Historical analysis and territorial vocations

Known as Iussagum in the 15th century, the municipality of Giussago was formed in the 19-20th century with the gradual aggregation of small nearby villages. Dating back mainly to Longobard and Roman times, the first traces of human settlement in the area are very ancient and can still be partly identified in the landscape matrix.
Near Cascina Darsena runs the ancient route of the Mediolanum-Ticinum, a Roman road that connected Milan to Pavia and that favoured the growth of small scattered rural settlements in its vicinity that already at that time intensively exploited the plain for agricultural aims. The Roman division of land is still visible from aerial images. The abundance of water that has characterised the area since its origins proved in the 16th century to be favourable to the production of rice, which quickly established itself as the main crop; even today, the province still ranks as Europe's largest producer. The inauguration of the Naviglio Pavese in 1819 was a further factor in the development of the territory, allowing not only navigation between Pavia and Milan, but also the irrigation of hectares of fields.

The Charter of 1818 testifies to the ancient foundation of both farmsteads that constitute NeoruraleHub: Cascina Cassinazza and Cascina Darsena. The 1954 aerial photo shows how the landscape structure appears almost unchanged from the situation of two centuries earlier. The intense agricultural activities confined forest ecosystems to residual forms along roads and canals in what has been defined as an 'agricultural desert'.

The area now presents itself as a multifunctional landscape, where industries, treatment plants and residential settlements are integrated into the historical and agricultural layout of Giussago. Neorurale, thanks to its agro-environmental ecosystem restoration efforts, is a central ecological area where a wide range of valuable habitats can support the conservation of local biodiversity in synergy with rice cultivation.

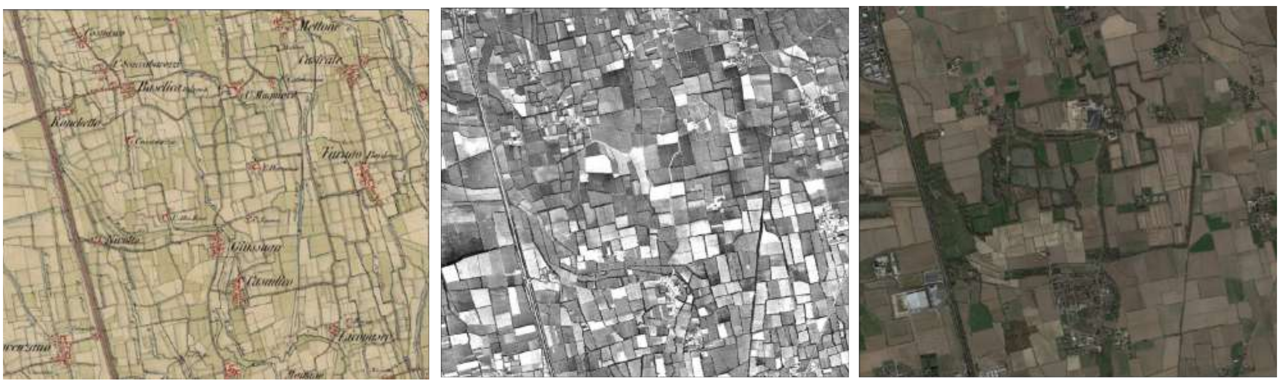

Fig. 1: The second Military Charter of the Austro-Hapsburg Empire (1818) - Aerial photo (1954) - Aerial photo (2022)

Territorial vision and strategy

The design team considered essential conceiving the intervention within a broader strategy. The 'Energy tracks' represent a spatial vision for potential replicability and upscaling of the project across the region. The site is the epicentre of a multifunctional green-blue-energy infrastructure capable of reconnecting the two large territorial systems of Pavia and Milan. Following the historical productive vocation of this territory, the project questions the role of the rural landscape in contributing actively to the development of the urban regions of the future. Within this framework, the vision reinte¬grates nowadays fragmented layers:

- accessibility and cultural network: cycle routes, rural roads and cultural highlights;
- green infrastructure: tree lines, riparian buffers, forests, wetlands and natural areas;
- blue infrastructure: main canals and primary hydrological network.

As a connective fabric linking these three spatial and performative dimensions, the agro-photovoltaic landscape, through the creation of energy and biodiversity axes, merges the renewable energy produc¬tion with services provided by ecosystems, reinforcing the 'Energy tracks'.
This new territorial system embodies the productive landscapes of the future. The fruition layer delineates a slow mobility itinerary from Milan to Pavia in which old and new cultural hubs are connected; the natural and water layer extends the good practices of ecosystem res¬toration undertaken by Neorurale by activating and improving ecosystem services; the space within them allows the permanence of agricultural and rice production and the integration of the new energy source. This territorial infrastructure will also allow the creation of an Energy Community to "feed" a series of adjacent functions (public buildings, private residential units, mobility services), strengthening the relations between the urban and rural spheres.

Fig. 2: extract of the project plan of the site as epicentre of the multifunctional green-blue-energy infrastructure

Design Concept

The territorial strategy of the energy tracks is coherently declined within the project area through the three layers of accessibility, nature and water, which constitute the backbone structure of the agrivoltaic system. The creation of photovoltaic axes orthogonal to these backbones, which integrate the energy component into the three layers, will favour a synergic relationship between the rice paddy and the photovoltaic system, enhancing the local ecological network and biodiversity. The photovoltaic system with biaxial technology will also cover an area of less than 30% of the cultivated area. These factors, together with the application of agro-ecological principles, will favour sustainable, organic agrivoltaic cultivation with an optimal production and energy efficiency.

The three perimeter layers will also play an active role within the project area. The nature and water layers will reinforce the boundary to the east through the creation of an environmental field margin (in line with the already known applications by NeoruraleHub), while the slow mobility path to the west will evolve into a belvedere for the creation of a privileged viewpoint over the rural landscape, above the photovoltaic system. This belvedere will also have the function of containing the service cabins for the photovoltaic system below.

