PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.1

SET UP OF PILOT SCECIFIC MANAGEMENT PRACTICES

D.T2.1.4 DESCRIPTIVE DOCUMENTATION OF PILOT ACTIONS AND RELATED ISSUES

PILOT ACTION PAC3.1: *PO RIVER BASIN*

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1. Introduction

In Italy, Po river basin area plays a huge role at environmental, economical, agricultural and industrial level but this also means that there are different interests in the area and potential conflicts could increase especially among upstream uses/pressures on catchment/water bodies and the downstream communities or new ones could break up. In fact, the presence of drinking water users near the basin outlet requires considering water quality and quantity aspects, highlighting the role of best practices among which monitoring systems, active participation, voluntary actions, sharing of information and standardization of methods and tools for water availability estimation. Moreover because of its economical value and social development, Po river basin is often object of sector studies and has one of the oldest water level gauge time series (Pontelagoscuro). All this consideration had led to choose Po river Basin as Pilot action, PA, for PROLINE-CE project.

The aim of the project is to consider this PA as representative of potential conflicts and their possible resolution strategies and to highlight how the implemented best practices can be upgraded to become guidelines for future revisions of water legislation and regulation, also considering climate change adaptation.

PROLINE activities will be done for the whole Po river basin, because the main conflicts are among upstream and downstream uses and. The whole basin scale is also crucial for the administrative organization given form Italian legislation in which Regions play the may role with their own policies, plans and actions needing integration as well as potential conflicts prevention and solution.

2. Basic data about pilot action

2.1. Hystorical description

Scarcely inhabited in the pre-Roman period, when forests and marshes extended almost everywhere, the Po Valley began to be intensely colonized since the third century B.C.. In the Imperial Age extended areas were cultivated with cereals (the traces of Roman agriculture organization "*centuriazione*" are still visible in the road network of some areas of Veneto and Romagna). In the last centuries of the Empire, the lack of labour, due to the depopulation and the shortage of slaves, led to the gradual abandonment of agriculture, which became more and more discontinuous, both in time (a regular bi-annual rotation of the Romans replaced a system that envisaged long intervals between sowings) and space: agriculture concentrated in patches around the few and decayed cities, located at the line of lowland springs "*risorgive*" and at the mouth of the valleys, while the high plain was covered with woods, and the low plain became more and more occupied by swamps for the abandonment of river regulation works. In the VIIIth century, the population of the Po Valley was about halved compared to the Roman age. After the 1.000 AD, agriculture and population restarted growing: the first reclamations began, channels were dug and some rivers were embanked. The population returned to concentrate in the cities, which, with the city rebirth, resumed that political prominence on the countryside they had lost during the Feudal Age. After the economic and demographic crisis followed by the plague epidemy of the XIVth century, during the Renaissance period, the Po Plain became familiar with a new period of development, thanks also to the economic resources carried out by the urban middle class. At that time, the modern type of cattle breeding has begun to spread, which uses stable irrigation grasslands. The XVIIth and XVIIIth centuries saw the introduction of maize and the spread of rice, hemp and flax; in the XIXth century there were significant changes in the forms of agricultural management, with the crisis of the actual agriculture organization, the so called "Mezzadria", and the development of the great capitalist company, managed with modern criteria by renters with the help of wage labour. In the XIXth century big hydraulic works, above all in land reclamation and flood protection, were provided and there was a development of cities and industrial districts. In the XXth century massive industrial and tertiary activities have been developed, creating a comprehensive and integrated economic structure that assures the region a national position in all economic sectors. Finally, at the beginning of the XXIth century the Po Plain changes in economic and demographic trends occur, considered well-established till yesterday, and is at a significant turning point: the push for urbanization, proper of the Industrial Age, seems already exhausted, and entirely new seems today the guiding principles that may or will lead the territorial development [2].

2.2. Geographical description

The Po River Basin (P-RB) - Figure 1, has an area of 74.000 km2 and among those about 71.000 km2 are in Italy, and for a small part in Swiss (Toce catchment) and marginally in France (Figure 2). With about 16 million inhabitants, P-RB territory represents an exceptionally socio-economical, landscape and geographical varied reality covering the territory of Piedmont, Valle d'Aosta, Lombardy, and portions of Emilia-Romagna, Liguria, Trentino, Veneto and Tuscany Regions.

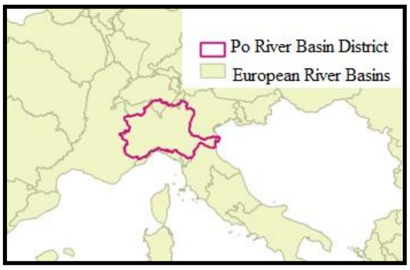

Figure 1. Po river basin layout in Southern Europe background [15]

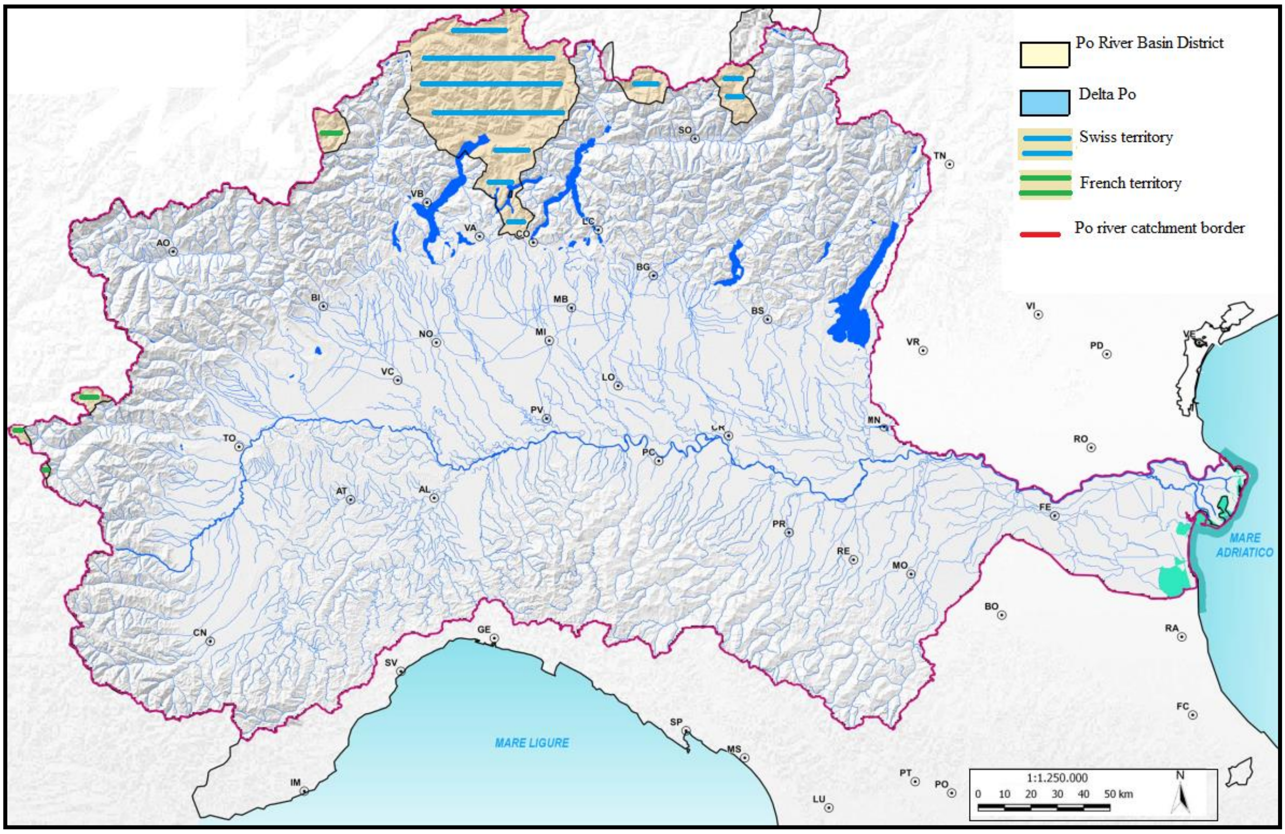

Figure 2. Po river basin [15]

Geographically the P-RB can be divided into four main areas: mountain (Alps and Apennine), hill, plain and coast. P-RB plain is well known as "Pianura Padana" or Po valley as one big plain area but the landscape deeply reflects the historical and socio-economical differences of human settlement [2]. It comprises large urban areas, among which Milano and Torino, and different plain areas: "Piemontese", which has terracing and abundance of rice crop areas, "Lombarda", characterized by a dense artificial channel networks, the "Oltrepò pavese", sub Apennine plain, “Emiliana” completely cultivated, “The Polesine”, which since the Middle Ages has been deeply modified to make the plain suitable for agriculture and human settlement, but often exposed to flood which has led to embank the Po river to higher and higher levels [2].

Also the hilly areas reflect the historical and socio-economical differences of human settlement but here also the geological and geographical differences concur to create a heterogeneous landscape. Some characteristic hilly areas are: “il Monferrato” with small grassy valley and slopes grown with grapes, “le Langhe” characteristic shaped hills with steep valley and terracing slopes grown mainly with grapes, “l’Oltrepò pavese”, which since the past was strongly modified and converted in agriculture area with terracing which are also useful for slope stability; “le colline emiliane” a mixed of grassland and cultivated areas, “sub-alpine venete”, characterized by isolated heterogeneous small hills [2].

The mountain area comprises the Apennines and the Alps. Apennines are clustered in “Appennino Ligure” and ”Appennino Emiliano”. In the Appennines a progressive decrease in population and activities is taking place. The Alpine region area is highly important for water resources as glaciers and big lakes, for landscape and environmental resources and for tourism. The Alpine region contains about a hundred peaks higher than 4000 meter. The altitude and size of the Alpine range affects the climate, especially precipitation and temperature. Alps are clustered in Westward Alps, which comprise Liguri, Marittime, Cozie, Graie and Pennine, Central Alps, which comprise Lepontine and Retiche, and eastward Alps but those are not included in Po river basin [2].

2.3. Geological description

Figure 3 shows the Italian geological map focused on Northern Italy [8].

Figure 3. Geological map of Northern Italy (Geological map at 1:1.000.000 scale Edited by Geological Survey of Italy - ISPRA, 2011)

The Alps form a northward convex arc around their southeastern foreland basin - the Po river basin (to be precise the south is in fact their hinterland). Quaternary and Neogene sediments in this basin lie discordant over the southernmost thrust units [24].

In the northeast, southward dipping and internally thrusted Cenozoic foreland deposits (flysch and molasse) are found. This Bavarian and Swiss foreland basin is called the Molasse basin. The foreland basin deposits are overthrusted from the south by the thrust front of the Alpine nappes. In Switzerland the Molasse Basin is rimmed to the northwest by the Jura mountains, an external fold-and-thrust belt, which can be seen as part of the Alps geologically. The western part of the Molasse basin forms the plateau of the Mittelland between the Alps and Jura Mountains. The Jura Mountains' location is still a topic for debate. A possible tectonic factor is the north-south extensional Upper Rhine Graben to the north.

The Alps continue fairly smoothly into the following related Alpine mountain ranges: the Apennines to the southwest, the Dinarides to the southeast and the Carpathians to the northeast. In the east the Alps are bounded by the Viennese Basin and the Pannonian Basin, where east–west stretching of the crust takes place.

The Po plain is the largest alluvial basin in Italy. The recent geological history (i.e., late Quaternary, the last 135 ka BP) of the Central Po Plain is mostly driven by phases of aggradation by large alluvial fans, mostly originating at the Pre-Alpine margin from glacier amphitheatres or from glaciated valley systems. Interglacials and other climate phases of glacier withdrawal from their piedmont culminations are marked by phases of deep entrenchment of major paleo rivers. Although most of the Central Po Plain is formed by various sediments of late Quaternary age, and despite a number of deep drillings focused on oil exploration and on assessment of nuclear power plants, limited geological information is available about the recent activity of these rivers in the unconfined plain. Also, the timing of aggradation and of intervening erosion phases is poorly constrained.

Summarizing, the geology of Po river basin is the following [23]:

- Highest part of northern Apennine: Tertiary sandstone and marly limestone
- Northern and central Apennine: Tertiary arenaceous marly flysch.
- Po plain and moraine hills of Piedmont and Lombardy: Quaternary alluvial and glacio-fluvial deposits
- Western Alps - calcareous sedimentary rocks and metamorphic rocks: Mesozoic and Tertiary calcareous and metamorphic rocks, granite and dolomitic limestone.
- Western and central Alps - igneous and metamorphic rocks: metamorphic and igneous rocks, Holocene alluvial deposits
- Eastern and central Alps on calcareous sedimentary rocks: Tertiary limestone and Mesozoic dolomite, Holocene alluvial deposits.

