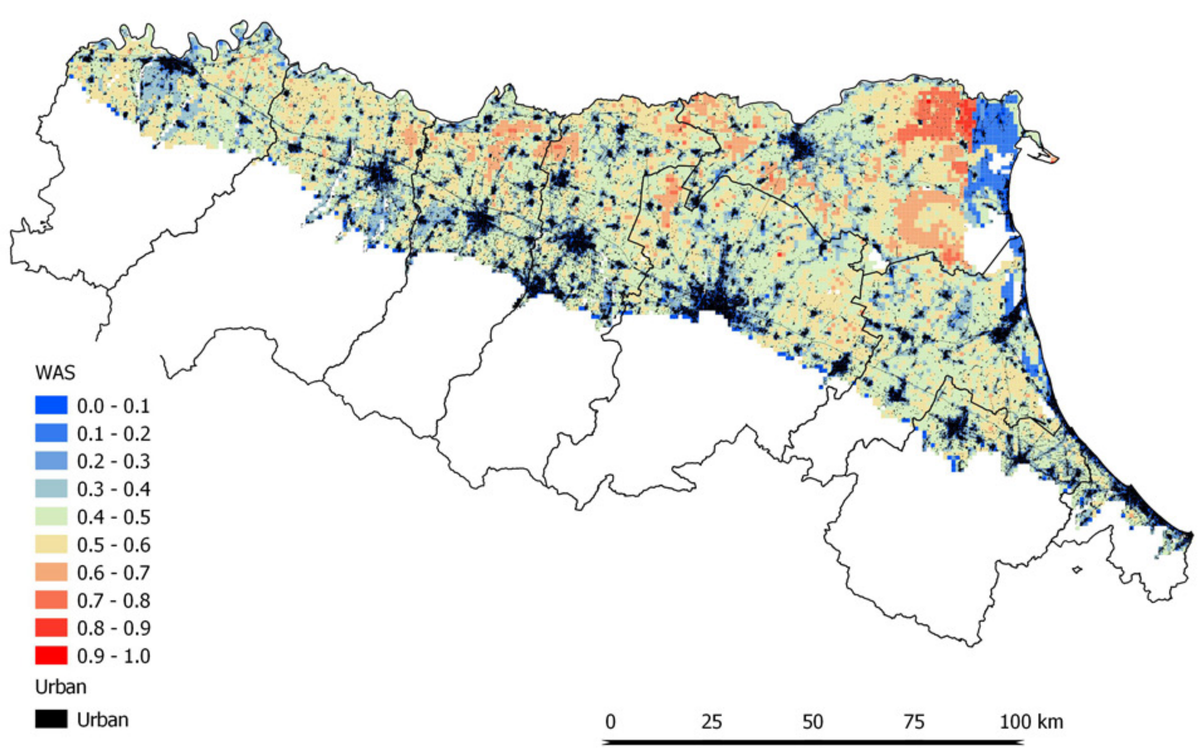


Fig. 229. Water storage (WAS). Interpolation with GIS, input soil data: Field capacity (-33Pa), Avarage shallow groundwater depth. source: Geological, Seismic and Soil Service of the Emilia-Romagna Region.

5.3 Moving foreward: perspective, issues, follows up

Ecosystem services provided by soil: a matter of datas and resolution

According to Hartemik and Adikari (2016), soil scientists seems to be hesitant to use the term *ecosystem services*. In fact we have considerable knowledge about *soil*, its *formation* and *distribution*, but our understanding on its *functions* and soil *ecosystem services* is incomplete, even if it is mentioned that soil is as an overlooked component in studies and policy level decisions[56]. In addition, as evidenced by several research, studies can differ in their results.

In general, the multiplicity of soil functions and the related ecosystem services has as counterpart the multiple expectations and perceptions of the various soil users, and, even if there is an increasing interest in economically quantifying the soil services, still some of them are difficult to monetise, such as those related to *public health*, *water quality*, *spiritual and cultural heritage, education*. This can lead to conflicts and contradictions when *land planning policies* take place.

Then, as soil-based *ecosystem services* co-occur in space and overlap - interacting at different spatial and temporal scales - their spatial distribution, synergies and trade-offs play a relevant role in the process of land planning.

Finally, scales of application can span from national *soil cover* to local *soil bodies* and data availability can be limited. It is therefore of pivotal importance to account explicitly for soil spatial distribution in order to characterise the multifunctional attributes of soils in a given area and to preserve their *natural capital*.