The axis structure of the photovoltaic system in the central and lower part of the plot will be contrasted by a chequerboard system in the northern part. Below this, a public space with therapeutic community gardens will be created for citizens to be actively involved in the project site. The square bordering the vegetable gardens and extending from the accessibility axis will create an entrance to the area and will host resting spaces and furnishings for the electric bike-sharing which will be powered by the photovoltaic system.

Fig. 3 - 4: Design views of both axis and chequerboard photovoltaic systems

Renewable Energy Community (REC)

If the project proposal will be selected, the set up and development of a Rural Renewable Energy Community (REC) will be foreseen involving the local communities. The objective of the AgriPV community will be self-produce and provide affordable renewable energy to its members located in the surrounding area. The model focuses on the concept of decentralization and localization of renewable energy production, with a view of sharing, cooperation, and support between active and aware users. The participation in the REC will be open to everyone, including low-income or vulnerable people. Citizens, school buildings, town halls, farms and farmsteads will have priority.
The possibility of creating charging stations for electric vehicles with particular attention to slow mobility will also be investigated, giving everyone the opportunity, including people with mobility difficulties, to enjoy the landscape and nature trails. The most suitable location to implement this infrastructure could be in the parking lot of the Cascina Darsena.
As first step an engagement plan will be developed to increase trust on the AgriPV and the REC approach, and directly involve the communities in the process. The aims are:

- Increasing awareness and transfer knowledge on AgriPV project not only for the direct economic benefits, but also for the social and environmental co-benefit.
- Information campaigns of rational uses of energy to spread good energy practices.
- Creating a long-term engagement with the future end users by constantly check and validate the proposed solutions.

A Community Energy Board (CEB) will be established as a local working group to support the community energy setting process.
Finally an analysis of the technical feasibility and socio-economic and environmental sustainability of the pilot plant will be developed, paying particular attention on the recyclability and reuse of components and materials both for the manufacturing and End of Life (EoL) of the pilot AgriPV system.

Type of user	MWh/user
Medium residential buildings	2,5
Municipal Buildings	45
Commercial activities	25
Schools	25
Farms and farmhouse	10

Fig. 5: Terna data on provincial sectoral electricity consumption and ISTAT census surveys for specific consumption.

Fig. 6: Cradle to Cradle systems design approach

Energy-structural solutions

The project involves the construction of a photovoltaic plant with a total peak power of 3 MWp, with a system of two types of FTV panels:

The first is chequered, with the aim of allowing efficient absorption of solar energy and creating a permeable surface for the sun's rays will cover an area if about 6000 m^2 with a height of about 5 m. The peak power of this part of the plant is 498 kW.
The second structure, In rows with 14 m spans, involves the installation of 5 m elevated rows spaced 20 m apart. It consists of 160 double-axis tracker structures, with 6 double-sided monocrystalline photovoltaic modules and a nominal power of 610 W. In total, each tracker has a peak power of 14.6 kWp for a total output of approximately 2.3 MWp. An adequate inverter system will ensure that the maximum admissible grid connection power cannot exceed 2.5 MW in order to remain within the 3 MW power limit.

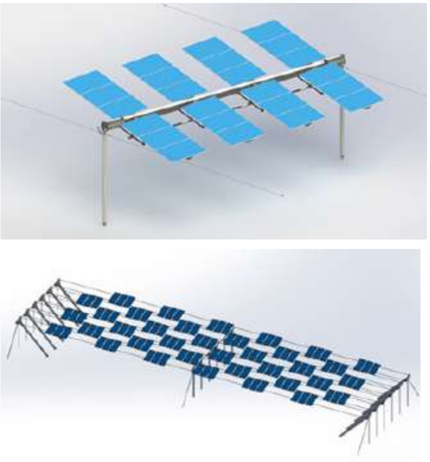

Fig. 7: The two photovoltaic system solutions from the RemTec company, used for project layout definition

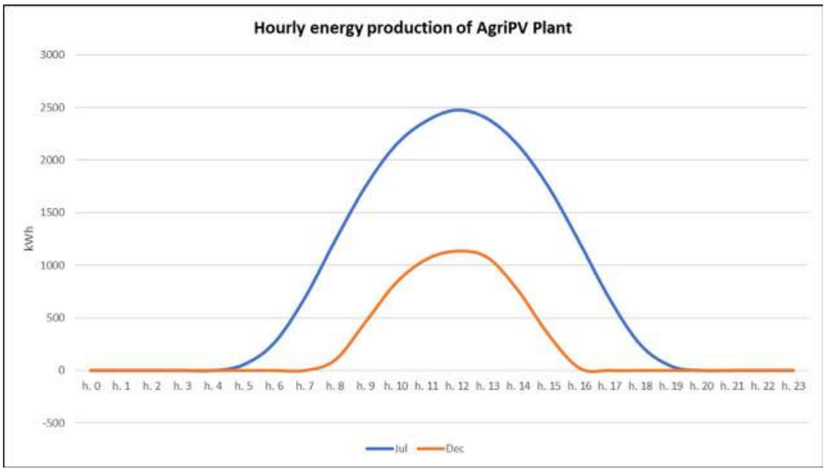

Fig. 8: Graph showing the average daily maximum and minimum production profile of the agrovoltaic system.

Photovoltaic structures have a height of 5.0 m, which makes them particularly sensitive to both horizontal wind actions and possible uplift in relation to their low weight. To counter these actions, the most effective and environmentally friendly system is to drive a pole into the ground to which the metal superstructure supporting the panels is attached.

The PALOVIT system, consisting of a Fe360 steel pole is screwed into the ground with a special hydraulic or pneumatic device. The steel posts have a diameter of between 27 and 60 mm and are internally hollow for the injection of pressurised mortar.