2.4. Pedology

In Po river basin there are four main soil regions listed below; Figure 5 shows the soil map for Po river basin, instead Figure 4 the percentage. White areas in Figure 5 are in the Swiss and French territories.

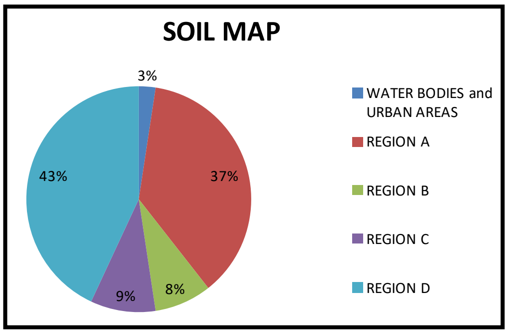

Figure 4. Soil region percentage

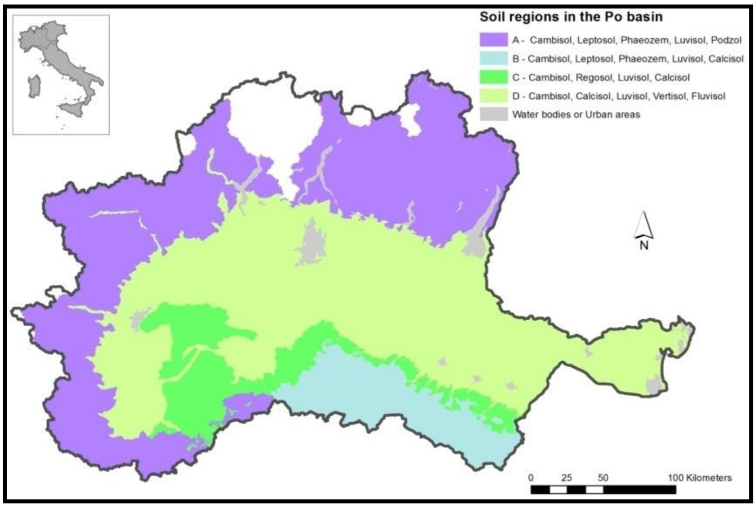

Figure 5. Soil regions [15]

The main soil regions are:

- A: soils of the Alps and pre-Alps
- B: soils of the Apennines with temperate climate

- C: soils of the hills of northern Italy on Neogene marine deposits and limestones
- D: soils of the Po plain and associated hill

The classes and sub-classes in Po river Basin comprise [26]:

A1: FLUVISOLS and LEPTOSOLS

Shallow to deep sandy and/or stony soils; on alluvial and colluvial deposits of valley bottoms and flood wetlands; somewhere cultivated. Sensitivity to climate change: flooding increasing.

A3: CAMBISOLS, PHAEOZEMS and LEPTOSOLS

Shallow to moderately deep soils, somewhere rich in organic matter; from limestones and dolostones on middle slopes; under broadleaf woodland or meadow. Sensitivity to climate change: likely altitudinal slipping of thermophile plants, slow changes in soil chemistry, and risk of organic carbon loss.

A4: LEPTOSOLS, CAMBISOLS, REGOSOLS and PHAEOZEMS

Shallow to moderately deep soils, frequently rich in calcium and magnesium; on carbonate ranges; under broadleaf woodland and pastures. Sensitivity to climate change: intensification of karstification and water erosion and risk of organic carbon loss.

A5: CAMBISOLS

Shallow to moderately deep soils, with base saturation rate decreasing with altitude; on limestones, dolostones, marls, shales; under broadleaf woodland and secondly conifers, pastures and alpine meadows. Sensitivity to climate change: possible altitudinal ascents of thermophile plants, slow changes in soil chemistry of soils, and risk of organic carbon loss.

A6: CAMBISOLS, LEPTOSOLS, PHAEOZEMS and LUVISOLS

Shallow to locally deep (where clayey) soils, rich in carbonates; on dolomitic and limestone bedrock in hillside districts; under broadleaf woodland and chestnuts. Sensitivity to climate change: risk of organic carbon leakage.

A7: PODZOLS, UMBRISOLS, CAMBISOLS, LEPTOSOLS, REGOSOLS, HISTOSOLS and CRYOSOLS

Prevalently shallow and stony soils, usually acidic; from igneous and metamorphic silicate rocks on steep slopes and high altitudes, with local moraine cover; under coniferous forests, deciduous (to lower rates), shrublands and grasslands (at higher altitudes). Sensitivity to climate change: risks of intensification of water erosion and landslides, also resulting in permafrost thawing.

B11: LEPTOSOLS, PHAEOZEMS, REGOSOLS, and CAMBISOLS

Shallow to moderately deep soils, frequently rich in carbonates; on calcarenitic and marly substrate; on high-hillsides with hydrogeological instability; under chestnut, oak (at the lower altitudes) and mixed woodlands (deciduous and conifers), with scattered croplands. Sensitivity to climate change: intensification of hydrological instability for intense and concentrated rainfall.

B12: PHAEOZEMS, LUVISOLS, and CAMBISOLS

Shallow to deep (where clayey), locally calcareous or acidified; on marls and sandstones; on hillslopes and low-mountain, often prone to hydrogeological instability; under prevalently deciduous woodland and scattered croplands. Sensitivity to climate change: intensification of the hydrological instability for intense and concentrated rainfall.

B13: CAMBISOLS, UMBRISOLS, LEPTOSOLS, and PODZOLS

Shallow to deep stony soils, with increasing acidity with altitude; on moraine deposits and sandstones; on steep mountain slopes and summit plateaux; under shrub and grassland vegetation; under shrubs and prairie. Sensitivity to climate change: risk of organic carbon loss for increasing temperatures.

B14: CAMBISOLS, REGOSOLS, LEPTOSOLS, and CALCISOLS

Shallow to moderately deep soils, with decarbonation and acidity increasing with altitude; on arenaceous-marly and calcareous-marly flysch; on medium and high slopes prone to runoff and mudslides; under cropland, mesophile woodland, beech woodland, meadows and pastures. Sensitivity to climate change: landslides and runoff intensification for climatic deterioration.

C15: LUVISOLS and CAMBISOLS

Somewhat shallow soils, weakly to moderately. Developed; on marine silty deposits; on hilly. Slopes; under coppice and meadows. Sensitivity to climate change: risk of runoff intensification due to climate deterioration.

C16: CALCISOLS, REGOSOLS and CAMBISOLS

Moderately developed and deep soils, calcareous; on argillaceous rocks and sandstone; on hillsides with variable slope; under crops, vineyards and deciduous woodland. Sensitivity to climate change: risk of channeled water erosion intensification due to climate deterioration.

C17: CAMBISOLS and REGOSOLS

Weakly developed and moderately deep soils,calcareous and somewhere clayey; on marine deposits of marl, sand and silt, affected by soil-flow and runoff; on low hills; under cropland, vineyards, hazel. Sensitivity to climate change: risk of water erosion intensification for climate deterioration (and for bad agricultural practices).

D18: CAMBISOLS, GLEYSOLS, LUVISOLS, CALCISOLS, and FLUVISOLS

Slightly to well developed sandy-gravelly soils; acidic in the western areas, neutral in the central ones, calcareous in the eastern ones; somewhere waterlogged; on level to gently undulating fluvial, glaciofluvial, and morainic deposits; prevalently under dry and irrigated cropland Sensitivity to climate change: possible damages to crops from droughts and floods.

D19: LUVISOLS, ULTISOLS, REGOSOLS, UMBRISOLS, PHAEOZEMS, GLEYSOLS, FLUVISOLS, and CAMBISOLS

Large unit of landscapes and soils; soils moderately deep to very deep; silty, clayey, sandy, and somewhere gravelly; very acidic to neutral; north, on outwash fans, fluvioglacial terraces (with frequent loess covers) and moraine hills; south, on fluvioglacial and fluvial deposits; under broadleaf woodland and croplands; heavy urbanization. Sensitivity to climate change: possible damage to crops from droughts and floods; intensification of gully erosion on terraces and moraines.

D20: CALCISOLS, LUVISOLS, VERTISOLS, CAMBISOLS

Loamy (western Po plain) to clayey (Po Western) soils; moderately to very deep; mainly neutral to the west, moderately alkaline, up to slightly saline, to the east; on post-glacial and recent Holocene alluvial deposits, level to undulating; under irrigated and dry croplands. Sensitivity to climate change: possible damage to crops from droughts and floods.

D21: LUVISOLS, REGOSOLS, CALCISOLS, and CAMBISOLS

High central and eastern plain of Lombardy: rather calcareous soils, silty-sandy-gravelly; moderately deep; neutral or slightly alkaline; on late Pleistocene fluvioglacial and fluvial deposits; level to slightly undulating; under irrigated and dry cropland; intense urbanization. Recent alluvial deposits of Sesia river and terraced old fluvial deposits in the south-east of Turin: slightly acidic soils, with local loess cover; silty on surface, clayey in depth; irrigated and dry cropland, grassland. Sensitivity to climate change: possible damage to crops from droughts and floods.

D22: LUVISOLS and GLEYSOLS

Soil covering large surfaces, both to the pre-Alpine margin, both to the Apennines fringe; level morphologies (high, medium and low fluvioglacial and fluvial plain) or terraced and slightly elevated paleosurfaces; springs ("fontanili") in the middle lowland; deposit ages between the middle-late Pleistocene and the middle Holocene; soils deep to very deep; loamy texture in the surface and clayey in depth; slightly acidic to the west, slightly calcareous to the east; frequently rubified; somewhere poorly drained; local loess covers; irrigated and dry cropland. Sensitivity to climate change: Runoff erosion intensification on the terraces; possible damage to crops from droughts and floods in the lowlands.

D23: FLUVISOLS, ARENOSOLS, CALCISOLS, GLEYSOLS, REGOSOLS, CAMBISOLS

Holocene alluvial soils of the low Po valley (Late Pleistocene fluvioglacial and fluvial deposits in the middle Lombard plain); calcium carbonate increasing from west to east; weak salinity in the eastern areas; deep to very deep soils; sandy-silty texture to clayey in the eastern area; frequently hydromorphic; lowland springs ("fontanili"); irrigated cropland, poplar groves, meadows. Sensitivity to climate change: increasing risks of flooding and drought due to climate irregularities; salinization in easternmost areas; climate irregularities; salinization in easternmost areas

D24: FLUVISOLS, ARENOSOLS, CALCISOLS, GLEYSOLS, REGOSOLS, CAMBISOLS

Holocene soils of the floodplains and backswamps along the Po river and its tributaries up to the delta; predominantly sandy soils in Lombardy and Piedmont areas, clayey and peaty in the Emilia-Romagna; deep and very deep; calcium carbonate most abundant in eastern areas; sulphates in the Po delta area; hydromorphism in most depressed areas; cropland mainly irrigated, poplar, and forage. Increasing risks of flooding and drought due to climate irregularities; salinization in easternmost areas.

2.5. Climate characteristics

Figure 6 and Figure 7 show the meteorological and the hydrometric networks in the Po basin.

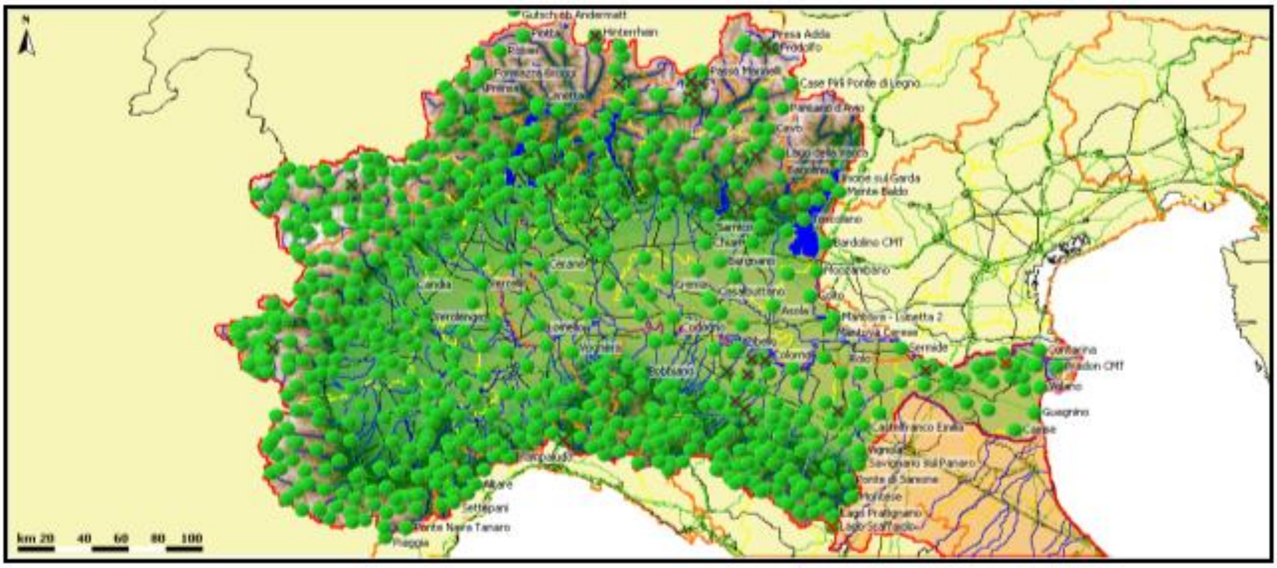

Figure 6. Meteorological stations in Po river Basin (source: FEWS screenshot)

Figure 7. River gauges (source: FEWS screenshot)

Temperature

Influenced by the closeness of Mediterranean Sea, P-RB has a mild climate which means a lower temperature range than the European regions. The climate within the basin is strongly influenced by the orography. The Alps- protect the Po Valley from Northern cold winds while the Apennines limit the mitigation action of the sea and the South Western air masses intrusion.

