



PROLINE-CE

Efficient Practices of Land Use Management Integrating Water
Resources Protection and Non-structural Flood Mitigation





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INTRODUCTION

The United Nations General Assembly declared safe and clean drinking water as a human right. However, recent studies have revealed that water resources are under increasing pressure, mainly due to land use and climate change.

Within the Central Europe (CE) Region, the need for adapted and target-oriented land-use activities concerning the protection of drinking water resources and balancing conflicts of land-use pressure on water is evident. This challenging task is ideally tackled by transnational cooperation projects suitable for intensified cooperation across borders, such as PROLINE-CE. The project, co-funded by European Development Funds, was carried out between July 2016 and June 2019.

Although drinking water protection is already an integrated part of some land-use management practices, its implementation and realisation often lags behind. The main objective of PROLINE-CE was therefore the creation of a concrete transnational plan for the implementation of sustainable land use and flood/drought management leading to an improved protection of drinking water resources. This new integrated land use management approach foresaw the involvement of stakeholders and decision makers from the very beginning, thus raising their awareness for the issue. The demonstration of best practice examples that were carried out in pilot actions in various geographic and thematic fields supports the stakeholder interest and decision processes even more.

The conclusions gained from these experiences led to a "Guide towards Optimal Water Regime (GOWARE)". This tool provides a tailored frame for the implementation of sustainable land use and flood/drought management with the overall purpose of improved protection of drinking water resources and protection against floods/droughts, even beyond project lifetime. To foster the importance of this transnational guiding tool also on policy level, a commonly developed DriFLU (Drinking Water/Floods/Land Use) Charta was signed by notable representatives from all participating countries during the final project conference in Vienna on 4th June 2019.

The transnational character of the topic as well as the broad-based project partnership - project partners are coming from institutions with a comprehensive range of responsibilities at the national, regional or local level, among them water suppliers and research institutions - ensured that PROLINE-CE was able to provide valuable contributions to existing EU directives, such as the Water Framework or the Floods Directive.



CAPITALIZATION: CAPACITY BUILDING AND STAKEHOLDER ENGAGEMENT

Main objectives

- to collect, evaluate and compare various factors which influence drinking water quality and quantity in Central Europe (CE) region, such as land use activities, flood, drought and climate change impacts, current management practices and/or gaps (including national legislation);
- to develop a comprehensive knowledge base of interrelated factors which influence drinking water quality and quantity in Central Europe countries;
- to actively involve and create a network of stakeholders, such as land use planners, water suppliers, decision makers, NGOs, practitioners and researchers (agronomists, hydrogeologists, ecologists, biologists);
- to capitalize upon existing knowledge from past projects, using their results and findings to improve PROLINE-CE outcomes - e.g. DrinkAdria, CC-WaterS, CC-WARE, CAMARO-D (in synergy with PROLINE-CE);
- to set the foundations for further PROLINE-CE activities, targeting environmental issues and management gaps on national level

Methodology

The thematic focus of PROLINE-CE is laid on land use management practices and their influence on drinking water quality and quantity, as well as on flood and drought events. In order to determine most relevant factors and impacts of land use on drinking water resources, floods and droughts, an analytical SWOT and DPSIR methodology was used in a bottom-up approach (from peer review national level reports towards transnational CE level). DPSIR (driving forces, pressures, state, impacts and responses) was used to acquire better understanding of interacting factors (drivers and pressures) that change the environment by methodically evaluating land use impacts on water resources quality and quantity, as well as on floods and droughts. Furthermore, the DPSIR conceptual framework can be used to support the implementation of the Water Framework Directive, namely in

the selection of Key Type Measures (KTM) required to achieve a good status of water resources.

Additionally, possible areas for change (weaknesses and threats) were identified along with solutions to the existing issues (opportunities and strengths) through a SWOT analysis. Based upon the results of the conducted analyses, improvements of existing long-term strategies, policies and management approaches, particularly those related to the protection of drinking water, can be devised.

Findings from SWOT and DPSIR analyses were coupled with Corine Land Cover (CLC) data as well as drinking water protection zone maps from each country in order to form the "big picture".



Agriculture has been identified as land use type that causes most significant pressures on water quality and quantity:

- the improper use of fertilizers and pesticides,
- 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 the use of heavy machinery not only affects the morphological structure of the soil, but also has a
- negative impact on the hydrological regime of the groundwater.

The improper use of fertilizers, pesticides or other substances as well as an inappropriate manure management can even lead to soil depletion and the contamination of surface and groundwater resources. Furthermore, the draining of wetlands in order to gain more land for intensive and ever spreading agricultural production is still a significant problem, even though wetlands have an important role in biodiversity, landscape diversity, water storage and groundwater recharge and reduction of down-stream runoff.

Forest areas provide essential hydrological functions that are often impeded due to clear-cuts which may cause increased surface runoff. Among the most serious bad practices the use of heavy machinery (e.g. skidder tractors), the improper removal of deadwood, and the expansion of forest roads or infrastructure can be found. Moreover, there are significant gaps in the management of private forests and plantation of monocultures (e.g. conifers).

