PILOT ACTION 5 – ENZA BASIN
OUTPUT O.T3.7

WORK PACKAGE T3 - IMPLEMENTATION AND FEEDBACK - TOOLBOX VERIFICATION

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1. Introduction

Testing of the Toolbox beta version by project partners (PPs) in pilot actions (PAs) will provide:

- documented learning experience, where PPs from different countries and disciplines will verify the Toolbox applicability and
- an important communication tool where project results will enable important outreach and key post-project capitalization leverage supporting bottom-up participatory principles in water management planning processes, generally drafted by the Common Implementation Strategy for the Water Framework Directive (WFD CIS No.11).

The Toolbox will also be tested by stakeholders during training workshops and in the post-training implementation phase, when strategies will be discussed. These stakeholder interactions will enable clarification of needs and provide recommendations for Toolbox improvements (bottom-up approach) and for direct local and regional implementation of the Toolbox.

Project partners will guide the testing process in the pilot area n. 5 Enza basin, in Italy, with the aim of addressing major water related issues in the area, represented by floods events and related risks, and water scarcity events impacting in particular the agricultural sector.

2. Basic data about pilot action

Enza river basin is situated in northern Italy, mainly in Emilia-Romagna Region, and spans from the Apennines to the Po river, the Enza river being one of its right tributaries. The Enza river springs in the Comano municipality, in Tuscany region, and after few kilometres it forms the Paduli lake, close to the Lagastrello pass that separates Tuscany from Emilia-Romagna Region. The Enza river draws the border between the two emilian provinces Reggio Emilia and Parma nearly to the mouth, situated in Reggio Emilia province.

The Enza Valley is one of the most beautiful in the Emilian Apennine area, coupling environmental protected areas with historical and architectural monuments, mostly connected to Matilda of Tuscany. Different types of protected areas are present in the basin, ranging from a national park along the Apennine divide to EU Natura2000 sites, to regional protection areas that safeguard small “Ecological rebalancing areas” and/or landscapes.

Typical Apennines rock formations (Clay, Flysch, marl, sandstones) are at the origin of protected landscapes such as ravines and river gorges, and the river itself ranges from confined reaches through braided to meandering (and embanked) in the low valley.

The hydrographic basin can be considered as a rural territory placed between the two cities of Reggio Emilia and Parma.

Rural areas and urban settlements alternate, while around the Via Emilia (named after the ancient consular roman road of which the modern infrastructure follows the path) urban sprawling patterns dominate.

The Via Emilia separates the high plain area of the basin from the low plain, that close to the Po river is formed by reclaimed land once covered by Po river marshes.

Enza basin is characterized by the production of the world famous Parmigiano Reggiano cheese, produced with milk derived by cows fed for the majority with natural forage, cultivated in the area, that represents the most water demanding crop in the basin.

Beside forage, agricultural production is important for cereals, vegetables, beetroot.

In the low plain area, together with agricultural productions, are mainly concentrated industrial activities, mostly related to food-production and manifactures.

2.1. Geographical description

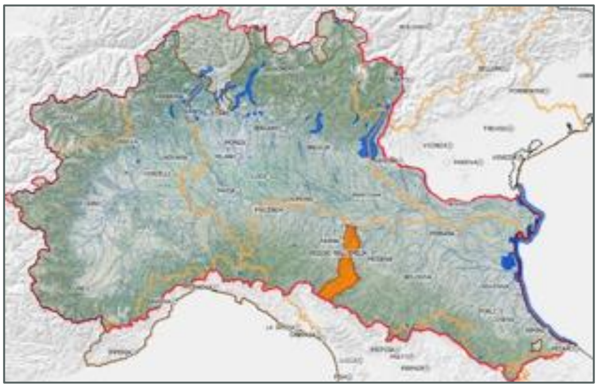
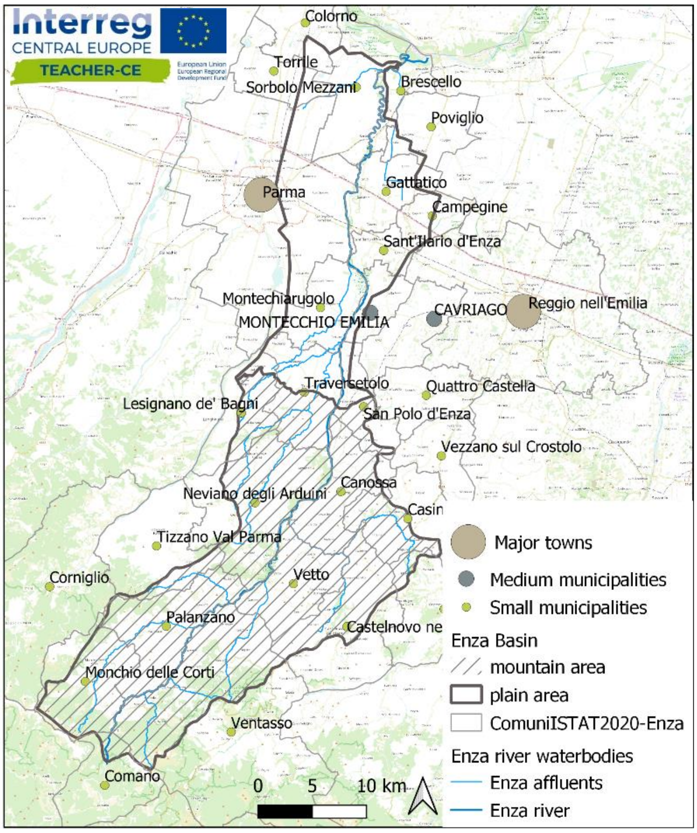


Fig. 1 – Overview of Enza basin in the Po river district (above) and detail of the basin with identification of mountain area (striped, to the South) and plain area to the North, and major towns.



The Enza River is a right tributary of the Po River, originating in the province of Massa Carrara, Comano Municipality (Tuscany), between the Giogo Pass (1.262 m a.s.l.) and Mount Palerà (1.425 m a.s.l.), crossing Emilia-Romagna region from the Apennine divide, which borders the hydrographic basin to the South, to the Po river.

The hydrographic basin confines to the east with the Crostolo and the Secchia river basin and to the west with the Parma river basin.

From the source up to Canossa the watercourse develops in a north-easterly direction, then mainly in a northerly direction to the opening in the plain, where it forms a vast alluvial fan with apex at S. Polo; subsequently it’s embanked up to confluence in the Po River, in Brescello.

From the source to the confluence in the Po River the riverbed has a length of about 112 km.

Enza river has numerous tributaries. The most important are: on the left side Cedra, Bardea, Termina and Masdona, on the right Liocca, Andrella, Lonza, Tassobbio and Cerezzola.

In the basin there are some natural and artificial lakes; the most important natural ones are the Ballano and Verde lakes, while among the artificial ones the Paduli Lake; there are also small artificial reservoirs that feed the hydroelectric plants of Rigoso, Rimagna, Isola Palanzano and Selvanizza. Overall, the reservoirs volume is approximately 7.1 million m^3.

The total area of the basin is 890 km^2 of which 583 (65% of total area) are made up of hilly and mountainous territory, and 307 (35% of total area) of plain territory.

There are 28 municipalities in this territory and there is a population of 146 990 inhabitants (ISTAT 2017) , 24% of whom are in the mountainous hilly area, while 76% live in lowland areas.

2.2. Climate characteristics

The climate of the Enza River Basin varies from Mediterranean, in the plain and hilly areas, to continental in the highest section close to the Apennine divide, though ameliorated by Mediterranean influences.

Several weather stations have been working in the last decades providing information about temperature, precipitation and additional weather forcing (https://simc.arpae.it/dext3r/). However, for the 30 years 1990-2019, using E-OBS[1] as reference dataset permits identifying the main climate features.

Temperature values follow a seasonal trend: they range from about 3°C during the Winter (December-January-February) at about 22°C during the Summer (June-July-August). In the intermediate seasons, values from 10° to 12°C are usually experienced. On average, the number of days for which maximum temperature exceeds 25°C (summer days) is about 90 while the number of days for which minimum temperature is below 0°C is about 59.

For what concern the precipitation values, the maximum seasonal cumulative value is observed in Autumn with about 350mm/season followed by Spring 250 mm/season. Lower values are usually observed in Winter (about 200mm/season) and, in special way, Summer (about 140 mm/month).

The mean value of maximum daily precipitation is about 60 mm/day at the basin scale.

