REWETLAND

A WIDE-AREA PROGRAMME FOR IMPROVING THE QUALITY OF SURFACE WATER IN THE AGRO PONTINO BY MEANS OF NATURAL PURIFICATION TECHNIQUES

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Final publication of the project LIFE+08 ENV/IT/000406 «Widespread introduction of constructed wetlands for a wastewater treatment of Agro Pontino»

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PREFACE

Starting from Legislative Decree 152/99, and with a stronger impulse after Directive 2000/60/EC (Water Framework Directive), the Province of Latina has dedicated a growing attention to the issue of quantity and quality of the water resource in its territory. Having been assigned the competences empowered by Regional Law 14/99, the Province has worked on the project "Monitoring of waters", which, in its first phases, has entailed specific activities for understanding the provincial water system, studying in detail the characteristics of springs, estimating the origins of pollutant loads, and also analysing the state of marine and coastal waters with the use of innovative methods.

Such in-depth understanding of this geographical context and the pressures caused by human activities has allowed to identify the most significant spots for controlling water quality through a network of monitoring stations.

The implementation of the monitoring activities has allowed to measure the real characteristics of the pollutant loads, orienting the necessary interventions for pursuing the water quality objectives envisaged by the European directive. Among these interventions, the natural purification techniques have revealed themselves as the most adequate solution for reducing the diffuse pollution from nitrates and phosphates from farming activities, which is an important component of the total pollutant load.

In order to facilitate the introduction of these techniques in the Agro Pontino, the Province has participated in the Rewetland project together with the Municipality of Latina, the Circeo National Park, the Land Reclamation Consortium of Agro Pontino, and the consulting company U-Space.

The project, co-financed by the LIFE+ Programme of the European Commission, has been implemented from January 2010 to June 2014; during this period, four pilot projects have been carried out, good practices and guidelines for the introduction of constructed wetlands in the Pontine area have been elaborated, and a programme of future interventions has been drafted and included within the local wide-area strategic programming, involving 19 municipalities of the Province.

The quality of the Pontine waters and the necessary interventions for its improvement are therefore the main theme of this publication, which I have the pleasure to invite you to read.

Nicoletta Valle

Project Manager of the Rewetland project

INTRODUCTION

The degradation of surface water quality in areas subject to human pressures is notoriously a complex problem, particularly in places such as the Agro Pontino, where the hydrographic network is very wide. The watercourses receive many polluting substances coming from human, urban, industrial and agricultural activities. Discharges linked to industrial and urban activities are generally concentrated, therefore more easily controllable and treatable. On the other hand, wastewater from crop farming and livestock farming activities is usually diffuse over wide areas, with concentrations being very variable in time and space, but eventually reaching, in any case, the surface and ground waters.

The high concentrations of nitrates and phosphates of agricultural origin in surface waters give rise to a proliferation of microorganisms and algae that consume the dissolved oxygen, leading to a progressive anoxia in the aquatic environment, in particular in the warmest and driest months. This causes a general alteration of the ecological state of the water body, with serious consequences in the aquatic fauna and the death of many fishes.

If particularly abundant, the pollutant load reaches the sea, giving rise to phenomena such as the "mucilage", sometimes having only an aesthetic impact, but in other cases very dangerous in sanitary terms, due to the presence of toxins that can be harmful to men and animals.

By acknowledging the strategic value of water for the economy and the quality of human life, the European Directive 2000/60/EC (Water Framework Directive) has set quality objectives for the surface waters, which Member States are obliged to achieve by 2015. Even if a recent report by the European Commission highlights that more than half of the Member States are lagging behind in the achievement of these goals, it is possible that, in the future, the congruence with the standards of the Directive will be one of the elements of evaluation of the environmental quality of territories, linked to the quality of generated goods and services, such as the farming products or the tourist offer.

In the agricultural and industrial Pontine Plain, whose coastal area is a much appreciated tourist destination in the warm season, the safeguard of water quality and quantity should be a fundamental objective in order to ensure the permanence of economic activities able to support a social development of adequate level. Indeed, the congruence with the water quality levels determined by the European legislation means first of all ensuring the basic conditions for the consolidation and evolution of high-quality agricultural productions, which could otherwise be subject to a decreased competitiveness. Moreover, a higher availability of quality surface water can contribute to a decrease in the overall pumping of groundwater – which is today already at its sustainability limits –, with positive consequences also on the safeguard of water quantity.

The norms established by the Water Framework Directive have been implemented in Italy with the "Consolidated Environmental Law" (Legislative Decree 152/2006), stating that the Regions must define specific plans for the safeguard of water, to be approved by 31 December 2007. In the case of Lazio, such Plan has been drafted in 2004 and approved within the deadline, but the related measures have encountered difficulties in being applied.

The Plan evaluates the state of the waters of the Province of Latina mainly as "very bad", and defines the Rio Martino basin as one of the priority intervention basins. Within this basin, there are, besides part of the city of Latina, at least three big water treatment plants, a number of industrial areas, and, above all, the coastal lakes of Fogliano, Monaci, Caprolace and Paola, i.e. a good part of the Circeo National Park.

In 2002, the Province of Latina, based on its own competences, has started many activities for studying and monitoring the state of the Pontine waters: validation of the hydrographic network, creation of a database of discharges and wells, implementation of measurement campaigns and, finally, activation of a monitoring network. With this geographic information, combined with other types of data (e.g. the land cover map), the Province has been able to evaluate the pollutant loads in each sub-basin. The first results show that the situation is less critical than the one defined by the regional Plan, and the work carried out has allowed to distinguish, with a high level of detail, the critical sub-basins from those in line with the European Directive.

The continuation of the monitoring until 2013 has allowed to compare the previous evaluation with the measured values, thus achieving a finer result.
Given the diffuse distribution of pollution deriving from farming activities and minor residential settlements (organic compounds, nitrogen and phosphorus), the natural water purification techniques have been recognised as the most appropriate, and causing the lowest impact, for the Pontine Plain.
The Province has therefore decided to undertake a process for testing the replicability and sustainability, in the Agro Pontino, of techniques already widely used elsewhere. For this reason, together with other partners (Municipality of Latina, Circeo National Park, Land Reclamation Consortium of Agro Pontino, U-Space s.r.l.), a proposal has been submitted to the 2008 call of the LIFE+ Programme of the European Commission; the proposal has been funded in 2009, and the Rewetland project has started in 2010.
The project has been co-financed by the Programme within its "Environment" sub-programme, sector "Governance", because the replicability and local sustainability of a diffuse water purification system depend essentially on the level of acceptance by the local actors and the capacity of the institutions to manage this process.
Indeed, many experiences have highlighted that the solution of complex territorial problems is always an integrated process, to be pursued through the consensus by local actors, who can facilitate it or hinder it, determining its success or failure.
Rewetland has been an occasion to begin a journey in this direction. The natural solutions to the problem of water treatment have been introduced using a participatory method, centred on meetings and workshops with citizens and stakeholders. This opening to the acknowledgement by the local actors is a necessary condition also for the transfer of technologies, especially when they are mainly good practices that need to be implemented by the actors with continuity, also in a perspective of economic sustainability.
The project, which has now ended, has allowed to carry out different activities, the most relevant of which have been:

- the numerous studies and territorial analyses on the hydrographic network of reclamation canals, on the state of the waters in general and on the lakes of Fogliano and Monaci in particular;
- the implementation of pilot experiences regarding plants, systems and practices of natural water purification in a protected area (Circeo National Park – Lake of Fogliano), in a peri-urban area (Marina di Latina) and along the network of reclamation canals (Fosso Spaccasassi and Canale Selcella); all directly on the open field, exposed to the real maintenance needs and the challenges related to their management;
- the elaboration, with the participation of citizens, of a strategic programme (the Environmental Restoration Programme, ERP, unanimously approved by the Provincial Council in July 2013) that has set the axes and measures to be implemented in the urban, agricultural and natural contexts in order to foster the introduction of the natural purification systems;
- the implementation of an intense dissemination and awareness-raising set of activities through different web tools, participation to local, national and international events, educational and informative campaigns targeted to schools, farmers and all citizens.

All these activities are described in this book, but the project web site (www.rewetland.eu) can provide more detailed information about the work that has been carried out.

PORTFOLIO

View from Mount Circeo (photo: Riccardo Copiz).

“Verdesca pool” in wintertime (photo: Mauro Iberite).

Lake of Paola (photo: Riccardo Copiz).

Bed of reeds – Phragmites australis (photo: Mauro Iberite).

Halophile rushy vegetation nearby Lake of Fogliano (photo: Riccardo Copiz).

Wetlands around the Lake of Monaci (photo: Riccardo Copiz).

“Cicerchia marshes” in springtime (photo: Riccardo Copiz).

THE “AGRO PONTINO”

1.1 ENVIRONMENTAL CHARACTERISTICS

Geographic and landscape features

The name “Pontine Plain” (*Pianura Pontina* or *Agro Pontino*) derives from the Latin word *pontus* meaning “sea”, referred to the wide gulf that used to cover the plain before its being filled with marine and alluvial sediments. The plain is located in southern Lazio, between the Lepini-Ausoni Mountains and the Tyrrhenian Sea (Fig. 1).

Its boundaries are rather undefined only in the north-eastern part, where the Pontine Plain connects to another plain located between the Colli Albani and the sea, known as “Agro Romano”. The medium-lower course of the Astura River is considered a conventional boundary between these two plains. Therefore, most of the Pontine Plain lies within the Province of Latina, but it is evident that the provincial administrative boundaries do not perfectly coincide with the historic and geographic context. For the sake of simplicity, the Pontine Plain can be described as a polygon of about 1,000 sq km (100,000 ha = 1,000,000,000 sq m), with vertices coinciding with Cori to the north-east, Aprilia to the north, Torre Astura to the west, the Circeo Promontory to the south, and Terracina to the south-east. The municipalities of the Province of Latina lying, totally or partially, within the Pontine Plain are those listed in Table 1.

In terms of landscape and morphology, the Pontine Plain would seem rather homogeneous to an observer placed on an elevated spot. However – notwithstanding the transformations caused by the land reclamation of the past century –, still today, when moving from the coast towards the inland, it is possible to recognise three very different zones: the coastal zone, characterised by the sand bar and the coastal lakes; the intermediate zone, having very different elevations and characterised in the past by depressed, wetter areas on the one hand (the so-called “piscine”, i.e. pools), and higher, dryer areas (the so-called “lestre”, i.e. clearings for pasture) on the other; and the zone at the foot of the Lepini-Ausoni Mountains, very wide and depressed, which used to host the actual Pontine marshes, today replaced by agricultural and industrial areas.

The apparent monotony of the plain is interrupted by the Circeo Promontory, a 541-metre-high carbonate mountain that used to be an island before the filling of the Pontine Plain; this island has surely contributed to slow down the sea streams and fostered the deposition of the carried sediments.

Figure 1 – Geographical location of the Pontine Plain.

Table 1 – Municipalities located in the Pontine Plain, and spatial extent in hectares.

In any case, the Circeo Promontory still looks like an island, due to its irregular contour, strongly contrasting with the rest of the flat coastal zone. It is therefore a unique landmark for the entire area and, besides, an important reference in cultural terms, thanks to the myth of Circe and the well-known adventures connected to the figure of Ulysses. Fascinating yet imaginary stories, which often leave little room to true, but no less fascinating, stories such as those related to the ancient presence of *Homo neanderthalensis*, or those linked to the variations of the sea level, impressed on the rocks in the caves located at the base of its southern side.

Climate

There are no great climate differences throughout the Agro Pontino.

The current climate belongs to the sub-humid thermo-meso-Mediterranean type, with dry summers and mild winters. The rainiest months are in autumn and winter, where 70% of the annual rainfall is concentrated (Fig. 2).

The proximity of the sea mitigates both winter climate and summer temperatures, thanks to the presence of moisture-laden sea breezes.

The general mildness of the climate becomes clear when observing the average temperatures registered in Latina: maximum temperatures range from 12 °C in January to 31 °C in July, while minimum values vary from 3 °C in January and February to 19 °C in August.
The average values of the maximum relative humidity are comprised between 94 and 97%. This factor has a negative consequence on liveability, especially in the areas that are less exposed to the wind breezes, and the most depressed zones where a stagnation of atmospheric and evapotranspiration humidity often occurs.
Therefore, notwithstanding the Mediterranean character of the climate and the scarce summer precipitations, humidity is always relevant, both due to the proximity of the sea and to the richness in ground and surface water.

Figure 2 – Temperature and precipitation diagram from the station of Latina airport. The red curve represents the monthly average temperatures, whereas the blue curve represents precipitations. The dotted area corresponds to the dry period (high temperatures and low precipitations).

The combination of high temperatures and high atmospheric and edaphic humidity allow for the presence of a rich vegetation that would be inconceivable in a Mediterranean climate, as can be seen in the lowland forest of the Circeo National Park. Of course, this is also an advantage for the local agriculture, which is highly productive and therefore important in economic terms.

Geology

In the framework of the geological evolution of Central Italy, the Pontine Plain is the southern portion of a wide subsiding zone comprised between the Appennine Mountains and the Tyrrhenian coast, which formed in the so-called post-orogenic distensive phase, starting from the end of the Miocene (around 5 million years ago).
From then, and during all the Pliocene and the Pleistocene, the carbonate substratum of this zone was dismantled and dislocated vertically by direct fault systems with a main NW-SE direction, and a secondary SW-NE direction, which generated the development of a deep "graben", filled during the centuries with marine, river and wetland sediments and, on the surface, pyroclastic sediments deriving from the "Vulcano Laziale" (Latium Volcano), active between 600,000 and 20,000 years ago.
The considerable variations of the sea level, which occurred at the time of the Quaternary glaciations (in particular the Würm glaciation, which ended only 10,000 years ago), have strongly influenced the deposition of the most superficial sediments, the coastal and river erosion processes and, therefore, the morphology of this area, as synthetically illustrated in Fig. 3.
Because of all these processes, the morphology of the area is not as monotonous as it may seem to an external observer. The distribution of the emerging lithological substrata (more or less covered by soil) is also very varied if observed in detail. It is surely more varied in comparison to what is commonly shown by the geological maps that, for scale and graphical reasons, tend to simplify its actual heterogeneity (Fig. 4).

Hydrography

The hydrographic network of the Pontine Plain has undergone deep transformations in the past, starting already from the land reclamations carried out by the pre-Roman populations who inhabited and governed for several centuries some portions of this area.

Figure 3 – Rise and evolution of the Pontine Plain.

Figure 4 – Lithology of the Pontine Plain (source: Province of Latina).

Important transformations have been carried out by the Romans, and, on more occasions after the Middle Ages, by many Popes. The hydrographical map of Italy, elaborated in 1895, already showed that, at that

time, the internal and marshy part of the Pontine Plain showed a dense network of canals and land reclamation works (Fig. 5).
In 1900, the Italian Parliament approved a consolidated law on the reclamation of wetlands, and after War World I the first comprehensive study for the reclamation of the Pontine Plain was elaborated in 1918 by Mr. Marchi of the Public Works Office of Rome. Following this study, the Pontine Marshes were divided into two sectors: the former, at the left of the Sisto River, was entrusted to the Consortium of Land Reclamation of the Pontine Marshes; the latter, at the right of the Sisto River, to the Consortium of Land Reclamation of Piscinara, later named Consortium of Land Reclamation of Littoria (later on Latina).
Marchi's project was based on the separation of waters, and the criteria at the basis of the current setting of the area are the practical application of his study. The essential principle of the project, besides the separation of "high", "medium" and "low" waters (see Box 1), was to provide for the mechanical draining, by means of water pumps, of the areas where a natural draining couldn't occur due to their morphology.
The Consortium of Land Reclamation of Piscinara, based on another project (known as the "Pancini-Prampolini" project), carried out the separation of waters by building the "High Waters" Canal, later renamed Mussolini Canal and then, only close to its mouth, Moscarello Canal. The land reclamation interventions carried out little less than a century ago, during the Fascism, determined a radical modification not only in the hydrography, but also in the topography, biodiversity, urbanisation, economy and, therefore, landscape (Fig. 6, 7 and 8).

Box 1 – Hydraulic functionality of the land reclamation network

High Waters

The "High Waters" network comprises all those watercourses that, due to their origin, have sufficient slope to spontaneously flow to the sea, but used to feed the marshes before the land reclamation.
The main works for the separation of the High Waters from the rest of the Pontine Plain is the High Waters Canal ("Canale delle acque alte", once called Mussolini Canal, today also known as Moscarello Canal), which marks for a long stretch the border between the municipalities of Cisterna and Latina. This canal flows through the northern sector of the plain, crosses the natural watercourses coming from the Lepini Mountains and Colli Albani, and collects their waters before flowing into the sea at Foce Verde (Municipality of Latina).

Medium Waters

The so-called "Medium Waters" network collects the waters flowing from the areas located above sea level, which could not freely flow into the sea due to the higher level of the coastal zone (the ancient and/or recent dune).
The main canals of this network are three. The first one is the "Medium Waters" Canal (Canale delle acque medie), which partly retraces the course of a canal of the Volscian era, and which, in the area closer to the sea, marks the border between the municipalities of Latina and Sabaudia, taking the name of Rio Martino.
The other two major canals, which were dug following the course of minor works carried out in the 17th and 18th centuries, are:

- Canale Sisto, which flows into the sea between Terracina and the Circeo Promontory, and runs roughly along the line of demarcation between the inner outcrops of the Quaternary dune and the alluvial plain;
- Linea Pio VI, which originates from Canale Sisto as a flood bypass canal (at the point where it changes its name from Ninfa to Sisto) and runs for almost its entire course along the Via Appia, before flowing out to the sea in Terracina. This canal is "hanging" in the second part of its course, where it partially crosses the "Low Waters" basin.

Low Waters

The "Low Waters" network flows where the land is mainly at, or below, sea level. The water flow is entrusted to mechanical water-lifting devices. The Mazzocchio pumping station is quite remarkable, and one of the biggest in Europe; it lifts the waters into the hanging course of the Ufente river, then into Linea Pio VI at Pontemaggiore near Borgo Hermada (Municipality of Terracina). There are many more minor pumping stations lifting the waters into secondary canals, mostly flowing into Linea Pio VI.

1.2 BIODIVERSITY, PROTECTED AREAS AND ECOLOGICAL NETWORKS

The Pontine territory is mainly characterised by an agricultural matrix, due to its flat morphology, the availability of water for irrigation and the mild climate. In this context, there are only a few natural areas left,

mainly within the Circeo National Park. However, small areas of high importance in terms of ecological network, especially with a view to restore its functionality, are present also in other portions of this area, as described in this chapter.

Circeo National Park

The Circeo National Park has a great importance in the Pontine area as far as nature, landscape and culture are concerned. Established in 1934 (the same year when the city of Sabaudia was founded), its boundaries have been modified and enlarged a couple of times, until reaching an area of 8,872 hectares. Even if not very large, it is characterised by a remarkable variety of environments and biocoenoses and, consequently, a relevant richness in flora and fauna.

Figure 5 – Extract from the Hydrological Map of Italy (1895).

The Park can be divided into five parts:

- the coastal dune belt, almost 30 km long, and morphologically linked to the actions of the sea, the wind, the typical psammophile vegetation, and, increasingly, the human transformations both along the coast and in the inland; moreover, the interventions along the water courses flowing into the sea to the north of the Park have caused considerable fallouts on the process of sediment transport, and therefore on the natural formation of beaches;
- the coastal dune lakes (Fogliano, Monaci, Caprolace and Paola, also named Sabaudia), once connected to each other by large wetlands, and differently shaped (only the Lake of Paola still conserves its old natural shape, with branches penetrating into the ancient dune towards the inland, see Fig. 9);
- the ancient dune, formed by the dune sand deposits dating back to the times when the coastline was more internal than today; in these deposits, clay and silt substrata (strongly contributing to the development of vegetation) can be found due to the morphology – succession of "lestre" (clearings) and "piscine" (pools) –, the changes in hydrological regimes and groundwater levels, and the pedogenetic processes;
- the Circeo Promontory (541 m high), characterised by two mountainsides with very different exposures, so that they have been named "Quarto freddo" ("cold", or northern, side) and "Quarto caldo" ("warm", or southern, side). This difference in exposure has a considerable influence on vegetation: the former hosts a thick, mixed thermophile forest, the latter a more varied vegetation, mainly composed by herbaceous vegetation, garrigue and maquis shrublands of different types (also due to natural and human disturbances such as frequent cuts and fires, farming, and urbanisation). The presence of several caves makes "Quarto caldo" very interesting also from the geo-speleological point of view, and for the presence of numerous prehistoric findings (e.g. the famous skull of the Neanderthal man);
- the isle of Zannone, located 25 km from the Circeo Promontory, mainly made up of volcanic rocks, but with sedimentary metamorphic outcrops in its northern part; the scarcity of precipitations and soil, the constant action of the wind, the morphology and the effects of the direct and indirect human disturbance have an influence on vegetation, represented by low shrubland and garrigues in the southern part, and evergreen holm oak woods in the northern part.

Figure 6 – The Lake of Fogliano and the surrounding marshes before the land reclamations of the past century (source: Province of Latina).

