IDENTIFICATION OF POTENTIAL LOCATIONS OF THE NATURAL SMALL WATER RETENTION MEASURES

D.T1.3.1

Report from pilot action - testing the prototype of the FroGIS tool in the river basins

Version 2

12 2018

Testing in the Blh pilot catchment

Table of content

1. PURPOSE AND SCOPE OF THE TEST

(similar text for all pilot catchment)

The main purposes of the testing are:

- the application of the developed method and particular GIS tool in pilot catchment
- the development of valorization maps for particular pressures relevant in the pilot catchment
- the comparison of valorization maps with a goals/goal maps proposed for the pilot catchment

Based on the results received the developed method would be improved and the developed GIS tool would be improved too.

2. CHARACTERISTICS OF THE CATCHMENT

(short catchment description similar to present on project webpage https://www.interreg-central.eu)

The Slaná River Basin (RB) is one of the ten River Basins into which is the area of the Slovak republic divided according so called Hydrological conditions of the Slovak Republic (SR). Nine of them belong to Danube River Basin District (96% of the territory of the SR) and one of them belongs to Vistula River basin District (4% of the territory of the SR). These are basic management units for which the River Basin Management Plans and Flood Risk Management Plans are compiled and reported to the European Commission. Slaná RB is cover by mountains but by lowlands too, it is quite often attached by flash floods with a necessity to find solutions to protect municipalities and farms in the lowlands against floods and during the dry periods to help improve the water quantitative in rivers with the aim to mitigate the impacts of drought. There are quite lot of exiting flood protection measures and water reservoirs to manage water flows during dry periods, but also a lot of flood protection measures as e. g. dry polders planned with the aim to mitigate flood impacts. Not well managed agricultural practises in the RB are causing slight deviations from reaching the good ecological status of river water bodies due to the nitrates and phosphorus (urban waste water is a pressure too), nutrient pollution is causing eutrophication in water bodies. Except organic and nutrient pollution, further impacts on water body status are change of biotopes (phytobentos and macrophytes) due to hydromorphological pressures. The southern part of the Slaná RB is assessed as vulnerable to fluctuation of discharges potentially caused by climate change. It is fan-shaped RB consisting of many quite narrow subcatchments with the orientation from south to west. These were the reasons for selection of the Slaná RB as suitable for the project purposes.

After starting the project and first discussions between project partners on the ways how to develop quite consistent and compatible methods and particular tools applicable in all river basins and suitable to test in the pilot catchments and to serve with comparable results, the consortia proposed to focused with huge Slaná River Basin (3 217 km^2) on some smaller subcatchment. Because of these reason the Slovak team was looking for some catchment serving with the most of pressures and their potential impacts to be a "representative sample" from Slaná River Basin. These was consulted with local water management authorities and with regional water management authority, it was agreed that Slovakia will focus on subcatchment of Blh River within Slaná River Basin. Some characteristics of the Blh River subcatchment are shown on Fig. 1 and 2 and in the Tab. 1 too.