The air temperature is strongly correlated to the altitude; temperature gradient varies by -1°C each 100 m. The mountainous areas are characterised by an annual average temperature of about 5°C, which increases to 10°C at medium altitudes either on Alps and Apennines, whereas the Po Valley is characterised by a higher average annual temperature of 15 - 22°C (Figure 9). Temperature is also influenced by local conditions (valleys) and urban areas. In winter a cold, heavier, pillow often occupies the lowest air layers and the temperature is higher in upper layers (thermal inversion) [11].

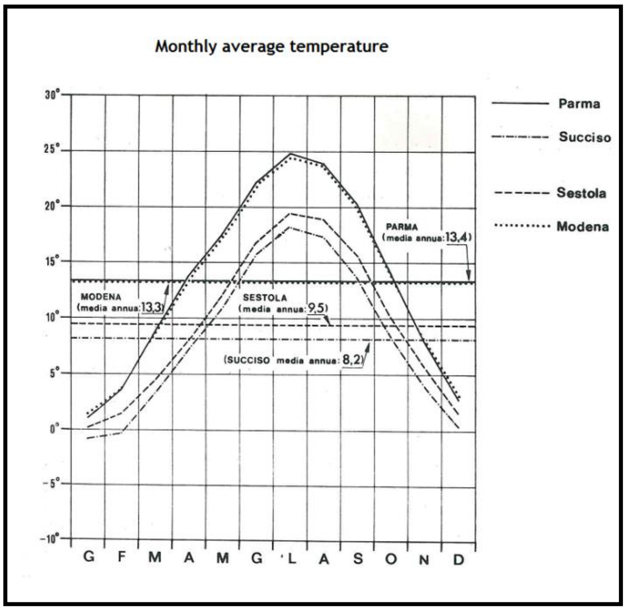

Figure 8. Monthly temperature regime in Sestola Succiso (mountain), Modena, and Parma (plain) stations.[11]

The seasonal temperature variability across the year has more or less the same path in any point of the basin which means the Winter season (December to February) has the coldest temperature values whereas the Summer season (June to August) is the warmest, finally the Autumn (September to November) has slightly higher temperatures than Spring (March to May). The minimum temperature occurs in January and rises until July, reaching the maximum value, and then decreases again.

Figure 8 shows the monthly average temperature in Sestola and Succiso (mountain), Modena and Parma (plain) stations.

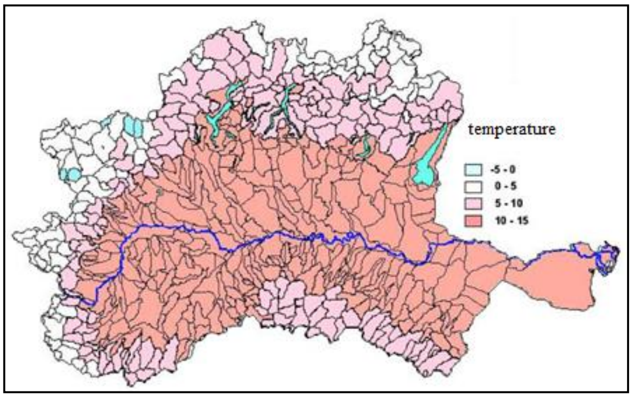

Figure 9. Average annual temperature (°C) in Sub-basins of Po river basin [15]

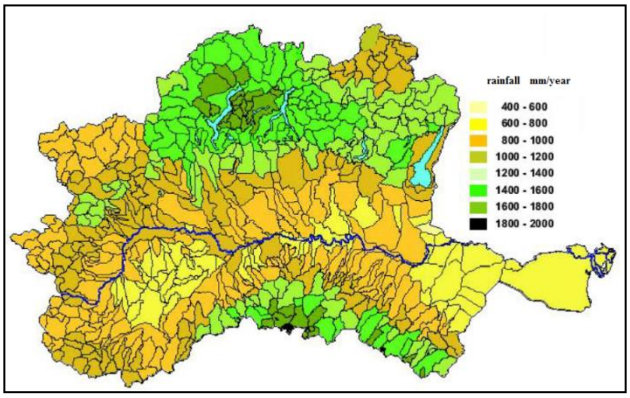

Figure 10. Average annual precipitation (mm) in Sub-basins of Po river basin [15]

Precipitation

The average annual precipitation vary from 400-600mm/year in the Po delta to more than 1800 mm/year in a small area in the upper Apennines (Figure 10). In winter large scale precipitation mainly derives from North Atlantic low pressure phenomena, whereas in spring, they are generated by Mediterranean and Genova Gulf low pressures phenomena. In summer, small scale intense and short duration precipitation derives from thermal low pressures as well as from convective and orographic phenomena. Finally, in autumn large scale precipitation are generated by Mediterranean, Genova Gulf or west Atlantic low pressure phenomena [7].

Precipitation distribution in P-RB is more complex than temperature and strongly influenced by local conditions and phenomena; the alpine basins of Oglio, Adda and Ticino rivers, effluents of the Northern Italy lakes, and the alpine not regulated basins, record the maximum precipitation in summer and the minimum in winter, while, in the remaining areas of Po River basin, precipitation is characterized by two maxima, in spring and autumn, and two minima, in summer and winter. In general, five rainfall patterns can be detected: continental, sub-littoral Alpine, sub-littoral Apennine, sub-littoral Padan, sub-littoral Western.

The snow rate, although strongly affected by the slopes orientation, varies with the elevation; an average value for mountain stations (more than 1000 m above sea level) is 1050 cm/year.

2.6. Surface Hydrology

Po river rises from its source in Monviso Mountain, in Piedmont, stretching for 652 km and flowing through many important Italian cities, including Turin, Piacenza, Ferrara and it is connected to Milan by a dense channel network, finally flowing into the Adriatic Sea with a 380km2-wide river delta (Figure 11).

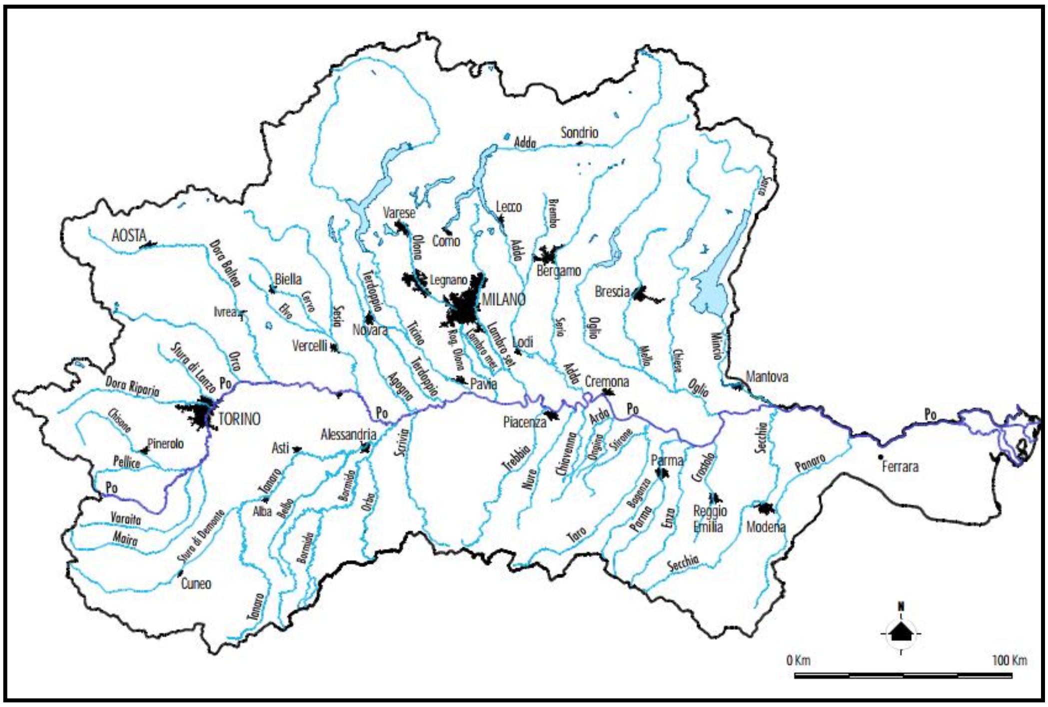

Figure 11. P-RB surface water: main tributaries and major cities [15]

The Pontelagoscuro gauging station is considered the closure section of the whole Po basin. Below are some characteristic information of Po river basin [1]:

- Catchment area: 70091 km^2
- Altitude max: 4807 m above sea level
- Max peak discharge: 10300 m^3/s (on 14th November 1951)
- Min discharge: 156.39 m^3/s (on 21st July. 2006)
- Annual average discharge: 1540 m^3/s.

The Po river discharge regime (Figure 12) is characterized by two maxima, in Spring and Autumn, and two minima, in Winter and Summer. The Summer low flow period is mainly influenced by the following factors: major lakes recharge in Autumn, snow precipitation in Winter, Spring rainfalls conditioning river discharges of Apennine tributaries and Summer temperature influencing snow melting and water demand.

Figure 13 shows the Po river duration curve. The Flow Duration Curve (FDC) is a graph of river discharge plotted against exceedance frequency derived from time series of recorded river flows. The construction is based on ranking the data (daily discharge) and calculating the frequency of exceedance for each value. It effectively reorders the observed hydrograph from one ordered by time to one ordered by magnitude. The percentage of time that any particular discharge is exceeded can be estimated from the plot.

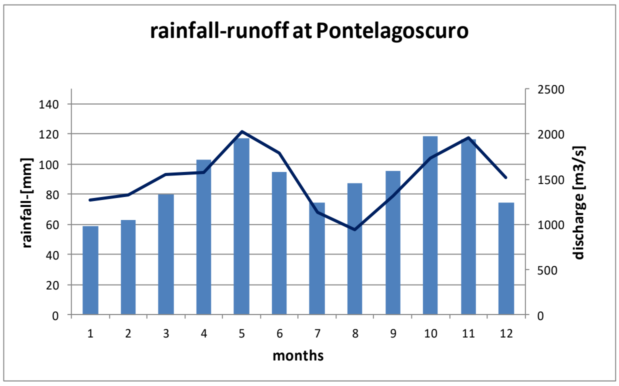

Figure 12. Po river discharge at Pontelagoscuro gauging station. In blue the monthly average value. The black line describes the monthly average discharge for the period 1923-2015

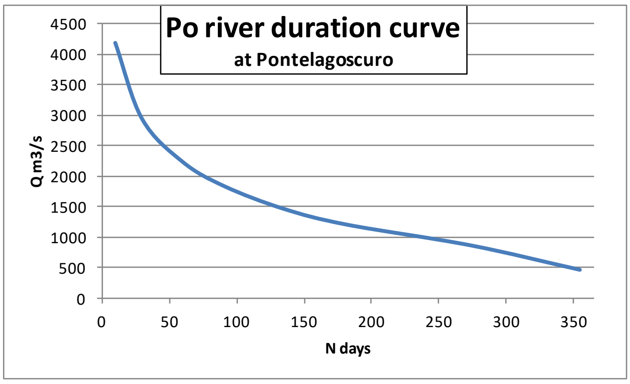

Figure 13. Po river duration curve at Pontelagoscuro gauging station; range data 1923-1990, 1992-2000 and 2003-2015

Along its course 141 tributaries merge into it letting the flow rate grow and be the main river in Italy. Temperature drives the regime of Alpine tributaries, late Spring and Summer discharges are the results of snow and glacier melting processes with a maximum in Summer and a minimum in Winter, despite precipitation drives the Apennines tributaries, which collect water from surface water runoff and groundwater, so that the Apennine tributaries discharges follow the rainfall seasonal regime with a minimum value in Summer.