Furthermore, over 1990-2019, the maximum time span of consecutive dry days is assessed equal to 36 days/year while for wet days, 8 days is the mean value.

It is worth stressing that such values are returned by the analysis of E-OBS gridded observational datasets. The reliability of the dataset is strictly related to the number of stations available in the area while the spatialization induces reductions compared to the weather observation points.

55% of rainfall transforms into runoff, while 45% infiltrates into the soil or goes back into the atmosphere through evapotranspiration.

2.3. Hydrology

2.3.1. Surface waters

The natural hydrographic network is made by the Enza river and its tributaries, for a total length of 264 Km, 190 km of which are situated in the mountain part of the basin.

Right main tributaries are: Cedra, Bardea, Termina, Masdone, Rio delle Zolle.

Left main tributaries are: Liocca, Andrella, Lonza, Tassobbio.

The hydrology of the Enza basin follows the pattern of precipitations: it has characteristics of a torrential regime with flood events during the autumn and spring periods, low-flow periods in winter and almost completely dry periods during summer. Total flow in June-July-August amounts to just 5% of the annual flow. Annual average discharge at the Sorbolo measurement station is 13,30 m3/s (period 2004-2009 and 2011-2013 and 2015-2018).

[1] Cornes, R., G. van der Schrier, E.J.M. van den Besselaar, and P.D. Jones. 2018: An Ensemble Version of the E-OBS Temperature and Precipitation Datasets, J. Geophys. Res. Atmos., 123. doi:10.1029/2017JD028200

The Enza plain hosts a rich artificial network that is 570 km long, used for irrigation and land reclamation purposes, having some of the channels used for both functions.

One of the most important artificial channels is the Enza Channel, realized in 1462 for irrigational purposes. It withdraws a maximum discharge of 8 m^3/s, that is rarely available during summer months. Downstrem the town of Ciano d'Enza there is a hydraulic work to separate the flow in two: one part irrigate the upper plain on the river right (Reggio Emilia Province), while roughly 40% passes under the Enza river to irrigate the parmesan part of the Enza basin, on the river left, through the Spelta Channel.

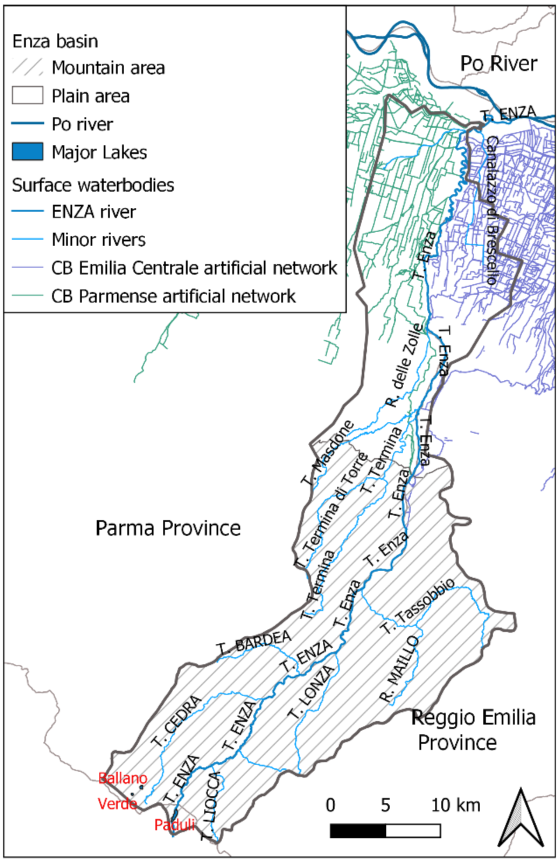


Fig. 2 - Hydrology of the Enza river. To the North it's clearly visible the dense artificial network. Marked with red names the three major lakes of the Enza basin.

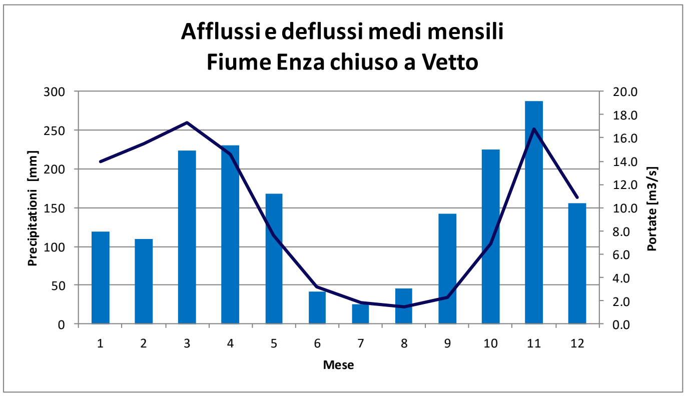


Fig. 3 – Monthly average precipitation and discharges in the mountain closed in Vetto

2.3.2. Flooding

The morphological and lithological characteristics of the basin, the shape and average steepness of the slopes, imply reduced time of concentration, with rapid formation of floods and high values of peak discharges. The morphological characters of the basin highlight that most of the tributary areas are included between the altitudes of 600 and 250 m a.s.l.; consequently, the meteoric inputs that cause higher hydrometric conditions for the last stretch of the Enza river are those characterised by maximum precipitation concentrated in the central part of the basin.

The Enza basin is thus prone to flooding events, and the whole area north of Montecchio Emilia to the confluence into the Po River has been identified as area at risk in the Po district Flood risk management plan[2]. Due to impacts of historical floods, the stretch of the river from Montecchio Emilia down to the confluence into the Po River is completely embanked, and just north of Montecchio Emilia flood retention basins have been realized for a total retention volume of 12 Milions cubic meters.

[2] Source: http://www.adbpo.it/PDGA_Documenti_Piano/PGRA2015/Sezione_A/Relazioni/Parte_4A/Schede_ARS_Distrettuali/18_Enza.pdf

The only discharge monitoring station in the basin with a significant data sequence is situated in Sorbolo, 19,6 km upstream the confluence of the Enza river with the Po river. The Sorbolo station has registered discharges from 1935 to 1959 and from 2004 until now.

Maximum peak discharge measured in the first period has been equal to 440 m^3/s (17 november 1940), while in the second period it reached the value of 521 m^3/s (20 January 2009).

The reference flood event for all planning activities in the basin has happened in September 1972, when short but heavy rains have invested the upper basin (400 mm cumulate rain between Paduli and Succiso), triggering many instabilities in the mountain areas. In the lowest part of the basin, flooded areas amounted to 5 km^2 in Parma province and 18 km^2 in Reggio Emilia province.

Peak discharge in Sorbolo during the 1972 event is between the highest ever measured and equal to 436 m^3/s.

As staten before, the two retention basins have been designed with reference to the 1972 flood event, and the whole embankment system is designed and built to control floods with peak discharges of 570 m^3/s downstream the two retention basins, given that the embankment system is correctly maintained and that the two retention basins work in reference conditions.

During the last flood in December 2017, Enza river breached its banks in the Brescello municipality, causing the flooding of an area of 650 ha, and thus reducing peak discharge in Sorbolo to 401,18 m^3/s, even if the water stage was the highest recorded and equal to 12,47 m over the stream gauge zero (at 23,76 m asl).