A limitation of the proposed approach is that at the adopted working scale it is not easy to validate the results. However, *pedo-landscape* units show significantly different behaviours as regards most of the selected indicators, and this is in good agreement with the local soil knowledge. A further limitation of this method is the relative subjectivity, both in identifying the indicators and in their calculation. However, the indicators are chosen on the base of well-established schemes and developed at a spatial scale suitable with available data on one side and with the identification of planning strategies on the other.

The adoption of an *ES* framework would require the modelling of interactions between soil functions and *external drivers* (e.g. *land use* and management, and *climate*)[57]. This would constitute the first step of a comprehensive ES mapping exercise helpful in supporting planning and land management policies.

[56] The majority of these studies were relating soils to the defined soil functions that ultimately determined the delivery of ecosystem services.

[57] The Emilia-Romagna Region focuses on the performance of soil functions based on soil properties regardless of external drivers, aiming at a multiple objective-based land evaluation.

Pending Issue

The research development offers a comprehensive and detailed overview on the topic without finalize the debate on it. The lack of a specific bibliography and the high interdisciplinarity of the topic - *landscape* and *soil* - leads to this effort of creating a new approach, able to bring innovative contributions. For a matter of time and possibilities the argument cannot be completed or ended but can be highly implemented both in *speculative* terms, and in *landscape design praxis*.

Moving from theoretical frameworks to operational approaches is however still a challenge, for a number of issues and one has to be aware that there are also difficulties for designers who want to conduct *research by design*. In particular, from an operative point of view, it can be deployed on more case studies in combination with parametric programs, the interpolation of soil data could bring to design implementation and more effective and realistic forecasting in territorial transformation. Otherwise the soil data and information basis are often not adequate - or it is at insufficient resolution or it is contradictive - and the simulation tools that can be used to test the design hypotheses are not always as much reliable as needed.

In fact methodologies used for identifying, assessing and mapping *ecosystem services* provided by soil are diverse and frequently inconsistent and, notwithstanding the examples from available literature, evident methodological gaps are still present.

Even if the recognition of the multifunctionality of soil was already present in the definition of soil quality, the difficulty of finding indicators able to describe this complexity remains a critical issue.

Since *soil data* and simulation tools are constantly developed and their reliability is continually improved, their value for design hypothesis testing within *research by design* continuously increases[58]. The framework is flexible, in defining indicators and in calculating them. It can be used at different spatial scales and is capable to integrate new knowledge when available.

In this view this framework opens new avenues for more *research by design* in the academic field of landscape architecture and environmental design in the future.

[58] The indicators were then thoroughly discussed with the Emilia Romagna regional soil service, and the results assessed on the base of local knowledge and decision context. For example the approach can be easily implemented at municipality level in order to assess the impact of soil sealing in terms of functions loss associated, for example, to new building infrastructures, or to better target compensation measures to be taken in order to restore the flow of soil-based ecosystem services and to support sustainable soil management.

Moving foreward, the EMyS (Equilibrium Mantainance on hYdro-Salinity) project

As we tried to demonstrate, the Ravenna *SECAP* experience has brought to refine some planning and designing processes related to the *adaptation measure* for climate change, through an approach based on understanding and transforming the soil as a fundamental material of this process.

On the other hand, it lacks a sufficiently clear and concrete data resolution in which inscribing the design procedure, so it has turned to be useless in grounding a proper approach dealing with soil parameters. Much is due to the scope of the work, data availability and scale of resolution. All things considered, the main issue concerns the fact that - in order to validate the results - the project would have needed a real application in which to apply the proposed strategic outlines starting from an in situ recognition of pedological parameters, in reference to the tables 40-41 at page 233.

In this regard, a monitoring process of a protected area within the Municipality of Ravenna - in collaboration with the research centre CESTHA (Experimental Centre for the Protection of Habitats) was initiated in 2021, to carry out activities dealing with CER (Canale Emiliano Romagnolo) support, oriented at improving and managing the area from an environmental point of view.

The project, named *Emys* (*Equilibrium Maintenance on hYdro-Salinity*) is envisioned as an experimental action plan at the protected area of Volta Scirocco, using it as an area of CER research and experimentation for the creation of *transition zones* to contrast climate change and to rebalance salinity levels with the aim of protecting and recreating habitats for local biocenosis and phytocenosis affected by saline wedge rising.

The activities are useful for acquiring detailed information on the *state of the art* through on-site monitoring (flora, fauna, salinity) and thematic representation of the site, with the aim of identifying strategies and feasibility of interventions to improve the conservation status of habitats.

