# DEVELOPING THE GIS BASED METHOD TO ASSESS CUMULATIVE EFFECT OF N(S)WRM AT THE RIVER BASIN SCALE

D.T2.2.1

Static method to assess cumulative effect of N(S)WRM in the river basins

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# 1. Introduction

The aim of the activity is to develop the GIS based method (static method) to assess cumulative effect of natural small water retention measures (N(S)WRM) at the river basin scale. This could be quite tough task as the effect of natural small water retention measures is rather local. And also requirements of different stakeholders in the river basin (area) are often contradictory, as for example the requirement of nature protection is to keep water in the locality to enhance biodiversity but the requirement of water managers is to convey water away in order to assure flood protection of the locality.

The purpose is to develop algorithms using effectiveness values of N(S)WRMs identified through literature or research results review of consortia within activity D.T2.1.1. and which should be further consulted with experts in the particular field, as the values could be dependent on the local conditions within the regions. The approach should be progressive and should integrate GIS with developed preferably "simple" algorithms to assess effectiveness of different combinations of N(S)WRMs in their mutual synergism.

For this purpose the concept of the tool to assess the effectiveness of measures was proposed and is described in the following chapters.

# 2. Concept of the Static Method

The purpose of the Static Method is to enable the estimation of the effects of small retention (SR) program implementation in a simplified way, which does not require a time-consuming and costly to set up, detailed hydrological model of the analyzed area (catchment). It was assumed that, just like in the valorisation method of the analyzed catchment area, SPU is a unit in which SR activities will be defined and their effects will be evaluated. The assessment of program implementation effectiveness is expressed as the expected improvement of primary valorisation results for the catchment in terms of the needs for the development of small water retention measures.

The development of the method consists of the following stages:

1. Preparation of the regional catalogue of measures (also called activities);

2. Analysis of the effect of individual measures on the indicators used in the valorisation of needs for the development of small water retention measures;

3. Assessment of the interrelation between the intensity of activities and their effect on the results of valorisation;

4. Evaluation of the effects of the proposed program of measures.

The algorithm of proposed Static Method showing interrelation to primary valorisation results (Valorisation map) for the river basin and at least two variants of programmes of measures (the expert variant and the variant of local preferences) which will be proposed during Concept plan compilation for particular river basin is in Figure 1.

The method has a universal character due to the size of the analysed area and regional climatic and geographical conditions, but requires the involvement of experts with experience in planning and implementation of small water retention measures. Experts with knowledge in the following disciplines are required: hydrology, hydrogeology, agriculture, land improvement, hydrotechnics, forestry and ecology.

## 2.1. Preparation of the regional catalogue of measures

The regional catalogue of measures is based on the activities analyzed within the FRAMWAT project, which may affect the improvement of the catchment water retention and may be applied in the analyzed region (country). When developing a regional catalogue, the assumption was made that measures can be defined as **individual** activity (eg conversion of arable land into meadows in a specified area, construction of a polder or small water retention reservoir, reclamation of a lake with a defined area or construction of ponds) or as **aggregated** activities (e.g. implementation of agricultural practices that allow obtaining water retention, such as mulching, intercropping, green cover crops, controlled traffic farming, or restoration activities, such as wetland restoration, reconnection of oxbow lakes, floodplain restoration and management). Aggregated activities include a group of measures whose implementation affects in a similar way the improvement of catchment retention properties. The assessment of the effects of individual activities (within the aggregated cluster), without detailed field and model studies, is not possible.

The regional catalogue of measures should be prepared by an interdisciplinary team of experts with experience in the planning and implementation of small water retention activities. A regional catalogue of measures developed by Polish experts for the upland landscape, including the pilot basin of the Kamienna River. In addition to the universal activities that can be applied in different regions and landscapes, specific activities have been identified that may be of limited use in another region or type of landscape.