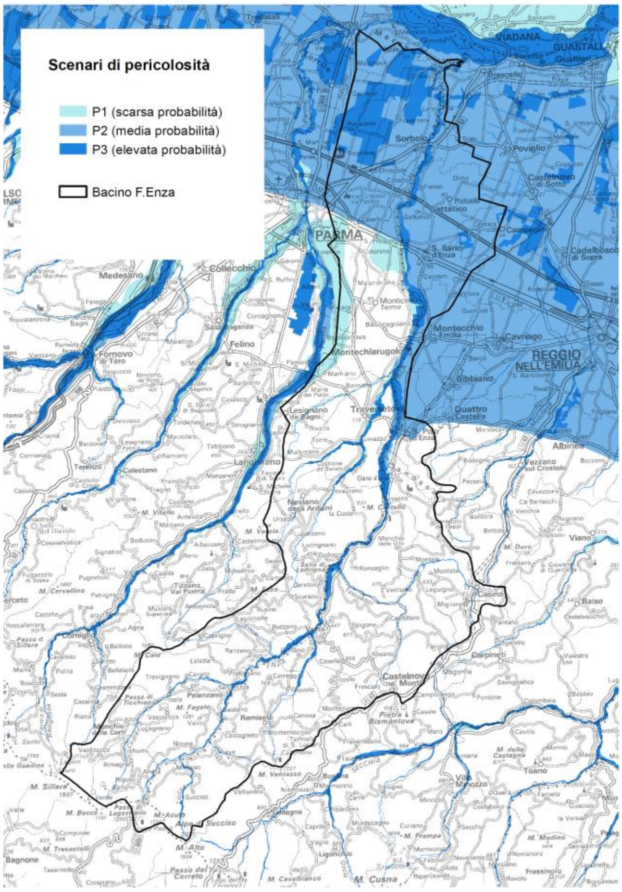


Fig. 4 – Flood Hazard map for the Enza basin after Directive 2007/60/CE: P1 (light blue) low probability hazard (extreme events); P2 (intermediate blue) medium probability hazard (return time longer than 100 years); P3 (darker blue) high probability hazard. Data from Po District Flood Risk Management Plan (http://www.adbpo.it/PDGA_Documenti_Piano/PGRA2021/Mappe_Rischio_2021/)

2.3.3. Heavy rain

Heavy rain events are strongly related to floods, and so the event of greatest intensity that hit the Enza Basin is that of September 1972, already described in paragraph 2.3.2.

Even during the flooding event of December 2017 (10-12 December) there have been intense precipitation patterns, subdivided in two main events: the first hit in particular the mountain part of the basin, while during the second heavy rains invested both the mountain and plain areas, causing a flood with hydrometric levels overtopping levees crest in Casaltone and subsequent levees breach and flooding.

During this meteorological event cumulated precipitations in 48 hours amounted to one sixth of the whole average annual precipitation.

In the mountain areas[3], cumulated precipitation heights measured at Lago Ballano in 48 hrs were equal to 360,6 mm, at Succiso equal to 441 mm.

2.4. Hydrologeology

The subsoil of the Enza basin is formed by a thick sequence of fluvioglacial deposits, that show the typical patterns of the Po plain, where coarse deposits in the high plain gradually turn into sands and then silty and clayey deposits in the low plain close to the confluence with the Po river.

The aquifer system related directly to the Enza river is tilted north-easterly with respect to the hydrographic basin, as it usually happens, thus extending outside its margins in that direction.

The Enza river formed a depositional fan from 400.000 years on, characterized by different depositional impulses, which increased in thickness due to subsidence and expanded laterally following a depositional axis roughly oriented S-SW – N-NE.

From 18.000 years ago the fan system has been deactivated and covered by finer alluvial deposits, while since 12.000 years ago the Enza river has had some avulsion episodes that caused its actual mis-alignment with respect to the buried alluvial fan.

The sequence of sedimentary deposits is detailed from the deepest to the shallowest, as follows (classified after the Emilia-Romagna Region subdivision in 3 aquifer groups A - the shallowest,B,C - the deepest, in turn subdivided in aquifer complexes):

- Quaternary Marine

  Stirone Torrent Unit (ATS) Lower Aquifer Group C (age > 940.000 y)

  Costamezzana Unit (CMZ) Upper Aquifer Group C (940.000 - 800.000 y)

- Lower Emiliano-romagnolo Sinthem (AEI): Aquifer Group B (650.000 - 400.000 y)

- Upper Emiliano-romagnolo Sinthem (AES):

  Monterlinzana Unit (AES 1) Aquifer Group A, Complex A4 (bottom at 400.000 y)

  Maiatico Unit (AES 2) Aquifer Group A, Complex A3

  Agazzano Unit (AES 3) Aquifer Group A, Complex A2 (top at 130.000 y)

  Villa Verucchio Unit (AES7) Aquifer Group A, Complex A1 (130.000- 18.000 y)

  Ravenna Unit (AES8) Aquifer Complex A0 (18.000 - present)

[3] Source: AdbPo study and https://www.arpae.it/cms3/documenti/_cerca_doc/meteo/radar/rapporti/Rapporto_meteo_20171208-12.pdf

The Enza fan deposits are characterized by the presence of a structural high, a buried tectonic structure active during quaternary marine sedimentation, that has strongly influenced the layout of sedimentary bodies. Two basins formed: a piggy back to the south and a foredeep one to the north.

The piggy back basin to the south is mainly occupied by aquifers B and C, while the foredeep external basin is occupied mainly by aquifers of A group.

Groundwater bodies hosted in this hydrogeological structure can be classified in four types, applied by Emilia-Romagna region and used in all planning tools, both at regional and district scale. From South to North (from high to low plain):

- free aquifer, hosted in alluvial fan coarse deposits, belonging to aquifer groups A and B; not much productive because of low thickness of these deposits: in the piggy back basin it can be found down to 10 meters deep, in the external (foredeep) basin it reaches depths of maximum 20 meters (upper part of A1 complex);
- upper confined aquifer, hosted in deposits of outer alluvial fan with mostly sandy deposits, alternated with finer deposits; in the external basin it belongs to the Aquifer Complex A1
- lower confined aquifer, hosted again in deposits of outer alluvial fan with mostly sandy deposits, alternated with finer deposits, but in deeper Aquifer complexes: in the piggy back basin it can be found in aquifer groups B and C, while in the external basin it's found in aquifer complexes A2, A3, A4, and just close to the slope of the structural high in aquifers B and C-
- hosted in fine sand deposits alternated to prevailing fines sediments, only present in the external basin, and representing aquifer complexes A1,A2,A3 and A4.

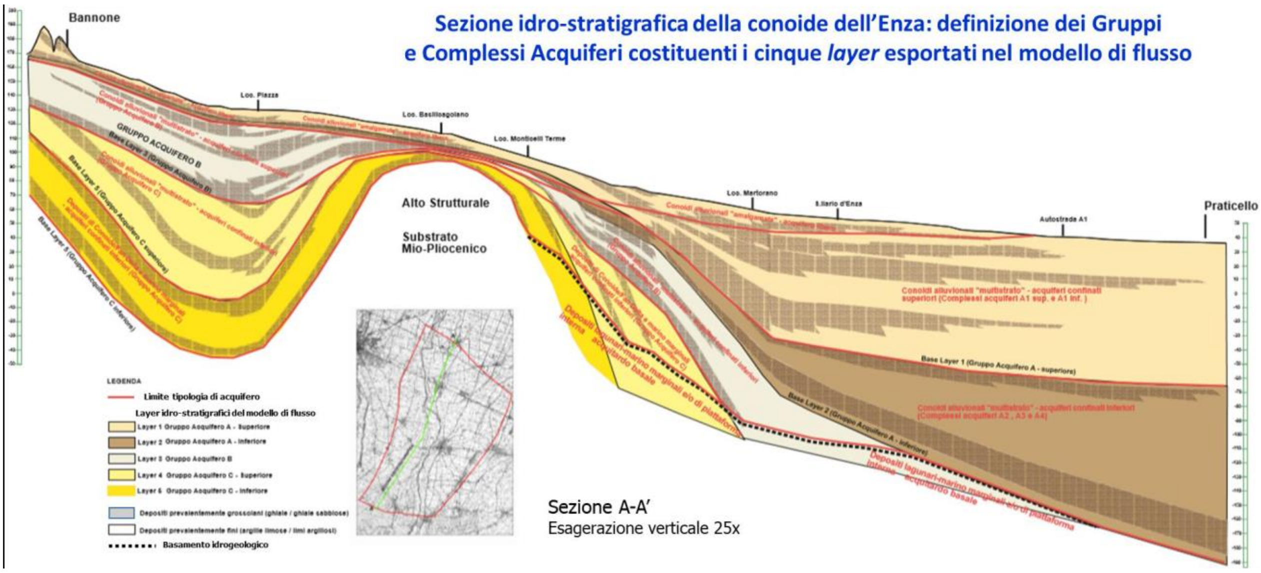
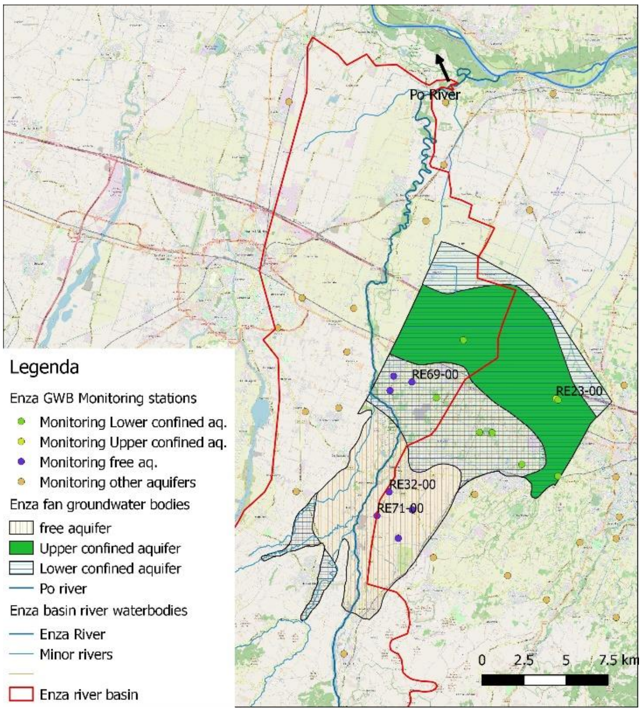


Fig. 5 – Hydrostratigraphic section of Enza alluvial fan – Outline of Aquifers individuated along a direction oriented SSW-NNE. Colours are as follows: brown shades identify aquifers of the A group, light grey identifies aquifers of the B group, yellow shades identify aquifers of C group.



