

WORKPACKAGE T3, ACTIVITY T3.2

DEVELOPMENT OF A TRANSNATIONAL ADAPTATION PLAN FOR INTEGRATED LAND-USE MANAGEMENT

D.T3.2.2 TRANSNATIONAL ADAPTATION PLAN FOR INTEGRATED LAND USE MANAGEMENT

ENGINEERING GUIDE AND USER'S GUIDE

June, 2019

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Date last release	June, 2019





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1. Introduction

The Transnational Guide towards Optimal Water REgime (GOWARE) has been developed as a Decision Support Tool (DST) in the framework of the PROLINE-CE project. Its main objective is to support interested Users and stakeholders in the decision-making process for the selection of the most suitable Best Management Practices (BMPs) for sustainable land use, drinking water management and flood risk protection. GOWARE design includes two main stages of analysis:

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. It permits reducing the list of the suitable options among the full catalogue included in the tool.

Stage 2 - Criteria ranking: this phase consists in assigning a “relative importance” to a number of characterizing criteria by means of pairwise comparisons, i.e. considering the defined criteria two-by-two. It permits ranking the alternatives according the preferences of the different Users.

Two different versions of GOWARE have been released: one works as off-line tool (Excel-based) and the other as on-line tool (Web-based). GOWARE Excel-based version is aimed at supporting the decision-making processes carried out by both single User and groups of Users; it is included in the GOWARE Toolkit, which is directly downloadable from a link available at the GOWARE Web-page. The kit is composed by the following files: i) *GOWARE_Single_User.xls*, which supports decision making process faced by single User and it has been developed following the design of the Web-based tool; ii) *GOWARE_Group_decision.xls*, which supports decision-making processes faced by groups of Users; it allows analysing all the judgements provided by each Participant and obtaining a synthetic result for the final decision; iii) *GOWARE_AHP_Comparisons*, which provides the pairwise comparison table (in Word and PDF format).

GOWARE Web-tool is designed for supporting on-line decision processes carried out by a single User and it is available at <http://proline-ce.fgg.uni-lj.si/goware/>.

Users can refer also to D.T3.2.1 and O.T3.1 for detailed outline of GOWARE concept and design.

In D.T.3.2.2, the GOWARE engineering guide, which introduces the analytical models supporting the analysis, is provided in Section 2 while the operative User’s guides for both the off-line versions and the Web-based version of the tools are provided in Section 4 and Section 5, respectively. For the sake of completeness, a brief description of “Catalogue of Best Management Practices” is provided in Section 3.



2. GOWARE engineering guide

Stage 1 - Analysis scoping

In this stage, the User context of analysis is defined by accounting for four filters:

- Land use/cover- 6 options are available: (i) forest, (ii) agriculture, (iii) wetland, (iv) grassland, (v) urban/industrial/infrastructure settlements or (vi) general water management strategies for heterogeneous landscapes;
- Topographic setting- 3 options are available: plain, mountain environments or coexistence of the two ones;
- Adaptation target- 7 options are available: water quantity, water quality, and flood risk mitigation (single or combined options);
- Time horizon for action- 3 options are available: operational (*day-by-day*), strategic (*up to 5 years*) or “all”. In this case, the option “all” can be selected with the meaning of “no preference” between possible choices if the User is interested to both operative and strategical practices.

The filters “Land use/cover” and “Topographic setting” refer to the physical context in which the BMPs have to be implemented while “Adaptation target” and “Time horizon for action” identify specific characteristics of the BMPs. The selection of these options allows filtering a subset of BMPs, extracted among those constituting the catalogue included in the DST and implemented in the sheet of the Excel file “BMPs Table”.

Stage 2 - Criteria ranking

In order to provide a ranking among the subset of BMPs provided by Analysis scoping, GOWARE adopts the Analytic Hierarchy Process (AHP; Saaty et al., 1980), a Multi-Criteria Decision Analysis (MCDA) tool widely used in environmental/natural analysis context.

To this aim, a “relative importance” judgment is assigned to the following criteria assumed as the most relevant for characterizing the BMPs:

- Water protection functionality, intended as the actual effectiveness of BMP for the target(s) of interest: water resources protection (in qualitative or quantitative terms) and/or flood risk mitigation;
- Cost necessary for the implementation of the BMP intended as the significance of economic factors in driving the selection of BMPs;
- Time necessary for the implementation of the BMP;
- Time interval of sustainability, intended as robustness of BMP to cope with also with not perfectly known or unexpected external forcing (e.g. climate changes or land use changes);



- Multi-functionality, intended as the capability to address also further functions and services (e.g. material provisioning, climate regulation, recreational).

Since this stage of analysis is aimed to collect the specific judgments about the relative relevance of the criteria, the User must take into account the specific context in which she/he is operating. For instance, in the comparison between the cost required for the BMPs implementation and another criterion, the User is not providing a preference for cheaper practices but she/he is defining how much the “Cost” issue is relevant in her/his context compared with other factors.

