ANNEX 8

Po river basin (PA3.1)

SET-UP OF PILOT-SPECIFIC MANAGEMENT PRACTICES

D.T2.1.2 Transnational case review of best management practices in pilot actions

BEST MANAGEMENT PRACTICES REPORT IN PILOT ACTION

"PO RIVER BASIN "

FINAL VERSION

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1. Introduction

In this report the main best management practices are presented on Pilot Action level, the Po river basin.

The goal is to provide a general background and the review of best practices focusing on conflicts of interest between land use management and water protection, in particular for drinking water supply in Ferrara waterwork.

The issues derived from previous stages of the Project will be briefly reviewed, whereas this report will provide the basis for further investigations and analysis.

2. Land use, drinking water and flood protection in the Pilot Action

The Po river basin District (P-RBD) plays a critical role for Italian agriculture, industry, and energy production. In addition, it is home to around 20 per cent of the country's population. The P-RBD is Italy's largest lowland, and the economically most developed part of the country. It comprises nearly 21 per cent of the total agricultural area; 21.5 utilised agricultural area; almost entire national production of rice and about or more than a half of the national production of soft wheat, rye, maize, sorghum, and other cereals; and almost 30 per cent of the agricultural value added. The District is also an economic engine of the country.

The GDP of the provinces comprised by the district varies between 21,000 and 38,000 (expressed as purchase power parity PPP, reference year 2009) and is higher than the EU-27 and national average with exception of three provinces (Pavia, Asti, Verbania) that are slightly below. The population of the district exceeds 17 million, 20 per cent of which concentrated in the eleven cities above 100.000 inhabitants. According to the EUROSTAT territorial typology, the Po plain is a large metropolitan area that extends from Venice in the north-east to Milan and Torino north-west, and back to Bologna along the ancient Via Aemilia.

The P-RBD is arguably the 'energy tower' of the country: the estimated 1,200 and 1,180 hydro- and thermo-electric plants situated in the P-RBD produce around 30 and 50 per cent of the hydro- and thermo-electricity respectively. Over the last decade the installed capacity of thermoelectric energy production in Italy increased by 40 per cent and the hydroelectricity by around 7 per cent. A half and a third of the respective new capacity development is situated in the P-RBD.

2.1. Land use

Land use in P-RBD was deeply described in D.T1.1.1 "Country Reports About the Implementation of Sustainable Land Use in Drinking Water Recharge Areas", as shown in Figure **1**. Considering Figure **2**, agriculture areas, forest and grassland areas cover the majority of P-RBD territory, 46% and 45%, respectively.

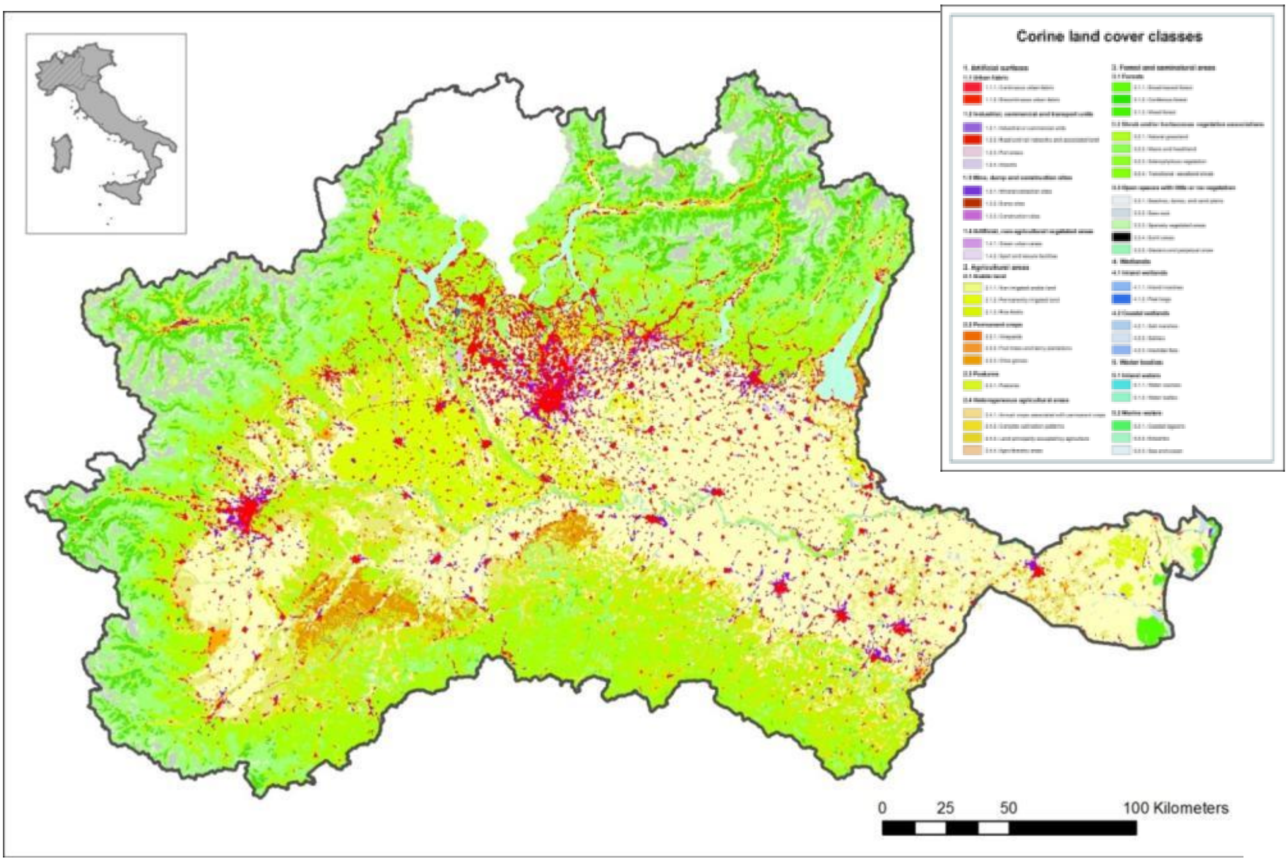

Figure 1. P-RBD land use map based on the Corine Land Cover (CLC) 2012 , Version 18.5.1, published on 19 September 2016