Strategies and measures for improved protection of drinking water resources

Once the main sectoral gaps had been identified, it was necessary to provide improvement mechanisms. Several approaches were fostered:

- (i) identification of existing best management practices in CE countries
- (ii) stakeholder involvement through workshops
- (iii) proposition of innovative measures to be integrated into existing policy guidelines

Pastures in Europe are often endangered by a high concentration of livestock that causes grass damage, soil erosion, higher surface runoff and transport of organic pollution. In karst terrains, the problem is even enhanced when grazing is done close to dolines, swallow holes and streams. Furthermore negligence, abandonment or change of traditional management systems of grassed parcels (meadows and pastures) leads to the degradation of pastures, to the increase of aggressive invasive species and finally to changes in soil and water quality. Additionally, inadequate drainage of pastures, intensive use of heavy machinery, ploughing up and application of manure are also undesirable practices.

Urban areas also exacerbate impacts that might affect water quality and availability, in terms of densely populated areas with a high amount of impervious surfaces resulting in increased surface runoff, inadequate sewage and waste disposal leading to an increased flood risk. In some areas, the low connectivity of the population to sewage systems, with a high number of permeable cesspits, prone to leakage, are problematic from the aspect of water quality. In less developed areas, high leakages in the water supply systems cause great losses of water resources and are therefore problematic, too. **Industrial** sites pose a threat if industrial waste and wastewater is not properly treated and - in a worst-case scenario - catastrophic discharges during accidents might occur.

(i) A country specific “catalogue” of existing best management practices was provided for each participating country and reviewed according to the different types of land use - agriculture, forestry, grassland, wetlands, riparian strips and dry areas, including a special chapter dealing with non-structural flood mitigation measures. Based on the national reports, a transnational best management practice report was developed, providing a potential for improvements in current management practices.

(ii) Since the main objectives of PROLINE-CE could only be achieved by both an integrative and an interdisciplinary approach, the intensive stakeholder engagement and feedback was an essential tool for achieving the desired project objectives. The first stakeholder involvement was carried out through workshops in each participating country. In total, around 200 stakeholders of various professional backgrounds attended. The specific objectives of workshops were:

- 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

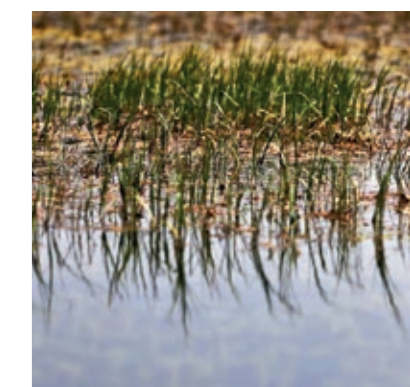
- operationalisation of best management practices for water protection
- capacity building for relevant stakeholders and administrations through panel discussions, workshops and dialogues.

(iii) the project partners aimed to transform the lessons learnt from the start-up stakeholder workshops 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. All of this should lead to an improvement of existing and the development of new and efficient management, control and behaviour practices.

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.

Based on previously defined gaps (status quo assessment and stakeholder involvement), the project partners compiled a transnational set of 38 best management practices to be integrated into existing policy guidelines. The factor for consideration, *de-facto* the most important one, is the implementation potential. Naturally, some best management practices are more complex than others (e.g. especially if they include technical or construction measures/in contrast to administrative measures, such as financial incentives or prohibitions), making them harder to implement due to higher costs and a higher degree of required census amongst decision makers, expert community and public.





IMPLEMENTATION IN PILOT AREAS

Methodology

Pilot Actions (PAs) were selected in each partner country in order to reflect conflicts (GAPs) of management and operation of water supply companies and land-use management in recharge/water protection areas. In PAs, the status of the implementation of best management practices (BMPs) was determined and - in case of lacks - identified. Moreover possibilities for improvement and implementation were assessed.

Each single PA is clustered concerning the geographic specification, natural site characteristics (type of drinking water source: surface water, groundwater, bank filtration) and main land use in three pilot action clusters (PAC):

- Pilot Action Cluster 1 (PAC1): Mountain forest and grassland sites,
- Pilot Action Cluster 2 (PAC2): Plain agriculture/grassland/wetland sites and
- Pilot Action Cluster 3 (PAC3): Special sites (riparian strips).

Main land uses in Pilot Action Clusters (PAC)

PAC1 - Mountain forest and grassland sites: In mountainous areas, drinking water sources are mainly originated from groundwater (fractured and karst aquifers). In PROLINE-CE project, two PAs in karstic mountainous areas have been allocated to this cluster; the major land use is forest, grassland and pastures. The main conflicts regarding drinking water protection are timber production, gaming and cattle grazing.

PAC2 - Plain agriculture/grassland/wetland sites: In plain sites, the main land uses are agriculture, grassland and urbanization. Drinking water sources can be surface water, bank filtered water or groundwater [mainly porous aquifer, but also karst aquifer (Croatian case)]. All PAs are in plain areas and the major land use is agriculture (with grasslands), but also urbanization.

