PROLINE-CE

WORKPACKAGE T1

OUTPUT O.T1.2

STRATEGY FOR THE IMPROVEMENT OF POLICY GUIDELINES

WP T1- CAPITALIZATION: CAPACITY BUILDING AND STAKEHOLDER ENGAGEMENT

March, 2018

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Date last release	March 2018

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Glossary of terms

AOX	Halogenated organic compounds
AP	Associated Partner
BMP	Best management practice
CLC	Corine Land Cover
DPSIR	Driver, Pressure, State, Impact, Response
DT	Deliverable title (refers to PROLINE-CE)
DWD	Drinking Water Directive (80/778/EEC) as amended by Directive (98/83/EC)
DWPZ or DWPA	Drinking water protection zones Drinking water protection areas
EDTA	Ethylenediaminetetraacetic acid
EC	European Commission
ESS	Ecosystem service
EU	European Union
EUSAIR	The EU Strategy for the Adriatic and Ionian Region
EUSALP	The EU Strategy for the Alpine Region
EUSBSR	EU Strategy for the Baltic Sea Region
EUSDR	The EU Strategy for the Danube Region
FD	Floods Directive (2007/60/EC)
FHRM	Flood Hazard and Risk Maps
FRMP	Flood Risk Management Plan
GIS	Geographical Information System
GW	Groundwater
GWB	Groundwater body
GWD	Groundwater Directive (2006/118/EC)
ha	hectare
KTM	Key Type of Measure
M	Million
N	Nitrogen
NAP	Nitrates Action Programme
P	Phosphorus
PE	Population equivalent (refers to wastewater purification plants)
PP	Project Partner
PoM	Programme of Measures
RBD	River Basin District

RBMP	River Basin Management Plan
RDP	Rural Development Programme
SW	Surface water
SWOT	Strength, Weakness, Opportunity, Threat
UWWT	Urban Waste Water Treatment
UWWTD	Urban Waste Water Treatment Directive (91/271/EEC)
WFD	Water Framework Directive (2000/60/EC)
WISE	Water Information System for Europe
WP	Work package (refers to PROLINE-CE)

1. Introduction

1.1. Programme overview

The transnational Interreg CENTRAL EUROPE Programme is a funding programme of the EU Cohesion Policy's objective "European Territorial Cooperation" running from 2014 to 2020. The overall Programme's objective is "to cooperate beyond borders in central Europe to make our cities and regions better places to live and work", in other words transnational cooperation should be a catalyst for implementing smart solutions that answer to regional challenges in the fields of innovation, low-carbon economy, environment, culture and transport.

The Programme will build regional capacities following an integrated bottom-up approach involving and coordinating relevant actors from all governance levels. Therefore, it will coordinate with other efforts in the regions including national and regional programmes, macro-regional strategies, the Horizon 2020 programme, the LIFE programme or the European Investment Bank.

Nine EU Member States cooperate in the programme, including all regions from Austria, Croatia, the Czech Republic, Hungary, Poland, Slovakia and Slovenia, as well as eight states from Germany and nine regions from Italy.

The European Regional Development Fund (ERDF) provides the total Programme budget of € 246 million, out of which € 231 million will be made available for financing transnational cooperation projects. The available funding is spread across the four priority axis until 2020 as follows:

- Innovation and knowledge development: around € 69 million
- Low carbon cities and regions: around EUR € 44 million
- Environmental and cultural resources: around € 89 million
- Sustainable transport: around € 30 million

PROLINE-CE was approved in the framework of the first call of the Central Europe Programme 2014-2020 (CE) in programme priority axis 3: "Cooperating on natural and cultural resources for sustainable growth in CENTRAL EUROPE", specific objective 3.1 "To improve integrated environmental management capacities for the protection and sustainable use of natural heritage and resources". The priority axis 3 responds to the need for protecting and sustainably using natural and cultural heritage and resources, which are subject to increasing environmental and economic pressures as well as usage conflicts. Heritage and resources also constitute valuable assets of central European regions and represent important location factors benefitting regional development. The financial allocation to this priority is around € 89 million ERDF. As mentioned above, PROLINE-CE takes part in achieving specific objective 3.1 which implies transnational cooperation aimed at improving the capacities of the public sector and related entities dealing with the protection and sustainable use of natural resources by supporting the development and implementation of integrated environmental strategies and tools as well as the joint testing of pilot solutions. This will facilitate a larger uptake of the integrated environmental concept into the public and private sector such as the application of innovative technologies and introducing resource efficient solutions.

There are a number of territorial challenges common to Central European countries that need adaptable land use activities regarding the protection of water resources, adaptation to climate change issues and dealing with land use pressures on water. These are the relevant topics PROLINE-CE tackles with on a transnational level.

1.2. PROLINE-CE background and partnership

One of the key motives for establishing PROLINE-CE partnership was joint transnational action with a multisector and multilevel approach that will ensure efficient, integrated land use and water resources management as well as higher security against floods/droughts. Three types of partners from 7 countries, representing a multi-sector consortium, complement their functions and implement PROLINE-CE activities. The partnership is composed of institutions responsible for the national and regional policy implementation with regard to water management and water supply, such as national institutions, ministries, authorities and water suppliers, with essential input by specific research institutions.

Table 1. PROLINE-CE partnership

Abb.	Partner name	Country	Role	No.
BMLFUW	Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management	Austria	LP	1
MA31	Municipality of the City of Vienna, MA31 – Vienna Water	Austria	PP	2
MWY	Municipality of Waidhofen/Ybbs	Austria	PP	3
UL	University of Ljubljana	Slovenia	PP	4
JP VO-KA	Public Water Utility JP VODOVOD-KANALIZACIJA Ljubljana	Slovenia	PP	5
HOI	Herman Otto Institute	Hungary	PP	6
OVF	General Directorate of Water Management	Hungary	PP	7
HGI-CGS	Croatian Geological Survey	Croatia	PP	8
ARPAE	Regional Agency for Prevention, Environment and Energy in Emilia-Romagna	Italy	PP	9
KZGW	National Water Management Authority	Poland	PP	10
GPW	Silesian Waterworks PLC	Poland	PP	11
HRBM	Technical University of Munich	Germany	PP	12
CMCC	Euro-Mediterranean Centre on Climate Change Foundation	Italy	PP	13
	Department of Silviculture and Mountain Forest	Germany	AP	14
	Global Water Partnership Central and Eastern Europe	Slovenia	AP	15
	Croatian waters	Croatia	AP	16
	Regional Water Management Board (Warsaw, Cracow, Gliwice, Gdansk, Wroclaw, Szczecin, Poznan)	Poland	AP	17
	University of Silesia in Katowice	Poland	AP	18

The above-mentioned environmental challenges of sustainable land use and water management have specific transboundary and transnational relevance. PROLINE-CE will capitalize upon existing knowledge and research, as well as improve the knowledge base. Notable projects upon which PROLINE-CE capitalizes upon and improves the knowledge base include:

- CC-WaterS – a transboundary project that aimed to prepare the South East European (SEE) Space for the challenge of ensuring water supply for society for several decades. Elaborated measures that adapted to climate change built the ground for a Water Supply Management System regarding optimization of water extraction, land-use restrictions, and socio-economic consequences under climate change scenarios for water suppliers in SEE.
- SHARP – an Interreg IVC project that focused on the exchange of innovative technologies to protect groundwater resources for future generations by considering the climate change and the different geological and geographical conditions of regions involved.
- CC-WARE – belonged to the South East Europe Programme and aimed to develop an integrated transnational strategy for water protection and mitigating water resources vulnerability which builds the basis for an implementation of national and regional action plans.
- DrinkAdria – an IPA Adriatic Cross-border Cooperation Programme project that examined the situation of cross-border drinkable water supplies and identified all the possible actions aimed at optimizing cooperation between operators in neighbouring countries, highlighting all the possible developments in the protection of their water resources.

Land use as well as raising awareness and involvement of stakeholders on various levels, are a common denominators of PROLINE-CE and another EU-funded project (Interreg DANUBE) called CAMARO-D (**C**ooperating towards **A**dvanced **MA**nagement **Ro**utines for land use impacts on the water regime in the **D**anube river basin). Both projects are in direct synergy, by means of sharing similar thematic fields, pilot actions and stakeholder groups (e.g. water suppliers, spatial planners, hydrogeologists). Results and findings of PROLINE-CE, focusing on land use influence on drinking water resources and CAMARO-D, focusing on land use impact on floods, bilaterally attribute and ennoble knowledge base of complex interdisciplinary fields of water and flood management.

PROLINE-CE results and outputs will provide an integrated land use approach by developing cost efficient management methods regarding land use and drinking water protection on a cross-border scale all over CE programme area and will contribute to the following EU policies:

- it will support sustainable use of water resources and implementation of:

  EU Water Framework Directive (2000/60/EC);
  EU Drinking Water Directive (98/83/EC);
  EU Groundwater Directive (2006/118/EC);
  EU Flood Directive (2007/60/EC);

- EC Communication on Water Scarcity and Droughts;
- EC Blueprint to Safeguard Europe's Waters;
- EU 2020 strategy: resource efficiency for ensuring water availability in sufficient quantities and quality;
- EU 2030 Agenda: SGD6 Integrated Water Resources Management;
- Action Plans: EUSDR (2010), EUSALP (2015), EUSAIR (2014), EUSBSR (2014);

1.3. Main objectives of PROLINE-CE

Behind the acronym "PROLINE-CE" stands "Efficient Practices of Land Use Management Integrating Water Resources Protection and Non-structural Flood Mitigation Experiences". The project focuses on key challenges regarding land use and drinking water resources management that are common to all EU countries. Therefore the **main project's objective is the improved protection of drinking water resources in an integrated land use management approach that takes into account climate change issues**. This encompasses the following:

- jointly developed methods and strategies towards an integrated and efficient approach of water management and proposed measures to adapt existing practices;
- minimized conflicts between drinking water resources protection and land-use activities;
- integrated land-use management and a developed implementation strategy for effectively harmonized environmental standards in drinking water recharge areas to improve water- and soil quality and reduce flood/drought risks - tailored to different regional environment- and policy conditions (via pilot actions);
- extended cooperation networks and knowledge exchange between partner regions, sector players and different decision makers on policy level to minimize still existing knowledge gaps concerning integrated water- and land-use management, interdependency cycles environment-flood/drought and flood/drought prevention in CE region; and
- improved effectiveness and sustainable use of capacities as well as efficient organisational structures of land-use management and drinking water protection.

The innovative PROLINE-CE approach will include:

- synopsis of comprehensive experiences gained within previous projects and studies as a basis for determination of sustainable land use and best management practices for drinking water supply;
- operationalization of best practice strategies in different pilot actions, clustered on a transnational scale by their thematic and geographic scope;
- common methodology and vision for integrated water management as an overall frame for the implementation of best practices resulting in “GOWARE” (Guide towards Optimal WAter REgime);
- transfer of PROLINE-CE results to policy level by means of DriFLU Charta, a joint declaration act signed by notable representatives;
- capacity building inside and outside of the programme area via several events and feedback loops for stakeholders with the possibility of public participation as well as different communication measures tailored to the needs of diverse target groups. The structured stakeholder involvement process will support the development of networks beyond the borders of disciplines, regions and countries.

The PROLINE-CE integrated approach with sustainable land use practices for drinking water protection will contribute to the programme priority specific objective and to further regional development in the water and land use sector. The synergy of PROLINE-CE objectives with other Interreg projects, will result in efficient protection of drinking water resources in relation to improved land use management on one end and protection against climate change induced hazards on the other (e.g. flood within Interreg Danube CAMARO-D project).

Expected project’s results can be differentiated on thematic and communication level:

- Results on thematic level:
- identified existing practices in the field of land-use and drinking water management
- developed and applied appropriate measures taken on pilot case scale -developed joint long-term vision to secure
- water resources and protect against flooding and droughts under changing conditions
- prepared legislative basis for integrated land-use and water management practices
- developed integrated efficient land-use management practices regarding optimisation of the use of capacities and resources
- sustainable management of recharge areas, aiming at establishing integrated protection of drinking water resources on transnationally comparable level and mitigating basin-wide flood/drought risks
- safeguarded water supply (safe operation of water supply systems) by minimizing quantitative and qualitative water-related risks

- Results on communication level:
  - national capacity building and transnational stakeholder dialogue (local authorities, interested communities, end users etc.) in order to reach a common approach towards sustainable transnational land use and water management
  - promoted achievements and measures proposed towards expert community, policy and decision makers, as well as to broad public

PROLINE-CE started its 36 months long implementation on July 1st 2016 and will end on June 30th 2019. Its implementation is divided into specific work packages with defined duration, budget, responsible partners and project outputs as outcomes of activities carried out in the course of work package. An overview of project's work plan is presented in the Table 2.

Table 2. PROLINE-CE work plan

Work package	WP name	Start date	End date
Preparation P	Preparation	01. 2015	11. 2015
Management M	Management	07. 2016	06. 2019
Thematic T1	Capitalization: Capacity Building and Stakeholder Engagement	08. 2016	01. 2018
Thematic T2	Pilots: Implementation and Feedback	02. 2017	07. 2018
Thematic T3	Synopsis: Vision and Guidance	10. 2017	03. 2019
Thematic T4	Advancement: Strategic Positioning and Commitment	04. 2018	06. 2019
Thematic T5	Communication	07. 2016	06. 2019

2. Status quo concerning drinking water resources and negative impacts through land use and floods/droughts

This chapter synthesizes the main results concerning complex relationships between land use activities and flood/drought impacts on drinking water quality and quantity. In order to properly develop this topic, status quo in Project Partner countries has to be taken into consideration, both on regional and national scale. Status quo was obtained via series of strategic questions, targeting the most important topics (as seen in DT.1.1.1 “Country reports about the implementation of sustainable land use in drinking water recharge areas”), with focus laid on **(i) drinking water protection zones** – status of implementation, national/regional statistics, restrictions, delineation methodology, impacts through land use and other particularities.

To identify and evaluate possible areas for change (weaknesses and threats) and solutions to the existing issues (opportunities and strengths) of actual land use practices and their interdependencies with the water management, a comprehensive **(ii) SWOT analytic framework** was carried out.

In order to evaluate the impacts of land use, floods and droughts on drinking water resources quality and quantity, **(iii) DPSIR analytic tool** was used to obtain better understanding of interacting factors (drivers and pressures) that change the environment. Therefore, impacts on water resources quality and quantity were assessed according to the given land use categories. For the purpose of reducing or preventing significant pressures to the extent required to achieve good status of water resources, Key Type Measures (KTM) were given.

A comprehensive online platform has been set by PP 4 – University of Ljubljana (Faculty of Natural Sciences and Engineering, Department of Geology), where all legislation concerning water and flood management can be seen, as well as comparison on regional, national or transnational level. An online platform is at public disposal, available at: http://proline-ce.fgg.uni-lj.si/legislation/legislation_comparison/.

2.1. Status quo of drinking water protection zones and impacts through land use

All PROLINE-CE Project Partner countries comply with the EU requirements (WFD, DWD, GWD), making protection of drinking water resources a top priority. EU directives and laws have been transposed into the laws of EU member states, hence establishment of drinking water protection zones is legally binding in all Project Partner countries, although the practical implementation is variable. Drinking water protection zones aim at prevention and/or reduction of potential impacts of human activities on surface/ground water quality and quantity. "Hard" measures within drinking water protection zones like prohibitions, restrictions and conditions have direct effects on water quantity and quality and they are effective within short-term period. But effectiveness is a matter of strict monitoring, control and enforcement. "Soft" measures like proper land use planning, research, awareness rising have mainly indirect impacts and they are rather effective in the long-term. Its effectiveness can be raised by e.g. financial incentives (EC, 2012).

The design of drinking water protection zones depends on nature of drinking water sources. In Central Europe region, both groundwater and surface water are used for water supply. Countries which primarily use groundwater resources for public water supply are Austria (>90%), Hungary (95%), Germany - Bavaria, (71%), Poland (71.2%) and Slovenia (97%), while Italy and Croatia extract lesser percentage of groundwater for public water supply (respectively 47% and 49%). In Croatia and Italy, springs (related to GW) comprise ~35% in total water supply. In CE countries, drinking water resources are contained mostly in intergranular and karst aquifers. Although in all PROLINE-CE countries water supply from surface waters is subordinate in comparison to groundwater, surface water bodies also play important role in public water supply, and they can be roughly divided into watercourses and still water bodies.

According to European Commission, all PROLINE-CE partner countries have adopted River Basin Management Plans (RBMP), although the information on DWPZs (restrictions and other particularities) is mainly available on country level and not on River Basin District level. A considerable gap in assessing and comparing the different measures and their effectiveness between PROLINE-CE partner countries is the lack of information about the status of their implementation.

Changes of land use practices and consequently land cover can be considered as the pivotal factors that impact and modify hydrological and hydrogeological systems. If not observed and handled in the right way, intricate relationship between some of the land use activities and water quality and quantity, can lead to adverse repercussions.

Hence, the role of land use practices in achieving water resources sustainability should be cautiously evaluated in order to mitigate current and prevent future major issues like water contamination, floods and droughts.

According to the Water Framework Directive, Member States shall collect and maintain information on the type and magnitude of the significant anthropogenic pressures to which the surface water bodies in each river basin district and groundwater bodies are exposed. Estimation of land use patterns, including identification of the main urban, industrial and agricultural areas and, where relevant, fisheries and forests need to be collected. Land use data needs to be collected in the catchment area from which the groundwater body receives its recharge, including pollutant inputs and anthropogenic alterations to the recharge characteristics such as rainwater and run-off diversion through land sealing, artificial recharge, damming or drainage.

Land use data (based on Corine Land Cover 2012) was provided by the Project Partner countries who also gave the overview of the current land use practices. GIS tools were used to obtain the land use categories within drinking water protection zones in each country and to calculate their area and percentage of presence. To compare the individual land use activities between the countries, correlation graphs and charts were constructed.

Table 3. Overview of types of DWPZ, territorial coverage and delineation criteria in Project Partner countries

	Drinking water protection zones	Delineation criteria	Delineation with spatial plans
Austria	The protection zone 1 (immediate surrounding)	Hydrogeological characteristics	DWPZ (zone 1+2) are delineated parcel-specific within the relevant spatial plans Large DWPZ do not have to be delineated mandatory within spatial planning instruments
	The enlarged protection zone 2		
Croatia	3 DWPZ in intergranular aquifers: III zone of limitations and surveillance; II zone of strict limitations and surveillance; I zone of strict protection and surveillance	Intergranular aquifers: groundwater travel times (days), discharge rate Fracture and fracture-cavernous porosity: same as for intergranular + groundwater flow velocity (m/s).	DWPZ are embedded into the physical planning documents
	4 DWPZ in fracture and fracture-cavernous aquifers: same as intergranular aquifers + IV zone of limitations;		
Germany	3 DWPZ with different levels of protective requirements for the drinking water protection	Hydrogeological characteristics - spatial delineation of the hydrogeological catchment area, assessment of aquifer properties	Borders of DWPZ are considered for each spatial planning process

	Drinking water protection zones	Delineation criteria	Delineation with spatial plans
Hungary	The inner protective block, zone; The outer protective block, zone Hydrogeological protective block – further subdivision into A, B and C protective zones	Travel times, assuming steady seepage flow	Spatial planning has to take into consideration all the vulnerable DWPAs and DWPZs (including those areas which are have not designated by authority yet, only are determined or estimated). DWPZs are part of the national water quality protection zone on the National Spatial Management Plan.
Italy	Buffer zones with applied “geometric” protection (a circular area of 200 meter radius from the catchment point) buffer zones with applied “dynamic” protection (monitoring of water quality in the catchment inflow)	Geological, hydrogeological, hydrological and hydrodynamic characteristics of springs, wells and supply points of surface drinking water + General criteria: geometric, hydrogeological and temporal	DWPZ are considered in the planning procedures and are drawn on cartographic maps and specific regulations/restrictions of land use or activities are established
Poland	Primary and secondary protection zones for surface and groundwater intake; Protected areas of inland water reservoirs	Hydrogeological characteristics	Yes
Slovenia	Outer protection area with moderate protection regime (III); Middle protection area with the rigorous (strict) protection of the water protection regime (II); Inner protection area with the most rigorous protection regime (I)	Hydrogeological characteristics – recharge area size, type of surface or groundwater body, residence time of pollutants, water velocity, travel time in saturated zone	DWPZ are presented as protected area with their limitations regarding spatial planning.

The following subchapters put focus on national particularities concerning DWPZ, restrictions and prohibitions, land use categories and their impact on drinking water quality and quantity.

2.1.1. Austria

2.1.1.1. Drinking water protection zones in Austria

The responsible authorities (The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management - BMLFUW - Water department; State governor or district authority) issue a decree for Drinking Water Protection Zones (DWPZ) and are accountable for the implementation of all relevant measures. Additionally several guideline catalogues (like the “Guideline ÖVGW”) exist, but are not mandatory. The responsible authorities also regulate the land use or prohibit the construction of certain facilities within these areas and ensure the delineation within the respective spatial plans (land use plan etc.). DWPZ (groundwater) are classified into two different protection zones:

- Zone 1
  > has to be protected with fences
- Zone 2
  > has to be marked by means of information boards.

DWPZ one and two are defined according to the hydrogeological characteristics and are delineated parcel-specific within relevant spatial plans. Depending on the respective planning authority, delineation of large DWPZ with spatial planning instruments is not mandatory.

In case of inadequate land use, breaches or legal conflicts within DWPZ, the report is submitted to the authorities, which than issue penalties according to the Austrian Federal Water Act. In case of any legal conflicts, water suppliers and land owners are accountable parties. The position of land owners is stronger than the position of water suppliers. Due to this fact the city of Vienna has bought a huge part of the related DWPZ and actually is its land owner.

Water conservation or water protection zones do not determine a construction ban in general. However, the responsible authority (Ministry, State governor or district authority) can regulate the land use or prohibit the construction of problematic facilities within DWPZ. Projects affecting surface/ground water resources quality or quantity can be prohibited in order to ensure a sustainable drinking water supply.

Water-polluting substances, such as nitrate fertilizer, pesticides, waste, sludge, chemicals and radioactive substances are regulated. The application of fertilizers or pesticides on saturated, flooded or frozen/snow-covered soil is prohibited in Austria.

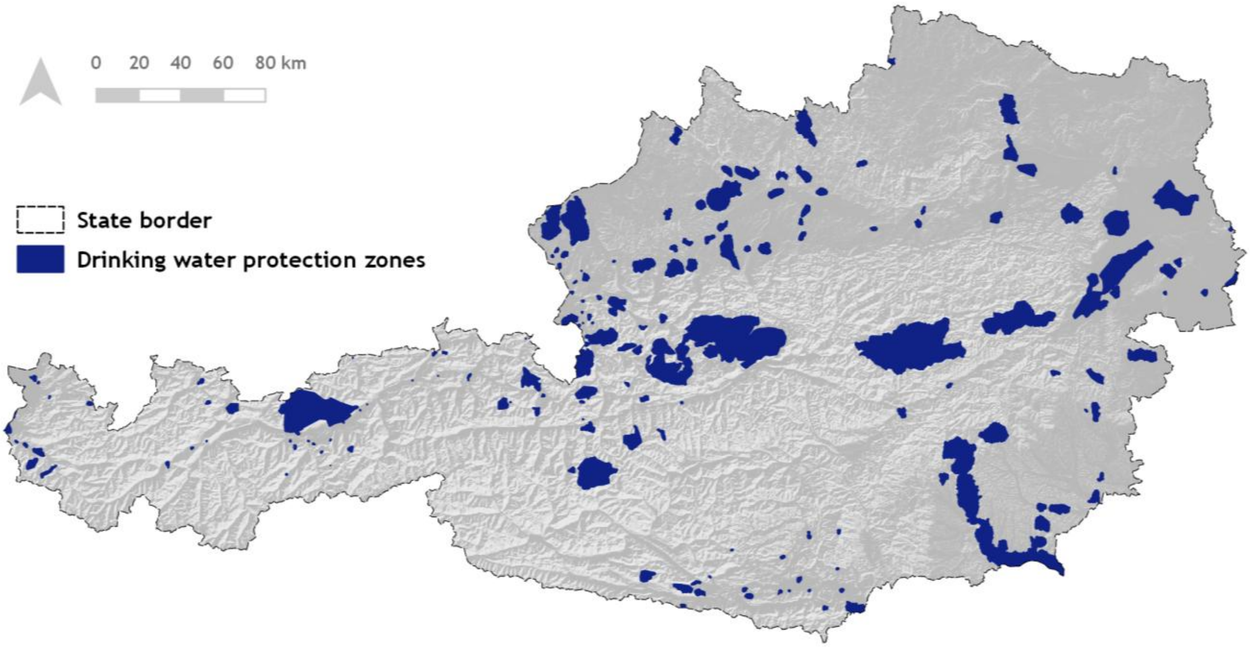


Figure 1. Drinking water protection zones in Austria

2.1.1.2. Impacts of land use activities on drinking water quality and quantity in Austria

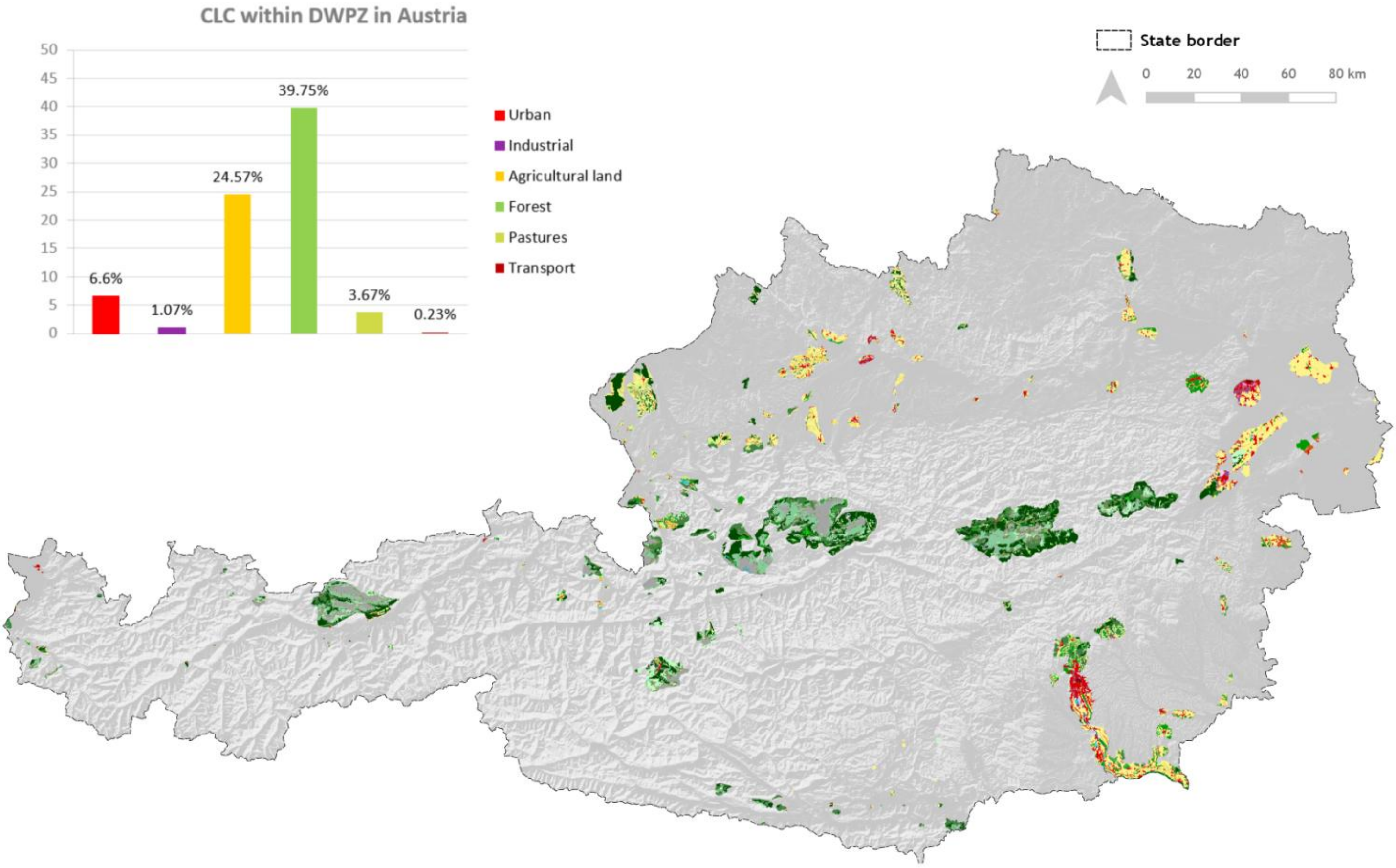


Figure 2. Land use categories within drinking water protection zones of Austria

Agriculture

More than 30% of the Austrian territory is used for agriculture. Within the river basin areas most of the area (42% of the Danube river basin, 72% of the Rhine basin) is cultivated through feed crop farms, whereas cash crop farms (e.g. grain, sugar beet growing) and also permanent crops (wine, intensive fruit farming) are mainly widespread within the Eastern Danube area. Grain growing is the dominant agriculture within almost all river basins in Austria. Maize is mainly cultivated within Mur, Rhine and Drava river basin, whereas potato growing decreased due to the increase of maize in the last decades. Only within Elbe and March river basin potatoes are a little bit more cultivated. **The amount of organic farming in Austria is the highest within the EU – 20% of agricultural areas** (14.5% of cropland, 26% of grassland). Due to favourable climatic and hydrological conditions only about 2.3% of the agricultural areas have to be irrigated (Umweltkontrollbericht, 2016).

In principle the results of the nitrogen balance show the highest surpluses within the regions with a high livestock density (some areas in Styria and Upper Austria as well as some valleys in Tyrol and Salzburg). But these nitrate surpluses were mostly identified (except the Traun-Enns-Platte in Upper Austria) below the Austrian average amount of 39.7 kg/ha. Pollution of groundwater through nitrate loads occurs indeed mainly in the eastern part of Austria, where on the one side intensive agricultural use takes place and on the other side yearly precipitation is relatively low. These circumstances cause negative effects on groundwater recharge and dilution. With regard to phosphorus loads it can be assumed that only low amounts of phosphorus from surface water are leached out into groundwater bodies.

Forest

The total forest cover of Austria encompasses 3,990,000 ha, what are 47.6 % of the total area. About 71.6 % are conifer and 28.4 % are deciduous tree species. The Austrian forest ecosystems are dominated by Norway spruce (*Picea abies* – 59.7 %), what is due to the high share of mountain forest sites and, above all, due to the establishment of spruce plantations on sites of various other forest communities. The most prominent deciduous tree species is European beech (*Fagus sylvatica* – 10.2 %). Further important conifers are European larch (*Larix decidua*), Scotts Pine (*Pinus sylvestris*) and Silver fir (*Abies alba*). Prominent deciduous species are oak (*Quercus robur, Quercus petraea, Quercus cerris*, etc.), ash (*Fraxinus excelsior*) and maple (*Acer pseudoplatanus, Acer platanoides*, etc.).

Actually forest ecosystems are used for the protection of drinking water sources (e.g. in case of the cities Vienna, Waidhofen/Ybbs, Salzburg, Innsbruck, Graz, etc.). Their use in the protection from floods is also important. There are various flood protection forests situated all over the country. Due to the mountainous morphology of Austria, special protective forests are established, which are providing shelter from floods, torrents, rock-fall, land slides and avalanches. These protective forests (category without timber production - 12.5 % of the total forest area) have to provide this ecosystem service and are legally decreed (Forest Development Plan – Map).

In case of the City of Vienna, the use of forests for the protection of karstic water sources is clearly defined and special internal guidelines regulate the silvicultural measures applied in the drinking water protection zone (DWPZ). In Waidhofen/Ybbs the regulation of silviculture within the DWPZ is part of the ongoing project, guidelines are already defined, but knowledge transfer to the stakeholders and Best Practices application still have to be fulfilled. The other cities of Austria, which use forest ecosystems for water protection purposes have individual regulations. A binding national guidance for forestry within DWPZ does not exist.

The most important issue of silviculture in DWPZ is the transformation of homogeneous conifer plantations into mixed forest stands, intending a tree species diversity conforming with the natural forest community. This provides more stability and resiliency for the forest ecosystems, hence ecosystem services can be delivered in a sustainable way. But this can only be achieved, if Best Practices for forested DWPZ are additionally applied. The whole package encompassing the application of “Best Practices”, information about natural forest communities (Forest Hydrotope Model) and the knowledge transfer to stakeholders in PROLINE-CE is the major task in the field of forestry, as there are still shortcomings in Austria in general.

The shortcomings are related to the wide spread application of the clear-cut technique, to the also wide spread homogenous Norway spruce plantations on various forest sites and to the browsing damages caused by wild ungulates.

Within more than 2/3 of the Austrian districts more than 50 % of the forest area is damaged by browsing of wild ungulates. Within 25 % of the Austrian districts those damages occur on more than 75 % of the forest area. The tendency of browsing damages is increasing (period 2010/2012) in comparison to the period 2007/2009 (Umweltkontrollbericht, UBA 2016). The stability and resiliency of the forest ecosystems is endangered through browsing damages, as natural regeneration and tree species diversity are threatened. This can be regarded as major threat for the provision of the ecosystem service “water protection”, both in relation to the protection of drinking water resources and to the mitigation or prevention of floods.

The most important target of forestry within DWPZ in Austria can be summarized with the improvement of forest ecosystem stability and resiliency for providing sustainable ecosystem services within the context of water management (water protection, water provision and water regulation). This can be achieved through the implementation of tree species diversity according to the natural forest community (e.g. application of the Forest Hydrotope Model) and through the application of Best Practices in forested DWPZ.

Pastures

Livestock farming is a prominent land use type in Austria, due to the dominance of alpine landscapes. The related grassland is either used as hayfields or as pastures, in some cases hayfields are partially used as pastures. Another type of grassland is forage cropping (e.g. red clover). In the accessible flatlands and alpine valleys of Austria grassland covers 1,600,000 ha and is mainly used for livestock feeding. More than 60% of the Austrian farmers have a pure grassland focus. At those grasslands mainly farm manure is used, only 5% of the farmers use mineral fertilizers. Liquid manure is a wide spread form of grassland fertilizing method.

A very important type of pastures are the so-called mountain-pastures, situated in the Alps, where livestock is allowed to graze only during summer season, what is due to climatic conditions (extended snow cover). Those mountain pastures (=Almen) in Austria sum up to 8,770 and cover an area of 460,000 ha.

The challenge of grasslands and mountain pastures in relation to DWPZ is in most of the cases the potential microbial contamination of the source water, caused by manure or e.g. cow dung. In some exceptional cases also nitrate leaching to the aquifers could be a threat for source water quality. The regulation of activities such as livestock farmin within DWPZ is necessary, especially in karstic catchment areas where it is mandatory.

Within the DWPZ of the City of Vienna, cattle-grazing is regulated in a way, that dolines and sinkholes are fenced so that cattle cannot approach these highly vulnerable sites. These measures keep on distance the critical dung of cattle and prevent direct connection to the aquifer. In order to avoid the direct entrance of precipitation water technical constructions like dams were used. They prevent precipitation water from directly flowing into dolines or sinkholes. The water can subsequently slowly infiltrate via the soil matrix, so that the potential contaminants are reduced (soils are acting like a filter).

Also the erosion processes caused by livestock trampling (above all cattle) can become a threat for source water quality. For avoiding such erosion processes, fencing of erosive sites was done for keeping livestock away. A subsequent planting with autochthonous vegetation is a further step towards prevention of such erosion processes.

Urban areas

The sewage disposal and treatment are carried out by means of 1,842 local purification plants and are mainly provided by municipalities or outsourced enterprises and associations. The connection rate to the sewer system in Austria is 94.9% (2011). Only three sewage treatment plants (> 2000 inhabitants) discharge their wastewater into groundwater on the basis of water permissions, but they do not cause any degradation of groundwater quality status. Due to national requirements all municipal sewage plants have to be equipped with carbon-extraction. Moreover, most of the plants have a further wastewater treatment stage (phosphor-/nitrogen-extraction). The cleaning power achieves 80% of N and 90% of P. Nevertheless, measures that will further reduce ammonium, zinc, AOX and copper emissions are foreseen in the future.

Concerning waste management Austria takes a leading role in Europe. The recycling rates (66% - 96%) are higher than the EU requirements.

Unfortunately due to 126 contaminated sites of point source pollution, groundwater contamination is expected or already existing (NGP, 2015). These sites are systematically registered and analysed since 1990.

Industrial areas

Regarding water consumption and wastewater emission following industrial branches are relevant: paper production, chemical industry, production of glass and metal.

Taking into account the trends observed concerning water abstraction and the expected production increase, the industrial water demand will probably decrease between 5% and 15% till 2015. Therefore also the wastewater amount is expected to decrease till 2015 (NGP 2015).

Transport units

A mandatory part of planning, construction and maintenance of motorways in Austria is the environmentally compatible removal of wastewaters. The drainage and purification of surface waters stemming from the motorway is constantly brought up-to-date in cooperation with the experts of the water authorities. For this purpose so-called retention-basins were and are constructed along the motorways.

The water retention systems prevent an eventual contamination of the groundwater bodies. All waters flowing from the motorway during precipitation or thawing events enter these retention systems and are cleaned there. After the cleansing process the water is discharged and enters the streams (brooks or rivers) or infiltrates into the ground.

The purification plants also serve for the prevention of accidents. This means that in case of a leakage of environmentally hazardous materials, those matters can be stored in the retention basins and subsequently can be professionally disposed. This contributes to safeguarding the quality of the streams and groundwater resources (ASFINAG, 2016).

Freezing on motorways is prevented by the application of thawing salts, in most of the cases NaCl. During some extreme events also $CaCl_2$ is mixed with NaCl, what provides more security for the drivers, as the mixture can thaw ice and snow also under conditions of lower temperatures, but it also causes more rust-damages on the cars. In Austria about 200,000 tons of thawing salts are applied during one winter season, sometimes even more (depending on the weather conditions). In case the roads or motorway are crossing DWPZ, thawing salts can have potentially negative impact on water resources. An alternative would be the application of KCl_2 in DWPZ, which is not that harmful to plants or to water quality, but has a strong alkalizing effect.

Transport units which drive huge construction materials are accompanied by a special task force, which provides the security of the units. The distance to the trucks is secured, also the signals for other motorway users are provided. Transport units which drive hazardous materials (chemicals, radioactive material, etc.) have to fulfil the laws regulating these transportations.

Mining Quarries

Further land use categories which impact water resources and flood protection are mines and stone-quarries. Those mining activities occur in various cases in Austria, also within DWPZ.

One specific case of stone quarries is situated within the DWPZ of Waidhofen/Ybbs. Those stone quarries, where dolomite was mined, are currently abandoned, but the status of the extraction areas has to be adapted according to the Austrian law. This situation causes the extension of the extraction areas, as the angle of the remaining rock-face is not allowed to be steeper than 45°. Due to this law the already abandoned mines have to be shaped, stones are again mined, and the area of the stone quarries has to be extended for achieving the defined angle of the rock-faces. This causes an extension of the area where water infiltration into the aquifer does not occur in such quantity and quality like e.g. in the case of undisturbed soil layers. Rock areas facilitate surface runoff, which is not desired within DWPZ. After the adaptation of the rock-face angle, the mine area is intended to be afforested with trees and other vegetation.

The potential impacts of active stone quarries on the aquifers are resulting from the applied detonations, from the trucks which can cause oil-spills and from further applied chemicals. Hence, it can be concluded that mines and stone quarries should not be situated within DWPZ.

A different condition is given in the case of gravel pits situated in groundwater aquifers along rivers, which are also very important as potential supra-regional drinking water resources in Austria. In many cases those gravel pits are opening the groundwater horizons. The groundwater becomes surface water and could be contaminated through various impacts due to the lacking gravel and soil cover (NGP 2015). In general the construction of gravel pits within DWPZ should be avoided.

Tourism – ski stations and alpine huts

Tourism activities can exert various impacts on aquifers, water courses or lakes. Particularly important are **ski stations**, which have potential negative impacts on aquifers. Those are resulting from sewage waters from restaurants or huts without sewage systems, from potential oil-spills caused by snow-groomers or emissions stemming from the transport facilities (cable-ways, chair-lifts, drag-lifts, etc.). In most cases the potential contamination is restricted to mineral oil products utilized for those facilities. The potential contamination stemming from groomers and transport facilities can be minimized, if the technical maintenance of those devices takes place periodically and also in acute cases in a very strict way. Further chemicals which are applied in the ski station should be restricted to the minimum and in necessary cases applied with outmost care.

The process of artificial snow-making can involve various potential impacts on aquifers and streams. Within DWPZ adding any chemicals or additives to the source-water for artificial snow-making should be forbidden. While withdrawing the source water for the snow-making process, environmental care should be taken into consideration (e.g. water balance of the region, only clean water can be used, microbiologically contaminated waters are not allowed to be used without prior treatment etc.). Also, the storage reservoirs have to be constructed in accordance with the environment. The respective Nature Conservation Acts and the Water Acts have to be especially considered. The process of ski-station-extensions (with cable-ways or also with artificial snow-making-facilities) provokes discussions in Austria, where various governmental and non-governmental institutions are involved. Environmental Impact Assessments are obligatory and the public has a very critical position towards ski station extensions. Despite this fact actually many ski stations extend their areas of operation on various levels (cable-ways, artificial snow-making, new ski-slopes, etc.). There is only one small ski station situated within the DWPZ of the city of Vienna. The restrictions for this specific ski station are strict, the restaurants are connected with a sewage channel and the used technical facilities have to be maintained in a very good condition. There is no artificial snow-making.

Alpine shelter huts occur within the DWPZ of the city of Vienna, which is situated within the Northeastern Limestone Alps of Austria, a renowned hiking area. Several alpine associations run the shelter huts in this area, where hikers stay overnight or just visit for refreshments. The main problem with those huts is the sewage water, which could potentially enter the aquifers within the karstic alpine landscape. Due to this potential threat all shelter huts within the DWPZ of the city of Vienna have been equipped with a sewage system. Some of them now have a sewage channel, directly connected with sewage treatment plants in the valley. Others have a sewage channel to a temporary storage, which can be disposed by special trucks. Huts which are situated on very remote locations have been equipped with special compost-toilets, which are disposed by helicopters. This initiative was part of the integral water protection policy of the city of Vienna. The sewage facilities were partly financed through the municipality of Vienna.

It is also important to inform the tourists about their responsibilities regarding source water protection. Information should be available at spots where many tourists are passing. This was already implemented in many DWPZ in Austria.

2.1.1.3. Impact of flood and drought on drinking water quality and quantity in Austria

According to the Austrian Forest Act, the Service for Torrent- and Avalanche Control (WLV) is responsible for the relevant hazard zone maps and the respective protective measures within the catchments of torrents.

Austrian flood mitigation measures are extensive and very well developed. In addition, they have a good example of positive flood management coupled with innovative engineering technology – the use of mobile flood walls.

The EU Flood Risk Directive was implemented within the Austrian Federal Water Act. Therefore the catchment-based water management comprises the assessment and the management of flood risks every six years. First of all, a temporary assessment of flood risk was conducted within all river basins leading to the provision of potential significant risk areas. For these areas flood hazard and flood risk maps (Fig. 3) were developed. Based on these results the Flood Risk Management Plan 2015 was published containing targets and measures for risk reduction.

Also torrent related risks are shown in relevant hazard zone maps based on intensive surveys within catchment areas and evaluation of previous events. Experts try to estimate possible damages in flood scenarios due to their experiences and by means of computer-assisted models.

Another pressure upon the flood management in Austria is incorrect forest management such as unregulated cuts or no wood harvest that contribute to increase of debris on hillslopes, which in turn can lead to barriers within channels and cause floods. Construction in the forest areas in general increase runoff and erosion processes.

Protection from droughts can be regarded as less relevant within the Austrian territory, as the precipitation regime mostly covers the water demand of the forest ecosystems. Within the context of climate change drought events could become more frequent. The stability and resiliency of forest ecosystems in those cases depends on the tree species composition of the forest stands, which has to be adapted in DWPZ according to the potential natural vegetation. Diverse forest ecosystems show more stability, also under drought conditions.

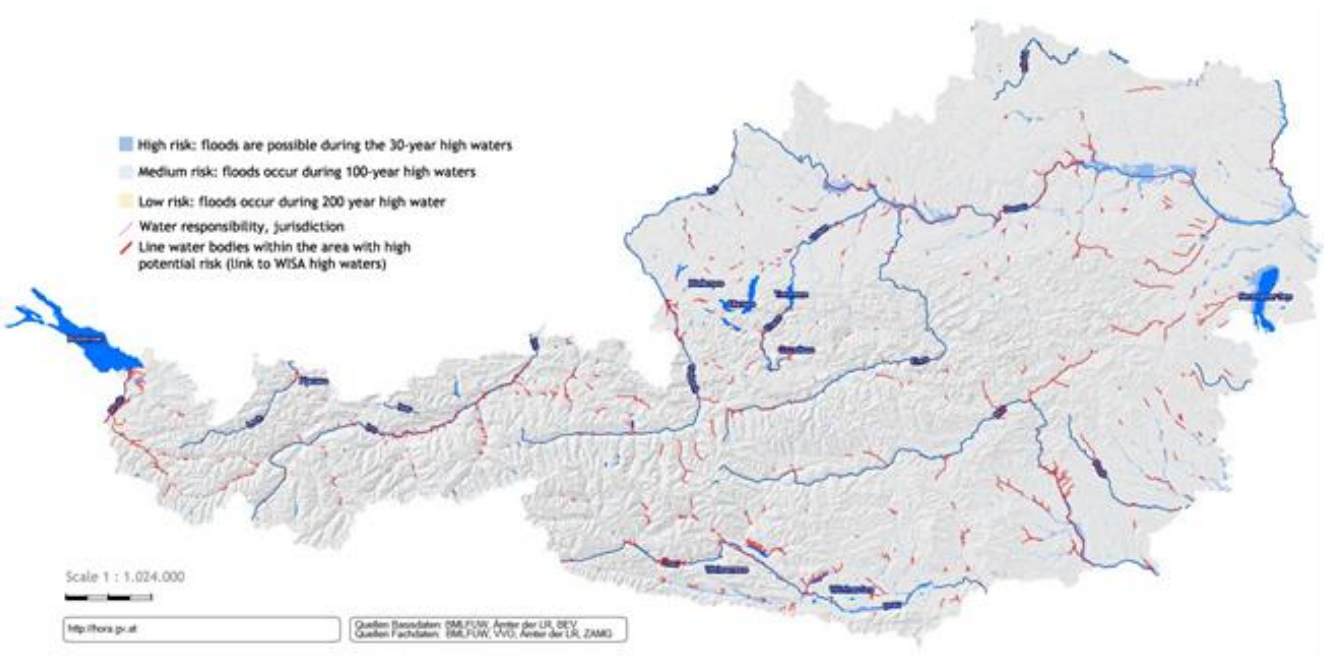


Figure 3. Flood risk map of Austria (data by Ministerium für ein Lebenswertes Österreich, HORA Natural Hazard Overview & Risk Assessment Austria)

2.1.1.4. Overview of status quo in Austria via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Austria as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Austria is shown in Table 4. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 4. SWOT analysis for Austria

S	W
Good quality and enough quantity of groundwater Austria takes a leading role in Europe concerning waste management The amount of organic farming in Austria is the highest within the EU High share of forested DWPZ Adaptability of farmers in terms of water protection goals Adaptability of governmental bodies to close ski-stations within important DWPZ (e.g. Villacher Alpe in Carinthia) Fertilizer and pesticides application plan and monitoring – limitations in DWPZ Agricultural advisory services Stimulation of farmers to implement soil conservation - Financial supports for farms for GW/SW resource protection Prevention of direct wastewater discharge into groundwater	Due to the “Federal State” structure of Austria regulations in general are different between the “Provinces” (limitations and guidelines for DWPZ, related consideration within spatial planning documents, etc.) No specific binding legislative rules for DWPZ in the Austrian Federal Forest Law (e.g. clear cuts are allowed to a certain extent) Values of nitrate and some pesticides are increased in the source water due to intensive agriculture (especially in the eastern part of Austria) Soil erosion on agricultural land occurs which increases mainly the phosphorus pollution in rivers Punctual pollution of groundwater due to contaminated sites Weak adjustment of adequate land use along rivers / torrents (buildings within hazard zones, over-aged trees, clear-cutting of the gallery-forests along streams, agricultural farming up to embankments…) Clear-cut technique (especially in DWPZ) Livestock-grazing close to vulnerable sites like dolines or streams Ski-stations with artificial snow-making and inadequate technical facilities within DWPZ
AU O	T
To guarantee a sustainable water supply also in the future, adequate water management plans are crucial Water efficiency programmes and proper water management , especially in dry areas, are necessary in the future River basin or catchment-oriented planning of measures Better communication and dissemination of knowledge and experience between decision-makers / legislators and experts Integrative flood risk management Stricter rules concerning fertilizer and pesticide applications and respective awareness raising Regulations for alpine pastures or grasslands to fence vulnerable sites like dolines or streams Strategic and Integral Source Water Protection Concepts and Planning for DWPZ Adaptive forest management for drinking water protection in DWPZ Closing ski stations within important DWPZ	Due to climate change, whose effect on water resources is still unknown, in the future groundwater recharge will probably decrease in some areas Aquifer potential contamination from ski stations Loss of Forest Ecosystem Services due to browsing damages caused by wild ungulates Forest soil compaction due to application of unsuitable extraction methods during timber yield (reduced infiltration, increased surface runoff) Heavy machinery intensive use (soil compaction) Severe conflict of raw material mining activities versus drinking water protection in DWPZs (especially in the Alpine foothills)

2.1.2. Croatia

2.1.2.1. Drinking water protection zones in Croatia

Croatian Waters is an executive body responsible for water management and the implementation and coordination of state policy in the field of water, including the development of River Basin Management Plan. Besides Croatian Waters, water policy is the responsibility of the Ministry of Environment and Energy, which proposes laws and regulation and adopts by-laws in the field of water management, performs administration and inspection, establishes international cooperation.

Determination of drinking water protection zones differ depending on the aquifer porosity. Criteria for delineation of DWPZ in intergranular aquifers are groundwater travel time and discharge rate, while in aquifers with fracture and fracture - cavernous porosity criteria additionally take into account groundwater flow velocity.

Legislation in Croatia also allows establishing special protected areas in the sense of water protection reserves in the remote and mountainous regions where several DWPZ can be joined together.

Borders of DWPZ are not necessarily following land plot (cadastral/parcel) borders for every DWPZ. The borders of the first DWPZ for all sources, according to the Regulation on the conditions for the establishment of DWPZ (Official Gazette 66/2011, 47/2013) must be aligned with the cadastral plot and in accordance with the actual situation on the field (particle property or possessory, i.e. fencing the water intake). The borders of the second zone are aligned with the cadastral parcels only if that's done / proposed by the executed water research works. All the other borders are not aligned with the cadastral parcels. The ownership of individual parcels or objects is not taken into account. However, the overall impact of human activities is taken into account, although other features are more significant and are considered as basic criteria: geologic features and hydrogeological relations between inflow areas, hydrological features of the inflow area, size, borders and yield of the aquifer, type of aquifer due to the porosity (intergranular, cracking and fracture - cavernous), thickness and permeability of covering layers of the aquifer, the aquifer feed mode, the way water flows into the reservoir or lake, the rate of groundwater flow to the source, purification capacity of covering sediments and aquifers, water quality and analysis of natural systems.

DWPZ are embedded into the physical planning documents as implementation provisions (interdictions and protection measures for each established zone), as well as the graphical representation of the Plan. All operations and activities in the area should be harmonized with the physical planning documents that are checked and confirmed by competent administrative authorities under the applicable legal regulations at national, regional or local level. On the other hand, the situation in the field is verified by the relevant water inspection.

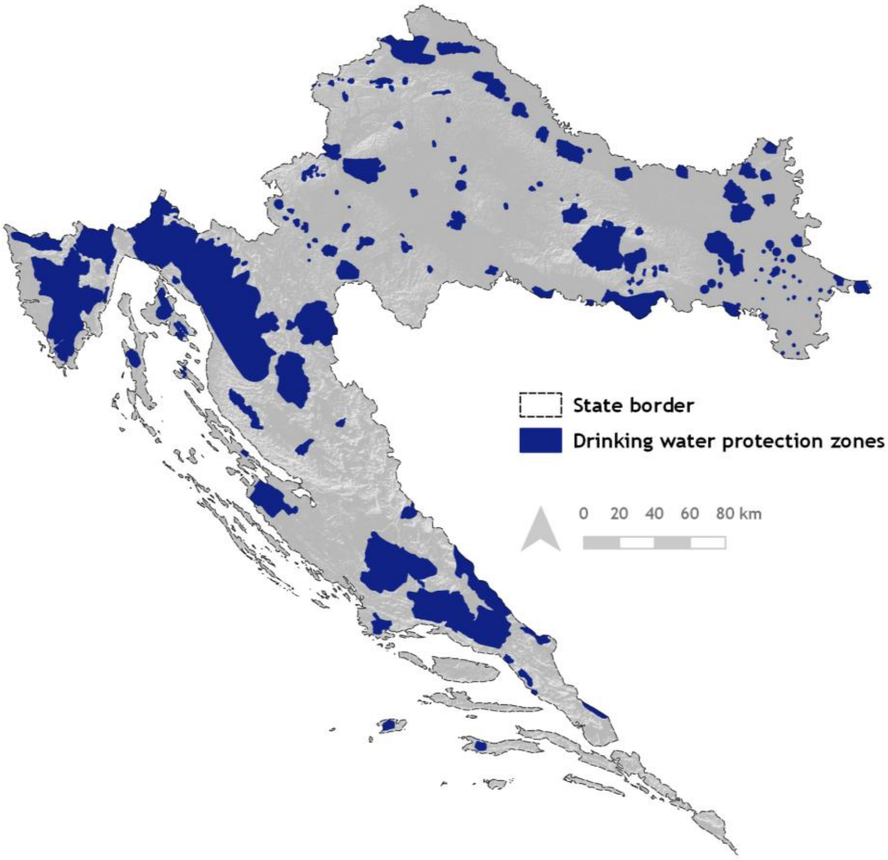


Figure 4. Drinking water protection zones in Croatia

According to Croatian regulations for DWPZ there are number of limitations and restrictions in the particular DWPZ (Official Gazette 66/2011, 47/2013). In aquifers with fracture and fracture-cavernous porosity, restrictions are more rigorous than in intergranular aquifers. According to the level of limitations and restrictions, DWPZ are divided into:

IV zone - zone of limitations

Prohibitions within the IV. zone are:

- wasterwater discharge without previous treatment
- construction of production facilities for hazardous supstances
- construction of facilities for recovery, treatment and disposal of hazardous waste
- construction of facilities for storage of radioactive, hazardous or oil-based fuels and materials
- removal of topsoil
- use of powder explosives
- exploration and exploitation wells, except for water research

III zone – zone of limitations and surveillance

Prohibitions within the III. zone are:

- all prohibtions from zone IV and additionally:
- temporary or permanent waste disposal,
- pipeline construction (hazardous fluids),
- construction of gas stations without proper technical precautions,
- surface of underground mining excluding geothermal and mineral waters.

II zone – zone of strict limitations and surveillance

Prohibitions within the II. zone are:

- all prohibtions from zone IV. and III. zone and additionally:
- agricultural production, except ecological (organic),
- cattle production (maximum 20 livestock units),
- the formation of new cementeries and expansion of existing,
- construction of all industrial facilities that pose threat to water environment,
- forest clear cuts except sanitary cuts.

I zone – zone of strict protection and surveillance

First zone is intended to protect all the capturing facilities (e.g. springs, wells, drainages, etc.) and the area which directly drains toward these facilities. First zone must be fenced. In the I. zone, all activities except those related to abstraction, conditioning and transfer of water in the supply system are prohibited.

The relevant water inspection establishes the breaches, while the penalties and inspection responsibilities are laid down in the penalty provisions of applicable laws.

According the Regulation on the conditions for the establishment of DWPZs (Official Gazette no. 66/11, 47/13), within 12 months from adopting the Decision on DWPZ it is necessary to draw up a Program of rehabilitation measures within the DWPZs for existing buildings and existing activities which becomes an integral part of the Decision on source protection. The Program of rehabilitation measures contains a list of all pollutants in the area of DWPZs, priority rehabilitation interventions, implementation deadlines for remedial interventions, remediation costs, institutions in charge of financing the implementation of the Program.

DWPZ on surface water bodies includes three zones of protection (standing waters). First zone includes water surface and all the facilities needed for water capture and supporting buildings, including the dam if exists and it is defined with the 10 m zone around the lake at his maximum stage. All the capturing and supporting facilities must be fenced. The second zone is defined with the distance at least 100 m from the border of the first zone. The outer border of the third zone is defined with the watershed. It is determined only for those natural lakes or artificial accumulations where no surface water inflow or torrents are present. Flowing water DWPZ recognizes one zone, whose border must be at least 10 m from capturing facility. All capturing and supporting facilities must be fenced (Drinkadria, 2016).

2.1.2.2. Impacts of land use activities on drinking water quality and quantity in Croatia

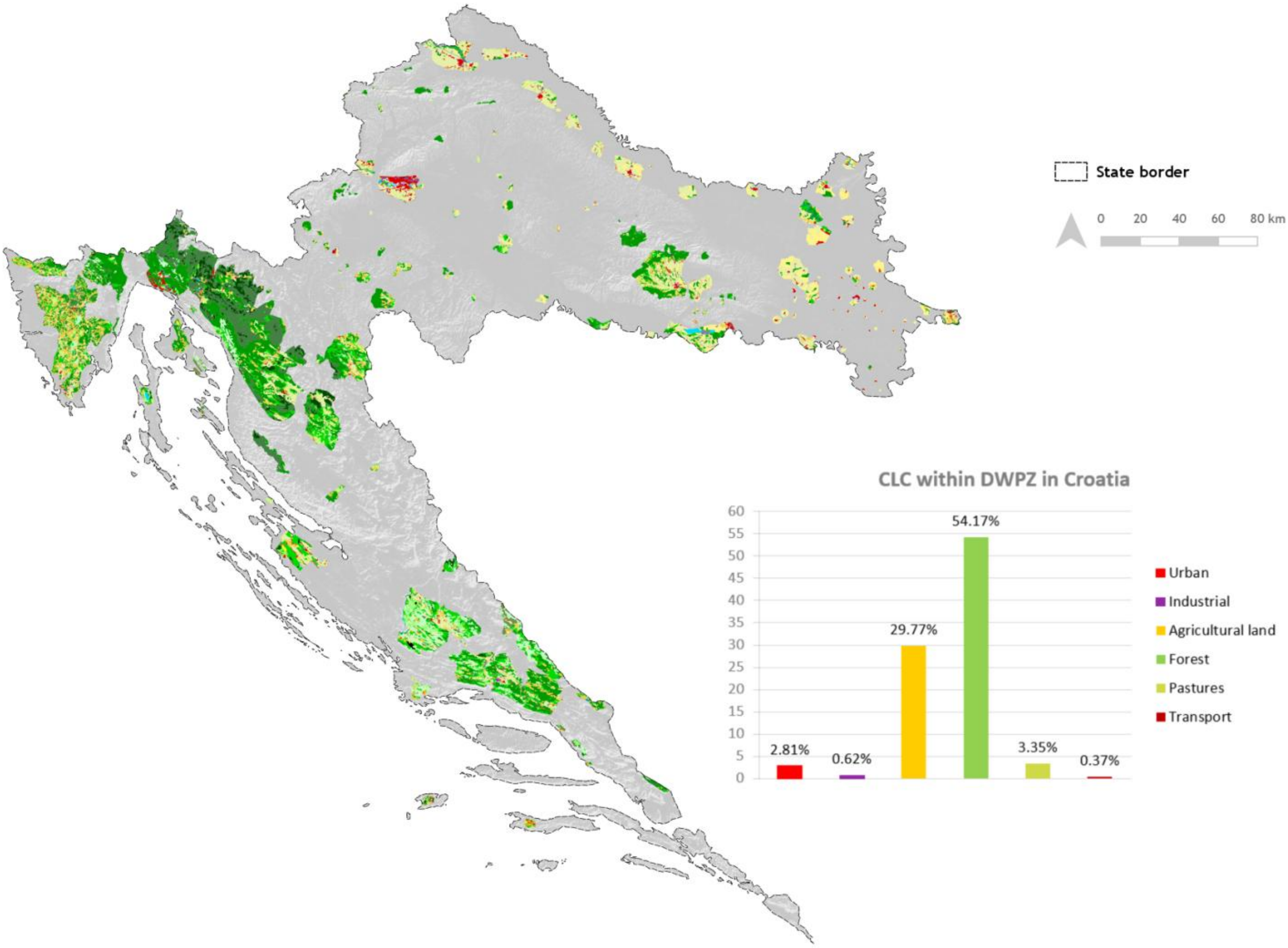


Figure 5. Land use categories within drinking water protection zones in Croatia

Agriculture

In 2011, utilized agricultural area was 23.4% of the total land area of the Republic of Croatia. Since 2007 the Republic of Croatia has a positive trend in the use of agricultural land with increase of 10.3%. Most represented category in 2011 was the arable land and permanent grassland. According to the Rural Development Programme of Croatia, high risk of soil erosion is present on 23.23% of arable land.

The use of pesticides in agriculture has especially harmful impact on water resources. In many areas in Croatia there is still lack of awareness of the dangers of pesticides and their influence on water resources. When using the pesticides, farmers often tend to follow the principle "more is better", not thinking of the damage they cause to the environment. There is National Action Plan to achieve the sustainable use of pesticides (NAP) for the period 2013 – 2023. It has the objective of reducing risks to human and animal health and to the environment associated with pesticide use, and stimulating integrated and alternative measures to control pests. One of the general objections of NAP is to reduce the levels of pesticide residues in food, drinking water and the environment including strengthening laboratory and administrative capacity for the implementation of monitoring and the number of active substances and metabolites that can be identified and including the use of non-chemical plant protection measures. According to The River Basin Management Plan (2016-2021), total consumption of mineral fertilizers in 2012 was 421,915 tons (N, P_2O_5, K_2O – 237,858 tons). The amount of used nitrogen was 137,152 tons (58%), phosphorus (P_2O_5) was 46,328 tons (19%) and potassium (K_2O) was 54,378 tons (23%). The Republic of Croatia is considered to belong to group of countries with low load of fertilizer per unit area.

Agricultural land use structure of Croatia is as follows (2011): ploughfields and gardens (67.3%), permanent grassland (26.1%), orchards (2.5%), vineyards (2.4%), olive groves (1.3%) and other (0.4%).

Organic production, with the application of the permitted fertilizers and plan protection compounds in line with the regulations, is allowed within the II. drinking water protection zone in Croatia. Regarding irrigation problem in agricultural production, individual water captures for the irrigation of crops can have significant effect on local water resources. According to the River Basin Management Plan (2016-2021), the pressure of uncontrolled or scattered water captures for the needs of irrigation will increase as a result of climate change. Main measure for the rational, sustainable irrigation is construction of public irrigation system, evaluation of investments for these systems as part of the Long-term Programme for Construction of Water Regulation and Protection Structures and Amelioration Structures.