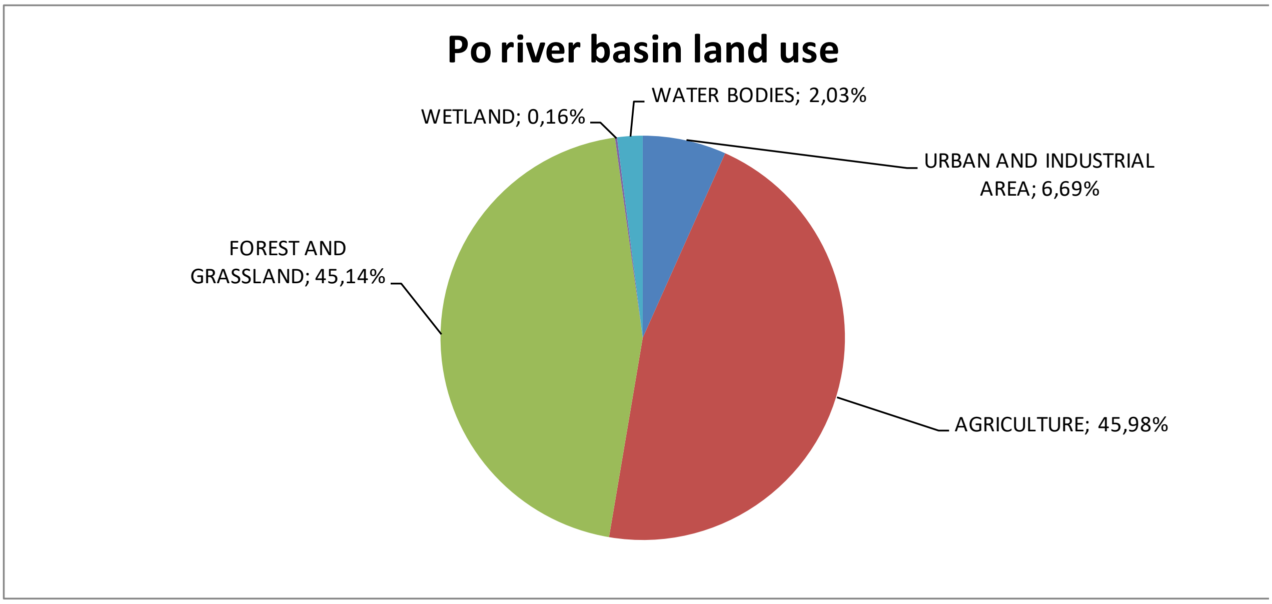

Figure 2. Land use, percentage

In **agriculture** the main driving forces, and potential causes of conflicts, concern: the use of mineral fertilisers, of pesticides, the inappropriate livestock waste and manure management, the increase of livestock density, the water abstraction for irrigation purposes, the excessive or inefficient irrigation. Consequently, the main pressure are:

- contamination of water bodies with chemicals and emerging contaminants from runoff and percolation
- Increase of water consumption/water demand. The conflict is bigger during drought events.
- Diffuse N inputs on/in the soil through runoff and percolation
- Diffuse pesticide contamination from runoff and percolation
- Diffuse contamination of pathogens and N into groundwater and soil through leaching
- Buildups of excess nutrients and heavy metal in the soil
- Decrease in water table height and land subsidence enhancing sea water intrusion into aquifers
- Decrease in dilution of salts in ground waters
- Increase runoff of nutrients, pesticides and salts
- Waterlogging in poorly drained soils enhancing evaporation and salinization.

On the contrary, urban and industrial areas cover a far smaller percentage, around 7%, but they strongly affect the environment, the ecosystems and the water cycle.

As for **urban areas,** the main driving forces and consequent conflict concern: soil consumption, increase in population density, expansion of artificial and concrete surfaces, the sewage overflows in case of extreme rainfall events, the non-compliant urban and domestic wastewaters treatment plans, the intensity of tourism supply, the areas without sewage systems.

In **industrial areas**, instead, the main driving forces and consequent conflict concern:

- Diffuse pollution of air and soils
- Lack of industrial effluents treatments systems
- Excessive water consumption
- Industrial accident risk
- Accidental/catastrophic discharge, including direct discharge of industrial waste waters into surface bodies.

Some of the main pressures generated by urban and industrial areas are:

- contamination of water bodies with direct discharge of industrial waste waters into surface bodies
- Increase in the volume of waste water and sewage to be treated
- Increase of runoff rates

- Increase of erosion rates
- Diffuse pathogens and organic matter contamination
- Effluents nutrients and pathogens concentrations above allowed standards
- Contamination from emerging contaminants
- Volume of sewage to be treated exceeding waste water systems capacity
- Direct discharge of nutrient, organic matters and pathogens i.e. coliformi, E.coli, Enterococchi) into surface and groundwaters

Forest and grassland effects and potential conflicts with water management are negligible.

2.2. Drinking water

2.2.1. Drinking water quality

The P-RDB includes 2155 surface water bodies, 70 of them used for drinking water, and 167 groundwater bodies. Water quality targets and status derived from WFD 2000/60/CE and previous Italian legislation are specified in the Regional Water Protection Plans and in the District Management Plan.

In P-RBD there are many drinking water plants, among those the Pontelagoscuro plant, on which this pilot action in Proline Project will be focused.

This plant (Figure 3), is managed by Hera SpA and provides drinking water to more than 250,000 inhabitants in Ferrara administrative district with an approximative mean annual discharge of 900 l/s. The plant water supply mostly depends on Po river surface water, consequentially it requires more complex treatments than plain disinfection, to meet the drinking water requirements derived from D.lgs. 152/2006 and D.lgs. 31/2001 and constantly monitored Arpae. In Figure 4 the main quality characteristic of treated water are shown.

Figure 3. Pontelagoscuro drinking water plant

The water is collected from Po river and carried in three open tanks in row. Each of them is 1 km –long able to store up to total 245,000 m^3 of water in total, and corresponding to 3 days plant water supply. In this tanks, it is induced a slow water flow in order to create a (three-day) contrived path, and obtaining in the meanwhile a natural biodegradation and a first level of sedimentation. After these preliminary phases, the water treatment consists in several processes both physical, such as settling and filtration, and chemical processes, such as disinfection and coagulation and biological processes such as slow sand filtration.

In Pontelagoscuro Drinking Water Plant, water firstly undergoes the Coagulation/flocculation process, secondly, it go through a slow-sand filtration process. Thirdly, the water is treated by ozonation process and flows through a granular active carbons filter. Finally the water is accumulated in large partially-buried tanks where it lays in stock. A Chlorine dioxide process is carried out on water before the distribution in the network.