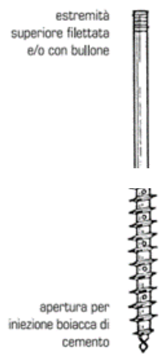

Fig. 9: PALOVIT anchoring system

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4 - 5	0,0	0,0	0,0	0,0	0,0	101,3	0,0	0,0	0,0	0,0	0,0	0,0
5 - 6	0,0	0,0	0,0	3,2	55,8	89,1	55,4	4,0	0,0	0,0	0,0	0,0
6 - 7	0,0	0,0	5,7	120,6	265,3	302,3	261,6	158,8	60,4	1,9	0,0	0,0
7 - 8	0,0	14,6	250,4	528,1	686,8	722,9	688,1	586,2	444,4	196,4	19,4	0,0
8 - 9	108,7	411,5	818,2	1.045,6	1.186,3	1.241,1	1.237,2	1.118,8	943,6	624,8	299,1	99,6
9 - 10	554,8	930,5	1.340,2	1.501,2	1.627,5	1.705,1	1.754,0	1.611,5	1.401,2	958,7	732,5	463,5
10 - 11	990,6	1.261,0	1.733,3	1.846,8	1.961,3	2.067,2	2.149,4	1.997,6	1.761,4	1.211,9	932,7	836,0
11 - 12	1.195,5	1.537,0	2.003,6	2.073,7	2.152,5	2.283,1	2.377,1	2.231,8	2.005,6	1.458,2	1.104,9	1.059,7
12 - 13	1.299,1	1.717,6	2.133,1	2.138,2	2.218,2	2.363,6	2.477,9	2.350,9	2.092,3	1.588,9	1.187,9	1.136,4
13 - 14	1.283,1	1.720,5	2.103,2	2.050,2	2.130,3	2.256,3	2.392,3	2.255,8	2.000,6	1.483,4	1.109,3	1.073,3
14 - 15	1.104,7	1.456,6	1.818,3	1.786,4	1.827,2	1.964,8	2.139,6	1.998,8	1.709,4	1.205,2	881,4	756,6
15 - 16	605,4	1.108,4	1.407,6	1.410,3	1.445,6	1.588,9	1.738,9	1.596,4	1.293,2	835,5	450,9	335,0
16 - 17	121,7	590,4	902,6	945,7	987,5	1.111,8	1.217,8	1.090,9	801,4	330,7	33,6	21,3
17 - 18	0,0	36,0	295,8	435,6	524,6	614,9	673,9	543,7	244,8	6,9	0,0	0,0
18 - 19	0,0	0,0	1,4	56,8	173,5	240,9	243,8	115,4	1,4	0,0	0,0	0,0
19 - 20	0,0	0,0	0,0	0,0	12,4	55,2	42,1	1,0	0,0	0,0	0,0	0,0
Sum Day	7.264	10.784	14.813	15.942	17.255	18.709	19.449	17.662	14.760	9.903	6.752	5.781
Sum Year	225.174	301.951	459.218	478.274	534.900	561.255	602.925	547.510	442.793	306.983	202.549	179.224

Fig. 10: Graph highlighting the intensity of photovoltaic production as a function of the time of day and month of the year.