In order to provide judgments for the five criteria, ten comparisons are required:

- 1) Water protection functionality vs Cost of the measure
- 2) Water protection functionality vs Time necessary for implementation
- 3) Water protection functionality vs Robustness of BMP
- 4) Water protection functionality vs Multi-functionality
- 5) Cost of the measure vs Time necessary for implementation
- 6) Cost of the measure vs Robustness of BMP
- 7) Cost of the measure vs Multi-functionality
- 8) Time necessary for implementation vs Robustness of BMP
- 9) Time necessary for implementation vs Multi-functionality
- 10) Robustness of BMP vs Multi-functionality

To each of these comparisons a qualitative judgment is provided. These judgments are then converted into numerical values generally ranging from 1 to 9. In Table 1 are indicated the scores and the judgments generally used in the comparison between the available alternatives (A_i , A_j) in a general decision-making process.

Table 1 - Judgments’ interpretation and corresponding numerical values.

Judgment	Score (a_{ij} values)
A_i is equal important to A_j	1
A_i is moderately more important than A_j	3
A_i is more important than A_j	5
A_i is strongly more important than A_j	7
A_i is absolutely more important than A_j	9

The resulting values are used to fill a (symmetric) matrix (Fig. 1) where the generic element a_{ij} results from the comparison between alternatives A_i and A_j .

If the number of alternatives is n , the number of total comparisons is $n(n-1)/2$.

	A1	A2	A3	Aj
A1	1	a_{12}	a_{13}	a_{1j}
A2	$1 / a_{12}$	1	a_{23}	a_{2j}
A3	$1 / a_{13}$	$1 / a_{23}$	1	a_{3j}
Aj	$1 / a_{1j}$	$1 / a_{2j}$	$1 / a_{3j}$	1

Figure 1 - An example of a generic pairwise comparison matrix.

From Fig. 1, it is clear that the comparisons are made between the elements of the upper region of the matrix (blue cells) and that the score values in the lower part (yellow cells) are equal to the reciprocal of the values assigned in the blue cells.

Priority vector

The priority vector “**w**” is an m-dimensional column vector whose elements indicate the weight of each alternative of the decision-making process. The model employed to translate the comparison scores provided by the matrix (Fig. 1) in relative criterion weights is the **mean of normalized values procedure**. 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}** is computed. These values represent the elements of the weight priority vector “**w**”.

Consistency

A comparison matrix for which the transitivity condition holds is defined “consistent matrix”. The transitivity condition implies that:

$$a_{ik} = a_{ij} \cdot a_{jk} \quad \forall i, j, k,$$

An illustrative example is shown in Fig. 2.

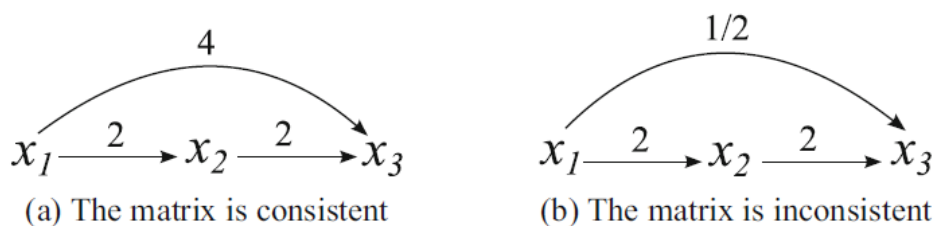


Figure 2 - An example of consistent (a) and inconsistent (b) transivities (Brunelli, 2015).

For checking the consistency of the User’s evaluations, thus trying to reduce the bias in the decision-making process, the accuracy of the pairwise matrix is evaluated by means of the Consistency Ratio [CR] (Malczewski, 1999):

$$CR = CI / RI$$

where **CI** is the Consistency Index and **RI** represents the so-called Random Index.

The Consistency Index **CI** is expressed as:



$$CI = (\lambda_{\max} - n) / (n - 1)$$

where λ_{\max} is the principal eigenvalue of the matrix (it is a scalar) and n is the order of the matrix.

Operatively, CI can be calculated by the matrix product of the pairwise comparison matrix and the weight vector (*multiplying each score in each column of pairwise comparison matrix by its weight*) and then calculating the weighted mean of each row of the new matrix.

RI depends on the number of elements that are compared (n): specifically, for n equal to 5 it is equal to 1.12.

According to Saaty (1980), in a 5 by 5 matrix, the threshold for CR should be fixed equal to 10% to be adopted for considering the matrix as consistent and therefore for accepting the estimation of the priority vector w .

It is worth to note that GOWARE will provide the list of suitable practices according to the specific requirements provided by the User even if her/his judgments are not consistent: checking the consistency is therefore just a warning that the tool gives to the User as operative advice to improve her/his decision-process.