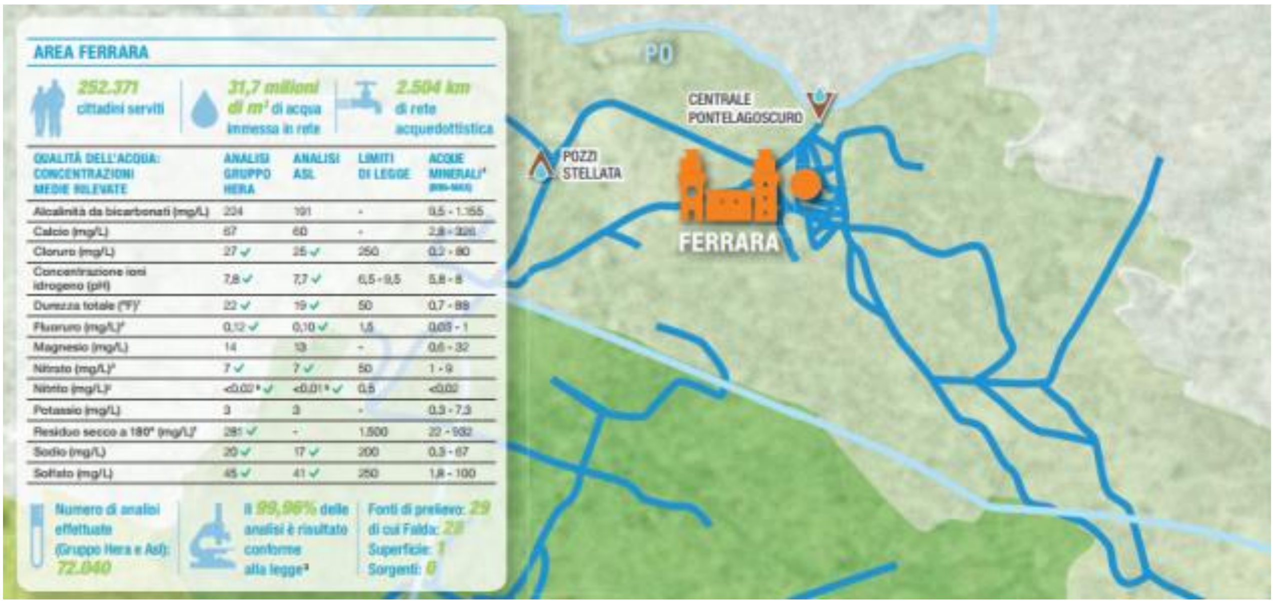

Figure 4. Ferrara drinking water plant: features and quality parameters

2.2.2. Drinking water quantity

The Regional Water Protection Plans and the District Management Plan also include the quantitative description of the 2155 surface water bodies and 167 groundwater bodies included in the P-RBD.

The following Figure 5 shows the distribution of the aforementioned water bodies suitable for drinking water and Figure 6 shows the main drinking water abstraction sites. Instead in Table 1 it is shown how drinking water supply sources in the P-RDB, groundwater (80%), from springs (15%) and surface water (5%). Ground and surface waters are used especially in plains, while spring waters are more used in mountain regions.

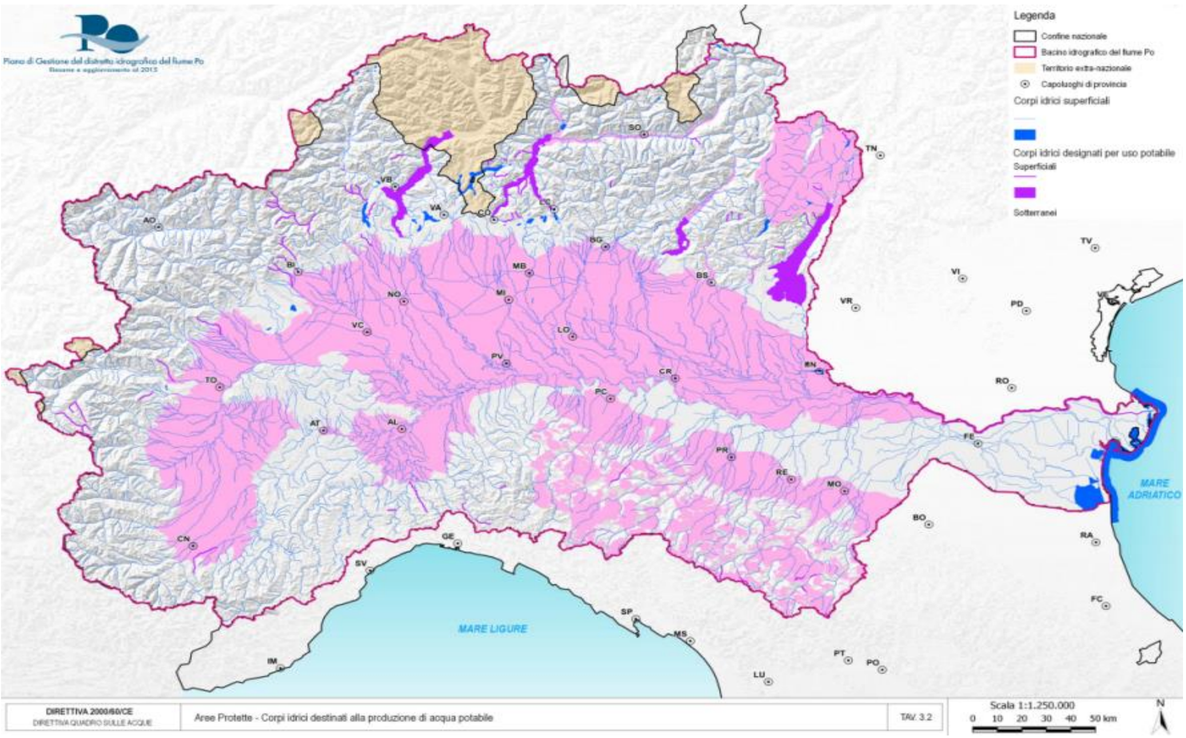

Figure 5. Distribution of the water bodies suitable for drinking water

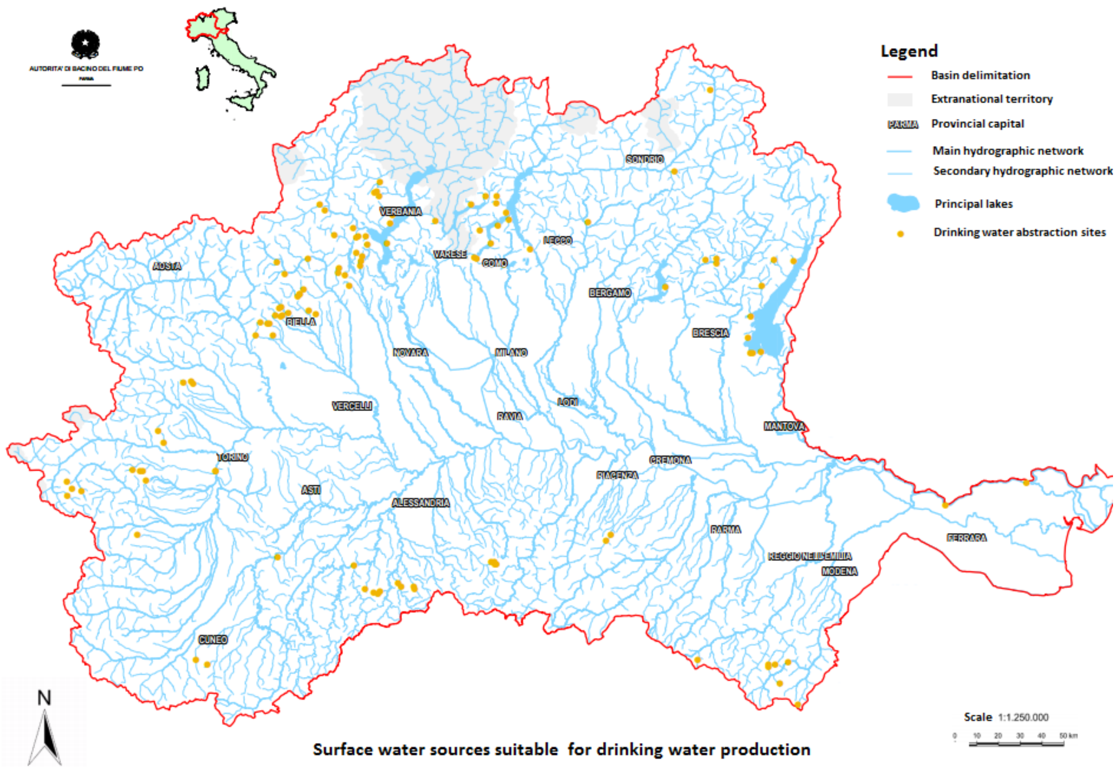

Figure 6. Surface water and drinking water abstraction sites

Year water abstraction in the Po River			
Uses	Withdrawal Volume (10^6 m^3/year)	% Surface water	% Ground water
Drinking	2.500	20	80
Industry	1.537	20	80
Irrigation	16.500	83	17
Overall	20.537	63	37