Forest

Total forest and forest land area in the Republic of Croatia amounted 2,795,039.05 ha, which as regarding total inland area of the Republic of Croatia represents forest cover of 48%. Out of total forest area, productive forest land with tree cover amounts 86% and the rest is productive forest land without tree cover (productive, non-productive and unfertile land). In total forest area, 76% of forests are owned by the state, managed by the company Hrvatske šume (Croatian forests Ltd.), while the rest is privately owned.

According to their purpose, forests in Croatia are classified as economic forests, protective forests and special purpose forests. Protective forest and forest land take up 832,095.82 ha or 30% of total forest and forest land area. These are forests in sensitive habitats (sloped land more than 50%, skeletal soil, riverine islands etc.), forests of high biodiversity, public water resources forests, rare or representative forest communities and forests for the protection of soil, roads and other structures against the erosion and flooding. Protective forests are also forest in lowland areas in humid depressions where water stagnates for the most of the year and disables its management and reconstruction. In line with Waters Act, all forests that are on water good are considered as protective forests. The most significant protective functions of forests are reduction of floods effects (maintaining the “natural” flow regime by reducing and delaying the stormflow peaks) and reduction of soil erosion caused by water (reduction of sedimentation of deposits incurred due to soil erosion in water stream channels and stagnant water bodies).

The Forest Management Plan in force determines growing stock of about 418.6 millions of m^3 while its yearly increment amounts about 10.1 millions of m^3. The abundance of some of the species in the total growing stock is as follows: Common beech 39.50%, Pedunculate oak 13.35%, Silver fir 9.62%, Sessile oak 7.92%, Common hornbeam 7.18%, Narrow-leafed ash 3.72%, Spruce 2.6%, Black alder 1.38%, Black locust 1.28%, Turkey oak 1.17%.

According to the Croatian Rural Development Programme forest cultures in Croatia (70.021 ha), due to the prevalence of only one type of tree, are very vulnerable with respect to resilience towards climate changes and actions of unfavourable biotic and abiotic factors when compared to stable high mixed forests consisting of indigenous types of tree. Given the prevalence of only one type of tree, forest plantations cannot fulfil the stability-criteria for forest ecosystems in drinking water protection zones. They are present on 0.1% of total forest area (according to The State of the Environment Report of Croatia).

According to the Forest Management Plan, if there is a high risk of damaging of young forest cultures due to game or cattle, so young forests need to be properly protected-enclosed. Also, serious problem of forest management are forest fires. In the last 10 years 2320 forest fires have occurred and affected 84.250 hectares of forests and forest land. Croatian Rural Development Programme addresses the need for the reforestation of areas, so that the biodiversity can be restored and enhanced, water management can be improved (including fertilizers and pesticides management), soil erosion can be improved and also for the fostering carbon conservation and sequestration in forestry. Forest management plan for the period 2016-2025 prescribes revitalization and regeneration of forests damaged by calamities.

Clear-cut of forest in Croatia is regulated by Forest Act and it is prohibited (except the sanitary forest cut) in the II. DWPZ.

Pastures

Although natural pastures occupy a large part of total agricultural area (especially in the Adriatic region where natural pastures comprise about 775,000 ha, i.e. 70% of the Adriatic part of the Croatian) it is estimated that their utilization is very low (around 10%).

According to the “Agriculture that protects nature, Protection of nature through measures of Rural Development Programme of the Republic of Croatia 2014-2020”, decreasing number of grazing animals in the last decade is leading to the disappearance of grasslands rich in plant and animal species. Also, cattle that used to graze the pastures is kept indoors in longer period through the year.

Croatian Ministry of agriculture issued conversion prohibition (in agricultural purpose) of permanent grassland and pastures in specific NATURA 2000 areas.

Urban areas

According to the documentation of Croatian waters, 245 public sewage system are recorded, 118 in the water area of the Danube River and 127 in the Adriatic Sea catchment area. The 46% of the total population is connected on sewage system. Wastewater treatment has about 80% of sewage system facilities, connected to the 110 active wastewater treatment utilities of different degree of purification. At the water area of Danube River basin second level of treatment dominates and the Adriatic Sea catchment area with submarine outlet treatment. The second level of wastewater treatment means treatment of urban wastewater by a process generally involving biological treatment with a secondary deposition and/or other procedures. Submarine discharge is water construction for discharge of wastewater into the sea at a certain distance from the coastline, normally not less than 500 m and to a depth greater than 20 m. 54% of the population is without public sewage system (56% of the water area of the Danube River and 52% in the Adriatic Sea catchment area).

Current waste management in Croatia is characterised by the lack of accurate information on the quantity of produced waste, who produces what type of waste and in what quantities, how it is further treated and disposed; then by inadequate treatment of waste, by the lack of adequate facilities within waste management system (treatment, disposal); by difficulties in finding appropriate location for disposal sites (difficulties in obtaining approvals by local communities and permits by relevant authorities). Only recently a database of dumps has been established. The regulatory framework is relatively good in Croatia, and in spite of problems, there is a growing activity and interest in waste management (Dragičević et al., 2006). Organised collection of municipal waste covers an average of 98% of the population of Croatia according to data from 2013. In Croatia cities and counties organise the collection and landfilling of waste in a way which cannot be called an integrated waste management system. In the past few years activities on setting up the system have been carried out (in Zagreb, Šibenik, Rijeka, Sisak, Osijek and other cities) which have been intensified by the adoption of the Croatia Waste Management Strategy. The composition of municipal waste changes depending on the environment in which it is generated and depends on a great number of factors such as: living standard of the population, type of inhabited area, the existing level of utility infrastructure and the like. In Croatia monitoring of the municipal waste system has not been systematically carried out. Results obtained from individual testing exist for some areas. Technical and technological capacities for collecting, storing and treating hazardous waste are being developed in accordance with market principles. Certain economic entities have been issued permits for collecting, transporting and temporary storage of hazardous waste. In addition, there are several smaller specialised facilities in Croatia built for the purpose of recovery/treatment of hazardous waste and there are available capacities within individual industrial installations which are used for recovery/treatment of some type of hazardous waste. For carrying out activities of collection and temporary storage of hazardous waste it is necessary to obtain a permit in accordance with Article 41 of the Waste Act. Currently in Croatia there are 47 companies in possession of the permit for the activities of collection and temporary storage of hazardous waste in accordance with the new Waste Act and its Amendments and the old Waste Act (OG 151/03).

The disposal of waste is prohibited within DWPZ. Any temporary or permanent waste disposal is prohibited as well as construction of building/structures for waste management. Discharge of wastewater within DWPZ is regulated according to the relevant legislation: for aquifers with intergranular porosity discharge of untreated wastewater is prohibited within III zone, while treated and untreated wastewater discharge is prohibited within II and I zone; in aquifers with fracture and fracture-cavernous porosity discharge of untreated wastewater is prohibited within IV and III zone, while treated and untreated wastewater discharge is prohibited within II and I zone.

Industrial areas

Until the recession, industrial production in the Republic of Croatia covered a significant place in the overall production, especially manufacturing and petrochemical industries and ship building. Some companies were abolished in transition process and some were destroyed during war.

Above mentioned, mainly refers to companies that manufacture textiles, leather, metal and wood products. The production in construction and energy sectors was also significant. Some industry still continues to generate positive results and participate in foreign trade. According to the total income, the leading industries are production of food, beverages and tobacco products followed by the chemical and petroleum industries. In exports, the most common industry is manufacture of refined petroleum products, motor vehicles, chemical products, food products, electrical equipment, machinery, fabricated metal products, pharmaceutical products.

In Croatia, about 50% of industrial wastewater was purified on pre-treatment plants. Such water is released into the public sewage system where it is further purified at the waste water treatment plant. 20% of industrial waste water after the previous purification is directly released into natural recipients, while the remaining 30% of waste industrial water is released in natural receivers without any treatment. Among wastewater treatment devices 61.6% are devices for mechanical purification, 4.8% are devices for chemical treatment, while biological devices are installed on 5% technical units. Devices for heat exchange are installed just on 0.05% technical units.

Transport units

The total length of roads in 2015 was amounted to 26,706.0 km (according to the National List of environmental indicators). In the period from 2011 to 2015, the number of motor vehicles decreased by 4.6%. Most passengers are transported by road and railway transport, and the most goods by road and sea water and coastal transport. In regard to 2011, in 2015 a total length of railway lines (2,604,260 km) reduced for 4.3% what is recognized as negative trend, because this mean of transport is more environmental friendly.

The network of inland waterways of the Republic of Croatian is 1016.9 km. Inland ports open to international public transport are: Osijek, Sisak, Slavonski Brod and Vukovar. The Republic of Croatia has 7 international airports: Zagreb, Split, Dubrovnik, Zadar, Osijek, Rijeka and Pula and 3 national airports: Brač, Mali Lošinj and Osijek for aircraft in commercial air transport. Pipeline transport includes transport of oil and gas. The 2015 length of the oil pipeline amounted to 610 km and has not changed since 2005. The length of the gas pipeline in 2015 was amounted to 26,932,693 km. Road transport makes more than 90% of all emissions of pollution from traffic, while other modes of transport (rail, air transport, marine and inner marine transport) make about 10%. It is estimated that considerable pollution is caused by traffic in protected areas (particular at karst springs). Still, total pollution from traffic is small in comparison with other sources of pollution.

Tourism

Due to significant increase of tourism activities in Croatia, water resources are exposed to pressures which cause degradation of drinking water quality and quantity. This effect is most prominent during summer months, when the tourism season is at its peak. Due to over-abstraction, water shortages are common in some parts of Dalmatia (this is enhanced by effects of climate change – reduced rainfall and increased evapotranspiration due to high summer temperatures). Another consequence of over-abstraction is saltwater intrusions, common for Dalmatian coast and some big cities (e.g. Zadar). Due to inadequate infrastructure (sewer systems, waste dumps and wastewater treatment infrastructure – see text above), overcapacity and poor tourism strategy (e.g. communal infrastructure is not developing fast enough to support massive rise in tourism), drinking water is exposed to diffuse and point source pollutants. Lastly, increase in tourism can be correlated to higher incidence in forest fires (especially in Dalmatia), causing drastic degradation of soil, water and destruction of ecosystems and related ESS.

2.1.2.3. Impact of flood and drought on drinking water quality and quantity in Croatia

The main objectives of the flood risk management in the Republic of Croatia are designated by The Water Management Strategy, Water Act and provisions of the Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.

Competent institutions for the flood risk management and implementation of the Flood Risk Directive are the Ministry of Agriculture, as the central governmental body responsible for water management and Croatian Waters, as a legal entity with public authority for water management. Croatian Waters implement any measures to manage the risks from flooding predicted by The Water Act and the National Flood Defence Plan and in accordance with their obligations, responsibilities and financial capacities (dedicated funds raised from water fees and fees for water regulation). According to the Water Act, Hrvatske vode (Croatian waters) are obliged to undertake a preliminary flood risk assessment (in compliance with Articles 4 and 5 of The Floods Directive); to develop flood hazard maps and flood risk maps (Article 6) and to prepare flood risk management plans (Article 7 and 8).

Croatia has had major problems with floods in the past years, most notably in 2014. In light of this hazard, the country should invest more in the implementation of mitigation measures. The flood prevention system is outdated and in dire need of reconstruction. Drought is an even bigger issue than flood. Irrigation systems should be modernized and better developed in order to salvage the food-bearing parts of the country that are most hit by the extreme weather.

According to Water Management Strategy, the aim is to increase levels of functionality of flood defence systems (against flood waters of I and II order):

- to a level of around 87% by the end of 2023,
- to the level of 100% by the end of 2038.

There are several pressures on flood management in Croatia that stem from various land use activities and include: conventional soil tillage, incorrect forest management, forest fires, insufficient dimensioning of sewer systems, urban development in flood prone areas, sealed surfaces related to transport infrastructure construction, sewage outflow during flood events, as well as leakage of wastewater that leads to microbiological pollution in case of floods. Investments in ecological agriculture and good management practices can reduce these risks.

In Croatia, drought is becoming a severe problem with the issuing climate change. Due to its karstic morphology, abstraction adjustments should be made to avoid the drying up of springs, especially during summer and increased tourism and agricultural water demand. There is a steady risk of saltwater intrusions in coastal aquifers which renders the groundwater polluted.

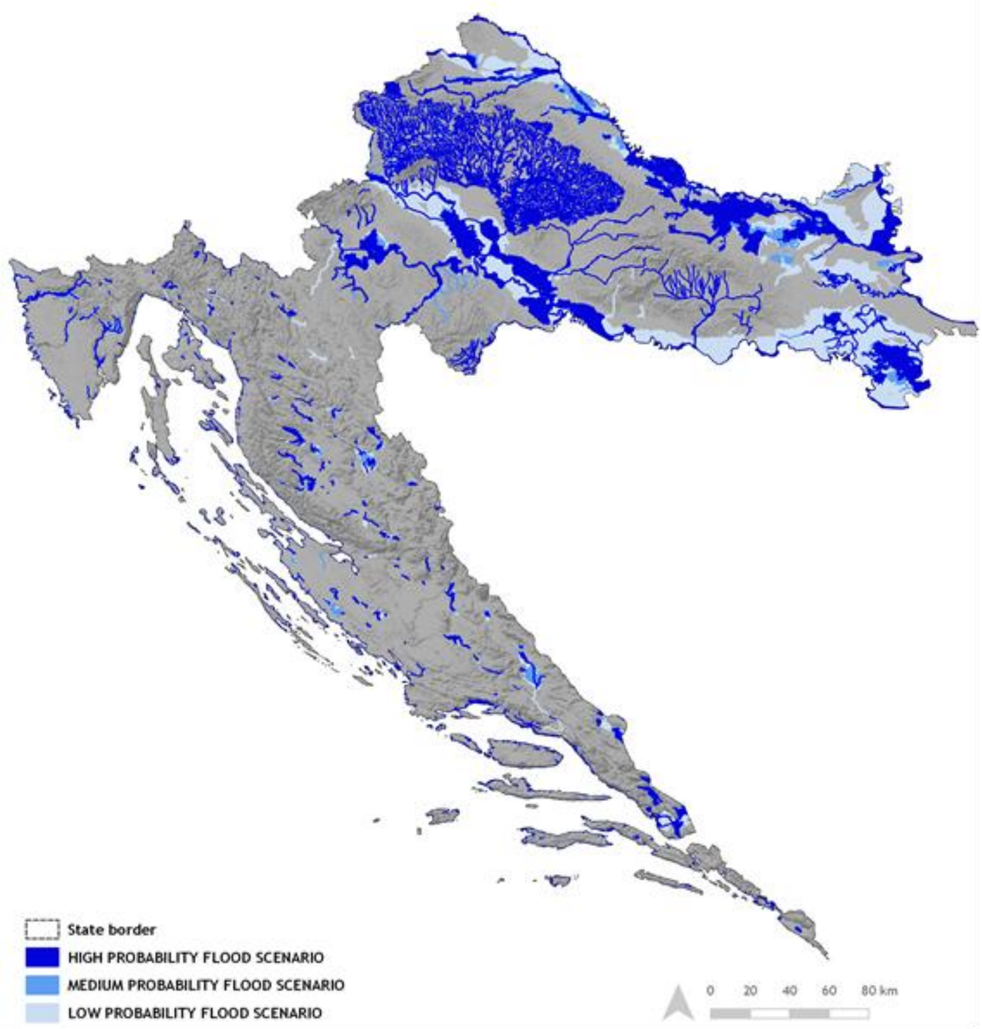


Figure 6. Flood risk map of the Republic of Croatia (data provided by Croatian Project Partner – Croatian Waters; hillshade by ArcGIS REST Services Directory)

2.1.2.4. Overview of status quo in Croatia via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Croatia as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Croatia is shown in Table 5. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 5. SWOT analysis for Croatia

S	W
Protected areas have been identified across the country, including drinking water protected areas and bathing water areas Croatia is engaged in international cooperation for water management with neighbouring countries in multilateral forums and through bilateral agreements (Art. 13 of the WFD) Arkod data base has been developed which keeps track of actual land use in agriculture: hydrological data (water protection zones – 3M, 10M, 20M), crop cultures and parcel slopes Good chemical status is achieved for > 90% of surface water bodies and > 80% of groundwater bodies Good quantitative status is achieved for 95% of groundwater bodies in Danube river basin district, and 66% in Adriatic river basin district Relatively low percentage of land use change (from agricultural to artificial) Low to moderate soil loss rate (2-5 tonnes per ha per year) Limitation of fertilizer and pesticide application on DWPZ Agricultural advisory services Prohibition of the use of chemicals in forestry practices Local development concepts - Coordination of land uses and land use demands at municipal level	The desired ecological state has not been achieved for: 58% of rivers, 54% of lakes, 55% of transitional waters , 12% coastal waters Croatia is at EU bottom concerning waste management Waste water treatment plants purify only around 35% of the waste waters used by population Only surveillance groundwater monitoring has been conducted so far which is not reliable due to the lack of monitoring stations in some areas Only the hydrological regime is reported to be monitored in rivers (without morphological conditions). Hydromorphology is not monitored in lakes, transitional and coastal waters Large number of rivers are strongly degraded (mostly in Pannonian part – Danube river basin district) due to high hydromorphological stress caused by construction (hydro power plants, flood protection, river traffic) Only 47% of the population is connected to the public sewage system nation-wide High percentage of loss during water abstraction and distribution – 46 % average nation-wide Pollution of groundwater with nitrates and pesticides related to excessive use in agriculture (e.g. Varaždin groundwaters) Inadequate landfills as a source of nitrate pollution (e.g. Zagreb aquifer is polluted with nitrates from Jakuševac landfill, trichloroethylene and tetrachloroethylene) Inefficient control system of measures for water protection Insufficient education of local population and farmers in some regions Poor forest management, forest fire hazard
CRO	
O	**T**
A set of 269 measures have been designated for implemented in period 2016-2021 with purpose of achieving at least "good" water status Action plan for water protection against nitrate pollution from agriculture has been developed Available EU funds for investments in public water supply network and wastewater treatment facilities In the period from 2010 to 2015 an increase of 376% in organic farming has been reported	Continued efforts in urban wastewater treatment plant installations due to point and diffuse pollution from household sources, agriculture and industry Coastal agglomerations discharge large amount of wastewater into sea (lack of sewage systems) Rising flood risk due to climate changes and inadequate flood protection infrastructure (flood risk maps have been created) Saline intrusion in many coastal areas (e.g. Bokanjac-Poličnik water body), caused by higher water abstraction and reduced precipitation during summer months Over-fertilization

2.1.3. Germany

2.1.3.1. Drinking water protection zones in Germany (Bavaria)

According to §51 in the German Federal Water Act (WHG), water protection zones (for surface and groundwater) are determined as far as it is required for the general well-being. In this context, three different criteria are:

- the protection of water bodies which are assumed to be of particular interest for currently existing or prospective public water supply;
- to quantitatively enrich the groundwater aquifer;
- to protect the water bodies from harmful rainfall runoff and discharges from agricultural lands carrying soil particles, fertilizers or pesticides.

In general, the WHG prescribes that water protection zones have to be designed based on state-of-the-art regulations and techniques. The water supplier engages a hydrogeological expert bureau to elaborate and assemble the required documents.

For groundwater, the assessment of water protection zone borders starts with the spatial delimination of the hydrogeological catchment area and thus with an assessment of aquifer properties. This investigation also comprises an assessment of the protective function of aquifer protective layers. Following a method introduced by HÖLTING et al. (1995), a mean protective effect of these layers can be achieved if the percolation time until the water reaches the aquifer is at least equal to 3 years. In respect of water flow length and residence time, the protective effect of the aquifer is taken into account as well. By taking possible detrimental acts and facilities as guiding criteria for the spatial delimination, the subsoil properties help to define the spatial extent of the area in which the general requirements of water protection are insufficient. The elaborated area represents the outer boundary of the water protection zone (zone III).

The spatial delimination of zone II is based on further protective requirements for the drinking water protection. This includes the assessment and implementation of hygienical requirements. Especially human-pathogenic germs should almost completely be degraded before the water arrives at the extraction well. A common empirical approach for this assessment is represented by the 50-day-isochrone, meaning that each water particle on the border line of zone II should take 50 days before reaching the extraction well. This isoline has to be established for the maximum extraction rate of the planned wells and for minimum input from the hydrological boundary conditions. Despite the aquifer properties, the effects of the aquifer protective layer can be considered as well. Therefore this layer has theoretically to be reduced by a thickness of 4m to take possible interferences in the aquifer protective layer outside the DWPZ into account.

However, this approach is not applicable for karstic or fractured aquifers since a complete degradation of human-pathogenic germs cannot be ensured due to reduced filtering and sorption effects. In this case, a more central role is assigned to the protective effects of aquifer protective layers which are thus considered for the border demarcation of protection zone II.

Generally, a minimum radius of 10m has to be maintained for the assignment of protection zone I. The criteria for the spatial delimination of zone I are similar or stricter to those for the determination of zone II (LfW, 1995; LfW, 1996; LfU, 2010a).

DWPZ are considered for each spatial planning process and as far as possible, borders of DWPZ should be drawn so they are following land plot borders (LfU, 2010a).

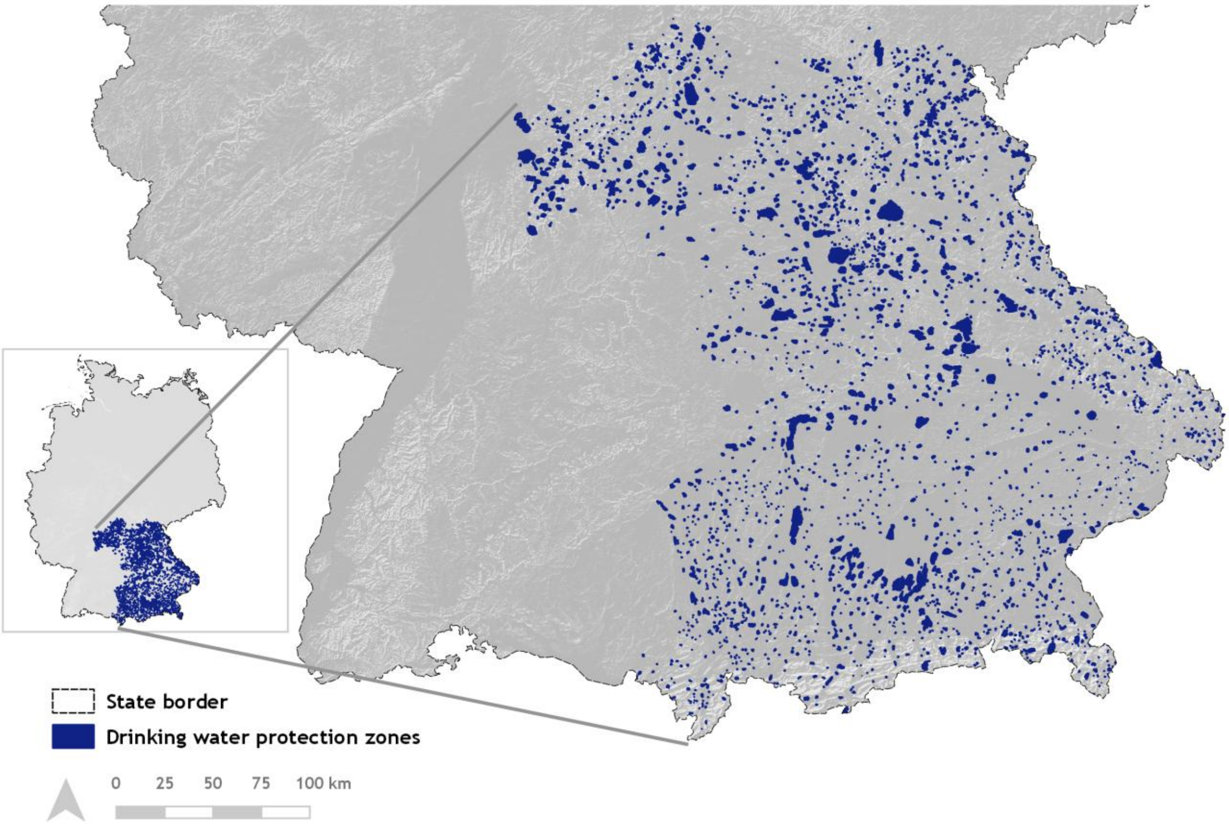


Figure 7. Drinking water protection zones in Germany (Project Partner provided data only Bavaria)

Basically, limitations and restrictions are mostly adapted to site-specific characteristics and thus may differ between water protection zones. However, general valid requirements are given by a model ordinance of the Bavarian Environmental Agency - LfU (LfU, 2003). Within the model ordinance, general limitations and restrictions are made for:

- activities intruding into the subsurface (e.g. limitations for activities intruding into aquifer protective layers),
- handling of substances hazardous to water (e.g. restrictions for the construction and use of installations for the treatment or distribution of substances hazardous to water),
- wastewater treatment and disposal (e.g. interdiction to implement overflow tanks for the discharge of rain or mixed waters),
- traffic routes, spaces for specific purposes and house gardens (e.g. interdiction to implement storage facilities for construction materials),
- structural installations (e.g. interdiction to designate new building areas) and agricultural, silvicultural and horticultural land uses (e.g. interdiction to spread sewage sludge).

The responsibility to control the implementation of measures as well as their success (in terms of enhanced water quality and/or quantity) is legally transferred to the water supplier. The water supplier thus performs a self-monitoring. Furthermore, penalties (up to 50,000 €) may be imposed in case of negligent or intentional non-compliance with the limitations and restrictions defined for each DWPZ.

2.1.3.2. Impacts of land use activities on drinking water quality and quantity in Germany (Bavaria)

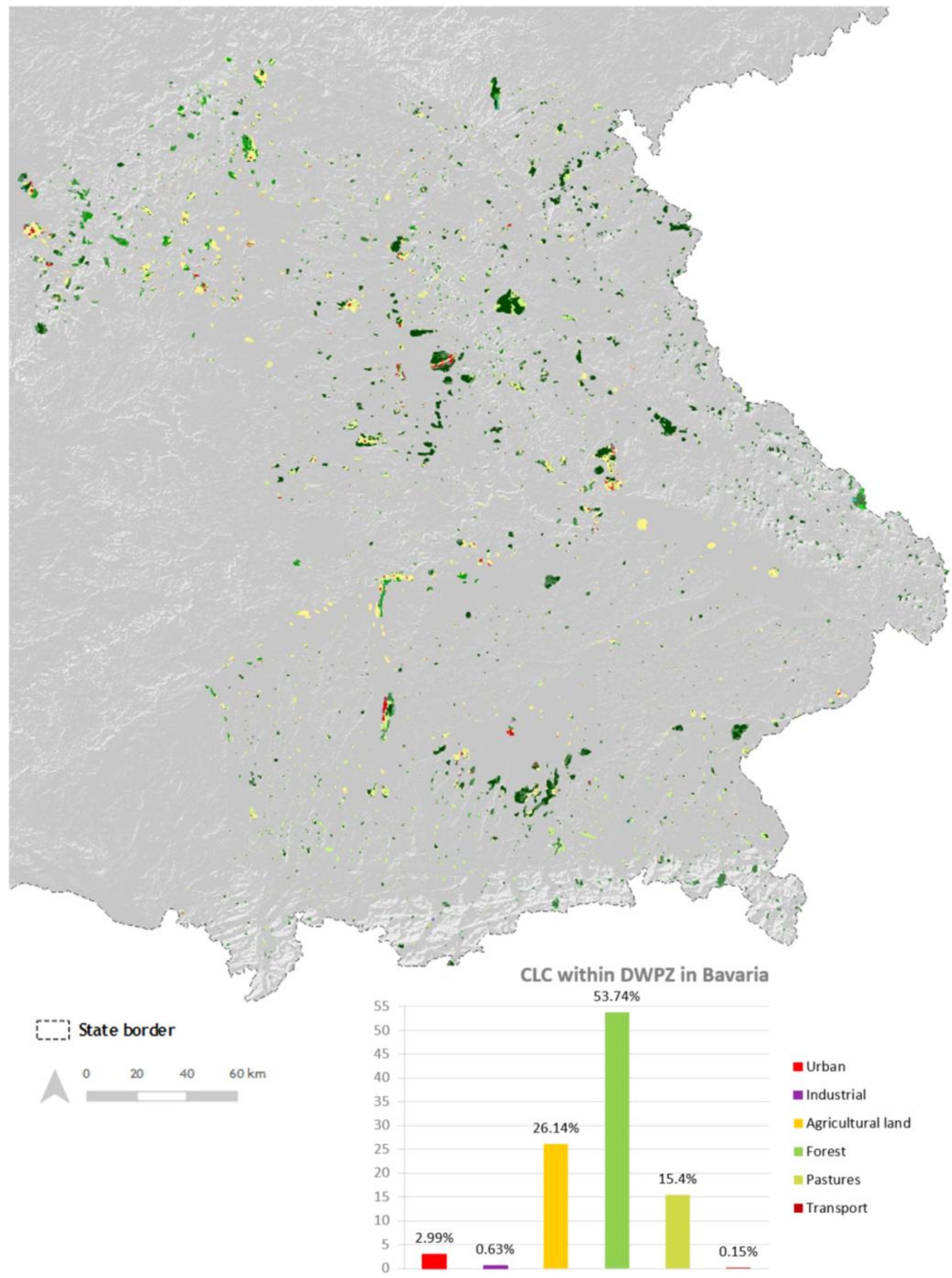


Figure 8. Land use categories within drinking water protection zones in Germany (Bavaria) – graph data is valid for Bavaria

Agriculture

Agricultural land covers a surface area of 3.15 M ha in Bavaria. 34% of this area is used as permanent grassland, 65.6% is used as arable land and only small areas (cca. 0.4%) are used for further uses, such as horticultural purposes and coniferous tree cultivation.

The largest share of surface area in arable lands is used for grain farming (1.17 M ha; 37.3% of total agricultural land, 56.9% of arable land).

Agricultural land is considered to be the main source for diffuse groundwater contamination. In order to reduce the leaching of nutrients (e.g. nitrate and phosphate) into the protected water bodies, several limitations and restrictions have been implemented in DWPZ. For example, limitations on using organic or synthetic fertilizers can be defined differently for each DWPZ while basically, the application of farm manure is prohibited in zone II of DWPZ due to its proximity to the water extraction plant (LfU, 2003). This interdiction may generate considerable conflicts between water management authorities and farmers farming livestock sustainably using the produced farm manure for the cultivation of fodder crops.

Legally implemented obligations to compensate economic losses from farmers resulting from limitations in land use (WHG) as well as state subsidy programmes, e.g. the cultural landscape programme (Kulturlandschaftsprogramm - KULAP), help to reduce the diffuse contamination of concerned water bodies. Moreover, voluntary cooperations between water suppliers and farmers are established to further reduce the input of fertilizers and land use intensification.

On average, 32% of the land surface in DWPZ is covered with arable land while 23% is covered with grassland in Bavaria. The following values are based on a data analysis of 12 different DWPZ provided by the LfU. Agricultural land use activities are regulated by voluntary cooperations between farmers and water suppliers in these DWPZ. Before the beginning of the cooperation, widespread crop cultivations in the considered DWPZ have been as follows (decreasing order of area percentage):

- winter wheat
- malting barley
- maize
- winter barley
- rapeseed

The implementation of set-aside areas, catch crop cultivations and the conversion from arable land to grassland is fostered by state subsidy programmes as well as by voluntary cooperations with the farmers. Especially the conversion to grassland is considered to be promising.

However, some districts in Bavaria still suffer from increased nitrate concentrations in the raw water according to LfU (2015). Especially in Lower Franconia, nitrate concentrations above the permitted threshold of 50 mg/l could be identified in 16.4 % of the extracted water amount. On average, the nitrate threshold exceeded in 3.4 % of the total water amount extracted for water supplying purposes in Bavaria in 2014.

While the EU failed to attach conditions of financial support primarily to greening activities making greening to the main target in agricultural policy, a more ecological-based implementation of EU agricultural policy on German and Bavarian level has not been done as well.

Forest

The Bavarian Forest Act (BayWaldG) defines that each forest in mountain sites, low mountain ranges, riparian strips and karstic areas serving to prevent flood events, inundations, rockfalls, landslides and other natural hazards represents a protection forest. Thus, the protective function of forests are recognized and considered in managing actions of the Bavarian State Forestry Office and supported by the Bavarian Forest Institute.

Moreover, the interests of nature conservation and water protection are integrated in the BayWaldG and have to be considered for each forest management task. In order to sustainably ensure the quality of drinking water from forest sites, the share of deciduous trees and firs should be increased continuously. These tree species foster diversity and stability of the forest stands which is of fundamental importance for drinking water protection. The Bavarian State Forestry Department pursues the long-term strategy to continuously increase the amount of deciduous trees and firs in the state-owned forests in Bavaria. Therefore especially spruce pure stands should be converted (BaySF, 2015a). Due to their shallow root networks spruces are vulnerable to drought stress, prone to being wind-thrown and thus increase the overall vulnerability of the forest system (including its soils) to external stresses.

State-owned forests cover an area of 808,000 ha in Bavaria representing 11.4% of the state territory. However, state-owned forests represent only 30% of the total forest area. 56% of the total forest areas are privately owned, 12% corporate forests and 2% national forests. According to a statistical survey of the Bavarian State Forestry Department, the following tree species have been the most widespread in Bavaria in the financial year 2015 (1 July 2014 - 30 June 2015) (decreasing order of area percentage, black numbers are state-owned forests, blue numbers are total Bavarian forests):

- spruce (43%, 42%)
- beech (18%, 14%)
- pine (16%, 17%)
- other deciduous trees (11%, 15%)
- oak (6%, 7%)
- other coniferous trees (4%, 3%)
- fir (2%, 2%)

Focussing on DWPZ, 26.6% of the state-owned forests located in DWPZ have been covered with deciduous forest and firs in the considered period (2015). The 5-year-objective is to increase these area to > 30%. Moreover, 78,580 ha of the state-owned forests are located in DWPZ. This area size increased by 2,000 ha compared to 2014 (BaySF, 2015b). Further 25% of the state-owned forests are considered to have further water protection functions.

Since the beginning of the 1990's the Bavarian State Forestry Office operates a monitoring network of forest climate stations in selected forest catchments. This network has been linked to the monitoring network for mass fluxes into the groundwater in 1996 in order to implement a comprehensive forest monitoring network. The implementation and operation of this network has legally been strengthened by an administrative agreement between the Bavarian State Forestry Office and the Bavarian Water Authority (RASPE et al., 2008).

While a sustainable development of state-owned forests can be fostered by the government as well as by the 2,700 employees working for the Bavarian State Forestry Office, a sustainable development and continuous controls of privately owned forests are difficult to handle. Moreover, the ownership structure makes this process even more difficult since, on average, for each owner there is an area of 2 ha forest.

Pastures

Since 1988 the Bavarian Ministry of Agriculture provides the cultural landscape programme (KULAP) giving advisory and financial support for sustainable and landscape preserving actions. Moreover, the Bavarian Ministry of the Environment provides a contract-based nature conservation programme (VNP) also supporting similar aspects. Different measures are prescribed with a fixed compensation payment per hectare of implemented measures. These programmes foster the conversion of arable land to grassland as well as the preservation of grassland on specific sites making grassland topics to a central theme of the Bavarian agricultural and environmental policy.

Grasslands cover more than one third of the land used for agricultural purposes in Bavaria. Already 34% of the agricultural land is permanent grasslands. The most frequent species groups on Bavarian grasslands are grasses (73%), herbs (20%) and leguminous plants (7%). In the following, the results of the Bavarian grassland monitoring from 2002 to 2008 serve as a base to describe the characteristic values of grassland use in Bavaria.

Basically, grasslands are used as pastures (73.7%), meadows (16.6%) and mountain pastures (6.7%) in Bavaria. As measured by the amount of cuts per year, 16% of grassland sites in Bavaria has been used extensively (between 1 and 2 cuts per year) while 17% have been used very intensively (≥ 4 cuts per year) (LfL, 2011).

To sustainably protect the ecosystem services of grasslands in DWPZ, grazing activities are prohibited in zone II. Further limitations of grazing activities are generally implemented for zone III to limit the extensive soil degradation through livestock trampling and to sustain the turf qualities and the physical properties of the soil system (LfU, 2003). Moreover, to use the water retention capacity of grasslands their preservation is also integrated in the WHG. Thus, the conversion of grassland to arable land is prohibited on riparian strips and inundation areas.

However, a tendency of grassland losses (-5% from 2003-2012) could be observed during the last decade (BfN, 2014). This tendency can further increase since future land use conflicts in DWPZ may arise from the adapted definition of permanent grasslands. Following the announcement of the European Court of Justice (ECJ) a permanent grassland is an *“agricultural land which is currently, and has been for five years or more, used to grow grass and other herbaceous forage, even though that land has been ploughed up and seeded with another variety of herbaceous forage other than that which was previously grown on it during that period”* (ECJ, 2014). This definition has been introduced by the ECJ as a result of a legal dispute of a German farmer who considered reseeding actions on his grassland sites would break the five-years regulation so that he keeps the status "*arable land*" for these sites. Generally, farmers try to avoid the status of permanent grasslands due to a lower sales value and the ban on ploughing. Thus, the implementation of ecologically valuable permanent grasslands is difficult since the economic value of arable land sites and permanent grasslands as well as the legal restrictions on both land use entities mostly are of top priority. Moreover, a ploughing up of grasslands can release great amounts of nutrients which can be leached into protected water bodies and thus pose a threat to water quality.

Urban areas

96% of the Bavarian population is connected to the public sewage system. Private sewers are estimated to be at least twice as long as the public sewage system. It can be assumed that 80% of the private sewage system is damaged which may harmful affect the environment (LfU, 2013a).

57% of the public sewage systems are combined sewers while 43% are separated sewers. In general, wastewater treatment is organized in a decentralized manner; if ecological and economical aspects do not permit a connection to the public sewage system, smaller wastewater treatment plants can be installed for settlement structures with a population equivalent (PE) of < 2000 (following Art. 3 of the Council directive concerning urban wastewater treatment, the minimum requirement for these plants is similar to municipal wastewater treatment plants of size class 1).

In Bavaria, nearly 2700 urban water treatment plants are installed with a PE of 26.9 M. With regard to PE, the majority of the public is connected to *active sludge plants with anaerobic sludge digestion* (12.53 M PE, 307 plants). Second are *multi-staged biological treatment plants* (7.95 M PE, 55 plants), followed by activated *sludge plants with aerobic sludge digestion* (4.22 M PE, 709 plants). The remaining treatment plants are as follows (decreasing order in terms of PE):

- trickling filter plants (0.87 M PE, 199 plants)
- sewage treatment ponds with biological treatment (0.4 M PE, 292 plants)
- aerated sewage treatment ponds (0.3 M PE, 196 plants)
- biological treatment plants in parallel operation (0.28 M PE, 15 plants)
- unaerated sewage treatment ponds (0.23 M PE, 683 plants)
- rotating biological contactor plants (0.12 M PE, 149 plants)
- substitutional sewage treatment ponds (0.02 M PE, 53 plants)
- constructed wetland (0.009 M PE, 46 plants)

During the last decades, a tendency towards a closure of small wastewater treatment plants can be observed due to a need of rehabilitation. The concerned settlements are thus more and more connected to large-scale treatment plants (LfU, 2010b).

Basically, the implementation of wastewater treatment plants as well as any kind of wastewater disposal is prohibited in zone I and II of DWPZ. Based on the EÜV and the valid (technical) guidelines the Bavarian State Office for Water Management (LfW, today LfU) published a technical guideline regulating the time intervals for technical inspections of sewage systems (LfW, 2003). In this guideline, hydrologically critical areas are clustered to ensure an adequate protection of sensitive areas. For example, karstic areas are grouped together with zone II of water protection zones meaning that these areas require a similar maintenance. The guideline regulates that a detailed visual inspection of public sewage systems and property drainages has to be performed once a year while leakage tests have to be conducted in a 5-year cycle. While the inspection of public sewer systems is systematically implemented, an inappropriate maintenance of private infrastructures may represent a source of contamination.

The districts and cities without districts are responsible for the public waste management in Bavaria. This task can also be further delegated to municipalities located in each district if a regular waste management can be ensured. Similar to the water supply, municipal associations can be founded in order to jointly organize an adequate waste management.

In general, the principle of waste management is hierarchically structured:

1. prevention (the production of waste should be avoided as far as possible)
2. preparation for recycling
3. recycling
4. further utilization (e.g. for energy production)
5. disposal

Thus, the waste management integrates the principles of resources protection and sustainable recycling economy (LfU, 2013b).

In water protection zones, the deposition of waste is prohibited in all zones to avoid a diffuse contamination. Moreover, the implementation of waste treatment plants is prohibited in zone II. Special permits can be assigned for small waste treatment plants (as usual for agricultural or household purposes) in zone III of water protection zones (LfU, 2003).

Industrial areas

Manufacturing industries contribute most to the industrial sector in Bavaria. From an economic point of view, the manufacturing industries contribute 27.4% to the gross value-added in Bavaria. Further 25.9% is accounted for financing, leasing and corporate services, 20.1% for the trading, transport and hospitality sector and 19% for public and other services.

In terms of sales and number of employees, mechanical engineering productions and car and car parts production represent the strongest industries in Bavaria. As a product of their operations, different pollutants have to be removed from the waste water before it can be discharged into a water body or the public sewage system (StMWi, 2014).

Basically, pollutants resulting from mechanical engineering are heavy metals (e.g. copper, lead or zinc), washing and cleaning agents (e.g. phosphonates, adsorbable organic halogen compounds [AOX], polycarboxylates, ethylenediaminetetraacetic acid [EDTA]), oils and lipids or acids and lyes from pickling. Many of these substances, in particular agents of washing and cleaning products, are persistent and thus require special treatment procedures. Moreover, oils and lipids have to be removed before the waste water can be recycled as process water.

An important source of contamination in the automotive industry results from painting processes. The use of solvent-based paints can pose a risk for the environment and thus sets requirements for industrial water treatment. Frequent solvents in paints are hydrocarbons such as toluenes and xylenes. In this context it is worth to note that the use of solvent-free powder paints is on the rise and was primarily used in the series production of BMW (GRUDEN, 2008). Further pollutants resulting from the production of cars and car parts are similar to the those emitted from the mechanical engineering industry. So, washing and cleaning agents, heavy metals and oils and lipids also represent typical water pollutants from the autmotive industry. Moreover, heavy metals also represent frequent pollutants from other main industries in Bavaria, e.g. electro industry.

The treatment of wastewater from industrial facilities has to be adapted to the specific requirements of each industrial sector since different branches emit different pollutants. The WHG regulates that private wastewater treatment plants have to correspond to state-of-the-art techniques. Moreover, the WHG regulates the conditions for which the construction, operation and modification of water treatment plants require authorizations. Basically, the requirements of sewage disposal and quality have to be met in terms of compliance with discharge threshold values.

The AbwV gives further requirements to reduce the discharge of pollutants from industrial sites. These requirements include water-saving techniques in the cleaning process, indirect cooling measures, the use of low-pollution operating materials as well as a process-integrated material recycling. Moreover, the AbwV integrates tables of limit values for various industrial sectors (e.g. metal processing industry) thus setting the frame of threshold values for branch-related sewage disposal.

Transport units

Basically, seepage of rainwater represents a usage of water and thus has to be permitted by law. However, the Bavarian ministry of the environment implemented an exemption regulation for the seepage of rainwater regulating that specific seepage actions do not require an official permission by the responsible public authority. To be exempted from permissions, specific requirements of the technical guidelines legislated by the ministry (TRENGW) have to be met. An important requirement is to ensure an extensive seepage through overgrown top-soils. The exemption regulation is not valid for any kind of seepage measures in water protection zones.

In 2005, the Supreme Building Authority of the Bavarian State Ministry of the Interior implemented a revised ordinance for the creation of roads and road drainage (RAS-Ew). The updated version of this ordinance integrates the concerns of water protection and nature conservation thus setting enhanced requirements for road drainage systems. The ordinance further gives a basis for the planning, assessment and implementation of drainage systems. Moreover, the ordinance refers to state-of-the-art guidelines published from the German Association for Water, Wastewater and Waste (DWA). These technical guidelines give practical references for the assessment of rainwater retention basins (DWA, 2013), the planning, construction and operation of features for the seepage of rainwater (DWA, 2005) and recommendations for handling rainwater (DWA, 2007). Moreover, the ordinance for structural measures on roads in DWPZ (RiStWag) sets specific requirements for road drainage in water protection zones. Thus, drainage systems have to be adapted to the protective effect of the groundwater cover, the protection requirements of the related water protection zone and the traffic volume.

Different drainage systems exist for road drainage within or outside built-up areas. While drainage ditches and basins are typical measures implemented outside built-up areas, drainage channels are frequently used drainage systems in built-up areas since adjacent buildings often do not allow an implementation of open drainage systems (e.g. ditches and basins). However, open drainage systems have to be preferred as far as possible.

Further risks for water quality can arise out of the restructuring or demolition of outdated transport-related structures, e.g. bridges. In this context, especially the demolition requires a particular attention since water pollutants, such as red lead used for corrosion resistance, can be leached and enter the water body. Moreover, requirements have to be set for temporary storages for demolition materials to preserve a diffuse contamination of the concerned water body.

A further source of risk results from the maintenance of water on transport unit construction sites and the reinjection of process water assuming specific requirements for the water treatment. In this context, further requirements can be set for the management of reinjection activities e.g. if a rise of water from underlying (protected) aquifer layers has to be avoided.

2.1.3.3. Impact of flood and drought on drinking water quality and quantity in Germany

In Bavaria, flood management plans are developed based on three steps:

- Preliminary risk assessment based on a status analysis of the river catchments;
- creation of flood hazard maps and flood risk maps for risky areas;
- development of flood risk management plans.

In order to develop comprehensive flood risk management plans for Bavaria, flood management strategies are based on four priorities: prevention, protection, provision and after-care. These priorities are key elements of the Bavarian flood management programme (StMUV, 2014). Risk assessment as well as adaption strategies for floods and droughts have been elaborated within the Bavarian climate adaption strategies project (BayKLAS) (StMUG, 2009).

The prevention of flood risks includes e.g. the leaving of inundation areas and the prevention of building developments on these sites to avoid an exposure of humans and economic goods to flood risks. Moreover, a removal or a relocation of infrastructures is considered as well under this item. The following priority of flood risk management is the protection that includes any kind of structural and non-structural measures fostering the technical flood protection as well as the natural water retention in the catchment. These may include the construction of dykes and flood control reservoirs or the implementation of water management measures in the catchment, respectively. The provision of flood risk management integrates flood forecasting, the planning of support measures for the emergency case (both in the sense of information provision) as well as improvements of behavioural precautions by sharpening the public awareness. As a result of a flood event, after-care measures have to be performed in order to recover and to check the effects of the flood event. In a first step, the impacts for individuals, societies and the environment have to be recovered. In a following step, the obtained data are used to review, to extend and also to revise fundamental aspects of flood risk management strategies (StMUV, 2014).

Current Bavarian research projects are focusing on the subject of estimating the significant risk areas for flash floods, where inter alia the Chair of Hydrology and River Basin Management of the Technical University of Munich are involved. First results are estimated to be published in three or more years.

The LfU provides a web-GIS application designating flood-prone areas for HQ100 and flood risk areas for HQfrequent, HQ100 and HQextreme (LfU, 2016a). Moreover, the flood information service provides gauge-based information on current water levels and discharges as well as notification stages in case a certain water level threshold has been exceeded.

Germany, i.e. Bavaria is doing a lot for the implementation of the European Flood Directive. The flood events in recent years (2013 and 2016) have prompted the government to invest more in the mitigation projects. The Bavarian state has maintenance responsibility for embankments (1350 km), flood protection walls (80 km) and mobile flood protection systems (20 km) for category I and II water bodies. Between Ulm/Neu-Ulm and Vilshofen the Bavarian Danube is secured with almost uninterrupted flood protection (ICPDR, 2013).

In terms of drought management, the LfU established a low-water information service in 2008 (LfU, 2016c). This service performs a continuous monitoring of the already existing meteorological and hydrological monitoring networks. The data is used to run forecasting models and to assess possible impacts of droughts. The provided data further supports the management as well as the decision-making process in case of droughts.

One of the great pressures in Bavaria is surface sealing whether through urbanization or through aggregate destabilization and particle transport. This phenomenon leads to decreased infiltration, enhanced overland flow contribution to direct runoff, flash floods and reduced groundwater recharge.

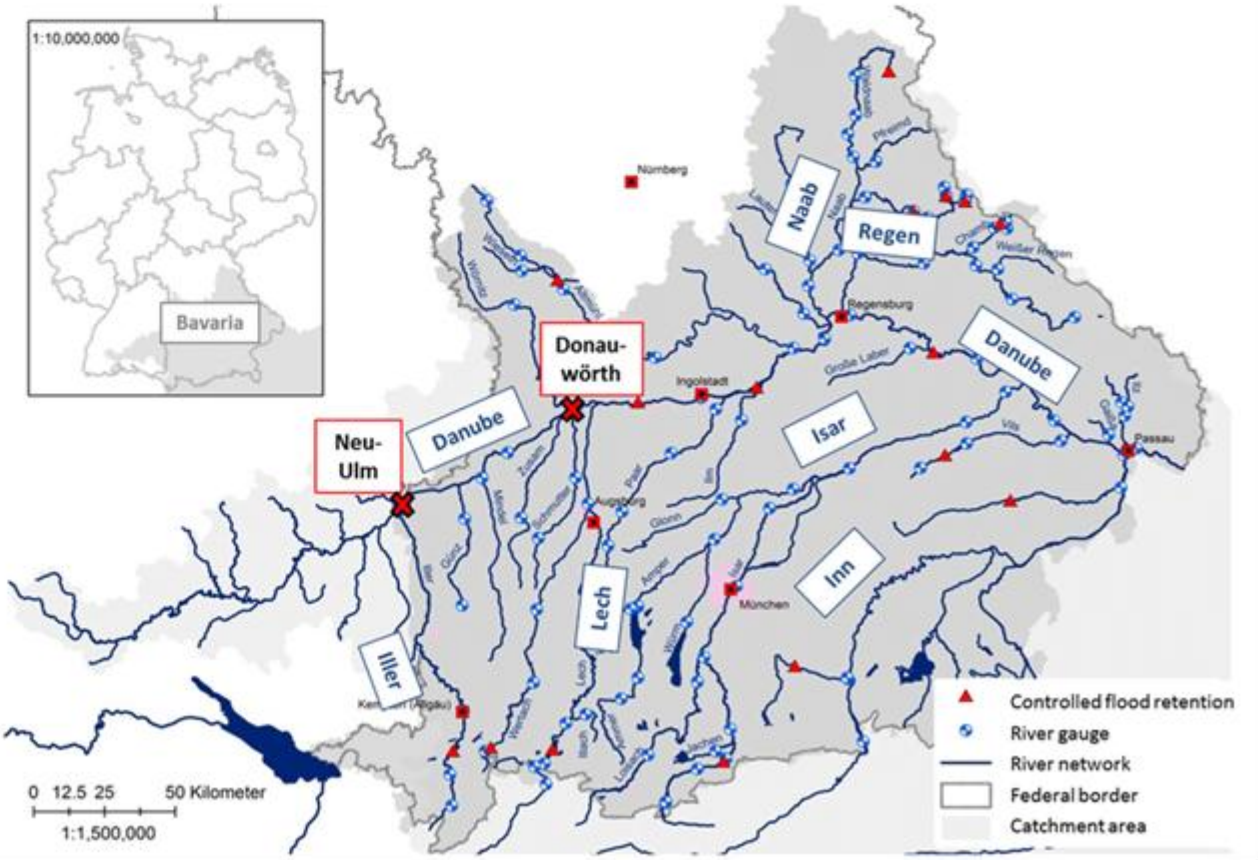


Figure 9. Catchment of the Danube with most important tributaries in Bavaria. Also indicated are large flood retention reservoirs, flood retention polders and important river gauges (from Seibert et al., 2014 (modified))

2.1.3.4. Overview of status quo in Germany (Bavaria) via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Germany (Bavaria) as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Germany (Bavaria) is shown in Table 6. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 6. SWOT analysis for Bavaria

GER	
S	**W**
Cooperation between farmers and water suppliers to enhance the drinking water protection in and beyond the borders of DWPZ Advisory and financial support for farmers (e.g. KULAP) for the implementation of adequate land use measures to enhance the protection function in DWPZ Legally implemented financial compensations for burdens resulting from official requirements in DWPZ and support by state offices for concerned farmers and foresters Considering the protective function of aquifer protection layers in the planning process of DWPZ Implementation of an ordinance for erosion protection regulating management strategies for areas vulnerable to erosion Legal regulations to maintain grasslands and their water retention function on riparian strips and inundation areas Ensuring minimum ecological flow through transition systems in vulnerable areas (e.g. transition system Danube river - Main river Establishment of protective forests Afforestation of degraded lands Greening measures for groundwater protection	Insufficient erosion protection measures enhance the risk of flood damages and surface water pollution Fostering the awareness of farmers and stricter legislations to reduce the risks resulting from erosion Attaching conditions of financial support primarily to greening activities has neither been successfully implemented in EU agricultural policy nor in German or Bavarian agricultural policy More consequent and ecological-based agricultural policy on EU, German and Bavarian level Heavy machinery intensive use (soil compaction) Inadequate handling of dead wood in forests
O	**T**
Fostering further advisory support for farmers to increase their awareness to drinking water and flood protection Increase the number of cooperations between water suppliers and farmers Attaching conditions of financial support primarily to greening activities Further restrictions and more precise limitations on using fertilizers and pesticides in and beyond the borders of DWPZ Increase the number and space of set-aside areas in agriculture Fostering the conversion of arable land to grassland Fostering conversion from forest monocultures to mixed forests Ensuring minimum ecological flow in drought-endangered river basins Fostering awareness of humans to flood risks to increase the individual protection of humans and belongings Reducing losses from water utilities	Estimated percentage of damaged private sewers and differing maintenance responsibility regulations of the municipalities Losses of grasslands during the last decade Increasing intensification of farming activities Inadequate management of privately-owned forests and control difficulties arising from fragmented estates Unknown sources of water pollution from (unremediated) abandoned contaminated sites Rivers and streams canalization Cultivation of arable land with no buffer zones along water courses

2.1.4. Hungary

2.1.4.1. Drinking water protection zones in Hungary

Protection of drinking water resources includes determination, designation, establishment and maintenance of a protective block or area or zone (DWPZ). Drinking water protection zones are delineated for both groundwater and surface water bodies. Protection is achieved by the implementation of part, or all of the safety measures. The boundaries of the protective zones shall be determined by observing the particular hydrological and hydrogeological conditions considering the permitted rate of abstraction or in the case of future sources of supply the full capacity of the aquifer(s). The protective measures set forth in the regulation serve the following purposes:

a) The inner protective block, zone: protection of the abstraction works and the water supplies from direct pollution and damage,

b) The outer protective block, zone: protection against refractory, further bacterial and other decomposable pollutants,

c) The hydrology or hydrogeological block, zone: Protection against refractory pollutants by measures prescribed for the entire, or part of the catchment (recharge) area of the abstraction. The hydrogeological protective block or area is subdivided to "A", "B" and "C" protective zones.

The delineation of the protection zones and determination of protective block sizes are based on the estimation of the travel time, assuming steady seepage flow. The period of seepage flow between the terrain and the surface as the saturated zone shall be neglected in the computations.

Borders of DWPZ are drawn in a way that they follow land plot borders. Spatial planning has to take into consideration all the vulnerable DWPAs and DWPZs (including those areas which are have not designated by authority yet, only are determined or estimated). DWPZs are part of the national water quality protection zone on the National Spatial Management Plan.

The owner of the property affected by the designation of a protective block, protective area or zone, or the person using the property under another title shall be obliged by the decision of the water authority on the designation and maintenance of a protective area to tolerate access to the property of the operator of the water facility and of the persons authorised to carry out official inspections, further the use of the property to the extent required for performing their professional functions. These, however, must not prevent, or hinder appreciably the normal use of the property.

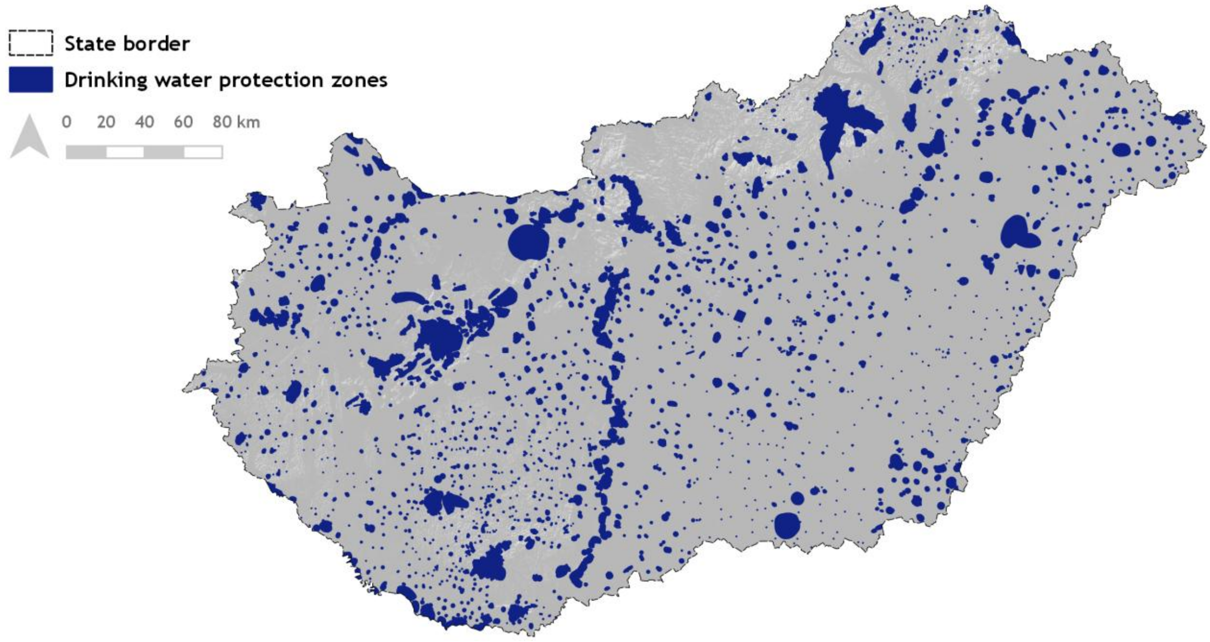


Figure 10. Drinking water protection zones in Hungary

The most stringent restrictions are in the inner zone (fences, guards). The owner of the inner zone shall be the same as that of the water facilities. In the protection zones several activities are prohibited, such as construction of new facilities (although some construction is possible with adequate environmental impact assessment).

Compliance with the provisions, obligations and use restrictions on designated and established protective blocks, protective areas and zones set forth in the present order and in the authority decision shall be monitored regularly by the water authority, the special authorities involved in the procedure and the operator (permit holder) of the water works.

Breaches or non-compliance with requirements defined by DWPZ are penalized by fines and suspension of licences.

Table 7. Activities and restrictions in drinking water protection zones in Hungary

	Surface and subsurface supplies		Subsurface supplies, hydrogeological	
	inner	outer	A	B
	protective zones			
Residential, recreation development				
Housing colony, real-estate development for recreation	-	-	-	o
Residential- or office building with sewerage	-	x	+	+
Residential buildings without sewerage	-	-	x	o
Sewer crossing the area	-	x	o	o

	Surface and subsurface supplies		Subsurface supplies, hydrogeological	
	inner	outer	A	B
	protective zones			
Sewage treatment plant	-	-	o	+
Domestic sewage seepage pit	-	-	o	o
Construction and operation of communal liquid wastes disposal facility	-	-	-	o
Communal solid (non-hazardous) wastes landfill	-	-	-	o
Building rubble deposit	-	-	o	x
Cemetery	-	-	x	+
Hobby gardens	-	-	o	o
Camping, bathing	-	x	+	+
Sports ground	-	x	+	+
Industry				
Production, processing of highly toxic or radioactive materials, storage, disposal thereof	-	-	-	-
Production, processing, storage of toxic materials	-	-	-	o
Plants using no toxic materials, with appropriate sewerage	-	x	o	+
Production, transport in pipelines, processing and storage of petroleum and such products	-	-	x	o
Hazardous wastes disposal facility	-	-	-	x
Hazardous wastes landfill	-	-	-	-
On-site collection of hazardous wastes	-	-	x	o
Seepage disposal and storage of food industry effluents	-	-	-	o
Seepage disposal of other industrial waste waters	-	-	-	-
Landfilling with slag and ash	-	-	o	o
Agriculture				
Forest planting and management without chemicals	-	+	+	+
Crop farming[1]	-	o	o	o
Composting facility	-	-	x	o
Animal farming beyond the home demand level	-	-	x	o
Grazing, keeping domestic animals	-	o	o	+
Manure application[1]	-	o	o	+
Fertiliser application[1]	-	o	o	o

[1] In particular investigations the provisions of the directive 91/676 EEC on pollution control against nitrate from agriculture should be applied

[1] In particular investigations the provisions of the directive 91/676 EEC on pollution control against nitrate from agriculture should be applied

	Surface and subsurface supplies		Subsurface supplies, hydrogeological	
	inner	outer	A	B
	protective zones			
Application of dissolved fertiliser and liquid manure	-	-	-	o
Release of liquid manure	-	-	-	-
Sewage irrigation[1]	-	-	-	o
Irrigation with sewage treatment plant effluent[1]	-	-	o	+
Pesticide application[1]	-	o	o	o
Pesticide application from aircraft[1]	-	-	-	o
Pesticide storage and residues disposal	-	-	-	x
Washing pesticide equipment, effluent disposal	-	-	-	o
Manure- and fertiliser storage	-	-	x	o
Sewage sludge storage	-	-	x	o
Farmland disposal of sewage sludge[1]	-	-	x	o
Burying carcasses, construction and operation of carcass wells	-	-	-	o
Fish farming, feeding	-	-	o	o
Transportation				
Motorway, highway, sealed storm drain	-	x	o	+
Other road with sealed storm drain	-	x	+	+
other road	-	-	x	+
Railway	-	-	o	+
Vehicle parking area	-	-	o	+
Fuel filling station	-	-	x	o
Washing, repair shop, de-icing salt storage	-	-	o	+
Other activities				
Mining	-	-	x	o
Drilling, sinking new well	-	o	o	o
Other activities affecting the cover, or the aquifer	-	-	o	o

2.1.4.2. Impacts of land use activities on drinking water quality and quantity in Hungary

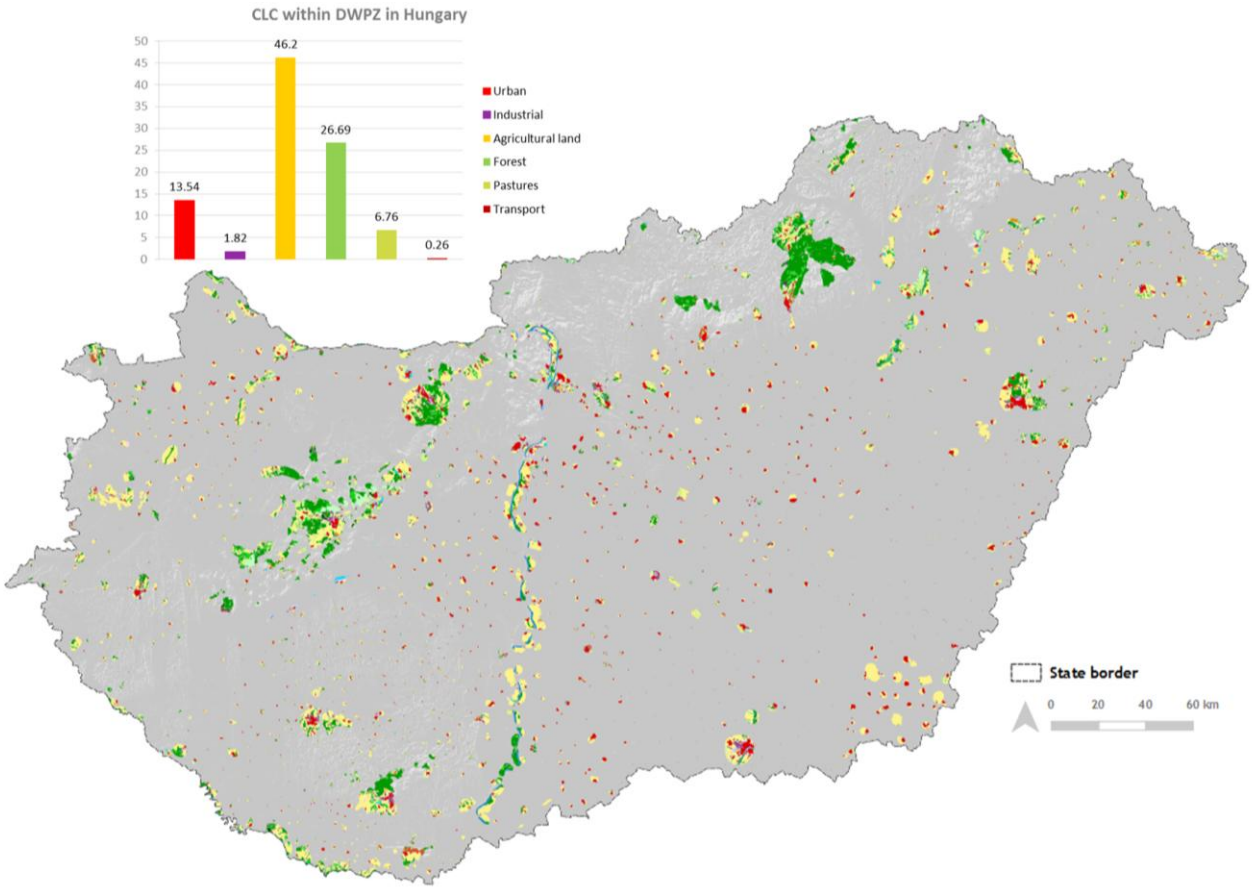


Figure 11. Land use categories within drinking water protection zones in Hungary

Agriculture

In Hungary, the agricultural land sums up to 7.4 M ha. About 75% of the potential agricultural land is used actively and half of that is managed by individual farms.