Piezometry varies according to the different aquifers, but the Emilia-Romagna regional monitoring network supplies data over a period spanning from 1973 to date[4].

Here below (fig. 7) is reported an example for two different kinds of aquifers. In both cases the relation with precipitation is made evident. Groundwater bodies monitored and position of the stations is shown in Fig. 6.

Station RE23-00 monitors the upper confined aquifer, while the other three monitor the free aquifer.

Fig. 6 – Overlapping groundwater bodies individuated in the Enza alluvial fan.
Codes highlight stations reported in fig. 7.

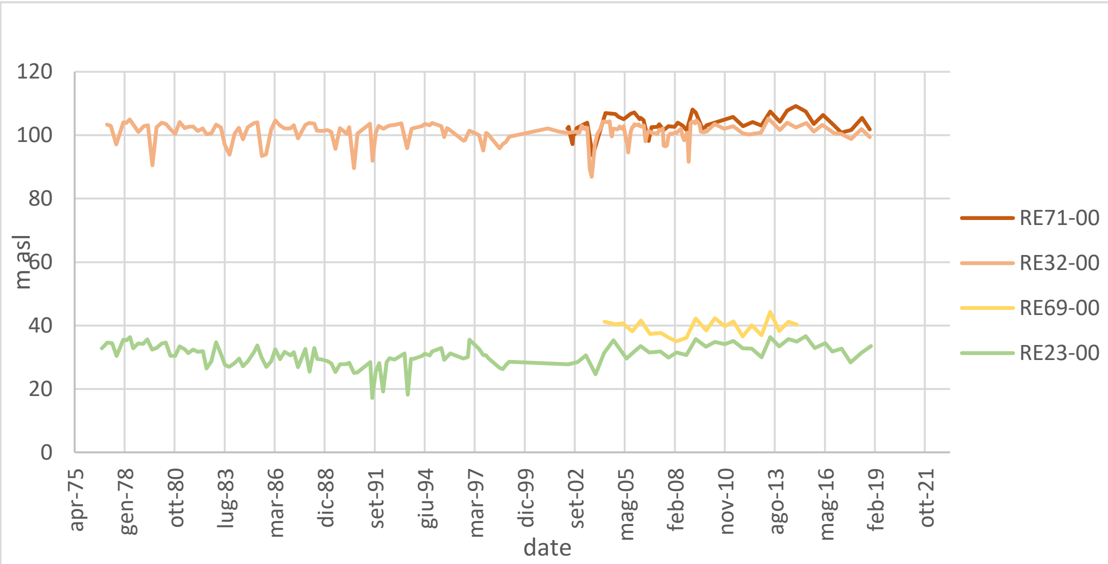


Fig. 7 – Piezometric levels of the free aquifer of the Enza alluvial fan and the upper confined aquifer. From upstream downwards: RE71-00, RE32-00, RE69-00, RE23-00.

This complex system stores roughly 3,4 Mld m^3 of exploitable water resources, intensely exploited for:

- Drinking use (see next chapter)
- Industrial use

[4] Source: https://dati.arpae.it/

- Irrigation for agriculture

Withdrawals from groundwater resources are not precisely known because of uncertainties related to the agricultural use, but they have been estimated to be roughly around 27,4 Mln m^3/y, with high variations depending on precipitations during summer than affect irrigational needs.

Industrial uses account for just 1,15 Mln m^3/y.

For what concerns the mountain area, there are several springs mainly used for drinking purposes.

At the time being an ongoing study is trying to evaluate future status of groundwater resources through application of climatic scenarios, but it's already clear that there will be a reduction in storage around 35%, consequent to changes in annual precipitation volumes and distribution.

2.5. Land use

Data on land use are extracted from Emilia-Romagna Region vectorial database, updated at 2017[5].

Numbers related to extension of different land use categories reported in table below correspond to the vector intersection between the Enza hydrographic basin and the Emilia-Romagna Region coverage.

Codes of land uses correspond to Corine Land Cover, in some cases integrated with more detailed information (e.g. code 1.4.3 – Cemeteries).

While urbanized areas are evenly distributed between the plain and the mountain areas of the basin, there is a sharp difference in distribution patterns for forested, cultivated and industrialized areas:

- around 78% of "1.2 - Industrial, commercial and transport units", occupying roughly 4% of the whole Enza basin, are concentrated in the plain area,
- 64% of "2.1 - arable land", occupying 35% of total Enza basin area, is concentrated in the plain area,
- 76% of permanent "2.3 – Pastures", covering around 10% of total Enza basin area, and 99% of "3.1 - forested areas", covering 34% of total Enza basin area, are concentrated in the hilly and mountain area.

[5] https://geoportale.regione.emilia-romagna.it/download/dati-e-prodotti-cartografici-preconfezionati/pianificazione-e-catasto/uso-del-suolo/2017-coperture-vettoriali-uso-del-suolo-di-dettaglio-edizione-2020