Table 1. Annual mean discharge of the major Po river tributaries

Tributary	Section	Area (km^2)	Qa (m3/s)
Ticino	Miorina	6599	**295**
Adda	S.Maria Lavello	4572	**159**
Tanaro	Montecastello	7985	**128**
Dora Baltea	Tavagnasco	3307	**94**
Sesia	Palestro	2566	**85**
Toce	Candoglia	1535	**65**
Oglio	Capriolo	1842	**58**
Mincio	Monzambano	2350	**57**
Taro	S.Secondo	1457	**40**
Chiese	Gavardo	934	**33**
Brembo	Ponte Briolo	769	**30**
Dora Riparia	Torino Dora Riparia	1322	**23**
Stura di Lanzo	Torino Stura di Lanzo	881	**23**
Stura di Demonte	Fossano	1198	**23**
Secchia	Ponte Bacchello	1371	**22**
Serio	Ponte Cene	455	**21**
Orco	S.Benigno	861	**20**
Panaro	Bomporto	1017	**19**
Trebbia	Bobbio	655	**18**
Orba	Casal Cermelli	756	**17**
Bormida	Cassine	1526	**17**
Enza	Sorbolo	648	**15**
Scrivia	Guazzora	905	**15**
Pellice	Villafranca	980	**13**
Maira	Racconigi	1160	**12**
Parma	Ponte Verdi	600	**12**

The main Po tributaries are the Ticino, Adda, Tanaro, Dora Baltea and Sesia river (Table 1). Ticino and Adda rivers receive the major precipitation in summer and the minimum precipitation in winter (Figure 14 & Figure 15), and they are influenced by the major lakes upstream. Dora Baltea and Sesia flow regime mainly reflect the influence of temperature causing snow cover melt in late Spring and summer. Glaciers give their maximum contribution during summer. Tanaro river discharges are majorly coherent with the rainfall regime, with maxima in spring and autumn.

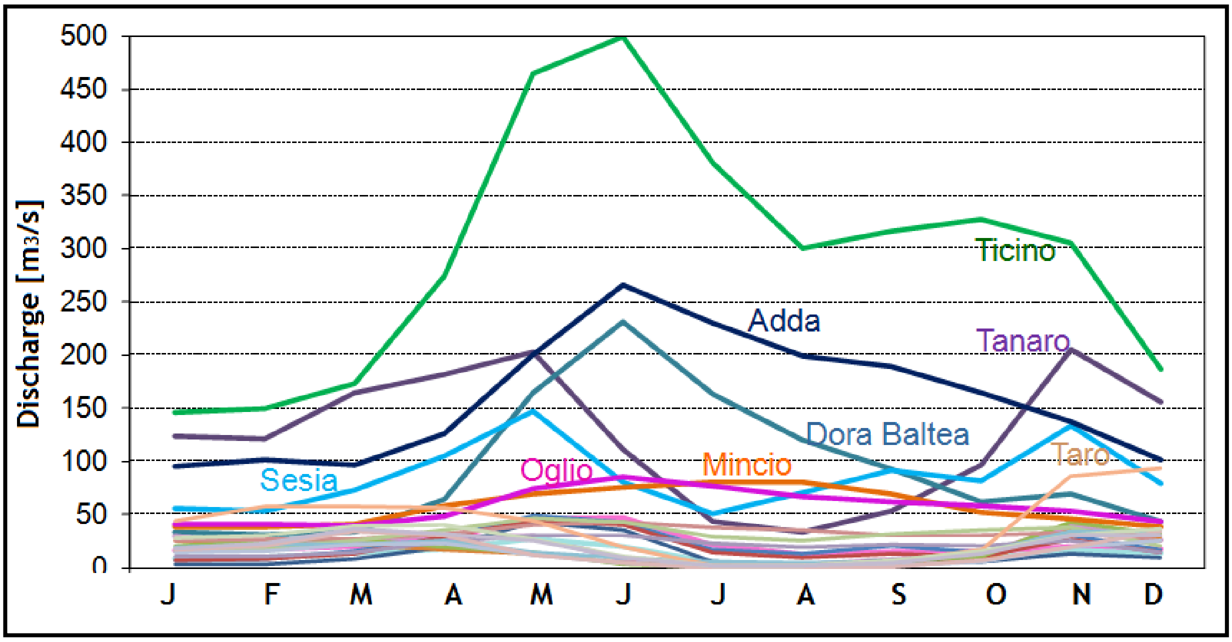

Figure 14. Monthly average discharge (m3/s) for the main tributaries of the Po river

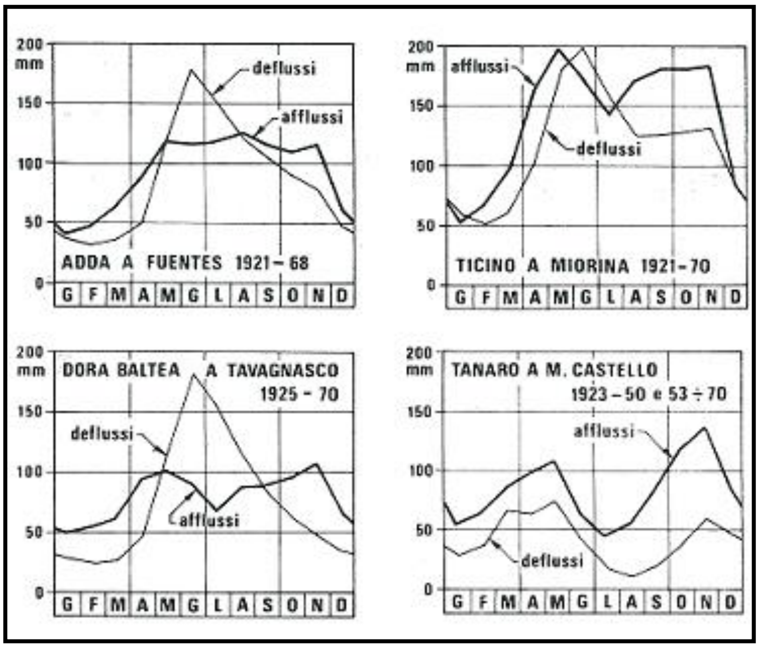

Figure 15. Monthly average values of precipitation and runoff for Adda, Ticino Dora Baltea and Tanaro rivers [11]

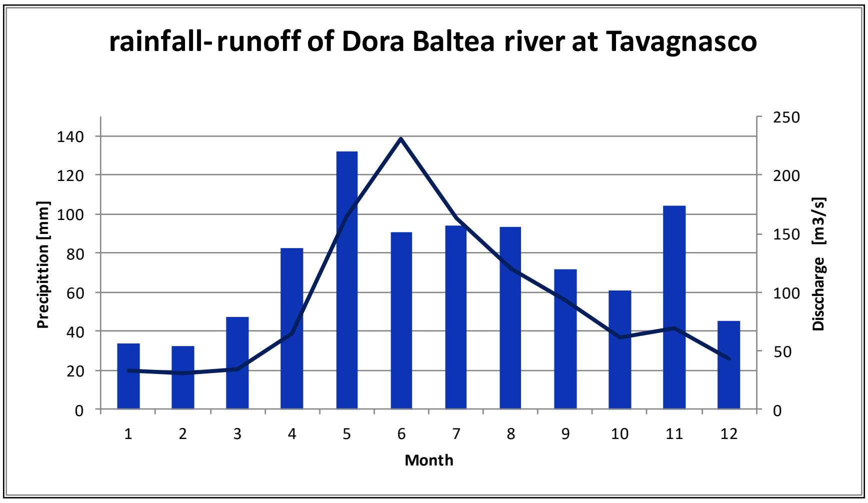

Figure 16. Dora Baltea river discharge at Tavagnasco gauging station. In blue the monthly average precipitation value. The black line describes the monthly average discharge (updated for the period 1971-2015)

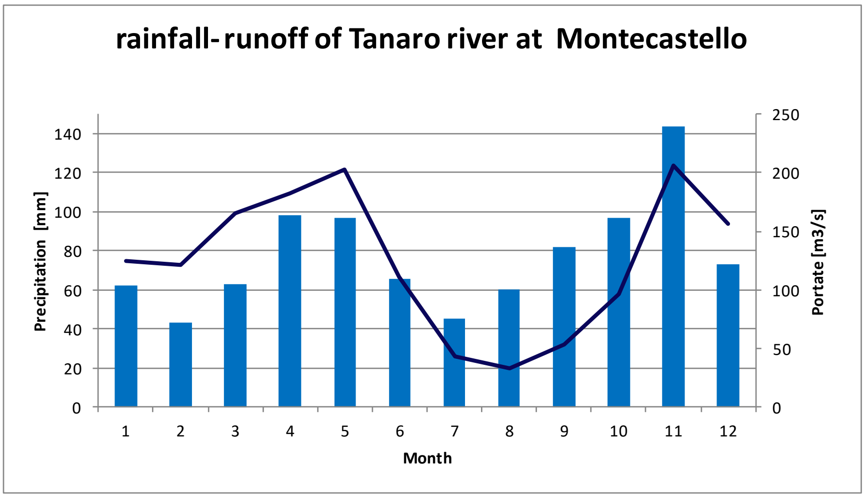

Figure 17. Tanaro river discharge at Montecastello gauging station. In blue the monthly average precipitation value. The black line describes the monthly average discharge (updated for the period 1971-2015)

In P-RB there are about 450 lakes but the 90% of those are less than 1 km2 wide. The most important and biggest which affect Po river regime are the pre-Alpine lakes: Maggiore, Como, Garda, Iseo and Idro (Figure 18).

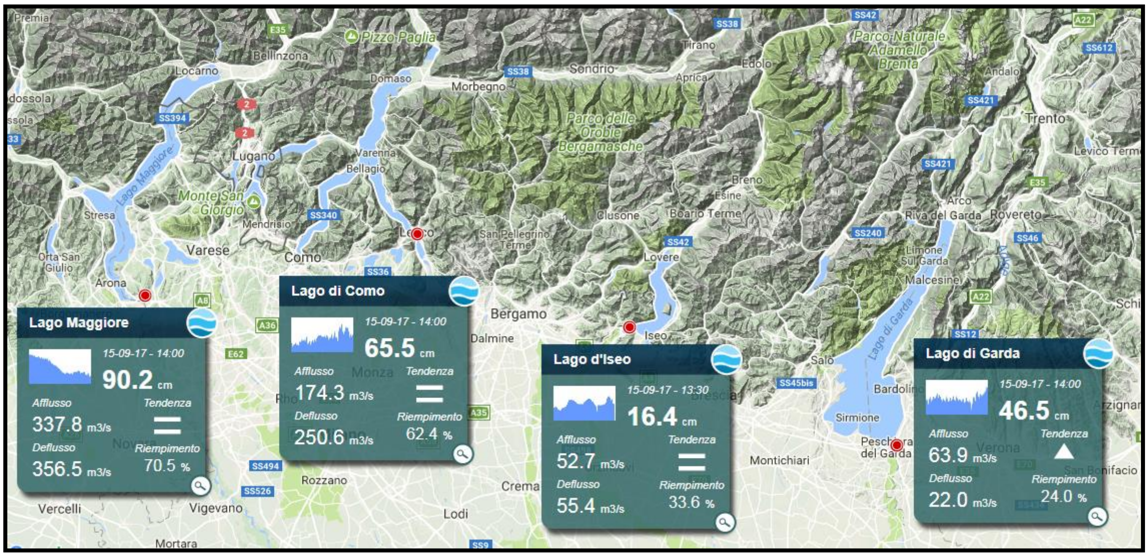

Figure 18. Pre-Alpine lakes: Maggiore, Como, Garda, Iseo (source: http://www.laghi.net/)

Concerning water balance and water availability, the water equivalent of the snow cover can reach eight billions of cubic meter. Glaciers equivalent water volume in not well known. The available water volume in the major lakes is about 1.2 billions of cubic meters. The available water volume in the artificial reservoirs is around 1.2 billions of cubic meters, too. The mean precipitation volume is about 77 billions of cubic meter/year. The mean stream flow volume per year is about 47 billions of cubic meter/year (60%): the remaining 30 billions of cubic meter leave the catchment as infiltration (15%) or evapotranspiration (25%). Total groundwater available volume in not well known and can be estimated in about 9 billions of cubic meter.

The surface water network is both natural and artificial (

Table 2 and Figure 19) with a dense network of drains and channel system as well, built mainly for irrigation and land reclamation works reasons [12].