PAC3 - Special sites (riparian strips): The main land uses are represented by agriculture and settlements. Both PAs face issues related to both water availability and water quality damage. Agricultural activities represent the main causes of contamination of water bodies and of the increase in water demand, associated to irrigation practices. Furthermore, both PAs struggle with direct and indirect impacts of flood and drought events.

Figure 1:
Transnational map of
Pilot Action sites

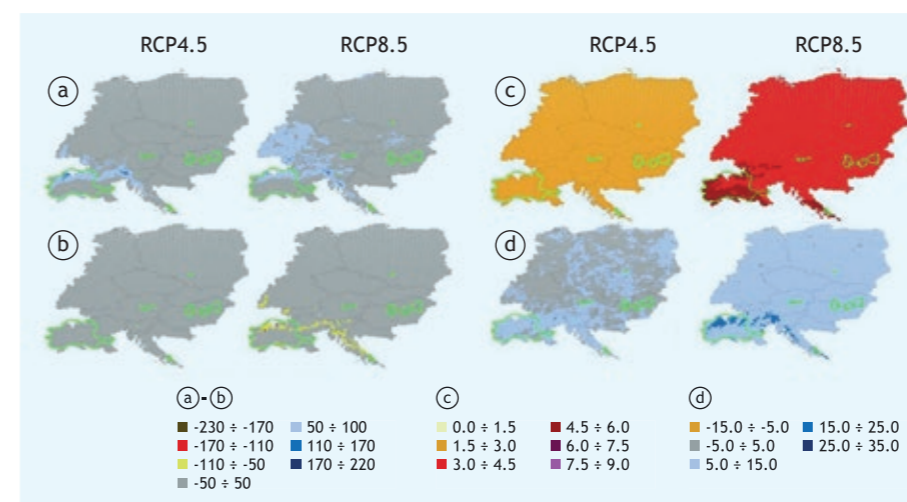


Climate change - general overview of the Central Europe region

PROLINE-CE evaluated the expected variations in weather patterns regulating water availability and occurrence/severity of water-related extreme events (droughts, floods) due to climate change. To this aim, variations in “proxies” were computed by considering the outputs of the multi-model ensemble of regional climate models, at the highest horizontal resolution available in Europe, EURO-CORDEX (=12 km) (<https://euro-cordex.net/>). In Figure 2, the variations in winter precipitation (a), summer precipitation (b), summer temperature (c) and maximum yearly precipitation on a daily scale (d) are displayed as anomalies between the end of the century 2071-2100 and a reference time span 1971-2000 under “mid-way” RCP4.5 and more pessimistic but “business as usual” RCP8.5. A clear increase in temperature is recognizable over the entire domain (c); it is even more evident under more severe scenario and in Southern part of the domain. Concerning winter precipitation, an increase is assessed in Alpine Regions and surrounding areas while the opposite occurs (mainly under RCP8.5) in the southern part of the area. Finally, a clear growth in maximum daily precipitation is detectable over the entire area, again, mainly under RCP8.5 and Alpine region.

The reported variations confirm the main remarks identified by ETC/CCA Technical Paper 2018/4¹ for the Central Europe area with consequently a higher probability of more frequent and severe drought events, a decrease in snow and ice coverage mainly on the Alpine arc and an increase in frequency and/or intensity of floods. Of course, they can result in strong variations in water availability in terms of impacts, location and timing. In this regard, the evaluation of the EU Adaptation Strategy undertaken by the European Commission (2018) stresses the relevant role of transnational programmes in promoting cooperation projects on Climate Change Adaptation. Furthermore, this document highlights that “approaching Climate Change Adaptation (CCA) as a global public good to tackle cross border risks may reveal opportunities to strengthen international cooperation on resilience”.

Figure 2: expected variations 2071-2100 vs 1971-2000 under RCP4.5 and RCP8.5 for: a) winter precipitation [mm/season], b) summer precipitation [mm/season], c) summer temperature [°C], d) maximum yearly precipitation on daily scale [mm/day]. Green areas represent the pilot areas



¹ Ramieri et al. (2018) Adaptation policies and knowledge base in transnational regions in Europe ETC/CCA Technical Paper 2018/4

Implementation possibilities of selected best management practices and acceptance of BMPs among stakeholders and experts (BMP)

The testing of BMPs in the pilot areas was done in three steps: In a first step, the most important and relevant BMPs were selected. Subsequently, various activities for the implementation of BMPs were performed (step 2) and the last step was to find out the stakeholder’s opinions about the selected BMPs (step 3).

The implementation of BMPs may require:

- adaptation of existing land use management practices with the purpose of drinking water protection,
- adaptation of existing flood/drought management practices with relation to drinking water protection,
- adaptation of policy guidelines.