Missing judgments

The tool is also enabled to cope with the case in which the User does not provide a score for the evaluation of the relative importance between two criteria. The employed approach was proposed by Harker (1987). According to this approach, a “zero value” is set for the matrix element referring to the missing comparison while the element of main diagonal on the same row is incremented by a unity. By way of example, it is possible to compare the findings provided by matrix B [3x3], where the comparison $b_{13}=w_1/w_3$ is missed (then, also, b_{31}), and the matrix C, where the modifications to B suggested by Harker (1987) are implemented. After such modifications, the computation of weights is carried out according the same approach reported in “Priority vector”.

$$Bw = \begin{bmatrix} 1 & 3 & w_1/w_3 \\ 1/3 & 1 & 3 \\ w_3/w_1 & 1/3 & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} = Cw = \begin{bmatrix} 2 & 3 & 0 \\ 1/3 & 1 & 3 \\ 0 & 1/3 & 2 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}$$

3. Catalogue of Best Management Practices

GOWARE is implemented with a catalogue of 92 BMPs (Forestry 14%, Agriculture 19%, Urban 22%, Grassland 12%, Wetland 5%, General Water Management 28%). Practices have been selected by experts who provided specific information for the four filters (land use, topographic setting, adaptation target, planning time horizon) and quantitative judgments for the five criteria in rates on 1-5, where “1” stands for low performances (low functionality, high cost/benefit ratio, long implementation times, low robustness, reduced multi-functionality) while “5” stands for best performing conditions.



Most of the measures (almost 87%) are aimed at protecting water resources in terms of water quality: about 40% of the practices address specifically the water quality aspect, approximately 32% 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 (~11%) issues. Very few practices are exclusively devoted to ensuring the protection of the water availability and the management of floods. Accounting for 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 results that half of the proposed measures are suitable for operative purposes (following a day-by-day implementation) and the other half is designed for strategical actions (with an acting time horizon up to five years).

4. GOWARE Toolkit User's guide

This section provides the operative User's guide for the GOWARE Excel-based version, explaining step-by-step how to use the "User Interface" sheet of the Excel files (Fig.3 and Fig. 4). The Excel-based version of GOWARE is enabled to face with decision making processes carried out by both "single User" (GOWARE_Single_decisions.xls) and "groups of Users" (GOWARE_Group_decisions.xls). The Excel files are available in the specific GOWARE Toolkit, provided to the Users for supporting off-line their activities.

Single User - GOWARE_Single_decisions.xls

By using the Excel file "GOWARE_Single_decision.xls", the User is enabled to select for each of the proposed filters (Land use/cover, Topographic setting, Adaptation target, Time horizon for action) one of the available options in the drop-down menu. This allows defining the analysis scoping that better fit the User's requirements (Fig. 3: Stage 1 of the analysis).

Scope your analysis in terms of:				Stage 1: Analysis scoping							
Land Cover/Use or Special Site	Topographic Settings	Adaptation Target	Time Horizon for Action								
Grassland	Plain	Water quality	Strategic (up to 5 years)								
Indicate your priorities in terms of:				Stage 2: Criteria ranking							
Water protection functionality vs. Cost of the BMP	Water protection functionality vs. Time necessary for implementation	Water protection functionality vs. Robustness of BMP	Water protection functionality vs. Multi-functionality	Cost of the BMP vs. Time necessary for implementation	Cost of the BMP vs. Robustness of BMP	Cost of the BMP vs. Multi-functionality	Time necessary for implementation vs. Robustness of BMP	Time necessary for implementation vs. Multi-functionality	Robustness of BMP vs. Multi-functionality		
Equal importance	Weak importance of 1st over 2nd	Strong importance of 1st over 2nd	Equal importance	Weak importance of 1st over 2nd	Equal importance	Equal importance	Equal importance	Equal importance	Equal importance		
Is the Priority choice consistent YES, PLEASE LOOK AT THE SUGGESTED BMPs BELOW											
List of suitable BMPs:				Results: BMPs prioritization							
	Suggested priority for BMPs:	Key Type Measure WFD (KTM)	EU legislation related to the measure	European Agriculture Fund for Rural Development (class)	Other reference documents	LABEL	Additional Project Measure (AMP)				
Preservation of existing (permanent) grasslands	1	2, 23	Groundwater Directive (2006/118/EC), Flood Directive (2007/60/EC), Drinking Water	234, 234	Research Article "Transformation of re-usable land to permanent grassland promotes pore rigidity and	Land use management					
Structures (e.g. dams) which prevent precipitation water from direct and fast	2	2	Groundwater Directive (2006/118/EC), Flood Directive (2007/60/EC), Drinking Water			Structural					
Consistency checking											

Figure 3 - "User Interface" sheet of the Excel-based tool for single User decision process.