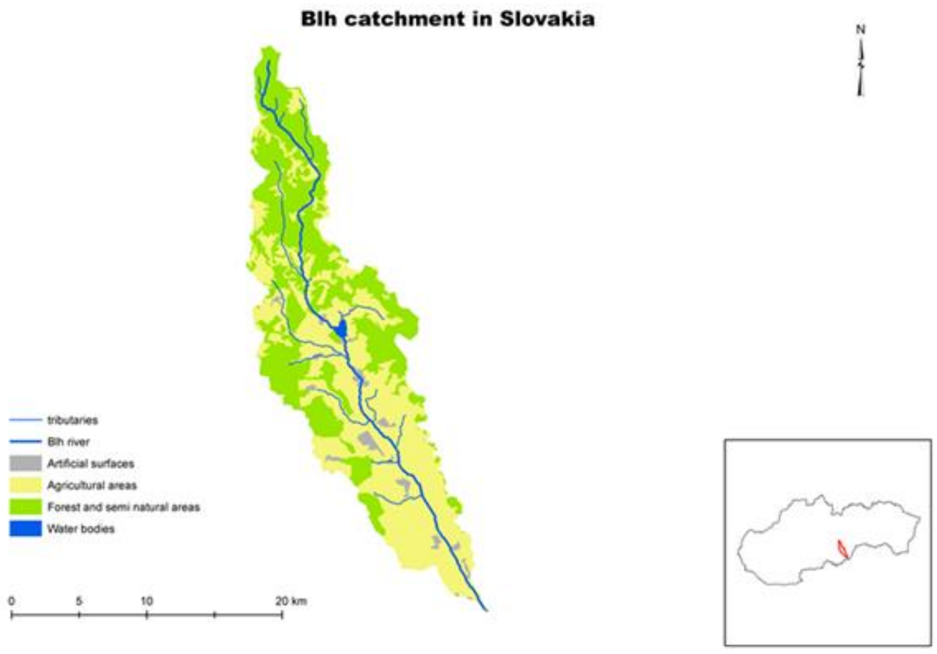


Fig. 1 Map of landuse in the Blh subcatchment

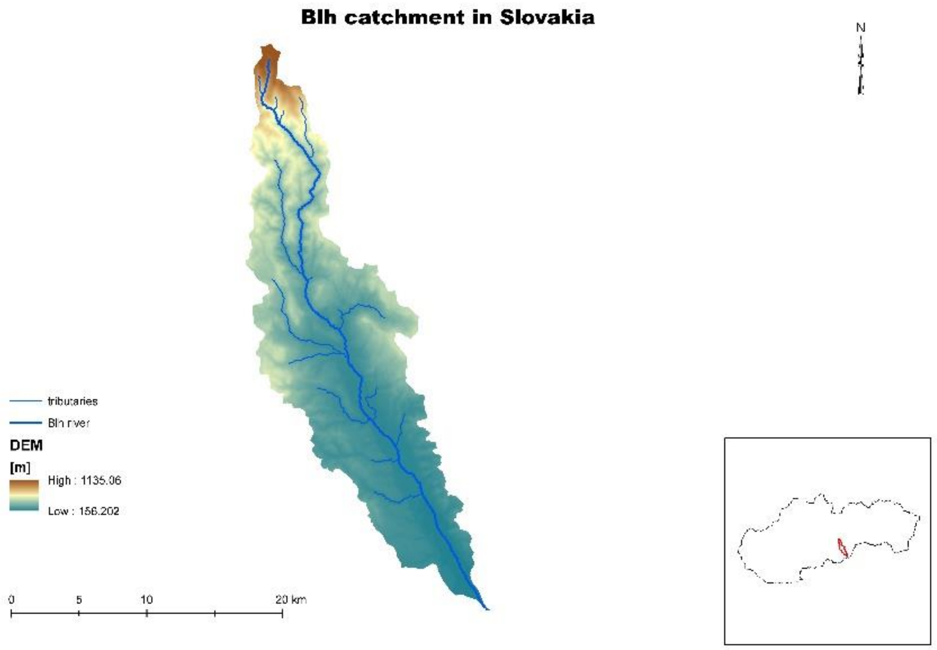


Fig. 2 Map of morphology in the Blh subcatchment

Tab. 1 Characteristic of Blh subcatchment

Characteristic	Unit	Value
Character of catchment		fan-shaped river network with surface

		of plains to higher highlands dissection
Catchment size:	km^2	270.656
Average flow low/avg/high*	m^3/s	1.064 (avg)
Extreme flow low/high**	m^3/s	Qmin = 0.001/Qmax = 69
Annual precipitation low/avg/high*	mm	568/714/1019
Annual air temperature min/avg/max*	°C	4/8/10
Agriculture area	%	43.00
Urban area	%	2.80
Forest area	%	53.76
Open Water area	%	0.43
Flooded area (1/100 years)	km^2	12.28
Artificial drainage area	km^2	
Ecological status no good/bad	water body	generally medium/bad
Major problems to achieve good ecological status		Phytobenthos, Macrophytes, NH4, PO4, Norganic

* *From multiannual statistic 1961 - 2000*
** *From multiannual statistic 1931 - 2010*

3. ISSUES IDENTIFIED IN THE CATCHMENT

The pressures mentioned already in the chapt. 1 are results of analyses provided by particular strategic documents focused on water body status and its improvement, flood risk management, nature protection, agriculture development and particular action plans, if available for particular strategic document. Further also consultations with local public authorities took place, whether there exist some local needs/wishes of local importance, which are playing a role as natural (small) water retention measures.

3.1. Review of existing assessments of floods / drought /water quality

(developing thematic map containing the following content: flood extent, draught extent, results of assessment water body status, sediment transport.)

Based on strategical documents there have been identified a following pressures and their impacts.

From River Basin Management plans it is possible to identify the surface water bodies and groundwater bodies classified based on their actual status assessment. In the Blh catchment there are 12 surface water bodies, there 11 rivers and 1 water reservoir Teplý Vrch. Generally we can say, that status of water bodies is good/moderate, there are only two heavily modified river water bodies determined. The status is as follows:

- Ecological status/potential:
  - ecological status/potential of river WBs (good for 6 WBs, moderate for 3 WBs, moderate potential for 2 WBs)
  - ecological potential of lake WB (moderate for 1WB)
- chemical status:
  - status of river WBs (good for 10 WBs, bed for 1 WB)
  - status of lake WB (good for 1 WB)

There are four groundwater bodies (quatenary and prequatenary, their chemical status is:

- prequatenary (good for 3 WBs, bed for 1 WB)
- quatenyra (bed for 1 WB)