Figure 7 – Current hydrographic network (source: Province of Latina).

Figure 8 – Interventions carried out during the land reclamation (source: La Bonifica delle Paludi Pontine, Istituto di Studi Romani, 1935).

Figure 9 – View of the Circeo National Park from the Promontory, with the Lake of Paola in the foreground (Photo: Stefano Magaudda).

The Park is a very important element for promoting researches and scientific analyses, besides activities of compatible management and environmental education, with the aim of protecting the Pontine wetlands, also taking into consideration their considerable extent. Moreover, five Natural State Reserves are contained within the borders of the Park, three of which are very important for the conservation of very rare wet habitats: "Pantani dell'Inferno", "Piscina della Gattuccia" and "Piscina delle Bagnature".

European ecological network Natura 2000

There are different nodes of the Natura 2000 network in the Pontine Plain (Fig. 10), both Sites of Community Importance (SCI) and Special Protection Areas (SPA), respectively designated under Directives 92/43/EEC (Habitat) and 2009/147/EC (formerly 79/409/EEC – Birds). In order to be designated as SCI, an area has to contain one or more habitats and/or one or more populations of species defined "of Community interest" and listed in Annexes I and II of the Habitat Directive; whereas in order to be designated as SPA, it has to contain one or more populations of birds listed in Annex I of the Birds Directive.

The presence of some of these areas within the Circeo National Park confirms the importance of this portion of the Pontine Plain (Fig. 11): one SPA (IT6040015 "Parco Nazionale del Circeo") and six SCIs, three of which are very important for the hygrophilous habitats and the aquatic species (IT6040012 "Laghi Fogliano, Monaci, Caprolace e Pantani dell'Inferno", IT6040013 "Lago di Sabaudia", and IT6040014 "Foresta Demaniale del Circeo").

Other three SCIs are located within the Agro Pontino, and even if they are far from the Park, they are no less important for the conservation of the wetland ecosystems and the functionality of the wider ecological network. These sites are IT6040002 "Ninfa (ambienti acquatici)", IT6040003 "Laghi Gricilli", and IT6040008 "Canali in disuso della bonifica pontina". The sites IT6030047 "Bosco di Fogliano" and IT6030049 "Zone umide a ovest del Fiume Astura" also deserve to be mentioned because of their natural value and their proximity. For all these areas, many actions of environmental protection and conservation of biodiversity have been carried out. To this end, specific obligations and prohibitions have been introduced, in particular for the wetlands. Specific Management Plans have been drawn up for the SCIs "Canali in disuso della bonifica pontina" and "Laghi Gricilli", in order to define actions and interventions necessary for the achievement of the conservation objectives. For the SPA "Parco Nazionale del Circeo" (and the SCIs that it contains), a Management Plan has been also recently drawn up.

SCI "Laghi Gricilli"

The SCI IT6040003 "Laghi Gricilli" is located at the inner border of the Pontine Plain (Fig. 12), at the foot of the small group of hills of Mount Saiano (hills of Priverno). It has an area of 179 hectares and is largely included in the Municipality of Pontinia, and for a small part in the Municipality of Sezze; it is fully included in the large SPA IT6030043 "Monti Lepini". This site is characterised by five small lakes: Lake San Carlo, Lake Mazzocchio, and the three "Laghi del Vescovo" (Lakes Verde, Bianco and Nero). These lakes are typical sinkholes, filled will groundwater and by a number of springs feeding the local hydrographic network, in particular the Ufente river. These small lakes are immersed in a partially urbanised agricultural matrix. Excluding the water bodies, the natural areas are very scarce and limited to the banks of the lakes and to a few marshes surrounding in particular the "Laghi del Vescovo", characterised by reed beds of *Phragmites australis*.

The tree vegetation is limited to a row of black poplars (*Populus nigra*) and eucalyptuses bordering Lake San Carlo. The human activities have strongly influenced the natural character of the place, and still today have a strong impact due to: water pollution (of agricultural and urban origin); water withdrawal; periodic removal of riparian vegetation; spread of invasive alien species; abandonment of waste; incompatible tourist and recreational uses. Such impacts have determined, also after the establishment of the SCI, an impoverishment

in terms of biodiversity, as well explained in the preparatory documents of the Management Plan of the site and in more recent studies.

Figure 10 – The Natura 2000 network in the Agro Pontino.

Figure 11 – Extent of the Circeo National Park.

Figure 12 – Extent of the the SCI IT6040003 "Laghi Gricilli".

Figure 13 – View of one of the Gricilli lakes (photo: Giancarlo Bovina).

SCI "Canali in disuso della bonifica pontina"

The SCI IT6040008 "Canali in disuso della bonifica pontina" is located at the south-eastern border of the Pontine Plain, at the foot of the Ausoni Mountains. It has an area of 593 hectares, and belongs to the municipalities of Terracina and Sonnino (Fig. 14). This site is characterised by some watercourses and land reclamation canals, among which the Pedicata ditch, which still retains some natural characters and biodiversity. To the west, the border of the SCI runs partly along the Amaseno River, which is the main watercourse of this portion of the Pontine Plain, but unfortunately in bad quality conditions.

The landscape matrix is mainly agricultural and partially urban, in particular along the roads, some of which have experienced an increase in traffic in the last years, following the building of the Frasso junction of the Frosinone-Terracina road.

Here also, the natural areas are very scarce, and limited to the banks of the watercourses, dominated by reed beds of *Phragmites australis* and/or by bramble bushes.

The hygrophilous woods, potentially very extensive in this context, are limited to single and scattered individuals of black poplars (*Populus nigra*), white willows (*Salix alba*), and black alders (*Alnus glutinosa*).

As already explained for the Gricilli lakes, the human activities have strongly affected the natural characters of this place, and still have a negative influence caused to:

- water pollution of agricultural and urban origin;
- water withdrawal;
- periodic removal of riparian vegetation;
- spread of invasive alien species.

In this case also, the impacts have determined a progressive impoverishment in terms of biodiversity, as illustrated in the preparatory studies of the Management Plan, and in more recent works.

Figure 14 – Extent of the SCI IT6040008 "Canali in disuso della bonifica pontina".

Figure 15 – Example of one of the dismissed canals dating to the land reclamation (photo: Giancarlo Bovina).

Ramsar reserves

In application of the Ramsar international convention, signed in 1971, four Ramsar reserves have been established in 1971: wetlands recognised as having considerable importance for the conservation of aquatic ecosystems and, in particular, migratory birds. Each of the four reserves is connected to one of the coastal lakes and the surrounding areas, periodically subject to waterlogging or anyhow functional to the conservation of the aquatic ecosystems (figures 16, 17 and 18).

The four lakes, today very similar to salt lagoons, are, from north to south, the Lake of Fogliano (4 sq km), the Lake of Monaci (0.9 sq km), the Lake of Caprolace (2.3 sq km), and the Lake of Paola or Sabaudia (3.9 sq km). Considering also the non-lake areas, these reserves have an area of 3,337 hectares, equal to 37.5% of the area of the Park.

Biosphere Reserve

The State Forest of the Circeo National Park, where important examples of hygrophilous forest communities are conserved (Fig. 19), as well as humid depressions (the "piscine", i.e. pools) and ephemeral pools, was declared Biosphere Reserve in 1977, implementing UNESCO's Man and Biosphere Programme.
According to the aims set by the MaB Programme, the Biosphere Reserve is an ideal place where to carry out research, education and sustainable development activities, in particular with the involvement of local communities. To achieve these objectives, a procedure for enlarging the Reserve is currently ongoing: an enlarged Reserve would include not only the Park, but also other large, surrounding areas, which need to be duly managed in order to ensure a long-term conservation of the natural, landscape and cultural heritage. To this end, the Rewetland project has been of great utility, because it has entailed systemic actions demonstrating the importance of a comprehensive management of the whole Agro Pontino.

Regional protected areas: the Natural Monument "Giardino di Ninfa"

The Pontine Plain hosts only one among the Natural Protected Areas established according to the regional regulations on protected areas (Regional Law n. 29/1997): the Natural Monument "Giardino di Ninfa" (Garden of Ninfa), in the Municipality of Cisterna di Latina, including the SCI "Ninfa (ambienti acquatici)" (Fig. 20).
Ninfa has been declared Natural Monument by the Region of Lazio in 2000, with the aim of protecting this internationally known historic garden, the habitat of the Ninfa river, the lake, and the surrounding areas being a natural frame for the entire complex, also including the Pantanello Natural Park, inaugurated in 2009 (Fig. 21).
The name "Ninfa" derives from a small Roman temple, dedicated to the Naiads Nymphs – deities of the spring waters – and built near the current garden.
After the 11th century, Ninfa assumed the role of city, and, under the government of the families Tuscolo and Frangipane, grew in economic and political importance. In 1294, Benedetto Caetani became Pope with the name of Boniface VIII, and in 1298 he helped his nephew Pietro II Caetani to buy Ninfa and other adjacent cities, marking the beginning of the presence of the Caetani family in this area, a presence that lasted for seven centuries.
In 1382 Ninfa was sacked and destroyed, and never reconstructed, also due to the malaria infesting the Pontine Plain. However, in the 16th century, Cardinal Nicolò III Caetani, lover of botany, wanted to create a "garden of delights" at Ninfa. The work was entrusted to Francesco da Volterra, who designed a *hortus conclusus*, i.e. a garden delimited by walls with a regular structure, near the Frangipanes' medieval fortress. After the Cardinal's death, the place was abandoned again. In the 17th century, the Duke Francesco IV, another member of the Caetani family, dedicated himself to the rebirth of the *hortus conclusus*, but malaria forced him, too, to leave Ninfa.

Figure 16 – Portion of the Ramsar reserve of the Lake of Fogliano (photo: Riccardo Copiz).

Figure 17 – Detail of a community of annual Salicornia, typical habitat of the salt marshes of the Circeo National Park (photo: Mauro Iberite).

Figure 18 – Wet meadows in the Ramsar reserve of Lake of Monaci (photo: Riccardo Copiz).

Figure 19 – Typical "pool" ("piscina") of the lowland forest of Circeo, included in the homonymous Biosphere Reserve, established by UNESCO implementing the Man and Biosphere Programme (photo: Mauro Iberite).

Figure 20 – Extent of the SCI IT6040002 "Ninfa (ambienti acquatici)".

At the end of the 19th century, the Caetanis came back to their abandoned land. Ada Bootle Wilbraham, wife of Onoraro Caetani, with two of her six children, Gelasio and Roffredo, decided to create an English-style, romantic garden. Later on, Marguerite Chapin, wife of Roffedo Caetani, continued to take care of the garden.

The last heir and gardener was Lelia, daughter of Roffredo Caetani, who took care of the garden as if it was a big picture (Fig. 22), combining colors and working with the natural development of the plants, without forcing them, and avoiding the use of polluting chemicals.
Lelia Caetani died in 1977, but before her death she decided to establish the Roffredo Caetani Foundation, in order to protect the memory of her family, preserve the Garden of Ninfa and the Castle of Sermoneta, and to valorise the territory of the Pontine Plain and the Lepini Mountains.
The Pantanello Natural Park, which covers 100 hectares outside the walls of the Garden of Ninfa, is an example of reconstruction of the original environment of the Pontine Plain.
Thanks to European and regional funding, the Roffredo Caetani Foundation, on an area previously occupied by farming activities, has recreated one of those wetland environments that, although very common in the recent past of the Pontine Plain, have nowadays substantially disappeared, or become very rare.
The idea of re-naturalising part of the farm of the Caetani Foundation, next to the Garden of Ninfa, arose by chance in 1991, during a conversation among Fulco Pratesi, then President of WWF Italy, Arturo Osio, President of the Foundation from 1998 to 2007, and Lauro Marchetti, Secretary General and Director of the Garden of Ninfa. The intention was to return an artificial area – strongly dominated by farming but potentially a wetland – to nature, in order to create a continuum with the Garden of Ninfa.
The ancient environment has been reconstructed based on historic evidence and accurate studies carried out by several experts (geologists, botanists, zoologists, etc.); the project aimed not only at restoring the wetland environments and allowing for the return of the typical flora and fauna, but also at providing scientific and educational services through study and environmental monitoring programmes, to be carried out in collaboration with schools and research institutes at national and international level (Fig. 23).

Other important areas subject to different types of constraints

Other types of regulations provide for partial or full limitations to land use in some portions of the Pontine Plain: for example, the military firing range of Nettuno, where rare plants, typical of the coastal wetlands and the ephemeral pools, have been found.

Figure 21 – View of the Garden of Ninfa (photo: Giancarlo Bovina).

Figure 22 – The Ninfa river in the homonymous garden (photo: Giancarlo Bovina).

Figure 23 – View of the Pantanello Park (photo: Giancarlo Bovina).

Ecological networks

The most important, and most ambitious, instrument for the protection of biodiversity within the project area is the Ecological Network.
The Province of Latina has launched, in the last years, a number of projects concerning this issue, thanks also to the financial support of the Region of Lazio (see Box 2).
The primary objective of the ecological network is to reduce the process of habitat fragmentation, which limits the chances of survival for many fauna and flora species, due both to loss of living space and to isolation of the remaining populations.
The conservation objectives mainly regard habitats of Community interest, species of Community interest (vascular flora, terrestrial fauna, and fauna of the internal waters), and endemic species or species included in the national and regional Red Lists.
At the same time, the Region of Lazio has launched another, similar project aimed at planning the regional ecological network (R.Eco.R.d. Lazio). The current phase of the project concerns an in-depth analysis of flora and habitats. What achieved so far shows that, at a regional scale, the Agro Pontino is not very important in ecological terms, with the exception of the Circeo National Park, which includes elements recognisable as “central areas”, such as the lowland forest and the promontory.

More in detail, in the studies being carried out in preparation of the spatial plan for the Circeo National Park (2009-2011), the ecological network has been identified by interpreting the results of multi-level and multi-taxon analyses, in order to highlight the areas being the most important for the conservation of biodiversity (core areas and buffer areas), and functional to the maintenance and restoration of connectivity (primary and secondary connections). The zoning of the Park has been planned based on this work, in order to avoid negative influences on the natural values.
Currently, the Park Plan is waiting to be adopted by the Region of Lazio, which is also completing, as competent authority, the related SEA procedure.

Box 2 – Ecological networks: study cases of the Province of Latina

The project for the "Ecological network of the Lepini, Ausoni and Aurunci Mountains" has been an occasion for developing a first model of territorial analysis for the Province of Latina, and a first attempt to identify all areas that have a value in terms of wildlife and natural vegetation and that may play a significant role in the conservation of biodiversity. The project has entailed the collection of published and unpublished data for the definition of a knowledge base on environmental issues. It is intended as an instrument for increasing and disseminating the knowledge about the provincial territory, and for identifying policies to be put in place for the protection of biodiversity.
A following study, named "Ecological Network of the Province of Latina", has collected the experiences made with the above mentioned project and with the programmes "Ecological network of the Aurunci Mountains, Rio Santa Croce, Gianola Promontory" and "Pilot project for an ecological network of the Circeo National Park and the Ausoni Mountains", implemented thanks to regional funding. Compared to the former experience, these following steps have focused on the search for connections between the mountain and the coastal environments. These projects have been implemented based on a preliminary setting of the main conservation objectives, i.e. the definition of target species and habitats at provincial scale. Particular attention has been paid to the preparation of projects – with the involvement of local authorities – to be implemented in the Pontine Plain and the Fondi Plain in order to increase the functionality of the ecological network.

Figure 24 – Some of the studies and publications of the Province of Latina concerning the ecological network.

Figure 25 – Extract from the Land Cover Map of the Province of Latina (source: Province of Latina).

1.3 SOCIAL AND ECONOMIC CHARACTERISTICS

The Agro Pontino, as already said, is the result of a radical territorial transformation occurred between the Twenties and the Thirties of last century. Even if the agricultural matrix, permeated by the hydrographic network of the land reclamation canals, still characterises the area, the urban sprawl and a progressive industrialisation of agriculture have caused evident landscape alterations and a clear loss of biodiversity.
The land reclamation works, the immigration of thousands of settlers' families coming from north-eastern Italy, and the building of new towns on the reclaimed land (the so-called "foundation cities") have also entailed a deep change in the administrative and social structure.
In those years, there was also an evolution in the approach to land reclamation: the concept of "total reclamation" was introduced, based on the contemporary implementation of:

- sanitary interventions, entrusted to the Italian Red Cross and, subsequently, to the "Istituto Antimalarico Pontino";
- hydraulic reclamation, entrusted to the two local Land Reclamation Consortia;
- agricultural reclamation, entrusted to the "Opera Nazionale Combattenti" (O.N.C.) established in 1917.

Between 1932 and 1938, five "New Towns" were founded in the Agro Pontino and Agro Romano, the so-called "agricultural towns": Littoria (now Latina) in 1932, Sabaudia in 1934, Pontinia in 1935, Aprilia in 1937, Pomezia in 1939.

Moreover, fourteen "Rural Villages" were built by the O.N.C., and about five thousand small farms were created with the support of the "Agrarian Associations" (associations managing the common lands) of Sermoneta, Cisterna and Bassiano, and of private citizens.
However, the settlement of a new urban system in the plain was not governed by any consistent programming: as the construction works advanced, the foundation of other new towns was announced, without having previously decided on their location, and failing to harmonise them with the existing settlements. For example, Littoria was still being built when it was decided to raise it to the rank of provincial capital.
The road system was completely transformed: many new roads were traced parallel to the reclamation canals and to the new farm areas, triggering an uninterrupted urban sprawl (Fig. 25).

The population

In 2009, the population of the municipalities of the Pontine Plain exceeded 441,000 inhabitants, with an increase, compared to 2002, of 11.6% of Italian citizens and 228.5% of foreign citizens. These figures show a greater increase compared to the regional average, especially as regards foreign population, which has only increased by 154.5% in the Region.
In absolute terms, besides Latina, which has approximately 122,000 inhabitants, the most populous municipalities are Aprilia (more than 73,000) and Terracina (almost 45,000).
Compared to the provincial average, the municipalities of the Pontine Plain have grown more. This shows a good increase in attractiveness, both in occupational and liveability terms, but at the same time it has determined a considerable increase of pressures on the environment.

Economy

The report "Latina 2009", edited by the Chamber of Commerce, highlighted an almost generalised, underlying trend of change in the economic indicators, consistent with the effects of the economic crisis that has affected all territorial levels in the last years.
The agricultural sector showed negative trends (-1.4% compared to -1.1% of the previous year), slightly worsening due to fewer subscriptions and a substantial stability of the mortality rate.
The manufacturing industry, confirming its progressive decline, continued to show negative trends (-0.1%, compared to +0.4% of 2008); both birth and morality rates were slowing down, the former to a greater extent (approximately -20%), and both converging to a value of 5%.
However, trends appeared rather diverging: the food industry, representing around 14% of the sector, showed a growing trend in 2009 (+1.2%); further confirmation, also if with a negative sign, shows metalworking (-0.5%), with a quota reaching about one fourth of the provincial manufacturing.
The decrease of the wood sector was worsening: the wood industry decreased by 2.7%, and furniture manufacturing by 3.3%.
For the first time after four years, during which the building sector had represented the driver of entrepreneurial demographic growth, with increase rates much above the average, in 2009 such differential have become almost zero.

Agriculture and livestock farming

Agriculture, even if for the most part entrusted to family-run farms, is still very profitable in the Pontine Plain (Fig. 26). For this reason, an abandonment of the land, typical of other contexts, has not yet occurred; on the contrary, almost 11% of workers are employed in this sector, one of the highest percentages in Italy. The sector has invested much in specialisation, aiming at particular cultivations such as kiwi, of which the Pontine Plain is the first producer in Italy (almost 76% of the total, in particular the local variant "kiwi Latina IGP"), watermelon (third national producer), artichoke (the variants "carciofo romanesco" and "carciofo di Sezze"), courgette, citrus, and spinach. The greatest production of open-field vegetables is tomato, followed

by watermelon, carrot, courgette, pepper, melon and lettuce; and, in the cereal sector, corn, common wheat and durum wheat.

Figure 26 – Agricultural landscape in the Pontine Plain (photo: Carlo Perotto).

Greenhouse production has developed in particular in the triangle comprised between San Felice Circeo, Terracina and Sabaudia. The greatest productions are courgette and tomato, followed by lettuce and melon. Production of strawberry is also important. Organic agriculture is currently increasing.
Livestock farming has also specialised in the last years. Besides traditional cattle farming, introduced in the Thirties but a little decreasing in the last years, there has been a re-discovery of buffalo cow breeding, already practiced in the past but then fallen into decline. Buffalo cows are connected to the typical production of buffalo mozzarella – slightly different from the one produced in Campania –, as well as to buffalo meat processing. The Pontine Plain is regional leader in this sector.
Sheep farming, much practiced before the land reclamation, has almost entirely disappeared.
At provincial scale, more than 66% of the cattle is bred in the municipalities of Pontinia, Latina, Terracina and Sabaudia. The same municipalities are also the greatest producers of cow milk. As regards buffalo cows, almost 40% of those bred in the entire Province belong to the Municipality of Pontinia. In some cases, especially within the Circeo National Park, buffaloes are bred free-range, and this gives a peculiar aspect to landscape, which reminds of its appearance before the land reclamation (Fig. 27). Most of the provincial pig breeding is also based in Pontinia.
As regards sheep farming, more than 33% of the sheep is bred in the Municipality of Aprilia, followed by Latina and Sermoneta.
More than 65% of provincial aviculture is also concentrated in a few municipalities: Aprilia, Cisterna di Latina and Latina.
In the last decade, the principles of organic farming have started, luckily, to be applied also to livestock farming.