Then, the User is enabled to select from the drop-down menu one of the available options for each of the proposed criteria (Water protection functionality, Cost, Time necessary for the implementation, Robustness of BMP; Multi-functionality) in order to provide judgments about their relative importance (Fig. 3: Stage 2 of the analysis). For each of the ten available comparisons, the options are:

- No choice, if the User does not give a judgment (corresponding to "0");



- Equal importance, if the User assigns the same importance to the accounted criteria (corresponding to “1”);
- Weak importance of the 1st criterion over the 2nd (corresponding to “3”);
- Strong importance of the 1st criterion over the 2nd (corresponding to “5”);
- Very Strong importance of the 1st criterion over the 2nd (corresponding to “7”);
- Extreme importance of the 1st criterion over the 2nd (corresponding to “9”);
- Weak importance of the 2nd criterion over the 1st (corresponding to “1/3”);
- Strong importance of the 2nd criterion over the 1st (corresponding to “1/5”);
- Very Strong importance of the 2nd criterion over the 1st (corresponding to “1/7”);
- Extreme importance of the 2nd criterion over the 1st (corresponding to “1/9”);

Group decisions - GOWARE_Group_decisions.xls

By means of the Excel file “GOWARE_group_decisions.xls”, GOWARE is enabled to face also with the case of “group decisions making processes”, i.e. the situation in which a group of Users collectively has to make a choice. In this case, the tool provides a dedicated Excel sheet (“Group decisions”) in which all the Users have to indicate their score (ranging from 1 to 9) to each of the pair comparisons. In order to facilitate the filling of this table, Users are provided with an individual table in Word/PDF format in which they can easily indicate the score values that have to be assigned to the comparisons. After filling the table, all the individual judgements can be collected in the Excel sheet. As shown in Fig. 4, in this case the User interface is designed to support only Stage 1 of the analysis (Analysis scoping), since Stage 2 (Criteria ranking) is carried out separately.

Scope your analysis in terms of:				Stage 1: Analysis scoping			
Land Cover/Use or Special Site	Topographic Settings	Adaptation Target	Time Horizon for Action				
Agriculture	Mountain	Flood mitigation	Strategic (up to 5 years)				
Is the Priority choice consistent? YES, PLEASE LOOK AT THE SUGGESTED BMPs BELOW							
List of suitable BMPs:	Suggested priority for BMPs:	Key Type Measure WFD (KTM)	EU legislation related to the measure	European Agriculture Fund for Rural Development (class)	Other reference documents	LABEL	Additional Project Measure (AMP)
Agro-Environmental schemes to financially support the design and the implementation of measures	1	2, 12, 14, 17	Groundwater Directive (2006/218/EC); Nitrates Directive (91/676/EEC); Floods Directive (2007/60/EC); Drinking Water	213	EU H2020 Project: "FAIRWAY" https://www.fairway-project.eu/ ; Research Article: "How to Enhance the	Governance / Structural	3
Organic farming (with biological pest control, permaculture) with guidelines for water protection	1	2, 12, 17	Nitrates Directive (91/676/EEC); Regulation on Registration, Evaluation, Authorisation and Restriction of	213		Governance / Structural	
Consistency checking				Results: BMPs prioritization			

Figure 4 - “User Interface” sheet of the Excel-based tool for group decisions.

The Group decisions tool is enabled for calculating the weight of each criterion accounting for all the available judgements provided by the Users. In order to calculate the priority vector, the “Aggregation of individual judgments (AIJ)” method is implemented. Following this approach, the comparison scores are aggregated as weighted mean into a single comparison matrix from which the comparison vector is calculate. The priority vector estimation, therefore, takes place after the aggregation of all the judgments in a single pairwise comparison matrix.



Interpreting the results

Once the relative importance values among the criteria have been defined (both in the “single User” and “Group decisions” case), the User can check the consistency of the judgments looking at the “B9 cell”, which will display:

- “Yes, please look at the suggested BMPs below”, if the provided judgments are consistent;
- “No, please revise your choices”, if the judgments are not consistent. In this case, the User should revise the comparisons in order to provide consistent judgments.

Nevertheless, in both cases, the tool will provide the list of the suitable BMPs ordered based on their relative rank resulting from the analysis of the provided judgments (light blue box in Fig. 3 and Fig. 4).

The selected BMPs provide tailored solutions for the management of the User’s issues. They are complemented by further key information supporting the Users (e.g. related Directives, scientific literature or projects carried out on the same topics). Further details about provided information are given in Section 5 and Annexes.

5. GOWARE Web-tool User's guide

This section provides the operative User's guide for the GOWARE web-based version, explaining step-by-step how to use the "web interface" (Fig. 5).

The screenshot displays the GOWARE web interface. At the top, there is a navigation bar with links: Home, GOWARE, Land use and water management practices, Pilot actions, Legislation, and About. Below this, the main heading "GOWARE" is centered. A breadcrumb trail shows "PROLINE-CE shared platform" > "GOWARE". On the right, a language selector shows flags for UK, DE, ES, NL, IT, and FR.

The interface is divided into two main sections highlighted by colored boxes:

- Green Box (Context Scoping):** This section contains four filter panels:
 - Land cover/use:** Includes checkboxes for Grassland, Wetland, All land uses (general water management), Agriculture, Forest, and Urban.
 - Topographic Settings:** Includes checkboxes for Mixed settings, Mountain, and Plain.
 - Adaptation Target (multiple options are recommended):** Includes checkboxes for Water quality, Water quantity / Water quality / Flood mitigation, Water quality / Flood mitigation, Water quantity / Water quality, Water quantity, and Flood mitigation.
 - Planning time horizon:** Includes checkboxes for Operational (day by day) and Strategic (up to 5 years).
- Red Box (Criteria Ranking):** This section is titled "Choose which parameter values more" and contains four sliders:
 - Cost of the measure:** Slider between "more" and "less" with a green dot at "equal".
 - Duration of implementation:** Slider between "more" and "less" with a green dot at "equal".
 - Time interval of sustainability:** Slider between "more" and "less" with a green dot at "equal".
 - Multi-functionality:** Slider between "more" and "less" with a green dot at "equal".
 Each slider has a checkbox below it labeled "I cannot provide a judgment".