The Oasis of Volta Scirocco is characterized by a mosaic of humid environments, formed by the mixing of fresh water from the Reno river and filtered brackish water from the ”valli” of Comacchio. It is an alternation of *ponds, reeds, flooded meadows* and *groves* where there is a rich biodiversity that includes rare species of conservation interest, among which is likely the presence of a relictual population of *Emys Orbicularis* - freshwater tortoise.

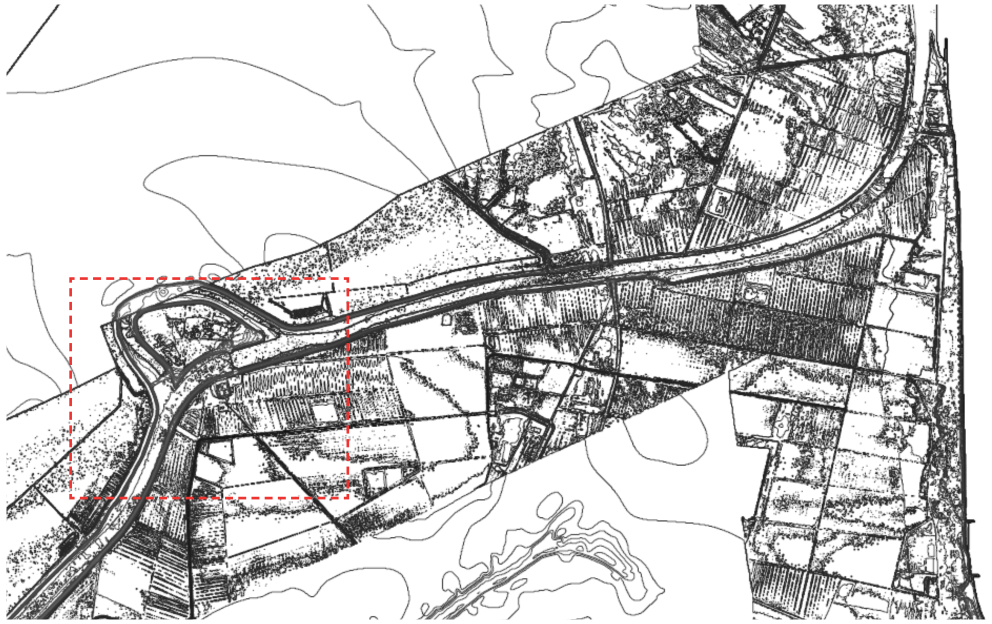


Fig. 230. Reno river flood plain in Ravenna, with evidenced Volta Scirocco areas. source: author

Fig. 231. Flamingos flying over the area. Flamingo's presence is a marker in salinization process. source: Simone D'Acunto, CESTHA.

Fig. 232. Emys orbicularis, target specie in EMyS projects. source: Simone D'Acunto, CESTHA.

The area is affected by critical *salinity* levels, which compromise the health status of habitats present. This phenomenon is amplified by both *subsidence* and the ongoing *climate change* characterized by increased drought events, as evidenced by numerous studies collected in the reports prepared by the Regional Climate Change Forum of the Emilia Region (2020).

The proposed activities are:
1. Seasonal monitoring of the minor flora and fauna present in the Oasis;
2. Significant monitoring over time of soil and water salinity, to safeguard the species identified;
3. Identification of improvement and conservation measures to be implemented;

Given these premises, in a broader perspective, we can assume actions to create transition areas against climate change and restore salinity levels with the aim of protecting and recreating habitats for *biocenosis* and local *phytocenosis* affected by critical salinity levels present today. The dual purpose is to enhance the ecological fabric of identified areas through restoring habitats at their very high ecological potential, in full implementation of the European directives on wetlands.

As a pilot project, a complete ecological system consisting of wetlands and specific tree planting will be implemented through actions aimed at:
/ Support the development of *halophytic* and *hydrophytic* plants through the contrast of salinity in soil and water, and the reintroduction of locally extinct plants;
/ Support for the reproduction of *Emys orbicularis* through the creation of an area suitable for the eggs deposition and development of young individuals;
/ Creation of habitats for the reintroduction of other missing minor fauna species such as reptiles and amphibians[59];
/ Management of fish stocks with analysis of species and monitoring of alien species.

The proposal will be deployed in stages and is designed to be used as a pilot activity for the creation of transition wetlands with the dual purpose of both to enhance the ecological fabric of the identified areas through the restoration of habitats at their very high ecological potential - in full implementation of the European directives on wetlands - and, at the same time, to make operational the provisions of the SECAP 2020 of the Municipality of Ravenna.

