4.3. Report on Common Methodology on Estimation of Climate Change Induced Land Use Changes and Changes in Water Quality on Test Areas

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Date last release	July, 2016
State of document	APPROVED

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DRINK ADRIA

Adriatic IPA Cross Border Cooperation 2007-2013

The project is co-funded by the European Union, Instrument for Pre-Accession Assistance

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"*This document has been produced with the financial assistance of the IPA Adriatic Cross-Border Cooperation Programme. The contents of this document are the sole responsibility of involved DRINKADRIA project partners and can under no circumstances be regarded as reflecting the position of the IPA Adriatic Cross-Border Cooperation Programme Authorities*".

TABLE OF CONTENT

1 INTRODUCTION

This report gives insight on impact of land use changes (caused by climate change and development of the area) on water quality in test areas of DRINKADRIA project.

Test areas that are covered within the project are (*Figure 1*):

1) Isonzo plain (Italy, LP),
2) ATO 3 (Italy, FB2),
3) Ostuni (Italy, FB3),
4) Kobariški Stol, Mia and Matajur aquifer (Slovenia, FB5),
5) Springs Sv. Ivan, Bulaž and Gradole (Croatia, FB8),
6) Spring Prud and Blatsko polje (Croatia, FB9),
7) Nikšić (Montenegro, FB10 and FB14),
8) Drini basin (Albania, FB11) and
9) Corfu Island (Greece, FB16).

The report is structured as follows; second chapter gives a description of the common methodology applied in DRINKADRIA project to analyse the land use changes (in the past and those expected in the future based on data about climate change and development of the area in the future) and the impact on water quality. Third chapter gives a short description of test areas. The fourth chapter gives description of present land use and land use changes in the past, while the fifth chapter gives the impact of land use on water quality on test areas. Chapter 6 presents the impact of climate change and planned development on land use in future with impact of future land use on water quality, while in chapter 7 problems of salt water intrusion on test areas are presented. In chapter 8 measures to improve water quality are given while chapter 9 gives conclusions of this report.

Figure 1: Test area locations.

2 COMMON METHODOLOGY

During project partners meeting in Belgrade 25/11/2014 it was agreed that for all test areas the following analyses should be carried out:

- analysis of the actual land use (using Corine Land Cover-CLC, spatial plans or/and other),
- analyses of the impact of land use on water quality for the present/past state,
- analyses of the impact of climate change and planned development (spatial plans or/and other) on the land use in future,
- analyses of the impact of land use on water quality for the future state,
- analyses of the problems of salt water intrusion (for test areas with this problem),
- list of measures that are and/or should be applied in order to improve the quality of drinking water on test areas.

For these analyses data from FBs reports 4.1. Climate and climate change database for Adriatic area and 4.3. Water quality trends on test areas were used.

It was agreed that for determining the present land use and land use changes in the past analyses Corine Land Cover, which represents a digital database on types of land cover/use, will be used.

It is expected that changes in land use in the future will have an impact on water resources quality. For assessment of land use change in the future the climate change impact and development impact in the area was analysed. Climate change data from activity 4.1. and also data about development in test area in the future (from spatial or other plans) were used.

For the description of relevant processes which endanger water quality, it was agreed to apply the DPSIR framework in the project, so the common methodology applied in the project is presented in Figure 2.

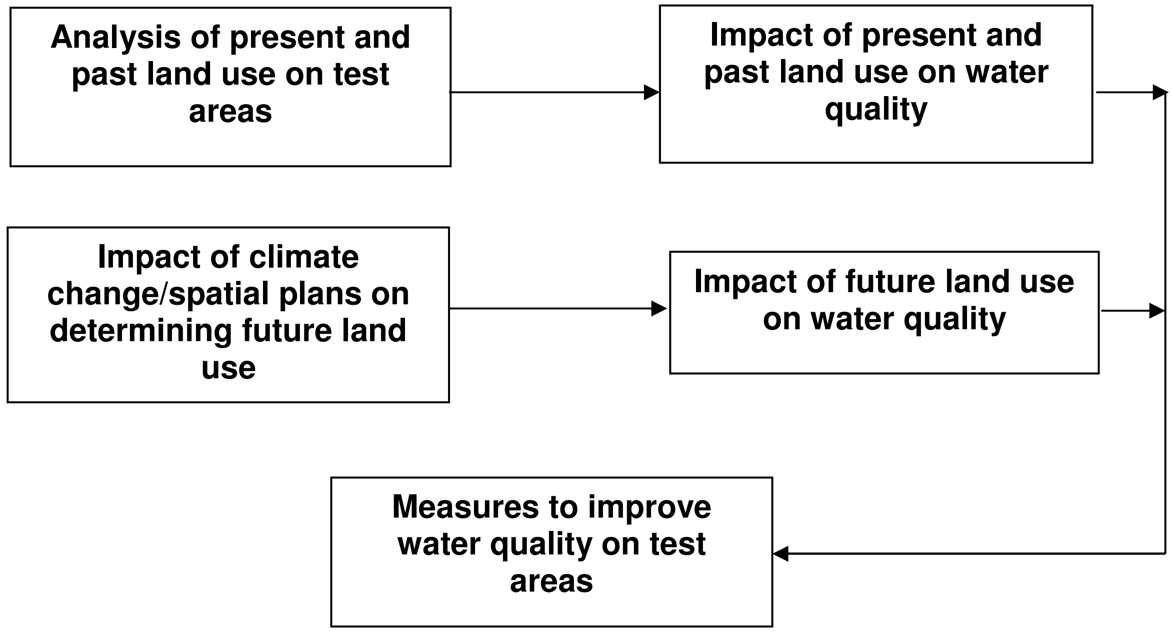

Figure 2: The common methodology used for test areas

The impact of land use changes on water quality on test areas is shown through the **DPSIR** approach [1]. The European Environmental Agency (EEA) assesses the State (**S**) of the environment using the **DPSIR** methodology. Namely, the State (**S**) is the result of specific Drivers (**D**) and Pressures (**P**), positive or negative, which Impact (**I**) the environment. The Responses (**R**) represent the solutions (e.g. policies, investments) that should then be done to improve or maintain that state. The EEA report also looks at Outlooks (**O**) for the state of the environment-namely, what will happen to that state over time based on various scenarios [1].

The DPSIR framework is in some way a conceptual model (see *Figure 3*) representing direct interactions through a loop in the way that human being interacts with the environment [1].

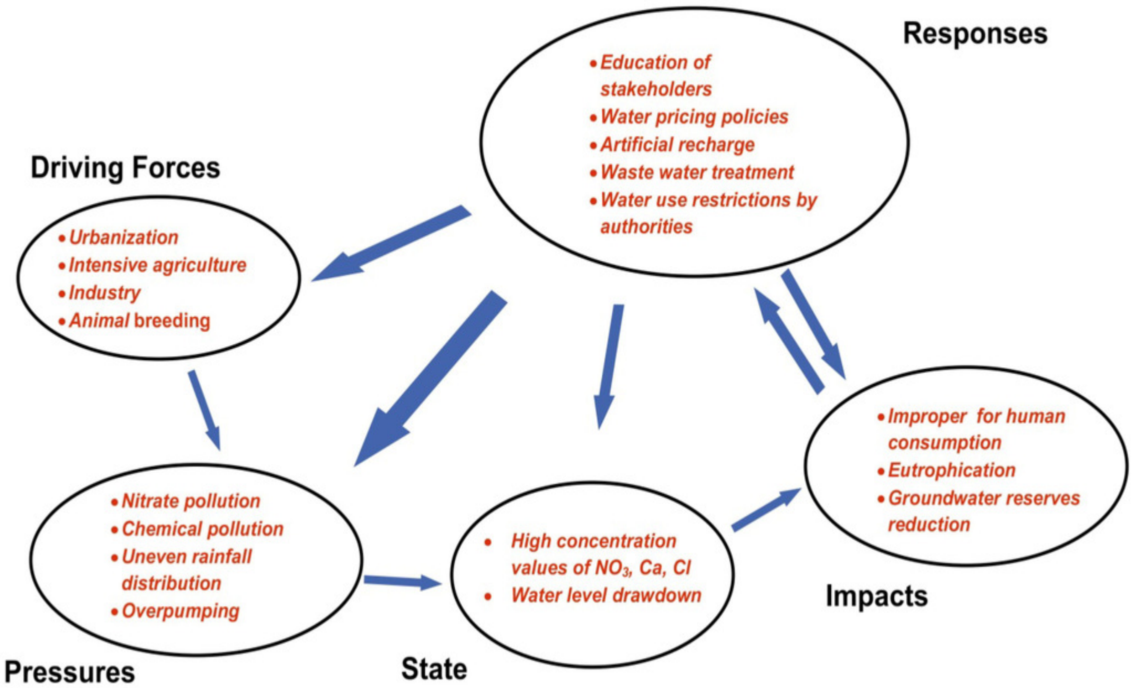

Figure 3: DPSIR methodology [1]

3 SHORT DESCRIPTIONS OF TEST AREAS

3.1 Isonzo plain

The Isonzo Plain (*Figure 4*), area of about 170 km^2, is located in the eastern side of the Friuli Venezia Giulia Region (NE Italy). It holds a significant phreatic aquifer and many rich artesian aquifers that represent an important natural wealth, in terms of quantity, quality and ease of supply. The aquifers are used for different purposes: drinking, household, industrial, agricultural and farming. They serve more than 350.000 inhabitants [2].

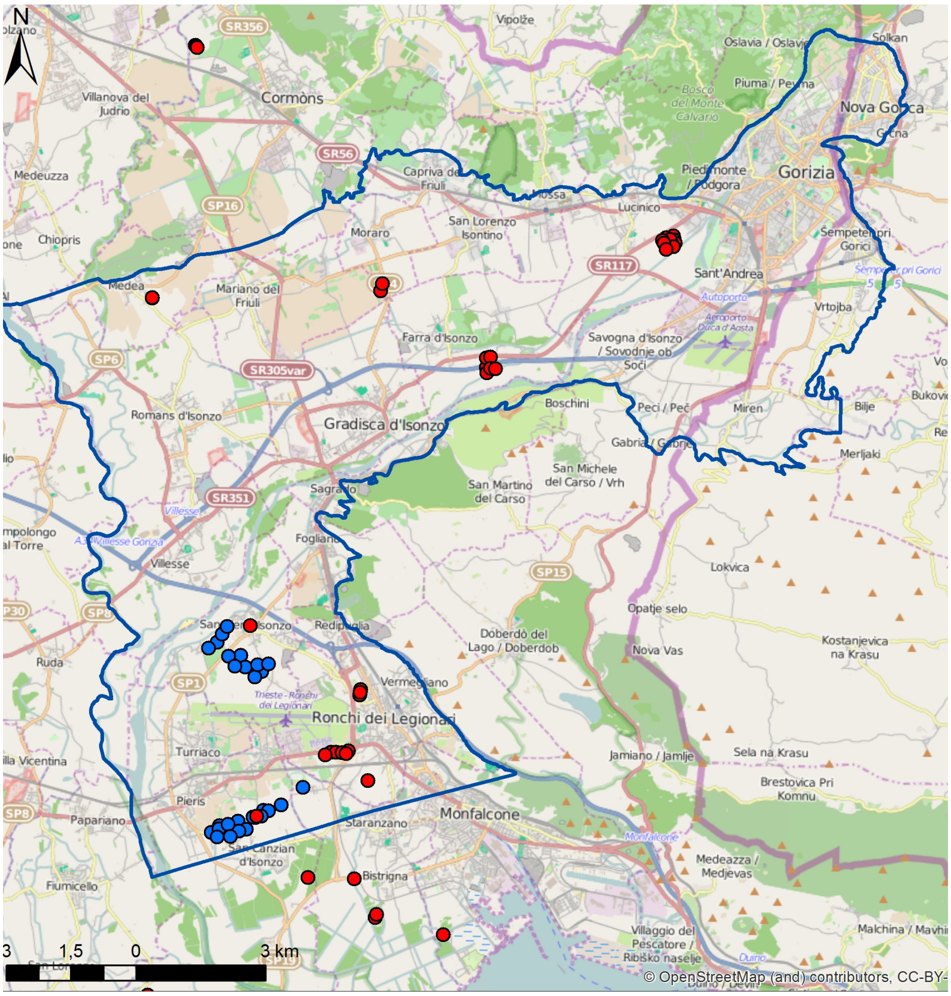

Figure 4: DRINKADRIA test area (in blue), the Isonzo/Soča River plain. [2]

3.2 ATO 3

ATO 3 Test Area territorial extent is around 2,520 km^2. It is located in the central part of Marche Region, Italy, stretching from the Apennines to the Adriatic coast. The most important Water Resources are located within two different physiographic "Macro-Regions" corresponding to as many hydrogeological domains (*Figure 5*). [3]

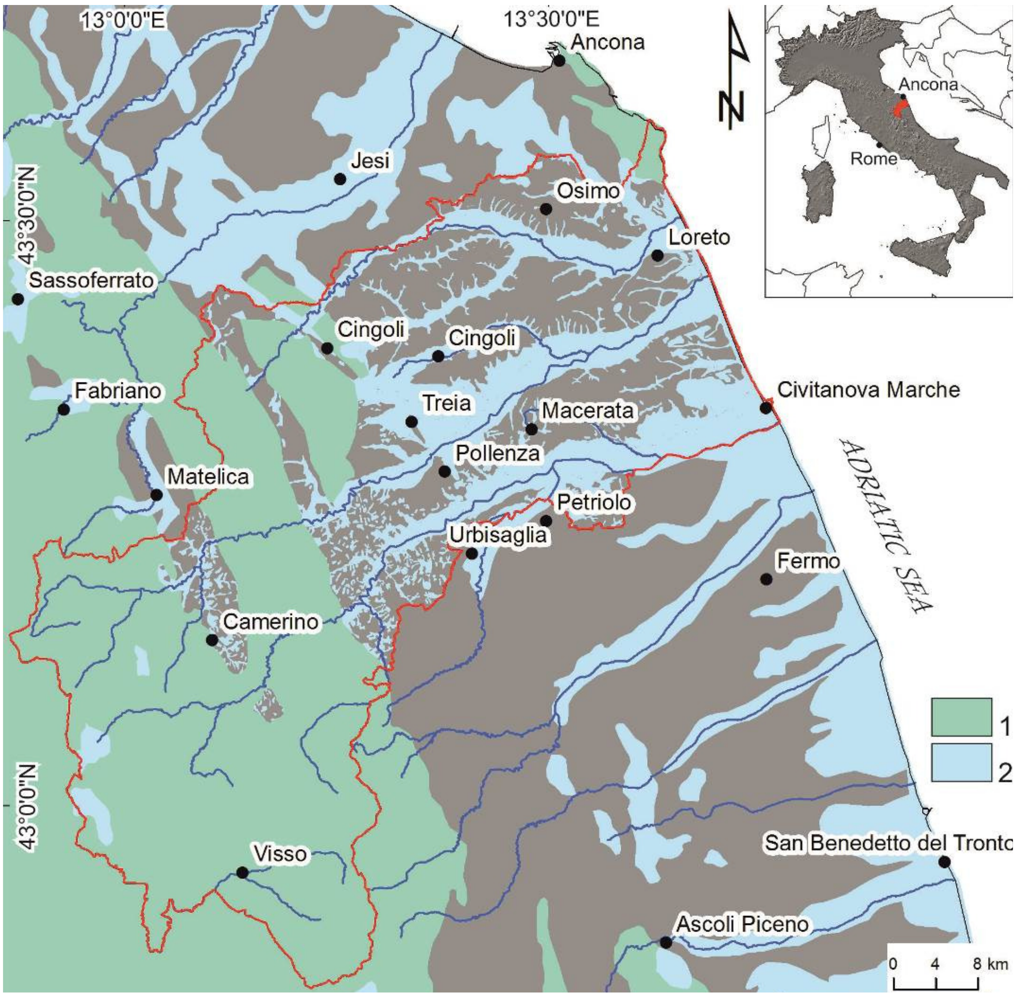

Figure 5: ATO3 Test Area (marked with the red line): 1) "Calcareous ridges" hydrogeological domain; 2) "Hills and alluvial plains" hydrogeological domain. [3]

3.3 Ostuni

The Ostuni test area is 1991 km^2, with a maximum length of 53 km, maximum width of 50 km. The area covers 24 municipalities of the Apulia region, which are in 3 provinces: Brindisi, Taranto and Lecce (*Figure 6*). [4]

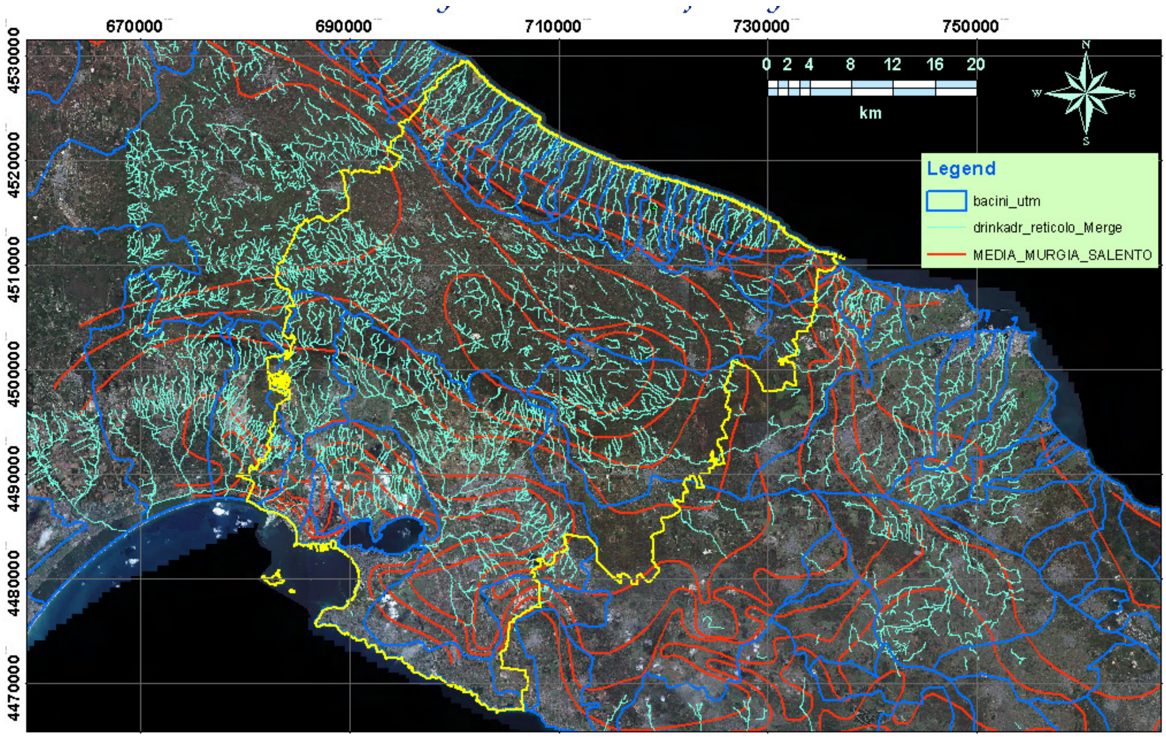

Figure 6: Ostuni pilot area and stream basins of the Salento peninsula (Apulia region, Southern Italy). [4]

3.4 Kobariški stol, Mia and Matajur aquifer

Kobariški stol, Mia and Matajur aquifers are positioned in NW Slovenia (Figure 7) and represent important potential sources of drinking water for the future, also for cross-border supply. The area covers 163.3 km^2 and has influence of sub-Mediterranean climate from SW Slovenia and alpine climate of NW Slovenia [5].

Figure 7: Slovenian test area: Kobariški Stol, Mia and Matajur aquifer.[5]

3.5 Springs Sv. Ivan, Bulaž and Gradole

Spring Sv.Ivan (*Figure 8*) is located in the bottom of the river Mirna Valley, about 1 km southeast of Buzet, and about 200 m from the Mirna riverbed, at an altitude of 49 m. Watershed area is about 70 km^2 (karst area 46 km^2, flysch 24 km^2) [6].

Spring Bulaž (*Figure 8*) is located at the beginning of the wide valley of Mirna middle flow near thermal water source Istarske toplice. The size of spring inflow area is about 105 km^2 (karst area about 43 km^2, flysch 62 km^2) [6].

Spring Gradole (*Figure 8)* is located on the left bank of river Mirna valley, about 9,5 km upstream of its confluence. Watershed area is about 104 km^2 (carbonate rocks about 85 km^2, flysh deposits about 19 km^2) [6].

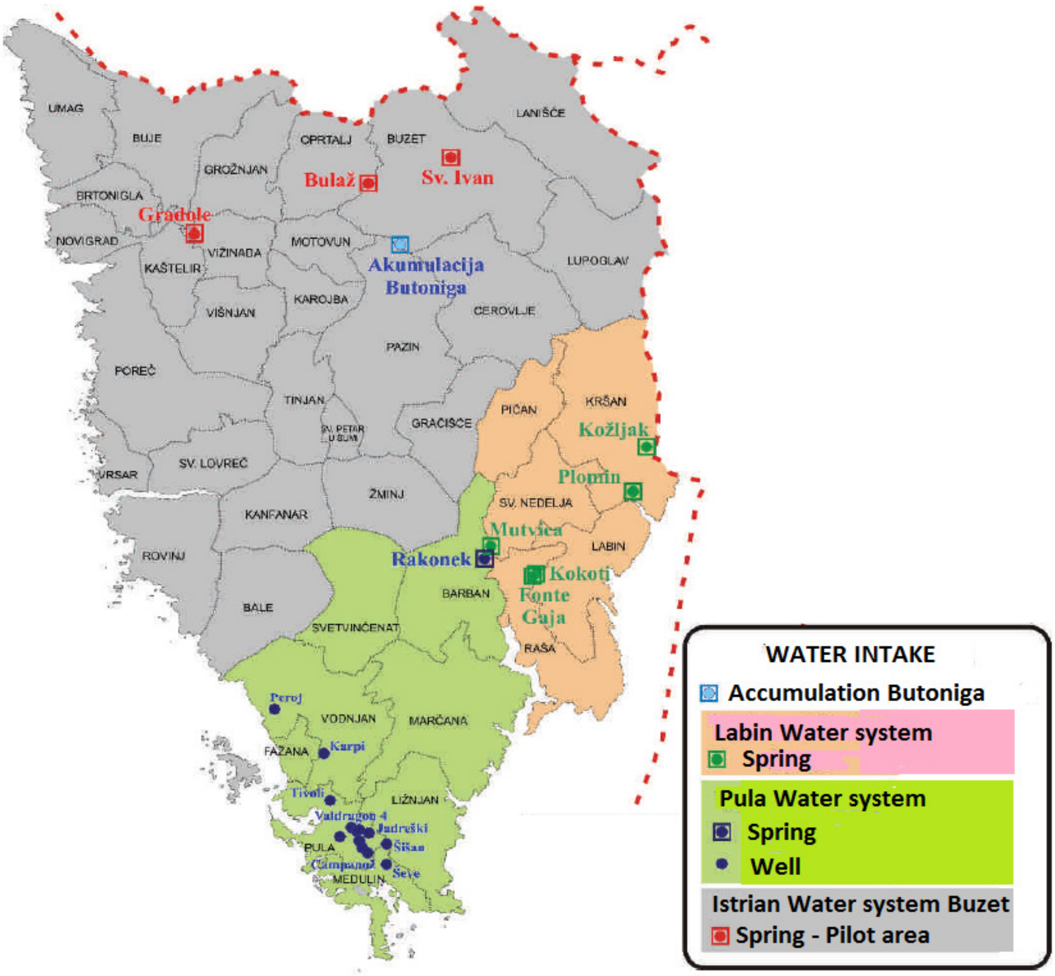

Figure 8: Monitoring stations for water resources used for water supply in Istrian Region [7].

3.6 Spring Prud and Blatsko polje

Prud spring is the most important spring in the lower course of the Neretva river. It represents the basis of water supply in the regional aspect. The size of spring catchment area is approximately 1200 km^2 (about 200 km^2 in Croatia and 1000 km^2 in Bosnia and Herzegovina) [8].

The western part of the island Korčula with the settlements of Blato and Vela Luka has a water supply from the island's karst aquifer in the area of the Blatsko karst polje Blatsko polje catchment covers about 28 km^2 [8].

3.7 Nikšić

Test area Nikšić is located in Central - Western part of Montenegro as depicted in Figure 9. More precisely, drinking water sources (karst springs) are located in Nikšićko Polje, karst field with significant water yield and partly within the Upper Zeta river basin [9].

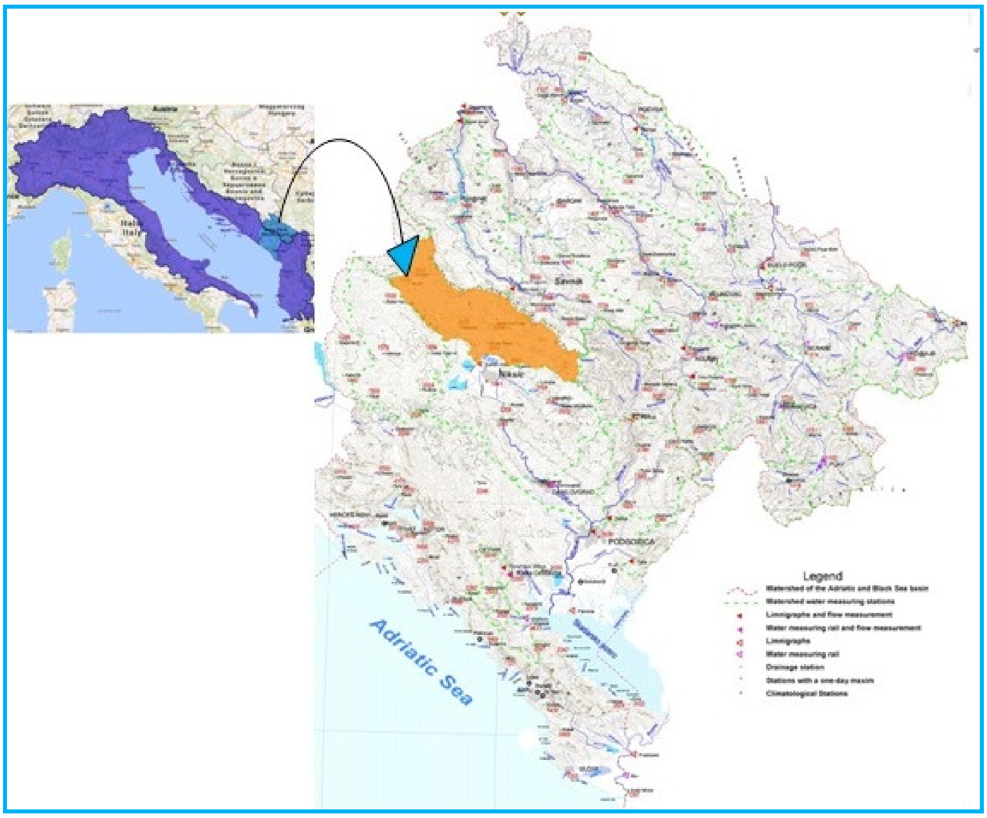

Figure 9: Position of Upper Zeta catchment. [9]

Drainage area of Upper Zeta catchments is 327 km2 while area that covers Drinking Water Protection Zones (***inner -I, middle - II and outer -III***) for 3 sources used for water supply is approximately 310 km^2 based on Report on Drinking Water Protection Zones (DWPZ) for Poklonci source. Two other springs Gornji and Donji Vidrovan are located within this area as well. Different geological groups of rocks create study area. Terrains are predominantly comprised of rocks from a group of hydrogeological collectors with fracture and cavernous porosity that are Mesozoic carbonate sediments characterized by limestone. [9]

3.8 Drini basin

On *Figure 10,* marked red is shown test area in Albania – Drini basin.

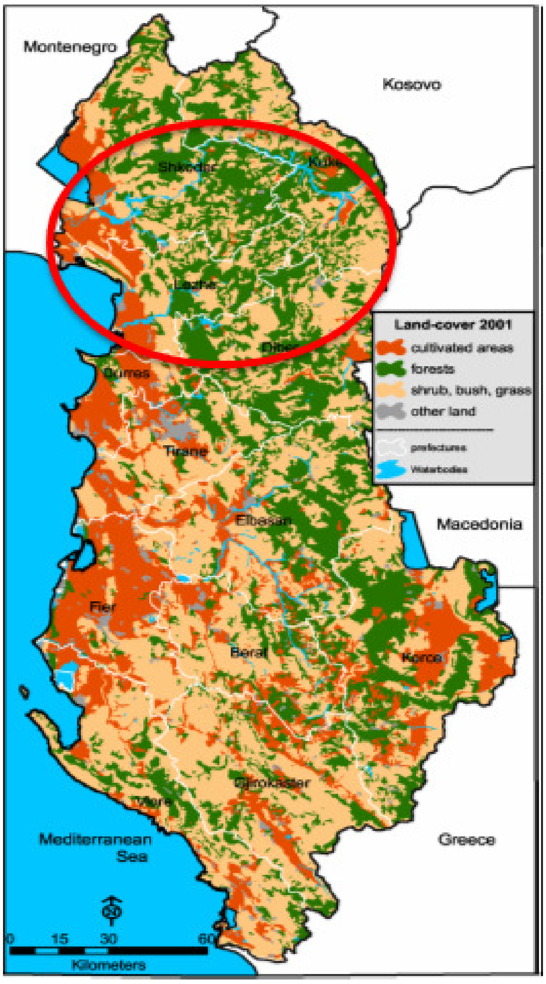

Figure 10: Location of test area in Albania- Drini basin (marked red) [10].

3.9 Corfu Island

Corfu Island is situated in the north part of the Ionian Sea and the whole Corfu prefecture (including Paxi and Othoni islands) has an area of 641 km^2 while the island of Corfu only has an area of 591 km^2. The coastal areas' length is 217 km [11].

4 ANALYSES OF PRESENT/PAST LAND USE AND LAND USE CHANGES ON TEST AREAS

4.1 Isonzo plain

Part of the territory within the test area, is agriculture (58,81 %) followed by the urbanized area (22,48 %) and by the natural environment (10,50 %). Water surface corresponds to approximately 3,56 % of the whole investigated area. Industries are the 3,14 %, while for the sport and leisure facility is dedicated 0,94 % of the territory; quarry and landfill are 0,57 % (*Figure 11*). [2]

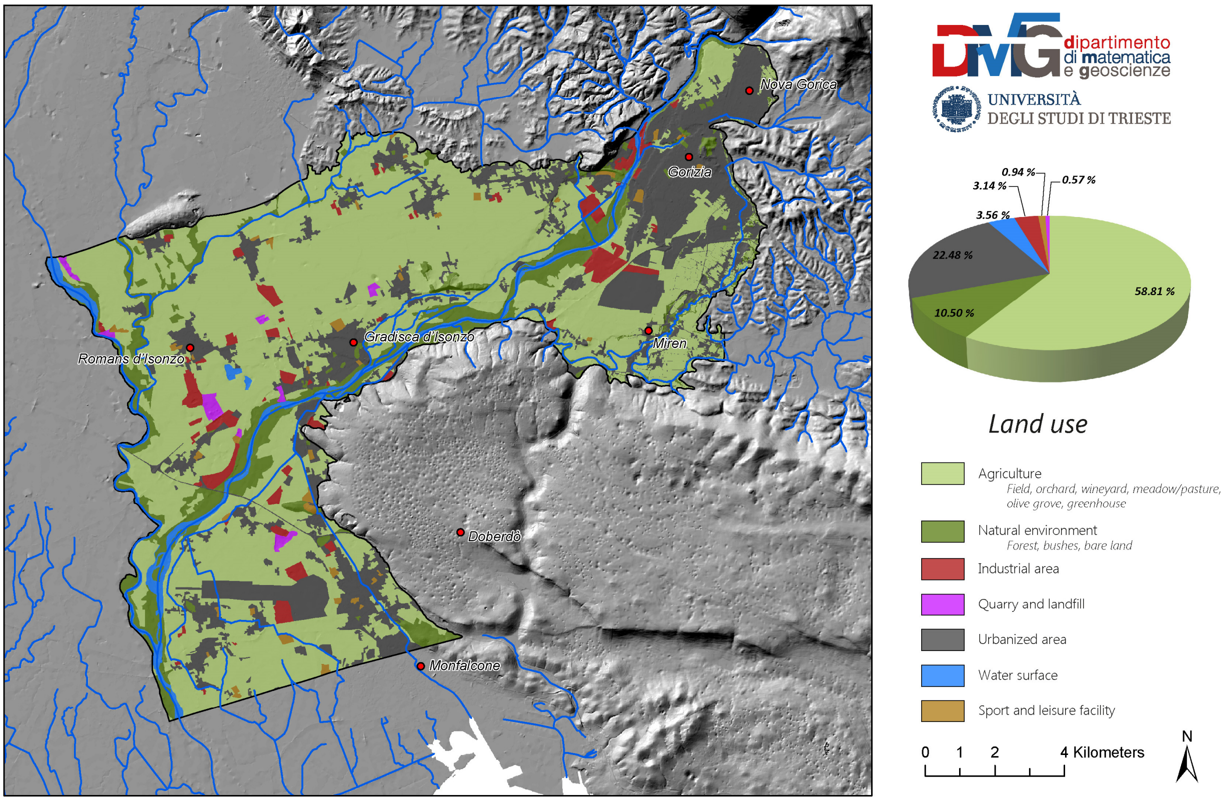

Figure 11: Land use map for the DRINKADRIA Project test site area. [2]

Figure 12 represents the land use evaluation between 1990 and 2012 for the just mentioned classes. Evidently artificial areas (urban fabric, construction sites, industrial areas) grow at the expense of agricultural areas. Artificial areas occupied 22.3 % of the test area (37.8 km^2) in 1990 and 25.2 % in 2012 (42.6 km^2). Instead agricultural area represented 69.2 % of the test area in 1990 (117.1 km^2) and 66.2 % in 2012 (112.0 km^2). During the same period natural and semi natural areas coverage remained stable, from 8.5 % to 8.7 % (corresponding respectively to 14.4 km^2 and 14.7 km^2).