At the local/regional level, the implementation of best management practices demands a transdisciplinary and participatory approach with dynamic interaction and feedbacks of stakeholders and experts. Therefore, an important part of the implementation is the acceptance of best management practices for drinking water protection and flood mitigation among stakeholders and experts. This was obtained thanks to stakeholder workshops and individual discussions. By this means, stakeholders’ opinions about selected BMPs were acquired. In most cases, stakeholders supported the proposed BMPs, but mostly they are not in the position to achieve changes in the system, at least not with immediate effect

Selected Best Management Practices in the Pilot Areas

The BMPs selected within each pilot area were categorized according to the type of land use/category each problem is related to: agricultural areas, urban areas, forest and alpine pasture. All GAPS/BMPs related to water management (general, drinking water and flood management) are actually related to all land uses. BMPs were therefore classified into the following categories: general water management (all land uses),

drinking water management (all land uses), flood management (all land uses), agricultural areas, urban areas, forest and alpine pasture.

The relevant Best Management practices (BMPs) selected for particular pilot action represent the management actions that were considered to solve the problems given through the existing GAPS.

BMPs assigned to general water management show a shortage in measures, tools or information, which would be necessary for ensuring a more efficient water management.
In drinking water management , BMPs offer solutions on how to manage the pressure on drinking water sources <ul style="list-style-type: none">■ quantity caused by anthropogenic pressure and pipeline leakage and■ quality caused by human activities in the recharge area (establishment of drinking water protection zones). In the Italian, Slovenian and Croatian pilot sites, also climate change was considered.
BMPs related to flood management solve the deterioration in both water quality and quantity. The most important measure proposed is hydrological/hydraulical modelling.
In agricultural areas , BMPs mainly propose monitoring and education regarding the improper use of pesticides and/or fertilizers and improper manure storage.
BMPs generated from GAPS identified in urban areas address issues like water quality deterioration due to insufficiency or lack of sewage systems and wastewater treatments, illegal waste disposal, waste disposal which does not meet environmental standards and unarranged road rainwater discharge.
BMPs assigned to forest land use mostly derive from (excessive) anthropogenic activities like clear-cutting, forest road construction, hunting or conifer tree plantations. They have to deal with the consequences such as increased surface runoff and decrease of groundwater quality and quantity.
All BMPs in alpine pastures address sustainable grazing management for cattle on karstic alpine pastures to prevent erosion processes and groundwater pollution.





The BMPs identified within PROLINE-CE project cover different levels, some of them are legislation and government oriented, whereas others are operational and based on practitioners' activities (farmers, individuals...).

14 out of 41 BMPs could be implemented, most of them (9) referring to general water management and forest land use. An excellent example is the implementation of BMPs in the pilot area in Waidhofen/Ybbs, Austria (PA1.2): A „Guideline for securing the Water Protection functionality of the forest ecosystems within the DWPZ” was elaborated and defines all relevant BMPs for the watershed. This guideline was resolved by the city council of Waidhofen/Ybbs and has now normative character. Another very good example is the multiscale monitoring of the water resources which was set up in the pilot area in Kozłowa Góra, Poland (PA2.2): water resources, sources of pollution and possible hazards are being investigated and assessed. Based on the results, mathematical models of hydrology and ecology of the Kozłowa Góra reservoir was established. Thanks to the simulations, an assessment of the impact of land use and water management on water quality and quantity and its ecology was possible. A proposal for the establishment of a drinking water protection zone (DWPZ) was prepared and is being implemented. The proposal includes amongst others the limitation in land use, wastewater management and fishery.

On the other hand, some BMPs are very complex and require system change or even a change of policy guidelines, which are long lasting procedures and cannot be done during the project lifetime. Moreover, implementation of BMPs is limited by economic, administrative, social acceptance or governance issues. Therefore, the continuation of the stakeholder dialogues plays an important role, in order to foster the implementation of BMPs into daily practice and/or policy guidelines. Further activities should have the focus on the implementation of the proposed BMPs on the national (guidelines issued by state agencies) and local levels (e.g. BMP implemented by a public water supplier or municipality). It is therefore crucial that BMPs for drinking water protection and flood mitigation are in concordance with all stakeholders (linked to all land use activities) in the recharge area of the drinking water source.



GOWARE - CE: TRANSNATIONAL GUIDE TOWARDS AN OPTIMAL WATER REGIME

GOWARE (Transnational Guide towards Optimal Water Regime) represents the interactive PROLINE-CE Decision Support Tool (DST), specifically designed for selecting, prioritizing and promoting the most suitable Best Management Practices (BMPs) for the drinking water protection and flood mitigation, considering the specific user's requirements.

In general terms, a DST is a computerized system that supports users in the decision-making process by using analytical systems for the examination of multiple alternatives and for the identification of the most suitable management strategies in the different contexts used. In recent years, DSTs have been extensively applied in different research and practical contexts and several applications have been proposed in the fields of environmental protection, water resources management and water-related risks mitigation.

