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

D.T2.2.2 - Reports from testing the static method to assess cumulative effect of N(S)WRM (Pilot action)

Testing in the Blh pilot catchment

Slovak Water Management Enterprise

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1. INTRODUCTION

The purpose of developing the StaticTool method and the computer application StaticTool.xlsm is to enable the estimation of the effects of the implementation of a program of natural small water retention measures (PoNSWRM, Program of measures) in a simplified way, which does not require the time-consuming and costly development of detailed models, hydrological or / and hydraulic, of the analysed catchment. Method is making use of a grading based on expert knowledge and is used to compare variants of the NSWRM program.

The potential effects of individual NSWR measures may be different, depending on the climatic and physiographic conditions (e.g. slopes, ground permeability) of the analysed area, so the method parameters should be adapted to local conditions (climate type, landscape type). The StaticTool method thus consists of two parts:

- developing method parameters for local conditions,
- estimation of the effects of activities planned under the Program of Natural Small Water Retention Measures.

The StaticTool method assumes that the expected effect of the PoNSWRM is to improve catchment retention properties, which is understood as increasing low flows (LowQ), reducing high flows (HighQ) and / or limiting the load of pollutants yielded from the catchment area (Qual). This effect depends on the planned measures, in particular: i) their type and ii) the level of intensity. The measures included in the StaticTool method are summarized in the local catalogue of measures. For each measure, an intensity criterion is formulated, and threshold values are defined that correspond to the characteristic intensity levels (low, medium, high). Each measure is also assigned the expected improvement of retention properties of the SPU, expressed on a point scale (0 - 5 points). The greatest improvement that can be achieved (maximum points for a given measure) corresponds to the implementation of the measure with maximum intensity. For lower intensity levels, the assigned grades are proportional to the level of intensity of planned measure. Hence, developing parameters of the StaticTool method means defining a set of functions that make grade assessment dependent on the type of planned measures and their intensity for each measure from the local catalogue.

The StaticTool method and the StaticTool.xlsm application were developed as part of the project FramWat, Work Package T2 (Effectiveness of the Natural Small Water Retention Measure), activity A.T2.2 (Developing the GIS based method to assess cumulative effect of N(S)WRM at the river basin scale), deliverable D.T2.2.1 (Static method to assess cumulative effect of N(S)WRM in the river basins). A detailed description of the methodology is in a separate file created by the author of the program. This report presents the results of testing the static method to assess cumulative effect of N(S)WRM via developed application (program) StaticTool.xlsm for the Slovak Pilot Catchment of the Blh River within Slaná River Basin.

2. DESCRIPTION OF INPUT DATA PREPARATION

The first step of the work with the StaticTool.xlsm program, it was necessary to specify the N(S)WRM types, for which calculations will be carried out for expert variant and for variant of local preferences. There were used measure types proposed within Concept plan preparation and these are showed in Fig.1 for both expert variant and for local preferences variant. For more information on variants see report on Concept plan preparation (4).

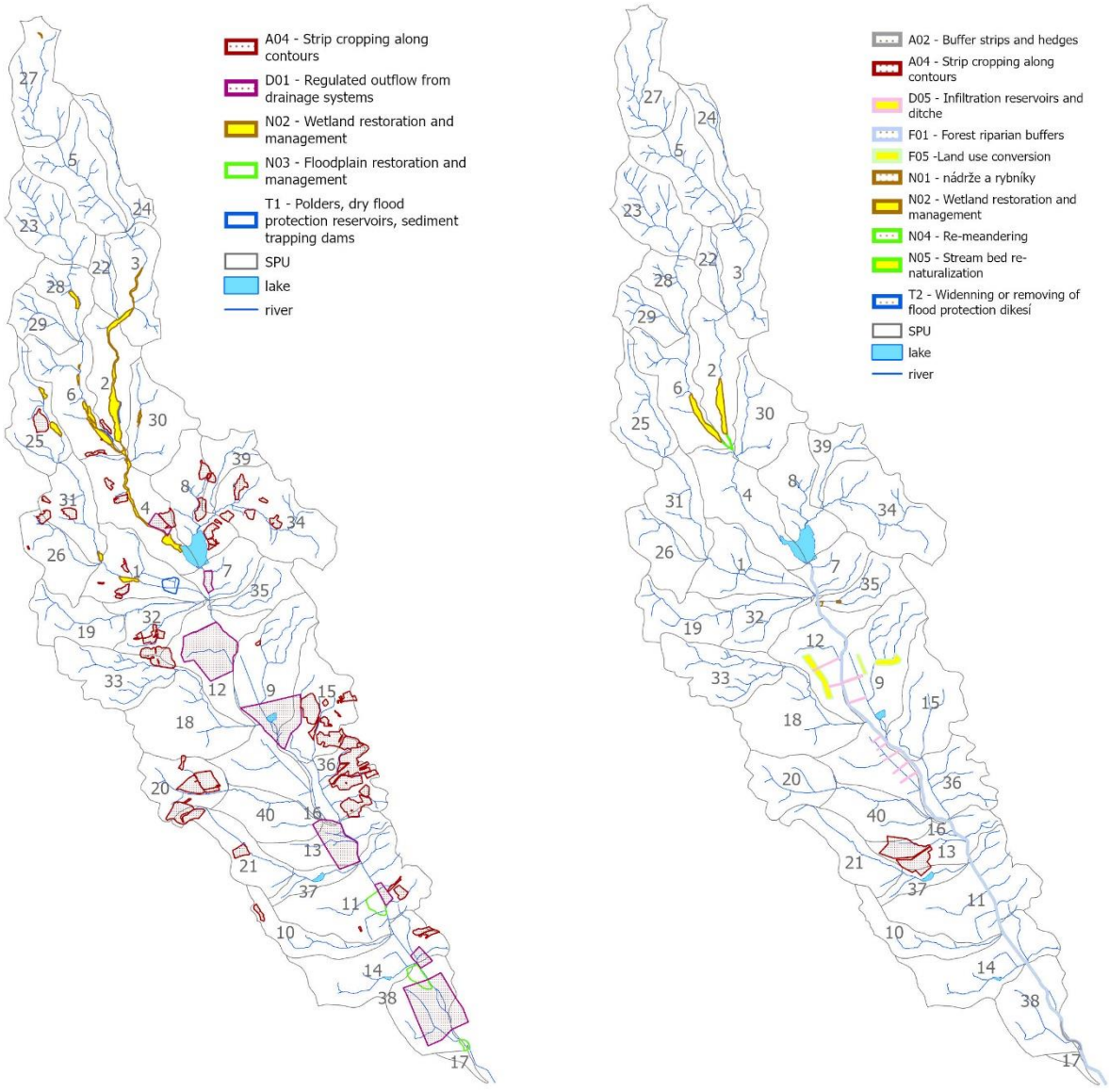

Fig. 1 Type and localization of measures proposed for expert variant and for local preferences variant

The types of measures are showed also in the table below (Tab. 1) and for all chosen individual measures the basic characteristic necessary to quantify criteria in the next steps of Statictool.xlsm application are calculated.

Tab. 1 Basic parameters of proposed measures for expert variant (Exp) and for local preferences variant (Loc)

Code	Variant	Type NSWRM	Name	Parameters	Count of NSWRM	Area [ha]	Length [km]
A04	Exp	Strip cropping along contours		tesne siate plodiny sa striedajú s riadkovými plodinami v minimálnej šírke pásov - 15 m	54	915	-
D01	Exp	Regulated outflow from drainage systems		na území s existujúcimi melioračnými zariadeniami sa navrhujú opatrenia na regulovaný odtok vody z drenážnych systémov	8	1268	-
N02	Exp	Wetland restoration and management		odstránenie inváznych druhov rastlín a drevín, výsadba pôvodných druhov drevín, obnova lúčnych ekosystémov	15	225	-
N03	Exp	Floodplain restoration and management		4 priepusty	4	115	-
T1	Exp	Polders, dry flood protection reservoirs, sediment trapping dams	polder Papča	Rozloha nádrže: 30,35 ha, celková kapacita: 287600 m3, dĺžka priehrady - asi 643 m, výška vzhľadom na dno doliny - 6 m	1	30,35	-
T1	Exp	Polders, dry flood protection reservoirs, sediment trapping dams	polder Hrušovo 1	Rozloha nádrže: 28,67 ha, celková kapacita: 275000 m3, dĺžka priehrady - asi 1041 m, výška vzhľadom na dno doliny - 10 m	1	28,67	-
T1	Exp	Polders, dry flood protection reservoirs, sediment trapping dams	polder Hrušovo 2	Rozloha nádrže: 18,08 ha, celková kapacita: 158200 m3, dĺžka priehrady - asi 761 m, výška vzhľadom na dno doliny - 7 m	1	18,08	-
A02	Loc	Buffer strips and hedges		výsadba drevín na bočnú stranu hrádze Blh-Ivanice	1	2	1,5
A04	Loc	Strip cropping along contours		tesne siate plodiny sa striedajú s riadkovými plodinami v minimálnej šírke pásov - 15 m	2	162	-

Code	Variant	Type NSWRM	Name	Parameters	Count of NSWRM	Area [ha]	Length [km]
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 47 m, dĺžka 789 m	1	3,7	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 40 m, dĺžka 802 m	1	3,23	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 31 m, dĺžka 740 m	1	2,31	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 26 m, dĺžka 455 m	1	1,2	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 30 m, dĺžka 405 m	1	1,21	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 49 m, dĺžka 697 m	1	3,41	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 48 m, dĺžka 460 m	1	2,2	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 63 m, dĺžka 796 m	1	5,08	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 33 m, dĺžka 1103 m	1	3,64	-
F01	Loc	Forest riparian buffers		výsadba stromu každých 6 metrov (vŕba, topol, jelša)	1	161	27,63
F05	Loc	Land use conversion		dubovo-brestovo-jasenové nížinné lužné lesy	3	79	-
N01	Loc	Basins and ponds		Rozloha nádrže: 1,82 ha, celková kapacita: 54600 m3, dĺžka 180 m, šírka 101 m	1	1,82	-
N01	Loc	Basins and ponds		Rozloha nádrže: 1,44 ha, celková kapacita: 43200 m3, dĺžka 164 m, šírka 88 m	1	1,44	-

Code	Variant	Type NSWRM	Name	Parameters	Count of NSWRM	Area [ha]	Length [km]
N02	Loc	Wetland restoration and management		odstránenie inváznych druhov rastlín a drevín, výsadba pôvodných druhov drevín, obnova lúčnych ekosystémov	3	240	-
N04	Loc	Re-meandering			1	161	27,63
N05	Loc	Stream bed re-naturalization			2	16,34	2,33
T2	Loc	Widenning or removing of flood protection dikes			1	161	-

At the initial stage, individual N(S)WRMs were merged under one (of the same) type and then aggregation was performed. Aggregated measures include a group of measures whose implementation in a similar way improves the retention properties of the catchment area, and assessment of the effects of individual activities, without detailed field or model studies at the current level of knowledge, is not possible. For the expert variant 4 records (A04 – WRAL; N02, N03 – ER; D01 - BPDA; T1) were received and for the local preferences variant 10 records (A02; A04 – WRAL; F01; F05 - AF; N01; N02 - ER; N04; N05 - BPRC; D05 - BPDA; T2) for variant local, see records in Tab. 2 and Tab. 3).

Tab. 2 Aggregated measures identification – expert variant

No	Individual measure ID	Individual measure name	Aggregated measure ID	Aggregated measure name
1	A04	Strip cropping along contours	WRAL	WRAL - best practices for Water Retention in Agricultural Lands
2	N02	Wetlands restoration and management	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems
3	N03	Floodplain restoration and management	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems
4	D01	Regulated outflow from drainage systems	BPDA	BPDA - Best Practices on Drained Areas
5	T1	Polders, dry flood protection reservoirs, sediment trapping dams	T1	Polders, dry flood protection reservoirs, sediment trapping dams

Tab. 3 Aggregated measure identification – local preferences variant

No	Individual measure ID	Individual measure name	Aggregated measure ID	Aggregated measure name
1	A02	Buffer strips and hedges	A02	Buffer strips and hedges
2	A04	Strip cropping along contours	WRAL	WRAL - best practices for Water Retention in Agricultural Lands
3	F01	Forest riparian buffers	F01	Forest riparian buffers
4	F05	Land use conversion	AF	AF - Afforestation
5	N01	Basins and ponds	N01	Basins and ponds

No	Individual measure ID	Individual measure name	Aggregated measure ID	Aggregated measure name
6	N02	Wetland restoration and management	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems
7	N04	Re-meandering	N04	Re-meandering
8	N05	Stream bed re-naturalization	BPRC	BPRC – natural channels and Best Practises of River Channels maintenance
9	D05	Infiltration reservoirs and ditches	BPDA	BPDA - Best Practices on Drained Areas
10	T2	Widening or removing of flood protection dikes	T2	Widening or removing of flood protection dikes

In the local preferences variant there exist only one individual measure relevant to one type of aggregated measure, so in fact no aggregation of measures in necessary and codes of individual measures may not be necessary replaced by codes of aggregated measures in the calculation below.

For each measure, the intensity criteria and the threshold values for characteristic intensity levels were defined. According to the assumptions of the StaticTool method, the expected improvement in the catchment retention properties depends on the type and level of intensity of planned measures. Three levels of measures' intensity were distinguished: low, medium and high. They correspond to three levels of the expected improvement in the catchment retention properties (e.g. small, average and large). Four threshold values were used: T0 – no action, Tlow – the boundary between low and medium intensity, Thigh – the limit between medium and high intensity and Tmax, which corresponds to the hypothetical maximum possible intensity of measure. There were determined expert assessments of the impact of aggregated measures on three elements of the catchment retention properties (low flows, high flows and erosion), with maximum intensity of measures' application. There was needed to formulate a general assessment of measures (three above-mentioned elements together) and defining effect coefficients for lower than maximum intensity of measures. For the assessment of the impact of aggregated measures on three elements of the catchment retention properties a 6-grade scale was adopted from 0 to 5, where:

- 0 - means no positive impact on the retention properties of the catchment area, and
- 5 – means very high positive impact on the retention properties of the catchment area.

The tables below show the parameters used for calculations in the expert and local preferences variants (Tab. 4- Tab. 7).

Tab. 4 Impact of measures on three elements of the catchment retention properties – expert variant

No	Code	Aggregated measure name	Low flows	High flows	Qual Erosion	AVG
1	WRAL/A04	WRAL - best practices for Water Retention in Agricultural Lands	0	2	4	2.00
2	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems	0	5	4	3.00
3	BPDA/D01	BPDA - Best Practices on Drained Areas	2	3	2	2.33
4	T1	Polders, dry flood protection reservoirs, sediment trapping dams	0	5	3	2.67

Tab. 5 Impact of measures on three elements of the catchment retention properties - local variant

No	Code	Aggregated measure name	Low flows	High flows	Qual Erosion	AVG
1	A02	Buffer strips and hedges	1	1	3	1.67
2	WRAL/A04	WRAL - best practices for Water Retention in Agricultural Lands	0	2	4	2.00
3	F01	Forest riparian buffers	0	1	3	1.33
4	AF/F01	AF - Afforestation	3	3	4	3,33
5	N01	Basins and ponds	3	3	2	2,67
6	ER/N02	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems	0	5	4	3.00
7	N04	Re-meandering	0	2	2	1,33
8	BPRC/N05	BPRC – natural channels and Best Practises of River Channels maintenance	4	4	2	3.33
9	BPDA/D05	BPDA - Best Practices on Drained Areas	0	2	2	1,33
10	T2	Widening or removing of flood protection dikes	0	3	3	2.00

Tab. 6 List of parameters for measures in expert variant

AggregN	4				Intensity thresholds					Grade thresholds [%]				Grade values			
No sort_AVG	No	Measure ID	Aggregated English	Definition of the intensity criteria in English	T0	Tlow	Thigh	Tmax	Grade_max	E%0	E%low	E%high	E%max	E0	Elow	Ehigh	Emax
1	1	WRAL	agriculture	Arable land area on which best practices of water retention are applied and SPU area ratio [km2/km2]	0,00	0,30	0,80	1,00	4	0	30	80	100	0,00	1,20	3,20	4,00
4	2	ER	swamps	Total area of restored (and managed) wetlands, floodplains and reconnected ox-bows and SPU area ratio [km2/km2]	0,00	0,10	0,40	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00
2	3	BPDA	drainage systems	Drained area under Best DA Practices and SPU area ratio [km2/km2]	0,00	0,05	0,15	1,00	4	0	60	95	100	0,00	2,40	3,80	4,00
3	4	T1	Polders, dry flood protection reservoirs, s	Catchment area upstream of measure (polder, dry reservoir) and SPU area ratio [km2/km2]	0,00	0,05	0,20	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00

Tab. 7 List of parameters for measures in local preferences variant

AggregN	10				Intensity thresholds					Grade thresholds [%]				Grade values			
No sort_AVG	No	Measure ID	Aggregated English	Definition of the intensity criteria in English	T0	Tlow	Thigh	Tmax	Grade_max	E%0	E%low	E%high	E%max	E0	Elow	Ehigh	Emax
5	1	A02	Buffer strips and hedges	Buffer strips density - total lenght of strips and SPU area ratio [km/km2]	0,00	0,50	2,00	6,00	3	0	60	95	100	0,00	1,80	2,85	3,00
6	2	A04	Strip cropping along contours	Arable land area on which best practices of water retention are applied and SPU area ratio [km2/km2]	0,00	0,30	0,80	1,00	3	0	30	80	100	0,00	0,90	2,40	3,00
2	3	F01	Forest riparian buffers	Total lenght of forest riparian buffers and doubled lenght of water courses in SPU ratio [km/km]	0,00	0,30	0,70	1,00	2	0	30	70	100	0,00	0,60	1,40	2,00
10	4	F05	Land use conversion	Newly afforested area and SPU area ratio [km2/km2]	0,00	0,05	0,20	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00
8	5	N01	Basins and ponds	Total area of basins and ponds and SPU area ratio [km2/km2]	0,00	0,01	0,10	1,00	4	0	60	95	100	0,00	2,40	3,80	4,00
9	6	N02	Wetland restoration and management	Total area of restored (and managed) wetlands, floodplains and reconnected ox-bows and SPU area ratio [km2/km2]	0,00	0,10	0,40	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00
3	7	N04	Re-meandering	Total length of re-meandered water bodies and water bodies length in SPU ratio [km/km]	0,00	0,30	0,60	1,00	2	0	30	60	100	0,00	0,60	1,20	2,00
4	8	N05	Stream bed re-naturalization	Total length of restored water bodies (natural stream bed, bank protection removal, etc) and water bodies length in SPU ratio [km/km]	0,00	0,20	0,60	1,00	2	0	20	60	100	0,00	0,40	1,20	2,00
1	9	D05	Infiltration reservoirs and ditches (similar	Drained area under Best DA Practices and SPU area ratio [km2/km2]	0,00	0,05	0,15	1,00	2	0	60	95	100	0,00	1,20	1,90	2,00
7	10	T2	Widening or removing of flood protection	Active floodplain area and max (during HHQ) floodplain area in SPU ratio [km2/km2]	0,00	0,05	0,20	1,00	3	0	60	95	100	0,00	1,80	2,85	3,00

For each planned measure (in SPUs), its intensity was given, expressed in accordance with the adopted intensity criterion definitions. For each SPU in the columns corresponding to individual measures, there was provided their intensity, with the value 0 - meaning no measure in the given SPU will be realized, and 1 – planning the measure with the maximum possible intensity. Intensity levels for 40 SPUs were determined for the Blh pilot catchment.

3. MODIFICATIONS TO THE STATICTOOLS.XLSX TOOL PARAMETERS

Defining the measures of the intensity and determining the thresholds for the characteristic levels of intensity (low, medium, high) was done with methodology developed by the company Pro-Woda (Tyszewski S. 2019).

Further the external expert with local knowledge and experiences in the field of assessment the efficiency of natural small retention measures was contacted and proposal of efficiency of each of measures defined in the catalogue of measures in more consultation rounds. There was assessed the potential effect of each measure within the five grade scale where 0 means no effect to particular goal and 5 means the maximum effect for particular goal. As the impact of different types of flood protection is different for small and extreme events, there was proposed to provide assessment for five groups of goals:

- low flows
- quality
- high flows - small floods (Q1-Q10)
- high flows - medium floods (Q10-Q50)
- high flows - extreme floods (Q50-Q1000)

For the water management structures there was proposed to divide measure T3 into two sub-groups:

- bigger and medium size water reservoirs
- small shallow water reservoirs and fishponds (less than 1 000 m^2)

The results of Mr. Marek Čomaj from Water Research Institute are showed in the Annex.

Further the different alternatives of measures proposed for local preferences variaant were examined. These are three alternatives assuming that:

a. Alternative a) - As criteria there was used "km^2/km^2" instead "km/km^2" for measures F01, N04 and N05 and "km/km" for measure A02. According the developed methodology for each planned measure (in SPUs), its intensity is given, expressed in accordance with the adopted intensity criterion definitions. This alternative is relevant only for some of measures proposed within local preferences variant.

b. Alternative b) - For each of the variant we tried to select only "most efficient measures" for high flows, low flows and quality

c. Alternative c) – based on results of consultation with national expert on concretizing the effects of measures for particular goals taking into account different discharges in rivers varying from Q10 up to Q1000 was created the alternative to minimize impacts of low flow conditions.

4. DESCRIPTION OF RESULTS

The scope of testing is to compare improvement of valorization results for entire pilot area or for individual SPUs. The valorization results are calculated according Valorization method developed within project, for more information see (3). Results of catchment valorization are shown in Fig. 1 where needs and possibilities of water retention are calculated for each particular SPU in the Blh pilot catchment.