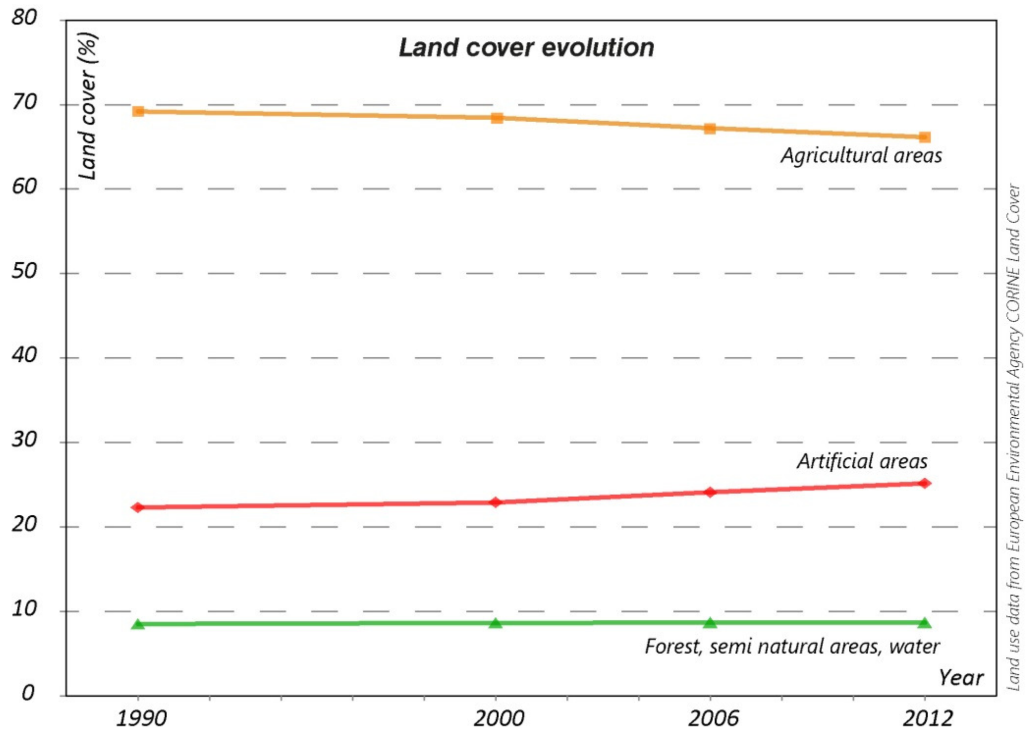

Figure 12: Land use evolution from CLC between 1990 and 2012 for agricultural, artificial areas and forests, semi natural areas and waters. [2]

4.2 ATO 3

The test area can be divided in four main land use classes, according to the Corine Land Cover, 2012 as shown in *Figure 13*. Two classes are dominant: agricultural areas, which characterize the low-hilly and flat zones and natural areas and forest which dominate the mountain areas. [3]

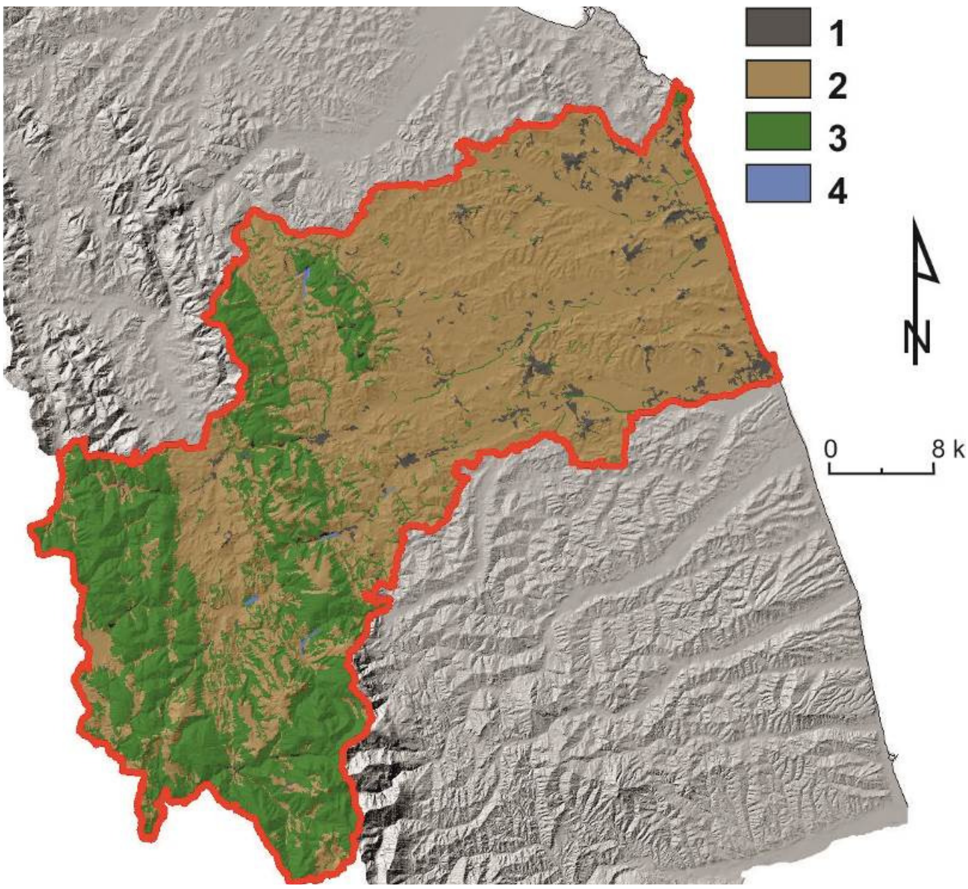

Figure 13: Land use classes (based on the Corine Land Cover, 2006): 1. artificial surfaces; 2. agricultural areas; 3. forest and semi-natural areas; 4. water bodies. [3]

The agricultural practices in particular, are widely spread throughout the region, while "artificial" surfaces (urbanized areas and/or zones characterized by the presence of important infrastructure) and "uncultivated" surfaces (unused and/or unusable land) are rare and mainly located in the southwest portion of the test area and along the coast respectively.

4.3 Ostuni

Actual land use on test area Ostuni (Southern Italy) is shown on *Figure 14*.

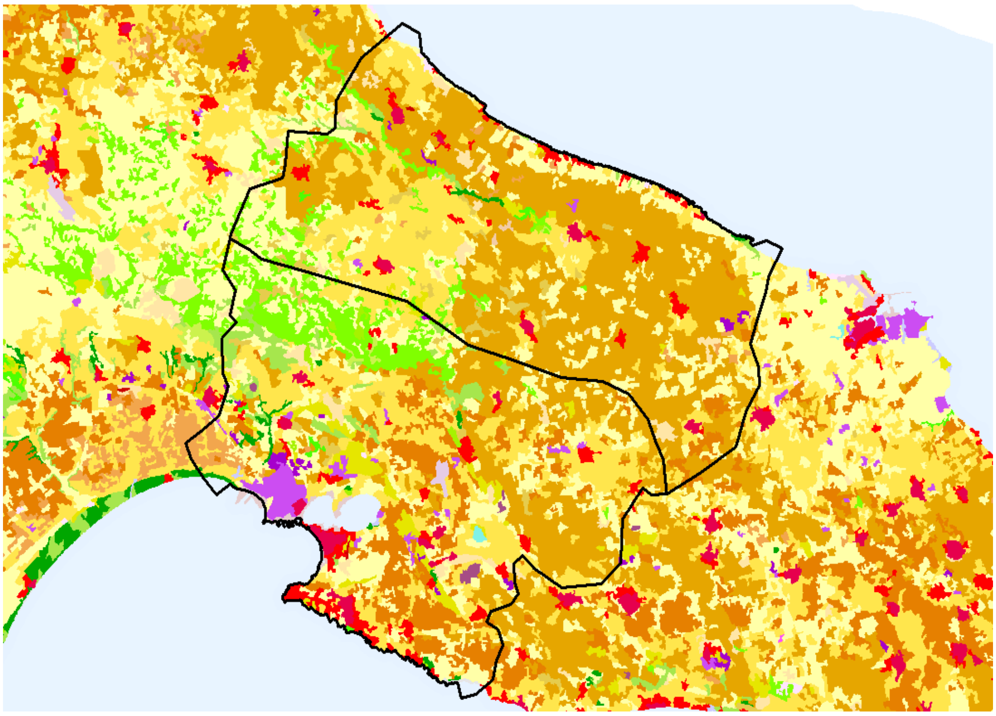

Figure 14: Actual land use (2012) at the Ostuni test area (Southern Italy, for colours see CLC Nomenclature). [4]

4.4 Kobariški stol, Mia and Matajur aquifer

The land use in the test area presents mostly forests and grassland (light and dark green; Figure 15). It covers less populated foothill area, where human activities occur only as isolated settlements, such as Kobarid at the eastern part of the map and agricultural areas that present mainly pastures. According to the CLC categories 85 % of the test area is covered by *forest and semi natural areas* and less than 15 % by *agricultural areas* and *artificial surfaces*. Actual land use in the test area is given on Figure 15 and 16 [5].

Comparison between land use maps (1995, 2000, 2006, 2012) shows that in the last 20 years no significant changes in land use occur. Minor changes are visible only within separate land cover group, such as different kinds of grassland or forest. Regarding this data and the information about spatial plans changes in this area, also in the future significant changes in land use are not expected [5].

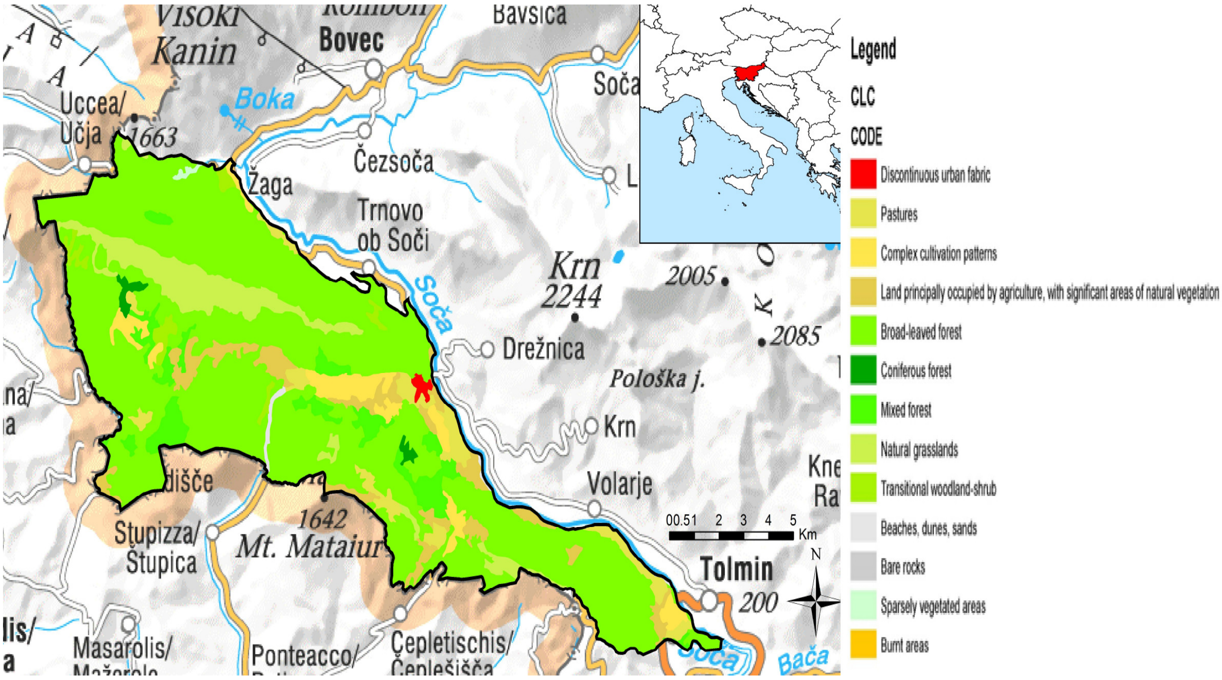

Figure 15: Actual land use on test areas in Slovenia (2012). [5]

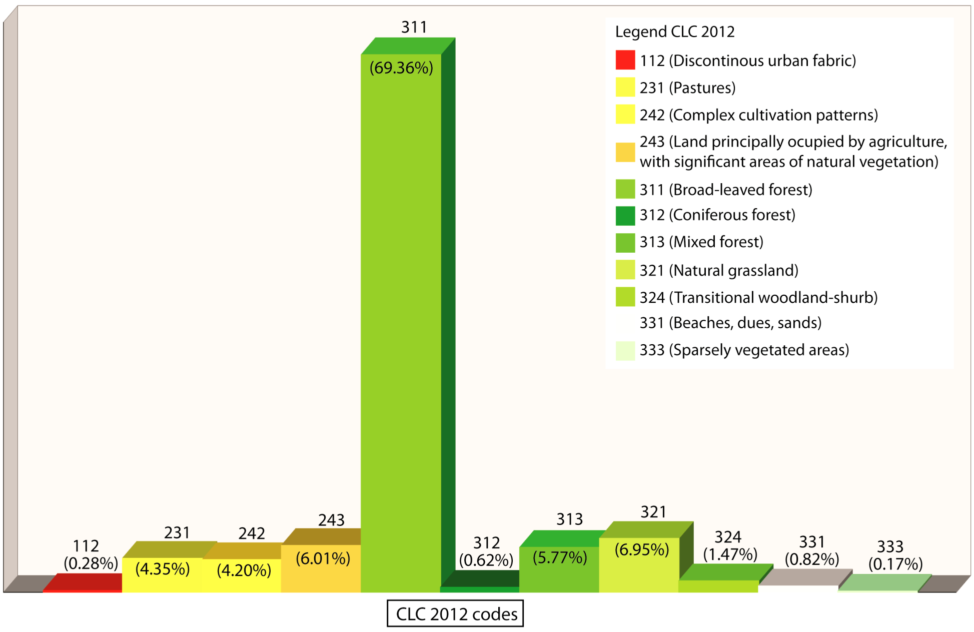

Figure 16: Percentage of CLC categories in the test area (CLC 2012). [5]

4.5 Springs Sv. Ivan, Bulaž and Gradole

Distribution of CLC in year 2012 for the test areas is given on *Figure 17*. It can be seen on the *Figure 17* that on the area of spring Sv.Ivan broad leaved forest covers about 53% of the area. On spring Bulaž area 36% is covered by broad leaved forest, and 22% by land principally occupied by agriculture. On spring Gradole area 36% is covered by land principally occupied by agriculture, and 26% by broad-leaved forest. It can be seen that most of the test area is covered by broad leaved forest and land principally occupied by agriculture. [6]

Changes in land cover using CLC are shown for periods between the years 2000-2006 and 2006-2012. Changes between 2000-2006 are notable on the area of spring Bulaž where the cover was changed from transitional woodland-shrub into broad-leaved forest, area of about 38 ha. On the area of spring Gradole two changes occurred; broad-leaved forest into complex cultivation patterns, area of about 5.5 ha, and pastures into complex cultivation patterns, area of about 21.4 ha. On the area of spring Sv.Ivan there haven't been any changes in land cover. [6]

Changes in period 2006-2012 can be seen on the area of spring Sv.Ivan where the land cover changed from pastures into transitional woodland-shrub, area of about 63.4 ha. On the area of spring Gradole there was a change from broad-leaved forest into vineyards, and land principally occupied by agriculture into vineyards with total area of about 19.6 ha. On the area of spring Bulaž there were no changes.

It can be concluded that in the period 2000-2012 there were no significant changes on the test areas. [7]

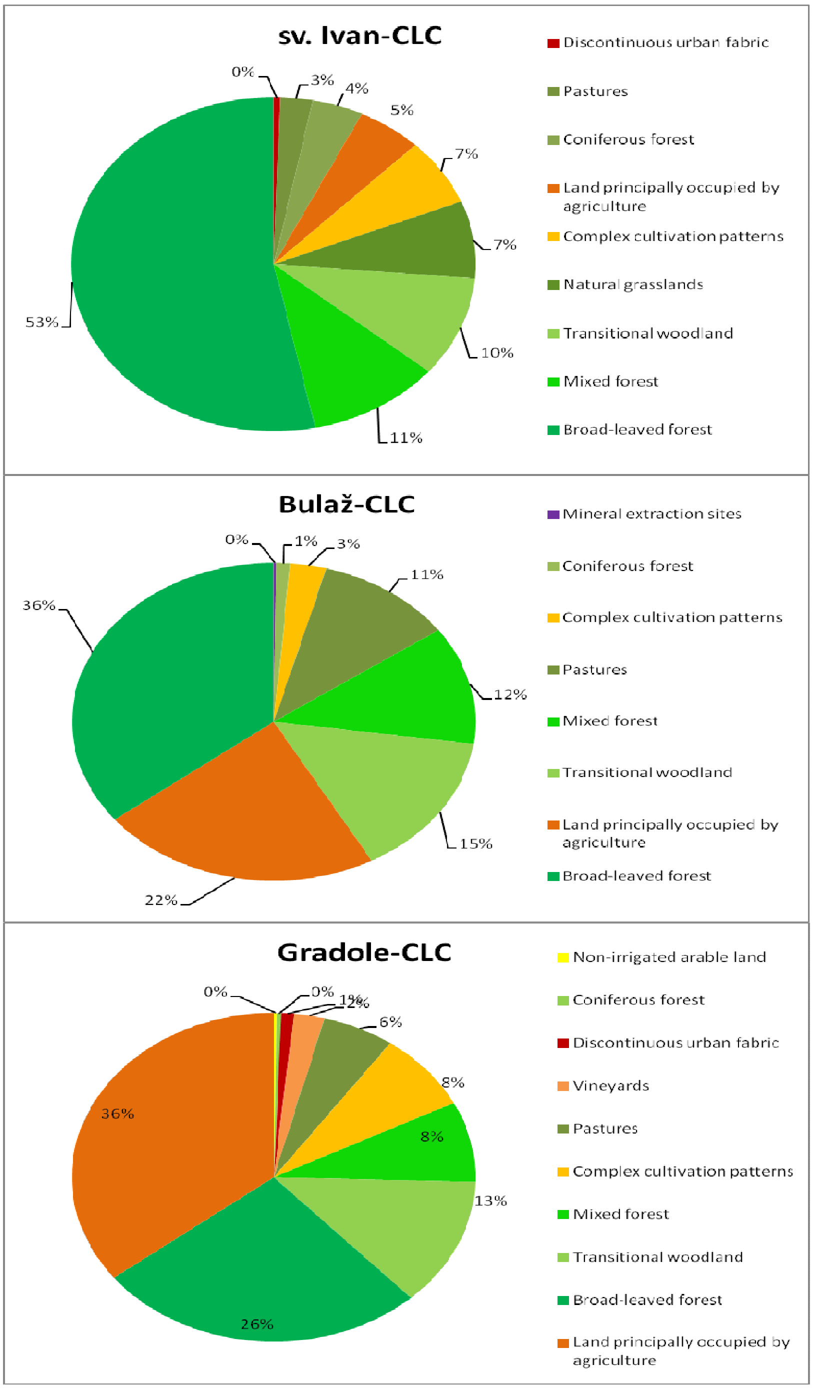

Figure 17: CLC in % for springs Sv.Ivan, Bulaž and Gradole in 2012. [7]

4.6 Spring Prud and Blatsko polje

Actual land use is presented for the year 2006 for both test area. Prud spring catchment area is a transboundary aquifer. Although spring Prud is located in Croatia, most of its catchment belongs to Bosnia and Herzegovina (BiH). CLC 2012 for Croatia is already done and available on the web site of the Croatian environmental agency, while for BiH CLC 2012 is still not available. Thus, as majority part of the catchment area belongs to BiH it is decided to present for both test areas CLC maps for 2006 (*Figures 18 and 19*). [8]

Land use changes can be seen in *Tables 1, 2* and *3*.

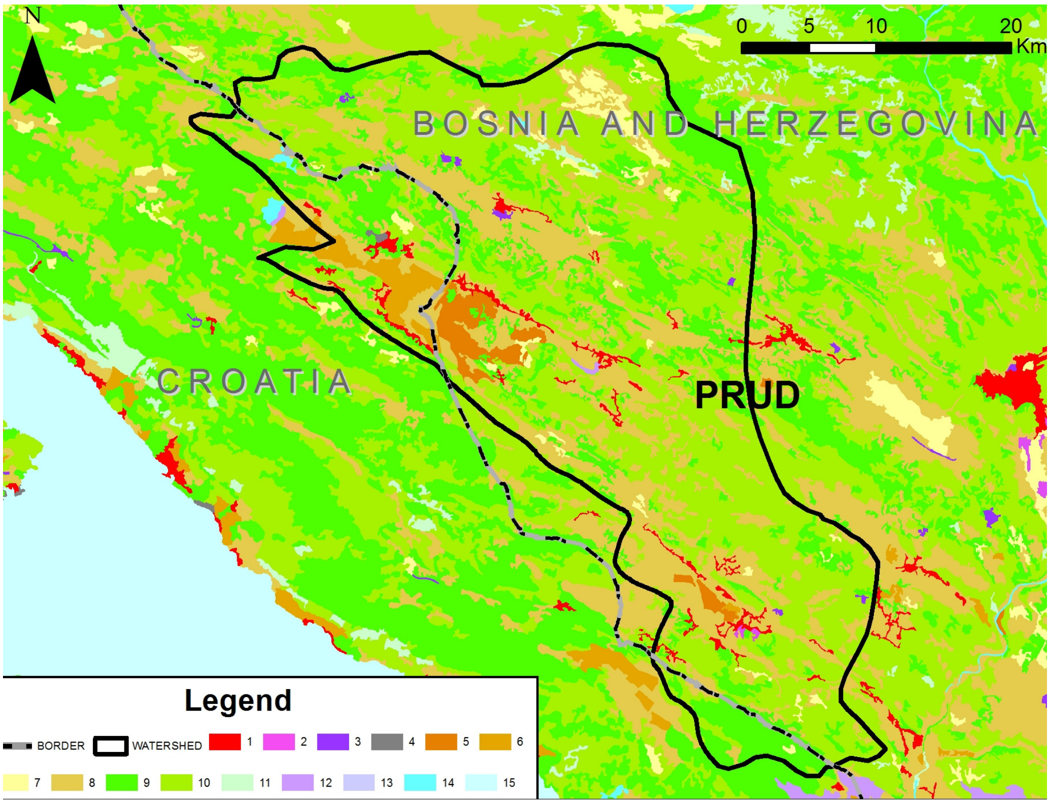

Figure 18: Corine land cover for the spring Prud catchment area for year 2006. [8]

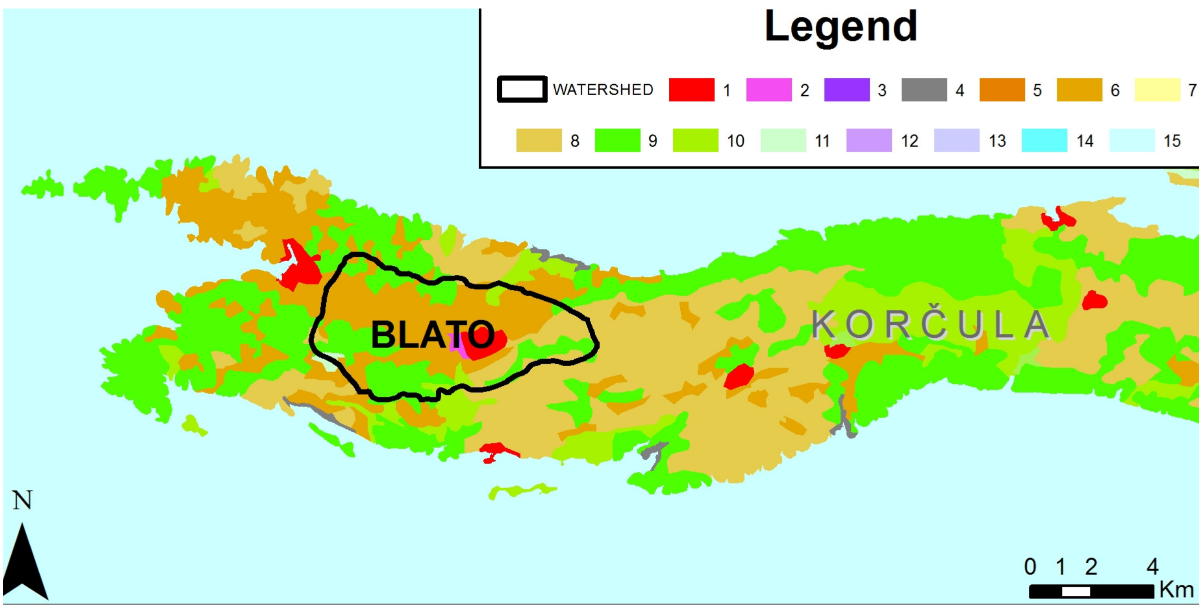

Figure 19: Corine land cover for Blatsko polje for year 2006. [8]

Table 1: Comparison in land use categories for different years of CLC for the Prud catchment test area on Bosnian-Herzegovinian side. [8]

Prud BiH CLC	2006	2000
Land use categories	Area (%)	Area (%)
Urban fabric	1,50	1,50
Industrial, commercial and transport units	0,07	0,07
Mine, dump and construction sites	0,24	0,24
Arable land	2,80	2,80
Permanent crops	0,06	0,06
Pastures	2,54	2,54
Heterogeneous agricultural areas	26,54	26,54
Forests	16,48	16,48
Scrub and/or herbaceous vegetation associations	49,27	49,27
Open spaces with little or no vegetation	0,39	0,39
Inland wetlands	0,08	0,08
Inland waters	0,04	0,04

Table 2: Comparison in land use categories for different years of CLC for the Prud catchment test area on Croatian side. [8]

Prud Croatia CLC	2012	2006	2000
Land use categories	**Area (%)**	**Area (%)**	**Area (%)**
Urban fabric	3,38	3,38	3,25
Mine, dump and construction sites	1,13	1,13	0,00
Artificial, non-agricultural vegetated areas	0,42	0,42	0,42
Arable land	0,09	0,09	0,00
Permanent crops	10,96	10,96	10,87
Pastures	0,69	0,69	1,07
Heterogeneous agricultural areas	26,94	26,94	22,77
Forests	41,27	41,27	40,39
Scrub and/or herbaceous vegetation associations	14,32	14,32	20,52
Open spaces with little or no vegetation	0,10	0,10	0,00
Inland waters	0,71	0,71	0,71

Table 3: Comparison in land use categories for different years of CLC for the Blatsko polje test area. [8]

Blatsko polje CLC	2012	2006	2000
Land use categories	**Area (%)**	**Area (%)**	**Area (%)**
Urban fabric	3,35	4,06	4,06
Permanent crops	30,83	50,12	50,12
Heterogeneous agricultural areas	30,90	11,59	11,59
Forests	6,62	29,76	29,76
Scrub and/or herbaceous vegetation associations	28,15	2,92	2,92
Open spaces with little or no vegetation	0,16	0,50	0,50

4.7 Nikšić

According to Study for Poklonci karst spring water protection zones delineation, outer protection zone is approximately 310 km^2 and includes other two springs (Donji and Gornji Vidrovdan) that are water sources for Nikšić Drinking Water Supply System. Based on Spatial plan of Montenegro [6], approximately 65 % of land within the drainage area is forests, followed by agricultural land (29%), artificial surfaces (5 %), and less than.2 % of surface waters. Land use within the area is depicted graphically in Figure 20. As mentioned in previous section, the most significant trigger for water quality within the test area are heavy rainfall. Secondly, un proper waste water treatment and lack of sanitary network should be considered seriously as a threat to water quality. The number of wild landfields [5, 6] within the drainage area should not been neglected. Given the size of area and type of water source, namely, karst aquifer more detailed assessment with respect to these and other polluters, e.g., agriculture is required. [9]

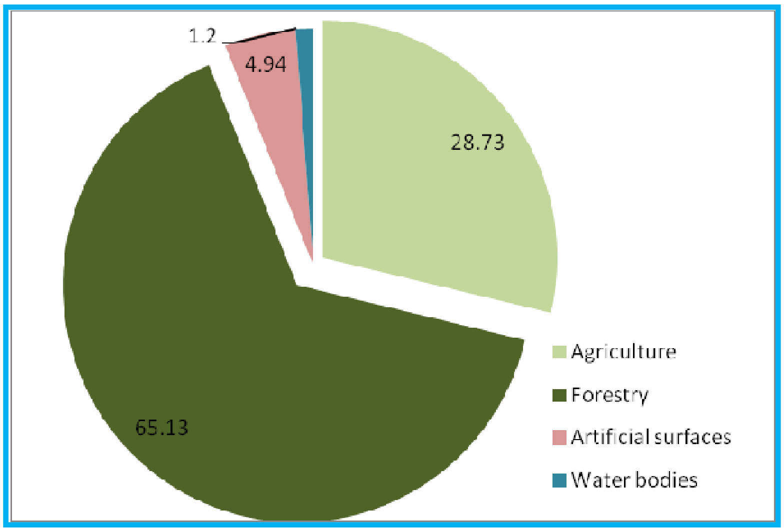

Figure 20: Percentiles of land use practices for NikšićTest Area. [9]

According to 2 CORINE land use for two referent years there is no significant changes in land use practices between 2006 (Figure 21) and 2012 (Figure 22). However, occurrence of burnt areas in Figure 8 should not be neglected. Very likely it is due to decrease in precipitation and increase in temperature during the summer season. [9]

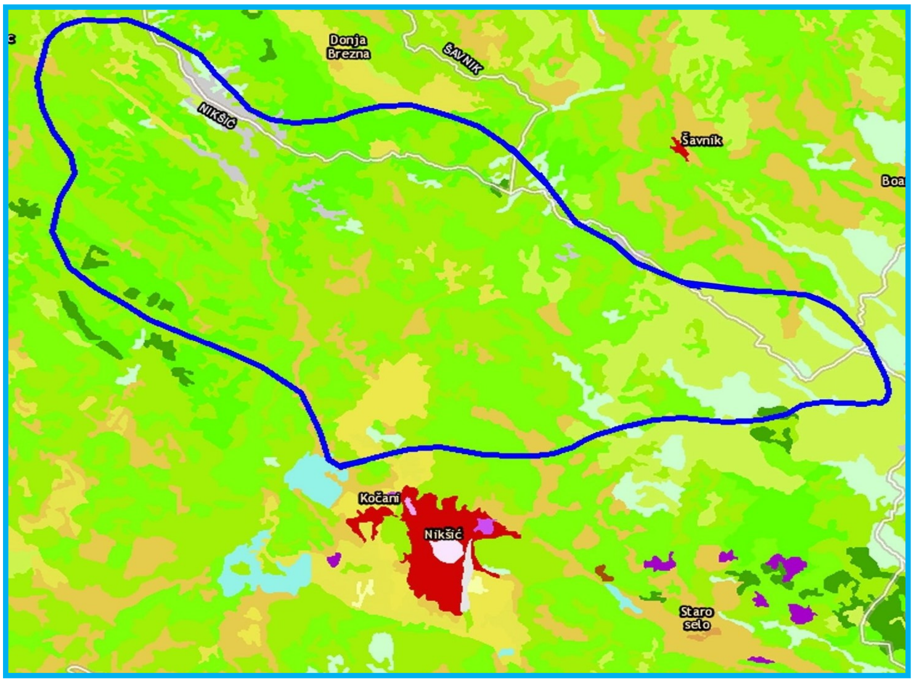

Figure 21: CORINE land cover (2006) for Nikši test area. [9]

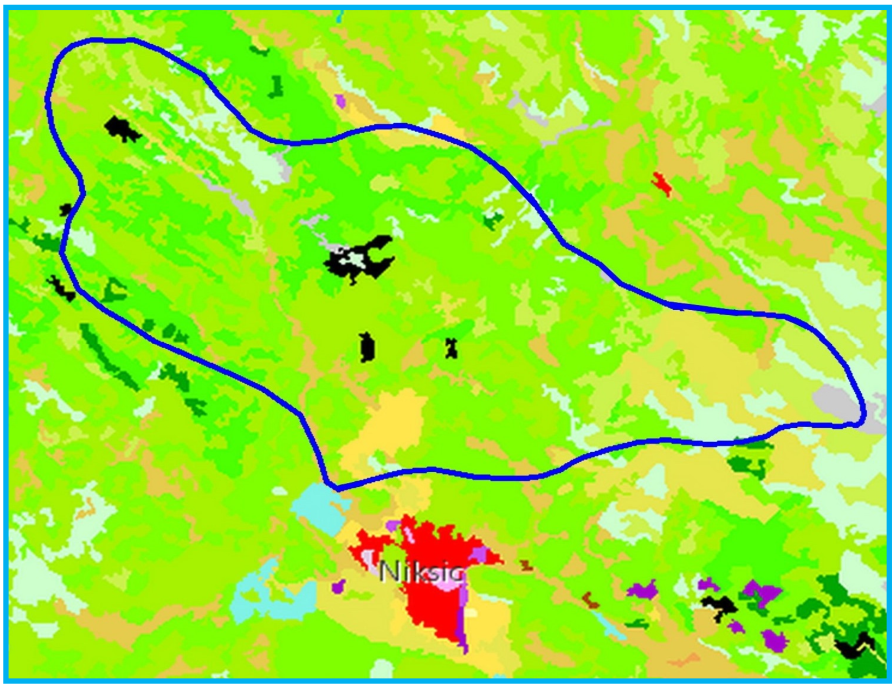

Figure 22: CORINE land cover (2012) for Nikšić test area. [9]

4.8 Drini basin

Land cover shows a very dynamic behaviour in the different areas in Albania between 1990 and 2007. In the (*Figure 23*), the land use structure in Albania today is shown.