Natural and anthropic semiology

Invariants and historical milestones

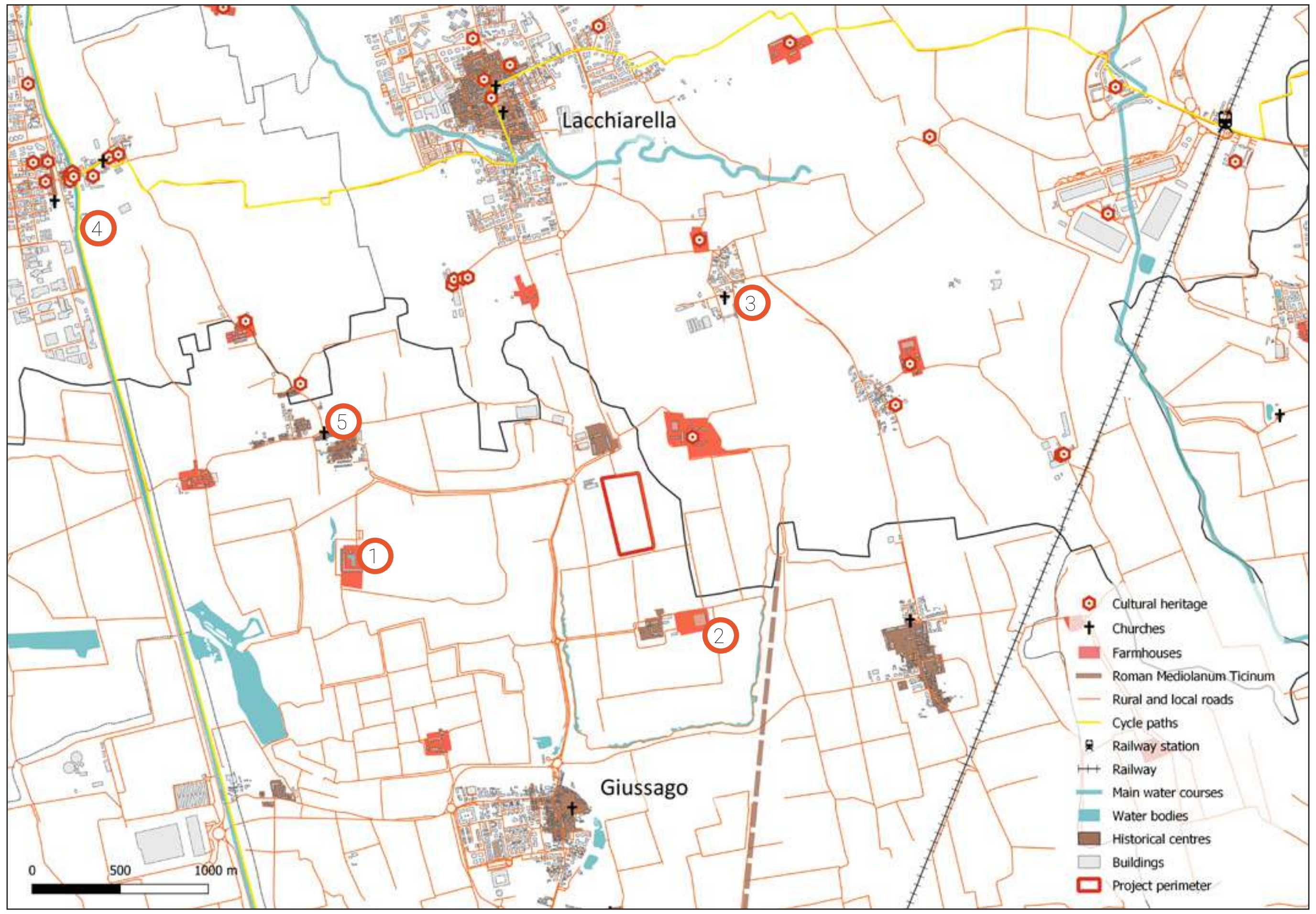

Fig. 1 - Anthropic semiology and historical milenstones

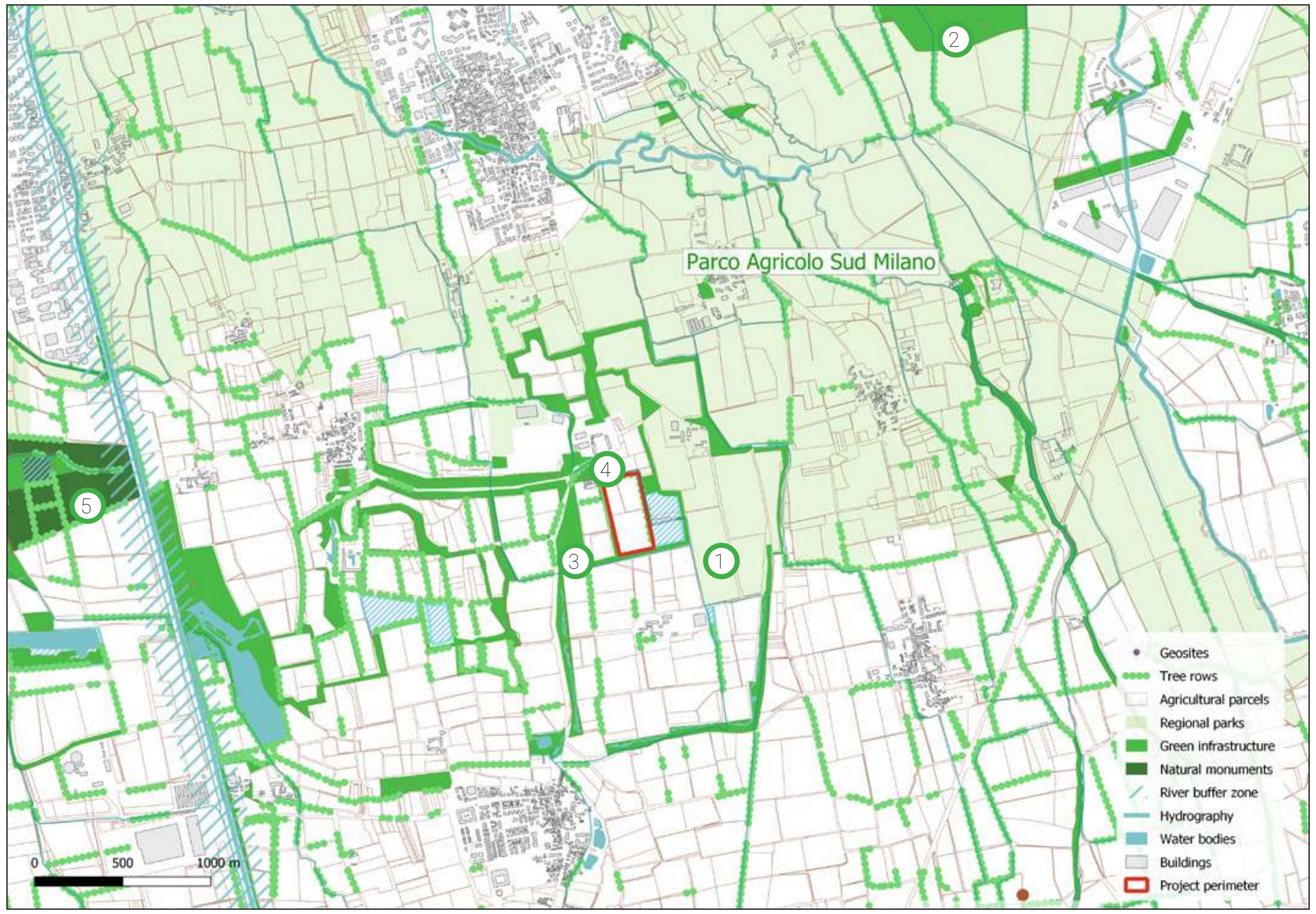

Fig. 2 - Natural and sinanthropic semiology

Since the early stages of the settlements in the area, human societies have modified the environment to meet their necessities. The landscape structure is characterised by several historical invariants belonging to different periods. We still perceive the sign of the Mediolanum-Ticinum, major roman road that testifies of their important influence in the area. The agricultural setup of Giussago dates of the same time and it materialises with the remnants of the agrarian centuriation.
The anthropic semiology of the landscape consists of small and diffuse historical settlements, farmhouses and churches uniformly distributed around the area. This wide occupancy of the territory testifies of the agricoltural vocation of the area, once based on the intense demand for labour in the rice paddies for harvesting, cutting, and transplanting. The matrix composed by roads and infrastructures such as the railroad and the Naviglio Pavese are mostly orientated North-South following in a way the direction of water flow and the polarities towards Milan and Pavia. The historical approach is likewise needed to interprete the natural - sinanthropic - semiology of the landscape. In the same way as other lowland regions, human societies have met no topographical limits to the exploitation of resources; for this reason, the natural structures and paths observed are from anthropogenic origins and differ from the original ecosystem composition. The presence of the natural monument of the Villarasca heronry and the Parco Agricolo Sud testify of the ecological value of the irrigated lowland, especially for migratory birds' conservation.
The project will stress this verticality highlighted by the anthropic and natural semiological elements. The historical and natural invariants will represent elements of valorisation, solid bases for the declination of a project that does not represent a punctual intervention but that wants to connect within a broader strategy on a territorial scale.