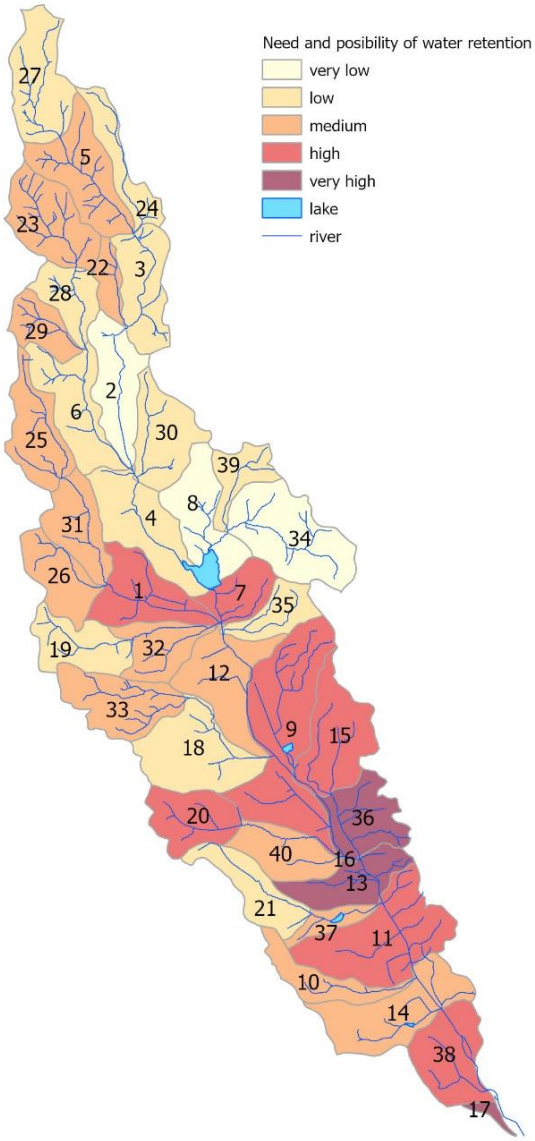

Fig. 2 Map of needs and possibilities of water retention in SPUs

4.1. For the expert variant

Type and localization of all the measures proposed for the expert variant in particular SPUs are showed in Fig. 2.

The results of the assessment were obtained from the StaticAssessment table of StaticTool.xlsm. This table contains the cumulative assessment for the entire pilot catchment and partial assessments for each group of measures and for each SPU.

The obtained results show that the highest impact on the final grade had aggregated measures - best practices on drained areas (BPDA = 30.80), then other 3 measures had significantly lower impact: Ecosystems Restoration/renaturisation of water dependent ecosystems (ER =

12.51), Polders, dry flood protection reservoirs, sediment trapping dams (T1 = 6.00) and lowest impact on the finale grade had aggregated measures - best practices for Water Retention in Agricultural Lands (WRAL = 5.78). In order to assess a single SPU while taking into account the size of the catchment area, additional calculations were made according to the following equation SPU grades * F_SPU/Σ F_SPU. The results are shown in Tab. 1.

The greatest impact on the final assessment had SPU 02, 09, 38 which are characterized by high values of SPU grade and used measures. The SPU rating which does not take into account the area shows similar results: the highest rating was obtained by SPU 38 in which measurements like ecosystems restoration and water retention in agricultural lands are planned. In a situation where the SPUs have different sizes, comparing their ratings is questionable. The final rating for the catchment also depends largely on the size of the SPUs. This variant contained a large number of measures with low efficiency, therefore the SPU assessment results are spatially dispersed and their discrepancies are small. The overall rating for this option is 1.77.

Tab. 1. Assessment of the effectiveness of the expert variant

Number of measures	4			Grading of the Program of Small Water Retention Measures					
Number of SPUs	40		Measure No.	1	2	3	4	Catchment grade for current variant	
Grade for a measure (total by SPUs):				5,78	12,31	30,80	6,00	1,54	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2		
1	SPU_01		7,79	0,11	0,38		2,34	2,82	0,093413
2	SPU_02		7,33	0,02	3,09		2,35	5,46	0,170098
3	SPU_03		7,27		0,93			0,93	0,028878
4	SPU_04		9,36	0,21	1,48	1,77		3,47	0,137861
6	SPU_06		8,22	0,04	1,53		1,32	2,89	0,100962
7	SPU_07		4,23			2,46		2,46	0,044255
8	SPU_08		7,95	0,42				0,42	0,014087
9	SPU_09		17,20	0,01		3,28		3,29	0,240159
10	SPU_10		4,58	0,08				0,08	0,001612
11	SPU_11		13,27	0,07	1,00	0,96		2,02	0,114010
12	SPU_12		8,59	0,06		3,85		3,91	0,142917
13	SPU_13		5,99	0,05		3,83		3,87	0,098555
14	SPU_14		10,10	0,08	0,24	1,18		1,51	0,064649
15	SPU_15		8,80	0,68		2,66		3,34	0,125058
16	SPU_16		0,04			3,98		3,98	0,000704
17	SPU_17		0,62		0,12			0,12	0,000325
18	SPU_18		10,29	0,00				0,00	0,000167
20	SPU_20		6,17	0,86				0,86	0,022615
21	SPU_21		5,84	0,40				0,40	0,009976
22	SPU_22		2,29			0,16		0,16	0,001551
25	SPU_25		6,82	0,20	0,71			0,91	0,026254
26	SPU_26		5,61	0,08				0,08	0,001951
27	SPU_27		8,46		0,03			0,03	0,001137
28	SPU_28		4,54		0,62			0,62	0,012017
30	SPU_30		7,26		0,15			0,15	0,004657
31	SPU_31		6,06	0,17	0,20			0,38	0,009704
32	SPU_32		5,20	0,41				0,41	0,008970
33	SPU_33		7,87	0,18				0,18	0,006186
34	SPU_34		11,57	0,21				0,21	0,010280
36	SPU_36		6,63	1,37		0,09		1,46	0,041200
37	SPU_37		2,14			1,19		1,19	0,010838
38	SPU_38		7,73		1,82	3,87		5,70	0,187260
39	SPU_39		3,67	0,06				0,06	0,000876
40	SPU_40		5,79			1,50		1,50	0,037049

Also alternative b) mentioned in the chapter 3 was examined here. In Tab 2 we tried to propose just those measures, which should improve water quality. Measures were selected based on highest impact grade on quality – WRAL, ER. The overall rating for this option is 0.63. In Tab 3 we tried to propose just those measures, which should improve high flows. Measures were selected based on highest impact grade on high flow – ER, T1. The overall rating for this option is 1.38. In Tab 4 we tried to propose just those measures, which should improve lowf lows. Measures were selected based on highest impact grade on low flow, in this case just one measure – BPDA was selected. The overall rating for this option is 2.25.

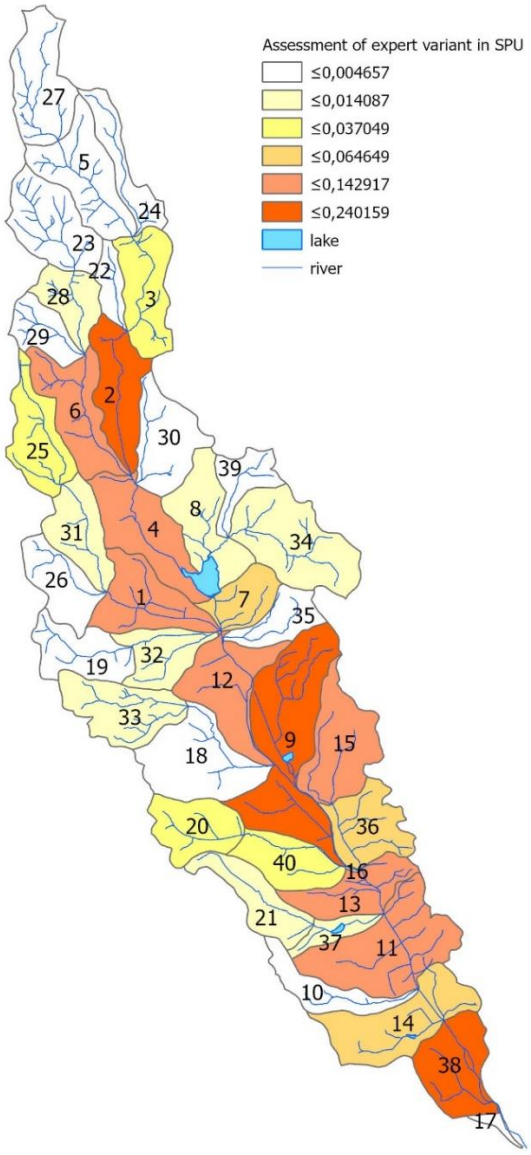

Fig. 3 Map of assessment of the expert variant at the SPU level

Tab. 2. Assessment of the effectiveness of the expert variant for quality improvement

Number of measures	4			Grading of the Program of Small Water Retention Measures									
Number of SPUs	27		Measure No.	1	2	3	4					Catchment grade for current variant	
Grade for a measure (total by SPUs):				5,78	11,38	0,00	0,00					0,63	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1					SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2						
1	SPU_01		7,79	0,11	0,38							0,48	0,02
2	SPU_02		7,33	0,02	3,09							3,11	0,11
3	SPU_04		9,36	0,21	1,48							1,69	0,08
4	SPU_06		8,22	0,04	1,53							1,57	0,06
5	SPU_08		7,95	0,42								0,42	0,02
6	SPU_09		17,20	0,01								0,01	0,00
7	SPU_10		4,58	0,08								0,08	0,00
8	SPU_11		13,27	0,07	1,00							1,06	0,07
9	SPU_12		8,59	0,06								0,06	0,00
10	SPU_13		5,99	0,05								0,05	0,00
11	SPU_14		10,10	0,08	0,24							0,32	0,02
12	SPU_15		8,80	0,68								0,68	0,03
13	SPU_17		0,62		0,12							0,12	0,00
14	SPU_18		10,29	0,00								0,00	0,00
15	SPU_20		6,17	0,86								0,86	0,03
16	SPU_21		5,84	0,40								0,40	0,01
17	SPU_25		6,82	0,20	0,71							0,91	0,03
18	SPU_26		5,61	0,08								0,08	0,00
19	SPU_27		8,46		0,03							0,03	0,00
20	SPU_28		4,54		0,62							0,62	0,01
21	SPU_30		7,26		0,15							0,15	0,01
22	SPU_31		6,06	0,17	0,20							0,38	0,01
23	SPU_32		5,20	0,41								0,41	0,01
24	SPU_33		7,87	0,18								0,18	0,01
25	SPU_34		11,57	0,21								0,21	0,01
26	SPU_36		6,63	1,37								1,37	0,04
27	SPU_38		7,73		1,82							1,82	0,07

Tab. 3. Assessment of the effectiveness of the expert variant for improvement of high flow conditions

Number of measures	4			Grading of the Program of Small Water Retention Measures									
Number of SPUs	14		Measure No.	1	2	3	4					Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	12,31	0,00	6,00					1,38	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1					SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2						
1	SPU_01		7,79		0,38		2,34					2,71	0,20
2	SPU_02		7,33		3,09		2,35					5,44	0,38
3	SPU_03		7,27		0,93							0,93	0,06
4	SPU_04		9,36		1,48							1,48	0,13
5	SPU_06		8,22		1,53		1,32					2,85	0,22
6	SPU_11		13,27		1,00							1,00	0,13
7	SPU_14		10,10		0,24							0,24	0,02
8	SPU_17		0,62		0,12							0,12	0,00
9	SPU_25		6,82		0,71							0,71	0,05
10	SPU_27		8,46		0,03							0,03	0,00
11	SPU_28		4,54		0,62							0,62	0,03
12	SPU_30		7,26		0,15							0,15	0,01
13	SPU_31		6,06		0,20							0,20	0,01
14	SPU_38		7,73		1,82							1,82	0,13

Tab. 4. Assessment of the effectiveness of the expert variant for improvement of low flow conditions

Number of measures	4			Grading of the Program of Small Water Retention Measures									
Number of SPUs	14		Measure No.	1	2	3	4					Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	0,00	30,80	0,00					2,25	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1					SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2						
1	SPU_04		9,36			1,77						1,77	0,16
2	SPU_07		4,23			2,46						2,46	0,10
3	SPU_09		17,20			3,28						3,28	0,55
4	SPU_11		13,27			0,96						0,96	0,12
5	SPU_12		8,59			3,85						3,85	0,32
6	SPU_13		5,99			3,83						3,83	0,22
7	SPU_14		10,10			1,18						1,18	0,12
8	SPU_15		8,80			2,66						2,66	0,23
9	SPU_16		0,04			3,98						3,98	0,00
10	SPU_22		2,29			0,16						0,16	0,00
11	SPU_36		6,63			0,09						0,09	0,01
12	SPU_37		2,14			1,19						1,19	0,02
13	SPU_38		7,73			3,87						3,87	0,29
14	SPU_40		5,79			1,50						1,50	0,09

Based on the overall values of calculated grades it can be assumed that when selecting only measures to improve low flow conditions the effect for whole pilot area will be higher (2.25 to 1,77).

4.2. For the variant of local preferences

Type and localization of all the measures proposed for the expert variant in particular SPUs are showed in Fig. 2.

The results of the local preferences variant assessment are also presented in the form of a table (Tab. 5) and map (Fig. 4). In this variant, wetland restoration and management (N02 = 13.56) and widening or removing of flood protection dikes (T02 = 10.36) have the greatest impact on the final score. Less impactful measures are polders, dry flood protection reservoirs, sediment trapping dams (T01 = 7.15) and land use conversion (F05 = 4.17). The impact of other measures is negligible. In order to assess a single SPU while taking into account the size of the catchment area, additional calculations were made according to the following equation SPU grades * F_SPU/Σ F_SPU. The results are shown

The greatest impact on the final assessment had SPU 12 and 09. SPUs assessment without taking into account the area gives different results, and in this case the SPUs 12, 16, 13, 17 dominate with a score of 12 = 6.28, 16 = 5.9, 13 = 5.28, 17 = 4.57. These variants included a small number of measures with high efficiency which caused the SPUs assessment results to be cumulated only in 4 SPUs (12, 16, 13, 17) and divergences between them and others are very significant. The overall rating for this variant is 1.68.

Tab. 5. Assessment of the effectiveness of the local preferences variant

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	20		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,70	0,93	2,16	4,17	1,77	13,56	1,08	0,26	0,46	10,40	1,63	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
1	SPU_01		7,79			0,02			0,02	0,01			0,02	0,07	0,003680
2	SPU_02		7,33						1,66		0,02			1,68	0,089060
4	SPU_04		9,36								0,01			0,01	0,000792
6	SPU_06		8,22						1,39		0,23			1,62	0,096037
7	SPU_07		4,23			0,08			0,47	0,04			0,57	1,15	0,035213
9	SPU_09		17,20			0,34	1,11		0,39	0,17		0,27	0,46	2,74	0,341066
10	SPU_10		4,58			0,01			0,01	0,00			0,02	0,04	0,001414
11	SPU_11		13,27			0,23			0,46	0,11			0,55	1,35	0,129282
12	SPU_12		8,59			0,40	3,06	0,13	1,24	0,20		0,19	1,49	6,71	0,416817
13	SPU_13		5,99		0,69	0,14			0,63	0,07			0,76	2,29	0,099195
14	SPU_14		10,10			0,11			0,29	0,05			0,35	0,81	0,059088
15	SPU_15		8,80			0,07			0,17	0,04		0,00	0,20	0,48	0,030268
16	SPU_16		0,04			0,05			3,12	0,02			2,30	5,49	0,001650
17	SPU_17		0,62			0,15			2,28	0,07			1,98	4,49	0,020229
21	SPU_21		5,84		0,01									0,01	0,000509
35	SPU_35		4,08			0,01		1,63	0,00	0,00			0,00	1,64	0,048437
36	SPU_36		6,63			0,26			0,44	0,13		0,00	0,53	1,36	0,065210
37	SPU_37		2,14		0,18									0,18	0,002822
38	SPU_38		7,73	0,70		0,30			0,98	0,15			1,17	3,31	0,184831
40	SPU_40		5,79		0,04	0,00			0,00	0,00			0,00	0,05	0,001963

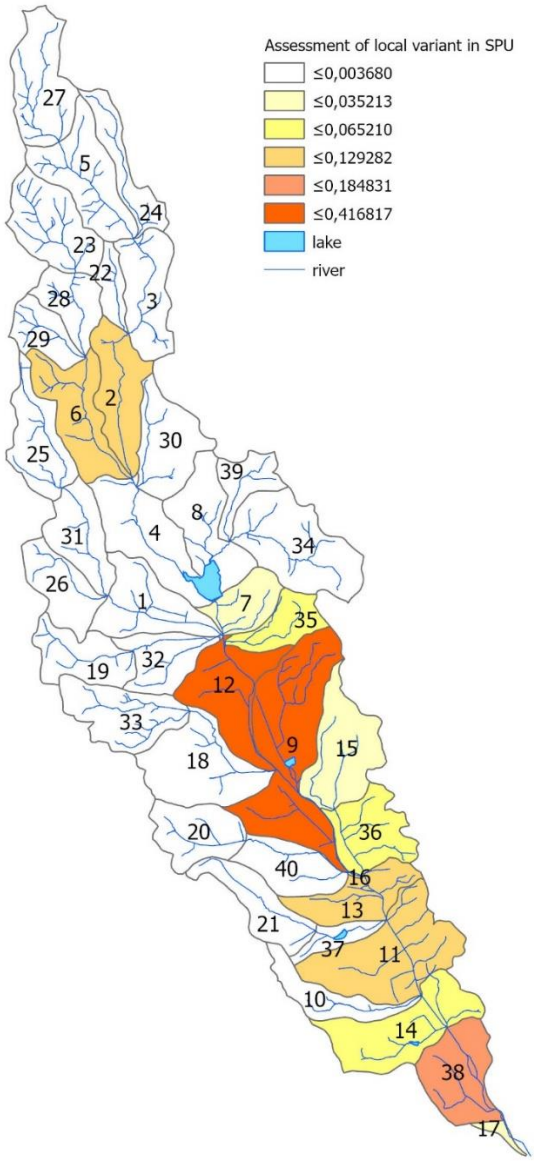

Fig 4 Map of assessment of the local preferences variant at the SPU level

Also alternative b) mentioned in the chapter 3 was examined. In Tab. 6 we tried to propose just those measures, which should improve water quality. Measures were selected bases on highest impact grade on quality – A02, F01, F05, N02, A04, T2. The overall rating for this option is 1.55. In Tab 7 we tried using just those measure, which should improve on high flows. Measures were selected based on highest impact grade on high flow – F05, N01, N02, D05, A04, T2. The overall rating for this option is 1.68. In Tab 8 we tried to propose just those measures, which should improve low flows. Measures were selected based on highest impact grade on low flow, in this case just measures F05, N01, D05. The overall rating for this option is 1.31.

Tab. 6. Assessment of the effectiveness of the local preferences variant for quality improvement

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	19		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,70	0,93	2,16	4,17	0,00	13,56	0,00	0,00	0,00	10,40	1,54	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
1	SPU_01		7,79			0,02			0,02				0,02	0,06	0,003476
2	SPU_02		7,33						1,66					1,66	0,094349
6	SPU_06		8,22						1,39					1,39	0,088374
7	SPU_07		4,23			0,08			0,47				0,57	1,11	0,036491
9	SPU_09		17,20			0,34	1,11		0,39				0,46	2,30	0,307168
10	SPU_10		4,58			0,01			0,01				0,02	0,04	0,001378
11	SPU_11		13,27			0,23			0,46				0,55	1,23	0,127025
12	SPU_12		8,59			0,40	3,06		1,24				1,49	6,19	0,412454
13	SPU_13		5,99		0,69	0,14			0,63				0,76	2,22	0,103134
14	SPU_14		10,10			0,11			0,29				0,35	0,75	0,059101
15	SPU_15		8,80			0,07			0,17				0,20	0,44	0,029844
16	SPU_16		0,04			0,05			3,12				2,30	5,47	0,001762
17	SPU_17		0,62			0,15			2,28				1,98	4,42	0,021339
21	SPU_21		5,84		0,01									0,01	0,000545
35	SPU_35		4,08			0,01			0,00				0,00	0,01	0,000259
36	SPU_36		6,63			0,26			0,44				0,53	1,23	0,063325
37	SPU_37		2,14		0,18									0,18	0,003027
38	SPU_38		7,73	0,70		0,30			0,98				1,17	3,15	0,189123
40	SPU_40		5,79		0,04	0,00			0,00				0,00	0,05	0,002053

Tab. 7. Assessment of the effectiveness of the local preferences variant for improvement of high flow conditions

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	17		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	0,00	0,00	4,17	1,77	13,56	0,00	0,00	0,00	10,40	1,46	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
1	SPU_01		7,79						0,02				0,02	0,04	0,002700
2	SPU_02		7,33						1,66					1,66	0,100573
6	SPU_06		8,22						1,39					1,39	0,094204
7	SPU_07		4,23						0,47				0,57	1,04	0,036173
9	SPU_09		17,20				1,11		0,39				0,46	1,96	0,278632
10	SPU_10		4,58						0,01				0,02	0,03	0,001173
11	SPU_11		13,27						0,46				0,55	1,01	0,110589
12	SPU_12		8,59				3,06	0,13	1,24				1,49	5,93	0,420958
13	SPU_13		5,99						0,63				0,76	1,39	0,068658
14	SPU_14		10,10						0,29				0,35	0,65	0,053884
15	SPU_15		8,80						0,17				0,20	0,37	0,026704
16	SPU_16		0,04						3,12				2,30	5,42	0,001863
17	SPU_17		0,62						2,28				1,98	4,27	0,021983
35	SPU_35		4,08					1,63	0,00				0,00	1,63	0,054985
36	SPU_36		6,63						0,44				0,53	0,97	0,053398
38	SPU_38		7,73						0,98				1,17	2,15	0,137526
40	SPU_40		5,79						0,00				0,00	0,00	0,000120

Tab. 8. Assessment of the effectiveness of the local preferences variant for improvement of low flow condition

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	3		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	0,00	0,00	4,17	1,77	0,00	0,00	0,00	0,00	0,00	1,78	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
9	SPU_09		17,20				1,11							1,11	0,639183
12	SPU_12		8,59				3,06	0,13						3,20	0,920293
35	SPU_35		4,08					1,63						1,63	0,222692

Based on the overall values of calculated grades it can be assumed that the effect for whole pilot area is the highest when taking into account all of proposed measures (1.68).