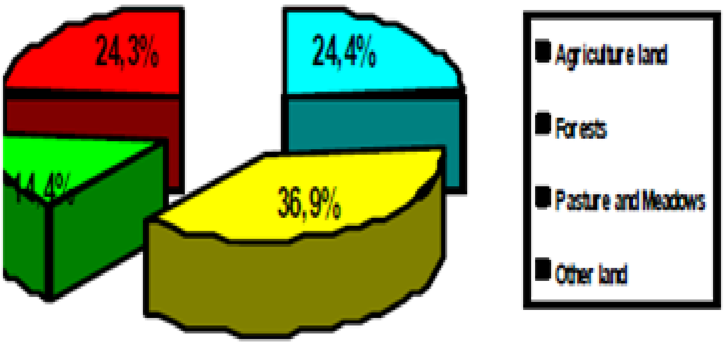

Figure 23: Land use in Albania.[10]

The main changes in land cover are forest regeneration, deforestation, and cropland abandonment which lead to a substantial reorganization of the landscape. Land change is highly heterogeneous across the four districts and across villages. A large share of the heterogeneity, particularly in shrub and grassland cover, cannot be explained by the variables hypothesized to influence land use. Nationwide land use in Albania changed little since the distribution of agricultural land to farm households in 1991. According to the MoAF (2007) the broad categories of arable land (24%), forests (36%), pastures and meadows (15%) and of other land (25%) remained stable between 1991 and 2006. According to preliminary results of the Albanian National Forest Inventory (ANFI), the first nationwide analysis of remote sensing data for the years 1991 and 2006, broad land-cover categories indeed changed relatively little. ANFI results for 2006 show cultivated area at 21% and forests cover at 32% (*Figure 24*). [10]

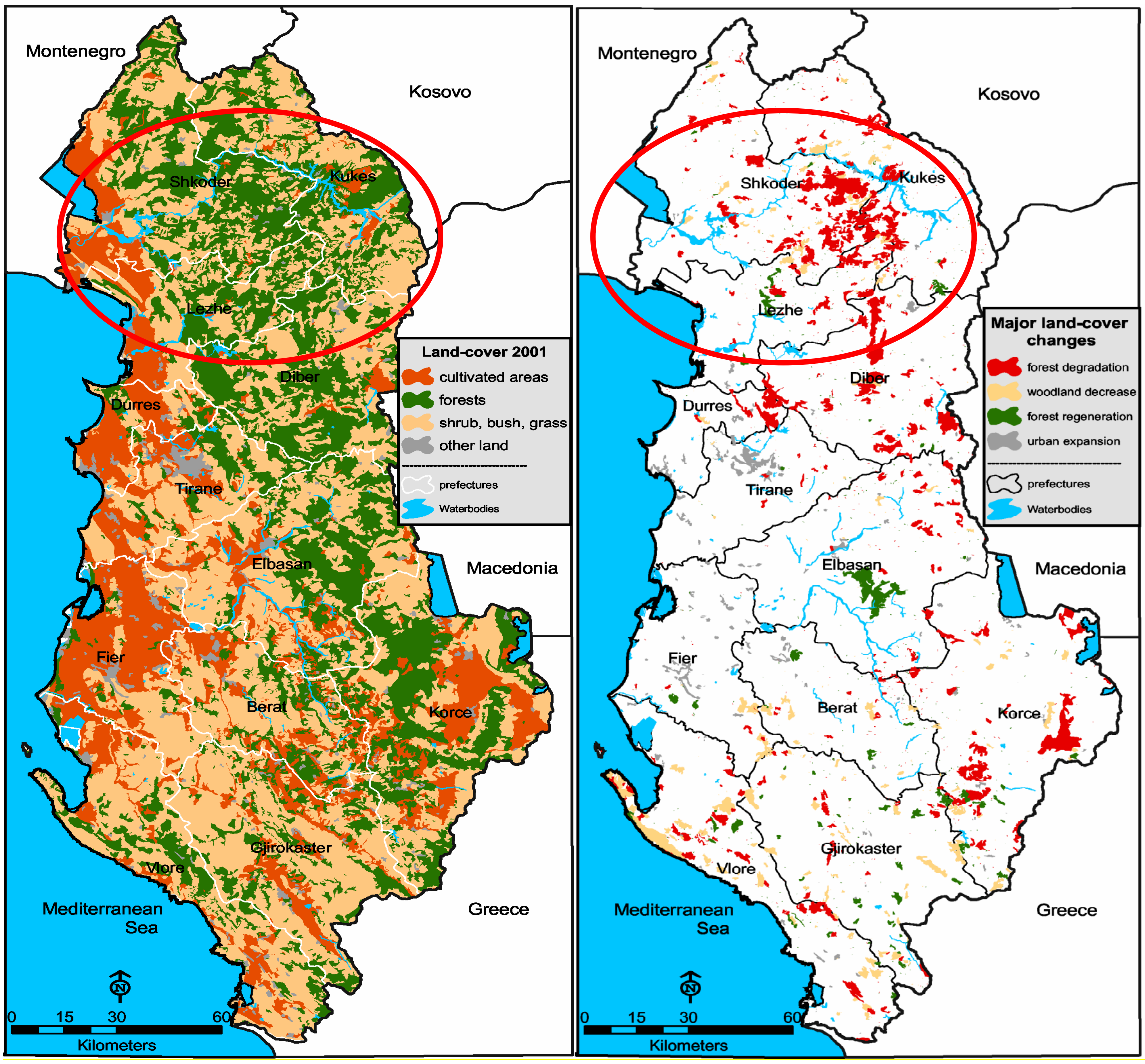

Figure 24: Major land-cover modification, 1991, 2001, 2006. [10]

4.9 Corfu Island

Corine Land Cover programme provides data regarding the land use cover in Corfu Island in 2000 (*Figure 25*). The dominant land use is agricultural areas (84.04%) followed by forests and semi-natural areas (9.52%), artificial surfaces (5.24%) and surfaces under water (1.2%). The main part of agricultural areas is covered by permanent crops. Urban areas cover 4.84% of the total area of the island. [11]

Land use cover from Corine project is available only for 1990 and 2000 for Greece. Greece is not included in the CLC of 2006 and 2012. The changes of Land use are shown in *Figure 26*. From *Figure 26* it is evident that the land use changes are not very significant from 1990 to 2000. [11]

Since there are no data available from the Corine Land Cover project, other sources are used to assess the land use changes in Corfu Island. A comparative study done in 2002 showed that agricultural land is increased by 4.9%, pastures increased by 1.4% and forests decreased by 10.62% from 1830 to 2000 (170 years, *Table 4*). [11]

Table 4: Land uses in Corfu in 1830 and 2000. [11]

	1830			2000				
%	Agriculture	Pastures	Forests	Agriculture	Pastures	Forests	Artificial surfaces	Other surfaces
Tot.	79.53	8.10	12.37	84.39	9.50	1.75	3.74	0.63

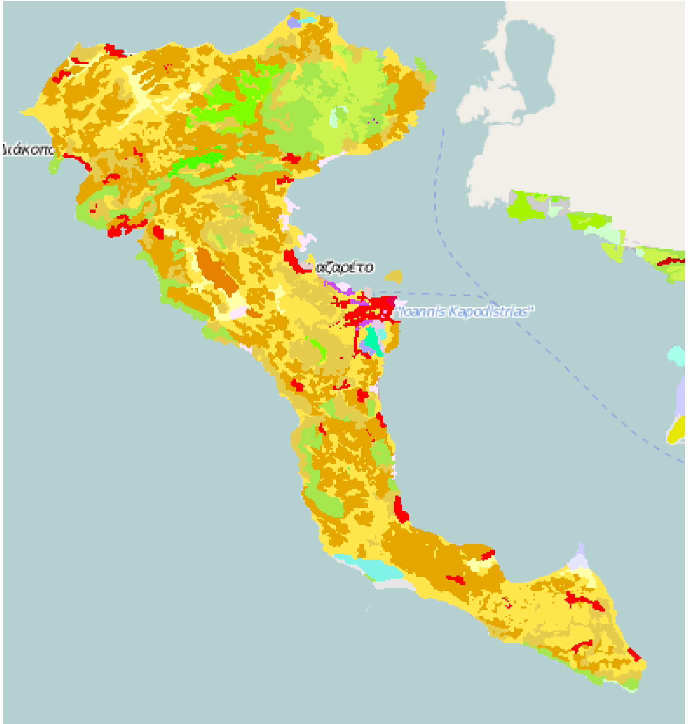

Figure 25: Land uses in Corfu Island from Corine Land Cover. [11]

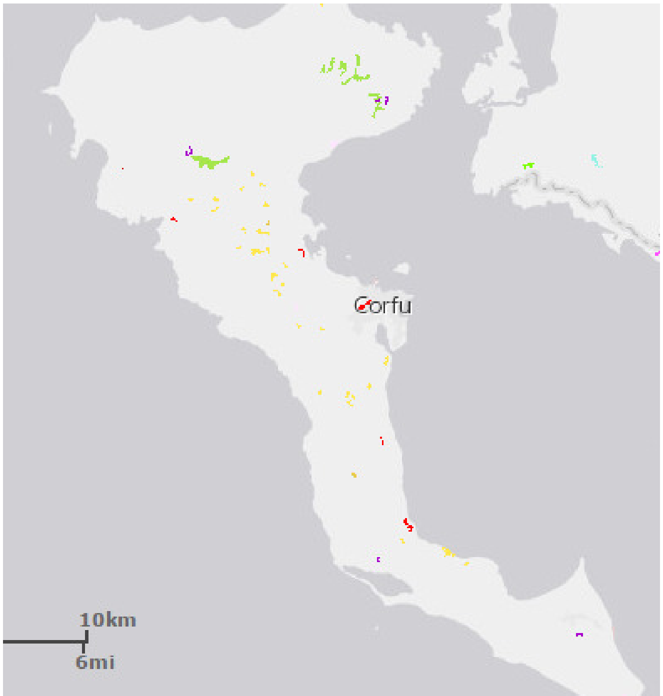

Figure 26: Differences in land use in Corfu, 1990-2000 (For colours see CLC Nomenclature). [11]

5 THE IMPACT OF PRESENT/PAST LAND USE ON WATER QUALITY ON TEST AREAS

5.1 Isonzo plain

Within the framework of GEP INTERREG project (A.A.V.V., 2014) [12], a specific study started for a part of the actual study area and a specific methodology was used in order to assign to the different soil categories a different score resulting from human activities that produce pressures on the quality of the aquifers.

The groundwater pollution, in space and time, is connected in almost all cases, directly or indirectly to human activities. The pollution sources are in fact associated with a wide range of industrial, agricultural, commercial and domestic activities. Land use activities having the potential to impact on groundwater quality are described as either point or non-point source discharges (*Figures 27 and 28*). [2]

Point source discharges can be defined as discharges from specific and identifiable sources (such as pipes or drains) concentrated at a given point, whereas non-point source discharges can be described as water contamination derived from diffuse sources where there is no single identifiable discharge point. Point source discharges can include tanks, offal holes, silage pits, landfills, leaking effluent ponds, underground storage tanks and wastewater application systems.

Non-point source discharges relate to the infiltration of water over a widespread area are often associated with agricultural or horticultural land use. Contaminants applied to land, including animal wastes and fertilizers, can leach through the soil profile to groundwater. The potential magnitude of non-point source discharges can also be exacerbated by land management practices such as the timing of soil cultivation. The effects of point source discharges on groundwater quality are typically localized but may be of significant magnitude and can involve a range of potential contaminants depending on the nature of the specific discharge.

For the project, within the test site area, was followed the analysis done for the GEP project. Were therefore collected and digitized point and non-point discharge areas. In particular: civil waste waters, urban solid waste, liquid storage, traffic and transportation, recreational services, mining operational and abandoned, industrial plants, electric power generators, industrial warehouses, animal husbandry, agriculture and other generic hazards. [2]

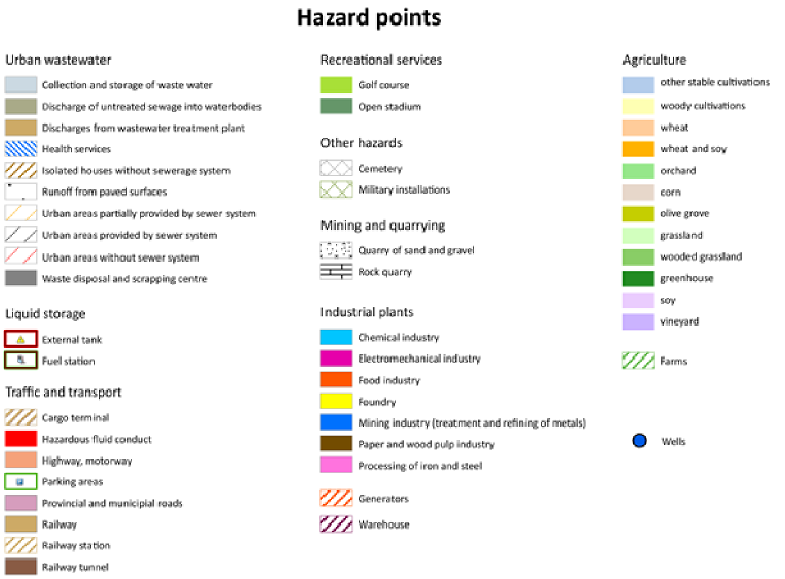

Figure 27: Legend of the hazard points identified in the analysed study area. [2]

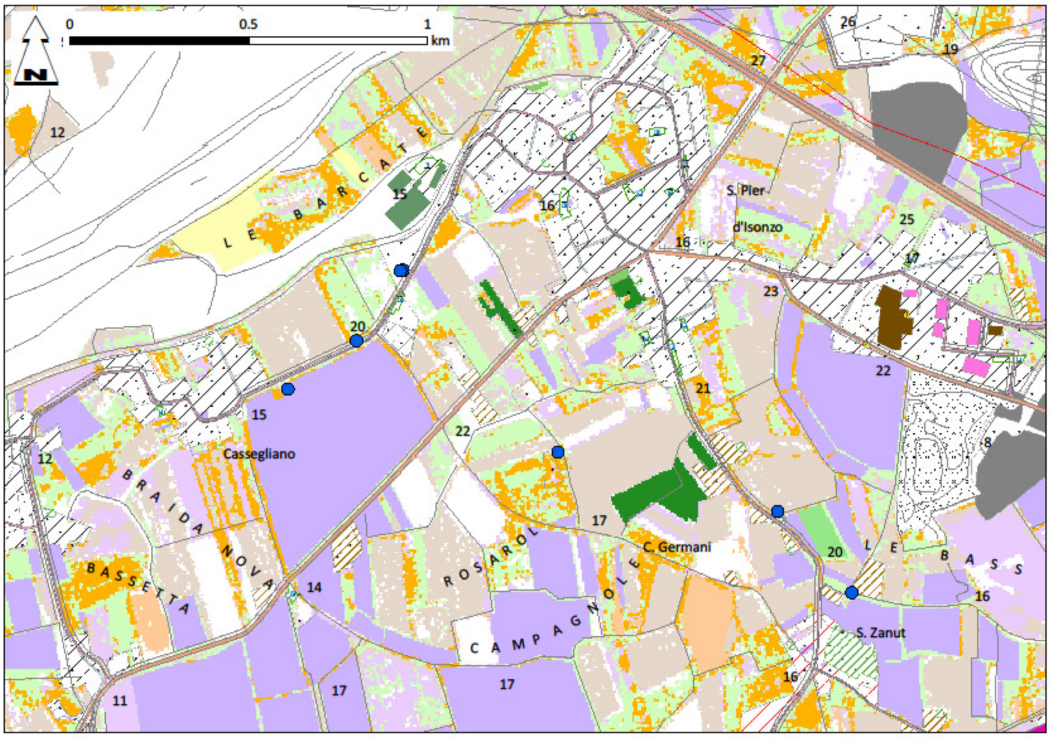

Figure 28: Sketch of the hazard points digitized for the study area. The map focused on the AcegasApsAmga pumping wells of the northern line (blue dots). Vineyards and corns are the more prevalent cultures in this area. [2]

The mapping provides an updated overview of the hazard points assessing the hazard of each hazard point in order to evaluate its compatibility with the protection of the groundwater resources.

Among the available different methods relative weight assignment scoring systems were used. These methods offer a quick preview of the scenario that can be caused by a pollution point source [13, 14].

According to the DPSIR method, in the test area DRIVERS are important and are defined in the Table 5.

If we look at the agriculture topic, the Regional Authority approved by Decree of the President of the region (R.D. n.3, 11 January 11 2013) as implementation of the DGR 2366 of 28 December 2012, the RFA, result of the transposition of the National Directive 91/676/EEC (the so-called Nitrates Directive), where are defined the "Criteria and general technical standards for the regional discipline on agronomic use of the breeding effluent, referred to in Article 38 of Legislative Decree 11 May 1999, n. 152 ". [2]

According to the directive the water bodies of the entire regional territory were analysed within the drafting of the Piano di Tutela delle Acque (Water protection plan). The Isonzo/Soča River High Plain has a good quality chemical status as the artesian aquifers in the Low Plain (A, B, C, D and the deeper ones). As visible also from *Figure 29*, the study area is characterized by a low concentration of nitrates ranging between 5.1 – 10.0 mg/l. In *Table 6* are given Drivers and pressures for agriculture.

Table 5: Drivers and pressures present in the Isonzo/Soča River study area. [2]

DRIVERS	PRESSURES
INDUSTRY	
Paper and wood pulp industry	Emissions of heavy metals, Cr and organic pollutants into groundwaters
Chemical industry	
Electromechanical industry	
Food indusry	
Foundry	
Mining industry (treatment and refining of metals)	
Processing of iron and steel	
TRAFFIC AND TRANSPORT	
Cargo terminal	Emissions from roads (statal, municipal and highways) and from railways of heavy metals (cd, Zn, Pb), salt (Cl, Br), spills (oils, chemical), oil and grease, pesticides, litter, and pollutants from vehicles
Hazardous fluid conduct	
Highway, motorway	
Parking areas	
Provincial and municipal roads	
Railway	
Railway station	
Railway tunnel	
URBAN WASTEWATERS	
Runoff form paved surfaces	Emissions of microbiological pollutants, pathogens, pharmaceutical, chemical, heavy metals
Collection and storage of waste water	
Health service	
Isolated houses without sewrage system	
Urban areas partially provided by sewer systems	
Urban areas provided by sewer systems	
Urban areas without sewer system	
Waste disposal and scrapping centre	
MINING AND QUARRYING	
Rock quarry	Mainly quarry of gravel, can higher the vulnerability due to the decreased unsatured thickness
Quarry of sand and gravel	
INDUSTRIAL WAREHOUSE	
Storage for raw and semifinished materials	
RECREATIONAL FACILITIES	
Golf course	Emissions of pesticides and oils
Motopark	
Open stadium	
ZOOTECHNIC INDUSTRY	
Farms	high concentrations of pathogenic animal waste
ELECTRICITY GENERATORS	
Biomasses energy plant	Emissions of carbon monoxide, nitrogen oxides, volatile organic compounds (VOCs), particulate matter and other pollutants
LIQUID STORAGE	
External tank	Fuel leakeges to soil and groundwater
Fuel station	
OTHER HAZARDS	
Cemetery	Emissions to groundwaters of pesticides to the paths
Military installations	

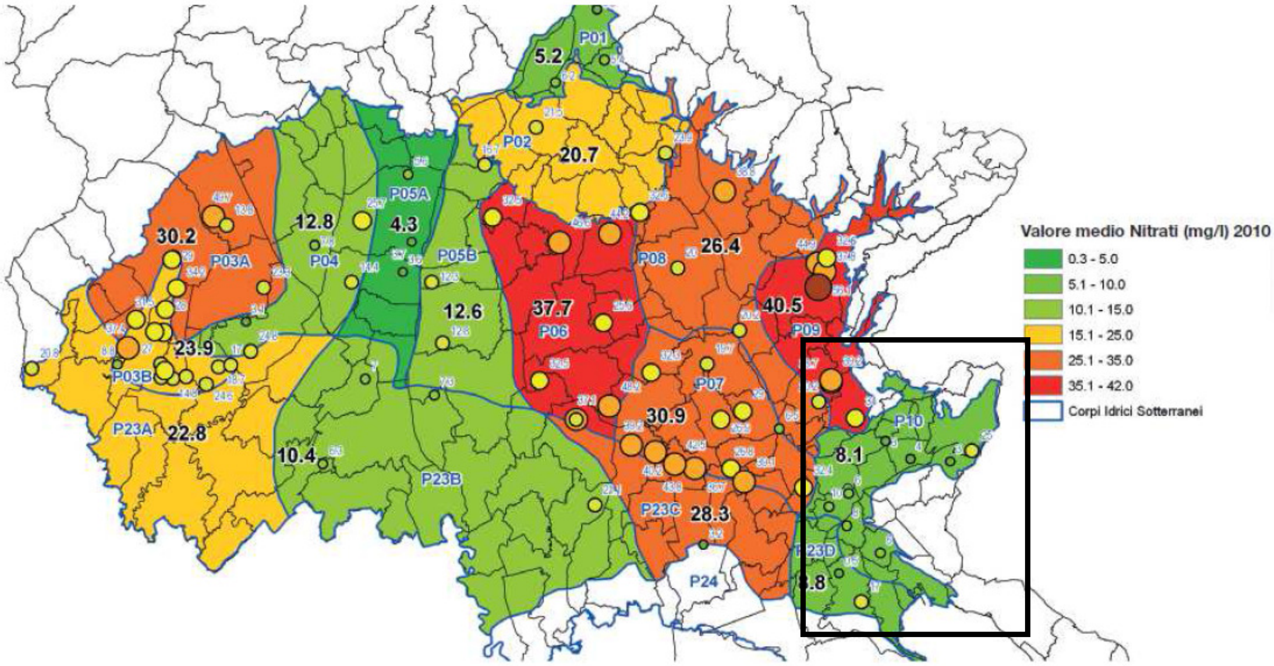

Figure 29: Mean value of the nitrates concentration (elaborated by ARPA FVG, 2010 in the framework of PTA, 2014). [2]

Table 6: Drivers and pressures for agriculture. [2]

STAGE	POSSIBLE INDICATORS
Driving forces	Climate Changes and demographical aspect were identified as primary driving forces. The agricultural sector is one of the secondary driving forces defined.
Pressures	In the Piano di Tutela delle Acque Plain, not jet approved, but since December 2014 under review, the following pressures were identified: water sources withdrawals and pollutant emissions mainly due to point and diffuse sources of nitrogen compound and plant protection products.
Status/ Impact	The PTA is considering the actual status of the pressures insisting on the environment of the FVG Region producing a general overview on which the actions need to be applied, working on air, water, soil, biodiversity landscape and health.
Response	The PTA Technical standards contain all the specification on the action that are necessary to define sustainable the way of living and to preserve and improve the quality of the surface waters and groundwaters. One of this is the National Directive 91/676/EEC (the so-called Nitrates Directive).

The dominant climate drivers for water availability are precipitation, temperature and evapotranspiration caused by net radiation at the ground, atmospheric humidity and wind speed, and temperature. Projected changes in these components of the water balance are described in the previous report on Climate Change in the pilot area [2]. In short, more intense rainfall events will lead to an increase in suspended solids (turbidity) in rivers, lakes and reservoirs due to soil fluvial erosion [15] and pollutants will be introduced [16, 17, 18, 19]. The projected increase in precipitation intensity is expected to lead to a deterioration of water quality, as it results in the enhanced transport of pathogens and other dissolved pollutants (e.g., pesticides) to surface waters and groundwater and in increased erosion, which in turn leads to the mobilization of adsorbed pollutants such as phosphorus and heavy metals. In addition, more frequent heavy rainfall events will overload the capacity of sewer systems and water and wastewater treatment plants more often. An increased occurrence of low flows will lead to decreased contaminant dilution capacity, and thus higher pollutant concentrations. In particular, in the study area, the occurrence of this scenario will take a while to verify due to the huge amount of available water [20], even if the path we are on is the one just described. In the Isonzo/Soča Plain area, the analysed chemical trends remain always well below the legal limits with not worrying fluctuations. What is worrying instead is the increased precipitation variability that may decrease the groundwater recharge due to the decreased effective infiltration capacity of the soil being exceeded more often. Anyway, the hydrologic changes associated with climate change cited thus will impact freshwater availability from both groundwater and surface water sources even in an area like the study site where freshwaters are abundant. Shallow, unconfined aquifer levels will be impacted most drastically. On the deep confined aquifers in the Low Plain the depressurization will take to the loss of humid environments and to the decreased discharge of the withdrawing wells. This is a general consideration, luckily in the study area, due to the presence of the Osimo international agreement there is the guarantee of the minimum amount of water discharged from Isonzo/Soča downstream Salcano dam. Here the hydro-picking withdrawals are the ones that regulate the amount of waters released from Slovenia to the Italian Plain with discharge problems. From a natural point of view, what will change will be the effective infiltration on the Italian territory that will decrease in the future not allowing the important recharge contribution to the groundwaters of the Isonzo/Soča River plain.

This allow saying that in the study area the water quantity present in the alluvial deposits is significant, but the ever-increasing demand requires careful withdrawal planning to maintain the sustainability. Now, the water quality is good. AcegasApsAmga within the years (1970s till now) had to face with atrazine and its metabolites issues that are visible on data analysis but with few criticisms (up to 0,05-0,06 µg/l of disetilatrazine). Also ARPA FVG (2015) referring to the groundwater data of 2010 and on phreatic ones, is declaring the good quality of the groundwater bodies. Regarding the residues of plant protection products, after many years from the prohibition of use of atrazine (1990), its degradation products (metabolites) are still present in the aquifers of large areas of the plains also in the groundwaters [2]. This is less visible in the concentrations analysed in the AcegasApsAmga wells, also because their wells reach important depths (-200 m). The problem is more felt by IRISACQUE that has its wells in the northern sector of the Isonzo/Soča High Plain. Here the wells are reaching risible depths (-40 and -25/-30 m) in the phreatic aquifer being more vulnerable to all the pollutants due to the fertilizers used in agriculture and to the cross-border contamination (Slovenian waste waters).

As known, in the groundwaters, within the 1990s, atrazine and desethylatrazine were identified. To date, the groundwater quality is still influenced by the presence of herbicides. In the Isonzo/Soča river basin, atrazine metabolites have been detected in concentration higher than 0,10 µg/l (drinkable limit according to D.Lgs. 31/2001) only in Povoletto municipality in the period 2000-05. It has long been started to detect, northern of Udine, the presence of other herbicides: terbuthylazine and in particular, its metabolite, the terbuthylazine-desethyl. This herbicide had been found also in a well (agricultural use) sited in the village of Cormons (Province of Gorizia). In some wells of the network, sporadic exceedances of the limit of 0.10 µg/l were detected in recent years, also for herbicide Alachlor (Comune di Premariacco) and Metolachlor (Cormons, the whole period within 2003-07). The terbuthylazine-desethyl is present in significant concentrations, equivalent to more than 0.10 µg/l in the previously mentioned well (Angoris well in Cormons municipality) [2]. For this reason, especially in the northern part of the study area, it is very important to follow a monitoring program able to verify the quality of the groundwaters.

5.2 ATO3

Tables 7 and *8*, show the results of the application of the DPSIR approach on the ATO 3 Test Area.

Table 7: Main Driving forces (Drivers) and related level of influence acting in the ATO 3 territory, for each Water Resource. [3]

ID	Water Resource	type	x-coord	y-coord	Drivers: level of influence			
					Population	Industry	Agriculture	Livestock
1	Via Pausola	W	4791669	2397328	**	**	***	*
2	Ponte Cannaro	S	4782462	2357291	*	**	*	*
3	San Giovanni	S	4777691	2353448	*	*	*	**
4	Acquasanta	S	4760287	2373488	*	*	*	*
5	Salette	S	4760116	2361079	*	*	*	*
6	Le Vene	S	4760735	2354664	*	*	*	*
7	Rotacupa	W	4796760	2390853	**	**	***	*
8	Acquevive	W	4791553	2395435	**	**	***	*
9	Centrale Nuova Campomaggio	W	4791130	2405338	**	**	***	*
10	Centrale Via Lelli	W	4794024	2415503	***	***	***	*
11	Crevalcore	S	4805339	2371807	*	*	*	*
12	Madonna dell'Ospedale	S	4800051	2377574	*	*	*	*
13	Sirolo 1	W	4820331	2407178	**	**	***	*
14	Valcimarra Trevase	S	4777704	2372035	*	*	*	*
15	Chiarino	W	4805622	2408251	**	**	***	*
16	Vallememoria	W	4803684	2405936	**	**	***	*
17	Marolino	W	4803552	2406728	**	**	***	*
18	Niccolini	S	4782392	2371180	*	*	*	*
19	Invaso Castreccioni	SW	4805028	2371136	*	*	**	**
20	S. Chiodo sul Nera	S	4750562	2369860	*	*	*	*

Type of Water body: S = spring; W = well field; SW = surface water

Level of influence: * low ** medium *** high

Referring to springs, mostly located in the mountain area, chemical contamination can be presently considered as non-existent, with Nitrate concentration below 5 mg/l NO_3, which would make this water suitable to be bottled. Bacteriological contamination, on the other hand, is frequent in small springs where intake works are obsolete and not well maintained. Available data indicate that the waters of the mountain area are generally safe. The risk of chemical pollution is particularly low, as these water resources are located in an area characterized by just few small human settlements, with scarce presence of industrial plants and limited agricultural activities.

Table 8: Assessment of the pressure level, in terms of relevant pressures on water bodies, global pressure and impact assessment for each Water Resource. [3]

Pressures level: W, without; M, moderate; H, high; **Global pressure:** L, low; NS, not significant; M, medium; S, significant

ID	Water Resource	type	x-coord	y-coord	Water Pollution (fertilizers)	Water pollution (chemicals, hydrocarbons)	Water pollution (metals)	Water pollution (bacteria)	Soil pollution (metals)	Soil pollution (oil-PCD)	Soil pollution (amiantus)	Nutrients	Water abstraction	Urban discharges	Global pressure	Impact assessment
1	Via Pausola	W	4791669	2397328	M	W	W	W	M	M	M	W	W	M	M-S	Verified
2	Ponte Cannaro	S	4782462	2357291	W	M	W	W	W	W	W	W	W	W	L-NS	Not apparent
3	San Giovanni	S	4777691	2353448	W	W	W	M	W	W	W	W	W	W	L-NS	Not apparent
4	Acquasanta	S	4760287	2373488	W	W	W	W	W	W	W	W	W	W	L-NS	Not apparent
5	Salette	S	4760116	2361079	W	W	W	W	W	W	W	W	W	W	L-NS	Not apparent
6	Le Vene	S	4760735	2354664	W	W	W	W	W	W	W	W	W	W	L-NS	Not apparent
7	Rotacupa	W	4796760	2390853	M	W	W	W	M	M	M	W	M	M	M-S	Verified
8	Acquevive	W	4791553	2395435	M	W	W	W	M	M	M	W	M	M	M-S	Verified
9	Centrale Nuova Campomaggio	W	4791130	2405338	M	H	W	W	M	M	M	W	M	M	S	Verified
10	Centrale Via Lelli	W	4794024	2415503	M	H	W	W	M	M	M	W	M	M	S	Verified
11	Crevalcore	S	4805339	2371807	W	W	W	W	W	W	W	W	M	W	L-NS	Not apparent
12	Madonna dell'Ospedale	S	4800051	2377574	W	W	W	W	W	W	W	W	W	W	L-NS	Not apparent
13	Sirolo 1	W	4820331	2407178	M	W	W	W	M	M	M	W	M	M	M-S	Probable
14	Valcimarra Trevase	S	4777704	2372035	W	W	W	M	W	W	W	W	W	W	L-NS	Not apparent
15	Chiarino	W	4805622	2408251	M	W	W	W	M	M	M	W	M	M	M-S	Probable
16	Vallememoria	W	4803684	2405936	M	W	W	W	M	M	M	W	M	M	M-S	Probable
17	Marolino	W	4803552	2406728	M	W	W	W	M	M	M	W	M	M	M-S	Probable
18	Niccolini	S	4782392	2371180	W	W	W	M	W	W	M	W	W	W	L-NS	Not apparent
19	Castreccioni	SW	4805028	2371136	W	W	W	M	W	W	W	H	M	W	M-S	Verified
20	S. Chiodo sul Nera	S	4750562	2369860	W	W	W	W	W	W	W	W	M	W	L-NS	Not apparent

Type of water body: S = spring; W = well field; SW = surface water

In the central, medium-low hill area, most of the wate central, medium-low hill area, most of the water supplied for drinking purposes comes from pumping well plants. Nitrates concentration is between 5 and 40 mg/l NO_3 and chemical contamination is mostly referable to and caused by greater agricultural activity, sometimes even resulting in exceeding the limit of 50 mg/l NO_3 required for drinking water. Bacteriological situation is similar to that of mountain springs.

Moving from the mountain area to the valleys (medium-high hilly area and flat-coastal zone), a progressive worsening of water quality features can be detected, also due to the slow underground movement and of the lithological nature of soils (presence of sand with gravel, mainly limestone elements). The significant increase in the concentration of the nitrates is a result of the use and abuse of fertilizers in agriculture. A relevant number of wells are used for irrigation, for industrial water supply and for drinking water supply to the largest urban centres and private country houses in this area, so determining a significant pressure on the natural resource.

Water withdrawn from pumping wells dug in the alluvial deposits near the coastal area shows chemical characteristics similar to the one abstracted in the valleys. In some cases, intense exploitation of wells located close to the sea and their overuse has produced saline ingression phenomena. High Nitrate concentrations and bacterial contamination are less frequent, but a progressive deterioration of groundwater quality has been registered since 1980's because of contamination caused by industrial activity (Tetrachloroethylene, Trichloroethane).

This deterioration of groundwater quality and the increased drinking water demand have led, since the early 1980's, to abandon the poorest sources of supply, to be replaced by the use of treated surface water or, whenever possible, by new mountain water resources. [3]

5.3 Ostuni

During DRINKADRIA activity the partner FB3 has carried out several water sampling in order to monitor groundwater and surface water the OSTUNI test area. In particular were selected three sampling locations into a channel and three wells for groundwater monitoring (*Figure 30*).

Figure 30: Monitoring: Sampling locations at the Ostuni test area.[4]

At each sampling site we have collected two litres of water in a sterile container to detect *Salmonella* spp., one litre to detect the indicators of faecal contamination and a third sample of twenty litres to detect somatic coliphage viruses. The coliphages will be determined after concentration to 50-100 mL of water sample by tangential ultrafiltration [4].

Furthermore the IRSA has defined sampling procedure in order to collect water samples from the OSTUNI wells and standard and bimolecular methods that must be used for microbiological analyses during DRINK ADRIA project at the Ostuni pilot area. In particular sampled water will be analysed for total bacterial count (TBC) at 22° and 37°, coliforms, *Escherichia coli*, spores of sulphate-reducing clostridia, somatic coliphages, and *Salmonella* spp., and physical-chemical constituents, such as ammonia, nitrates, chemical oxygen demand (COD). The presence and abundance of antibiotic resistance genes (ARGs) will be also determined by q-PCR and large volumes of 5-120 L and 200-250 L will be sampled for the protozoa and virus analyses, respectively. For Enteroviruses determination, the groundwater will be filtered on electropositive cartridges (Virasorb CUNO MK/Cuno, Sanford, FL). Cartridges will be eluted with a meat extract solution (elution buffer 0.05 M glycine in 0.3% meat extract pH9.5) and viruses will be further concentrated by precipitation with PEG6000 and centrifugation. Finally viral particles will be quantified by cultivations on cellular systems or by bimolecular methods. Cysts and oocysts will be concentrated by filtration in IDEXX foam filters, purified by means of immune-magnetic separation (*Dynabeads*® Crypto-Combo) and stained with fluorescently labelled monoclonal antibodies (*MERIFLUOR® Crypto & Giardia* kit, Meridian Bioscience, Europe). *Giardia* and *Cryptosporidium* cysts and oocysts will be finally enumerated by epifluorescence microscopy (Olympus BX-51) and phase contrast observation.

Microbial and chemical constituent results during the first sampling period of the DRINK ADRIA project, have been reported in the following *Table 9*, whereas the *Salmonella* was below detection limit of the proposed microbiological method (q-PCR). [4]

Table 9. Surface water and groundwater quality sampled at Ostuni test area. [4]

	D'Antelmi Mouth			Channel 1		
Water constituents	19/11/2014	13/01/2015	17/02/2015	19/11/2014	13/01/2015	17/02/2015
pH	7.2	6.9	7.5	7	7.2	7.4
Electrical conductance (µS/cm)	1808	1721	1872	1288	1773	1817
COD (mg/L)	64	35	28	41	38	29.6
$N-NH_4$ (mg/L)	<0.4	8.86	4.5	<0.4	11	5.68
$N-NO_3$ (mg/L)	7.2	8	3.8	7.2	6.7	4.33
$N-NO_2$ (mg/L)	0.01	3	1	0.026	2.3	1.2
Microbiological indicators						
E. Coli (MPN/100mL)	2240	31	135	6490	240	137
Total Coliforms (MPN/100 mL)	32550	3450	4160	48800	9210	9606
Spores of C.Perfrigens (CFU/100 mL)	3000	3000	2000	2000	3200	1800
Somatic Coliphages (PFU/100 mL)	300	2400	1300	1000	2800	2000
Enterococci (MPN/100 mL)		218	185		2420	161
HPC 37°C (CFU/mL)		3550	4200		6900	6500
HPC 22°C (CFU/mL)	390	850	680	795	980	840

	Channel 2			Well	Well 1		Well 2	Well 3	Well 4	Well 5
Water constituents	19/11/2014	13/01/2015	17/02/2015	13/01/2015	19/11/2014	17/02/2015	13/01/2015	17/02/2015	17/02/2015	17/02/2015
pH	7.5	7.7	7.3	6.9	7.2	7.4	7	6.9	7.2	7
Electrical conductance (µS/cm)	1845	1696	1888	9180	1977	3850	687	8500	2700	4000
COD (mg/L)	48.6	44.4	30	21.2	56	8.8	4	20.6	7	8.5
$N-NH_4$ (mg/L)	<0.4	8.66	4.2	0.56	<0.4	0.5	0.12	1.3	0.5	<0.4
$N-NO_3$ (mg/L)	7.3	5.6	3.29	3.2	2.5	2.24	1.9	1.3	5.5	1.2
$N-NO_2$ (mg/L)	0.016	1.5	0.6	0.22	0.04	0.013	0.01	0.01	0.014	0.004
Microbiological indicators										
E. Coli (MPN/100mL)	2183	41	47	<1	67	<1	<1	2	<1	<1
Total Coliforms (MPN/100 mL)	14000	3076	3088	260	30800	2419	50	345	387	1
Spores of C.Perfrigens (CFU/100 mL)	1000	4500	2430	800	200	400	200	0	1500	0
Somatic Coliphages (PFU/100 mL)	500	1900	1200	0	0	0	0	0	0	0
Enterococci (MPN/100 mL)		866	44	100		10	2	48	8	0
HPC 37°C (CFU/mL)		4500	2900	800		324	100	311	248	260
HPC 22°C (CFU/mL)	475	520	600	350	85	155	450	300	185	110

5.4 Kobariški stol, Mia and Matajur aquifer

The major part of test area is covered with forests and grassland and present less populated foothill area. The possible anthropogenic impact represents cattle grazing in lowland and highland, which may reflect in pollution with nitrogen compounds and microbes. Another anthropogenic impact is isolated settlements, such as Kobarid at the eastern part of the map. Due to low percentage of the anthropogenic activities in the test area, the potential impact of land use on water quality is low and problems with water pollution on the test area are not expected. [5]

5.5 Springs Sv. Ivan, Bulaž and Gradole

Analysis of actual land use on test areas and the impact on water quality

Results of pollutant loads in the watersheds are obtained using simple pollutant load model - STEPL [21]. Results of model are presented in *Table 11* and *12* for each land use category (urban land, agricultural land, pastures, forests, natural grasslands, septic systems or direct discharge of wastewater in underground and wastewater treatment plants - WWTP).

Larger watershed areas usually have greater pollution load. But, this does not mean that smaller watershed areas cannot produce more pollution load of the larger watersheds. In fact, smaller watersheds can have a bigger population, more developed agricultural production and more intensive livestock farming. For this reason it is important to determine the specific loads or loads per km^2 of watershed area.