Industry and manufacturing

The process of industrialisation of the Province of Latina started in the 1950s with the opening of a number of factories, almost all connected to the agricultural sector, rapidly followed by many manufacturing industries that, during the 1960s, have grown and strengthened.
In the first period, the most represented sectors were mechanical industry, agroindustry, wood and furniture, chemical-pharmaceutical, textile and clothing, ceramics, glass and brick.
In the following period, industrial development has concentrated especially in the municipalities of Aprilia, Latina and Cisterna, the ones being closer to Rome.
The abolition of the "Cassa del Mezzogiorno", which used to grant fiscal subsidies to factories operating in Southern Italy, has caused the closure of several companies, which preferred to rely on the cheaper labour force of Asian countries and Eastern Europe, with obvious socio-economic impacts. However, many large factories remained and continued working in the agroindustry and pharmacy sectors.
There are five important industrial areas, all belonging to the "Consortium for the industrial development of Rome and Latina", which has its own land use plan:

- Latina Scalo: in the municipalities of Latina, Sermoneta and Sezze, with an area of approximately 448 hectares;
- Pontinia: despite its name, it is located completely within the municipality of Latina, with an extent of 1.2 sq km;
- Aprilia: in the municipalities of Aprilia and Lanuvio, with an extent of approximately 256 hectares;
- Cisterna di Latina: in the homonymous municipality, with an extent of approximately 368 hectares;
- Mazzocchio: in the municipality of Pontinia, at the boundary with Priverno and Sonnino, with an area of 445 hectares.

There is no typical handicraft in the Pontine Plain. However, there are several family-led craft businesses operating in different sectors (carpentry, furniture, ironwork, shipbuilding, etc.). Handicraft is an important part of the local economy.

Figure 27 – Free-range buffalo cow pasture near the Lake of Monaci (photo: Riccardo Copiz).

Tertiary sector

The service sector today occupies a large proportion of the workforce. Recently, the greatest investments have been made on technological and scientific research in the field of information technology and in the chemical-pharmaceutical sector. Some important fashion and entertainment companies have also strongly invested in this area in the last years. The tourism sector is also important, having recently experienced a great expansion. The main tourist destinations are obviously the seaside resorts (Sabaudia, San Felice Circeo and Terracina).

The Circeo National Park is certainly an important attractor. In the last years, the inland of the Agro Pontino has also been discovered by tourism: an area rich in history, yet characterised by a landscape completely transformed by man.

The report "Tourism in the Province of Latina" (published in April 2010 by the Tourism Promotion Agency of the Province of Latina – www.latinaturismo.it) has provided a comprehensive picture of the tourism trend in 2009. The accommodation capacity counted on 195 active businesses, 4 more than 2008, with a positive balance of 226 beds (+107 rooms, +112 bathrooms). Moreover, there has been a constant growth of other registered lodging options such as agritourism, bed & breakfast, tourist homes, hostels and other types of accommodation. However, these "new" types of accommodation are still a very small portion of the total offer.

Since the demand is strongly seasonal, one of the major goals to be achieved in the future is to increase tourist attractiveness in the rest of the year.

Urban sprawl

As previously said, urban growth in the last decades has been characterised by a linear development along the roads and a scattered development in the rural areas (Fig. 30).

This process is synthetically referred to as urban sprawl, i.e. a progressive spread of the city and its suburbs towards the surrounding rural areas, which, consequently, turn into low-density urbanised areas.

Therefore, the clear urban-rural dichotomy, characterising the local landscape after the land reclamation, has turned into a sprawl town, strongly characterised by a scattered residential settlement, where the rural areas tend to lose their values and their identity, and to mix up with the peri-urban areas.

The "total land reclamation", therefore, although it can be considered as an epic undertaking, especially from the social and economic points of view, has produced many sudden transformations, causing a loss of identity. Many believe that the sprawl town is economically inefficient, socially unjust, and environmentally unsustainable, because it consumes too many natural resources, especially soil, giving rise to a space without identity and fostering the use of private transport. Of course, together with the growth of intensive agriculture and industrialisation, also this transformation contributes to increasing the pollution of surface and ground water, and water consumption.

Figure 28 – Industrial area (photo: Carlo Perotto).

Figure 29 – Seaside tourism (photo: Riccardo Copiz).

Figure 30 – Urban sprawl (photo: Riccardo Copiz).

1.4 WATER RESOURCES: QUALITIES AND USES

Analysis of pollutants

This chapter describes the pressures on the hydrographic network in the Agro Pontino.

Much of the data used in the Rewetland project has been collected and elaborated within the project "Monitoring of the inland and coastal surface waters", launched in 2003 by the Province of Latina. When planning this monitoring action, the main assumption was that the quality characteristics of a watercourse derive from the sum of the following components:

- flow rates and characteristics of spring waters flowing into the network;
- characteristics of runoff waters (in rainy periods) coming from large cultivated fields, urban and industrial areas (diffuse sources);
- flow rates and characteristics of urban, agricultural and industrial discharges (point and concentrated sources);
- presence of water diversions or intakes (mechanical pumping, or exchanges with ground water), which may alter the levels of dilution of pollutants, causing an apparent increase or decrease of pollution values.

These monitoring actions have allowed acquiring, with a considerable degree of detail, the following information:

- hydrographic network;
- identification of basins and sub-basins;
- characterisation of the watercourses in terms of basic flow rate and yearly runoff volumes;
- estimate of point and diffuse discharges in the sub-basins.

For the purposes of controlling the quality of surface waters, the hydrographic basins and sub-basins have been identified (Fig. 31), dividing the area according to criteria of morphologic and land use homogeneity, and taking into account:

- their geological and geo-morphological characteristics;
- the hydrogeological structures feeding their base flows;
- the different possible modalities of formation of the natural base flow in the riverbeds.

A summary of this study for each of the basins of the Pontine Plain is reported in the following paragraphs; the data is updated at the period when the Rewetland project started, and has been used as a reference for selecting and planning the interventions for the improvement of water quality and, more in general, for achieving the project objectives. More information is contained in the publications illustrated in Box 3.

Figure 31 – Hydrographic basins and sub-basins (source: Province of Latina).

Astura basin

This basin includes the towns of Borgo Montello and Le Ferriere, and the Consortia "Astura" and "S. Barbara". Residential areas occupy 6% of the basin, with a resident population of around 7,000 inhabitants and a floating population of more than 400 equivalent inhabitants from May to September.

Estimates show that more than 5,500 inhabitants, and the totality of the floating population, are not connected to any wastewater treatment plant. The working plants are two (Borgo Montello and Le Ferriere), with a total flow rate of 2.47 l/s.

13 civil annual wastewater discharges[1] have been officially surveyed, for a total flow rate of 6,145 cu m/year (0.2 l/s) released into the network. Moreover, the flow rate coming from the discharges of Campoverde, not connected to any treatment plant (around 2.3 l/s) have to be added to these figures.

[1] These are civil, but not residential, discharges (e.g. commercial or tourism activities, or bathrooms of factories). They usually drain into the surface water network after a simple treatment (Imhoff tanks), but unlike the discharges from sparse houses not connected to treatment plants, they are registered in a specific provincial cadastre.

Productive activities occupy around 1% of the basin. Seven discharges have been surveyed, for a total flow rate of 5,782 cu m/year (183 l/s) released into the network; of these, 181 l/s come from the pharmaceutical sector only. Other sectors are connected to compost and wine production (the latter is a seasonal activity).
Agricultural uses mainly include non-irrigated arable land (55%), greenhouses and nurseries (around 2%), and specialised tree crops (21%, mainly vineyards and kiwi). The application of the estimate model adopted indicates a total nitrogen load of 268 t/year due to agricultural uses. The spreading of manure on the land causes a nitrogen load of 67.5 t/year. Phosphorus load amounts to approximately 10 t/year.
The total phosphorus and nitrogen load in the watercourses of this basin is mainly due to industrial activities. An overall estimate indicates a total phosphorus load of around 74 t/year and significant volumes of nitrogenous substances (365 t/year).
The presence of the landfill of Borgo Montello, serving the entire Province, is also of great importance.

Canale Moscarello basin

Many towns are located in this basin: Aprilia, Cisterna di Latina, Cori, Norma, Giulianello, Lariano, Velletri and Lanuvio. The towns of Genzano and Rocca Massima are also partially located here.
Residential areas occupy 9% of the basin, with an estimated population of 176,500 resident inhabitants and a floating population of about 11,000 equivalent inhabitants in the period from May to September. Estimates show that around 62,000 equivalent inhabitants are not connected to waste water treatment plants.
The treatment plants draining into the basin are eleven. Eight of these are located in the Province of Latina, with a total declared flow rate of 108.7 l/s. A comparison between the served population and the potentials declared for the different plants shows that the plants of Cori, Giulianello and Velletri are under-sized by respectively 2,000, 1,000, and 17,600 equivalent inhabitants.
159 civil annual discharges have been surveyed in the basin, for a total flow rate of 21.8 l/s of wastewater released into the network.
Productive activities occupy 865 hectares (1.5% of the basin), where 48 industrial discharges have been surveyed, for a total flow rate of 10,830 cu m/year. Some important productive activities of the pharmaceutical, chemical and food sectors are located here. Moreover, an important fishing industry is located near the mouth of the basin (203 l/s). The seasonal activities linked to wine and oil production are also significant, causing a substantial input of eutrophic substances, such as wastewater from the oil mills (vegetation waters).
Agricultural uses include non-irrigated arable land (29%), specialised tree crops (25%), specialised tree crops mixed with arable land (11%), greenhouses and nurseries (1%). Specialised tree crops are mainly kiwi, especially in the Municipality of Cisterna di Latina, where they are an important part of the local economy. The application of the estimate model indicates a total phosphorus load of 49 t/year, and a total nitrogen load of 1,311 t/year. Livestock farming contributes to nitrogen load in a limited way.
The total estimated phosphorus load in the watercourses of this basin is of around 245 t/year, mainly coming from industrial activities, residential wastewater treatment plants, and, secondly, from agricultural activities. The calculation of the different nitrogenous substances leads to very high figures (around 1,804 t/year). Next to the mouth of the basin, there is also the nuclear power plant of Latina.

Coastal basins between Torre di Foce Verde and Torre di Fogliano

The suburbs of Borgo Sabotino and Lido di Latina are located in this basin. Residential zones occupy 10% of the area, with an estimated resident population of 2,794 inhabitants and a floating population of about 2,700 equivalent inhabitants from May to September.
Estimates show that, among the residents, at least 600 equivalent inhabitants are not connected to waste water treatment plants. There is one working plant draining into the basin near the Moscarello canal, with a flow rate of 39.6 l/s. Six civil annual discharges have been surveyed, with a flow rate of 15,806 cu m/year (0.5 l/s) released into the network.
Productive activities occupy 1% of the basin; no industrial discharge has been surveyed.

Agricultural uses include predominantly non-irrigated arable land (46%) and pastures (9%). The pollutant load of agricultural origin is 36.6 t/year of total nitrogen and 1.4 t/year of total phosphorus. The spreading of manure on the land causes a nitrogen load of 13 t/year.
The total nitrogen load in this basin is approximately 54 t/year, mainly due to agricultural activities. The total phosphorus load is 14 t/year, of which 12 are due to civil discharges.

Rio Martino basin

The towns of Doganella, Borgo Podgora, Latina, Borgo S. Michele, Borgo Grappa, Borgo S. Donato and Bella Farnia are located in this basin.
Residential zones occupy 13% of the area, with an estimated resident population of 88,428 inhabitants and a floating population of about 3,984 equivalent inhabitants from May to September.
There are eight wastewater treatment plants with a declared total flow rate of 263.4 l/s. Besides these plants, 114 civil annual discharges have been surveyed in the basin, with a total flow rate of 6.17 l/s released into the network. In addition, the loads caused by the 12,349 residents and the 1,787 floating inhabitants not connected to any treatment plant have to be added to these figures.
Productive activities occupy approximately 3% of the basin, where more than 20 industrial discharges have been surveyed, with a total flow rate of 150 l/s released into the network, mainly coming from chemical and food factories.
Agricultural uses include non-irrigated arable land (44%), irrigated arable land (18%), greenhouses and nurseries (2%), and specialised tree crops (5%). The application of the estimate model indicates a total nitrogen load of 551.25 t/year, and a total phosphorus load of 20.6 t/year. The spreading of manure causes a load of 264 t/year.
The total phosphorus load in this basin is approximately 126 t/year, mainly due to agricultural activities, but also coming from industrial and residential origins. The total nitrogen load is also very high: 882 t/year, of which 551 coming from agriculture. These figures are in any case underestimated, because a number of important industrial discharges are missing from the database.

Fiume Sisto basin

The towns of Latina Scalo, Borgo San Donato, Borgo Vodice, Borgo Montenero, and parts of the towns of Latina, Terracina and San Felice Circeo are located in this basin.
Residential zones occupy 7% of the area, with an estimated resident population of 23,422 inhabitants, and a floating population of about 3,344 equivalent inhabitants from May to September. There are four wastewater treatment plants with a declared total flow rate of 58.52 l/s. There are also approximately 9,748 residents and 1,397 floating inhabitants not connected to any treatment plant.
45 civil annual discharges have been surveyed in the basin, with a total flow rate of 1.36 l/s released into the network. Productive activities occupy approximately 1% of the basin, where 3 industrial discharges have been surveyed, with a total flow rate of 0.32 l/s released into the network, mainly coming from food factories.
Agricultural uses include non-irrigated arable land (44%), irrigated arable land (27%), greenhouses and nurseries (5%), and specialised tree crops (3%). The estimated total nitrogen load is 436 t/year, and the total phosphorus load is 16 t/year. The spreading of manure on the soils causes a nitrogen load of 327.6 t/year.
The total estimated phosphorus load in this basin is approximately 60 t/year, whereas the total estimated nitrogen load is 436 t/year; the origins of both are equally parted among different economic activities.

Coastal basins between Rio Martino and Foce Sisto

The towns of Sabaudia and San Felice Circeo are located in this basin.
Residential zones occupy 12% of the area, with an estimated resident population of 14,091 inhabitants, and a floating population of about 11,921 equivalent inhabitants from May to September. 1,292 residents and

2,148 floating inhabitants are not connected to any wastewater treatment plant. The plant of San Felice Circeo (Torre Olevola) drains directly into the sea through an underwater pipe.
The plant of Sabaudia (Caterattino) also drains into the sea. Five civil annual discharges have been surveyed in the basin, with a total flow rate of 0.54 l/s released into the network.
Productive activities occupy 1% of the basin, where 3 industrial discharges have been surveyed, having a total flow rate of 0.32 l/s released into the network, mainly coming from food factories.
Agricultural uses include non-irrigated arable land (37%), greenhouses and nurseries (3%), and pastures used for buffalo cow farming (4%). The total estimated nitrogen load is 94.6 t/year, and the total phosphorus load is 3.5 t/year. The spreading of manure on the soils leads to an equivalent nitrogen load of 7.9 t/year.
The total amount of phosphorus produced in the basin is 40.6 t/year, mainly due to agricultural activities; the total amount of nitrates is approximately 119 t/year, rather low but anyhow significant. Due to the low level of protection of the shallow aquifer of the ancient dune, these amounts lead to a considerable pollution of groundwater.

Canale Linea Pio basin

Only part of the town of Sermoneta is located in this basin.
Residential areas occupy 5% of the basin, with an estimated resident population of 5,992 inhabitants, and a floating population of less than 500 equivalent inhabitants. There are two wastewater treatment plants (Borgo Faiti and Pontinia) with an average total flow rate of about 17 l/s. A comparison between served inhabitants and declared plant potentials highlights a deficit in wastewater treatment.
Around 3,500 equivalent inhabitants (considering both resident and floating population) are not connected to any treatment plant. Considering the characteristics of the area (poorly permeable soils and groundwater on average at 1-1.5 m from ground level), the pollutant loads released by scattered houses not connected to the sewers (approximately 2.8 t/year of phosphorus and 17.7 t/year of nitrogen) can easily reach the surface waters. This is clearly noticeable from the smelly waters of many canals bordering the roads.
Productive activities occupy around 2% of the basin, where nine industrial discharges have been surveyed, mainly from chemical-pharmaceutical factories. The discharges connected to industrial activities have a flow rate of some tens of litres per second.
Agricultural uses include irrigated arable land (75%), specialised tree crops (3%), non-irrigated arable land (1%). The application of the estimate model indicates a total nitrogen load of 203.8 t/year, and a total phosphorus load of 7.6 t/year. The spreading of manure on the soils leads to an equivalent nitrogen load of 263 t/year.
The total amount of phosphorus produced in the basin is 37.6 t/year, mainly due to industrial activities; the total amount of nitrates is 483.7 t/year – rather important – of both industrial and agricultural origin.

Canale Botte basin

Part of the town of Pontinia is located in this basin.
Residential areas occupy 6% of the basin, with an estimated resident population of 8,728 inhabitants, and a floating population of about 779 equivalent inhabitants. Between resident and floating inhabitants, approximately 3,800 equivalent inhabitants are not connected to any wastewater treatment plant.
Productive activities occupy 3% of the basin, where three industrial discharges have been surveyed, with a flow rate of 40 cu m/year (1.2 l/s) released into the network, mainly coming from the dairy industry.
Land cover mainly includes irrigated arable land (87%), and greenhouses and nurseries (2%). The total estimated nitrogen load is 188.5 t/year, and the total phosphorus load is approximately 7 t/year. The spreading of manure on the soils leads to an equivalent nitrogen load of 226 t/year.
The total amount of phosphorus produced in the basin is 10.9 t/year, mainly due to agricultural activities but also to residential discharges. Nitrates derive mainly from agricultural activities (approximately 188.5 t/year over a total amount of 205 t/year).

Canale Selcella basin

The town of Sezze Scalo is located in this basin.

Residential areas occupy 2% of the basin, with an estimated resident population of 8,352 inhabitants, and a floating population of 1,033 equivalent inhabitants. The wastewater treatment plant of Sezze Scalo has a declared flow rate of 8.3 l/s. Approximately 6,000 equivalent inhabitants (considering both resident and floating population) are not connected to any treatment plant. This is of considerable importance because, also in this case, the presence of poorly permeable soils and of a shallow aquifer cause the discharges from scattered houses to easily reach the surface waters.

Productive activities occupy 2% of the basin, where eleven industrial discharges have been surveyed, with a flow rate of 69.13 l/s, mainly coming from a fish farm (50 l/s) and a pharmaceutical factory (15 l/s).

Land cover mainly includes irrigated arable land (87%). Natural and semi-natural areas occupy only 5% of the basin. The total estimated nitrogen load from agricultural activities is 425 t/year, and the total phosphorus load is 16 t/year. The spreading of manure on the soils is very high, and it leads to an equivalent nitrogen load of 446.7 t/year.

The total amount of phosphorus produced in the basin is 46.39 t/year, mainly due to agricultural and industrial activities. Nitrates (455.5 t/year) derive mainly from agricultural activities, but also from residential and industrial discharges.

Given the nature of the soils and aquifers of this basin, it is important to evaluate carefully the effects of the spreading of manure on the soils.

Fiume Ufente basin

The towns of Bassiano and Sezze are located in this basin.

Residential areas occupy 4% of the basin, with an estimated resident population of 18,128 inhabitants, and a floating population of 2,461 equivalent inhabitants. More than 4,400 equivalent inhabitants are not connected to any wastewater treatment plant. The plants of Bassiano and Sezze drain into this basin, with a total flow rate of 30 l/s. The surveyed residential discharges are 23, with a total annual release of 2.2 l/s.

Productive activities, concentrated in the industrial area of Mazzocchio, occupy 2% of the basin, where twelve industrial discharges have been surveyed, with a total flow rate of 12.31 l/s released into the network.

Agricultural uses mainly include irrigated arable land (35%), non-irrigated arable land (10%) and specialised tree crops (9%). The application of the estimate model indicates a total nitrogen load of 118 t/year, and a phosphorus load of 4.4 t/year. The spreading of manure on the soils leads to a nitrogen load of 190 t/year.

The total amount of nitrogen produced in the basin is 140 t/year, and the total amount of phosphorus is 20 t/year, the latter being rather negligible if compared to the basic outflow, and deriving mainly from civil discharges and, secondly, industrial and agricultural discharges.

It is important to notice the presence of sulphurous waters coming from the Gricilli Lakes, lifted by the homonymous pumping station, and of the waters coming from springs and artesian wells, which are a natural source of alteration of the chemical composition of the basin waters.