Table 1. Yearly water abstraction for different uses in the P-RBD

The average water supply in the P-RBD consists of 307 l per person per day, whereas the national average supply consists of 286 l per person per day, as shown in Figure 7.

The increase of water availability has been recently developing due to the following factors:

- the improvement of drinking water services and the economic growth that led to lifestyles characterized by high water consumptions;
- the reduction of the number of family members. In fact, in general, the less members constitute a family nucleus, the more the consumption of drinking water per person increases.

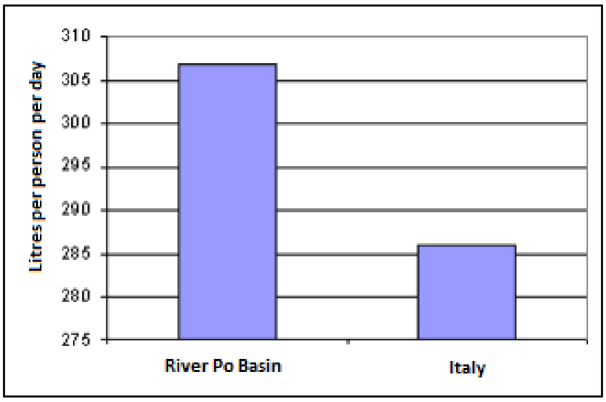

Figure 7. Water supply per person per day

Noteworthy is the outcome of ISTAT (the National Institute for Statistics) poll on water losses in the drinking water distribution systems of the Po river basin. It has been estimated around 22%, usually lost through ground infiltration.

2.3. Drinking water protection

Water is a public, essential, finite and vulnerable economic, environmental and social resource. For Europe and Italy, this general concept has been respectively translated into the European and National Directive, 2000/60/EC and D.Lgs. 152/2006 respectively. This new point of view has led to an increasing awareness of the role and importance of water resources and its inter-connection with socioeconomic, cultural, and political issues and regional regulation with protection tool and plan has been introduced to safeguard it. So that for instance a drinking water source such as a well or spring is to be protected by a three-level safeguard zone: an *Absolute Safety Zone* close to the source, a *Respect Zone* depending on groundwater travel time, and a *Protection Zone*, ad shown in Figure 8. Those protection zones are defined on the basis of hydrogeological, hydrochemical and hydrological analysis; vulnerability to pollution is also taken into account (Figure 9). Specifically, springs protection zones correspond to the entire recharge area. Currently the "Absolute Guardianship Zone" and the Respect Zone have already been delineated in most cases, while Regions are establishing protected areas. In few cases protected areas have been already identified and protection measures are in force.

For example, in Emilia-Romagna Region, those protection measures are organised in a Regional Plan and are different in relation to the different features of the protected areas. They concern agriculture and cattle breeding activities (manure spreading, fertilisers and pesticides use), quarrying activities, urbanisation (sewage networks, waterproofing), industrial activities (also in relation to quantitative aspects), landfill location. Hazardous activities in relation to water quality must be specifically authorised.

Measures and rules have been discussed and modified through a participatory process in which public and private stakeholders (water companies, agriculture associations, industry representatives, environmental organisations and others) have been involved. Pollution indicators (e.g. NO3) have been selected and monitoring activities have been undertaken in the protected areas in order to check the effectiveness of the adopted measures. The possibility of introducing corrective actions during the implementation of the Regional Water Protection Plan have been foreseen.

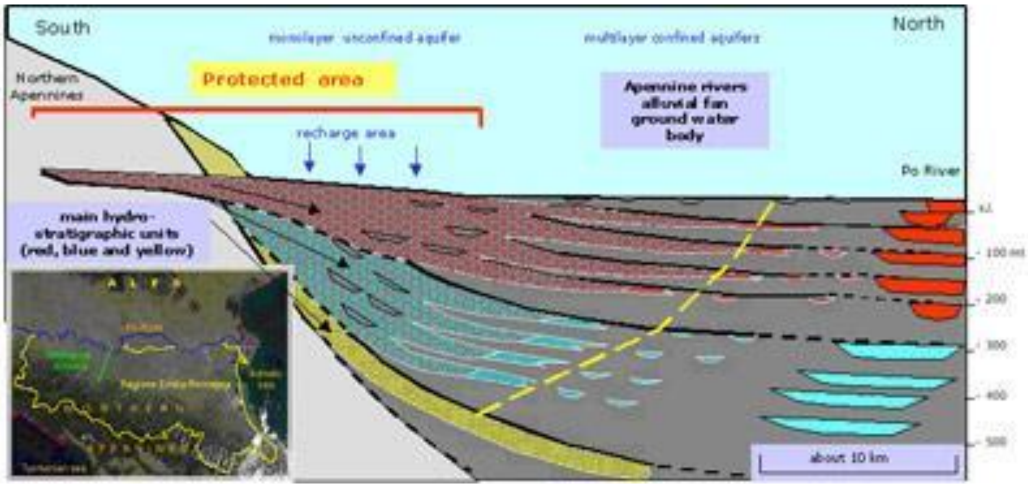

Figure 8. Location map and schematic cross section of the aquifers showing the protected areas for the "Apennine river alluvial fan" ground water body