Table 2. Po river basin hydrological network

District	Main natural hydrological network [Km]	Secondary natural hydrological network [Km]	Total natural hydrological network [Km]	Main artificial Hydrological network [Km]
Piemonte	2829	14345	17174	2216
Valle d'Aosta	338	1179	1517	-
Liguria	217	891	1108	-
Lombardia	1925	9425	11350	8346
Emilia-Romagna	1284	5576	6860	5433
Trentino-Alto Adige	108	630	738	-
Veneto	52	267	319	750
Total	**6753**	**32313**	**39066**	**16745**

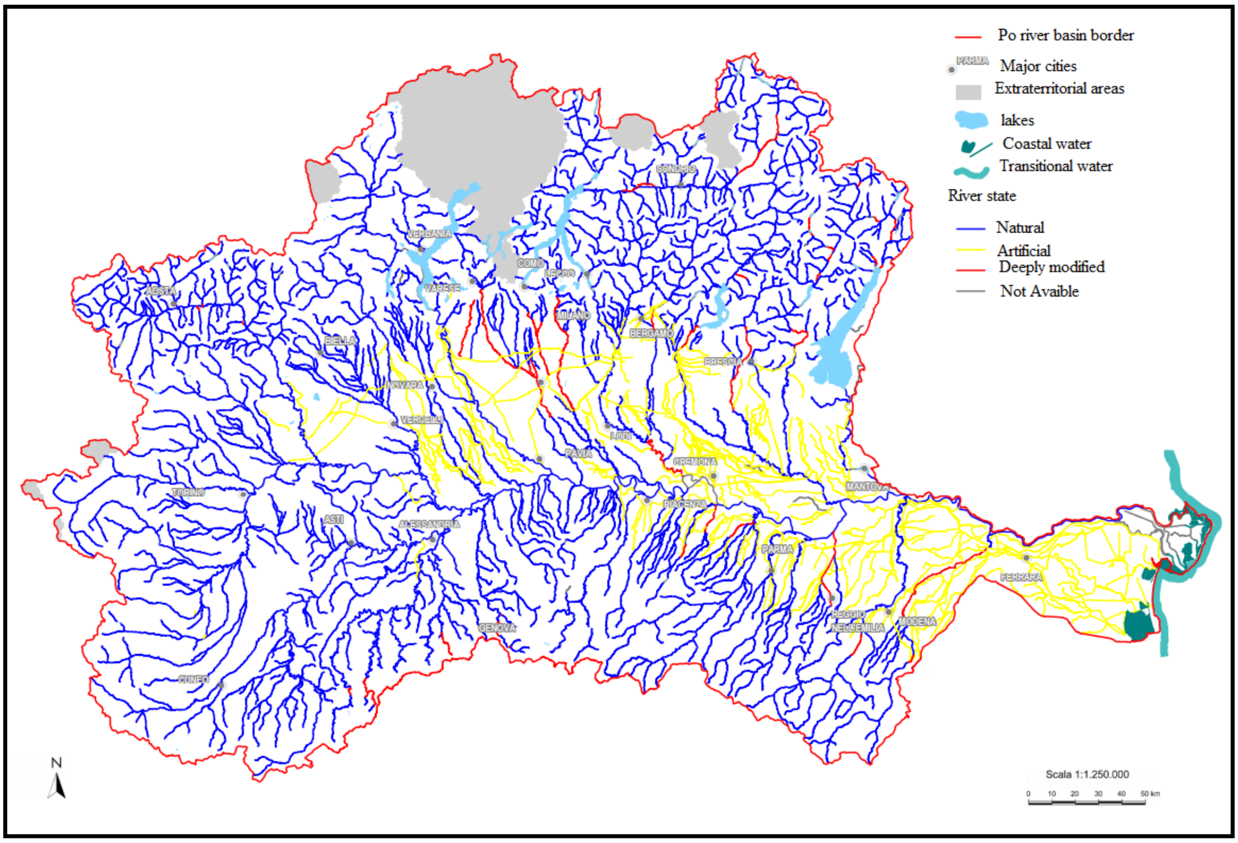

Figure 19. Po river basin hydrological network (Piano di Gestione del Distretto Idrografico del Fiume Po. 2015 [15])

2.6.1. Flood issues

Po major floods usually occur in late spring/early summer and in late autumn/early winter. They can last from seven to eight days up to two or three weeks, depending on antecedent soil moisture, precipitation volume, duration and spatial distribution, the synchronicity of peak flows from the tributaries, lake releases and snow melting. The water levels in the delta and near the sea mouth also depends on marine conditions.

2.6.1.1. Main historical floods

In the last seventy years the Po river and in its tributaries experienced a lot of disasters, suffering loss of people and heavy damages to the territory. Among them it is possible to mention the Po flood in 1951, with the catastrophic levee break at Occhiobello, the Valtellina debris flows in 1987, the Po upper valley flood in 1994, the Po extended flood in 2000. After a severe snow event, snow melt drove very high flows in the Apennine rivers in 2012. In the last years the historical flash floods on Parma and Santerno rivers, the levee breach on Secchia river and the long duration flood on the main reach of the Po river, all in 2014; in September 2015 a dramatic flash flood occurred in Trebbia and Nure rivers. Peak discharge had more than 200 years return period, and extended debris flow and landslides occurred on the upper catchment network. The Chisola river in the upper Po basin experienced a severe flood event in Autumn 2016.

2.6.1.2. Origin of Po river basin floods

The main tributaries are Alpine regulated and not regulated rivers and Apennine rivers; the differences between those two geographical and morphological areas affect the tributaries regime and consequentially sets different timing and shape of a flood wave in Po river and Po river flow value as well. The data collections and study on the past flooding events led to the definition of four possible flood scenarios:

- Piemontese: the main tributaries involved are Dora Baltea, Sesia, Tanaro and Ticino, followed by the other Alpine tributaries and, although less effective, Apennine tributaries (Staffora e Scuropasso). The rainfall rate is higher on the westward basin area or middle west basin area. This type of flood scenario has occurred in autumn, like the flood events in 1705, 1755, 1857, 1907, 1994 and 2000.
- Lombarda: the main tributaries involved are: Ticino, Lambro, Adda e Oglio, like the flood events in 1807, 1812 and 1868. Also this type of flood scenario has occurred in autumn.
- Piemontese-lombarda: this type of flood scenario mainly involves central and western Alpine basin. The main tributaries involved are Sesia, Tanaro, Adda e Oglio and occasionally Scrivia, Dora, Lambro and Olona, all of them with not a high flow rate but the pick timing that bring all the river flows to sum their discharges along the Po river and to increase the Po main reach discharge. Sometimes also peak flows from Apennine tributaries give additional contribution downstream. Belong to this scenario flood events in 1801, in autumn and in 1917 and 1926 during spring.
- Whole basin: all the catchment area is involved. The tributaries start to increase Po River discharge starting from the west area and as time goes by the central and Apennine sum their flow rate. Flood events belonging to this scenario occurred in 1839, 1872, 1879 and 1951. This type of flood scenario usually has occurred in autumn, except for the event in 1879, occurred in late Spring.

In the Table 3 the major sub basins are listed in classes as shown in Figure 15.

Table 3. Sub basin classes and features

Class	Sub-basin	Flow regime	Features
1	Dora Baltea	Alpine	Maximum in summer and a minimum in winter; a single discharge peak in summer and an extended low flow period in winter
2	Toce, Ticino, Adda and Mincio	Alpine	Maximum in summer and a minimum in winter, regime altered by the regulation of subalpine lakes
3	Brembo, Oglio		Two maxima and two minima almost equivalent, monthly flow varies around the average annual value
4	Sesia	Alpine	A Maximum in summer and a minimum in winter
5	Agogna, Lambro-Olona, Serio		Two maxima and two minima almost equivalent, monthly flow varies around the average annual value
6	Orco, Malone, Stura di Lanzo, Dora Riparia	Transition between alpine and apennine	Alpine flow regimes, with some periods of rainfall regime, more evident in Autumn
7	Alto Po, Chisone, Pellice, Varaita, Maira, Stura di Demonte	Transition between alpine and apennine	
8	Tanaro	Transition between Alpine and Apennine	Strong territorial variability; flow regime mainly follows the rainfall characteristics, with a earlier discharge peak in spring, minimum low flow in summer and increasing discharge rate in Fall
9	Belbo, Bormida	Transition between Alpine and Apennine	
10	Bacini emiliani from Scrivia to Panaro rivers	Apennine	Two maxima and two minima, with the fall value higher than the spring and the summer value lower than winter one.
11	Middle Po river		Two maxima and two minimum, the Spring value tend to decrease downstream
12	Lower Po and Po delta		Two maxima and two minimum; the Spring value tend to decrease downstream

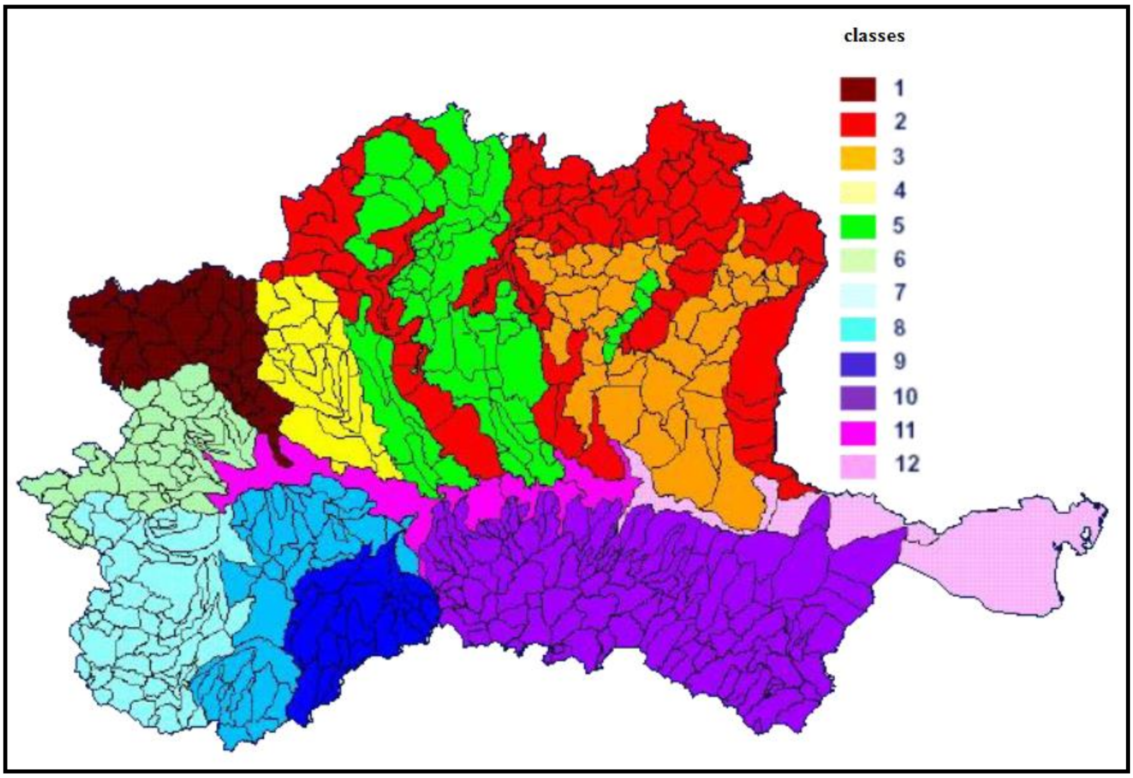

Figure 20. Classes of clustered sub basin in P-RB [15]

2.6.1.3. Flood risk management

In P-RB flood management is regulated by the Italian Laws D.lgs. 49/2010, according to the European Flood Directive 2007/60/EC and D.lgs 152/2006.

National river basin districts, as Po District, are in charge of establishing the "Flood Risk Management Plan (PGRA)" and the "Hydrogeological Regulation Plan (PAI)" [17].

Main targets of these Plans are:

- identifying flooding areas (Figure 21)
- arranging and managing activities in flood areas,
- defining security targets and priorities actions in agree with Regional Administrations and with the participation of stakeholders, in order to:
    - improve the effectiveness of existing hydrological and hydraulic protection system,
    - reduce flood risk exposure,
    - ensure more space for rivers flow,

- safeguard of cities and metropolitan areas,
- improve the awareness of flood risk.