Fiume Amaseno basin

Residential areas occupy 2% of the basin, with an estimated resident population of 42,309 inhabitants, and a floating population of around 3,500 equivalent inhabitants. Approximately 12,600 residents, and at least 1,000 floating inhabitants, are not connected to any wastewater treatment plant. Fourteen treatment plants drain into this basin, of which nine in the Province of Latina, for a total flow rate of around 78 l/s. The surveyed civil discharges are 10, with a total annual release of 0.2 l/s. There is no data concerning the flow rates of the treatment plants located in the Province of Frosinone.

Productive activities occupy less than 1% of the basin, where fifteen industrial discharges have been surveyed, with a flow rate of 11.9 l/s, mainly due to the food industry.

Agricultural land uses include irrigated arable land (6%), non-irrigated arable land (17%), and specialised tree crops (17%). The nitrogen load due to agricultural activities is 401 t/year, and the total phosphorus load is 15 t/year. The spreading of manure on the soils leads to a nitrogen load of 321 t/year.
The total amount of phosphorus produced in the basin is 53.4 t/year, deriving from civil, agricultural and, secondly, industrial uses. The total amount of nitrates is 465 t/year.

Fosso Pedicata basin

The suburb of La Fiora (Municipality of Terracina) is located in this basin.
Residential areas occupy 2% of the basin, with an estimated resident population of 998 inhabitants, and a floating population of 63 equivalent inhabitants from May to September; none is connected to wastewater treatment plants. There is no surveyed discharge from productive activities.
Agricultural uses mainly include non-irrigated arable land (7%), irrigated arable land (24%) and specialised tree crops (13%). Estimates indicate a total nitrogen load of 15.6 t/year, and a phosphorus load of 0.5 t/year.
The total amounts of phosphorus and nitrates produced in the basin – mainly due to civil discharges and, secondarily, to farming activities – are limited. The total amount of phosphorus is 1.6 t/year. The spreading of manure on the soils leads to a nitrogen load of 28 t/year.

Fiume Portatore basin

The suburb of Borgo Hermada (Municipality of Terracina) is located in this basin.
Residential areas occupy 9% of the basin, with an estimated resident population of 11,024 inhabitants, and a floating population of 5,780 equivalent inhabitants. Approximately 4,000 residents, and 3,100 floating inhabitants, are not connected to any wastewater treatment plant. There is a new treatment plant draining 39 l/s towards Canale Portatore.
Productive activities occupy 3% of the basin, where three industrial discharges have been surveyed, with a flow rate of 0.05 l/s released into the network.
Agricultural uses mainly include irrigated arable land (41%), non-irrigated arable land (22%), greenhouses and nurseries (4%), and specialised tree crops (7%). The application of the estimate model indicates a total nitrogen load of 105 t/year, and a total phosphorus load of 3.9 t/year.
Phosphorus and nitrogen loads produced in the basin mainly derive from residential uses; phosphorus accounts for 22.9 t/year.

Water use in agriculture

The use of water for irrigation purposes in the Pontine Plain has started right after the land reclamation, with the first free-surface plants connected to the dense canal network, originating from the springs at the foot of the Lepini and Ausoni Mountains and, secondly, from the aquifers, especially the ones of the ancient dune.
Many years after the war, more modern plants with pressurised distribution have been introduced, thanks to the financial support of the Cassa del Mezzogiorno.
Currently, the "Consorzio di Bonifica dell'Agro Pontino" (Land Reclamation Consortium of Agro Pontino) manages six irrigation districts equipped with collective irrigation plants (Latina Nord, Campo Setino, Campo Dioso, Valle di Terracina, Centrale Sisto, Sisto Linea), corresponding to homonymous irrigation sectors (Fig. 32). Only the Sisto Linea district is divided into three sectors (Sisto Linea 1st, 2nd and 3rd).
A large agricultural area (Linea pedemontana) is instead served by the so-called rescue irrigation, a system of drain ditches regulated with the help of sluices and electrical pumps installed in different locations.
Within the irrigation sectors of the Consortium, irrigation is carried out thanks to the flow rates provided by the same Consortium, but also drawing directly from the surface waters, and from groundwater through wells. This last case creates both administrative and environmental problems: wells are often unauthorised, and their intensive use gives rise to salt wedge intrusion and subsidence.
The main network has a total length of 45.98 km, more than half of which belongs to the Linea Sisto district.

88.3% of the main and secondary networks is made up of pressurised pipes, and 10.6% of closed canals and/or free surface pipes. The rest is composed of open-air canals.
The irrigation districts currently serve many different cultivations, most of which are herbaceous crops. Among the woody crops, kiwi is the most common. As regards horticulture and woody crops, irrigation plants are characterised by high technological levels and very water-demanding varieties (Fig. 33). In the case of fodder cultivations, the introduction of new irrigation systems could help in reducing water consumption, but it would need more work, or a reorganisation of the farms.
Water consumption in the horticulture sector is approximately 400-500 mm per cycle, both on the field and in greenhouses. Irrigation methods are different: for open-field vegetables, sprinkler irrigation (mostly localised) is still used; for greenhouse cultivations, water is distributed through a drip system.

Figure 32 – Irrigation districts (source: Consorzio di Bonifica dell'Agro Pontino).

Figure 33 – Water demands of the main cultivations in the Agro Pontino (source: Consorzio di Bonifica dell'Agro Pontino).

However, a value of 600 mm is closer to the current reality of greenhouse horticulture, considering the recent evolution of this sector, which has allowed having two cultivation cycles – and consequently higher water demands –, but also improving the efficiency of irrigation systems.
The cereal/animal husbandry sector is the most traditional in the Pontine Plain. Water consumption in this sector is significant, due to irrigation of meadows and, even more, of silo corn, which can require up to 600 mm per cultivation cycle. Irrigation methods are mainly of a traditional type, with the use of the "roll" for sprinkler irrigation.
The Pontine Plain has become increasingly known for the woody crops, in particular kiwi and grapevines. Grapevine is not demanding in terms of water consumption, because it requires only a few rescue irrigations in case of spring droughts; on the other hand, kiwi can demand even more than 600 mm. However, localised irrigation is becoming increasingly popular, leading to reduce water consumptions down to 400-500 mm.
For the agricultural needs, there is an overall water demand of more than 76 million cubic metres of water. Cultivations used for livestock farming (corn and alfalfa) are the ones with the highest demands (around 60%), followed by horticulture.

Rationalisation of irrigation

The updating of the data on irrigation systems confirms the need to modernise the least efficient ones. Each irrigation method entails a different relationship among maintenance, investment, energy and water-related costs.
Generally, the methods entailing a reduction in labour need bigger investments. One of these methods is the drip system, with high material costs on the one hand and unquestionable agronomic benefits and important reductions in labour on the other.
A plot irrigated with this system is accessible during and after each irrigation. Drip irrigation (or micro irrigation) can also fulfil three needs at the same time: irrigation, top dressing (fertirrigation), and harvesting.

Table 2 – Water consumptions and irrigation methods in the main agricultural sectors of Agro Pontino (source: Consorzio di Bonifica dell'Agro Pontino).

Sector	Cultivation	Main localisation	Water consumption	Irrigation method
Horticulture	Open field	Central and southern areas, in particular for greenhouses (Sabaudia, San Felice Circeo, Terracina)	400-500 mm per cycle	Sprinkler
	Greenhouse			Localised

Cereal/livestock farming	Fodder, corn and other cereals	Central and southern areas	Relevant, in particular for corn (up to 600 mm per cultivation cycle)	Sprinkler
Woody crops	Grapevine	Northern areas	Low	Localised
	Kiwi	Northern areas (Latina, Cisterna di Latina)	Relevant (even more than 600 mm)	

Horticulture, also on open field, is usually served by this system. This type of cultivation is often characterised by progressive productions and a long crop cycle. For these reasons, harvesting, top dressing and irrigation operations are frequent. Being able to perform these operations at the same time allows for an obvious saving of time and labour.

This technique allows to increase crop water use efficiency, satisfying the irrigation need of the plants during its growth and production cycle. Moreover, water does not wet the surface of the leaves, leading to an advantage especially in greenhouses, where fungal diseases are frequent.

The high efficiency of this system also minimises losses caused by runoff and deep percolation of water and nitrogen fertilisers, ensuring a higher protection of surface and ground water.

Unfortunately, the high costs involved do not combine well with the current habits, the great availability of water (except for the driest periods), and the presence of low-value crops such as corn and sugar beet.

The sprinkler system (with its moving devices) is more widely used – compared to localised irrigation – in all irrigation districts, with the sole exception of the district of Valle di Terracina. Indeed, fodder crops and corn are the most common cultivations in terms of covered area. This system requires a high pressure, with considerable fallouts on energy costs and water consumptions.

The Land Reclamation Consortium believes that the main efforts for improving and modernising the irrigation service should be focused on a progressive shift from sprinkler to localised irrigation. The modernisation of irrigation plants could reduce the waste of the water resource, increasing the efficiency especially for fodder and corn cultivations.

Figure 34 – Greenhouses (photo: Carlo Perotto).

Box 3 – Reference publications

Origin of pollutant loads and state of eutrophication of the internal waters of the Province of Latina

This publication illustrates the results of the preliminary studies carried out as a basis for the quantitative water monitoring in the Province of Latina. It is part of the project "Monitoring of internal and coastal surface waters", with which the Province of Latina has programmed the necessary actions for carrying out its duties, conferred by article 106 of Regional Law n. 14/99, on monitoring of production, use, diffusion, persistence in the environment, and effects of water pollution on human health, and on monitoring of eutrophication of internal and coastal waters.

Atlas of springs in the Province of Latina

The availability of up-to-date and detailed information on ground water level, location and flow rate of water springs, outflows of watercourses, chemical and physical characteristics of ground waters, and use of water resources, is fundamental in any hydrogeological analysis applied to modern planning.

Drawing of water and water resource in the Mazzocchio basin

The Province has integrated the basic studies carried out by its staff with the contributions derived from the collaboration with other institutions (Sapienza University, ENEA, ISS), especially as regards the analysis of complex environmental phenomena and the elaboration of more effective study and intervention approaches. This publication is an example of the results achieved by integrating different studies on the exchanges occurring among surface waters, groundwater and wells in the Pontine Plain. The studies have been carried out in the artificially drained hydrographic basin of Mazzocchio (approximately 100 sq km).

Project "Lepini Mountains – Hydrogeological studies for the protection and management of water resources"

A very complex knowledge base has arisen from this project: a new acknowledgement of the geological features of

the mountain ridge, a new set of information acquired through hydrogeological and hydro-chemical surveys carried out on the mountain structure and on the surrounding plain, a verification of the current and future water needs of the Latina Nord irrigation district. All this has allowed to define, in terms of area and volume, the geometry of the catchment area, and to evaluate the state of conservation of the resource, its vulnerability and exposure to risks of pollution and/or overexploitation. This project has allowed to outline, with a good approximation, the general directions to be followed for the future and correct management of the water resource.

Monitoring the state of eutrophication and the pollutant loads of surface waters in the Province of Latina

With this publication, the Province of Latina intends to disseminate the information acquired on the characteristics and fragilities of its territory, starting from the consideration that the environmental protection depends firstly on information and education of citizens. The results acquired in the previous phases of the project "Monitoring of internal and coastal surface waters" have been used in order to choose the sampling and measurement points in the monitoring network. Currently, the results of this project can supply:

- a comprehensive overview on the distribution of discharges of substances potentially leading to eutrophication;
- the physical and chemical characteristics and the flow rates of the main watercourses of the Province.

THE PROJECT'S CONTRIBUTION: EXPERIMENTATION

One of the most relevant results of the Rewetland project has been the implementation of four different pilot projects within the Agro Pontino.
Natural water purification systems are not innovative *per se*, since they are already known by the general public and the scientific community, but their importance in the framework of this project is related to the experimentation and verification of their actual effectiveness in the project areas, and their replicability in similar contexts.
Indeed, the construction of widespread biofiltering systems in the Agro Pontino, aimed at reducing the nutrient loads in surface waters, can greatly contribute to a more sustainable management of the water resource, and to achieving the objectives of the Water Framework Directive.
The pilot projects described in this chapter, and experimented within the Rewetland experience, have been implemented in four types of geographic contexts, typical of the Pontine Plain (a protected area, an urban area, the reclamation canals, a wine farm).

2.1 PILOT PROJECT 1: FILTER ECOSYSTEM IN A NATURAL PROTECTED AREA

Among the four planned interventions, Pilot Project 1 is the only one located in a natural protected area: the Circeo National Park, on the coastal sector of the Pontine Plain, between the Lake of Fogliano and the Cicerchia Canal (Fig. 1). The planned works have been carried out in two different areas: around Pantano Cicerchia (Area 1), between the Litoranea road and the Lake of Fogliano, and along the right bank of Canale Allacciante (Area 2), about 250 metres northwest of the "Casino Inglese" ("English Lodge") of Villa Fogliano.
The former area is ecologically important for the bird fauna, since it provides suitable environments for the resting, feeding and nesting of most of the aquatic bird species detected in the Park.
The project comprises the following interventions (Fig. 2 and Fig. 3):

- creation of a filter ecosystem (Area 1.b), composed by the existing bed of reeds located along the irrigation canal Rio Martino-Foce Verde, and by the new wet meadows located on its western side, directly in contact with the banks of the lake (Fig. 4);
- creation of a trail for nature observation.

Area 2, although adjacent to Villa Fogliano, is close to intensive agricultural areas (greenhouses for flowers and horticulture) (Fig. 5). It comprises a number of unfinished reservoirs, built at the end of the Nineties and originally intended for the creation of a constructed wetland (Foglianello project). Currently, the area comprises three basins with an L-shaped arrangement (Fig. 6) along the right bank of Canale Allacciante, separated from the adjacent agricultural area by a ditch.
The three basins are filled with both rainwater and groundwater (thanks to an aquifer outcrop), and are vegetated with herbaceous plants, typical of the wet meadows, and/or helophytes (reeds); whereas the trees, not always of natural origin, can be found only on the isle of Basin C and on the boundaries of basins A and B.
The project has entailed the construction of Free Water Surface systems (FWS) in basins A and B, for treating the waters of the Rio Martino-Foce Verde canal (in summer time) and Canale Allacciante (in winter time) (Fig. 6).
A waterproofed area (Fig. 7) in Basin B is aimed at treating the wastewater coming from Villa Fogliano. The waters are then channelled in Basin C, where they undergo a further refinement through a lagooning system, before flowing into Canale Allacciante.

2.2 PILOT PROJECT 2: URBAN PARK OF MARINA DI LATINA

Pilot Project 2 is located in a suburban area behind Marina di Latina, between Canale Mastropietro to the north and Canale Colmata to the south (Fig. 8). This area is characterised by uncultivated land, frequently submerged in winter time.
The project consists in the creation of four basins (Fig. 9), fed by the polluted waters flowing from Canale Colmata; after the treatment, the waters are discharged into Canale Mastropietro.
The basins have an area of approximately 1,000 sq m each: the first and fourth are Sub-Surface Horizontal Flow basins (H-SSF), while the second and third (refinement basins) are Free Water Surface (FWS) basins (Fig. 10). All basins have been adequately waterproofed with inert material, in order to avoid contamination of soils and superficial groundwater.
The plant species used in basins 1 and 2 are mainly common reed (*Phragmites australis*), bulrush (*Typha spp.*), and rush (*Juncus spp.*) (Fig. 11). On the other hand, the refinement basins 2 and 3 have been planted with rooted hydrophyte species, such as water lily (*Nuphar lutea* and *Nymphaea alba*). The design envisages also adjacent green areas with species belonging to the native flora, a car park, a rest area and a number of walking and cycle paths.
Objective of the project is to create an urban park, accessible by citizens and, at the same time, having an environmental function.

Figure 1 – Location of Pilot Project 1 (source of orthophoto: Province of Latina).

Figure 2 – Aerial view of the intervention area near Borgo Fogliano (photo: Carlo Perotto).

Figure 3 – Interventions in Area 1- Pantano Cicerchia.

2.3 PILOT PROJECT 3: BUFFER STRIPS ALONG THE RECLAMATION CANALS. AN EXAMPLE OF WATER TREATMENT APPLIED TO THE CONSORTIUM CANALS

Pilot Project 3 envisages an experimentation of buffer strips along one or more portions of the canal network managed by the Land Reclamation Consortium.
In this case also, the interventions have been carried out in two different areas: floodplain of Canale Allacciante Astura, and the emissary of the Forcellata water pump (Canale Selcella) (fig. 12).
The former area ("Reed beds in the floodplain of Canale Allacciante Astura") will host reed bed habitats, where the flowing waters are purified by plants – mainly helophytes such as *Phragmites* and *Typha* – able to assimilate the trophic substances, reducing their quantity in the waters. The treated water is discharged into Canale Allacciante Astura. This intervention consists in an artificial channel along the lower left floodplain of Fosso Spaccasassi (currently Canale Allacciante Astura), in the stretch comprised between the confluence of Fosso Bottagone and the confluence with Canale Acque Alte (Fig. 13). This "hanging" artificial channel is fed by Fosso Bottagone through a bypass located at its confluence with Canale Allacciante Astura (Fig. 14). After approximately 4 km, the waters treated along the reed bed flow into Canale Allacciante Astura.
The latter intervention – "Naturalisation of the emissary of the Forcellata water pump (Canale Selcella)" – envisages the creation of wetland phytocoenoses with dominance of helophytes (marsh reeds) along the bed of the canal, and a tree buffer strip along the right bank, in order to foster the natural water purification processes (Fig. 15).
The intervention, which involves a canal stretch of 1.4 km, has been carried out after remodeling the bed of the canal (Fig. 16). The whole system is fed by the Forcellata pumping station.

2.4 PILOT PROJECT 4: GOOD PRACTICES OF WATER MANAGEMENT IN A FARM

Pilot project 4 entails the study of processes and good practices of water management in a farm of the Agro Pontino. The farm, called "Casale del Giglio", produces quality wines and is located between Aprilia and Latina (Fig. 17). Within this project, an "Action Plan" has been set up, in order to carry out the interventions

described by the "Master plan for the environmental multi-functionality of the farm", containing a number of objectives (Fig. 18) achieved and achievable within the farm.
The experimentation has been organised starting from an analysis of the farm, regarding climatic, geological and hydrological factors, and the water needs of the vines. In particular, the most relevant environmental features of the farm have been taken into account: a ditch (Fosso Valle), the watercourses along the borders (Fosso Piscina Panzesi and the Astura river), and an artificial basin close to the wine cellar (Fig. 19).
The analysis of the context and the farming activities has led to identifying a number of good practices that the farm already performs – such as grassing the land between the rows of vine, and using organic fertilisers –, and the criticalities connected to water management. One of the greatest criticalities surely is the surface runoff of rainwater in the rainiest periods, which triggers a diffuse superficial erosion and an accumulation of sediments in one of the most depressed areas of the farm, where the Fosso Valle flows.
The measures undertaken by the Province within the Rewetland project aim at:

- setting up a runoff system for the surface waters;
- enhancing the current natural water treatment capacity of Fosso Valle, through a number of actions for the maintenance of the ditch (maintenance plan for the banks and the tree strip, reinforcement of the bank vegetation, etc.);
- obtaining a more detailed knowledge about the farm environment, through biological, chemico-physical and chemical surveys (see § 2.5);
- experimenting the water treatment efficiency of vegetated floating islands;
- creating paths and nature observation points.

The experimentation and the monitoring of the interventions will provide useful information as regards the replicability of the project in similar farms and contexts.

2.5 ENVIRONMENTAL MONITORING

The building of the plants, briefly described in the above paragraphs, cannot be disconnected from an environmental monitoring plan. Indeed, the plants themselves are not sufficient for the experimentation, but it is also necessary to assess their actual effectiveness in terms of reduction of trophic loads. To this end, a programme for their environmental monitoring has been set up, in order to adjust and improve them according to the data collected.
The environmental monitoring will analyse the fundamental parameters of the single pilot projects, before and after the building of the plants. The monitoring activities comprise continuous measurements by means of twelve multi-parameter stations and one weather station, and campaigns for collecting samples.
The multi-parameter stations can measure the following indices: dissolved oxygen (mg/l and percentage of saturation), temperature, pH, transparency/turbidity, alkalinity (capacity to neutralise acids), level, electrical conductivity. They are located at the inflow and outflow points of the pilot plants, as shown in Figures 20, 21, 22 and 23, and Table 1.
The environmental components that will be monitored are:

- surface waters of ditches and canals: by monitoring these waters, it will be possible to verify their quality upstream and downstream of the pilot plants, allowing to assess their actual effectiveness;
- soil and sediments in Basin C: part of the nutrients contained in the waters of the basin are adsorbed by the soil particles. To this end, the soil is being monitored before and after the building of the filter ecosystem;
- microorganisms used as indicators of pollution and pathogens: the current pollution of the canals, in terms of pathogens, can be assessed using specific indicator microorganisms. Detailed studies and researches carried out through the years have allowed to identify the most significant groups of indicators or microbe species for the assessment of faecal pollution in the water: faecal streptococci and Escherichia coli;

Figure 4 – Detail of the new wetland areas (photo: Ester Del Bove).