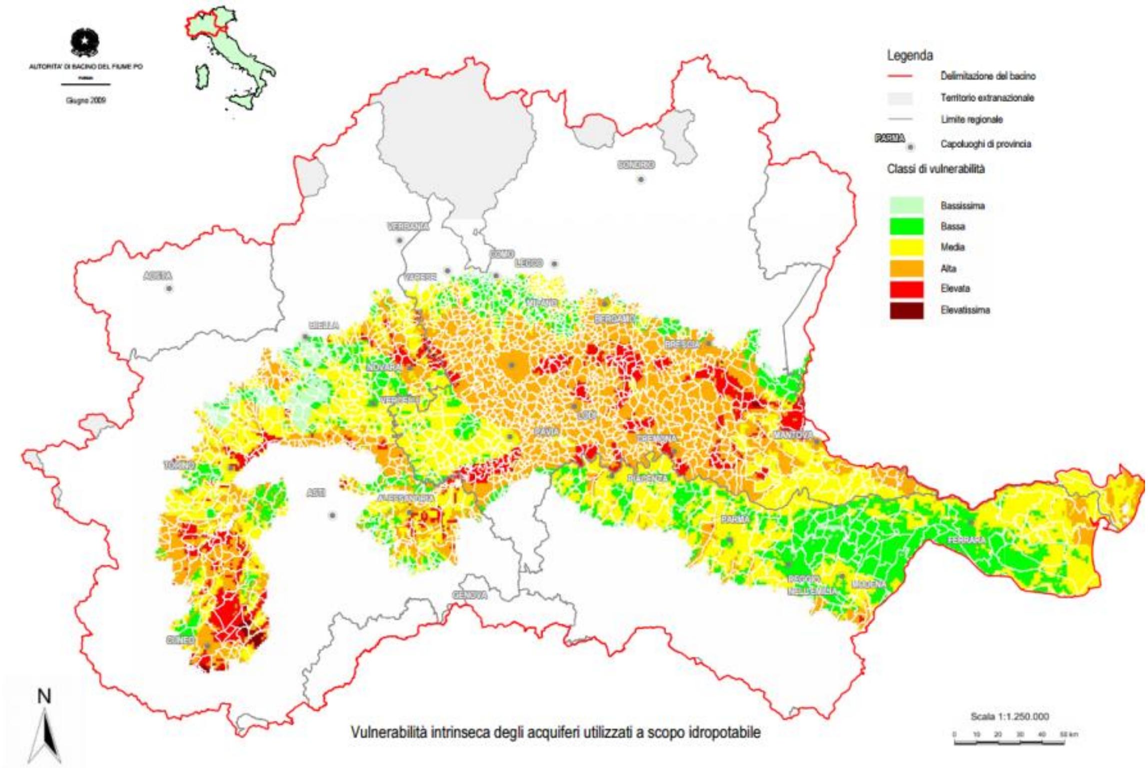

Figure 9. Natural vulnerability of aquifers suitable for drinking water

2.4. Flooding issue

In P-RBD 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 P-RBD is, are in charge of establishing the “Food Risk Management Plan” and the “District Hydrogeological Regulation Plan (PAI)”.

Main targets of these Plans are:

- identifying flood areas (Figure 10),
- 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,
    - defence of cities and metropolitan areas,
    - improve the awareness of flood risk.

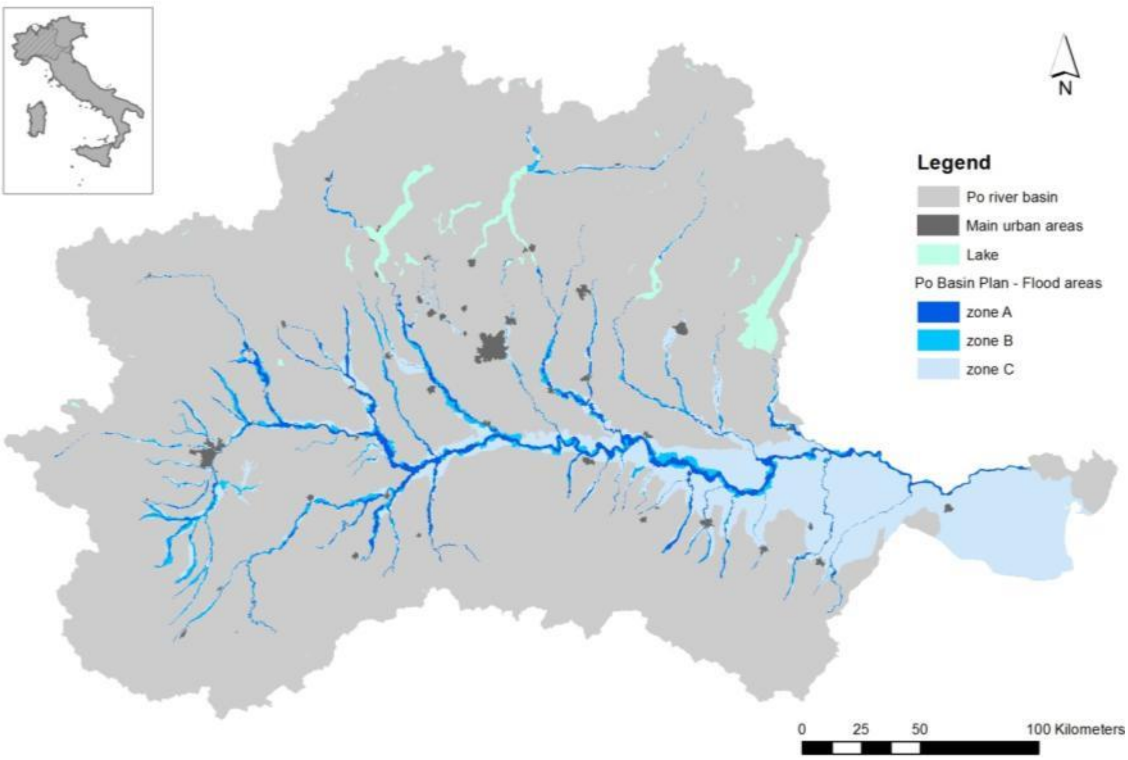

Figure 10. Flooding areas in P-RBD

Concerning the non-structural actions of the Flood Risk Management Plan, Regions included in P-RBD, in accordance with the Nationa Civil Protection Department, drown up the flood alerting system FEWS Po (Flood Early Warning System for the Po river basin) following the Directives of the President of the Ministers Council on 27.02.2004 and on 08.02.2013 concerning "Organization and functional management of the national and regional distributed alerting system for hydrogeological and hydraulic risk for Civil Protection".

2.4.1. Interrelations between drinking water and flood management

Whereas general flood impact and risk analysis methods focus on direct damage due to the effects of water on objects, indirect damages related to critical infrastructures are also associated with interruptions in services (for instance waterworks supply interruption).
Analysis of past flood data lead Regional and State managers to arrange flood defence and mitigation measures, flood forecasting, management of reservoirs; besides emergency management have been improved to respond more effectively. Additionally, quays and embankments have been strengthened to make flooding less likely. The potential impact of flooding has been reduced by protecting transformer stations from flood depths of more than one meter.
Also drinking water production plants need to be protected and prepared for floods, in order not to suspend the distributing service and to minimize disruptions. In case of flood another potential impact on drinking water systems could be the effects of rushing water, in terms of concentrations of faecal contaminants. For instance, Marcheggiani et al. showed a potential association between flood events and a range of water-borne infectious diseases, including legionellosis, salmonellosis, hepatitis A, and infectious diarrhea.
In particular, in the Po river basin case study, the management of the drinking water plant of Pontelagoscuro need always to cope with water quality characteristics, no matter the severity of the flood.

3. Best Management Practices

The present paragraph deal with best management practices in the P-RDB focusing on conflicts of interest between land use management and water protection.

It is preliminary important to consider that in the P-RBD, beside local, regional and national institutions, the main water management actors are: the Big Lakes Regulation Consortia, the Hydropower Reservoirs Managers, the Land Reclamation and Irrigation Boards and the Public Water Supply Companies.