The agricultural land (about 7.4 M ha) can be categorized as follows: plough field 58.5%, forest 26.2%, grassland 10.6%, orchard 1.2%, vineyard 1.1%, kaleyard 1.1%, reedbed 0.9% and fish pond 0,5%. About 75% of the potential agricultural land is used actively and half of that is managed by individual farms. They cultivate 58% of all agricultural land and 56% of plough fields within. The production area of corns and root plants decreased by 16% between 2013 and 2016, and they were replaced by vegetables, fodder and leguminous plants. Corns made up 60% of the plough fields. The main crops in 2016 were: wheat (1.05 M ha), maize (1.03 M ha), winter barley (0.2 M ha), triticale (0.1 M ha). Other important crops were: sunflower (0.64 M ha), oil rape seed (0.25 M ha), alfalfa (0.13 M ha), corn silage (77 thousand ha), soy bean (63 thousand ha), potato (16.5 thousand ha), sugar beet (16.2 thousand ha). Hay was produced on 0.2 M ha and the area of fellow land was 0.135 M ha.

Table 8. Land by type of cultivation in Hungary – 2015 (Source: Hungarian Central Statistical Office)

Cultivation	area (1000 ha)	Share (%)
Arable land	4,332	46.6
Garden	80	0.9
Orchard	92	1.0
Vine	81	0.9
Grassland	761	8.2
Agricultural land	5,346	57.5
Forest	1,940	20.8
Reed	65	0.7
Fishpond	36	0.4
Production area	7,388	79.4
Non-agricultural land	1,916	20.6
Total land	**9,303**	**100.0**

Drought is a serious risk for the Hungarian agriculture, which will probably increase with global warming. In Hungary, 223,000 ha of agricultural land can be irrigated potentially, however only 99,000 ha was irrigated in 2014. The main plants targeted by irrigation were maize, vegetable (e.g. peas) and orchards. It is important that 90% of the water used for irrigation comes from surface water and only 10% from ground water.

Most of farming in Hungary is based on the usage of rainwater; therefore production is highly depending on the climate and climatic variations. Uncertainties in agricultural production can be compensated with irrigation thus in the next years irrigated area is planned to double. Water supply of large areas can be accomplished using irrigation systems, as well as integrated, connected water distribution systems. In irrigated areas, 72% of irrigation water comes through the state-owned irrigation systems. 83% of the irrigation water used nationally is ensured by lowland irrigation systems.

In 2014, with 115/2014. (IV.3.) Government Decree irrigation water became free for farmers. To meet ex-ante conditions related to EU Water Framework Directive this legislation is being withdrawn stepwise.

The size of area declared for irrigation is nearly unchanged compared to previous years, the water actually used is a question of the given year's hydrometeorological situation and water pricing policy in place. There is also a very good coherency between the size of irrigated area and the evolution of droughts.

Table 9. Irrigation in 2015 in Hungary (Source: General Directorate of Water Management)

Licensed area for irrigation (ha)	Irrigated area (ha)	Irrigated area (%)	Water amount utilized for irrigation (1000 m^3)	Irrigation water used for 1 ha (m^3)
172,703	105,852	61.3	156,474	1,478

To use more effectively the capacity of the irrigation infrastructure, the General Directorate of Water Management has made crucial steps placing great emphasis on the maintenance and upgrading of water supply systems. Promotion of water saving technologies is also a priority in irrigation bearing in mind sustainable water management. The Irrigation Department recently assessed possible irrigation plots and conducted a survey on the irrigation water demand in 2014. The irrigation water demand survey's evaluation was based on the water resources and service and showed that approximately 30% of the demand could be provided to the farmers with or without any restrictions. It is essential that irrigation investment and support is to be given only for those who clearly need it underpinned by the also this survey. The design of an Irrigation Information System is also under development. There are projects under the Environment and Energy Efficiency Operative Programme which are connected to irrigation improvement for 2014-2020. A study/project is currently under compilation targeting to explore the possibilities of water reuse. Supporting also irrigation development, a drought monitoring and early warning system is under development. The monitoring system is introduced in more details among Best Practices.

The use of pesticides in the agriculture has been steadily growing since 2000. In 2014, 29092 tons of pesticides were sold in Hungary out of which 31% was herbicide, 22% insecticide, 20% fungicide and 27% was other type of pesticide. That amount of pesticides contained a total of 8971 tons of active substance. The largest areas treated with pesticides were fields of maize (981,000 ha), wheat (854,000 ha), sunflower (486,000 ha), oil rape seed (203,000 ha) and grape (60,000 ha). The most used substances were glyphosate, sulphur, S-metolachlor, pendimetalin, copper oxychloride, chlorpyrifos, paraffin, terbuthyazine, mancozeb and tebuconazol.

Based on the available data, the total amount of fertilizers used in Hungary has been growing steadily in the past years, especially those containing nitrogen. Considering the substances in fertilizers, in total 358,000 tons of nitrogen, 81,000 tons of phosphorus and 80,000 tons of potassium were sold to farmers in 2015. Those values were 327,000 tons, 82, 000 tons and 78,000 tons, respectively. In natural weight, it means 1,489,000 tons of fertilizers in total. The ratio of simple (one substance) and complex (more substances) fertilizers were 77% / 23% in 2015 (75% / 25% in 2014).

Table 10. Fertilizer usage in 2015 in Hungary (Source: Hungarian Central Statistical Office, Research Institute of Agricultural Economics)

Nitrogen-	Phosphorous-	Potassium-	TOTAL
fertilizer, in active substances			
Amount sold (1000 tons)			
358	81	80	520
For 1 ha agricultural area (kg)			
67	15	15	97

The nitrate-sensitive areas in Hungary total 6,526,800 ha, most of them in agricultural use. In respect of surface waters, the "highly nitrate-sensitive" designation was reserved for nutrient sensitive areas subject to Government Decree 240/2000 (23 December) "on the designation of surface waters and their catchment areas that are sensitive to settlement waste water treatment" (watershed areas of larger lakes and watershed areas of drinking water reservoirs.).

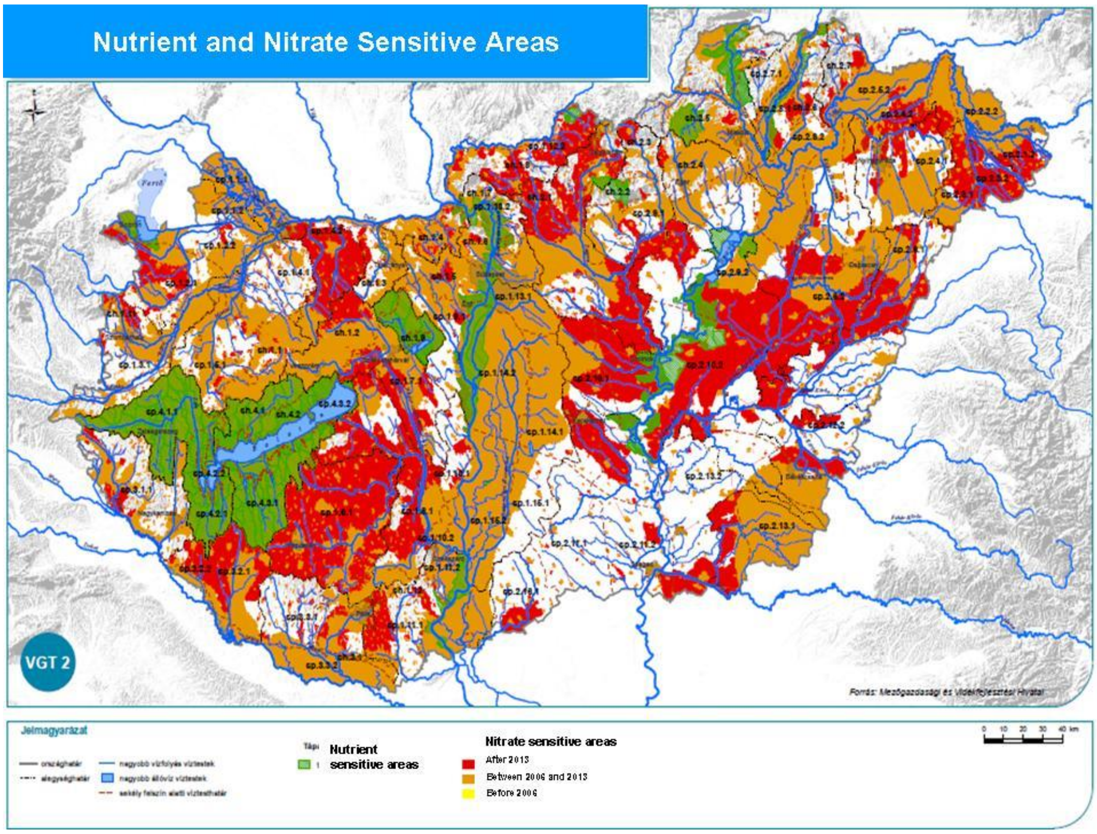


Figure 12. Map of nitrate sensitive areas in Hungary

Hungary's Government Decree 27/2006 (7 February) lists nitrate-sensitive areas specifying the settlements (1779 settlements) and makes reference to "Good Agricultural Practices" whereby farmers will be able to meet the criteria articulated in Directive 91/676/EC, known as the Nitrate Directive. The rules of these "Good Agricultural Practices" are set in Ministerial Decree 59/2008 (29 April). The action programme includes the pursuit and enforcement of "Good Agricultural Practices," with aid and funding allocated for this purpose in the National Rural Development Plan and under the ARDOP.

Organizations and self-employed farmers cultivating nitrate-sensitive lands number 450,700. According to the General Agricultural Census (2000) data by the Hungarian Central Statistical Office, the farmers breeding livestock in nitrate-sensitive lands number 320,700. From the point of view of protecting water supplies, the greatest problems are presented by the liquid manure and waste water discharges of large, industrialized livestock farms raising pigs, cattle, and poultry. The most urgent task is to reduce harmful nitrate discharge. Harmful nitrate discharge in this country comes partly from inadequate manure storage methods at livestock farms as noted above and partly from the disposal of untreated sewage from settlements, neighbourhoods, and buildings without drain canals.

Pesticide pollution is derived from agriculture either from current use, drainage water, or from previous soil contamination. Relevant pesticide list (included in the next Table) was compiled based on current use, presence in surface and groundwater and environmental persistence.

Table 11. Use of pesticides relevant for water resource protection (2013-2014)

Name of plant protection products	Area treated (ha)	Application cases
2, 4-D (dichlorophenoxy acetic acid)	8599	1302
acetochlor	133	40
atrazine	45	15
dicamba	16530	2999
Dimethenamid-P	7644	1145
captan	7944	3011
sulphur	42331	24930
chlorpyrifos	18536	2799
mancozeb	13013	8144
metazachlor	6023	709
Copper-hidroxide	6586	3817
S-metholachlor	14519	2531
Tebuconazole	50345	10179
terbutilazine	16386	3006

Forest

Forests cover 2.56 M ha in Hungary and they can be found predominantly in the hills and mountains and less in the lowland, which latter makes 2/3 of the area of Hungary (central and eastern parts). The area of forests has been growing steadily in the last decades. The two major type of the forest ownership are state forests and private forests. The forest management is determined by the function of a given forest. In that respect, the most widespread type is the for-profit “economic” forests that make up to 59% of the forest area. They are followed by the “protection” forest with 34%. That type includes all forests that are designated for nature and landscape conservation, preventing soil erosion, game reserves, forests serving water management functions or protecting artificial objects (roads, railways, buildings, etc.). Forests designated for nature conservation gives 42% of all forest areas. Invasive black locust is also considered as a forest-making species in the forestry statistics.

Table 12. Forest land, forest cover in 2015 (Source: National Food Chain Safety Office)

Category	area (1000 ha)
TOTAL land	**9,303**
Total land under forest management	2,061
from which: - Area covered with forest stands	1,941
- State-owned forests	1,067
- Public-owned forests	20
- Private forests	854
Forest cover (%)	**20.9**

Table 13. Afforestation in 2015 (Source: National Food Chain Safety Office)

Type	Reforestation (ha)	Forestation, forest establishment (ha)
State forest holders	7,241	135
Other forest holders (private and public)	9,452	183
TOTAL	**16,693**	**318**

The climatic and geographic features of a given area determine the species for the given area. As for the type of dominant tree species 89% of the forests is deciduous and 11% is coniferous forest. Most widespread forest species in Hungary are Oaks (*Quercus* spp.) covers 387,000 ha, European Turkey oak (*Quercus cerris*) follows with 208,000 ha, beech (Fagus sylvatica) can be found on 110,300 ha, common hornbeam (*Carpinus betulus*) gives 96,300 ha. The invasive black locust (*Robinia pseudoacacia*) also forms “forests” in Hungary that covers 447,900 ha. Other hardwood species (maple, elm and ash species) cover 110,000 ha.

Softwood forests that can be found mostly along rivers and in floodplains cover 294,500 ha, out of which 40% is poplar clones for industrial use.

Finally, conifers cover 207,600 ha, out of which 58% is Scots pine (*Pinus sylvestris*), 31% is the black pine (*Pinus nigra*) that is alien to Hungary and 11% other coniferous species.

According to the following table there are some differences in the share of species whether the categories of occupied land, standing tree stocks or wood production are considered.

Table 14. Distribution of forest species in Hungary

Species	Occupied land (%)	Standing tree (%)	Wood production (%)
Oak	20.8	23.3	13.7
Acacia	24.0	13.5	23.0
Pine	11.3	15.0	12.6
Turkey oak	11.1	12.6	11.7
Other deciduous	11.1	12.0	7.4
Aspen	10.5	8.0	18.0
Beech	6.0	10.8	9.7
Hornbeam	5.2	4.8	4.0

As an improvement the wastewater treatment plant in Nagykálló was renewed in 2014 under the National Wastewater Program. The plant treats Nagykálló’s and Biri’s urban waste water. Previously it was operated as a water treatment plant using aspen plantations. After the renewal the treated and purified wastewater flow into an overflow reservoir system now by gravity, from where it is possible to irrigate the surrounding area.

The General Directorate of Water Management recently initiated a project proposal on the practical feasibility of wastewater reuse. The project would be implemented in dry pilot areas such as the “Kecskemét-Tiszaalpár” plot. Within the framework of the project such possibilities as energy production, agricultural use, irrigation etc. would be examined aiming to reuse wastewater of Kecskemét and Kiskunfélegyháza.

Floodplain forests play a crucial role in flood management having the capacity to slow down the flow of waters. The negative process taking place in riverbed caused higher flood levels and decreased our flood protection facilities. This fact and high cost of flood protection developments needed to improvement of the conveyance capacity of the flood bed in Hungary. One of the cheaper solution is the removal of the vegetation which caused run-off barriers. This implemention helps to provide better run-off conditions. In some zones clear-cut is planned while in other places undergrowth of the forests on floodplain will be taken away.

River Basin Management Plan for Hungary, developed in 2009 and 2015, aims to improve not just ecological status of waters but also management of water supply. One of the solutions that satisfy both demands is “giving more space to the rivers”, developing their hydromorphology and improving water retention capacity on rivers’ floodplains.

Drinking water resources especially that are results of infiltration of surface water are often covered by softwood forests. Such area can be found e.g. in the Szentendre island that is the drinking water source protection area for wells that serve potable water to Budapest. The potable water comes from the surface water as infiltrated mainly from Danube through the bank.

The establishment of agro-forestry systems is considered a new potential development area in terms of diversification. The agro-forestry systems are extensive land use systems where trees are attended and agricultural activities are pursued simultaneously, thus a mosaic of agricultural and forestry systems is created. The agro-forestry systems are of great ecological, landscape and social value since they combine extensive agricultural and forestry systems aimed at the production of excellent quality wood and other forestry products.

Concerning the agroforestry systems grazing forests have traditions in Hungary. This new measure is considered as a great possibility to introduce new land use systems. For farming point of view, introducing agro-forestry system in certain special regions of Hungary (floodplains, regions of threat to wind and water erosion) is expected to achieve major positive environmental effects. In agro-forestry system tree plantation in a broad network or tree lines, keeping animals, provide for the multi-purpose use of the given land. The selection of species that fit the needs and the conditions of the area, and, to secure the continuation of agricultural land use, the planting of arboreal plants and herbs for the *creation of wooded grazing areas, grassland protecting shrubbery and tree lines and groups of trees, extensive grazing, broad network of trees for wood production for industrial purposes, forest fruit (apple, cherry, walnut, mulberry, apricot, pear, almond, sour cherry, chesnut, plum), medicinal herb and honey production*.

Pastures

Animal stock increased by 0.8% since 2013. About 90% of the livestock is concentrated in large farms with more than 500 animal units – that ration has not changed since 2010. The main breeds are cattle, sheep, pig and poultry. The numbers of livestock in the end of 2015 were as follows: 821,000 cattle, 1.2 M sheep, 3.1 M pig and the number of poultry (all breeds combined) was 37 million. The major types of livestock breeding are extensive and non-extensive breeding. Sheep, horses and partly cattle are kept extensively using pastures for grazing. It is almost exclusively the cattle that is bred also non-extensively in stables. Pigs are not relevant respecting pastures. Also recently, according to Hungarian legislation, grazing of any livestock breed is forbidden in forests. According to a new scheme (agro-forestry systems) amendment of this rules will be change in floodplain forests.

Pastures make 7.4% of the area of Hungary. As of recently, according to Hungarian legislation, grazing of any livestock breed is forbidden in forests. According to a new scheme (agro-forestry systems) amendment of this rules will be change in floodplain forests.

As follows from the number of livestock, pastures are grazed predominantly by sheep and cattle, and less by horse and other livestock. Livestock grazing has an important role in the conservation management of Natura 2000 grassland areas. Those areas are semi-natural habitats transformed from natural steppes through hundreds of years by livestock grazing. Due to the geographical position, Hungarian grasslands can be considered the westernmost Eurasian steppe or steppe-like areas hosting a diverse flora and fauna with significant populations of steppe species that cannot be found more to the west. Thus agri-environment support scheme was – and probably will be – available for nature friendly grazing to conserve those wild flora and fauna. Hence, such management has positive impact on water quality.

In addition, there are legal obligations on grazing and livestock breeding on drinking water basis, regulating the number of animals, treatment of manure, etc. in line with WFD.

Urban areas

The estimated population number of Hungary calculated from the 2011 census data was 9.8 M on 31st December 2015 (source: Hungarian Central Statistical Office).

Since 2007 the rate of settlements supplied with safe drinking water is constantly 100%. The same rate for dwellings is 94.7%. Between 2000 and 2013, the amount of water produced and supplied, within this the amount of water supplied to households decreased as a result of rising water rates and the proliferation of private wells. This represents a more than 17% decline in case of produced water. The weather had a significant influence on annual household water consumption, e.g. there were water consumption spikes in the droughty years (2000, 2003, 2007, and 2012).

The rate of settlements connecting to utility sewage system is continuously increasing, and was 60.2% in 2014 (there is no data available for 2015 yet). The same rate for dwellings is 77.0%. Between 2000 and 2013, the number of settlements connected to the sewage system increased from 854 to 1860. Along with this, the number of dwellings connected to the sewage system increased by more than 1.2 million to 3.3 million resulting in 75% coverage. Between 2000 and 2013, the average output of the sewage system was 527 million m^3, which was more than 80% of the drinking water abstraction of public water works (661 cubic meters) (source: Hungarian Central Statistical Office).

Municipal wastewater plays an important role in the pollution of surface waters. Individual desiccation-type sewage disposal in residential areas with no sewage system puts a heavy load on groundwater. Due to development of collection and sewage treatment pressure on groundwater decreased, while in the last decade the pressure on surface waters increased.

One of the highest priority point sources (due to the volume of emission) is communal sewage, mainly as a source of nutrient and organic matter load, but may also contribute to hazardous chemical contamination (e.g. metals, salts, antibiotics and other pharmaceuticals, household chemicals and personal care products). Nutrient emission from communal sewage treatment is monitored and reported (BOD, COD, total N, total P, salt and particulate matter) by treatment plant. However, data on hazardous substance emission is scarce. Next Figure indicates the overall estimated impact of treated sewage emission on surface water quality (including hazardous substances), and next Table lists the emissions from communal wastewater in Hungary.

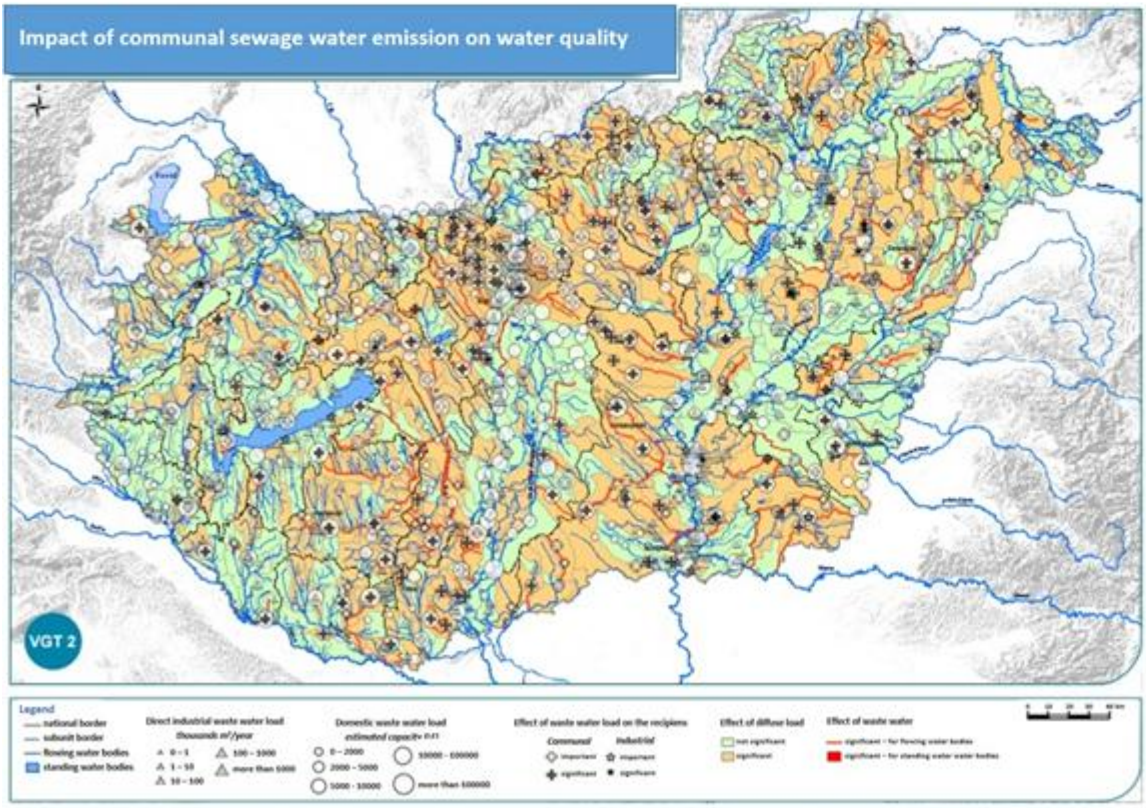


Figure 13. Impact of communal sewage water emission on water quality in Hungary

Table 15. Hazardous substance emission of communal wastewater treatment plants, 2010

Category	Number of records	Pressure on surface water kg/year	Pressure on soil kg/year	Measured components
Cyanides	1	0.6	n.a.	All cyanides (1)
Other non-categorized substances	3	3,118	125	Ethyl-mercaptan (1), surfactants (reacting with methylene blue) (2)
Semi-metals and metals	116	16,311	200	Chromium (VI) (1), total aluminium (1), total barium (1), total silver (3), total mercury (compounds as Hg) (21), total cadmium (compounds as Cd) (18), total cobalt (1), total nickel (30), total lead (24), total iron
Phenols	8	3,729	n.a.	Phenol (3), phenols (phenol index) (5)
Fluorides	3	498	n.a.	Fluorides (3)
Oils, greases	383	1,008,380	18,476	Total aliphatic hydrocarbons (TPH) C5-C40, aliphatic hydrocarbons used as a fuel C10-C32 (1), organic solvent extract (oils)

Urban precipitation runoff is an additional, though not well characterized contamination source in Hungary. In addition in combined sewage systems, heavy precipitation may also lead to sewage overflow, increasing the release of contaminants significantly.

Table 16. Contaminants from urban precipitation runoff

Pollutant	Source
Rubbish, solid materials	Construction works, erosion from unpaved surfaces, air deposition (of transportation and industrial emission), built environment deterioration, stormwater outlets
Oxygen demanding (organic, degradable) substances	Plant debris (leaves, grass), animal faeces, street waste and other organics
Microbial contaminants, pathogens	Animal faeces, combined sewage outlets
Nutrients (N, P)	Air deposition, erosion of unpaved surfaces, combined sewage, fertilizer used in gardens or parks
Heavy metals (Zn, Cu, Cd, Ni, Cr, Pb)	Air deposition (of transportation and industrial emission), outdoor metal objects (e.g. gutters), drainage of waste dumps
Oil, grease	Transportation (vehicles), pumping stations, car-wash
Other organic micropollutants (pesticides, phenols, PAHs)	Air deposition (of transportation and industrial emission), pesticides used in gardens
Salts	De-icing of pavements

In Hungary, household waste is mixed, separately collected as well as bulky waste generated in households including waste generated in homes, residential properties and premises used for the purpose of recreation and leisure. The proportion of recycled and composted municipal waste has risen since 2005. This is mainly due to the expansion of separate collection, since separate collection is available to an increasing number of people with the establishment of civic amenity sites and the location of waste collection points, and separately collected waste can be removed directly from houses in more and more settlements. The average proportion of incinerated municipal waste steadily increased since 2004. However, the proportion of landfilling has declined for years. Comparing the distribution of the three forms of treatment, it is apparent that landfill, which is the least environment friendly form of waste treatment, is the most common process of treatment in Hungary, mainly because it is cheaper than incineration or recycling. The ratio of hazardous wastes (3.4%) to all generated wastes was near the EU average (source: Hungarian Central Statistical Office).

Industrial areas

Industrial sewage from industrial or commercial activities has either directly impacts on the receiving water, or if the facility is located within a municipality, its sewage is generally combined with communal sewage after pre-treatment or stored if necessary. The emissions from industrial and communal sewage in the latter case cannot be separated at the emission point but are estimated based on the scope of the industrial activity. Operations qualifying as significant sources of pollution are listed in the European Pollution Release and Transport Register (E-PRTR) and report yearly on their emission. The proportion of various activities among the facilities listed in E-PRTR is shown in the next Figure.

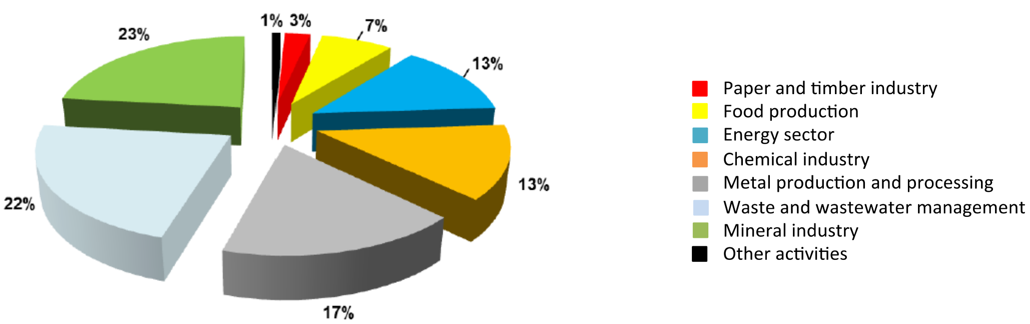


Figure 14. Proportion of various industrial activities in the E-PRTR

Industry using hazardous substances (registered in Seveso) does not necessarily have continuous emission, but it is a risk of pollution in case of industrial accidents, and should be therefore considered. The location of E-PRTR and Seveso facilities is shown on Map below.

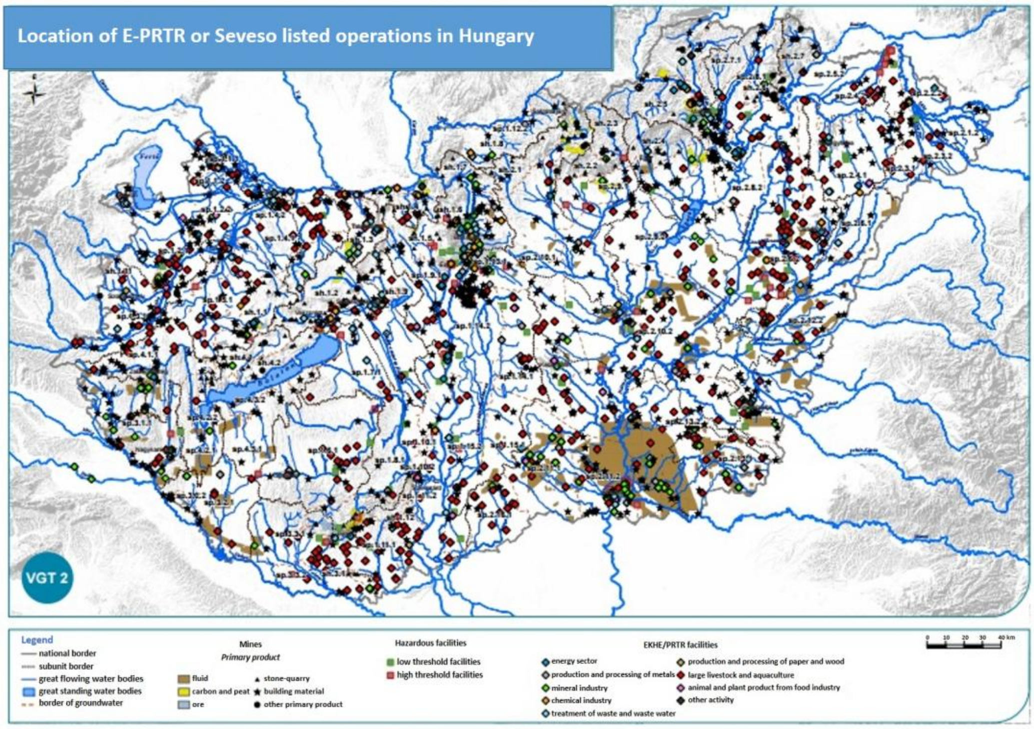


Figure 15. Location of E-PRTR or Seveso listed operations in Hungary, with the indication of activity

All industrial or commercial activity (import, manufacturing, storage, transport, distribution or retailing) related to hazardous substances is to be reported to national authorities. The lists of CLP, REACH, PIC and biocide related activities was used to identify substances which may contribute to water pollution during regular or accidental release (see next Table).

Table 17. Hazardous substances linked to commercial activities, on national and sub-catchment scale

Compound	Number of activities	Danube	Tisza	Drava	Balaton
1,2,5,6,9,10-hexabromocyclododecane (1,2,5,6,9,10-cyclodecane)	1	1			
1,2- dichloroethane	1	1			
alachlor (technical)	1		1		
Anthracene	1	1			
Benzo(a)pyrene	2	2			
Benzo(b)fluoranthene (benz[e]acephenanthrylen) Benzo(k)fluoranthene (PAH_c)	2	2			
Benzo(g,h,i)perylene, indeno[1,2,3-cd] pyrene	3	3			

Compound	Number of activities	Danube	Tisza	Drava	Balaton
Benzol	10	3	5	1	1
cybutryne (N'-terc-Butyl-N-cyclopropyl-6-(methylthio)-1,3,5-triazine-2,4-diamine)	1	1			
Cyclodiene pesticides (aldrin, dieldrin, endrin, isodrin)	4	3	1		
Cypermethrin	14	14			
dichlorvos 2,2-Dichloroethenylphosphoric-dimethyl-ester; 2,2- Dichlorovinyl-dimethyl-phosphate	1	1			
Diuron	6	3	3		
hexachloro-cyclohexane	1	1			
Isoproturon	14		14		
Naftalin	37	23	9	1	4
Heavy metals: cadmium (1), nickel(49), lead (41), mercury (20)	111	92	11	4	4
nonylphenol (4-nonyphenol)	19	4	15		
octyphenol (4-(1,1,3,3 -tetra-me hyl-butyl) phenol)	4	4			
Pentachlorophenol	2	2			
Tetrachloromethane	4	2	2		
terbutryn (2 tert-butylamino-4-etylamino-6-methyltio-1,3,5-triazine)	5	4	1		
tetrachloroethylene (tetrachloroethene)	2		2		
Trifluralin	1	1			
trichloroethylene (trichloroethene)	4	4			
trichloromethane (chloroform)	13	4	6	2	1
Total	**264**	**176**	**70**	**80**	**10**

The list of activities clearly shows the location of large industrial zones, and the predominance of Budapest. Other potential point sources include previously contaminated sites and active or recultivated waste dumping sites. Mining is considered a diffuse source of heavy metals.

Transport units

Hungary has one of the highest motorway densities in all of Europe and the third highest road density, after Belgium and Holland. Highways reach the borders of the country and the different regions of Hungary. Hungary has a central location in Europe, at the crossroads of four main European transportation corridors. Major Hungarian towns are connected to the capital city, Budapest, by motorways.

Due to its central location, Hungary has an extensive railway network. Rail transport carries more than 20% of total freight, which is well above the EU average. Several main train lines connect Hungary with the main ports of Western Europe and the Adriatic with regular services. The total length of the Hungarian railway system is 7,729 km, of which double-track is 1,335 km (17.3%) and the electrified railway network is 2,628 km (34%). Záhony and its region is the junction and reloading centre for European standard-gauge railways and the wide-gauge system of the CIS states.

Hungary has excellent waterway connections, as the Danube crosses through the whole country from north to south. The Danube-Rhine-Main canal in Europe links the North Sea and the Black Sea: several scheduled block train lines connect Hungary with the seaports on the North Sea, and on the Adriatic.

Runoff from transport areas may carry rubbish, petroleum compounds, salts, and contaminants from air deposition (e.g. heavy metals) including greenhouse gases as well. The contaminants from transportation can be detected in surface and groundwater as well. Eco-friendly de-icing alternatives are more and more used in the last decades like Calcium Chloride or Magnesium Chloride (both in liquid form), just sand or zeolite granulates on pavement. Also the anti-icing technology instead of de-icing is spreading. Anti-icer brine solutions are applied prior to snowfall to prevent snow and ice from bonding to the pavement.

2.1.4.3. Impact of flood and drought on drinking water quality and quantity in Hungary

Hungary is facing serious issues due to both floods and droughts. The temporal and spatial distribution of surface water resources is very extreme. Generally there are two main periods of river flooding events: floods in early spring are caused by runoff from snowmelt, while floods in early summer are the consequences of maximum precipitation at the beginning of summer. Nearly the half of Hungary is plain area (44,500 km^2), with endorheic lowlands having a significant share. More than 20,000 km^2 are exposed to floods, of which 5,610 km^2 belong to the river basin of River Danube, and 15,641 km^2 to the river basin of River Tisza. The most recent flooding event was is Budapest in May 2017.

Flood management of Hungary has been based on the EU Floods Directive (2007/60/EC). Riverbed management plans are aimed at reduction of flood levels, keeping or repairing capacity of riverbed and ensuring the flood protection safety. Government Regulation 232/1996 (XII.26.) on protection against damages caused by water regulates the flood protection tasks and competencies including the governance of activities and responsibilities of institutions. The height of the damage protection infrastructures is based on the Minisztatial Regulation 74/2014 (XII. 23.).

There are 8 areas with potential significant flood risk identified in Hungary (Felső-Duna, Balaton, Dráva, Alsó-Duna, Közép-Duna, Felső-Tisza, Középső-Tisza, Alsó-Tisza).

A good management practice example is the establishment of the NAGIS map portal by Natér which offers up-to-date data on the policy-making, strategy-building and decision-making processes related to the impact assessment of climate change and founding necessary adaptation measures in Hungary.

According to the flood risk .shp data provided by Hungarian Project Partner, around 14.9% of flood risk area has high probability flood scenario, medium flood probability scenario occupies 37.8% of the flood risk area, while low flood probability scenario take the remaining 47.3%.

One of the major issues is certainly the accumulation of silt on the riverbed and in flood plains which contribute to increased flood risk and water quality deterioration. The floodplains are narrow and the dykes are low that can expand the flood risk hazard.

The drought can occur in 90% of the Hungary and can primarily affect the centre of the Great Plain, where the evapotranspiration usually exceeds the precipitation amount (climatic water scarcity). The climatic water scarcity/excess is ranging from 100 mm/year excess to 350 mm/year scarcity, with the peaks in the southern Tisza catchment. This periodically occurring phenomena – causing long-term water scarcity for the flora and the fauna, the agriculture and for the society – will be worsen by the climate change.

Drought risk assessment is based on a national methodology called “Pálfai Index” (PAI). There are no specific regulations on droughts management but according to the Act LVII of 1995 on water management there is priority order of sectors in water supply. In case of water shortage the drinking water utility supply has the priority. But the situation will only worsen in the coming years as groundwater level differences exceed the -10 meter mark. Therefore, drought management should become a priority. Hungary adopted the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa. Our obligation is to report regularly to the UNCCD on the activities supporting the implementation of the Convention.

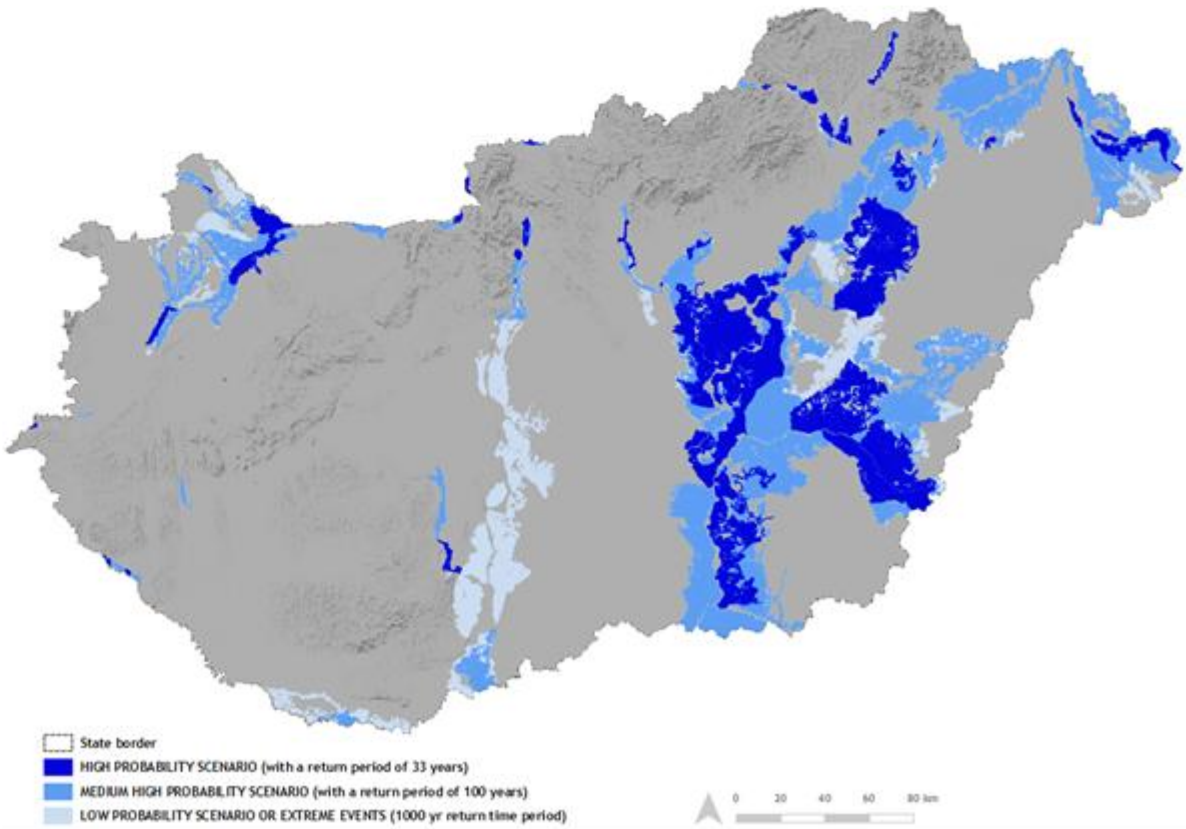


Figure 16. Flood hazard map of Hungary (data provided by Hungarian Project Partner; hillshade by ArcGIS REST Services Directory)

2.1.4.4. Overview of status quo in Hungary via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Hungary as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Hungary is shown in Table 19. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 18. SWOT analysis for Hungary

S (HU)	W (HU)
Implementation of DWPZ for drinking water sources with limitations of spatial planning and activities in those areas Hungary has well established system for regulation of groundwater and surface water abstraction (water permits) Considering the protective function of aquifer protection layers in the planning process of DWPZ Development of supplying networks from different drinking water production areas to ensure a continuous water supply with clean drinking water Advisory system and support of EARDP for farmers to implementation agro-environmental measures UN Sustainable Development Goals approved by several governments/politicians Agricultural advisory services Protection and restoration of wetland areas Policy and legislation initiatives Sustainable agriculture in nature-protected areas	Conflicts of interests in DWPZ areas (agricultural lobby, industry) Insufficient inspections of good legislation implementation Unstable public administrative structure with several organizational changes in last decades especially on water sector Data quality and water databases are not reliable in all aspects No compensation for the owner of the area of the designated DWPAs Insufficient education or disinterest of local population and farmers in some regions Low percentage of wastewater reused Missing or incomplete water treatment plants Losses from water utilities Lack of the individual sewage treatment Low willingness to cooperate between farmers, other stakeholders and water suppliers to ensure water protection Financial commitments are not enough to implement completely the Program of Measures of RBMP/FRMP Single area payment scheme (SAPS) and primarily direct payments to farmers weakly support environmental protection, implementation of “greening” not really effective
O	**T**
Combined approach addressing droughts and floods with multiuse reservoirs The use of EU funds, particularly agricultural, structural and cohesion funds for co-financing projects to manage groundwater and surface water resources The upgrading of the requirements of water management in urban planning Intensification of the cooperation between farmers and water suppliers to enhance the drinking water protection in and beyond the borders of DWPA Ensuring minimum ecological flow in drought-endangered river basins Fostering awareness of humans to flood risks to increase the individual protection of humans and belongings Synchronized water protection and flood risk management measures Realization of “greening” scheme to enhance water protection Promotion of precision agriculture; Research on ecosystem services	Lack of investments into sewage and wastewater treatment Climate change with more intensive precipitation and dry periods No effective control of groundwater and surface water abstraction by water authorities Lack of the authority decisions of the DWPAs Alien and invasive species deteriorate ecosystem services Complicated and unsettled ownership of agricultural lands, forests, watercourses, etc. Unknown impact of priority substances (e.g. biocides, drugs) on ecosystem Cultivation of arable land with no buffer zones along water courses Intensive plant production, regardless of soil and water conservation

2.1.5. Italy

2.1.5.1. Drinking water protection zones in Italy

According to art. 94 of Italian D.Lgs. 152/06 (that implements 2000/60/EC), Regional Administrations establish “protection zones”, within catchments and ground water recharge areas, for water bodies used for the abstraction of drinking water. In the protection zones specific land use limitation and constraints can be imposed to different settlements and activities (civil, industrial, touristic, agricultural etc.) to be adopted within sectoral and general planning at municipal, wide area and regional level. According to the same legislation, Regional Administrations also define more territorial constraints aimed to ensure the quality of drinking water, that is "safeguard zones", organized in:

- “absolute protection zones" immediately near water abstraction points (water wells, water uptakes), where there can be only uptake devices and services structures;
- "buffer zones", around absolute protection zones”, where constraints and land use limitation are imposed.

Within this general national framework, the operational criteria for determining water protection zones are defined by the Regional Administrations at the proposal of the Water Services Regulation Authority (consequently they may be slightly different each other); the regulation is finalized to avoid contamination of water resources for drinking water supply, from pollutants. Water Services Regulation Authority cooperates with the Environmental and Health Agency and local authorities.

The protection zones for surface and groundwater resources are designated based on the geological, hydrogeological, hydrological and hydrodynamic characteristics of springs, wells and supply points of surface drinking water. The general criteria are: geometric, hydrogeological and temporal.

Near the catchment with protected areas, land-use constraints are established, designed with the aim to ensure the appropriate quality of drinking water supply. The protection areas are designed through: “static security”, “dynamic” or “geometric” criteria.

The “static” protection consists of prohibitions, restrictions and regulations aimed at preventing deterioration in the quality of water at the catchment points, as well as measures and limiting land use for both quantitative defence and resource vulnerability.

The “geometric” protection and “dynamic” is applied in the buffer zones. For example according to the Emilia Romagna Region, the “geometric” protection is established by a circular area of 200 meter radius from the catchment point (“Water Protection plan” 2005). The “dynamic” protection is formed by the activation of a management system to monitor water quality in the catchment inflow able to check the quality parameters to allow the reporting of any resource faults.

Data within the .shp provided by Project Partner include only DWPZ within Northern Italy, and they take up around 36.33% of the total Italy’s territory.

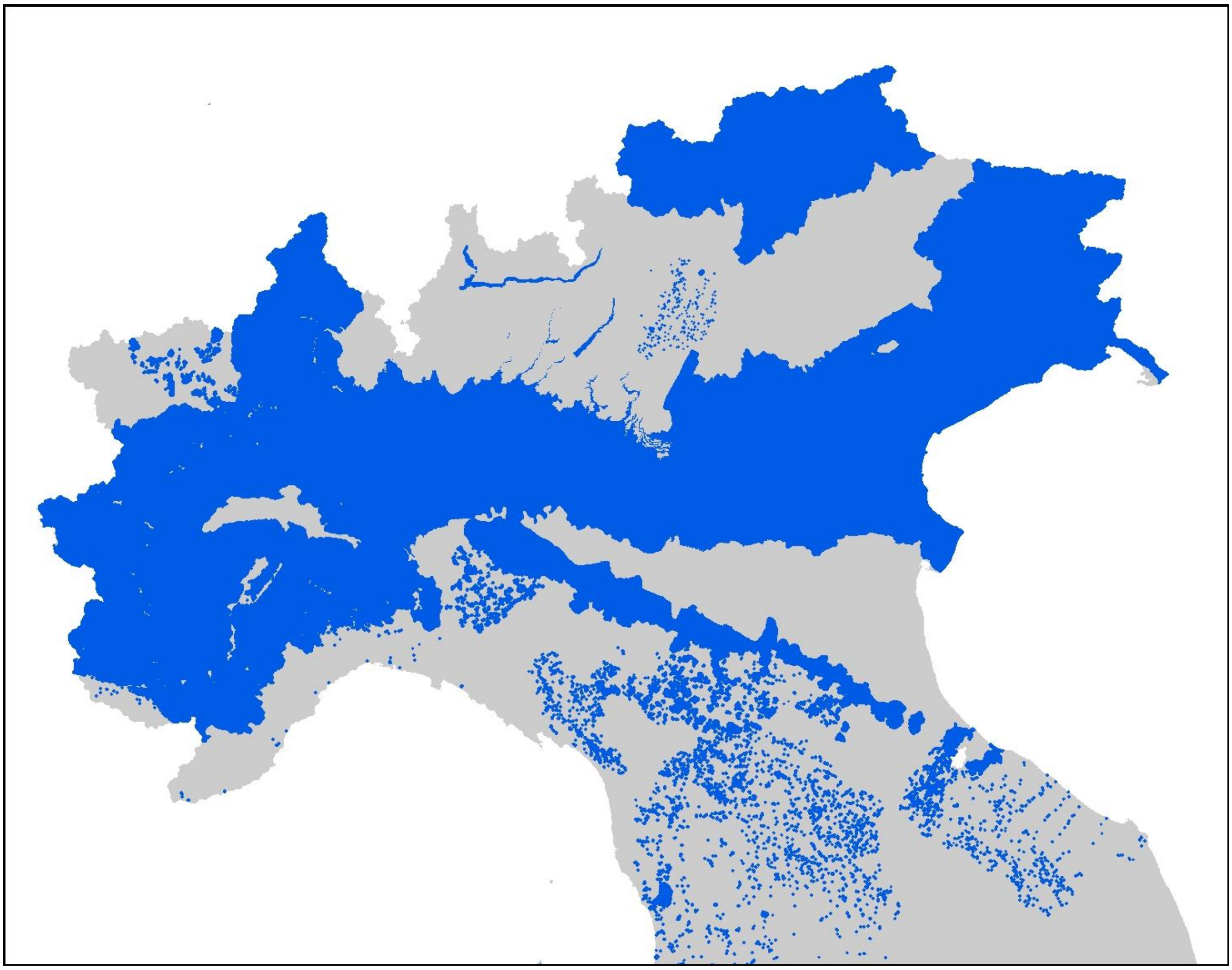
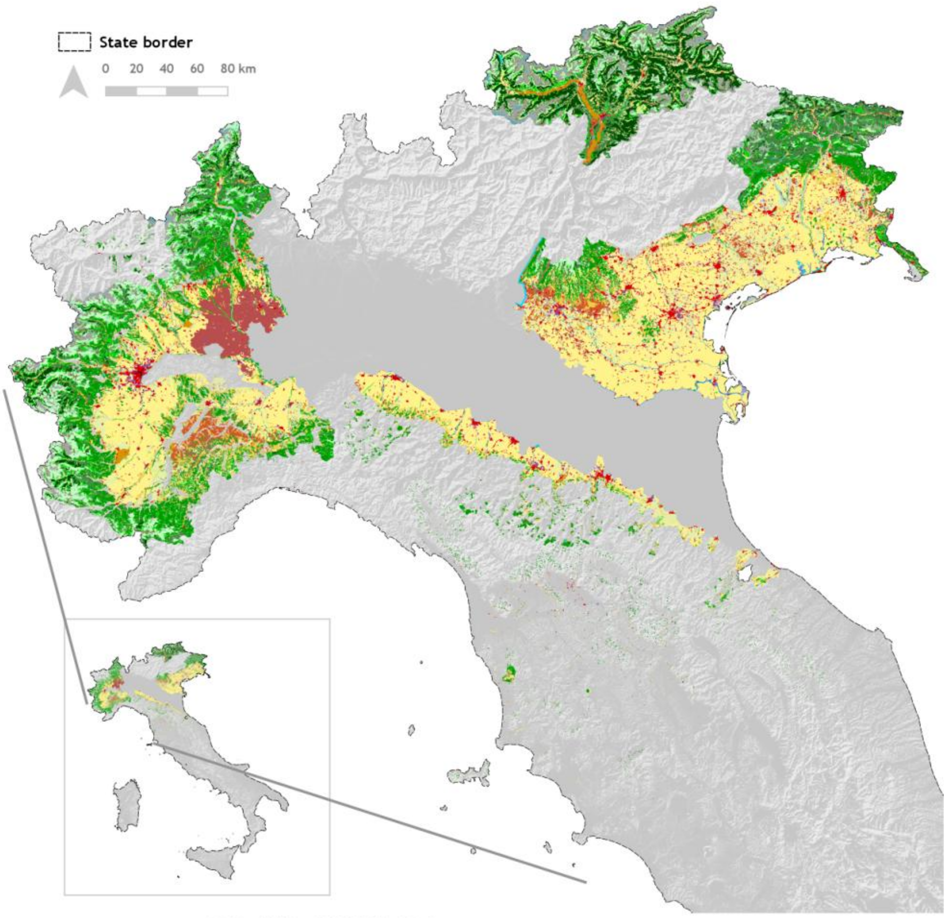


Figure 17. Drinking water protection zones (blue) in the Northern Italy

2.1.5.2. Impacts of land use activities on drinking water quality and quantity in Italy



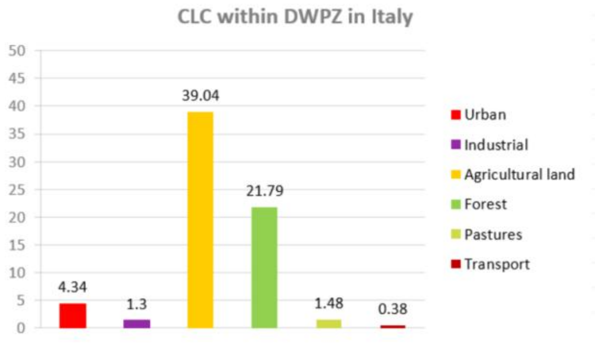


Figure 18. Land use categories within drinking water protection zones of Northern Italy

Agriculture

Agriculture is one of the main economic sectors in Italy: in 2010, 43% of the country territory was devoted to agriculture, including arable land, permanent grassland and meadow, permanent crops and kitchen gardens (EC, 2010).

Agriculture consumes large quantity of water in Italy, around 11,600 M m^3 (in the agricultural season 2009-2010). Italy has 2.4 M irrigated hectares and share of irrigated area with respect to the Utilised Agricultural Area (UAA) is 19%. However, the potential for irrigated surface is exploited at 66%. Large differences exist between the North, Centre and South of Italy, with the North consuming two times the water volume per hectare with respect to the Centre and the South, and presenting more than four times the share of irrigated area of the UAA. Thus 73% of irrigation in Italy occurs in the North (especially in the North West), almost 23% in the South and major Islands, and the remaining in the Central territories. Also in case of organic farming, irrigation is concentrated in the North-Western regions, but directly followed in this case by Southern regions as Sicily, Puglia and Calabria. In general, plans host most of irrigation practices (72% of total and 42% of the UAA).

Used water is of public origin (aqueducts and/or irrigation consortia) for the 63%, mainly in the North, while the remaining sources are managed privately (53% and 47% from underground and superficial resources, respectively). Around 62% of the system is at low efficiency (datum mainly affected by the "submersion" practice adopted for rice) while 38% has high efficiency (e.g. drip or sprinkler irrigation); organic farming is committed to use most efficient systems, with twice utilization of drip systems.

From a water quality point of view, fertilizers and pesticides remain the main problems although their gradual reduction (since 2000) thanks to the diffusion of organic farming (ISPRA, 2016). Several laws and norms in the last two decades regulate the use of organic and mineral fertilizers. First, the EU Nitrates Directive (1991) fixed to a maximum of 170 kg N/ha/year the amount of manure to be applied on soil and to 50 mg/l the maximum amount of nitrates admitted in water bodies. This Directive was then reinforced by EU Directives in 2000 and 2006 (for Water in general and for underground waters, respectively) and, from 1999 to 2014, by Italian legislation aiming at regulating the impact on water resources from agriculture and the role of organic waste treatments, mainly favouring good agricultural practices and by identifying vulnerable areas. Mineral fertilizers are still the most used (45%), followed by organic fertilizers and improvers of mechanical soil characteristics (35%), and by products corrective of soil chemical-physical properties, mixed organic-mineral products, cultivation substrates, and more specific product to improve absorption of nitrates by soil and to correct physiological anomalies.

The other threats for water bodies are phytosanitary products which are regulated by specific Strategies and Directives, and by cross-sectoral governing instruments as the Water Directive. From 2004 to 2014 the active ingredients are in decrease, but in the year 2013-2014 there was an inversion of tendency. Both long term and short-term trends are opposite for organic active ingredients. The most treated crops are vineyards and tomato (more than 10 kg/ha of active ingredients).

Forest

According to the last national inventory on forest and forest carbon sink (INFC, 2015) the Italian forested surface, based on the international definition adopted by the Global Forest Resources Assessments (FRA), cover 10,982,013 hectares (i.e. 34% of the national territory), showing an increase with respect to the 10,345,282 hectares estimated in the previous inventory (INFC, 2005), and a +300% of coverage in the last 60 years, due to the gradual abandonment of the mountainous areas and of agrosilvopastoral systems.

The forested surface (forestland) consists of the macrocategory “forest” (84% of the total and 29% of the national territory), and of the macrocategory “other forestlands”, made of shrublands and Mediterranean maquis.

In terms of landscape composition, 44.4% of forests are close to agricultural areas, 28% adjacent to grassland, pastureland and uncultivated lands, 8.7% are near low or no vegetated zones, and 4.7% and 0.9% close to water bodies and wetlands, respectively. For the “forest” macro-category of forested lands, the density range from 62.6% of Liguria region to 7.5% of Puglia, while 67.5% of forests have a total coverage of 80%. For the macrocategory “other forestlands”, 60.3% of the surface presents a coverage higher than 50%, and 38.6% higher than 70%.

Forests are made of about 75% needleleaf communities (most diffused forest formations: Sessile, Pubescent and English oaks, common beech, chestnut and Turkey, Hungarian, Macedonian and Valonia oaks), except for several alpine areas in Valle D’Aosta and Trentino Alto Adige, and 15% of coniferous dominated by spruce (586,082 hectares that correspond to about 6.7% of forests in Italy); the remaining 10% consist of mixed communities. The main management practice is coppice (41%, 3,663,143 hectares) with prevalence of coppice with standards (35%), mainly represented by forest stands near to the utilization period or aged.

High stands occupy 36% of Italian forests (3,157,965 hectares), with slightly prevalence of even-aged (15.8%) rather than multi-aged (13.5%) and they are mostly represented (50%) by mere coniferous, especially spruce, silver fir, European larch, Mountain and Mediterranean pines. The most productive coniferous are in the North-East. Moreover, cultivation typologies considered special (chestnut, black walnut, cork oak), represent a significant genetic and economic local resource, and they cover around 200,000 hectares (INFC, 2005).

Forest plantations cover 1.12% (122,252 ha) of forests, whose 84% are pure broadleaved with a prevalence of poplar (66,269 ha) and noble hardwood and Eucalyptus (40,985 ha).

The net removal of CO_2 from the atmosphere by Italian forests is 34 Mt/year, considering losses due to wood harvest, fires and other biotic and abiotic disturbances. According to the INFC (2005), the 81.3% of Italian forestlands is available for wood harvesting, corresponding to about 35.5 Mm^3 of wood. However, the wood volume effectively harvested through silvicultural operations is less than 9 Mm^3 (whose more than 60% is wood for energetic use) according to FAOSTAT, and around 13.5 Mm^3 according to INFC (2005). Data about harvesting, probably underestimated, mainly by FAOSTAT that does not consider the utilization of small forest properties (< 3ha) for which cutting is declared but without information about the harvested volumes, are between 25% and 38% of yearly production, and largely lower than the average of EU-28 countries that is around 65% of the yearly production (MCPFE, 2015).

Around 1,854,659 hectares of forestlands (17.7% of the total) contain infrastructure. In terms of property, 63.5 % are private, 32.4 % public and around 4% unclassified.

Some important restrictions refer to Italian forestlands: 81% of them (87% of forests) are under hydrogeological constraints (Royal Decree 3267/1923; i.e. soil working or movements are not possible without demonstrating they do not alter the hydrogeological equilibrium of the area), so that 77% of forests' soils are not affected by instability. The 27.5% of forestlands are under environmental restrictions (mainly in the Centre and South): National Parks, Regional Reserves and Natura 2000 network (SIC and ZPS) occupy 7.6%, 6.7% and 22.2% of the forestlands.

Forests are strategic for soil instability/landslide mitigation and water cycle regulations. Forest cover in general reduce runoff and erosion thanks to interception of rainfall from canopy vegetation and increase water storage in soils by reducing evaporation; moreover, tree roots have a stabilization role on soil particles. However, usually forests are also the dominant land cover/use on steepest slopes, where hydrogeological instability and superficial water flow are facilitated by gravity. This is the reason why correct forest management is crucial and should avoid for example the increase of woody debris weight on the hillslope or its transport by runoff and creation of barriers in the river channels. Finally, protecting forests by fires is crucial as fires effects consist not only of direct damage of vegetation but also on alteration of physical and chemical soil properties, as loss of organic matter, increase of bulk density, reduction of soil porosity and infiltration capacity, and increase of soil water repellency.