In this context, GOWARE is dedicated to propose a common methodology for integrated water protection management and enhancing the operative BMPs implementation with the purpose of favouring the sustainable land use and

mitigating the impacts of flood/drought events in the participating regions beyond project lifetime. The tool relies on a catalogue of BMPs identified at national and regional levels by means of expert judgment, desk review and stakeholders' feedbacks. Afterwards, BMPs were revised according to the issue at hand (e.g. fixed land use or general water management, geomorphological setting) and ranked according to specific requirements and constraints (their relevance in respect to water protection functionality, cost and time of the implementation, multi-functionality and their robustness in terms of sustainability).

In its final release, GOWARE could assist stakeholders at different levels of management and of various professional backgrounds such as ecologists, hydrogeologists, foresters, urban planners, university researchers, policy and decision makers as well as local water suppliers and farmers. The tool can work off-line (as Excel-based tool) or on-line (as Web-tool) and it is suitable for single users or within physical workshops/meeting activities.



GOWARE design

As sketched out in Figure 3, GOWARE design includes two main stages:

Stage 1- Analysis scoping: this phase consists in defining the context that appropriately represents the issues that the user is facing in the decision-making process. According to the defined context, the most suitable BMPs are pre-selected among the entire set of available practices (Box A in Figure 3);

Stage 2- Criteria ranking: this phase consists in assigning a “relative importance” between a number of defined characterizing criteria, by means of a pairwise comparison (i.e. considering the criteria two-by-two). The criteria ranking allows the prioritization of the pre-selected BMPs, which consists in giving to each BMP an order of suitability, according to the user judgments about the relative importance of the criteria (Box B in Figure 3).

The specific context of analysis in which the user is operating is defined through four filters:

- Land Cover / Use (forests, agriculture, wetlands, grasslands; urban and industrial areas and general water management measures for heterogeneous landscapes);
- Topographic settings (plain, mountain or both);
- Adaptation target (single or combined actions among water quantity, water quality, and flood risk mitigation);
- Planning time horizon (operational - day-by-day, strategic - up to five years).

In this last case, the option “all” could be selected with the meaning of “no preference” between possible choices.

The selection of these options allows filtering a sub-set of BMPs, extracted among those constituting the catalogue included in the DST (and identified in the initial project activities).

In the second stage of the BMP analysis, the user assigns a relative importance to each of the following characterization criteria:

Criterion 1) Water Protection functionality, intended as the BMP effectiveness for the main adaptation target then in terms of protection of water resources and/or flood risk mitigation;

Criterion 2) Cost, defined as a general BMP cost to performance ratio;

Criterion 3) Time necessary for the implementation of the BMP;

Criterion 4) Robustness of BMP, intended as the BMP resilience also to external further forcing not planned in the design phase or perfectly recognizable;

Criterion 5) Multi-functionality, intended as the BMP capability to address also further functions (e.g. better provisioning, climate regulation, recreational).

Once the user has defined the relative importance of the above criteria, GOWARE prioritizes the BMPs among those passing the pre-selection. In this way, the system provides tailored solutions for the management of the user’s issues. For this purpose, GOWARE adopts the Analytic Hierarchy Process (AHP), which permits putting together quantitative scores on the BMPs characteristics provided by expert judgments (ranging from 1 - worst quality, to 5 - best quality) with user-defined priorities to finally obtain the ranking of the suitable sub-set of BMPs.

Figure 4:
An example of a consistent pairwise comparison matrix for criteria of GOWARE DST

AHP Multi-criteria analysis					
Pairwise comparison	Water protection functionality	Cost of the measure	Duration of impementation	Robustness	Multi-functionality
Water protection functionality	1.00	5.00	7.00	5.00	3.00
Cost of the measure	0.20	1.00	1.00	0.33	0.20
Duration of impementation	0.14	1.00	1.00	1.00	1.00
Robustness	0.20	3.00	1.00	1.00	1.00
Multi-functionality	0.33	5.00	1.00	1.00	1.00

The Analytic Hierarchy Process (AHP) is a Multi-Criteria Decision Analysis (MCDA) tool widely adopted in natural resources and environment decision-making processes (Schmold et al., 2001). It allows assigning a priority to a series of decision-making alternatives and identifying the one that achieves the most suitable trade-off among all the different solutions. It is based on the pair comparison between the criteria in order to give to each of them a score of relative importance. According to Saaty (1980), the scores that are commonly assigned in the evaluation of the relative importance of each alternative range from 1 (the alternatives A_i and A_j are equally important) to 9 (alternative A_i is absolutely more important than alternative A_j). Based on the scores given to the comparisons, a comparison matrix is created in which the diagonal elements are always equal to 1 while the non-diagonal elements show the relative importance of the corresponding alternatives (Figure 4). If the elements of the pairwise comparison matrix are shown with a_{ij} , which indicates the importance of alternative “ i ” over “ j ”, for consistency a_{ji} is calculated as $(a_{ij})^{-1}$ (Borouhaki and Malczewski 2008).