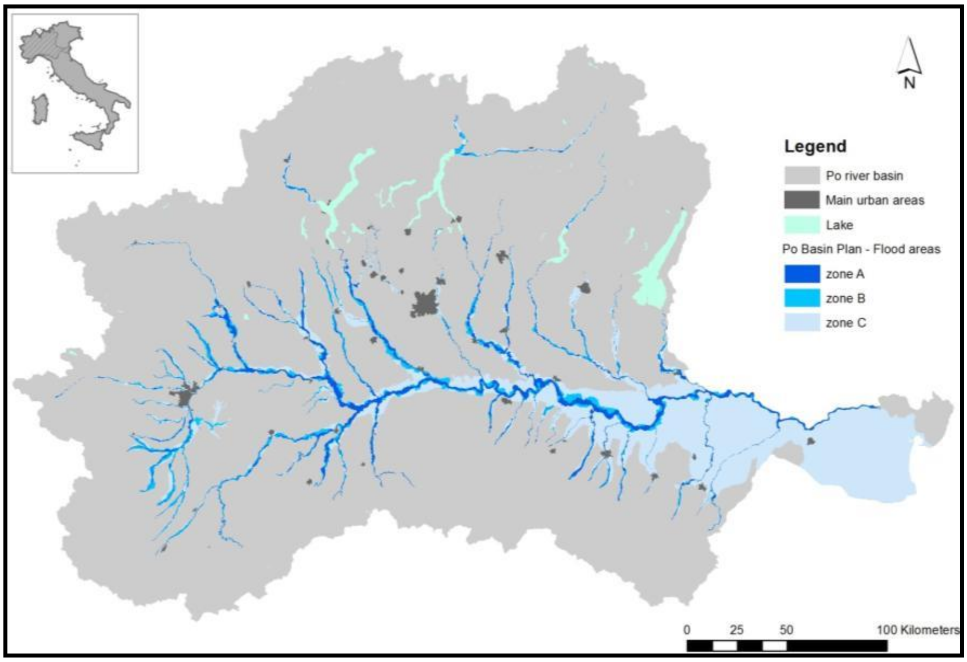

Figure 21. Flooding zones in P-RB [15]

Figure 21 shows the flooding area in P-RB, which defines an hydraulic, morphological and environmental sensitive areas. The aims of the flooding area management are not only safety against hydraulic risk, but also the recovery of the river environment, the preservation of landscape, historical, artistic and cultural values within the river region.

District Authorities designs Flood Risk Management Plan, with the contribution of Regional Administrations and Civil Protection and taking into account all the nested sector plans (regional and local). District Authorities in particular coordinate the planned actions and they put in place instruments to foster active participation and information sharing among all stakeholders involved [17].

Concerning the non-structural actions of the Flood Risk Management Plan, Regions included in P-RB, in accordance with the National Civil Protection Department, implemented the Flood Early Warning System (FEWS-Po) for the Po river basin, which is the operational tool considered in the Directive of the President of the Ministers Council on 08.02.2013 concerning the implementation of flood control in the Po river basin [5].

2.6.1.4. Hydrogeological and hydraulic risk, warning system and emergency plan

The alerting system consists of procedures to communicate forecasted risk scenarios and the possible effects (such as floods, landslides) to activate protection actions for the safeguard of citizens, properties and environment. “National and Regional Distributed Early Warning System Network for hydrogeological extremes”, has been first established by the Civil Protection Directive on 27.2.2004. It is composed of regional warning centers CFD, a national coordination center CFC and local and national competence centers (CC).

With the Civil Protection note RIA/0007117 10/02/2016 “"Metodi e criteri per l’omogeneizzazione dei messaggi del Sistema di allertamento nazionale per il rischio meteo-idrogeologico e idraulico e della risposta del sistema di protezione civile" a new homogeneous coding of critical levels was established [21]. It defines:

- critical levels using a defined color code. Each color code define a scenario (meteo-hydrogeologic or hydraulic) of possible damages and losses (Table 4) also considering different scenarios of events (heavy rain/thunderstorms, storm surges, or hydraulic-hydrologic). More and more critical scenarios from green to yellow, orange and red are given comparing forecasted/observed precipitation/water levels with specific rainfall/water level thresholds;
- standard operation criteria to design and put in place actions during all operational phases during hydro-geological extremes. The operational alerting levels are: attention, pre-alarm, alarm;
- the correlation between alert levels, subjects involved, classes of actions, coordination, operational activities and resources. The correlation between operational and alert phases is: yellow/orange alert leads to attention, orange/red to pre-alarm, red leads to alarm phases.

In Emilia-Romagna Region a standard procedure was defined for sharing alerting information among the regional Civil Protection and the local authority, in order to activate the emergency plan [16].

Every day on a dedicated website a “meteo hydrogeological and hydraulic bulletin” is published. When forecasted critical level is different from green, an alert bulletin is published and updated with higher frequency; after an alert bulletin a monitoring phase gets started and a monitoring report is delivered on the same website.

Table 4. Extract of critical levels, colour codes, scenarios and damages for hydraulic extremes

Alert	Critical classes	Colour code	Flood scenario	Damages and losses
No alert	No significant events forecasted		Local events such as small flooding area	Possible local damages
Low	Hydraulic		local flooded area Increasing of river water level	Local damages potential injuries and accidental casualties

Moderate	Hydraulic		diffuse flooded area Increasing of river water level	Diffuse damages, safety at risk, injuries or potential casualties
High	Hydraulic		river flood, flooded areas	Risk for health and safety, high potential number of casualties, injuries and losses

Lately, the Civil protection Directive on the 8.2.2013 state that the Command and Control Unit (UCC) is in charge of the flood control for the Po river. Moreover, the Interregional Agency for the Po river (AIPO) is the Flood Forecast Center for the Po river, supporting the UCC together with the Hydrology Area of ARPAE-ER, using FEWS PO.

When a flood event on the Po river main reach is forecasted (forecasted water levels higher than L1 threshold) a daily forecast bulletin is delivered to interested institutions. If observed water levels exceed at least the L1 threshold a monitoring bulletin is delivered two or more times a day.

FEWS system allows the combination of hydrological observations/measures with three different hydrological-hydraulic chains (HEC HMS/RAS, MIKE11 NAM/HD, Topkapi/Sobek). Several meteorological inputs (observed precipitation/temperature, COSMO N2-RUC, I2, 5-M, I7, LEPS [25]) feed the hydrological hydraulic chains whereas the observation networks and historical data are used for forecast correction and cross validation. Forecast uncertainty is estimated and communicated to decision makers in order to have a comprehensive scenario and to better plan prevention actions. FEWS was briefly described in “Best management practices report in pilot action” D.T2.1.2 and will be further described forwards in Proline next activities.

2.7. Hydrogeology

Figure 22, show Po river basin hydrogeological map and water bodies maps [15].

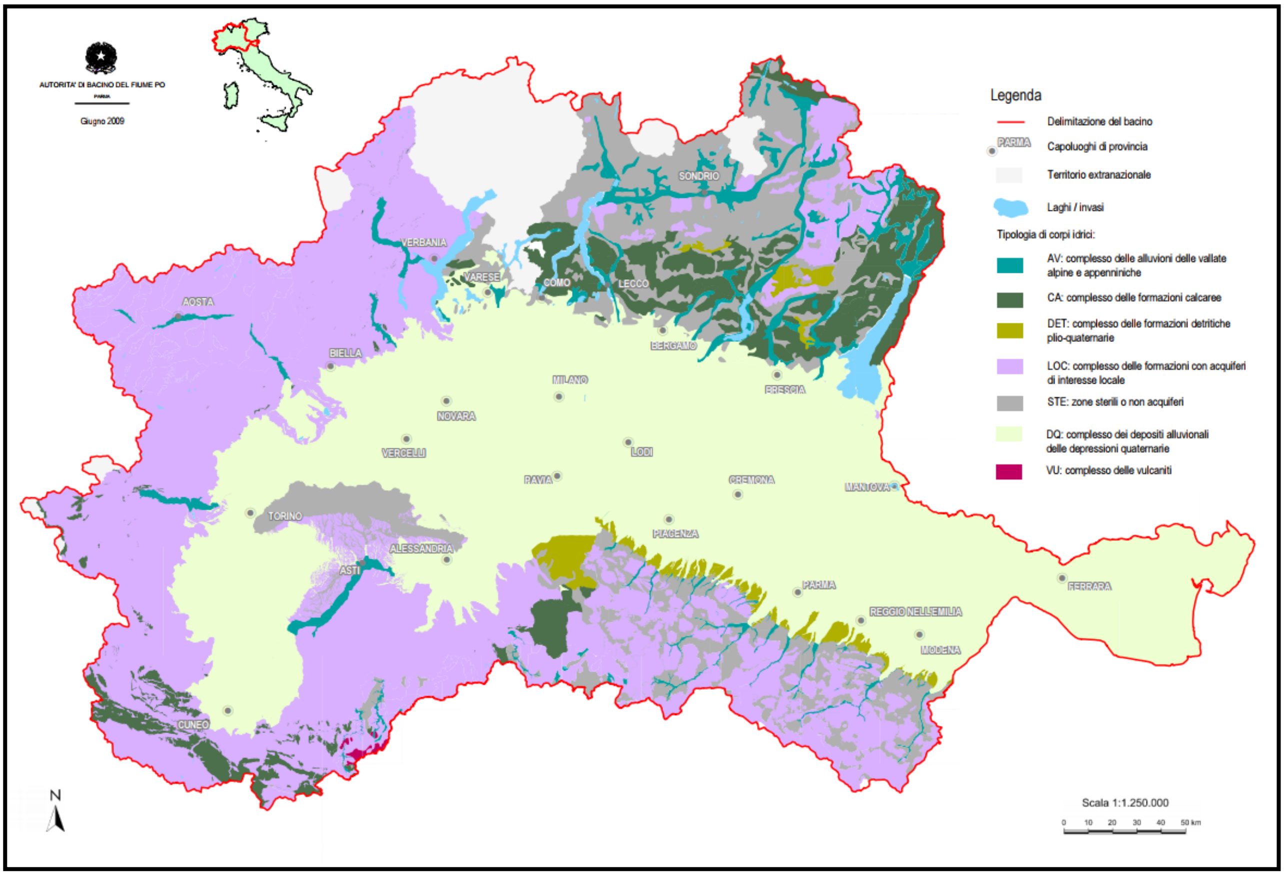

Figure 22. Hydrogeological map [15]

In Po river basin some hydro-geological groups were defined and listed in Table 5. In brief, these complexes can be summarized as follow:

- AV: hydrogeological complex of alluvial deposits in Alpine and Apennine valley floors
- CA: hydrogeological complex of calcareous rocks
- DET: hydrogeological complex of detrital Plio-Quaternary formations
- LOC: hydrogeological complex of rocks with small aquifers
- STE: areas with no aquifers
- DQ: hydrogeological complex of alluvial Quaternary deposits of the Pianura Padana Depression

Table 5. Hydrogeological groups in Po river basin (only available in Italian language).

Complessi idrogeologici	sigla	Sub-complessi	Tipologia di acquifero (assetto idraulico)
Depositi alluvionali delle depressioni quaternarie	**DQ**	**DQ 1** indifferenziato dell'alta pianura padano-veneta	**DQ 1.1** Acquifero monostrato freatico
			DQ 1.2 Acquifero complesso a livelli sovrapposti: falda freatica superficiale e livelli confinati profondi interconnessi
		DQ 2 Differenziato della media e bassa pianura padano-veneta	**DQ 2.1** Acquifero multifalda confinata con orizzonti impermeabili di estesa continuità spaziale; in superficie può essere presente un acquifero freatico connesso o meno con la rete idrografica
		DQ 3 Depositi alluvionali delle depressioni interne e litoranee	**DQ 3.1** Acquifero prevalentemente freatico con locali confinamenti
			DQ 3.2 Acquifero complesso a livelli sovrapposti: falda freatica superficiale e livelli confinati profondi interconnessi
Alluvioni vallive	**AV**	**AV 1** Depositi delle vallate alpine	**AV 1.1** Acquifero prevalentemente freatico con locali confinamenti
		AV 2 Depositi delle vallate appenniniche	**AV 2.1** Acquifero prevalentemente freatico con locali confinamenti
			AV 2.2 Acquifero complesso a livelli sovrapposti: falda freatica superficiale e livelli confinati profondi interconnessi
Calcari	**CA**	**CA 1** Successione calcareo-dolomitica di piattaforma prevalente	**CA 1.1** Acquifero basale freatico con eventuali falde sospese in calcari fratturati e/o carsificati
		CA 2 Successione carbonatica di bacino pelagico prevalente	**CA 2.1** Acquifero prevalentemente freatico, anche con livelli confinati profondi, in calcari fratturati e/o carsificati
Vulcaniti	**VU**	**VU 1** Lave massive prevalenti	**VU 1.1** Acquifero freatico a circolazione discontinua
		VU 2 Piroclastiti e lave	**VU 2.1** Acquifero a doppia porosità prevalentemente freatico a circolazione discontinua

Complessi idrogeologici	sigla	Sub-complessi	Tipologia di acquifero (assetto idraulico)
Formazioni detritiche plio-quaternarie	**DT**	**DT 1** Depositi prevalentemente sabbiosi	**DT 1.1** Acquifero complesso a livelli sovrapposti: falda freatica superficiale e livelli confinati profondi interconnessi acquifero a circolazione discontinua
			DT 1.2 Acquifero poroso prevalentemente freatico
		DT 2 Depositi conglomeratici, calcarenitico-sabbiosi, calcarenitici	**DT 2.1** Acquifero a doppia porosità prevalentemente freatico
Formazioni con acquiferi di interesse locale	**LOC**	**LOC 1 Depositi prevalentemente calcareo-marnoso-argillosi e evaporitici**	**LOC 1.1** Acquifero freatico in rocce fratturate o carsificate
			LOC 1.2 Acquifero multifalda confinata con orizzonti impermeabili di estesa continuità spaziale; in superficie può essere presente un acquifero freatico connesso con la rete idrografica
		LOC 2 Granitico-metamorfico	**LOC 2.1** Acquifero a circolazione discontinua
		LOC 3 Rocce di litologia mista	**LOC 3.1** Acquifero a circolazione discontinua
			LOC 3.2 Acquifero freatico a doppia porosità
			LOC 3.3 Monostrato freatico
Zone sterili o Non acquiferi	**STE**		

2.8. Land use

Land use in P-RB was also described in D.T1.1.1 “Country Reports About the Implementation of Sustainable Land Use in Drinking Water Recharge Areas” and included in D.T2.1.2 “Best Management Practices Report in Pilot Action”[18]. Figure 23 present land use according to Corine land cover map [3] and Figure 24 presents percentages of major land use categories within the P-RBD. Agriculture areas and forest and grasslands cover the majority of P-RB territory: 46% and 45%, respectively.