The most used species to consolidate hillslopes are: *Acer campester*, *Robinia pseudoacacia*, *Carpinus betulus*, *Quercus pubescens* and *Sorbus domestica*, while along riparian areas, to reinforce river banks or adjacent areas, the most appropriate species are: *Salix alba*, *Alnus glutinosa*, *Morus alba*, *Sambucus nigra*.

Pastures

Livestock farming represent almost 1/3 of the Italian agricultural production, corresponding in 2013 to more than 17.5 M Euros, with meat representing more than 60% of production value, followed by milk, eggs and honey (CREA, 2016). Livestock farming is mainly intensive, with farms well distributed but cattle is concentrated in few areas (the North). Because of this concentration, many parts of the Country's territory are suffering from pressures on the environment and on the economic costs, because of the need to be compliant with severe Laws and Directives as the Nitrate Directive (1991). To give an idea, Lombardy hosts 25% of bovines and more than 50% of swines, while more than 40% of sheep and goats are concentrated in Sardinia. However, livestock sector is not only intensive and concentrated on the plans but it is also active in hilly and mountainous areas of the Centre and the South to value local production contributing also to environmental protection. In the last decade, there was an increase if farm size, and especially in in the North West the share of livestock farming over the whole agricultural sector almost doubled rising by 17% and reaching 31%.

The Legislative Decree 152/2006 (known as "Environmental Code") and its integrations in the Legislative Decree 128/2010, are the main texts on pollution, and also regard the livestock sector and implement the EU Water and especially Nitrates Directives concerning the need of monitoring both superficial and underground water bodies, the definition of vulnerable areas, the identification of good practices and the adoption, implementation and monitoring of actions.

If the livestock activity is conducted within a vulnerable area to nitrates, the yearly average nitrogen load should be less than 170 kg N per hectare, included the manure applied and left on pasture. In general, during autumn and winter both mineral and organic fertilizers are prohibited, and storage facilities or removal of livestock manure are required during periods of prohibition. The use of fertilizers and manures should be limited to the crop needs, and application on saturated or flooded soils, on soils with very shallow groundwater or covered with snow or ice, or on steep slopes (>10%) is not permitted. The application should be as much homogeneous as possible and respecting distances from water bodies. All data about fertilizers and manure should be registered by farmers together with information about farming practices.

For farms exceeding in the production of animal-source nitrogen, the limit of 170 kg N per hectare per year was changed (in 2011) to 250 kg N/hectares but only for bovine and swines, and only if farmers, on at least 70% of the UAA, conduct long-season cultivations that uptake nitrogen. To manage livestock manure it is required that 2/3 is applied by the end of June, and the remaining by the end of October, so to maximize nitrogen use efficiency.

However, the EU Nitrates Directive is a dynamic one: water quality should be monitored in the meantime, and both vulnerable areas and actions plans need to be updated (at least every 4 years). The Nitrates Directive is today embedded into the Water Framework Directive and is one of the Mandatory Management Criteria in the context of eco-conditionality of the Common Agricultural Policy.

Urban areas

In Italy, 28% of population (about seventeen million people) live in eighty five centres exceeding 40,000 inhabitants. Concerning water resources, over a water uptake of about 26 M m^3/d, the 30% is conveyed to water treatment plants. Such value is also strongly conditioned by the source: groundwater resources (if not in highly anthropogenic areas) do not normally require purification processes while they are necessary for surface waters. In this regard, the highest percentages are detected for Basilicata (83%) and Sardinia (75%) regions while the minimum value is for Valle D'Aosta (3%) (ISTAT, 2012). In summary, groundwater, surface water bodies and marine or brackish water respectively cover about 85%, 15% and 0.1% of water demand. The water supplied per capita for domestic use is about 175 l/in./d (updated to 2011 for the 116 chief towns; ISTAT, 2012) with a remarkable decrease compared to 2008 survey (210 l/in./d; -16%); however, large variations are detectable among the urban centres with values ranging slightly over 100 l/in./d for Arezzo (Central Italy) and nearly 250 l/in./d for Catania. In this regard, a crucial role is played by pipeline leaks; indeed, the difference in percentage between water fed into the network and dispensed amount reveal losses above equal to 50% for 27 cities over 84 while only in 8 cases it does not reach 15% (average value 37%) (De Gironimo et al., 2015). About waste waters, in terms of population equivalent (PE - expressed as 54 grams of BOD over 24 hours), four cities have values close to or greater than two Ms (in order, Rome, Turin, Man and Naples) while in other nine cases 500,000 in. are passed. Although 91/271/CEE (Art.3) limits the use of individual systems to conditions where "no environmental benefit" or "excessive cost" are recognizable, in 33 over 85 cities their use is over 2% and in 10 cases exceeds 10% (22% for Venice, 36% for Pordenone and 50% for Catania). Moreover, in such contexts, a non-negligible fraction of wastewaters are not treated: i.e. 3% in Naples, 4% in Genova and 9% in Catania (UWWTD Questionnaire 2013; Salvati et al., 2015). On the other side, in about 30 cities all wastewater is channelled into sewers. To assess the diffusion of water treatment plants on the national territory, the ratio between unit per capita loading produced and that reaching the plants is investigated. For 54 towns it ranges between 95% and 100%, in 29 cases it is over 60% while for Benevento and Catania (Southern Italy) it is about 20% (UWWTD Questionnaire 2013). Furthermore, other interesting information arise by monitoring of percentage of waste water that, after the treatments, comply with limits set by 91/271/CEE in terms of concentration (mg/l) or reduction percentage. In this regard, reference parameters are BOD5, COD and nutrients (only for sensible areas). Such areas are defined as already eutrophic or prone to eutrophication. For 62 centres, the percentages are higher than 75% (100% for 29 cases) while, for 11 cities, they are lower than 25% (6 in South and 5 in North Italy) (UWWTD Questionnaire 2013). Up to 2012 (ISTAT, 2012), over 18,000 plants were recognized working in Italy; the largest part is located in North-West Italy (35%). If they are discriminated according typology, about 8,000 Imhoff tanks, 2000 plants with primary treatments, 6000 with secondary and over 2000 with tertiary treatments are reported. However, in terms of population equivalent, the first two serve less than 4 M while the other two respectively 26 M and 45 M PE.

Industrial areas

According to ISTAT (2011) survey, in Italy manufacturing enterprises employ about 4 M people (2,6 M in North, 662 K in Central and 549 K in South Italy). In this regard, are considered only activities labelled as "Manufacturing activities" by ATECO 2007 Italian classification (ATtività ECOnomiche, Economic Activities) implementing European NACE Rev.2 (Statistical classification of economic activities in the European Community). Six sectors cover around 74% of employees: manufacture of basic metals and fabricated metal products (17%), textiles and similar (13%), machinery and equipment (12%), food and beverage (11%), rubber and plastic products (10%), other manufacturing including repair and installation of machinery and equipment (11%). Concerning water resources, slightly over 5 billion m^3 of water have been used in 2012 (the only year for which investigations are currently available) (Istat - Eurostat Grant agreement 2013). Three sectors exert a high water demand (about 33%): manufacture of chemicals and chemical products (681 M of m^3), rubber and plastic products (645 M) and manufacture of basic metals (552 M). Furthermore, other high water consuming sectors including, for example, textiles, food and beverage, paper and related products exploit about 34% of water. An effective way to investigate environmental pressure is given by Water Use Intensity (WUI) Indicator representing, for sector, the ratio between consumed water and sold production on yearly scale. According to ISTAT analysis (2016) for 2012, higher WUI values are returned for textiles sector (25.1 l/€); moreover, for six sectors values ranging between 17 and 19 litres are estimated. In this regard, less water demanding sectors (4 or less l/€) include food production, leather and related products and pharmaceutical preparations. Moreover, it is interesting to observe how greatly higher WUI values are found for mining and quarrying activities (about 70 l/€). Regarding the sources of water supply, enterprises with less than 5 employees usually adopt drinking water provided by civil pipelines (195 K m^3) while medium and large firms use systems at their exclusive service or serving industrial clusters (ISTAT, 2016). Concerning wastewaters, ISTAT (2012) displays how 19.5% of waters undergoing treatment derive from industrial facilities (respectively, 21%, 25% and 13% for North, Central and South Italy). They correspond to about 14 M of PE over an overall value of around 75M.The significant decrease with respect the previous

2008 survey is primarily due to increase in greater pollution load from domestic use and the economic crisis leading to the closing of many activities. Furthermore, through European Pollutant Release and Transfer Register (E-PRTR), a first picture about pollutant releases to water can be furnished. Indeed, such register, established after Regulation (EC) No 166/2006, report data on the main pollutant releases to air, water and land of about 28,000 industrial facilities across the European Union and EFTA countries and on off-site transfers of waste water and waste from these facilities. Currently, the available most recent data are for 2014. Considering, for Italy, again only "Manufacturing activities", 1652 facilities have provided data regarding air and water pollutant releases; regarding the most dangerous substances, it can be note that 427 t of heavy metals are declared released in water bodies (about 172 t for Zn, 93t for Cr and 63 for Ni). Concerning inorganic substances, are detectable high amount of chlorides (2,590,410 t with 14,310 t accidentally released) while nitrogen and phosphorus releases respectively amount to 28866.3 t (44.6 t accidentally released) and 2896.2 t (4.89 t) and 219 kg for pesticides. The comparison performed by NGO environmental organization Legambiente (2014), for 2011 data, with corresponding provided by the most developed European countries (France, Germany, UK) reveals how in Italy the direct input of chemicals releases by industrial activities in the surface water bodies is still high with potential extremely negative consequences. A further interesting information is provided by data about pollution releases of wastewater treatment plants; indeed, they represent a "measure" of effectiveness of treatments. In this regard, available data (source E-PRTR) display how, also after treatments, remarkable amounts of pollutants are released in water bodies; for the 19 facilities considered in the survey, for example, about 53 t of heavy metals and about 60 kg of pesticides; indeed, as they are often designed primarily for civil/domestic wastewaters, they do not include in the treatment "ad hoc" processes for industrial wastewaters.

Transport units

ACI (Automobile Club d'Italia-Italian Car Club) reports in detail the features of the national road network updated at 2011 discriminating on the basis of road type or its location. At National level, the entire network road extends for 154,000 km; in the specific, highway network extends for about 7,000 km (27% in North-West [NW] Italy,23% in North-East [NE], 18% in Central [C] Italy, 22% in South [S] and 10% in Insular [I] areas), primary roads for 20,423 km (about 10% for NW, NE and C, and about 33% for S and I), secondary roads are about 8000km while provincial ones extend for over 100,000 km. On average, the ratio between road length (km) and surface (km^2) returns at national level a value about equal to 0.5 while the ratio between road length and population is about 0.25. Concerning the management of wastewaters from roads, the reference legislation is represented by 152/2006 Law; in the specific, the article 113 addresses the matter. According to it, control and management of wastewaters produced by precipitation that, through runoff processes, wash out impervious surfaces has to be regulated at Regional level. Moreover, Regions regulate treatments and permissions for "acque di prima pioggia" (first rains) and washing waters considered most polluted. In particular, the identification of activities for which more significant hazards may arise in terms of stormwater contamination are required. In this regard, the regional regulation adopted by Lombardy (L.R. 4/2006) could represent a valuable example. It defines "acque di prima pioggia" as the first 5 mm fallen on the draining surface while to discriminate between two distinct events, it considers an interarrival time longer than 96 hours. After, it defines in detail activities subject to regulation (i.e. chemical, concrete, leather, paper, textiles industries or car repair services). Then, it prescribes that first rains or washing waters, in these cases, should be separated from the remaining, stored in specifically sized tanks and subject to treatments that allow the reduction of pollutants below required thresholds. For what concern the activities carried out to prevent freezing on the roads, for example the main highway company operating in Italy, Autostrade s.p.a., drew up the "Plan for Management of Snow Emergencies" in which procedures for operators and drivers to follow in case of snow are reported in detail. Moreover, the location of deposits for calcium chloride (168) and of vehicles (i.e. snow blades, salt spreaders) is indicated. Finally, five color codes allow communicating to drivers the hazard level.

2.1.5.3. Impact of flood and drought on drinking water quality and quantity in Italy

Flood management is regulated by the Italian Laws D.lgs. 49/2010, according to the European Flood Directive 2007/60/EC and D.lgs 152/2006. These laws establish the Flood Risk Management Plan and the District Hydrogeological Regulation Plan (PAI). According to the D.P.C.M. 29/9/1998, River basin Authorities are charged with identifying flood risk areas and dividing them into four risk classes, from low risk areas (R1) to very high risk areas (R4).

The Italian National Institute for Environmental Protection and Research, ISPRA, yearly publishes the updated maps of flood hazard, deriving from the collection of flood hazard maps supplied by every Italian River District Authority. The estimation of potential flood damage has been done at a national level, considering flood exposure, vulnerability, hazard maps and the number and location of exposed people as well. Italy has a high probability of floods and should focus their efforts in protection and update of existing facilities, measures and buildings.

Drought management is regulated by the Italian law D.Lgs. 152/2006, according to the European WFD 2000/60/EC. This law establishes the District Management Plan, containing the Water Balance Plan to manage drought and water scarcity. Also the Regional Water Protection Plans, introduced by the same Law, are instruments for water resources management and protection during drought events (Fondazione CIMA, 2011). The permanent national network of “Observatories on water uses” established on 13 July 2016 assess temporary water scarcity and shortage events. This network considers three scenarios, low, medium and high, for temporary water scarcity.

No drought risk assessment is done at a national level, because the Law R.D 1775/1933 requires the nomination of an emergency commissioner in case of drought/water scarcity events. There are no designated areas exposed to significant drought risk at national level. Many River District Authorities have developed drought risk assessment within the Water Balance Plan, as part of the River Basin Plan. ISPRA has published a report about desertification prone areas in Italy and another about guidelines for locating aridity and desertification prone areas.

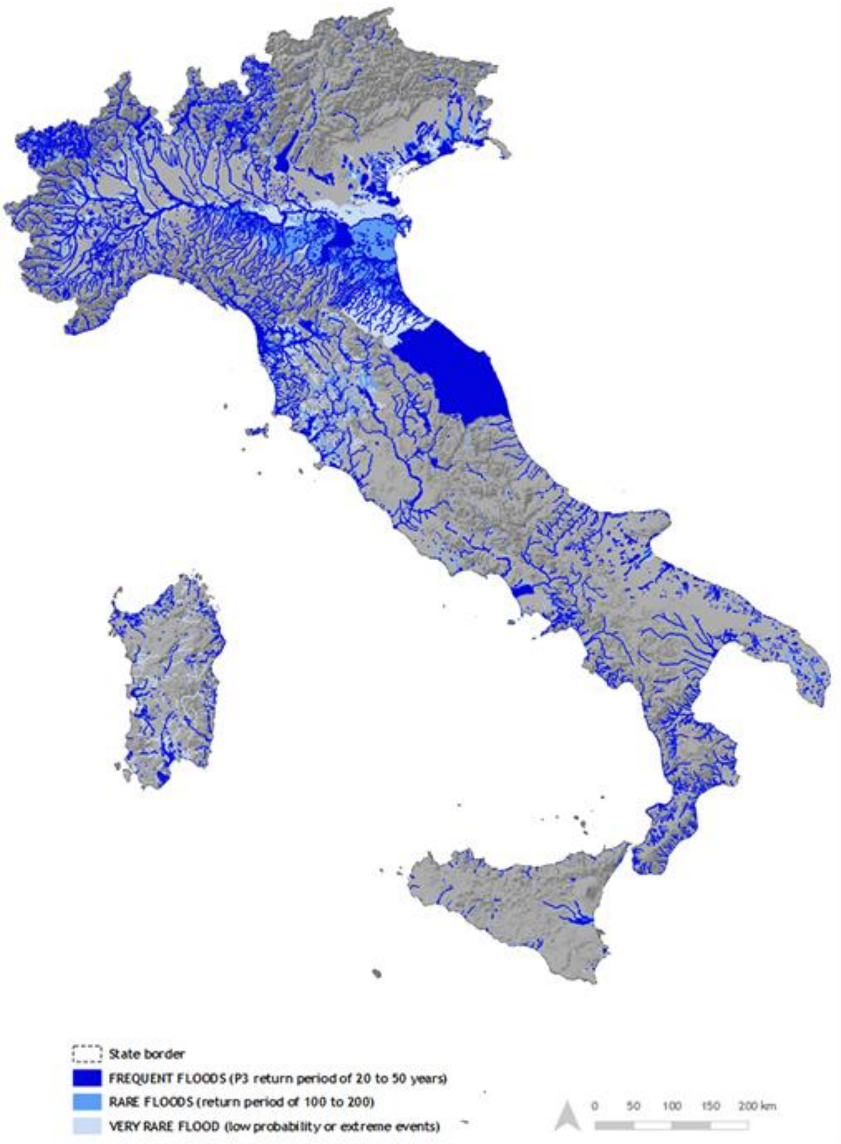


Figure 19. Flood hazard map of Italy (data provided by Italian Project Partner and created by ISPRA; hillshade by ArcGIS REST Services Directory)

2.1.5.4. Overview of status quo in Italy via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Italy as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Italy is shown in Table 20. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 19. SWOT analysis for Italy

The quantitative status of several ground water bodies is good, and there is a positive trend of rising of piezometric levels for several monitoring wells Emilia-Romagna Region has started a phase of review and rationalization of the abstraction permission of surface and ground water Chemical status of "transition waters" recognized as "good" according WFD 2000/60/CE thresholds for large part of Eastern Alps (53%) and Venice lagoon (75%) (source: data covering 2010-2016 from 2016 ISPRA Environmental Data Yearbook) Chemical status of surface waters is recognized as good for a large part of river and lakes in North-Central Italy (e.g. about 85% for Eastern Alps, 70% for Central Apennine) According index about groundwater quantitative (Directive 2000/60/CE), about 85% groundwater bodies are in "good" conditions The administrative capacity for effective (ground)water management is significant Synergies / conflicts between Water Directive and flood Directive have been analysed in the process of drawing up the RBMPs	Lack of awareness of the existence, relevance and value of groundwater Not all groundwater protected areas are clearly defined in spatial planning documents Chemical status of "transition waters" recognized as "not good" according WFD 2000/60/CE thresholds for large part of Central (80% Northern Apennine) and Southern Italy (75% for Apulia , 100% for Campania Region, 55% for Sardinia) (source: data covering 2010-2016 from 2016 ISPRA Environmental Data Yearbook) Chemical status of surface waters is not currently monitored for a large part of water bodies in Southern and Insular Italy (source: 2016 ISPRA Environmental Data Yearbook) Chemical status of ground waters is recognized as "not good" according 2000/60/CE Directive thresholds for about 35% of water bodies (about 42% in terms of surfaces); much worse values are found at regional scale for Lombardy (85%) and Apulia (78%) Monitoring system of water quality is quite limited, mostly concentrate on the Northern part (ISPRA, 2016) Negligible percentage of wastewater directly reused (sometimes wastewater discharged in rivers and canals is abstracted for irrigation) Areas without sewage system
S	W
IT	
O	T
Use of structural and cohesion EU funds for co-financing (ground)water projects The start of realization of interdisciplinary scientific project on valuation of groundwater resources and ecosystem services Enable a better communication between scientists-professionals and local actors and improve the transfer of results to decision makers and authorities responsible for the implementation of European directives Building of interdisciplinary research topics with significant stakeholders in the region in order to meet the transboundary (ground)water policy and (ground)water management needs to develop efficient education system for public water management administration in cooperation with decision-makers, legislators, NGOs and research institutions Initiation of better communication and dissemination of knowledge and experience between decision-makers and legislators and water scientists and experts working on national or international scientific or professional (ground)water projects	Other sectorial (national) strategies (i.e. energy) are not harmonized with water management strategies (i.e. incentivizing thermoelectric plants fueled with highly water demanding biomasses) The impact of climate change and changes in land use on water resources is strongly linked to the agricultural land use (cultivation practices and, mostly, crops grown); until now the choice of crops grown and cultivation practices is a free option of farmers, thus hardly predictable for the future Trends of irrigation water abstractions in the last forty years show a progressive increase, because of irrigated area increase and, in the last years, of the global warming; future scenarios envisage a substantial increase of crops irrigation needs Lack of investment in water service infrastructures due to the economic crisis and to the lack of clarity, even in legal rules, on financing methods (rate of costs recovering, remuneration of wastewater service provider)

2.1.6. Poland

2.1.6.1. Drinking water protection zones in Poland

The authorities in charge of water management in Poland include:

- Minister in charge of water management;
- President of the National Water Management Authority – as a central government authority, supervised by the Minister in charge of water management;
- Head of the Regional Water Management Board – as a non-combined government administration authority, who reports to the President of the National Water Management Authority;
- Voivodeship Governor;
- local government authorities.

Pursuant to Art. 51 of the Water Law, in order to ensure the appropriate quality of water abstracted for the public supply of water for human consumption and supply water to industrial plants requiring high-quality water and also to protect water resources, it is possible to establish water intake protection zones and protected areas of inland water reservoirs. DWPZ are determined based on hydrogeological characteristics.

Water intake protection zones are divided into primary and secondary protection zones. In primary surface water and groundwater intake protection zones it is forbidden to use land for purposes unrelated to water intake. In such areas:

- rainwater must be discharged in a way which prevents it from penetrating into water abstraction devices;
- land should be covered with greenery;
- wastewater from sanitary equipment intended for use by persons employed to operate water abstraction devices must be discharged outside the primary protection zone;
- the presence of non-employees in the area of operation of water abstraction devices must be limited to situations in which it is absolutely necessary.

Primary protection zones must be enclosed and their borders along surface waters must be marked using permanent standing or floating signs located in visible places; the enclosures and signs must feature information boards containing information about the water intake and warning that entry by non-authorised persons is prohibited (Art. 53 (3)).

Secondary protection zones may impose a ban or restriction on works and other activities which could reduce the suitability of the abstracted water or water-intake efficiency, in particular:

- Discharging wastewater into water or onto land;
- Using wastewater for agricultural purposes;
- Storing or landfilling of radioactive waste;
- Using fertilisers and plant-protection products;
- Constructing motorways, roads and rail tracks;

- Conducting drainage and excavation works;
- Locating industrial establishments and breeding farms;
- Locating warehouses for petroleum products and other substances, and also pipelines for their transport;
- Locating landfills for municipal, hazardous, non-hazardous and non-inert, and inert waste;
- Washing motor vehicles;
- Establishing car parks, camps and bathing sites;
- Locating new water intakes;
- Locating cemeteries and burying animal carcasses.

In secondary groundwater intake-protection zones, in addition to the said bans and restrictions, the following activities might be banned or restricted:

- Extracting minerals;
- Performing building or mining drainage works.

In secondary surface water intake protection zones, in addition to the said bans and restrictions listed in points 1 to 13, the following activities might be banned or restricted:

- Locating residential and tourism-related buildings;
- Using aircraft for agricultural operations;
- Depositing silage heaps;
- Fish farming, feeding or baiting;
- Watering and grazing animals;
- Extracting stone, gravel, sand and other materials, and cutting plants growing in the water or along its banks;
- Doing water sports;
- Using ships propelled by internal-combustion engines.

Measures in protected areas of inland water reservoirs should be based on the current land-management type and specific bans, orders and restrictions on land and water use are defined in order to protect the water resources from degradation. Activities such as construction, which could result in significant environmental impact such as permanent land or water pollution are banned within these areas.

Spatial planning in Poland will place greater focus on the coexistence of various ways in which water resources are utilised and also on regulating how long water stays in the environment, with a view to reducing any risks to the quality and amount of this resource.

Owners of land located within a protection zone are eligible for compensation for any damage incurred in connection with the establishment of bans, orders or restrictions on land and water use in the zone from the owner of the water intake under the terms and conditions specified in the Water Law (Art. 61 (1)). The rules for the payment of compensation for restricting the ways of using land in connection with the establishment of inland water reservoir protection zones are specified by provisions on environmental protection (Art. 61 (2)).

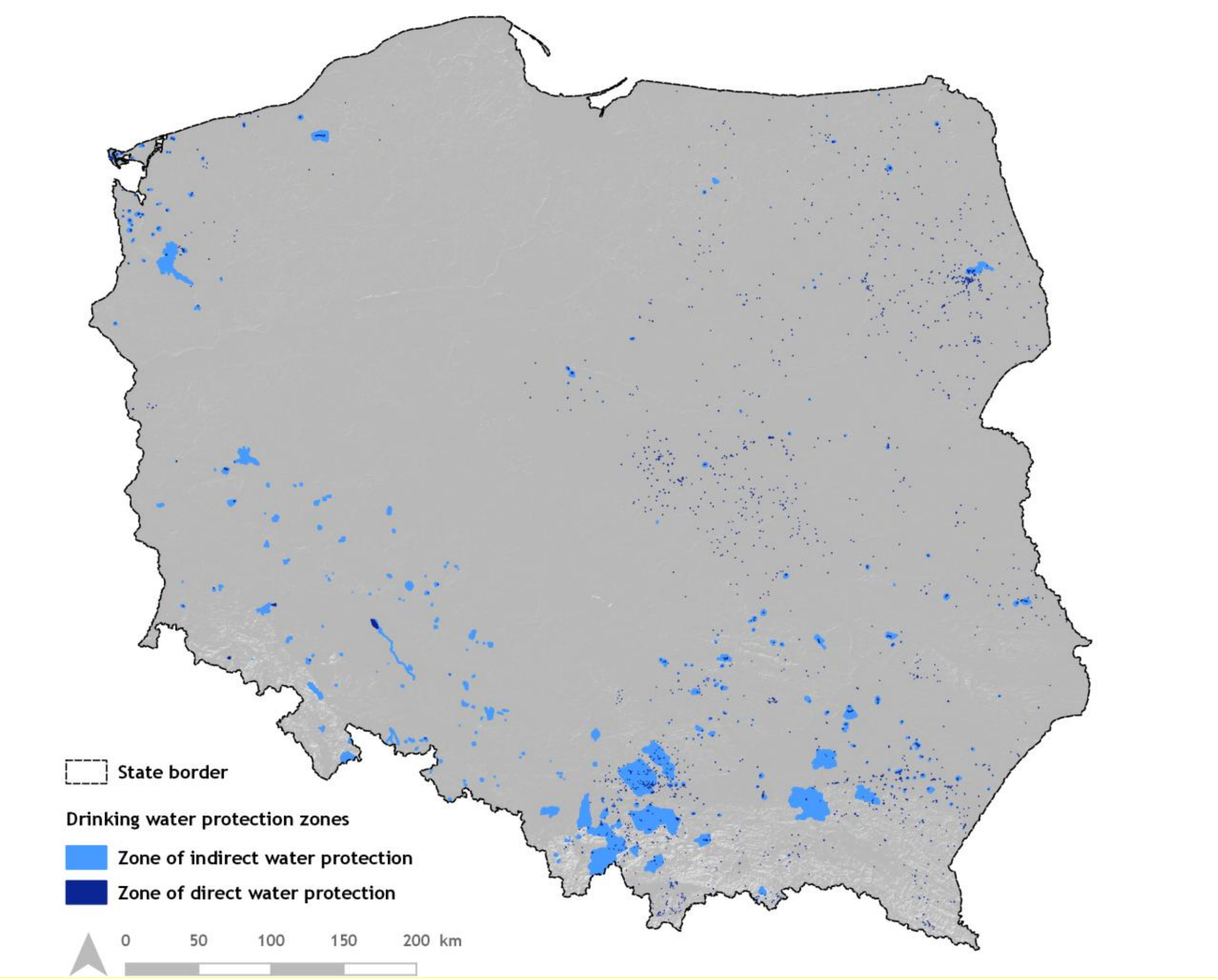


Figure 20. Drinking water protection zones in Poland

2.1.6.2. Impacts of land use activities on drinking water quality and quantity in Poland

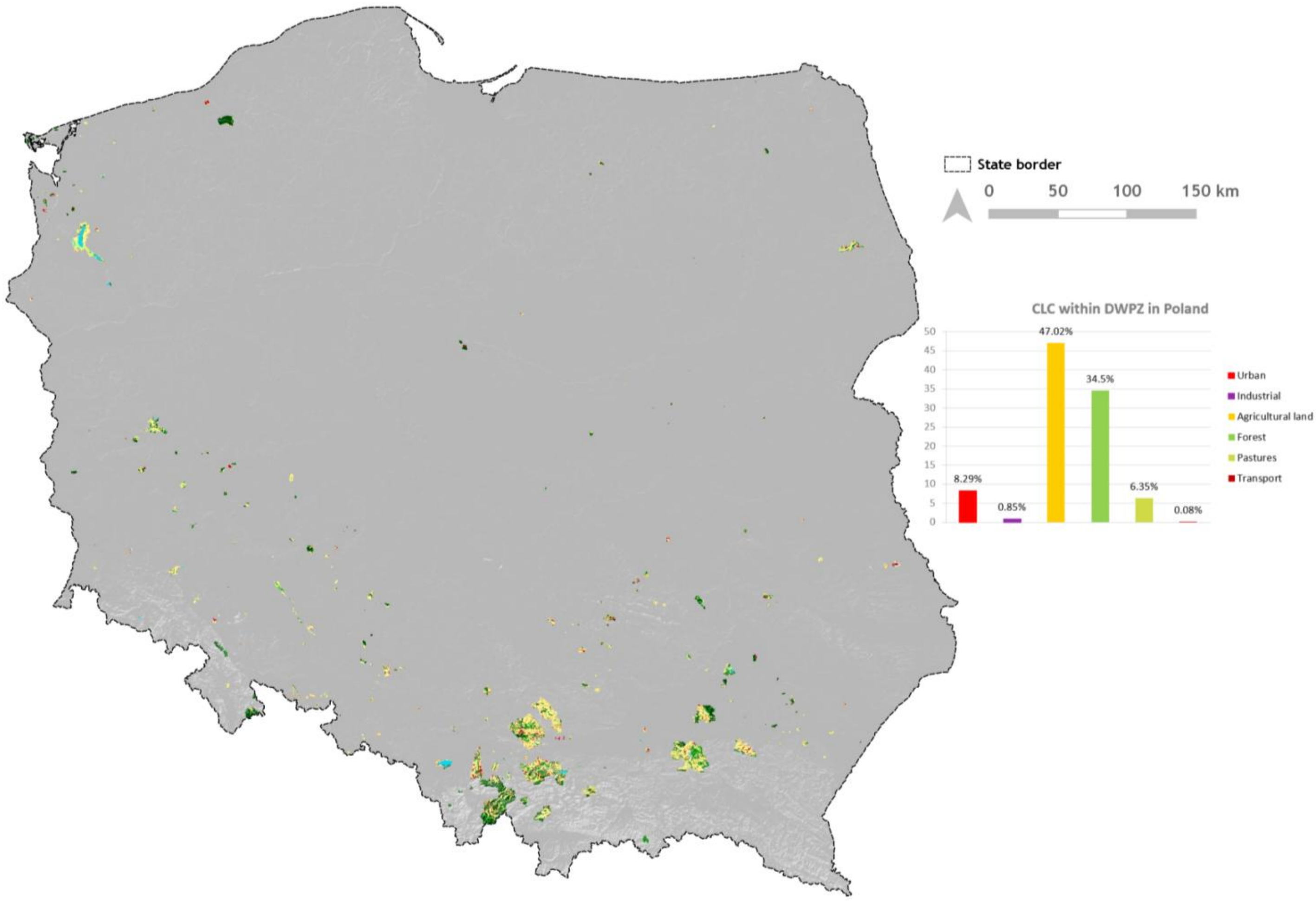


Figure 21. Land use categories within drinking water protection zones of Poland

Agriculture

In the total area of the country, which is ~ 31.3 M ha, agricultural lands comprised 16.3 M ha in 2015 (52%). Approx. 14.9 M ha of lands belonged to individual households, which are the dominant units in Polish agriculture.

The dominant share of the total agricultural land area was constituted by sown areas - 73.9 %. Permanent grasslands comprised 18.3 % and permanent pastures 3.0 %. Set-aside land equalled 0.9 % of the total agricultural lands. The share of permanent crops was 2.7 %, whereas the area of kitchen gardens comprised 0.2 %.

When Poland joined the EU, it was obliged to adopt EU legislation concerning water protection, including Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. The purpose of the Nitrates Directive was to reduce water pollution caused by nitrates from agriculture and to prevent further contamination of water. In 2012, after examining the comments of the European

Commission, the number of Particularly Vulnerable Areas was verified. Due to that fact, starting from 2012, Poland has 48 PVAs, including 4 regions designated as at high risk of underground water pollution by nitrates of agricultural sources, 3 regions designated as at high risk of underground and surface water pollution by nitrates of agricultural sources, and 41 areas selected due to the risk of surface water pollution by nitrates from agricultural sources.

The areas particularly susceptible to pollutants, especially nitrogen compounds from agricultural sources, are those lands whose waters have already been polluted or are at risk of being contaminated. The Nitrates Directive defines the threshold values for the pollution of waters with nitrates. The basic qualification introduces the threshold value for the concentration of nitrates in underground waters at the level of 50 mg $NO3/l$.

Mineral fertilisers (NPK) use per 1 ha of agricultural land in the year 2013/14 in pure component amounted to 132.9 kg/ha, including nitrogen fertilisers (75.5 kg, which is 6.4 % less than in the previous year), phosphorus fertiliser (23.4 kg, which is 8.6 % less than in the previous year) and potassium fertilisers (34.1 kg, which is 27.7 % more). Farmers used around 1935 thousand tonnes of mineral fertilisers (NPK) per pure component on their crops. The use of fertilisers by particular groups:

- nitrogen – 1098.4 thousand tonnes
- phosphorus – 341.1 thousand tonnes
- potassium – 495.8 thousand tonnes
- calcium – 697.2 thousand tonnes

Forest

Poland is one of European leaders when it comes to the surface of forests. They occupy 29.2 percent of the territory of the country - an area of 9.1 M hectares. Poland aims to increase the forest cover to 30 % in 2020 and to 33 % in 2050 ("National Programme of Increasing Forest Cover").

Forests serve, either naturally or as a result of forest management, a very important role in environmental protection, among others, through their environmental, social and industrial functions, according to the principles of sustainable forest management. According to the Polish Law on Forests, forests can be considered protective forests, if they:

- protect soil before washing or sterilizing, refrain removal of the ground, pull up the rocks or avalanches,
- protect the resources of surface and underground water, regulate hydrological relations in basin and watershed areas,
- reduce the formation or spread of the sands,
- are permanently damaged as a result of industrial activities,
- are the seed stands or animal refuges and position plants subject to species protection,
- have a special status for natural science or for the defence and security of the country,

are located:

- within the administrative boundaries of cities and at a distance of 10 km from the administrative borders of cities with more than 50,000 inhabitants,
- within the protection zone around the sanatoria and health resorts,
- within the upper limit of the zone forests.

Forest affect the flow of water in river basins, affecting the reduction of flood risk and mitigating the effects of drought by increasing, compared with agricultural land, capacity to retain rainwater, as well as affecting the improvement of the quality of water flowing through the ecosystem. This feature is particularly important in the situation where the trend is the sequential growth of steppe areas, which are the cause of climate change and the development of industrial infrastructure. This is evident in areas with very permeable soils and poor habitats (most forest areas), as well as rich habitats fed by rainwater and groundwater. Forests contribute to increasing rainfall and the formation of misty deposits. Forests also decrease evaporation from the soil surface. Forest soil owes its porosity accumulation of humus in the litter, entering roots deep into the soil and the soil fauna. Small retention applied in the forests refers to activities related to the detention of the greatest amount of water in its surface and nearly-surface circulation. This is done using procedures that are divided into:

- Technical: small water tanks, valves, weirs,
- Non-technical: reforestation, forestation, plant shelterbelts, ponds, rural, ponds, wetlands.

Pastures

Pastures occupy 8.78% of total surface area of Poland. Polish pastures were covered in scope of the development of research in the field of animal breeding and animal production. Main thematic concept is environmental protection and increased welfare as part of the development of state-of-the-art animal production. Together with the intensification of animal maintenance systems, problems involving animal welfare and environmental protection have occurred. Environmental protection was not an issue when animal maintenance was not concentrated to such a degree as it is today. The issues of providing the minimum level of farm-animal welfare and reducing the environmental impact of breeding methods were raised in late 1970s, at the same time becoming new determinants in the development of breeding technology.

Ecological agriculture is an alternative in the field of environmental protection and the improvement of animal welfare which should be developed in Poland. Small farms could serve this purpose. Livestock buildings and equipment should not only consume energy but also save it, or even generate it. The use of solar collectors, photovoltaic cells, wind generators, biogas plants of varying power, adjusted to the scale of production, is currently becoming an opportunity for these facilities.

Urban areas

The data submitted by Polish municipalities were collected and analysed. It was established that:

- all the agglomerations with a PE of ≥ 15 000 are equipped with combined sewage systems,
- only 162 agglomerations with a PE of 2000 ÷ 15 000 (out of the total number of 936 agglomerations in this size group) are not provided with a sewage system,
- 561 agglomerations have combined sewage systems,
- in agglomerations with a PE of > 15 000, there are mostly mixed sewage systems, with both combined sewage networks and sanitary sewage networks,
- in agglomerations with a PE of < 15 000, there are sanitary sewage systems.

Moreover, the analysis showed that there are 683 wastewater treatment plants in the agglomerations, whose effluents meet the requirements laid down in the Regulation of the Minister of the Environment of 29 November 2002 on the conditions to be met for the discharge of wastewater to water or the ground and on the substances of particular hazard to the water environment (Journal of Laws, No. 212, item 1799), and Directive 91/271/EEC regarding the quality of wastewater.

377 wastewater treatment plants constitute a permanent solution, providing a full or partial service for an agglomeration by 2015. On the other hand, 306 wastewater treatment plants provide the service of the existing sewage systems, but to ensure the service by 2015 and a wider scope of provided sewage services connected with the expansion of network systems, the plants will require extension, or it will be necessary to build new wastewater treatment plants. In some of the plants, the only element which requires modernisation is sludge management, but the reduction of biodegradable loads is currently achievable.

The quantity of wastewater sludge created in municipal wastewater treatment plants in 2001 amounted to 397.2 thousand tonnes of dry matter.

The number of agglomerations in the 2015 update amounted to 1 502 (38 M PE), where 1643 wastewater treatment plants were located. According to the adopted methodology, these agglomerations were divided into four priorities on the basis of the significance of investment and the urgency for providing financial resources. In addition, the update included the so-called agglomerations not classified into any of the priorities, which do not meet the conditions set out in the Council Directive 91/271/EEC, but are planning to implement investment measures, bringing them closer to meeting the requirements. As a result of work on the update and the performed analysis, the investment plans concerning the construction of sanitary sewage networks were limited in agglomerations for which the concentration ratio did not exceed 90 inhabitants for each kilometre of the planned sewerage network (Regulation of the Minister of the Environment of 22 July 2014 on the method for designating the area and boundaries of agglomerations, Journal of Laws of 2014 item 995). The amount of outlays for their completion has also been reduced proportionally to the reduction of the planned scopes of sewage-network construction works.

The investment plans presented by agglomerations show that 119 new wastewater treatment plants are due to be built and 985 other investments within the plant area are planned within the framework of the fourth update. Furthermore, it is necessary to conduct additional works resulting from the changes to the legal regulations. It means the obligation to adjust wastewater treatment plants to the requirements of art. 5 (2) of Directive 91/271/EEC, i.e. the provision of the enhanced removal of nitrogen and phosphorus in all the plants in agglomerations of over 10 000 PE. The analysis shows that the measures will include 187 wastewater treatment plants in 157 agglomerations. Also, 21780.8 kilometres of a new sewage network and the modernisation of 4193.6 kilometres of existing networks are due to be completed. Following the completion of all the investments, the PE for the users of sewage network will amount to 36 454 505, which accounts for 95.9% of the total PE. The financial resources needed for the implementation of the undertakings amount to PLN 29.91 billion in total.

Industrial areas

In the area of the Vistula river basin (the largest river basin area in Poland - covering 59% of the area of Poland), industrial pollutants influencing surface water bodies are pollution from crude oil processing, organic and inorganic chemical plants, paper mills, the textile industry, the iron and steel industry, food production and shipyards. In total, 1057 industrial wastewater discharge points were identified in the Vistula river basin area. In the area of the Oder river basin (the second largest river basin area in Poland - covering 38% of the area of Poland), 513 industrial wastewater discharge points were identified in the Oder river basin area.

The main causal agents of the point sources of pollution of groundwater located in the Vistula river basin area are: industrial waste disposal sites and industry (industrial wastewater discharge), including the oil refining industry and gas and dust emissions.

The outcome of groundwater pollution, especially in heavily urbanized areas and those utilized commercially, is their poor chemical condition reflected mainly in low pH values (caused by discharge of acidic mine wastewater), the presence of light hydrocarbons, locally increased concentrations of heavy metals and the change in water chemical status which is reflected in the increased concentration of the following ions: sodium, potassium, chloride, nitrate and sulfate ions.

The intensive exploitation of groundwater constitutes another threat to the quantitative status of groundwater bodies in the Vistula river basin area. The total volume of water intake across the entire river basin area amounts to 1,253,376.14 thousand m^3 a year (intake registered in 2011), whereas nearly a third is related to mine dewatering. The main causal agent of the poor qualitative status of groundwater bodies is, apart from dewatering (of mining excavations), water intake for industrial purposes.

The point sources of pollution in the Oder river basin area were mainly analyzed in terms of their impact on the chemical status of groundwater bodies. In most cases, due to a small area of facilities and related pollution emissions, as compared to the area of groundwater bodies, they were not considered a significant factor in the deterioration of the chemical status of a part of groundwater.

The measures defined in the National Water and Environmental Programme also include activities aimed at reducing pollution from industry, and these include:

- the obligation to obtain a water-law permit for the discharge of industrial wastewater into the municipal wastewater collection and treatment systems (Art. 122 (1) (11) of the Water Law Act, the Regulation of the Minister of the Environment on the substances of particular hazard to the water environment, the discharge of which through industrial wastewater into sewage infrastructure requires a water-law permit;
- the inspection of permissible substance masses in discharged industrial wastewater (Art. 45 (2) in conjunction with art. 156 (1) (3) of the Water Law Act, Art. 2 (1) (1(b)) of the Act on Environmental Protection Inspection, the Regulation of the Minister of the Environment on the permissible substance masses, discharged to industrial wastewater.

Transport units

Wastewater management of roads has to meet the requirements mentioned in the preceding paragraph and taking flood wave created as a result of heavy rainfall on land roadway, characterized by a high ratio of impervious surface.

Meeting the requirements of Section 21 of the Regulation of the Minister of Environment of 18 November 2014. (Dz. U. 2014, item. 1800) also determines the use of the purification devices (clarifiers, separators, petroleum hydrocarbons) and the necessary technical parameters resulting from the adopted design solutions, allowing for reduce pollution to the values required by Regulation.

Similar solutions are used in case of objects that support highways and expressways. Such objects are: MOP-s (service areas) and OUD / OUA (road / highway maintenance circuits). Additional factor that may have an effect on water pollution is wastewater with high loads of pollutants generated in those facilities. This type of wastewater includes sanitary sewage. The solution to the problem of sanitary sewage is connecting it to the existing local sewer or the use of biological sewage treatment plant, allowing the required reduction in pollution loads.

Additional sealed septic tanks, preceded by a dedicated separator petroleum hydrocarbons, allow receiving wastewater from places that generate strong pollution on OUD / OUA (brine factories, petrol station, car wash or buildings, workshop and garage). Similar solution, based on the use of a sealed holding tank, is applied to the MOP-s, the places designed as stop/rest areas for vehicles transporting hazardous materials. Applied fittings allow redirecting a leak from the tanker, caused by unsealing of the tank.

Proper prevention of slippery roads in winter requires conducting specialized meteorological services for roads. This is done by using the appropriate chemicals, such as the wetted salt and brine; production of which is placed on OUD / OUA objects. In cases of substantial temperature decrease, a mixture of sodium chloride and calcium chloride is used. The use of chemicals reduces winter nuisance and improves road safety pollution from traffic is small in comparison with other sources of pollution.

2.1.6.3. Impact of flood and drought on drinking water quality and quantity in Poland

In line with the Floods Directive and the Law on Water Management of 18 July 2001 (Journal of Laws of 2015, item 469, as amended), by 22 December 2011, the Preliminary Flood Risk Assessment (WORP) was published. Flood risk areas were identified for two types of floods, namely river floods and coastal floods. In total, 253 rivers, with a total length of 14,481 km, were identified for flood risk areas. This preliminary flood risk assessment was conducted under the project “IT system for the protection of the country against extraordinary threats” (ISOK), by the Institute of Meteorology and Water Management – National Research Institute, Flood and Drought Modelling Centres in Gdynia, Poznań, Kraków and Wrocław (centres are the part of the Institute of Meteorology and Water Management), in consultation with the National Water Management Authority. The ISOK project also produced coastal flood risk maps and flood hazard maps.

Flood hazard maps and flood risk maps were prepared in scale 1:10 000, in digital form, and include spatial data and cartographic visualisations as well as information about potential flood losses. Flood hazard maps show areas where the likelihood of flood is low (Q0.2% – once every 500 years), moderate (Q1% – once every 100 years) and high (Q10% – once every 10 years), and areas at risk of flooding as a result of destruction of, or damage to, a flood bank or a storm dyke. The flood hazard areas presented on the maps were identified through hydraulic mathematical modelling. The modelling was based on a high- accuracy (10-15 cm) digital elevation model, obtained using airborne laser scanning between 2011 and 2013.

Flood risk management plans for river catchment areas and water regions were prepared with the support from the European Regional Development Fund under the Technical Assistance Operational Programme 2007-2013. The draft flood risk management plans were subject to social consultations and whenever justified, the conclusions and follow-up recommendations were used to complement or review the draft PZRP.

The legislative procedure for the approval of flood risk management plans for river catchment areas and water regions has not been completed yet.

The Law on Water Management, which governs drought control, entrusts this task to government and local-government authorities. Efforts of KZGW and RZGW in this area have focused on the development of drought mitigation plans in river catchment areas and in water regions, which, in addition to water management plans for river catchment areas, the national water environment programme, flood risk management plans, terms of use for water regions, and terms of use for catchment area water, prepared on an ad-hoc basis, constitute an essential planning documentation for water management.

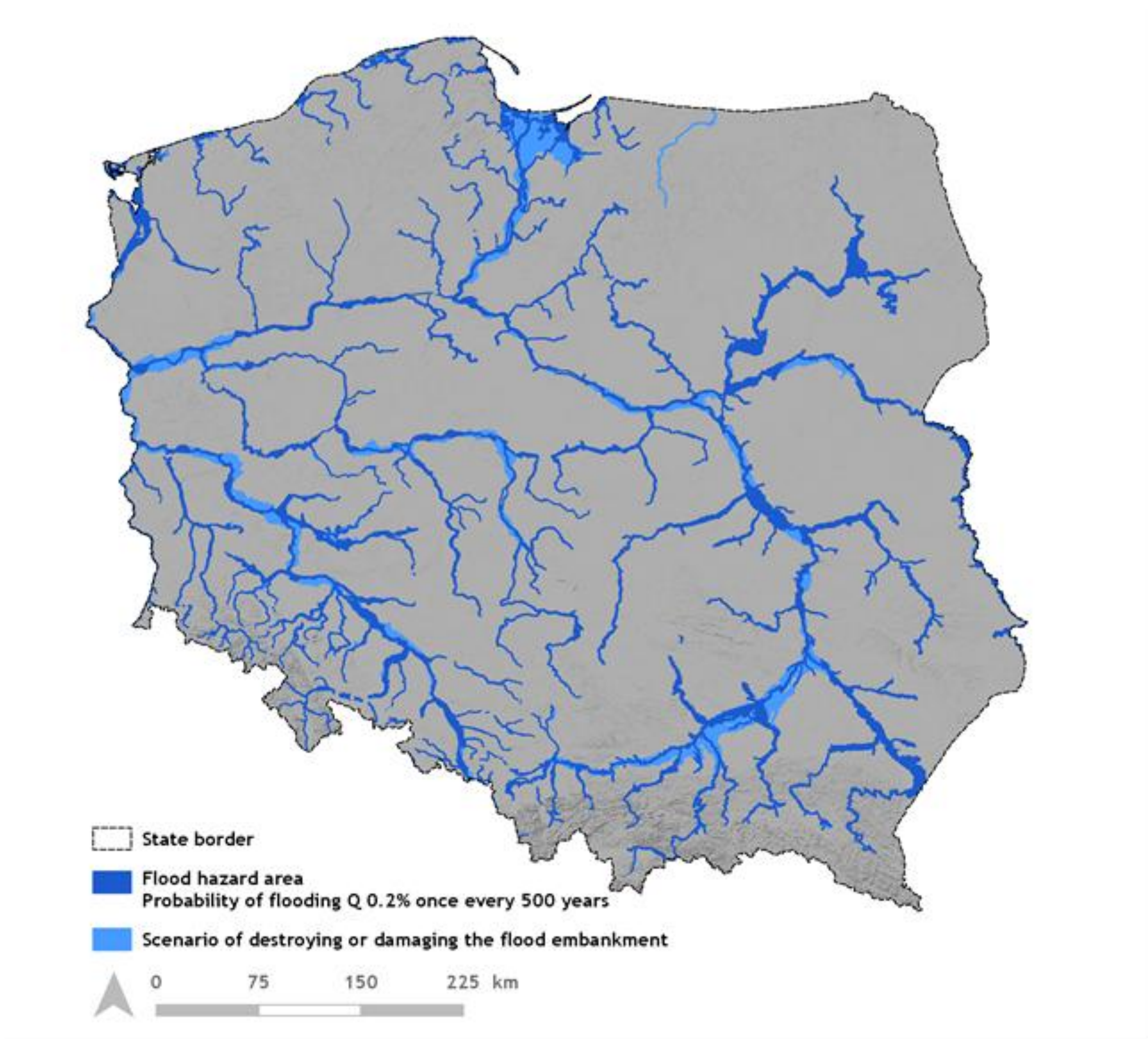


Figure 22. Flood risk map of Poland (data provided by the Polish Project Partner and by the Hydroportal of the National Water Management Authority)

2.1.6.4. Overview of status quo in Poland via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Poland as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Poland is shown in Table 21. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 20. SWOT analysis for Poland

S	W
Poland has a well-established system for regulation of groundwater and surface water abstraction (water permits) Strong legitimacy of water management authority The increase innovation in water management Implementation of the National Program of Municipal Sewage (extension of the sewerage network and municipal wastewater treatment plants) Improvement of flood safety (hazard maps and flood risk maps - the precise ranges of areas of flood risk basis for the proper land use policy in the areas of flood risk) Implementation of the measures defined in the Water Framework Directive (compliance with environmental objective, monitoring of surface water and groundwater)	Lack of awareness of the existence, importance and value of groundwater Insufficient financial and technical resources for establishment of a stable model of water management Rural areas without sewage system Bad quality status of most of the surface water bodies Lack of flexibility in the implementation of EU directives (for instance CD 98/83/EC, CD 2015/1787, CD 2013/51/EURATOM) Agricultural use of wastewater from food, especially for potato, industry Utilization of the parts of municipal wastewater by infiltration fields Current Water Act and legal regulations on conditions for establishing DWPZs is questionable and not good enough for efficient water protection Weak regulations on DWPZ incorporation in land-use planning documents Inconsistent and irrational law in the area of water management No reform water management Improper strategic positioning of the National Council of Water Management
O	**T**
The use of EU funds, particularly structural and cohesion funds for co-financing groundwater and surface water projects To enable better transfer of the results of scientific and professional groundwater researches to target groups, namely the legislators, the decision-makers and those working on the implementation of EU directives Financing national and regional scientific and applied interdisciplinary research on land use activities in order to protect drinking (potable) water The promotion of the economical water and energy management Implementation of good practice for maintenance of biodiversity, landscape, soil protection and water resources Changing the thinking and understanding of the Floods Directive 2007/60 / EC (minimizing flood risk and its management by: “moving away the flood from the people, “moving the people from the flood”, “learning to live with floods” Updating water management plans Implementation of the National Water- Environmental Program.	Water Management Strategy is only partly harmonized with other sectoral national strategies, which may threaten the implementation of the groundwater protection measures Program of measures on DWPZ is not based on the application of economic criteria and principles of "best environmental practice" Karstic areas and aquifers are not specifically treated in water legislation, which may pose the problems with implementation of the requirements set by EU directives Long-term, low rank of water management in state policy Low awareness and lack of responsibility of society for the use and protection of drinking water Inadequate land use policy of local governments in terms of water management Lack of consolidation of the water management community No effective control of groundwater and surface water abstraction, No effective control of groundwater and surface water abstraction,

POL

2.1.7. Slovenia

2.1.7.1. Drinking water protection zones in Slovenia

DWPZs represents almost one fifth of the territory of Slovenia, which is around 347,000 hectares. The majority of areas is covered with forest (60%), 31% are agricultural areas; the other predominantly natural surfaces occupy 3% and urban areas slightly less than 6%. Such a ratio is very similar to the structure of land use all over Slovenia. In Slovenia, the surface of the water protection zone should not be smaller than the natural recharge area.

General criteria for determination of the size of inner protection areas are:

- The size of the protection areas is determined according to the type of surface- or ground-water body and characteristics and their recharge area and on the basis of residence (retention) time of pollutants, dilution of pollutants from the site of input to the capture or the time for action.
- Residence time and dilution of pollutant from the input point to the capture depends on the water velocity through the aquifer, which is determined on the basis of water inflow time estimates from any point in the recharge area to the point of capture.
- Time of the water inflow shall be calculated on the basis of measurements and model calculations. Time is the sum of the inflow of pollutants to the capture from the input point to the groundwater flow (travel time through the unsaturated zone) and the flow of pollutants within the groundwater (travel time in the saturated zone).
- The time for action is determined on the basis of estimates of time of implementation of possible intervention measures and the measures dealing with the effects of pollution before the pollutants arrive to the capture.

Methodology for detailed determination of drinking water protection zones depends on the water source type (surface water (surface water, lake) / groundwater (aquifer type: porous, fractured and karst aquifer)).

Ministry of the Environment and Spatial Planning controls and manages legal acts for determination of DWPZ. Borders are mostly following cadastral / parcel borders, but it is not necessary (e.g. in case of large parcels). DWPZ are designed that natural criteria are considered. There are some exceptions in cities, e.g. Ljubljana, where industrial zones already exist and inner DWPZ is divided into two subzones with different limitations.

Implementation of DWPZ ordinance is supervised by the inspectors responsible for water. Notwithstanding of this, practices on agricultural land and forest are inspected by inspectors responsible for agriculture and forestry; prohibitions and restrictions for construction of buildings perform building inspectors, prohibitions and restrictions directly on capture are inspected by health inspectors. Penalties are defined in the Decree of particular drinking water source and have to be paid by the company and the responsible person of the legal entity or by individual person.

Prohibitions, restrictions and protective measures for interventions in the environment depending on the protection level in the inner zones are defined for particular intervention type: residential buildings, non-residential buildings, transport infrastructure, pipelines, communication and power lines, complex industrial facilities, other civil engineering facilities, the implementation of construction work, unpretentious facilities, simple facilities, maintenance of facilities, fertilization of agricultural land, fertilization of non-agricultural land, use of plant protection products on agricultural land.

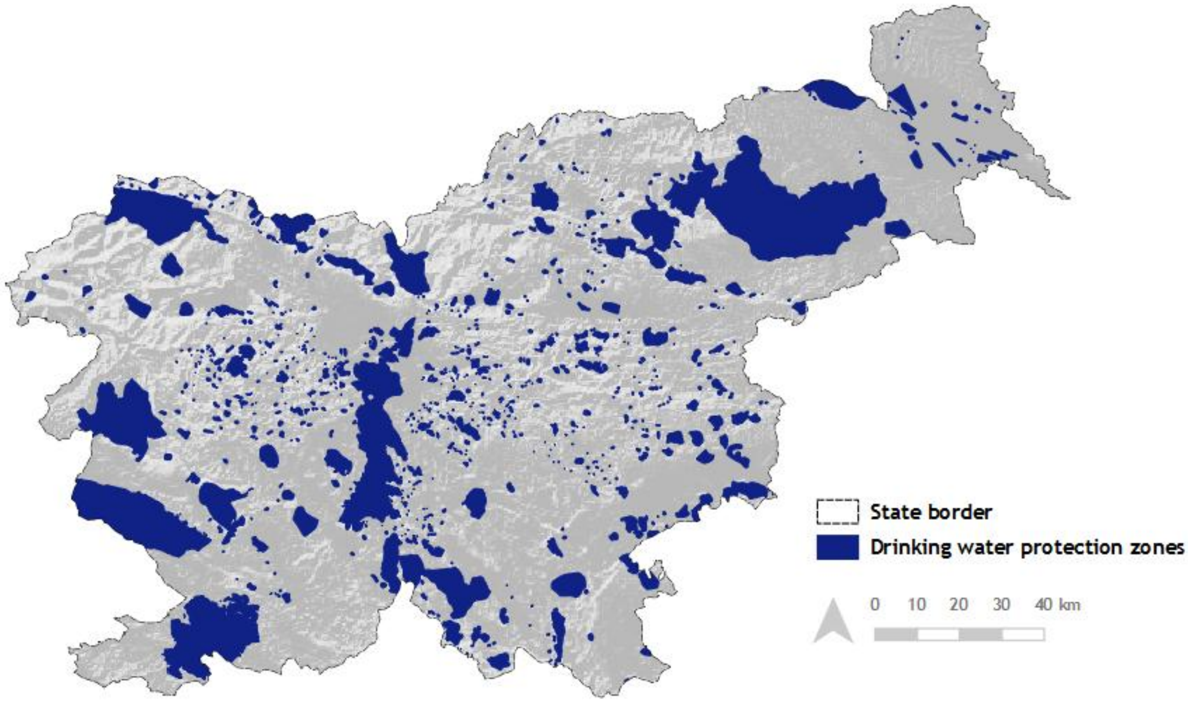


Figure 23. Drink water protection zones in Slovenia

With the delineation of drinking water protection zones for particular drinking water source, prohibitions, restrictions and protective measures are defined and depend on the protection level in particular DWPZ (I, II, III) – majority refers to groundwater and there are only few drinking water sources from surface water in Slovenia.

Protective measures for different interventions in DWPZ, such as facilities constructions, implementation of the construction work, etc., for which it is expected that during the construction and implementation a risk for pollution of the water body can exist, must be planned based on the risk analysis, so that the risk of pollution of the water body due to facilities constructions and implementation of the construction works is acceptable. The risk analysis for pollution of water bodies is provided by investor of intervention in the environment in DWPZ.

2.1.7.2. Impacts of land use activities on drinking water quality and quantity in Slovenia

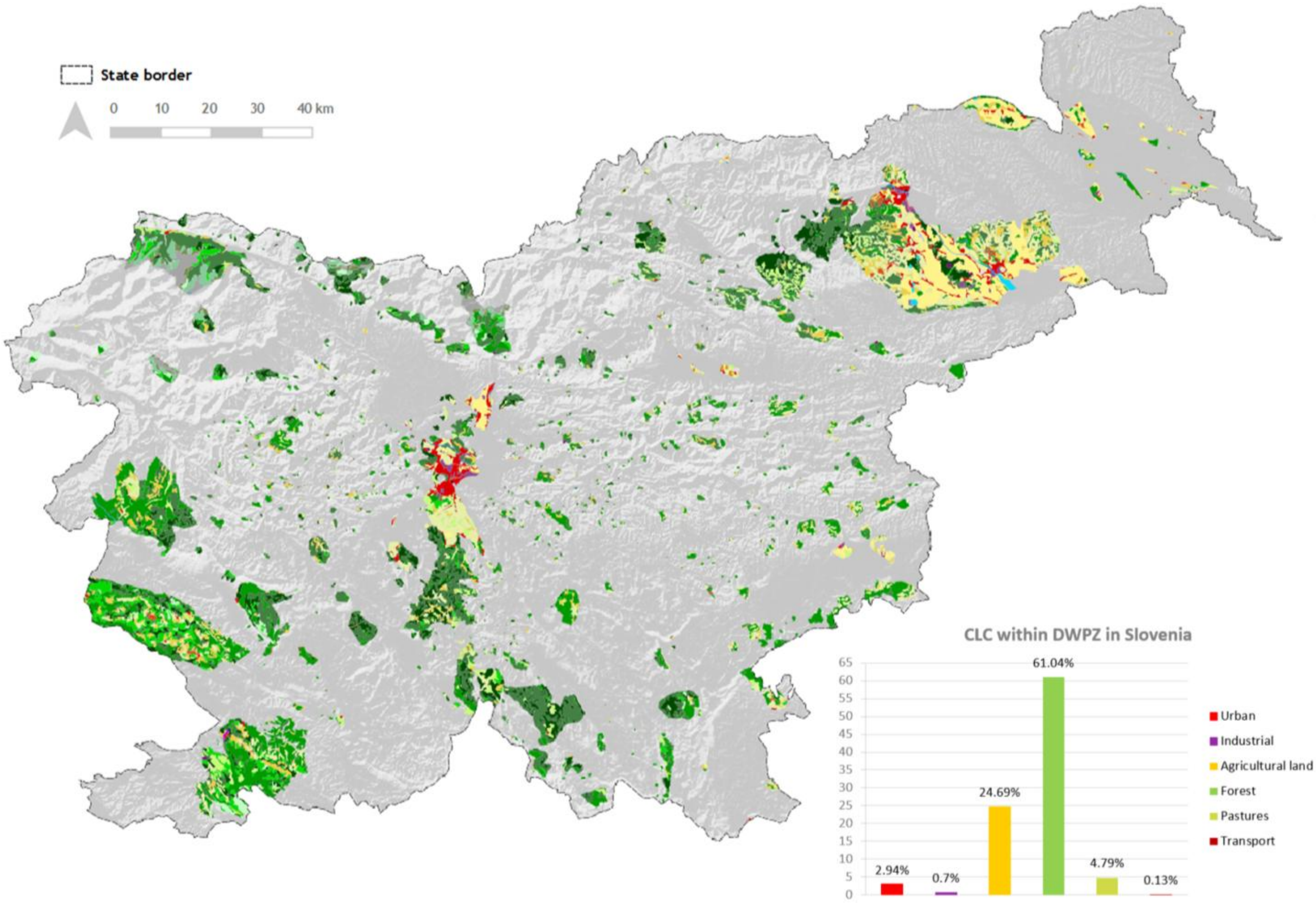


Figure 24. Land use categories within drinking water protection zones of Slovenia

Agriculture

Agriculture in Slovenia represents 2.1% of the gross domestic product (GDP) of the national economy, with a downward trend in the last period. Agricultural areas are decreasing in favour of the overgrowth of agricultural areas, the building construction and transport infrastructure. Planting structure of fields is adapting to market requirements, areas with oilseeds, dry beans, vegetables and mowed fodder are increasing and areas with potatoes, hops and maize (for grain and silage) are decreasing. In Slovenia a large proportion of the areas are under special management regimes in terms of environmental protection, therefore a number of farming practices were developed and supported through agricultural-environmental program.