3.1. BP: identifying vulnerable areas and Nitrile Vulnerable Areas

Vulnerable areas are designed on basis of field investigations and desk studies. According to Italian D.Lgs. 152/06, Environmental Code, the criteria for determining these zones are defined by the Regional Administrations in Water Protection Plans. Specific **measures are in place** directed at avoiding contamination of water resources. The general demarcation have been established on the basis of geological, hydro-geological, hydrological criteria. The vulnerable areas (Figure 11) are designed by Regional Administrations, local authorities and Water Services Regulation Authority during planning procedures, whereas monitoring plans are carried out by Environmental and Health Agencies.

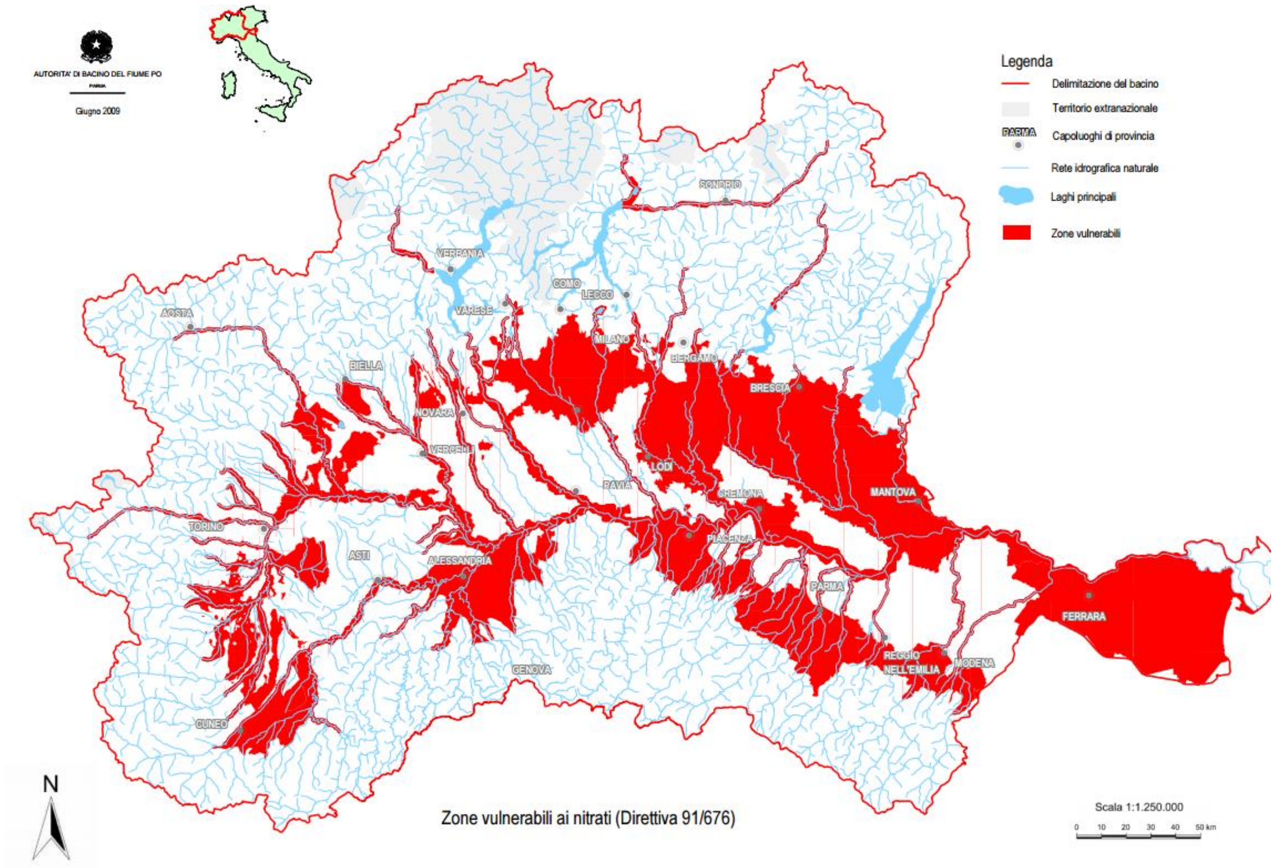

Figure 11. Vulnerable areas in P-RDB.

Measure advantages

- The vulnerable areas, defined by cartographic delimitation, are considered in the planning procedures and territorial management; in these cases local authorities must make provisions in protection zones in order to protect water resources;
- The Regional Environmental Agencies (ARPA/ARPAE/APPA) monitor compliance with the law and regulation requirements for the dispersion of sewage treatment sludge, waste water and livestock effluents;

Challenges

- reducing of fertilizers and phytosanitary products;
- enforcement of education and of the implementation of regulations;

3.2. BP: Identifying and providing Minimum Vital Flow

The Minimum Vital Flow (MVF) is a management tool designed to cope with critical situations that arise in river ecosystems due to large exploitation of natural discharges for civil, industrial or agricultural purposes, aimed to ensure a minimum hydrological component for the survival of local ecosystems downstream and along the river basin. Regional Regulations define procedure to evaluate the MVF in each river and introducing procedures for issuing public water-supply concessions in according with the Po River Basin Management Plan.
Water supply and water distribution are subject to the availability of water bodies resources and when a drought event is imminent or occurs, water intake must be limited or ceased.

Measure advantages

- Produce an effective and objective benefit to the water bodies hydrological regime;
- Manage and control of water consumption and protection of river or stream ecosystems;
- Mitigate the conflicts between upstream and downstream communities;
- Regulation governing concessions for public water abstraction.

Challenges

- Reducing exceptions to the quality targets of water bodies;
- Reducing derogations from regulation and concession acts requirements;
- Enforcing of education and of the implementation of regulations;
- the MVF is limited to the assessment of the minimum hydrological component, while it appears more and more important to move to the environmental flow (EF).

3.3. BP: technical regulation on water uptakes: the water intake directive

Water intake directive (*Direttiva tecnica contenente i criteri per la valutazione dell'impatto degli usi in situ e dei prelievi sullo stato dei corpi idrici superficiali e sotterranei ai fini del rilascio e del rinnovo si concessioni di acqua pubblica nel Distretto idrografico Padano*), included in the Po Basin Water Balance Plan, concerns an objective tool to evaluate an application for water concessions; when new water concession or a renewal application are presented, the Authority evaluates the submitted form and may decide to approve or reject it on the basis of a risk analysis. A water intake, in fact, represents a specific pressure on a water body state and an environmental risk analysis must be carry out using the "ERA" methodology (Exclusion, Repulsion, Acceptance).

Measure advantages

- Manage and control of water consumption and protection of river or stream ecosystems;
- Mitigate the conflicts between upstream and downstream communities;
- Manage and control water consumption and reduction in water utilizations.

Challenges

- Reconsider and balance water abstractions taking in account the effect of ongoing and future climate changes;
- Water Balance Plan for Po River Objective 2 requires a reduction of about 5% on basin scale of water for irrigation withdrawals taking into account the current discrepancies in water use and the farmers who put in place tools and procedures that allow water resource saving;
- Define an objective tool for the Authority with decision-making power able to manage water crisis conditions avoiding time losses and bureaucratic problems.