In the case of drinking water sources Sv. Ivan, Bulaž and Gradole greater watershed area also means greater pollution load, so the greatest pollution load is obtained from Gradole watershed, then from Bulaž and finally from Sv. Ivan. After dividing the total pollution load with watershed area specific pollution loads were obtained. Obtained results for specific loads also give the largest pollution load per km^2 of watershed area for Gradole watershed (according to all indicators of pollution), then for Bulaž and finally, the smallest load for Sv. Ivan. Total and specific loads by watershed are given in *Table 10*.

Table 10: Total and specific loads by watershed. [7]

Watershed	Sv. Ivan	Bulaž	Gradole
Area [km^2]	103,00	108,22	163,38
Total Load by Watershed [t/yr]			
BOD_5 Load	40,48	55,01	200,34
N Load	11,41	18,85	57,08
P Load	3,39	6,18	16,98
Sediment Load	4126,99	9021,62	20619,61
Specific Load by Watershed [t/km^2/yr]			
BOD_5 Load	0,39	0,51	1,23
N Load	0,11	0,17	0,35
P Load	0,03	0,06	0,10
Sediment Load	40,07	83,36	126,21

Results for different categories of pollution sources (population, agriculture and livestock farming) are shown in *Table 11*. Urban land and forests are not taken into account, so these categories are not shown in the table. The first part of the table shows the load that is produced by population (i.e. septic systems or direct discharge of wastewater in the underground and the pollution load generated at the WWTPs, if they exist), and the second part shows the results for pollution load from agriculture and livestock farming (agricultural land, pastures and natural grasslands). Agriculture and livestock farming are presented as one category because STEPL does not calculate separately loads from livestock; the load is equally distributed to areas with livestock farming.

Table 11: Total load from population, agriculture and livestock farming by watersheds. [7]

Watershed	Sv. Ivan	Bulaž	Gradole
Total Load from Population [t/yr]			
BOD_5 Load	27,60	26,97	136,44
N Load	5,02	4,90	25,15
P Load	1,00	0,98	5,07
Total Load from Agriculture and Livestock Farming [t/yr]			
BOD_5 Load	12,38	27,67	63,23
N Load	6,18	13,78	31,68
P Load	2,31	5,14	11,83
Sediment Load	4034,09	8941,81	20534,03

Also, it is important to point out that phosphorus largely depends on erosion by flood events, while nitrogen directly on the discharged water volume due to its higher solubility.

Water quality on test areas

Conclusions from the report on water quality on test areas (Water quality analysis and trends on test area in Northern Istria - Croatia, 2013; [22]) are presented below.

All springs are well saturated with oxygen, owing to the well-developed underground relief. The content of the substance that can be oxidized and decomposed by microorganisms (expressed as a five-day biochemical oxygen demand-BOD_5) or by using a strong oxidant (expressed as a chemical oxygen demand-COD permanganante index), is very low.

Nutrient content is shown through the content of nitrates and total phosphorus. For all springs maximum values of these indicators have decreasing trend. The values of total nitrogen are several times below the MAC (Maximum Allowable Concentration) for drinking water (for nitrate content is 50 mg/l (NO_3-) or 11.3 mgN/l). The largest contribution to the total nitrogen is from inorganic content of nitrogen due to the nitrate content. Generally the content of the inorganic nitrogen is almost all composed of the nitrates, which means that the content of ammonium and nitrite, as indicators of present fresh contamination is very low and very rarely appears in detectable concentrations. Nitrate content on springs that drain water from Ćićarija Mountain and the northern part of Istrian peninsula (Sv. Ivan and Bulaž) is low. Due to the more developed agricultural activities in the catchment of spring Gradole which drains water from the interior of Istrian peninsula content of nitrate is higher. But on all springs in last years we have a decreasing trend, although up to year 2007 we have increasing trend for total N and nitrates. All values are bellow MAC for drinking water.

For all springs phosphates and total phosphorus are very low. Phosphorus content on all test areas is generally below the MAC for drinking water for dissolved phosphates.

Microbiological contamination is present on all springs which is associated to the hydrological conditions in the watersheds. High values are associated with the occurrence of torrential waters and increased amounts of silt which is entering in the aquifers. Due to turbulent flow of water, move of the internal sediment occurs and then results with the appearance of turbidity.

Higher concentrations of total number of microorganisms and microorganisms of fecal origin were observed also on all springs (at least occasionally). The source of these organisms can be wild animals or livestock which moves in the watershed areas of springs, but mostly the main sources are untreated urban waste waters from settlements in the observed watersheds.

Due to occurrence of extreme turbidity increased concentrations, above the MAC for drinking water, of iron and manganese occur.

From observed mean annual values of BOD_5, COD, total suspended solids, nitrates, total phosphorus, iron and manganese it can be concluded that: on spring Sv. Ivan all tested parameters have declining trend only TSS have slightly increasing trend, on the spring Bulaž there are slightly increasing values of BOD_5 and TSS, and at spring Gradole increasing trend is only for TSS. However, the content of TSS depends primarily on hydrological conditions in the basin, on the amount and intensity of rainfall, so this should not be considered as an indicator of pollution.

From the analysis of the water quality for springs Sv. Ivan, Bulaž and Gradole can be concluded that the values of nearly all indicators are decreasing, respectively as the quality of the water on springs improves.

Impact of present land use on water quality in test areas

From the report "Water quality analysis and trends on test areas in Northern Istria – Croatia" [22] in *Table 3* are presented mean annual concentration of nutrients, average annual flow and the average nutrient load for the springs of Sv. Ivan, Bulaž and Gradole in 2012. In the absence of detailed information regarding water quality and hydrological conditions, average nutrient loads were calculated as a multiple of mean annual concentrations of nutrients and average annual flows. As such they are not relevant, but they could be taken for comparison with the estimated pollutant loads.

Comparing the values in *Table 12* with estimated values (*Table 10)* it can be observed that the values in *Table 12* for total nitrogen are almost twice higher than those estimated with STEPL. The values for total phosphorus are however much less. Therefore for further analysis estimated values with STEPL will be used because this is a standard approach in estimation of pollution load in watersheds when there is insufficient measured data.

Table 12: Mean annual concentration of nutrients, average annual flow and average nutrient loads on springs Sv. Ivan, Bulaž i Gradole in 2012. [7]

Indicator / spring	Sv. Ivan	Bulaž	Gradole
Total N (mgN/l)	1,071	1,3706	3,5823
Total P (mgP/l)	0,0278	0,0329	0,0218
$Q_{ave.yr}$ (m^3/s)	0,684	0,986*	0,866
Total N (t/god)	23,1	42,63	97,86
Total P (t/god)	0,6	1,02	0,6

Note: some data are missing

From *Table 10*, pollution load at the spring Sv. Ivan is ranging from 11,41 t/year for total nitrogen and 3.39 t/year for total phosphorus, for Bulaž the values are 18.85 t/year and 6.18 t/year and for Gradole 57.08 t/year and 16.98 t/year, respectively. Specific load at spring Sv. Ivan is 0.11 t/km^2/year for total nitrogen and for total phosphorus 0.03 t/km^2/year. Spring Bulaž has 0.17 t/km^2/year for total nitrogen and 0.06 t/km^2/year for total phosphorus while spring Gradole has 0.35 t/km^2/year and 0.10 t/km^2/year, respectively. According to this data spring Gradole has the biggest nutrient load. The same results are written in report "Water quality analysis and trends on the test areas in Northern Istria -

Croatia“ [22] and in “Report on water quality on springs in the Istria County for 2012“ [23]. In these reports measured concentrations are below the MAC and that for now do not have a negative impact on water resources.

Changes of land use in test areas in the past and the impact on water quality

Summarizing all the reports on water quality on springs in the Istria County (see also “Water quality analysis and trends on the test area in Northern Istria – Croatia”) [22] it can be concluded that the concentrations of total nitrogen and total phosphorus had an increasing trend to year 2007, while after 2007 the trend is decreasing.

In previous sections can be seen that in the period 2000-2012 there were no significant changes in land use, and that this changes did not have a significant impact on the nutrient trends. Most likely the decreasing trend of nutrients after 2007 is related to more rational usage of fertilisers in agriculture which have become more expensive. Also farmers are more educated in application of fertilisers so they can be better incorporated into the plant biomass and not needlessly washout into groundwater.

5.6 Spring Prud and Blatsko polje

Drivers and Pressures are estimated by analysis of CORINE land use maps for 2000, 2006 and, where possible, 2012 and from Municipal/Regional Spatial plans. State for present is known and is determined from the water quality monitoring (see Water quality report - [24]). DRINKADRIA is focusing on drinking water resources, therefore impacts are effects to human health (e.g. microbiological pollution may cause digestion problems). Responses are measures to improve the quality of drinking water.

The most widespread land use on test areas in Southern Dalmatia is agriculture and urban areas, therefore, in *Table 13*. are given the most important *Drivers, Pressures, States, Impacts and Responses for those land use categories.*

Table 13: The most important Drivers, Pressures, States, Impacts and Responses in test areas of Southern Dalmatia. [8]

URBAN AREAS				
Driving forces	**Pressures**	**State**	**Impacts**	**Responses**
Areas without sewage system	Emission of microbiological pollutants, nutrient N&P compounds	Groundwater state [6]	Deterioration of groundwater quality, impact on human health	Implementation of appropriate measures, for example, the construction of the sewage system and devices for wastewater treatment
AGRICULTURE				
Driving forces	**Pressures**	**State**	**Impacts**	**Responses**
Use of fertilisers (N consumption)	Diffuse N contribution (runoff and percolation)	Groundwater state[6]	Deterioration of groundwater quality, impact on human health	Implementation of appropriate measures, for example, ecological agriculture

5.7 Nikšić

Based on results presented here and studies and reports used in water quality assessment for Test Area Nikšić water has good quality, in generally. However, some triggers should not be neglected. With respect to water quality within the test area there are impacts that should be addressed given the land use. At the present, the drinking water sources have high quality with less than 10 % of monitored data above MAC during the heavy rainfall events. Thus need for more comprehensive study with respect to extreme rainfall events exist. [9]

5.8 Drini basin

Soil loss studies using watershed sediment assessment methods indicate that the river network transports in a year about 60 million tons of fine and coarse sediment, 1.2 million tons of organic materials and 170 thousand tons of N, P, and K salts. The environmental consequences of cropland abandonment are largely unknown. Nevertheless, research from other parts of Europe suggests that land abandonment can lower soil fertility, decrease biodiversity levels, degrade water ecosystems, and lead to a loss of cultural landscapes. An initial increase in landscape heterogeneity may be followed by later homogenization due to the decease of the aging population. Such a homogenization affects both the biological and scenic diversity of the land.

The statistical data shows that agricultural abandonment in Albania is strongly mediated by both the biogeophysical environment and transportation infrastructure. District level effects provide some evidence that abandonment is more likely in some regions than others, but were most likely in relatively remote areas, or in the presence of other economic opportunities, such as tourism. Interestingly, the importance of remittance income was not a significant correlate of cropland abandonment, perhaps because a low share of remittance income is channelled into agricultural investments. Forest-cover loss was highly sensitive to the time period. Forest clearing tended to shift from subsistence orientation in the first years after the collapse of socialism to more commercial extraction in later stages. Effects on biodiversity are of global significance as the research area is located within the Mediterranean Basin, which is recognized as a global biodiversity hotspot in terms of endemic flora and fauna species. On the other hand, land abandonment may also lead to increases in biomass, e.g., through an expansion of woodland and a regeneration of forest land, with positive effects on global carbon cycles and local hydrological cycles. [10]

5.8 Corfu Island

The identified pressures on the water bodies of the test area include point pollution sources (wastewater treatment plants, industries, landfills and unmonitored waste disposal sites) and diffuse pollution sources (agriculture, livestock farming, urban waste) and other pollution sources (fish farming).

There are 7 wastewater treatment plants in Corfu island discharging in the sea (6 of them) and in a river (1 of them) (*Table 14 & Figure 31*) [25]. The most important pressure is caused by the wastewater treatment plant (WWTP) serving equivalent population of more than 10,000 people (WWTP of Corfu town). *Table 15* shows the aggregate status of the town served with WWTPs and the pollutant loads [25]. The River Basin Management Plan also provided data for settlements not connected to WWTP. In Corfu Island there are no such settlements.

In Corfu prefecture there are 121 industrial units recorded in the River Basin Management Plan [9]. 82% of them are oil mills (*Figure 32*). *Table 16* provides the data for the industrial activity in the basin of Corfu – Paxi [25].

Figure 31: WWTPs in Corfu island [25]

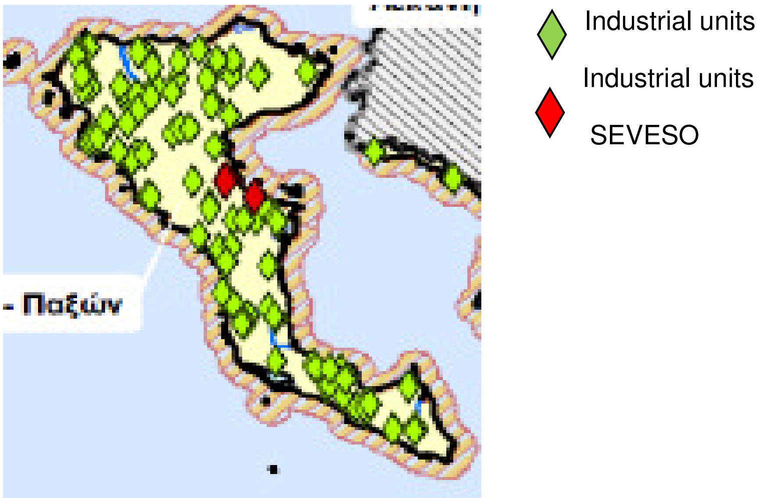

Figure 32: Industries in Corfu island [25]

Table 14: WWTP characteristics in Corfu Island [25].

WWTP	Population served (ep)	Current operating conditions (ep)	Type of treatment	BOD load (tn/year)	SS load (tn/year)	N load (tn/year)	P load (tn/year)	Receiving water body
Benitses	13,500	1,200	2	3.5	4.7	4.2	0.9	Sea
Kinopiaston	5,500	2,600	2	3.8	4.9	9.1	1.9	River
Melitieon	10,000	8,000	2NP	17.5	21.9	7.0	1.5	Sea
Agios Stefanos		120	2	0.3	0.3	0.4	0.1	Sea
Paleokastriton	1,500	1,500	2NP+Distillation	1.6	0.4	0.6	0.1	Sea
Corfu	69,674	47,000	2N	102.9	128.7	41.2	34.3	Sea
Agios Markos		8,600	2N	18.8	23.5	7.5	6.3	Sea

2: secondary treatment
2N: secondary treatment with Nitrogen (N) removal
2NP: secondary treatment with Nitrogen (N) and Phosphorus (P) removal
+ Distillation: further treatment for the removal of suspended soils (SS)

Table 15: Operating WWTP and pollutant loads in Corfu Island [25]

<table>
<tr><td></td><td colspan="4">WWTP</td><td colspan="3">Without WWTP</td><td></td></tr>
<tr><td></td><td colspan="4">Types of Settlements</td><td colspan="4">Types of Settlements</td></tr>
<tr><td></td><td>A</td><td>B</td><td colspan="2">C</td><td>A</td><td>B</td><td colspan="2">C</td></tr>
<tr><td></td><td colspan="3">>15,000 permanent population (pp) in sensitive receiving body</td><td>>10,000 permanent population in normal receiving body</td><td>10,000>pp>2,000 in normal and 15,000>pp>2,000 in sensitive receiving body</td><td>>15,000 permanent population in sensitive receiving body</td><td>>10,000 permanent population in normal receiving body</td><td>10,000>pp>2,000 in normal and 15,000>pp>2,000 in sensitive receiving body</td></tr>
<tr><td>Corfu – Paxi GR34 Basin</td><td colspan="3">0</td><td>1</td><td>2</td><td>0</td><td>1</td><td>0</td></tr>
</table>

	WWTP	Current Operating Conditions (ep)	Pollutant Loads (tn/year)			
			BOD	**TSS**	**TN**	**TP**
Corfu – Paxi GR34 Basin	7	69,020	148.5	184.4	70.1	45.0

Table 16: Industrial units pollutant loads in Corfu-Paxi Basin [25]

	Total Units	**SEVESO units**
Corfu – Paxi GR34 Basin	121	3

	Total Units	**Units drained in WWTP**	**Pollutant Loads (tn/year)**							
			BOD	**TSS**	**TN**	**TP**	**Fats, oils**	**Phenols**	**Sulphides**	**Cr**
Corfu – Paxi GR34 Basin	121	2	2172.5	9576.4	2.0	0.4	3.4	0	0	0

There are no livestock farms recorded in the Corfu-Paxi basin [25].

There are no mining or quarries activities recorded in the Corfu-Paxi basin [25].

The sanitary landfill of Central Corfu serves the central and northern part of the island (*Table17 and Figure 32*) [25]. A second sanitary landfill is expected to operate in the Southern Corfu (its construction is concluded).

Table 17: Landfills characteristics in Corfu Island [25]

Name	**Municipality**	**Operating condition**	**Area (m^2)**	**Equivalent population served in 2010**	**Annual quantity of waste (tn/year)**	**Treatment type of leachate**	**Annual production of leachate (m^3/year)**	**Receiving water body**
Landfill of Central Corfu	Corfu	Operating	100,000	166,874	67,000	Tertiary	130,435	Irrigation & recirculation
Landfill of Southern Corfu	Leykimmeon	To be operable soon	16,840	38,854	15,600	Secondary	16,840	Irrigation & recirculation

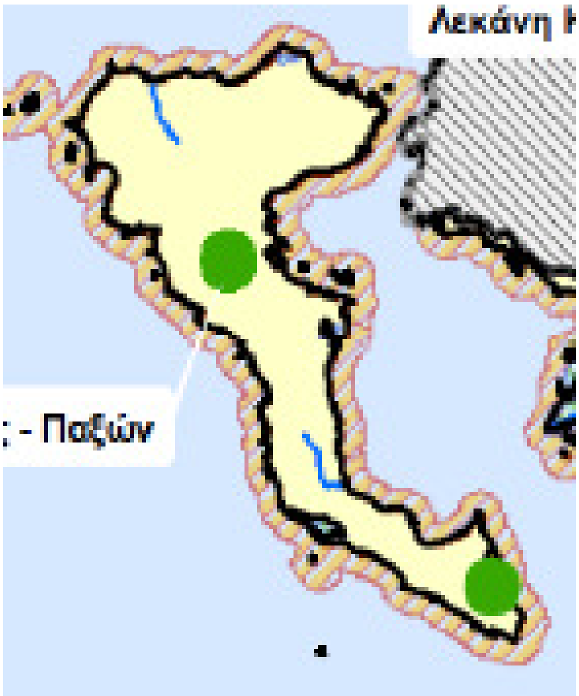

Figure 33: Landfills in Corfu island [25]

Figure 34: Uncontrolled waste disposal sites in Corfu Perfecture [25]

The River Basin Management Plan recorded 11 uncontrolled waste disposal sites in Corfu Perfecture (including the islands of Paxi and Othoni) [25] (*Figure 33)*. 4 of them are active (in the 4 islands namely Paxi, Othoni, Erikouses and Manthraki) while the rest are closed but not restored [25].

The land uses per river basin in Corfu island is identified in the River Basin Management Plan based on Corine 2000 [25] (*Figure 34*).

Agriculture is identified as a diffuse pollution source. In Corfu – Paxi basin the annual nitrogen load drained in surface towards the water bodies is estimated to be 24 tn with special annual charge per sub-basin from 1.7 to 2.2 kgN/ha [25] (*Table 18* and *Figure 35)*. Respectively the annual phosphorus load is estimated to be 8.5 tn with special charge per sub-basin of 0.55 to 0.74 knP/ha [25] (*Table 18*).

Table 18: Special Nitrogen and Phosphorus loads per river basin in Corfu island [25]

	Special Nitrogen load (kg/ha/year)	**Special Phosphorus load (kg/ha/year)**
Potami basin	1.7	0.55
Messagis basin	2.2	0.74
Fonissa basin	1.9	0.72

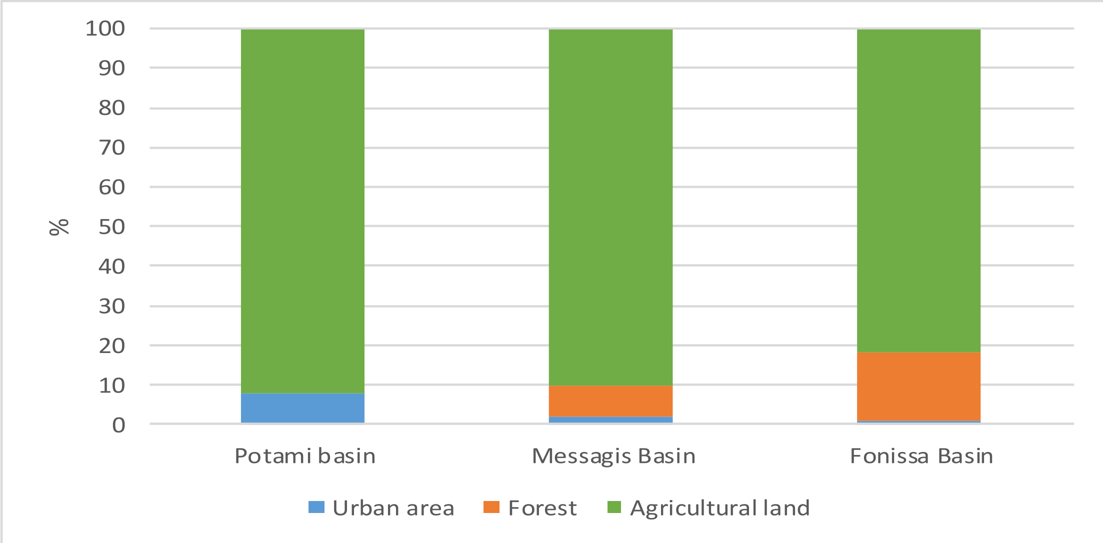

Figure 35: Land uses per surface water body in Corfu island [25]

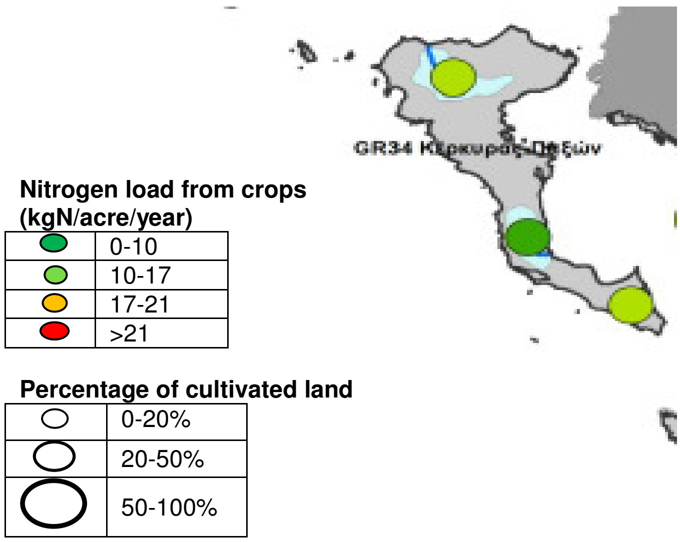

Figure 36: Nitrogen load from agriculture in river basins in Corfu island [25]

Another diffuse pollution source is the livestock farming. The breeding animals include sheep and goats, poultry, cattle and pigs. Each kind of animals produces pollutant loads. The loads drained in surface bodies are estimated for the Corfu-Paxi basin in the River Basin Management Plan (*Table 19; Figure 36*) [25].

Table 19: Pollutant loads from livestock farming drained in surface bodies in Corfu Island [25]

	BOD (tn/year)	N (tn/year)	P (tn/year)
Sheep and goats	10	5.1	0.24
Poultry	8	2.2	0.12
Cattles	3	0.8	0.01
Pigs	0	0.1	0.00
TOTAL	**22**	**8.2**	**0.38**

The more intense livestock activity is identified in the sub-basins of Mesaggis and Fonissa rivers where most of the pollutant loads end up [25] (*Figures 37-40*).

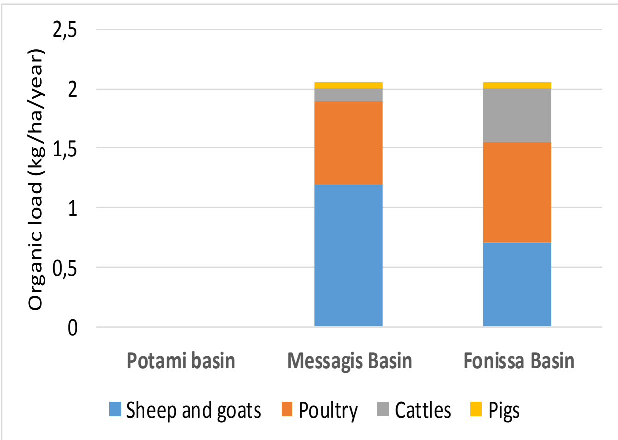

Figure 37: Organic load in Corfu sub-basins [25]

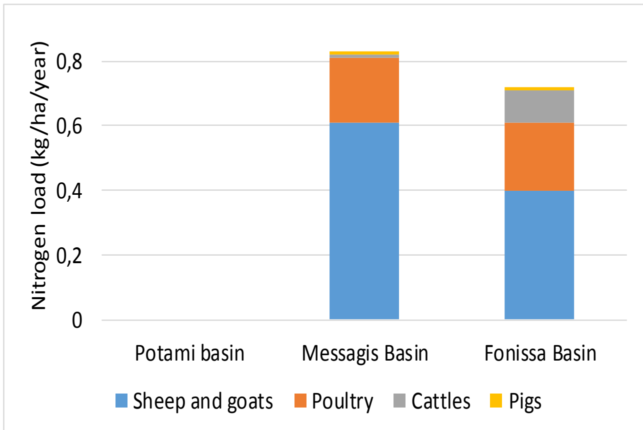

Figure 38: Nitrogen loads in Corfu sub-basins [25]

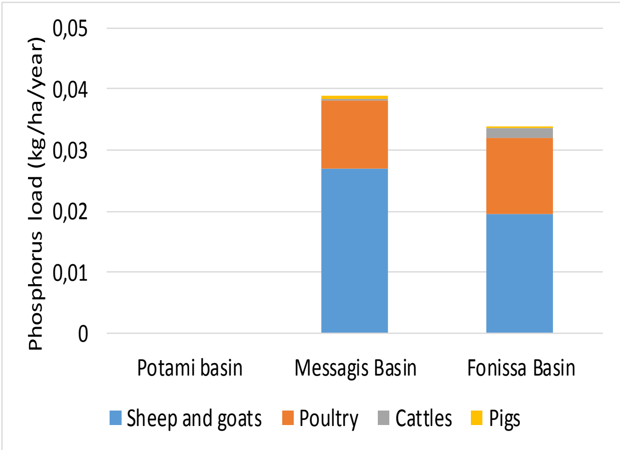

Figure 39: Phosphorus load in Corfu sub-basins [25]

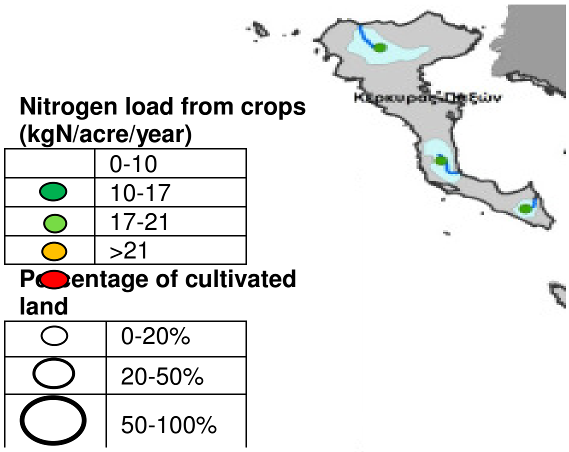

Figure 40: Nitrogen load in Corfu sub-basins [25]

In the Corfu-Paxi basin there are 50 settlements with a total permanent population of 35,362 people (as estimated in the RBMP) while the population categorization based on the settlement's size is provided in *Table 20* [25]. According to the Framework Directive 91/271/EEC all settlements with permanent population above 2,000 people are obliged to have sewerage networks and wastewater treatment plants. In the area there are no settlements with population above 2,000 people not served from a WWTP [25]. The contribution of the urban waste to the diffuse pollution is connected with the predominant practice in settlements not served by WWTPs. The equivalent population not served by WWTPs is 27,024 people. The pollutant loads ending up to the surface bodies are estimated in the RBMP (*Table 21*) [25].

Table 20: Types of settlements in Corfu-Paxi basin [25]

Settlements types	Settlements' number		Equivalent population	
	Without WWTP	With WWTP	Without WWTP	With WWTP
Below 2,000 ep	48	1	27,024	637
2,000 to 10,000 ep		1		7,701
10,000 to 15,000 ep				
Above 15,000 ep				
TOTAL	48	2	27,024	8,338

Table 21: Pollutant diffuse loads due to the urban population drained in sub-basins Corfu-Paxi basin [25]

Water Body		BOD (kg/year)	N (kg/year)	P (kg/year)
GR0534R000501082N	Fonissa	39,898.81	11,399.66	393,07
GR0534R000301081N	Messagis	30,201.62	8,629.04	272,22
GR0534R000101080N	Potami	8,327.93	2,379.41	74,49

The aggregate pressures are evaluated regarding diffuse pollution in Corfu – Paxi basin in the RBMP [25]. The results showed that the surface runoff from agriculture and urban waste contribute significantly to the diffuse pollution. Specifically for the Corfu-Paxi basin (GR34) the total pollution loads are given in *Table 22* [25]. Analytically they are presented in *Figure 41* [25].

Table 22: Total pollution loads Corfu-Paxi basin [25]

		Corfu – Paxi basin
BOD (kg/year)	Urban	78,428
	Livestock	21,646
N (kg/year)	Urban	22,408
	Livestock	8,192
	Agriculture	23,928
P (kg/year)	Urban	740
	Livestock	380
	Agriculture	8,527

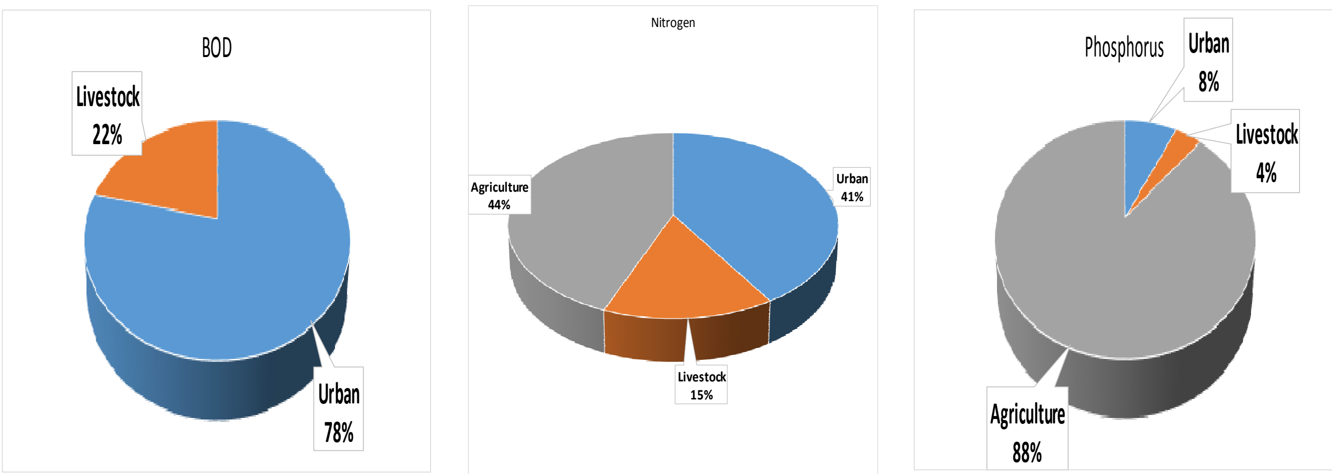

Figure 41: Contribution of urban waste, agriculture and livestock to (a) BOD; (b) N; & (c) P loads [25]

In all the sub-basins of the Corfu-Paxi basin the produced pollutant loads concentrations are lower from the existing limits and it is concluded that there is not a significant pressure on the surface water bodies due to the diffuse pollution sources in this basin.

Table 23 presents the estimated pollutant loads in the surface runoffs of the sub-basins on Corfu-Paxi basin. The total pollution pressure intensity from diffuse point sources is presented in *Figure 42*.

Table 23: Total pollution loads in surface water bodies in Corfu-Paxi basin [25]

Water body code	Water body name	BOD mg/l	N mg/l	P mg/l
GR0534R000301081N	Messagis	7.88	5.01	0.96
GR0534R000501082N	Fonissa	6.63	4.28	0.92
GR0534R000101080N	Potami	4.38	3.25	0.68

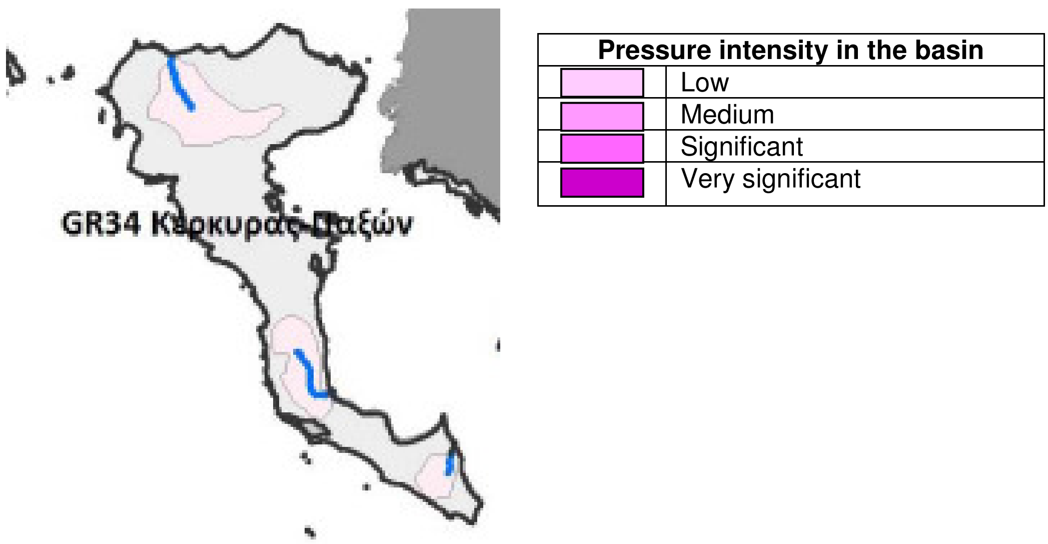

Figure 42: Diffuse point sources pressure intensity in Corfu. [25]

Fish farming is another pollution source. Fish farming units in Corfu are situated in sea water in Lorida Sagiadas, belonging in the coastal water body of "North part of the Eastern Coast of Corfu Sea". The data and pollution loads of fish farming are given in *Table 24.*

Table 25: Total pollution loads from fish farming in sea water in Corfu-Paxi basin [25]

Basin		Units	Pollutant Loads (tn/year)		
			BOD	TN	TP
GR 34	Corfu-Paxi	1	199.4	36.4	8.3

Impacts

The pollutants are both conventional and unconventional.

Conventional pollutants:_When the organic matter, the ammonium, nitrate and phosphate salts' concentrations are low in receiving waters, they are not considered as pollution. Their concentrations are increased due to anthropogenic activities causing pollution problems to the aquatic ecosystem. Such substances are met in point pollution sources such as urban wastewater, livestock waste, industrial waste and non-point pollution sources such as surface runoff from agricultural land.

Nonconventional pollutants: This category includes mainly toxic substances such as lead, mercury, cadmium, fluorinated and radioactive material that can be found in the water. Nickel, chromium, arsenic, selenium, sulfuric acids, cyanide acids have also toxic effects when their concentration in water exceeds the limits. *Tables 25 and 26* show the basic conventional and nonconventional pollutants and their related pollution problems.