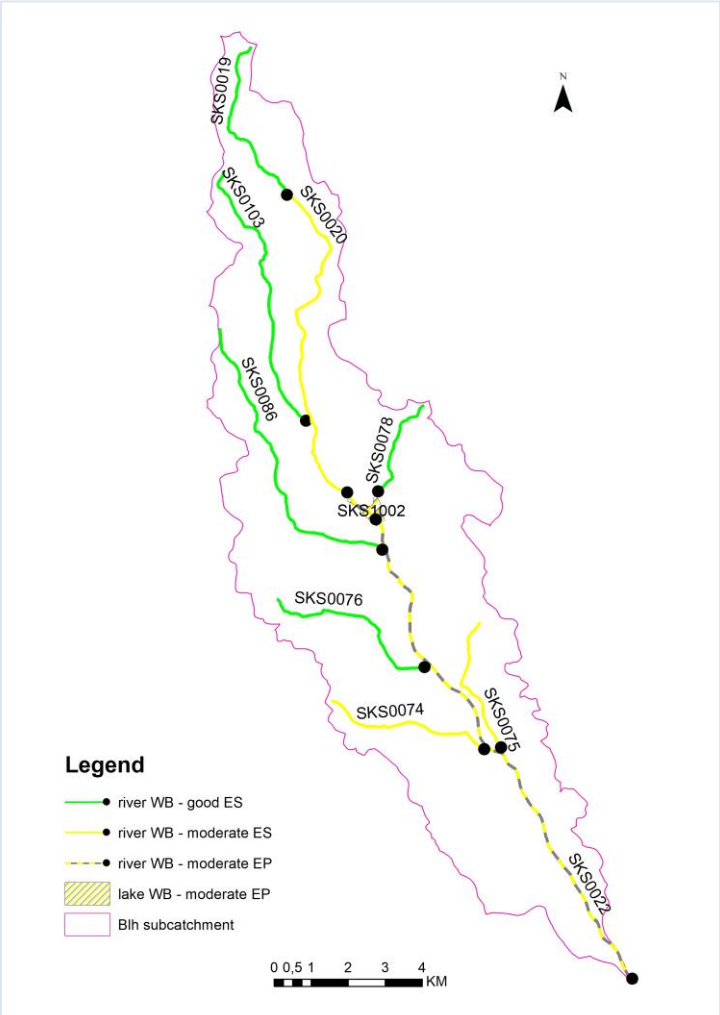


Fig. 3 Surface water bodies – ecological status/potential assessment

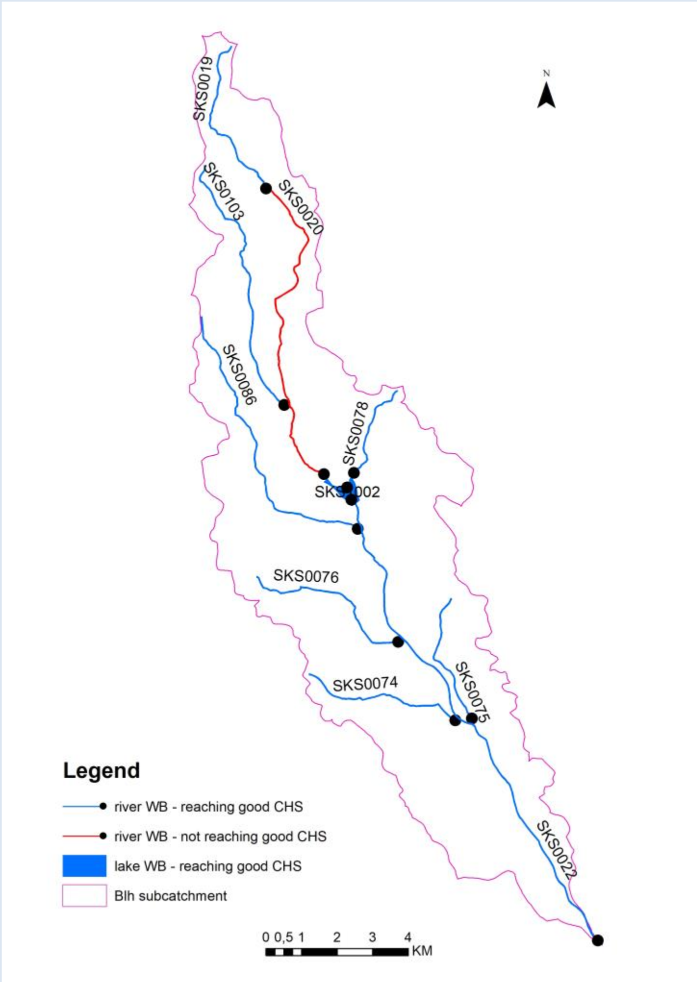


Fig. 4 Surface water bodies – chemical status assessment

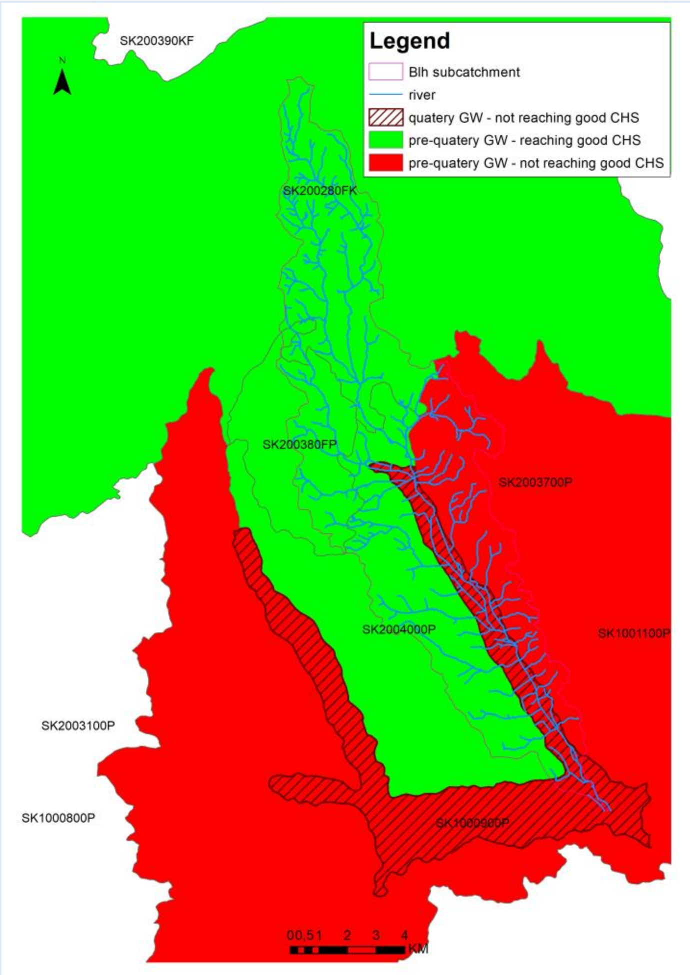


Fig. 5 Groundwater bodies – chemical status assessment

Sediment problems were not identified within River Basin Management Plan II, but were identified as problem by local water management authority.