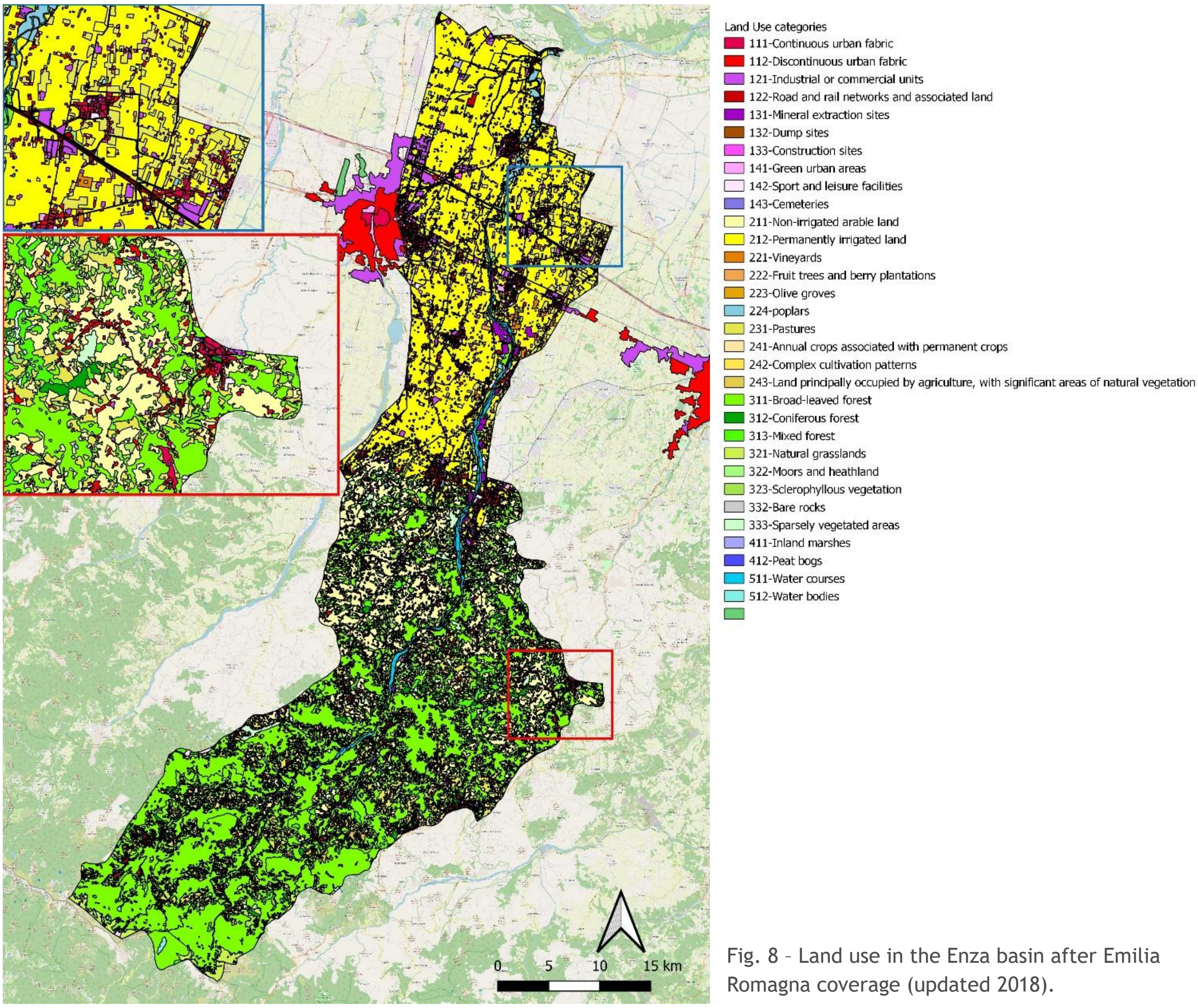


Fig. 8 – Land use in the Enza basin after Emilia Romagna coverage (updated 2018).

In the table below areas for single Corine Land Cover categories are reported, updated at 2017.

CLC_CODE	Description	Area Ha
111	Continuous urban fabric	1445,9
112	Discontinuous urban fabric	3041,3
121	Industrial or commercial units	2224,3
122	Road and rail networks and associated land	1392,6
131	Mineral extraction sites	334,7
132	Dump sites	24,4
133	Construction sites	179,6
141	Green urban areas	502,0
142	Sport and leisure facilities	375,2
143	Cemeteries	33,7
211	Non-irrigated arable land	10306,8
212	Permanently irrigated land	21140,4
221	Vineyards	416,8
222	Fruit trees and berry plantations	83,7
223	Olive groves	1,1

CLC_CODE	Description	Area Ha
224	poplars	375,1
231	Pastures	8342,7
241	Annual crops associated with permanent crops	120,9
242	Complex cultivation patterns	101,3
243	Land principally occupied by agriculture, with significant areas of natural vegetation	994,7
311	Broad-leaved forest	28472,4
312	Coniferous forest	473,3
313	Mixed forest	1148,8
321	Natural grasslands	731,4
322	Moors and heathland	33,4
323	Sclerophyllous vegetation	2826,3
332	Bare rocks	175,4
333	Sparsely vegetated areas	1227,3
411	Inland marshes	63,4
412	Peat bogs	3,0
511	Water courses	1913,4
512	Water bodies	126,4

2.5.1. Forestry

Emilia-Romagna region has produced an inventory of forested areas, subdivided by provinces, municipalities, and “inventory units”, based on aerophotogrammetric and survey data. It has been produced at the end of 2006, and it’s based on data gathered in the decade 1984-1994. Based on these data, it has been produced a regional plan for management of forested areas for the period 2014-2020[6].

The inventory unit that covers our pilot area is made of two basins: Enza and Crostolo (bordering the eastern side of Enza basin), and so data on detailed land use of Emilia-Romagna Region, already represented in fig. 8, have been used to describe distribution patterns of forested areas, reported in the table below. These data are updated at 2017.

Forest type	Area (Ha)
Beech dominance	8.770,57
Oak, hornbeam and chestnut dominance	19.379,29
Willow trees and poplars dominance	216,81
Lowland forests with dominance of english oak and ash	23,34
Chestnut orchards	35,52
Ruderal scrubs	46,87
Fir	473,34
Fir and broadleaf trees mixed forests	1.148,79
Highland meadows and moors	731,41
Bushes and shrubs	33,43

[6] https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/foreste/pianificazione-forestale/piano-forestale-regionale

Forest type	Area (Ha)
Evolving bush and shrub vegetation	2.701,94
Recent reforestation	124,33
Other sparse vegetation areas	570,51
Total	**34.256,15**

Forested areas are mostly concentrated in the hilly and mountainous areas of the Enza basin, and they show an expanding trend since the end of World War 2, due on one side to reforestation activities carried out in the second half of 20th Century, on the other side on natural expansion of woods on abandoned pastures and cropped areas.

The dominant element of forested areas are the extensive beech woods that cover the mountain slopes, sometimes alternating with reforestation of conifers and chestnut trees, with meadows and pastures in the gently sloping areas. The beech forest at lower altitudes forms mixed woods with hornbeam, ash, field maple, hazel, dogwood and hawthorn, while at higher quota the beech prevails, with few specimens of sycamore maple, rowan and mountain laburnum.

2.6. Protected areas

Enza basin is rich in biodiversity and thanks to its rural predominant character it has been possible to preserve different habitats and biotopes, so there are many protected areas of different kinds, from Nature2000 areas to Italian national parks, to regional protected landscapes and other protected areas as requested by EU directives as the Nitrates Directive. Often different kinds of protected areas partially overlap.

14 areas inside the basin are designated as Special areas of Conservation (SAC), of which four are designated even under Bird Directive as Special Protection areas (SPA). 1 area is designated both as Site of Community Importance (SCI) and as SPA[7].

Managing authorities are shown in table below.

Identifier	Name	SCI-SAC	SPA	Managing authority
IT4020020	Crinale dell'Appennino parmense	SIC	SPA	Managing Authority for Parks and Biodiversity - Western Emilia; National Park Appennino Tosco-Emiliano; Lucca Carabinieri for Biodiversity
IT4020027	Cronovilla	SAC	SPA	Emilia-Romagna Region
IT4020015	Monte Fuso	SAC		Managing Authority for Parks and Biodiversity - Western Emilia; Emilia-Romagna region
IT5110003	Monte Matto - Monte Malpasso	SAC		National Park Appennino Tosco-Emiliano; Tuscany Region
IT5110004	Monte Acuto - Groppi di Camporaghena	SAC		National Park Appennino Tosco-Emiliano; Tuscany Region

[7] https://www.minambiente.it/pagina/sic-zsc-e-zps-italia

Identifier	Name	SCI-SAC	SPA	Managing authority
IT4030024	Colli di Quattro Castella	SAC		Emilia-Romagna Region
IT4030022	Rio Tassaro	SAC		Managing Authority for Parks and Biodiversity - Central Emilia
IT4030023	Fontanili di Gattatico e Fiume Enza	SAC	SPA	Emilia-Romagna Region
IT4030013	Fiume Enza da La Mora a Compiano	SAC		Managing Authority for Parks and Biodiversity - Central Emilia; Emilia-Romagna Region
IT4030014	Rupe di Campotrera, Rossena	SAC		Managing Authority for Parks and Biodiversity - Central Emilia
IT4030007	Fontanili di Corte Valle Re	SAC		Managing Authority for Parks and Biodiversity - Central Emilia; Emilia-Romagna Region; Reggio Emilia municipality
IT4030008	Pietra di Bismantova	SAC		National Park Appennino Tosco-Emiliano; Emilia-Romagna Region
IT4030001	Monte Acuto, Alpe di Succiso	SAC	SPA	National Park Appennino Tosco-Emiliano;
IT4030002	Monte Ventasso	SAC	SPA	National Park Appennino Tosco-Emiliano; Emilia-Romagna Region
IT4020023	Barboj di Rivalta	SAC		Emilia-Romagna Region

In the upper part of the basin is situated the national park Appennino Tosco-Emiliano, which is extended for 26.149 ha across the divide and between Tuscany and Emilia-Romagna Regions. It's partially overlapped by 7 Natura2000, 6 SAC and one SCI areas.

Along the Enza river there are 3 Natura2000 protected areas, which from upstream are: "Fiume Enza da La Mora a Compiano", "Cronovilla", and "Fontanili di Gattatico and fiume Enza"[8].

The "Fiume Enza da La Mora a Compiano" protects the landscape of about 13 km of the river Enza, in the hilly area: there are no specific protection restrictions except that linked to the local landscape, however this is one of the most representative torrential river stretches of the hilly-submontane continental area of the north Apennine side. It hosts 15 habitats of community interest, of which four are priority ones.