3.4. BP : IRRIFRAME and IRRINET projects

IRRIFRAME, at national scale, and IRRINET, for Emilia Romagna Region, are two web services, available also as application for mobile devices, able to support farmers in definition of optimum amount of water for irrigation according to the weather conditions, crops and soils in the area of interest.

Measure advantages

- Reductions in water resource wastage;
- Support farmers in definition of optimum amount of water for irrigation;
- Improvement of available information.

Challenges

- Enforce farmers education.

3.5. BP: Salt intrusion management and monitoring

The Po river delta is composed of 5 reaches: Goro, Gnocca, Maistra, Tolle, and Pila. They are affected by salt intrusion from the Adriatic sea, moving upstream especially during low flows periods. As the Po river serves as water supply for the agricultural activities in the area, it is therefore of utter importance to have a warning system, which issues an alert in case salinity threshold values are exceeded and provides salt intrusion length along the Po river delta reaches. The salt intrusion is computed by two numerical suites respectively based on the Sobek hydraulic numerical model, with its quality module DELWAQ, and the simplified salinity distribution analytical model (Savenije et Al., 2006).
The salt intrusion is also managed with mobile barriers installed in the Tolle and Gnocca branches, to prevent salt intrusion in the Po Delta branches. They operate a one directional opening in order to allow river-to-sea flow and to constraint the reverse one.

Measure advantages

- Salt intrusion observation and forecasts to support water managers in P-RBD;
- Reduce salt intrusion and the impact of saline wedge in the delta Po;
- Consider the variability of resources linked to water demands;
- The salt intrusion management is a component of the flood/drought alerting system FEWS/DEWS.

Challenges

- Currently, some barriers (Po di Tolle and Po di Gnocca) are working but they do not result sufficient;
- Further investments should be made but they should be covered by all communities and actors living/working in Po river basin and not in charge only of affected ones.

3.6. Voluntary agreements for water management: best practice in Po river basin district

3.6.1. BP: The Drought Steering Committee and DEWS (Drought Early Warning System)

Drought Steering Committee is a Multisectoral partnership that consists in a forum of major water users in River Po basin, initiated and presided by the Po River Basin Authority (P-RBA). It was firstly established in May 2003 to face a severe drought event in Po river Basin and then set up as a permanent institution. Its main scope is to manage water shortage on a basin level, enforces water restriction on existing water withdrawal across the district, and instructs water releases from the Alpine reservoirs and large regulated lake, assess needs and water consumption in the various sectors and address the rules for withdrawals and uses, including adaptation measures to climate change as well.

Drought Steering Committee manage a extensive monitoring network and uses the outcomes of numeric model system to manage the water balance and evaluate alternative water resources allocation, Figure 12. The numerical modelling system used includes fully-distributed physicallybased hydrologic model TOPKAPI (TOPographic Kinematic APproximation and Integration) and RIBASIM (RIver BAsin SIMulation Model) water balance model. TOPKAPI reproduces the hydrological behavior of the basin, including subsurface, overland and channel flow, infiltration, percolation, evapotranspiration and snow melt. The model outputs (simulated discharges) are the input for RIBASIM model, designed for river basin planning and management. Both models are fed with real-time precipitation and discharge data. The modelling framework also allows for forecasting over the next few weeks and up to season simulation.

The hydro-meteorological monitoring network consists of 600 water level gauges, more than 1000 rain gauges and more than 700 thermometers. The system also uses the daily updated data from the Italian Dams Registry (RID). The reservoir management rules are based on past observation data.

On 13 July 2016, a permanent network of "Observatories on water uses" has been established among all public and private stakeholders of national relevance. According to this network the Po Drought Steering Committee has the new role of Observatory on water uses in the P-RBD.

Measure advantages

- These measures was and are the result of cooperation and negotiated agreements and voluntary commitments, founded on long term experiences and territorial knowledge included in water balance and drought emergency management plans;

- DEWS Drought Early Warning System, is a decision support tool for management of water shortages during the drought spells and allow to face some difficult conflicts thanks to the evaluation of alternative water resources allocation in a river basin. The flexibility of its structure allows the evaluation of a large set of alternative options for water resource allocation, as well as for sensitivity and scenario analysis.

Challenges

- Available and reliable data collection taking in account the sensitive data;
- Implementation of indices/indicators/tools suitable to represent water availability (for instance "*siccidrometro*" and so on);
- Systematic and unified collection of data related to climatic, hydrological and water uses scenarios;
- Strategic proposals for seasonal water resource uses.

3.6.2. BP: The Flood Forecast Center for the Po River and FEWS Flood Early Warning System

the Po operational forecasting and modeling system for flood events on the Po river FEWSPO (Figure 13) was designed and implemented by the Environmental Agency of Emilia Romagna ARPA-ER on the base of the 2005 Agreement among the National Civil Protection (DPCN) the Interregional Agency for the Po river, the Po River Basin Authority, the Emilia-Romagna, Lombardia, Piemonte Valle d'Aosta and Veneto Regions. The FEWS is a pillar o for the National and regional Distributed Early Warning System Network for hydrogeological extremes, build according to the Civil Protection Directive on 27.2.2004 Directive. Successively the Civil protection Directive on 8.2.2013 established the Command and Control Unit for the Po river Floods, the Flood Forecast Center for the Po river, in charge to the Interregional Agency for the Po river supported by the Hydrology Unit of ARPA-ER , managing the FEWS PO system. Through FEWS PO it is possible to manage observed data (in situ and remote sensed), and forecasts obtained from meteorogical-hydrological- hydraulic simulation in order to early detect floods, their occurrence entity and characteristics in order to support Civil Protection System . The numerical modelling system used includes 3 chains of hydrologic and hydraulic model. Both models are fed with real-time precipitation, temperature and discharge data. The modelling framework also allows for forecasting up to 72 hours and up to 120 hours for ensemble simulations. The hydro-meteorological monitoring network consists of 600 water level gauges, more than 1000 rain gauges and more than 700 thermometers. The outcomes provides the information on the basis of which flood warnings can be issued and provided in time to allow a proper response by the responsible authorities. The modeling chain is completed by a number of scenarios simulating different possible operations of the flood control structure in real time to support the flood service management.

Measure advantage

- It is a regional and national guide for flood alert strategies;
- An early flood warning and flood management could minimize the risk of damage and casualties caused by a flood event.

Challenges

- Verification and validation of forecast models, tools and procedures;
- Manage and reduce the lead time, the time between the moment the warning is issued and the moment flooding starts. In fact, the fast flood propagation has pointed out the necessity of implementing specific modeling procedures allowing the forecast of rapid phenomena, for instance by more frequent runs of hydrometeorological chains when hydrological thresholds are reached or statistical decisional trees based decision support system.