Figure 5 - GOWARE WEB-Interface. The green box includes the context scoping (first stage of the analysis) while the red box encompasses the criteria ranking (second stage of the analysis).

In order to define the specific context of analysis (Stage 1-Analysis scoping), the User can check for each of the proposed filters the elements of her/his interest.

In detail, the User can define:

- 1) **Land cover/use** by indicating the typology/typologies of her/his interest between: forest, agriculture, wetland, grassland, urban/industrial/transport settlements or general water management strategies for heterogeneous landscapes (green box in Fig. 5a).

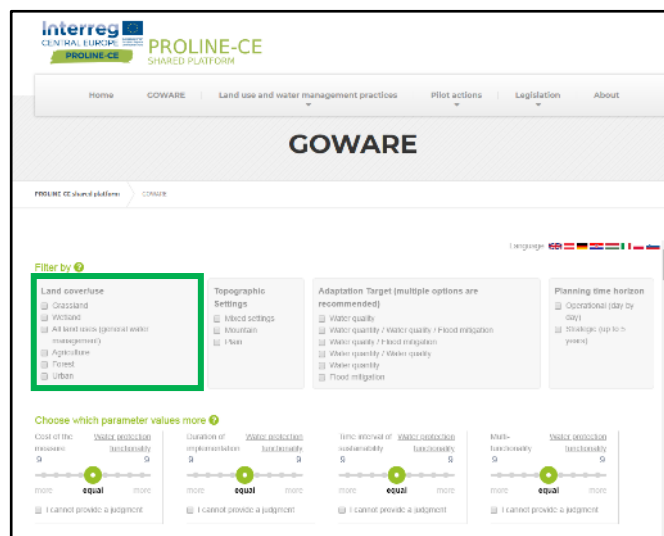


Figure 5a - GOWARE WEB-Interface: the “Land cover/use” filter proposed for indicating the land typology of the User’s interest.

- 2) **Topographic setting** by indicating the topographic characteristics of the environment in which she/he is operating between: mountain, plain and mixed setting (green box in Fig. 5b). If the User is interested in practices suitable to be implemented in one topographic setting, she/he must check both the option of her/his interest (e.g. “Mountain”) and the option “Mixed setting”, since the practices included in this last option are suitable for all the topographic settings (i.e. even for the mountain areas).

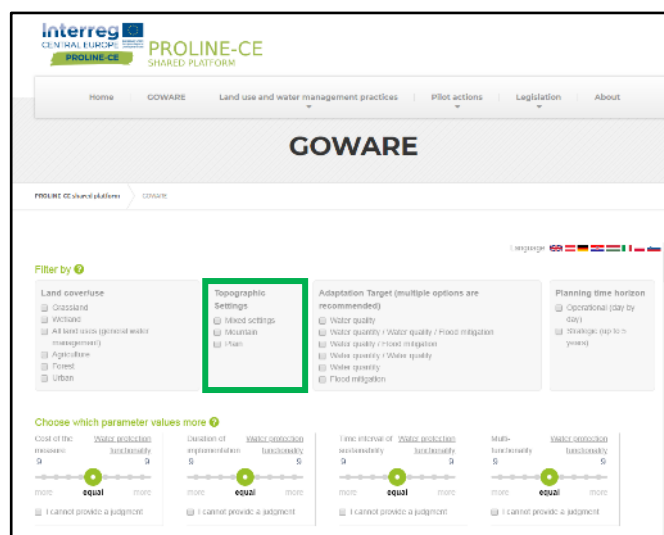


Figure 5b - GOWARE WEB-Interface: the “Topographic settings” filter proposed for indicating the land typology of the User’s interest.

- 3) **Adaptation target** by indicating the issue that she/he is facing between: water quality protection, water quantity management and flood risk reduction (green box in Fig. 5c). If the User is interested in one issue (e.g. water quality), she/he should check all the options in which the issue is indicated (i.e. all the check points including the water quality should be flagged then also “water quantity/water quality”, “water quantity/water

quality/flood risk reduction”, “water quality/flood risk reduction”) and the same for other filters. If the User is interested in two or more issues jointly acting (e.g. water quality and flood mitigation) she/he must check all the options in which the issues are indicated together (water quantity/water quality/flood risk reduction, water quality/flood risk reduction). Furthermore, if the User flags only the single checkpoint “water quantity/water quality/flood risk reduction”, this means that she/he is interested in practices able to cope at the same time with all the water-related issues.