The Cronovilla area is important for habitats related to humid areas (even if of anthropic origin) but mostly as migration flyway along the route Tirrenian area - Northern Europe.

The "Fontanili di Gattatico e fiume Enza" protected area, together with "Fontanili di Corte Valle Re" (even if this one is not along the Enza river) are important for the conservation of particular habitats related to the outflow of groundwater that marks the passage from the high plain hydrogeological structure, with phreatic undifferentiated aquifers, to the low plain where the presence of finer deposits originates a complex multi-layered structure. "Fontanili" were much more diffuse and spread throughout the whole Po plain, but with overexploitation of groundwater resources they have nearly disappeared. They originate particular habitats related to constant conditions for T and quality of the outflowing water.

[8] Details about protected areas from: https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/aree-protette/aree-protette-in-er

Another type of protected area is represented by "Protected landscapes", characterized by the equilibrium between natural and anthropic elements gained through the centuries, together with panoramic values. For example one of this protected areas partly included in the Enza basin is the "Collina Reggiana - Terre di Matilde" (Reggio Emilia hill and Matilde territory).

Another important protected areas related to TEACHER project is represented by Nitrates Vulnerabile Zones, that have been recently expanded in Emilia-Romagna Region following the outcomes of the infringement procedure. This expansion impacts Enza basin too, with the inclusion of fluvial bands and drinking wells and springs respect areas and other minor areas into the NVZ.

At the time being area designated as NVZ in the Enza basin amount to roughly 280 km^2; to the biggest original NVZ 285 km^2 large, 50 drinking water respect areas have been added, and the area corresponding to the Enza fluvial band, that is roughly 7 km^2 large[9].

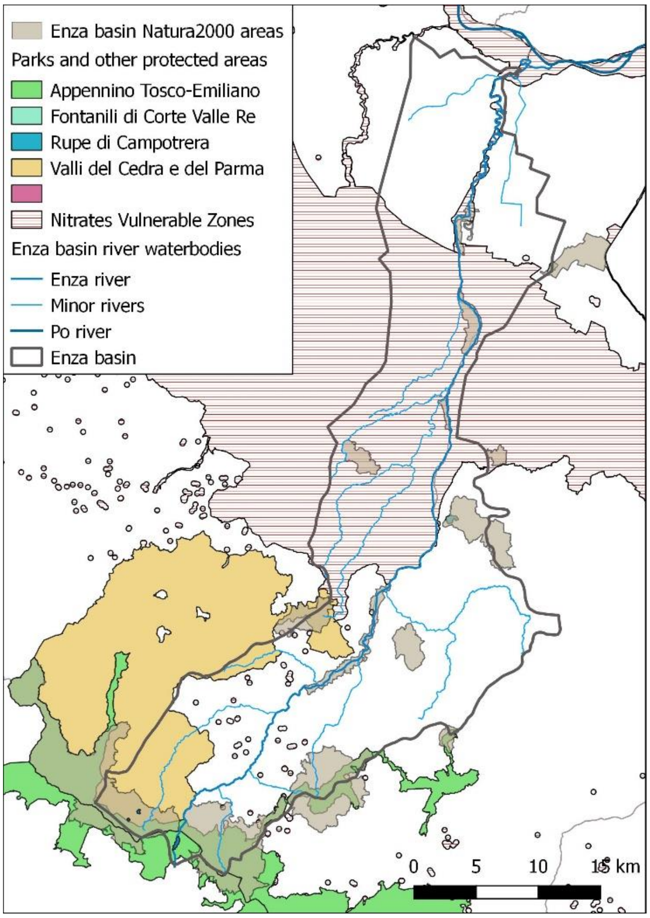


Fig. 9 – Protected areas in the Enza basin. Natura 2000 sites are in pale brown to show the overlapping with national and regional designated protected areas. Vulnerable zones are also represented, even in the mountain part of the basin (to the South), as respect areas around intakes of drinking water.

2.7. Drinking water sources and protection

The alluvial fan represents the main recharge area of the aquifers, through direct infiltration of precipitations and riverine water, favoured by the coarse deposits. For this reason, it is also the most vulnerable area of the system, that is, the one with the greatest natural sensitivity to the introduction of any polluting elements. From the qualitative point of view, best waters are potentially those residing in the high plain free aquifers; moving downstream the change in sediments and thus in the hydrogeological structure, as already seen in paragraph 2.4, cause slower groundwater circulation, longer residence times,

[9] Source: Po river basin management plan https://pianoacque.adbpo.it/progetto-di-piano-di-gestione-2021/

with reactions taking place between water and hosting sediments/rocks, that progressively worsen the state of the deep water, making them unsuitable for drinking use due to natural phenomena.

In the Enza basin drinking water supply is provided by springs in the upper basin, but for minor amounts, and for the majority by wells. Two river water bodies of the Enza river are indicated as used for drinking water supply, with code IT080118000000006-1ER and IT080118000000004_5ER. In this case drainage galleries are built to intercept sub-riverine groundwater, benefiting from bank filtration.

The porous groundwater bodies of the Enza alluvial fan are all indicated as groundwater bodies for drinking water use in the Po river district Management Plan. In the mountain area other groundwater bodies have been individuated in fractured rock formations, from which springs originate that are fundamental for drinking water supply in those areas.

List of groundwater bodies of the Enza basin that supply on average more than 10 m3/d or more than 50 persons for drinking use.

Name oft he groundwater bodie	Eu ID oft he GWB	Type of aquifer
Alluvial fan Parma-Baganza - phreatic	IT080080ER-DQ1-CL	Quaternary depression alluvial deposits
Alluvial fan Enza - phreatic	IT080090ER-DQ1-CL	Quaternary depression alluvial deposits
Alluvial fan Parma-Baganza - upper confined	IT080360ER-DQ2-CCS	Quaternary depression alluvial deposits
Alluvial fan Enza – upper confined	IT080370ER-DQ2-CCS	Quaternary depression alluvial deposits
Alluvial fan montane e Sabbie gialle	IT080650ER-DET1-CMSG	Plio-quaternary detrital formations
Alluvial fan Parma-Baganza – lower confined	IT082360ER-DQ2-CCI	Quaternary depression alluvial deposits
Alluvial fan Enza – lower confined	IT082370ER-DQ2-CCI	Quaternary depression alluvial deposits
Apennine Valleys deposits Taro-Enza-Tresinaro	IT085030ER-AV2-VA	River alluvial deposits in mountain valleys
M Marmagna - M Cusna - M Cimone - Corno alle Scale - Castiglione dei Pepoli	IT086050ER-LOC1-CIM	Local aquifers
M Fuso - Castelnovo Monti - Carpineti	IT086190ER-LOC3-CIM	Local aquifers
M Ventasso - Busana	IT086200ER-LOC3-CIM	Local aquifers
Ramiseto	IT086210ER-LOC1-CIM	Local aquifers
Corniglio - Neviano Arduini	IT086220ER-LOC1-CIM	Local aquifers
Calestano - Langhirano	IT086230ER-LOC1-CIM	Local aquifers
Bosco di Corniglio - M Fageto	IT086460ER-LOC1-CIM	Local aquifers

Actual volumes for drinking use are as follows[10]:

- Ca 26 Mln m3/y from groundwater
- 1 Mln m3/y from springs
- 2,5 Mln m3/y from surface water

[10] Source: https://adbpo.gov.it/studio-enza/

In the Enza basin, as well in the whole country, every water intake structure has a "Total protection area" defined as a buffer of 10 m width around it, surrounded by a "Respect area" where there are limitations in possible activities and land use.

In addition to this, protection areas for drinking water resources must be identified, which contain resources already used for drinking purpose, or that could be in the future.

These drinking water resources protection zones must include groundwater bodies recharge areas, springs and reserve areas.

Emilia-Romagna region has individuated four types of protection zones, which are all present in the Enza basin:

A: direct recharge areas, generally close to the foothills, overlying a phreatic monolayered aquifer directly fed by infiltration;

B: indirect recharge areas, connecting A areas and the plain, overlying a slightly confined system where a shallow phreatic aquifer overlies a semi-confined aquifer connected by vertical drainage;

C: areas where surface runoff prevails and can be considered as collectors of runoff to recharge areas A

D: areas related to rivers where they are connected to groundwater, and especially where rivers recharge groundwaters.