Results of assessments for all three phenomena are shown in the Fig, 5, 6 and 7.

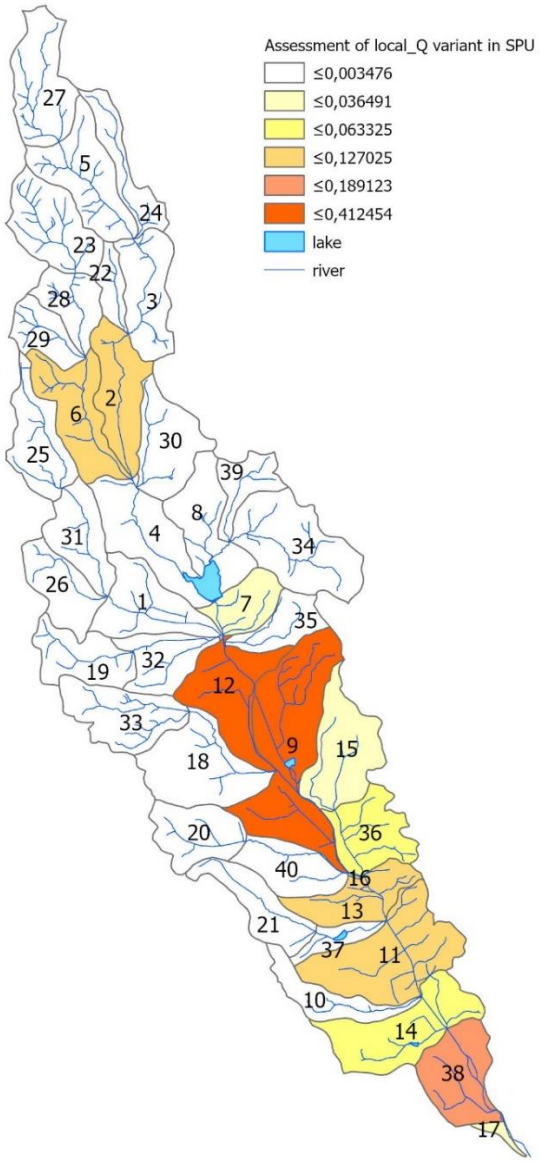

Fig. 5 Map of assessment of the effectiveness of the local preferences variant for quality improvement

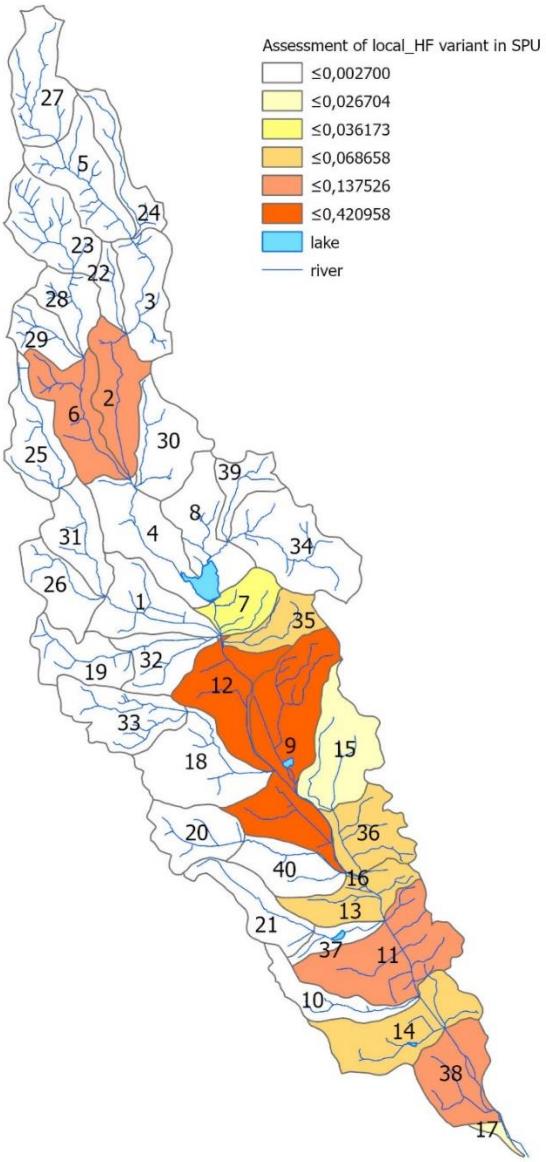

Fig. 6 Map of assessment of the effectiveness of the local preferences variant for improvement of high flow conditions

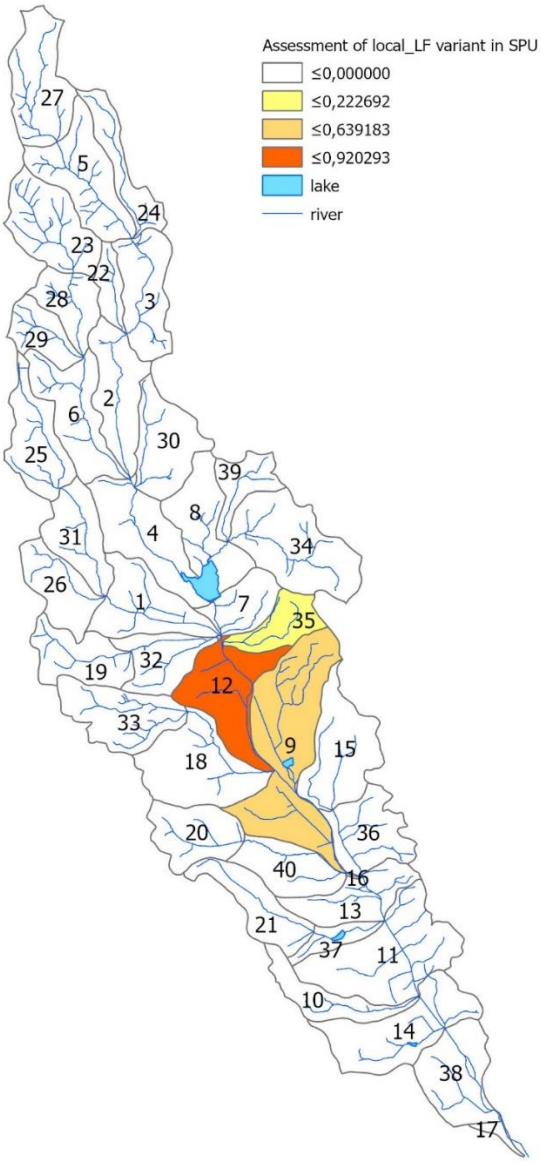

Fig. 7 Map of assessment of the effectiveness of the local preferences variant for improvement of low flow conditions

Also alternative a) mentioned in the chapter 3 taking into consideration the change of criteria from "km/km" and "km/km^2" to "km^2/km^2" was examined here. Results and chosen criteria are shown in the tables Tab. 9 and tab. 10 and assessments are shown in Fig. 8 and 9. Based on the reached grading (1.41, 1,37) it seems to be even less efficient alternative as calculated above, so the change of criteria was wrong and we have to keep criteria proposed by project.

Tab. 9. Assessment of the effectiveness of the local preferences variant with changed criteria

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	20		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,01	0,93	0,73	4,17	1,77	13,56	0,73	0,02	0,46	10,40	1,41	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2		
1	SPU_01		7,79			0,00			0,02	0,00			0,02	0,04	0,002505
2	SPU_02		7,33						1,66		0,01			1,67	0,088270
4	SPU_04		9,36								0,00			0,00	0,000087
6	SPU_06		8,22						1,39		0,01			1,40	0,083038
7	SPU_07		4,23			0,03			0,47	0,03			0,57	1,10	0,033556
9	SPU_09		17,20			0,03	1,11		0,39	0,03		0,27	0,46	2,28	0,283449
10	SPU_10		4,58			0,00			0,01	0,00			0,02	0,03	0,001088
11	SPU_11		13,27			0,03			0,46	0,03			0,55	1,07	0,102588
12	SPU_12		8,59			0,08	3,06	0,13	1,24	0,08		0,19	1,49	6,28	0,390020
13	SPU_13		5,99		0,69	0,04			0,63	0,04			0,76	2,17	0,093717
14	SPU_14		10,10			0,02			0,29	0,02			0,35	0,68	0,049986
15	SPU_15		8,80			0,01			0,17	0,01		0,00	0,20	0,39	0,024982
16	SPU_16		0,04			0,24			3,12	0,24			2,30	5,90	0,001775
17	SPU_17		0,62			0,15			2,28	0,15			1,98	4,57	0,020599
21	SPU_21		5,84		0,01									0,01	0,000509
35	SPU_35		4,08			0,00		1,63	0,00	0,00			0,00	1,63	0,048093
36	SPU_36		6,63			0,03			0,44	0,03		0,00	0,53	1,03	0,049536
37	SPU_37		2,14		0,18									0,18	0,002822
38	SPU_38		7,73	0,01		0,07			0,98	0,07			1,17	2,29	0,127994
40	SPU_40		5,79		0,04	0,00			0,00	0,00			0,00	0,04	0,001823

Tab. 10. Assessment of the effectiveness of the local preferences variant with changed criteria for quality improvement

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	19		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,01	0,93	0,73	4,17	0,00	13,56	0,00	0,00	0,00	10,40	1,37	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2		
1	SPU_01		7,79			0,00			0,02				0,02	0,04	0,002610
2	SPU_02		7,33						1,66					1,66	0,094349
6	SPU_06		8,22						1,39					1,39	0,088374
7	SPU_07		4,23			0,03			0,47				0,57	1,07	0,034963
9	SPU_09		17,20			0,03	1,11		0,39				0,46	1,99	0,264824
10	SPU_10		4,58			0,00			0,01				0,02	0,03	0,001134
11	SPU_11		13,27			0,03			0,46				0,55	1,04	0,106889
12	SPU_12		8,59			0,08	3,06		1,24				1,49	5,88	0,391457
13	SPU_13		5,99		0,69	0,04			0,63				0,76	2,12	0,098566
14	SPU_14		10,10			0,02			0,29				0,35	0,67	0,052082
15	SPU_15		8,80			0,01			0,17				0,20	0,38	0,025810
16	SPU_16		0,04			0,24			3,12				2,30	5,66	0,001825
17	SPU_17		0,62			0,15			2,28				1,98	4,42	0,021358
21	SPU_21		5,84		0,01									0,01	0,000545
35	SPU_35		4,08			0,00			0,00				0,00	0,00	0,000013
36	SPU_36		6,63			0,03			0,44				0,53	1,00	0,051611
37	SPU_37		2,14		0,18									0,18	0,003027
38	SPU_38		7,73	0,01		0,07			0,98				1,17	2,22	0,133374
40	SPU_40		5,79		0,04	0,00			0,00				0,00	0,04	0,001951

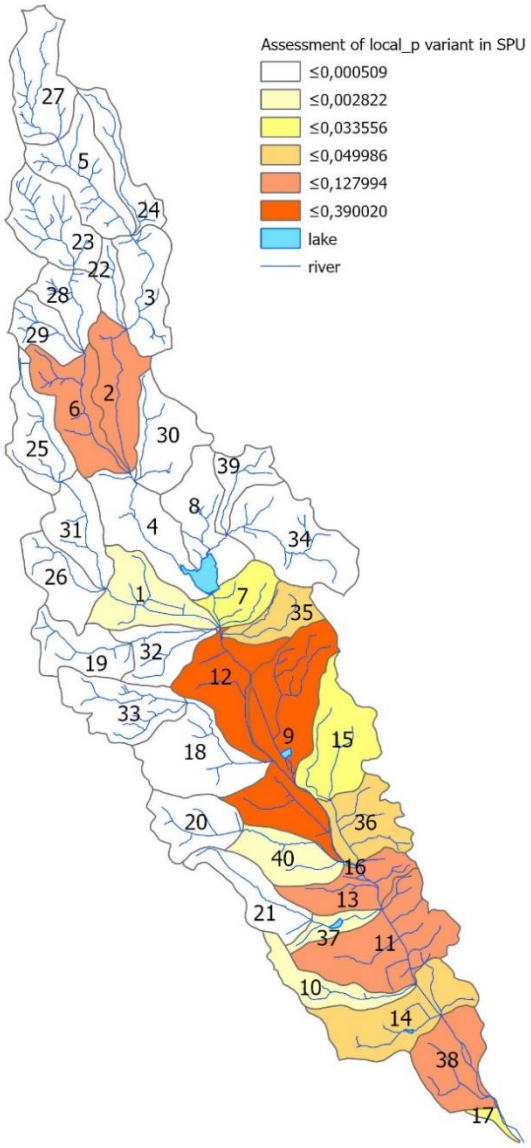

Fig. 8 Map of assessment of the local preferences variant with changed criteria at the SPU level

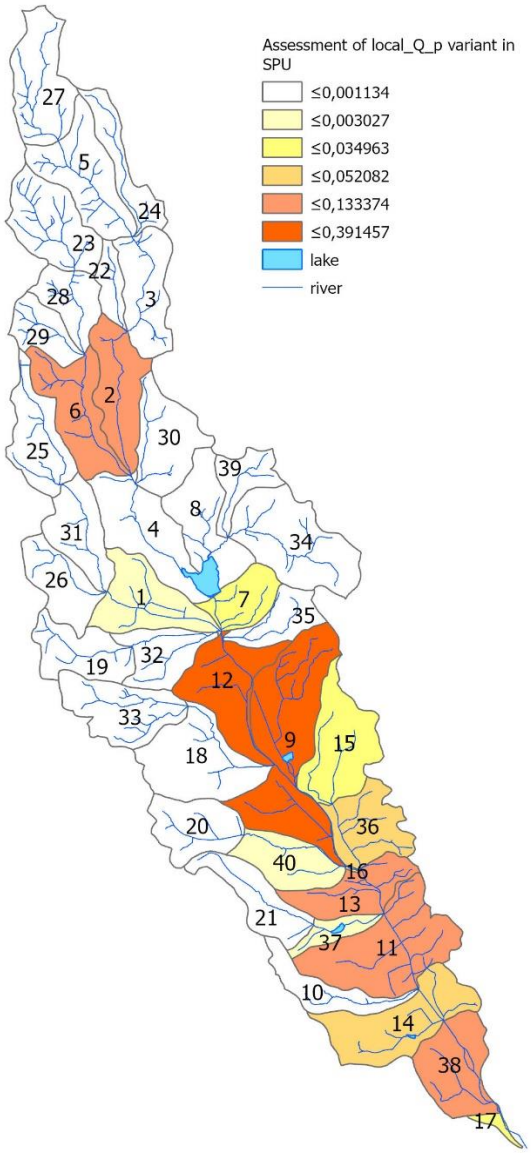

Fig. 9 Map of assessment of the effectiveness of the local preferences variant with changed criteria for quality improvement

Also alternative c) mentioned in the chapter 3 based on the consultation with an external expert the variant with the most effective measures for minimizing the negative effects of low flow conditions were calculated. Even if the measures selected by national expert were not proposed in local preferences variant. The results are shown in Tab. 11. Intensities and grades were kept the same as proposed by project consortia.

Tab. 11. Assessment of the effectiveness of the local preferences variant (measures proposed by external expert) for improvement of low flow condition

2	Number of measures	8			Grading of the Program of Small Water Retention Measures								
3	Number of SPUs	40		Measure No.	1	2	3	4	5	6	7	8	Catchment grade for current variant
4	Grade for a measure (total by SPUs):				0,00	13,07	0,00	4,86	12,14	0,00	0,00	0,00	0,79
5	No.	SPU Id	SPU name	Measure Id by User	WRAL	F01	KF	F05	F14	N02	N13	D04	SPU grades
6				F_SPU [km^2]	km2/km2	km/km	-	km2/km2	km/km	km2/km2	km2/km2	km2/km2	
7	1	SPU_01		7,79				4,86	0,22				5,08
8	2	SPU_02		7,33			0,00						0,00
9	3	SPU_03		7,27					0,06				0,06
10	4	SPU_04		9,36		0,14			0,44				0,58
11	5	SPU_05		9,00					0,34				0,34
12	6	SPU_06		8,22					0,09				0,09
13	7	SPU_07		4,23					0,16				0,16
14	8	SPU_08		7,95		0,27			0,41				0,69
15	9	SPU_09		17,20		0,20			0,10				0,30
16	10	SPU_10		4,58		1,17			0,30				1,47
17	11	SPU_11		13,27		2,00			0,34				2,34
18	12	SPU_12		8,59					0,38				0,38
19	13	SPU_13		5,99					0,44				0,44
20	14	SPU_14		10,10		0,00			0,16				0,16
21	15	SPU_15		8,80		0,64			0,15				0,79
22	16	SPU_16		0,04		0,01			0,13				0,15
23	17	SPU_17		0,62		0,49			0,24				0,73
24	18	SPU_18		10,29		0,76			0,41				1,17
25	19	SPU_19		6,04					0,15				0,15
26	20	SPU_20		6,17		0,06			0,19				0,25
27	21	SPU_21		5,84		0,73			0,50				1,23
28	22	SPU_22		2,29					0,52				0,52
29	23	SPU_23		8,17					0,28				0,28
30	24	SPU_24		4,60		0,11			0,44				0,54
31	25	SPU_25		6,82		0,10			0,10				0,20
32	26	SPU_26		5,61		0,91			0,50				1,41
33	27	SPU_27		8,46		0,01			0,26				0,27
34	28	SPU_28		4,54		0,99			0,17				1,15
35	29	SPU_29		3,87					0,58				0,58
36	30	SPU_30		7,26		0,26			0,12				0,38
37	31	SPU_31		6,06		1,33			0,68				2,01
38	32	SPU_32		5,20		0,67			0,67				1,34
39	33	SPU_33		7,87		0,56			0,12				0,68
40	34	SPU_34		11,57		0,27			0,27				0,54
41	35	SPU_35		4,08		0,05			0,25				0,30
42	36	SPU_36		6,63		1,08			0,60				1,68
43	37	SPU_37		2,14		0,24			0,28				0,52
44	38	SPU_38		7,73					0,37				0,37
45	39	SPU_39		3,67		0,03			0,14				0,17
46	40	SPU_40		5,79		0,00			0,59				0,59

The total grade for area reached is 0.79 which is less than in calculations above. It seems to be not sufficient and further proposals of extents of selected measures should be examined.

4.3. Comparison of variants

The differences between variants result mainly from the spatial distribution, structure and number of planned measures. The expert variant is characterized by a smaller number of measures spread over an area of catchment (4 measure types and there of 1 aggregated measure spread over 35 SPUs). On the contrary, the local variant contains 10 measure types and none of aggragated measures placed in 20 SPUs. Despite these large differences, the assessment ratio of the final score of the expert to local variant is 1.05 (1.77/1.68). Larger differences are noticeable after comparing the spatial distribution, which is shown in Fig. 13 as a difference between local and expert variants. The map shows that the local variant dominates in the middle part of the catchment.

Additionally, by carrying out a visual comparison of both variants (Fig. 14) and the valorization map generated via valorization tool FroGIS (Fig. 2), it can be concluded that introducing the expert variant will reduce the need for water retention in particularly sensitive

areas, except upper parts of the catchment. In the upper parts of the catchment, the need of water retention comes out of idea to protect from floods lower parts of the catchment, which are more inhabited (municipalities). These seems to be in correlation with dynamic modelling results for pilot catchment, for more information see (11). On the other hand, in the local variant, in most cases, it would improve areas with low water retention needs.

Maps of comparison of expert and local preferences variants were created by using the method of natural breaks for six classes.