The farmers, who receive a subsidy, are obliged to attend lectures about plant protection products every five years and follow the plan for spreading manure, which is done on the basis of soil analysis and depends on which culture will be cultivated. Farmers are encouraged to perform organic farming without pesticides and fertilizers.

30.2 % of the DWPZs are agricultural areas. 46.16 % are meadows and pastures and 40.8 % cultivated land; 7.44 are permanent crops and 6.32 % overgrowth areas. In all DWPZ it is prohibited to fertilize without fertilization plan. In the narrowest area (I) it is prohibited to use nitrogen fertilizers, as well as liquid organic fertilizer. The only allowed fertilizers are those that are normally allowed for organic farming. In the narrow area (II) it is exceptionally allowed to fertilize in accordance with the requirements of integrated or organic farming, if the nitrogen values are not exceed and also if the results of monitoring of water quality show that the water from wells in the last five years had good chemical analysis in accordance with the regulations on the quality of groundwater. In the wider area (III) the fertilization is generally allowed, if the values of nitrogen in the DWPZ are not exceeded.

National map of spatial distribution of nitrogen and phosphorus in agricultural areas is not available in Slovenia, but the map of intensity of fertilization with nitrogen on representative agricultural areas is available. Net nitrogen surplus in 2014 was 10 kg per hectare and gross phosphorus surplus was 1 kg per hectare of agricultural areas (source: Statistical Office of the Republic of Slovenia).

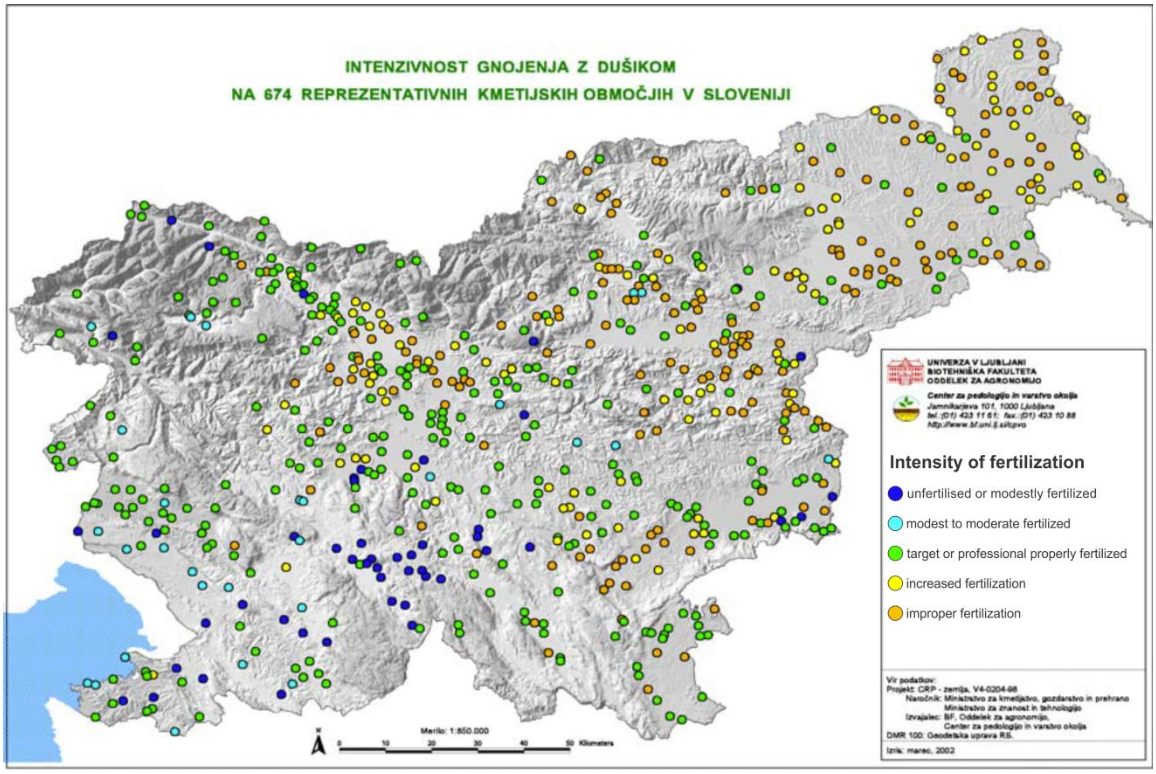


Figure 25. The intensity of fertilization with nitrogen on the 674 representative agricultural areas in Slovenia (MKGP 2006)

Groundwater is mostly polluted by nitrates, pesticides and their degradation products due to agriculture. In 2015 pesticide and fertilizer pollution is detected in several areas in Slovenia: Sava Basin and Ljubljana Marsh, Savinja Basin, Krško Basin, Sava Hills, Dolenjska karst, Drava Basin and Mura Basin. Long term chemical status (2008—2015) of all groundwater bodies in Slovenia is good, except for groundwater bodies in Savinja Basin, Drava Basin and Mura Basin. But for trends for the period 1998 to 2015 the results of monitoring of groundwater quality show statistically significant downward trends in concentrations of nitrate, atrazine, desethyl-atrazine and total sum of pesticide for Sava Basin and Ljubljana Marsh, Savinja Basin, Drava Basin and Mura Basin. In some measuring sites the values of atrazine and desethyl-atrazine does not decrease anymore, but is around the detection limit of the analytical method. This means that parameters are no longer present in those aquifers.

In 2015, 59 drinking water wells were included in monitoring. At 9 measuring points the drinking water has nitrate, atrazine, desethyl-atrazine, metolachlor and bromacil exceeded the limit values.

Forest

Forests in Slovenia cover 11,819.4 km2 which represent 58.2% of the total area. Slovenia ranks fourth in the European Union in relation to the forest cover. 75% of forests are privately owned, 25% are owned by the state and municipalities. The average forest property is 2.5 ha and is divided into several separate parcels. Forests are owned by 461,000 owners and co-owners.

In the Slovenian forests deciduous trees dominate with a 54.4%, followed by coniferous tree with 45.6%. A more detailed distribution according to tree species is shown in Figure 26.

Forest with natural vegetation composition and stand structure are best for filtering pollution from neighbouring agricultural areas, roads and urban centres, leaking into surface streams and groundwater.

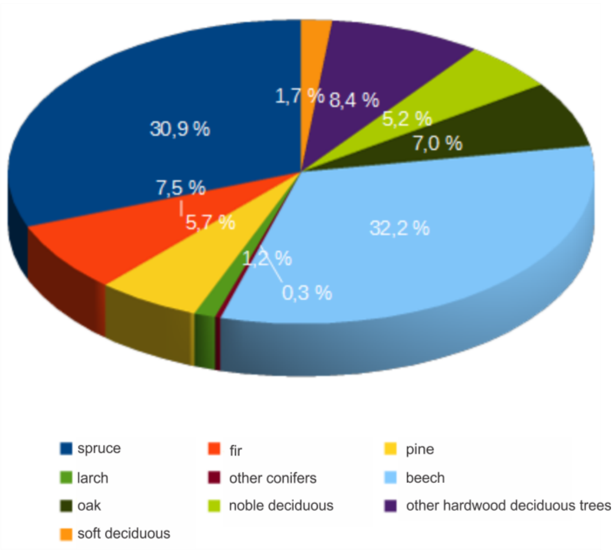


Figure 26. Percentages in growing stock by tree species (Slovenian Forest Service, 2014)

Forest management plans include also guidelines for optimization of hydrological function of forests. In this respect, three levels of hydrological function are determined:

- 1st level: on areas in DWPZ I and II; areas over karst caves and underground water flows; in the zone 50-500 m around lakes (depending on terrain);
- 2nd level: on areas in DWPZ III; on potential water protection areas; along streams and smaller standing water in the width of one to two tree heights;
- 3rd level: all forests, since all contribute more uniform runoff.

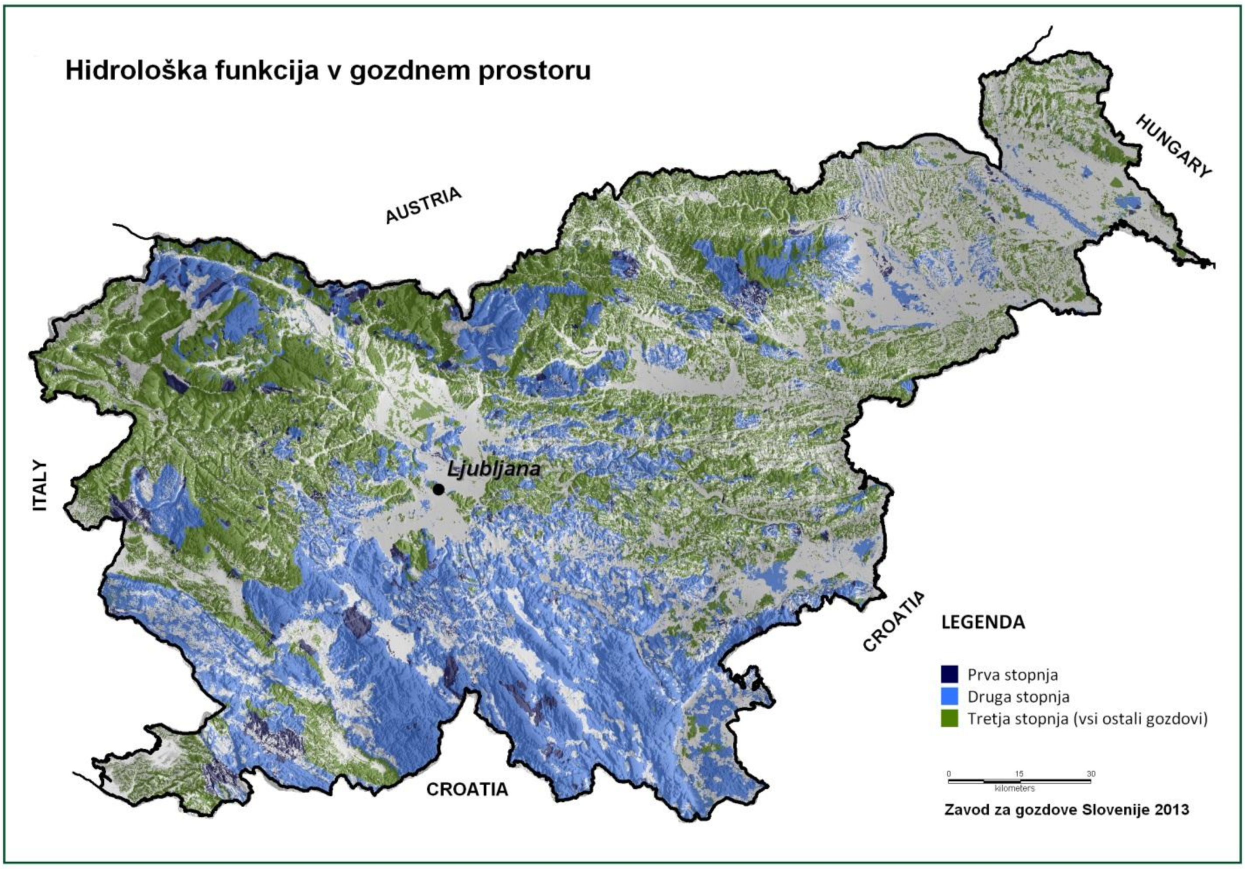


Figure 27. Hydrological function of forests (Slovenian Forest Service, 2013) – purple is first level, green is third level

Protective forests are forests which protect from landslides, forests on steep slopes or river banks, forests, exposed to strong winds, forests in torrential areas for holding excessive runoff, forest belts, which protect forests and land from wind, water, snowfall and avalanches, forest management in agricultural and suburban landscape with emphasized function of preserving biodiversity and forests at the upper limit of forest vegetation. There are around 99,000 ha of protective forests in Slovenia. A map of protected forests in Slovenia is presented in Figure 28. Protected forests are defined in Decree on protective forests and forests with a special purpose (Official Gazette of the Republic of Slovenia 88/2005, 56/2007, 29/2009, 91/2010, 1/2013, 39/2015).

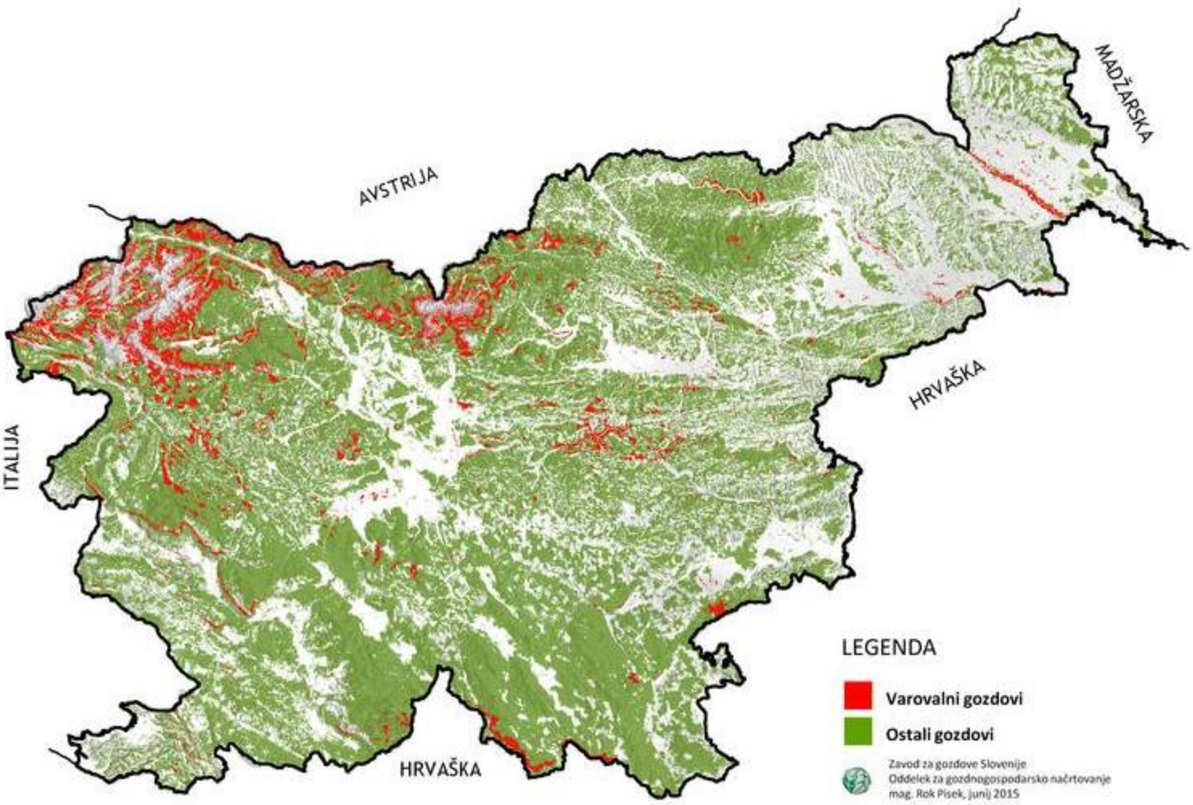


Figure 28. Map of protected forests (red colour). Green colour: other forests. (Slovenian Forest Service, 2015)

The importance of forests on the total discharge from the catchment area and the water quality increases with the proportion of the forest area. Forests can reduce the possibility of occurrence of high waters of shorter and less intense precipitation, but cannot prevent the occurrence of flooding during major precipitation over a large area. In all DWPZ (I, II and III) afforestation is allowed. In DWPZ (I and II) the clear-cutting is not allowed. Also the use of pesticides and supply of machinery and equipment with fuel in the forest is not allowed in the narrowest DWPZ (I).

Pastures

Livestock farming is the most important sector of the Slovenian agriculture. The livestock sector is dominated by cattle, followed by pig, sheep and goat breeding, horse breeding, poultry farming, rabbit, beekeeping and others. Grassland in Slovenia is of great importance for livestock production, it represents an important source of fodder for cattle, sheep and goats. Meadows and pastures represent the average of around 58% of the total agricultural area.

Urban areas

Notable negative impacts on water quality in Slovenia are urban waste waters and use of pesticides in sport areas, parks and cemeteries.

In 2014, Slovenia had released 810 M m^3 of treated wastewater, or 21% more than in 2013. The amount of untreated waste water in 2014 compared to 2013 decreased by 38% (80 M m^3 of water).

In 2014, 94.5 M m^3 of rainwater was discharged in the public sewer system, surface water and soil. Their quantity, in comparison with 2013, decreased by 1%. 81% of wastewater was discharged into surface water.

Around 58 % of the Slovenian population has access to piped sewer systems. Only 54% of wastewater discharged from sewage systems is treated.

In recent years, the amount of waste water treated by processes of secondary or tertiary treatment increased, while the amount with primary treatment decreased. The amount of wastewater that was treated with secondary treatment processes has, since 2002, increased by 205% or 38 M m^3 (in 2002) to 78 M m^3 (in 2014). Tertiary wastewater treatment was almost non-existent in Slovenia in 2003, while in 2014 50 % of all treated wastewater, or 78 M m^3 wastewater was treated by tertiary processes. Share of Slovenian population whose waste water was treated in urban or common waste water treatment plants of a certain treatment level in 2014 is 0.5 % in primary, 33.4 % in secondary and 24.3 % in tertiary treatment (in total 58.2 % population; ARSO 2016b).

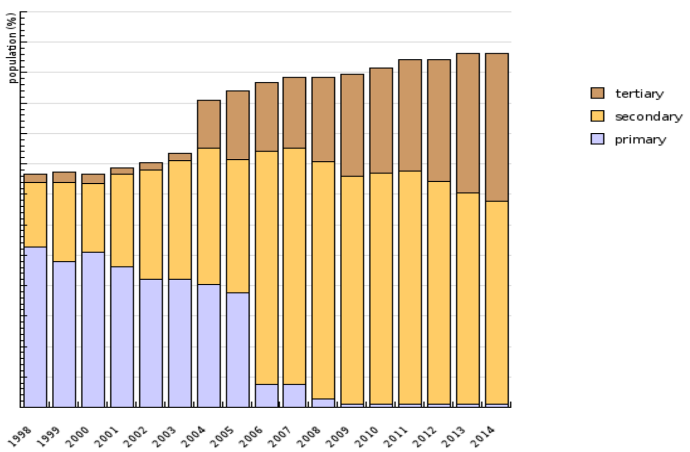


Figure 29. Share of Slovenian population whose waste water was treated in urban or common waste water treatment plants of a certain treatment level (source: ARSO, 2016b)

Sewage is generated by residential and industrial establishments and also rainwater. Table 13 shows the proportion of produced waste water in Slovenia for the year 2014.

Table 21. Wastewater pollution according to the source for Slovenia (SURS, 2016)

Year	Waste water from agriculture, forestry, fisheries	Waste water from industrial activities	Waste water from other activities	Waste water from households	Other waste water
2014	0.2%	5.8%	5.8%	37.5%	50.6%

In 2014, 800 M m^3 of water were discharged into surface waters. Most of it was discharged treated (730 M m^3). 183 M m^3 of wastewater were discharged into the public sewage system: before discharge 80 M m^3 of waste water were treated. 1 M m^3 of wastewater was discharged untreated into land and 0.4 M m^3 of wastewater was treated. Most of the rainwater (92.8 M m^3) was discharged into the public sewage system and the rest into surface waters (1.7 M m^3) and into land (0.02 M m^3; SURS, 2014).

Industrial areas

Around 19,000 industrial enterprises were registered in Slovenia in 2012, of which about 17.000 (90%) in manufacturing and 1.300 (almost 7%) in electricity, gas, steam and air conditioning supply. There were almost 400 enterprises in water supply, sewerage, waste management and remediation activities, which is just over 2% of all industrial enterprises in the country. The fewest enterprises (only 106 or less than 1%) were registered in mining and quarrying (SURS, 2013).

Manufacturing industry can pollute water with toxic substances and heavy metals, mining and construction with sediments and acids, and food production with organic substances. Main pollutants resulting from mechanical engineering are tri- and tetra-chloroethene.

The energy sector uses water for cooling thermal power plants and nuclear power plants. This heated water is then discharged back to the source (surface waters), so the source water temperature rises.

The systematic monitoring of waste water emissions to surface and groundwater related to industrial operation is defined in Decree on the emission of substances and heat when discharging waste water into waters and the public sewage system (Official Gazette of the Republic of Slovenia 64/2012, 64/2014, 98/2015) and Rules on initial measurements and operational monitoring of wastewater (Official Gazette of the Republic of Slovenia 94/2014, 98/2015). Industrial waste water regulations follow the ex EU IPPC directive (IPPC 1996/61/EC) and related BAT/BREF documents which are defining the treatment processes for each type of industrial facility and production process related. This includes also Priority substances directive (2013). The relevant regulation was changed to Industrial Emissions Directive (IED 2010/75/EU), and the technologies available within sealing devices was improved.

Impact of landfills or wastewaters emission on surface water quality is determined in Rules on surface water status monitoring (Official Gazette of the Republic of Slovenia 91/2013). Impact of landfills or operation of the plant on groundwater quality is determined in Rules on groundwater status monitoring (Official Gazette of the Republic of Slovenia 53/2015). In both Rules details regarding operational monitoring of groundwater are determined, such as: the scope of operational monitoring of groundwater status, determination and regulation of measuring points, parameters of the operational monitoring of groundwater, frequency and sampling time; methodology of sampling, measurement, analysis and treatment of samples; evaluation of impact on groundwater status; contents of the report on the operational monitoring of groundwater; the basis for determining the program of operational monitoring of groundwater; conditions and certification for implementing of operational monitoring groundwater status.

Groundwater bodies are polluted due to industry with chlorinated organic solvents in two areas in Slovenia; in the Savinja Basin and in the Mura Basin (ARSO, 2016d). In the Savinja basin the values were exceeded at only one measurement point. Higher pollution by chlorinated organic solvents is found in the central part of the Mura Basin. For both areas no long term trends are specified.

Transport units

Waste water from roads in managed with Decree on the emission of substances in the discharge of meteoric water from public roads (Official Gazette of the Republic of Slovenia 47/2005), which define measures to reduce emissions due to discharge of meteoric waste water from public roads, limits of emissions into water and public sewer system for meteoric waste water from public roads and evaluation and measurement of emissions. Measures are divided regarding the manner of waste water discharge:

- point discharges of waste water,
- diffuse discharges of waste water,
- indirect discharges into groundwater and other measures.

Point discharge is discharge of treated waste waters, which are collected in impermeable meteoric waste water. Collection and treatment of meteoric waste waters from public roads is obligatory in case of 12,000 vehicles per day and crossing porous and fractured aquifers; 6.000 vehicles per day and crossing karst aquifers; 40,000 vehicles per day and crossing geological structures with permeability less than 10^{-6} m/s. For other cases diffuse discharge of meteoric waste water from public roads is allowed.

Limits for parameters for waste water from roads have lower values for DWPZ.

In winter freezing is prevented with solvents (salt) and sands. Environmentally unfriendly solvents are allowed to use only in the minimum necessary quantities. For sanding solvents only such device should be used, that enables accurate dosing quantities. The dosing quantities of solvent should take into account the amount of solvent that it is already on the road.

Negative impact on water quality can have also the use of pesticides on railway tracks and on the roadsides.

2.1.7.3. Impact of flood and drought on drinking water quality and quantity in Slovenia

Slovenian flood management is in compliance with EU Floods Directive. Transfer of provisions of Directive 2007/60/EC is implemented within the framework of the Water Act (2002) and its amendments and the regulations thereunder. Implementing regulations summarize the main provisions for the implementation of the Directive, namely:

- Rules on methodology to define flood risk areas and erosion areas connected to floods and classification of plots into risk classes (Official Gazette of the Republic of Slovenia 60/2007), which provides for the preparation of warning maps and methodology for the determination of flood hazard and risk maps and classifying,
- Decree on conditions and limitations for constructions and activities on flood risk areas (Official Gazette of the Republic of Slovenia 98/2008), which can be considered partly as the transfer of provisions of the Flood Directive and partly already as a measure for reducing the vulnerability of flood and erosion related to the field of spatial planning,
- Decree on establishment of flood risk management plans (Official Gazette of the Republic of Slovenia 7/2010). On the basis of this Decree a document named Preliminary flood risk assessment (2011) was prepared and later the 61 Areas with Potential Significant Flood Risk (APSFR) (2013) were identified. Decree on establishment of flood risk management plans (Official Gazette of the Republic of Slovenia 7/2010) provides that flood hazard and flood risk maps must be prepared for the APSFR. Next step was to prepare Flood Risk Management Plan (2015), which is key document imposed by the European regulations. At the moment there are still flood hazard and flood risk maps for some of the 61 APSFR missing and Flood Risk Management Plan is in validation.

Ministry of the Environment and Spatial Planning is responsible for flood and drought risk assessment on a national level. Flood risk assessment has been prepared for the areas with potential significant flood risk on the national level. For other areas it is done by local communities or by private investors. There are 61 areas with potential significant flood risk identified for Slovenia.

Within the preparation of expert basis for implementation Floods Directive (2007/60/EC) the task of preparation of reducing flood risk's economic plans has been carried out, which defines the assessment of the expected annual damage to APSFR and cost structure actions. A map of the floods risk can be seen in web GIS from the Slovenian Environment Agency (EARS, 2016). According to the flood risk .shp data provided by Slovenian Project Partners, around 6.9% of flood risk area is taken up by frequent floods; rare floods occupy 28.5% of the flood risk area, while very rare floods take the remaining 64.7%.

Drought is not implemented directly in Slovenian legislation, except in Protection against Natural and Other Disasters Act (Official Gazette of the Republic of Slovenia 51/2006, 97/2010), where drought (and also flood) is considered a natural disaster.

Slovenian Environment Agency is very active in drought management, because it was leading the Drought Management Centre for South-eastern Europe – DMCSEE, which will now continue within new project DriDanube, Drought Risk in the Danube Region. Slovenia prepared also Slovenian guidelines for drought management and its implementation. Drought Management Plan will be part of the Slovenian River Basin Management Plan (RBMP) 2015-2021. Proclamation of droughts enables determination of periods, in which intervention measures for water management are valid.

Slovenian Environment Agency publishes short-term warnings for drought (1-7 days) with information about drought indexes on its web page (e.g. temperature of air and soil in different depths, precipitation for current week, water balance for the precedent day and week) and long-term warnings for drought (10-15 days) with information about hydrological conditions in Drought monitoring Bulletin for each month. There is a map of the risk of agricultural drought by municipalities.

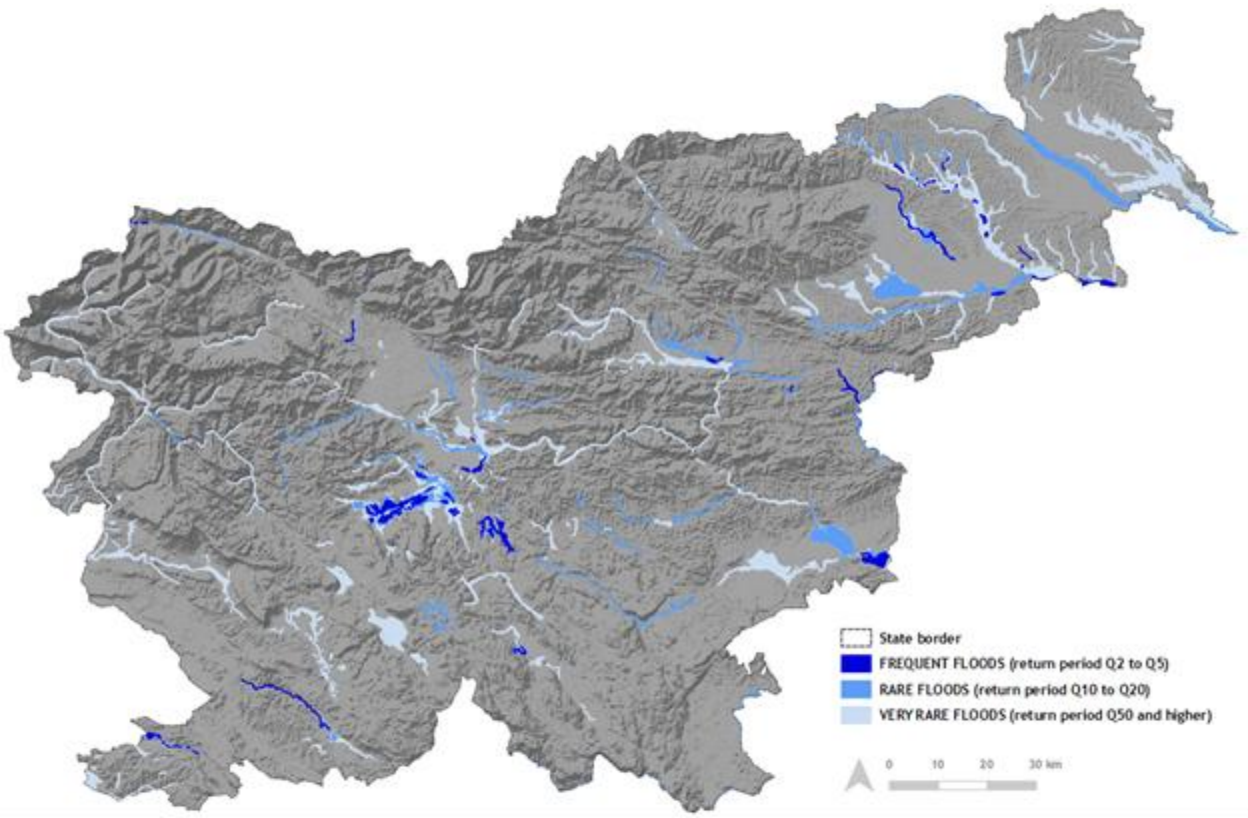


Figure 30. Flood risk map of Slovenia (floods data provided by Slovenian Project Partner; hillshade by ArcGIS REST Services Directory)

2.1.7.4. Overview of status quo in Slovenia via SWOT framework

Methodical overview of land use activities, flood and drought impacts on drinking water resources within Slovenia as well as identification of strengths (S), weaknesses (W), opportunities (O) and threats (T) for Slovenia is shown in Table 23. The SWOT framework showcases the most important achievements, issues and potential for improvement that the project partner has addressed.

Table 22. SWOT analysis for Slovenia

S	W
Implementation of DWPZ for drinking water sources with limitations of spatial planning and activities in those areas Education of farmers by municipality and water supply companies regarding farming and drinking water protection Limitations of farming activities in DWPZ I with paying compensations for crop loss Management of forests following sustainability principles: sustained preservation of forests and the sustainable use of their assets and intangible functions; use of forests to such an extent and in such a way that allows the conservation of all natural forest stands; multiple purpose management with a balanced significance of ecological, production and social functions of forests Forest management plans: including of professional guidance on optimization of hydrological role of forests, application of the criteria for the evaluation of forest functions spatial forest management plans Public service of river and hydraulic structure maintenance with tradition New legislation supporting development of flood hazard maps which impose limitations on developments on flood prone areas Increased awareness in public due to the recent flood events Vegetated buffer zones along water bodies that reduce surface runoff Agricultural advisory services Avoidance of clear-cuts Establishing protective forests Subsidies for sustainable water management	Conflicts of interests in DWPZ areas (agricultural lobby, industry) Legislation on application of nitrates (EU Nitrates Directive) adopted, but poorly implemented For the acquisition of mineral nutrients there are no restrictions on quantities For the acquisition of pesticides an exam and certification is required, but the amount is not limited (farmers can buy it also for others, who do not have certificate). The consumption of pesticides is not monitored (there are no fertilization plans). Farmers have to adhere to the instructions. For use of pesticides the application diary is not obligatory. Insufficient inspection of the Inspectorate for Agriculture, Forestry, Hunting and Fishing Unstable governance structure with several organizational changes in last decades Missing registry of assets of hydraulic structures Flood hazard maps not always developed according to unified standards Insufficient financing of the flood management domain in recent decades causing degradation of existing infrastructure Inter-institutional cooperation – horizontal (among different sectors) and vertical (among different levels of governance – state, regional, local) is inefficient Manure application in DWPZ Incomplete wastewater treatment plants Direct urban drainage into water courses No sewage systems due to dispersed settlements
SLO	
O	T
Eco farming with eco products with higher prices Use of ecosystem services Combined approach addressing droughts and floods with multiuse reservoirs	Lack of investments into sewage and wastewater treatment Climate change with more intensive precipitation (floods) and dry periods (drinking water shortage) in Slovenia Floods potentially causing pollution (i.e. flooding of oil tanks and warehouse with plant protection products in 2010) Intensive urbanization in floodplains

2.2. Evaluation of land use, flood and drought impacts on drinking water quality and quantity in Central Europe

This subchapter summarizes most relevant factors and impacts of land use on drinking water quality and quantity, by means of comparison and conclusions on transnational level. Each type of land use is evaluated individually. Main findings and comparable data are shown graphically wherever possible.

Statistical data is derived either from PROLINE-CE D.T1.1.1 “Country Reports About the Implementation of Sustainable Land Use in Drinking Water Recharge Areas” or EUROSTAT, unless specified otherwise.

An analytic tool called “DPSIR” (i.e. **d**riving forces, **p**ressures, **s**tate, **i**mpacts and **r**esponses) was used to acquire better understanding of interacting factors (drivers and pressures) that change the environment by methodical evaluation of land use and flood/droughts impacts on water resources quality and quantity. DPSIR conceptual framework can be used to support the implementation of WFD at different scales. Its practical application depends on the complexity of the situation in the river basin, the existing pressures and impacts and the potential, feasible measures. For the purpose of reducing or preventing significant pressures to the extent required to achieve good status of water resources, Key Type of Measures (KTM) were given (Table 14). They are groups of measures identified by Member States in the PoMs (Programme of Measures) and their implementation is expected to deliver the bulk of actions (improvements through reduction in pressures) required to achieve WFD Environmental Objectives. More than one KTM may be applicable to any particular pressure depending on the impacts of the pressure and the specific conditions in a Project Partner country.

Table 23. List of Key Type of Measures - KTM (predefined for the 2016 WFD implementation reports)

KTM	Title
1	Construction or upgrades of wastewater treatment plants.
2	Reduce nutrient pollution in agriculture.
3	Reduce pesticides pollution in agriculture.
4	Remediation of contaminated sites (historical pollution including sediments, groundwater, soil).
5	Improving longitudinal continuity (e.g. establishing fish passes, demolishing old dams).
6	Improving hydromorphological conditions of water bodies other than longitudinal continuity (e.g. river restoration, improvement of riparian
7	Improvements in flow regime and/or establishment of minimum ecological flow
8	Water efficiency measures for irrigation (technical measures).
9	Progress in water pricing policy measures for the implementation of the recovery of cost of water services from households.
10	Progress in water pricing policy measures for the implementation of the recovery of cost of water services from industry.

KTM	Title
11	Progress in water pricing policy measures for the implementation of the recovery of cost of water services from agriculture.
12	Advisory services for agriculture.
13	Drinking water protection measures (e.g. establishment of safeguard zones, buffer zones etc.)
14	Research, improvement of knowledge base reducing uncertainty.
15	Measures for the phasing-out of emissions, discharges and losses of Priority Hazardous Substances or for the reduction of emissions, discharges and losses of Priority Substances.
16	Upgrades or improvements of industrial wastewater treatment plants (including farms)
17	Measures to reduce sediment from soil erosion and surface run-off.
18	Measures to prevent or control the adverse impacts of invasive alien species and introduced diseases.
19	Measures to prevent or control the adverse impacts of recreation including angling.
20	Measures to prevent or control the adverse impacts of fishing and other exploitation/removal of animal and plants.
21	Measures to prevent or control the input of pollution from urban areas, transport and built infrastructure.
22	Measures to prevent or control the input of pollution from forestry.
23	Natural water retention measures.
24	Adaptation to climate change.
25	Measures to counteract acidification.

2.2.1. Agriculture

Agricultural production can present a negative impact on both the quality and quantity of water resources. Intensive and non-conservational tillage, cultivation of arable land with no buffer zones along water courses, monoculture production or intensive production regardless of soil and water conservation as well as use of heavy machinery will affect the morphological structure of soil, but will also impact the hydrological regime of the groundwater. Improper use of fertilizers, pesticides or other substances as well as inappropriate manure management can lead to soil depletion and contamination of surface and groundwater resources. Draining of wetlands in order to gain more land for intensive and ever spreading agricultural production is still a significant problem, even though they have an important role in biodiversity, landscape diversity, water storage and groundwater recharge and reduction of down-stream runoff.

Inadequate irrigation of land changes the use and distribution of surface water and groundwater, but can also affect ecosystems that are dependent upon it. Irrigable land is total maximum utilised agricultural area which could be irrigated in the reference year using the equipment and the quantity of water normally available on the agricultural holding (Eurostat, 2014). The following graph shows irrigable land in Project Partner countries, where Italy stands out with over 4000 k ha of irrigable land.

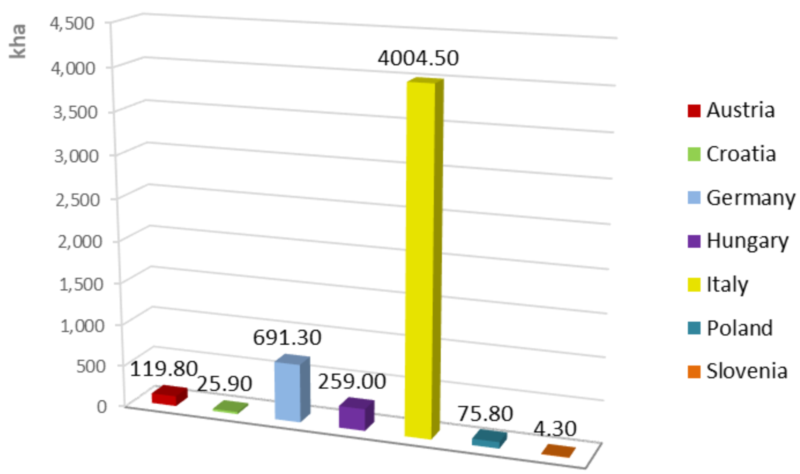


Figure 31. Irrigable land in Project Partner countries (data by Eurostat, 2013; for Austria, Croatia, Slovenia, Italy and Hungary UAA in 2013 was calculated without common land)

According to the Eurostat, the largest total utilised agricultural area (UAA) occupied by organic farming (existing organically-farmed areas and areas in process of conversion) is present in Austria, which has around 20.25% of total utilised agricultural area occupied by organic farming. Italy has 12.34% UAA under organic farming, followed by Slovenia with 8.69%, Germany with 6.35%, and Croatia with 4.83% of UAA under organic farming. Poland with 4.03% and Hungary with 2.79% have smallest UAA under organic farming.

At the EU level, farming is only considered to be organic if it complies with Council Regulation (EC) No 834/2007, which has set up a comprehensive framework for the organic production of crops and livestock and for the labelling, processing and marketing of organic products, while also governing imports of organic products into the EU.

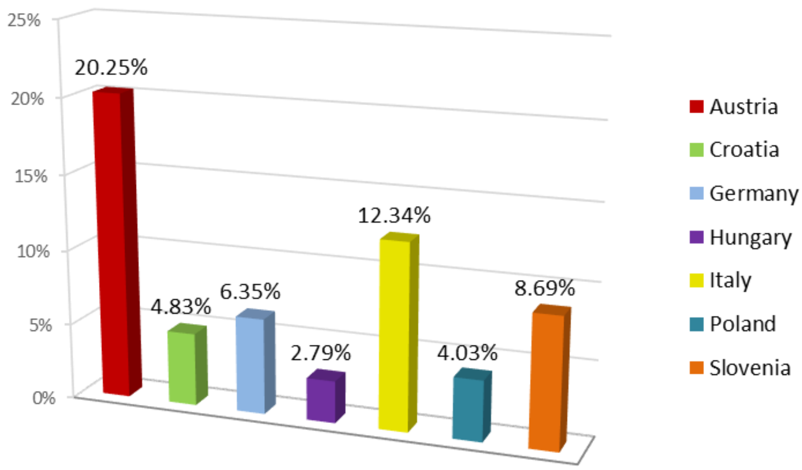


Figure 32. Area under the organic farming in Project Partner countries (data by Eurostat)

Furthermore, according to the Eurostat the amount of sold pesticides from 2011-2014 was highest in Italy (64,071 tonnes) and lowest in Slovenia (1,009 tonnes).

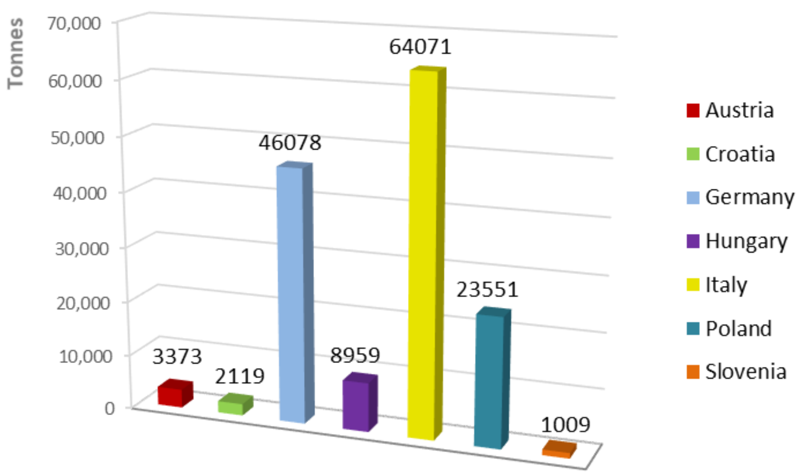


Figure 33. Sales of pesticides, 2011-14 (tonnes of active ingredient) in Project Partner countries (data by Eurostat)

Agricultural land, along with forests ocuppies the significant areas of the drinking water protection zones in Project Partner countries. According to the Corine Land Cover data, agricultural land takes up nearly half of the DWPZ in Italy (39.04%), Hungary (46.2%) and Poland (47.02%). In other Project Partner countries land used for different agricultural production occupies somewhat smaller areas of the DWPZ (24.57% of land in Austria, 24.69% of land in Slovenia, 26.14% of land in Germany and 29.77% of land in Croatia). The most frequent types of agricultural land use are non-irrigated arable land followed by complex cultivation patterns and land principally occupied by agriculture.

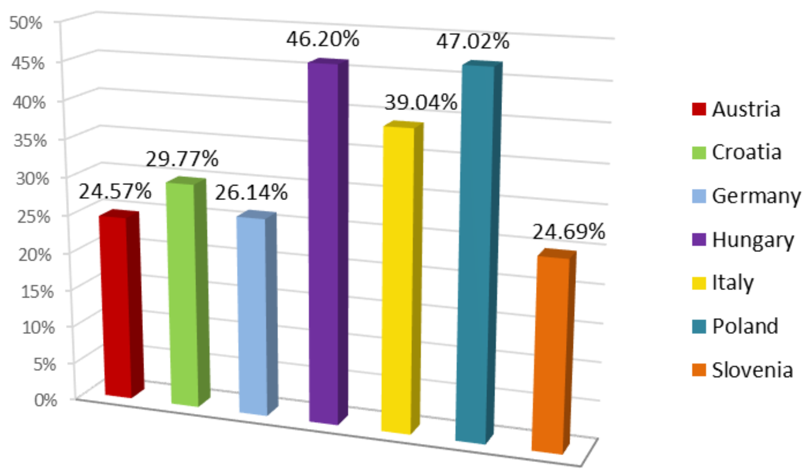


Figure 34. Agricultural land in drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Also an interesting fact is that according to the CLC data, only Croatia has the land use category - permanently irrigated land within the DWPZ (around 0.06% of total area).

Vineyard and orchards often present the agricultural land-use category with the most amounts of applied fertilizers or pesticides. Within the DWPZ of Project Partner countries, Italy has the largest area under the vineyard production (around 1.44% of land). Italy is followed by Hungary with 1.04% of DWPZ land under the vineyards, while on the other hand we have Germany with only 0.10% and Poland with no vineyards recorded within DWPZ.

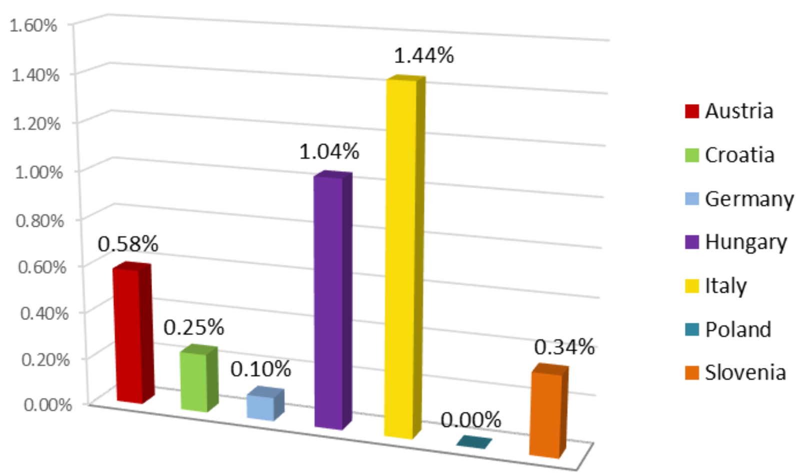


Figure 35. Vineyards in drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Land that is principally occupied by agriculture but has significant areas of natural vegetation, can present a positive management practice of agricultural land because it not only contributes to the biodiversity and landscape diversity but can also consequently contribute to the water and soil conservation. Among the Project Partner countries Croatia precedes with 9.55% of land within DWPZ used for this category. On the other end Germany has the smallest area of land within DWPZ (0.25%) under agricultural land with significant areas of natural vegetation.

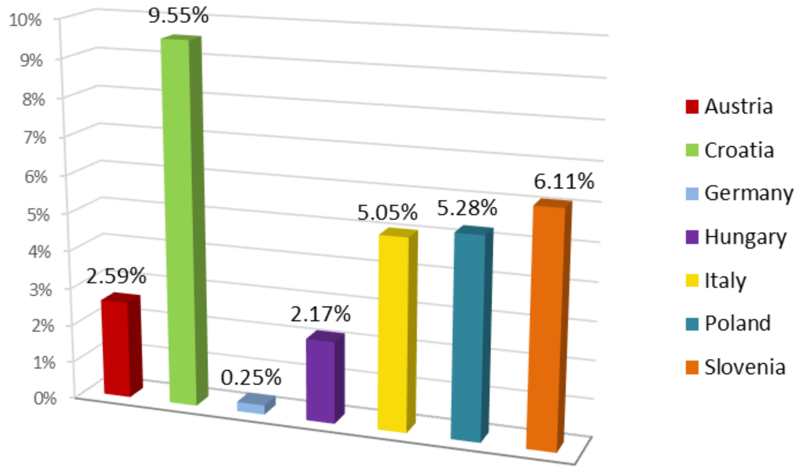


Figure 36. Land principally occupied by agriculture with significant areas of natural vegetation within drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Higher amounts of pesticides and fertilizers application on fruit trees and berry plantations can also present unfavourable impacts on water resources. This agricultural land-use category is present to a small extent in all Project Partner countries.

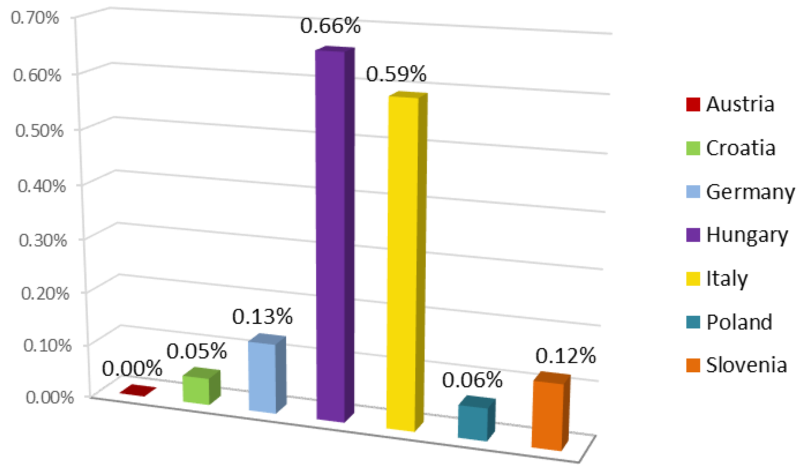


Figure 37. Land principally occupied by fruit trees and berry plantations within drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Complex cultivation patterns of arable land occupy around 15.21% of land within DWPZ of Croatia, while Germany has only 0.17% of land under this land use category.

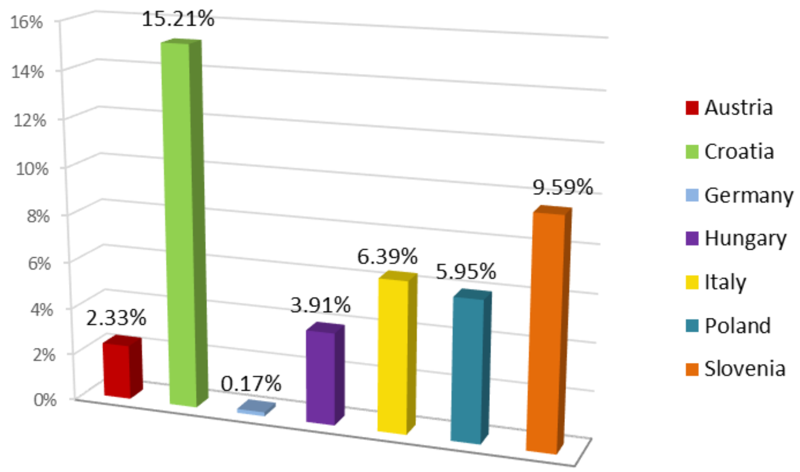


Figure 38. Complex cultivation patterns within drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Hungary, Poland and Germany have the biggest areas under the non-irrigated arable land use within DWPZ, while Croatia with 4.52% and Slovenia with 8.53% has the smallest areas ocuppied by this land-use category.

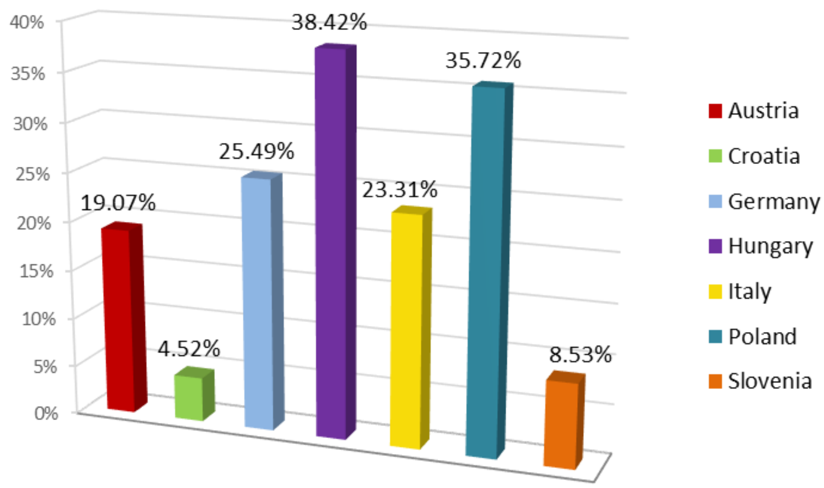


Figure 39. Non-irrigated arable land within drinking water protection zones (Corine Land Cover 2012 data and DWPZ provided by Project Partners)

EU Common Agricultural Policy (CAP) has defined a set of policy mechanisms aimed at the protection of European environment from adverse agricultural practices. As Member States, Project Partner countries should implement CAP principles. Cross-compliance as a baseline for agri-environment measures is a mechanism that links direct payments to compliance by farmers with basic standards concerning the environment, food safety, animal and plant health and animal welfare, as well as the requirement of maintaining land in good agricultural and environmental condition. Farmers that are receiving direct payments are subject to implement Good agricultural and environmental conditions (GAECs: The obligation of keeping land in good agricultural and environmental condition refers to a range of standards related to soil protection, maintenance of soil organic matter and structure, avoiding the deterioration of habitats and water management).
Education and informing of agricultural producers, associations, distributors and broader public on the sustainable use of fertilizers and pesticides as well as encouraging of farmers to perform organic farming is a paramount for the preservation of soil and water resources in regard to agricultural production. Slovenia states how farmers who receive a subsidy, are obliged to attend lectures about plant protection products every five years and follow the plan for spreading manure, while Croatia highlights the important role of Advisory Service that conducts the educative workshops.

An overview of the most significant driving forces (within CE countries) in the form of land use activities that exert pressures on water resources, causing the change of their state, are given in tables below.

Table 24. Impact of agricultural activities on water quality and quantity - DPSIR approach for the present/past state in CE

IMPACT OF AGRICULTURAL ACTIVITIES ON WATER RESOURCES QUALITY AND QUANTITY				
AGRICULTURE		Driving forces	**Use of fertilizers (especially nitrate consumption)**	
		Pressures	Diffuse nitrate loads (runoff and percolation)	
		State	Due to high nitrate concentrations in soils emissions of nitrous oxide is increasing	
			Values of nitrates exceed the thresholds in some areas (strengthened by less precipitation)	
		Impacts	Deterioration of groundwater quality	
			Negative effects through nitrous oxide emissions on climate protection	
		Responses	Evaluation and amendment of the Nitrate Action Plan every 4 years	**KTM 2, 12**
			Optimisation of Nitrate Directive	
			Optimization of the application of fertilisers (according to time and amount due to soil samples)	
			Waiver of fertilisers, especially within sensitive areas	
			Agri-environmental measures	
			Strengthening of consultancy and research programmes	
			Acceleration of organic farming (e.g. financial incentives)	
			Effectiveness of Common Agricultural Policy should be improved towards	

	sustainability		
	Shift of the water intake area to forested catchments (if possible)		
Driving forces	**Use of pesticides**		
Pressures	Diffuse load of pesticides within intensive agricultural areas		
State	Values of some pesticides (especially Triazine) exceed the thresholds within intensively used areas		
Impacts	Deterioration of groundwater and surface water quality		
Responses	Buffer zones	**KTM 3, 12**	
	Acceleration of the Agro-Environmental Programme (e.g. ÖPUL)		
	Incentives for organic agriculture and education of farmers		
	Minimizing and regulation of the application (e.g. application in spring preferred to autumn		
	Prohibition of pesticide application in DWPZ (organic farming in DWPZ)		
Driving forces	**Inappropriate livestock waste and manure management**		
Pressures	Diffuse contamination of pathogens and N into groundwater and soil through leaching		
State	Presence of excess pathogens and N in ground waters and soils		
Impacts	Impact on human health		
	Water unfit for drinking and irrigation		
Responses	Optimisation of Nitrate Directive	**KTM 2, 12**	
	Support for investments in storage of manure and training of farmers		
Driving forces	**Water abstraction for irrigation purposes**		
Pressures	Decrease dilution of salts into groundwater		
	Decrease in water table height and land subsidence enhancing sea water intrusion into aquifers		
State	Increased of salinity and conductivity above drinking water standards		
Impacts	Over exploitation of water resources		
	Salinization of soils and desertification		
Responses	Investments for improving the state of irrigation infrastructures or techniques	**KTM 7, 8, 11**	
	Water pricing policies		
	Water sources differentiation		
	Desalinization treatments		
Driving	**Increase of livestock density**		

		forces		
		Pressures	Build-ups of excess nutrients and heavy metal in the soil	
		State	Values of nutrients and heavy metals concentration above the drinking water standards	
		Impacts	Impact on human health	
			Unfit for drinking and irrigation	
		Responses	Optimisation of Nitrate Directive	**KTM 2, 12**
			Support for investments in storage of manure and training of farmers	
		Driving forces	**Excessive or uncontrolled irrigation**	
		Pressures	Increased runoff of nutrients, pesticides and salts	
			Waterlogging in poorly drained soils enhances evaporation and salinization	
		State	Values of nutrients, pesticides and salinity above the drinking water standards	
		Impacts	Salinization of soils and desertification	
			Human health	
		Responses	Farming practice regulation	**KTM 8, 11, 12**
			Agri-environmental scheme	
			Creation of buffer/sink zones for nutrients	
			Water pricing policies	
		Driving forces	**Open croplands between main crops**	
		Pressures	Nutrient leaching through mineralisation of harvest residues	
			Erosion and soil degradation processes	
		State	Growing trends of nitrate concentrations; solute transport to receiving waters	
		Impacts	Deterioration of water quality	
			Impact on human health	
			Surface water eutrophication	
		Responses	Implementation of catch crops	**KTM 2, 12, 14, 17**
		Driving forces	**Conventional soil tillage**	
		Pressures	Nutrient leaching (runoff) and reduced humus content	
		State	Increased nutrient concentration in receiving waters (e.g. nitrate)	
			Reduced water purification	
		Impacts	Deterioration of water quality	

			Impact on human health	
			Surface water eutrophication	
		Responses	Fostering conservation tillage	**KTM 2, 12**
			Non-turning techniques	
		Driving forces	**Harvesting perpendicular to the slope**	
		Pressures	Preferential flow paths and erosion, increased solute transport to receiving waters	
		State	Increased nutrient and herbicide concentration in receiving waters; less purification	
		Impacts	Deterioration of surface and groundwater quality	
		Responses	Implementation of legal restriction	**KTM 2, 12, 17**
			Fostering harvesting parallel to the slope	
		Driving forces	**Agricultural areas in floodplain**	
		Pressures	Diffuse pollution to surface waters	
		State	Eutrophic surface waters or not good chemical status	
		Impacts	Deterioration of surface waters quality	
		Responses	Land use change	**KTM 2, 3**
			Organic farming	
			Riparian buffer strips	

2.2.2. Forest

Forests have multiple, significant roles within the protection of water resources. They not only directly contribute to the biodiversity and protect the land by reducing the soil erosion caused by water, but also regulate and mitigate climate changes, affect the flow regime by reducing and delaying the stormflow peaks, therefore mitigating flood hazards. Forest clear-cuts may cause increased surface runoff and hence endanger both settlements and their drinking water resource. Stability, resilience and natural regeneration possibility are crucial features of forest ecosystems that are dependent on structural diversity of forest stands. Strategic and sustainable forest management that implements the use of the autochthonous plant material in forest stands, maintains good vertical and horizontal forest stand diversity, prevents forest fires, establishes protective forest buffers along watercourses and improves protective roles of forests in general, is one of the prerequisites for sustainable water resources protection.

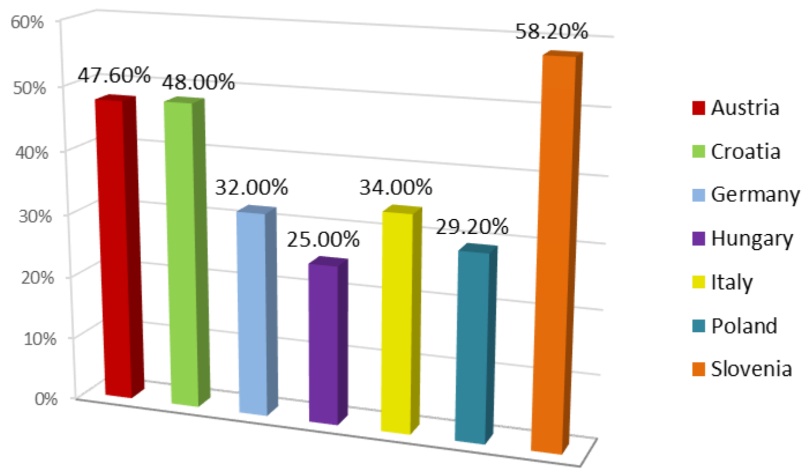


Figure 40. Forests within Project Partner countries (based on data provided by Project Partners)

Slovenia stands out with 58.2% of total country territory covered with forests. Germany (32%), Hungary (25%), Italy (34%) and Poland (29.2%) all have similar quantity of forested areas. Around 48% of total country area is under the forests in Croatia and Austria. Since the majority of Project Partner countries have significant areas under the forest coverage, it can be seen as a positive factor regarding water resources protection, given that forests positively affect the hydrological regime and mitigate surface runoff which is especially important for flood prevention and mitigation.

According to the data provided by Project Partners, the amount of land covered with forest in drinking water protection zones varies between 21.79% in Italy and 61.04% in Slovenia. The majority of area is covered with broad-leaved forests, coniferous forests and mixed forests, while the transitional woodland-shrub and agro-forestry areas occupy smaller areas within the DWPZ.

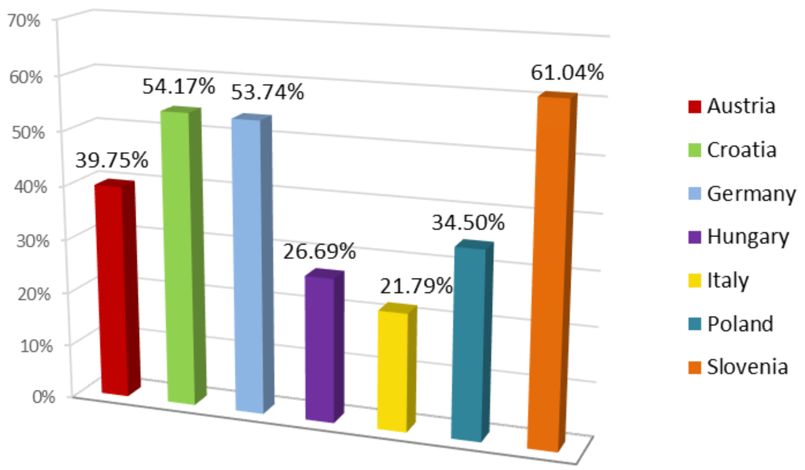


Figure 41. Areas of DWPZ that are covered with forest (CLC 2012 data and DWPZ provided by Project Partners)

Since the majority of Project Partner countries have significant areas (including DWPZ) under the forest coverage, it can be seen as a positive factor regarding water resources protection, given that forests positively affect the hydrological regime and mitigate surface runoff which is especially important for flood prevention and mitigation.