At national level, with Ministry Decree 14 June 2017 which takes into Italian legislation Directive 1787/2015/CE, Water Safety Plans have been introduced to ensure the good quality of drinking water: they will have to take protection measures and controls over the whole supply chain, from the intake point, to the treatment to the distribution network to the end-user. At the time being they are still under preparation, deadline being 2025.

3. PA issues concerning TEACHER-CE topics

The Enza basin is a small basin where different issues related to water resources have impacts on both human activities and safety and on the environment.

Main impacts concentrate in two opposite issues: droughts, affecting mostly the agricultural sector, and floods, affecting the safety of human settlements and infrastructural system, and the industrial sector.

But other issues concerning TEACHER-CE topics are still relevant so we submit a short description for all of them.

3.1. Heavy rain

Heavy rain events are becoming more common in Italy and the Enza basin follows the same trend.

During the last flood event dated 08-10 december 2017, in the mountain area of the basin peak rain intensities have reached values higher than 24 mm/h.

Impacts of heavy rain events, apart from being the cause of floods, see next paragraph, can cause urban flooding due to inadeguacy of the sewage system network, and much more landslides in the hilly-mountain area.

Measures in place are related to flood risk reduction and are shortly described in the next paragraph.

3.2. Floods

The Enza basin, in its portion from Montecchio Emilia down to its confluence in the Po river, is a critical node for flood risk historically identified in planning tools at basin level.

About a third of the basin municipalities are affected by flooding hazard from high to very high; these are the municipalities that are located along the stretch downstream of San Polo d'Enza, up to confluence in Po.

Measures in place are listed in the recently updated Programme of Measures of the Po Flood Risk Management Plan (EU Dir. 2007/60/CE), some of which are specific for the Enza basin while others relate to the whole Emilia-Romagna Region territory:

- Implementation of the dykes along the Enza river, through seismic checks, tests of stability and resistance during flood events, update of their structure and height to new flooding scenarios
- Improvement of the surveillance systems and maintenance programs of dykes and reclamation channels
- Maintenance of the Enza water retention basins (storage capacity 12 Milion m3)
- Maintenance of the riparian vegetation to guarantee full downflow capacity and improve ecological functionality and landscape quality
- Restoration of alluvial plains in most eroded stretches, to reconnect alluvial plains to the active riverbed and reduce river channelization
- Increase knowledge through new accurate surveys (realization of a new detailed DTM in particular for the hilly-mountain area pf the basin)
- Preparation of the Enza river sediment load management plan
- Management of a regional alert system, based on a website (https://allertameteo.regione.emilia-romagna.it/) and an organisation and functional document where procedures are set to evaluate risks, communicate them to the population, and actions are individuated for each type of risk, together with risk thresholds
- Development of a bidimensional hydraulic model to study the flood events dynamics and evolution in residual risk scenarios following levees breach
- Application of hydraulic invariance methods to landuse planning tools from regional to local scale, from Montecchio Emilia to the confluence of the Enza into the Po river
- Study and design the adaptation of existing infrastructures (e.g. bridges) to updated flood scenarios
- Improvement of monitoring networks to evaluate flood risk
- Development of a “risk culture” between citizens, through dissemination material on description and understanding of flood events and how to auto-protect in case of risk, and through development of local Civil Protection plans, actively involving the citizens
- Strengthening of the pumping system in the artificial reclamation channels network to increase safety from flooding

3.3. Drought

One of the most important economic features of the Enza basin lies in its agricultural activities, with the production of Parmigiano Reggiano playing the major role. This product relies on permanent pastures that are surface irrigated, thus increasing water demand for agriculture.

The agricultural system is fed by the Enza river through the Enza Channel, partially by groundwater, and in the downstream territories is fed by the Po river.

Acquifers belonging to the Enza alluvial fan are mainly fed from the river itself, and from direct infiltration of precipitation in the recharge area.

Climate change impacts are causing increased frequency of extreme events, and in summer water scarcity events are common.

Measures in place are both organisational and structural.

At national level a modelling system (www.irriframe.it) has been developed to support farmers in improving the irrigation techniques through continuous update of meteorological data, coupled with detailed data on type of soils and water demands of different crops. Outputs of this model help farmers individuate the exact amount of water needed and the best moment to irrigate.

Water demands for irrigation are nearly completely managed by Irrigation and reclamation waterboards, that organize shifts in irrigation, based on farmers demands and on characteristics of the network of irrigation channels, that optimise the use of water resources even through re-use from upstream downwards.

Where possible, irrigation systems have been moved to more water saving ones, but still there's discussion about irrigation techniques for permanent pastures supporting the production of Parmigiano Reggiano cheese.

From the structural point of view, projects are already available to maintain and upgrade existing weirs on the river Enza to create small, temporary reservoirs supporting irrigation in dry periods.

3.4. Forest management

Though this issue has been chosen as not relevant for the PA in the frame of the TEACHER project, nevertheless it's reported for information that there is a regional forestry management plan for the period 2014-2020, reporting an update of forested areas status, and measures to ensure sustainable management and at the same time conservation in the long term, improving resilience of these areas to climate change impacts.

Issues and measures are identified at regional scale and can be therefore considered as valid in general fo the Enza basin territory.

Relevant to the TEACHER project topics and to what emerged during the first Italian workshop are the following measures:

- Improve extension of forested areas in the plain part of the Region
- Improve forestry management to reduce hydrogeological risk
- Promote initiatives and actions for the acknowledgement of ecosystem services, even from an economic point of view
- Promote communication and education for active sustainable management of forested areas.

3.5. Drinking water sources protection

As already reported in paragraph 2.7, every drinking water intake is directly protected through "Total protection areas" which in turn are surrounded by a "Respect area", that can be defined with travel time and hydrogeological methods. There is an "inner" (restricted) zone which is 60 days travel time of pollutant to intake point, and a "larger" zone which is 180 or 365 day travel time of pollutant to intake points.

"Total protection areas" have been included, as seen in paragraph 2.6, in Nitrates Vulnerable Zones.

Other measures are reported in the recently updated Po river district management plan after Dir. 2000/60/CE:

- Connection of isolated settlements to efficient wastewater treatment plants through improvement of sewage networks
- At Emilia-Romagna regional scale the measure "Improvement of wastewater treatment plants to EU Directive 271/91/EEC requirements" must be applied, Enza basin included.
- Preparation of plans to control pollutants input from urban runoff

4. Testing of the TEACHER-CE toolbox CC-ARP-CE

The testing of the TEACHER – CE toolbox CC-ARP-CE has been carried out by several in vivo and hybrid events between July and November. It permitted retrieving several feedbacks, remarks and suggestions on the different parts of the toolbox. Two main sections highly interested the Participants: the process for sharing and analysing ISSUES and the identification of the related MEASURES and (2.) the RANKING of the measures using the Analytical Hierarchy Process (AHP).

The Teacher Toolbox has been tested by the Italian project partners AdbPo and CMCC, and by the Focus Group in July. The observations which are provided to improve functionality and usability, have been grouped by sub-pages and summarized below.

All comments refer to the version of the Toolbox available in November, the current version is already improved with respect to these considerations.

Home page

In general, it emerged that the home page should be integrated with references to what every single parameter is and represents (e.g.: what field of action/issue/type of measure/land use mean); moreover, a brief introduction of the project would be useful for those users who must deal with the Toolbox for the first time or, in any case, to clarify the concepts. As for the Toolbox usability, in the description of the sub - pages it could be useful to have clickable links for the names of the Toolbox sub-pages to facilitate the navigation. As this tool could be used by a wide range of users, translation of the home page could be useful. Finally, when the user logs in, "undefined undefined" appears instead of the user name and the Toolbox opens on the page "*Identification of issues with selection of measures and measures*", when it should open instead on the homepage, where the main functionalities are described.

Issues and Measures

Among all the pages of the toolbox this one has received the highest number of comments, probably because it is the focal point of the toolbox, but also because it is the most interactive and rich in content and the one that should encourage dialogue between different users.

Many observations concern the addition of a new issue: visibility of the "Add new issue" button is low, and in general more descriptions and explanations are needed (as for the concepts of "issue", "voting for measures", what "location type" represents, meaning of linking the issue to a "land use", multicriteria ranking parameters and related meaning of ranking stars, just as examples), avoiding redundances with descriptions already given in the "home" page.

When adding a new issue, "Relator type" list should be integrated with "District Authority" and "Irrigation and reclamation waterboards", and "location type" list could be integrated with "Irrigation and reclamation waterboards".

In the description of measures acronyms should be avoided or clarified.