[59] As defined by the Regional Law 15/2006

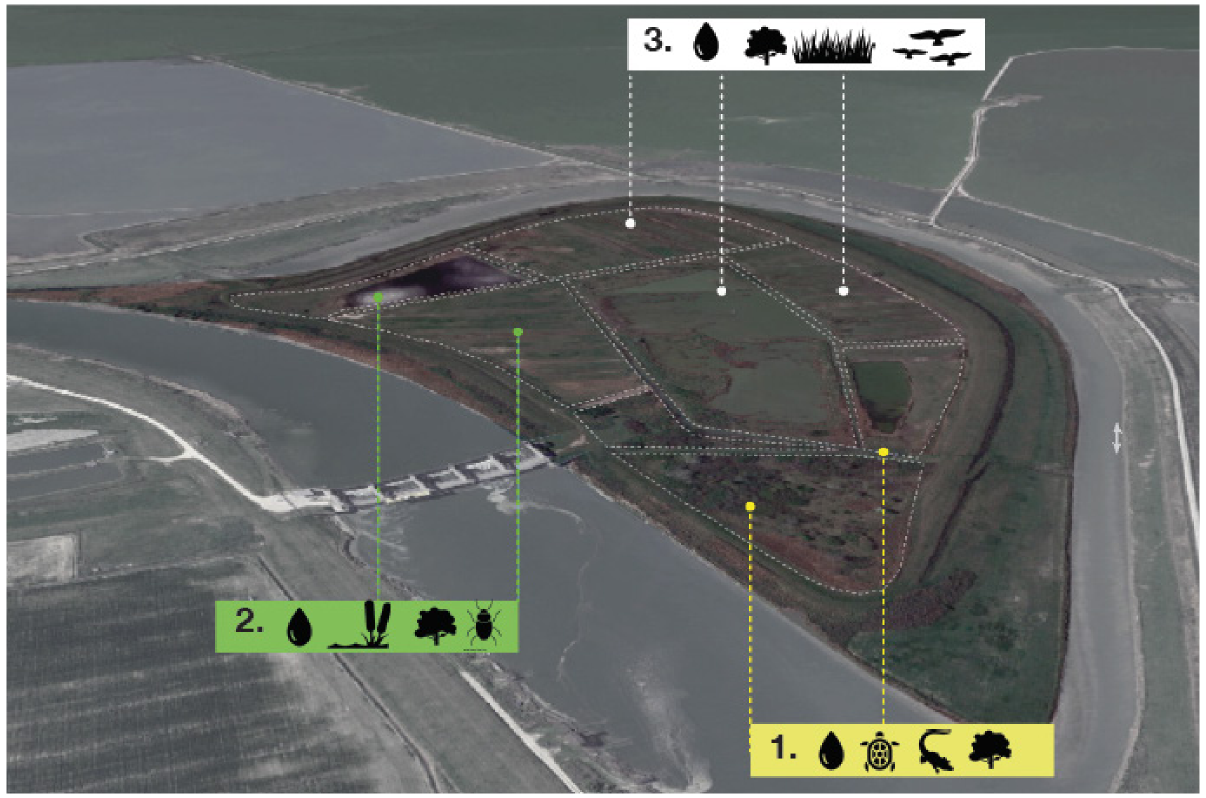
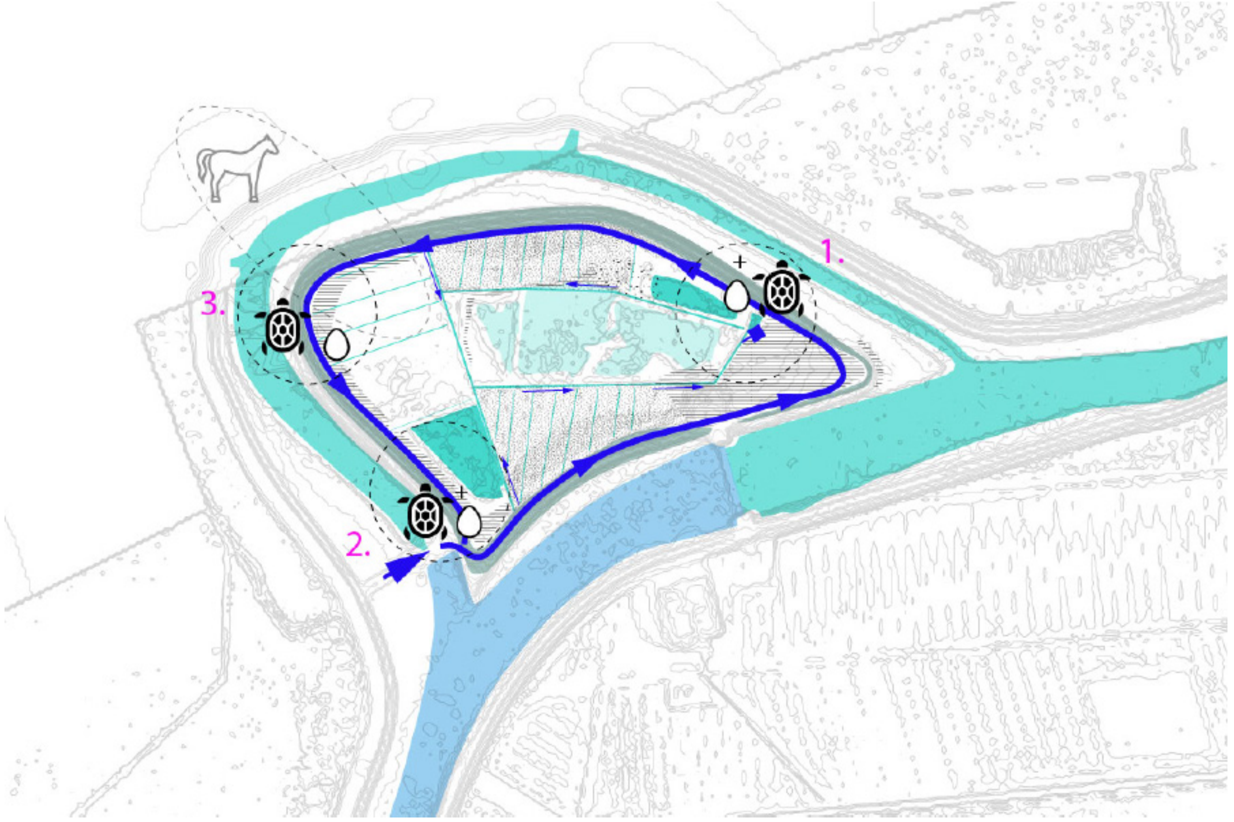