Within the Flood Risk management Plans I (FRMP I) there have been identified 10 geographical locations (see Fig. 5) where existing flood risk exist or potentially can occur within the Blh subcatchment. Namely these are:

- Blh - Ivanice – code SK514985_455
- Blh - Bátka - code SK514519_452
- Blh - Cakov - code SK514594_454
- Blh - Drienčany - code SK514659_448
- Blh - Potok - code SK515345_447
- Blh - Rovné - code SK515485_446

- Blh - Teplý Vrch - code SK515671_449
- Blh - Uzovská Panica - code SK515701_451
- Blh - Veľký Blh - code SK515744_450
- Blh - Žíp - code SK515841_453

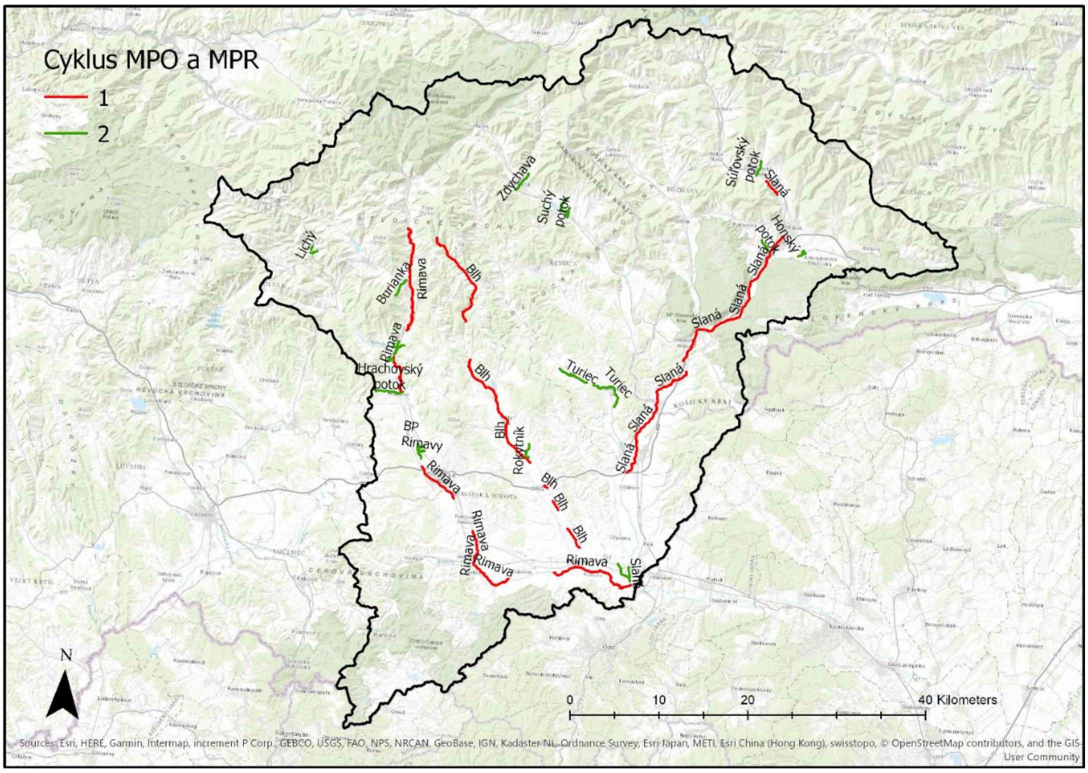


Fig. 6 Geographical localities within Slaná River Basin

The main flood sources are flash floods with water flowing from mountains to lowlands, from south to east. The assessment of potential flood risk was examined for Q100 recurrence period because of impacts on municipalities.

The nature protection areas depending on water were identified from River Basin Management Plan II (RBMP II), management of these areas officially reported to RBMP II is also substantial part of Action Plans on wetlands management. The very small wetlands of local importance not officially reported by national nature protection authority to the RBMP II were identified by local nature protection authorities. Result of evaluation is shown in Fig. 7.

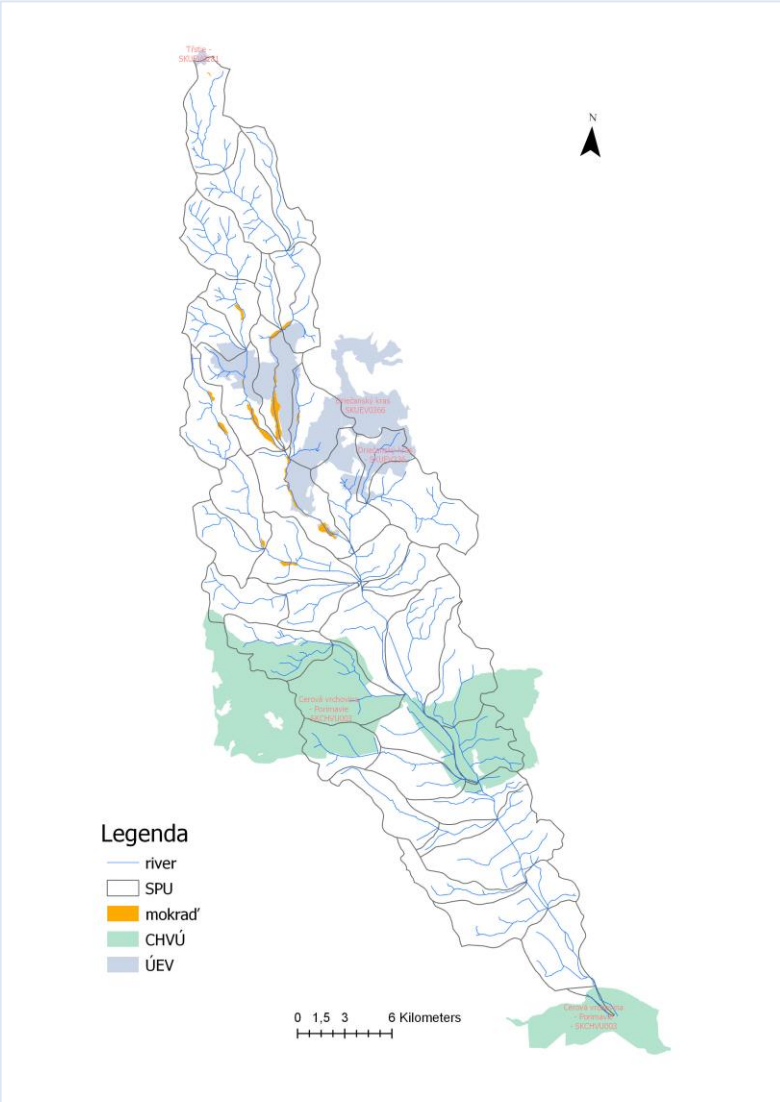
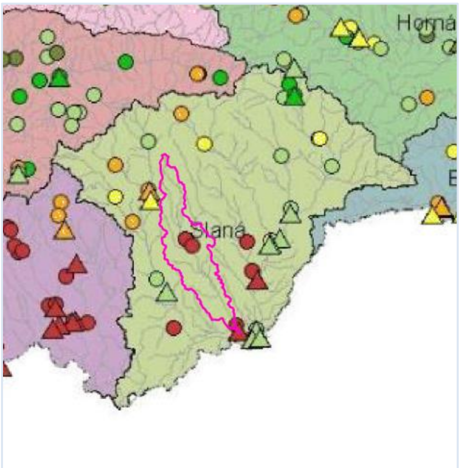
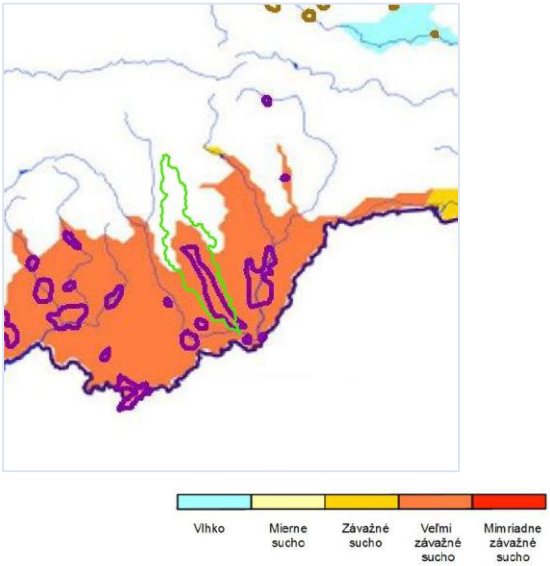