When inserting an issue, it must be explained that first SAVE is needed, and then measures can be evaluated, otherwise it's not possible to save the choice of measures.

Furthermore, in the definition form of "Add new issue", in the drop-down menu LAND USE, there is "River training and erosion control" which seems not coherent. Needs to be clarified.

For the "Issue report" there are several observations: in "View climate indicators" it would be useful to have an explanation of the parameter "IMPORTANCE" and of its range of values, and parameters values are missing in the saved report, but they are visible during the compiling phase.

Again, in the issue report: field of action and land use category, expressed through the symbol of the issue (icon and colour) should be reported in words in the report (at the moment the two are enumerated but not compiled).

In the end, to close a selected report, the link should be written more clearly (now there is a long numerical code with an X).

At the time of testing and reporting, it's not possible to delete or modify an inserted issue, even by the same user who has inserted it. Anyway, it should be possible to modify it and in this case it would be useful to communicate the change to the developer.

A further observation concerns the aesthetic component of the fluvial flood icon, which is considered as resembling more sea waves and beaches than fluvial floods.

<u>Map of climate indicators</u>

This section contains the expected variations in climate indicators assumed as proxy for water protection and water related issues. The data are provided in terms of maps considering two different time horizons (short and long term) and two concentration scenarios (RCP4.5 and RCP8.5). It would be useful to clarify some aspects, that could help the user during the Map consultation, especially when the user doesn't have a specific technical background. For instance, a detailed description of the indicators and how they are calculated would be needed, with translation too, so that the user is fully aware of what is displayed and what the results mean.

Regarding the Map interface operativity, by selecting the various indicators included in the drop-down menu, it was found that the *TG_DJF* and *TG_JJA* indicators are not available. Remaining in the indicator drop-down menu, the parameters descriptions are sometimes affected by special characters anomalies, that could compromise the definition understanding and, consequently, the complete comprehension of the selected analysis shown in the map. Another thing that could make the Map more interactive, is to display the label that shows the indicator value for each NUTS by hovering the mouse pointer over a particular area. In relation to indicators, it should be noted that SCD (Snow Cover Duration) values must be checked, as well as seasonal precipitation values, which are probably not expressed as a percentage. Moreover, it should be explained why scenarios are only in the short (2021-2050) and long (2071-2100) term time scale, missing the medium one (2051-2070).

Drop-down menu to choose climate indicators at the time of reporting is not working properly, and the tab that opens up with technical description of the single indicator available is not readable.

<u>Ranking and catalogue of measures</u>

It is very important to explain well what the measures are and what they represent, as these are directed to different users (from single farmer to a regional or national administration); furthermore, an explanation on how measures are chosen, integrated and how the priority is associated to them would be needed. Also, Analytic Hierarchy Process (AHP) criteria should be shortly described: in this way the user will have clearer ways of assigning priorities to the different parameters.

A note from a functional point of view is that the text color used in the catalogue makes it difficult to read; also, some measure titles should be changed to make them more easily understandable, without needing to go through description: for example, measure T061 "Update/preparation of various exact documentation".

Staying on the theme of the 161 measures catalogue, while some measures related to fluvial and pluvial flood risk seem redundant (e.g.: those related to water retention), for others it would be useful to characterize them according to more than one type (e.g.: "Implementation and usage of early warning systems, alerting procedures incl. Guidelines and SOPs" is even a CC adaptation and affected measure) and more than one field of action (e.g.: "Strategic documentation and cooperation on national level" attributed only to Fluvial flood risk management, should be attributed to pluvial risk flood management and ecosystems management too).

Furthermore, the measure "Agreements (voluntary / nonvoluntary) to prevent conflicts among the users during droughts (e. g. water use plans, drought management plans, observatories, incentives, monitoring and prevention activities)" (measure ID T078) is wrongly referred to fluvial flood risk management, while it should be referred to water scarcity and drought.

Finally, a relation or link should be created to integrate somehow in the Toolbox measures from flood risk and river basin management plans.

4.1. Ranking of Measures Procedure

The evaluation of ranking of measures still needs further assessments, given the high number of measures involved.

Commenting functionality was not available during the testing phase.

4.1.1. Evaluation of Ranking based on User Priorities

From the results of the first testing phase measures selected on the basis of user priorities are appropriate, but further testing is still needed, given the number of possible combinations of user needs and measures.

4.1.2. Evaluation of Usability of Ranking Tool

The AHP Criteria ranking tool is a useful instrument to determine the best available measures according to the priorities and the necessities of the users. A point of considerable interest is that it allows not only to analyze the issues present in a given area and to identify the mitigation measure, but it also facilitates the dialogue between the different parties involved.
However, sometimes the tool appears rather counterintuitive and difficult to use in a proper way, especially for the least expert users or for the generic public. Moreover, the resulting output may also be quite confusing and not completely clear, if not to specialized/expert users.

For these reasons it would be useful to introduce in this section also a guideline or, even better, a video tutorial, to explain the functionalities and the characteristics of the tool and to better present its outputs and capabilities.

5. Synthesis of the National Stakeholder Workshop

The National Stakeholder Workshop, held in Parma on the 09th of November 2021, was attended by 24 participants from 12 institutions (Regions, Municipalities, National institutions, irrigation water boards, Environmental Agencies, Po interregional Agency, Universities) – of which 9 onsite – plus partners AdBPo and CMCC.
The programme of the workshop was as following:

10:00 – 10:10 – Introduction to the event

10:10 – 10:25 – Presentation of TEACHER-CE Project (Guido Rianna - CMCC)

10:25 – 10:40 – Presentation of the TEACHER toolbox ARP-CC-CE (Guido Rianna - CMCC)

10:40 – 10:55 – Presentation of the pilot area “Enza basin” (Beatrice Bertolo - AdBPo)

10:55 – 11:10 – TEACHER - CE and strategies for water resources management

11:10 – 11:25 – Pause

11:30 – 12:30 – Toolbox testing and discussions on Project TEACHER-CE

12:30 – 13:00 – Final synthesis

A complete update on Project activities has been supplied to the stakeholders, coupled with a detailed description of the pilot area, in order to be able to collect their views on specific issues pertaining to it. A little bit less than an hour has been dedicated to toolbox testing: during this phase, participants had the chance to discuss with CMCC and AdBPo partners about pilot area specific issues and the need for strategies development to adapt to climate changes. Issues have been inserted in the toolbox, even if just for the sake of testing the functionality, and the catalogue of measures has been used and read through. The toolbox raised the interest of present participants, even if it needs to be further refined and developed, and it needs to be clarified how it will be managed in the future. This question has been raised considering that in the pilot area activities for the drafting of the "Enza river contract" are at their start and could benefit from the ARP-CC-CE toolbox, but it should be directly "managed" by institutions and stakeholders of the pilot area. For what concerns major problems of the pilot area, stakeholders have confirmed that major issues are related to floods, drought and water scarcity events and water for irrigation, followed closely by drinking water supply and water dependent ecosystems management, even if with lower priority. There's a high quest for update and improvement of local strategies to adapt to flood risk (both fluvial and pluvial), and to manage water dependent ecosystems. Finally, stakeholders have suggested measures needed.
The general satisfaction with the event has been quite high, reaching an average score of 8.88 out of 10.

6. Conclusions

What emerges from the toolbox use and from the stakeholder workshop highlights the usefulness of the tool in the water associated issues management and in the water related risks prevention, also in consideration of climate change. This need arises mainly from the fact that the analyzed context is extremely complex from a management point of view.
In fact, this complexity derived mainly from the heterogeneity of the issues involved regarding the water aspects. One of the most important economic features of the Enza basin lies in its agricultural activities, with the production of Parmigiano Reggiano playing the major role. This product relies on permanent pastures that are surface irrigated, and the agricultural system is mainly fed by the Enza river.
In addition to the important aspect of water resource management, fundamental for the local economy, there is also the aspect of flood risk management which plays a central role in the area of interest, characterized by a marked variability of hydrological conditions as well as a concentration of inflows in short-term events. From this, it is possible to infer the need to have tools aimed at supporting territorial planning and water resource management, which can count on shared knowledge at the different management levels. Moreover, from discussions with various stakeholders, the importance of such an innovative tool for the management of water resources was highlighted, but possible problems or misunderstanding were found, such as the complexity of some toolbox components that do not allow user friendly (e.g. technical terms) and the lack of some components (e.g. water quality) that could be linked to water resource management and make the information even more complete.