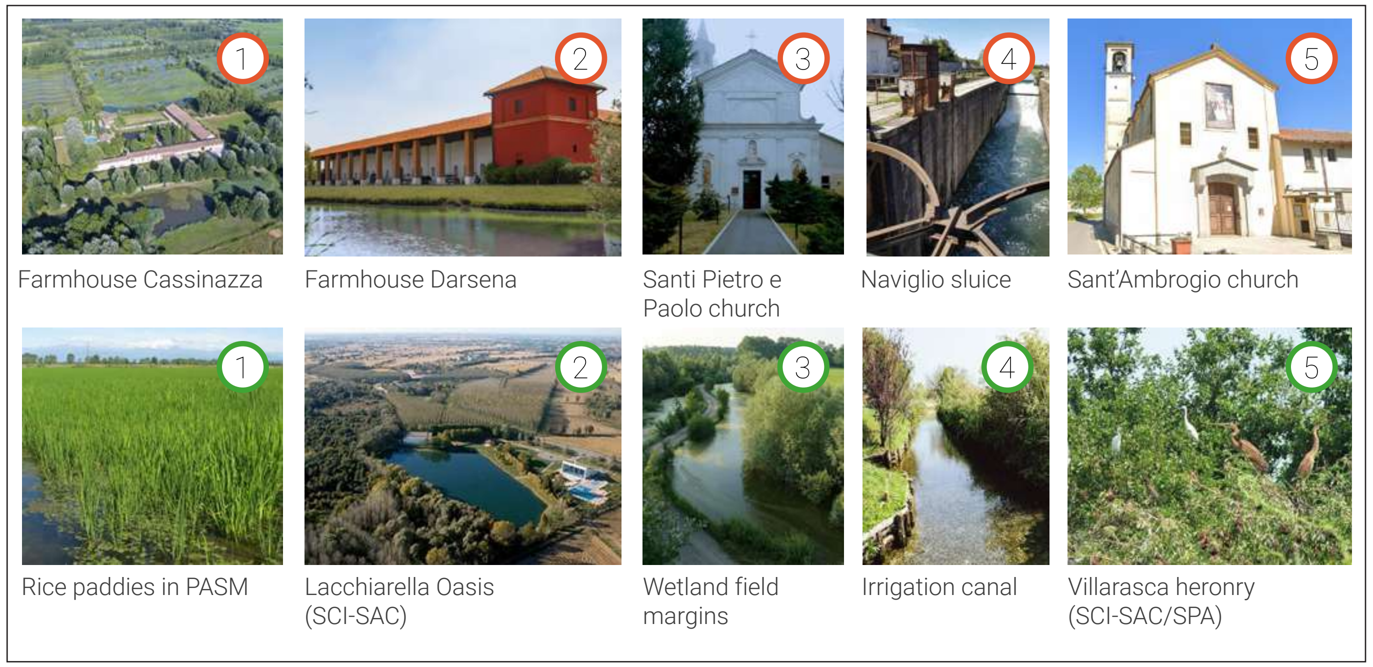

Fig. 3 - Natural and anthropic semiology abacus

Ecological and agricultural ecosystems

Habitats and ecosystem services

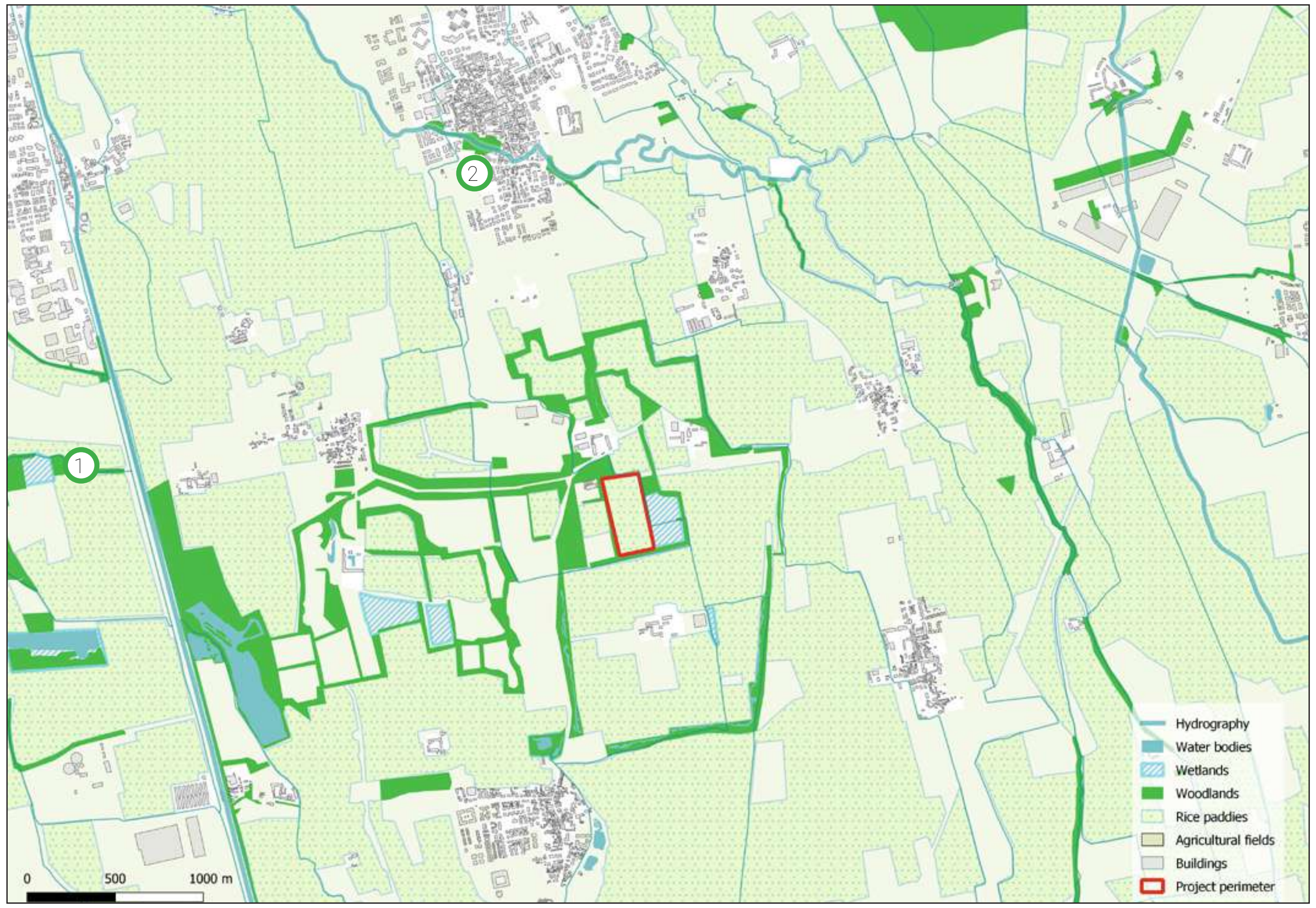

Fig. 4 - Macro-ecosystems and habitats

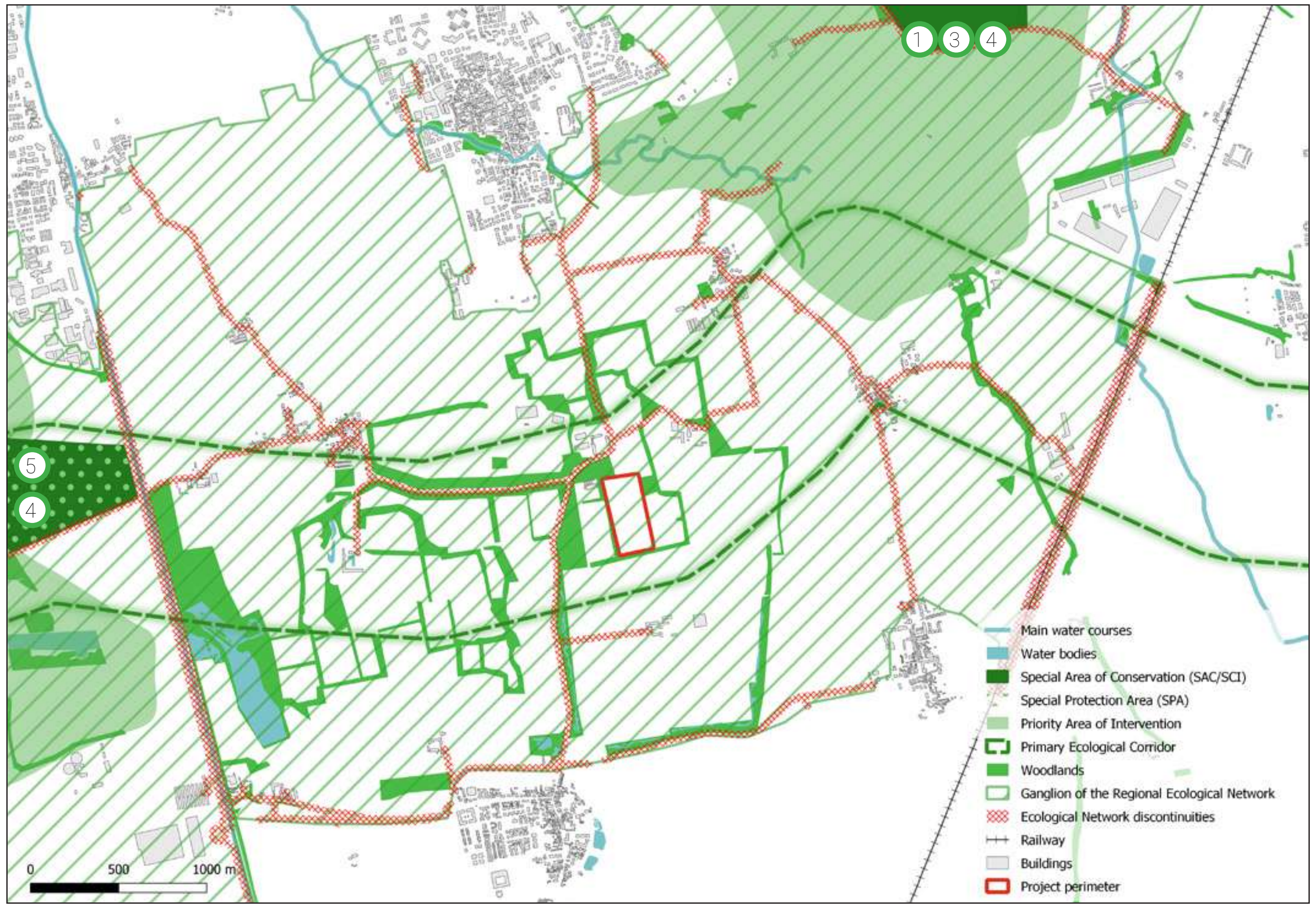

Fig. 5 - Ecological network and Natura 2000 protected areas

Alluvial forests with *Alnus glutinosa* · Mixed riparian forest of *Quercus robur* · Oak forests of Carpinion betuli · Hygrophilous formations with *Salix spp* · Eutropich lakes (Hydrocharition) · Phragmiteto

