PROLINE-CE

WORKPACKAGE T3, ACTIVITY T3.2

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

D.T3.2.1 ROADMAP TO TRANSNATIONAL ADAPTATION FOR INTEGRATED LAND USE

March, 2019

Lead Institution	CMCC
Lead Author/s	Guido Rianna, Monia Santini
Contributor/s	Angela Rizzo, Barbara Čenčur Curk, Primož Banovec
Date last release	March 2019

Contributors, name and surname	Institution
Guido Rianna	CMCC Foundation
Monia Santini	CMCC Foundation
Angela Rizzo	CMCC Foundation
Barbara Čenčur Curk	University of Ljubljana, Faculty of Natural Sciences and Engineering
Primož Banovec	University of Ljubljana, Faculty of Civil and Geodetic Engineering

Sommario

1. Introduction

The Deliverable D.T3.2.1 "*Roadmap to transnational adaptation for integrated land use*" was initially thought as a Concept Report, defining the necessary steps for reaching a transnational adaptation plan for integrated land use. The Deliverable would have included an operational definition of essential management adaptation measures towards the protection of drinking water resources, including those against flood events. During the project development, thanks to a better and increased awareness by PPs about the needs of end-users, stakeholders and decision makers, and building on intensive literature review, as well as on exchanges and discussions among PPs, the Deliverable was partially re-interpreted, and its content better defined, to ensure higher concreteness and practicality. Specifically, the tool to be developed is designed to support all the stakeholders for proper selecting the Best Management Practices (BMPs) (indistinctly referred to as "measures" or "practices" hereafter) for drinking water protection and joint flood risk mitigation more effective or suitable according the geomorphological features, regulatory constraints and objectives in the area of interest.

Indeed, for complex systems requiring the evaluation of impacts of joint measures, decision making process results always challenging. It is heavily dependent on specific local features (topological, land use, climate), already deployed measures, and other all with significant uncertainties. The decision making is therefore almost always in the hand of skilled practitioners which can, based upon the available information (e.g. previous similar cases, findings provided by modelling or observation) and recognized constraints (e.g. location, costs, time), decide upon the priority interventions. In order to underpin experts in avoiding mistakes Decision Support Tools (DST) are usually employed serving above all as pre-defined check-list standardizing the decision-making process itself.

The D.T3.2.1 was thus intended as a preliminary design for a Web&IT DST, aiming at operatively advising interested end-users about BMPs to be selected, prioritized, promoted and/or applied in their activities to ensure/enhance drinking water protection and flood risk mitigation.

Also, during the project meeting held in Waidhofen in November 2018, it was agreed that the Deliverable D.T3.2.1 acts as interim product – with concept purposes - anticipating the successive Deliverable D.T3.2.2 of Activity T3.2, "*Transnational adaptation plan for integrated land use management*", where the current DST design will be implemented and tested to facilitate and speed-up its successive put into practice. This will be possible also thanks to PPs-users' interactions within Pilot Studies (WP T2) and by exploiting the Deliverable D.T3.3.1 "*Local application: recommendations of optimal structures for sustainable land use*".

Essentially, the PROLINE DST relies on the BMPs previously identified in Activity T1.2, and consolidated in the Deliverable D.T1.2.2 "*Transnational best management practice report*". Further, tables from Deliverable D.T4.1.1 "*Compilation of delineated objectives for sustainable function-oriented land use management*" (this already based on D.T1.2.2) can be used for further confirming BMPs on which stakeholders and decision makers can commit themselves through the final PROLINE-CE main outputs: **GOWARE and DriFLU Charta.**

In the following Sections, the DST concept and the main reasoning behind are described, showing how the information collected during the PROLINE-CE Work Packages is exploited, and adding the possibility to take into account specific choices by users, i.e. in ranking their preferences while prioritizing different BMPs according to specific characterization criteria.

2. PROLINE Decision Support Tool – General Description

The DST reasoning follows a bottom-up approach, i.e. it starts from the D.T1.2.2, where Tables of BMPs (about 150 in total) are reported for the different categories of Land Cover/Use (Forests, Agriculture, Wetlands, Grasslands) and of Special Sites (Riparian and Dry areas). Further, any of the above category distinguishes into mountain- and plain-dominant topographic settings. Moreover, in Deliverable D.T1.2.2, four main criteria are considered to characterize the BMPs: 1) Water protection functionality; 2) Cost of the BMP; 3) Duration of implementation; and 4) Time interval of sustainability. Based on the expert elicitation of PPs and their network of stakeholders, these characteristics were qualitatively classified, for each BMP, into levels ranging from "high" to "low" - for 1) and 2) - or "long" to "short" when referring to time-based characteristics – i.e. for 3) and 4).