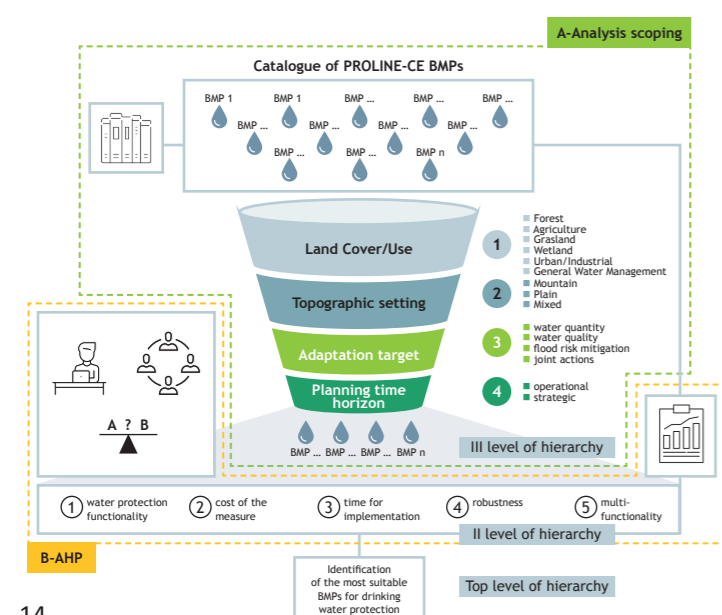
In scientific literature, different methods have been proposed to translate the comparison scores in relative criterion weights (priority vector) (Brunelli, 2015). In GOWARE, the model employs a procedure referred to the mean of normalized values. In this case, first the sum of the scores in each column of the pairwise comparison matrix “ A ” is calculated. Then, each element in the column is divided by the calculated sum in order to obtain normalized values and the corresponding normalized pairwise comparison matrix “ A_{norm} ”. Last,

the arithmetic average of the entries on each row of A_{norm} . These values represent the elements of the weight priority vector “ w ”. Based on the results of this analysis, it is possible to state how important each pre-selected BMP is in the decision-making process, regarding the specific user’s requirements.

As usually carried out in literature, GOWARE incorporates techniques for checking the consistency of the decision maker’s evaluations, thus trying to reduce the bias in the decision-making process. Specifically, the accuracy of the pairwise matrix is evaluated by means of the Consistency Ratio (Malczewski, 1999) and, according to Saaty (1980), a threshold is set to consider the comparison matrix consistently. The proposed tool is also enabling to cope with the case in which the user does not provide a score for the evaluation of the relative importance between two criteria. In this case, the AHP model automatically sets its parameters to avoid overestimating weights by setting “zero value” in the cell referring to the missing comparison so that the weight calculation is not affected by the missing value.

Finally, when decisions are taken by groups of decision makers such as boards or team of experts, it is opportune considering all the provided judgments and aggregating them in order to obtain a synthetic weight priority vector. In the case of GOWARE, if the decision process is undertaken by a group of people, the aggregated priority weights can be calculated, by using the off-line version as both geometric and arithmetic mean of the weights calculated from each individual expert judgement.

Figure 3:
Schematic representation of the GOWARE design. The context scoping and pre-selection of BMPs (first stage of the analysis) are shown in the green dashed box A, while the criteria ranking and BMPs prioritization (second stage of the analysis) are shown in the yellow box B.





Analytic Hierarchy Process (AHP) testing phase

The first test of the AHP model implemented in GOWARE for ranking the suitable BMPs has been carried out during the second Round Table held in Budapest in February 2019. During the event, participants were asked to fill in a questionnaire (Figure 5) and to give their opinion about the relative importance of each criterion (two-by-two comparisons).

The processing of the results revealed how due attention should be reserved to providing “consistent” pairwise comparisons; indeed, several matrix largely exceed the minimum threshold fixed, according to the literature indications, to identify “consistent judgments” potentially mining the reliability of findings. However, in general terms, it emerged that water protection functionality

turns out to be the most relevant criterion taken into account by stakeholders in their decisions, as well as the time necessary for the implementation of the BMPs is considered as the less relevant aspect in the selection of suitable water management strategies. As expected, an important role in the identification of suitable practices is played by the capability of the measure to address more than one function and service (multi-functionality). Finally, the costs for the implementation of the measures and their robustness have a variable level of relevance: the cost has a higher relevance if only consistent judgements are taken into account otherwise, the robustness is considered more relevant.

Figure 5:
Pairwise comparison
between the five
criteria identified
in the PROLINE-CE
project for the
characterization
of the BMPs

Please indicate which criteria you consider more relevant:				How much more?				
A		B						
1	Water protection functionality	Cost of the measure	A B	1	3	5	7	9
2	Water protection functionality	Time necessary for impementation	A B	1	3	5	7	9
3	Water protection functionality	Robustness of BMB	A B	1	3	5	7	9
4	Water protection functionality	Multi-functionality	A B	1	3	5	7	9
5	Cost of the measure	Time necessary for impementation	A B	1	3	5	7	9
6	Cost of the measure	Robustness of BMB	A B	1	3	5	7	9
7	Cost of the measure	Multi-functionality	A B	1	3	5	7	9
8	Time necessary for impementation	Robustness of BMB	A B	1	3	5	7	9
9	Time necessary for impementation	Multi-functionality	A B	1	3	5	7	9
10	Robustness of BMB	Multi-functionality	A B	1	3	5	7	9