Fig. 6 - Habitat abacus

The landscape eco-mosaic is mainly characterised by the presence of a dense network of irrigation canals and cultivated rice paddies. A primary element of every biological life cycle, this enormous quantity of water represents a unique opportunity for the area's plant and animal biodiversity, allowing for possible synergies between agricultural activities and biodiversity enhancement objectives. It is in this direction that the actions promoted by NeoruraleHub have moved through the creation of wooded buffer zones around cultivated fields, providing ecosystem services and ecological value to all surrounding activities. The main barriers to ecological continuity are the large north-south oriented infrastructures. In this respect, the project area contained within a Primary ecological corridor and a Ganglion of Ecological network, plays a key role in overcoming barriers and providing natural connections between protected Natura 2000 habitats.

The site analysis and the CICES analysis respectively identified the habitats and the main ecosystem services provided in order to support the choice of ecosystems and the respective services to be included and improved in the project phase (more details: Table 3 - Project details)

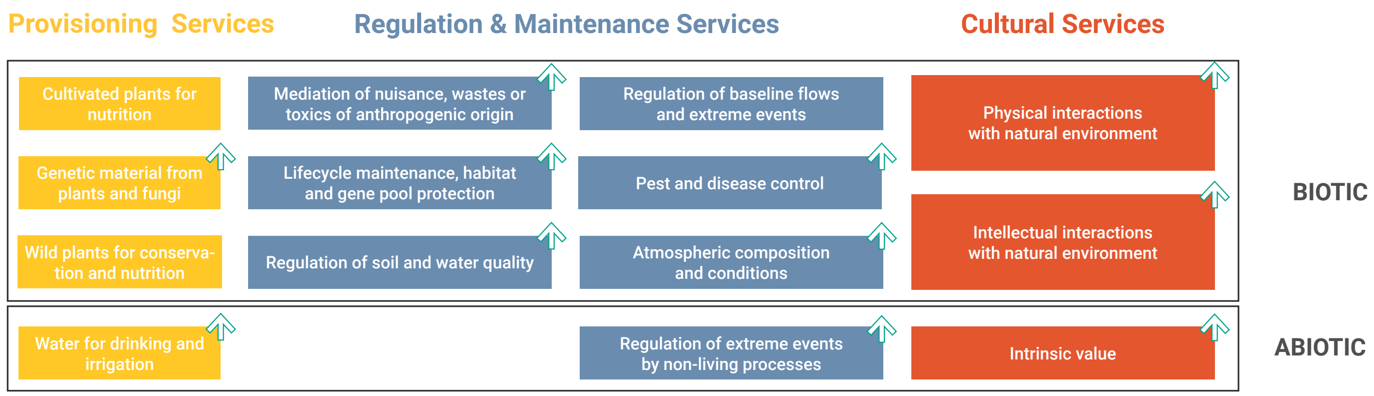

Fig. 7 - Landscape analysis - Common Classification of Ecosystem Services

Enhanced Ecosystem Service in the project scenario

LAND

Aesthetic value of landscape

Colours, textures and materials

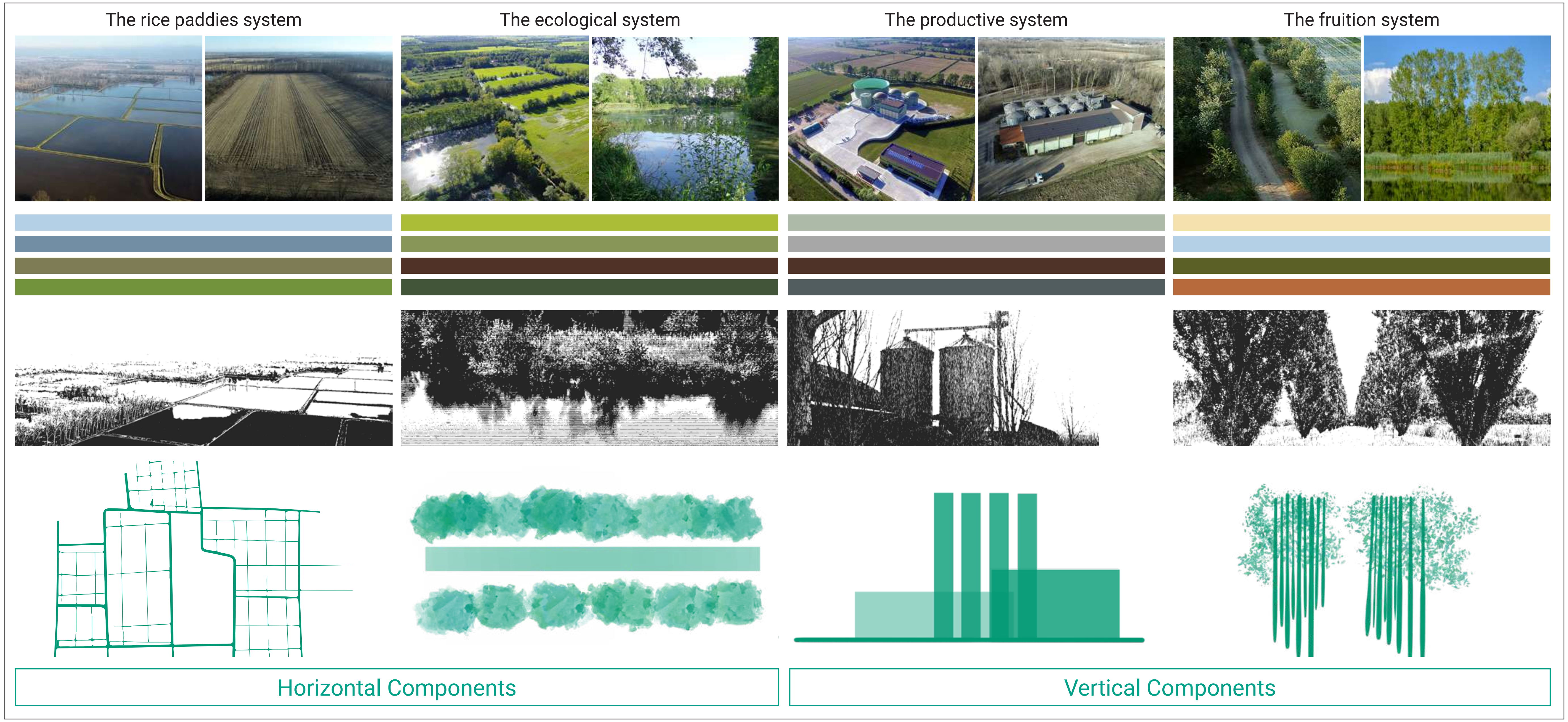

Fig. 8 - Analysis of aesthetic value of the main landscape systems

The values of the landscape are analysed through the study of its different characterising components, contextualised by the systems to which they belong. The perception of the landscape strongly depends on the life cycle of rice and related agricultural operations, which influence water levels within the paddy fields and reveal different patterns and colours that change with seasonal dynamism. The banks and dykes between the fields frame the cultivated plots and create the grid around which our proposal is structured. Likewise, the hygrophilous plants and their habitats along the edges of the fields represent the value of the ecological system of the landscape. These elements define the horizontal component of our landscape analysis.

If water represents the central element of the agricultural and ecological system, the production system represents the element of relationship between the natural and anthropic tracks. Rural areas have favoured the settlement of industrial activities within a 'flat' territory, as elements of verticality. The landscape insertion of these buildings must dialogue with the surroundings to maintain a coherent style with little impact on the aesthetic value of this area, in order to build new cultural landscapes of sustainability in harmony with the architectural tradition of Giussago. This can be achieved through the study