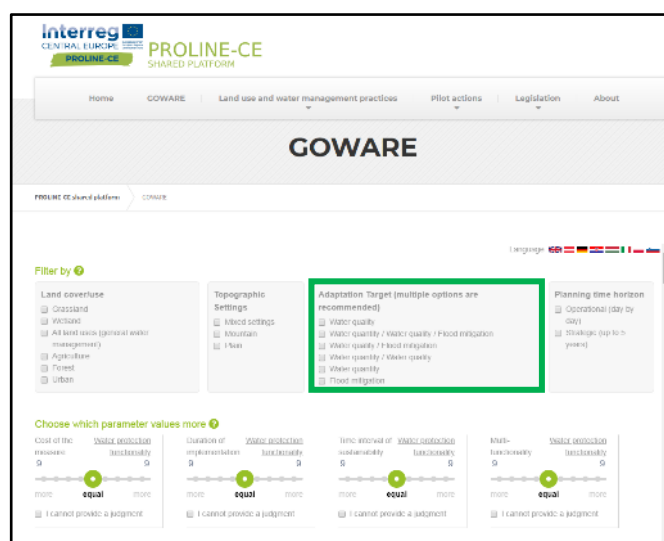


Figure 5c - GOWARE WEB-Interface: the “Adaptation target” filter proposed for indicating the water-related issue/issues of the User’s interest.

- 4) **Planning time horizon** by indicating the management action of her/his interest between: operational, if she/he is looking for practices that can be implemented day-by-day, or strategical, if she/he is interested in practices on a longer time horizon (Fig. 5d). If the User has no preference between the possible choices of planning time horizon, she/he can leave the checkpoints unselected or check both the available options.

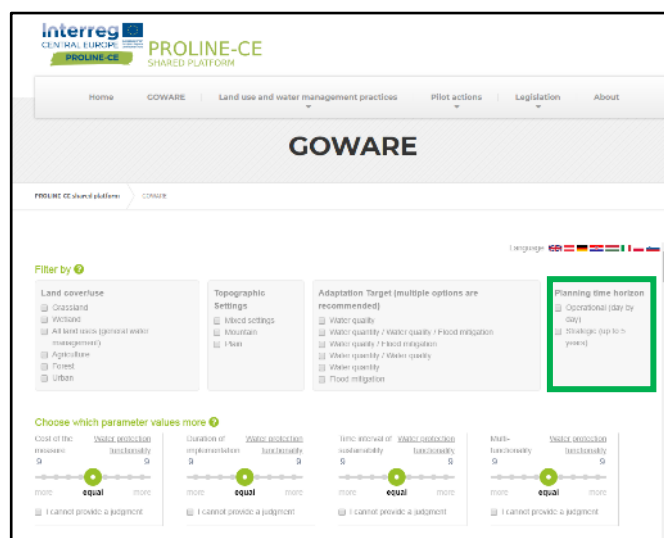


Figure 5d - GOWARE WEB-Interface: the “Planning time horizon” filter.

In order to identify the BMPs suitable for coping with the User's issue (i.e. accounting for the specific context defined in Stage 1) and to give an order of relevance to the selected BMPs (Stage 2- Criteria ranking - Fig. 6), the AHP model is implemented in the GOWARE web-tool.

Choose which parameter values more ?

<p>Cost of the measure</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Duration of implementation</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Time interval of sustainability</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>
<p>Duration of implementation</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Time interval of sustainability</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	
<p>Time interval of sustainability</p> <p>Duration of implementation</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Duration of implementation</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>		
<p>Multi-functionality</p> <p>Time interval of sustainability</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>			

Figure 6 - GOWARE WEB-Interface: Stage 2 of analysis.

In detail, in Stage 2 the User can define how much each criterion is more relevant than another (comparing the criteria two by two) by moving the cursor towards right or left and provide a judgment by selecting a numerical value ranging from 1 (the criteria have equally relevance) to 9 (one of the two criteria is extremely more important than the other).

Practical examples are provided in Fig. 7a and 7b. In Fig 7a, the “Water protection functionality” is compared with all the other criteria and it results, in all the cases, much more relevant than the other options (e.g. “Water protection functionality” is extremely more relevant than “Cost” and “Duration of implementation”, corresponding to value “9”).

Choose which parameter values more

<p>Cost of the measure</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Duration of implementation</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Time interval of sustainability</p> <p>Water protection functionality</p> <p>7</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Water protection functionality</p> <p>5</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>
<p>Duration of implementation</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Time interval of sustainability</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	
<p>Time interval of sustainability</p> <p>Duration of implementation</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Duration of implementation</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>		
<p>Multi-functionality</p> <p>Time interval of sustainability</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>			

Figure 7a - GOWARE WEB-Interface: in these boxes, the judgments for the comparisons between “Water protection functionality” and all the other criteria are provided.

In Fig. 7b, the judgments for all the available comparisons (10) are provided. As shown in the both figures, the criterion more relevant is in bold style and, as consequence, if the two criteria have equal importance, none of them is in bold style.