Table 25. Impact of forestry activities on water quality and quantity - DPSIR approach for the present/past state in CE

IMPACT OF FORESTRY ON WATER RESOURCES QUALITY AND QUANTITY				
FOREST		Driving forces	**Clear Cut application**	
		Pressures	Humus decomposition, soil erosion, increased surface flow, further erosion processes	
		State	Decreasing water protection functionality of the involved forest sites	
		Impacts	Increased turbidity in the source water, increased matter concentration in the source water	
			Microbial contamination of the source waters, source waters are not able to be used for water supply	
		Responses	Avoidance of clear-cut applications	**KTM 13, 17**
			Application of continuous cover forest systems	
		Driving forces	**Forest ecologically unbalanced (high) wild ungulate densities**	
		Pressures	Browsing damages on deciduous tree species and silver fir	
			Fraying damages in case of various tree species	
			Bark stripping damages in case of various tree species	
		State	Destabilisation of the forest ecosystems through lacking natural regeneration	
			Extinction of tree species	
			Decreasing water protection functionality of the involved forest ecosystems	
		Impacts	Forest decline, growth of weed species instead of trees at forest sites, erosion processes, rock-fall, avalanches, increased flood damages, contamination of the source water through elevated turbidity, SAC, nitrate, DOC	
		Responses	Balancing the wild ungulate densities to a forest ecologically sustainable level	**KTM 13, 17,22**
			Increased hunting activities with the purpose of forest ecology	
			Resettlement of wild predators like wolves, lynx, etc.	
		Driving forces	**Extended application of the tractor skidder method in the course of timber yield**	
		Pressures	Soil compaction on at least 20% of the forest sites; long lasting soil compaction	
		State	Water protection functionality in terms of infiltration capacity and water storage capacity disappeared at minimum 20% of the forest site	
		Impacts	Surface Flow in the course of heavy rainfall events; erosion processes like gully formation, soil erosion.	
			Increased danger of flood creation through increased surface flow	
			Contamination of the source water with various substances (clay, nitrate, DOC, increased turbidity, etc.)	
		Responses	Avoidance of the tractor-skidder method	**KTM 13, 17,22**
			Application of alternatives	

		Driving forces	**Incorrect management (e.g. unregulated cut)**	
		Pressures	Mobilisation of salts and sediments from subsoil	
		State	Increase of salinity and total dissolved solids above drinking waters standards	
		Impacts	Unfit water for drinking, irrigation and specific industrial uses	
		Responses	Improved management	**KTM 17**
			Zonation of land to preserve habitat	
			Increased conservation areas	
		Driving forces	**Forest fires**	
		Pressures	Alteration of soil physical, biological and chemical characteristics	
		State	Increased water repellency of soil and loose of soil structure	
		Impacts	Post-fire increase of runoff and erosion processes that also transport soil contaminants then infiltrating into low slope areas	
		Responses	Improved management, including preventive measures	**KTM 17**
			Fire fighting	
		Driving forces	**Harvesting with heavy machinery**	
		Pressures	Soil compaction and deterioration of soil structure	
		State	Decreased infiltration capacity and water recharge	
		Impacts	Decreased water availability and provision for supplying purposes	
		Responses	Implementation of a resource-friendly exploitation system	**KTM 13, 23**
		Driving forces	**Coniferous monocultures**	
		Pressures	High water storage capacity of the trees and year-round interception; shallow root network	
		State	Decreased groundwater recharge	
		Impacts	Decreased water availability and provision for supplying purposes	
		Responses	Fostering a conversion to mixed forests	**KTM 13, 23**
		Driving forces	**Removal of deadwood**	
		Pressures	Reduced formation of humus	
		State	Decreased water purification	
		Impacts	Increased leaching of free nutrients and air pollutants	
		Responses	Fostering an adequate deadwood management	**KTM 6**
		Driving forces	**Spreading of invasive species**	
		Pressures	Plantation of alien species	
		State	Less water protection capacity purification	
		Impacts	Fewer ecosystem services	

		Responses	Promotion of plantation of native species	**KTM 18**
		Driving forces	**Agro-forestry scheme**	
		Pressures	Agricultural activity in the forest (e.g. grazing)	
		State	Pollution from agricultural activities	
		Impacts	Higher nutrient content of the waters	
		Responses	Control on agricultural activities to keep extensive usage	**KTM 2, 3**

2.2.3. Pastures

European meadows and pastures as land covers rich in plant and animals species often represent endangered habitats that are included in Natura 2000 ecological network. They should be maintained only by grazing and mowing. However, high concentration of livestock at the pasture leads to grass damage, soil erosion, higher surface runoff and organic pollution transport. On the other end negligence, abandonment or change of traditional management systems of grassed parcels (meadows and pastures) leads to their degradation, increase of aggressive invasive species and soil and water quality changes. Furthermore, inadequate drainage of pastures will result in decreased water retention capacity of the catchment, decreased level of groundwater and can lead to disbalance of groundwater recharge in infiltration zones.

According to the Corine Land Cover data, there are only few lands used as pastures within the drinking water protection zones of Project Partner countries. In Italy they cover just 1.5% of land within the DWPZ. In other Project Partner countries the amount of land covered with pastures varies around 3 to 6%. Only Germany stands out as the country with almost 15.4% of pastures present in DWPZ.

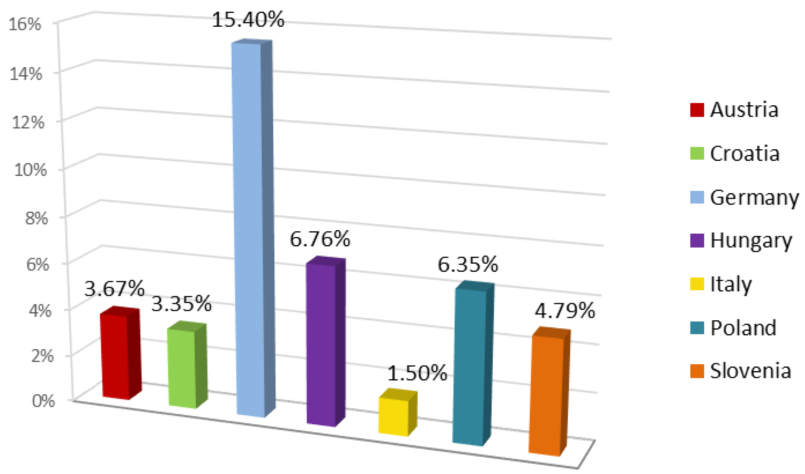


Figure 42. Pastures in drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners) – data for Italy refers only to North Italy

Table 26. Impact of pasture/grassland activities on water quality and quantity - DPSIR approach for the present/past state in CE

IMPACT OF LAND USE ON WATER RESOURCES QUALITY AND QUANTITY				
PASTURES		Driving forces	**Livestock grazing close to dolines, swallow holes and streams**	
		Pressures	Entrance of faeces and faecal micro-organisms to the aquifer	
		State	Source waters contaminated with faecal micro-organisms	
		Impacts	Source water cannot be used for drinking water supply	
			Source water creates serious health damages among people	
			High costs for the treatment of the raw water	
		Responses	Prevent livestock from grazing close to dolines, swallow holes or streams	**KTM 2**
			Construction of dams etc. what prevents precipitation water from direct and fast entrance into dolines and swallow holes	
		Driving forces	**Intensive application of liquid manure to the grassland**	
		Pressures	Leaching of the liquid manure (nitrate and faecal micro-organisms) to the aquifer	
		State	Source waters contaminated with faecal micro-organisms, nitrate, etc.	
		Impacts	Source water cannot be used for drinking water supply; or source water creates serious health damages among people; or high costs for the treatment of the raw water	
		Responses	Limitation of the application of liquid manure: prohibition or reduction in quantity and limitation to days when plants can provide a high nitrate uptake rate	**KTM 2**
		Driving forces	**Ploughing up of grassland**	
		Pressures	Deterioration of soil structure and vertical connectivity	
		State	Decreased water retention	
		Impacts	Enhanced overland flow contribution to direct runoff	
		Responses	Implementation of measures for advisory and financial support to avoid conversion of grassland	**KTM 23**
		Driving forces	**Intensive use of heavy machinery on grasslands**	
		Pressures	Soil compaction and deterioration of the turf and the vertical connectivity	
		State	Decreased water retention due to decreased infiltration capacity	
		Impacts	Enhanced overland flow contribution to direct runoff	
		Responses	Extensification of land-use activities on grasslands	**KTM 23**
		Driving forces	**Intensive grazing activities**	
		Pressures	Soil compaction and deterioration of the turf and the vertical connectivity	
		State	Decreased groundwater recharge	

		Impacts	Decreased water availability and provision for supplying purposes	
		Responses	Implementation of adapted grazing strategies	**KTM 23**
		Driving forces	**Intensive manuring of grasslands**	
		Pressures	Diffuse N contribution	
		State	Values of nitrates and pathogens above legally permitted limit values in some areas	
		Impacts	Deterioration of groundwater or surface water quality	
		Responses	Manure management – controls and supervisions, prohibitions of manuring in DWPZ	**KTM 2**

2.2.4. Urban areas

Bad management practices along with gaps in the national legislation related to the urban land use can cause numerous negative issues that might affect water quality and availability. Thus densely populated or constructed urban areas with high amount of impervious surfaces can result in increased surface runoff, increased water usage, inadequate sewage and waste disposal. Furthermore, poor spatial planning in the development of rural or urban areas in flood prone areas can lead to serious flood risks.

According to the CLC data provided by Project Partners, the amount of land used as an urban area in drinking water protection zones varies between the smallest amount in Croatia with 2.81% and largest amount of 13.54% in Hungary. These urban areas often encompass continuous and discontinuous urban fabric and areas that are constructed more than 80%. Other urban areas that can be found within DWPZ are green urban areas and sport and leisure facilities.

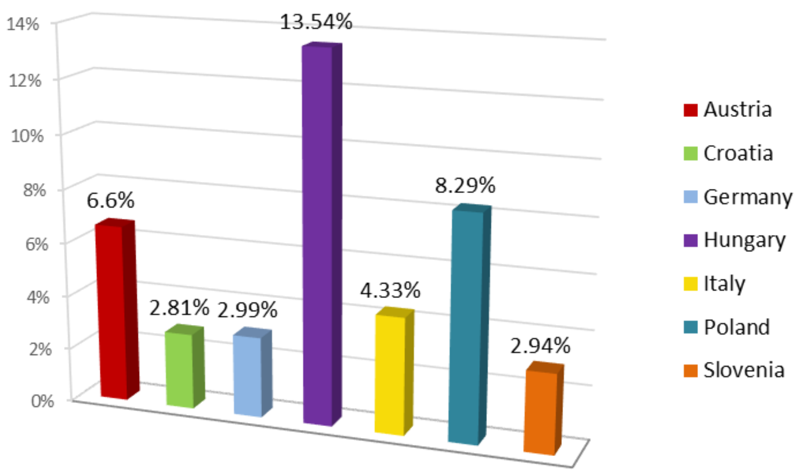


Figure 43. Urban areas in drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Given the amount of urban land use in DWPZ of Project Partner countries generally low, it is a praiseworthy fact concerning the aspect of water resources protection.

According to the Eurostat data, in majority of Project Partner countries more than a half of the population is connected to the sewage systems (**Fig. 37**). One half of the Project Partner countries have the connectivity around 95% which is commendable, while the other half has around 70% of population connected to sewage systems. Only Croatia stands out with just 46% (data from Croatia River Basin Management Plan 2016-2021) of population connected to the sewage systems.

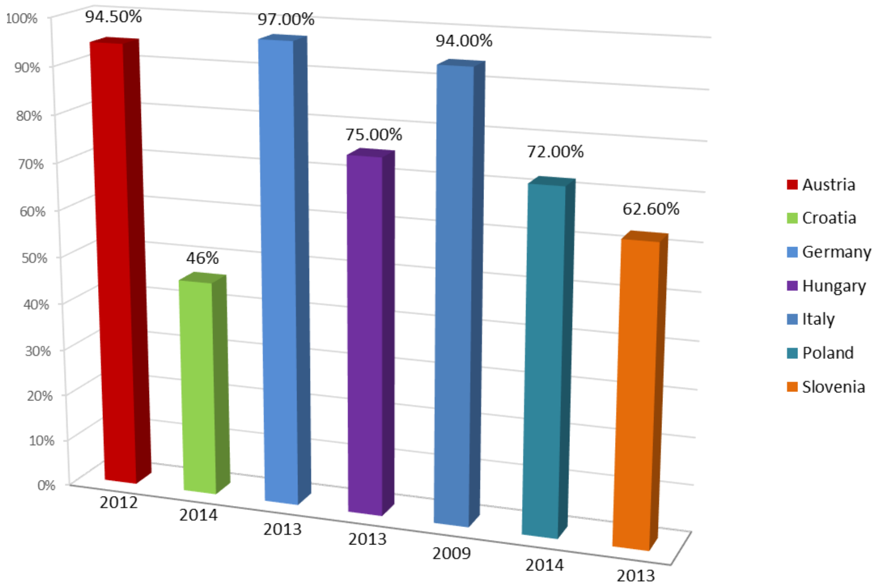


Figure 44. Connectivity of population to sewage system in Project Partner countries (data by Eurostat; some of the data is estimated; X axis shows the year of the acquired data)

Low connectivity of the population to the sewage systems are often repercussions of inadequate or unsustainable spatial (urban and rural) development, insufficient funding and exhaustive legislation procedures. Individual properties or whole settlement without the proper sewage systems and wastewater treatment facilities, as well as those having these systems that are unmaintained or devastated, pose a serious environmental problem especially from the aspect of water resources protection. Some of the poorly developed settlements that, due to their dispersed spatial structure and distance from the urban or rural fabric with adequate sewage network, have cesspits which are in most cases permeable and prone to leak. Germany stated that almost 80% of the private sewage systems are damaged which may harmfully affect the environment. Although the sewage network development in Croatia is not on the satisfactory level, significant efforts (planned measures) are being taken according to the River Basin Management Plan. In Hungary number of settlements connected to utility sewage system and wastewater treatment facilities is continuously increasing which has decreased pressure on groundwater while on surface waters increased in the last decade. Also Slovenia stated that the amount of treated wastewater increased, but it is still only around 54%. Remarkable is the fact that in Austria only three sewage treatment plants discharge their wastewater into groundwater on the basis of water permissions, but they do not cause any degradation of groundwater quality status.

According to the data provided by Project Partner countries, Italy has the largest number of wastewater treatment facilities (18,000), while Croatia has the smallest number of treatment facilities (110).

Table 27. Number of wastewater treatment facilities per Project Partner country

County	Number of wastewater treatment facilities
Italy	18,000
Germany	2,700
Austria	1,842
Poland	1,643
Slovenia	683
Croatia	110
Hungary	No data

Less than a half of Project Partner countries recycle around 55% of produced municipal waste. Croatia stands out as a country that recycles the least (only 18% of municipal waste).

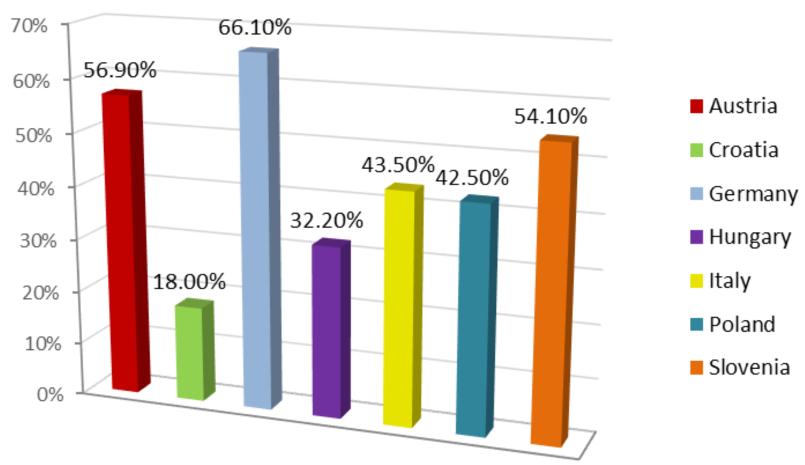


Figure 45. Recycled municipal waste in Project Partner countries in 2015 (data by Eurostat, some of the values were estimated)

Austria stated that they have a leading role in Europe concerning waste management, while in Croatia and Hungary the activities and interest in waste management are growing and the proportions of recycled or composted waste are increasing.

Table 28. Impact of urban activities on water quality and quantity - DPSIR approach for the present/past state in CE

<table>
<tr><th colspan="5">IMPACT OF URBAN ACTIVITIES ON WATER RESOURCES QUALITY AND QUANTITY</th></tr>
<tr><td rowspan="32">URBAN AREAS</td><td rowspan="6"></td><td>Driving forces</td><td colspan="2">Contaminated sites</td></tr>
<tr><td>Pressures</td><td colspan="2">Punctual pollution of groundwater</td></tr>
<tr><td>State</td><td colspan="2">Punctual high values of pollutant in groundwater</td></tr>
<tr><td>Impacts</td><td colspan="2">Punctual deterioration of groundwater quality</td></tr>
<tr><td rowspan="2">Responses</td><td>Implementation of appropriate measures;</td><td rowspan="2">KTM 4</td></tr>
<tr><td>Remediation of contaminated sites</td></tr>
<tr><td rowspan="16"></td><td>Driving forces</td><td colspan="2">Floods (along rivers & torrents)</td></tr>
<tr><td>Pressures</td><td colspan="2">Temporary increased turbidity values caused by heavy rainfall events</td></tr>
<tr><td>State</td><td colspan="2">Floods are increasing and water quality can be influenced negatively</td></tr>
<tr><td rowspan="2">Impacts</td><td colspan="2">Destruction of buildings and infrastructures</td></tr>
<tr><td colspan="2">Erosion processes</td></tr>
<tr><td rowspan="11">Responses</td><td>Integrative flood risk management (monitoring of the risk management plan);</td><td rowspan="2">KTM 6, 7, 23</td></tr>
<tr><td>Acceleration of natural water retention measures;</td></tr>
<tr><td>Best Practice implementation (avoidance of discharge – and erosion-increasing measures, adaptation of land-use in areas close to rivers/torrents, conservation and improvement of protection forests);</td><td rowspan="9">KTM 12, 13 15</td></tr>
<tr><td>Strategy for flood events caused by heavy rainfall;</td></tr>
<tr><td>Provision and protection of flooding and retention areas;</td></tr>
<tr><td>Limitation and prohibition of building area zoning;</td></tr>
<tr><td>Mandatory consideration of hazard maps within spatial planning (area zoning);</td></tr>
<tr><td>Preference for non-structural measures;</td></tr>
<tr><td>Improvement of ecological functions of water bodies;</td></tr>
<tr><td>River basin or catchment-oriented planning of measures</td></tr>
<tr><td rowspan="5"></td><td>Driving forces</td><td colspan="2">Lack of sewage systems in some areas / Insufficient dimensioning of sewage systems</td></tr>
<tr><td>Pressures</td><td colspan="2">Potential contamination, discharge of contaminant compounds during floods</td></tr>
<tr><td>State</td><td colspan="2">High pollutant compounds in the water bodies</td></tr>
<tr><td>Impacts</td><td colspan="2">Lower quality of surface and groundwater</td></tr>
<tr><td>Responses</td><td>Investment and constructions efforts towards better sewage systems must continue</td><td>KTM 15, 16, 21</td></tr>
<tr><td></td><td>Driving forces</td><td colspan="2">Areas without waste water treatment facilities</td></tr>
</table>

		Pressures	Concentration of hazardous substances above allowed standards	
		State	Values of nutrients, pathogens and other contaminants above the maximum allowable concentration for drinkable water	
		Impacts	Deterioration of water quality	
		Responses	Effluent treatment needs to be increased	**KTM 16, 21**
			Construction of additional treatment facilities	
		Driving forces	**Concrete and artificial surfaces**	
		Pressures	Discharge of surface pollutants (e.g. from traffic, construction sector)	
		State	Increased amount of pollutants contained in water	
		Impacts	Deterioration of water quality (both surface and ground water)	
		Responses	More efficient control of wastewater discharge	**KTM 21**
			Separate system for meteoric waters (infiltration into ground) and waste waters (discharged to WWTP)	
			Increase the amount of green surfaces and blue infrastructure in urban areas	
		Driving forces	**Increase in population density**	
		Pressures	Increase in the volume of waste water and sewage to be treated	
		State	Alteration of phosphorous, nitrogen, dissolved oxygen, BOD, COD and pathogens concentration in treated waters	
		Impacts	Unfit for drinking and irrigation	
			Impacts on human health	
			Eutrophication	
		Responses	Optimization of urban waste water management systems	**KTM 21**
			Increase effluent treatment	
		Driving forces	**Sewage overflows in case of extreme rainfall events**	
		Pressures	Diffuse pathogens and organic matter contamination	
		State	Presence of pathogens and into ground waters	
		Impacts	Impacts on human health (i.e. vector borne diseases)	
		Responses	Optimization of urban waste water management systems	**KTM 21**
			Improvement of urban drainage system	
		Driving forces	**Intensity of tourism supply**	
		Pressures	Volume of sewage to be treated exceeding waste water systems capacity	
		State	Alteration of phosphorous, nitrogen, dissolved oxygen, BOD, COD and pathogens concentration in treated waters	
		Impacts	Unfit water for drinking and irrigation	
			Impacts on human health	

			Eutrophication	
		Responses	Optimization of urban waste water management systems	KTM 21
			Increase effluent treatment	
			Sustainable tourism	
		Driving forces	**The potential effects of Climate Changes are not taken into account in action planning**	
		Pressures	New artefacts or updating of existing ones (e.g. drainage networks) could not address new needs	
		State	Few experiences at urban level for Municipal Adaptation Plans (e.g. Bologna, Ancona)	
		Impacts	Higher costs for induced hazards, for future updates	
		Responses	Providing incentives (economic or legal) to increase awareness and initiatives about the effect of climate changes	KTM 24
		Driving forces	**Lack of Emergency Municipal Plans for many towns/cities**	
		Pressures	Procedures, roles and strategies are not specified for anthropic or natural induced disasters	
		State	Data for Italy: Municipalities with approved Plan (39% in Campania, 54% in Calabria,49% in Sicily and 66% in Lazio) (source: National Civil Protection webpage, update October 2016)	
		Impacts	Higher risks for civil population in case of disaster	
		Responses	Providing incentives through legislation or economic support to draw up the plans	KTM 14
		Driving forces	**High leakage of water supply systems**	
		Pressures	Over-abstraction of water	
		State	Quantity status deterioration	
		Impacts	Ecological flow cannot be guarantied	
		Responses	Establishment of reconstruction programme and financing strategy	KTM 8, 9
		Driving forces	**Heat pumps (water-water)**	
		Pressures	Emissions of warmer water into aquifer	
			Discharge into sewer	
			Not professional wells – possible direct pollution channels	
		State	Higher GW temperatures	
			Lower GW quantity	
			GW* pollution (mainly mineral oils)	
		Impacts	Deterioration of groundwater quantity and quality	
		Responses	Strict implementation of legislation (water return, wells in compliance with standards)	KTM 21
			Banning of heat pump system without permission	
		Driving forces	**Cemeteries**	

		Pressures	Application of pesticides to cemetery paths	
		State	GW pollution with pesticides	
		Impacts	Deterioration of groundwater quality	
		Responses	Optimized use of pesticides	**KTM 21**
		Driving forces	**Construction of big buildings or construction areas with underground facilities**	
		Pressures	Deep construction pits	
		State	Higher vulnerability due to diminishing the unsaturated zone thickness	
			GW pollution: heavy metals, oil spill	
		Impacts	Deterioration of groundwater quality and locally also quality	
		Responses	Measures for pollution prevention	**KTM 21**

2.2.5. Industrial areas

Industry is one of the key driving forces for the development and prosperity of today's economy and society. From the aspect of environmental protection it represents potentially negative pressures and impacts. Bad management practices along with gaps in national legislation related to the industrial land use can cause numerous adverse issues that can affect water resources. Inadequate treatment and discharge of wastewater produced during industrial processes and industrial waste disposal can cause groundwater pollution as well as surface water pollution.

According to the data provided by Project Partners, the amount of land used as an industrial area in drinking water protection zones varies between the smallest amount in Croatia with 0.62% and largest amount of 1.82% in Hungary. These industrial areas often encompass construction sites, industrial or commercial units, mineral extraction sites and dump sites.

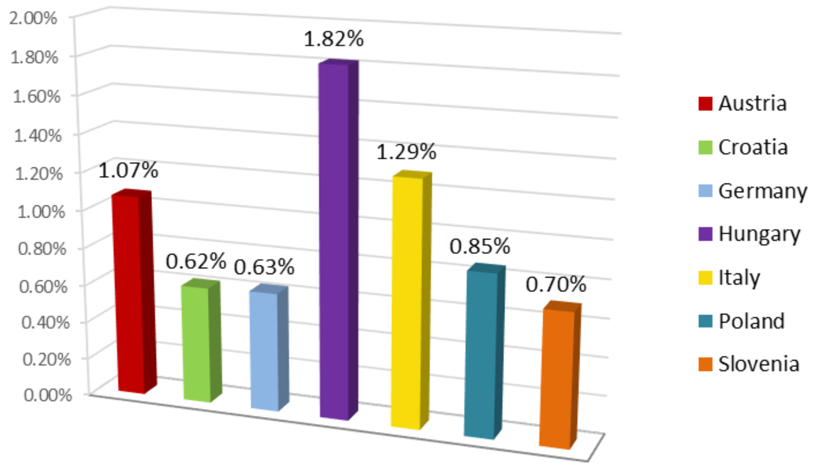


Figure 46. Industrial areas in drinking water protection zones (Corine Land Cover 2012 data and DWPZ provided by Project Partners)

Similar to the urban land use, industrial land use in DWPZ of Project Partner countries occupies only around 0.99% of the total area, which is a commendable fact concerning the aspect of water resources protection.

According to the Eurostat, Germany stands out as a country with the largest amount of waste (61 M t) produced during manufacturing processes, while Croatia produced around 0.48 M t of waste.

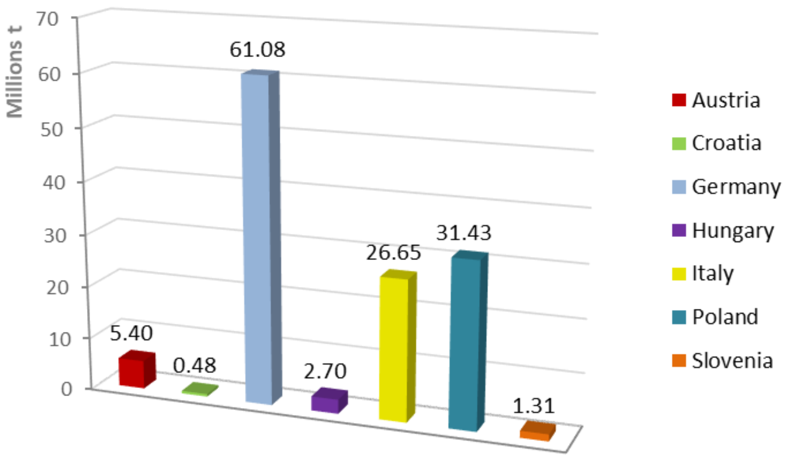


Figure 47. Total amount of produced waste (in tonnes) due to manufacturing processes (data by Eurostat)

In Austria it is expected that industrial water demand and also wastewater amount will decrease in years to come. Croatia state that 20% of industrial wastewater is directly released into natural recipients after the previous purification and remaining 30% of waste industrial water is released in natural receivers without any treatment. Nevertheless, Croatia is taking serious measures for the improvement of industrial contamination control. Furthermore, in Italy direct input of chemicals released by industrial activities in the surface water bodies is still high with potential extremely negative consequences, while in Savinja Basin and Mura Basin in Slovenia groundwater bodies are polluted due to industry with chlorinated organic solvents.

In spite of the above mentioned facts, all of the Project Partner countries recognized industrial by-products (waste and wastewater) as factors that can interfere with the aims of water resources protection. Thus they are actively trying to implement appropriate measures in order to solve this ongoing problem.

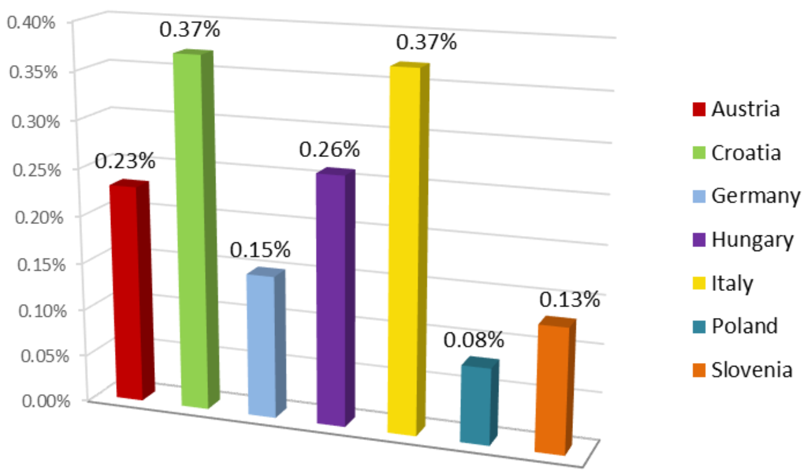
Table 29. Impact of industrial sites/activities on water quality and quantity - DPSIR approach for the present/past state in CE

INDUSTRIAL AREAS		Driving forces	**Lack of industrial effluents treatments systems / Accidental/catastrophic discharge**	
		Pressures	Direct discharge of industrial waste waters into surface bodies	
		State	Values of nutrients, metals, salts and priority contaminates too high for drinkable water	
		Impacts	Unfit for drinking and irrigation Water and soil contamination	
		Responses	Implementation of appropriate sewage system and devices for wastewater treatment	**KTM 15, 21**
			Optimization of waste management systems and storage	
		Driving forces	**Industrial waste waters**	
		Pressures	Emissions of pollutants to ground and surface waters	
		State	Pollutants in ground and surface waters (e.g. heavy metals, organic pollutants)	
		Impacts	Deterioration of ground and surface water quality, impact on human health	
		Responses	Implementation of appropriate measures, such as strict regulation of effluent discharge, monitoring, emergency plans in case of contamination	**KTM 1, 21**
			Better monitoring	
		Driving forces	**Old industrial locations**	
		Pressures	Soils contaminated with industrial sector-specific pollutants	
		State	Contamination of groundwater	
		Impacts	Deterioration of groundwater quality, impact on human health	
		Responses	More stringent persecution of contaminated site remediation	**KTM 4**

2.2.6. Transport units

Although transport infrastructure is of great importance for the development of society, economy and spatial mobility of people and goods, it also poses potential negative impacts on environment and human health.

Since the pedestrian or vehicle communication paths are linear structures that usually only intercept DWPZ, they take up really small amount of space within them. Therefore roads, rail networks and associated land cover only 0.03% (Germany) to 0.32% (Croatia). Only airports and ports cover slightly bigger areas due to their spatial structure (e.g. 0.14% of land within the DWPZ in Hungary and 0.12% of land in Germany). Total transport areas that include roads, railroads, ports, airports and associated land within DWPZ are given in the following graph.



Figures 48. Transport units in drinking water protection zones (CLC 2012 data and DWPZ provided by Project Partners)

Table 30. Impact of transport infrastructure/activities on water quality and quantity - DPSIR approach for the present/past state in CE

TRANSPORT UNITS	Driving forces	**Road and parking cleaning and maintenance**	
	Pressures	Diffuse salts and metals contribution trough runoff and percolation	
	State	Values of metals, salts and priority contaminates concentration for drinkable water	
	Impacts	Unfit for drinking and irrigation Water and soil contamination	
	Responses	Implementation of appropriate sewage system and devices	**KTM 21**
	Driving forces	**Road accidental spills**	
	Pressures	Diffuse salts and metals contribution trough runoff and percolation	
		Emission of fuel, oil and other dangerous substances	
	State	Contaminated soil, possible infiltration of fuel, oil or other dangerous substances into groundwater	
	Impacts	Deterioration of soil and water quality	
	Responses	Effective action plan in case of spills, low reaction time and fast intervention	**KTM 21**
	Driving forces	**Road traffic**	
	Pressures	Waste waters from roads and highways	
	State	Heavy metal pollution in soils, ground and surface waters	
	Impacts	Deterioration of water quality Impact on human health	
	Responses	Slovenia - Strict implementation of decree on the emission of substances in the discharge of meteoric water from public roads (OG RS 47/2005)	**KTM 21**
		Croatia - Implementation of National environment protection strategy and action plan (NN 46/02)	
	Driving forces	**Sealed surfaces**	
	Pressures	Decreased infiltration capacity	
	State	Decreased water retention	
	Impacts	Deterioration of non-structural flood protection	
	Responses	Implementation of extensive seepage measures with overgrown topsoils	**KTM 23, 24**

2.2.7. Drivers and responses – present state in CE

It can be stated that drinking water quality in Project Partner countries, is mostly good to very good concerning quantitative and qualitative status. To assess drinking water quality in water supply zones, a very large number of analyses have to be carried out, namely on microbiological, chemical and physical (quantitative) parameters. As groundwater is main source of abstraction in Project Partner countries, chemical and quantitative status is shown in Table 32.

Table 31. Chemical and quantitative status of groundwater bodies

Chemical status of groundwater bodies			
Country	Good	Poor	Unknown
Austria	97.8 %	2.2 %	0 %
Croatia	87.5 %	12.5 %	0 %
Germany	62.7 %	37.10 %	0.2 %
Hungary	79.5 %	20.5 %	0 %
Italy	49 %	26.3 %	24.7 %
Poland	93.2 %	6.8 %	0 %
Slovenia	81 %	19 %	0 %
Quantitative status of groundwater bodies			
Country	Good	Poor	Unknown
Austria	97.8 %	2.2 %	0 %
Croatia	84.4 %	9.4 %	6.2 %
Germany	96.2 %	3.8 %	0 %
Hungary	85.4 %	14.6 %	0 %
Italy	52.7 %	15.7 %	31.7 %
Poland	82 %	18 %	0 %
Slovenia	100%	0 %	0 %

Source: Report on the implementation of the Water Framework Directive - River Basin Management Plans for EU Member States; data for Croatia is from 2015 and for other countries from 2012

Throughout the course of Chapter 2, two useful analysis tools were used to acquire methodical overview/evaluation of land use and flood/droughts impacts on water resources - **SWOT** and **DPSIR**. Possible areas for change (weaknesses and threats) were identified along with solutions to the existing issues (opportunities and strengths). Agriculture has been identified as a land use type that causes most significant pressures on water quality and quantity, mainly because of the conventional soil tillage and inadequate application of pesticides and fertilizers. Likewise, urban areas with sealed surfaces and insufficient sewage systems, as well as poor forest management pose a serious risk from the aspects of water protection and defence against hazardous effects of floods. The overview of three most common driving forces in the form of land use activities that exert pressures on water resources, floods and droughts, causing the change of their state, are given. According to the recognized land use impacts, Key Type Measures (KTM) were assigned with the aim of reducing significant pressures to the extent required to achieve good status of water resource or preventing its deterioration.

Based upon the results of conducted analyses, improvements of existing long term strategies, policies and management approaches, particularly those related to the drinking water preservation, can be devised.

Some of the positive management practices recognized in Project Partner countries were just to name a few: adaptability to manage DWPZs, incentives for organic farming, advisory support and financial compensation for land users in DWPZ, well-structured system for ground- and surface water regulation, legislation implementation that improved the overall chemical and quantitative status of water resource.

Furthermore, the common endeavour of Project Partner countries were integrative flood management, adaptive forest, grassland and agriculture management. The countries share the plan to use EU funds in order to co-finance water projects; the need to improve the communication between the decision-makers and experts; to invest further in organic farming; to develop education and raise awareness amongst the local population; to implement stricter laws in a variety of cases (ranging from pesticide application to EU directives); to upgrade water management and flood risk management measures, ensuring minimum ecological flow in drought-endangered river basins and minimalizing water utility losses.

The general conclusion is that vertical and horizontal compliance of legislative documents on all hierarchy levels, have to be achieved primarily within Project Partner countries, in order to be upgraded to a transnational level. Nonetheless, Project Partner countries should integrate already existing EU regulations and policies in full. Furthermore, continuous multi-sectoral liaison is essential, as well as the implementation of transparency and equality policies which will allow all relevant stakeholders (land users) to be engaged in the decision-making processes. Pivotal factor is the education of broader public or land users whose role in carrying out the sustainable, resource-friendly practices and measures is equally important as is the expert ones. Lastly, all Project Partner countries should implement stricter repercussions for bad management practices and upgrade their monitoring to be more up-to-date with the water status. The results should have media coverage in order to promote responsible water management.

3. Identification of strategies and measures to be integrated into existing policy guidelines

Through the course of this chapter, focus is laid on identification of main sectoral gaps, as well and proposing measures and strategies to overcome those gaps. Since main objectives of PROLINE-CE could only be achieved by integrative and interdisciplinary approach, it is obvious that intensive stakeholder engagement and feedback is essential tool for achieving the desired project objectives. Furthermore, in order to tackle common challenges regarding protection of water drinking water resources in CE, it is necessary to incorporate a multi-level approach, starting from local scale (communities, local public utilities and water providers), across regional scale (municipalities, cities, regions) and finally transnational level (CE), where PROLINE-CE partnership will be justified through joint cooperation, development and implementation of project activities and results.

3.1. Lessons learnt from stakeholder workshops

Through PROLINE-CE Output O.T1.1 “Start-up stakeholder workshop series”, seven national stakeholder workshops were carried out. Specific objectives concerning stakeholder involvement, which PROLINE-CE project is aimed to achieve, are:

- Identification of challenges of integrated water resources protection
- Reflection on national SWOT analysis and identification of main gaps
- Strategies for the implementation of land use management concepts for drinking water protection;
- Operationalisation of best management practices for water protection;
- Capacity building for relevant stakeholders and administrations through panel discussions, workshops and dialogues.

The accomplishment of these specific objectives is done by two main communication objectives: “raising awareness and increasing knowledge” and “influencing attitude and behaviour”. Intensive engagement of stakeholders as well as knowledge exchange and dialogue with all relevant sector players and different decision makers on national and transnational level, can enhance their knowledge and acceptance and guarantee the implementation of drinking water protection strategies in land use management. In order to achieve the above mentioned, structured stakeholder involvement process will support the development of networks beyond the borders of disciplines, regions and countries, while joint strategies and communication concepts will be developed and tailored to the needs of diverse target groups. Therefore, throughout the project administrations and institutions representing the target groups will be informed about gap analysis, results of activities in pilot cases and proposed policy recommendations. This will enable further work in the project regions, in transnational discussion and policy dialogue. A strong stakeholder involvement will disseminate results by existing networks on national, transnational and EU level and support further development on the topic.

Seven start-up stakeholder workshops were organized in each PROLINE-CE project partner country during May and June, 2017. This represented the first active involvement of stakeholders in the project activities.

The main organizational data on the held national workshops, such as dates, locations and partners involved, along with the total number of attending participants can be seen in the Table 32. The number of participants refers to every participating expert, which includes professionals from partner institutions that cannot be counted as stakeholders.

Table 32. List of national stakeholders workshops

Location	Venue	Date	Responsible project partner + Supporting partner(s)+ Associated partner(s)	Number of participants
Austria, Vienna	"Alte Schieberkammer" Vienna Waters	31.05.2017.	Municipality of the City of Vienna -Vienna Water (MA31) Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) Municipality of Waidhofen/Ybbs (MWY)	16
Croatia, Zagreb	Croatian waters	12.06.2017.	Croatian Geological Survey (HGI-CGS) Croatian waters	24
Germany, Munich	Technical University of Munich	03.05.2017.	Technical University of Munich (TUM)	17
Hungary, Budapest	Conference Centre of Herman Ottó Institute	07.06.2017.	Herman Otto Institute (HOI) General Directorate of Water Management (OVF)	18
Italy, Rovigo	Fondazione Ca' Vendramin	16.05.2017.	Euro-Mediterranean Centre on Climate Change Foundation (CMCC) Regional Agency for Prevention, Environment and Energy in Emilia-Romagna (ARPAE)	33
Poland, Katowice	Silesian Waterworks PLC	24.05.2017.	Silesian Waterworks PLC (GPW) National Water Management Authority (KZGW) Regional Water Management Board (Warsaw, Cracow, Gliwice, Gdansk, Wroclaw, Szczecin, Poznan) University of Silesia in Katowice	53
Slovenia, Ljubljana	JP Vodovod-Kanalizacija d.o.o.	18.05.2017.	JP Vodovod Kanalizacija d.o.o. (JP VO-KA) University of Ljubljana (UL)	30
			TOTAL	191

Concerning the participating stakeholders, i.e. individual participants who have professional interest or experience related to PROLINE-CE topics (e.g. public water suppliers, agronomists, planners and consultants, foresters, hydrologists etc.), the highest range was from the higher education and research (18%), followed by infrastructure and (public) service providers (14%), and 13% of national public authority, while regional authority constituted 12% (**Fig 50.**).

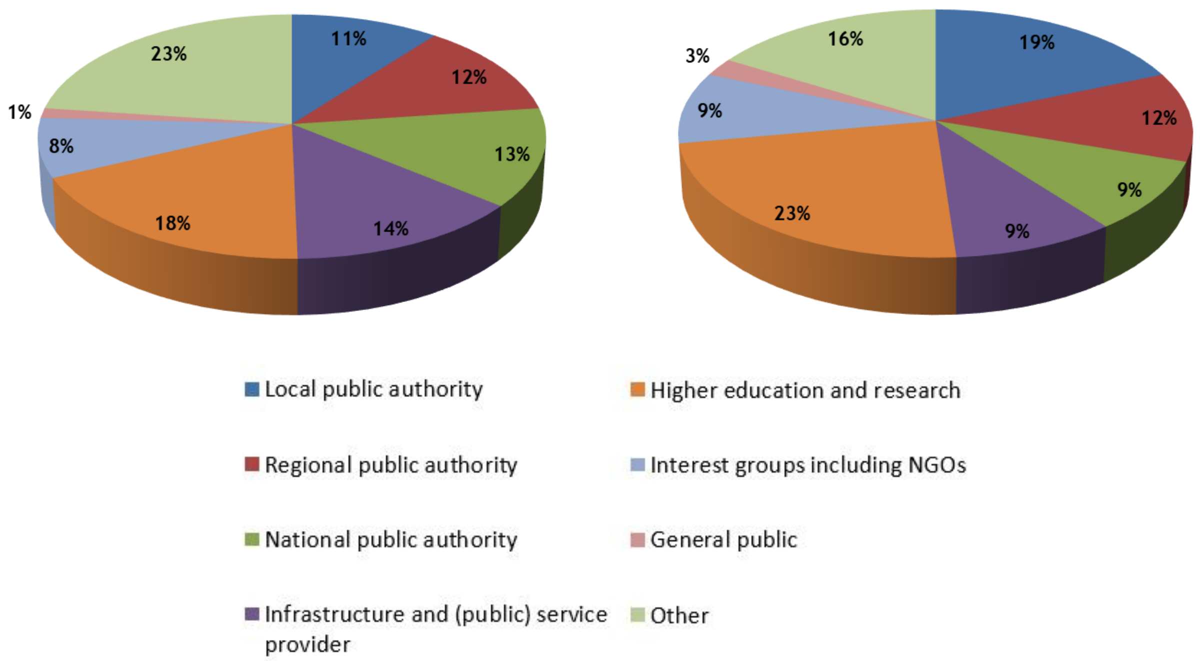


Figure 49. a) stakeholders reached during the workshops (left), b) target groups (institutions) that attended the Start-up national stakeholder workshops (right)

Regarding target groups that represent clusters of institutions (e.g. ministries, authorities, universities, institutes, public utilities, NGOs, laboratories and consultant offices etc.), the higher education and research is the largest participating category (23%), followed by the local public authority (19%). The representatives from the institutions that belong within these categories represented the majority of the target groups that took part in the event.

During the events a general presentation of the project was given, the current challenges of drinking water resources protection and protection against floods and droughts through integrated land-use management were presented, as well as examples of best management practices in water management and flood mitigation. The involvement of various authorities, experts and decision makers has resulted with the identification of current gaps that occur in their specific daily operations (Table 33).

Table 33. Overview of problems and proposed solutions concerning interrelations between land use and water management, as identified by stakeholders during national workshops

	IDENTIFIED PROBLEM	PROPOSED SOLUTION
FORESTRY/AGRICULTURE	Input of pollutants and outdated pollution monitoring system	Establish sensitive areas, with clear prohibitions and strict controls
		Continue efforts to improve monitoring system; increase education of farmers and other users
	New pollutants	Update and improve monitoring plans
	Leaching problems in short-rotation plantations	Establish better relationship between nutrient pool and plant requirements
	Inadequate or non-existent monitoring of pesticide acquisition and use	Training of professional pesticide users, distributers and advisors
		Establish monitoring and record keeping on sold quantities of pesticides; limitation on quantities based on farm land and crops; ban sales for non-trained users
	Water retention in the valleys	Increase retention capacities through natural retention (enhance forest and grassland ESS) and construction of retention basins
	Inadequate machine usage (tillage)	Minimum tillage; cover crops; cultural rotation; conservation tillage techniques; no tillage on slopes
	Small parcels / land fragmentation	Agricultural land census; tenure of land; promote agricultural holdings; consolidation of land
	Land loss on prior forested areas; Erosion in general	Adapted land use; promotion of mixed forests; reforestation all year long; good grassland management, enhance forest protection; promote permanent forests
	Clearcutting	Prohibit clear cuts, except sanitary cuts; establish continuous cover forest systems (CCF)
	Forests appear as clusters, not as land cadastre data	Turn some agricultural areas into forests; promote silvopastoral initiative; greening practices; complex landscape utilization; remote sensing
WATER MANAGEMENT/LEGISLATION	Inadaptability of national legislation to the current and future challenges	Improve trans-border cooperation and propagate integrative measures
		Long term planning and research must be taken into account when legislation and policies are devised
	Short-term nature of general thinking and policy implementations	Systematization of research and planning; interdisciplinary cooperation; development of prognostic models (for influence of climate changes)
	Gaps in legislation – charges and water fees for specific water use	Application of numerical modelling to improve water resource management
	Conflicts about water abstractions	Encouraging new forms of collaborations among the stakeholders; managing the water resources accounting for potential reductions induced by more frequent droughts; properly accounting for cascading effects; adopting less water demanding crops
	Availability of public funds for the implementation of water resource-friendly land management practices	Develop national scheme/strategy (e.g. water fund) for investments into good management practices; include key decision makers and stakeholders into development of scheme/strategy (good example is KULAP programme from Bavarian State) Ministry for Food, Agriculture and Forestry)

	IDENTIFIED PROBLEM	PROPOSED SOLUTION
	Lenient penalties for environmental misdemeanour	Establish sensitive areas, with clear prohibitions and strict controls
		Enforce laws and penalize misdemeanour activities
	Violations of restrictions and prohibitions in DWPZ	Enforce laws and penalize misdemeanour activities; enforce stricter controls
		Water utilities buy land in narrowest DWPZ
	Data on water quality and quantity is often unavailable to broad public	Establish pollutant cadastre and improve spatial data organization
		Increase public awareness and knowledge by publications, newsletters, public seminars, etc.
WATER MANAGEMENT - INFRASTRUCTURE	Low quality of tap water	Improve water treatment systems and water supply network; prevent pollution; establish DWPZ and set prohibitions and restrictions; define site specific solutions; increase education of farmers and other water users
	Water stagnation in water network	More control points in the network to define leakages and stagnation points leakage
	Outdated water infrastructure	Investments into infrastructure improvements
		Assessment of climate change impact on pipelines and local water supply systems
	Insufficient dimensioning and territorial coverage with sewage systems	Continue efforts to improve urban waste water treatment
		Continue investments into sewage systems and prevent sewer leakage
OTHER	Climate changes are not taken into account while planning (utilities, dams, retentions)	Use prognostic models and scenarios to project CC effects on population, buildings, water resources, floods and droughts
	Erosion due to ski resorts	Technical and ecological measurements to reach the goal of a sustainable restoration of affected areas
SPATIAL PLANING	No vision or strategy regarding land use	Long term national development strategy; reconcile spatial plans and data; inter-institutional cooperation
	City plans influenced by local interest which leads to unfair planning	More flexibility in the planning of action plans; more interdisciplinary and intrasectoral approach; promote high involvement of land owners and users; promote transparency
	Land use conflict between agricultural and urban areas; Drought in agriculture	Implementation of the Nitrate Directive; smart irrigation system
	Land ownership situation (private land and unresolved ownerships)	Complex landscape utilization; remote sensing; privatization or nationalization of land in narrow DWPZ; more rigorous penalty implementation
	Municipalities would like to change land from building land to open space for flooding, but owners dispute because then land has lower value	Abide flood hazard measures in spatial plans; define what is allowed in flood hazard zones; Flood protection measures have to be separately determined for agricultural and urban areas

In majority of PROLINE-CE partner countries general remarks such as following were made:

- low level of public awareness and often the lack of education of some water users (e.g. farmers)
- local communities are not adequately involved in development of drinking water protection plans - plans are presented to the community as a finished work and little discussion is allowed to find more appropriate site specific solutions;
- public funds for the implementation of water-friendly land management practices are usually inadequate;
- a problem that might be hardest to solve is controlling irregular and harmful behaviour of individuals, especially in DWPZ (waste dumping, illegal gravel excavations, etc.) – controls are inadequate, punishments are usually very lenient while good management practices are usually not stimulated or rewarded.

3.1.1. Issues for further consideration

In order to achieve positive progress of management that is adaptable, along with legislation which is in accordance with the present day and future challenges, systematic and long term approach should be fostered, as well as transnational dissemination of experiences and best management practices. Many countries find it hard to define a balance between overprotection and development - overprotection might impede development, while rapid development with no regard to protection of drinking water resources might affect sustainable development and deplete resources.

Since all the project partners pointed out the need for constructive dialogue between the various involved sectors, it is important to continue the communication and offer opportunities for the exchange of information and best management practices. Best management practices – using efficient and good examples of problem-specific solutions that have strong scientific basis and have been tested and proven in real scenarios – should be implemented. There is also a need to increase public awareness and change people's behaviour towards the environment, to offer opportunities for the exchange of information and management practices and stimulate two-way communication between the general public and authorities. Positive effect could be achieved by thematic media releases, promotional campaigns and workshops of this kind. The first step in the right direction was the involvement of stakeholders (e.g. land users and owners, public water suppliers, researchers) and their input in relevant topics which creates an avalanche of actions.

Furthermore, many countries experience diverse issues with poor implementation of the existing legislation. Even though it should be dealt with on a national level, the first step is bringing and syncing the regulations on the EU plane in order to have a uniform base on which to build upon.

Since "General public" was the smallest stakeholder and target group category present at the national workshops, it is clear that further efforts must be directed so that the main topics of PROLINE-CE reach broader non expert audience, whose participation is essential in order to achieve project objectives. Two other categories that dominated the stakeholder workshops were Higher education and Regional public authority. Such results are indicative of a good stakeholder base in relevant institutions and organizations that have an impact in the public.

The problems discussed during the workshops were summarized and divided into four thematic groups – general management, water management, land use and flood mitigation. The first group of issues is mostly connected to legislation and several proposed solutions include: address the climate changes and their impact on water resources, stimulate good management practices and penalize bad management practices, apply international best management practices and use existing knowledge or methodology, enhance adaptation potential and incorporate more flexible practices. The water management problems were mostly country-specific, but could be applicable to other countries as well. Some of the suggested ideas are: establishment of sensitive areas with clear prohibitions and strict controls, increase retention capacities through natural retention (enhance forest and grassland ESS) and construction of retention basins, update and improve monitoring plans, training of professional pesticide users, distributers and advisors and improve the water treatment systems and water supply network in order to prevent pollution and maximize the efficiency of the water system. Issues related to land use management had the following proposals given: technical and ecological measurement to reach the goal of a sustainable restoration of affected areas, minimum tillage, cover crops, cultural rotation and conservation tillage technique implementation, turning of some agricultural areas into forests, promoting of silvipastoral initiative, greening practices and complex landscape utilization, as well as abiding the flood hazard measures in spatial plans and defining what is allowed in flood hazard zones.

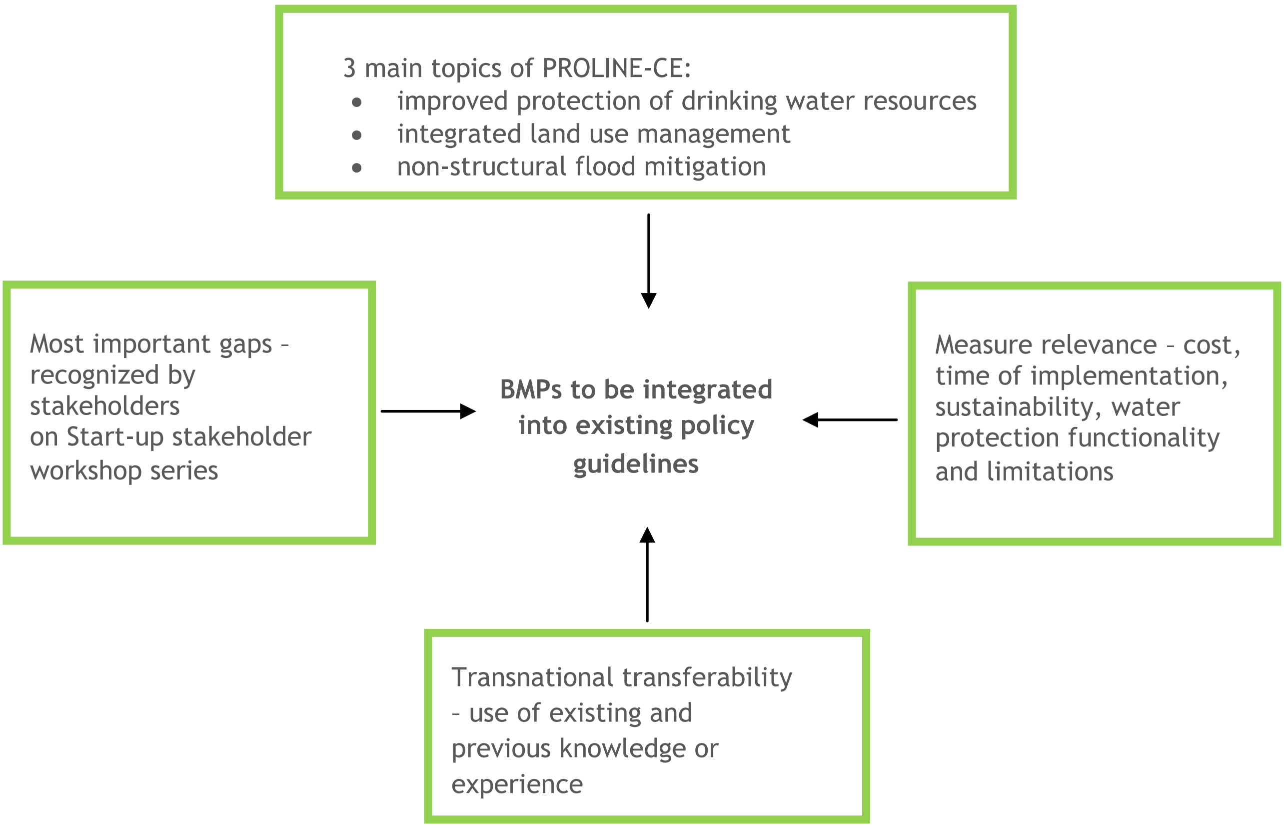
Flood mitigation was a topic many countries could closely relate to and the ideas for its management included: spatial planning and urbanization must be in line with flood risk and hazard maps, improvement of groundwater research in order to reduce uncertainty and develop better models in case of pollution, developing estimative models of drinking water vulnerability on flood and drought, as well as investing into non-structural measures such as prevention, forecasting, early warning system and planning to minimize flood impact. Non-structural measures use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education. In respect to flood mitigation, some of the measures mentioned were managing the upper parts of the basin, better spatial planning, synching of legislation on a local and national level and an interdisciplinary approach to the problems encountered in flood prevention strategies.

3.2. Identification of best management practices and their integration into existing policy guidelines

This chapter aims to transform the lessons learnt from start-up stakeholders workshops (identification of main gaps in land use and flood management in relation to drinking water protection; proposed solutions; specific action) into measures and solutions (referred to as Best management practice – BMP) which could be integrated into existing practices and policies in water management, land use management, flood management etc., offering improvement of existing and development of new and efficient management, control and behaviour practices.

The selection of BMPs to be implemented either on national/regional level, or if possible, in pilot areas, was done based on the following criteria:

Figure 50. Best management practice selection criteria scheme



Another important selection criterion is innovative nature of the Best management practice, meaning that the specific measure has not yet been implemented in country which suggested it and that measure is not integral part of EU, national or regional policy, strategy or action plan. However, since many Project Partner countries identified gaps in practical implementation, BMPs regarding implementation of existing policies (legislation) could be considered very valuable.

Each gap and accompanying BMP is presented within separate table sheet, in a form of a catalogue. Gaps are characterized and described in a way that they point out the essence of the specific problem, occurring location, occurrence reason and upon who/what is negative influence inflicted upon. Section describing BMP contains general description of the BMP, such as type of land use regarded, general description, relevance, source/reference, limitation, advantages, challenges and location. Location refers both to the country which reported the gap and proposed specific best management practice to overcome that particular gap, as well as to the example or specific location where that measure could be applied. Gaps and BMPs are sorted according to type of land use (see colour legend below).

Table 34. Legend for the identified gaps and accompanying BMPs

	Forest
	Agriculture
	Urban
	Grassland
	Wetland
	General / all

Note: *first row of each GAP/BMP sheet is in different tone in order to enhance visibility and separation of individual sheets

* BMP is sometimes referred to as “measure”

Table 34. Summary of gaps and best management practices to be integrated into existing policy guidelines

Gap	Best management practice
Application of the clear-cut technique in drinking water protection zones (DWPZ)	Avoidance of the clear-cut technique
Elevated densities of unnaturally high stock of ungulate game as result of trophy-hunting activities and resulting browsing and bark-stripping damages.	Creation of forest-ecologically sustainable stocks of ungulate game
Extensive forest road construction within the DWPZ	Limitation of Forest Roads within DWPZ
Plantation of conifer species on all forest sites	Tree Species Diversity According to the Natural Forest Community
Cutting of huge, old and stable tree individuals	Foster old, huge and vital tree individuals
Forest deployment and cultivation, forestry practice in drinking water resources protection areas	Forest installation rules in floodplain of drinking water resources protection area
Inadequate management of forests. The conservation and appropriate enhancement of biodiversity	Establishment of an adequate deadwood management
Funding for land use actions for water protection	Linking land use measure funds to water resources protection
Deterioration of water quality due to agricultural pollution	Establishment of buffer strips
Application of intensive crop production technology and its impact on water resource protection	Intensive crop production possibilities in water protection areas
Obsolete conduction of agricultural practices	Increasing the efficient use of water in agriculture and adapting to climate change and crop irrigation to achieve optimum yields
Pollution of watercourses	Encouraging organic farming
Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application
Pollution caused by inappropriate sludge management	Effective sludge management
Domestic gardens for small-scale cultivation in the drinking water protection areas	Controlling cultivation of domestic garden and small garden in the drinking water protection area
Discharge of rainwater from the inner road network in soil	Impact assessment and pollution prevention of rainwater from the inter-urban road network to groundwater
Not arranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas
Pollution of watercourses	Supporting guidance for creation of low-input grassland to convert arable land at risk of erosion or flooding
Continuous conversion of (permanent) grasslands	Preservation of existing (permanent) grasslands
Pollution of watercourses	Wetland restoration
Flood risk reduction, Erosion / sediment control	Preservation and revitalization of wetlands on floodplains
Public engagement in development of action plans	Implementation of site-specific solutions
Saltwater intrusions in coastal areas	Prevention of saltwater intrusions
Pressure on water resources quantity	Climate change adaptation and resilience
Community use of inner and outer district of groundwater protection area	Community use of partitioned groundwater in inner and outer protection zones

Gap	Best management practice
Design of infrastructure under steady-state weather conditions	Adaptation of building standards for design, maintenance and operation of infrastructures
Pressure on water resources management	Integrated Water Management for implementing efficient voluntary agreements
Soil degradation and consumption	Evaluating effects of Soil Protection Plans on water bodies
Flood impact	Assessing flood impacts on drinking water supply systems and on water bodies
Qualitative/Quantitative unbalance of law/plans/measures implementation	Identification of priorities and measurable effects of responses to environmental drivers and pressures on water quality/quantity
Climate Change	Implementation of practical responses to mitigate climate change and to adapt to its effects
Analysis of links between employment/education policies and the water sector	Social, employment and education policies in water resources sector
Lack of information regarding groundwater salinity while designing and operating unconfined coastal aquifers	Assessment of salinization of groundwater and surface waters
Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas
Surface water intrusion in the well	Sealed wells heads
Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources
Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources	Joined and integrated management of drinking water resources (horizontal and vertical co-operation)
Lack and not effective control over implementation of DWPZ restrictions	Strict implementation and inspection of DWPZ restrictions

Table 35. Gaps and best management practices related to forestry

Identified GAP provoking action	
GAP short name	**Application of the clear-cut technique in drinking water protection zones (DWPZ)**
GAP short description	Erosion processes triggered by the clear-cut technique, like mineralisation processes, humus decomposition, surface-flow in the course of strong precipitation events, etc. All those processes can cause source water contamination with various substances like nitrate, dissolved organic carbon (DOC) or sediments.
Best management practice	
Name of BMP	**Avoidance of the clear-cut technique**
Type of land use regarded	Forest
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC1)
Location	Austria All forest areas within all provinces (DWPZ), ***especially relevant for Pilot Action Waidhofen/Ybbs***. Example of successful measure implementation: Austria, Pilot Action City of Vienna – Water Protection Zone of the City of Vienna
Description of the BMP	The sustainable protection of the source water for drinking water supply is the main purpose of any drinking water protection strategy. Within forested DWPZ the application of the clear-cut technique exerts the main risk for source water quality. The avoidance of the clear-cut technique and the creation of continuous cover forestry systems which include small-scale operations for timber yield and for creating regeneration processes hence become essential within DWPZ.
BMP advantages	The avoidance of the clear-cut technique opens the path for the establishment of Continuous Cover Forest Systems. The whole catalogue of BMP's in the field of forestry becomes accessible for a DWPZ if clear-cuts are avoided there. It can be regarded as the basic condition which has to be fulfilled in order to open the field for the application of the whole BMP catalogue. The main advantage is the improvement of forest soil conditions and the facilitation of forest stand stability, which prevents the mobilisation of soil and humus substances, which in turn could be transformed into contamination for the source water.
Challenges	The main challenge for the avoidance of the clear-cut technique is the given resistance among forest owners and the related local/regional/national forest authorities. In Austria the clear-cut technique is the main silvicultural strategy for timber yield and forest regeneration. To break the resistance against its avoidance through e.g. consequent application of the Austrian Federal Forest Act or direct talks with the forest owners respectively local forest authorities becomes vital for drinking water protection.
Relevance	Water protection functionality: High Cost of the measure: Medium Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	The BMP is derived from scientific literature, the CC-WARE BMP descriptions and classic examples of treatments in DWPZ (e.g. Pilot Action City of Vienna).
Limitations	Limitations to be expected are the already stated resistance of private as well as public forest owners and authorities in Austria, who just want to continue with their business-as-

	usual approach towards any forest-related themes, and the clear-cut technique is currently applied very wide spread in Austria's economics-dominated forest management.
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☒SLO Croatia – illegal clear cuts are common, although forbidden by law
Implementation example	This BMP has been implemented in Austria within the DWPZ of the city of Vienna since decades. No limiting actions were possible due to the fact, that the city owns the DWPZ. There were no limitations or challenges which would oppose this BMP. Also in Slovenia clear-cuts are not applied anywhere throughout the nations forests.
Comments	The avoidance of the clear-cut technique will open the path within Austrian DWPZ in order to implement integrative drinking source water protection strategies. In current times the implementation of this BMP is realistic in Austria. Adequate financial compensation for additional costs occurring through the implementation of sustainable forest management measures have to be taken into account – for example by means of compensations by the "Rural Development 2014+" (ELER).
Identified GAP provoking action	
GAP short name	**Elevated densities of unnaturally high stock of ungulate game as result of trophy-hunting activities and resulting browsing and bark-stripping damages**
GAP short description	Unnaturally high stocks of ungulate game elevated through trophy-hunting activities provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-stripping damages. Those inhibit the natural regeneration process of whole forest ecosystems and by the way destabilize them.
Best management practice	
Name of BMP	**Creation of forest-ecologically sustainable stocks of ungulate game**
Type of land use regarded	Forest
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1)
Location	Austria All forest areas within all provinces (DWPZ), ***especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2)***. Example of partly successful measure implementation: Austria, Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1), but despite this fact the measure remains relevant for this Pilot Action.
Description of the BMP	High stocks of wild ungulate game provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-stripping damages. Those inhibit the natural regeneration process of whole forest ecosystems or destabilize them. Natural regeneration is the crucial process in forest ecosystems, which has to be given on an optimal level for all present tree species, especially within DWPA. This can only be guaranteed, if the stocks of ungulate game are regulated to a forest ecologically sustainable level, hence providing vital regeneration of all tree species. The regulation can be achieved through adequate hunting activities, the abandonment of feeding during winter and through the additional introduction of wild predators like lynx or wolf, which regulate the stocks of ungulate game.
BMP advantages	Forest ecologically sustainable stocks of ungulate game provide the huge advantage that the forest ecosystems can evolve naturally, can grow according to their natural inner dynamics (self-organisation of forest ecosystems). This includes a vital regeneration layer within the forest stands, encompassing all tree species of the respective natural forest community. It is the most essential precondition for providing the water protection functionality of forest

	ecosystems, especially under climate change conditions.	
Challenges	In Austria the high stocks of ungulate game is the greatest threat for continuous regeneration dynamics in forest ecosystems. Browsing damages occur wide spread and also several DWPZ are affected. To solve this issue is a true challenge, as the hunter organisations have a strong lobby and do not want to have significant changes, as those could affect their hunting habits. To establish forest ecologically sustainable stocks of ungulate game can be regarded as the main challenge for the Austrian forest sector. The resistance of the hunter lobby and of many forest owners has to be resolved. This task gains high priority within DWPZ, as stable forest ecosystems are the precondition for providing secure drinking water supply in a sustainable form.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as one of the most crucial ones for the establishment of an Austrian source water protection strategy.	
Limitations	Limitations to be expected concerning implementation are above all the resistance of the hunters lobby, and on national level also the related lacking political will. The introduction of wild predators like lynx or wolf, which would regulate the stocks of ungulate game species, is very difficult in Austria as these animals are sometimes killed illegally.	
Implemented in	☐AT ☒BAV ☒CRO ☐HU ☐IT ☐POL ☒SLO Bavaria – implemented in specific case studies	
Implementation example	In Austria there exist only few examples, where the creation of forest-ecologically sustainable stocks of ungulate game was successful. Again some parts of the DWPZ of the city of Vienna actually have already achieved this target and are exhibiting vital and abundant natural regeneration of all specific forest tree species. The implementation required consequent hunting activities. Until now none of the two Pilot Actions (DWPZ of Waidhofen/Ybbs and of Vienna) has both adequate hunting practices and the presence of wild predators implemented.	
Comments	The creation of forest-ecologically sustainable stocks of ungulate game is one of the biggest challenges for Austrian forestry and would provide the second most important basic condition for a sustainable drinking source water protection strategy within forested DWPZ. In Austria further convincing processes within the involved stakeholders will be necessary in present times and also in future.	
Identified GAP provoking action		
GAP short name	**Extensive forest road construction within the DWPZ**	
GAP short description	Forest Road construction and maintenance can cause several adverse impacts on water bodies and should hence be limited in DWPZ. The increase of surface runoff and of water storage loss is the main negative effect. Forest roads also cause interruptions of the lateral flow, spatial concentrations of surface runoff derived directly from the forest road and gaps in the canopy cover.	
Best management practice		
Name of BMP	**Limitation of Forest Roads within DWPZ**	
Type of land use regarded	Forest	

Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1)	
Location	Austria All forest areas within all provinces (DWPZ), ***especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2) and Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1)***.	
Description of the BMP	Forest Road construction and maintenance can cause several adverse impacts on water bodies and should hence be limited in DWPZ. The increase of surface runoff and of water storage loss is the main negative effect. Hence the construction of forest roads should be generally avoided within DWPZ. Only in cases, if forest roads are necessary for the stabilization of forest areas, their construction could be considered. In those cases their construction has to meet strict environmental restrictions, like e.g. interventions as small as possible, the avoidance of highly vulnerable areas within the DWPZ, an operational drainage system which avoids the concentration of surface-flow and the application of fleece-materials which hinder in case of potential accidents the entrance of oil spills into the aquifer.	
BMP advantages	For avoiding potential contaminations and hydrological adverse impacts caused by forest roads, the limitation of their construction within DWPZ is an indispensable need. Also in case of unavoidable forest road constructions, the application of the state-of-the-art technique with integration of fleece-materials and specific drainage systems secures a reduction of potential risks.	
Challenges	In Austria forest roads and their construction is a cornerstone of "normal economic management situations". Foresters appreciate to construct forest roads. Hence it is very difficult to convince them about the need of abstaining from constructing them. Actually there can be identified the tendency to construct forest roads even in very remote or isolated forest areas. Focused information transfer and persuasive efforts will have to be applied in order to avoid their construction or even for the application of the technical adaptations. Forest owners in Austria do not want to be interfered in the course of their decision processes.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as relevant for both related Pilot Actions, for Pilot Action Waidhofen/Ybbs (PAC1.2) and for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).	
Limitations	Actually there can be identified a profound resistance against limitations of forest roads among foresters in Austria, even within DWPZ. Also the local/regional and national authorities did not show any sign to change their attitude towards forest road constructions. Even technical improvements like the application of fleece-materials or drainage-techniques are not included for forest road constructions within DWPZ. Hence the measure implementation seems to be limited fundamentally in Austria under current policies. Only parts of the population have a critical attitude towards forest road constructions, but they are actually not relevant for the decision-processes.	
Implemented in	☐AT ☒BAV ☐CRO ☐HU ☐IT ☐POL ☒SLO Bavaria – implemented in specific case studies	
Implementation example	A similar BMP has not been implemented anywhere else in Austria.	
Comments	It would be a great advantage if forest road construction in Austrian DWPZ would be limited,	

	especially for the sustainable guarantee of drinking water supply security. The current funding policy in Austria is partially counteracting this limitation.