of appropriate materials and the analysis of the colours characterising the surroundings. The utilisation system, with its capillary rural roads, forms the backbone of this area, leading inhabitants and visitors through the agricultural fields on a slow path, allowing them to observe the environment in its daily and seasonal changes thanks to green paths defined by tree rows, which support the ecological connection in multiple directions. These elements define the vertical component of our landscape analysis.

Horizontal and vertical elements will form the backbone for the definition of our design strategy.

Economic evaluation

n.	DESCRIPTION	u.m.	Quantity	Unit price	Total €
	1. GREEN WORKS AND WATER SYSTEM				**€ 147.302**
1.1	Soil preparation, creation of 40 cm thick permanent bumps and wetlands with soil from the paddy field.	sq.m	80.000	€ ,50	€ 40.000
1.2	Formation of turf and meadow, including the soil preparation by mechanical working up to 15 cm	sq.m	11.631	€ 2,00	€ 23.261
1.3	Supply and planting of shrubs	sq.m	2.655	€ 25,00	€ 66.368
1.4	Supply and planting of hygrophilous plants	sq.m	443,70	€ 28,00	€ 12.424
1.5	Supply and planting of trees circum. 20 - 25 cm	cad	15	€ 350,00	€ 5.250
	2. PAVEMENTS				**€ 141.690**
2.1	Beaten earth paving	sq.m	4.723	€ 30,00	€ 141.690
	3. FUNCTIONAL AREAS AND FURNITURE				**€ 119.280**
3.1	Realisation of vegetable garden including soil preparation, wooden curbs, tool sheds, wooden pots	sq.m	6.190	€ 12,00	€ 74.280
3.2	Charging station for electric bike sharing	fixed price	1	€ 40.000,00	€ 40.000
3.3	Supply and installation of benches, litter bins, and information boards	fixed price	1	€ 5.000,00	€ 5.000
	4. BELVEDERE				**€ 145.760**
4.1	Wooden ramp including supporting structure, flooring and railing	fixed price	1	€ 110.000,00	€ 110.000
4.2	Wooden finishes including, flooring, staircase and railing	fixed price	1	€ 8.000,00	€ 8.000
4.3	Brick structure for photovoltaic cabins including foundations, curtain walls and roofing	fixed price	1	€ 27.760,00	€ 27.760
	5. PHOTOVOLTAIC SYSTEM				**€ 3.188.200**
5.1	Plant support facilities (tracker, grid)	kW	3.000	€ 450,00	€ 1.350.000
5.2	Photovoltaic modules	kW	3.000	€ 330,00	€ 990.000
5.3	Transformer cabins and inverters	kW	3.000	€ 80,00	€ 240.000
5.4	Photovoltaic plant wiring (incl. excavations for burying)	lm	12.500	€ 20,00	€ 250.000
5.5	Connection costs	each	3	€ 3.000,00	€ 9.000
5.6	Installation costs (manpower, equipment, elevations, permitting, practices)	kW	3.000	€ 100,00	€ 300.000
5.7	PALOVIT photovoltaic anchoring system with Fe360 steel pole and mortar injection	each	164	€ 300,00	€ 49.200
	TOTAL				**€ 3.742.232**
	COST €/sqm				**€ 47**
	Project area (sqm)				**80000,0**

Preliminary estimates were elaborated on the basis of the Municipality's price list of Milan 2021 and on the basis of quantifications deriving from previous project experiences of the LAND group and the working group, in the lack of standardised costs in the reference price list.