Fig. 7 Protected areas dependent on water

Regional water management authority and local water management authority are expecting that the planned measures to be realised in the Blh subcatchment in the near future.

Regarding the drought assessment, southern part of the Blh subcatchment is evaluated in more literature/conceptual documents as vulnerable to drought impacts.





According RBMP II the southern part of the Slaná RB is assessed as vulnerable to fluctuation of discharges potentially caused by climate change. The red dots on the figure above left represent water gauge stations where the vulnerability to discharges decrease was assessed and Blh subcatchment belongs to such areas.

On the figure right the areas of drought occurrence in SR in 2013 are shown, and the orange coloured areas corresponds to very significant drought, the fourth of five classes (1 = wet, 5 = extremely significant drought). These analyses were done within the Conception of revitalisation of hydromeliorations in SR.

3.2. Review of existing and planned measures

(review existing action plan, developing of map existing and planned measure. Paste also maps of existing valorisation developed in the action plan)

The background for identification of exirting and planned measures were information available in the national strategic and planning documents as follows:

- River Basin Management Plans (2009, update 2015)
- Flood Risk Management Plans (2015)
- National Climate Programme (since 1993)
- Adaptation strategy of the SR for negative impacts of climate change (2014, update 2017) and
- Wetlands management programmes (2008 – 2014, update 2015 – 2021) and its Action Plans (2008 – 2011, 2012 – 2014, 2015 – 2018)

There are structural measures existing which revitalisation is planned and also new measures planned. They are of technical matter but measures with retention effect are planned there too. The measures are concretely mentioned in the annexes of strategic documents. Also measures focused on revitalization of hydromeliorations are planned and are part of so called Conception of revitalisation of hydromeliorations in SR.

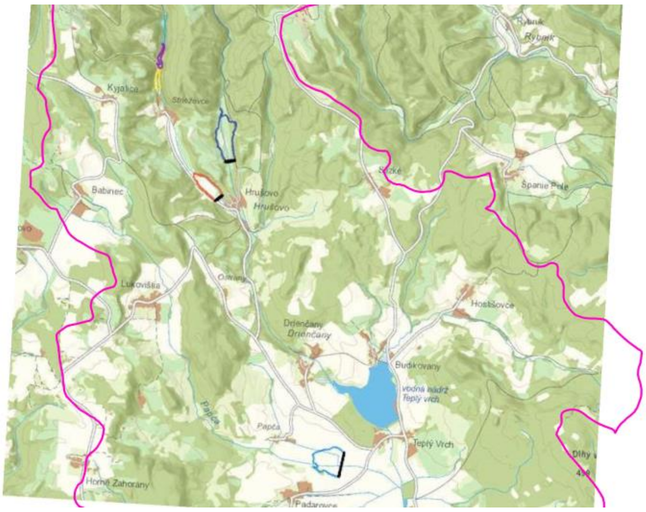
3.3. Results of first consultations with stakeholders

(during the National meeting 2018; field trip or by phone)

During the National dialogue held on may 10th, 2018 in Banská Bystrica where the stakeholders acting on regional or local level within Slaná River basin and/or Blh subcatchment participated, the first proposals of State nature Conservancy to take into account also small wetlands of local importance were proposed. Further bed forest management was address by participants and the representative from Slovak technical University in Nitra cautioned on improper management of agricultural areas causing floods and erosion of arable land too (sediments problems).