Fig. 233. Volta Scirocco, actual state. source: author

Fig. 234. Volta Scirocco, vision. source: author

Fig. 235. Topography and satellite views. This image shows how the most critical zones are beneath sea level rise. source: author

Fig. 236. Water-salinity sampling. source: CER.



CICLI	G	F	M	A	M	G	L	A	S	O	N	D
RIPRODUTTIVO												
SVERNAMENTO												

ACCOPPIAMENTO	tra Marzo ed Aprile	acqua/terra
DEPOSIZIONE	seconda metà di Maggio e la prima metà di Luglio	sabbia
SCHIUSA	fra i 50 ed i 110 giorni	sabbia
SVERNAMENTO	fine Ottobre o Novembre fino a Marzo	acqua/fango

Fig. 237. First proposal for turtle nest monitoring and turtle nests creation related to topography, habitat peculiarities, soil texture, turtle breeding cycle. It is also supposed to reintroduce big mammals (such as a couple of horses) in order to improve the soil eutrophization. source: author

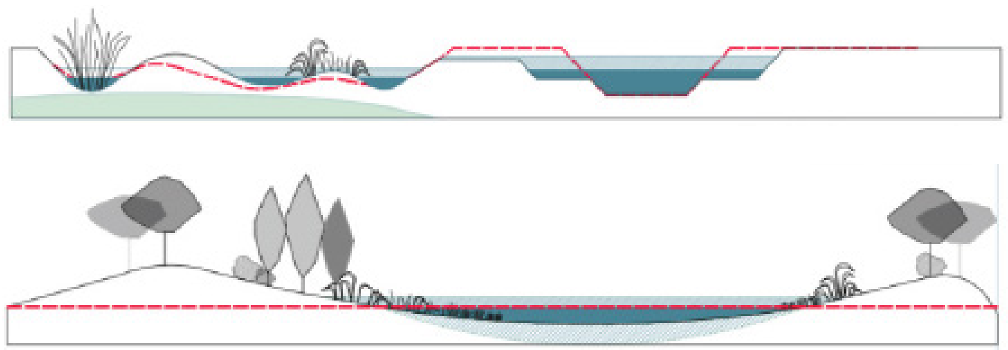


Fig. 238. Supposed intervention for fresh water supply. source: author

Landscape remains a profoundly imaginative project, requiring both a creative "reading" and "writing" of sites. […] Here one might cite a movement from theory to practice, but it is more precise to recognize that both the writings and the designed works are in themeselves projects, and they therefore share the same impulse: to project new possibilities for the field.

James Corner, 2011
The Landscape imagination

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