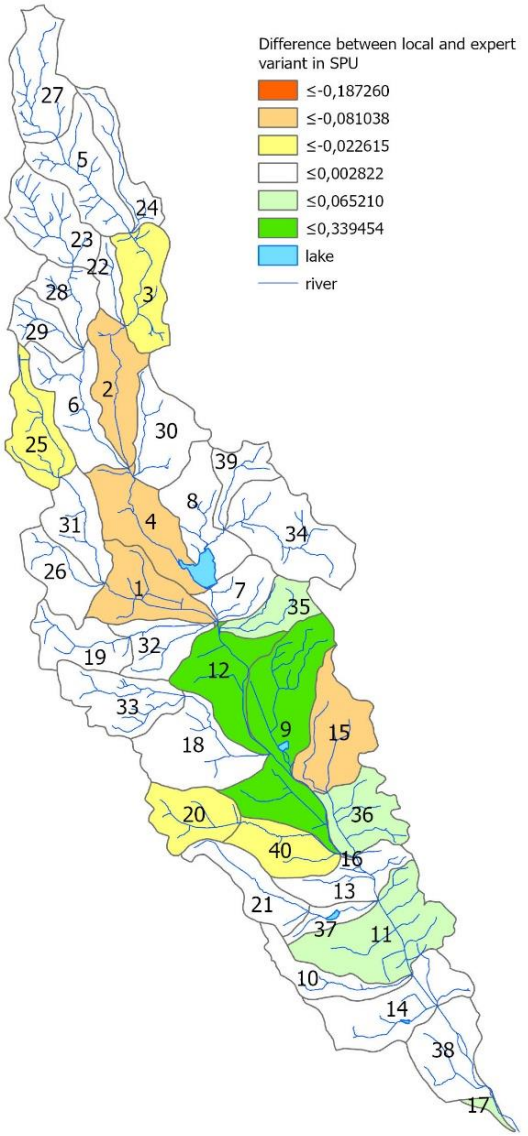

Fig. 10 Map of difference between local preferences and expert variant (green color shows dominance of local variant and red shows the opposite)

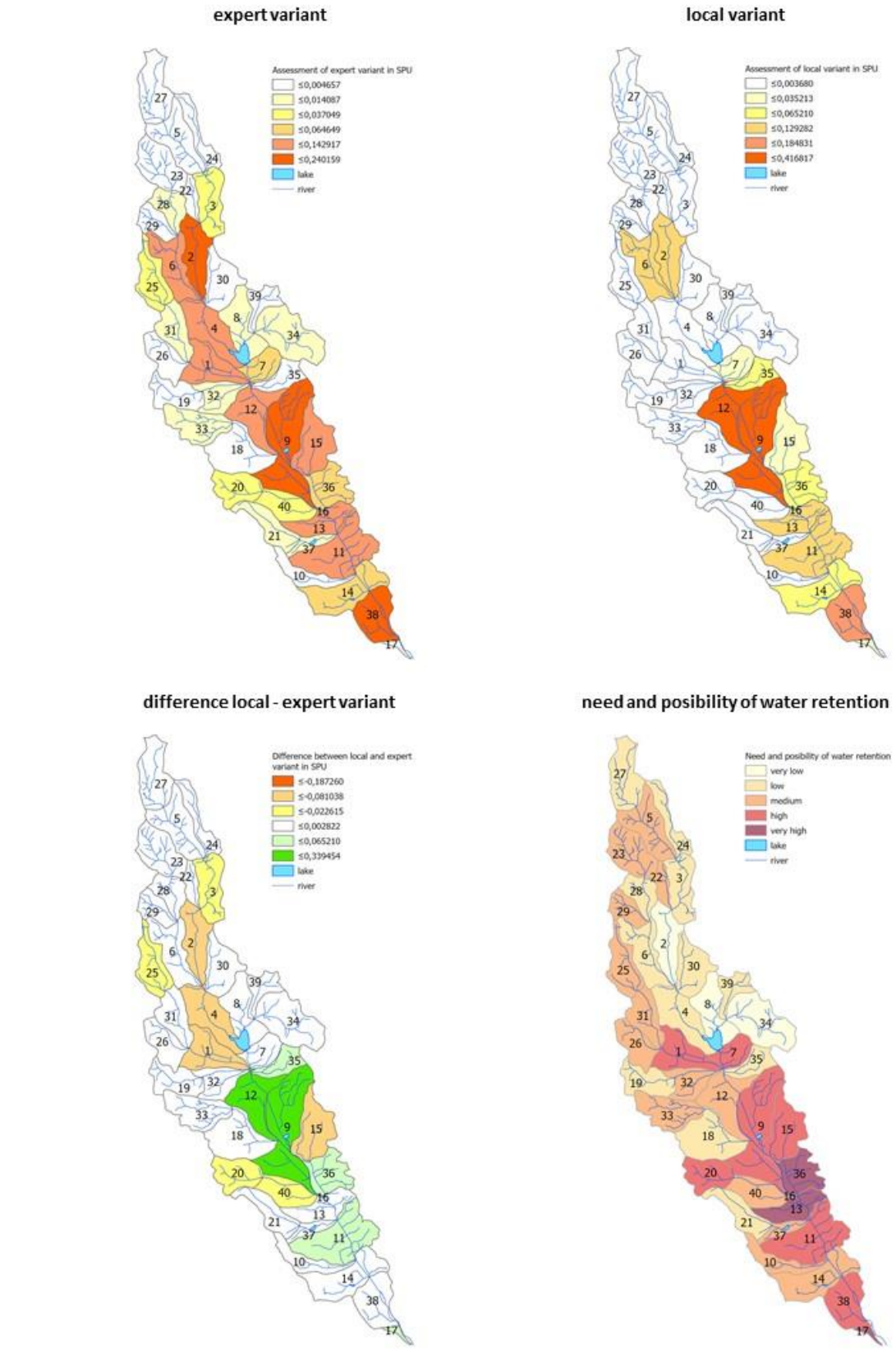

Fig. 11 Visual comparison of local preferences and expert variant assessments with the map of valorisation of needs and water retention possibilities

In the following maps there are visualised differences between expert and local preferences variants analysed within alternative a) where criteria of some measures were changed and alternative b) where only "most efficient measures" for particular goals were selected as described in the chapter 3.

Alternative b) - for each of the local preferences variant we have selected only "most effective measures" for particular goal as high flows, low flows and quality. The differences to expert variant are shown in Fig. 15, 16 and 17.

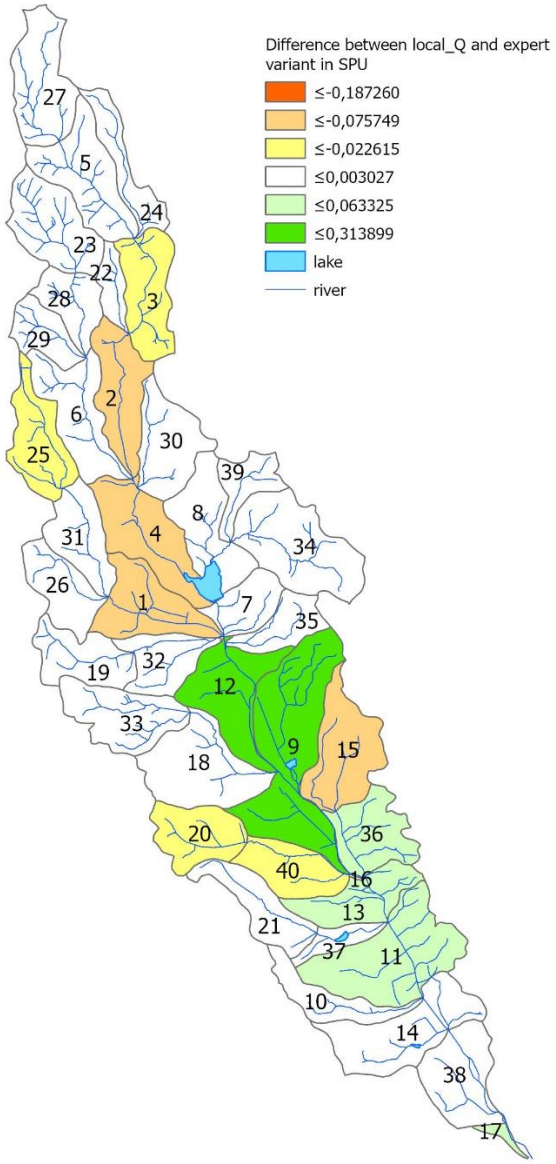

Fig. 12 Map of difference between local preferences variant for quality improvement and expert variant (green color shows dominance of local variant and red shows the opposite)

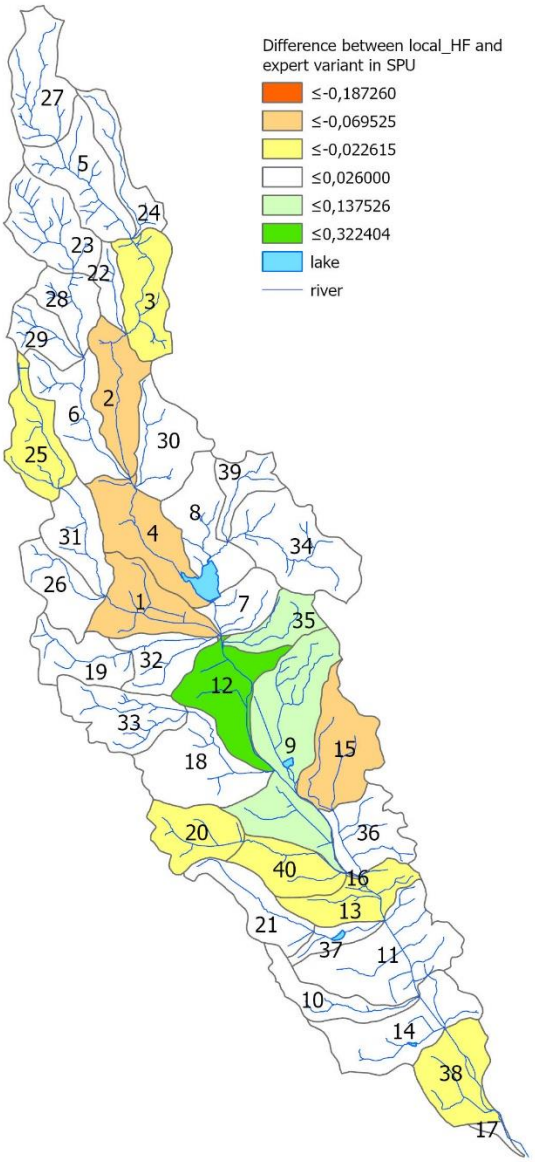

Fig. 13 Map of difference between local preferences variant for improvement of high flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

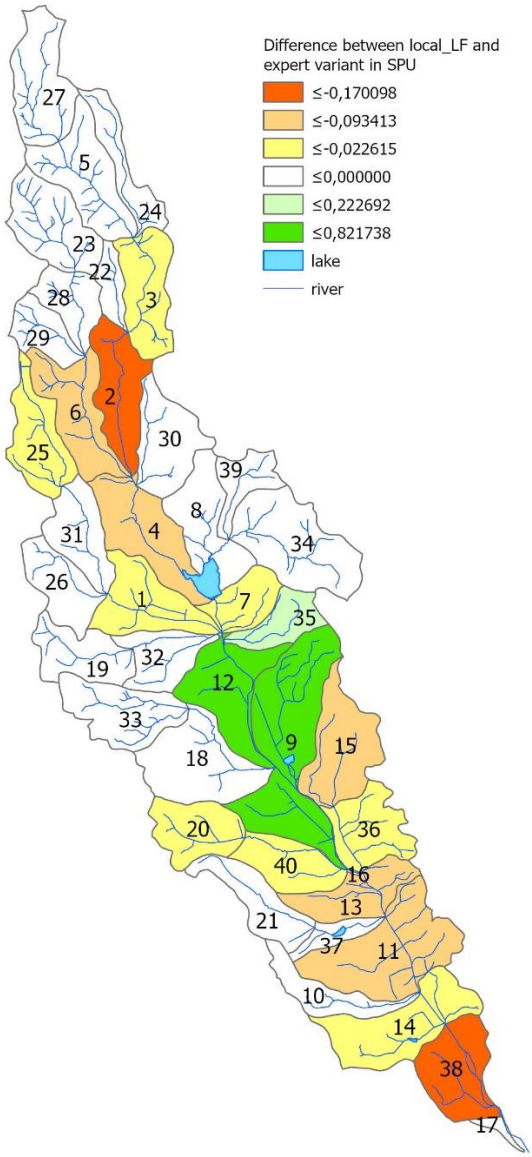

Fig. 14 Map of difference between local preferences variant for improvement of low flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

Also based on visual comparison of above showed figures for differences between expert variant and alternatives of local preferences variant, it can be assumed that selection of measures relevant for particular goal (low flow, high flow, quality) is most relevant for low flow conditions.

Alternative a) – where the definition of intensity criteria for some of measures was changed from "km/km^2" and "km/km" to "km^2/km^2". This is relevant only for some of measures proposed

within local preferences variant. See results of differences to expert variant in the following figures Fig. 18, 19, 20 and 21.

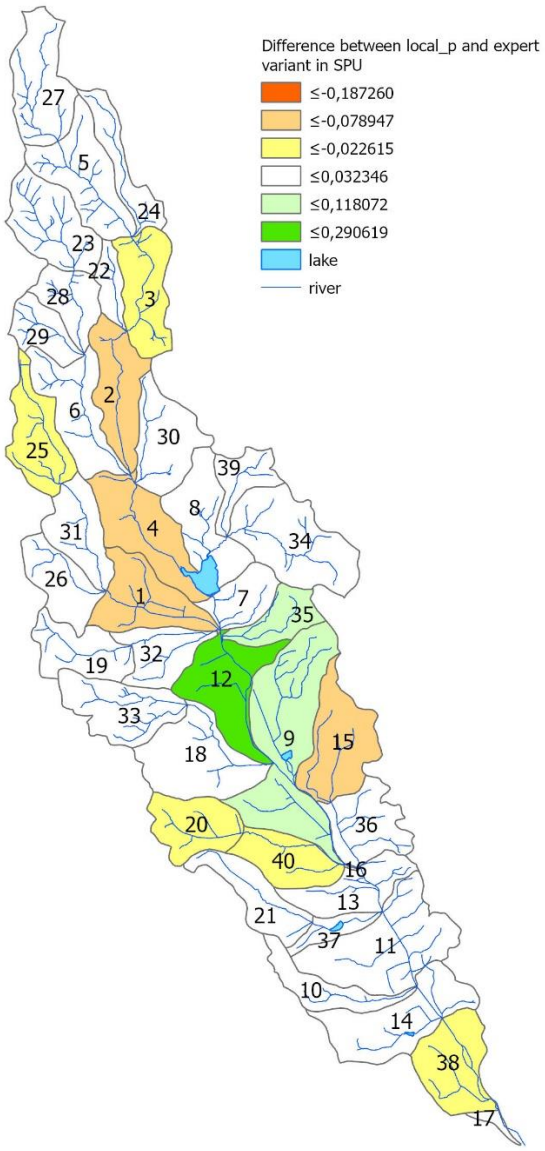

Fig. 15 Map of difference between local preferences with changed criteria and expert variant (green color shows dominance of local variant and red shows the opposite)

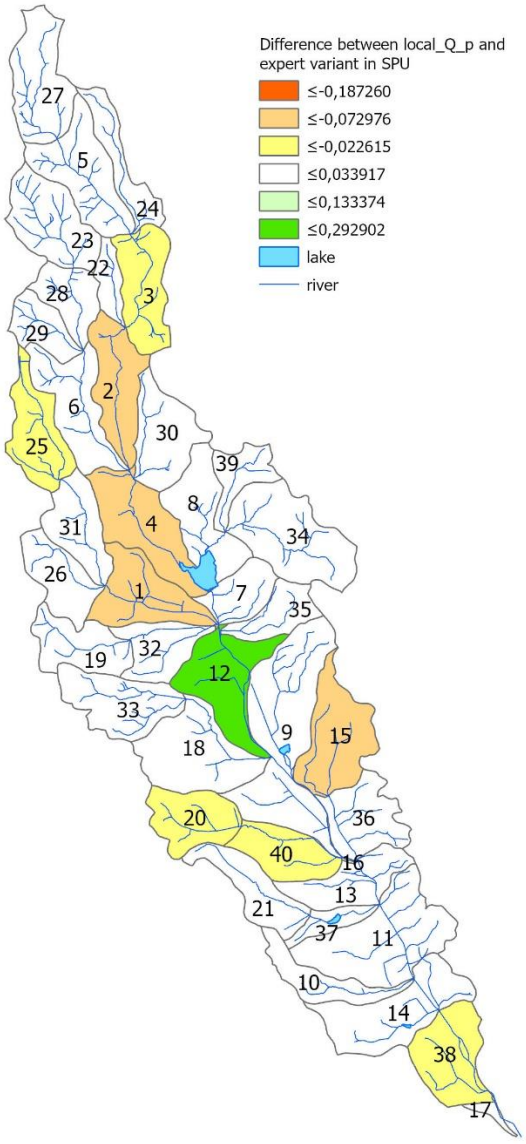

Fig. 16 Map of difference between local preferences variant with changed criteria for quality improvement and expert variant (green color shows dominance of local variant and red shows the opposite)

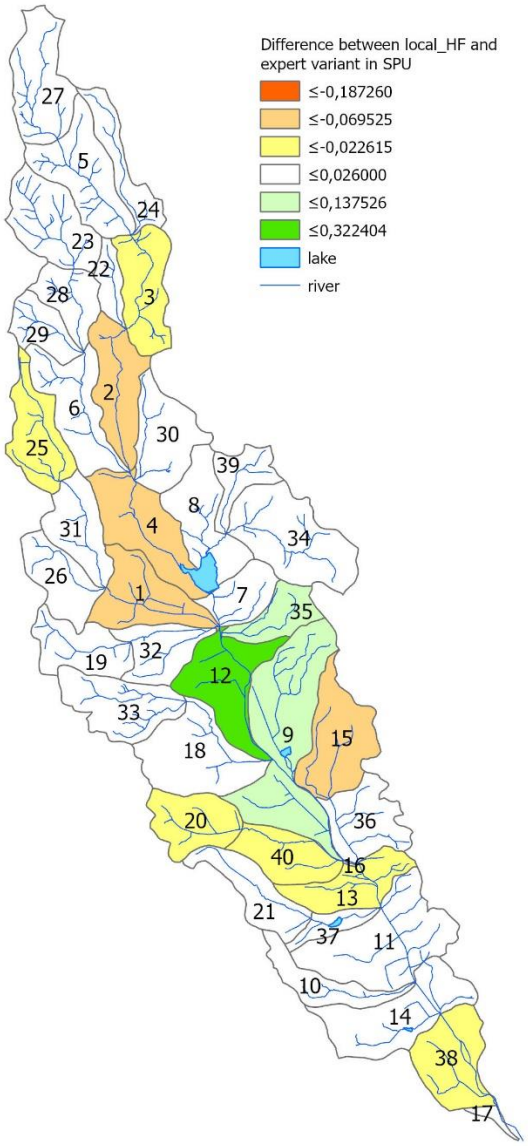

Fig. 17 Map of difference between local preferences variant with changed criteria for improvement of high flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

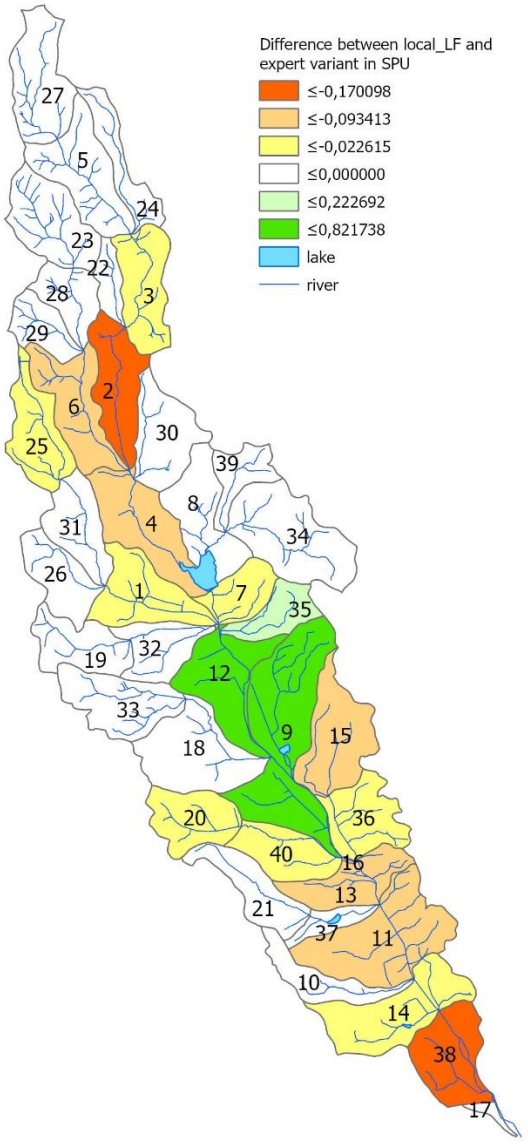

Fig. 18 Map of difference between local preferences variant with changed criteria for improvement of low flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

Based on visual comparison of above showed figures for differences between expert variant and alternatives of local preferences variant with changed criteria, the trend is the same as for alternatives of local preferences variant where the most relevant criteria are chosen. Differences are obvious mainly for variant of low flow conditions.

5. CONCLUSIONS

Based on the testing of the StaticMethod and StaticTool.xlsm it can be concluded:

- StaticTool.xlsm seems to work properly even when using the pre-defined criteria and their values
- variant with proposed measures in the upper part of catchment to reduce flood impacts in the lower parts of catchments (municipalities) dynamic modelling results
- to calculate parameters for proposed measures is quite time consuming but feasible
- results in the tool are quite easy to interpreted even for non expert but a short guide how to do it and how to create the map will be efficient
- with the results obtained and after preparing the maps it was easy to compare particular alternatives of natural small water retention measures

6. RECOMMENDATIONS

Based on the experiences with testing of the StaticMethod and StaicTool.xlsm it can be assumed:

- Content related:
    - How to interprate Grades is necessary to explain/to add somewhere in the tool
    - As intensities and maximum grades definitions are country/region/catchment characteristics relevant, it will be efficient to include some recommendations for future users of the tool if gained during the testing by PPs
    - As it is not necessary to use aggregated measure codes to run calculations, it should be mentioned somewhere in the methodology, that calculations will run anyway.
- Functionalities:
    - SK translation of names of aggregated measures is missing. We see it as valuable information for national stakeholders, who will use the tool.
    - SK translations of definitions of intensities criteria are missing. We see it as valuable information for national stakeholders, who will use the tool.
    - It was experienced during the testing that “grey fields” which should be filled-in automatically was necessary to overwrite manually.
    - For local national stakeholders, it would be efficient to provide description of Methodology on static assessment of cumulative effect of N(S)WRM at the river basin scale and of Manual on how to work with Static tool in national languages. It will facilitate wider use of project deliverables.

7. LIST OF FIGURES

8. LIST OF TABLES

9. REFERENCES

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(11) D.T2.4.1 Reports from testing the dynamic model to assess cumulative effect of N(S)WRM (Pilot Action), Slaná river basin, Blh pilot catchment, Slovakia

10. ANNEX

Assessment of effects of natural small water retention measures based on national experiences, elaborated by Mr. Marek Čomaj, Water Research Institute, Bratislava.

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

D.T2.2.2 - Reports from testing the static method to assess cumulative effect of N(S)WRM (Pilot action)

Testing in the Blh pilot catchment

Slovak Water Management Enterprise

Version 1

02 2020

Circulation			
Issue	Date	Details	Editor
v1	02.2020	Document first draft version	J. Dobias, E. Harman, M. Koli, SWME
v1-1	03.2020	Document second draft version	J. Dobias, E. Harman, SWME
v1-2	05.2020	Document third draft version	M. Čomaj, Water Research Institute (WIR), M. Supeková, SWME,

Table of content

1. INTRODUCTION

The purpose of developing the StaticTool method and the computer application StaticTool.xlsm is to enable the estimation of the effects of the implementation of a program of natural small water retention measures (PoNSWRM, Program of measures) in a simplified way, which does not require the time-consuming and costly development of detailed models, hydrological or / and hydraulic, of the analysed catchment. Method is making use of a grading based on expert knowledge and is used to compare variants of the NSWRM program.