Table 25: Effects of conventional pollutants to aquatic ecosystems [25]

Conventional pollutants	**Effect to aquatic ecosystems**
Organic matter increase	Deoxygenation of the receiving water
Nutrient N, P increase	Eutrophication
NH3 concentration increase	Toxicity in aquatic organism
NO3-N concentration increase	Toxicity
Suspended soils concentration increase	Sediment creation, turbidity increase in receiving water, reduction of the aesthetic value of the receiving water

Table 26: Effects of non-conventional pollutants [25]

Non-conventional pollutants	**Effects**
Heavy metals Cd, Zn, Cr, Hg, Ni, Cu, etc.	Toxic effect in the short and long term in human and aquatic organisms. Some of them (e.g. Cd) are suspicious for cancer. The organic compounds are responsible for bioaccumulation
Synthetic organic compounds, chlorinated hydrocarbons, organophosphorus compounds, trihalogenated methanes	Mainly long term toxic effects to the health. Low biodegradability→ bioaccumulation and growth. Some of them are suspicious carcinogenic
Nox, SO2	Acid rain. Nitrogen increase in receiving waters
Petroleum	Toxic immediate effect. Carcinogenic compounds. Deoxygenation.

Table 27: Impacts Assessment in sub-basins of Corfu for surface and coastal waters [25]

Water body code	**Water body name**	Pressure intensity in the sub-basin	Settlements with WWTP	IPPC units	Industrial units related to the dumping of priority substances	Industrial units related to the dumping of other substances	Livestock farms	Farm fishing units	Number of quarries	SEVESO units number	Land use of urban region	Land use of cultivated land	Settlements without WWTP	Organic matter and nutrients concentration in surface runoff, mg/l	BOD concentration in surface runoff, mg/l	Nitrogen concentration in surface runoff, mg/l	Phosphorus concentration on surface runoff, mg/l
GR0534R000101074N	Potami	H	L	L	L	H	L	L	L	L	L	H	L	L	L	L	L
GR0534R000301075N	Messagis	H	L	L	L	H	L	L	L	L	L	H	L	L	L	L	L
GR0534R000501076N	Fonissa	H	L	L	L	H	L	L	L	L	L	H	L	L	L	L	L

River Basin District	Pressure intensity in the sub-basin	Livestock farms	Industrial units related to the dumping of priority substances	Industrial units related to the dumping of other substances	SEVESO units number	IPPC units	Farm fishing units
Corfu	H	L	L	H	H	L	L

Other effects are thermal pollution and contamination.

According to the River Basin Management Plan of Epirus, the impacts assessment in the water bodies took place taking into consideration the pressures' analysis and their intensity based on criteria. The pollution pressure is estimated for each sub-basin for surface and coastal waters.

In Corfu the pollution pressures are estimated as high because of the industrial units, the cultivated land and the number of SEVESO units (*Table 27*).

Impacts in the groundwater bodies

All five groundwater bodies identified in Corfu-Paxi basin are assessed to be in good chemical status (*Table 28)* [9]. Locally increased concentrations of SO_4 are met due to the geological background (gypsum presence). Only locally some increased concentrations of nitrates and ammonium are found because of the diffuse and point pollution sources. Also locally in the coastal zones increased concentrations of chlorides are found because of the sea water intrusion from excessive pumping and natural causes [25].

Table 28: Main quality problems of groundwater bodies of Corfu sub-basin [25]

Groundwater body code	Groundwater body name	Type of aquifer	Quality problems	Pollution trend	Chemical status
GR0500010	Limestone system	Karstic	Locally increased values of NO3 due to agricultural activities	Yes	Good
GR0500020	Ternary breccia system	Karstic	Naturally increased values of SO4 due to gypsum. Locally increased values of NO3 due to agricultural activities	No	Good
GR0500030	Granular aquifer system	Granular	Locally increased values of NO3 due to agricultural activities. Naturally increased values of SO4 due to gypsum.	Yes	Good

As already indicated in the report "Water quality and trends on Corfu test area in Greece" by FB16, University of Thessaly, the groundwaters' quality is assessed as follows [25]:

Limestone system: In detail, the increased concentrations of conductivity, chlorides and sulphates are due to the natural background. The increased values of the chlorides are connected to the exploitation of the aquifer (sea water intrusion) but they are also due to natural causes. The increased values of sulphates are due to the natural geological background met in the central part of the water basin district. Increased values of nitrates are met locally and they are due to anthropogenic activities.

Ternary breccia system: the increased presence of sulphates and conductivity is connected to the high values of the natural geological background. Locally increased concentrations of nitrates and ammonium are met due to anthropogenic activities as part of the water system's land use is agricultural land while the remaining one is woodland with increased urbanization.

Granular aquifer system: Concentrations of conductivity, chlorides and sulphates exceed the Maximum Allowable Concentrations in some monitoring points. The increased presence of sulphates is connected to the increased value of the natural background due to the geological status of the area. Increased concentration of nitrates and ammonium are due to human activities. A big part of the water system is agricultural land. The local increased concentrations of nitrates, chlorides and conductivity are due to human activities and exploitation.

Figure 43 presents land use and pollution causes in Corfu Island.

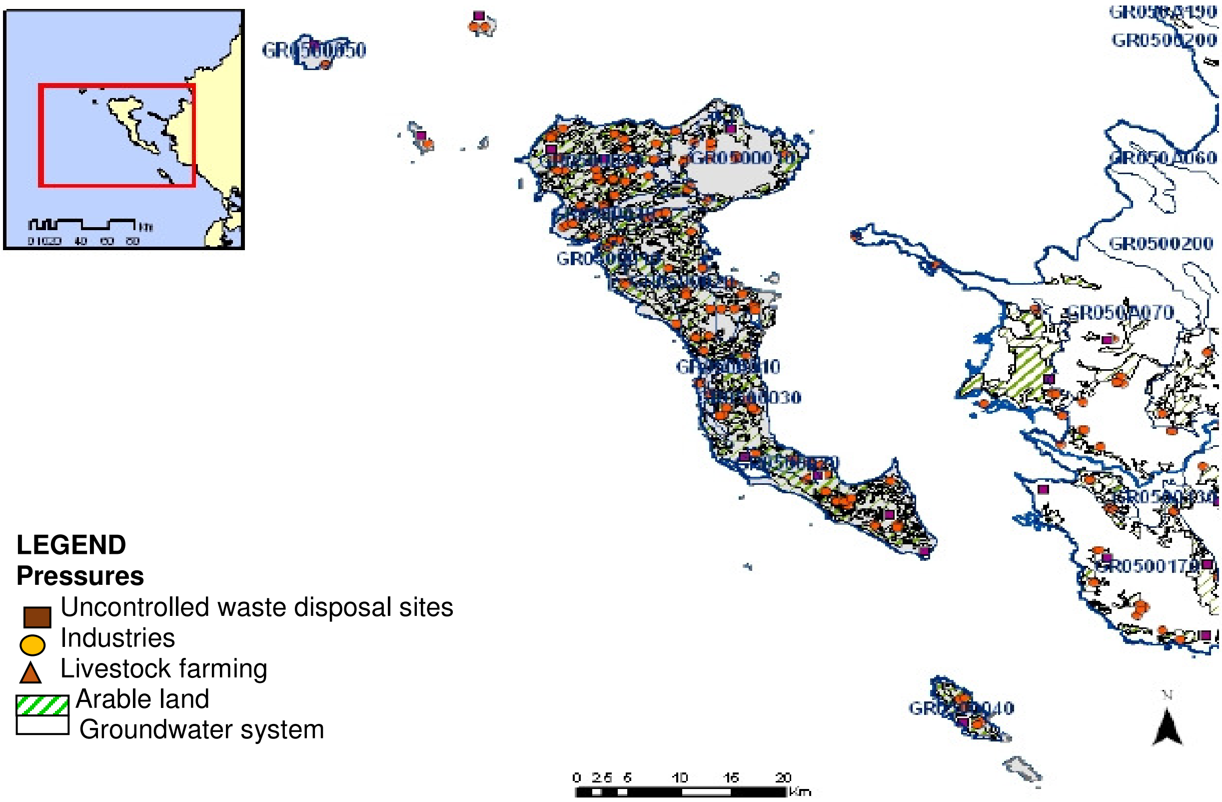

Figure 43: Land use and pollution causes in Corfu [25]

The impacts of human activities in the two (out of three) groundwater bodies of Corfu island requiring further classification are given in *Table 29*.

Table 29: Human activities' impacts in groundwater bodies of Corfu [25]

Groundwater body code	Groundwater body name	Current overexploitation conditions	Diffuse pollution sources	Point pollution sources	Sea water intrusion	Human causes for water quality degradation
GR0500010	Limestone system	No	Crops	Animal farms, oil mills, cheese dairy	Yes. Local in the north	Crops, oil mills, livestock farming
GR0500030	Granular aquifer system	No	Crops	Animal farms, oil mills	Yes. In the coastal areas	Crops, oil mills, hotel units

Impact of the land use on water quality (present state)

The DPSIR approach is followed to assess the impact of land use on water quality in the present state.

Based on the land uses described in section 2 of this report the predominant land use in Corfu Island is agriculture, followed by forestry and urban settlements. The DPSIR approach for agricultural activities, forestry, urban settlements, climate change and tourism is given in *Table 30* below.

Tourism is the main activity of the inhabitants (*Figure 44*) and according to the spatial plan [9] there is a conflict of land used for agriculture and tourism in the island. Thus, tourism is considered as an important pressure.

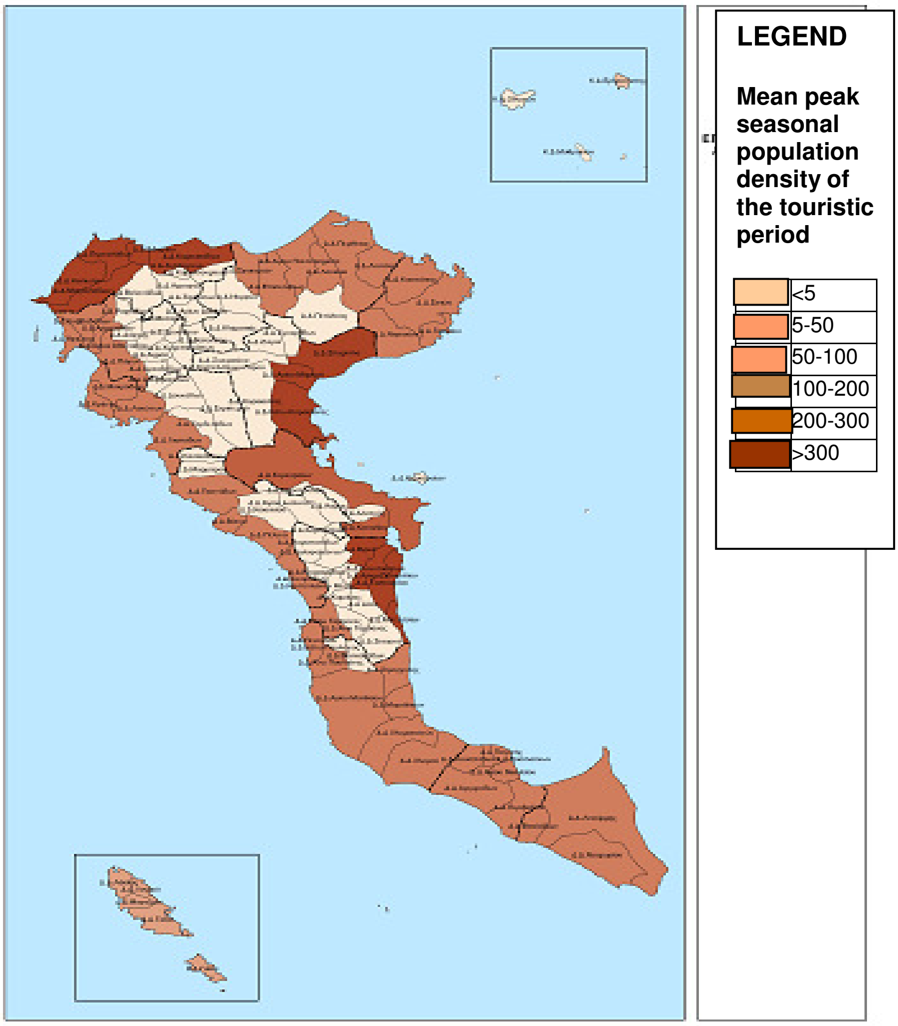

Figure 44: Mean peak seasonal population density of the touristic period in Corfu regional unit [26]

Table 30: The DPSIR approach for land uses in Corfu – present state

DRIVING FORCES	PRESSURES	STATE	IMPACT
Agriculture: use of fertilizers and pesticides	• Diffuse nitrogen contribution (runoff) • Nitrogen and phosphorus towards the aquatic environment	Groundwater and surface water quality deterioration	• Eutrophication • Contamination risks
Agriculture: irrigation	Water abstraction	Water quantity	Water shortage / drought
Urban areas: Sewage and wastewater	• Microbiological pollution • Pharmaceuticals • Heavy metals to groundwater	Groundwater and surface water quality deterioration	• Contamination risks • Public health risks
Urban areas: transportation	Heavy metals and oil spills	Groundwater and surface water quality deterioration	• Contamination risks • Public health risks
Industry: oil mills	Pollutants in groundwater & surface water	Groundwater and surface water quality deterioration	• Contamination risks • Public health risks
Forestry: loss of trees due to urbanization & temperature increase	• Climate change conditions • Higher temperatures • Drought periods • Forest fires	Deforestation	Loss of forest cover; erosion process (may affect water quality)
Climate Change	Land uses	Increased temperature; decreased precipitation	Drought conditions Water unavailability
Tourism	• Land uses • Construction • Wastewater and solid waste	Limited cultivated land Pollutants in groundwater and surface water	• Contamination risks • Public health risks • Climate change

RESPONSE

European Legislation: WFD 2000/60/EC; Drinking Water Directive 98/83/EEC; GW directive 2006/118/EC; Urban Wastewater Treatment Directive 91/271/EEC; Nitrates Directive 91/676/EEC; Environmental Impact Assessment 85/337/EEC; Special Protection Zones Directives 92/43 & 2009/147/EC

Greek Legislation: Law 3199/2003; JMD Y2/2600/2001; PD51/2007; JMD 146896/2014; Law 4117/2003; JMD 146896/2014; MD 39626/2208/E130/2009; River Basin Management Plans; MD 85178/820/2000; JMD 161690/1335/1997; JMD 5673/400/1997; JMD 191002/2013; JMD 145116/2011; MD 33318/3028/1998; 37338/1807/E.103

Measures: Water Safety Plans; Drinking Water Masterplans; Drinking Water Protection Zones

6 THE IMPACT OF CLIMATE CHANGE AND PLANNED DEVELOPMENT ON LAND USE IN FUTURE WITH IMPACT OF FUTURE LAND USE ON WATER QUALITY ON TEST AREAS

6.1 Isonzo plain

All the problems have a common international character, being directly related to quantitative and qualitative pressures present in the Slovenian territory; the definition of the necessary corrective measures must therefore necessarily traced by the initiatives of cross-border cooperation between Italy and Slovenia already started following the Osimo Agreement implemented in the far 1975.

In accordance with the international agreement concerning this transboundary river, the Authority who has to supervise over this precious resource is the Basin Authority that drawing up its Plans is able to minimize the pressures induced by nature and humans.
To these more legal aspects it is necessary to add to the general framework, the climate change that are occurring on the whole planet. In the Drinkadria study area the temperature increasing, with a following not well defined precipitation behaviour (*Table 31*) (decreasing trend 100y analysis and uncertain trend on 50y analysis), are partially compromising the recharge of the aquifers taking to an escalation of the actual problems. [2].

If we look at possible other pressures a short digression has to be done analysing the demographic trend in the study area. The number of inhabitants in fact creates an expectation of a better life with more comforts sometimes acting in a negative way on the natural environment.

In view of the consumption of water for drinking purposes, based on demographic data made available and analysed in the framework of the Report WP4.2 [2], it is observed that the situation in the Trieste and Gorizia provinces is slightly increasing with a forecast of a future stable water consumption. AcegasApsAmga in fact, estimated for the next years, a withdrawal amount of 50 million of m^3/y. According to the ISTAT FVG elaboration (Dominutti & Abatangelo, 2008), the amount of residents in Trieste Province will decrease from 236.515 in 2007 to 216.455 in 2050. In Gorizia Province instead there will be an increasing in the amount, passing from 141.229 in 2007 to 151.720 in 2050.

In Friuli Venezia Giulia Region, there are about 98.000 manufacturing companies, divided in different sectors. Among them there is a clear predominance of the agriculture, trade and building which together represent the 57.1% of the total. The decisive reference industrial risk is mainly represented by the chemical, energy, metallurgy and manufacturing sectors which sum is just over the 6% of the total (Regione Autonoma FVG, 2014).

Table 31: Results obtained from the analysis of the experimental data and the relative trends using different Climate Change models. [2]

Gorizia prese CBPI	ARPEGE	PROMES	ECHAM5	Observed
Temperature [°C/10y] 50y	0,18	0,19	0,14	0,28
Temperature [°C/10y] 100y	0,34	0,17	0,38	
P (50y) [mm/10y]	25	9	-19	-20
P (100y) [mm/10y]	-28	-12	-26	

Torviscosa	ARPEGE	PROMES	ECHAM5	Observed
Temperature [°C/10y] 50y	0,06	0,11	0,06	0,9
Temperature [°C/10y] 100y	0,34	0,47	0,38	
P (50y) [mm/10y]	47	4	-30	-36
P (100y) [mm/10y]	-22	-30	-11	

Alberoni	ARPEGE	PROMES	ECHAM5	Observed
Temperature [°C/10y] 50y	0,13	0,13	0,17	0,37
Temperature [°C/10y] 100y	0,34	0,47	0,38	
P (50y) [mm/10y]	38	6,6	-22	-9
P (100y) [mm/10y]	-19	-13	-6	

The *Figure 45* indicates that Gorizia and Monfalcone municipalities are the one that have more active plants lumped in the industrial consortium in both areas and the port in

Monfalcone. From the Figure 45, instead, is possible to notice that there are no plants at high risk of major accident in the studied area.

In recent years, the manufacturing sector, in Friuli Venezia Giulia, is certainly the one that most suffered the consequences of the economic crisis together with the construction industry sector (*Figure 46*). The suffering is in terms of reduced production, depletion of the productive fabric, the heavy impact on employment and the bending in sales both in foreign markets and especially in the internal ones. The considerable weight of the manufacturing industry, combined with the strong projection to the international markets characterized by a reduction in demand, has made the regional economy particularly exposed (REGIONE FVG, 2014). This recession phase discourage the increase of new industrial sites with a potential return to the agriculture, and this is sometimes even more dangerous for the phreatic aquifers in the High Plain due to the intense use of pesticides and other substances.

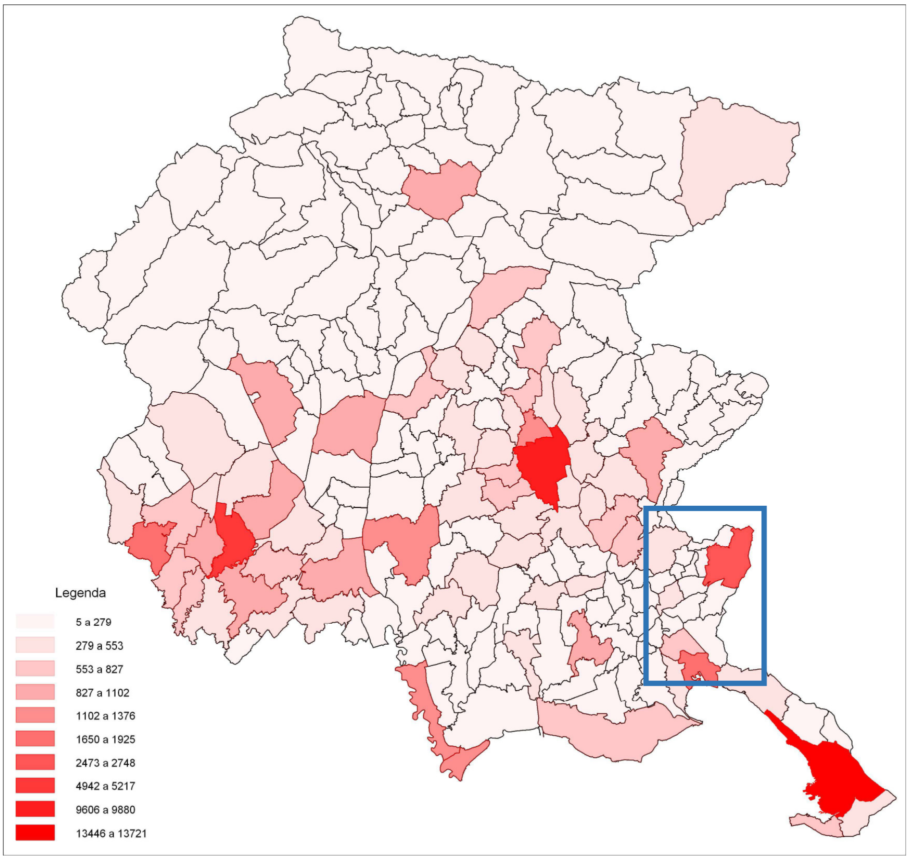

Figure 45: Number of active plants in the industrial and services sector (RAFVG, Servizio Pianificazione Territoriale, 2009). [2]

Farming and the rural world in recent years are in the middle of a deep structural transformation and planning. At the end of the '90s was in fact begun to acknowledge to the agricultural activity a new role of balance and land conservation. The selected indicators outline for the regional context, the most salient characteristics of the agricultural sector and its evolution from the environmental point of view.

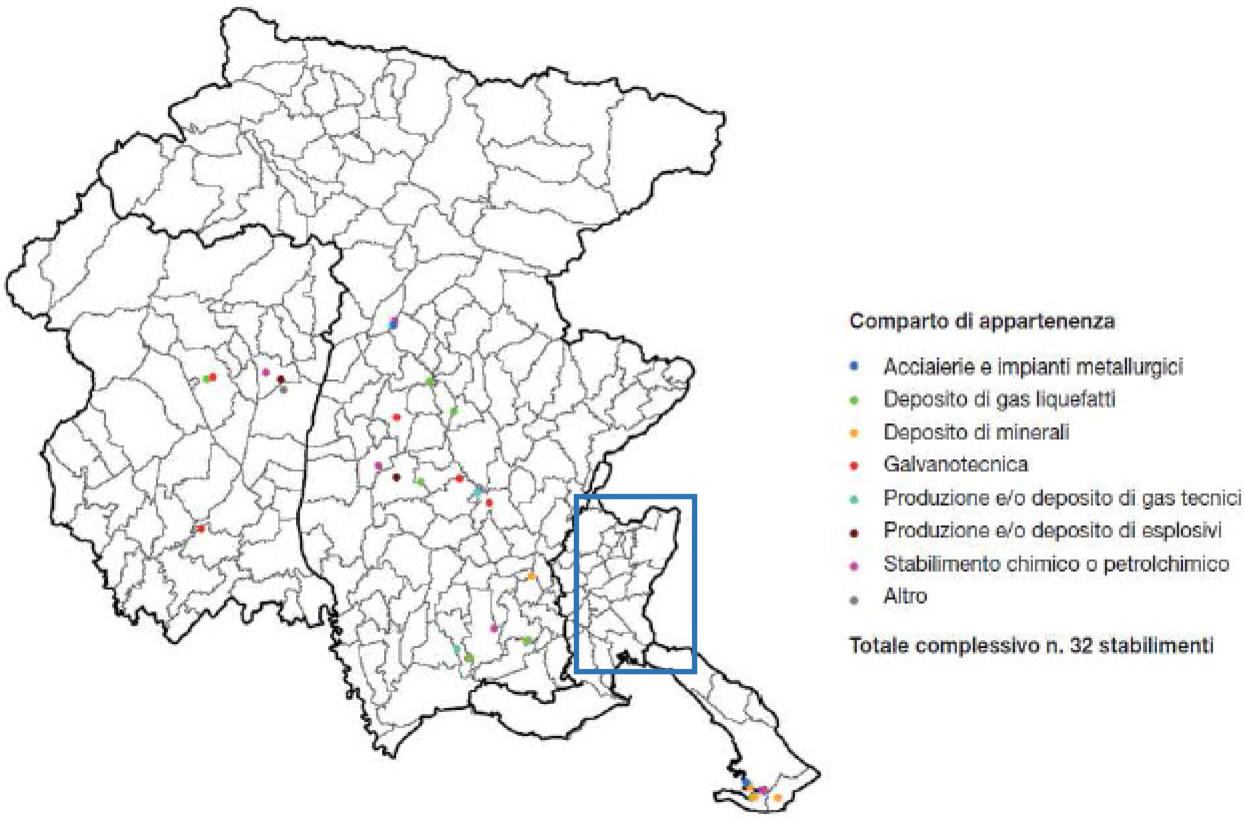

Figure 46: Areal distribution of the industrial plants at risk of major accident (ARPA FVG, 2011). [2]

The Used Agricultural Area has fallen by 12.6% between 1990 and 2005; the decrease in FVG was less pronounced than the national one until 2000, while it seems more pronounced in the latest five-year period. The relationship between the UAA and the total cultivated area has actually increased between 1990 and 2005. Arable crops are the most widespread in Friuli Venezia Giulia and in 2005 occupy about 71% of the UAA (Regione Autonoma FVG, 2014). According to what diffused in the Piano di Tutela delle Acque [2], the 2010 Census of Agriculture counts 22.327 farms in the FVG region, down compared to the census had in 2000. This decrease however occurred with a corporate restructuring that gradually reduced the family farms according to a trend which is estimated to continue in the coming years. Of these farms only a small part was biological agriculture (226 units in 2000), but in the period between 2000 and 2005, an increase was observed reaching to about 400 units at the end of 2005. In recent years, the number of regional biological farms has stopped growing.

In addition to agriculture and to the industries present on the regional territory, an increasing sector is the one related to the rural tourism. The number of farm businesses in 2009 stood at 524, entitled to accommodation and catering. Udine province is leading with 70% of the farms, Gorizia Province is following with 17,4%. The two mentioned provinces are indeed those that lend themselves to this type of activity, thanks to the variety of the territory and the typical agricultural food production. In particular there is a significant concentration of the agritourism in the eastern hills close to the border with Slovenia and in the Collio area. Seen the increase of this type of farms as the increased requirement of agricultural land, specific strategies have been implemented in order to limit the accumulation of detrimental substances in the soil and in the surface and groundwaters. The intention is to reduce upstream the chemical fertilizers and plant protection products introduced in the non-organic agro ecosystems.

The Regulations for agronomic use of nitrogen fertilizers and the action program in the areas vulnerable to nitrates according to the regional laws (L.R. n.16, 5 December 2008; L.R. n.17, 25 Agosto 2006; L.R. n.24, 30 Dicembre 2009) contemplate the necessity of specific action programs in order to reduce the found pollution and to prevent further pollution caused or induced by nitrates from agricultural sources. The *Figure 47*, is identifying, in the FVG Region, the areas vulnerable to nitrates. The Province of Gorizia, and so, also the study area, is considered not jet affected by this risk. [2]

If we look more in detail, considering only the study area and not the whole FVG Region, for the assessment of land use evolution, we analysed the Corine land Cover (CLC) dataset by EEA. [2]

Available data cover a 22 years range (years 1990, 2000, 2006 and 2012). Land cover data from 1990 coverage are only distributed in raster format (100*100 m grid) and cover the entire test area. Instead data corresponding to years 2000 and 2006 are provided in both raster and vectorial format. The whole test area is covered by these datasets. The 2012 dataset covers the whole Italian part of the test area in vectorial format. Unfortunately part of the Slovene territory has not yet been processed and is not available. For this relatively small area (4.7 km^2) the 2006 coverage has been used to complete the 2012 dataset.

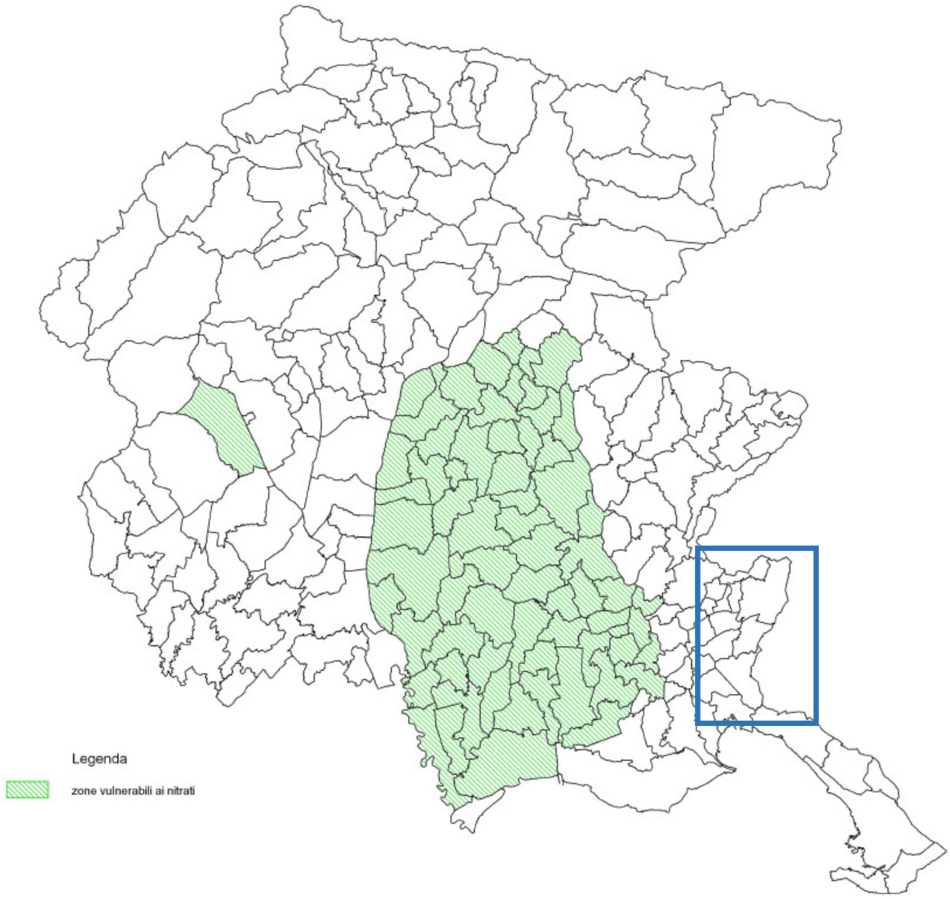

Figure 47: Areas vulnerable to nitrates from agricultural sources (RAFVG, servizio Pianificazione territoriale,2008). [2]

For all datasets the vectorial format has been used if available. Comparison of land use variations obtained either with raster or vectorial datasets showed negligible differences. Therefore the land use variation between years 1990 and 2000 are valid even if the first dataset is in raster format and the second in vectorial format.

The CLC dataset is classified in 3 levels. Level 1 corresponds to the wider classes (five items) and level 3 being the more detailed one (44 items). For the test areas an intermediate nomenclature has been used between level 1 and level 2. *Table 32* shows the equivalences between the adopted nomenclature and the level 3 nomenclature, also areas and percentage of the test area surface covered by the different classes are presented in *Table 32*.

For the assessment of long term land use evolution a further reclassification has been performed. Three major classes have been maintained (Agricultural area / Artificial area / forest, semi natural and water). Evidently artificial areas (urban fabric, construction sites, industrial areas,…) grow at the expense of agricultural areas. Artificial areas occupied 22.3 % of the test area (37.8 km^2) in 1990 and 25.2 % in 2012 (42.6 km^2). Instead agricultural area represented 69.2 % of the test area in 1990 (117.1 km^2) and 66.2 % in 2012 (112.0 km^2). During the same period natural and semi natural areas coverage remained stable, from 8.5% to 8.7% (corresponding respectively to 14.4 km^2 and 14.7 km^2).

Table 32: Comparison of land use classes (areas and percentage) for years 1990, 2000, 2006 and 2012. Level 3 description is available and compared to the intermediate classification used in the test area (merged classes field). [2]

CLC_CODE	Level 3 description	Merged classes	1990 raster Area (Km^2)	1990 raster %	1990 raster Merged classes %	2000 vectorial Area (Km^2)	2000 vectorial %	2000 vectorial Merged classes %
112	Discontinuous urban fabric	Urban fabric	27.84	16.4	16.4	28.3	16.7	16.7
121	Industrial or commercial units	Industrial, commercial and transport units	4.76	2.8		5.3	3.1	
122	Road and rail networks and associated land		1.25	0.7		1.3	0.7	
124	Airports		2.63	1.6	5.1	2.6	1.5	5.4
131	Mineral extraction sites	Mine, dump and construction sites	0.66	0.4		0.7	0.4	
133	Construction sites			0.0	0.4		0.0	0.4
141	Green urban areas	Artificial, non-agricultural vegetated areas	0.65	0.4	0.4	0.7	0.4	0.4
211	Non-irrigated arable land	Agricultural areas	71.33	42.1		70.7	41.8	
221	Vineyards		4.17	2.5		4.2	2.5	
222	Fruit trees and berry plantations		0.43	0.3		0.4	0.3	
231	Pastures		2.99	1.8		3.0	1.8	
242	Complex cultivation patterns		23.28	13.7		22.8	13.5	
243	Principally agriculture, significant areas of natural vegetation		15.04	8.9	69.2	14.7	8.7	68.5
311	Broad-leaved forest	Forest and semi natural areas	2.71	1.6		2.7	1.6	
312	Coniferous forest		0.29	0.2		0.3	0.2	
313	Mixed forest		1.76	1.0		1.8	1.1	
322	Moors and heathland		0.46	0.3		0.5	0.3	
324	Transitional woodland-shrub		1.81	1.1		1.8	1.1	
331	Beaches, dunes, sands		4.34	2.6	6.7	4.4	2.6	6.8
511	Water courses	Water bodies	2.79	1.6		2.9	1.7	
512	Water bodies		0.26	0.2	1.8	0.3	0.1	1.9
		Sum	169.5	100	100	169.3	100	100

CLC_CODE	Level 3 description	Merged classes	2006 vectorial Area (Km^2)	2006 vectorial %	2006 vectorial Merged classes %	2012 vectorial Area (Km^2)	2012 vectorial %	2012 vectorial Merged classes %
112	Discontinuous urban fabric	Urban fabric						
121	Industrial or commercial units	Industrial, commercial and transport units	29.8	17.6	17.6	29.7	17.6	17.6
122	Road and rail networks and associated land		5.7	3.4		6.3	3.7	
124	Airports		1.3	0.7		1.3	0.7	
131	Mineral extraction sites	Mine, dump and construction sites	2.7	1.6	5.7	2.7	1.6	6.1
133	Construction sites		0.7	0.4		1.0	0.6	
141	Green urban areas	Artificial, non-agricultural vegetated areas		0.0	0.4	1.0	0.6	1.2
211	Non-irrigated arable land	Agricultural areas	0.7	0.4	0.4	0.7	0.4	0.4
221	Vineyards		65.4	38.7		63.5	37.5	
222	Fruit trees and berry plantations		5.9	3.5		6.2	3.7	
231	Pastures		0.4	0.3		0.4	0.3	
242	Complex cultivation patterns		3.0	1.8		3.0	1.8	
243	Principally agriculture, significant areas of natural vegetation		24.3	14.3		24.2	14.3	
311	Broad-leaved forest	Forest and semi natural areas	14.7	8.7	67.2	14.6	8.6	66.2
312	Coniferous forest		2.7	1.6		2.5	1.5	
313	Mixed forest		0.3	0.2		0.3	0.2	
322	Moors and heathland		1.8	1.1		1.8	1.1	
324	Transitional woodland-shrub			0.0			0.0	
331	Beaches, dunes, sands		2.7	1.6		2.8	1.6	
511	Water courses	Water bodies	4.0	2.4	6.8	4.1	2.4	6.8
512	Water bodies		2.9	1.7		2.9	1.7	
		Sum	0.3	0.1	1.9	0.3	0.1	1.9
			169.3	100	100	169.3	100	100

6.2 ATO3

The impact of CC and planned development (spatial plans) on the future land use

Quite uncertain are the information about the ongoing climate change in the test area, even though local climatic models indicate, for the next future, an increase of periods with prolonged absence of precipitation followed, on the other hand, by even more frequent extreme rainfall events.