Figure 5 – Aerial view of the intervention area of Pantano Cicerchia (photo: Carlo Perotto).

Figure 6 – Interventions in Area 2 – Borgo di Fogliano.

Figure 7 – Detail of the constructed wetland.

Table 1 – List of automatic monitoring stations.

N.	Location	Type of station	Pilot Project
…	…	Solar station Electric station Solar weather station	…

- macrophytes: the communities of aquatic macrophytes are an important bioindicator, because they are very sensitive to some kinds of pollutants such as biocides, to organic pollution and pollution from nutrients (eutrophication) (Rossi et al., 2011). The analysis of the status of macrophyte populations allows assessing water quality and alteration of watercourses. The macrophyte indices are used for their marked sensitivity to the alterations of the trophic state, and for this reason the Water Framework Directive places the macrophyte community among the indicators of biological quality;
- diatoms: unicellular algae suitable for monitoring running waters, because they are present with a high diversity in all rivers; moreover, they are very sensitive to the variations of the chemical and physical parameters, and have a short time of resilience (2-4 weeks). Monitoring diatoms is important within small wetlands, because they tend to reflect very well the impacts on the physical and chemical characteristics of the waters (D'Antoni et al., 2011);
- macroinvertebrates: they are characterised by long and complex lifecycles, and have a high sensitivity to environmental variations; moreover, the benthonic invertebrates have a limited vagility. They are frequently used as very good bioindicators, and, since they are easily samplable and widely diffused in watercourses, are often used in biomonitoring and in the assessment of river quality;
- ichthyofauna: fish populations are an important component of the fauna of watercourses, because they are strictly dependant on the aquatic ecosystem – important for the development of their lifecycle and their survival – and respond to environmental stresses of different kinds (APAT, 2007). The Italian legislation (Legislative Decree n. 156/2006 and following modifications) has identified the ISECI index – index of ecological state of fish communities (Zerunian, 2004; Zerunian, 2007; Zerunian, et al., 2009) – among the indices to be used for assessing the ecological state of a fish community. This index takes into consideration also the presence of endemic, alien and hybrid species;
- batrachofauna and herpetofauna: these communities are an important indicator of the state of the aquatic environment, because they are sensitive to environmental variations;
- vegetation: the constructed wetlands are monitored, in terms of performance, by assessing their vegetation's capacity to effectively purify the surface waters;
- alien species: the diffusion of some exotic species can alter the ecological conditions of the project areas, considerably damaging the native fauna and flora, which have to interact and compete with species occupying the same ecological niche and, frequently, having a higher ecological plasticity. Since the presence of exotic species can be a symptom of a pre-existing environmental degradation, ISPRA recommends, in its report n. 153/2011 on "Contributions for the safeguard of biodiversity in wetlands", to monitor this process, and to supply the national database – set up for the implementation of the National Strategy for Biodiversity – with data regarding the presence of these species collected in the course of monitoring activities, in order to better understand the processes of

biological invasion, to better manage them, and to control the environmental quality (D'Antoni et al., 2011).

The direct samplings regard, therefore, the analysis of chemical, physical, microbiological and biological parameters (Table 2); they have been carried out in the course of the entire monitoring campaign, with a variable frequency – according to the different parameters – comprised between 2 and 16 times. The above list has been obtained through consecutive steps:

- analysis of the feasibility studies for the pilot projects, aimed at identifying possible useful indications regarding the reduction of nutrients due to the single pilot project;
- analysis of the final designs or the pilot projects and discussion with the designers;
- analysis of the existing legislation on the subject.

The sampled point are 29 (Fig. 20, 21, 22 and 23), distributed among the four pilot projects, as reported in Table 3. Each sampling point includes the measurement of one or more parameters. The monitoring campaign comprises approximately 2,250 samplings, carried out between 2013 and 2014. So far, the surveys have been carried out in the following periods:

- June-July 2013;
- November 2013;
- January 2014;
- March 2014.

At the time of the printing of this book, the springtime measurements of April and May 2014 still have to be carried out.

The results of the surveys will be therefore available starting from June 2014, when the Rewetland project will be ended. The monitoring campaign will continue also in the following years. The list of the analytic parameters could undergo modifications or integrations, based on the results of the monitoring: the objective is to select the most significant parameters able to highlight the effectiveness of the pilot plants.

Table 2 – List of environmental parameters measured through direct sampling.

CHEMICAL PARAMETERS	Total nitrogen
	Nitrogen dioxide (NO2)
	Nitrate (NO2)
	Ammonium (NH4)
	Total phosphorus
	Soluble phosphorus (orthophosphorus)
	COD
	BOD
	Chlorides
	Sulphates
	SAR index: Na, Ca, Mg
MICROBIOLOGICAL PARAMETERS	*Escherichia coli*
	Faecal streptococci
CHEMICO-PHYSICAL PARAMETERS	Dissolved oxygen (mg/l and percentage of saturation)
	Temperature (°C)
	pH

	Turbidity
	Alkalinity (capacity to neutralise acids)
	Electrical conductivity
BIOLOGICAL PARAMETERS	Macrophytes (IBMR)
	Diatoms (ICMi)
	Macroinvertebrates
	Ichthyofauna (ISECI)
	Amphibians - Reptiles
	Alien species (flora/fauna)
	Lists of flora
PARAMETERS FOR SPECIFIC POLLUTANTS	Pb
	Cr tot
	Cu
	Zn
	Hexachlorohexane
	Hexachlorobenzene
	Isodrin
HYDROLOGICAL PARAMETERS	Water flow
CHEMICAL PARAMETERS ON MOWED VEGETATION	Dry biomass
	Carbon
	Nitrogen
	Phosphorus
CHEMICAL PARAMETERS OF SOILS AND SEDIMENTS	Ammonium
	Nitrogen dioxide (NO2)
	Nitrate (NO2)
	Total nitrogen
	Total phosphorus
	Organic carbon
	Texture
	Active carbon
	Cation exchange capacity
	pH
	Total carbonates
	Calcium

	Magnesium
	Potassium
	Iron
	Total suspended solids (residue at 105°)
	Organic nitrogen
	Total carbon
	Heavy hydrocarbons (C>12)
	Light hydrocarbons (C<12)
	Polychlorobiphenyls

Table 3 – List of manual sampling points.

Water body/Environment	Pilot Project	Number of points
…	…	…

Figure 8 – Location of Pilot Project 2 – Marina di Latina (source of orthophoto: Province of Latina).

Figure 9 – Aerial view of the intervention area (photo: Carlo Perotto).

Figure 10 – Design of Pilot Project 2 – Marina di Latina.

Figure 11 – Section of Basin 1 and adjacent areas.

Figure 12a – Location of Pilot Project 3 – Fosso Spaccasassi (Canale Allacciante Astura) (source of orthophoto: Province of Latina).

Figure 12b – Location of Pilot Project 3 – Canale Forcellata (Canale Selcella) (source of orthophoto: Province of Latina).

Figure 13 – Aerial view of the intervention area of Canale Allacciante Astura (photo: Carlo Perotto).

Figure 14 – Interventions of Pilot Project 3 – Canale Allacciante Astura.

Figure 15 – View of the intervention area of Canale Selcella (photo: Elio Murianni).

Figure 16a – Interventions of Pilot Project 3 – Fosso Selcella.

Figure 16b – Interventions of Pilot Project 3 – Fosso Selcella (cross section).

Figure 17 – Location of Pilot Project 4 – "Casale del Giglio" farm (source of orthophoto: Province of Latina).

Figure 18 – Interventions of Pilot Project 4 – "Casale del Giglio" farm.

Figure 19 – Aerial view of the intervention area (photo: Carlo Perotto).

Figure 20 – Location of the multi-parameter stations (in red) and the sampling points (in light blue) in the area of Pilot Project 1 (source of orthophoto: Province of Latina).

Figure 21 – Location of the multi-parameter stations (in red) and the sampling points (in light blue) in the area of Pilot Project 2 (source of orthophoto: Province of Latina).

Figure 22 – Location of the multi-parameter stations (in red) and the sampling points (in light blue) in the area of Pilot Project 3 (source of orthophoto: Province of Latina).

Figure 23 – Location of the multi-parameter stations (in red) and the sampling points (in light blue) in the area of Pilot Project 4 (source of orthophoto: Province of Latina).

THE PROJECT'S CONTRIBUTION: A TOOL FOR THE GOVERNANCE OF PROCESSES

3.1 THE PROCESS OF CONSTRUCTION OF THE ENVIRONMENTAL RESTORATION PROGRAMME

Introduction

The general objective of the Rewetland project is to contribute to the improvement of water quality in the Agro Pontino through the introduction of constructed wetlands and other natural purification systems. To this end, the project, besides the building of four pilot plants, has entailed the drafting of an innovative, wide-area planning tool: the Environmental Restoration Programme (ERP).

The Programme will be the strategic and technical reference for the actions that the subjects involved in the use and management of the water resource will have to implement with a view to environmental sustainability.

Such tool, result of Action 8 of the project, arises from the interaction among the project partners, who have shared their knowledge and criticalities in order to involve different institutional and technical levels, attempting to solve a "multi-variable equation".

This co-planning process has produced a "Programme Action Plan", identifying objectives, scenarios, priority actions and verification methods. It is accompanied by guidelines for the implementation of the different types of actions: in urban contexts, in natural protected areas, and along the banks of the surface water network. A number of project sheets, containing more specific details – useful for the executive phase –, have been set up for the actions identified as priorities.

Before entering the details of the Plan, the following paragraphs will give some preliminary considerations, useful for placing this proposal in its administrative, legislative and geographic context.

An innovative programme

It is important to underline that the "Environmental Restoration Programme" does not belong to any of the typologies provided for by the national and/or regional legislation concerning sector planning and spatial planning. The ERP is intended as a new planning tool of local scale, conceived to achieve the objectives contained in Directive 2000/60/EC, and in Legislative Decree n. 152/06. Indeed, the actions for the re-establishment and the restoration of wetlands, which in our case have also the role of purifying plants, are intended as "supplementary and additional measures" that have to be included in the framework of the hydrographic district management plans.

Moreover, the "Plan for the Protection of Waters of the Lazio Region" (PTAR), in its technical norms, defines as "*executive tools of the plan: … the programming acts by the local authorities, aimed at the construction of works for the protection of waters*". Article 29 of the norms provides measures for protecting the areas functionally relevant to the restoration of watercourses; and section 3 of the same article states that *"the Provinces identify, within their spatial planning, the minor watercourses, or their stretches, or their pertinent areas, on which to take safeguard measures concerning the objectives of protection of the areas and water resources potentially affected*".

The PTAR defines the basin of Rio Martino (one of the basins comprised in the area of the Rewetland project) as "priority intervention basin", given the very bad conditions of its waters. This basin is at the centre of the project actions, both as regards the pilot projects and the programming of future actions.

Therefore, this Programme, even if not "typical" nor "consolidated" in the framework of the most recent European, national and regional legislation, is a fully legitimate planning tool, and can be intended as an executive tool, at provincial level, of the regional planning for the protection of water quality.

A participated programme

Great attention has been paid to the activities of participation, consultation and debate on the issues of water quality and constructed wetlands. The working group has been in contact with many segments of the local community: farmers and pupils of the secondary schools, professionals and environmental associations, industry representatives and simple citizens interested in environmental quality (Fig. 1).

These frequent, and sometimes conflicting, contacts with the local communities (i.e. the stakeholders) have produced considerations that have been used later in the development of the Programme. For example, specific measures aimed at informing the population and training the operators have been included in all intervention axes. Moreover, a great attention has been paid to the financial sustainability of the actions, as a determinant factor for their feasibility.

In addition, the role of local authorities in the management of the "water system" has been explored, in order to identify governance mechanisms able to simplify the management of processes.

Therefore, partners have decided to submit the ERP to adoption by the Provincial Council, which is the most important body representing the local community.

This process, started with the approval of a "Preliminary Orientation Document" by the Provincial Council with deliberation n. 16 of 26 July 2013, is currently continuing with the implementation of the Strategic Environmental Assessment, which will identify the synergies with other regional spatial and sector policies.

In a nutshell, the ERP is an innovative economic and strategic programming tool, to be integrated in the higher-level plans and programmes in force. The ERP, acknowledged as strategic objective by the Province of Latina, will have to be included in its economic and management programming.

Figure 1 – Relationship between criticalities and actions of the ERP.

Criticalities	Associated criticalities	General problem	General measures	Specific actions
Loads from waste water treatment plants of major urban areas	Pollutant loads from point sources	Pollution of residential and industrial origin	1.1 Reduction of pollutant loads from point sources coming from waste water treatment plants of urban and industrial areas	Enhancement of waste water treatment plants through constructed wetland systems
				Promotion of constructed wetland systems for the tertiary treatment of industrial waste water
Loads from industrial areas				Identification of protection measures focused on constructed wetland systems and discharge limitations
				Promotion of the re-use of treated waters for irrigation purposes
Loads from small urban areas	Pollutant loads from diffuse residential sources		1.2 Reduction of pollutant loads from diffuse sources coming from low-density residential areas	Promotion of evapotranspiration systems in settlements not connected to water treatment plants
Loads from isolated houses				Promotion of constructed wetlands in settlements between 50 and 300 equivalent inhabitants
Loads carried by rain				Promotion of

runoff from roads				treatment of rainwater and first flush rainwater runoff
Canalised watercourses	Loss of purification capacity		1.3 Restoration and re-naturalisation of banks in urban areas	Re-naturalisation of canalised watercourses in urban and peri-urban areas
Unmanaged banks				Construction of parks and natural recreational areas with educational functions
Nature loss in cities				Actions of ecological improvement
Lack in shared management mechanisms	Reduced capacity in governing the problem		1.4 Promotion of more attentive citizens' and enterprises' behaviours concerning the protection of waters; promotion of governance actions	Implementation of awareness-raising campaigns on the issue of protection of the water resource
				Implementation of educational campaigns in provincial education facilities
Little sensitivity of local community				Promotion of local participation processes ("Water Forum")
				Promotion of mechanisms of participated governance

3.2 THE SOCIAL ACTORS' PERSPECTIVE

The perception of territory by local actors (stakeholders) has been one of the determinants in the drafting of the Action Plan of the ERP. Indeed, their involvement in labs/workshops (see Chapter 4) has allowed the elaboration of a SWOT analysis[2], which is the result of a systematisation of their individual perceptions, and whose results have been included in the ERP.

The analysis has highlighted that the Pontine Plain is perceived as a container of great environmental and landscape potentials and resources. Indeed, the main strengths identified are favourable climate, a natural environment rich in biodiversity, availability of water, soil fertility, with the important additions of the historic and cultural heritage of the land reclamation, and the presence of the Circeo National Park. This richness in resources, however, is put at risk by an excessive consumption of soil and natural resources, favoured also by a scarce environmental awareness. In the agricultural sector, the survival of the traditional activities is considered at risk, especially in the least structured farms. The progressive urbanisation of the Agro Pontino is seen as a substantial loss of the rural identity of places. On the other hand, the Agro Pontino has great potentials that, according to the participants in the workshops, are tied to a sustainable reconversion of the farming activities and to the development of an ecological tourism, based also on the recreational use of the dense canal network.

The active participation of local actors has therefore contributed to the definition of scenarios: those perceived as likely to occur, and those desired as optimal.

[2] The SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis is a participated method for strategic planning, which tends to highlight the interrelations between characteristics and potentials of a subject, through the definition of a matrix that, based on the proposed objectives, identifies strengths and weaknesses and relates them to opportunities and threats present around the subject itself.

The perceived trends reflect the fear of overexploitation and loss in quality of the water resource, with significant fallouts on agriculture and the environment. This scenario is characterised by a diffuse eutrophication of the surface waters, and by a depletion and salinization of groundwater. Moreover, the progressive expansion of impervious surfaces (buildings, squares, roads, greenhouses), will entail a radical modification of the regime of surface waters, enhancing the risk of floods and reducing the ecological and landscape value of the land. Other consequences could concern biodiversity, with the extinction of species already reduced in terms of population, and the diffusion of invasive alien species.

In the agricultural sector, in order to face this situation, management costs will have to grow, due to difficulties of irrigation. As regards the land reclamation plants, the costs will be higher (more powerful pumps, higher energy consumption), and interventions of maintenance or extension of the hydraulic works will probably become necessary (e.g. raising and strengthening the banks of the watercourses). The main concerns emerged during the meetings are those related to the new quality policies in the agricultural sector, which impose increasingly restrictive constraints for obtaining quality certifications. Moreover, producers are increasingly oppressed by the price reductions imposed by the great distribution, and by the increase of production costs. The deterioration of water quality, therefore, can strongly destabilise the agricultural activities, with negative consequences in terms of production and employment, in a place where agriculture is one of the main resources of the local economy.

The optimal scenario should be based on policies ensuring a higher coordination among farms, and a "green reconversion" of the entire sector, also by means of projects acting as catalysts such as an "Agricultural Park". Other elements identified by stakeholders regard a substantial reduction of pollutant loads, an enhancement of the natural self-purification capacity of waters, and a strengthening of the ecological networks. As regards the economic development strategies, it would be important to foster sustainable agricultural practices, promote local productions with quality and origin brands, and increase the offer of typical menus, in the framework of an overall strengthening of the local eco-tourism network. Institutions are asked to define a territorial identity and to ensure a higher effectiveness and a simplification in the delivery of services.

The governance action will also be important, and will have to be performed establishing a permanent confrontation and consultation table among institutions and stakeholders, contacts with farmers, and offices offering environmental advice to farmers.

According to the participants in the workshops, therefore, it is important that territorial policies adopt a global systemic vision for the Agro Pontino. A quality territory and a quality economy will have to be promoted, where the activities having an impact on water quality are subject to control mechanisms, and object of information, awareness raising and education campaigns.

3.3 OBJECTIVES AND STRUCTURE OF THE ERP

Legislation concerning the protection of waters

The management and protection of the quality of natural resources is a central objective within the European environmental policies. In particular, the water resource has been subject to a progressive legislation culminated in Directive 2000/60/EC, laying down a general framework for harmonising protection objectives and mechanisms at European level.

The objectives of protection and improvement of the quality of surface waters are stated by article 4, section 1, paragraph a), subparagraph ii) of Directive 2000/60/EC: *"Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status in accordance with the provisions laid down in Annex V, at the latest 15 years after the date of entry into force of this Directive"*.

Target of the Directive is to achieve a minimum status of water quality, defined as "good" according to specific parameters. The Directive states also that this objective will have to be achieved, for all Member

States' bodies of water, by 22 December 2015, unless extensions are decided at European level, and except for heavily modified bodies of water, for which special objectives will be defined.
The European Directive has been implemented at national level with Legislative Decree n. 152/06. In particular, the quality objectives and the modalities for their achievement or maintenance are defined in articles 76, 77 and 78 of the Decree, which also establishes the "Water Safeguard Plans" (art. 121), to be adopted by the Regions by 31/12/2007.
The Directive has acknowledged the "river basin districts", defined by the Member States, as the main unit for managing the water resource at subnational scale. Such districts are made up of one or more neighbouring river basins, according to geographic and management criteria. Within this classification, defined in Italy by Legislative Decree 152/99, the Agro Pontino has been assigned to the Authority for the Regional Basins of Lazio, which is in turn part of the Hydrographic District of the Middle Apennines. The Basin Authority of the Tiber River, coordinator of the District, is currently defining the Management Plan for the District of the Middle Apennines, where the protection and restoration measures are divided into basic measures and additional measures, according to the European legislation.
The Region of Lazio has approved, with Deliberation of the Regional Council n. 42 of 27 September 2007, the "Water Safeguard Plan of the Region of Lazio" (PTAR). The Plan ratifies the quality objectives defined at European and national level, summarised in art. 10, section 3, of its Technical Norms, which also sets the deadline of 22 December 2015 for the achievement of a "good" status of water quality for the watercourses currently in a "poor" or "bad" status.
In article 5, section 1, paragraph c), the "*programming acts by local authorities for the implementation of works concerning the safeguard of waters*" are defined as "*executive instruments of the Plan*".
Art. 29 of the Norms provides for safeguard measures for the watercourses' pertinent areas and for the areas subject to river restoration; and section 3 states that "*the Provinces identify, within their spatial planning, the minor watercourses, or their stretches, or their pertinent areas, on which to take safeguard measures concerning the objectives of protection of the areas and water resources potentially affected*".
However, the Decree specifies more in detail the provisions related to the executive instruments only in the case of the "River Restoration Plans" (art. 29, sections 4-10), to be approved at regional level, which should define the list of the priority watercourses, the types of intervention and the funding assigned.
The assessment made by PTAR assigns a quality value between "poor" and "bad" to most watercourses of the Pontine Plain; such status is assigned also to the respective basins, as visible in table 6 of PTAR (Fig. 2 and 3). For all basins, the quality objectives set by sections 2 and 3 of art. 21 of PTAR have to be applied. Moreover, art. 27, section 1, defines as a priority the interventions to be carried out in the basins of Rio Martino and Moscarello.
Other legislative and programming tools, to be implemented in synergy, are those related to the implementation of the so-called Nitrates Directive (91/676/EEC), among which the "Action programme for the zones vulnerable to nitrates of agricultural origin" (Regional Regulation n. 14 of 23 November 2007, implementing Regional Law n. 17 of 23 November 2006). In addition, with Regional Deliberation n. 63 of 24 February 2012, the implementation of some agricultural good practices and the construction of buffer strips have been made mandatory.
The combined provisions of the relevant national (Legislative Decree 152/06) and regional (PTAR) legislation provide for the following regulation of discharges:

a) discharges up to 50 equivalent inhabitants (art. 22, section 1), "*when not connectable to sewer networks, have to release into the soil or its superficial layers; they have to be treated through biological systems such as Imhoff tanks and successive subirrigation or evapotranspiration of the treated waters*";
b) discharges between 50 and 300 equivalent inhabitants (art. 22, section 1b), "*when not connectable to sewer networks, can release into surface waters. In this case, they have to be treated with suitable treatment systems, able to achieve an abatement of no less than 70% of the incoming pollutant load.*

The achievement of these emission limits can be achieved through treatment systems of biological type, associated to natural purification treatments";

c) discharges between 300 and 2000 equivalent inhabitants (art. 22, section 1c), "*releasing in surface waters, have to be treated with systems able to ensure emissions compliant with Table 1 of Annex 5. The emission limits of such discharges can be achieved through biological systems associated to nitrification and denitrification treatments or natural purification treatments*";

d) discharges above 2000 equivalent inhabitants (art. 100 of Legislative Decree n. 152/06, section 1). "*Settlements above 2000 equivalent inhabitants have to be provided with sewer networks for the urban waste water*".