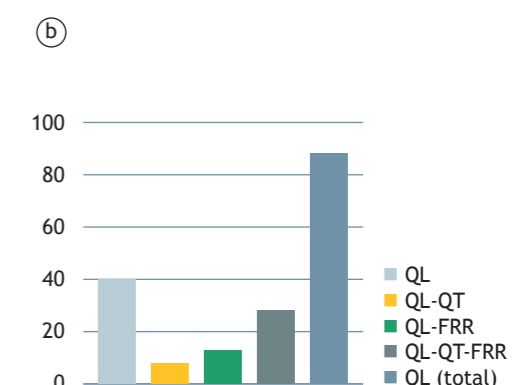
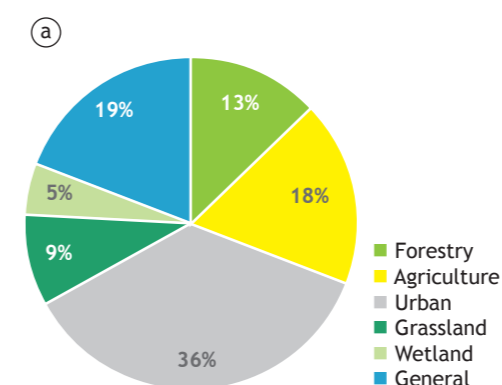
Catalogue of Best Management Practices

Regarding gaps and leading problems in land use and floods management in relation to drinking water protection, GOWARE operatively advises interested end-users and stakeholders about the most suitable and applicable practices, which should be operatively integrated into management strategies and policy guidelines. To this purpose, a catalogue of about 120 measures has been provided and implemented into the GOWARE tool. Practices were characterized by experts who provided specific information for the four filters (land use, topographic setting, adaptation target, planning time horizon) and quantitative judgements for the five criteria in rates on 1-5, where “1” stands for worst performances (low functionality, high cost/benefit ratio, long implementation times, low robustness, reduced multi-functionality) while “5” stands for best performing conditions. Details for each land use category are reported in Figure 6 (a). As shown in Figure 6 (b), the analysis of the BMPs highlights that most of the investigated measures (almost 88%) are aimed at protecting water resources in terms of water quality: about 40% of the practices address specifically the water quality aspect, approximately 28% are able to cope with all the water-related issues

considered in the project while some can address at the same time also water quantity (=8%) or flood mitigation (=13%) issues. In addition, the analysis shows that very few practices are exclusively devoted to ensuring the protection of the water availability and the management of floods (6% and 4%, respectively).

Regarding the topographic setting, most of the selected BMPs can be implemented in both mountain and plain areas and very few are appropriate for a specific zone. Furthermore, considering the planning time horizon, it turned out that half of the proposed measures are suitable for operative purposes (following a day-by-day implementation) and the other half is designed for strategic actions (with an acting time horizon up to five years). This aspect highlights the suitability of the proposed tool for different stakeholders: administrators and decision-makers could benefit from the availability of strategic practices that meet their long time territorial planning requirements while, on the other hand, operational practices, such as those devoted to the implementation of sustainable agricultural practices, can be of greatest interest for local end-users (e.g. farmers).

Figure 6:
a) Percentage of BMPs
identified for each land
use category.
b) Percentage of BMPs
suitable for addressing
water quality issues
(QL=Quality;
QT=Quantity;
FRR=Flood Risk
Reduction)





Taking into account each criterion, it emerged that most of the practices (up to 40%) are characterized by high functionality in terms of both - protection of water resources and flood risk mitigation. Considering the implementation costs, most of the practices (40%) exhibit a medium cost/benefits ratio. Concerning the time necessary for the implementation it turned out that, even if some practices have long implementation timeframe, most of the measures could be implemented quite rapidly (45%). In both cases (cost and time for implementation), less than 6% of the practices present the lowest rank value. Furthermore, a very high number of practices presents high resilience to external factors not planned in the design phase and very few of them (<5%) present a low robustness. Finally, almost half of the BMPs are suitable to address issues/opportunities not directly related to the water protection, being characterized by a high multi-functionality (rank value: 4-5) while very few of them are characterized by a low level of multi-functionality (<5%).

In conclusion, it is possible to state that the list of identified measures provide an effective way to address water related issues and to enhance water protection in different land-use contexts, matching the needs and requirements of different categories of potential end-users.



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ADVANCEMENT - STRATEGIC POSITIONING AND COMMITMENT

Methodology and content of the DriFLU Charta

One of the main outputs of PROLINE-CE is the **DriFLU Charta**. The abbreviation “DriFLU” stands for “**Drinking water/Floods/Land use**” combining the most important thematic issues within this project.