The potential effects of individual NSWR measures may be different, depending on the climatic and physiographic conditions (e.g. slopes, ground permeability) of the analysed area, so the method parameters should be adapted to local conditions (climate type, landscape type). The StaticTool method thus consists of two parts:

- developing method parameters for local conditions,
- estimation of the effects of activities planned under the Program of Natural Small Water Retention Measures.

The StaticTool method assumes that the expected effect of the PoNSWRM is to improve catchment retention properties, which is understood as increasing low flows (LowQ), reducing high flows (HighQ) and / or limiting the load of pollutants yielded from the catchment area (Qual). This effect depends on the planned measures, in particular: i) their type and ii) the level of intensity. The measures included in the StaticTool method are summarized in the local catalogue of measures. For each measure, an intensity criterion is formulated, and threshold values are defined that correspond to the characteristic intensity levels (low, medium, high). Each measure is also assigned the expected improvement of retention properties of the SPU, expressed on a point scale (0 - 5 points). The greatest improvement that can be achieved (maximum points for a given measure) corresponds to the implementation of the measure with maximum intensity. For lower intensity levels, the assigned grades are proportional to the level of intensity of planned measure. Hence, developing parameters of the StaticTool method means defining a set of functions that make grade assessment dependent on the type of planned measures and their intensity for each measure from the local catalogue.

The StaticTool method and the StaticTool.xlsm application were developed as part of the project FramWat, Work Package T2 (Effectiveness of the Natural Small Water Retention Measure), activity A.T2.2 (Developing the GIS based method to assess cumulative effect of N(S)WRM at the river basin scale), deliverable D.T2.2.1 (Static method to assess cumulative effect of N(S)WRM in the river basins). A detailed description of the methodology is in a separate file created by the author of the program. This report presents the results of testing the static method to assess cumulative effect of N(S)WRM via developed application (program) StaticTool.xlsm for the Slovak Pilot Catchment of the Blh River within Slaná River Basin.

2. DESCRIPTION OF INPUT DATA PREPARATION

The first step of the work with the StaticTool.xlsm program, it was necessary to specify the N(S)WRM types, for which calculations will be carried out for expert variant and for variant of local preferences. There were used measure types proposed within Concept plan preparation and these are showed in Fig.1 for both expert variant and for local preferences variant. For more information on variants see report on Concept plan preparation (4).

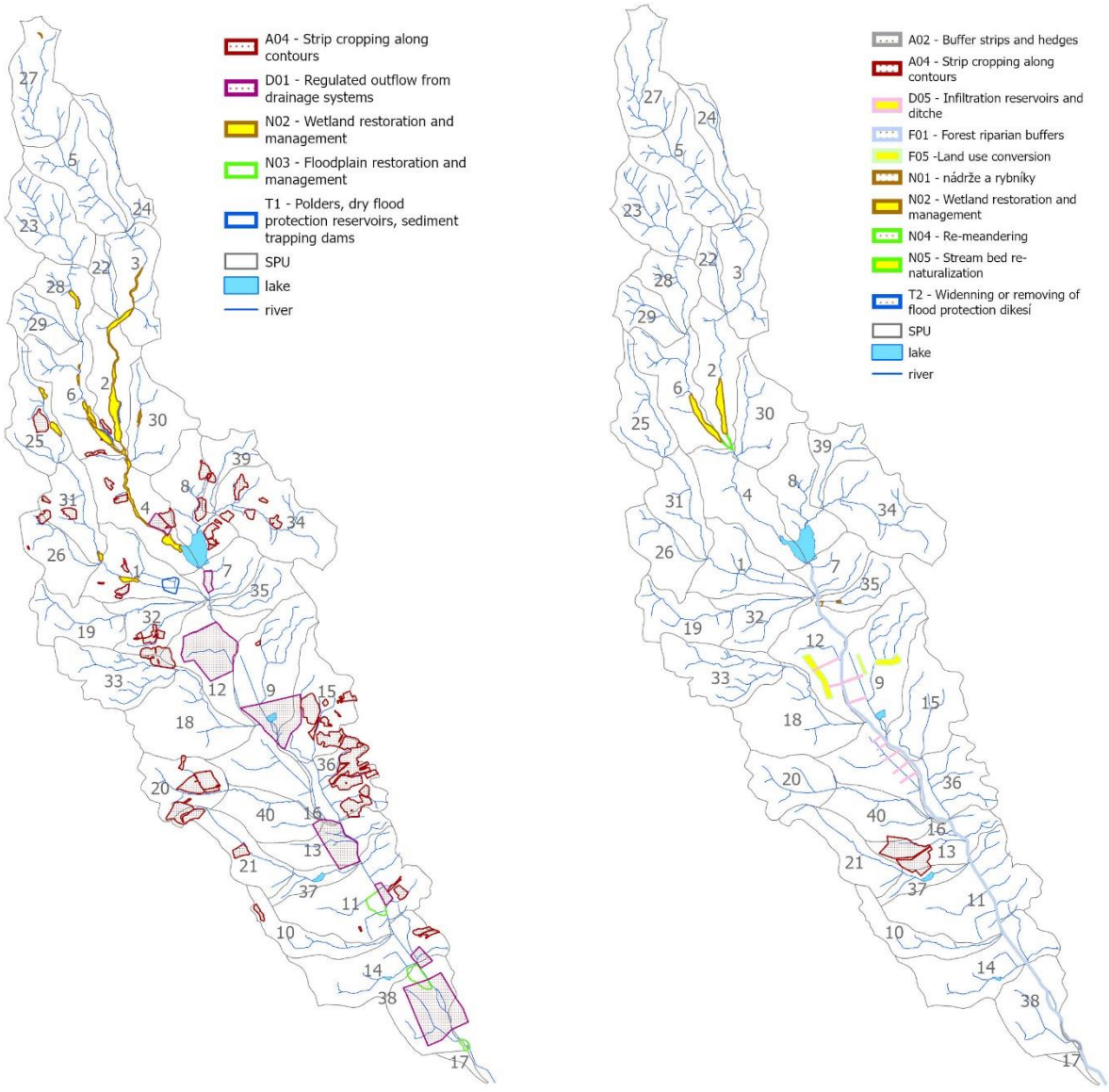

Fig. 1 Type and localization of measures proposed for expert variant and for local preferences variant

The types of measures are showed also in the table below (Tab. 1) and for all chosen individual measures the basic characteristic necessary to quantify criteria in the next steps of Statictool.xlsm application are calculated.

Tab. 1 Basic parameters of proposed measures for expert variant (Exp) and for local preferences variant (Loc)

Code	Variant	Type NSWRM	Name	Parameters	Count of NSWRM	Area [ha]	Length [km]
A04	Exp	Strip cropping along contours		tesne siate plodiny sa striedajú s riadkovými plodinami v minimálnej šírke pásov - 15 m	54	915	-
D01	Exp	Regulated outflow from drainage systems		na území s existujúcimi melioračnými zariadeniami sa navrhujú opatrenia na regulovaný odtok vody z drenážnych systémov	8	1268	-
N02	Exp	Wetland restoration and management		odstránenie inváznych druhov rastlín a drevín, výsadba pôvodných druhov drevín, obnova lúčnych ekosystémov	15	225	-
N03	Exp	Floodplain restoration and management		4 priepusty	4	115	-
T1	Exp	Polders, dry flood protection reservoirs, sediment trapping dams	polder Papča	Rozloha nádrže: 30,35 ha, celková kapacita: 287600 m3, dĺžka priehrady - asi 643 m, výška vzhľadom na dno doliny - 6 m	1	30,35	-
T1	Exp	Polders, dry flood protection reservoirs, sediment trapping dams	polder Hrušovo 1	Rozloha nádrže: 28,67 ha, celková kapacita: 275000 m3, dĺžka priehrady - asi 1041 m, výška vzhľadom na dno doliny - 10 m	1	28,67	-
T1	Exp	Polders, dry flood protection reservoirs, sediment trapping dams	polder Hrušovo 2	Rozloha nádrže: 18,08 ha, celková kapacita: 158200 m3, dĺžka priehrady - asi 761 m, výška vzhľadom na dno doliny - 7 m	1	18,08	-
A02	Loc	Buffer strips and hedges		výsadba drevín na bočnú stranu hrádze Blh-Ivanice	1	2	1,5
A04	Loc	Strip cropping along contours		tesne siate plodiny sa striedajú s riadkovými plodinami v minimálnej šírke pásov - 15 m	2	162	-

Code	Variant	Type NSWRM	Name	Parameters	Count of NSWRM	Area [ha]	Length [km]
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 47 m, dĺžka 789 m	1	3,7	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 40 m, dĺžka 802 m	1	3,23	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 31 m, dĺžka 740 m	1	2,31	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 26 m, dĺžka 455 m	1	1,2	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 30 m, dĺžka 405 m	1	1,21	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 49 m, dĺžka 697 m	1	3,41	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 48 m, dĺžka 460 m	1	2,2	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 63 m, dĺžka 796 m	1	5,08	-
D05	Loc	Infiltration reservoirs and ditches (similar to N13)		šírka 33 m, dĺžka 1103 m	1	3,64	-
F01	Loc	Forest riparian buffers		výsadba stromu každých 6 metrov (vŕba, topol, jelša)	1	161	27,63
F05	Loc	Land use conversion		dubovo-brestovo-jasenové nížinné lužné lesy	3	79	-
N01	Loc	Basins and ponds		Rozloha nádrže: 1,82 ha, celková kapacita: 54600 m3, dĺžka 180 m, šírka 101 m	1	1,82	-
N01	Loc	Basins and ponds		Rozloha nádrže: 1,44 ha, celková kapacita: 43200 m3, dĺžka 164 m, šírka 88 m	1	1,44	-

Code	Variant	Type NSWRM	Name	Parameters	Count of NSWRM	Area [ha]	Length [km]
N02	Loc	Wetland restoration and management		odstránenie inváznych druhov rastlín a drevín, výsadba pôvodných druhov drevín, obnova lúčnych ekosystémov	3	240	-
N04	Loc	Re-meandering			1	161	27,63
N05	Loc	Stream bed re-naturalization			2	16,34	2,33
T2	Loc	Widenning or removing of flood protection dikes			1	161	-

At the initial stage, individual N(S)WRMs were merged under one (of the same) type and then aggregation was performed. Aggregated measures include a group of measures whose implementation in a similar way improves the retention properties of the catchment area, and assessment of the effects of individual activities, without detailed field or model studies at the current level of knowledge, is not possible. For the expert variant 4 records (A04 – WRAL; N02, N03 – ER; D01 - BPDA; T1) were received and for the local preferences variant 10 records (A02; A04 – WRAL; F01; F05 - AF; N01; N02 - ER; N04; N05 - BPRC; D05 - BPDA; T2) for variant local, see records in Tab. 2 and Tab. 3).

Tab. 2 Aggregated measures identification – expert variant

No	Individual measure ID	Individual measure name	Aggregated measure ID	Aggregated measure name
1	A04	Strip cropping along contours	WRAL	WRAL - best practices for Water Retention in Agricultural Lands
2	N02	Wetlands restoration and management	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems
3	N03	Floodplain restoration and management	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems
4	D01	Regulated outflow from drainage systems	BPDA	BPDA - Best Practices on Drained Areas
5	T1	Polders, dry flood protection reservoirs, sediment trapping dams	T1	Polders, dry flood protection reservoirs, sediment trapping dams

Tab. 3 Aggregated measure identification – local preferences variant

No	Individual measure ID	Individual measure name	Aggregated measure ID	Aggregated measure name
1	A02	Buffer strips and hedges	A02	Buffer strips and hedges
2	A04	Strip cropping along contours	WRAL	WRAL - best practices for Water Retention in Agricultural Lands
3	F01	Forest riparian buffers	F01	Forest riparian buffers
4	F05	Land use conversion	AF	AF - Afforestation
5	N01	Basins and ponds	N01	Basins and ponds

No	Individual measure ID	Individual measure name	Aggregated measure ID	Aggregated measure name
6	N02	Wetland restoration and management	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems
7	N04	Re-meandering	N04	Re-meandering
8	N05	Stream bed re-naturalization	BPRC	BPRC – natural channels and Best Practises of River Channels maintenance
9	D05	Infiltration reservoirs and ditches	BPDA	BPDA - Best Practices on Drained Areas
10	T2	Widening or removing of flood protection dikes	T2	Widening or removing of flood protection dikes

In the local preferences variant there exist only one individual measure relevant to one type of aggregated measure, so in fact no aggregation of measures in necessary and codes of individual measures may not be necessary replaced by codes of aggregated measures in the calculation below.

For each measure, the intensity criteria and the threshold values for characteristic intensity levels were defined. According to the assumptions of the StaticTool method, the expected improvement in the catchment retention properties depends on the type and level of intensity of planned measures. Three levels of measures' intensity were distinguished: low, medium and high. They correspond to three levels of the expected improvement in the catchment retention properties (e.g. small, average and large). Four threshold values were used: T0 – no action, Tlow – the boundary between low and medium intensity, Thigh – the limit between medium and high intensity and Tmax, which corresponds to the hypothetical maximum possible intensity of measure. There were determined expert assessments of the impact of aggregated measures on three elements of the catchment retention properties (low flows, high flows and erosion), with maximum intensity of measures' application. There was needed to formulate a general assessment of measures (three above-mentioned elements together) and defining effect coefficients for lower than maximum intensity of measures. For the assessment of the impact of aggregated measures on three elements of the catchment retention properties a 6-grade scale was adopted from 0 to 5, where:

- 0 - means no positive impact on the retention properties of the catchment area, and
- 5 – means very high positive impact on the retention properties of the catchment area.

The tables below show the parameters used for calculations in the expert and local preferences variants (Tab. 4- Tab. 7).

Tab. 4 Impact of measures on three elements of the catchment retention properties – expert variant

No	Code	Aggregated measure name	Low flows	High flows	Qual Erosion	AVG
1	WRAL/A04	WRAL - best practices for Water Retention in Agricultural Lands	0	2	4	2.00
2	ER	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems	0	5	4	3.00
3	BPDA/D01	BPDA - Best Practices on Drained Areas	2	3	2	2.33
4	T1	Polders, dry flood protection reservoirs, sediment trapping dams	0	5	3	2.67

Tab. 5 Impact of measures on three elements of the catchment retention properties - local variant

No	Code	Aggregated measure name	Low flows	High flows	Qual Erosion	AVG
1	A02	Buffer strips and hedges	1	1	3	1.67
2	WRAL/A04	WRAL - best practices for Water Retention in Agricultural Lands	0	2	4	2.00
3	F01	Forest riparian buffers	0	1	3	1.33
4	AF/F01	AF - Afforestation	3	3	4	3,33
5	N01	Basins and ponds	3	3	2	2,67
6	ER/N02	ER - Ecosystems Restoration / renaturisation of water dependent ecosystems	0	5	4	3.00
7	N04	Re-meandering	0	2	2	1,33
8	BPRC/N05	BPRC – natural channels and Best Practises of River Channels maintenance	4	4	2	3.33
9	BPDA/D05	BPDA - Best Practices on Drained Areas	0	2	2	1,33
10	T2	Widening or removing of flood protection dikes	0	3	3	2.00

Tab. 6 List of parameters for measures in expert variant

AggregN	4				Intensity thresholds					Grade thresholds [%]				Grade values			
No sort_AVG	No	Measure ID	Aggregated English	Definition of the intensity criteria in English	T0	Tlow	Thigh	Tmax	Grade_max	E%0	E%low	E%high	E%max	E0	Elow	Ehigh	Emax
1	1	WRAL	agriculture	Arable land area on which best practices of water retention are applied and SPU area ratio [km2/km2]	0,00	0,30	0,80	1,00	4	0	30	80	100	0,00	1,20	3,20	4,00
4	2	ER	swamps	Total area of restored (and managed) wetlands, floodplains and reconnected ox-bows and SPU area ratio [km2/km2]	0,00	0,10	0,40	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00
2	3	BPDA	drainage systems	Drained area under Best DA Practices and SPU area ratio [km2/km2]	0,00	0,05	0,15	1,00	4	0	60	95	100	0,00	2,40	3,80	4,00
3	4	T1	Polders, dry flood protection reservoirs, s	Catchment area upstream of measure (polder, dry reservoir) and SPU area ratio [km2/km2]	0,00	0,05	0,20	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00

Tab. 7 List of parameters for measures in local preferences variant

AggregN	10				Intensity thresholds					Grade thresholds [%]				Grade values			
No sort_AVG	No	Measure ID	Aggregated English	Definition of the intensity criteria in English	T0	Tlow	Thigh	Tmax	Grade_max	E%0	E%low	E%high	E%max	E0	Elow	Ehigh	Emax
5	1	A02	Buffer strips and hedges	Buffer strips density - total lenght of strips and SPU area ratio [km/km2]	0,00	0,50	2,00	6,00	3	0	60	95	100	0,00	1,80	2,85	3,00
6	2	A04	Strip cropping along contours	Arable land area on which best practices of water retention are applied and SPU area ratio [km2/km2]	0,00	0,30	0,80	1,00	3	0	30	80	100	0,00	0,90	2,40	3,00
2	3	F01	Forest riparian buffers	Total lenght of forest riparian buffers and doubled lenght of water courses in SPU ratio [km/km]	0,00	0,30	0,70	1,00	2	0	30	70	100	0,00	0,60	1,40	2,00
10	4	F05	Land use conversion	Newly afforested area and SPU area ratio [km2/km2]	0,00	0,05	0,20	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00
8	5	N01	Basins and ponds	Total area of basins and ponds and SPU area ratio [km2/km2]	0,00	0,01	0,10	1,00	4	0	60	95	100	0,00	2,40	3,80	4,00
9	6	N02	Wetland restoration and management	Total area of restored (and managed) wetlands, floodplains and reconnected ox-bows and SPU area ratio [km2/km2]	0,00	0,10	0,40	1,00	5	0	60	95	100	0,00	3,00	4,75	5,00
3	7	N04	Re-meandering	Total length of re-meandered water bodies and water bodies length in SPU ratio [km/km]	0,00	0,30	0,60	1,00	2	0	30	60	100	0,00	0,60	1,20	2,00
4	8	N05	Stream bed re-naturalization	Total length of restored water bodies (natural stream bed, bank protection removal, etc) and water bodies length in SPU ratio [km/km]	0,00	0,20	0,60	1,00	2	0	20	60	100	0,00	0,40	1,20	2,00
1	9	D05	Infiltration reservoirs and ditches (similar	Drained area under Best DA Practices and SPU area ratio [km2/km2]	0,00	0,05	0,15	1,00	2	0	60	95	100	0,00	1,20	1,90	2,00
7	10	T2	Widening or removing of flood protection	Active floodplain area and max (during HHQ) floodplain area in SPU ratio [km2/km2]	0,00	0,05	0,20	1,00	3	0	60	95	100	0,00	1,80	2,85	3,00

For each planned measure (in SPUs), its intensity was given, expressed in accordance with the adopted intensity criterion definitions. For each SPU in the columns corresponding to individual measures, there was provided their intensity, with the value 0 - meaning no measure in the given SPU will be realized, and 1 – planning the measure with the maximum possible intensity. Intensity levels for 40 SPUs were determined for the Blh pilot catchment.

3. MODIFICATIONS TO THE STATICTOOLS.XLSX TOOL PARAMETERS

Defining the measures of the intensity and determining the thresholds for the characteristic levels of intensity (low, medium, high) was done with methodology developed by the company Pro-Woda (Tyszewski S. 2019).

Further the external expert with local knowledge and experiences in the field of assessment the efficiency of natural small retention measures was contacted and proposal of efficiency of each of measures defined in the catalogue of measures in more consultation rounds. There was assessed the potential effect of each measure within the five grade scale where 0 means no effect to particular goal and 5 means the maximum effect for particular goal. As the impact of different types of flood protection is different for small and extreme events, there was proposed to provide assessment for five groups of goals:

- low flows
- quality
- high flows - small floods (Q1-Q10)
- high flows - medium floods (Q10-Q50)
- high flows - extreme floods (Q50-Q1000)

For the water management structures there was proposed to divide measure T3 into two sub-groups:

- bigger and medium size water reservoirs
- small shallow water reservoirs and fishponds (less than 1 000 m^2)

The results of Mr. Marek Čomaj from Water Research Institute are showed in the Annex.

Further the different alternatives of measures proposed for local preferences variaant were examined. These are three alternatives assuming that:

a. Alternative a) - As criteria there was used "km^2/km^2" instead "km/km^2" for measures F01, N04 and N05 and "km/km" for measure A02. According the developed methodology for each planned measure (in SPUs), its intensity is given, expressed in accordance with the adopted intensity criterion definitions. This alternative is relevant only for some of measures proposed within local preferences variant.

b. Alternative b) - For each of the variant we tried to select only "most efficient measures" for high flows, low flows and quality

c. Alternative c) – based on results of consultation with national expert on concretizing the effects of measures for particular goals taking into account different discharges in rivers varying from Q10 up to Q1000 was created the alternative to minimize impacts of low flow conditions.

4. DESCRIPTION OF RESULTS

The scope of testing is to compare improvement of valorization results for entire pilot area or for individual SPUs. The valorization results are calculated according Valorization method developed within project, for more information see (3). Results of catchment valorization are shown in Fig. 1 where needs and possibilities of water retention are calculated for each particular SPU in the Blh pilot catchment.