Deliberation of Regional Council n. 219/11 has defined in detail the technical characteristics to be met by natural purification plants serving settlements below 2000 equivalent inhabitants.

The Province of Latina, besides implementing the basic measures, deriving from its competences, for the safeguard of waters, intends to carry out, though the ERP, a number of additional measures that are deemed necessary for achieving the quality objectives.

Such measures, included among those defined "supplementary and additional" by the European Directive, are focused on the reduction of pollutant emissions thanks to the application of good practices, and on the enhancement of the self-purifying capacities of waters thanks to natural purification systems.

Objectives and criteria for the intervention

General objective of the ERP is to improve the conditions of surface waters in the Agro Pontino through the introduction of constructed wetlands. The achievement of a "good" status of water quality, as defined by the legislation, can be considered an indicator of achievement of this general objective.

The general objective can be achieved through actions and instruments belonging to two major intervention categories:

- the reduction of pollutant loads discharged to watercourses, thanks to the implementation of good practices of water and soil management within residential, industrial and farming activities;
- the implementation of interventions aimed at the restoration and enhancement of the watercourses' natural self-purification capacity (natural water purification systems, buffer strips, constructed wetlands).

Such categories can be further subdivided based on the characteristics of the activities producing the pollutant loads, identifying the following specific objectives:

- reducing the presence of pollutant loads in residential and industrial wastewater;
- reducing the presence of pollutant loads coming from farming activities;
- restoring the river and canal environment and enhancing the purification capacity of watercourses in natural protected areas and in Natura 2000 sites.

Such specific objectives, directly connected to the general objective, have helped in defining the three intervention axes of the ERP, and are at the basis of the intervention criteria.

Intervention areas

The geographic intervention context of the ERP is defined by the overlapping of two different institutional competences: on the one hand, the Authority for the Regional Basins of Lazio (ABR), on the other, the Province of Latina (Fig. 3). This context includes only the areas defined as "intervention areas" by art. 21, section 1 of PTAR, as shown in Table 7 of the same PTAR.

Figure 2 – Regional Water Safeguard Plan 2007 – Table 5: Safeguard.

Figure 3 – Regional Water Safeguard Plan 2007 – Table 6: Quality status.

In the Agro Pontino, the basins identified in this way are the following:

- Basin 24 (Astura), whose main watercourse is the Astura river;
- Basin 26 (Moscarello), which includes the watercourses of Canale Acque Alte, Fosso Spaccasassi, Fosso Leschione;
- Basin 27 (Rio Martino), which includes Canale Acque Medie, the Ninfa-Sisto river, and the lakes of Fogliano, Monaci, Caprolace, and Paola;
- Basin 28 (Badino), including Canale Botte, the Amaseno River, the Linea Pio and Cavata canals, and the Ufente River.

The pertinent areas of each basin (Table 1), located within the Province of Latina and the intervention areas, amount to 1,456 sq km, divided among 19 municipalities, of which 16 completely included in the intervention context, and 3 partially included (Aprilia, Rocca Massima and Terracina). The correspondence between the administrative and the natural boundaries of the basins actually facilitates the policies for implementing the programme. On the other hand, a strong coordination with the Province of Rome will be necessary in the northern sector of Basin 26, where significant pollutant loads originate from the diffuse settlement belonging to the Municipality of Velletri.

This whole territory falls under the jurisdiction of the Land Reclamation Consortium of Agro Pontino, and comprises the entire Circeo National Park; these two institutions, therefore, have to be considered as strategic partners for the implementation of the actions.

Land cover

Land cover analysis is important in order to identify the intervention priorities in the single basins subject to the actions. In the area of the basins 24-28 under provincial jurisdiction, the following conditions can be found:

- urbanised residential areas amount to 6.3% of the total area. Together with industrial zones, mining areas and artificial, non-agricultural green areas, they reach a total of 14,000 hectares, equal to 9.6% of the area involved;
- the rural characteristic of the Pontine Plain is clearly reflected by the land cover data. Agricultural areas (almost 100,000 hectares), amount to 66.9% of the total; arable land amounts to 47.9% of the total;
- natural areas are only 21.7% of the total, in particular wooded areas amount to 11.2% and are mainly concentrated in the Circeo National Park;
- water bodies and wetlands, notwithstanding their importance and diffusion, occupy less than 1% of the area. This figure is in any case underestimated, because the low-detail scale adopted for the interpretation of land cover fails to detect the smallest areas.

Table 1 – Areas of the municipalities included in Basins 24-28.

	Total area of municipality (sq km)	24 – Astura	25 – Astura-Moscarello	26 – Moscarello	27 – Rio Martino	28 – Badino	Total areas of basins included in municipality	% over total area of municipality
Aprilia	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
Overall total								

Figure 5 – Geographical context of intervention of the ERP.

Figure 6 – Agro Pontino: area with high greenhouse density (photo: Carlo Perotto).

Figure 7 – Residential area: Latina waterfront (photo: Carlo Perotto).

Structure of the ERP

The ERP is composed of three different operational instruments:

- the Action Plan is the main instrument defining the programme of activities and interventions necessary for the achievement of the general objective. The Plan is structured into three levels of coordinated actions (Axes), each targeted to the achievement of a specific objective, referring to the different origins of wastewater (residential/industrial settlements, farms, and natural areas), where habitats have to be restored and their self-purification capacity improved;
- the Guidelines are reference texts for the implementation of the interventions identified by the Action Plan. They contain the information necessary for the technical design and the maintenance of the different types of plants. They are divided into three different parts: interventions in residential/industrial areas, in agricultural areas, and in natural areas;
- the Project Sheets transpose the information contained in the Guidelines into operational examples.

The Action Plan coordinates the logic of the entire Programme, entrusted to three lines of intervention. These lines are developed and illustrated with examples by the Guidelines, which give recommendations on how to implement the different types of actions.

The Project Sheets give practical hints on how and where to implement the actions, and what are the costs and the problems related to the construction works and maintenance interventions. The Project Sheets provide, for each intervention, sufficient information for carrying out a specific feasibility study, or for starting directly the design for the works.

Action Plan

The Action Plan is a tool for planning and organising the necessary activities for achieving the objectives of the Programme. The actions are organised into different levels, from the highest to the lowest level of definition. Level 0 is the Programme itself.

Level	**Objective**
Level 0: Environmental Restoration Programme	Improve water quality

The following level (Level 1) is divided into three intervention lines (Axes). Each Axis contains the major intervention typologies. The axes are directly referred to the specific objectives and concern respectively residential/industrial, agricultural, and natural areas.

Level 2 divides the actions to be carried out into three typologies, called Measures. Each axis is composed by four typologies of measures, some of which are related to the building of infrastructure, i.e. direct interventions of construction of wetlands or buffer strips, depending on the geographic context and the sources of pollutant loads. In the residential/industrial areas, sources are represented by wastewater treatment plants, or settlements not connected to sewers; whereas in the agricultural areas, sources are diffuse throughout the ditch and canal network.

Each axis contains also non-infrastructural measures, such as promotion of good practices for the reduction of pollutant loads, awareness-raising activities, and activities aimed at improving an inclusive governance of the processes related to wastewater treatment and prevention of pollution.

Level	**Objective**
Level 1: Axes	Axis 1 – Reducing the presence of pollutant loads in residential and industrial wastewater
	Axis 2 – Reducing the presence of pollutant loads in wastewater from farming activities

	Axis 3 – Restoring the river and canal environment and increasing the self-purification capacity of watercourses in natural protected areas and in Natura 2000 sites

Level 3 concerns the single actions: the actions are the basic level for implementing the Programme, and contain also cost indications. Each measure contains a variable number of actions, describing the fields of application of the interventions.
The proposals, contained in axes, measures and actions, define a "menu" of intervention typologies, which have to be applied to the specificities of the different areas. At the executive level, they will be spatially located, and referred to the single sub-basins. The executive tools will choose, among the action typologies, those directly applicable and having potential for the highest impact on the single areas. These tools can be "Programme Agreements" (defined by art. 34 of Legislative Decree 267/00), if they involve only public authorities; or can be implemented as "River Contracts", aimed at building new mechanisms of participative management among private local actors, associations, citizens. These instruments can also be related to the "River Restoration Programmes" provided for by art. 29 of PTAR.
Some of the measures, especially the non-infrastructural ones related to promotion and governance, can be implemented at municipal or provincial level, through different types of instruments such as agreements and memoranda of understanding, or can be directly executed by the involved authorities.

Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
0 – ERP	1 – Axes (3)	2 – Measures (12)	3 – Actions (circa 60)	4 - Interventions
Strategic planning Action Plan of the ERP				Executive planning: River Contracts, River Restoration Programmes (art. 29 of PTAR), Programme Agreements (art. 34 of Legislative Decree 267/00), etc.

The action typologies are the following:

- infrastructural actions: directly aimed at enhancing the self-purification capacity of watercourses through constructed wetland systems, buffer strips, and other similar systems;
- management actions: aimed at enhancing the purification capacity through the application of different methods of management of the banks and of the areas adjacent to watercourses;
- control and monitoring actions: concerning the different components of wastewater from point and diffuse sources in residential, industrial and agricultural settlements;
- institutional actions: aimed at implementing or promoting inter-institutional coordination for solving specific problems falling under overlapping jurisdictions; the integration of measures into spatial planning tools falling under other authorities' jurisdiction; or the creation of participative management mechanisms, open to citizens (governance);
- socio-economic actions: actions aimed at implementing or promoting changes in farming practices, such as the introduction of environmentally sustainable techniques or crops, productive diversification, valorisation of culture and landscape, training.

Figure 8 – Diagram showing the process for the drafting of the ERP, and its components.

3.4 INTERVENTION AXES OF THE ERP

Axis 1: Reducing the presence of pollutant loads in residential and industrial wastewater

Actions contained in Axis 1 share the common objective of reducing the pollutant loads in residential and industrial wastewater. This axis is divided into four types of measures, which in turn contain 14 types of possible actions. The types of measures are:

1. Reduction of pollutant loads from point sources coming from wastewater treatment plants in urban and industrial areas.
2. Reduction of pollutant loads from diffuse sources coming from low-density residential areas.
3. Restoration and re-naturalisation of banks in urban areas.
4. Promotion of more attentive citizens' and enterprises' behaviours concerning the protection of waters.

The intervention strategy is firstly (1.1) based on the identification of the possibility to further reduce the quantity of pollutant loads coming from wastewater treatment plants of residential and industrial areas. In this context, given the high quantity of loads, constructed wetlands can refine and further improve the quality of waters, already treated by traditional, existing plants according to legal requirements. In this case, the PTAR (art. 29 of the Technical Norms) states that the actions can also concern the identification of non-significant watercourses, or stretches thereof, and respective pertinent areas, where suitable limitations to discharges and additional safeguard measures can be applied.

In the above cases, the role of constructed wetland systems is mainly an integration of the existing water treatment capacity; on the other hand, it has a greater importance in minor urban areas with discharges smaller than 2,000 equivalent inhabitants, where the regional regulation provides for the application of constructed wetland systems. Indeed, the second measure (1.2) regards the strategies and interventions necessary for reducing pollutant loads in sparse settlements, not connected to the sewer network.

A different role is assigned to the third typology of actions (1.3), which intends to foster the self-purification capacity of waters in urban contexts, through interventions of re-naturalisation of the banks. The creation of urban parks centred around these types of interventions, besides increasing the availability of natural spaces open to citizens, contributes to improving the urban and peri-urban environment with recreational, educational and environmental functions. In this type of intervention, therefore, additional social and economic objectives have been associated to the primary objective concerning the increase of self-purification capacity.

The social and educational objectives are specifically focused by the fourth (1.4) type of action of this axis. As already proved by the participation process carried out in the course of the project, the promotion of sustainable behaviours, and the actions of environmental information, play a fundamental role in the possibility of sharing the environmental objectives of a given area. Besides facing the issues of the quantitative management of the water resource, it is also essential to raise citizens' awareness on the importance of adopting sustainable behaviours, such as a responsible use of detergents used in domestic activities, and on the effects that they generate on waters.

This last measure includes strategies for sharing inclusive mechanisms of water management, open to social actors.

Table 2 – Axis 1: Reducing the presence of pollutant loads in residential and industrial wastewater.

MEASURES		**ACTIONS**	
1.1	Reduction of pollutant loads from point sources coming from wastewater treatment plants in urban and industrial areas	1.1.1	Enhancement of wastewater treatment plants with capacity greater than 300 equivalent inhabitants through constructed wetland systems for the tertiary treatment of waters (art. 22, section 1b of PTAR)
		1.1.2	Promotion of constructed wetland systems for the tertiary treatment of industrial wastewater (art. 23 of PTAR)
		1.1.3	Identification of non-significant watercourses where to apply safeguard measures focused on constructed wetlands and limitations to discharges (art. 29, section 3 of PTAR)
		1.1.4	Promotion of the re-use of waters treated with constructed wetlands for irrigation purposes
1.2	Reduction of pollutant loads from diffuse sources coming	1.2.1	Promotion of evapotranspiration systems in settlements below 50 equivalent inhabitants, not reached by sewers (art. 22, section 1 of

	from low-density residential areas		PTAR)
		1.2.2	Promotion of constructed wetlands in settlements between 50 and 300 equivalent inhabitants (art. 22, section 2 of PTAR)
		1.2.3	Promotion of the treatment of rainwater and first flush rainwater runoff (art. 24 of PTAR)
1.3	Restoration and re-naturalisation of banks in urban areas	1.3.1	Re-naturalisation of canalised watercourses in urban and peri-urban areas
		1.3.2	Construction of parks and natural areas with recreational and educational functions along watercourses in urban contexts
		1.3.3	Actions of ecological improvement on the urban and peri-urban water network
1.4	Promotion of more attentive citizens' and enterprises' behaviours concerning the protection of waters	1.4.1	Implementation of local and provincial awareness-raising campaigns on the issue of protection of the water resource
		1.4.2	Implementation of educational campaigns in provincial education facilities, on the issues of safeguard of the water resource, water quality, and the historic heritage of the land reclamation works
		1.4.3	Promotion of local participation processes ("Water Forum"), where institutional and private actors can evaluate, together with citizens, results and proposals on the issue of water requalification
		1.4.4	Promotion of governance mechanisms facilitating the implementation of interventions of constructed wetlands and natural purification of waters

Figure 9 – Settlement on a coastal dune (photo: Carlo Perotto).

Figure 10 – Land cover in the Rewetland area: urban and industrial areas (source: Province of Latina).

This approach complies with both European and national regulations, implemented also at regional level with Law 4 April 2014 n. 5 "Safeguard, governance and public management of waters", which focuses on public participation as a determinant factor for the success of European environmental policies.

Axis 2: Reducing the presence of pollutant loads in wastewater from farming activities

Actions contained in Axis 2 aim at reducing pollutant loads in wastewater from farming activities, diffusely discharged along the reclamation canal network. These loads derive from the use of fertilisers and from the wastewater generated by livestock farming and the agro-food industry. Because of the diffuse distribution of the discharges, the interventions have to be carefully calibrated according to their location in the canal network, and be part of a complex set of actions.

The different measures have been organised in order to diversify the interventions according to their scale of implementation, also taking into consideration the synergies among them. The measures are:

1. Direct promotion of good practices and environmentally friendly farming management methods.
2. Creation of buffer strips and constructed wetland systems in farms.
3. Creation of buffer strips and constructed wetland systems along the main water network (canals, rivers).
4. Promotion of greater awareness towards the protection of water by the agricultural sector.

As regards the farms, the priority is to adopt good practices in farm management and in production policies, allowing to reduce nutrients at source. The cases studied during the preparation of the Guidelines and within Pilot Project 4 have supplied useful indications about the types of possible actions, on which the intervention proposals have been based.

The second measure groups actions implementable in medium-large farms, and aimed at the creation of buffer strips along the banks, or small artificial wetlands in marginal areas.

On the other hand, the most relevant interventions, related to the creation of buffer strips and/or to the re-design of the banks, are located in the main canal network, and pertain to the third measure. Even if they are similar to the actions of the second measure, the larger scale of intervention implies the involvement of public actors, in particular the Land Reclamation Consortium of Agro Pontino. An example of these interventions is the creation of buffer strips in the Spaccasassi and Selcella canals, carried out within Pilot Project 3.
Here also, given their importance, the fourth group of actions has been entirely dedicated to information, training and awareness-raising activities.

Table 3 – Axis 2: Reducing the presence of pollutant loads in wastewater from farming activities.

MEASURES		**ACTIONS**	
2.1	Direct and indirect promotion of good practices and environmentally friendly farming management methods	2.1.1	Promotion of good farming practices in water, soil and crop management through dissemination and training programmes targeted to farmers
		2.1.2	Promotion of soil survey techniques for irrigation in farms
		2.1.3	Promotion and support to precision farming techniques and experiences, ensuring savings of water and pollutants
		2.1.4	Promotion and support to the cultivation of traditional species in marginal agricultural areas
		2.1.5	Promotion of good practices in the management of wastewater from livestock farming
		2.1.6	Promotion of methods of biomass recovery for energy production
2.2	Promotion of buffer strips and constructed wetland systems in the minor water network and in farms.	2.2.1	Direct implementation and support to the maintenance of buffer strips and artificial wetlands in farms
		2.2.2	Promotion and support to the preparation of business plans and programmes for environmental improvement, financially sustainable and including interventions of constructed wetlands and natural purification systems
2.3	Promotion of natural purification systems, management and maintenance of the self-purification capacity of the main water network (canals, rivers).	2.3.1	Creation of artificial wetlands and buffer strips in the Consortium's water network, with infrastructural and/or vegetation interventions, and multi-purpose criteria
		2.3.2	Application of natural purification techniques to the management and maintenance of the banks of the Consortium's water network
		2.3.3	Recovery and re-use of biomass deriving from the maintenance of the Consortium's canals
		2.3.4	Recovery and management of windbreaker tree lines, to be also used as buffer strips with multi-purpose criteria
2.4	Promotion of greater awareness towards the protection of water by the agricultural sector.	2.4.1	Diffusion of good farming practices and experiences through programmes, events, dissemination products
		2.4.2	Promotion of "territorial marketing" of the local agricultural sector through "agricultural parks", farmers' markets, and other "short chain" sale systems, and initiatives connected to water quality and agro-food products obtained with the application of good practices
		2.4.3	Promotion of quality certification of local agro-food products through the existing certification networks, based also on water quality
		2.4.4	Implementation of training and innovation processes targeted to sector organisations and the staff of the Land Reclamation Consortium
		2.4.5	Promotion of local participation processes and mechanisms of shared decision making on the issue of quality and innovation in agriculture,

			coordinated by the Land Reclamation Consortium and by sector organisations

Figure 11 – Agro Pontino: agricultural area (photo: Carlo Perotto).

Figure 12 – The Rewetland area: land cover – agricultural areas (source: Province of Latina).

Axis 3: Restoring the river and canal environment and increasing the self-purification capacity of watercourses in natural protected areas and in Natura 2000 sites

Actions contained in Axis 3 aim at restoring the environment and increasing the self-purification capacity of watercourses in natural protected areas and other similar areas. The latter areas are those subject to any kind of environmental safeguard, such as Natura 2000 sites, geotopes, biotopes, etc.

This axis is structured into four types of measures (in turn divided into 16 types of possible actions):

1. Increase of the quality of aquatic ecosystems and the functionality of the ecological network.
2. Improvement of the specific composition and the physical and chemical characteristics of the above ecosystems.
3. Strengthening of the multifunctionality of protected areas through the promotion of sustainable development projects.
4. Creation of research and communication centres and activities focused on environmental values and criticalities.