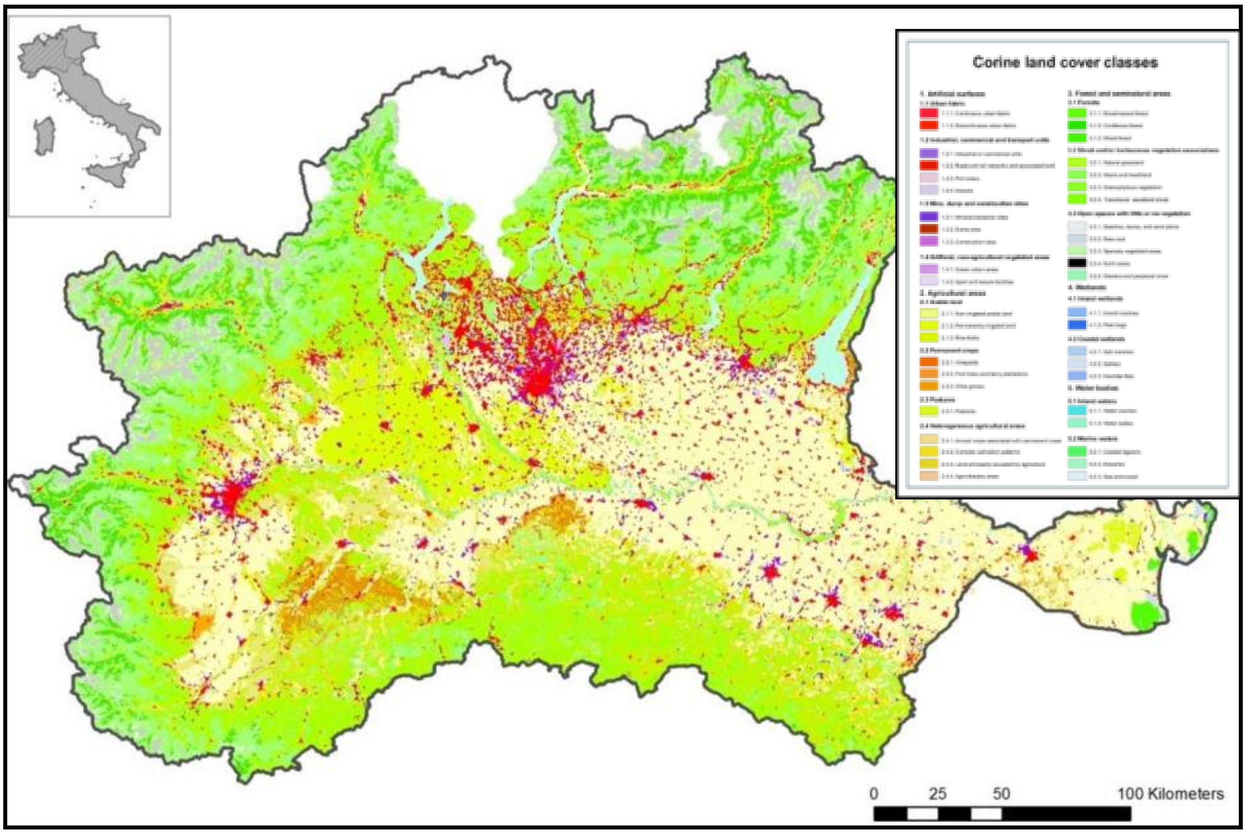

Figure 23. P-RB land use map based on the Corine Land Cover (CLC, 2012) [3]

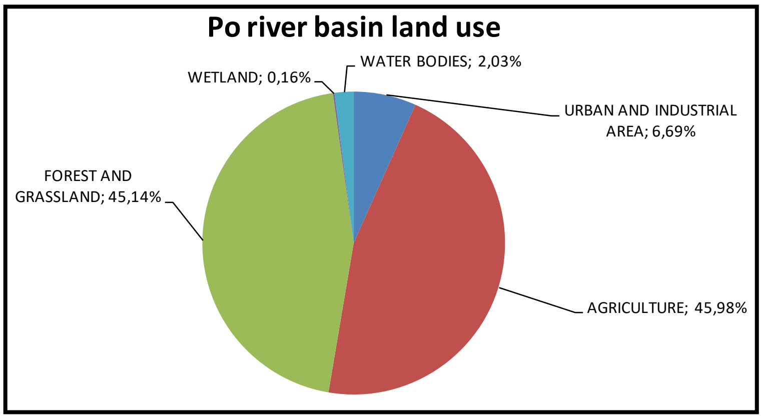

Figure 24. Land use categories percentage

2.9. Protected areas

2009/147/CE and 92/43/CEE,the so called ‘Birds’ and ‘Habitats’ Directives (BHD), together form the backbone of the EU’s biodiversity policy as they protect Europe’s most valuable species and habitats. The protected areas designated under these directives form the Natura 2000 network.

Italian legislation has a complex structure for ecosystems and nature preservation. According to the Framework Law on protected areas 394/1991, protection targets are: conservation of species, communities, ecosystems, geological formations, landscape and other valuable sites; application of environmental management and restoration methods aimed at the integration between man and the environment; fostering of education, training and multidisciplinary scientific research. Protected areas considered in the Framework Law are: national and regional parks, national and regional reserves, protected marine areas.

The Italian Environmental Code d.lgs 152/2006, following the Water Framework Directive, introduced other protected areas among which: designed areas for drinking water extraction, fish and shellfish life suitable waters, bathing devoted waters, fixed areas for protection of water species with high economic value, nitrates vulnerable areas and sensible areas. Moreover the Environmental Code includes protection instruments among which: the Register of protected areas, regulation for waters bodies in protected areas, penalties for wastewater releases in protected areas, state of the art on parks and protected areas with the contribution of local municipalities, quality targets for water bodies included in protected areas, rules for exclusion of mixing zones from protected areas, reservoir management in protected areas.

The system of protection instruments including actions, restrictions and prohibition fosters effects on water quality and quantity both at local and the whole river basin scale. Local effects are less significant than entire river basin ones on the PA and PROLINE activities at all.

In fact global basin effects are considerable for surface water quality and related drinking water uses in Pontelagoscuro outlet where the Ferrara water work uptake.

General effects of the protected areas system could be better investigated within the PROLINE project and river basin management plans.

In this way, within the big category of protected areas in fact there are different regulations from International, EU, national, regional and local legislation, with different targets spreading from total nature protection of wild areas to special protected areas (as for migrating birds reproduction) habitat conservation, preservation of landscapes, sustainable promotion of marginal zone, where industrial development produced less impact.

In the P-RB are located sites of Community Interest SCIs, special areas of conservation SACs, and Special Protection Areas SPAs (Natura 2000 network), national and regional parks, national and regional natural reserves, protected marine areas and other protected areas.

The District Management Plan approved in 2015 contains the Register of protected areas [20], including links to regional reports on protected areas and the identification of interactions among water bodies and protected areas included in Natura 2000 network.

In the Po river basin there are 837 constrained areas with different types of protection rules. The biggest are national and regional parks covering about 70% of total protected areas, whereas national and regional reserves cover 9,4 % and wetlands the 0,7 %; all the other protected areas not previously described form the remaining constrained surface.

3. Water supply in the pilot action

3.1. Drinking water sources

According to Po River Basin Authority[1]: groundwater withdrawal is 6,0 billion m^3/year instead surface water withdrawal is 14,5 billion m^3/year. Of the total 20,5 billion m^3/year, 2,5 billion m^3/year is for drinking water use, 1,5 m^3/year for industrial sector, and 16,5 for agriculture. Figure 25 shows surface water bodies for drinking water supply, whereas Figure 26 shows groundwater sources suitable for drinking water uses. In the PROLINE-CE project activities will be focused on Ferrara drinking water supply.

[1] http://www.adbpo.gov.it/it/distretto-del-po/alcuni-dati

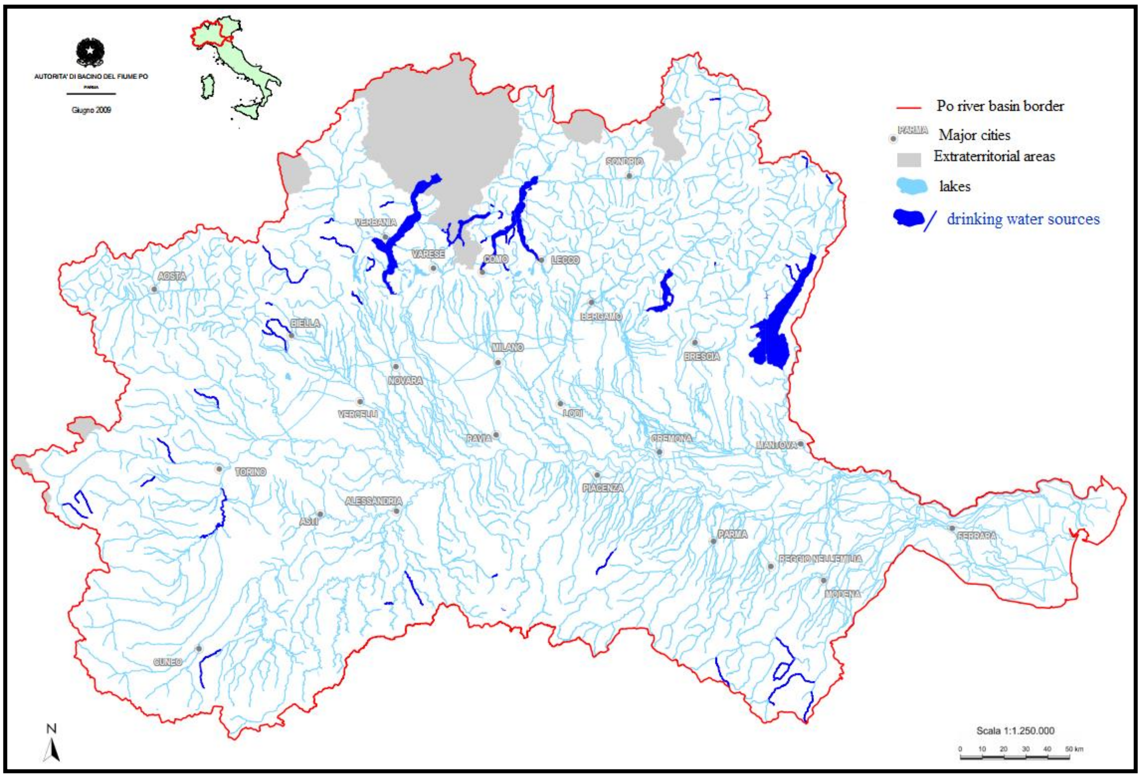

Figure 25. Surface water bodies suitable for drinking water [15]