For the purpose of the DST, the above four criteria have been better defined during WP.T3 activities, in particular the fourth one was slightly revised, and a fifth one added, as better explained in Section 2.2 below. Furthermore, during the development phase, the land use categories have been modified (Forests, Agriculture, Wetlands, Grasslands, Urban/Industrial) and a set of general water management strategies has been included in the final Table to ensure consistency with those assumed as reference in DRIFLUCHARTA.

Thus, the BMPs' characterization, and classification therein, is partially pre-compiled (see D.T1.2.2), while the qualitative classification of the revised/new elements will be further adjusted/filled by circulating the BMP table among PPs to have additional advices and expert elicitation. After that, the finalized characterization will be fully embedded in the DST.

Successively, the user can directly or indirectly intervene on other components consisting in:

a) Scoping the analysis, to outline the context (e.g. territorial settings, adaptation target, time horizons of intervention) in which the researched BMPs would be suitable to act, thus allowing to reduce the set of BMPs to be considered with respect to the initial catalogue in D.T1.2.2;

b) Ranking the preferences, to express the importance he/she wants to give to the different BMPs' characterization criteria (i.e. those described in Sect 2.2);

c) Prioritizing the suitable BMPs, to enable automatic ranking of sub-selected BMPs based on the points *a)* and *b)* here above.

These steps *a)*, *b)* and *c)* are better detailed in the next Sections.

2.1. Scoping the analysis

From the user perspective, the *analysis scoping* consists in identifying the main context appropriately representing the issues tackled in his/her usual operations or decision-making, aiming at reinforcing/facilitating the whole decision process.

From a "territorial" point of view, the user can:

i) look at single land use/cover (forest, agriculture, wetland, grassland, urban and industrial area) or consider the general water management strategies for heterogeneous landscapes;

ii) define topographic attributes, limiting the choice among plain, mountain and mixed settings.

The above territorial attributes are included in D.T1.2.2.

However, in designing the DST during Activity T3.2, the analysis context can be also described, thanks to PPs' expertise, in terms of other factors related to:

iii) the issue/adaptation target each practice/measure can respond to (single or combined among water quantity, water quality, and flood risk mitigation);

iv) the time horizon for action: Operational (*day-by-day*); Strategic (*up to 5 years*)

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

This process of *analysis scoping* recalls a Decision Tree algorithm structure (Figure 1), but the decision process is simplified as, in this case, there is no mandatory order in choosing options within the four – *i)* to *iv)* - steps above, since in general there is no exclusivity for an option after outlining any other option before. The DST, in this scoping process, works so that whenever the user selects an option along the steps above, all the BMPs not representing this option are "switched off". At the end, the scoping can result in one or more BMP(s).