The territory of the Pontine Plain, since the times of the land reclamation, has undergone substantial modifications, with a heavy reorganisation of its environmental structure and a consequent increase of the impacts connected to human activities. The emergence of urban settlements, industrial areas and vast areas dedicated to agriculture has entailed a reduction of the natural areas, once covering the entire plain. Nowadays, natural areas are confined to small linear patches along the canals in remote zones, in protected areas and in Natura 2000 sites, which are important reservoirs of biodiversity for the Pontine Plain. Thanks to their residual natural characteristics, these areas are suitable for environmental restoration interventions, intended as the set of actions that can bring an area to a condition as close to natural as possible, also valorising it from a socio-economic point of view.

The self-purification capacity of watercourses can be increased through the actions of Measure 3.2, aimed at improving the physical and chemical characteristics of aquatic ecosystems, and at increasing their specific biodiversity. Indeed, by reducing the number of alien species and implementing shared processes of conservation of the existing natural elements, especially the most threatened ones, management interventions can be experimented and replicated elsewhere.

On the other hand, the restoration of the ecological functionality and the connections among natural areas is entrusted to Measure 1, which will concentrate a good part of its actions on aquatic ecosystems.

The protected natural areas and the Natura 2000 sites can be, if suitably valorised, an important driving force for the Agro Pontino and become, therefore, experimental labs of promotion of sustainable development projects. This is the objective of measure 3.3, which will implement, through its actions, interventions able to offer also an economic resource for the territory.

Environmental education and awareness raising targeted to the population are the focus of Measure 4, which, as in the other axes, is more targeted to social and governance issues.

Thread of this axis, as already said, is the ecological network, which suits multiple aims and functions (APAT, 2003), among which:

1. ecological network as system for connecting habitats whose biodiversity has to be protected;
2. ecological network as system of parks and reserves, part of a coordinated system of infrastructures and services;
3. ecological network as landscape system, supporting perceptive and recreational functions;
4. ecological network as multifunctional ecosystem, supporting sustainable development.

Table 4 – Axis 3: Restoring the river and canal environment and increasing the self-purification capacity of watercourses in natural protected areas and in Natura 2000 sites

MEASURES		**ACTIONS**	
3.1	Increase of the quality of aquatic ecosystems and of the functionality of the ecological network	3.1.1	Renaturalisation of the artificial banks of watercourses
		3.1.2	Creation of new freshwater wetlands (also aimed at fostering the diffusion of wader and amphibian fauna)
		3.1.3	Creation and management of buffer strips and filter ecosystems
		3.1.4	Definition of prescriptions and good practices for the maintenance of riparian vegetation
3.2	Improvement of the specific composition and the physical and chemical characteristics of the aquatic ecosystems	3.2.1	Control of invasive alien populations
		3.2.2	Improvement of the state of conservation of threatened native species
		3.2.3	Restoration of the connections of coastal lakes to the water network (after having improved the biochemical quality of watercourses) in order to reduce the salinization of the lakes
		3.2.4	Creation and adaptation of areas functional to groundwater recharge
3.3	Strengthening of the multifunctionality of protected areas through the promotion of sustainable development projects	3.3.1	Regulation of greenhouse farming and promotion of sustainable greenhouses
		3.3.2	Regulation of free-range cow, buffalo cow and horse farming
		3.3.3	Promotion of organic agriculture, agritourism and educational farms
		3.3.4	Promotion of a sustainable biomass supply chain
3.4	Creation of research and communication centres and activities focused on environmental values and criticalities	3.4.1	Development of programmes of environmental education and training aimed at increasing the "culture of nature"
		3.4.2	Requalification of hiking and bike trails and creation of educational areas and biodiversity observation points
		3.4.3	Integration of the surface water environmental monitoring system, also extending it to the monitoring of the ecosystem components
		3.4.4	Promotion of the participatory design of interventions of adaptation to the effects of climate change

Figure 13 – The coastal lakes (photo: Carlo Perotto).

Figure 14 – The Rewetland area: forests and natural areas, SCIs and SPAs.

3.5 THE PROCEDURE FOR THE STRATEGIC ENVIRONMENTAL ASSESSMENT OF THE ENVIRONMENTAL RESTORATION PROGRAMME

The Strategic Environmental Assessment (SEA) of the ERP of Agro Pontino is an experimental activity, because there are no other experiences of SEA applied to environmental restoration programmes, in application of the Water Framework Directive, at provincial level. However, a similar process of environmental assessment has been implemented by the Province of Novara in the framework of the River Contract of the Agogna stream (Province of Novara, "Interventions of environmental requalification of the Agogna stream in its southern stretch, September 2011").

What is exactly the procedure of Strategic Environmental Assessment? Art. 5 of Legislative Decree 152/2006 defines SEA as "the elaboration of a report concerning the impact on the environment consequent to the implementation of a plan or programme to be adopted or approved; the implementation of

consultations; the assessment of the environmental report and of the results of the consultations in the decision-making process for the approval of a plan or programme; and the publication of information concerning the decision".

This assessment procedure has been included within the complex methodology of the LIFE+ Rewetland project, and already in 2008, in the phase of elaboration of the proposal to be submitted, its implementation has been considered particularly suitable for the entire governance and co-planning process – not as much for assessing the environmental impacts of the programme (which are mainly positive), but rather with the aim of experimenting a planning process shared with all environmental authorities. The assessment is an essential and significant part of the planning process, and this surely is the first example in the Region of Lazio where the SEA has been launched at the same time when the planning process has started.

The Strategic Environmental Assessment is applied according to Legislative Decree n. 152/2006 and following modifications ("Regulations regarding the environment"), and Regional Council Decree n. 169/2010, which at point 1.3 states: "the following are subject to Strategic Environmental Assessment: a) the plans/programmes that are drafted for the assessment and management of air quality, for the farming, forest, fishing, energy, industry, transport, waste management, water management, telecommunication, tourism, and spatial planning sectors, and those defining the reference framework for the approval, authorisation, localisation, or implementation of projects subject to environmental assessment based on the law in force".

The process of Strategic Environmental Assessment, started in 2010, has undergone the following phases:

1. definition of the "knowledge base" and the geographic database, and elaboration of the Report on the State of the Environment;
2. launching of the participatory process for sharing the objectives and actions of the Programme;
3. drafting of the Preliminary Environmental Report and definition of the environmental objectives and the external and internal coherence;
4. launching of the scoping phase, and "planning conference" with the environmental authorities;
5. definition of scenarios and assessment of the environmental, social and economic impacts of the Programme;
6. drafting of the Environmental Report;
7. monitoring of the Programme.

The first phase has entailed the definition of the "knowledge base" concerning the Agro Pontino. This activity has been based on studies, data and information collected in the course of the Rewetland project.

The following have been elaborated:

- the "Planning Framework", i.e. a survey of above twenty plans and projects being implemented in the Programme area, focused on objectives and actions aimed at the safeguard of water and the environment. This activity has highlighted that many types of plans, programmes, and constraints – deriving from different approaches and regulations – exist in the Agro Pontino;
- the Report on the State of the Environment, which, starting from the results of the preliminary reports on the use and quality of waters, on the conditions of the coastal wetlands and on the "Planning Framework", describes the state of the Agro Pontino and its ecological landscape, highlighting pressures, qualities and criticalities concerning the main issues of water and soils;
- the geographic database has collected and harmonised the data and information elaborated in the phases of territorial analysis and monitoring. The heterogeneous data, coming from different information systems, have been harmonised and made compliant with the national standards, and the metadata have been structured according to the specifications of the "National Repository of Spatial Data", and of the ISO 19115 standard (ISO-TC211).

Following the construction of the knowledge base, a participation process involving local actors has been launched (see Table 5); this process has led to the definition of axes, measures and actions of the Environmental Restoration Programme of Agro Pontino.

After the consultation with citizens, the drafting of the Preliminary Environmental Report has started; this document is a preliminary version of the Environmental Report, regulated by Legislative Decree 152/2006,

which states: “the Environmental Report has to identify, describe and evaluate the significant effects that the implementation of the proposed plan or programme can have on the environment or the cultural heritage, and the reasonable alternatives that can be adopted in consideration of the objectives and the geographic context of the same plan of programme”. Besides the analysis of the geographic context, the Preliminary Report contains an analysis of the environmental components and pressure factors, highlighting what already reported in the previous chapters of this publication, i.e.:

- surface waters suffer from a serious state of contamination caused by heavy human pressures. The concentration of important residential, industrial and agricultural settlements has caused a significant impact in terms of water availability and quality;
- a progressive soil contamination is taking place, caused by excessive loads from farming activities;
- there is an important loss of wetland biodiversity;
- landscape is damaged by land reclamation activities and high human pressure.

Table 5 – Participation events.

Participation events with stakeholders and citizens	**Date**
Dissemination meeting 9.1: presentation Dissemination meeting 18.1: presentation	13/10/2011
Workshop 9.1: definition of the objectives of the ERP Dissemination meeting 18.2: Marina di Latina	26/1/2012
Workshop 9.2: definition of the scenarios of the ERP Workshop 18.1: future scenarios Marina di Latina	23/2/2012
Workshop 9.3: verification of the scenarios of the ERP	22/3/2012
Dissemination meeting 9.2: presentation of the results of the ERP Workshop 9.4: discussion on the ERP Workshop 18.2: project proposals Marina di Latina	7/6/2012
Dissemination meeting 9.3: final presentation of the ERP Dissemination meeting 18.3: projects Marina di Latina	25/10/2012

Following the context analysis, the environmental objectives have been defined, based on a survey of the general objectives adopted by the national and regional programming, and choosing those being more suitable for the characteristics of the Pontine Plain.

The environmental objectives referring to themes such as energy and climatic factors, quality of internal, surface and ground waters, soil, flora, fauna and ecosystems, cultural resources and landscape, and health, have been compared with the objectives of the ERP through internal coherence matrices.

The *internal coherence* has highlighted that, as regards the interventions on the environmental system and on landscape, there is a substantial coherence with the environmental objectives, and, in particular, the ERP provides for the safeguard of surface and ground water, the hydrographic network and the lake and marine environment. Soils and rural landscapes are also protected and valorised by the actions of the ERP. More generally speaking, the implementation of the ERP would produce an enrichment of the characteristic ecosystems and an enhancement of the connections among ecological networks.

The main criticalities emerging from the evaluation of the matrices substantially regard the hydrogeological risk generated by the presence of plants on the banks of the reclamation canals, which could compromise their hydraulic function.

The analysis of the relations between the ERP and the environment cannot disregard its coherence with the plans of higher hierarchy; therefore, the environmental objectives of the ERP have been also compared with the objectives adopted by the plans being, currently, the main reference framework within which the ERP itself will operate. These plans are:

- the Management Plan for the District of the Middle Apennines (PGDAC);
- the Operational Programme of the Region of Lazio (POR);

- the Regional Landscape Plan (PTPR);
- the Hydrogeological Risk Plan (PAI);
- the Water Safeguard Plan of the Region of Lazio (PTAR);
- the Rural Development Programme 2007-2013 (PSR);
- the Ecological Network of the Province of Latina.

This *external coherence* analysis has highlighted:

- a considerable overlapping among the environmental objectives concerning the safeguard of surface waters, groundwater and soil, and among the measures to be adopted in order to reduce their pollution;
- as regards landscape protection, the choices of the ERP correspond to those of the plans and programmes aiming especially at the safeguard of rural landscape and its values;
- as regards the safeguard and valorisation of protected areas, there is a considerable coherence of objectives concerning the area of the Circeo National Park;
- the main mismatch concerns the prevention of hydrogeological risk and the safeguard from environmental risks connected to the containment of rainwater and the control of watercourses.

Table 6 – Sustainability objectives for the SEA.

Theme	**Sustainability objective**
Climate factors and energy	Increase of the production of energy from renewable sources, and the use of energy from renewable sources, in particular biomasses
	Reduction of the emissions of greenhouse gases for the productive sector, deriving from an excessive use of pesticides in agriculture
Quality of internal, surface and ground waters	Maintenance of the quality characteristics for each use of water, in particular for those used in agriculture
	Prevention and reduction of pollution of surface and ground water, recovery of polluted water bodies, improvement of the state of waters and suitable protection of those intended for particular uses
	Protection and improvement of all groundwater bodies, prevention or limitations to discharges of pollutants, significant reduction of pollution
	Achievement of sustainable uses of the water resource (water saving, reduction of consumptions, re-use, etc.), with particular attention to farming activities
	Protection of territorial and marine waters and achievement of the objectives of the international agreements on this theme, including those aiming at avoiding and eliminating pollution in the marine environment
	Blocking the advancement of the salt wedge
	Limit to the process of salinization of coastal lakes
Soil	Maintenance and restoration of the coastline: integrated coastal planning and management
	Reduction of soil contamination and the related risks
	Ensuring the safeguard and restoration of soil and subsoil through the prevention of instabilities
	Safeguard of high-value agricultural areas
Biodiversity, flora and fauna	Avoiding biodiversity loss, and increasing the contribution of agriculture and forestry to the maintenance and strengthening of biodiversity
	Complete application of the Habitat and Birds Directives
	Fighting invasive alien species

	Preservation and restoration of ecosystems and their services
	Development of ecological connectivity and extension of protected areas
Cultural heritage and landscape	Safeguard, restoration and valorisation of high-value agricultural landscapes
	Safeguard and valorisation of the cultural assets of the Pontine Plain
Health	Fostering the conversion towards an agriculture using limited quantities of pesticides, or no pesticides at all, in particular by raising awareness in consumers, promoting the application of codes of conduct and good practices, and analysing the possibilities offered by the application of financial instruments
	Before flowing into the sewers, wastewater has to be subject to a secondary, or equivalent, treatment

The preliminary phase of the SEA (*scoping*) has ended with a consultation with the institutional actors: the Region of Lazio (competent authority) has called above thirty environmental authorities to the table of discussion. Among these, there are the Offices of the Region of Lazio dealing with spatial planning, environment and agriculture, the Superintendence offices responsible for archaeology and landscape, the regional agencies for the environment, soil protection, parks and agriculture, the 19 municipalities of the Pontine Plain, the Basin Authority of the Tiber River, the Land Reclamation Consortium of the Agro Pontino, and the Circeo National Park. After this consultation phase, the Region of Lazio has issued the scoping document containing the procedural and analytical recommendations for the drafting of the Environmental Report.

The Environmental Report evaluates the impacts of the Environmental Restoration Programme on all environmental components (water, soil, air, biodiversity), also as regards the social and economic issues. It identifies, describes and evaluates the significant effects on the environment, taking into account the objectives and the geographic context of the Programme, and the reasonable alternatives, based on Annex I to Directive 2001/42/EC. In order to assess the impacts of the Programme and identify the alternatives, four scenarios have been elaborated, making the environmental effects and the reasons of the Programme's choices explicit and comparable.

A "Baseline Scenario" represents the trend occurring in the case the Programme is not implemented; this scenario entails a progressive deterioration of water quality, with very negative impacts on the agricultural sector, the coastal areas, the protected areas and the tourism and leisure sector. The other three scenarios represent the implementation of the Programme taking into consideration its three axes of intervention (urban, rural and natural areas).

The four scenarios represent:

- Baseline Scenario: development of the current trend without the implementation of the Programme;
- Scenario 1: implementation of the Programme giving priorities to the actions in the urban areas;
- Scenario 2: implementation of the Programme giving priorities to the actions in the rural areas;
- Scenario 3: implementation of the Programme giving priorities to the actions in the natural areas.

The assessment of the alternative scenarios highlights the impacts of the Programme on the environmental, social and economic components of the three axes of intervention, and allows to correctly address the local sustainable development policies.

As regards the last phase, concerning the monitoring of the Programme, the Province of Latina has enhanced its network of stations for monitoring water quality, and has set up a geographic information system supporting the verification of the achievement of the environmental objectives. In the next years, this complex and detailed monitoring system will be used for verifying periodically the results of the Programme activities, and for updating and redefining the instruments for its implementation.

3.6 INTERVENTION SCENARIOS

Among the preparatory activities carried out before the drafting of the Programme, the modelling of the intervention scenarios has proved essential in order to verify the effectiveness and impact of the measures.
The survey and studies carried out by the Province of Latina starting from 2008 within the project "Monitoring of the surface waters" have been used for the modelling.

Baseline Scenario

The values of the pollutant loads within each sub-basin of the ERP area have been derived from the analysis of the provincial databases, in particular:

- "Origin of pollutant loads and state of eutrophication of the internal waters of the Province of Latina", Office for Ecology and Environment, Province of Latina 2011;
- "The Database of Hydrographic Basins", Office for Ecology and Environment, Province of Latina 2006.

Table 7 – Parameters taken into consideration.

N	Total nitrogen
P	Total phosphorus
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand

The latter database contains the data about all pollutants estimated at sub-basin level, and summarises them according to synthetic parameters (Table 7). The available data have been elaborated and grouped into typologies in order to obtain a specific load value for each typology at sub-basin level. Table 8 shows the current load condition valued as average specific load coefficient bearing upon the whole set of sub-basins analysed by the project.

Table 8 – Average yearly loads bearing on the studied area – percentage for each load typology.

CURRENT	N		P		BOD		COD	
	kg/km^2/ year	% of load type	kg/km^2/ year	% of load type	kg/km^2/ year	% of load type	kg/km^2/ year	% of load type
Crop farming	2,167	51%	81	28%	-	-	-	-
Livestock farming	1,251	29%	-	-	-	-	-	-
Civil (diffuse source)	328	7%	68	23%	1,638	82%	2,949	63%
Industrial (point source)	490	11%	138	48%	344	17%	1,719	36%
Total	**4,236**	**100%**	**287**	**100%**	**1,982**	**100%**	**4,668**	**100%**

Summary of COD and BOD loads

The pollution deriving from civil sources is mainly composed of organic substances with high values of BOD, nitrogen in form of ammonia and Coliforms. The analysis of the data contained in the database has showed that BOD and COD loads are generated exclusively by civil and industrial sources. In particular:

- in the sub-basins at the south of Colli Albani, near Cisterna di Latina and Aprilia, there are high BOD and COD values caused by the low percentage of connections to the sewers;

- in the sub-basins located along the coast between Terracina and San Felice Circeo, in particular near Porto Badino, there are high concentrations of COD and BOD caused by seasonal load peaks linked to tourism.

The total nitrogen load deriving from crop farming and livestock farming activities is particularly high (levels "very bad" and "critical") in most of the Agro Pontino, up to the mountain areas of Priverno and Monte San Biagio.

The nitrogen load caused by the spreading of manure is limited to the central zone of the plain, where livestock farming activities are more intense. The distribution of nitrates coming from crop farming activities extends upon most of the Pontine Plain, but with much lower intensities compared to the peaks estimated for the loads coming from livestock farming activities.

The phosphorus load has sustainable values, with critical levels concentrated in the area of Cisterna di Latina, Latina, Sermoneta, and the southern coastal zone. The sub-basins affected by the pollutant loads are 30, and are part of the macro-basins "Amaseno", "Dune area between Badino and Sisto", "Rio Martino", "Linea Pio", "Sisto and Ufente", "Badino" and "Watercourses between Badino and the Fondi Plain".

The distribution of phosphorus linked to agriculture shows that the phosphorus loads are distributed on most of the project area, with particular intensity in the central zones hosting intense farming activities; however, these loads are clearly lower than those deriving from residential and industrial sources.

Instruments of intervention

For the environmental restoration of the hydrographic network, combined actions have been proposed for abating pollutants upstream of the discharges, through a functional improvement and a better management of wastewater treatment plants and bypasses, a reduction of the loads deriving from agriculture and other productive activities, and an improvement of the self-purification capacity of watercourses. The different types of intervention concern the application of different natural purification techniques, chosen according to the characteristics of pollutants, watercourses, orography and morphology of the areas, the possibility of recycling wastewater and, finally yet importantly, the opportunity of developing projects in cooperation with the owners of the areas included in the Programme.

The typologies of intervention for controlling and reducing pollutant loads have been evaluated according to how pollutants are generated. The choice and evaluation of the results that can be achieved through an extensive application of the proposed guidelines have been evaluated according to the specific performance expected from each action typology, and to its actual applicability.

The definition of the intervention typologies has been made starting from the evaluation of a number of alternative scenarios – each describing a different possible use of the geographic area involved –, and considering their evolution based on the current trends and the provisions of the spatial planning tools in force.

The measures and the actions to be carried out can be grouped according to the type of pollutant taken into consideration; they are illustrated in Table 10.

The effects of the actions can be assessed singularly, or combined according to different application scenarios. Table 9 illustrates a set of preliminary scenarios defined in order to assess the specific actions.

The scenarios used to verify the results are obtained through a simple or combined application of the different actions envisaged. The assessment of the effectiveness of the abatement of pollutant loads bearing on the sub-basins of the Pontine Plain is based on a hypothetical widespread use of the different techniques. Within this analysis, a hypothetical spatial distribution of the application typologies has been assessed, proposing an overall basic scenario, based on which the actual impacts of the different lines of action have been verified. These values have been preliminarily set in order to evaluate, according to the completeness of the information collected in the database of the discharges elaborated by the Province of Latina, the intensity levels necessary for achieving the quality objectives set by the existing regulations concerning surface water quality.