Partial data (to be validated) indicate a shortening in the recurrence of dry seasons: if during the period 1950-2000 a dry season occurred every 10-15 years (Amici and Spina, 2002), after 2000 it seems to occur with a frequency of 5-10 years. More specifically, in the last fifteen years, there has been a peremptory alternating of dry periods especially in early autumn and late winter, followed by periods of intense and prolonged rainfall (even of 48-72 hours), with a total of 250-300 mm (equal to 20-30% of the annual value). The meteoric characteristics above described tend to favour and/or reinforce gravitational and flood phenomena already widespread in the test area and, consequently, to limit infiltration and groundwater recharge. [3]

Less evident, on the other hand, is the increasing trend in the mean temperature (monthly and annual), even though the available data indicate positive variations mostly in the summer months.

The future, possible, consequences of such climate changes on land use, in the ATO3 territory would therefore be mainly related to:

- evapotranspiration increase and reduction of water content of the soils, especially in summer seasons, resulting in loss of productivity;
- higher incidence and development possibilities of forest fires, especially in the mountain areas, related higher temperatures as well as drier soils and vegetation;
- increased soil erosion phenomena (simple leaching or surface mass movements), as a result of the increased frequency and intensity of storm events and increased degree of dryness of the soils themselves, making them more prone to surface erosion;
- loss of soil rich in nutrients, resulting in less vegetation biodiversity, and growth of species which tend to be fire resistant (Erica, Maritime Pine, D'Aleppo Pine, etc ...), suitable for soils poor in nutrients and highly flammable;
- loss of productivity and pollution of the soils in agricultural areas close to riverbeds, in consequence of overflows: during the phases of higher raising of the water level, exchange phenomena can in fact be activated, leading to a transfer of polluting substances from the river to the groundwater.

Impact of land use on water quality – future state

Looking at the next future, changes in land use caused by climate change will produce their greatest effects especially in areas with strong rural traditions as well as in flood plain and coastal areas, where most of the groundwater abstraction works (wells, well fields) are located.

Future regional policies, which look at the development and transformation of the agricultural entrepreneurship as a vehicle of growth for the whole Marche Region will also play a fundamental role. Regional Rural Development Programmes (RDPs) highlight that the areas with greater propensity for growth in the agricultural sector are concentrated in a particular way precisely in the hilly and coastal territory of ATO3, where, however, there is already a considerable density of farms (*Figure 48*). [3]

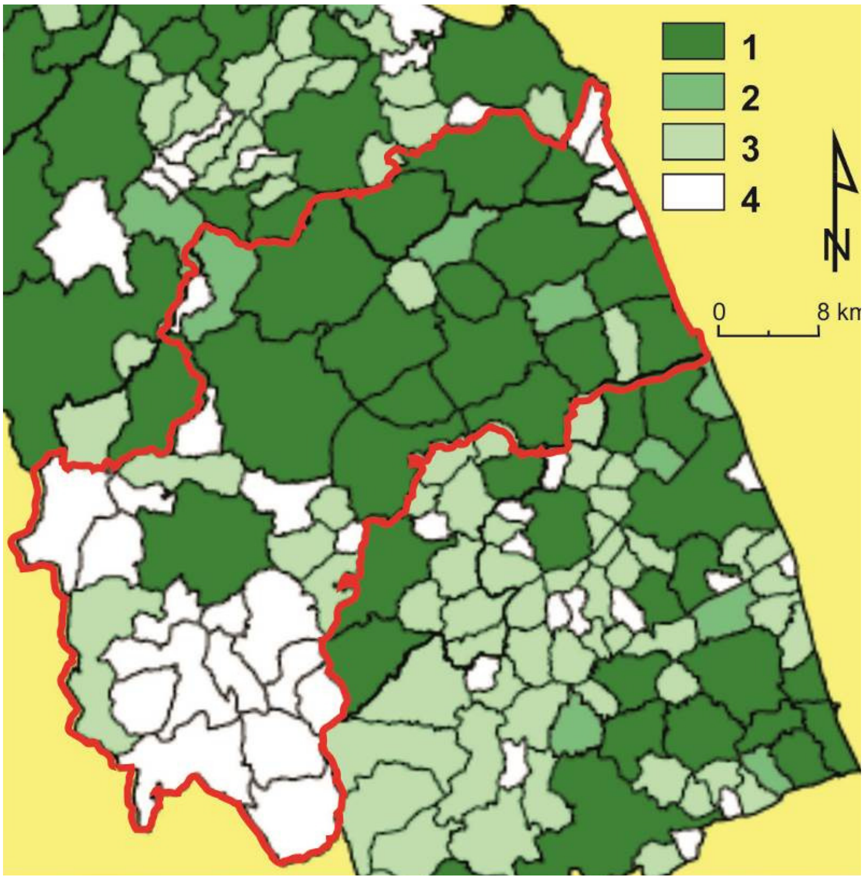

Figure 48: Map of the suitable areas for agricultural development (modified from Assam, 2010): 1. high; 2. good; 3. moderate; 4. low. [3]

The effects on the state of local water resources, as a consequence, will probably be relevant.

Table 33 shows the results of the application of the DPSIR approach on the ATO 3 Test Area for the future state and, in particular, concerning the variation in the level of influence of the Drivers.

Table 33: Main Driving forces and related level of influence acting in the ATO 3 territories, for the future state and for each Water Resource: red stars indicate sites with substantial variation with respect to the present state. [3]

ID	Water Resource	type	x-coord	y-coord	Drivers: level of influence			
					Population	Industry	Agriculture	Livestock
1	Via Pausola	W	4791669	2397328	***	**	***	*
2	Ponte Cannaro	S	4782462	2357291	*	**	*	*
3	San Giovanni	S	4777691	2353448	**	*	*	**
4	Acquasanta	S	4760287	2373488	*	*	*	*
5	Salette	S	4760116	2361079	*	*	*	*
6	Le Vene	S	4760735	2354664	*	*	*	*
7	Rotacupa	W	4796760	2390853	***	***	***	*
8	Acquevive	W	4791553	2395435	***	***	***	*
9	Centrale Nuova Campomaggio	W	4791130	2405338	***	***	***	*
10	Centrale Via Lelli	W	4794024	2415503	***	***	***	*
11	Crevalcore	S	4805339	2371807	**	*	*	*
12	Madonna dell'Ospedale	S	4800051	2377574	*	*	*	*
13	Sirolo 1	W	4820331	2407178	***	***	***	*
14	Valcimarra Trevase	S	4777704	2372035	**	*	*	*
15	Chiarino	W	4805622	2408251	***	***	***	*
16	Vallememoria	W	4803684	2405936	***	***	***	*
17	Marolino	W	4803552	2406728	***	***	***	*
18	Niccolini	S	4782392	2371180	**	*	*	*
19	Invaso Castreccioni	SW	4805028	2371136	**	*	***	**
20	S. Chiodo sul Nera	S	4750562	2369860	**	*	*	*
Type of Water body: S = spring; W = well field; SW = surface water								
Level of influence: * low ** medium *** high								

As it can be noted the level of influence would remain high, or would tend to increase, for all the well fields and for the Castreccioni abstraction facility (from surface waters), located right in the hilly or coastal areas: this is not only due to an increased influence of the driver "Agriculture" but also to the "Population", because of the growth (although quite light, according to recent demographic studies) of the resident population. Concerning the other Drivers, on the opposite, no significant changes are expected.

The “less suitable” areas of the region, according to these intervention policies and plans, would be those of the mountain zone, where the transformations and changes will certainly be less relevant. Nevertheless, an increase in the level of influence of the driver "Population" could be assumed, indirectly, even for the mountain springs: this because of the increased demand arising from the deterioration in the quality of groundwater abstraction in the hilly areas and coastal zones and population living in the same areas. As well known, mountain aquifers feed almost all the waterworks supplying drinking water in the major municipalities in ATO3.

With regard to the "Pressure level" (*Table 33*) the most sensitive changes would consequently occur only in those indicators closely linked to the activities described above: an increase, although probably minor, in the use of fertilizers and in the quantities of water abstracted from the most important facilities will cause, as a result, an overall increase of the "Global Pressure" for many of the considered Water Resources. [3]

6.3 Ostuni

Climate change impact on groundwater discharge: local sea-level rise effect on test area

Considerable work has been published about the impact of climate change on local sea-level rise (LSLR). However, the estimation of its impact on human health and hydrological stress in coastal regions has, surprisingly, not been sufficiently investigated. Focus has been mostly concentrated on direct impacts of sea level related disasters. The impact of LSLR on human health [27] and on groundwater volume reduction has not yet been fully investigated [28], especially in fractured aquifers. Even if there are many challenges relating to predicting and projecting future LSLR, a small increase in sea-level may have a severe impact on many coastal environments. There are many effects potentially caused by LSLR that can affect human health and water availability in various ways. Sea storms amplified by LSLR would also lead to severe impacts on wastewater treatment plants. Furthermore, the reduction of groundwater outflow increases the intrusion length by producing a serious reduction of groundwater volume. This may be very significant in coastal regions, where groundwater is the main source for irrigation and drinking. The sea intrusion problem is truly global in proportion. In Spain, the most severely affected areas by seawater intrusion are the Mediterranean and South-Atlantic coastlines and seawater intrusion is currently one of the main causes of groundwater pollution of about 60% of coastal aquifers. In the world, the most affected areas include Mexico’s Pacific and Atlantic coastlines [29], Chile, Peru and Australia. The situation is particularly acute in the Mediterranean, the Yucatan peninsula in Mexico, the Middle East, the SE and SW United States as well as on many islands with arid to semi-arid climates, such as Cyprus.

The aim of our investigation is an experimental evaluation of the LSLR impact during the 21st and 22nd centuries on the Salento peninsula (Southern Italy). Here, the fractured aquifer supplies 80% of the total population's drinking requirements (of about 1 million inhabitants) with 126 million m^3/y of water.

The evaluation has been carried out by generalizing the annual rate of LSLR from the best-fit of ultrasonic tide-gauge sea level measurements recorded at three tide-gauge stations on the Salento coast. Then, the Ghyben-Herzberg formula for fractured aquifers has been inverted to determine the progressive reduction of Salento's groundwater volume during the 21st and 22nd centuries. The new proposed formula highlights the reduction of annual groundwater discharge, which corresponds to the sea inland advancement due to LSLR and can be applied in any coastal fractured groundwater (at a regional scale) in order to evaluate the impact of climate change on local water resources.

6.4 Kobariški Stol, Mia and Matajur aquifer

In the report about surface and groundwater quality in test area (prepared within DRINKADRIA project [5], good quality status of water was described. Analyses of climate and climate changes and land use changes in the last decades show no significant changes as well as trends for the future are not observed. Therefore, we can conclude that the climate changes and potential changes in land use within the test area will not affect the water quality of potential cross-border aquifers.

6.5 Springs Sv. Ivan, Bulaž and Gradole

Future changes of land use in test areas and the impact on water quality

According to the Spatial Plan of Istria County in the future there are planned no significant changes in land use. Almost every change that is predicted should have a positive impact on quality of drinking water sources. Also, the Spatial Plan should enable organic farming, which means production without the use of fertilisers, pesticides, hormones and similar products. Such concept of agricultural production is more complex and its essence is not only in omitting agrochemicals, but also in everyday management which allows us to achieve all this. In the Spatial Plan can also be seen that most of drinking water sources areas are under protected areas. [30]

Article 45 of Spatial Plan of Istria County says: [30]

"*In the use of agricultural land development of conventional agriculture should gradually be rejected, while development of organic farming should be anticipated and promoted.*

Organic farming (also ecological or biological) is agricultural production without the use of fertilisers, pesticides, hormones and similar product.

Conventional agriculture is agricultural production which with help of machinery, agrochemicals, newly varieties and breeds, and with large amounts of energy manages to achieve very high yields.

Spatial Plans for cities and municipalities must separately evaluate areas designated exclusively for organic farming, but after verification of studies from Point 1 of Article 149 of the provisions of the Plan."

On the area of Istria County until 2008, there were only seven family farms with organic production, which on the one hand shows that food production in the Istria County is present, but also shows that it is necessary to develop it more intensively. The efforts and resources invested in programs of ecological production of agricultural and food products (co-financed by the Administrative Department of Agriculture, Forestry, Hunting, Fishery and Water Management of Istria County) have a solid base for the development, which is consistent with the strategic goals and interest for sustainable development of Istria County [30].

Although Istria County has very favourable conditions for the development of ecological agriculture, agricultural entities have started only sporadically to be interested in the possibilities of mass production. However, organic food production has still not received its proper place.

Among the first Croatian regions, Istria County has recognized the importance of organic food production as one of the strategic commitments in the sector. The development of organic farming supports the establishment and operation of associations by offering financial support through the budget of the Istria County.

Istria County in many ways was the initiator of changes in the current development programs of organic farming and also through related projects.

The pioneer advantage of Istria County was slowed down by the impossibility of active participation in more international development projects due to lack of financial resources. However, a lack of skilled personnel, the resistance of the business of the agricultural sector, advertising of industry chemicals for fertilization and protection, abuse of ecological product names, identification of traditional agriculture with conventional, the lack of large quantities of products for installation in tourist companies are more than clear limitations for overall development.

The basis for development beside registered organic producers represents also a critical mass of registered family farms which are ready for certification i.e. entry into the system of organic production.

Ongoing implementation of the program for production of bio-food (stimulation of interest associations, promotion of typical and organic products, development of programs for the protection of originality, geographical origin and genetic material, incentive programs for traditional and cultural heritage of the organization of fairs and exhibitions) showed that the implemented activities yielded good results. The prohibition of the use of genetically modified seeds and foods, and installation of organic farming in the Spatial Plans are a starting point for systematic planning and development of organic farming.

Also, with implementation of Istria water protection system Ltd. (Croatian: Istarski vodozaštitni sustav d.o.o.) [31] plan "Sewerage and wastewater treatment for small settlements in drinking water sanitary protection zones of Istria County" the problem of wastewaters drainage with corresponding WWTP will be solved. The primary purpose of the Plan is to protect drinking water sources from pollution, but the positive side effect is also the protection of the environment in the broad sense, including the protection of the sea.

The Decision on sanitary protection zones of the Istria County requires that residential buildings in the zone III and IV must have a septic tank or biological treatment device, while in zone II for springs and also in the zone II and III for reservoirs and lakes must have watertight collecting tank with controlled discharge done by authorized institutions [6].

The real situation is that tanks are not watertight and untreated wastewater is drained into the underground, there is no control on discharging tanks and the removal of their content to adequate treatment, and also Istria County does not even have enough equipped devices for the reception of content from all septic and collecting tanks. The consequences of such conditions pose a threat to the safety of the water supply because of:

- more demanding treatment in the process of obtaining drinking water,
- need for more chemicals used in water purification
- greater insecurity of water supply system regarding health safety of drinking water.

Significant are also negative consequences for the environment because it increases the concentration of micro-organisms (many of which may be pathogenic) in surface and groundwater and the concentration of nitrogen and phosphorus in the reservoirs and coastal sea, causing an overgrowth of algae and other undesirable organisms which ultimately leads to the degradation of water and sea quality.

With the construction of watertight sewage systems and WWTP with tertiary treatment it can be prevented:

- contamination of surface and groundwater flows with pathogens,
- pollution of reservoirs and coastal waters with nitrogen and phosphorus and their degradation,
- aesthetic violation of the environment.

Also, this will open the possibility to re-use the treated water for irrigation or other needs, which is particularly important for Istria County which has limited water resources in the summer [7].

Therefore, goals and challenges of Istria water protection system Ltd. are: construction and management of water protection systems of Istria County, construction of sewage systems and wastewater treatment plants for small settlements to the highest standards, and maintenance of the system with providing high customer service [31].

Analysis and synthesis of both the actual and the expected future scenarios in the framework of the DPSIR approach

Analysis of current scenario refers to 2012. Development of future scenarios is possible based on analysis of Spatial Plan of Istria County [30] and project documentation of the Istria water protection system Ltd. [31] that has, for the final goal, the improvement of water quality on all water sources used for drinking purpose.
In Table 34 the most significant *Driving forces*, *Pressures*, *States*, *Impacts* and *Responses* on test areas in Northern Istria associated with urban and agriculture areas are given.

Table 34: Most significant Driving forces, Pressures, States, Impacts and Responses on test areas in Northern Istria. [7]

URBAN AREAS				
Driving forces	**Pressures**	**State**	**Impacts**	**Responses**
Areas without sewage system Runoff from paved structures Collection and storage of wastewater Health service Waste disposal	Emission of microbiological pollutants, pathogens, nutrient N&P compounds, chemicals, heavy metals	Groundwater state Health	Deterioration of underground water quality, impact on human health	Implementation of appropriate measures, i.e. construction of sewer systems and WWTP
AGRICULTURE				
Driving forces	**Pressures**	**State**	**Impacts**	**Responses**
Use of fertilisers (N and P consumption)	Diffuse N contribution (runoff and percolation)	Groundwater state Biodiversity landscape Health	Deterioration of underground water quality, impact on human health	Implementation of appropriate measures, i.e. organic farming: National Directive 91/676/EEC (the so-called Nitrates Directive)
FARMS				
Driving forces	**Pressures**	**State**	**Impacts**	**Responses**
Farms	High concentration of pathogenic animal waste	Groundwater state Health	Deterioration of underground water quality, impact on human health	Implementation of appropriate measures, i.e. appropriate WWTP and waste disposal

6.6 Spring Prud and Blatsko polje

The impact of climate change and planned development (spatial plans) on the land use in future on test areas

Unfavourable predictions of climate changes in the test areas, what is presented in the report of water resources [32], lead to decrease of possible pumping quantities already in the period 2021-2050. The total annual recharges will decrease as well as the minimum mean monthly discharges. Future spatial plans for Dubrovačko-Neretvanska County do not provide significant changes in the land use on test areas in Croatia in the near future [33].

Impact of land use on water quality - future state

An important driver determining water quality is land use. Impacts on drinking water quality may change in the future due change in land use, which can be caused by climate change, politics (spatial plans), etc. Land use change in the future can be estimated on the basis of trends in land use changes in the past with comparing CORINE land cover maps from different years. On the other hand, also future spatial plans of the area have to be considered, where information about activities in the area are defined [33].

Comparing CLC for different years in order to evaluate trends in land use, it was observed following:

- Part of Prud spring catchment area in Bosnia and Herzegovina
  - there is no any changes in land use comparing CLC 2000 and 2006.
- Part of Prud spring catchment area in Croatia
  - there is just minor changes in land use - areas of Pastures and Scrub and/or herbaceous vegetation associations are reduced while, Mine, dump and construction sites and Heterogeneous agricultural areas are slightly increased.
- Blatsko polje catchment has significant changes, but in a way that there has been a change in use of agricultural areas – areas of Permanent crops are reduced approximately as much as Heterogeneous agricultural areas are increased, but there is not significant changes between agricultural and natural areas.

Evaluated trends of changes in Corine land cover shows that there is no significant changes in land use categories over the years that could have negative impact on water quality. Moreover, as mentioned in the previous section, after county spatial plans, it is not expected significant changes in land use in the future at Croatian part of Prud catchment and Blatsko polje. On the other side, there are a number of measures which are in County strategic plan which should have positive impact on groundwater quality. These are:

- development of energy which would promote clean technologies,
- renewable energy, entrepreneurial development,
- environmental protection,
- reduced using of fertilizer,
- building of sewer systems in areas where they don't exist and making devices for wastewater treatment,
- restoration of existing and construction of regional waste disposal sites,
- definition of sanitary protection zones for the spring Prud which should enable better protection of groundwater from agricultural areas located in the Prud catchment.

Still, as Croatian part of spring Prud catchment is just a smaller part and majority of catchment is in BiH, in the report on land use from BiH partner will be mentioned its future plans in land use and its impacts on water quality.

Despite above analyses did not determine significant impact on groundwater quality, the impact of climate change could have significant negative impact. Climatological models have indicated [8] that the amount of runoff could significantly reduce during the modelled period of 2021-2050. Problems associated with the predicted climate change [8] will caused that pumping at present rates at Blatsko polje wells will lead to more expressed and more usual saline intrusions of this karst aquifer. The situation will, in the periods after that, only get worst. Predicted climate change would certainly have a negative impact on both, water quality and quantity on spring Prud also, however, there is not sufficient data to predict the extent on which these changes will impact on Prud spring water in the future.

6.7 Nikšić

According to Corine Land use maps for 2006 and 2012 there is no significant changes in land use practices. However, there is evidence that percentage of burned areas increase after 2006 very likely due to temperature increase and precipitation decrease during the summer season. Thus, future land use planning should seriously consider projected changes in average values for temperature and precipitation within the test area. [9]

6.8 Drini basin

The impact of climate change and planned development (spatial plans) on the land use in future on test areas

In general, predictions of climate change will lead to warmer and more variable weather in the DMRD area. Studies have aimed to elucidate how warmer temperatures, decrease in annual precipitation, increase of atmospheric concentrations of CO_2, likely changes in sea level, and increase in extreme weather events, (including spells of very high temperatures, torrential rains and flooding, and droughts) may affect a) crop yields, and b) the economic costs of agricultural production. The following conclusions can be reached:

- Expected temperature increases are likely to hasten the maturation of annual crop plants, thereby reducing their total yield potential, with extremely high temperatures causing more severe losses;
- Climate change projections include an increased likelihood of both floods and droughts. Variability of precipitation - in time, space, and intensity - will make the agriculture in the area increasingly unstable and make it more difficult for farmers to plan what crops to plant and when;
- Higher temperatures and lower precipitation are likely to result in the spread of plant pests and diseases. Higher temperatures reduce insect winterkill, and lead to increased rates of development and shorter times between generations. Wet vegetation promotes the germination of spores and the proliferation of bacteria, fungi, and nematodes. Prolonged droughts can encourage other pests and diseases; -especially those carried by insects;
- Increased crop pests may necessitate intensified use of agricultural chemicals that carry long-term health, environmental, and economic risks.

Falls in crop yields will be exacerbated by an increase in prolonged periods of droughts, a lack of water availability and a drop in precipitation incidence, which will in turn be much more intense. More frequent occurrences of extremes, such as dry spells and heat waves, will contribute as well. Thus, as elsewhere in the Mediterranean countries, there is a need to invest in better irrigation systems, more balanced crop-rotation methods and crops better adapted to water and heat stress, and to maintain levels of soil organic matter. The expected impact of climate change on agriculture (*Figure 49*), will have an indirect impact on other sectors of the economy in the area that have some degree of dependency on agricultural production (e.g. tourism). The expected impact of climate change on agriculture will definitely have an indirect impact on other sectors of the economy in the area and tourism will be most probably one of highly affected. The region has become a popular tourist destination as a result of some unique environmental features, for example, the Patok lagoon. Since most of the food for the tourist facilities comes from the region and is based on organic farming, a change in the structure of the crops, yield and the phenological stages will affect the tourism industry. [10]

Figure 49: Agriculture areas that risks from flooding. [10]

6.8 Corfu island

The impact of climate change and planned development (spatial plans) on the land use in future on test areas

Land use cover from Corine project is available only for 1990 and 2000 for Greece. Greece is not included in the CLC of 2006 and 2012. Figure 50 shows the CLC 1990 and *Figure 51* shows the CLC 2000. The % change is shown in *Figure 52*. From *Figure 52* it is evident that the land use changes are not very significant from 1990 to 2000.

Since there are no data available from the Corine Land Cover project, other sources are used to assess the land use changes in Corfu Island. A comparative study done in 2002 showed that agricultural land is increased by 4.9%, pastures increased by 1.4% and forests decreased by 10.62% from 1830 to 2000 (170 years) [34] (*Table 43*).

Table 43: Land uses in Corfu in 1830 and 2000 [34]

	1830			2000				
%	**Agriculture**	**Pastures**	**Forests**	**Agriculture**	**Pastures**	**Forests**	**Artificial surfaces**	**Other surfaces**
Total	79.53	8.10	12.37	84.39	9.50	1.75	3.74	0.63

The spatial plan of 2008 for the island of Corfu [26] identified that the island's economy is based on the tertiary production factor mainly due to the touristic development. According to data from 2001 census, 51.7% of the island's working population are occupied in services and tourism. The regional unit of Corfu accepts annually about 983,000 foreign tourists (data from 2007). However, officially only 430,000 foreign and 126,000 domestic tourists are recorded (*Table 44*) [26].

Table 44: Number of overnight stays and arrivals in hotel type settlements except camping in Corfu regional unit [26]

	Overnight stays				
	2003	**2004**	**2005**	**2006**	**2007**
Corfu Regional Unit	3,372,053	1,754,043	4,340,803	4,339,576	4,158,743
	Arrivals				
	2003	**2004**	**2005**	**2006**	**2007**
Corfu Regional Unit	439,801	245,879	563,321	564,636	555,539

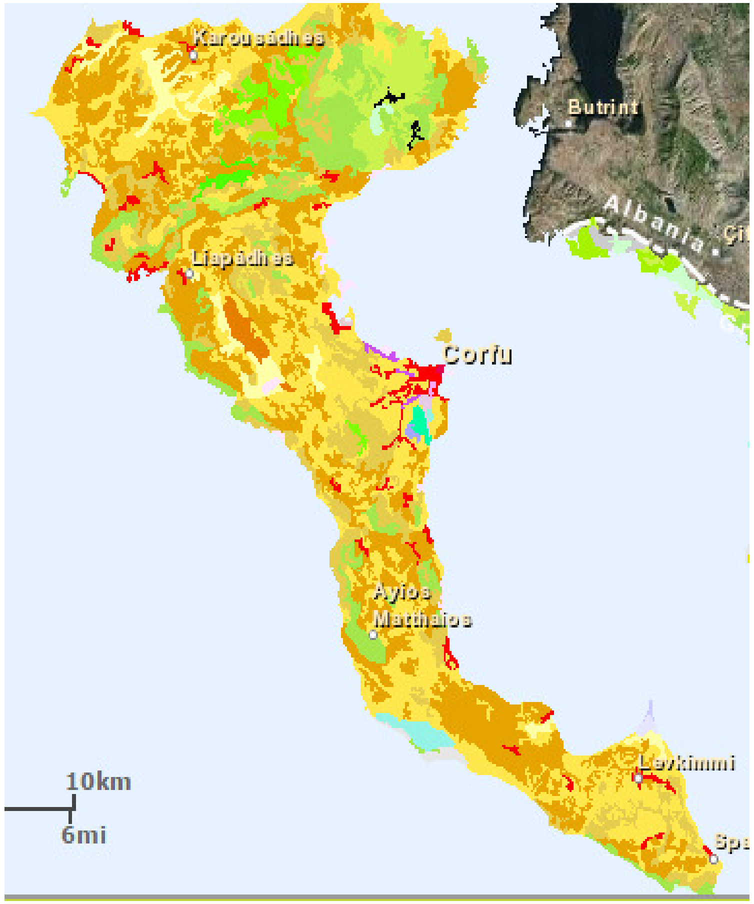

Figure 50: Land use in Corfu, 1990 [35]

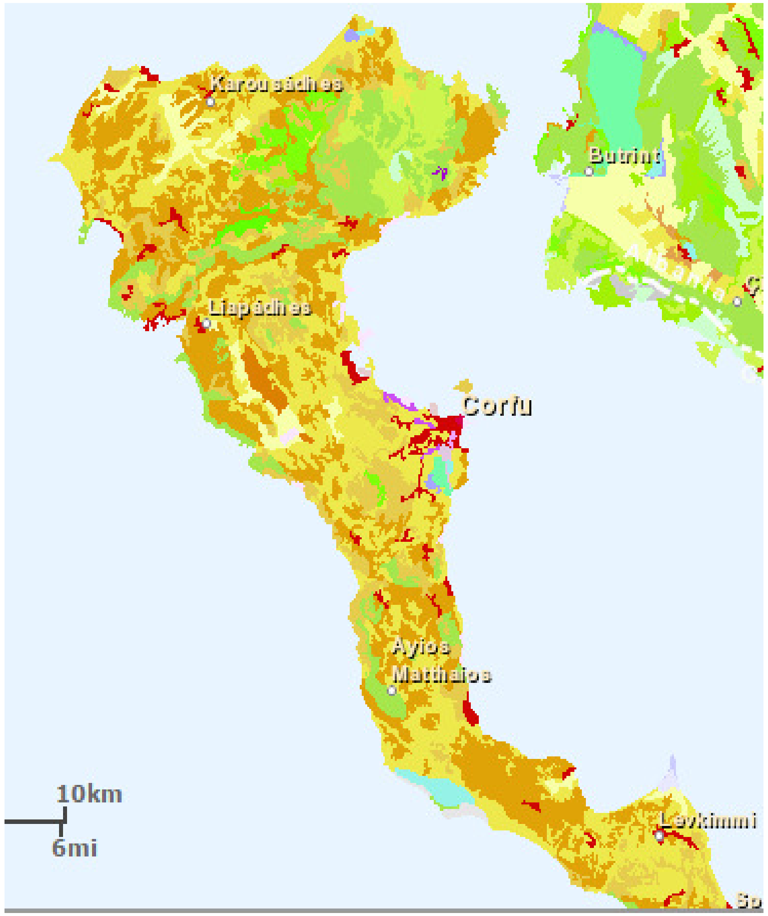

Figure 51: Land use in Corfu, 2000 [36]

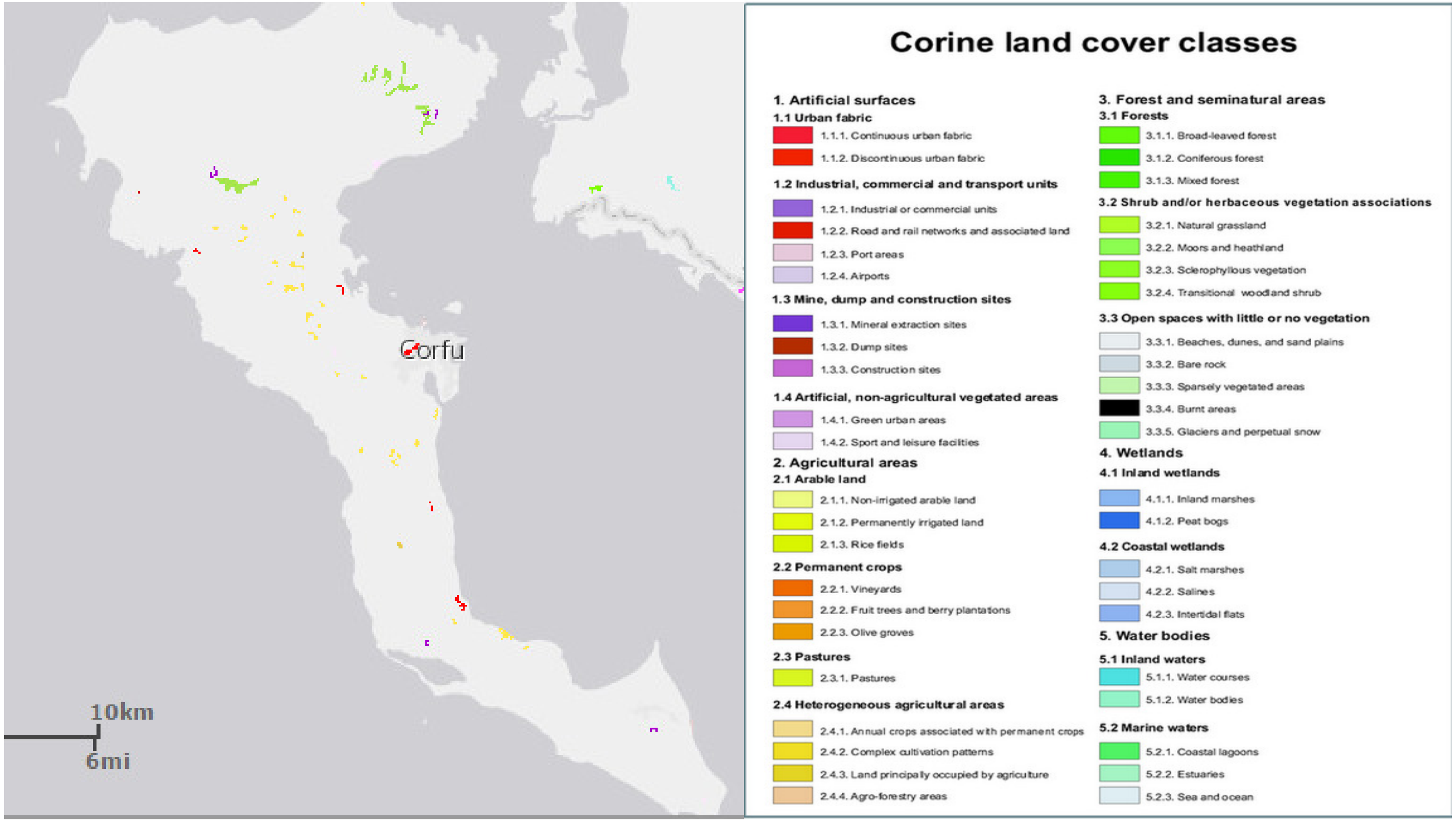

Figure 52: Differences in land use in Corfu, 1990-2000 [37]

Land uses conflicts: A large number of rural settlements are located in the island (some of them with population of less than 100 people). Their extended boundaries increased the residential space against the agricultural land. Two are the main problems in the island: the demand for buildings due to tourism and the institutional framework allowing the settlements to develop against the natural resources. Zones of land uses conflicts exist in the whole area of the island mainly in the coastal zones. The conflict of the industrial use with residential of agricultural use is based on the oil mills operation within the limits of the rural settlements [26].

In conclusion the land uses in the future are not expected to vary greatly. Due to the touristic development of the island it is expected that the agricultural use will be decreased. However there are measures applied to protect the natural environment.

Impact of land use on water quality - future state

The DPSIR approach is also used for the assessment of the impact of land use changes on water quality. The climate change prediction for the future (2021-2050) in Corfu test area showed that the average annual mean temperature is expected to increase from 1.23°C to 4.27°C. The total precipitation is expected to decrease especially in the summer months [39]. In the winter months two out of four models predict a slight increase in total precipitation values. Total annual precipitation values are expected to decrease from 3.93% to 25.4% depending on the model [39]. Climate change is expected to have an impact in the water quality. Land uses are expected to change but their variations are not expected to be big. Tourism is expected to turn agricultural land to urban settlements.

7 PROBLEMS OF SALT WATER INTRUSION

7.1 Isonzo plain

One of the sources of pollution, in addition to organic matter, pathogens and microbial contaminants, nutrients, acidification (precipitation and runoff), heavy metals, toxic organic compounds and micro-organic pollutants, silt suspended particles, that impact water resources at local scale, is the salinization due to salt water intrusion. The natural balance between freshwater and saltwater in coastal aquifers is disturbed by groundwater withdrawals and other human activities that lower groundwater levels, reduce fresh groundwater flow to coastal waters, and ultimately cause saltwater to intrude coastal aquifers.

The chloride concentration of groundwater samples has been the most commonly used indicator of saltwater occurrence and intrusion in coastal aquifers [40, 41]. In the study site area, the wells close to the coast areas were analysed to face this problem. Chlorides were taken into account and the results are visible on *Figure 53*.

To understand if in the study area there can be the evidence to face with salt water intrusion problems, were taken into account the data coming from the deepest wells and the ones were chemical analyses for each single different aquifer were available.

Analysing singly the different exploited wells, emerges that in the Well 2 the higher chloride concentrations are identified at depths higher than 170m with values greater than 100 mg/l. The other aquifer among 60 and 170m presents values ranging between 10 and 50 mg/l.

In the Well 6, have been measured values ranging between 30 and 60 mg/l at depth of 140-180m. The shallower part (6-140 m) presents instead always lower values of about 15 mg/l.

The La Risaia well, located in the area where the salt wedge is present (*Figure 56*), has “high” chloride values of 20-30 mg/l in the shallower (8-22 m) and in the deeper (184-186 m) exploited aquifer. All the other aquifers present values lower than 15 mg/l.