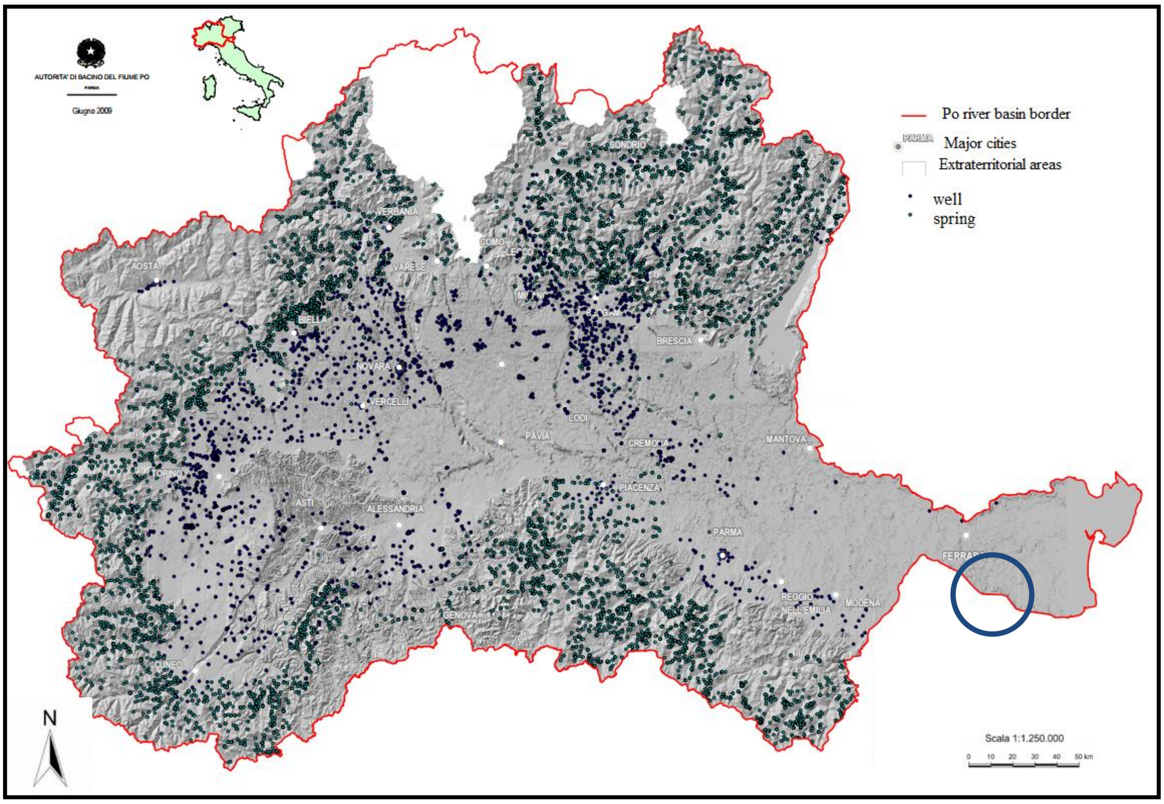

Figure 26. Groundwater intakes [15]

3.2. Ferrara drinking water supply

In Ferrara district, water supply is guaranteed by four drinking water plants (Figure 27). Among those Pontelagoscuro is the biggest one. It treats both surface water drawn from the Po river and groundwater drawn from the wells.

Pontelagoscuro drinking water plant has the following features[2]:

Municipality	Ferrara, Argenta, Masi Torello, Mirabello, Poggio Renatico, Porto Maggiore, S. Agostino, Vigarano Mainarda, Voghiera, Cento (partially)
N inhabitant	215.000
Potential [L/sec]	1.400

[2] From gruppohera, data update *31.12.2015*

Volume of drinking water drawn (Mm^3)	26,7

The surface water is withdrawn by two intakes equipped with electric pumps, whereas groundwater is carried out by 24 wells in the Po river floodplain area [19]. Although the groundwater has a better quality, since 1930s the surface water become the main water supply resource thanks to the biggest availability and the improvement of water treatment technologies. However, the partition between the two sources (surface and groundwater) varies according to different factors such as: the water quality of surface water, for instance during flood events when the solid transport is higher, or water quantity, for instance during drought events. Roughly it can be stated that the surface and groundwater are respectively at 80% and 20% from autumn to apring, and 75% and 25% in summer. The total annual average withdrawal is 1.040 l/s [19].

There are two surface water intakes at “Pontile vecchio” and “Pontile nuovo”. The latter is a small concrete tower which has 4 submersible electric pumps at the river bed level of -8,20 m which can works up to about -7,00 m. “Pontile vecchio” is a small concrete tower to which four pipes of electric pumps are anchored. Moreover, after the drought event of 2007, two more submersible electric pumps were added, those can work when Po river water level is less than –7,00 (and up to almost -8,20), so when the “Pontile nuovo” submersible electric pumps can’t work anymore [19].

As for the groundwater intakes, the wells are 35-40 meter deep, located in Po river floodplain area. There are 24 wells even though only 21 are used. Each well has a steel pipe of DN200 with a pump within. To guarantee the water supply from 16 up to 19 wells work together, the others are spare ones. To ensure uniform use the wells in service are periodically swapped [19]. The water processing in the plant has been briefly described in D.T2.1.2 “Best Management Practices Report in Pilot Action”.

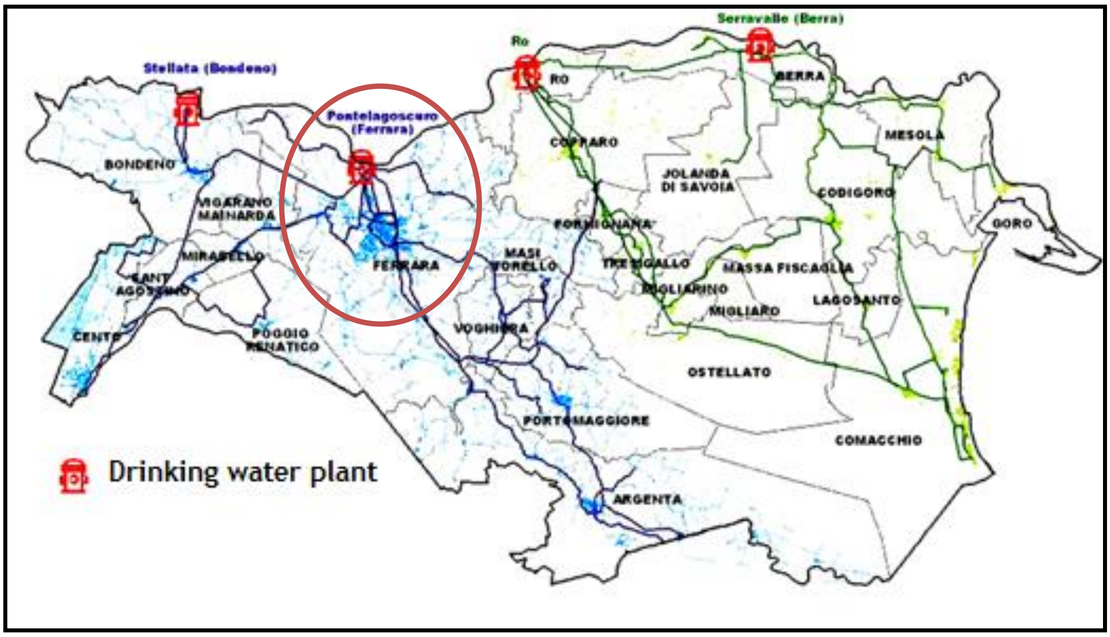

Figure 27. Drinking water plants in Ferrara district [22]

3.3. Drinking water protection

The drinking water quality, intended for human consumption, is assessed in accordance with Legislative Decree 31/01, following the commitment with the Directive 98/83/EC. It defines the withdrawal points, which parameter must be checked and assures that those are within the Law Limits. As integration of national Law, each Regional administration can supply (Table 6) and lay down stricter rules in order to define the drinking water protection areas and which activities can be carrying out in those areas (Figure 28).

As for the monitoring plans, water system managers must monitor and verify water quality parameters with internal monitoring plan, besides the ASL (Azienda Sanitaria Locale), the public local agency for Health, is in duty to periodically monitoring the water quality in the water supply network.

Regulation of drinking water protection areas for the Ferrara water supply system, including the Pontelagoscuro intake, is given by the Italian Environmental Code approved with the Legislative Decree 152/2006.

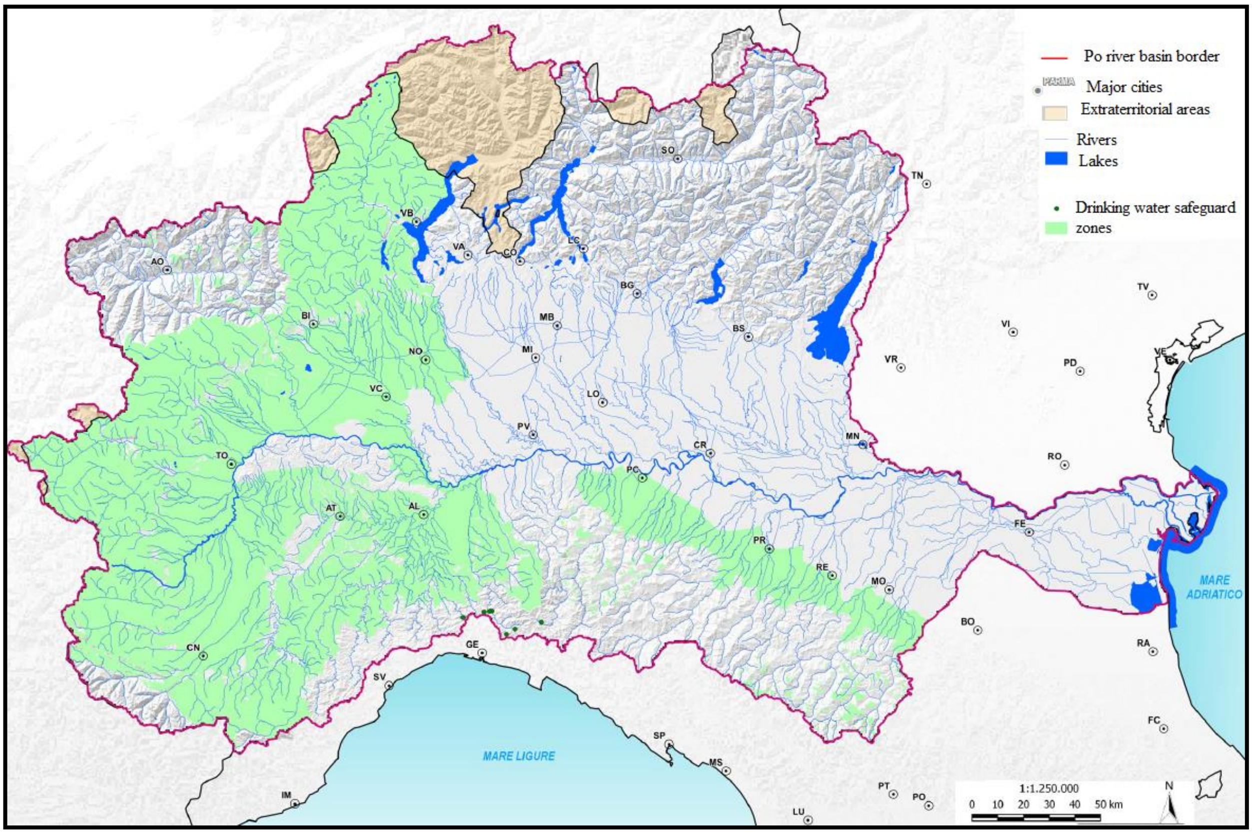

Figure 28. Drinking water protection areas in Po basin [15]

Table 6. Regional Law references

Regional Administrations	Law act
Emilia Romagna	Art. 44 delle Norme del PTA della Regione Emilia
Liguria	D.G.R. n. n.1806 del 30 dicembre 2014 - allegato Registro delle Aree Protette
Lombardia	R.R. 24 marzo 2006 n. 2.
Piemonte	R.R. n. 15/R/2006 e ss.mm.ii.
Provincia Autonoma di Trento	D.G.R. 1470/2015
Valle d'Aosta	D.G.R 4172/2006 e ss.mm.ii.
Veneto	DGR n. 211 del 12/2/2008

3.3.1. Risk analysis of water security

The Pontelagoscuro water abstraction plant in Po river is affected by some risks, in particular [22]:

- Variability of chemical/physical characteristics: direct river pumps suffer of several problems, such as variations and peaks of parameter (turbidity, temperature, ..); especially turbidity can reach very high peaks during flood events;
- Difficulty in withdrawals during low flows: a typical problem in surface water is that during drought periods withdrawals are difficult and in the past were faced using temporaneous solution, but they need permanent solutions;
- Pollution risks: pollution risk is linked to accidental oil spills, fires in chemical Companies, bacterial and faecal releases, abnormal pesticides releases, and many others.

4. Main identified problems / conflicts

The P-RB is basically rich of water resources but the increase of water consumption and climate change are affecting them. Especially during drought events, the conflicts among the users reach an extreme level, and as pointed out in D.T2.1.2, only on a river basin level the optimal area for soil, subsoil and water protection actions can overcome Institutional fragmentation and competences with unitary plans besides an Authority with decision-making power able to manage water crisis conditions.

Moreover in D.T2.1.2, it has been highlighted that communities and not-technical stakeholders should be involved on the issues directly and indirectly associated to water shortage; the necessity of improving and maintaining the best practices already undertaken like a generalized utilization of IRRIFRAME and IRRINET sharing data and information about water resource; administrative management of water withdrawals including the so called "*Antichi diritti*", concerning previous rights for water abstraction; the necessity of reconsidering the irrigation method in order to reduce water resource wastage; and at last but not least the necessity of maintaining permanent care and a financial and technical support of FEWS and DEWS systems.

These conflicts and best management practices identified in T1 and D.T2.1.2 will be the focus of activities within this PA.

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