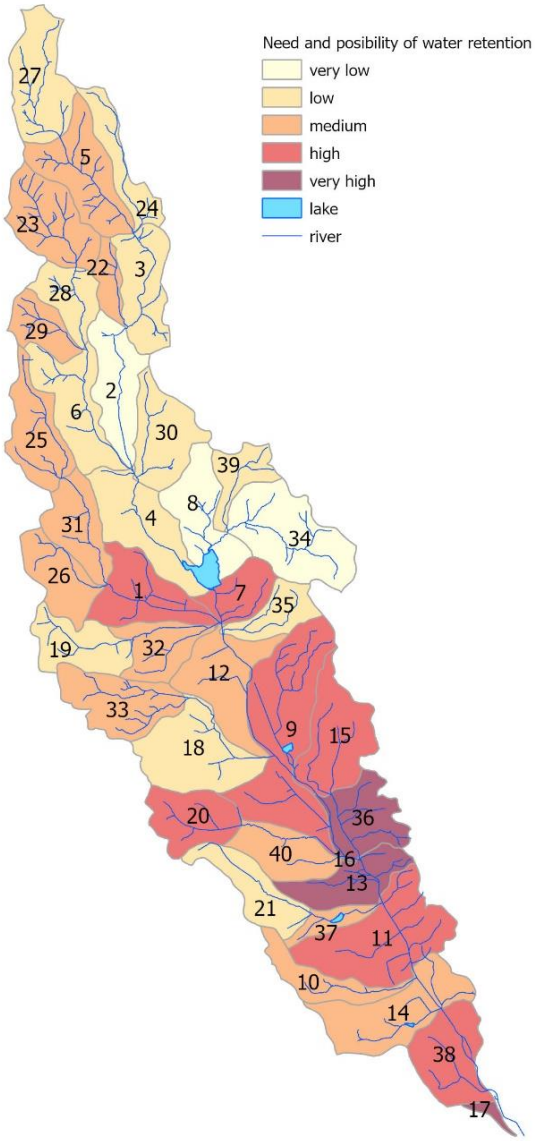

Fig. 2 Map of needs and possibilities of water retention in SPUs

4.1. For the expert variant

Type and localization of all the measures proposed for the expert variant in particular SPUs are showed in Fig. 2.

The results of the assessment were obtained from the StaticAssessment table of StaticTool.xlsm. This table contains the cumulative assessment for the entire pilot catchment and partial assessments for each group of measures and for each SPU.

The obtained results show that the highest impact on the final grade had aggregated measures - best practices on drained areas (BPDA = 30.80), then other 3 measures had significantly lower impact: Ecosystems Restoration/renaturisation of water dependent ecosystems (ER =

12.51), Polders, dry flood protection reservoirs, sediment trapping dams (T1 = 6.00) and lowest impact on the finale grade had aggregated measures - best practices for Water Retention in Agricultural Lands (WRAL = 5.78). In order to assess a single SPU while taking into account the size of the catchment area, additional calculations were made according to the following equation SPU grades * F_SPU/Σ F_SPU. The results are shown in Tab. 1.

The greatest impact on the final assessment had SPU 02, 09, 38 which are characterized by high values of SPU grade and used measures. The SPU rating which does not take into account the area shows similar results: the highest rating was obtained by SPU 38 in which measurements like ecosystems restoration and water retention in agricultural lands are planned. In a situation where the SPUs have different sizes, comparing their ratings is questionable. The final rating for the catchment also depends largely on the size of the SPUs. This variant contained a large number of measures with low efficiency, therefore the SPU assessment results are spatially dispersed and their discrepancies are small. The overall rating for this option is 1.77.

Tab. 1. Assessment of the effectiveness of the expert variant

Number of measures	4			Grading of the Program of Small Water Retention Measures					
Number of SPUs	40		Measure No.	1	2	3	4	Catchment grade for current variant	
Grade for a measure (total by SPUs):				5,78	12,31	30,80	6,00	1,54	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2		
1	SPU_01		7,79	0,11	0,38		2,34	2,82	0,093413
2	SPU_02		7,33	0,02	3,09		2,35	5,46	0,170098
3	SPU_03		7,27		0,93			0,93	0,028878
4	SPU_04		9,36	0,21	1,48	1,77		3,47	0,137861
6	SPU_06		8,22	0,04	1,53		1,32	2,89	0,100962
7	SPU_07		4,23			2,46		2,46	0,044255
8	SPU_08		7,95	0,42				0,42	0,014087
9	SPU_09		17,20	0,01		3,28		3,29	0,240159
10	SPU_10		4,58	0,08				0,08	0,001612
11	SPU_11		13,27	0,07	1,00	0,96		2,02	0,114010
12	SPU_12		8,59	0,06		3,85		3,91	0,142917
13	SPU_13		5,99	0,05		3,83		3,87	0,098555
14	SPU_14		10,10	0,08	0,24	1,18		1,51	0,064649
15	SPU_15		8,80	0,68		2,66		3,34	0,125058
16	SPU_16		0,04			3,98		3,98	0,000704
17	SPU_17		0,62		0,12			0,12	0,000325
18	SPU_18		10,29	0,00				0,00	0,000167
20	SPU_20		6,17	0,86				0,86	0,022615
21	SPU_21		5,84	0,40				0,40	0,009976
22	SPU_22		2,29			0,16		0,16	0,001551
25	SPU_25		6,82	0,20	0,71			0,91	0,026254
26	SPU_26		5,61	0,08				0,08	0,001951
27	SPU_27		8,46		0,03			0,03	0,001137
28	SPU_28		4,54		0,62			0,62	0,012017
30	SPU_30		7,26		0,15			0,15	0,004657
31	SPU_31		6,06	0,17	0,20			0,38	0,009704
32	SPU_32		5,20	0,41				0,41	0,008970
33	SPU_33		7,87	0,18				0,18	0,006186
34	SPU_34		11,57	0,21				0,21	0,010280
36	SPU_36		6,63	1,37		0,09		1,46	0,041200
37	SPU_37		2,14			1,19		1,19	0,010838
38	SPU_38		7,73		1,82	3,87		5,70	0,187260
39	SPU_39		3,67	0,06				0,06	0,000876
40	SPU_40		5,79			1,50		1,50	0,037049

Also alternative b) mentioned in the chapter 3 was examined here. In Tab 2 we tried to propose just those measures, which should improve water quality. Measures were selected based on highest impact grade on quality – WRAL, ER. The overall rating for this option is 0.63. In Tab 3 we tried to propose just those measures, which should improve high flows. Measures were selected based on highest impact grade on high flow – ER, T1. The overall rating for this option is 1.38. In Tab 4 we tried to propose just those measures, which should improve lowf lows. Measures were selected based on highest impact grade on low flow, in this case just one measure – BPDA was selected. The overall rating for this option is 2.25.

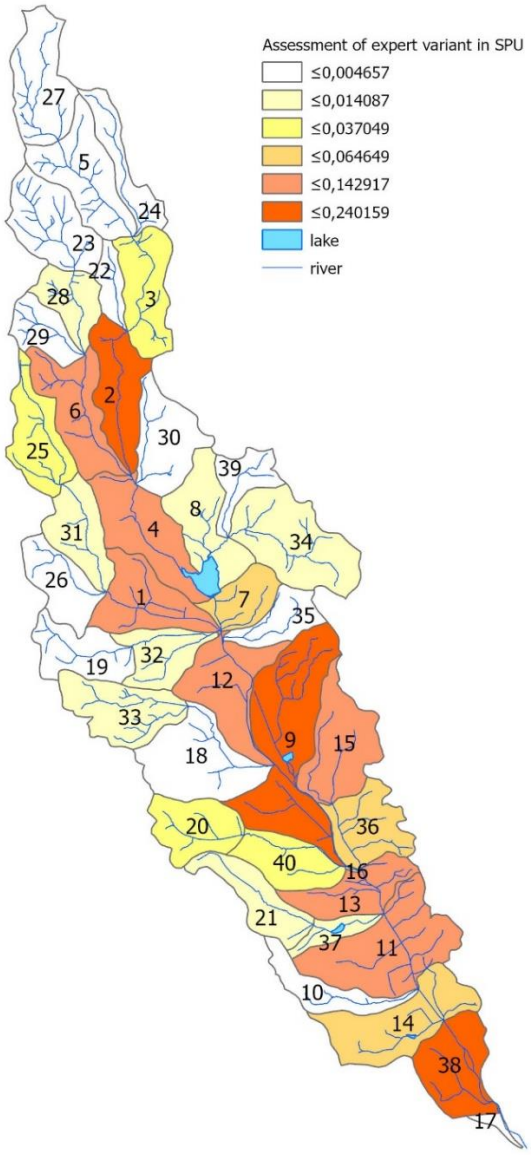

Fig. 3 Map of assessment of the expert variant at the SPU level

Tab. 2. Assessment of the effectiveness of the expert variant for quality improvement

Number of measures	4			Grading of the Program of Small Water Retention Measures									
Number of SPUs	27		Measure No.	1	2	3	4					Catchment grade for current variant	
Grade for a measure (total by SPUs):				5,78	11,38	0,00	0,00					0,63	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1					SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2						
1	SPU_01		7,79	0,11	0,38							0,48	0,02
2	SPU_02		7,33	0,02	3,09							3,11	0,11
3	SPU_04		9,36	0,21	1,48							1,69	0,08
4	SPU_06		8,22	0,04	1,53							1,57	0,06
5	SPU_08		7,95	0,42								0,42	0,02
6	SPU_09		17,20	0,01								0,01	0,00
7	SPU_10		4,58	0,08								0,08	0,00
8	SPU_11		13,27	0,07	1,00							1,06	0,07
9	SPU_12		8,59	0,06								0,06	0,00
10	SPU_13		5,99	0,05								0,05	0,00
11	SPU_14		10,10	0,08	0,24							0,32	0,02
12	SPU_15		8,80	0,68								0,68	0,03
13	SPU_17		0,62		0,12							0,12	0,00
14	SPU_18		10,29	0,00								0,00	0,00
15	SPU_20		6,17	0,86								0,86	0,03
16	SPU_21		5,84	0,40								0,40	0,01
17	SPU_25		6,82	0,20	0,71							0,91	0,03
18	SPU_26		5,61	0,08								0,08	0,00
19	SPU_27		8,46		0,03							0,03	0,00
20	SPU_28		4,54		0,62							0,62	0,01
21	SPU_30		7,26		0,15							0,15	0,01
22	SPU_31		6,06	0,17	0,20							0,38	0,01
23	SPU_32		5,20	0,41								0,41	0,01
24	SPU_33		7,87	0,18								0,18	0,01
25	SPU_34		11,57	0,21								0,21	0,01
26	SPU_36		6,63	1,37								1,37	0,04
27	SPU_38		7,73		1,82							1,82	0,07

Tab. 3. Assessment of the effectiveness of the expert variant for improvement of high flow conditions

Number of measures	4			Grading of the Program of Small Water Retention Measures									
Number of SPUs	14		Measure No.	1	2	3	4					Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	12,31	0,00	6,00					1,38	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1					SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2						
1	SPU_01		7,79		0,38		2,34					2,71	0,20
2	SPU_02		7,33		3,09		2,35					5,44	0,38
3	SPU_03		7,27		0,93							0,93	0,06
4	SPU_04		9,36		1,48							1,48	0,13
5	SPU_06		8,22		1,53		1,32					2,85	0,22
6	SPU_11		13,27		1,00							1,00	0,13
7	SPU_14		10,10		0,24							0,24	0,02
8	SPU_17		0,62		0,12							0,12	0,00
9	SPU_25		6,82		0,71							0,71	0,05
10	SPU_27		8,46		0,03							0,03	0,00
11	SPU_28		4,54		0,62							0,62	0,03
12	SPU_30		7,26		0,15							0,15	0,01
13	SPU_31		6,06		0,20							0,20	0,01
14	SPU_38		7,73		1,82							1,82	0,13

Tab. 4. Assessment of the effectiveness of the expert variant for improvement of low flow conditions

Number of measures	4			Grading of the Program of Small Water Retention Measures									
Number of SPUs	14		Measure No.	1	2	3	4					Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	0,00	30,80	0,00					2,25	
No.	SPU Id	SPU name	Measure Id by User	WRAL	ER	BPDA	T1					SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2						
1	SPU_04		9,36			1,77						1,77	0,16
2	SPU_07		4,23			2,46						2,46	0,10
3	SPU_09		17,20			3,28						3,28	0,55
4	SPU_11		13,27			0,96						0,96	0,12
5	SPU_12		8,59			3,85						3,85	0,32
6	SPU_13		5,99			3,83						3,83	0,22
7	SPU_14		10,10			1,18						1,18	0,12
8	SPU_15		8,80			2,66						2,66	0,23
9	SPU_16		0,04			3,98						3,98	0,00
10	SPU_22		2,29			0,16						0,16	0,00
11	SPU_36		6,63			0,09						0,09	0,01
12	SPU_37		2,14			1,19						1,19	0,02
13	SPU_38		7,73			3,87						3,87	0,29
14	SPU_40		5,79			1,50						1,50	0,09

Based on the overall values of calculated grades it can be assumed that when selecting only measures to improve low flow conditions the effect for whole pilot area will be higher (2.25 to 1,77).

4.2. For the variant of local preferences

Type and localization of all the measures proposed for the expert variant in particular SPUs are showed in Fig. 2.

The results of the local preferences variant assessment are also presented in the form of a table (Tab. 5) and map (Fig. 4). In this variant, wetland restoration and management (N02 = 13.56) and widening or removing of flood protection dikes (T02 = 10.36) have the greatest impact on the final score. Less impactful measures are polders, dry flood protection reservoirs, sediment trapping dams (T01 = 7.15) and land use conversion (F05 = 4.17). The impact of other measures is negligible. In order to assess a single SPU while taking into account the size of the catchment area, additional calculations were made according to the following equation SPU grades * F_SPU/Σ F_SPU. The results are shown

The greatest impact on the final assessment had SPU 12 and 09. SPUs assessment without taking into account the area gives different results, and in this case the SPUs 12, 16, 13, 17 dominate with a score of 12 = 6.28, 16 = 5.9, 13 = 5.28, 17 = 4.57. These variants included a small number of measures with high efficiency which caused the SPUs assessment results to be cumulated only in 4 SPUs (12, 16, 13, 17) and divergences between them and others are very significant. The overall rating for this variant is 1.68.

Tab. 5. Assessment of the effectiveness of the local preferences variant

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	20		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,70	0,93	2,16	4,17	1,77	13,56	1,08	0,26	0,46	10,40	1,63	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
1	SPU_01		7,79			0,02			0,02	0,01			0,02	0,07	0,003680
2	SPU_02		7,33						1,66		0,02			1,68	0,089060
4	SPU_04		9,36								0,01			0,01	0,000792
6	SPU_06		8,22						1,39		0,23			1,62	0,096037
7	SPU_07		4,23			0,08			0,47	0,04			0,57	1,15	0,035213
9	SPU_09		17,20			0,34	1,11		0,39	0,17		0,27	0,46	2,74	0,341066
10	SPU_10		4,58			0,01			0,01	0,00			0,02	0,04	0,001414
11	SPU_11		13,27			0,23			0,46	0,11			0,55	1,35	0,129282
12	SPU_12		8,59			0,40	3,06	0,13	1,24	0,20		0,19	1,49	6,71	0,416817
13	SPU_13		5,99		0,69	0,14			0,63	0,07			0,76	2,29	0,099195
14	SPU_14		10,10			0,11			0,29	0,05			0,35	0,81	0,059088
15	SPU_15		8,80			0,07			0,17	0,04		0,00	0,20	0,48	0,030268
16	SPU_16		0,04			0,05			3,12	0,02			2,30	5,49	0,001650
17	SPU_17		0,62			0,15			2,28	0,07			1,98	4,49	0,020229
21	SPU_21		5,84		0,01									0,01	0,000509
35	SPU_35		4,08			0,01		1,63	0,00	0,00			0,00	1,64	0,048437
36	SPU_36		6,63			0,26			0,44	0,13		0,00	0,53	1,36	0,065210
37	SPU_37		2,14		0,18									0,18	0,002822
38	SPU_38		7,73	0,70		0,30			0,98	0,15			1,17	3,31	0,184831
40	SPU_40		5,79		0,04	0,00			0,00	0,00			0,00	0,05	0,001963

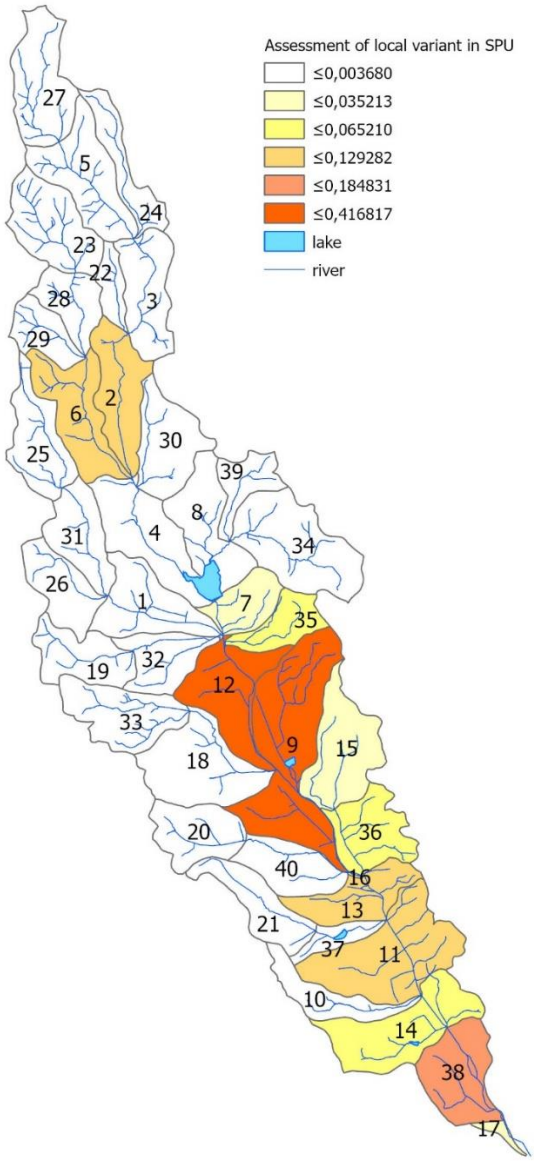

Fig 4 Map of assessment of the local preferences variant at the SPU level

Also alternative b) mentioned in the chapter 3 was examined. In Tab. 6 we tried to propose just those measures, which should improve water quality. Measures were selected bases on highest impact grade on quality – A02, F01, F05, N02, A04, T2. The overall rating for this option is 1.55. In Tab 7 we tried using just those measure, which should improve on high flows. Measures were selected based on highest impact grade on high flow – F05, N01, N02, D05, A04, T2. The overall rating for this option is 1.68. In Tab 8 we tried to propose just those measures, which should improve low flows. Measures were selected based on highest impact grade on low flow, in this case just measures F05, N01, D05. The overall rating for this option is 1.31.

Tab. 6. Assessment of the effectiveness of the local preferences variant for quality improvement

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	19		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,70	0,93	2,16	4,17	0,00	13,56	0,00	0,00	0,00	10,40	1,54	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
1	SPU_01		7,79			0,02			0,02				0,02	0,06	0,003476
2	SPU_02		7,33						1,66					1,66	0,094349
6	SPU_06		8,22						1,39					1,39	0,088374
7	SPU_07		4,23			0,08			0,47				0,57	1,11	0,036491
9	SPU_09		17,20			0,34	1,11		0,39				0,46	2,30	0,307168
10	SPU_10		4,58			0,01			0,01				0,02	0,04	0,001378
11	SPU_11		13,27			0,23			0,46				0,55	1,23	0,127025
12	SPU_12		8,59			0,40	3,06		1,24				1,49	6,19	0,412454
13	SPU_13		5,99		0,69	0,14			0,63				0,76	2,22	0,103134
14	SPU_14		10,10			0,11			0,29				0,35	0,75	0,059101
15	SPU_15		8,80			0,07			0,17				0,20	0,44	0,029844
16	SPU_16		0,04			0,05			3,12				2,30	5,47	0,001762
17	SPU_17		0,62			0,15			2,28				1,98	4,42	0,021339
21	SPU_21		5,84		0,01									0,01	0,000545
35	SPU_35		4,08			0,01			0,00				0,00	0,01	0,000259
36	SPU_36		6,63			0,26			0,44				0,53	1,23	0,063325
37	SPU_37		2,14		0,18									0,18	0,003027
38	SPU_38		7,73	0,70		0,30			0,98				1,17	3,15	0,189123
40	SPU_40		5,79		0,04	0,00			0,00				0,00	0,05	0,002053

Tab. 7. Assessment of the effectiveness of the local preferences variant for improvement of high flow conditions

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	17		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	0,00	0,00	4,17	1,77	13,56	0,00	0,00	0,00	10,40	1,46	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
1	SPU_01		7,79						0,02				0,02	0,04	0,002700
2	SPU_02		7,33						1,66					1,66	0,100573
6	SPU_06		8,22						1,39					1,39	0,094204
7	SPU_07		4,23						0,47				0,57	1,04	0,036173
9	SPU_09		17,20				1,11		0,39				0,46	1,96	0,278632
10	SPU_10		4,58						0,01				0,02	0,03	0,001173
11	SPU_11		13,27						0,46				0,55	1,01	0,110589
12	SPU_12		8,59				3,06	0,13	1,24				1,49	5,93	0,420958
13	SPU_13		5,99						0,63				0,76	1,39	0,068658
14	SPU_14		10,10						0,29				0,35	0,65	0,053884
15	SPU_15		8,80						0,17				0,20	0,37	0,026704
16	SPU_16		0,04						3,12				2,30	5,42	0,001863
17	SPU_17		0,62						2,28				1,98	4,27	0,021983
35	SPU_35		4,08					1,63	0,00				0,00	1,63	0,054985
36	SPU_36		6,63						0,44				0,53	0,97	0,053398
38	SPU_38		7,73						0,98				1,17	2,15	0,137526
40	SPU_40		5,79						0,00				0,00	0,00	0,000120

Tab. 8. Assessment of the effectiveness of the local preferences variant for improvement of low flow condition

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	3		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,00	0,00	0,00	4,17	1,77	0,00	0,00	0,00	0,00	0,00	1,78	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km/km2	km2/km2	km/km	km2/km2	km2/km2	km2/km2	km/km	km/km	km2/km2	km2/km2		
9	SPU_09		17,20				1,11							1,11	0,639183
12	SPU_12		8,59				3,06	0,13						3,20	0,920293
35	SPU_35		4,08					1,63						1,63	0,222692

Based on the overall values of calculated grades it can be assumed that the effect for whole pilot area is the highest when taking into account all of proposed measures (1.68).