The three wells reach approximately the same depths and the same aquifers, so the data are comparable. They indicated that in the area is clear that the southern well has definitively lower chloride values than the northern ones (2 and 6). The higher recorded values were found within the limestones at depths exceeding the 200 m. It is known [2] that a fossil marine aquifer is present in the depths in the carbonates. This aquifer supplies the Monfalcone thermal springs and has been exploited also at Grado (Grado-1 well) beneath 700m [2]. Therefore the high chloride values identified in the northern well (2 and 6) can be linked to this resource and not to the salt water intrusion. This contamination interests only the deeper aquifers and not the shallower ones (*Figures 54 and 55*). *Figure 56* shows chlorides concentration measured while drilling on La Risaia well. Values correspond to the different exploited aquifers. [2]

Figure 53: Chloride concentration evaluated for the surface and groundwater. The red line represents the maximum ingression of the salt wedge measured in correspondence of the surface waters (rivers and channels). [2]

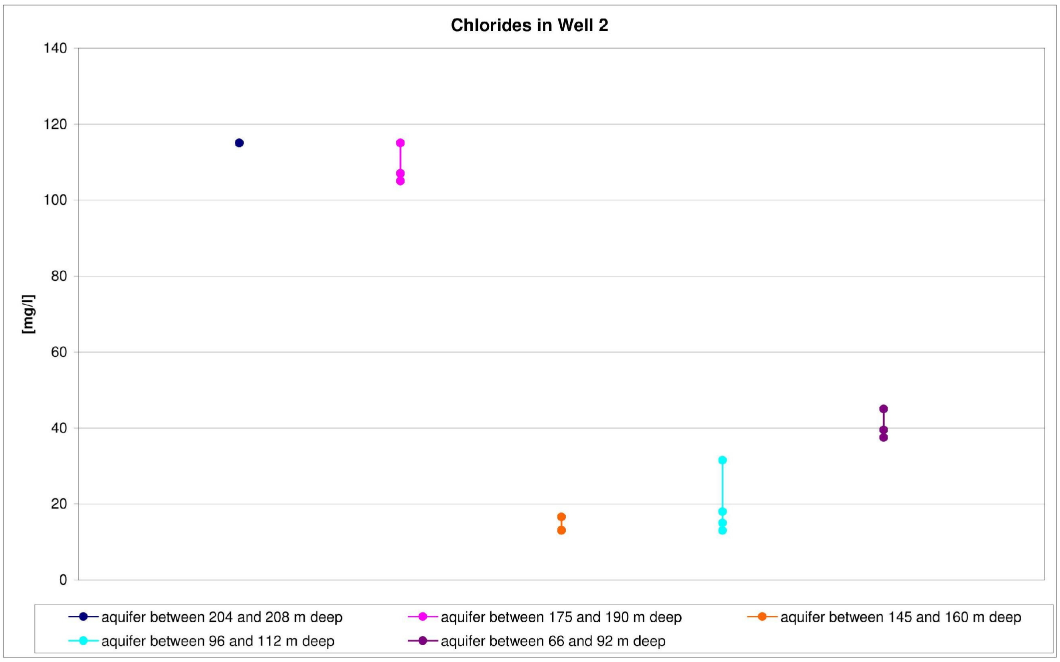

Figure 54: Well 2, chlorides concentration measured while drilling. Values correspond to the different exploited aquifers. [2]

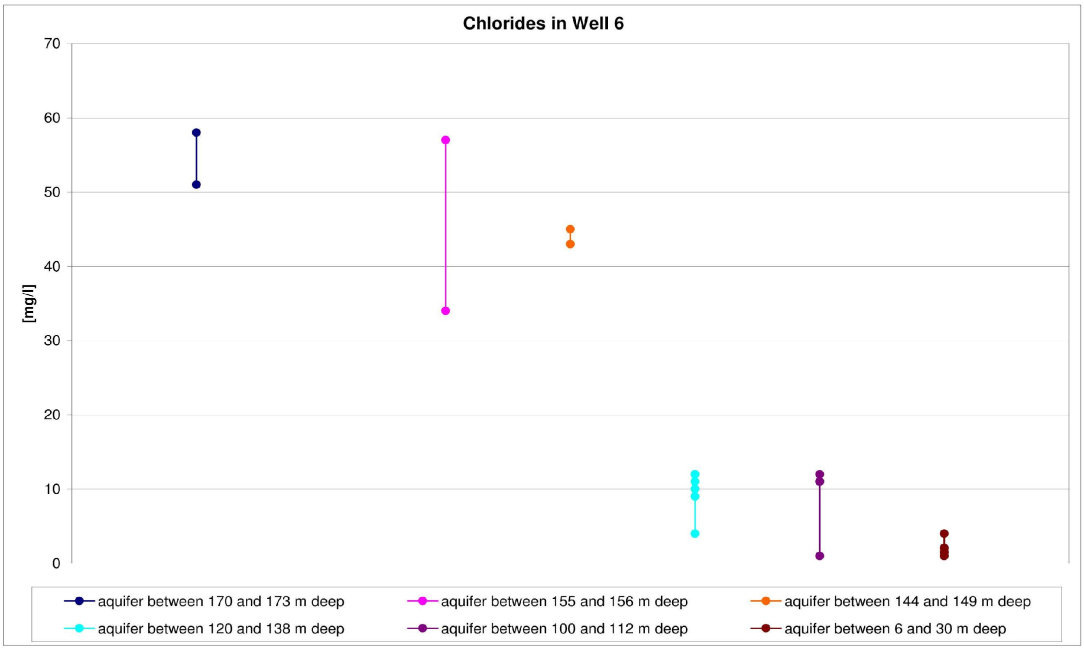

Figure 55: Well 6, chlorides concentration measured while drilling. Values correspond to the different exploited aquifers. [2]

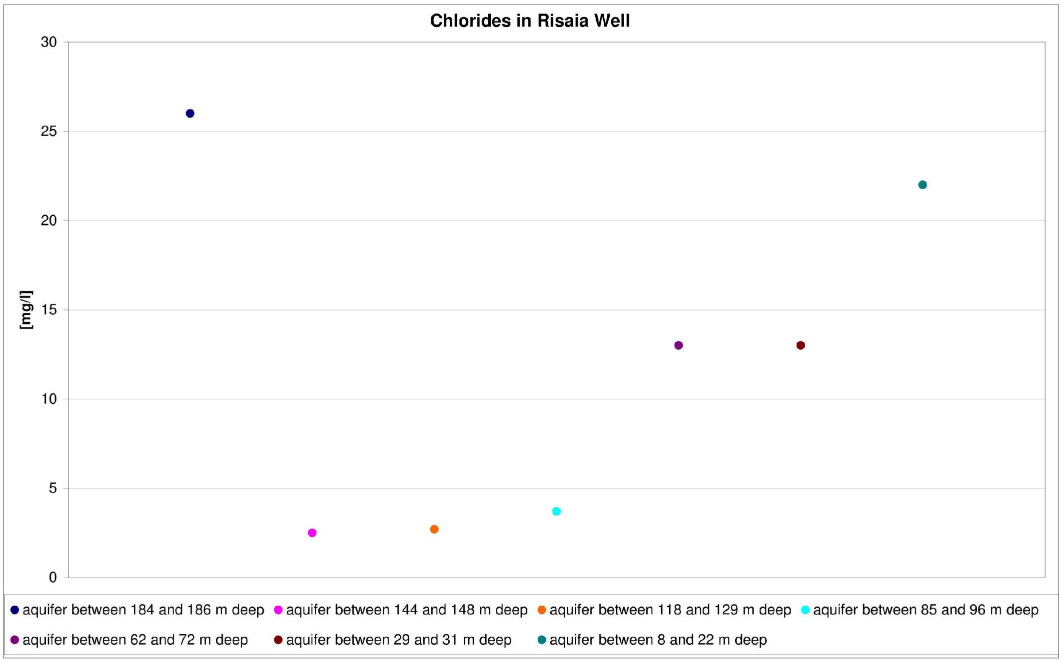

Figure 56: La Risaia well, chlorides concentration measured while drilling. Values correspond to the different exploited aquifers. [2]

7.2 Ostuni

The Salento peninsula was selected among the Mediterranean regions because it is one of the driest areas, with an average rainfall of less than 600 mm/y. Here, similarly to other Mediterranean regions (Greece, Cyprus, Lebanon, Egypt, Tunisian, Spain, etc.) the economy largely depends on farming, leading to mainly agricultural land use with a large share of irrigated crops due to low precipitations. The total water consumption in Apulia is estimated to be about 2400 Mm^3/y, where 58% (1400 Mm^3/y) [4] is consumed by agriculture, 18% (430 Mm^3/y) by industry and 24% for drinking use (580 Mm^3/y). Furthermore, according to other studies [4], the Mediterranean region is expected to undergo particularly negative climate change consequences over the next decades. These effects, combined with the anthropogenic stress of natural resources, make the Salento one of the most vulnerable areas in Europe. The anticipated negative impacts are mainly related to possible extraordinary heat events (especially in summer), increased frequency of extreme storms and reduction of total annual precipitation.

As the Salento peninsula does not have any relevant surface water sources, groundwater has traditionally been the main source of water supply in the region. Moreover, natural recharge does not refill the aquifers sufficiently, and overexploitation, with consequent seawater intrusion into groundwater, is a critical problem at many locations. The number of private wells (often illegally drilled) is around 140,000. The main problem at the Salento peninsula is related to the increase of groundwater salinization due to groundwater over-abstraction and subsequent seawater intrusion. Here, data (specific conductivities) were collected from 120 wells during the winter of 2009 at a depth ranging from 5 to 10 m below the water table, and were fitted by Surfer (v. 11, Golden Software Inc., Colorado, USA). At several places along Salento's coast, groundwater salinity already exceeds 7 g/l.

In Salento's subsoil, groundwater flows under low pressure inside karstic fissures of carbonate (limestone) aquifers at a depth ranging from 5 to 100 m from the soil. The natural recharge of rocky aquifers occurs via both existing vertical karst fractures and by sinkholes replenished by small ditches (i.e., *lame*) with runoff and, sometimes, [4] with treated effluents derived from municipal plants.

The protection of water resources from seawater intrusion may include several measures to preserve global groundwater balance, considering not only limitations of water supplies and dynamic barriers, but also potential new sources (i.e. reclaimed water) for groundwater replenishment by artificial recharge [4].

Method: Tide-gauge measurements

Many intensive studies have been recently published about global and local sea level forecasting during the 21st and 22nd centuries. Among them, the global rate of sea level rise during the 20th century is generally agreed to be 1–2.5 mm/y, and many authors concur that sea level data series available for the Mediterranean show a sea level rise of a similar rate. However, other authors [42] noted that, from 1990 onward, the sea level recorded in most Mediterranean tide-gauges indicates a rise in sea level at a rate 5-10 times higher than the 20th century mean rate. In addition, Milne et al. [43] have noted a tenfold increase in the sea level rise rate that can be attributed to climate change through glacier melting and ocean water thermal expansion.

Sea-level rise may significantly differ locally and globally due to variations in the ocean circulation as part of variable climate patterns, the isostatic adjustment of the Earth's crust, past and ongoing changes in polar ice masses and continental water storage [4]. In particular, the LSLR spatial variability may also arise for heat content and salinity changes in seawater [4], for vertical geological layer displacement due to tectonics, groundwater reservoir (and hydrocarbon deposit) exploitations, natural sediment consolidation [4] and subsidence. According to Stammer et al. [44], currently, regional sea level changes seem to be primarily caused by natural climate variability.

In the present study, ultrasonic measurements of three tide-gauge stations on the Salento peninsula, from 2000 to 2014, have been fitted using Microsoft Excel [4]. The data are available on the ISPRA website [4]. Measurements are available at intervals of 10 min and were resampled in order to have one measurement per hour. All measurements refer to sea level on January 1, 2000. When, due to device malfunctioning, measurements were missing, no values were considered for replacements, i.e. series have been plotted with missing values. This is because missing data had no influence on the evaluation of the rate during the long period of 14 years, with 129,039 measurements per station (*Figure 51*). The straight-line trends of the Bari and Taranto stations have the same rate, i.e. the increasing LSLR is 10^{-4} cm/h (or 8.76 mm/y), while the rate is 0.5×10^{-4} cm/h or 4.38 mm/y (i.e., half) at the Otranto station. Bari and Taranto trends perfectly agree with global sea level (GLS) rise projection as defined by Kopp et al. [4] (see *Figure 57*). They consider 90% (very likely) of probability under representative concentration pathway 8.5 [4], i.e. corresponding to scenarios with usual industrial emissions until the end of the simulation, under maximum radiative forcing (i.e., > 8.5 W/m^2 by 2100) [4]; IPCC AR5 WG1 [4]) and without greenhouse gas mitigation.

It should be considered that this GLS rise accounts for the melting of both Greenland (about 20%) and Antarctica's (10%) ice sheets, thermal expansion (40%), melting of glaciers and ice caps (25%) and the reduction of land water storage (5%). The Bari and Taranto LSLR trends match with the global rise forecast, as defined during the 2100 by IPCC in the fifth assessment report (AR5 WG1 2013) [4] under representative concentration pathway 8.5 and with estimations carried out by Klein and Lichter [42] in the Mediterranean area for decades after 1990. [4]

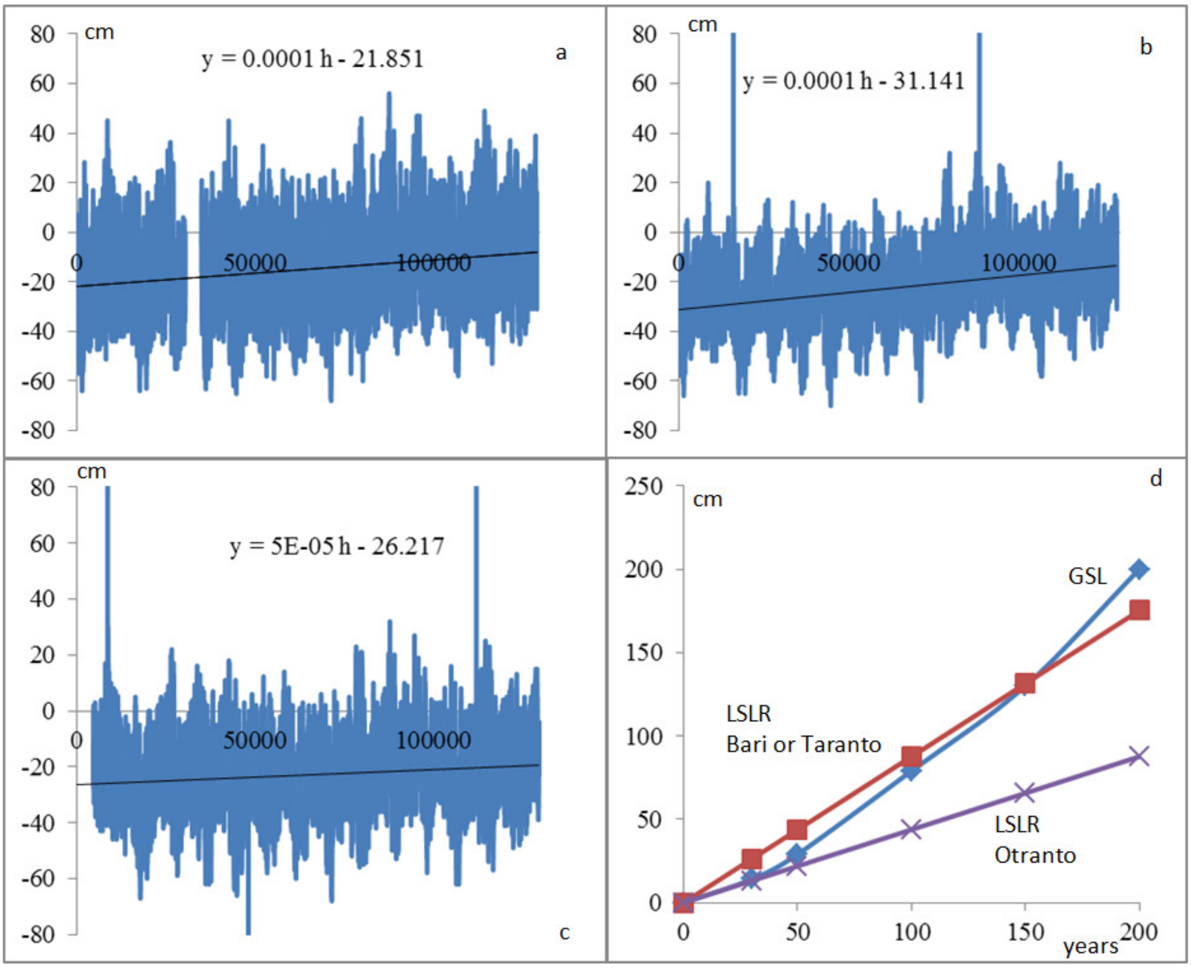

Figure 57: Tide-gauge measurement trends in (a) Bari, (b) Taranto and (c) Otranto stations from 2000 to 2014, and (d) LSLR trends compared to global level rise projections given by Kopp et al. [45] under representative concentration pathway 8.5 (i.e., 90% very likely). [4]

The coastal salinity map

The sea-level rise may produce inland sea advancements, which depend on the coast morphology. Considering a maximum increase of 2 m until 2200, the Salento sea advancement extension due to this LSLR is below 220 m, on average. This distance was estimated to be in a range from 43±30 m to 781±400 m along the Salento peninsula coastline, according to elaborations made by ArcGIS (http://www.esri.com/software/arcgis) of the coast digital elevation model (http://www.sit.puglia.it) at 8 m of grid size. This average sea advancement is lower than the value of 700–1200 m determined along the same Ionic coast by other authors Romanazzi et al. [46]. *Figure 58* shows the advancements (contour lines) of the sea line determined during the 21st (yellow) and 22nd (blue) centuries compared to the coastline during 2000 (red) along the Lecce's coast (Italy) using ArcGIS. In the same figure is shown in a separate window the groundwater salinity progression in an apparent (i.e. fictitious) borehole placed 1 km from the actual coastline.

The overall LSLR impact is very far from the catastrophic hypothesis suggested by Andrew Thaler (http://www.weather.com/news/science/environment/drownyourtown-sea-level-rise-your-city-20131219?pageno=4), showing how the Vatican and St. Peter's Square in Rome (Italy) will look with LSLR of 20, 30 and 45 m. The resulting LSLR of 4.4–8.8 mm/y in the present study and consequent average sea advancement (~220 m) are not negligible when compared with anthropogenic effects, such as over-pumping [4], and surely cannot be neglected in future groundwater volume balances and water management actions. In a previous study at the Ostuni area [4], we showed how stopping the artificial injection of 62 L/s of reclaimed water, it was caused during 1998 a seawater intrusion of about 200 m along 3 km of the coast. This led to a water salinity increase from 2 to 6 times into the wells within 1.5 km from the coastline. [4]

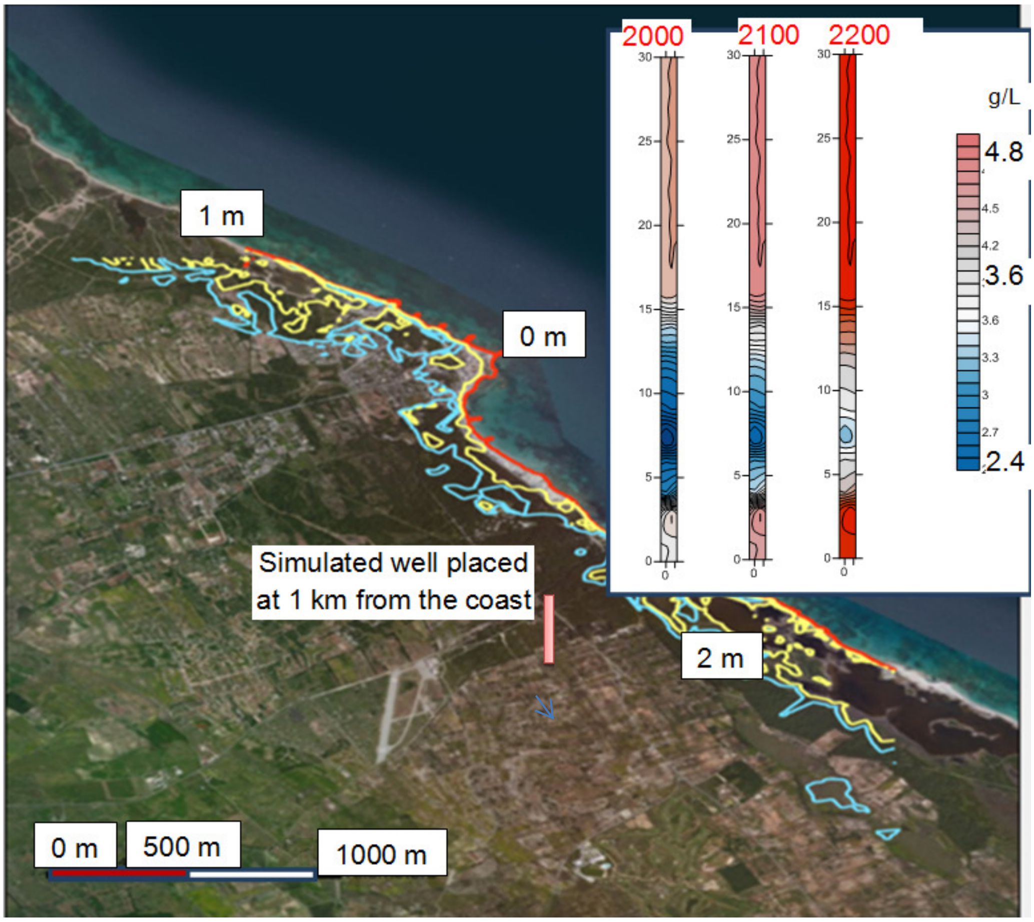

Figure 58: Sea line advancement (contour line) during the 21st (yellow) and 22nd century (blue) compared to the coastline location in 2000 (red) along Lecce's coast on the Salento peninsula (Italy), using ArcGIS and groundwater salinity progression, in a borehole placed at 1 km from the current coastline. [4]

Evaluating a coastline length of about 80 km, the substantial groundwater availability reduction due to the LSLR will be 2.5 Mm^3/y until 2200, i.e. 9.7% (or 79 L/s) of Murgia's current groundwater withdrawal (813 L/s) for drinking purposes (*Figure 59*).

The same estimation was performed along Brindisi's coast, where K= 0.0037 m/s (or 320 m/d), B=15 m, L_d =1250 m and L-L_d = 125 m, estimating a groundwater reduction of 2.5 Mm^3/y, i.e. 3.2% (or 77 L/s) of current withdrawal (2500 L/s) for drinking, measuring a coast length of 77 km. On Lecce coast, we have K= 0.008 m/s (or 691 m/d), B=15 m, L_d =2800 m and L-L_d = 480 m, and we obtained a total reduction of 9.25 Mm^3/y, i.e. 11.9% (or 293 L/s) of current withdrawal for drinking, measuring a coast length of 189 km. Along the same coast, if we consider the rate of 4.8 mm/y until 2200, L-L_d is close to 220 m and we will have a total groundwater volume reduction of 4.6 Mm^3/y, i.e. 5.9% of actual withdrawal for drinking.

Finally, along Taranto's coast (about 116 km), we have K= 0.0008 m/s (or 69 m/d), B=15 m, L_d =2500 m and L-L_d = 190 m, estimating a groundwater source reduction of 0.3 Mm^3/y, i.e. 1.2% of Murgia's current groundwater withdrawal for drinking purposes.

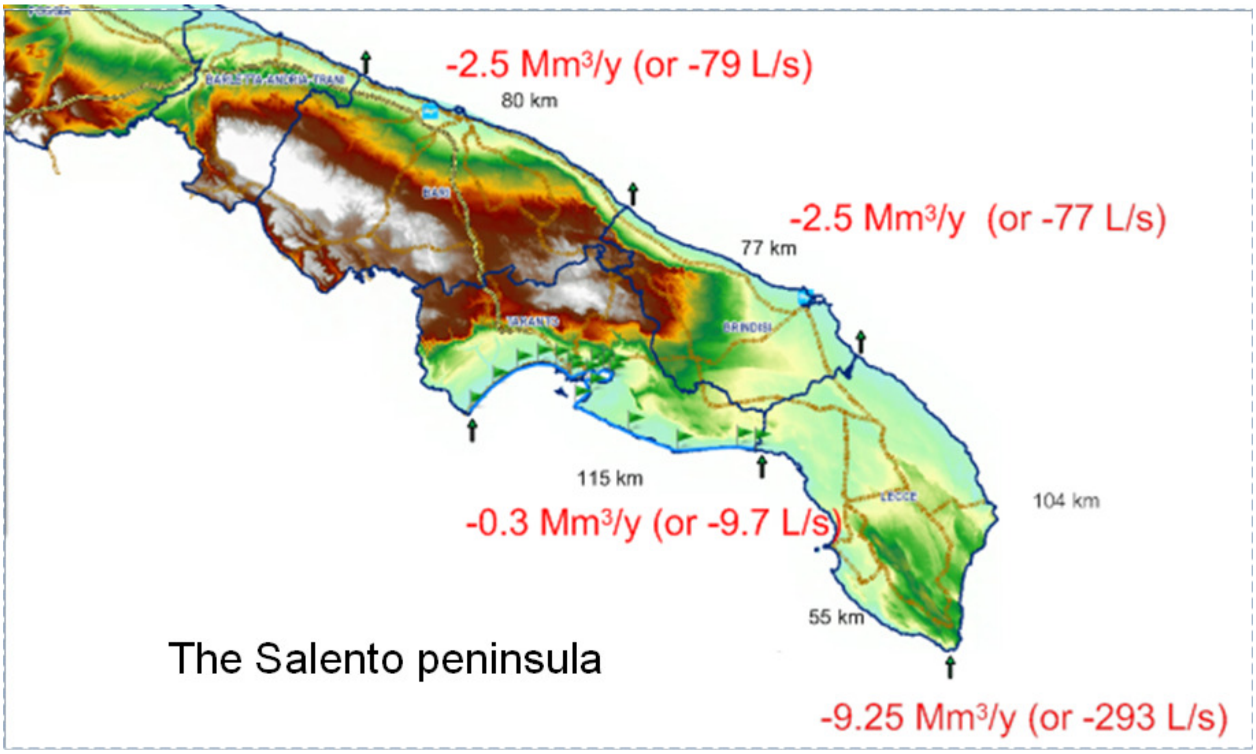

Figure 59: Groundwater discharge reduction during the 22nd century due to LSLR (over exploitations have not been included) at the test area (Southern Italy). [4]

7.3 Spring Prud and Blatsko polje

There are no problems associated with seawater intrusion at the spring Prud for now, but recent activity in Bosnia and Herzegovina has shown that this is a very sensitive area. Because of the large construction project of six hydropower plants upstream from this area, spring downstream from spring Prud has been salinized. Water from this spring is used for the water supply of the city Metković, and as a result, the Metkovic was compelled to connect on spring Prud water supply system. In addition to this, Neretva valley, which is intensively used for agriculture, was also salinized as well as water used to irrigate agricultural land, therefore this situation is a major threat to this valuable agricultural area.

Blatsko polje test area has occasional sea water intrusion problems. Maximum rates from pumping wells in Blatsko polje are always extracted in the summer seasons when the need for water is increased as a result of tourism and agricultural production, while the recharge in this period of the year is usually minimal or none. When hydrological conditions are extremely unfavourable, there is a significant salinity increase of the pumped water. The sea water intrusion happens only when the pumping rates are close to maximal and a dry season (much below average) has lasted for at least one hydrological year. In such years surface flow does not occur at all, so there is no surface water to retain before the tunnel entrance. In the seasons when surface flow occurs, the underground will usually be saturated enough not to allow any sea water intrusions during the summer season. [8]

7.4 Drini basin

Freshwater inland resources can be contaminated due to the intrusion of saline water, both underground and on surface, increasing drought problems (e.g. experienced in 2003 in the southern region of the Venice lagoon), both for human use and agriculture production. Along the Adriatic and the Mediterranean, storm surge and saltwater intrusion into aquifers threaten parts of the Croatian, Albanian, and Turkish coasts. Problems of saline intrusion would be further exacerbated by reductions in runoff and by increased withdrawals in response to higher demand. Excessive demand already contributes to saline intrusion problems in many coastal areas of Italy, Spain, Greece and North Africa. The coasts have started to erode along almost the entire Adriatic coastline in Albania due to sea level rise. In some places the sea has advanced more than 50 m inland, destroying the coastal forests and vegetation, and increasing the salinity in the lagoons and fields near the coast. Sea level rise has wreaked havoc on the beautiful Mediterranean Pine forests that cover the Adriatic coast in Albania. Most of the trees that are found on the coastal margins are dying from increasing salinity. In other places, especially in villages near the coast, the salinity in the soil and in the water wells has increased significantly, damaging the small rural economies along the coast. Salt water intrusion due to sea-level rise is mostly a very slow process that may take several centuries to reach equilibrium.

Even small rates of groundwater pumping from coastal aquifers are expected to lead to stronger salinization of the groundwater than sea-level rise during the 21st century.

Salt Water intrusion occurs in freshwater coastal aquifers where the density difference between fresh water and saline water causes the sea water to intrude in the freshwater aquifer. Saline intrusion can be detected by monitoring the amount of Cl-, K+, Na+, water conductivity and TDS in the coastal aquifer. According to EPA, to assess the presence of saline intrusion the electrical conductivity should be more than 0.8mS/cm and the Cl-concentration should be more than 24 mg/l. These two values indicate a possible salt water intrusion.. The saline investigation for this case study was determined by evaluated the distribution maps of Cl, Na+K and TDS. These maps clearly illustrate that the concentration of these parameters increases towards the coast line of Durres. The highest value for Cl concentration is registered in Durres city (400mg/l in the period 1982-2001). Further analyses of two time series data (Cl distribution map for the period 1982-2001 and 2010) shows that the amount of Cl- ions has increased toward the centre of the region. The main source of this intrusion is the urbanization of the area and the high demand of freshwater. The groundwater is the primarily in Durres City for drinking, domestical and irrigation purpose. The fresh water is withdrawn at a faster rate than it can be replenished. 0 2 4 6 8 10 12 1 NH4 concentration (mg/l) Stations Fig. NH4 Concentration Ibe Ndroq Sallmone Brari Ishmi Gjola Lana Rinasi Papër Labinot Rrogozhinë.

Another reason of saline intrusion is the poor management of the river sediments that are discharged in Durres city. Erzeni and Ishmi River's sediment are highly exploited for construction materials. Through past ten years, due to this situation, the sea line has progressed towards the land, and most possibly intruded to the ground water resources. Immediate measurements should be taken to control and improve the current situation. A recommended solution is to build injection wells. These injection wells should be placed strategically such that the injected freshwater can produce barriers to prevent further intrusion of the salt water. [10]

7.5 Corfu Island

The groundwater bodies in the basin of Corfu-Paxi are surrounded by the sea. Each groundwater body is examined separately based on the River Basin Management Plan of Epirus [25].

Increased concentrations of chlorides are met in the northern part of the system. The main causes are natural (open karstic system to the sea) and excessive abstractions locally. The chlorides values exceed 2,000mg/l with average values of 800-900mg/l [25].

Local salinization is met due to excessive abstractions in the coastal area in the north western part of the system (south part of Lefkimi). The chlorides values are 1,900 mg/l [25].

Totally the results are presented in *Figure 60* and *Table 45*.

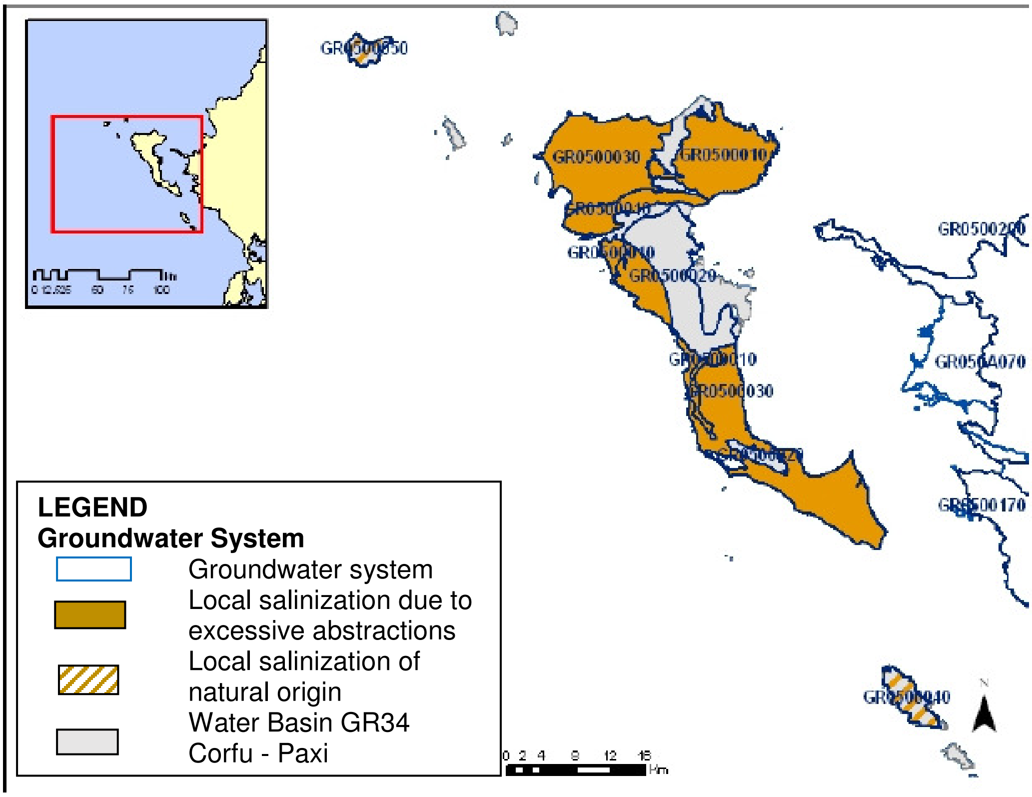

Figure 60: Salinization map of Corfu-Paxi basin [25]

Table 45: Temperature and precipitation variations predicted for the future in Corfu [39]

	Ensemble (A1B)					**Prudence (A2)**					**Prudence (B2)**					**REGCM (A1B)**				
Change in	Winter	Spring	Summer	Autumn	Year	W	S	S	A	Y	W	S	S	A	Y	W	S	S	A	Y
minimum air temperature (°C)	1,04	0,89	1,52	1,51	1,24	3,58	3,29	5,55	4,26	4,17	2,46	2,39	4,43	3,12	3,1	1,14	0,77	1,52	1,36	1,19
maximum air temperature (°C)	0,98	0,93	1,5	1,51	1,23	3,81	3,77	6,19	4,68	4,61	2,43	2,48	4,78	3,4	3,27	1,15	0,9	1,53	1,47	1,26
average air temperature (°C)	1,01	0,91	1,51	1,49	1,23	3,58	3,44	5,76	4,32	4,27	2,37	2,42	4,51	3,2	3,12	1,15	0,87	1,53	1,15	1,25
total precipitation (%)	2,29	-13,9	-11,13	-5,31	-3,9	-1,47	-15,1	-60,01	-24,88	-25,4	5,94	-1,19	-44,54	-3,15	-10,7	-16,56	-6,3	-44,01	-9,19	-7,9

8 MEASURES TO IMPROVE THE QUALITY OF DRINKING WATER

8.1 Isonzo plain

Fresh water is essential for human life and in general, it is an essential input to human production and to the economic development. Unfortunately, in many countries around the world, some drinking water supplies become polluted and the deteriorated quality is becoming a grave issue. Water pollution is not only a serious environmental issue but also an economic and human health problem. So this requires a monitoring adaptation based on community-based monitoring programs. This will play a central role in keeping communities abreast of the state of their waters. Information gathered from monitoring water (this could include water quality parameters, water levels ….) can be used in source water protection plans and water management decision-making at local, regional and national levels. Community-based water monitoring programs have the potential to provide essential localized information to support community decision-making and community participation in regional watershed governance partnerships. They will often require initial training and capacity support to ensure quality control, maintain complete community data collections, and a usable database up-to-date.