Identified GAP provoking action

GAP short name	**Plantation of conifer species on all forest sites**
GAP short description	Plantation of conifer species instead of using the natural regeneration of the tree species according to the specific Forest Hydrotope Types (natural forest communities).

Best management practice

Name of BMP	**Tree Species Diversity According to the Natural Forest Community**	
Type of land use regarded	Forest	
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1).	
Location	Austria All forest areas within all provinces (DWPZ), **especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2)** and to a lesser degree for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).	
Description of the BMP	Tree species diversity according to the natural forest community guarantees the highest level of stability and resilience. Tree species diversity provides a high level of adaptability, also under climate change. Forest stands created by diverse tree species can utilize a broader scope of the forest soils, if deep-rooting and shallow-rooting trees are growing together. Knowledge about spatial distribution of the natural forest communities (forest hydrotopes) is required for the operational stratification of the DWPA and adaptive forest management. Man-made conifer plantations with not-natural tree species should be transformed gradually to stands dominated by native species, all time depending on the local experience and legislation.	
BMP advantages	For many Austrian forests, tree species diversity according to the natural forest community would be a definite advantage, as homogeneous conifer plantations are actually dominating the forests. Especially in times of climate change tree species diversity becomes mandatory for achieving forest ecosystem stability. Only stable and resilient forest ecosystems can provide water protection functionality in order to fulfil the related ecosystem-service. Tree species diversity has also positive side effects, like e.g. for conservation purposes.	
Challenges	In most of the Austrian forest areas there can be expected resistance against tree species diversity according to the natural forest community, as the habitual forestry practices in most of the cases had a strong focus on conifer plantations or other homogeneous timber yield focused plantations.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium/High
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2). Within Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1) the measure was already implemented, tree species diversity according to the natural forest community is a declared target for silviculture there.	
Limitations	There can be identified in many cases (for many forest owners) a resistance against the implementation of this measure, as many forest owners still perceive Norway spruce as the	

	only valuable tree species in terms of economic perspectives. There also does not exist any national guideline for establishing tree species diversity according to the natural forest community. Especially within DWPZ this should become mandatory.
Implemented in	☐AT ☒BAV ☒CRO ☐HU ☐IT ☐POL ☒SLO Bavaria – implemented in specific case studies
Implementation example	This specific BMP has already been implemented within Pilot Action PAC1.1. As forest succession needs time, the outcome of the measure implementation already becomes visible in some forest districts of the huge DWPZ. The basis for the implementation was the application of the Forest Hydrotope Model as outcome of an aerial forest site mapping survey, which defines the tree species diversity adaptive to the differing forest site conditions within the DWPZ. The Forest Hydrotope Model was elaborated within the PAC1.1 on behalf of the city of Vienna. It is a declared forest management goal to implement the natural tree species diversity according to the different forest hydrotope types. The process is ongoing, as on huge forest areas homogeneous conifer plantations were created in the past century. The tree species shift needs time. The limiting beliefs of the foresters were overcome, as Norway spruce actually suffers more and more from wind-throw events and bark-beetle infestations, a process which supported their learning capacity.
Comments	It is of central interest for drinking water protection to establish within Austrian forest ecosystems in DWPZ tree species diversity according to the natural forest community, as it guarantees the highest level of forest ecosystem stability and resilience.
Identified GAP provoking action	
GAP short name	**Cutting of huge, old and stable tree individuals**
GAP short description	Reduction of the natural gene reserves through cutting of old and stable tree individuals in the course of timber yield
Best management practice	
Name of BMP	**Foster old, huge and vital tree individuals**
Type of land use regarded	Forest
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1).
Location	Austria All forest areas within all provinces (DWPZ), especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2) and to a lesser degree for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).
Description of the BMP	Old, huge and vital tree individuals carry excellent genetic information. They can supply younger and smaller tree individuals with nutrients via their common mykorrhizal network. They also act as structural stabilizing trees for whole forest stands. Thereby they provide a substantial contribution to forest stand stability. Hence they have to be selected and protected, so that they can provide their services as long as possible.
BMP advantages	The genetic information provided by old, huge and vital tree individuals has a high value for the stability and sustainability of the forest ecosystem. Old and huge tree individuals can provide stability for the whole forest stand (in a quasi-mechanical way) and are also important for the nutrition of young trees (including the regeneration phase), who may receive nutrients from the old trees via the mycorrhiza-interconnected root system. The genetic information which they carry inside is a treasure for any silvicultural activity but also for the self-organisation capacity of the forest ecosystem.
Challenges	The old, huge and vital tree individuals have to be selected for remaining in a forest stand.

	Recently huge trees in Austria are in general selected for being cut for timber yield. The necessary change of behaviour has to be achieved through information and persuasive efforts.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as especially relevant for both Pilot Action Waidhofen/Ybbs (PAC1.2) and for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).	
Limitations	In present times the old tradition in forestry to protect some exceptional huge, old and stable tree individuals was abandoned and in many areas huge trees are felled for timber yield as they provide lots of biomass. This modern trend in forestry is due to the purpose to maximise timber yield. The implementation of a nation-wide supervising/implementation mechanism could be a solution for this obstacle.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO Bavaria – implemented in specific case studies	
Implementation example	In Austria there does not exist a current implementation example. In the past foresters have traditionally protected some exceptional huge, old and stable tree individuals. This was done because they saw the value which those trees provided for natural regeneration and forest stand stability. In present times this tradition was abandoned and in many areas huge trees are felled for timber yield as they provide lots of biomass. Actually the selection of old, huge and vital tree individuals with the purpose to remain in the forest stand may still be envisaged by some foresters. In order to implement this Best Practice more consequently or to re-establish its implementation, information transfer to the foresters would be an adequate solution (e.g. a nation-wide supervising/implementation mechanism).	
Comments	The genetic information provided by old, huge and vital tree individuals has an exceptional high value for the stability and sustainability of forest ecosystems and hence gains importance within DWPZ.	
Identified GAP provoking action		
GAP short name	**Forest deployment and cultivation, forestry practice in drinking water resources protection areas**	
GAP short description	Particularly important in the external protection area of the river bank-filtered drinking water basin is that the afforestation is successful and their canopy closes rapidly.	
Best management practice		
Name of BMP	**Forest installation rules in floodplain of drinking water resources protection area**	
Type of land use regarded	Forest stock aiming water resource protection	
Pilot action cluster (if relevant)	Forest (in plain areas)	
Location	Hungary The most significant bank-filtered groundwater resources of Budapest Waterworks from Szentendre Island and the other partitioned water basins near the Danube.	
Description of the BMP	As listed in Annex 5 of 123/1997. (VII: 18.) Government decree agricultural part, afforestation in the internal protection area is prohibited - due to the root dams' perishable	

damaging effect. In external and hydrogeological protection areas, silviculture can be carried out without limitation or any restriction, and also forest refurbishment without chemical treatment can be carried out without limitation in all protection areas.

At the same time, plant cultivation, organic fertilization, fertilization, use of pesticides must be carried out on the basis of an environmental impact assessment or a review or a specific test. The same provisions apply to the external hydrogeological protection area and hydrogeological protection area "A".

The utilization of wood of the partitioned water basins along the rivers, of the hydro-geological protection area „A“ and of the potable water wells creates the best, close-to-nature state. In many cases, the Budapest Waterworks owns the external protection area and maintains a forest stock, and it manages the installations and renovations. These forests are planned forests. Cultivation of non-invasive, well-closed tree species is difficult, especially with limited use of chemicals. On the external and "A" hydrogeological protection areas, crop production may be continued in such a way that it does not endanger the water supply, in an environmentally friendly way, and water conservation aspects must be put to the fore. Appropriate management rules can be individually defined in the most accurate way, while the general environmental friendly aspects are contained in the regulations of the "Good agricultural practice" set out in the legislation.

Environmentally friendly farming rules are contained in Decree 59/2008 on "Detailed rules for action to protect waters from nitrates from agricultural sources". (IV.29) FVM regulation, "Decree No 27/2006" on the protection of waters against nitrates from agricultural sources " (II.7) Government Decree and the "Good Agricultural and Environmental Condition" to be fulfilled for the application of the simplified area payments and rural development subsidies FVM regulation, and the definition of the "Good Practice " 4/2004 (I 13) FVM Decree.

Waterworks can only ultimately use rabbit chemicals, with great care and questioning the soil protection and plant protection authority. However, forest planting and maintenance activities are fundamentally designed in a chemical-free manner.

Tree species choice:

In view of the fact that the afforestation costs are constant for all types of forests and forest reconstruction works cannot be avoided, in the water conservation area, for non-economic forests, the use of longer tree rotations is preferable.

It is important to choose tree species that are well tolerated to the site conditions. In protected areas managed by the waterworks, floodplain areas are often dry in the background of wells. Where the groundwater is unavailable to the roots of the plants because of the drainage of the wells, water demand is solely dependent on rainfall. Over the last decade, the frequency and length of droughts are increasing. All these factors have to be taken into account when choosing a tree species. Decades of experience shows that noble poplar populations in these areas do not develop properly. This is not surprising, as the noble poplar likes particularly intense, well-nutrient, nutrient-rich areas. The installation of very valuable, 100-120 years rotation oak in the background of wells in typically water-deficient areas, is only possible with irrigation or with the application of a substantively different installation technology with the hope of success. In the case of a good place of supply for groundwater from the groundwater, the mixed installation of grey ash and Hungarian ash can bring favourable results. Mixing a couple of white walnuts creates a nice plant together. It is advisable to install mild alder and willow in good water supply but in poor soils. In the case of adequate site conditions, the spread of Hungarian ash and alder is also favourable from a nature protection point of view. Hungarian ash is a very valuable tree of the Danube floodplain. The mildew alder can produce very strong soils shade for 60-70 years, helping to maintain the green maple-free reservation, which is the most popular invasive tree species in the forest. When selecting tree species, spontaneous tree species in the area or in its vicinity can provide guidance.

Following the installation, the plant care work has to be done in the seedling age. If the

	wood is well closed, no further clearing work is required after the 3rd year.
BMP advantages	In addition to proper installation, the fast-lying crown can withhold pollutants, absorb nutrients, invasive species are not settled.
Challenges	Challenges are to create a healthy, well-closed forest in a small area, with different groundwater conditions, special protection needs and to repel invasive species, without plant protection and fertilization intervention with as little work as possible.
Relevance	Water protection functionality: Medium or high Cost of the measure: Medium Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	The installation and maintenance of forest take place as mentioned above in the area of Szentendre's and Csepel's river bank-filtered water resource.
Limitations	Non-chemical cultivation
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Bavaria – implemented in specific case studies
Implementation example	Budapest Waterworks Ltd.
Comments	

Identified GAP provoking action

GAP short name	**Inadequate management of forests. The conservation and appropriate enhancement of biodiversity**
GAP short description	Deadwood influences the action of water by arresting surface flows on slopes during heavy rainfall and by accumulating in watercourses. Debris dams in streams and rivers generate pools and marshes, deflect flows, generate shoals of silt and small pebbles, and generally diversify the course into a sequence of pools, falls and riffles. Raised water levels and migrating channels create marshes and a variety of other riparian habitats. This habitat diversification, combined with the deadwood acting as a source of energy and nutrients, increases biodiversity and enlarges fish populations.

Best management practice

Name of BMP	**Establishment of an adequate deadwood management**
Type of land use regarded	Forestry, Agriculture
Pilot action cluster (if relevant)	Plain site, Mountain
Location	Polish forests and backwoods
Description of the BMP	Coarse deadwood should be present within all forest hydrotope areas of the drinking water protection headwaters. A tree during the time span from just before its death, as well as during the specific decomposition-phases, is a habitat and an ecological niche for a large amount of organisms and succession-chains which form in specific micro-habitats on continually decomposing tree trunks. Life and death are therefore inseparable in an undisturbed forest (Otto, 1994). The relevance of deadwood for biodiversity was mostly underestimated in the past. It was possible to show, that wood caves created by woodpeckers-species in strong upright deadwood trunks, subsequently may be populated by bat, squirrel, marten-species and owl-species. It is also important to mention the first inhabitants of deadwood, like fungi,

	bacteria, mites and nematodes (Krajick, 2001). For the water protection functionality of forests, coarse deadwood (trunks with strong diameters, upright and horizontal) have a predominant relevance because of the impacts previously mentioned, which nurture forest stand stability. This stand stability is created for example by the regulation of the mouse population by owls and the result ensures regeneration dynamics of beech. On the other hand, the decomposing woody parts of the trees are an area where water storage takes place. The presence and leaving of deadwood in forest ecosystems plays an important role for the biodiversity. Therefore it was proposed and has been accepted as an indicator for biodiversity on the pan-European level. In Bavaria, the establishment of an adequate deadwood management in state-owned forests is regulated by law, whereas this implementation is still voluntary in privately owned forests. Deadwood provides a rich source of nutrients that is continuously released in the process of its decomposition. In particular carbon, calcium and magnesium are provided. In this way, on the one hand this management practice enhances the formation of humus and on the other hand improves the silvicultural productivity. Moreover, deadwood represents an important habitat and ecological niche for several micro- and macroorganisms, e.g. fungus-types, bacteria, different woodpecker species and owls, and thus enables a species-rich ecosystem. Deadwood is an integral part of the soil development process. While fostering the production of humus, deadwood directly helps to increase the water storage capacity of the uppermost soil layer. A thick humus-layer on the one hand enhances the purification of seepage water and on the other hand increases the water storage capacity of the soil. Hence, an adapted deadwood management enhances the ecosystem functions such as water provision, water regulation and water quality regulation. Moreover, deadwood locally regulates the microclimate and helps to keep the living conditions near the soil surface more constant (Schiegg, Pasinelli, Suter (2002)). In terms of soil degradation, deadwood also locally hinders erosion processes and inhibits the outwash of nutrients and soil particles. The Measure advantages of an adequate deadwood content go beyond its direct impacts on the water-related ecosystem functions. In fact, it also positively affects other forest management practices, e.g. natural regeneration. The natural regeneration of spruce, fir and Swiss stone pines has been proved to be very effective on deadwood (Schiegg, Pasinelli, Suter (2002)). Additionally, deadwood helps to protect the young stands from browsing by game making the natural regeneration process more efficient. The ecologically-valuable properties of adequate deadwood content are prerequisites to obtain a stable, vital and especially resilient forest which can fulfil its protective function. This best practice is valid for both mountain and plain sites.
BMP advantages	Dead wood is ecologically important to forests. By slowly releasing carbon back into the atmosphere, dead wood plays a role in long-term carbon storage. Dead wood maintains biodiversity by supporting, sheltering, and feeding many species. It also shapes riparian ecosystems by altering the hydrology and morphology of the river channels, and helping to decrease the speed of flood waters. Dead Wood in Riparian Ecosystems Riparian areas are the transitional zones between streams and land adjacent to streams, which are important for in improving the stream health (Ilhardt et al. 2000). When tree branches or logs fall into the water, they hydrologically and hydraulically influence river channels by enhancing slope stability (Gurnell et al. 1995). Large dead wood stabilizes small streams and diverts water flows by controlling and dissipating the river’s energy, which substantially reduces bank erosion. By reducing the impacts of fast flow on eroded banks, especially during heavy rainfalls, dead wood stabilizes and shapes the riparian ecosystem (Rose et al. 2001). Dead wood also helps stabilize stream ecosystems by retaining sediment. Logs in the stream reduce the velocity of the nearby water flow and thus lower the amount of sediments carried by the flow. After

	the debris dam is removed from the pool, the stored sediments trapped by the logs are tremendously reduced. Stored sediments that are 6 trapped and consolidated by logs are sources of nutritional particles, which are an important part of aquatic wildlife food sources (Rose et al. 2001). A stable riparian ecosystem plays an important role in relieving the urban stream syndrome—the ecological degradation of streams due to urbanized land (Pickett et al. 2011). Rushing stormwater, the result of impervious surfaces, can wash off sediments on the bank leading to bank erosion. Stream bank erosion accounts for two thirds of the total sediment load in the Chesapeake Bay Watershed (CBW) (Donovan et al. 2015). Placing dead wood in the riparian ecosystems is effective in reducing the erosion and improving stream health. It is suggested that dead wood should not be removed in the watershed since it acts like a strategic buffer in protecting and enhancing the watershed health by storing large amount of sediments and gravel (Palone and Todd 1998). Other advantages include: • Positive impacts on the ecosystem services water regulation, water provision, water quality regulation; • provision of nutrients and thus improvement of silvicultural productivity; • protective function from browsing by game of young stands; • coupling with other measures (e.g. natural forest regeneration of mixed-forests) can enhance the effect of an adequate deadwood management. • Woodland alongside watercourses where fallen trees and deadwood play an important role in freshwater ecosystems by fostering the development of 'debris dams'	
Challenges	May hamper logging procedure; may increase the vulnerability to bark beetle infestations and forest fires.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	KATER II, CCWare	
Limitations	Resistance of population, especially private land and forest owners, lack of proper education, possible conflicts of land use vs water management vs flood management.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO Bavaria - implemented in specific case studies	
Implementation example	Galloway Forest Park, Abernethy Forest, Scotland. Balancing management objectives In most woods there will be a need to balance the provision and enhancement of deadwood with other factors, some of which may include: • risks to public and worker safety of retaining and managing standing deadwood • visual and recreational impact of deadwood and of management operations; • other biodiversity objectives; • economic objectives, especially timer and woodfuel production; • the extent to which pests and diseases associated with large amounts of dead and dying trees might be encouraged, to the detriment of living trees.	

Table 36. Gaps and best management practices related to agriculture

▪ Identified GAP provoking action	
GAP short name	**Funding for land use actions for water protection**
GAP short description	Funding programmes for the implementation of land use measures are not related to water resources protection
▪ **Best management practice**	
Name of BMP	**Linking land use measure funds to water resources protection**
Type of land use regarded	Mostly agriculture
Pilot action cluster (if relevant)	All areas
Location	Bavaria
Description of the BMP	Funding programs for eco-friendly land use practices in Bavaria are related to the StMELF (Bavarian State Ministry for Food, Agriculture and Forestry), while concerns about water resources protection measures are related to the StMUV (Bavarian State Ministry of the Environment and Consumer Protection). The proposed measure intends to point to the joint responsibility of the mentioned resorts and highlights the importance to elaborate interlinked funding programs for integrated, water resources-friendly land use practices on relevant sites. Going beyond the targets of existing funding programs (e.g. KULAP, see below), this measure should help land owners and local stakeholders (such as water suppliers) to find adequate, site-specific solutions for a common target.
BMP advantages	Closing gaps between two ministries may foster closer collaboration and facilitate finding solutions for interdisciplinary matters.
Challenges	Two important Bavarian funding programs for land owners implementing eco-friendly practices on their farms are KULAP (Kulturlandschaftsprogramm, cultivated landscapes program) and VNP (Vertragsnaturschutzmaßnahmen, natural protection program), awarding payments to farmers on a hectare basis. However, these programs are already widely ascribed to and overstrained. Moreover, these funding programs are related to the StMELF, while funds and questions related to water resources protection measures are matters for the StMUV. Due to this essential splitting of responsibilities on the state level, the elaboration and implementation as well as the generation of funding programs for integrated, water resources-friendly land use practices is hampered.
Relevance	Water protection functionality: High Cost of the measure: Medium Duration of implementation: Medium term Time interval of sustainability: Medium term
Reference / source	Stakeholder interviews, Online stakeholder survey (own analysis)
Limitations	Existing policies, intending public engagement once a plan and measures have been elaborated; Existing mistrust between decision makers, water suppliers and land owners and thus resulting hardened fronts and difficult discussions between the relevant stakeholders;
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☒SLO Bavaria, Slovenia - implemented in specific case studies
Implementation example	

Comments		
Identified GAP provoking action		
GAP short name	**Deterioration of water quality due to agricultural pollution**	
GAP short description	In cases where agricultural land is adjacent to the water bodies (rivers or streams), runoff of commonly used phytosanitary products may cause drastic deterioration of water quality. Additional pressures include on water bodies include phosphorous and nitrogen compounds from manure, sediment runoff and increased erosion. Farmers in Croatia are insufficiently educated, hence agriculture is purely conventional and the use of pesticides and fertilizers is still under the motto of "the more the better".	
Best management practice		
Name of BMP	**Establishment of buffer strips**	
Type of land use regarded	Agriculture	
Pilot action cluster (if relevant)	PAC2: South Dalmatia – Prud, Klokun and Mandina springs Imotsko Polje springs	
Location	Croatia Adjacent to all water bodies / agricultural areas	
Description of the BMP	Establishment of buffer strips along water courses is a conditionality aimed to protect surface and groundwater pollution resulting from agricultural activities. The main polluting agents (nitrates, phosphates, chemical residues and insoluble mineral particles) are generated by excessive application of fertilisers to crop fields, by use of fertilisers inadequate for crop cycles and by inappropriate tillage or irrigation practices. The pollutants transfer is linked to water flows: for substances with lesser absorbance by soil particles (e.g. nitrates) the transfer happens mainly through surface flow or deep percolation of solutions; for highly absorbed substances, (phosphorus compounds), erosion and sedimentation are the main transfer systems. The term “buffer” identifies linear formations of herbaceous vegetation, tree and/or shrub interposed between the crops and the stream/channel which intercept surface and sub-surface runoff water, acting effectively as a filter against pollutants / sediments carried by water. Besides agriculture, buffer strips are also useful in forests in a way that they protect the streams from lateral erosion.	
BMP advantages	Buffer strips along streams are common best management practices on global scale. They have high ecological and water protection value since they prevent spreading of contaminants (e.g. nitrates) from adjacent surfaces (e.g. industry, agriculture) towards water bodies.	
Challenges	As usual when dealing with agricultural land willingness to accept this measure depends largely on the amount of compensation payments.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term (if clear cuts are prevented)
Reference / source	PROLINE-CE D.T1.2.2 Transnational best management practice report	
Limitations	Unwillingness to change habits; insufficient education of farmers; lack of government stimulation/compensation	

Implemented in	☒AT ☒BAV ☒CRO ☐HU ☒IT ☐POL ☐SLO Bavaria, Croatia – implemented in specific case studies
Implementation example	Best practice on global scale PROLINE-CE examples: Austria, Italy (experimental study in Chienti basin)
Comments	
Identified GAP provoking action	
GAP short name	**Application of intensive crop production technology and its impact on water resource protection**
GAP short description	The Hungarian legislation contains rules for the utilization of potable water protection areas for crop production, which gives the opportunity to take into account the different impacts of different cultivation systems and other protection options other than discounts in the licensing of the activity.
Best management practice	
Name of BMP	**Intensive crop production possibilities in water protection areas**
Type of land use regarded	Agricultural area, crop production
Pilot action cluster (if relevant)	Agricultural production (PA C2, PA C3)
Location	Hungary Part-filtered drinking water resource on Szentendre Island
Description of the BMP	On the Szentendre Island the production of strawberries is a tradition, which is carried out by the use of organic fertilizers, fertilizers and irrigation. The irrigation used is typically a sprinkling system even today. At traditional cultivation, nitrate from organic and fertilizer is washed through the soil into groundwater. According to the Government Decree 123/1997 (VII 18) the water protection regulations valid in Hungary, growing plants, organic and artificial trimming and pesticide application on internal protection areas is prohibited, while on external and "A" and "B" hydrogeological protection areas may be permitted depending on the results of an environmental impact assessment or an environmental review or a specific test. From a drinking water quality point of view, nitrate from the plant nutrients is mobilized in the soil and is washed away with water from the surface to the groundwater. To make this process happen, two factors have to occur: there must be nitrogen excess and in the soil layer must be downstream water flow reaching groundwater. In the soil, excess nitrate can be produced by over-fertilization and unbalanced nutrient supply, because the plant utilizes all other nutrients in proportion at the minimum nutrient content. By itself, therefore, reducing the amount of nitrogen does not necessarily have the desired effect. Intensive cultivation systems that follow different plant nutrient requirements at different development stages can achieve more favourable results with multiple nutrient applications in the case of reducing nutrient loss and leaching, like the inadequately extensible systems. On the island of Szentendre, a twin-line rest-balk cultivated strawberry growing plant was established, where the ridges were covered with foil. Micro-irrigation was used and nitrogen nutrition was provided with daily irrigation water after a larger initial organic fertilization. With irrigation the root zone of the plant was moistened, that is the top 20-30 cm soil layer. However, the plant was also exposed to precipitation. During the experimental cultivation, the nitrate profile of the soil was continuously measured up to 150 cm depth. In particular,

	due to the wet weather, no significant amount of nitrate washes were found, which reached the groundwater hazard. With the use of smart and environmentally friendly pesticides, such intensive systems are suitable, that they minimize the environmental load with continuously controlling and applying to plant needs. Intensive agricultural utilization is also possible in water protection areas.	
BMP advantages	Producers and landowners can use intensive systems that provide greater profitability. There is no need to limit their activity just to regulate.	
Challenges	Implementation of plant protection activities in an environmentally friendly way.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium term
	Duration of implementation	Medium term
	Time interval of sustainability	Long term
Reference / source	Bank-filtered groundwater resources of Szentendre	
Limitations	The shift towards the extensive production method is now more widely accepted under the protection principles.	
Implemented in	☐AT ☒BAV ☐CRO ☒HU ☐IT ☐POL ☐SLO Bavaria - implemented in specific case studies	
Implementation example	Budapest Waterworks Ltd.	
Comments		

Identified GAP provoking action

GAP short name	**Obsolete conduction of agricultural practices**
GAP short description	Traditional agriculture in terms of fulfilment of crop water requirement, not accounting for potential effects of climate changes (CC) and especially of intra-annual (seasonal) variability of rainfall and temperature regime leading to droughts.

Best management practice

Name of BMP	**Increasing the efficient use of water in agriculture and adapting to climate change and crop irrigation to achieve optimum yields**
Type of land use regarded	Agriculture
Pilot action cluster (if relevant)	Po river basin (upstream, midstream to downstream area) (PAC 3)
Location	Italy Agricultural areas
Description of the BMP	The introduction, in farms, of irrigation infrastructures in case of previously rained agriculture, or implementation of more sustainable irrigation techniques for already irrigate agriculture, allow improving the economic performance of agricultural production, facilitating the process of restructuring and modernization, and providing an effective mechanism at farm level for climate-change adaptation and mitigation of the damage caused by droughts. The new construction or modernization of existing farm irrigation systems lead to an increase in water efficiency. The development of irrigation infrastructure should be only undertaken where it does not conflict with the Water Framework Directive (Directive

	2000/60/EC) and does not cause any deterioration in water status. Furthermore, all actions include the appropriate prevention and mitigation measures to offset potential environmental impact.	
BMP advantages	The measure is aimed to: • Provide efficient systems to avoid water losses and optimize the irrigation application only in case of effective crop needs. • Save irrigation water under increasing rainfall variability under climate change, especially in the context of preserving water for downstream areas • Enable the use of irrigation also for crops usually under rainfed agriculture.	
Challenges	High costs, very local scale.	
Relevance	Water protection functionality	High (quantity aspect)
	Cost of the measure	Medium-High
	Duration of implementation	Short to medium term
	Time interval of sustainability	Long term
Reference / source		
Limitations	The advancing of technologies to make water use in irrigation more efficient require relevant initial costs, training of farmers and knowledge transfer to them in order to interpret and maximize results of monitoring/measurements of effective crop water requirement before applying irrigation.	
Implemented in	☐AT ☒BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies (special consulting related to irrigation or up to a soil moisture of 70% of the usable field capacity)	
Implementation example	A good example of implementation was conducted by CMCC jointly with WWF-Italy in supporting Mutti SpA (one of the main industrial tomato producer). Mutti SpA experimented the use (by providing to farmers) of soil moisture monitoring devices to advise farmers about the exact timing and amount of irrigation needs. This reduced water consumption up to 30% and reduced the water footprint of cultivation phases.	
Comments	BP MA9 Increasing the efficient use of water in agriculture and adapting to climate change BP MA26 Irrigate crops to achieve optimum yields (as reported in T1.2.1 National Report)	
■ Identified GAP provoking action		
GAP short name	**Pollution of watercourses**	
GAP short description	Exposure of streams, rivers and groundwater to pollution (pesticides, fertilizers)	
■ Best management practice		
Name of BMP	**Encouraging organic farming**	
Type of land use regarded	Agriculture	
Pilot action cluster (if relevant)	Plain sites, Mountain sites	
Location	Poland	
Description of the BMP	According to the European Commission, between 2014 and 2020, over € 100 billion will be invested in the European Union's rural areas to help farming meet the challenges of soil and	

	water quality, biodiversity and climate change. At least 30% of the rural development programmes' budget will have to be allocated to agro-environmental measures, support for organic farming or projects associated with environmentally friendly investment or innovation measures. The support is granted to farmers in the form of direct payments, on the condition that they respect strict rules on human and animal health and welfare, plant health and the environment. Green direct payments account for 30% of EU countries' direct payment budgets. Farmers receiving an area-based payment have to make use of various straightforward, non-contractual practices that benefit the environment and the climate. These require action each year. They include: diversifying crops; maintaining permanent grassland; dedicating 5% of arable land to "ecologically beneficial elements". Organic farmers automatically receive their greening payment for their holding, as they are considered to provide environmental benefits. Additional payments are available, for example for farming methods that go beyond basic environmental protection or for farmers working in areas with natural constraints. The amount of support they receive is not linked to the quantities they produce. Action Plan for the future of Organic Production in the European Union presents strategy for organic production, controls and trade. EU offers funding possibilities to operators for campaigns which aim to increase consumer awareness on the main features of the organic production scheme, on specific products produced according to the EU organic production rules, the EU system of control and on the EU organic logo. This best practice is also applicable to plain sites.	
BMP advantages	Ensure awareness of organic farming benefits; Organic farming combines best environmental practices, supports biodiversity and natural resources conservation. Not only does organic farming build healthy soil, but it helps combat serious soil and land issues, such as erosion. A major study comparing adjoining organic and chemically treated wheat fields showed that the organic field featured eight more inches of topsoil than the chemically treated field and also had only one-third the erosion loss. Erosion issues are extremely serious, affecting the land, food supply, and humans. However, organic farming practices do help discourage erosion from occurring. Dwindling water supplies and poor water health are very real threats. When our water supply is at risk, people and the planet end up suffering. Major water pollution threat to rivers is runoff from non-organic farms, such as harmful pesticides, toxic fertilizers, and animal waste. Organic farming helps keep our water supplies clean by stopping that polluted runoff. Organic farming also helps conserve water. Organic farmers, in general, tend to spend time amending soil correctly and using mulch - both of which help conserve water. Cotton, an in-demand crop, requires a lot of irrigation and excess water when grown conventionally. However, organic cotton farming needs less irrigation and thus conserves water. Organic Farming Discourages Algae Blooms. Algal blooms (HABs) result in adverse effects on the health of people and marine animals and organisms. Algal blooms also negatively affect recreation, tourism and thus, local and regional economies. While there is more than one cause of algal blooms, a primary human-based cause of algae blooms is runoff from the petroleum-based fertilizers often used in conventional farming.	
Challenges	Compliance to strict EU definition of organic farming and food.	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Long term

	Time interval of sustainability	Long term
Reference / source	Orientgate	
Limitations	High costs, resistance of population, lack of supervising/implementation mechanisms, possible lack of market demand – due to product pricing.	
Implemented in	☒AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Italy – implemented but not fully funded Bavaria - Case study specific, but not legally implemented	
Implementation example	ÖPUL – Austrian Program for the promotion of an environmentally suitable, extensive and the natural habitat protecting agriculture explains necessary steps: • Consulting of farmers (focus on water and climate protection) • Promotion of regional marketing initiatives and organic farms • Biogas-eco-power plants (utilization of agricultural fertilizer)	
Comments	On 28 June 2017 the Maltese presidency and the European Parliament reached a preliminary agreement on an overhaul of the existing EU rules on organic production and labelling of organic products. The agreed regulation sets more modern and uniform rules across the EU with the aim of encouraging the sustainable development of organic production in the EU. The new rules also aim to guarantee fair competition for farmers and operators, prevent fraud and unfair practices and improve consumer confidence in organic products. Organic farmland has more than doubled in the last decade and each year 500 000 hectares of land are converted into organic production. However, the legislative framework has not kept up with such market expansion and still includes different practices and derogations. The new rules will: - make the life of organic farmers easier by enhancing legal clarity and allowing for further harmonization and simplification of production rules. A number of past exceptions and derogations will be phased out subject to relevant Commission reports. - increase consumer confidence by strengthening the control system. Preventive and precautionary measures have been clarified and made more robust (e.g. the roles and responsibilities of the different controlling bodies). The new regulation introduces checks on retailers and a risk-based approach to controls, thus reducing the administrative burden for operators in general and SMEs in particular. Specific controls on organic farming will be complemented by the recently introduced rules on official controls along the agri-food chain.	

Identified GAP provoking action

GAP short name	**Inflexible time ban of fertilizers and manure application**
GAP short description	Period of restriction of fertilizers and manure application is defined with exact date and does not adjust to current weather.

Best management practice

Name of BMP	**Redefinition of time ban of fertilizers and manure application**
Type of land use regarded	Agriculture: grassland, arable land
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland
Location	Slovenia

Description of the BMP	The restriction period of mineral fertilizers containing nitrogen use is defined from 15th November till 1st March and prohibition of manure and slurry use from 15th November (manure: 1st December) to 15th of February (according to Nitrate Directive and Decree on the protection of waters against pollution caused by nitrates from agricultural sources). Vegetation activity depends on current weather conditions which are unstable and yearly changing. If vegetation is not active, the N-compounds pass through soil directly into the groundwater. Consequently the period of restrictions should be redefined according to the weather condition instead of calendar date. The Slovenian Environment Agency (meteorology section) monitors and predicts weather conditions should determine for each year date of fertilizing period. The storage of manure and slurry in the time of application restriction should be properly sealed to be safe from overflowing and consequently contamination of water sources. In order to spread environmental awareness among locals and local farmers, educational lectures should be frequently organized.	
BMP advantages	Since some farmers must keep a fertilization plan (only those with fields within on DWPZ and those included in sustainable farming program), supervision over fertilizing has improved. Farmers receiving subsidies are obligated to attend trainings for pesticide use, personalized expert advice and lectures every 5 years. In the first DWPZ fertilizing is forbidden for: mineral fertilizers containing nitrogen, manure and slurry, ploughing of permanent grassland and irrigation with water containing plant nutrients. On the narrowest DWPZ (VVO-I) farmers get money compensations because of fertilizer application limitation and consequently smaller harvest.	
Challenges	Farmers are not satisfied with the prohibition and would like to repeal it, therefore main challenge present farmers' approval of implementation of widening the restriction period. A frequent supervision of manure and slurry storages In the period of prohibition would present a better control of the nitrate directive implementation, according to which, the manure and slurry should not be stored longer than two months on the farming area and should be located every year on a different place. The main challenge is to implement integral management of agricultural activities within recharge area of drinking water source (and in general in water body), which means that farmers have to be linked up with each other and share manure to farmers needing it etc. farming and cattle breeding.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from bad practice causing deterioration of groundwater quality. REFERENCE: *Nitrates directive* and Slovenian *Decree on the protection of waters against pollution caused by nitrates from agricultural sources.*	
Limitations	Expected limitations are lack of political will and resistance of local farmers - conflicts of land use vs water management, lack of supervising / implementation mechanisms.	
Implemented in	☐AT ☒BAV ☐CRO ☐HU ☒IT ☐POL ☒SLO Bavaria - redefined in the framework of the new drinking water ordinance, but not satisfying for farmers Slovenia – improvement is needed	
Implementation example		

Table 37. Gaps and best management practices related to urban areas

Identified GAP provoking action	
GAP short name	**Pollution caused by inappropriate sludge management**
GAP short description	Sludge is one of the by-products of wastewater treatment plants. Authorities in Croatia have not yet tackled this issue in appropriate manner (which is also case in many EU countries), resulting in poor sludge management (both in planning and operation phase). For now, sludge is deposited on solid waste dumps, causing pollution of soil and water, enhanced by degraded air quality for surrounding population. This issue was brought to public attention when sludge of unknown characteristics (toxicity, chemical and physical characteristics) was deposited on several agricultural fields in northern Croatia.
Best management practice	
Name of BMP	Effective sludge management
Type of land use regarded	Predominately urban, but other land uses are also affected (namely agriculture, forest – wherever sludge is deposited)
Pilot action cluster (if relevant)	This measure can be considered relevant for all populated places, including pilot areas. Additionally, pilot areas in Croatia urgently need improvement in sewage and wastewater treatment plant infrastructure, hence sludge management is also concerned.
Location	Croatia Every agglomeration with >2000 P.E (according to Croatia RBMP 2016-2021). Many agglomerations have not yet established UWWTP, which is one of key goals
Description of the BMP	Sludge should not be released into environment without treatment. Many options for sludge handling are available, such as landfilling, thermal reuse (incineration), reuse in production of materials, land application or biomass for power plants. The high organic content in the sludge will result in methane production during landfilling, which should be extracted and used for energy generation to avoid the release of potent greenhouse gases. Groundwater has to be protected from landfill leachate. For incineration, the water content of sludge has to be reduced significantly. It is probably not viable for each treatment plant to install a separate incineration facility, so sludge has to be transported safely to a central facility. Groundwater protection measures have to be applied to the incineration facility and storage of dewatered sludge should be handled accordingly. The reuse of sludge in construction materials is the safest option with regards to groundwater protection as contaminants are immobilised in the cement matrix. This reuse option should be considered in karst areas. If land application is envisaged, any plastics, sanitary items etc. should be disposed of separately during primary treatment and should not be included into biosolids. While pathogens can be largely eliminated through treatment, biosolids have accumulated all contaminants attached to particulates (like heavy metals and persistent organic contaminants) that are not significantly decreased during treatment. Therefore, sludge application in karst areas is prohibited in many European countries (BGR, 2011).
BMP advantages	Principle is based on turning a potentially harmful substance into useful one. Therefore, main advantages include utilising the energy potential of sludge when it is economically possible; reducing the amount of harmful micro-organisms (also reducing unpleasant odour and potential contamination of soil and groundwaters); recovering phosphorous for agriculture (fertility improvement) and utilisation of sludge incineration products (ash) in construction industry (production of concrete and other building materials); production of biomass for energy plants.
Challenges	Main challenge is high cost of sludge treatment. Processing and final deposition of the sludge is very expensive procedure, which can generate costs up to 50% of those required to

	construct and operate an urban wastewater treatment plants. This problem is enhanced by the fact that only 46% of population in Croatia has adequate sewage system and only 35% is connected to wastewater treatment plants. In order to improve sludge management, the latter issue must also be tackled. Principle which should be followed here states that establishing wastewater treatment facilities sooner rather than later is commonly less costly than doing nothing (BGR, 2011).	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Medium to long term
	Time interval of sustainability	Long term
Reference / source	Mogućnost zbrinjavanja mulja koji nastaje u procesu obrade otpadne vode u betonskoj industriji (article in Croatian) http://www.voda.hr/sites/default/files/pdf_clanka/hv_94_2015_277-286_vouk-et-al.pdf sludge2energy - Innovative Sludge Utilisation Concepts http://www.sludge2energy.de/index.html Project RESCUE – Recycling communal sludge for use in construction industry http://www.grad.hr/rescue/ Protection of Jeita Spring; German-Lebanese Technical Cooperation Project https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Libanon/techn_rep_2.pdf?__blob=publicationFile&v=4 PURE – Project on urban reduction of eutrophication http://www.purebalticsea.eu/index.php/gpsm:good_practices	
Limitations	Mainly high costs and long implementation time	
Implemented in	☒AT ☒BAV ☐CRO ☒HU ☒IT ☐POL ☒SLO	
Implementation example	See references	
Comments	Sludge application (e.g. as fertilizer) is prohibited in karst areas and drinking water protection zones in Croatia – basically all areas south of Karlovac city.	

Identified GAP provoking action

GAP short name	**Domestic gardens for small-scale cultivation within the drinking water protection areas**
GAP short description	In the case of rural or suburban settlements, the home gardens have significant territorial expansion. In a garden, fertilization, pesticide application and irrigation are used. Thus, the gardens could have significant impacts.

Best management practice

Name of BMP	Controlling cultivation - awareness of domestic and small gardens within the drinking water protection area
Type of land use regarded	Municipal areas with rural or suburban structure where collection, treatment and disposal of waste water and waste is solved. The gardens are partly ornate gardens, kitchen gardens and orchard areas.
Pilot action cluster (if relevant)	Polluting effect of agricultural crop production at small gardens in municipal area. (PAC 2, PAC 3)
Location	Hungary Our example comes from Szentendre Island, where our practical experience is the most significant regarding bank-filtered groundwater resources of Budapest Waterworks.
Description of the BMP	In case of ornamental or cognate plants or fruit trees, nutrient and water demand are

	important, as well as protection against pests and pathogens are required. According to the Government Decree 123/1997 (VII. 18), the regulations in force in Hungary the small-scale cultivation is prohibited on internal and external protection areas, while on hydrogeological protection areas "A" and "B" it could be permitted, depending on the results of an environmental impact assessment or an environmental review or a specific test with adequate content. Implementation of this cannot be expected from the owners of the gardens, also the large number of licensing procedures cannot be handled by the environmental authorities, and by the specialized authorities. In Hungary, the polluting effects were investigated, including the cultivation of small gardens and, if necessary, the possibility of reducing the impact during the development of the protection systems for drinking water resources. However, the legislative measures and the provisions on water protection systems have not been put into practice. Recently, on the Szentendre Island, the integrity grows, thus small-scale cultivation rate grows, and with this the significance of their effects is also increasing. It will be increasingly important, that garden owners consciously cultivate their garden, from water protection, nature conservation and their own health protection point of view. The owners of the gardens are typically hobby gardeners who, in the hope of higher yields, use a significant amount of organic fertilizer and fertilizer. Their plant protection activity is also non-proper but luckily, the freely available vermicides that they can buy are not dangerous in terms of toxicity. In the gardens clearings are getting more and more habitual, especially total clearing and soil disinfection. These tendencies may cause significant soil erosion, meaning infiltration of f soil and groundwater through the soil into the aquifer. Stopping and reversing these processes requires intervention. This intervention cannot be legislative, because it is not possible to implement within such a fragmented and uncontrolled situation. Exceptions could be the local regulations by the local governments, which can help to regulate certain (plant protection) activities. The garden owner's attention should be attracted to the importance of their activities. With professional advice, adequate and effective nutrition, plant protection and the choice of suitable breeds can be promoted. It is necessary to encourage the cultivation of resistant varieties (ancient landscape varieties) whose plant protection needs are minimal. The propagation or distribution of these varieties, professional counselling could be carried out with the help of local governments and social organizations in the area, with the involvement or establishment of garden friendly associations. By supporting the users of drinking water, garden-friendly associations or municipalities can organize professional lectures for garden owners. In village celebrations and other community events, for owners of the small garden can be also incorporated professional programs. In addition to or in favour of beautiful gardens, the activity could be strengthened by introducing environmentally friendly gardens. In schools, environmental education could also provide students with environmentally friendly, animal-friendly, small-scale cultivation knowledge. The use of slow-moving fertilizers should be encouraged, or perhaps the organization of discount fairs and study tours in the area.
BMP advantages	Environmentally conscious small-scale farming encourages the public to be able to influence the environment and to change it. This kind of way of thinking is also incorporated into other areas of life. The environmentally-friendly cultivation of the gardens helps to keep the soils and groundwater clean, and increases the rate of near-natural plant associations and increases the living space of insects, birds and small mammals.
Challenges	The modification of the current general horticulture and the way of thinking of the population about horticulture need to be changed. Compliance with regulatory requirements

	cannot be enforced nor controlled, but only on a voluntary basis. It is necessary to actively support the water utility or other professional organization, financial help, the professional commitment of local governments, the involvement of local social organizations or other relevant organizations.	
Relevance	Water protection functionality	Medium or High
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The protection measures of the bank-filtered groundwater resources in Szentendre Island include the main elements of the above.	
Limitations	Slow change in residential gardening practice	
Implemented in	☐AT ☐BAV ☐CRO ☒HU ☐IT ☐POL ☐SLO	
Implementation example		
Comments		

Identified GAP provoking action

GAP short name	**Discharge of rainwater from the inner road network into soil**
GAP short description	On the drinking water protection areas, the placement of rainfall collection systems of existing road network is carried out in the soil by scavenging in an uncovered rainwater collecting ditch. In the case of a new road or rainwater drainage system, a rigorous licensing procedure and annual control measurements shall be used to demonstrate the appropriateness of the solution. This is the case for all investment phases. Authorization is too complicated and fragmented, monitoring measurements are ineffective.

Best management practice

Name of BMP	**Impact assessment and pollution prevention of rainwater from the inter-urban road network to groundwater**
Type of land use regarded	Interior, road network, parking areas
Pilot action cluster (if relevant)	
Location	Hungary Road network, which is in bank-filtered groundwater resources protection area, Szentendre and Csepel Szigeti water resource
Description of the BMP	In the Government Decree 123/1997 (VII.18) regulating the protection of water resources, it is forbidden to use a system of watertight rainwater systems of the motorway in the inner protection area, while on external and "A" hydrogeological protection areas it may be permitted depending on the results of an environmental impact assessment or an environmental review or a specific test. There is no restriction in hydrogeological protection zone "B". Other roads with waterproofed rainwater systems are not limited in the hydrogeological protection area "A" compared to the above. Other roads (with non-impermeable rainwater drains) are prohibited in the inner protection area, while on external and on "A" hydrogeological protection areas it may be permitted depending on the results of an environmental impact assessment or an environmental review or a specific test. There is no restriction in hydrogeological protection zone "B". It is also forbidden to build a car park within the protection area.

	In practice, the road network has been built up in the past with terrain ditch rainwater drainage. With the development of inner areas, the pavement and reconstruction of the unpaved roads is further developed. When a road is paved and rainwater drainage and discharge systems are installed, then the introduction of pollutants is archived into the geological medium (hydrocarbons that may be discharged from the road), which is a subject of an authorization under Regulation 219/2004 on the protection of groundwater. (VII.21.) of the Hungarian Government on the basis of the specified content and form requirements. Typically, a monitoring system should be used for this activity. Given that the investments are progressively implemented, each of them individually, the license applications and their assessment are also individual. In the highlighted water resources protection areas, the features and effects are well-known, professionally the situation and the necessary specifications do not change within a region. If, in such cases, legislation could allow a simplified procedure based on the professional judgment of the licensing authority, it would greatly help to make the licensing process faster and simpler, making it cheaper. A common, combined monitoring system would be possible. The effectiveness of protection would not be reduced, but savings for small settlements are important. This provision affects only the new investments. The impact of the existing road network on the water resources can be detected from water quality inspections wells monitoring system operated by the water producer.
BMP advantages	The advantage of extending simplified procedures is faster administration, the lower cost for investor and maintainer, reducing the number of licensing and specialist authorities.
Challenges	It is necessary to change the legal regulations and practice so far and to review the situation of the environmental status of the given area.
Relevance	Water protection functionality: Medium Cost of the measure: Low (results savings) Duration of implementation: Medium term Time interval of sustainability: Long term
Reference / source	
Limitations	Changing legislation and changing the course of licensing
Implemented in	☐AT ☒BAV ☐CRO ☒HU ☐IT ☐POL ☒SLO Slovenia – improvement is needed
Implementation example	
Comments	

Identified GAP provoking action

GAP short name	**Not arranged road rainwater discharge**
GAP short description	Road rainwater discharge of roads in DWPZ is not led to the road rainwater colleting system and it is not treated.

Best management practice

Name of BMP	**Collection and treatment of road rainwater discharge, particularly within drinking water protection areas**

Type of land use regarded	Urban area		
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland,		
Location	Slovenia		
Description of the BMP	Roads in the DWPZ should have arranged road rainwater discharge. In order to control and to collect rainwater which rinses sediments, waste and waste oil from the road, impermeable rain water drains along roads have to be arranged, with collection of rain water in storm water management pond (retention basins with variety of grasses, shrubs and/or wetland plants) for sedimentation of suspended material and for treatment of polluted water with oil-grit separators (OGS) or oil-sediment separators (OSS). However on motorways and main roads rainwater drainage and retention ponds with treatment are arranged but the infrastructure is not maintained.		
BMP advantages	Undesirable liquids such as mineral oils or other chemicals can be rinsed from the road into the groundwater and can consequently result in pollution of the drinking water source. Therefore controlled and regularly maintained road rainwater discharge is necessary for all roads and motorways. Furthermore road rainwater should not run through public sewage system.		
Challenges	Regulations are hard to change.		
Relevance	Water protection functionality	Very High	
	Cost of the measure	Medium	
	Duration of implementation	Long term	
	Time interval of sustainability	Long term	
Reference / source	BMP derives from bad practice. References: Slovenian legislation: Rules on road design. Decree on the emission of substances in the discharge of meteoric water from public roads. Decree on the emission of substances and heat when discharging waste water into waters and the public sewage system.		
Limitations	Expected limitation is a lack of political will to change regulation and/or municipalities to implement the measure in spatial plans.		
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☒SLO Croatia, Slovenia – improvement is needed		
Implementation example			
Comments			

Table 38. Gaps and best management practices related to grassland

▪ Identified GAP provoking action	
GAP short name	**Pollution of watercourses**
GAP short description	Exposure of streams and rivers to lateral erosion or flooding
▪ Best management practice	
Name of BMP	**Supporting guidance for creation of low-input grassland to convert arable land at risk of erosion or flooding**
Type of land use regarded	Grassland
Pilot action cluster (if relevant)	Grassland, Mountain sites
Location	Poland Tatra Mountains
Description of the BMP	The purpose of this best practice is to establish a new sward by sowing a low productivity grass mix containing at least four flowering species. The sward has to be established before beginning of June (in the first year) – sawing in spring or autumn. The wildflower mixture should be made up of autochthonous species. At least 15% of the mixture should be herbs and the rest grasses. Grazing animals are good at creating variety with their trampling, dunging and eating. Grazing should be at light to moderate levels to keep the sward at a range of heights and to allow some plants to flower. A way to create as diverse habitats as possible and to consider as many species as possible is „rotational grazing", which means a spatial and temporal change of grazed and un-grazed areas. Where no stock are available to graze, grassland should be cut (not before mid of August) to a height between five and ten centimetres.
BMP advantages	The benefit of this BP is the improvement of soil and water quality as well as biodiversity within arable fields which are prone to flooding and / or soil erosion. The grass area should be located within fields or areas at risk to help prevent soil erosion. For example: • Particularly long uninterrupted slopes; • field valleys, low corners or other areas which tend to concentrate run-off; • light soils (with a relatively high sand or silt content) tend to be more prone to erosion particularly those with a low organic matter content; • areas which drain directly to a watercourse will be of greater risk of transferring eroded soil to the watercourse; • areas with flooding risk (adjacent to watercourses).
Challenges	Challenges associated with this measure can be seen on Austria's example in the so-called "Austrian Agrarian Environmental Programme" ÖPUL for environmentally friendly management of agrarian land provides a funding system for certain sustainable measures: • Protection, restoration and conservation of biodiversity also in Natura 2000 sites, endangered or rural areas, land management with high nature value; • enhancement of water management incl. manure management and pesticides; • reduction of soil erosion, enhancement of soil management; • reduction of emissions from agriculture (through site-appropriate cultivation, reduction of fertilisation, field-related fertilisation accounting in combination with

	soil samples, compulsory participation at trainings); • promotion of carbon storage in agriculture and forestry; • Nitrate Action Plan 2012: regulation of nitrate-fertiliser; • promotion of buffer strips, especially along water courses to avoid erosion and pollution through nutrients; • Groundwater 2020 (in Upper Austria): comprehensive protection of groundwater sources and the respective funding of sustainable land-use management measures.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Orientgate, ÖPUL	
Limitations	High costs, lack of political will, resistance of population,	
Implemented in	☐AT ☐BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example	Scottish Government Riaghaltas na h-Alba – Rural Payments and Services Scheme The majority of support schemes available to UK farmers have their origins in the EU's Common Agricultural Policy (CAP). Structured in two parts, Pillar 1 and Pillar II, CAP 2014-2020 provides funding to support environmental, economic and rural development. The amount of CAP funds available from the EU was agreed within the Multi-annual Financial Framework (MFF) and for 2014-2020 is €387 billion. The funds are allocated to Member States, including the four UK devolved administrations, which have their own implementation models for delivering funding from both Pillar I and II. In some years, if the expected Pillar I budget is likely to exceed the available funds, the European Commission implements a mechanism called Financial Discipline. This effectively reduces the total value of Pillar I payments across all Member States. In 2016 this reduction was 1.35391%. The following sections provide an overview of the individual CAP schemes adopted in each UK administration. Relevant government websites should be viewed for more detailed information and up-to-date guidance. Note: Although the UK's referendum decision to leave the EU has created uncertainty over future CAP payments the UK Government has pledged to keep overall payments at the same level until 2022. Agri-Environment Climate Scheme - targeted support is available for land managers to undertake management and capital work that will deliver biodiversity benefits, manage water quality and flood risk, conversion and maintenance of organic farming and improve public access. Creation of Low-Input Grassland to Convert Arable Land at Risk of Erosion or Flooding (Scottish Government, 2015g) option and must be utilised in combination with: - Converting Arable at Risk of Erosion or Flooding to Low-input Grassland - Management of Floodplains - Wetland Management. This funding mechanism offers improved soil structure, water quality and attenuation of runoff but requires evidence that the conversion will provide this. The capital payment rate is £333.51/ ha.	
Comments		

Identified GAP provoking action		
GAP short name	**Continuous conversion of (permanent) grasslands**	
GAP short description	Political and socio-economic conditions fostering a continuous conversion of (permanent) grasslands to arable land, e.g. leading to a considerable increase of leached nitrate	
Best management practice		
Name of BMP	**Preservation of existing (permanent) grasslands**	
Type of land use regarded	Grassland	
Pilot action cluster (if relevant)	Plain areas	
Location	Bavaria	
Description of the BMP	Grasslands represent ecologically valuable spaces in most water protection zones. Basically, grassland experience less intensive use as compared to arable lands, thus offer considerable water provision, purification and regulation functions.	
BMP advantages	The enriched content of soil organic matter of the topsoil of permanent grassland favours the water storage capacity and the process of water purification. Generally, the activity of soil organisms is high and keeps the bioturbation on an adequate level (BAUCHHENß, 2005). Bioturbation positively affects the soil (aggregate) structure; it improves the connectivity of macropores and enhances the infiltration capacity (SCHEFFER et al., 2010). Additionally, the intensity of bioturbation positively correlates with the distribution of macropores which in turn is crucially important for the water provision and water regulation function of the soil system. Moreover, a dense turf on permanent grasslands provides a protection function against erosion processes, soil aggregate destabilization and evaporation losses. The turf decreases the susceptibility to surface sealing and lower the probability of breaching the infiltration capacity and the resulting Hortonian Overland Flow. Analogous to less surface sealing, enhanced vertical connectivity and increased losses through interception and evaporation, this measure can enhance the mitigation of floods in small catchment areas during convective storm events (DWA, 2015).	
Challenges	Farmers try to avoid the status of permanent grasslands due to a lower sales value and the ban on plowing. Thus, the implementation of ecologically valuable permanent grasslands is difficult since the economic value of arable land sites and permanent grasslands as well as the legal restrictions on both land use entities mostly are of top priority. A further challenge of preserving existing grasslands is the new definition of a permanent grassland introduced by the European Court of Justice in 2014, defining a permanent grassland as an *'agricultural land which is currently, and has been for five years or more, used to grow grass and other herbaceous forage, even though that land has been ploughed up and seeded with another variety of herbaceous forage other than that which was previously grown on it during that period'*. According to the stakeholders involved, this new definition further increases the spatial share of converted grasslands.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Short term
	Time interval of sustainability	Short term
Reference / source	Stadtwerke Freising (https://www.lfu.bayern.de/wasser/trinkwasserschutzgebiete/kooperation_mit_landwirten/doc/freising.doc)	

Limitations	Legislation mandating that land owners cannot return to arable land what has been classified as permanent grasslands (according to the new definition as mentioned above); Lower sales value of permanent grasslands Internal structures, e.g. focus on farmland and no livestock, making grasslands unprofitable
Implemented in	☐AT ☐BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO
Implementation example	
Comments	

Table 39. Gaps and best management practices related to wetlands

▪ Identified GAP provoking action	
GAP short name	**Pollution of watercourses**
GAP short description	Exposure of streams and rivers to lateral erosion, sediment infiltration and pollution (pesticides, fertilizers)
▪ **Best management practice**	
Name of BMP	**Wetland restoration**
Type of land use regarded	Wetlands
Pilot action cluster (if relevant)	Plain areas: Wetland
Location	Poland
Description of the BMP	Wetlands perform multiple essential functions including flood and erosion management, climate and water regulation. Wetlands induce wave and tidal energy dissipation and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland vegetation also help to stabilise soil and sediments, thus reducing erosion. Wetland restoration means re-establishes these advantageous functions for the benefits of floods, erosion and water protection. Restoration of existing wetland ecosystems and their services is required as they have been increasingly degraded by both natural and human activities. Different kinds of techniques can be used to reintroduce wetlands in areas where they previously existed depending on the habitat type and the level of degradation. In terms of flood and water quality protection, the main benefit of wetland restoration is related with their function to act as “buffer zone”, improving flooding and erosion protection by reducing incoming wave and tidal energy. In contrast to hard defences, wetlands are capable of undergoing ‘autonomous’ adaptation to increase sea levels, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level (Nicholls & Klein, 2005). In this way, coastal wetlands also provide a natural barrier to salt water intrusion into coastal aquifers, which can be maintained without additional investments. Restored wetlands also provide a number of additional ecosystem services including water quality and climate regulation, representing valuable accumulation sites for sediment, contaminants, carbon and nutrients coming from productive activities located upstream. Challenges of wetland restoration are minimal if compared with benefits provided.
BMP advantages	Restored wetlands improve water quality by reducing concentrations of targeted pollutants (nitrogen, phosphorus, sediment) in runoff or subsurface flows before they reach other surface waters. The basic biogeochemical processes involved in nutrient and sediment removal as well as mercury methylation. Nitrate removal or denitrification occurs mainly through plant uptake and microbial mediated processes. Nitrogen is an essential plant nutrient and some plants are able to absorb and use nitrate directly as a nitrogen source for their growth h, however denitrification is a more important process for nitrogen removal. Denitrification requires a retention time long enough to maximize nitrate removal, anoxic conditions (without oxygen) and enough organic carbon to support bacterial activity. Since denitrification is a biological process, it is also temperature-dependent (Kadlec and Knight 1996, Crumpton 2001). Phosphorus reduction and cycling in wetlands is a highly complex process. Initially, the restored wetland can intercept and retain a significant amount of phosphorus. However, as the wetland matures and reaches a saturation point (or as the water regime changes) the wetland begins to export phosphorus (Kadlec and Knight, 1996). Wetlands are more prone to phosphorus saturation when they are well connected to upstream drainage networks,

	especially a drained catchment area more than 5 times the size of the wetland basin. Once a wetland is saturated, phosphorus may pulse out of the wetland into downstream lakes and streams via the drainage network. During rainfall events and snowmelt periods, fine sediments are transported from land to rivers, streams, lakes, and wetlands via overland runoff and, to a lesser extent, via drainage systems. The sediment load is related to the hydraulic energy of overland or subsurface flows. High-energy flows also significantly increase streambank erosion, which increases sediment loads in streams. Properly designed wetland restorations can reduce the hydraulic energy of the water flowing through them and intercept sediments before they reach other waters. Mercury is a potent neurotoxin. Environmental exposure and damage from mercury is particularly problematic when the mercury is methylated. Mercury methylation is a complex biogeochemical change that occurs in wetlands. Methyl mercury (MeHg) is more toxic and bioavailable than elemental mercury (Hg). Mercury methylation is known to occur in inundated and saturated soil wetlands and, therefore, the production and release of methyl mercury (MeHg) due to wetland restorations has been suggested as a potential pollution concern. However wetlands can also effectively capture and remove mercury from downstream waters. The MPCA recently compared mercury cycling in three types of wetlands: natural wetlands, stormwater wetlands and wetlands that receive water from agricultural lands.All behaved similarly in terms of mercury removal and MeHg production. However, through-flow wetlands receiving extensive urban or agricultural drainage water had a higher percentage of MeHg to total Hg. This may be at least partly due to the residence time and drainage area. Other advantages include: • Improved surface and ground water quality by collecting and filtering sediment, nutrients and pesticides in runoff; • Reduce soil erosion and downstream floods by slowing overland flow and storing runoff water; • Wetland plants utilize trapped nutrients, restore soil organic matter and promote carbon sequestration; • Provide food, shelter and habitat for many species and enable the recovery of rare or threatened plant communities; • May significantly reduce sea water intrusion into coastal aquifers; • Improve groundwater supply recharge by slowly releasing water into the ground; • Provide recreational and aesthetical functions.	
Challenges	• Require large surface to be implemented which is likely to create conflicts with alternative land uses (i.e. agriculture, forestry); • Require a degree of expertise, especially in locations where wetland re-colonisation has to be encouraged by transplanting wetland plants.	
Relevance	Water protection functionality	Medium
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	OrientGate Project	
Limitations	The restoration of wetlands is often associated with potentially conflicting issues such as the demands of food production against the requirement to enhance biodiversity. Embedded in these issues is the limiting factor of how wetland restoration will be financed. In some EU	

	member states the restoration of wetlands or actions for their conservation are considered agri-environmental measures which are eligible for financial support within rural development plans. The criteria to access state financing for wetland restoration in the agricultural landscape are mainly based on the delivery of positive impacts on biodiversity or nutrient retention. However, in most cases agricultural landowners have to prioritise production to ensure economic viability, and often it is incumbent on the landowner to take the final decision regarding initiating a restoration project. Consequently, there is a strong need to find new ways of engaging landowners and other key stakeholders in wetland restoration. In this respect, the promotion of multi-functional wetlands may be a promising way forward (Andersson, 2012). From a farming perspective, the appealing wetland services include the provision of irrigation water and hunting and fishing opportunities, offering recreational benefits with an economic return. From a societal perspective, the flood buffering capacity of wetlands may be valuable (Jenkins et al. 2010). To achieve flood risk protection, it is necessary to consider the implementation of a broad range of wetland systems such as wet grasslands and larger wetlands with permanent water, preferably developed at a catchment level (Mitsch & Gosselink, 2000). Applying a catchment approach supports more coordinated actions and facilitates large-scale impact modelling and monitoring. Schemes that deliver payments for ecosystem services (PES) represent potential instruments to create new financial arrangements to support wetland restoration and conservation. For instance, landowners who convert drained cropland into wet grasslands facilitating seasonal flooding can be financially rewarded for providing a flood risk reduction service. Under such initiatives the role of farmers is rebalanced from primarily producing food to delivering a broader suite of ecosystem services. This has the potential for new actors to be engaged in wetland restoration. …
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO¤
Implementation example	Hortobagy National Park Directorate The project aimed at expanding a 4 ha lake into a 9 ha habitat to ensure the survival of fish living in the marsh during winter. Meanwhile, wetland restoration has already been completed in the 10 ha Fekete-rét area. The overall ecological restoration plan has paved the way for larger overnighting sites for transiting water birds. In addition, existing infrastructures have been improved – these include an educational nature trail to boost ecotourism. The trail presents the area's development and the education activities of the National Park's Directorate. The park's observation tower has also been revamped and orientation signs have been installed.
Comments	

Identified GAP provoking action

GAP short name	**Flood risk reduction, erosion / sediment control**
GAP short description	Exposure of streams and rivers to lateral erosion, sediment infiltration, mitigation of possible flood and drought scenarios.