Further consultations with local water management authority leads to:

- identification of localities to be suitable for 3 dry reservoirs (see figure down) within Blh subcatchment and based on appropriate terrain morphology. These proposals were results of consultations of local water management authority with municipalities endangered by regular floods



- sediments problem identification in lower part of the Blh subcatchment. These is based on empirical experience of local water management authority with regular sediment maintenance works, whereby as a source of sediments the erosion from agricultural land was identified.

And further consultations with local Nature Protection Authorities, Cerová vrchovina and Muránsky planina the locations of very small wetlands of local importance not officially reported by national nature protection authority to the RBMP II were identified:

- small wetland of local importance identified, showed in the figure above

3.4. Results of field recognition

During the Field recognition held commonly with representative from Local Water management Authority, Rimavská Sobota and during which the status of existing hydraulic structures was examined along the Blh River, but there was also identified one locality for potential retention of water within the most lower part of the Blh subcatchment before its mouth into Rimava River. It is located on agricultural land/meadow not intensively used and geographical is suitable. The retention of water in this depression will reduce the amount of water discharged during flood events from Blh River into Rimava River, so will co-act as "measure based on solidarity principle" and reduce flood risk in the lower situated localities. Its potential effectiveness will be further examined within proposals of measures to be discussed with local stakeholders too.

Fig. xxx Water reservoir Teplý Vrch - transversal dam at Blh River

Fig. xxx Channel of Blh River (from bridge) - downstream, dykes along Blh River, agricultural land

3.5. Summary

Based on inputs on pressures identified within strategic documents of relevant stakeholder or sectors the goal map was produced. As the most crucial and on the other hand with a potential to realistic and real implementation of particular measures, the flood goals were chosen as the most crucial. The goal map will serve to identify weights of indicators to be determined for SPUs within Blh subcatchment.

Based on the planned enhancements of existing measures or proposed new measures including measures relevant for the water retention purposes the classes for each of SPUS were determined as follows:

- class 1 – if one measure is relevant for the SPU
- class 2 - if two measures are relevant for the SPU
- class 3 – if three and more measures are relevant for the SPU

There was assessed the surplus of types of technical measures and nature solutions within the Blh subcatchemnt as of maintenance, retention, channel improvements, dykes improvements and dry reservoirs planned.

The result of assignment of goals classes and there of coming weights assignment to indicators for each particular SPU is shown in Fig. 3.

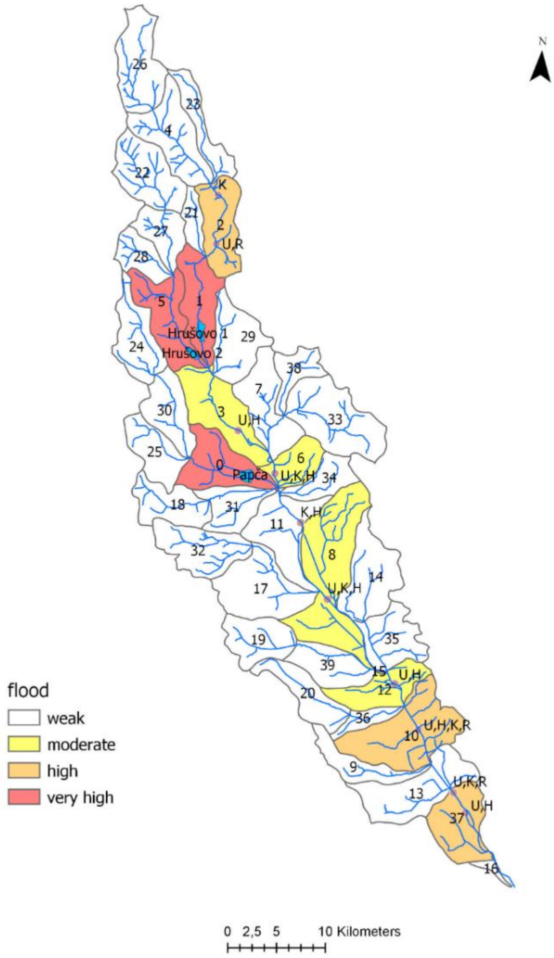


Fig. 8 Map for identifying flood indicators weights

4. DESCRIPTION OF WORKFLOW

4.1. Selected SPU

(Describe all tested SPUs in the context of the needs and accuracy / scale of the input data)

Firstly was the Blh subcatchment divided into 29 SPUs, which correspond to natural hydrological units and are the smallest hydrological management units defined within so called National hydrological division/list. The testing of the developed GIS tool FroGIS shows that such a division is insufficient for proper functioning of FroGIS and it was necessary to subdivide the SPUs into more detailed units. But the calculations in excel spreadsheets outside the FroGIS were functioning well also for the 29 SPUs. So for proper functioning of FroGIS the natural hydrological units were subdivided into 40 more precise units (based on DEM).

So after division into 40 SPUs, the smallest one (No. 16) is of area of 0,042 km^2 and the biggest one is of area of 17.201 km^2. The divison of the Blh catchment nto SPUs is in the Fig. 4.