Water quality monitoring data collected regularly throughout the year, over a number of years will contribute to reveal seasonal water quality fluctuations and trends over time. This plays an important role in the development of more effective contextual community water treatment regime and source water protection plans. Monitoring water quality and quantity parameters over the long-term will make communities more conscious on the ongoing changes. Such information provides powerful leverage to support decision-making in favour of water stewardship.

Community outreach and education will be required to support watershed stewardship initiatives and to raise overall awareness not only of climate change impacts but also on land use changes impact so that community members clearly understand the importance of water conservation in the broader attempt to nourish watershed health.

Community is important, but not sufficient. It is necessary in fact to guarantee the safeguard of the resource introducing an Authority dedicated. The combined provisions of art. 13, paragraph 3 and article 3, paragraph 6 of the Water Framework Directive 2000/60/EC allows to identify in a mixed international Italian-Slovenian Commission the institutional entity that most likely could ensure the mutual harmonization between the management plans being drawn up by the Italian and Slovenian authorities [2]. Eastern Alps Hydrographic District Management Plan has individuated the stakeholders necessary to be part of the Permanent Italian Slovenian Commission for Hydro-economy as an official public organism to discuss transboundary water problems. The first step of the commission will be the definition of an expert group to prepare a road map for implementation of “First Italian Slovenian Isonzo-Soča Common Management Plan”.

Surface water, groundwater and precipitations of the Isonzo plain were monitored thanks to a monitoring network realized in collaboration with the Italian and Slovenian partners in the framework of GEP and ASTIS projects, according to the different realities existing over the territories. The aim of this monitoring network has been the one to monitor the surface and groundwaters from a quantitative and qualitative point of view. This means that were analysed the water levels within the water level devices and qualitative through geochemical and isotopical analysis. In Italy were used and joined the network of the Servizio Idrografico Regionale, the one of the ARPA FVG and some other points. In Slovenia were used some points of the Slovenian Geological Survey and some made available by ARSO. An important issue is the monitoring network maintenance in order to verify, in the foreseen years, the changes in quantity and quality of the exploited waters.

The Permanent Italian Slovenian Commission for Hydro-economy has recognized the need to set up a wide monitoring network in order to define the quality and quantity of water bodies in accordance with the Water Framework Directive. In this framework, a transboundary monitoring network will be planned and it should be immediately operating.

The recent monitoring programmes for water quality are prepared according to a new monitoring approach. They are based on pressure analyses, i.e., data on emissions, land use, surpluses of nitrogen and the amounts of pesticides used etc. According to the analysis of these data, the monitoring program is problem oriented and involves predominantly problematic water bodies. Other water bodies are less frequently included in the program. All the specific activities foreseen have been defined on the Technical Standards proposed in the Piano di Tutela delle Acque actually in approval phase [2].

8.2 ATO3

The analysis makes it clear that, for many of the Water Resources in use in ATO3 Test Area, scenarios of medium-high criticality can be expected in the next future, both concerning the use of the soil (as a consequence of prospective CC and connected anthropogenic actions) and the possible use and the quality of the water resources.

In the hilly areas and coastal zones, however, part of these impacts could be mitigated by the same intervention measures and policies provided by the RDPs (Rural Development Programmes) of the Marche Region, whose overall objective is the continuation of farming but in a framework of ecological and sustainable development (with special reference to the extensive livestock activities). As recommended in these Plans, given that the most widely spread crops and cropping systems are identifiable as high-risk in terms of soil degradation, they should be avoided and other kind of crops, rotations and modern practices introduced.

However, considering that farmers are often attached to current crops and practices, because of profitability, tradition and social norms, long-term investment in machinery, limited skills, pressures from processors and retailers, and other factors, it may be difficult to abandon damaging practices in the short term. Therefore incremental change and more limited technical adjustments may be more realistic goals in the immediate future.

In mountain areas, where the risk of overexploitation and decrease in water resource quality appears not existing or very limited in the short-term, measures should be addressed to the maintenance and modernization of the abstraction facilities, in order to reduce the risk of losses and optimize the management of water intakes, also in view of a general increase in future demand.

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8.3 Ostuni

The measure to improve the groundwater quality by contrasting seawater intrusion in coastal aquifers is the Management of Aquifer Recharge (MAR).

The principal benefits of the concept of MAR are twofold:

- It allows storage of large quantities of surface water (including surface runoff, storm water, reclaimed water, and also freshwater from desalination) at those periods of the hydrological year when availability exceeds demand and to restore them when demand exceeds availability.
- The underground passage (unsaturated and saturated zone) can constitute a complementary treatment step, due to physical, chemical and biological processes that will affect water quality.

The major challenge to meet is thus a potential conflict of the MAR system with other uses, mainly in terms of water quality (risk of degradation of chemical or biological background quality for one or more parameters due to infiltration or infiltration-induced chemical processes in the storage medium). In order to address those benefits and risks, the designer or operator of any MAR system will need to address the following key questions:

(1) How efficient is my system in terms of recovery of the recharged water?

(2) How long will the water and solutes reside in the system and be in contact with reactive minerals and biofilms?

(3) In which way will the recharge-recovery cycles affect the quality of the recovered water and the background water, on short term and long term?

These questions will be asked from the very beginning of the planning phase and over the whole lifetime of the MAR project and groundwater models provide the unique possibility to preview the feasibility of the MAR system in the regional context, to optimize the choice of the site, the configuration of an appropriate recharge-recovery system, to optimize operating conditions in a way to meet fixed quantity and quality targets. Those targets are most frequently quantified through the key parameters recovery efficiency, residence time, and recovered water quality compared to target quality. Recovery efficiency [4] as a measure of success of a MAR system, is defined either by the percentage of injected water that can be recovered or by the percentage of usable water (meeting a defined target quality, e.g. drinking or irrigation water standards) compared to the injected volume per cycle of injection.

Residence time or transfer time (in the case of Aquifer Storage, Transfer and Recovery, ASTR) will be the average duration of water and solutes in the reservoir determining the time available for water-rock interactions and bio-geochemical reactions. Residence time will largely influence the potential for degradation of pollutants and thus the efficiency of Soil Aquifer Treatment (SAT) systems and to estimate this parameter may therefore be legally compulsory. A typical example is the Californian draft regulations applying to new recharge projects [47].

They define the minimum retention time to allow identification of treatment failures and implement remediation actions and to guarantee the overall treatment efficiency. Target quality for the groundwater quality is generally defined by law and water reuse guidelines. Potential use of recovered water is also defined in these guidelines. The quality of the recovered water has to be constantly compared to this target quality and is determined by the quality of recharged water, the attenuation potential of the unsaturated and saturated aquifer and the background water, frequently but not necessarily of lower quality than the recharged water (e.g. freshwater injection into saline aquifers). The underlying processes controlling water quality are (1) mixing by advection and hydrodynamic dispersion (2) density dependent stratification (3) ambient groundwater displacement and (4) reactions within the aqueous phase induced by mixing and reactions with aquifer material and subsurface microbial communities.

Those key parameters are determined by intrinsic, physical factors (aquifer properties like permeability, effective porosity, dispersivity, preferential flow zones and the natural hydraulic gradients, aquifer mineralogy and background water quality) and by operational variables (e.g. storage period, volumes recharged, and recharge/recovery rates). The intrinsic properties are generally constant but may evolve over the lifetime of a MAR system (e.g. through clogging [4]). Intrinsic factors will depend on the selection and design of the system, operational variables on the strategy for MAR operation. Groundwater models can help for both purposes.

Currently available groundwater models allow quantifying recovery efficiency, residence time and quality of recovered water. However, a complete response to the questions listed above may need the use of state of the art models (reactive transport models) or go beyond the current capacities of the state of the art (bio-geochemical reaction modelling). Even simple models (analytical models) can provide sufficient information at least for preliminary design or evaluation of MAR systems but, most frequently, numerical models will be used. Standard numerical models will nowadays be able to simulate up to full 3D advective (e.g. through particle tracking) and dispersive flow and transport of water and solutes. Supplementary features may be needed as, in the order of increasing complexity:

• Density driven flow (in the context of highly saline waters, like in coastal aquifers)

• Sorption and (bio-) degradation of solutes (e.g. through sorption isotherms, degradation factors)

• Variable saturation flow (in the case of a significant thickness of the unsaturated zone, in particular if the latter plays an important role for water quality improvements in SAT systems)

• Geochemical reactions through the combined use of flow-transport models and thermodynamic equilibrium models or thermo-kinetic models taking into account the reaction kinetics

• Biologically mediated geochemical reactions (specific models available)

• Aquifer ecosystem simulation accounting for changing microbial communities and their assimilation of nutrients, competencies for metabolism of organic contaminants, enzymatic attack on pathogens and their influences directly and through microbial products (such as polysaccharides) on aquifer porosity and hydraulic conductivity.

The IRSA outlines the use of groundwater models suitable for MAR focusing on the strategic phases of a MAR system (site selection, MAR design, MAR operation), on the data needs to build and run such models.

8.4 Kobariški Stol, Mia and Matajur aquifer

Regarding analyses of climate and climate change on national and local level [5] no significant changes are noted in temperature and precipitation that could have a significant impact on land use. Comparisons between land use in the last 20 years show no significant changes in land use. Besides, surface and groundwater quality in test area [5] show good quality status of water. According to these facts and the results obtained, it can be said that measures to improve the quality of potential resources of drinking water in the area of Kobariški stol, Mia and Matajur are not necessary. [5]

8.5 Springs Sv. Ivan, Bulaž and Gradole

The Spatial Plan of Istria County gives advantage to organic farming which means production without mineral fertilisers, pesticides, hormones and similar products. Such concept of agricultural production is more complex and its essence is not only in omitting agrochemicals but also in everyday management which allow us to achieve all this.
In the Istrian County Spatial Plan [30] it can also be seen that most of drinking water sources areas are under protected areas.
Also, with implementation of Istria water protection system Ltd. [31] plan "Sewerage and wastewater treatment for small settlements in drinking water sanitary protection zones of

Istria County" the problem of wastewaters drainage with corresponding WWTP will be solved.
It is also expected that the application of other structural (arrangement of road runoff through protected areas with the treatment of storm waters) and non-structural measures (restrictions and stimulations in agriculture and livestock farming) will achieve reduction of negative pressures on water resources.

All above listed measures are given to improve the quality of drinking water sources in test areas in Northern Istria. [7]

8.6 Spring Prud and Blatsko polje

Despite a number of measures to improve water quality, directly and indirectly, that are provided by county strategic plan, it is necessary continuous and regular monitoring of water quality trends. As the two test areas have intensive agricultural production, and by the fact that they are characterized by karst nature which is very sensitive to pollution, it would be highly preferable to increase organic agriculture in the future that will ensure the best preservation of underground water. It is important not only for people, but for the entire ecosystem. Therefore, it is necessary to organize educational workshops to raise human awareness of the need of preserving the quality and quantity of water and the ways in which this can be achieved, which creates a basis for good health and quality of life.

The sea water intrusion problems on the Blatsko polje test area can be solved by decreasing pumping rate, because this leads to groundwater levels recover and its pressure improves the underground dynamic relation of fresh and seawater, partially according to the Ghyben-Herzberg law. Since such events are quite rare the problem is not too extent, but according to predicted climate changes and their influence on water balance, such event will occur more often and with higher extent. That will probably cause the necessity of decreasing the pumping rates, especially during the summer dry periods, when water demand is on its yearly peak because of tourism and agriculture. This water, on the other hand, does not influence any protected water dependent ecosystem [8].

Due to the negative predictions of climate change on test areas [8], it is necessary to establish continuous monitoring of the karst system behaviour – by the monitoring of groundwater levels, their quantity (especially chloride ion concentrations and – to make the monitoring efficient, fast and cheap – electrical conductivity). Also, there is a need for further exploration of the karst aquifer by pumping tests with further assessments of the present state and future risk.

8.7 Nikšić

Some of the measures (Response) that would decrease water quality vulnerability are technical but there are number of them that are non technical but would contribute to protection of water sources within the test area. In summary, all measures should decrease adverse effects from the different triggers. Generally speaking following practices are of interest for Nikšić test area [9]:

- Households waste waters from Gornje polje (Vidrovan, Miločani, Rastovac, Zavrh etc.) are properly managed;
- Uncontrolled waste dumping within the drainage area are managed in the way that there is no negative impacts on water quality at the present and in the future;
- Agricultural measures to intensity productivity (pesticides, herbicides) should be applied in a way and by application of BAT in line with Common Agricultural Policy and other policies that consider inter sectoral cooperation that would generate protection of drinking water sources;
- Manure wild landfills should be managed in a way to decrease water sources pollution during the heavy rainfall events;
- Re – cultivation of areas with waste substances along the abandon railway Nikšić – Bileća to decrease risks for water sources pollution;
- Proper storm water management to decrease adverse effects of seasonal floods;
- Forest management that would decrease deforestation within the Nikšić Plain;
- Management of the forest ecosystems in an integrated manner;
- Re-mediation of the areas with transforming oils remains to prevent uncontrolled spilling;
- Other.

Given the high water quality within the test area any future development has to follow integrated approach and improved sectoral cooperation. Thus, in addition to before mentioned measures, that are technical some of non-technical measures should be considered to prevent water quality in the future. Following institutional and other measures [48] that contribute to sustainable development with respect to water quality, land use changes and climate change are:

- Land management policy of Montenegro;
- Strategy for food production and development of rural areas;
- Long-term program for development of forestry;
- Integrated environmental protection in Montenegro with elaboration of cadaster of environmental polluters (air, water and land);
- Protection and use of waters with elaboration of cadaster of sanitary zones for protection of water springs;

- Elaboration of the management program for urban cores protected by national legislation;
- Program of vitally developed towns and settlements in Montenegro;
- Spatial and urban norms and standards for equipment of settlements in Montenegro;
- Project for reform of system for construction land use;
- Harmonization of legislation in the field of spatial and urban planning, environmental Protection and construction of facilities in accordance with the EU regulations;
- Study of urban agglomerations, as a base for settlement determinations, where the waste water treatment facilities should be built,
- Research of spatial factors of Montenegro and research of measures for planning direction of development of special areas (borders, hills, mountains, etc.);
- Research of water supply in pasture areas (karst);
- Elaboration of methodology for monitoring and evaluation of realization of the Spatial Plan of Montenegro;
- Evaluation of environmental capacities and spatial sensitivity of Montenegro, with elaboration of the map of ecological potential of Montenegro with elements of ecological limitations and conflicts and the map of ecological risks with elements of ecological endurance in the existing and future (projected) conditions;
- Research for the needs of use and management of water resources;
- Research of basic geological, hydro-geological, engineering-geological, geomorphologic, conditions and development of maps.

8.8 Drini basin

Benefits of improved drinking water will accrue (i) to households that have a new connection to water supply, and (ii) to households that already have water supply, but are guaranteed better quality water. The actual connection rate in the year 2005 is 72% instead of the 82.5%, which was set as an objective for the year 2004. Given the rather optimistic objective, it was preferred to apply an experts' estimate of 5% increase to calculate future connection percentages. Adding the 5% estimate of new connections to the current connection rate of 72% yields a total share of 77% which can be assumed to benefit from quality improvements of drinking water. The coastal area and the inland lakes have a big potential for tourism in Albania. The water quality of the lakes and of most of the coastal area is good, except for Durres area (Golem, Shkembi I Kavajes, Durres, Currila). This is caused by discharge of urban waste water without treatment in this area. Based on the Water Supply and Sanitation Strategy, approved in 2003 by Council of Ministers, the aim is to treat 25% of the urban wastewater in 2012. According to the local experts, the improvement of the river water quality will result in increase of the number of local tourists. The total population was assumed to benefit from the bathing water quality improvement of inland waters, through a reduction of the nitrates and phosphates load discharged. The population of the coastal counties and the tourists visiting seaside resorts were assumed to benefit from the coastal bathing water quality improvement. 60% of the rivers in Albania belong to quality class III and 30% of the rivers belong to quality class IV to V. As it was not possible to assess what the precise effect of the implementation of the various water directives (mainly Urban Waste Water Directive, the Nitrate Directive and the Dangerous Substances Directive) would be on river quality, it has been assumed that the full implementation of the various directives will have the effect that the real water quality in all watercourses will be such that the designated Water Quality Objective class I or II will be met. This seems a reasonable assumption, as the main cause of not meeting the WQO is the discharge of various substances by sewage and industrial discharges and these discharges will be dealt with by the directives. The total benefits of clean drinking water are estimated to amount to around 44.1 million EUR/year upon full compliance.

There are about 500 monitoring points at the distribution water supply system in Albania in the urban area. For the studied period (2000- 2005), the average of bacterial pollution is about 4.015 % of water samples analysed. Between May 2004 and May 2005, the IPH has reported testing of 3,801 samples, out of which only 15.8 percent do not comply with national standards. The percentage of the population supplied with safe drinking water is estimated to be 96.72% (data of 2005). Some years ago the Institute of Public Health has organized a programme for the monitoring of nitrates in drinking water, controlling the water sources which are used for water supply. The water samples has been analysed in a laboratories of the Institute of Public Health. In 1998, the IPH controlled the ground water quality in some areas where intensive agricultural activity was assumed. After the analyses the level of nitrates was under the standard, negligible. There were no nitrates in spring water, because of the lack of agriculture activity in those areas. The level of pesticides in spring water was below detection limit. [10]

8.9 Corfu Island

According to the River Basin Management Plan of the Water District of Epirus [49] the following measures are proposed (*Table 46*).

Table 46: The proposed measures according to the River Basin Management Plan of the Water District of Epirus [49]

Measures		Measure category
WD05B010	Promotion - Integration of the introduction procedure of the River Basin Management plans for the protected areas of species and habitats with special reference to water management issues	Natura sites (Directives 92/43/EEC - 2009/47/EC)
WD05B050	Promotion and implementation of management and safe disposal of sludge projects	Sludge disposal (Dir.86/227/EEC); Point disposal sources; Diffuse disposal sources; Confrontation of impacts in the water status
WD05B060	Integration of the necessary projects for the urban wastewater and sewage networks to comply with the Directive 91/271/EEC	Urban Wastewater treatment (Dir. 91/271/EC); Diffuse disposal sources;

		Confrontation of impacts in the water status; Measures to avoid pollutants disposal directly to groundwater systems
WD05B070	Completion of the vulnerable areas list and upgrade of the existing wastewater treatment plants	Urban Wastewater treatment (Dir. 91/271/EC); Point disposal sources; Confrontation of impacts in the water status
WD05B080	The whole island of Corfu will be included in the vulnerable zones from nitrates from agricultural activities, including all three aquifers	Nitrates Pollution Protection (Dir. 91/676/EEC); Diffuse disposal sources; Confrontation of impacts in the water status
WD05B120	Actions to update the operation of drinking water distribution networks in combination with actions to reduce Non-Revenue Water	Drinking Water (WFD article 7)
WD05B140	Projects for the restoration of the existing drinking water distribution network	Drinking Water (WFD article 7)
WD05B150	Recording of water quantities from the abstraction points of surface and/or groundwater for drinking, irrigation from the organized networks and the big consumers	Control of surface and groundwater intake
WD05B200	Prohibition of new drillings in: - Water systems at bad quantitative status - 200m zone from the coast line - Within the zones of collective irrigation networks - In the protection zones (I and II) of the springs and the drinking water boreholes, except of special cases (drinking water) to be examined from the Water Directorates with the submission of hydrogeological report	Drinking Water (WFD article 7); Control of surface and groundwater intake; Confrontation of impacts in the water status
WD05B210	Set in principle protection zones for abstraction point of groundwater for drinking purposes	Drinking Water (WFD article 7)
WD05B220	Update the General Masterplans from the water utilities	Drinking Water (WFD article 7)
WD05B230	Amendment / update of the regulatory decisions of prohibitive, restrictive and other regulatory measures aiming at the protection and management of the water potential based on the RBMP program of measures	Drinking Water (WFD article 7)
WD05B240	Determination of registry for areas of disposal of treated wastewater either through irrigation or artificial recharge (Off.Gaz.354/B/08.03.2011)	Confrontation of impacts in the water status; Measures to avoid pollutants disposal directly to groundwater systems
WD05B250	Immediate integration of the program to close and restore all uncontrolled waste disposal sites	Point disposal sources; Confrontation of impacts in the water status; Measures to avoid pollutants disposal directly to groundwater systems
WD05B260	Review of the existing permits for reuse of wastewater according to the requirements of the articles 9&11 of the	Point disposal sources

	JMD 145116/2011	
WD05B270	Reinforcement of the environmental controls and inspections	Point disposal sources; Confrontation of impacts in the water status; Measures to avoid pollutants disposal directly to groundwater systems
WD05B280	Application of control and measures for the zones of fish farming in internal water systems	Point disposal sources; Confrontation of impacts in the water status
WD05B290	Determination of the pollutants emissions limits from the Regional Water Directorates at the river basin level	Point disposal sources
WD05B310	Establishment of a registry for pollution sources (emissions, disposals and leakages) from priority substances and special pollutants and update of the related permits	Point disposal sources; Measures to avoid pollutants disposal directly to groundwater systems
WD05B320	Integration of the infrastructure of sewage and wastewater treatment in the industrial areas	Point disposal sources; Confrontation of impacts in the water status
WD05B330	Promotion of the replacement of absorbent cesspools with water proof ones	Point disposal sources; Diffuse disposal sources; Confrontation of impacts in the water status
WD05B340	Amendment of the Decisions of Approval of Environmental Conditions of existing establishments without a permanent permit for disposal, so that the modified decision will be a definite permit for disposal according the article 12 of the Law 4014/2011	Point disposal sources
WD05B350	Examination of integration of additional measures to the action program of vulnerable areas in nitrates pollution	Diffuse disposal sources; Confrontation of impacts in the water status
WD05B360	Gradual, selective conversion of conventional cultivations to biological ones	Diffuse disposal sources; Confrontation of impacts in the water status
WD05B370	Prohibition of establishment of small hydropower plants in the areas characterized as internal waters recreation areas in the Protected Areas Registry	Confrontation of impacts in the water status
WD05B380	Ensuring controls to comply with the predictions of the environmental permits of the industries according article 13 of the Directive 91/271/EEC	Confrontation of impacts in the water status
WD05B390	Reinforcement of control actions for the more efficient operation of the existing projects for wastewater and sewage treatment	Confrontation of impacts in the water status
WD05B400	Reinforcement of actions for the hydromorphological restoration of coastal zones	Confrontation of impacts in the water status
WD05B410	Reinforcement of the synergy of spatial and urban planning with the river basin management planes of each water district	Confrontation of impacts in the water status
WD05B420	Assure the good operation level of the existing wastewater treatment plants	Confrontation of impacts in the water status
WD05B430	In principle determination of the seashore in protected areas of species and habitats	Confrontation of impacts in the water status

WD05B440	In principle preparation of the cadastre in protected areas of species and habitats	Confrontation of impacts in the water status
WD05B060	Integration of all necessary projects for wastewater	Measures to avoid pollutants disposal directly to groundwater systems

9. CONCLUSIONS

During project partners meeting in Belgrade 25/11/2014 it was agreed that for all test areas the following analyses should be carried out:

- analysis of the actual land use (using Corine Land Cover-CLC, spatial plan or/and other),
- analyses of impact of land use on water quality for the present/past state,
- analyses of the impact of climate change and planned development (spatial plans or/and other) on the land use in future,
- analyses on impact of land use on water quality for the future state,
- analyses of the problems of salt water intrusion (for test areas with this problem),
- list of measures that should be applied in order to improve the quality of drinking water on test areas.

For these analyses data form FBs reports 4.1. Climate and climate change database for Adriatic area and 4.3. Water quality trends on test areas were used.

It was agreed that for determining the present land use and land use changes in the past analyses Corine Land Cover, which represents a digital database on types of land cover/use, will be used.

It is expected that changes in land use in the future will have an impact on water resources quality. For assessment of land use change in the future the climate change impact and development impact in the area was analysed. Climate change data from activity 4.1. and also data about development in test area in the future (from spatial or other plans) were used.

It became evident during solving problems of water quality and land use, that relevant processes, which endanger water quality in relation to land use category can be defined and structured by the application of the DPSIR framework.

Of course it has to be considered, that the DPSIR framework does not cover all needs to assess environmental processes with relevance for water quality. Some authors have stated, the framework should be adapted or improved in order to cover specific processes more adequately, especially within the context of the selected indicators, and also proposed specific indicators, which define the environmental processes more adequately [50]. Also shortcomings of the approach because of the fact, that it is oversimplifying linkages and structures within the model and also postulating linearity within them, have been highlighted [51]. In [52] problems of the framework to deal with the multitude of attitudes and definitions given by diverse stakeholders and the general public. Others highlighted, that the framework is too simplistic to capture the multiple relationships that exist within a land system [53].

Being aware about the shortcomings of the DPSIR approach, it was used in a clearly defined way in the course of the DRINKADRIA project. The framework is not the only method, which were applied in work-package 4. In combination with the water quality trends and other models, which describe trends of land-use change due to climate change, the DPSIR framework serves as strong tool for the description of environmental processes with relevance for water suppliers, also with regard to processes in future which are driven by climate change.

It has to be mentioned that the selection of the proposed indicators solely was based on the best way to represent the described environmental processes.

To capture the essence of DPSIR methodology each country had for its test areas first analysed the present land use and its changes in the past which then compared with the water quality to see whether land use or its changes have impact on water quality. In the second part, it was necessary to determine the changes of land use caused by climate changes in the future but also to predict land use change due to future development of the area by analysing spatial and other plan. After this, impact of future land use on water quality was made. At the end, depending on what the impacts were (positive or negative), each country has proposed appropriate measures to protect water quality. This measures represents the Responses in DPSIR methodology.

Some countries have also in addition to the impact of land use on water quality, had problems with salt water intrusion, which affected the water sources in the coastal areas and had to be solved.

In *Table 47* are given information about aquifer type, present land use, changes of land use in the past and in the future and possible impacts on water quality on test areas inside DRINKADRIA project.

From *Table 47* can be seen that most of test areas have karst aquifer, only Isonzo plain has porous aquifer and ATO 3 has mainly unconfined sandy-gravelly aquifers. Present land use is various on all test areas, from natural areas (forests, grasslands ...), to agricultural land and urbanized ares.

Changes of land use in the past are mainly made using CLC for certain years in the past and then compared.

Future land use is predicted; (1) comparing land cover maps from different years, (2) use of Spatial Plans and (3) by impact of climate changes.

Above mentioned changes of land use have positive and/or negative impacts on water quality. While positive impacts are welcome, negative impacts will be solved by implying certain measures which will improve water quality.

Table 47: Test areas, type of aquifer, land use and impacts on water quality.

Test area	Aquifer type	Present land use	Changes of land use (past)	Changes of land use in future (CC and development)	Impacts on water quality
ITALY: Friuli Venezia Giulia - Isonzo plain	Porous aquifer. Mainly phreatic in the northern part and confined in the southern, downstream the resurgence belt.	From CLC 2012 Agriculture 58,81%; Natural environment 10,50%; Urbanized area 22,48%; Water surface 3,56%; Industrial area 3,14%; Sport and leisure facility 0,94%; Quarry and landfill 0,57% (for the whole study area)	CLC 1990, 2000, 2006 and 2012 Artificial areas grow at the expense of agricultural areas. Artificial areas occupied 22.3 % of the test area (37.8 km^2) in 1990 and 25.2 % in 2012 (42.6 km^2). Instead agricultural area represented 69.2 % of the test area in 1990 (117.1 km^2) and 66.2 % in 2012 (112.0 km^2).	Comparing land cover maps from different years. Use of Spatial Plans.	Impact of nitrates to water quality. Use of Nitrates Directive and monitoring programs to reduce the impact.
ITALY: Marche Region - ATO3	WR 1: Presence of at least three overlapped aquifers, sometimes hydraulically connected: groundwater circulation mainly due to a secondary porosity connected to several joint and fracture networks. WR 2: Mainly unconfined sandy-gravelly aquifers: local presence of perched or leaky confined aquifers near the coast	From CLC 2006 WR 1: Agriculture 35%, Forestry 63%, Artificial surfaces ~ 1%, Water bodies ~ 1% WR 2: Agriculture 77%, Forestry 16%, Artificial surfaces 6%, Water bodies <1%	As much of the Italian territory, ATO 3 test area has undergone a significant land use change, related to urbanization and infrastructure construction, resulting in the permanent loss of agricultural land and green belts.	Climate changes will possible have an impact on changes of land use in the future.	The most sensitive changes would consequently occur only in those indicators closely linked to the activities like: an increase, although probably minor, in the use of fertilizers and in the quantities of water abstracted from the most important facilities will cause, as a result, an overall increase of the "Global Pressure" for many of the considered Water Resources. Proposed measures will help to reduce these changes.

ITALY: Apulia Region - Ostuni	Karst limestone aquifer	Agriculture 80%, Forestry 13%, Artificial surfaces 7%	No data	No data	Climate change impact on groundwater discharge. Proposed measures to improve water quality; Management of Aquifer Recharge.
SLOVENIA: Kobariški stol and Mia - Matajur aquifers	Karstic	From CLC 2012 Artificial areas 0.28 %, Agricultural areas 14.56 %, Forest and semi natural areas 85.27 %	CLC 1995, 2000, 2006 Comparison between land use maps shows that in the last 20 years no significant changes in land use occur. Minor changes are visible only within separate land cover group, such as different kinds of grassland or forest.	No data	No data
CROATIA: Northern Istria - springs Gradole, Sv.Ivan and Bulaž	Karstic aquifer: spring	From CLC 2012 Sv Ivan: Discontinuous urban fabric 0.50 %, Pastures 2.61 %, Coniferous forest 4.07 %, Land principally occupied by agriculture 5.18 %, Complex cultivation patterns 6.53 %, Natural grasslands 7.45 %, Transitional woodland 9.74 %, Mixed forest 10.62 %, Broad-leaved forest 53.31 %. Bulaž: Mineral extraction sites 0.21 %, Coniferous forest 1.10 %, Complex cultivation patterns 2.91 %, Pastures 10.99 %, Mixed forest 12.02 %, Transitional woodland 14.70 %, Land	CLC 2000, 2006, 2012 In the period 2000-2012 there were no significant changes on the test areas.	Comparing land cover maps from different years. Use of Spatial Plan of the Istria County.	No significant impact in present state. In future negative impact will be decreased through certain measures like: organic farming, drinking water sources areas are under protected areas, the problem of wastewaters drainage with corresponding WWTP will be solved, and other structural and non-structural measures will also achieve reduction of negative pressures on water resources.

		principally occupied by agriculture 22.53 %, Broad-leaved forest 35.55 %. Gradole: Non-irrigated arable land 0.21 %, Coniferous forest 0.40 %, Discontinuous urban fabric 0.98 %,Vineyards 2.46 %, Pastures 5.73 %, Complex cultivation patterns 7.73 %, Mixed forest 7.92 %, Transitional woodland 12.69 %, Broad-leaved forest 26.41 %, Land principally occupied by agriculture 35.48 %.			
CROATIA: Southern Dalmatia - spring Prud and Blatsko polje	Karst aquifer	Spring Prud: Forest and semi natural areas 68,88 %, Agricultural areas 29,14 %, Artificial surfaces 1,77 %, Water bodies 0,18 %, Wetlands 0,04 % Blatsko polje: Agriculture 56,8 %, Forestry 38,7 %, Artificial surfaces 4,5 %	CLC 2000, 2006, 2012 There are some minor changes observed on Prud spring catchment. Significant changes are observed in Blatsko polje in types of agricultural land use.	Comparing land cover maps from different years. Future spatial plans gives information about activities in the area.	There is no negative impact of land use on water resources. Further measures will help to obtain this state.
MONTENEGRO: Nikšić	Karsts aquifer	Agriculture 28.73% Forestry: 65.13% Artificial surfaces: 4.94% Water bodies: 1.20%	CLC 2006, 2012 **There are no significant changes in land use practices.**	No data	No data

ALBANIA: Drini basin	Karst ,Aquifer	Agriculture 30.26 %, Forestry 21.76%	No data	Climate changes will have an impact on changes of land use in the future.	Impact on water resources, measures; invest in better irrigation systems ...
GREECE: Corfu Island	Karstic, granular; groundwater	From CLC 2000 Area under cultivation and fallow land 73.0 %, Forests 10.2 %, Areas occupied by settlements 4.9 %, Pastures 4.7 %, Areas under water 1.1 %, Other areas 6.1 % (for the whole island)	CLC 1990, 2000 In the period 1990-2000 there were no significant changes on the test area.	Comparing land cover maps from different years. Future spatial plans gives information about activities in the area.	Climate change is expected to have an impact in the water quality. Land uses are expected to change but their variations are not expected to be big. Implemented measures will help to reduce these impacts.

Some **relevant measures** that are/will be applied on test areas in DRINKADRIA project are:

Isonzo plain: [2]

- Community-based monitoring programs.
- Water quality monitoring data collected regularly throughout the year.
- Community outreach and education.
- Surface water, groundwater and precipitations monitoring was made.
- Set up a wide monitoring network.

ATO 3: [3]

- Scenarios of medium-high criticality can be expected in the next future, both concerning the use of the soil (as a consequence of prospective CC and connected anthropogenic actions) and the possible use and the quality of the water resources.

- Measures and policies provided by the Rural Development Programmes of the Marche Region, whose overall objective is the continuation of farming but in a framework of ecological and sustainable development.

- In mountain areas, where the risk of overexploitation and decrease in water resource quality appears not existing or very limited in the short-term, measures should be addressed to the maintenance and modernization of the abstraction facilities.

Ostuni: [4]

- Measures to improve the groundwater quality by contrasting seawater intrusion in coastal aquifers is the Management of Aquifer Recharge (MAR).

- The principal benefits of the concept of MAR are twofold:

    - It allows storage of large quantities of surface water (including surface runoff, storm water, reclaimed water, and also freshwater from desalination) at those periods of the hydrological year when availability exceeds demand and to restore them when demand exceeds availability.

    - The underground passage (unsaturated and saturated zone) can constitute a complementary treatment step, due to physical, chemical and biological processes that will affect water quality.

Springs Sv. Ivan, Bulaž and Gradole: [7]

- Spatial Plan of Istria County gives advantage to organic farming which means production without mineral fertilisers, pesticides, hormones and similar products.
- In the Istrian County Spatial Plan it can also be seen that most of drinking water sources areas are under protected areas.
- With implementation of Istria water protection system plan "Sewerage and wastewater treatment for small settlements in drinking water sanitary protection zones of Istria County" the problem of wastewaters drainage with corresponding WWTP will be solved.
- It is also expected that the application of other structural and non-structural measures will achieve reduction of negative pressures on water resources.

Spring Prud and Blatsko polje: [8]

- Measures to improve water quality that are provided by county strategic plan.
- Continuous and regular monitoring of water quality trends.
- Increase of organic agriculture in the future.
- Need of preserving the quality and quantity of water and the ways in which this can be achieved, which creates a basis for good health and quality of life.
- The sea water intrusion problems on the Blatsko polje test area can be solved by decreasing pumping rate.

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10 ANNEXES

1. Report, LP: Change induced land use changes and the impact on water quality, Isonzo river test area.

2. Report, FB2: Estimation of CC induced land use changes and the impact on water quality, test area ATO3.

3. Report, FB3: Present and future water safety and risk for drinking supply, test area Ostuni.

4. Report, FB5: Climate change and land use change impact on water quality, test area Kobariški Stol, Mia and Matajur aquifer.

5. Report, FB8: Impact of land use changes on water quality, test areas Gradole, Bulaž and Sv. Ivan.

6. Report, FB9: Impact of land use changes on water quality, test areas spring Prud and Blatsko polje.

7. Report, FB10: Estimation of climate change induced land use changes and the impact on water quality on test area Nikšić, Montenegro.

8. Report, FB11: Estimation of climate change induced land use changes and the impact on water quality , test area Drini Basin.

9. Report, FB16: Estimation of Climate Change Induced Land Use Changes - Impact of land use changes on water quality.

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The project is co-funded by the European Union,
Instrument for Pre-Accession Assistance