Best management practice

Name of BMP	**Preservation and revitalization of wetlands on floodplains**
Type of land use regarded	Floodplain restoration can be applied on any type of land use, as long as a (current or former) natural floodplain is present. If artificial areas (urban, industrial) are located on the floodplain though, the associated cost for the measure's implementation is likely to be higher, due to land acquisition costs and to the high land anthropization. These costs will also be important for agricultural areas.
Pilot action cluster (if relevant)	Plain areas: Wetland
Location	Poland

	Any large floodplain
Description of the BMP	Floodplains are areas immediately adjacent to the stream and are periodically inundated with water. They present a vital part of the river ecosystem. The main function of these areas is carrying excess water in time of flood events and consequently reducing the flood water's potential energy. Besides, the functions of these areas are improving water quality, reducing runoff and erosion, providing an environment for a diversity of plant and animal life and helping to sustain base flow of adjacent streams and rivers during drought conditions. Floodplains are also important regulators of the movement of energy and materials through the catchment area towards the river and water flowing from surrounding hills and across the floodplain. Wetlands are often located within floodplains and provide important functions within the context of water quality and quantity. They work as natural water treatment areas, removing pollutants from inland river waters, maintain sufficient quantity of water during the whole year and represent one of the most productive and biologically diverse ecosystems, providing the essential breeding and feeding habitats for many species of water birds, fish, invertebrates and plants. The preservation or revitalization of those wetlands encompasses all measures necessary for this purpose.
BMP advantages	The preservation of wetlands in floodplains is of crucial importance for both the protection of drinking water resources and for the protection against floods. Only if the wetland areas are in natural or close-to-nature conditions, their ecosystem services can be rated as functional for water protection. Ecosystem services benefits include: • Water storage - Floodplain restoration aiming at promoting actions against soil impermeability and increasing buffers and storage areas will help the floodplain in ensuring its natural storage role. • Fish stocks and recruiting and natural biomass production - By promoting natural functioning of the aquatic ecosystem and of immediate and remote environments, floodplain restoration measures will have a positive impact on water quality, vegetation population, temperatures and habitat conditions. This will naturally be followed by a recovery of the aquatic ecosystem, and thus an increase in fish populations, a greater biodiversity and a higher natural biomass production. • Biodiversity preservation - the restoration site could be planted with native grasses, shrubs, and trees. This is the first step to develop biodiversity. Environment resilience could be very important especially when the original seed bank, which has been covered by legacy sediment, is once again near the surface, and the dormant seeds begin to germinate and grow. So native flowering plants that have not been planted could appear. Creating a more natural stream channel and floodplain should also be accompanied by the immediate removal of invasive species on the site. The post-construction planting of native vegetation along the stream corridor discourages the re-establishment of invasive, non-native vegetation. Leaf litter from riparian woody plants also provides a source of food for macroinvertebrate life in the stream. • Climate change adaptation and mitigation - Large floodplain restoration could have an impact on climate change through CO2 storage linked especially to afforestation. • Groundwater / aquifer recharge - Measures for floodplain restoration can have low to high impact on groundwater recharge. In particular, wetland restoration enhances high aquifer recharge due to high water connection between surface flows and groundwater. Revegetation measures can also more or less favour groundwater recharge, as they enhance water infiltration in soils.

	• Flood risk reduction - By allowing the stream naturally functioning, with controlled flooding, floodplain restoration measures reduce the risk of flooding damages. Buffer zones and storage infrastructures slow the water transfer time between the floodplain and the river, thereby spreading the flow and thus decreasing the flood intensity. Remark: For a high positive impact, floodplain restoration measures should be accompanying by management measures, corresponding to the full range of codes, ordinances and other regulations adopted for minimizing flood damage, including zoning codes, building codes and subdivision regulations that may either prohibit construction in flood-prone areas or allow some construction under certain conditions. Floodplain regulations also may be enacted to prevent consumer fraud by requiring disclosure of possible flood hazards. • Erosion / sediment control - Land use and cover on riverbanks are closely linked to the river capacity for erosion and sediment control, by protecting soils, regulating flows and protecting the most vulnerable areas of erosion as the banks (increasing their cohesiveness). By reducing flood intensity, floodplain restoration decreases streambed and banks erosion during extreme events. River morphology may change as the water and sediment discharge conditions change. Restoring a balance between erosion and sedimentation conditions will help in recovering adequate hydrologic functioning and hydromorphologic conditions. • Filtration of pollutants - Herbaceous plants in the wetland pockets help in reducing nutrients through nitrogen and phosphorus trapping. Riparian vegetation also provides a pollutant filtration action.
Challenges	Wetlands as one of the most complex ecosystems of paramount importance due to their biodiversity and role in water regime, are also most threatened ones. Around 50% of world's wetlands have disappeared in the last century. In Europe they are among most endangered landscapes due to land reclamation, drainage, pollution and overexploitation of its resources. According to the European Commission, it is estimated that two thirds of Europe's wetlands have disappeared since the beginning of the 20th Century, mainly lost through development processes which did not take their functions and values adequately into account. Overall, drainage and conversion to farm land alone have reduced the wetland area in Europe by some 60%. Despite recognized significance and considerable interest in their global protection, comprehensive overview of the remaining wetlands without appropriate protective status is still lacking. Numerous wetlands proclaimed as Ramsar sites are surrounded with agricultural land, making them vulnerable to farming practices. Throughout Europe roads and railway generate proximity problems and hence pressure on these habitats. Furthermore, wetlands hydrological function and regime can be degraded by activities such as improper forestation, water regulation (changing of river flow and channelization), over-exploitation of groundwater resources etc. Therefore, spatial planning along with river basin management planning must consider objectives for conservation of these types of habitats. For example in Austria, floodplain wetlands were under threat during the last half of the 20th century, when various hydro-electric power plants were constructed at the main rivers like Danube or Mur. In 1984 protests allowed the creation of the "Donau-Auen National Park" (Danube Floodplain National Park), that now protects the hugest floodplain area and forest in Europe and also the wetlands within. From this huge floodplain area, the City of Vienna also derives drinking water for the supply in critical situations (drought periods or other challenging situations). The share of floodplain wetlands is actually very low in comparison to the times prior to human settlements (pre-Neolithic phase). At those times the wetlands in the floodplains were a hindrance for human settlements (marshes and malaria) now the last floodplain wetlands have to be protected for the purposes of water protection.

	A floodplain is the area bordering a river that naturally provides space for the retention of flood and rainwater. Floodplain soils are generally very fertile and they have often been dried-out to be used as agricultural land. Floodplains in many places have also been separated from the river by dikes, berms or other structures designed to control the flow of the river. They have also been covered by legacy sediments. Major floodplains roles have thus been lost, due to land drainage, intensive urbanization and river channelization. The objective is to restore them, their retention capacity and ecosystem functions, by reconnecting them to the river. Restoring the floodplain roles requires measures such as: - modification of the channel, - removing of the legacy sediment, - creation of lakes or ponds in the floodplain, - new/modification of agricultural practices, - afforestation, - plantation of native grasses, shrubs and trees, - creation of grassy basins and swales, - wetland creation, - invasive species removal, - riparian buffer installation and development.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Orientgate	
Limitations	High costs, lack of political will, resistance of population	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☒SLO	
Implementation example	Room for the Waal project, Netherlands The Nijmegen Room for the Waal project is one of the largest and most awe-inspiring of the projects being realised within the framework of Rijkswaterstaat's national Room for the River flood risk management programme. By widening the river, the risk of Nijmegen and the surrounding upriver area becoming flooded, today or in the future, has been considerably reduced. The Waal takes a sharp bend near Nijmegen and becomes narrower, forming a bottleneck. At times of high water, the river could not cope with the volume of water. To protect residents from flooding, the dyke has been moved 300 metres inland and a 4-kilometre-long secondary channel has been dug. This has created an island in the centre of the city. Three new bridges connect the island to Nijmegen-Noord. The work commenced in January 2013. Fifty households had to be relocated as a result of the flood risk management measures. River Waal now has more room around Nijmegen. As a result, the water level of the river has dropped by 34 centimetres. A unique urban river park has been created in Nijmegen: the Spiegelwaal and the Veur Lent island are part of a plan in which flood risk management and urban quality go hand in hand. In the 1995 flooding, Nijmegen residents were up to their neck in water. Now, the Waal can cope with a similar volume of water with no problem at all. Nijmegen is prepared for future high water levels caused by climate change.'	

	River park The flood risk management measures have been carried out in a manner that ensures they can add value to the city in other ways. The new area has become a place where there is room for living, nature, recreation, education, hospitality venues, and small-scale events. A new quay forms the beating heart of the river park. Facts and figures: • Project area: 250 hectares • State budget: 358 million euros • Earthwork: 5.2 million cubic metres • 50 houses/business buildings demolished • 34 cm drop in the water level of the Waal • Special components of the Room for the Waal project: • Secondary channel: 4 kilometres long, 200 metres wide, 8 metres deep measured in respect of the ground level of the flood plain, 14 metres deep measured in respect of the height of the quay and the dyke • Waterproof cut-off wall to prevent the seepage situation in Lent from worsening, 1.6 km long, 20 metres deep, 80 cm wide • Unique island in the Waal with potential as an urban river park in the centre of Nijmegen with room for living, recreation, nature and culture • Existing railway bridge columns: a reinforcing wall around the three columns of the Spoorbrug (railway bridge dating from 1880); 23 metres deep and 1.5 metres wide • New dyke as well as a new quay of 1.2 kilometres in length • Three new bridges for access to and from the Veur Lent island • Archaeological and cultural-historical activities in the oldest city of the Netherlands with traces from Roman times, the Middle Ages, the Renaissance and World War II
Comments	

Table 40. Gaps and best management practices related to general water management or multiple types of land use

▪ Identified GAP provoking action		
GAP short name	**Public engagement in development of action plans**	
GAP short description	Little involvement of local (public) communities in the development of site-specific actions implemented in protection plans	
▪ **Best management practice**		
Name of BMP	**Implementation of site-specific solutions**	
Type of land use regarded	Mostly agriculture	
Pilot action cluster (if relevant)	All areas	
Location	Bavaria	
Description of the BMP	Public engagement should take place already at early steps of the decision process. The development of action plans for the implementation of protection plans should be carried out in close cooperation with land owners that are directly affected by future regulations in the delineated protection zones. Possible actions and measures should be elaborated based on land owner's possibilities to use existing structures/facilities/machinery. Thus, site-specific solutions can be found which can reduce the trade-offs between decision makers and land owners.	
BMP advantages	Engaging local stakeholders and affected land owners in the process of finding adequate, site-specific solutions can increase the acceptance of the finally proposed measures and potentially decrease the costs for compensation measures. Due to their daily business, land owners know best about potentials of how to restructure or manage their field operations. Moreover, the proposed measure can significantly reduce the existing mistrust between authorities and land owners.	
Challenges	Little involvement generally leads to lower acceptance of planned measures that could be decreased if site specific actions would be planned in cooperation with the affected land users. In this context, the stakeholders noticed that when their interests are affected by the implementation of a measure, then local stakeholders show a higher acceptance than those who just operate their business in the respective region (and live somewhere else). Local stakeholders feel more the problematic issues about planned measures and recognize the advantage of a solution, while stakeholders who are not so much connected to the territory do not feel the related danger/problem.	
Relevance	Water protection functionality	High->difficult to quantify
	Cost of the measure	Low
	Duration of implementation	Short term
	Time interval of sustainability	Long term -> if acceptance is high then the measure will last in time
Reference / source	Stakeholder interviews, Online stakeholder survey	
Limitations	Existing policies, intending public engagement once a plan and measures have been elaborated; Existing mistrust between decision makers, water suppliers and land owners and thus resulting hardened fronts and difficult discussions between the relevant stakeholders;	
Implemented in	☐AT ☐BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO	

Implementation example	
Comments	
Identified GAP provoking action	
GAP short name	**Saltwater intrusions in coastal areas**
GAP short description	Saltwater intrusions can happen due to either natural processes or human activities. Increasing water demand (agriculture, households, increase of tourism activities) during summer months is causing saltwater intrusions into coastal aquifers. This problem is additionally enhanced by climate change, mainly due to decreased rainfall, when aquifer water intake is lower, allowing sea water to penetrate into it. This presents direct impact on available freshwater resources and could result in water shortage, endangering local population. Endangered aquifers can be seen in comments section.
Best management practice	
Name of BMP	**Prevention of saltwater intrusions**
Type of land use regarded	Any
Pilot action cluster (if relevant)	PAC2: South Dalmatia
Location	Croatia Coastal areas
Description of the BMP	Scientific monitoring and assessment provide basic characterization of the groundwater resources of an area, providing an understanding of the different pathways by which saltwater may intrude an aquifer, and a basis for sustainable management of water supplies. Main indicative parameters are chloride concentrations and electrical conductivity. Some common approaches for monitoring, often used in combination are: measuring groundwater levels and hydrograph analysis; water quality sampling; and, geophysical logging. Water-quality monitoring networks are particularly important to serve as early-warning systems of saltwater movement toward freshwater supply wells, as well as providing information on the rates of saltwater encroachment. Furthermore, early warning system could be useful for water suppliers and distributers as they could adjust the extraction quantities and provide immediate response in case of saltwater intrusion. This is particularly important for dry summer periods, as the water demand for population (including tourism) and agriculture is on the rise, causing imbalance between extraction and aquifer recharge. Other successful mitigation methods include deep recharge wells, barrier wells, aquifer research (potentiometric surface mapping, plotting of water levels, climate change modelling). Another successful method include maintenance of coastal wetlands - which can provide natural barrier to saltwater intrusions as they are capable of undergoing “autonomous” adaptation to increase sea levels, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level (Nicholls & Klein, 2005) - in contrast to hard defences.
BMP advantages	Main advantage of this measure is protection of freshwater resources (groundwater) in vulnerable coastal areas – such as Dalmatia.
Challenges	Effects of climate change (sea level rise, decreased rainfall, prolonged drought periods) are not fully taken into consideration while making long term strategies and plans. Also, socio-

	economic aspects also should be addressed in more appropriate manner - such as increase of population and tourism activities and increase of agricultural water demand. Additional problem is relatively high costs of "hard" mitigation infrastructure and monitoring network, supplemented by medium to long term implementation periods and long periods of investigation and research.	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Medium to long term
	Time interval of sustainability	Long term
Reference / source	Best Practices for Prevention of Saltwater Intrusion https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/saltwaterintrusion_factsheet_flnro_web.pdf USGS Seawater Intrusion https://ca.water.usgs.gov/sustainable-groundwater-management/seawater-intrusion-california.html Schlumberger Coastal Zone Aquifer Management Solutions http://www.slb.com/services/additional/water/resources/coastalzone.aspx	
Limitations	Relatively high costs, lack of awareness, climate change effects are not taken seriously, lack of adaptation strategies for vulnerable areas	
Implemented in	☐AT ☐BAV ☒CRO ☐HU ☐IT ☐POL ☐SLO Croatia - in the pilot action South Dalmatia, there was a successful salinity prevention project that constructed a submerged step that prevents salt water intrusion into the Baćina lakes.	
Implementation example	World examples: California, British Columbia, China	
Comments		

Identified GAP provoking action

GAP short name	**Pressure on water resources quantity**
GAP short description	Climate change in form of droughts, floods, shorter winter season with reduced snow cover, in general change of the timing of seasonal events etc., will drastically affect freshwater resources. Water scarcity could not only lead to serious economic losses but also have severe impact on the environment, agriculture and food production and consequently human welfare. This problem is enhanced by high losses in water supply in Croatia - 42% national average, while some networks in Dalmatia have up to 80% losses.

Best management practice

Name of BMP	**Climate change adaptation and resilience**
Type of land use regarded	All
Pilot action cluster (if relevant)	PAC2: South Dalmatia
Location	Croatia CC mitigation measures are necessary for all areas, especially those with prominent dry periods (e.g. South Dalmatia, where summer season is very dry with low amount of

	precipitation).
Description of the BMP	Croatia has recently developed drafts for CC Adaptation Strategy 2040-2070 and Action Plan 2019-2023 which serve as a basis for future mitigation action against CC. Roughly speaking, measures be divided into 2 categories (Rubinić, 2017): • Initial measure – to minimize the presence of negative anthropogenic pressures • Administrative measures: rationalization of water consumption and water re-use wherever possible; promoting alternative sources of water; spatial planning measures for mitigation of flood effects in flood prone areas; monitoring and modelling projections; improvements in legal regulations • Structural measures: reduction of losses from water supply network; construction and revitalization of accumulation structures; construction of thresholds in the basin to stabilize the water level in river/lake bed and the surrounding aquifer; construction of retention objects in flood prone areas; control of surface runoff in urban environment (construction of separate systems for meteoric water and sewage); construction of green retention and infiltration zones, green roofs, urban retention and accumulation
BMP advantages	A timely reaction and development of CC adaptation plans benefits all ESS and population, therefore, it is a prerequisite for freshwater availability of future generations. Furthermore, adaptation plans and strategies could save money in the long run due to prevention, instead of intervention.
Challenges	Raising awareness on the climate change and adaptive management practices among relevant stakeholders Financial support in form of subsidies for adaptation
Relevance	Water protection functionality: High Cost of the measure: High Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	Drinkadria - http://www.drinkadria.eu/ CC Waters - http://www.ccwaters.eu/ Ministry of Environment and Energy project - http://prilagodba-klimi.hr/
Limitations	Lack of funds, long implementation periods, low awareness of key stakeholders
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies Croatia – in the process of implementation
Implementation example	
Comments	

Identified GAP provoking action

GAP short name	**Community use of inner and outer district of groundwater protection area**
GAP short description	Bank-filtered groundwater resources along the Danube can be found within the most beautiful areas, so there is the need for utilization of this area as bike roads, and boat harbours. This question has more importance on the area of groundwater reserves of Szentendre-island, where the wellheads occur along the complete river bank. Accordingly the appropriate legal act, in inner groundwater protection zone these types of activities are

	not allowed, and in case of utilization of inner districts, it is impossible to ensure the integrity of inner protection zones.
Best management practice	
Name of BMP	**Community use of partitioned groundwater in inner and outer protection zones**
Type of land use regarded	River banks, outer settlement districts
Pilot action cluster (if relevant)	
Location	Hungary All partitioned groundwater reserves, for example Szentendre Island
Description of the BMP	The wellheads are along the complete river bank on Szentendre Island. They are in the operation of Budapest Waterworks in the inner and almost in the whole outer protection zone, so these are guarded and isolated areas. Local inhabitants and those who are looking for recreation may reach the river banks on very short sections. The operational roads of the Waterworks are running along on both sides of the island and they reach at some points the inner protection zones of the wellheads. Considering the number of the wellheads and their different size of protection zones, they are not isolated with fence but only with bush hedges. It is not possible to move away the road or isolate the inner protection zone by fence. Although there is a high need for opening or some parts of the areas of the Waterworks. Bike roads, touristic paths and boat harbours are rising from time to time as development directions. The wells are technically secured and the possibility of surface water intakes is minimal even in case of flooding, the superstructures can be locked and an alarm system is in operation. With appropriate technical protection, a specific regulation would be able to resolve the requirement for the internal protection area of the bank-filtered wells. Even so because in Margaret Island and on other banks of Budapest there are also bank filtered water wells with qualitatively good water, but there is no space for protection area. There is a park, a playground around the wells, as well as a road stretching across the wells protection area. In practice, therefore, it has been shown that community use does not necessarily endanger the water quality of wells. Certainly it is necessary to set up adequate rest areas, waste collection and removal, mobile toilet use. Treatment should be performed by an organization. Supervision of the usage is required on a regular and frequent way throughout the entire coast. Auditors are required to have appropriate knowledge to act effectively against the perpetrators.
BMP advantages	It would meet a long-standing and growing social need.
Challenges	Legislative modification is required. The design and operation of the open and freely used waterworks area - internal and external protection area - is more complicated and costly than the current system.
Relevance	Water protection functionality: Medium Cost of the measure: Medium (results savings) Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	Bank-filtered groundwater resources
Limitations	Legislative amendment, taking care of the operator's tasks and costs

Implemented in	☐AT ☐BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO Croatia – various land uses exist within DWPZ and there are specific ordinances that prescribe restrictions for the specific land-use types, additionally the first DWPZ is fenced
Implementation example	
Comments	
Identified GAP provoking action	
GAP short name	**Design of infrastructure under steady-state weather conditions**
GAP short description	Not accounting for potential effects of climate change (CC) for design of new infrastructures could strongly affect their performances and safeguarding
Best management practice	
Name of BMP	**Adaptation of building standards for design, maintenance and operation of infrastructures**
Type of land use regarded	All, according the type of infrastructure of interest
Pilot action cluster (if relevant)	All
Location	Italy Example: urban drainage systems generally more vulnerable to pluvial flooding as designed using IDF curves not accounting for CC
Description of the BMP	Buildings and infrastructures designed for coping with the effects of flooding events (e.g. riverbanks) or potentially affected by such events (e.g. urban drainage systems) are currently built assuming steady-state weather conditions. Under the effect of climate change, such assumption could err not on safe side inducing an improper design and realization; for these reasons, the findings made available by climate projections should be explicitly considered for the definition of reference “design events” (e.g. storms). In this perspective, in last years, several literature approaches have been proposed and, in some cases, transposed also through “qualitative methods” in regulations, guidelines and design of key critical infrastructures. Moreover, it should be integrated in building regulations.
BMP advantages	The measure is aimed to: • increase the resilience of infrastructures (in special way, newly built); • attempt to enhance coherence between climate change adaptation (CCA) and disaster risk reduction (DRR) approaches and tools; • reduce the costs associated to failure or outages of infrastructures
Challenges	Climate projections are currently characterized by significant uncertainties. As well known, they are due to natural variability of weather conditions, limited knowledge about future socio-economic development and/or technological progress and current constraints in modelling. In order to manage such uncertainties are often adopted ensemble of climate simulations; adequate procedures and relevant expertise are then required to properly handle with such results; nevertheless, constraints and limitations associated to adoption of expeditious approaches should be made clear to practitioners. Moreover, the significant and constant improvements in climate modelling should periodically entail the update of adopted design values.
Relevance	Water protection functionality — High

	Cost of the measure	Medium
	Duration of implementation	Short term
	Time interval of sustainability	Long term
Reference / source	Climate-ADAPT platform; coordination unit of Italian Government "Italia Sicura"	
Limitations	Up to now, current uncertainties associated to climate projections prevented accounting for potential effects of climate change for design of new infrastructure; in this regard, only in some areas, policymakers and administrators have properly evaluated the threats represented by them; nevertheless, potential current higher costs against potential future profits often limit the appealing of such approaches.	
Implemented in	☒AT ☒BAV ☐CRO ☐HU ☐IT ☐POL ☐SLO	
Implementation example	Two examples of implementation for the proposed measure are retrieved by Climate-ADAPT platform; they relate to design of metro in Copenhagen and "Adaptation of French standards for design, maintenance and operation of transport infrastructures". In the first case, in attempting to take into account the potential effects of climate change on storm surges and heavy rainfall events, "the elevation level of critical elements of the Copenhagen metro stations (entrance, stairs, tunnel ventilation, ramps, technique room, shaft, elevator, and control and maintenance centre) increased from approximately 2.25 m on the existing metro to approximately 2.50 m on the City ring, which is currently under construction, considering the various IPCC projections available and their evolution in time". Moreover, several precautions have been implemented to deal with potential future events characterized by intensities and durations higher than the current ones. In the second case, a deep interdisciplinary study has been carried out in order to detect standards and regulations requiring an update to take into account climate change and to provide ways to adequately consider them.	
Comments	The coordination unit established by Italian Government "Italia Sicura" proposed a comprehensive set of guidelines for programming activities and intervention planning against geological, hydrological and hydraulic risk (http://italiasicura.governo.it/site/home/dissesto/linee-guida.html; in Italian); among these ones, "Linea 11" proposes "Considerations about the resilience of the intervention, including climate change scenarios" in which accounting for climate projections in design of infrastructures also through qualitative approaches is explicitly reported.	
Identified GAP provoking action		
GAP short name	**Pressure on water resources management**	
GAP short description	Qualitative and quantitative over exploitation of water system and unbalanced exploitation rate between surface and ground water bodies	
Best management practice		
Name of BMP	**Integrated Water Management for implementing efficient voluntary agreements**	
Type of land use regarded	Agriculture, industry, urban areas	
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)	
Location	Italy Po river basin (P-RB)	
Description of the BMP	The P-RB is basically rich of water resources but the increase of water consumption and climate change are affecting them. Especially during drought events, the conflicts among	

	the users reach an extreme level, and as pointed out in D.T2.1.2, only on a river basin level the optimal area for soil, subsoil and water protection actions can overcome institutional fragmentation and competences through unitary plans; besides an Authority with decision-making power able to manage water crisis conditions.
BMP advantages	Overcoming of actual weaknesses of voluntary agreements connected with the lack of implementation, implementation efficacy, and efficacy indicators of implemented measures foreseen in norms and plans. Establishment of a permanent network of “Observatories on water uses” among all public and private stakeholders of national relevance included in Po river basin. Transferring and tailoring experiences and practices to the P-RB suggested and currently implemented with valuable results in other countries, coping with water scarcity shortage and crisis.
Challenges	Practicable, measurable and effective overcoming of institutional fragmentation through an Authority with more decision-making power and more structured decision processes based on flow charts. Business continuity guarantee to maintain the operational system on water resources management (DEWS-Po) in Po river basin to support planning and integrated management processes. Integrated Water Resources Management supports Institutional change. Following a widely shared approach to transform good BMP in regulation and legislation norms (i.e. ERA directive)
Relevance	Water protection functionality: Medium Cost of the measure: Low Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	WFD 2000/60/CE, Enhance FP7 project, Italian D. Lgs. 152/2006, Po river basin Water Balance Plan
Limitations	Factors to consider are: lack of implementation of political will, scarce awareness of population, conflicts of land use vs water management vs flood management, lack of supervising/implementation mechanisms
Implemented in	☐AT ☒BAV ☒CRO ☐HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies Croatia – prevention measures are a part of the existing legislation, but it is not implemented
Implementation example	Documentation from National Committee of River basin Authorities Directors and from the Italian Operational Hydrology Group. International comparison among Sava River, Israeli and Australia taking into account difficulties of implementation and instruments to overcome them. Hydrological monitoring and modelling, water data sharing, capacity building, education and training of stakeholders and general public.
Comments	

Identified GAP provoking action

GAP short name	**Soil degradation and consumption**
GAP short description	Qualitative and quantitative over exploitation of soils, soil consumption, loss of soil

	biodiversity and lack of legislation for soil planning produces negative impacts on water cycle.
Best management practice	
Name of BMP	**Evaluating effects of Soil Protection Plans on water bodies**
Type of land use regarded	Agriculture, urban areas, industrial areas, transport networks
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin
Description of the BMP	Soil, land use solid wastes planning, including contaminated sites, contributes to overcome the actual reductionist implementation of WFD.
BMP advantages	Water quality and quantity aspects, including ecosystem services, are strongly affected by uncontrolled and excessive land use and soil exploitation in Po river basin. Without a wise governance of this issue, all water policies, actions and measures may be less effective; moreover fixed environmental targets on water bodies can be reached with more costs acting only on water aspects, disregarding soil management. The transition to a green and circular economy supported by institutions, organization and private sector will strongly affect soil and land use management inducing a better use of water and reducing water ecosystem stressors.
Challenges	Upgrade of European and National policies taking into account soil management and planning into water management plan and measures. Acting on the coupled land use and water use can improve social and economic resilience including water scarcity and flood events. Supporting crosscut policies and leverage of different lobbies. Reducing ecosystems fragmentation and loss of connectivity. Fostering the ability of ecosystems to provide services among which natural health capital increases and water resources are more available. Reducing the conflicts of interests between land use management and water protection.
Relevance	Water protection functionality: High Cost of the measure: Medium Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	European Environmental Action Programme, EU Communication on Biodiversity, EU Landscape and Soil Thematic strategies
Limitations	Factors to consider are: expertise coupling soil degradation aspects and their effects on water, lack of legislation, conflicts of land use vs water management vs flood management, lack of soil availability, social costs to support soil transformation and social acceptance of soil recovery.
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Croatia has no Soil Act, but there are laws for nature protection, Environment protection Act, Agricultural soil law and laws regarding waste management that include soil protection.
Implementation example	

Comments		
Identified GAP provoking action		
GAP short name	**Flood impact**	
GAP short description	Impacts of floods on water quality, especially on drinking water supply system and the whole environment is not yet fully considered in the flood risk management cycle	
Best management practice		
Name of BMP	**Assessing flood impacts on drinking water supply systems and on water bodies**	
Type of land use regarded	Infrastructures, industrial soil and contaminated sites, agriculture, urban areas.	
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)	
Location	Italy Po river basin	
Description of the BMP	Implementation of monitoring and modelling system in order to evaluate and reduce negative impacts of floods on water quality and water supply systems and focus on positive contribution to ecosystem services. Planning at river basin scale.	
BMP advantages	Evaluating flood impacts on water bodies at environmental level is useful to plan and manage water supply systems Evaluating flood impacts may be useful in preserving the access to satisfactory quality water, which may be damaged by the adverse consequences of floods for human health and economic activity To permit a better allocation of funds devoted to demolition and removal of building included in flooding areas in order to fulfil the objective of ensuring more space for river flows, the increase of concentration times, and giving them back the natural retention and recharge rules	
Challenges	Comprehensive and objective (not emotional nor political) comparing of costs and benefits of floods including the impact of the infrastructures The big effort for reconstruction and recovery after flood events and their impacts may be reduced The increasing trend of unbalance between proactive (prevention/preparation) measures and reactive measures should be inverted. Considering the effects of recovery of natural role of flood plains and increase concentration times can be useful for ground water recharge, landscape enhancement, natural processes development (sedimentation/transformation of pollutants) Reducing the conflicts of interests between agriculture, urban and natural areas and between land use and water protection and management	
Relevance	Water protection functionality	Medium
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Regional studies, environmental associations, Flood Directive, Italian D.lgs 49/2010, Po river flood risk management plan	
Limitations	Factors to consider are: lack of skills, knowledge and experience, lack of political and	

	communities awareness, resistance of population, potential conflicts of land use vs water management vs flood management, lack of supervising/implementation mechanisms
Implemented in	☒AT ☐BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO
Implementation example	Case studies, from scientific publications, examples of pilot implementation by EEA and some EU member states, research projects
Comments	
Identified GAP provoking action	
GAP short name	**Qualitative/Quantitative unbalance of law/plans/measures implementation**
GAP short description	Effectiveness, motivation and efficacy of resources allocation for environmental issues faces with the heavy weight of environmental drivers (pollution, water stress, climate change, geological and hydrological risks, soil degradation, floods and droughts)
Best management practice	
Name of BMP	**Identification of priorities and measurable effects of responses to environmental drivers and pressures on water quality/quantity**
Type of land use regarded	Infrastructures, industrial soil and contaminated sites, agriculture, urban areas.
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin
Description of the BMP	In Italy, activities are mainly concentrated during the emergency phases and efforts are often not integrated. Nevertheless, in some sectors (agriculture, public health, civil protection) is rapidly rising the need of a wider approach, and sometimes the implementation is ongoing. A participative process including all stakeholders will be helpful in focusing and addressing local weaknesses (salt intrusion and soil salinization in Po delta area, population and land management decrease in the Apennines, intensive livestock and farming in plain areas).
BMP advantages	Implementation should ensure that water management will be based on a better understanding of the main risks and pressures in a river basin founded on proper monitoring and assessment The “green revolution” acting in Italy will shift resources, efforts, social awareness and political consensus to circular economy and sustainable use of natural capital. A proper monitoring and application will permit the institutions to be tuned with these changes.
Challenges	Pragmatic approach to identification of priority drivers and pressures on water quality/quantity and possible responses Decomposition of governance process in sub processes in order to find weaknesses, opportunities and gaps including all economic, social environmental and political aspects (administrators, job opportunities, social acceptance, zero option, education and training)
Relevance	Water protection functionality: Medium Cost of the measure: Medium Duration of implementation: Long term Time interval of sustainability: Long term

Reference / source	
Limitations	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☒SLO
Implementation example	
Comments	

Identified GAP provoking action

GAP short name	**Climate Change**	
GAP short description	Potential conflicts among users and impacts on drinking water systems derived from climate change are not fully identified and faced	

Best management practice

Name of BMP	**Implementation of practical responses to mitigate climate change and to adapt to its effects**	
Type of land use regarded	Infrastructures, industrial soil and contaminated sites, agriculture, urban areas.	
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)	
Location	Italy Po river basin	
Description of the BMP	Processes including climate change studies, downscaling of their effects, considering main impacts in river basin planning, and following the implementation of measures for mitigation and adaptation	
BMP advantages	To avoid redundancy of measures and specific resources for implementation, considering effects on climate change deriving from applied measures to other sectors (agriculture, forestry, transport) To reduce lack of information and communication to population connected with water shortage problems To measure the effective reduction of impacts due to climate change on water shortage, floods and salt intrusion.	
Challenges	To combine hydrological, environmental, water and soil knowledge with economic and political programmes for adaptation and mitigation of climate change Overexploitation of water, soil degradation and over consumption, drought and flood extremes are not yet fully implemented global governance combines with shadows projected by climate change generating potential conflicts and impacts for drinking water systems.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source		
Limitations		

Implemented in	☐AT ☒BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies Croatia – there is a draft of the National Climate Change Adaptation Strategy as well as an Action Plan draft that are implemented in specific case studies
Implementation example	
Comments	
Identified GAP provoking action	
GAP short name	**Analysis of links between employment/education policies and the water sector**
GAP short description	Water shortage and scarcity and difficulties of access to water resources and water treatment may limit economic growth and employment
Best management practice	
Name of BMP	**Social, employment and education policies in water resources sector**
Type of land use regarded	All
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin
Description of the BMP	Water scarcity, water access, water quality, lack of water cycle knowledge and lack of integration of water knowledge with environmental, economic and institutional background may obstacle the territory governance, management, and social progress. Supply with skilled and large work force the sectors of integrated water planning and management, together with effective education and training of people involved will foster a progress in actions regarding sustainable water and societal benefits. Then a focus on water resources norms, regulation, plans, the private and public sectors, on human resources needs and their skill
BMP advantages	Sustainable management of water promotes job and employment creation and economic growth. But also education and training of administrators, experts, technical and the private sectors will contribute to more effective and efficient processes
Challenges	A trend can be identified in unemployment and environmental degradation growth and should be inverted Links between the above mentioned problems and the lack of governance and management and protections of water, land and soil Capturing social benefits of ecosystem services may generate economic and social growth Strategic efforts in employment education and training and water culture diffusion may foster the fulfilment of the targets of removing obstacles to water quality, water availability and water access
Relevance	Water protection functionality: Medium Cost of the measure: Medium Duration of implementation: Long term Time interval of sustainability: Long term

Reference / source	UNESCO, 2016
Limitations	
Implemented in	☐AT ☐BAV ☐CRO ☒HU ☐IT ☐POL ☐SLO
Implementation example	
Comments	

Identified GAP provoking action

GAP short name	**Lack of information regarding groundwater salinity while designing and operating unconfined coastal aquifers**
GAP short description	Current unconfined aquifer plans do not take into account properly the impacts of climate change (CC) and sea level rise (SLR) in the future causing autonomous salinization via seepage of saline/hypersaline groundwater; seawater intrusion, and lateral mixing between brackish/saline coastal lagoons and the unconfined aquifers. Therefore, there is a need to quantify the foreseeable impacts of climate change on the unconfined aquifers to establish adaptation initiatives in the future plans.

Best management practice

Name of BMP	**Assessment of salinization of groundwater and surface waters**	
Type of land use regarded	All, according the type of infrastructure of interest The reclamation drainage network	
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)	
Location	Italy The coastal floodplain of the Po River	
Description of the BMP	First, we need to quantify the increase in salinization of groundwater, the salt loads export towards surface waters and the changing volumes of freshwater due to climate change and socio-economic dynamic. Then, adaptation initiatives need to be established to cope with these impacts corresponding with different climate and socio-economic scenarios. These initiatives are expected to enhance the sustainability of freshwater and groundwater resources in the future in term of quality and capacity.	
BMP advantages	The measure is aimed to: • contribute our understanding of groundwater dynamics and salinization processes to lowland coastal aquifer plans in the future; • enhance climate change adaptation in coastal aquifer infrastructure; • improve freshwater resources in term of both quantity and quality	
Challenges	There are many uncertainties in quantifying the evolution of salinity process and the impacts of CC and human intervention on this process. First, groundwater salinity processes are quite complex, including evaporation, evaporate leaching, mobilization of salts stored in the unsaturated zone, infiltration of non-marine polluted surface waters, slow-moving saline/salt waters of marine origin (Giambastiani, Colombani, Mastrocicco, & Fidelibus, 2013). Second, the impacts of CC vary in time and space, depending on geographical and climatic condition. Finally, human intervention and socio-economic dynamic is highly heterogeneous. All these factors lead to the difficulty to assess the dynamic of salinization of groundwater and surface waters as well as the establishment of adaptation plans.	
Relevance	Water protection functionality	Medium

	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Climate ADAPT Platform, Trust Project. Colombani, N., Osti, A., Volta, G., & Mastrocicco, M. (2016). Impact of Climate Change on Salinization of Coastal Water Resources. Water Resources Management, 30(7), 2483–2496. https://doi.org/10.1007/s11269-016-1292-z Giambastiani, B. M. S., Colombani, N., Mastrocicco, M., & Fidelibus, M. D. (2013). Characterization of the lowland coastal aquifer of comacchio (ferrara, italy): Hydrology, hydrochemistry and evolution of the system. Journal of Hydrology, 501, 35–44. https://doi.org/10.1016/j.jhydrol.2013.07.037	
Limitations	First, there are lacks of monitoring data on groundwater in some regions for calibration and validation of models. Secondly, regional climate scenarios are not available for public users. Finally, there are political constraints in implementing these initiatives.	
Implemented in	☐AT ☐BAV ☒CRO ☐HU ☐IT ☐POL ☐SLO Applied in Germany, but not in Bavaria Croatia – Water Salinity Monitoring	
Implementation example	Few studies have quantified the impacts of CC of groundwater salinity. For instance, SEAWAT 4.0 model allowed identifying the zones of influence of RSLR and to quantify the increase in salinization of groundwater, the salt loads export towards surface waters and the changing volumes of freshwater by 2050 (Colombani et al., 2016). Giambastiani et al., 2013 invested groundwater dynamics and salinization processes in this lowland coastal aquifer. TRUST Project (Tool for regional-scale of groundwater storage improvement in adaption to climate change), has tested the implementation of water banking/Managed Artificial Recharge measures for groundwater management.	
Comments	A step forward is to establish adaptation initiatives based on the projections of salinity dynamic, taking into account climate scenarios and socio-economic development. The implementation of these initiatives needs to consider local conditions and political constraints.	

Identified GAP provoking action

GAP short name	**Legalization of illegal construction on flood areas**
GAP short description	Despite prohibition of constructing buildings on flood areas, construction takes place and with time gets legalized. Ineffectiveness or lack of penalties from state authority on illegal construction (legislation implementation problem).

Best management practice

Name of BMP	**To prevent legalization of construction on flood areas**
Type of land use regarded	Riparian strips
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland Riparian strips
Location	Slovenia
Description of the BMP	Despite the fact that construction of buildings on flood areas is prohibited and is not safe, people insist on constructing on such areas in belief, the flood won't reach them. Institute for Water of the Republic of Slovenia has evaluated parcels with flood risk. Unfortunately

	many take this document only for a recommendation and not for a regulation, although it is a mandatory requirement for building permit. Therefore construction on such areas is illegal. Municipalities legalize such constructions due to tendency of keeping the spatial register up to date. If not sooner, constructions get legalized after flood when owners of parcels want compensation from insurance companies, for which real estate has to be legal. Municipalities should not agree on such acts. With legalization of illegal construction on flood areas municipalities undertake responsibilities and must provide flood protection and included costs	
BMP advantages	Strict implementation of construction inhibition on floodplains considering flood hazard map.	
Challenges	Usually corruption at municipalities or at planning companies makes such acts possible and to avoid such cases is a big challenge.	
Relevance	Water protection functionality	Medium
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from past projects. Reports on flooding of constructions in floodplains due to noncompliance of the legislation and large material damage.	
Limitations	Expected limitations are lack of common sense of people which construct illegal buildings on flood area. Another limitation is corruption problem.	
Implemented in	☒AT ☐BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example		
Comments		

Identified GAP provoking action

GAP short name	**Surface water intrusion in the well**
GAP short description	Exposure of wells during flood events

Best management practice

Name of BMP	**Sealed wells heads**	
Type of land use regarded	Flood prone areas	
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland	
Location	Slovenia in cases of wells in flood prone zones.	
Description of the BMP	Many water supply wells are on flood-prone plains, so the wells heads should be constructed as sealed in a way to prevent the surface water intrusion in the well during the flood event.	
BMP advantages	Surface water cannot be mixed with groundwater, which is used for drinking water supply source, during floods. Water supply is not interrupted during the flood event.	
Challenges	No specific challenges are foreseen.	
Relevance	Water protection functionality	High
	Cost of the measure	Low

	Duration of implementation	Short term
	Time interval of sustainability	Long term
Reference / source	Flood event in Celje in 1990 and flood event in Ljubljansko barje (Brest - Iški vršaj) in 2010.	
Limitations	No limitations are foreseen.	
Implemented in	☒AT ☐BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO¤	
Implementation example	During the flood events in 1990 (Celje, Slovenia) the wells were flooded, but their heads were constructed as sealed so their operation was not interrupted.	
Comments	The information on the type of the well (sealed) should be emended to the data specification according to INSPIRE directive. Recommendations on the level of strategic guidelines resulting from the PROLINE-CE project, implementation on the level of national legislation requesting obligatory sealed well heads for the water supply wells on flood prone areas. Awareness rising and education process on this risk and potential measure.	

Identified GAP provoking action

GAP short name	**Pollution sources in flood prone areas are not known / identified**
GAP short description	Identification of the potential pollution sources locations in flood areas is a challenging task.

Best management practice

Name of BMP	**Register of potential point pollution sources**	
Type of land use regarded	Flood prone areas	
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland	
Location	Slovenia	
Description of the BMP	Aggregated list of all potential point pollution sources (industry, heating oil tanks in households, etc.) is needed for efficient incident management in case of flood event. Potential pollution sources are exceeding current requirements of national legislation (Slovenia: Environmental protection act O.G. 39/2006) and EU requirements SEVESO Directive, IED Directive 2010, E-PRTR Register.	
BMP advantages	It is very important to know all the potential pollution locations to implement prevention measures in the case of floods (i.e. flood proofing) and improve response of intervention forces during the flood events.	
Challenges	Data collection, data validation and maintenance, legal framework for the data collection.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Mid term
	Time interval of sustainability	Long term
Reference / source	Flood event in Ljubljana in 2010.	
Limitations	Household inventory and data privacy.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example	Some of the potential pollution sources are known (especially industrial establishments	

	under Seveso Directive), but there is among others no list of heating oil tanks in households, which are still quite common in Slovenia. Some non-SEVESO and non – IED facilities are handling nevertheless significant amounts of polluting substances on flood prone areas. This includes also households storing small amount of chemicals, and especially heating oil tanks, that might leak during the flood event.		
Comments	Challenge is how to adopt and enforce legislation enabling access to data and reporting on the amount of stored pollution substances on flood prone areas. Maintenance of the dataset. After the identification it is important to raise awareness and provide measures leading to improvements.		
Identified GAP provoking action			
GAP short name	**Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources**		
GAP short description	Ministries, agencies and experts do not jointly develop measures for drinking water protection, but each "fight their own battle" and for interests, which are not necessarily in favour of protection of drinking water resources. Lack of co-operation and willingness to negotiate in favour of protection of drinking water resources.		
Best management practice			
Name of BMP	**Joined and integrated management of drinking water resources (horizontal and vertical co-operation)**		
Type of land use regarded	Agriculture, Grassland, Wetland - all		
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland		
Location	Slovenia		
Description of the BMP	Ministries, experts and public independently approach to common problematics, such as drinking water resources protection, instead of combining their knowledge and experiences to find unified and optimal solutions. Therefore more communication and cooperation is needed horizontally (inside ministries, among ministries, among experts, etc.) and vertically (panel discussions/round tables with experts and governmental bodies). More interactions (discussions, negotiations), finding solutions for sectors on which drinking water protection measures (trying to find win-win situations) are needed for achieving the main goal – drinking water protection.		
BMP advantages	In brief this is a general problem and not only specifically for this problematic.		
Challenges	A challenge is to change organisation strategy of drinking water sources management, among all within governmental institutions.		
Relevance	Water protection functionality	Very high	
	Cost of the measure	Low	
	Duration of implementation	Long term	
	Time interval of sustainability	Long term	
Reference / source	The BMP derives from experiences.		
Limitations	Expected limitations are lack of political will and also resistance to adaptation of many institutions.		
Implemented in	☐AT ☐BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO		

Implementation example		
Comments		
Identified GAP provoking action		
GAP short name	**Lack and not effective control over implementation of DWPZ restrictions**	
GAP short description	There is lack of control over implementation of DWPZ restrictions, which is mostly not effective due to lack of co-operation among sectors (Environment, Health, etc) and due to low penalties (in case they are issued at all)	
Best management practice		
Name of BMP	**Strict implementation and inspection of DWPZ restrictions**	
Type of land use regarded	All	
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland - all	
Location	Slovenia, central part, PA area Dravlje valley in Ljubljana	
Description of the BMP	In the narrowest area of water protection zones regulations governing the construction of buildings is prohibited, with the exception of construction intended for the public supply of drinking water. It is prohibited to carry out activities in the catchment area that could endanger the ground water quality, such as: the disposal of waste, the storage of dangerous substances, the use of pesticides and fertilizers, salting undrained surfaces like yards and gravel roads, vehicle maintenance and parking of construction machinery, except in the case of activities for the public supply of drinking water. Hence well directed restrictions for DWPZ area there is no inspection and no control over its implementation. Implementation should be supervised by inspectors of the Ministry of Agriculture, Forestry and Food.	
BMP advantages	With restrictions truly implemented, quality of drinking water supply would not be endangered. In the DWPZs Agricultural Advisory Services encourage farmers to organic farming without pesticides and fertilizers. Because of smaller harvest, farmers get money compensations.	
Challenges	Ministry of the environment and spatial planning should assign supervisors to control locals and local farmers and their acts in DWPZs.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from bad practice. Decree on the water protection area for particular aquifer in Slovenia, which is based on Rules on criteria for the designation of a water protection zone.	
Limitations	This limitation is a lack of supervising of implemented mechanisms.	
Implemented in	☒AT ☒BAV ☒CRO ☐HU ☒IT ☐POL ☐SLO¤	
Implementation example		

The starting point for catalogue of BMPs to be integrated into policy guidelines were the gaps and issues recognized during panel discussions with stakeholders at Start-up stakeholder workshops (Activity A.T1.3 “Identification of strategies and measures to be integrated into existing policy guidelines”). The workshop participants included local, regional and national public authorities, infrastructure and service providers, higher education and research facilities, interest groups and NGOs and also general public – hence their experience and knowledge of sectoral gaps and issues as well as proposed measures (as seen in PROLINE-CE D.T1.3.3 “Lessons learnt: synthesis report about start-up stakeholder workshops”) were the basis for this catalogue. During the Start-up stakeholder workshops, in order to facilitate more efficient practices, stakeholders were introduced to existing best management practice (as seen in PROLINE-CE D.T1.2.2 “Transnational best management practice report”), fostering transnational transferability of results and using past knowledge and experience of other countries/partners with specific gaps and BMPs.

Provided catalogue of identified gaps and BMPs could facilitate a major step in improvement of water resources management, flood and drought mitigation, reducing the effects of climate change and reducing the anthropogenic impact on water quality and quantity. This catalogue is also presented in a way which could be useful to planners, decision and policy makers, highlighting how specific gap could be resolved in an effective manner. Project Partner countries had the liberty of freely selecting the measures which they thought were most important and should be prioritized.

Majority of the provided BMPs have high water protection functionality and long term time intervals of sustainability, demonstrating how sustainable and long term approach with adequate planning and research has drastically higher effect over reactionary (most often structural/construction) measures.

In total, a set of 38 recognized gaps and BMPs is provided. According to land use, BMPS related to **general** (multiple) land uses, **agriculture** and **forestry** dominate, which is expected due to the fact that those types of land use are most widely present in European countries (and also most problematic from the point of protection of water resources, especially agriculture). The least amount of measures was provided for wetlands, grasslands and riparian strips. To conclude, further efforts must be put into:

- More effective implementation of existing measures and protection mechanisms (e.g. DWPZ) as well as more efficient financial stimulus for good practices (e.g. organic agriculture, subsidies for prevention of negative land use change)
- Climate change adaptation, research and inclusiveness into planning processes
- Sustainable and long term approach towards common problematics in water, flood and land use management (e.g. avoid reactionary measures)
- Target population consciousness through education, awareness raising activities and active participation of all social groups.

4. Conclusions and recommendations

Drinking water in Central Europe is abstracted mainly from groundwater and surface water (including bank filtration) resources. Water quality and quantity are major responsibilities of each and every country. Water is steadily becoming a potent strategic resource and the benefits of investing in its protection are manifold. Given this, water management should be oriented towards mitigation and prevention of negative impacts before they occur, due to the fact that once the negative impact has been inflicted upon drinking water resources, it takes substantial amount of time, financial and technical resources to restore or improve its conditions. Monitoring, modelling, development of adaptive scenarios and prompt reactions in case of contamination are best ways to preserve drinking water quality and quantity for future generations.This document provides an in depth overview of status quo in Central European region regarding conflicts and interdependencies between land use activities, floods, droughts and drinking water resources protection.

O.T1.2 “Strategy for the improvement of existing policy guidelines” is based on two priority activities:

- Determination of major land use, flood and drought impacts on drinking water quality and quantity

  - Status quo in CE is analysed and knowledge base is formed

- Identification of best management practices to mitigate those impacts

  - Vision and mechanism for further action is defined: basis for implementation of best management practices through action plan in CE and beyond is defined

Firstly, country-based overview of drinking water protection zones is provided – with delineation criteria, restrictions and prohibitions, concordance with spatial plans and other particularities. Notable issue in CE concerning DWPZs are discrepancies between prescribed legislation (restrictions and bans) and implementation, which often falls short. Common response to overcome this persistent management gap is to conduct stricter controls and enforce prompt action against law violation. In contrast, good management practices (e.g. organic farming, eco-friendly systems) should be encouraged even further (e.g. financial stimulus).

Based on the wide knowledge basis of drinking water protection zones, comprehensive analyses of how particular land use aspects affect drinking water quality and quantity were conducted (status quo). By pinpointing gaps in land use and water management, a knowledge base is formed, fostering further action for mitigating negative impacts on drinking water resources.

By stakeholders’ engagement via workshops, a valuable input was acquired concerning many interacting factors related to PROLINE-CE focal points. Stakeholders were represented by a wide variety of experts, such as land planners, foresters, farmers, hydrologists, public utility representatives, researchers and many others (chapter 3.1). By their involvement, existing knowledge base of gaps and pressures in water management was improved significantly, paving way for selection of best management practices and strategies to improve protection of water resources. Intensive stakeholder engagement and feedback is essential tool for achieving the desired project objectives and ensure dissemination of PROLINE-CE outputs and results.

On the basis of previously defined gaps (status quo assessment and stakeholder involvement), Project Partners compiled a set of 38 best management practices to be integrated into existing policy guidelines (D.T.1.3.4 "Transnational catalogue of strategies and measures to be integrated into existing policy guidelines"). The majority of provided BMPs could resolve multiple gaps. Another factor to consider, de-facto most important one, is the implementation potential. Naturally, some BMPs are more complex than others (e.g. especially if they include technical measures or construction / in contrast to administrative measures, such as financial incentives or prohibitions), making them harder to implement due to higher costs and higher degree of required census amongst decision makers, expert community and public.

For the majority of project partner countries, agriculture is regarded as the land use which causes significant impacts on drinking water quality (result of pesticides, herbicides, fertilizers and poor agricultural practices). Common issue is pollution of groundwater and surface waters with excess nitrogen and phosphorous compounds. Although the legislation concerning maximum allowed weight of active substance (usually 170 kg N / ha / year), time of application (autumn and winter are forbidden) and conditions of application (application of flooded, frozen or snow-covered-soil is generally forbidden) is well defined, by yet again implementation and control remains inadequate. Another point worth mentioning is a generally low percentage of organic farming (exceptions are Austria – 20% of agricultural area and Italy – 12%). In some countries, conversion to organic farming can be related to insufficient education of farmers, who are unwilling to convert from classical agricultural practices (due to lower yield and lack of any financial compensation from the state). However, a positive trend is emerging and percentage of organic farming is certain to increase in periods to come (good example is Croatia, where organic farming increased by 367% from 2010-2015). Recommendations include several best management practices in response to these pressures: establishment of buffer strips adjacent to water bodies, redefinition of time ban of fertilizers and manure application, incentives for organic farming and eco-friendly land use practices.

In respect to forest coverage, the establishment and management of protective forests are the most notable features of this land use. Their significance lies in preventing leaching of agricultural pollution to waters, increased water infiltration and reduction and slowing down the runoff. The majority of Project Partner countries have vast land areas (including DWPZ) covered in forests which has tremendous positive impact on drinking water resource protection, some are nature-given and some are result of diligent afforestation (good example is Austria). The leading country in forested DWPZ is Slovenia (61%), followed closely by Croatia (54%) and Germany (53%). On the contrary, there are several malpractices which include clear-cutting, heavy machinery harvesting that leads to soil compaction and tractor skidder method of timber yield.

Concerning urban areas which are constantly expanding, several conclusions can be drawn. Majority of Project Partner countries do not have high percentage of urban areas in DWPZ (Hungary – 13.5 % and Poland 8.3% can be considered an exception). Significant pollution source are sewers, which are lacking in some areas (Croatia stands out with only 46% population connectivity). Additional problems with sewage systems include leaks, overflows in case of extreme rainfalls, insufficient dimensioning or improvised constructions. Furthermore, outdated sewage and public water supply systems are in need of an overhaul, in order to reduce leeks (this is emphasized in cases of private ownership of infrastructure). Recommended BMPs deal with issues of sludge management, domestic gardens for small- scale cultivation in DWPZs and another very important issue – road rainwater discharges into groundwater (also present in DWPZs). Appropriate responses serve high water protection functionality, although they usually come with somewhat of higher costs due to required technical solutions (especially sludge reuse and energy production from it, along with separate collection systems for rainwater in traffic infrastructure).

Several BMPs could not be directly linked to particular land use, due to the fact that they either deal with general (management) issues or with multiple types of land use at once. These BMPs are tailored in response to tackle arising future challenges, such as climate change (adaptation and resilience), mitigation of saltwater intrusions (particularly relevant for coastal aquifers in Italy and Croatia), improvement of building standards and several other non-structural measures: prevention of construction of flood prone areas, pollutant registers, integrated management of drinking water resources, enhancement of implementation and inspection of DWPZ restrictions and implementation of site-specific solutions.

Concerning future outlook, the aim of this document is to facilitate development of PROLINE-CE outputs (WP3 and WP4), namely:

- GOWARE (Guide towards Optimal WAter Regime) and
- DriFLU (Drinking Water/Floods/Land use) Charta,

which will provide methodology and implementation support at operational level, by fostering implementation-roadmaps and transferability of results, operationalisation of best management practices, identifying funding systems and encourage intensive cooperation with relevant stakeholders to push application of PROLINE-CE outputs.

5. References

Internal PROLINE-CE documentation:

- D.T1.1.1 Country reports about the implementation of sustainable land use in drinking water recharge areas
- D.T1.1.2 Transnational synthesis status quo report
- D.T1.2.1 Country-specific best management practice report
- D.T1.2.2 Transnational best management practice report
- D.T1.3.3 Lessons learnt: synthesis report about start-up stakeholder workshops
- D.T1.3.4 Transnational catalogue of strategies and measures to be integrated into existing policy guidelines

Other:

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