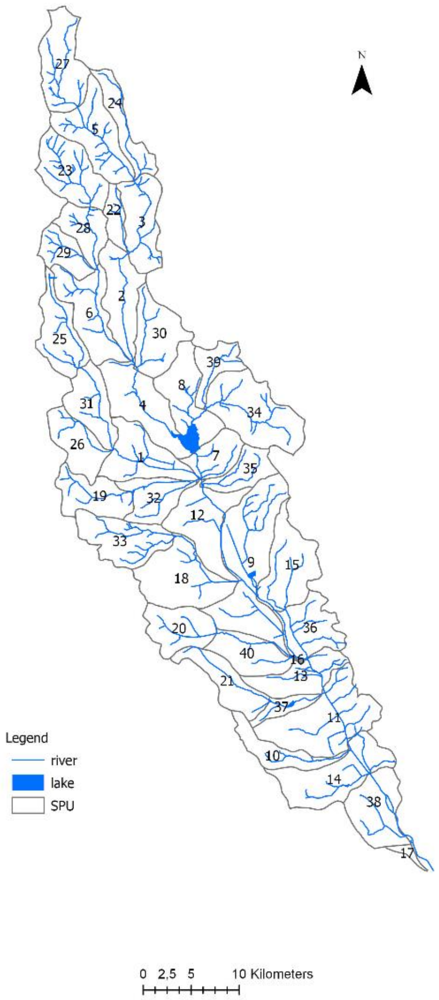


Fig. 9 SPU of Blh subcatchment

4.2. Selected indicators

(what indicators have been used in the analysis – reason, why others were rejected)

The calculations were tested in the escel spreadsheet outside the FroGIS and in the GIS tool FroGIS too. For the testing were used 20 available indicators. After correlation analyses were 9 of the indicators eliminated. For the analyses of flood and sediment goals there have been used 11 indicators. The list of indicators used is shown in the Tab. 2.

Tab. 2 List of selected indicators

Name	Flood	Sediment
DrainageD	x	
FloodRiskAreaRatio	x	
ForestRatio	x	x
LakeRatio	x	
LakeCatchRatio	x	
MeanderRatio	x	x
NonForestedRatio	x	x
OrchVegRatio	x	
RiverSlope	x	x
SoilErodibility		x
UrbanRatio	x	

4.3. Input data

(In table format: name, source, scale (quality), time interval)

The input data for which the higher spatial resolution were obtained from the internal sources of SWME or from free available sources. As the rest of input data there have been used the global dataset data. In the present SWME is not serving with the official data on discharges and rainfalls, these are based on the official purchase of the data from responsible authority in the SR. Data on nature protection areas were also obtained from official database sources from state nature protection authority, but afterwards were consulted with local nature protection authorities and few very small wetlands of very local importance were identified by them. These precised data used for identifying goals within the goal map. List of input data is shown in the Tab. 3.

Tab. 3 List of input data

Name	Source	Data type	Accuracy
Soil data	SWME	polygon	1:10000
Lenght of Growing data	Geoportal for climate change	raster	
DEM	SWME	raster	10x10 m
Effektive infiltration of prepitation into groundwater	Slovak Geological Institute	polyline, point	
River network, Water reservoirs	SWME	polyline	1:10000
Protected areas	State nature Conservancy	polygone	
SPU	National dataset precised by SWME	polygon	1:50000
Land use	Corine Land Cover 2012	polygon	1:25000
Soil organic carbon content	http://soilgrids.org	raster	250x250 m

The geometry of the DEM was repaired through the more precise geodetic data of the Blh riverbed, localization of the dykes and other water management structures measured in the terrain. The geometry of vector data, mainly polygons, was repaired too, the unnecessary attributes were removed from shape file datasets.

4.4. Correlation matrices

(insert correlation matrix and criteria for rejecting correlated indicators)

The results shown in the correlation matrix (Fig. 5) marked in red, were analysed, and the indicators showing very high correlation of value 0.8 and over 0.8 were eliminated from further calculations. Using this indicators would lead to double counting of indicators. Namely these are: ArableRatio, BFI, CWB, EcoAraBuf20mRatio, EcoAreaRatio, GRR, LandSlope, TWI, SWR.

Indicator EcoNumRatio was eliminated in the next step within aggregation and classification, as it was not possible to divide these indicators automatically in the GIS tool FroGIS into five classes.