Choose which parameter values more

<p>Cost of the measure</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Duration of implementation</p> <p>Water protection functionality</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Time interval of sustainability</p> <p>Water protection functionality</p> <p>7</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Water protection functionality</p> <p>5</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>
<p>Duration of implementation</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Time interval of sustainability</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Cost of the measure</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	
<p>Time interval of sustainability</p> <p>Duration of implementation</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>	<p>Multi-functionality</p> <p>Duration of implementation</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>		
<p>Multi-functionality</p> <p>Time interval of sustainability</p> <p>9</p> <p>more equal more</p> <p><input type="checkbox"/> I cannot provide a judgment</p>			

Figure 7b - GOWARE WEB-Interface: in these boxes, the judgments for all the comparisons (ten) between the five criteria are provided.



Once the User has assigned the score to all the comparisons, GOWARE is able to:

- calculate the relative weight of each criterion (yellow box in Fig. 8);
- evaluate the consistency of the User's judgments (orange box in Fig. 8);
- provide the number of suitable BMPs (blue box in Fig. 8).

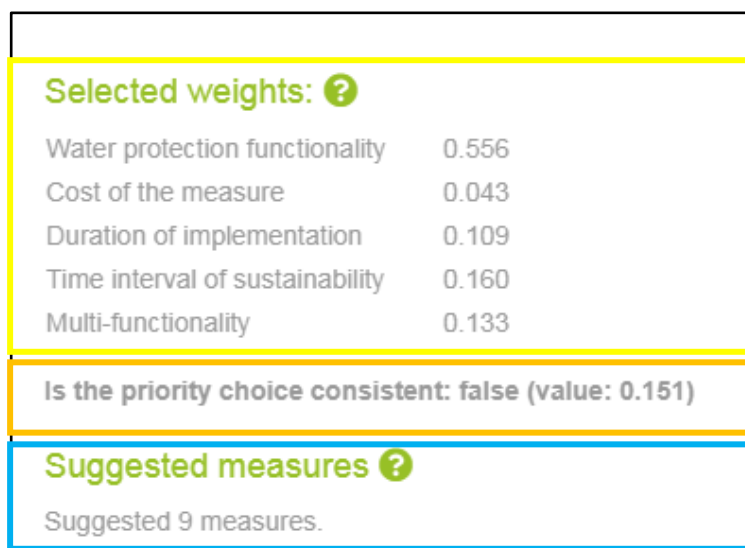


Figure 8 - GOWARE WEB-Interface: analysis results (priority weights, Consistency Factor value and number of suggested BMPs).

In Fig. 9, the list of the suitable practices selected from the catalogue and related information regarding their characteristics are shown.

	Score	Name	Land cover/use	Topographic settings	Adaptation target	Planning time horizon	Water protection functionality	Cost of the measure	Duration of implementation	Time interval of sustainability	Multi-functionality
+	0.88	Investments for storage of manure and training of farmers	Grassland	Mixed settings	Water quality	Operational (day by day)	★★★★★	★★★	★★★★★	★★★★★	★★★★★
+	0.67	Implementation of measures for advisory and financial support to avoid conversion of grassland to field	Grassland	Mixed settings	Water quantity / Water quality / Flood mitigation	Operational (day by day)	★★★★★	★★★	★★★★★	★★★★★	★★★★★
+	0.63	Extensification of land-use activities on grasslands and reduction of the use of heavy machinery	Grassland	Mixed settings	Water quantity / Water quality / Flood mitigation	Operational (day by day)	★★★★★	★★★	★★★★★	★★★★★	★★★★★

Figure 9 - GOWARE WEB-Interface: analysis results (list of suitable BMPs).

As shown in Fig. 10, for each BMP additional information is displayed by clicking on the green bottom on the left side. The additional information accounts for:

- 1) Key Type of Measures (KTM) provided in the Water Framework Directive (2000/60/EC), indicated by a number from 1 to 25 (see Annex 1);
- 2) EU legislation related to the practices (see Annex 2);
- 3) Measures included in the European Agricultural Fund for Rural Development (2007-2013), indicated by a three-digit number referred to the Axis of reference (see Annex 3);
- 4) Other relevant resources of reference for the practices, including grey literature, peer-reviewed papers and EU Projects;
- 5) A specific label regarding to the nature of the practice (governance, structural, land use management);
- 6) Additional Project Measures (APM), indicated by a number from 1 to 5 corresponding to one of the five measures proposed in PROLINE-CE (see Annex 4).

KTM	2, 12, 17
EU legislation related to the measure	Groundwater Directive (2006/118/EC); Nitrates Directive (91/676/EEC); Drinking Water Directive (98/83/EC); Fertilisers Regulation (EC Regulation N. 2003/2003); Environmental Quality Standards Directive (2013/39/EU); Common Agricultural Policy (CAP)
European Agriculture Fund for Rural Development (class)	213
Other reference documents	
Label	Governance
APM	1

Figure 10 - GOWARE WEB-Interface: analysis results (list of additional information provided for each BMP).