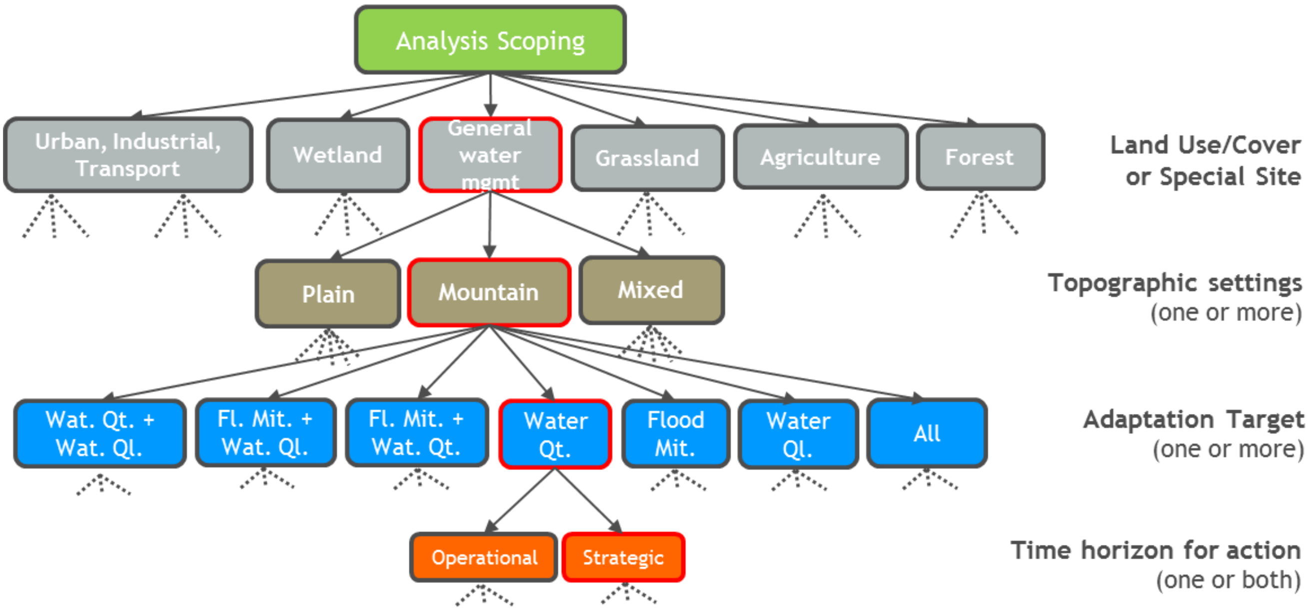

Figure 1 - Example of the structure of the DST - Scoping Analysis. The four steps of choices identified in Sect. 2.1 are shown on different lines and with different colours; the multiple choices are represented by arrows, while an illustrative process of consecutive choices is highlighted through red borders. Dashed lines are simplifications of the overall branching due to space constraints. There could be no fixed order in the four steps to select the options, the order shown by arrows is just an example of what could be implemented in the DST for logical purposes. Abbreviations: Wat = Water; Qt. = Quantity; Ql. = Quality; Fl. Mit. = Flood Risk Mitigation.

2.2. Ranking the preferences in BMP characteristics

For BMP ranking, five main characterization criteria are considered:

1) **Water protection functionality**, intended as the effectiveness for the main Adaptation target in terms of protection of water resources and flood risk mitigation;

2) **Cost of the measure**, defined as a general cost to performance ratio. Sometimes this ratio is very difficult to assess, due to local peculiarities;

3) **Time necessary for the implementation** of the BMP. Some BMPs could be implemented quite rapidly (sealing of well heads) because they usually do not require demanding permitting procedure and property rights. Some other can have long implementation timeframe, even several years (e.g. retention basins);

4) **Robustness of BMP**, intended as resilience also to external further forcing not planned in design phase or perfectly recognizable (e.g. adaptation to climate change). This is a slight revision of the attribute “Time interval of sustainability” present in D.T1.2.2;

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

In the DST, a user is enabled to express, in a pairwise comparison of the above criteria (i.e. considering the criteria two-by-two), the “relative importance” between criteria (Table 1).

Table 1- The semantic scale used in AHP [modified from Ramanathan (2001)]

Intensity of importance	Definition
1	Equal importance
3	Weak importance of Ai over Aj
5	Strong importance
7	very strong or demonstrated importance
9	Extreme, absolute importance
Reciprocal of the above judgments	If Ai has one of the above judgments assigned to it when compared with Aj, then Aj has the reciprocal value when compared with Ai

For example, a user could be only interested on the water protection function of a practice/measure, regardless of costs, or in other cases, available budgets are so constraining that the remaining characteristics take second place. These user’s preferences are then elaborated recurring to Analytical Hierarchy Process (AHP) approaches (see Sect. 2.3).

2.3. Prioritizing the suitable BMPs

As soon as the user has:

- scoped the analysis context he/she is interested on, which allows the DTS to extract a sub-set of suitable BMPs from the initial catalogue of D.T1.2.2 (see Sect. 2.1); and

- expressed, through weights, the “relative importance” that each BMP characterization criterion assume vs. any other characterization criterion in his/her specific field of operation or action capability (see Sect. 2.2);

these weights need to be combined with the qualitative classification of the characterization criteria, reported in DT1.2.2 or newly filled during WP T3.2.

To this aim, first those qualitative classes are flagged with quantitative values indicatively ranging from 1 (to indicate the worst quality, i.e. low functionality, high costs, long times, low robustness, reduced multi-functionality) to 5 (to indicate the best quality).