Results of assessments for all three phenomena are shown in the Fig, 5, 6 and 7.

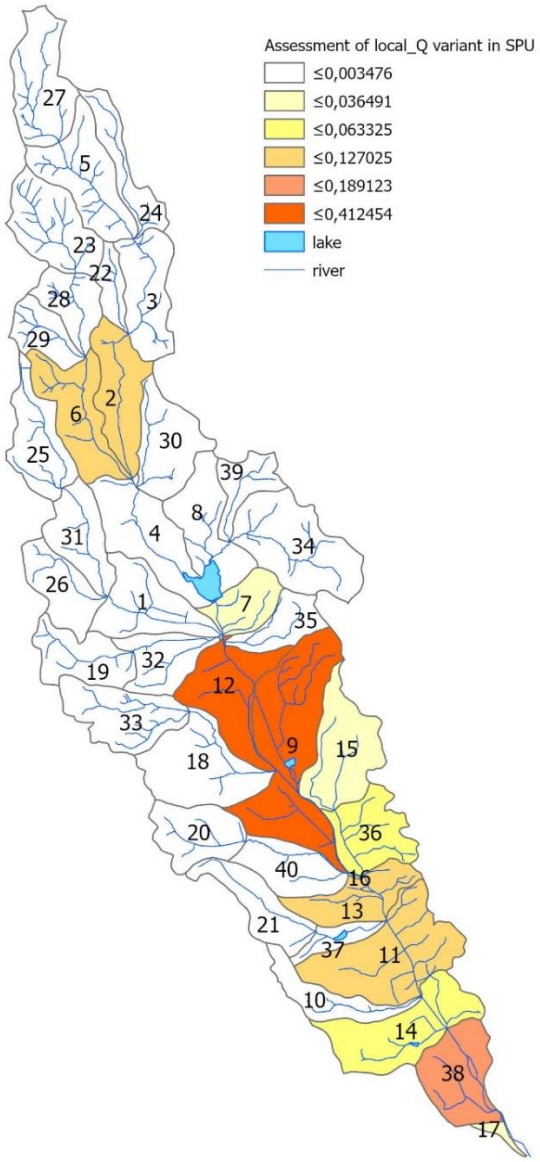

Fig. 5 Map of assessment of the effectiveness of the local preferences variant for quality improvement

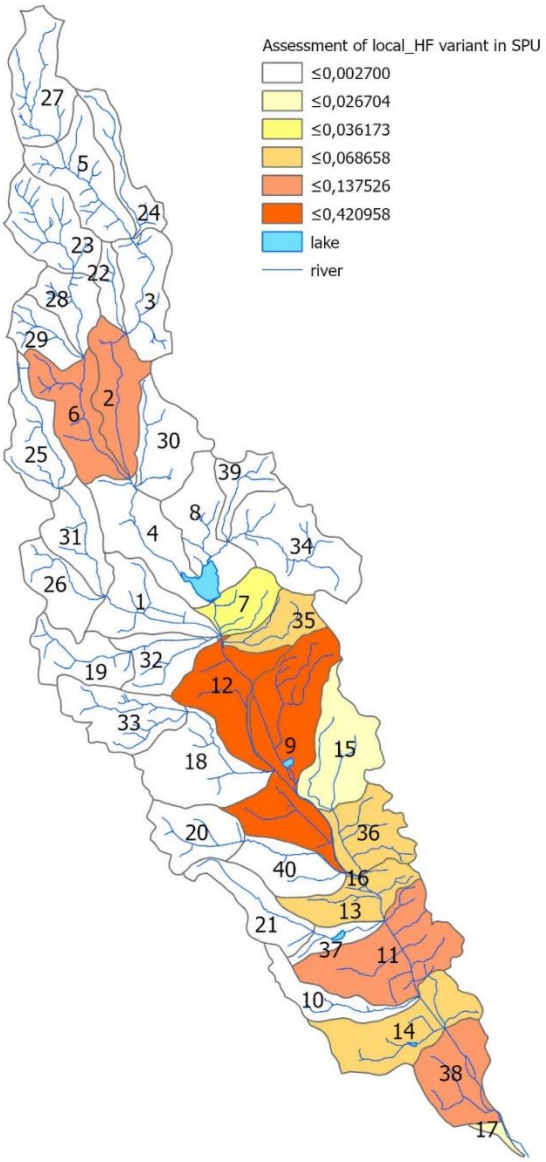

Fig. 6 Map of assessment of the effectiveness of the local preferences variant for improvement of high flow conditions

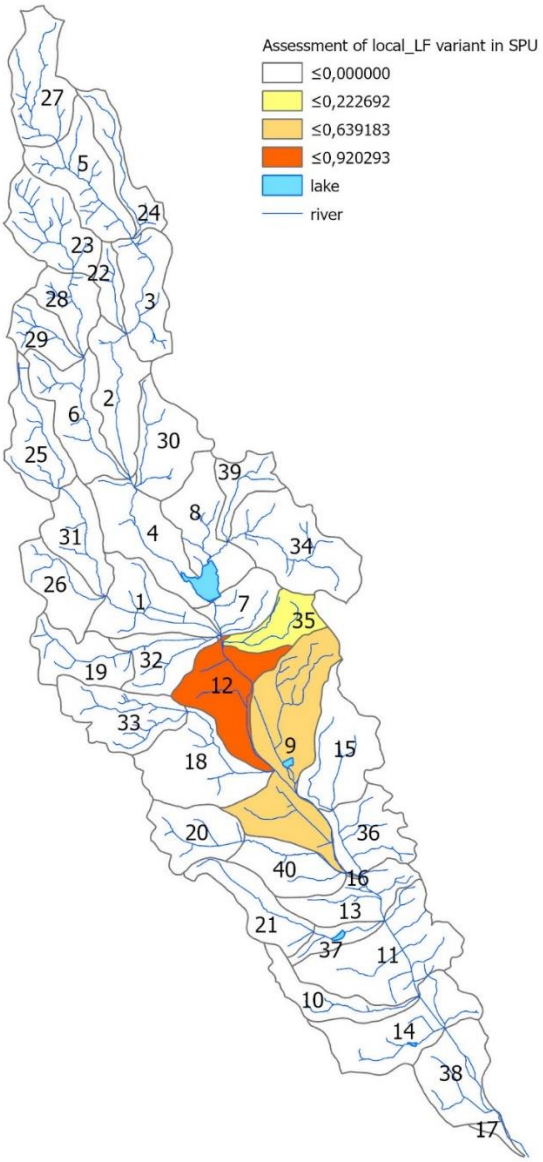

Fig. 7 Map of assessment of the effectiveness of the local preferences variant for improvement of low flow conditions

Also alternative a) mentioned in the chapter 3 taking into consideration the change of criteria from "km/km" and "km/km^2" to "km^2/km^2" was examined here. Results and chosen criteria are shown in the tables Tab. 9 and tab. 10 and assessments are shown in Fig. 8 and 9. Based on the reached grading (1.41, 1,37) it seems to be even less efficient alternative as calculated above, so the change of criteria was wrong and we have to keep criteria proposed by project.

Tab. 9. Assessment of the effectiveness of the local preferences variant with changed criteria

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	20		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,01	0,93	0,73	4,17	1,77	13,56	0,73	0,02	0,46	10,40	1,41	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2		
1	SPU_01		7,79			0,00			0,02	0,00			0,02	0,04	0,002505
2	SPU_02		7,33						1,66		0,01			1,67	0,088270
4	SPU_04		9,36								0,00			0,00	0,000087
6	SPU_06		8,22						1,39		0,01			1,40	0,083038
7	SPU_07		4,23			0,03			0,47	0,03			0,57	1,10	0,033556
9	SPU_09		17,20			0,03	1,11		0,39	0,03		0,27	0,46	2,28	0,283449
10	SPU_10		4,58			0,00			0,01	0,00			0,02	0,03	0,001088
11	SPU_11		13,27			0,03			0,46	0,03			0,55	1,07	0,102588
12	SPU_12		8,59			0,08	3,06	0,13	1,24	0,08		0,19	1,49	6,28	0,390020
13	SPU_13		5,99		0,69	0,04			0,63	0,04			0,76	2,17	0,093717
14	SPU_14		10,10			0,02			0,29	0,02			0,35	0,68	0,049986
15	SPU_15		8,80			0,01			0,17	0,01		0,00	0,20	0,39	0,024982
16	SPU_16		0,04			0,24			3,12	0,24			2,30	5,90	0,001775
17	SPU_17		0,62			0,15			2,28	0,15			1,98	4,57	0,020599
21	SPU_21		5,84		0,01									0,01	0,000509
35	SPU_35		4,08			0,00		1,63	0,00	0,00			0,00	1,63	0,048093
36	SPU_36		6,63			0,03			0,44	0,03		0,00	0,53	1,03	0,049536
37	SPU_37		2,14		0,18									0,18	0,002822
38	SPU_38		7,73	0,01		0,07			0,98	0,07			1,17	2,29	0,127994
40	SPU_40		5,79		0,04	0,00			0,00	0,00			0,00	0,04	0,001823

Tab. 10. Assessment of the effectiveness of the local preferences variant with changed criteria for quality improvement

Number of measures	10			Grading of the Program of Small Water Retention Measures											
Number of SPUs	19		Measure No.	1	2	3	4	5	6	7	8	9	10	Catchment grade for current variant	
Grade for a measure (total by SPUs):				0,01	0,93	0,73	4,17	0,00	13,56	0,00	0,00	0,00	10,40	1,37	
No.	SPU Id	SPU name	Measure Id by User	A02	A04	F01	F05	N01	N02	N04	N05	D05	T2	SPU grades	SPU_grades * F_SPU / Σ F_SPU
			F_SPU [km^2]	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2	km2/km2		
1	SPU_01		7,79			0,00			0,02				0,02	0,04	0,002610
2	SPU_02		7,33						1,66					1,66	0,094349
6	SPU_06		8,22						1,39					1,39	0,088374
7	SPU_07		4,23			0,03			0,47				0,57	1,07	0,034963
9	SPU_09		17,20			0,03	1,11		0,39				0,46	1,99	0,264824
10	SPU_10		4,58			0,00			0,01				0,02	0,03	0,001134
11	SPU_11		13,27			0,03			0,46				0,55	1,04	0,106889
12	SPU_12		8,59			0,08	3,06		1,24				1,49	5,88	0,391457
13	SPU_13		5,99		0,69	0,04			0,63				0,76	2,12	0,098566
14	SPU_14		10,10			0,02			0,29				0,35	0,67	0,052082
15	SPU_15		8,80			0,01			0,17				0,20	0,38	0,025810
16	SPU_16		0,04			0,24			3,12				2,30	5,66	0,001825
17	SPU_17		0,62			0,15			2,28				1,98	4,42	0,021358
21	SPU_21		5,84		0,01									0,01	0,000545
35	SPU_35		4,08			0,00			0,00				0,00	0,00	0,000013
36	SPU_36		6,63			0,03			0,44				0,53	1,00	0,051611
37	SPU_37		2,14		0,18									0,18	0,003027
38	SPU_38		7,73	0,01		0,07			0,98				1,17	2,22	0,133374
40	SPU_40		5,79		0,04	0,00			0,00				0,00	0,04	0,001951

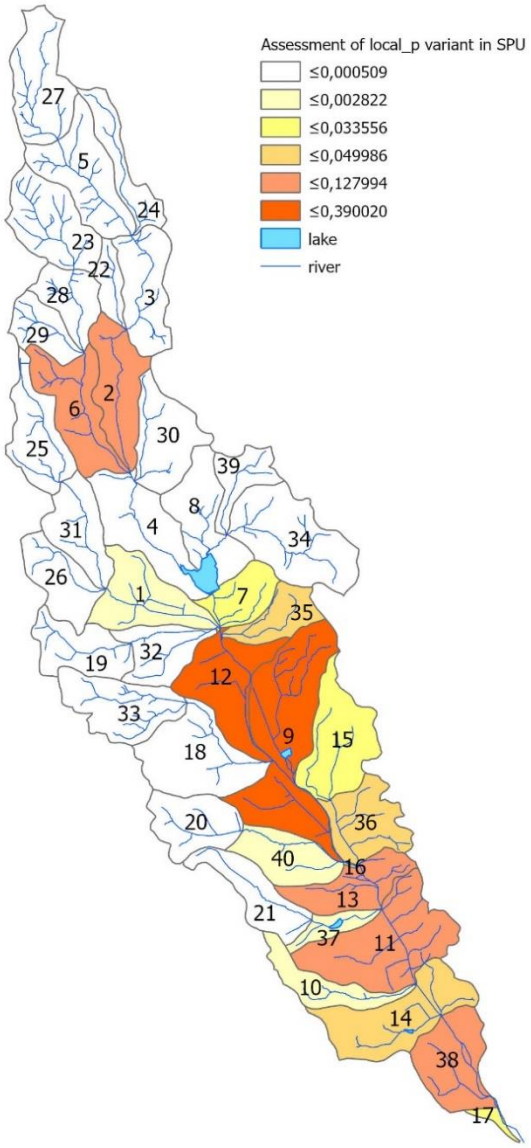

Fig. 8 Map of assessment of the local preferences variant with changed criteria at the SPU level

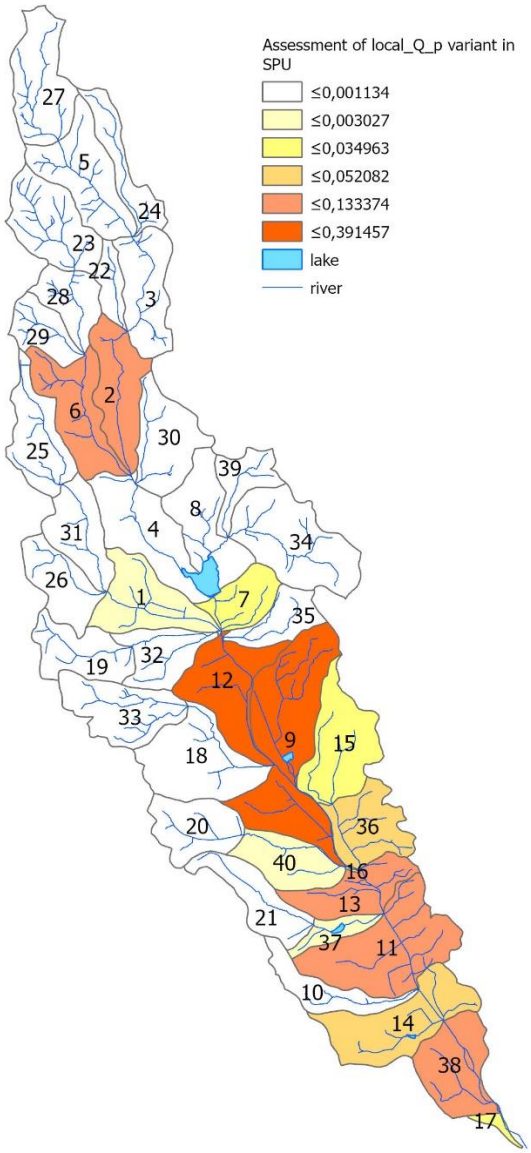

Fig. 9 Map of assessment of the effectiveness of the local preferences variant with changed criteria for quality improvement

Also alternative c) mentioned in the chapter 3 based on the consultation with an external expert the variant with the most effective measures for minimizing the negative effects of low flow conditions were calculated. Even if the measures selected by national expert were not proposed in local preferences variant. The results are shown in Tab. 11. Intensities and grades were kept the same as proposed by project consortia.

Tab. 11. Assessment of the effectiveness of the local preferences variant (measures proposed by external expert) for improvement of low flow condition

2	Number of measures	8			Grading of the Program of Small Water Retention Measures								
3	Number of SPUs	40		Measure No.	1	2	3	4	5	6	7	8	Catchment grade for current variant
4	Grade for a measure (total by SPUs):				0,00	13,07	0,00	4,86	12,14	0,00	0,00	0,00	0,79
5	No.	SPU Id	SPU name	Measure Id by User	WRAL	F01	KF	F05	F14	N02	N13	D04	SPU grades
6				F_SPU [km^2]	km2/km2	km/km	-	km2/km2	km/km	km2/km2	km2/km2	km2/km2	
7	1	SPU_01		7,79				4,86	0,22				5,08
8	2	SPU_02		7,33			0,00						0,00
9	3	SPU_03		7,27					0,06				0,06
10	4	SPU_04		9,36		0,14			0,44				0,58
11	5	SPU_05		9,00					0,34				0,34
12	6	SPU_06		8,22					0,09				0,09
13	7	SPU_07		4,23					0,16				0,16
14	8	SPU_08		7,95		0,27			0,41				0,69
15	9	SPU_09		17,20		0,20			0,10				0,30
16	10	SPU_10		4,58		1,17			0,30				1,47
17	11	SPU_11		13,27		2,00			0,34				2,34
18	12	SPU_12		8,59					0,38				0,38
19	13	SPU_13		5,99					0,44				0,44
20	14	SPU_14		10,10		0,00			0,16				0,16
21	15	SPU_15		8,80		0,64			0,15				0,79
22	16	SPU_16		0,04		0,01			0,13				0,15
23	17	SPU_17		0,62		0,49			0,24				0,73
24	18	SPU_18		10,29		0,76			0,41				1,17
25	19	SPU_19		6,04					0,15				0,15
26	20	SPU_20		6,17		0,06			0,19				0,25
27	21	SPU_21		5,84		0,73			0,50				1,23
28	22	SPU_22		2,29					0,52				0,52
29	23	SPU_23		8,17					0,28				0,28
30	24	SPU_24		4,60		0,11			0,44				0,54
31	25	SPU_25		6,82		0,10			0,10				0,20
32	26	SPU_26		5,61		0,91			0,50				1,41
33	27	SPU_27		8,46		0,01			0,26				0,27
34	28	SPU_28		4,54		0,99			0,17				1,15
35	29	SPU_29		3,87					0,58				0,58
36	30	SPU_30		7,26		0,26			0,12				0,38
37	31	SPU_31		6,06		1,33			0,68				2,01
38	32	SPU_32		5,20		0,67			0,67				1,34
39	33	SPU_33		7,87		0,56			0,12				0,68
40	34	SPU_34		11,57		0,27			0,27				0,54
41	35	SPU_35		4,08		0,05			0,25				0,30
42	36	SPU_36		6,63		1,08			0,60				1,68
43	37	SPU_37		2,14		0,24			0,28				0,52
44	38	SPU_38		7,73					0,37				0,37
45	39	SPU_39		3,67		0,03			0,14				0,17
46	40	SPU_40		5,79		0,00			0,59				0,59

The total grade for area reached is 0.79 which is less than in calculations above. It seems to be not sufficient and further proposals of extents of selected measures should be examined.

4.3. Comparison of variants

The differences between variants result mainly from the spatial distribution, structure and number of planned measures. The expert variant is characterized by a smaller number of measures spread over an area of catchment (4 measure types and there of 1 aggregated measure spread over 35 SPUs). On the contrary, the local variant contains 10 measure types and none of aggragated measures placed in 20 SPUs. Despite these large differences, the assessment ratio of the final score of the expert to local variant is 1.05 (1.77/1.68). Larger differences are noticeable after comparing the spatial distribution, which is shown in Fig. 13 as a difference between local and expert variants. The map shows that the local variant dominates in the middle part of the catchment.

Additionally, by carrying out a visual comparison of both variants (Fig. 14) and the valorization map generated via valorization tool FroGIS (Fig. 2), it can be concluded that introducing the expert variant will reduce the need for water retention in particularly sensitive

areas, except upper parts of the catchment. In the upper parts of the catchment, the need of water retention comes out of idea to protect from floods lower parts of the catchment, which are more inhabited (municipalities). These seems to be in correlation with dynamic modelling results for pilot catchment, for more information see (11). On the other hand, in the local variant, in most cases, it would improve areas with low water retention needs.

Maps of comparison of expert and local preferences variants were created by using the method of natural breaks for six classes.