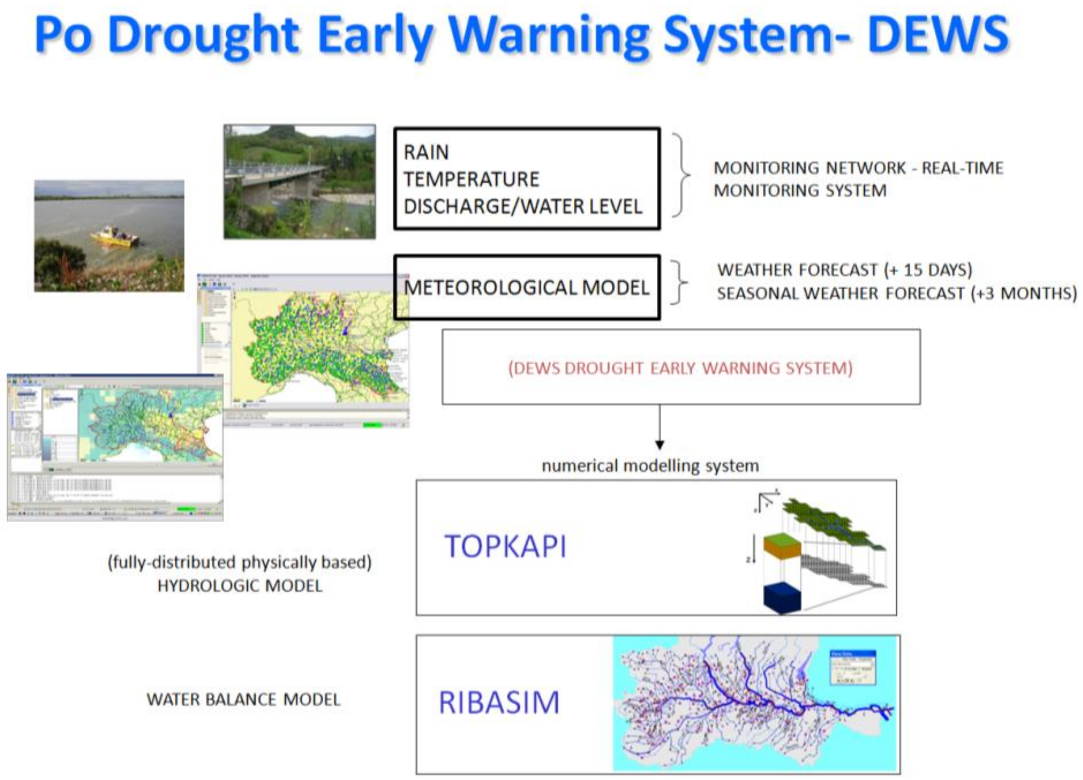

Figure 12. Po Drought Early Warning System.

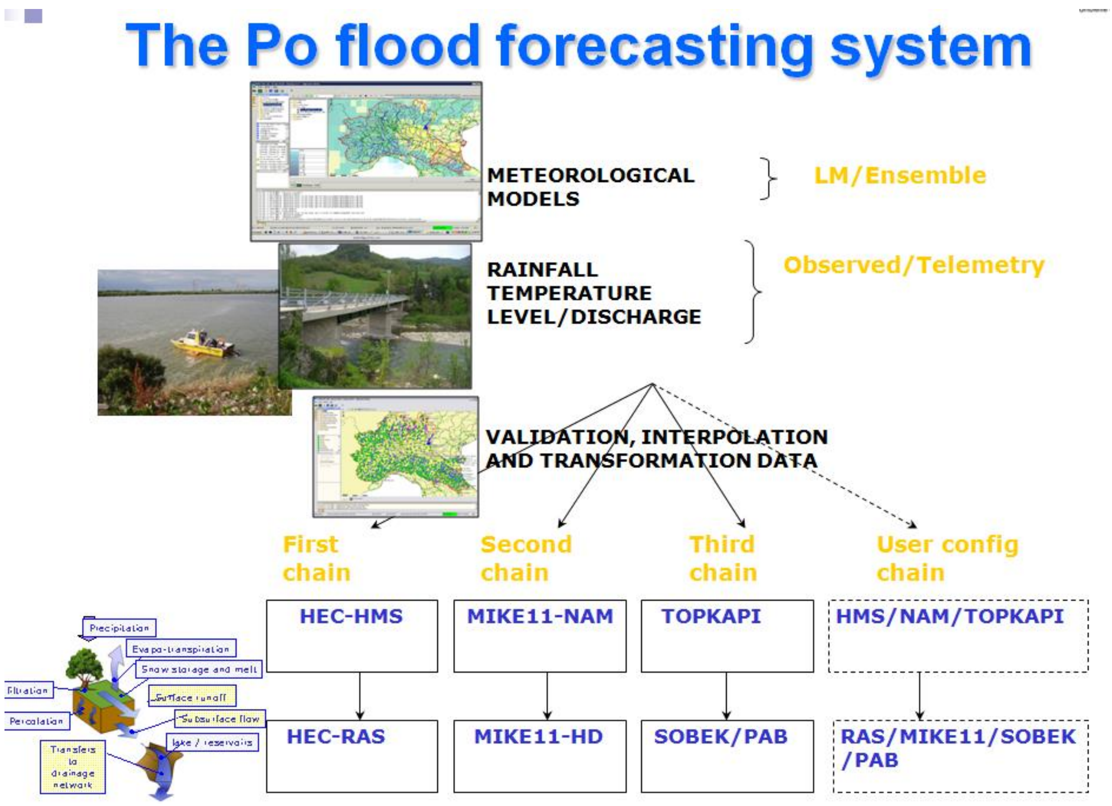

Figure 13. The Po flood early warning system FEWS.

4. Conclusions

P-RBD is the largest in Italy, it includes the territory of Piedmont, Valle d'Aosta, Lombardy, Emilia-Romagna, and portions of Liguria, Trentino, Veneto, Tuscany, French and Swiss territory as well. P-RBD territory represents an exceptionally varied reality besides being one of the main national economic force.

The P_RBD is rich of water resources but the increase of water consumption and climate change are affecting them and especially during drought events the conflicts among the users reach an extreme level. Only on a river basin level the optimal area for soil, subsoil and water protection actions can overcome institutional fragmentation and competence with unitary plans and an Authority with decision-making power able to manage water crisis conditions.

This is a starting point but not only stakeholders involved in technical issues but also communities, actors and not technical stakeholders in the area should be involved on the issues directly and indirectly associated to water shortage. In this perspective the main best practices briefly shown could be useful. For instance, the generalized utilization of IRRIFRAME and IRRINET could both improve the amount of available and reliable data collection on water usage, and entail remarkable reductions in water resource wastage or reconsidering the adoption of surface irrigation (flooding, furrows) that should be instead limited as far as possible. Moreover, the activities of the Observatory could represent a valuable option to address activities and actions like the need of reconsidering and balancing water abstractions along the river course in attempting to mitigate the conflicts between upstream and downstream communities, taking into account the effects of ongoing and future climate changes, as well.

Finally, it is necessary to highlight that climate changes could affect water shortage and induce a substantial worsening of current conditions, so that further investigation should be carried out.

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