Based on the main outcomes of the previous working steps within PROLINE-CE, a commonly agreed paper between all participating project partners was prepared. At the end of the project - during the Final Conference (Vienna, 4th June 2019) - the charta is signed by notable representatives of each country to determine the most important tasks towards an optimized and effective land use and flood/drought management with efficient organizational structures regarding drinking water protection.

For the charta, those gaps in actual management practices that were most commonly mentioned respectively the driving forces in each partner country and the relevant Best Management Practices (BMP) were selected according to the different categories of land use and vegetation cover. Also the “general recommendations” were summarized containing mainly common water management related issues, derived partially from diverse stakeholder involvement processes on different levels (transnational and national/regional/local).

To each of the gaps respectively BMPs the related “Adaptation of strategies/policies” were selected and supplemented or adapted according to the main results and findings of PROLINE-CE.

Providing an adequate link between the proposed measures within PROLINE-CE and the Key Type Measures (KTM) of the Water Framework Directive the respective numbers were listed in each BMP.

In order to ensure the usability of this Charta not only on transnational but also on national/regional/local level courses of action for BMP implementation in accordance with the DriFLU Charta were prepared for each participating country, enabling to focus more on national specific characteristics and problems.

Based on the SWOT-analysis and the DPSIR-frameworks (see Chapter Capitalization: Capacity Building and Stakeholder Engagement) of each partner country, up to five of the most relevant gaps and BMPs per land use respectively vegetation cover category, which are relevant and surveyed within the pilot areas, were selected supplemented by general objectives.

As some of these BMPs and their operationalisation possibilities were tested and assessed within the pilot areas (see Chapter Implementation in pilot areas) necessary steps towards adaptation, implementation and acceptance of each BMP were delineated for each pilot action containing also remaining issues to be solved.

Furthermore, the main results and findings of the 2nd stakeholder workshops, carried out in November and December 2019, especially recommendations made by the participants, were taken into consideration and supplemented within the relevant issues. Moreover, funding possibilities surveyed in each partner country were added to the respective BMP.



Figure 7: Course of action for BMP implementation

Course of action for BMP implementation	
Forestry	
Agriculture	
Urban areas, Transport/Industrial units, Energy production	
Grassland	
Wetland	
General water management	

Targets of DriFLU Charta

The DriFLU Charta will pursue the following targets:

- Provide recommendations for optimized, effective and integrated land use and flood/drought management, derived from the main project results, offering efficient organizational structures for drinking water protection
- Safeguard drinking water resources for the future by means of effective steering of land-use for drinking water protection
- Develop “Courses of action” in accordance with the DriFLU Charta in each participating country to consider (also) national specific issues and problems as well as to foster a network beyond the borders of disciplines, regions and countries
- Reach a political agreement between all participating countries by signing the Charta by notable representatives during the Final Conference
- Provide important inputs for different EU guidelines and strategies (especially EU Water Framework Directive, Drinking Water Directive, Groundwater Directive, Floods Directive)
- Secure the commitment by partner representatives in each participating country to monitor the implementation of the recommended actions beyond project lifetime



Lessons learnt

Based on different **stakeholder involvements** during project lifetime - mainly two national stakeholder workshops in each participating country and two transnational Round Tables with experts coming from different field of actions - the most common statements identified a need for:

- **A better communication and dissemination of knowledge and experience** between decision-makers/legislators, experts and other stakeholders and for the improvement of the transfer of results (transnational and interdisciplinary experiences) to decision makers and authorities responsible for the implementation of European directives
- The development of **efficient education systems for farmers** (at eye level! - calling attention also to economic benefits) and **public water management administrations** in cooperation with decision-makers, legislators, NGOs and research institutions (all affected stakeholders have to be involved and informed)
- **A change of human consciousness** of decision makers and all other stakeholders. Decision makers must directly stimulate good practices, and vice-versa, whereas other stakeholders should adapt and generally open their minds for changes in actual management practices.
- **Awareness raising** - drinking water protection provides not only benefits for water suppliers, but also for foresters, nature conservation, the economy and the general public. It is important that relevant stakeholders are included in planning right from the beginning of the process and they should be continuously involved. In this context, the agenda 2030 gives us a chance for better cooperation among different sectors and levels.
- Encourage the **adoption of PES** (Payments for the provision of Ecosystem Services) **schemes** for stakeholders (e.g. farmers), if the implemented measures (e.g. Best Management Practices of PROLINE-CE) go beyond the level of national/regional legal frame. These payments should be made transparent for all stakeholders to raise the awareness.
- Particular emphasis on the importance of **water governance** and the integration within water and land use related policies: Different plans addressed to several topics related to water highlight potential priorities, externalities, **synergies** (e.g. drinking water protection and flood mitigation) and conflicts, which have to be carefully considered in further implementation steps.
- **Application of hydrological/hydro-geological models on catchment level** to estimate impact of land use, provide reliable risk analysis, find efficient site-specific solutions and determine drinking water protection zones in spatial planning.
- **Best practice examples**, which should be spread around to other regions and affected stakeholders (e.g. water suppliers) and implemented through a network of stakeholders





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