Finally, once the list of suitable BMPs is displayed, the User can complete her/his activity by exporting the suggested measures' list to an Excel file by using the "Export to excel" bottom. Before saving the results, the User is asked to provide information about "Type of institution" (by selecting a single choice between Governmental, Educational, Research, Company, NGO, Public utility, Specific area manager, Person, Other - Fig. 11a, b) and her/his "Professional background" (by selecting a single choice between: Agriculture studies, Civil engineering studies, Environmental studies, Geology studies, Geography studies, Chemistry studies, Biology studies, Forest studies, Landscape studies, Social sciences studies, Economy studies, Other Fig. 11a, c).

Figure 11 - GOWARE WEB-Interface: exporting the results. a) Required User's personal information; b) Type of institution; c) Professional background.



6. References

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Annex 1

List of Key Type of Measures (KTM):

- KTM1. Construction or upgrades of wastewater treatment plants
- KTM2. Reduce nutrient pollution from agriculture
- KTM3. Reduce pesticides pollution from agriculture
- KTM4. Remediation of contaminated sites (historical pollution including sediments, groundwater, soil)
- KTM5. Improving longitudinal continuity (e.g. establishing fish passes, demolishing old dams)
- KTM6. Improving hydromorphological conditions of water bodies other than longitudinal continuity
- KTM7. Improvements in flow regime and/or establishment of ecological flows
- KTM8. Water efficiency technical measures for irrigation, industry, energy and households
- KTM9. Water pricing policy measures for the implementation of the recovery of cost of water services from households
- KTM10. Water pricing policy measures for the implementation of the recovery of cost of water services from industry
- KTM11. Water pricing policy measures for the implementation of the recovery of cost of water services from agriculture
- KTM12. Advisory services for agriculture
- KTM13. Drinking water protection measures (e.g. establishment of safeguard zones, buffer zones etc.)
- KTM14. Research, improvement of knowledge base reducing uncertainty
- KTM15. 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
- KTM16. Upgrades or improvements of industrial wastewater treatment plants (including farms)
- KTM17. Measures to reduce sediment from soil erosion and surface run-off
- KTM18. Measures to prevent or control the adverse impacts of invasive alien species and introduced diseases
- KTM19. Measures to prevent or control the adverse impacts of recreation including angling
- KTM20. Measures to prevent or control the adverse impacts of fishing and other exploitation/removal of animal and plants
- KTM21. Measures to prevent or control the input of pollution from urban areas, transport and built infrastructure



KTM22. Measures to prevent or control the input of pollution from forestry

KTM23. Natural water retention measures

KTM24. Adaptation to climate change

KTM25. Measures to counteract acidification



Annex 2

List of EU legislations:

- Groundwater Directive 2006/118/EC
- Priority Substances Directive 2013/39/EU
- Marine Strategy Framework Directive 2008/56/EC (MSFD)
- Nitrates Directive 91/676/EEC (ND)
- Floods Directive 2007/60/EC (FD)
- Urban Waste Water Treatment Directive 91/271/EEC (UWWTD)
- Drinking Water Directive 98/83/EC (DWD)
- Bathing Water Directive 2006/7/EC)
- Regulation (EC) N° 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
- Industrial Emission Directive 2010/75/EU (IED)
- Sewage Sludge Directive 86/278/EEC (SSD)
- SEVESO Directive 82/501/EEC
- Environmental liability with regard to the prevention and remedying of environmental damage Directive 2004/35/EC
- Fertiliser Regulation N° 2003/2003
- The Biocide Products Regulation N° 528/2012 (BPR)
- The Plant Protection Products Regulation N° 1107/2009 (PPPR)
- The Cosmetic Products Regulation N° 1223/2009 (CPR)
- Waste Directive 2008/98/EC
- Environmental Quality Standards Directive 2013/39/EU
- Habitat Directive 92/43/EEC
- Birds directive 2009/147/EC
- EU Regulation 1143/2014 on Invasive Alien Species
- Commission decision establishing a Community civil protection mechanism 2007/779/EC
- Common Agricultural Policy (CAP)



Annex 3

List of Rural Development Measures proposed by the EAFRD (2007-2013) - Axis 2: Environment, land management:

- 211 - Natural handicap payments to farmers in mountain areas
- 212 - Payments to farmers in areas with handicaps other than mountain area
- 213 - Natura 2000 payments and payments linked to Directive 2000/60/EC
- 214 - Agri-environment payments
- 215 - Animal welfare payments
- 216 - Non-productive investments
- 221 - First afforestation of agricultural land
- 222 - First establishment of agroforestry systems on agricultural land
- 223 - First afforestation of non-agricultural land
- 224 - Natura 2000 payments
- 225 - Forest-environment payments
- 226 - Restoring forestry potential and introducing prevention actions
- 227 - Non-productive investments



Annex 4

List of Additional Project Measures (APM):

APM1: Improved permitting, control and supervision procedures

APM2: Regulatory processes regarding flood risk management

APM3: Improved financing mechanisms for all water

APM4: Landslide and erosion control measures

APM5: Improved understanding of the impacts of different man-made structures and infrastructure potentially affecting flood flows