Then, to translate the above weighting of the “relative importance” into absolute preferences for the different characterization criteria, it was decided that the DST embeds an Analytic Hierarchy Process (AHP; Saaty et al., 1980). The AHP is an effective tool for dealing with complex decision making, and it may aid the decision makers to set priorities and make the best decision. Operatively, the AHP can be implemented in three simple consecutive steps: 1) Computing the vector of “relative importance”, i.e. the user preference weights given to each characterization criterion vs. any other characterization criterion; 2) Filling the (symmetric) matrix of these weights, see e.g. Figure 2; 3) Calculating the absolute weight (user’s preference) of each characterization criterion.

AHP Multi-criteria analysis					
Pairwise comparison	**Water protection functionality**	**Cost of the measure**	**Duration of implementation**	**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 implementation	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

Figure 2 - Illustrative example of symmetric matrix to apply the AHP algorithm: relative weights of each characteristics in the rows vs. that in the column are reported. Note that white cells are reciprocal of the light-yellow cells with respect to the light grey diagonal.

For each BMP characterization criterion, its quantitative classification is thus operated with the absolute preference, to finally obtain the ranking of the identified sub-set of suitable BMPs. Further, the AHP should incorporate a useful technique for checking the consistency of the decision maker’s evaluations, thus reducing the bias in the decision-making process (see for example Figure 3). Within the activities for DST development, desk review concerning several approaches proposed in the scientific literature for evaluation of Priority vectors (weights provided by pairwise comparison analysis) and consistency have been performing (Brunelli, 2015). Final choice will be in line with the State-of-the-art, minimizing as some drawbacks recognized in the approach (e.g. rank reversal issue) as time and computational resources required by the overall estimation.

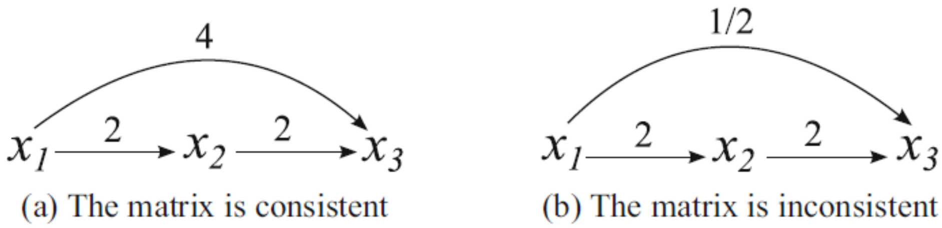

Figure 3 Examples of consistent and inconsistent transitivities (Brunelli, 2015)

3. Conclusions

In WP T3, PROLINE-CE aims at providing interested users and stakeholders with a Decision Support Tool (DST) guiding them in selecting and prioritizing one or more Best Management Practice(s) towards drinking water protection, including mitigation against flood risks.

This Deliverable D.T3.2.1 presents a concept of the DST, describing its main features that will be better refined during the DST full implementation (through both offline and Web tool, for test phases and final release, respectively).

First of all, it is expected that the DST takes advantage of the information collected in WP T1/Deliverable D.T1.2.2 to help outlining the application context (in terms of land cover/use, special sites and topographic settings) and to characterize the Best Management Practices (BMPs) according to five criteria: *1)* Water protection functionality, *2)* Cost of the BMP, *3)* Time for the BMP implementation, *4)* Robustness of the BMP, and *5)* Multi-functionality. The former three criteria were qualitatively flagged during activities in WP T1 by PPs with the help of their stakeholders' network. This is somewhat valid for the fourth one, which tends to partially overlap the previous criterion used in WP T1 "Time interval of sustainability", while the fifth one "Multi-functionality" is totally new and is classified during WP T3.

Further, during current activities in WP T3, the BMPs are being further described in terms of the Adaptation Target (water quantity, water quality and food risk mitigation) and the short or long time-horizon for action (operational or strategic). The DST can also enable users to express the subjective and relative importance they associate to the five characterization criteria above, in a pairwise comparison, to finally allow the DST deriving the absolute preferences among criteria and ranking the suitable BMPs within the sub-set previously identified for the outlined context.

4. References

- Brunelli, M. (2015) *Introduction to Analytic Hierarchy Process* Springer Briefs in Operations Research doi: 10.1007/978-3-319-12502-2
- Ramanathan, R. (2001) *A note on the use of the analytic hierarchy process for environmental impact assessment* Journal of Environmental Management 63, 27–35 doi:10.1006/jema.2001.0455
- Saaty, T.L. (1980) *Multicriteria decision making - the analytic hierarchy process. Planning, priority setting, resource allocation*, RWS Publishing, Pittsburgh