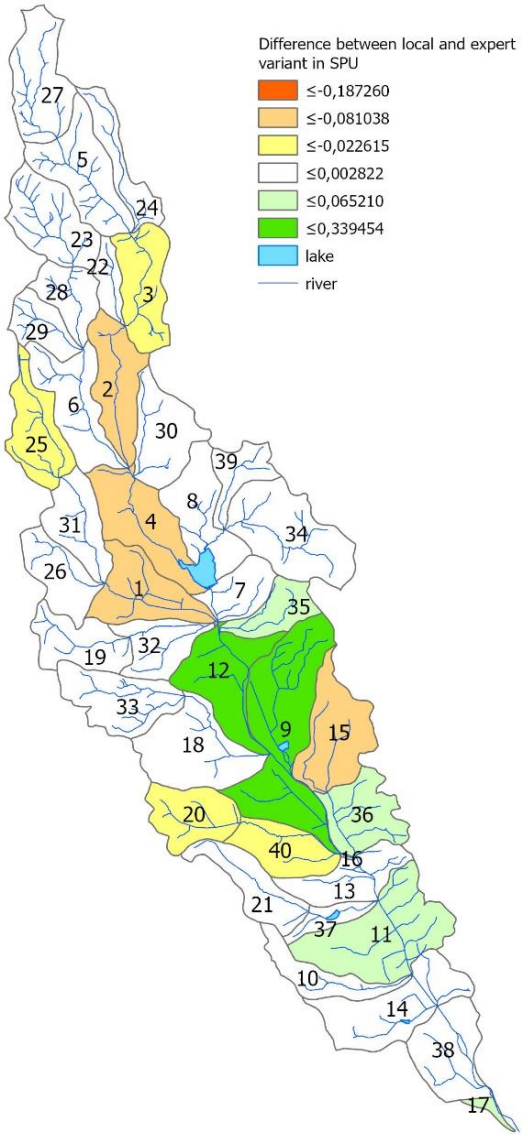

Fig. 10 Map of difference between local preferences and expert variant (green color shows dominance of local variant and red shows the opposite)

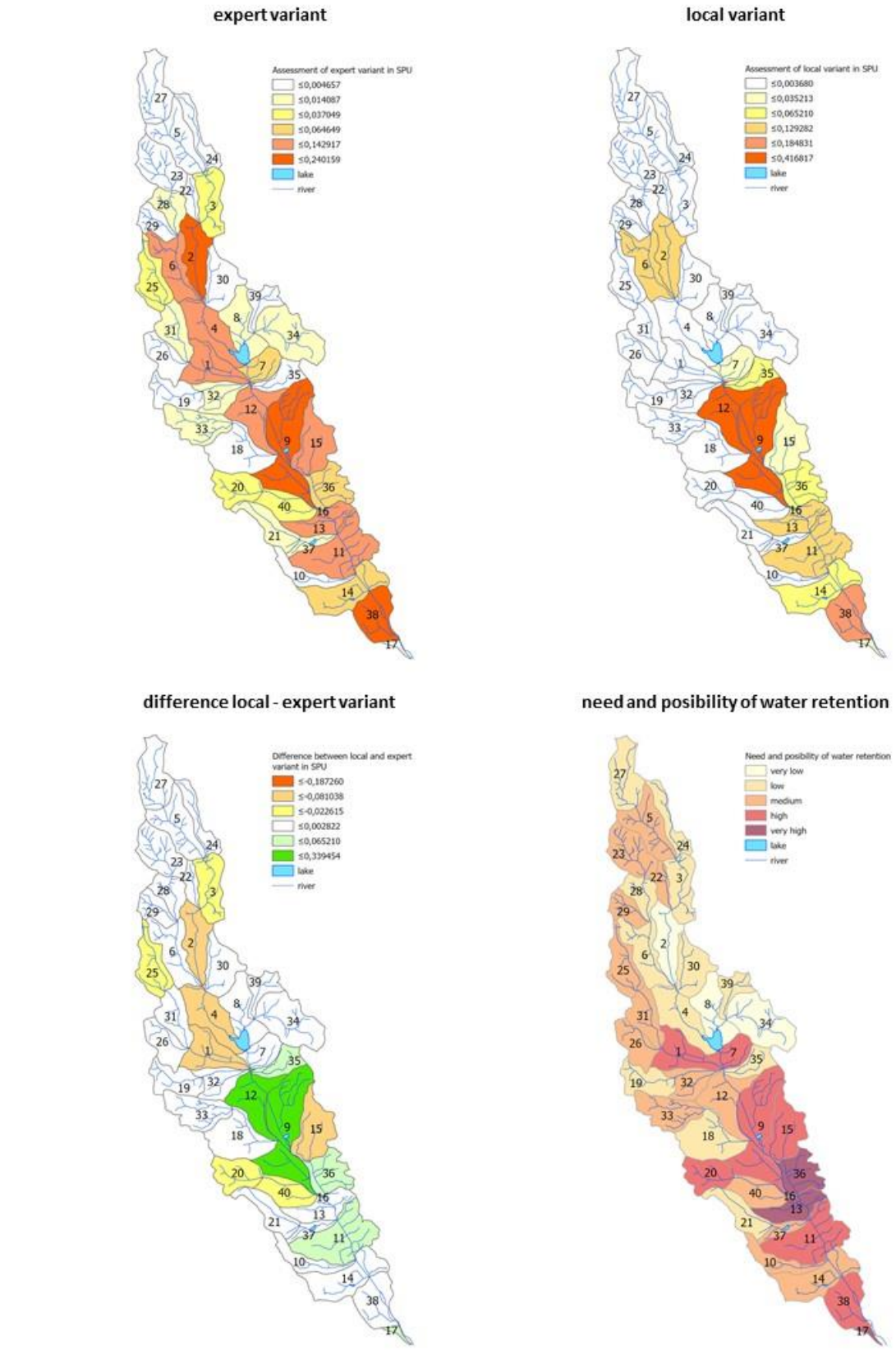

Fig. 11 Visual comparison of local preferences and expert variant assessments with the map of valorisation of needs and water retention possibilities

In the following maps there are visualised differences between expert and local preferences variants analysed within alternative a) where criteria of some measures were changed and alternative b) where only "most efficient measures" for particular goals were selected as described in the chapter 3.

Alternative b) - for each of the local preferences variant we have selected only "most effective measures" for particular goal as high flows, low flows and quality. The differences to expert variant are shown in Fig. 15, 16 and 17.

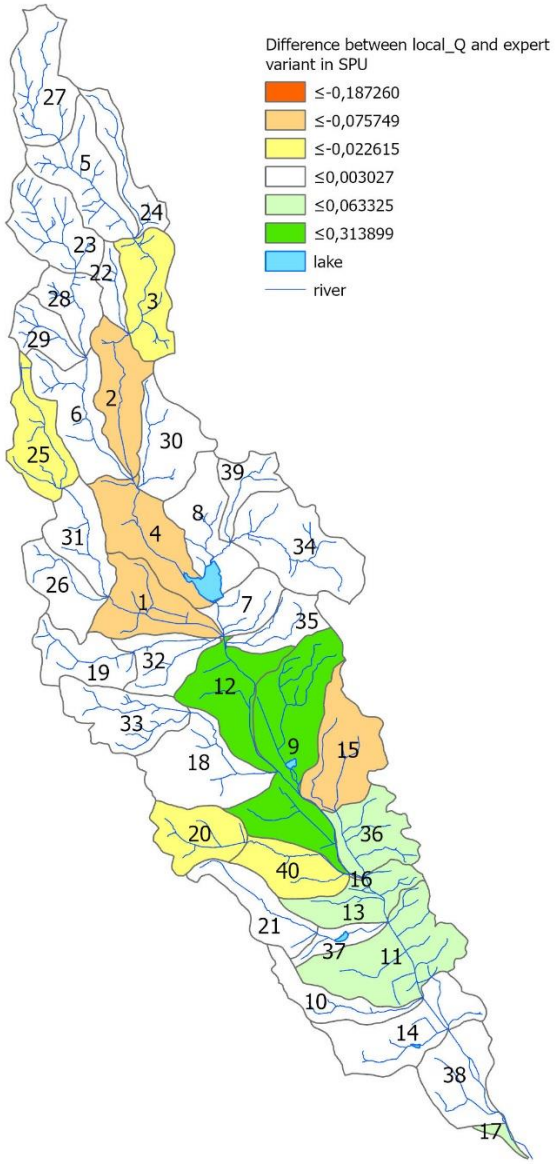

Fig. 12 Map of difference between local preferences variant for quality improvement and expert variant (green color shows dominance of local variant and red shows the opposite)

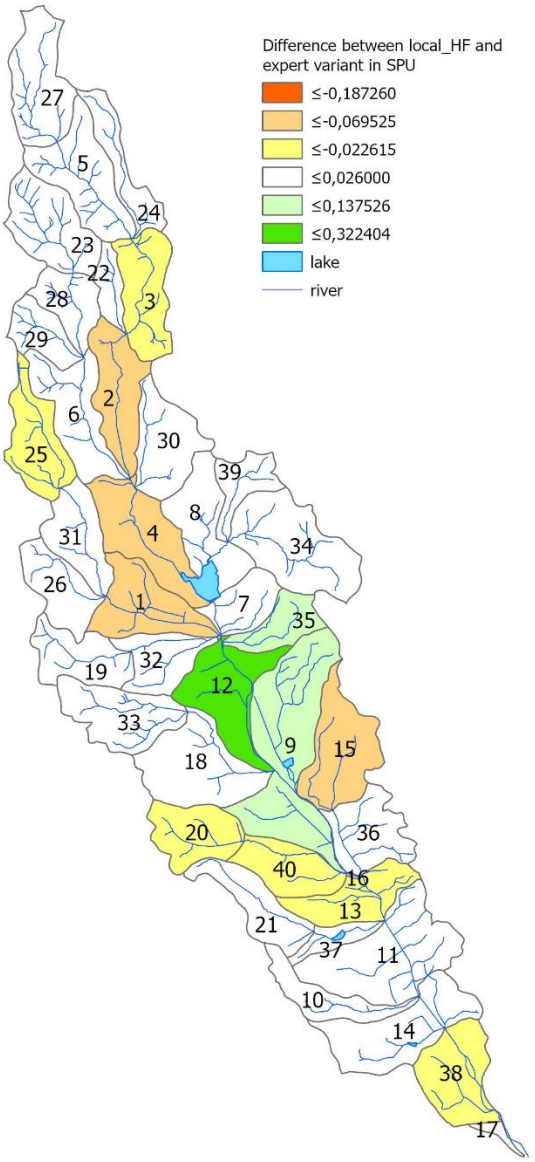

Fig. 13 Map of difference between local preferences variant for improvement of high flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

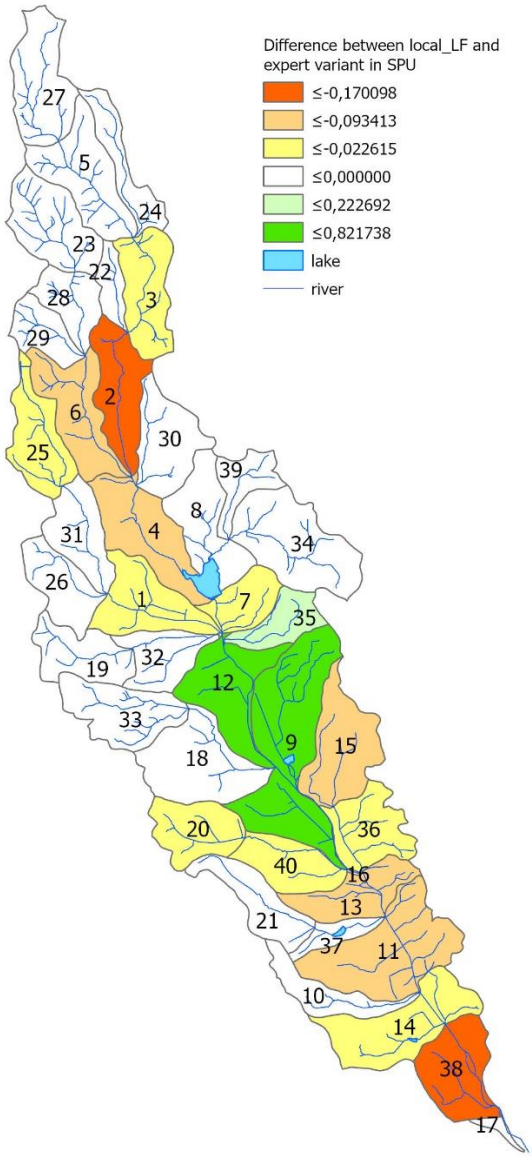

Fig. 14 Map of difference between local preferences variant for improvement of low flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

Also based on visual comparison of above showed figures for differences between expert variant and alternatives of local preferences variant, it can be assumed that selection of measures relevant for particular goal (low flow, high flow, quality) is most relevant for low flow conditions.

Alternative a) – where the definition of intensity criteria for some of measures was changed from "km/km^2" and "km/km" to "km^2/km^2". This is relevant only for some of measures proposed

within local preferences variant. See results of differences to expert variant in the following figures Fig. 18, 19, 20 and 21.

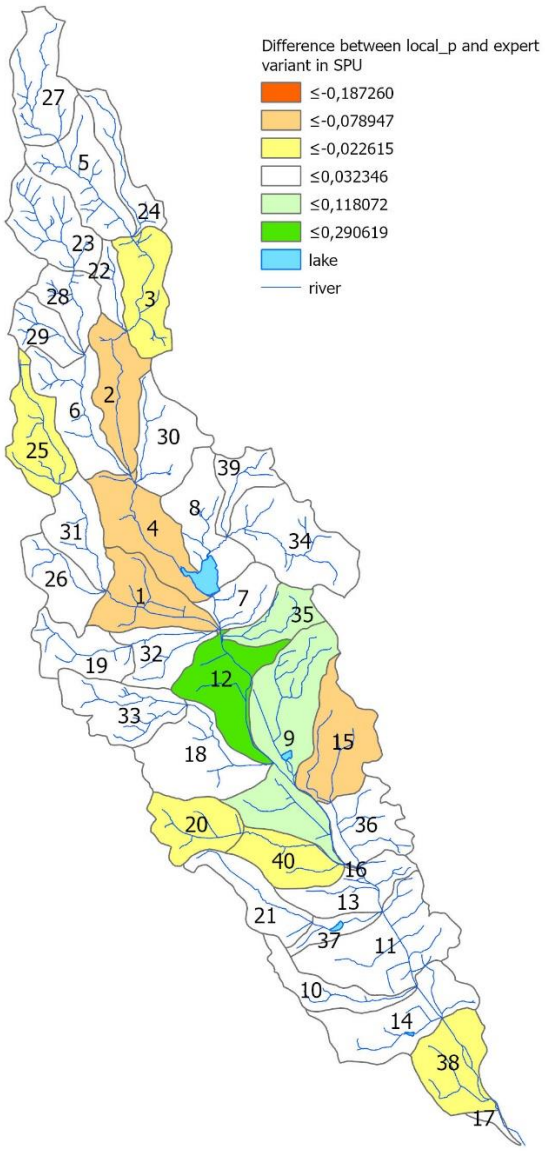

Fig. 15 Map of difference between local preferences with changed criteria and expert variant (green color shows dominance of local variant and red shows the opposite)

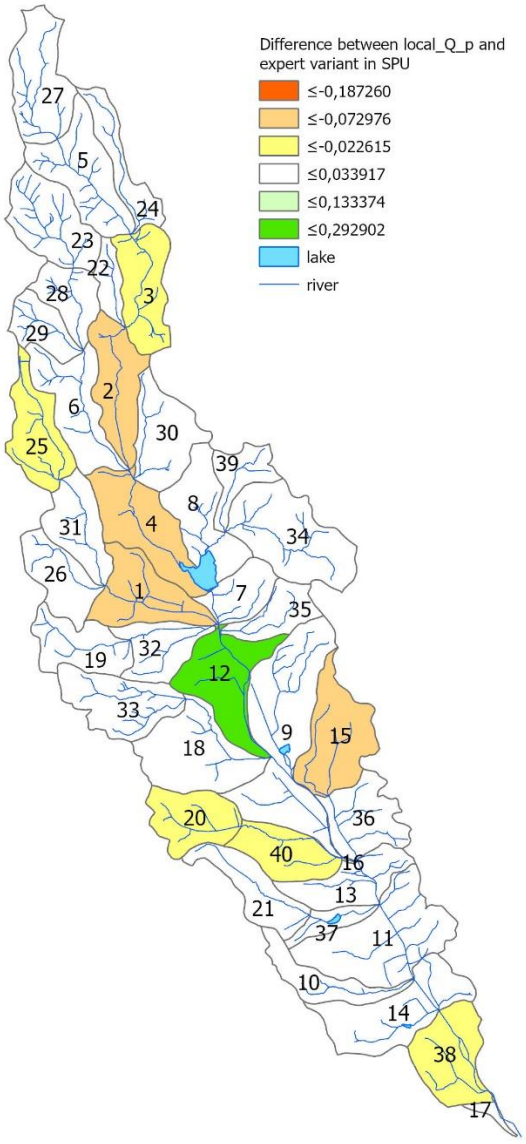

Fig. 16 Map of difference between local preferences variant with changed criteria for quality improvement and expert variant (green color shows dominance of local variant and red shows the opposite)

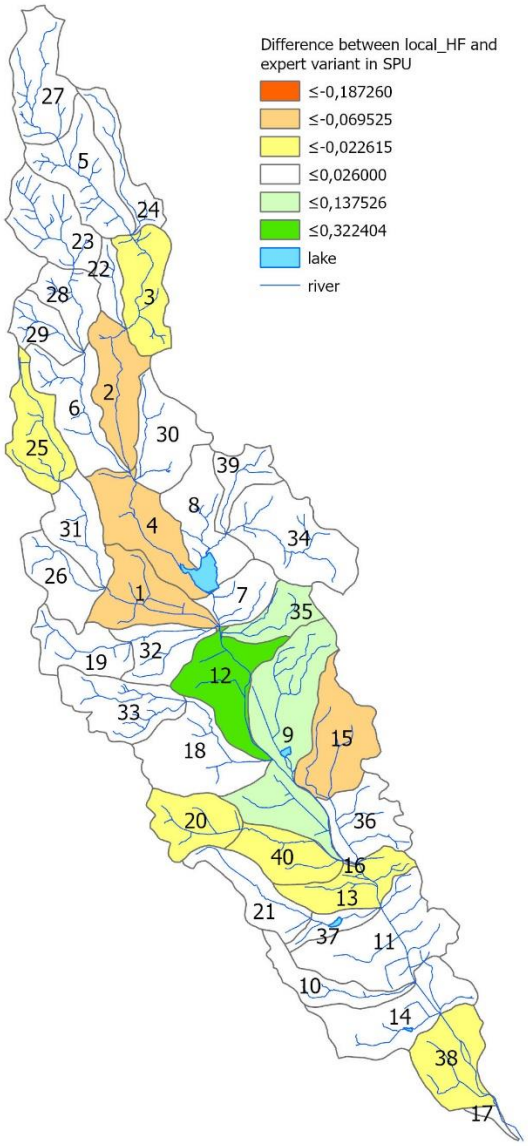

Fig. 17 Map of difference between local preferences variant with changed criteria for improvement of high flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

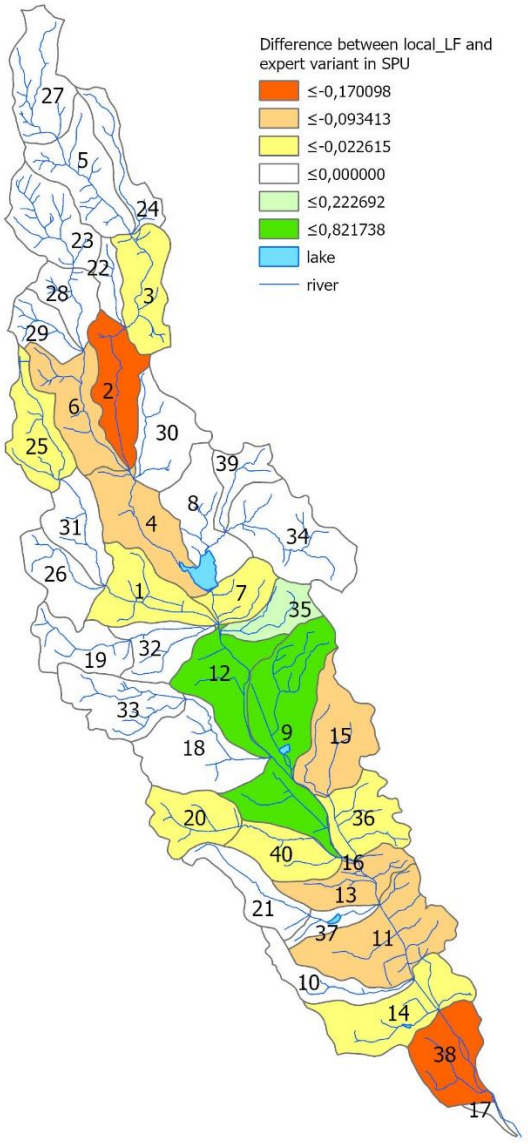

Fig. 18 Map of difference between local preferences variant with changed criteria for improvement of low flow conditions and expert variant (green color shows dominance of local variant and red shows the opposite)

Based on visual comparison of above showed figures for differences between expert variant and alternatives of local preferences variant with changed criteria, the trend is the same as for alternatives of local preferences variant where the most relevant criteria are chosen. Differences are obvious mainly for variant of low flow conditions.

5. CONCLUSIONS

Based on the testing of the StaticMethod and StaticTool.xlsm it can be concluded:

- StaticTool.xlsm seems to work properly even when using the pre-defined criteria and their values
- variant with proposed measures in the upper part of catchment to reduce flood impacts in the lower parts of catchments (municipalities) dynamic modelling results
- to calculate parameters for proposed measures is quite time consuming but feasible
- results in the tool are quite easy to interpreted even for non expert but a short guide how to do it and how to create the map will be efficient
- with the results obtained and after preparing the maps it was easy to compare particular alternatives of natural small water retention measures

6. RECOMMENDATIONS

Based on the experiences with testing of the StaticMethod and StaicTool.xlsm it can be assumed:

- Content related:
    - How to interprate Grades is necessary to explain/to add somewhere in the tool
    - As intensities and maximum grades definitions are country/region/catchment characteristics relevant, it will be efficient to include some recommendations for future users of the tool if gained during the testing by PPs
    - As it is not necessary to use aggregated measure codes to run calculations, it should be mentioned somewhere in the methodology, that calculations will run anyway.
- Functionalities:
    - SK translation of names of aggregated measures is missing. We see it as valuable information for national stakeholders, who will use the tool.
    - SK translations of definitions of intensities criteria are missing. We see it as valuable information for national stakeholders, who will use the tool.
    - It was experienced during the testing that “grey fields” which should be filled-in automatically was necessary to overwrite manually.
    - For local national stakeholders, it would be efficient to provide description of Methodology on static assessment of cumulative effect of N(S)WRM at the river basin scale and of Manual on how to work with Static tool in national languages. It will facilitate wider use of project deliverables.

7. LIST OF FIGURES

8. LIST OF TABLES

9. REFERENCES

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10. ANNEX

Assessment of effects of natural small water retention measures based on national experiences, elaborated by Mr. Marek Čomaj, Water Research Institute, Bratislava.