Figure 1. The algorithm of Static Method to assess effect of N(S)WRMs

## 2.2. Analysis of the effect of individual measures on the indicators used in the valorisation of needs for the development of small water retention measures

Work at this stage begins with the determination of valorisation indicators, which will improve (or deteriorate) as a result of the implementation of activities listed in the regional catalogue. One activity can have an effect on one or more indicators and in most cases, it can be assumed that the more indicators are improved, the greater the impact of a given action (measure) on the retention properties of the catchment. It was assumed that three levels of **intensity** of activities will be considered: **low**, **medium** and **high**, which correspond to three levels of expected improvement of catchment retention (eg small, medium and large). For each of the measures included in the regional catalogue, a definition of the intensity criterion of a given measure should be specified, eg the share of arable land transformed into permanent meadows or pastures in the SPU area, and threshold values defining individual intensity levels. There will be 4 values: **T0** - no effect, **Tlow** - the boundary between low and medium intensity, **Thigh** - the boundary between medium and high intensity, and **Tmax**, which corresponds to the maximum possible intensity of impact. In case of converting arable land into meadows or pastures, the Tmax value corresponds to the situation when 100% of the SPU area is occupied by arable land that will be converted into meadows or pastures. It is a difficult situation to achieve, although physically possible.

The threshold values for activity intensity levels are regional in nature, they may differ for countries or landscapes. These values, in addition to the estimate of the expected improvement of valorisation, which will be considered in the next stage (chapter 2.3), are the key parameters. Their determination should be carried out with the participation of an interdisciplinary team of experts.

## 2.3. Assessment of the interrelation between the intensity of activities and their effect on the results of valorisation

The measure of the effect of a given action, at a given intensity level, is the number of classes that will be improved (in general - that will be changed) in the valorisation results if the given activity is implemented with this intensity level. Such a concept requires determining for each activity included in the regional catalogue, the expected improvement of valorisation results if the action would be carried out with the highest possible intensity level and the expected improvement if the action was implemented with low or high (see chapter 2.2) intensity level.

In order to facilitate determination of the abovementioned thresholds, it was proposed that activities from the regional catalogue should be assigned to groups of activities (from 1 up to 5 groups), where each group has a similar effect on improving catchment retention capability (expressed through the expected improvement of valorisation). For each designated group of activities, it is, therefore, necessary to determine: i) the maximum improvement in valorisation that can be achieved as a result of any action belonging to this group with the maximum possible intensity level (**Emax**), and ii) how much of the defined maximum improvement can be achieved by implementing actions with low or high intensity level (see chapter 2.2). It was assumed that for each group different **Emax** values can be determined and the percentage of improvement corresponding to the lack of actions (**E%0**) and low (**E%low**) and high (**E%high**) intensity. On the basis of the given percentages, the effects of activities for intensity levels expressed an improvement of the valorisation class are calculated (**E0, Elow, Ehigh**, where Elow = E%low · Emax, Ehigh = E%high · Emax and E0 = E%0 · Emax = 0 ). It was assumed that the values between the threshold values of the effects on the intensity of activities have a linear relationship.

Exemplary relationships of intensities and effects for activities belonging to the 1st and 3rd group of activities are shown in Figure 2. Group 1 measures more significantly improve catchment retention and - according to the assumptions - valorisation results, then activities from group 3. For the first group Emax, 1 = 1,5, which means that any activity belonging to this group, carried out at the maximum possible level, will improve the results of valorisation by 1.5 classes.

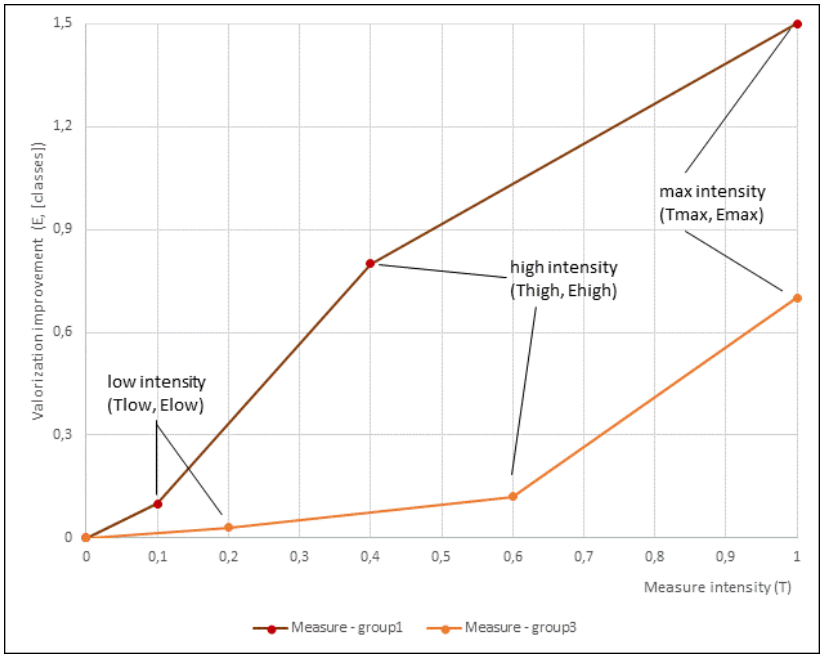

Figure 2. The dependence of the expected effects on improving the valorisation on the intensity of activities from group 1 and 3