The "application intensity" of the different techniques for the containment of pollutants, used in the preliminary analysis, is described in Table 10. The real application intensity indices will have to be carefully evaluated in the implementation phase, by studying in detail the combination of actions being the most suitable for each sub-basin.

The effectiveness of the applications has been also analysed based on the existing literature, in order to identify the specific performances of the natural purification techniques in the abatement of organic loads and nutrients. Table 10 also illustrates the figures concerning the theoretical unit abatements for each action, considering, hypothetically, an optimal application of the proposed techniques.

Table 9 – Composition of the actions taken into consideration in the assessment scenarios.

Assessment scenario	**Action**
Baseline Scenario	Business as usual, no action
Scenario 1	Extensive application of wooded buffer strips
Scenario 2	Extensive application of constructed wetlands
Scenario 3	Limits to point residential and industrial discharges, enhancement of the capacity and efficiency of the wastewater treatment network
Scenario 4	Limits to pollutant loads deriving from crop farming and livestock farming activities, application of good farming practices comprising the re-use of wood and waste material
Scenario 5	Simultaneous application of all actions

Table 10 – Possible actions, application intensity and percentage of optimal theoretical abatement.

Main action	**Effect**	**Application intensity**	**Percentage of theoretical abatement in case of an optimal application of the techniques for limiting pollutants**			
			BOD5	COD	P tot	N tot
Creation of wooded buffer strips	Abatement of pollutant loads deriving from diffuse discharges (crop farming and livestock farming)	60% of watercourses receiving discharges	80	80	80	80
Creation of constructed wetlands	Abatement of pollutant loads deriving from diffuse discharges (residential settlements and small built-up areas)	60% of diffuse discharges from scattered houses and small built-up areas not connected to sewer network	90	90	90	90
Increase of capacity of the water treatment network	Containment and abatement of pollutant loads deriving from diffuse civil discharges, and from point residential and industrial discharges	Connection of 40% of diffuse residential discharges to new treatment plants	80	80	80	80
Increase of water treatment efficiency	Containment and abatement of pollutant loads deriving from diffuse civil discharges, and from point civil and industrial discharges	Application on 40% of treatment plants	10	10	10	10
Application of good farming practices and re-use of wood and waste material	Containment and abatement of pollutant loads deriving from diffuse crop farming	Application on 80% of the total area	10	10	10	10

	and livestock farming discharges					

Summary of the intervention scenarios

The examination of the widespread application of the scenarios has allowed to highlight, for each sub-basin, the actual performance of the single actions, verifying the utility of the applications and identifying the situations where the sub-basins are under critical load conditions.

Figures 15 and 16 show a comparison among the alternative scenarios for each pollutant. Scenario 5 is a combination of all the actions, whose effects are overlapped according to their order of application.

The combined action of Scenario 5 envisages a high reduction for BOD and N tot, respectively reduced by 54% and 52%. COD and P tot are reduced by respectively 42% and 34%. This application would also allow for a substantial reduction of the number of basins under critical load conditions for the different parameters: the number of sub-basins under critical load conditions are reduced by 52% for COD, 63% for BOD, 50% for P tot and only 13% for N tot.

The criticalities in the Agro Pontino, described in the Baseline Scenario, have been derived from the analyses of the data contained in the above-mentioned database of discharges of the Pontine Plain. The main problems arisen are briefly exposed here:

- presence of high loads from diffuse civil discharges, located in particular in the area at the south of Colli Albani, in the sub-basins comprised between Aprilia and Cisterna di Latina;
- high loads caused by floating population in the areas next to the coast; in particular, in Sabaudia and between Terracina and San Felice Circeo, near Porto Badino and in Lido di Fondi;
- some high-capacity treatment plants discharge into sub-basins with critical load conditions; among these plants, there are:
    - Latina Capoluogo;
    - Latina Sud;
    - Cisterna La Castella;
    - Pontinia.
- the N tot load deriving from crop farming and livestock farming activities is particularly high throughout the whole Agro Pontino, with greater concentrations in the plain among Sezze, Priverno, Sonnino and Pontinia.

The analyses of the different intervention scenarios have highlighted that the application of the single actions is not sufficient to ensure an effective containment of pollutant loads; Scenario 5 shows, indeed, how an overall application of all the actions can allow containing the pollutant loads, potentially fostering an achievement of the water quality objectives in the Pontine Plain.

A widespread application of the buffer strips would allow for a high abatement of P and N deriving from crop farming and livestock farming activities, whereas the creation of constructed wetlands, coupled with an improvement of the current wastewater treatment system, can allow for an effective containment of the pollutant loads deriving from civil and industrial settlements.

Figure 15 – A: BOD distribution in the current scenario. B: BOD distribution in Scenario 5. C: COD distribution in the current scenario. D: COD distribution in Scenario 5. Optimal – self-purification limit. Sustainable – LIM 2 – state "good". Critical – LIM 3 – state "sufficient". Very bad – LIM 4/5 – state "very bad".

Figure 16 – A: N tot distribution in the current scenario. B: N tot distribution in Scenario 5. C: P tot distribution in the current scenario. D: P tot distribution in Scenario 5. Optimal – self-purification limit. Sustainable – LIM 2 – state "good". Critical – LIM 3 – state "sufficient". Very bad – LIM 4/5 – state "very bad".

THE PROJECT'S CONTRIBUTION: COMMUNICATION AND AWARENESS-RAISING

4.1 COMMUNICATION TOOLS: OBJECTIVES AND REFERENCE TARGETS

Within an environmental project, an adequate communication is a strategic instrument ensuring a good governance, able to enhance the effectiveness of the actions and to foster the establishment of correct environmental policies.

Together with the actions having direct effect on the environment, Rewetland has implemented a number of communication and awareness-raising activities, using different tools described in the project's Communication Plan. The objectives pursued by the communication initiatives and activities can be described as follows:

- modify the perception of landscape of the Pontine Plain, culturally and historically determined by the land reclamation works, which have nevertheless altered its ecosystem and natural balance;
- disseminate, among the population and professionals, an understanding of the role of agriculture in the management of water quality;
- transmit knowledge on natural water purification techniques, in order to modify the current canal management systems and improve territory and landscape;
- foster the implementation of the Water Framework Directive in order to maximise the coherence of the government tools aimed at a sustainable use of water and the protection of aquatic ecosystems and wetlands;
- foster the sharing of objectives, actions and results of the Environmental Restoration Programme of Agro Pontino, promoting an information and participation process within the SEA and the activities of environmental design, in order to involve the actors able to influence the decision-making process.

The methodology for the dissemination of knowledge and information has been based, firstly, on a correct identification of the targets of the communication activities. The environmental contents have been made comprehensible by adopting, each time, suitable wordings and tools, contextualising the environmental issues according to the experiences of those participating in the communication events.

Three different targets have been identified: local, national and international audiences. As regards the local level, communication activities have been targeted firstly to farmers and sector professionals: people directly involved in the problems and solutions proposed within the Rewetland project. The environmental results will largely depend on how much this sector will acknowledge the water purification techniques disseminated by the project.

Another fundamental target is the students of first and second grade secondary schools: the information disseminated in schools have aimed at promoting knowledge on the issues related to pollution and criticalities of water protection.

As regards the inhabitants of Agro Pontino, the communication activities have been aimed at achieving the greatest diffusion of information according to the peculiarities and criticalities of the area. In this sense, the approach of the "travelling events" has been a good solution for obtaining a wider geographic coverage.

Besides the events, the communication implemented through newsletters and the use of the Geoblog have enhanced people's interest in the issues of landscape and water protection. The communication of the results at national and international scale have been, since the beginning, arranged through the creation of a website and a dedicated Facebook page.

The project partners have participated to events, conferences, meetings and specific working days on the theme of environmental and landscape restoration, addressing the communication efforts especially towards contexts where the natural water purification techniques are more easily replicable.

Figure 1 – Images of the events and materials created during the Rewetland project.

4.2 THE WEB PORTAL AND WEB TOOLS

The project web portal, accessible at www.rewetland.eu, makes use of the Internet for disseminating the project's environmental information and contents. The portal provides information concerning the project, and the objectives and results achieved by the different project partners. It contains the tools that have fostered the active participation of stakeholders in the programming process, contributing to the diffusion of knowledge and awareness on the themes of water and landscape protection in the Agro Pontino.
The portal allows reaching, besides the website, the project's WebGIS and Geoblog, tools targeted mainly to the local public and the professionals and experts having a good knowledge of the geographic context. A detailed analysis of the organisation and structure of the portal is provided in the following sections.

Website

The website is the tool providing the public image of the project, for an immediate understanding of the contents and nature of the project itself. Its graphic design is coordinated with all other information materials, and comprises the Rewetland and LIFE logos.
The website provides users with updated information on the results and the state of advancement of the project, through dedicated sections and specific tools. All materials are available in Italian and English, in order to foster the transmission of the results also to an international context. The accessible sections are the following:

- Home Page: contains a brief description of the project, the news, and the documents on the pilot projects. The news are in a high-visibility section, updated in real time with the information concerning the last results achieved and the public events and initiatives in progress (conferences, workshops, press conferences, etc.);
- Project: describes location, budget, duration, partners and main phases of the project, and is divided into sub-sections (Background, Actions and Expected Results);
- Gallery: contains a photo repertory on the Pontine Plain and the project areas;
- Partners: describes in detail the peculiarities of the involved partners;
- Results: contains the deliverables and documents developed in the course of the project, indexed on the base of the actions they refer to;
- Communication: contains the materials prepared for all the events in which the Rewetland partners have participated;
- Geoblog: the contents of the Geoblog are described in the next section;
- WebGIS: the contents of the WebGIS are described in the next section;
- Forum: a tool for fostering the debate on the project actions;
- Contacts: contains the contacts of the project staff responsible for the communication activities.

Figure 2 – Home page of the Rewetland web portal.

WebsGIS and Geoblog

Directly accessible from the Rewetland website, the WebGIS and the Geoblog are tools for the active participation of citizens, and other interested actors, in the project activities. The WebGIS system allows for the distribution of geo-spatial data on the Internet, starting from the spatial analyses carried out with the support of GIS software, and offers web-based services of visualisation, query and interpretation of geo-referenced data. The WebGIS application is based on a modular architecture, which can be easily integrated with GIS systems and distributed geodatabases.
Besides the WebGIS, there is also a Geoblog for the participation and involvement of partners and citizens in the project activities. The Geoblog is a communication tool enabling users to insert comments, photos and videos linked to an exact geographical location (for example, the places where the pilot projects are being implemented).

Thanks to their geo-referenced comments, users can highlight environmental criticalities and problems, or point up the effects of unsustainable practices, but also any possible strength and potential, or proposal for future interventions of environmental restoration.
The communication agency appointed by the Municipality of Latina has also created a Facebook page dedicated to the project. Besides informing on the activities carried out through the "itinerant information point" (see 4.3), the page contains also images of the construction works of the pilot projects, and the updates on their development. This page, which has become very popular, has allowed to reach a young target and to activate an exchange of opinions and information on the proposals and projects implemented by Rewetland.
During the project implementation, a quarterly newsletter has provided registered users with a detailed periodic update on the state of development and on the scheduled initiatives and events. Moreover, citizens have been informed, through the newsletter, on the dates of the workshops and on the process of the Strategic Environmental Assessment. The web tools have eased and enhanced the communication about the environmental contents and the results achieved during these years by Rewetland, allowing for a reduction in the use of paper materials.

Figure 3 – The Rewetland geoblog.

Figure 4 – The Rewetland Facebook page.

4.3 THE EVENTS AND THE ITINERANT INFORMATION POINT

The participation to events and the organisation of conferences, seminars and workshops are very good tools for enhancing the dissemination of the objectives and results achieved at the local, national and international level. The pre-set objective was to promote the project in its implementation phase, in the testing of the method and in the dissemination of its results, in order to propose the replicability of the choices made by Rewetland not only in the Agro Pontino, but also in other local, national and international locations.
Moreover, the events promoted and organised by the Municipality of Latina have been an occasion to disseminate the good practices and the water purification techniques, spreading a greater awareness on the issue of water quality to the widest possible public, which has been reached on the multiple occasions when the project was presented.
The communication actions have been defined following a careful consideration of the criticalities and opportunities determined by the ERP. In particular, they have focused on:

- advantages for the whole community in terms of environmental improvement;
- advantages for the farmers' community in terms of improvement of farm production, and, therefore, market competitiveness.

The "public", as identified in the audience segmentation phase, is composed by categories of persons with different interests and expectations regarding the advantages deriving from the programmed action. In order to face such variety of interests, and appeal on the different motivations able to activate the involvement of all actors, the communication strategy has used a mix of tools composed of informative materials, IT and interactive tools, and direct communication tools such as public meetings.
The modalities of communication have always aimed at the direct involvement of participants, in order to make the exchange more active and fruitful.
The Rewetland partners have carried out 6 participation events such as workshops and meetings with citizens, and 8 events at local and national scale. They have also participated in other 18 events focused on environmental issues, or concerning the theme of water quality. For each event, partners have prepared a data sheet describing the communication contents and results in terms of dissemination of the project objectives; the data sheets are downloadable from the project website.

Figure 5 – One of the events – The stand of the Province of Latina at FORUM PA (2010 edition).

Figure 6 – The itinerant information point and other Rewetland events.

4.4 THE COMMUNICATION FOR THE FARMING SECTOR

Farmers active in the Agro Pontino are the main and most direct target of the Rewetland actions, because project objectives can be achieved only through a direct application of the project initiatives at the local scale. Therefore, the acknowledgement by the farming sector of the good practices identified by the project is of extreme importance.

The communication actions directed to this target have demonstrated the validity of the chosen natural purification techniques and the other tools for the protection of water quality, to be considered also as a development and profit opportunity for the farming sector and for the whole area.

The goal of the communication activities was to make farmers feel responsible, by underlining the importance of their role in the ERP, even taking into consideration the current economic crisis.

Rewetland has created an information desk at the Land Reclamation Consortium of Agro Pontino – given its strong connection with the farming sector –, providing assistance services for farmers, professionals and all those needing information on the issue of buffer strips and the sustainable use of water in agriculture. The information desk allows disseminating the best techniques for water saving in agriculture and for the reduction of the use of polluting products. It has supplied information on how to support the programme and on the related economic and fiscal advantages; farmers are offered technical assistance both in the creation of buffer strips, and in the search for adequate funding through the Rural Development Plan.

For their part, farmers have made available the experience gained, which has been included in the project actions and in the guidelines. The information desk, open once a week at the premises of the Land Reclamation Consortium, will continue its activities even after the end of the project, becoming an ordinary information service offered by the Consortium. The assistance service is supported by informative material in hard copies and digital version, distributed not only through the information desk but also via the Consortium's website. Specific training has been offered to the Consortium staff in order to ensure the coherence with the project's contents and proposals.

Figure 7 – The information events targeted to farmers.

4.5 THE ENVIRONMENTAL EDUCATION CAMPAIGN

Another fundamental action has been dedicated to environmental education in schools.

Objective of the action has been to provide an integrated educational offer, able to establish a relationship between educational and environmental policies.

Students have not only been made aware of the problems of the local environment, but also "culturally" addressed to a style of active citizenship, responsible for the choices that are necessary for a future sustainability. Reference target have been the students of all school levels and types in the Pontine area.

Students are bearer of educational needs that have to be satisfied also beyond the limits of the project: while growing, they will make choices gradually more aware and autonomous: the communication actions have been therefore oriented to the emergence of a critical conscience that should make them active citizens in the future management of this territory.

The Circeo National Park has created the necessary informative material, adopting languages and graphic styles suitable for the different ages. Over 5,000 booklets and 1,000 brochures have been prepared and distributed in schools, and, together with the classroom presentations, have helped in the educational activities. Besides natural purification of water, the issues addressed have been water saving and nature conservation in the Agro Pontino.

Between December 2012 and March 2014, lessons have been held in 84 classrooms, for a total of 1,689 pupils involved, mainly in primary and secondary schools in the Pontine area, but also in the public

“Scientific” High School “G. B. Grassi” of Latina and the Agricultural Institute “San Benedetto”, in Latina as well.
Moreover, between March and May 2014, the Circeo National Park has guided 33 school classes in the area of Pilot Project 1, on the banks of the Lake of Fogliano.
Following the meetings in schools, teachers have shown interest in further possible initiatives, also after the end of the project, concerning the issues addressed by Rewetland. The Technical Institute for Economics “Vittorio Veneto Salvemini” has started a multi-disciplinary educational initiative involving teachers of Italian Literature, English and Business Economics, and targeting fourth grade pupils, called “Water Paths”, aimed at enhancing awareness on the issue of environmental protection in business management. Other schools have presented to the Lazio Region a number of projects for promoting water saving and landscape protection in the Pontine area: the projects will simulate enterprise management activities entailing particular care for the issues of environmental protection and water saving.

Figure 8 – Educational events in schools carried out by the Circeo National Park.

Figure 9 – Guided tour to Pilot Project 1 in the Circeo National Park.

CONCLUSIONS

Surface waters in the Agro Pontino, as described in the previous chapters, suffer from a serious state of degradation caused, essentially, by the heavy human pressures from diffuse settlements, often not connected to the sewers, which, together with a high concentration of intensive farming activities, generate considerable eutrophising loads. As a result of this situation, the Water Safeguard Plan of the Region of Lazio (PTAR) has classified as "poor" or "very bad" the state of the waters of regional basins 24 (Astura), 25 (Astura-Moscarello), 26 (Moscarello), 27 (Rio Martino), and 28 (Badino).

As shown in the previous chapters, the current situation is not as drastic in the whole Pontine Plain as presented by PTAR, but article 27 of its technical norms has to be anyhow seriously taken into consideration, where it states that the interventions for improving water quality have to be carried out, primarily, in the basins of Rio Martino and Moscarello, given the complexity and seriousness of their conditions. To this end, as regards the diffused sources of pollutants, which are not treated, or cannot be treated, with traditional, point-type systems, it is necessary to exploit the natural purification function of wetlands. This process is carried out in particular by some kinds of bacteria living around the roots of water plants: they are able to oxidise the nitrogen and phosphorus compounds carried by civil and agricultural wastewaters, which are the main responsible for the eutrophisation of surface waters and the consequent ecological disruptions and quality degradations. The techniques selected for the creation of effective water purification systems fall within the category of *constructed wetlands*. This category comprises also the *buffer strips*, linear vegetation systems on the banks of watercourses, able to filter polluting substances before they enter the water body.

Given their low costs and their high environmental value, the strategy for the environmental restoration of the Agro Pontino, promoted by Rewetland, relies on these types of interventions. In particular, a Programme for the Environmental Restoration of Agro Pontino (ERP) has been drafted within the project activities; it is a strategic coordination tool that the Province of Latina proposes to public and private actors who intend to perform interventions aimed at the improvement of surface water quality, through the diffusion of natural purification systems and the application of good practices in the activities generating water pollution. The ERP intends to contribute to:

- setting up a strategy for achieving the water quality objectives of the Water Framework Directive, avoiding in the first place the possible infringement procedures that may arise from the failure in achieving their fulfilment;
- being part of the *greening* process set by the EU policies for Horizon 2020, in particular of the reconversion of the local farming sector as a condition for renovating and strengthening the development of one of the main productive plains of southern Italy;
- fostering participatory planning, oriented to solving problems rather than imposing constraints, through innovative techniques and the transfer of virtuous practices;
- fostering the interconnection and the synergy among institutional actions, by including the strategic actions in the programming tools of regional and hydrographic district level;
- acting as premise and occasion for interventions, processes and practices, and as a vehicle for the interchange of experiences, all aimed at fulfilling positive, concrete, visible and sharable actions.

In the implementation phase, coordinated sets of interventions will have to be adequately selected from the general menu of actions envisaged by the ERP, and implemented through specific executive tools, such as, for example, "programming agreements" and river contracts.

With its approval by the Provincial Council of 26 July 2013, the proposal for the ERP has all the potentials for pursuing its objectives also after the end of the LIFE project, assuming the role of "orientation document" for the natural water purification activities in the Agro Pontino. Its contents are based on the analysis of the pollutant loads that the whole society releases into the watercourses. The Programme identifies solutions, measures and actions that anyone, as far as his competences and peculiarities are concerned, can carry out in order to contribute to the common objective of improving water quality, which is not only a sector objective, but also an objective with territorial significance, because water quality affects many other aspects of local

development. Even more so, this is valid for a province that, for geologic and historic reasons, was “born” by water, and whose wealth relies on the water resources necessary for irrigation and industrial production.
A fundamental choice of the proposal has been to identify, starting from everybody’s responsibilities in the deterioration of the water resource, a possible positive action, in proportion to the pollutant loads generated and to the geographical context. This way, all local actors will be able to reduce their emissions, and contribute to creating concrete practices and solutions in the benefit of their own local communities and the Agro Pontino.

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REWETLAND
Widespread introduction of constructed wetlands for a wastewater treatment of Agro Pontino

The project, started in 2010 and concluded in 2014, has been co-financed by the European Commission within the LIFE+ Programme

Working group
Province of Latina
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