The dependence of the expected improvement of valorisation (E) on the intensity of activities (T), E = f (T), is typically assigned to each activity belonging to a given group. In order to ensure greater flexibility of the evaluation in the **StaticTool** application, which will be further developed, the user will be allowed to make changes in **Emax, E0, Elow, Ehigh** values for individual activities. Therefore, it is possible to evaluate the proposed SR program on the basis of standard parameter values for groups or user-defined values.

The values of the expected valorisation results improvement (Emax, E0, Elow, Ehigh), as well as the previously defined thresholds for activity intensity levels, are the key parameters of the method of evaluating the effects of the activity program (program of measures) with the use of the **StaticTool**. For each measure included in the regional catalogue, the interrelation of valorisation improvement with intensity is determined, E = f (T), which is then used to assess small water retention measures programme (SWRMP) variant. The determination of these values should be carried out with the participation of an interdisciplinary team of experts.

## 2.4. Evaluation of the effects of the proposed program of measures

In estimating the effects of the analyzed variant of the SR program, expressed by improving the valorisation of the SR development needs, the dependence of improving valorisation on the intensity of SR activities (E = f (T)) and the set of activities proposed for implementation in individual SPUs in the pilot area are used. The set of proposed activities includes individual activities from the regional catalogue of measures, assigned to individual SPUs of the analyzed area. These activities are described by their intensity, as defined in stage 2 (chapter 2.2). The best presentation of the analyzed SWRMP variant would be therefore in the form of a table (PoNWRM) with the following proposed dimensions: number of rows equal to the number of SPU (**SPUn**) x number of columns corresponding to the number of activities in the regional catalogue (**nMeasures**). In individual cells of the table, the intensity of activities planned in the SPU has to be specified. It is necessary to prepare as many separate PoNWRM tables as there are analyzed options for the program of measures (eg the expert variant and the variant of local preferences).

After inputting to the **StaticTool** application a properly prepared table of measures (PoNWRM), the user of the application will call the VBA procedure and the partial valorization improvement values will be calculated. Those values are a result of the implementation of a

planned activity of a certain intensity in a given SPU. The expected improvement in the valorisation of individual SPUs is the sum of partial improvement if several activities/measures are planned in the SPU (the sum of partial improvement in rows). The overall improvement of valorisation in the entire catchment, characterizing the analyzed variant, is calculated as the sum of improvement in the SPU. It is also possible to determine the improvement in the catchment associated with each of the planned types of activities (the sum of partial improvement available in columns).

# 3. Conclusions

In the chapters above the proposal of Static Method to assess effectiveness of measures is described based on the actual development of other interrelated deliverables. The basic input into the method are results of valorization GIS method developed as D.T1.1.1. According the valorization results of the analysed area the user/stakeholder will propose a set of measures (individual or aggregated) in each particular SPUs of the analysed area with the aim to improve valorization results of particular SPUs.

As all the values which are necessary to pass through four main steps of the Static Method could change depending on region and local conditions of the analysed area, there is open space to propose with the team of interdisciplinary experts focused on effectiveness of measures to propose own local conditions depending values. But user/stakeholder would also have a possibility to use the values pre-defined by consortia.

As a next steps the project consortia will except tasks mentioned within chapter 2:

- propose at least two variants of programs of measures, so called Expert variant and Local preferences variant, these are in line with actual status of the development of the Concept plan (D.T2.3.1)
- test the proposed Static Method in the Pilot Area
- develop the **StaticTool** application
- try to test the results of Static Method by applying a Dynamic modelling, which could be a challenge

Partners will promote the Static Method, Concept plan or Dynamic modelling issues an National trainings to be held in the first half of 2019 and due to stakeholders meetings mainly with experts with knowledge in the effectiveness of measures and it is

recommended to contact experts from the field of hydrology, hydrogeology, agriculture, land improvement, hydrotechnics, forestry and ecology.