	ArableRatio	BFI	CWB	DrainageD	MeanderRatio	EcoAraBuf20mRatio	LakeRatio	EcoAreaRatio	EcoNumRatio	FloodRiskAreaRatio	ForestRatio	GRR	LakeCatchRatio	LandSlope	RiverSlope	TWI	NonForestedRatio	OrchVegRatio	SWR	UrbanRatio
☑ ArableRatio	-	0.67	-0.76	0.13	0.3	0.85	0.04	0.06	0.08	0.54	-0.95	-0.82	-0.63	-0.88	-0.77	0.86	0.19	0.37	0.88	0.49
☑ BFI	0.67	-	-0.58	0.09	0.02	0.64	-0.32	0.41	0.13	0.25	-0.58	-0.6	-0.85	-0.66	-0.59	0.56	0.08	0.3	0.72	0.41
☑ CWB	-0.76	-0.58	-	0.05	-0.03	-0.68	-0.09	0.04	0.09	-0.3	0.72	0.84	0.65	0.93	0.81	-0.75	-0.11	-0.26	-0.9	-0.44
☑ DrainageD	0.13	0.09	0.05	-	0.53	0.5	-0.14	0.23	0.11	0.43	-0.15	0	-0.05	-0.04	0.25	0.3	-0.4	-0.16	0.06	0.21
☑ MeanderRatio	0.3	0.02	-0.03	0.53	-	0.47	-0.07	0.12	0.12	0.29	-0.34	-0.22	0.03	-0.09	0.03	0.32	-0.08	0.02	0.15	0.25
☑ EcoAraBuf20mRatio	0.85	0.64	-0.68	0.5	0.47	-	-0.05	0.14	0.04	0.56	-0.83	-0.72	-0.59	-0.78	-0.62	0.89	-0.07	0.19	0.81	0.59
☑ LakeRatio	0.04	-0.32	-0.09	-0.14	-0.07	-0.05	-	-0.91	-0.48	-0.07	-0.13	-0.07	0.27	-0.11	-0.15	0.08	0.29	-0.01	0.05	-0.04
☑ EcoAreaRatio	0.06	0.41	0.04	0.23	0.12	0.14	-0.91	-	0.54	0.07	0.04	-0.01	-0.26	0.04	0.1	-0.02	-0.25	-0.03	0.02	0.04
☑ EcoNumRatio	0.08	0.13	0.09	0.11	0.12	0.04	-0.48	0.54	-	0.08	0.03	0.01	-0.02	0.06	0.08	-0.07	-0.24	-0.17	-0.02	-0.12
☑ FloodRiskAreaRatio	0.54	0.25	-0.3	0.43	0.29	0.56	-0.07	0.07	0.08	-	-0.47	-0.32	-0.25	-0.41	-0.16	0.65	-0.35	0.09	0.42	0.08
☑ ForestRatio	-0.95	-0.58	0.72	-0.15	-0.34	-0.83	-0.13	0.04	0.03	-0.47	-	0.82	0.57	0.84	0.78	-0.87	-0.3	-0.5	-0.84	-0.57
☑ GRR	-0.82	-0.6	0.84	0	-0.22	-0.72	-0.07	-0.01	0.01	-0.32	0.82	-	0.59	0.87	0.87	-0.75	-0.25	-0.35	-0.88	-0.48
☑ LakeCatchRatio	-0.63	-0.85	0.65	-0.05	0.03	-0.59	0.27	-0.26	-0.02	-0.25	0.57	0.59	-	0.71	0.61	-0.56	-0.12	-0.34	-0.76	-0.39
☑ LandSlope	-0.88	-0.66	0.93	-0.04	-0.09	-0.78	-0.11	0.04	0.06	-0.41	0.84	0.87	0.71	-	0.86	-0.85	-0.12	-0.33	-0.97	-0.52
☑ RiverSlope	-0.77	-0.59	0.81	0.25	0.03	-0.62	-0.15	0.1	0.08	-0.16	0.78	0.87	0.61	0.86	-	-0.69	-0.36	-0.35	-0.86	-0.47
☑ TWI	0.86	0.56	-0.75	0.3	0.32	0.89	0.08	-0.02	-0.07	0.65	-0.87	-0.75	-0.56	-0.85	-0.69	-	-0.12	0.35	0.84	0.6
☑ NonForestedRatio	0.19	0.08	-0.11	-0.4	-0.08	-0.07	0.29	-0.25	-0.24	-0.35	-0.3	-0.25	-0.12	-0.12	-0.36	-0.12	-	0.35	0.15	-0.02
☑ OrchVegRatio	0.37	0.3	-0.26	-0.16	0.02	0.19	-0.01	-0.03	-0.17	0.09	-0.5	-0.35	-0.34	-0.33	-0.35	0.35	0.35	-	0.34	0.42
☑ SWR	0.88	0.72	-0.9	0.06	0.15	0.81	0.05	0.02	-0.02	0.42	-0.84	-0.88	-0.76	-0.97	-0.86	0.84	0.15	0.34	-	0.52
☑ UrbanRatio	0.49	0.41	-0.44	0.21	0.25	0.59	-0.04	0.04	-0.12	0.08	-0.57	-0.48	-0.39	-0.52	-0.47	0.6	-0.02	0.42	0.52	-

Fig. 10 Correlation matrix for all indicators

The difference between first calculations done in the excel spreadsheet and calculations done in the upgraded version of FroGIS was in choosing the number of indicators available for the excel spreadsheet calculations and available for the versions of FroGIS calculations at that time.

4.5. Classification and aggregation method

Fort the classification there have been used three classification methods Equal With, Natural Break and Quantiles. Each indicator was divided into five classes. Results of division of indicator values into five classes are shown in the Fig. 5. The final classification of the SPUs was obtained as aggregation of indicators with weighted sums. The results of valorization of particular SPUs are shown in Fig. 6.

Tests were promoted for two methods of particular indicators weights assignment:

- Wht1 – all weights for all indicators are equal to 1 (flood and sediment goal)
- Wht01 – weights for indicators are within interval from 0 to 1 (flood goal)

Tab. 4 Statistics of indicator values

Short name indicator	Statistic				
	Min	Max	Mean	Stdv	Units
DrainageD	0.758	2.736	1.397	0.413	km/km^2
FloodRiskAreaRatio	0	100.000	5.824	16.685	%
ForestRatio	0	87.842	42.198	28.578	%
LakeRatio	0	7.168	0.399	1.410	%
LakeCatchRatio	0	100.000	44.649	48.514	%
MeanderRatio	89.429	98.795	93.982	1.669	%
NonForestedRatio	0	70.894	32.776	14.872	%
OrchVegRatio	0	11.409	2.230	2.685	%
RiverSlope	0.185	15.038	4.401	3.851	-
SoilErodibility	0.170	0.250	0.200	0.020	-
UrbanRatio	0	15.771	2.377	3.756	%

Tab. 5 Results of division of indicator values into five classes

		Equal Widht			Natural Breaks			Quantile		
Indicators	**Classes**	**Count**	**Min**	**Max**	**Count**	**Min**	**Max**	**Count**	**Min**	**Max**
DrainageD	1	13	0,8	1,1	6	0,8	1,0	8	0,8	1,1
	2	14	1,2	1,5	11	1,0	1,3	8	1,1	1,2
	3	11	1,6	1,9	13	1,3	1,6	8	1,3	1,4
	4				7	1,6	1,9	8	1,5	1,6
	5	2	2,6	2,7	3	1,9	2,7	8	1,6	2,7
FloodRiskAreaRatio	1	38	0,0	18,3	26	0,0	0,7	26	0,0	0,7
	2	1	30,7	30,7	5	0,7	3,0	5	0,7	3,0
	3				6	5,0	16,4	6	5,0	16,4
	4				1	18,3	18,3	1	18,3	18,3
	5	1	100,0	100,0	2	30,7	100,0	2	30,7	100,0
ForestRatio	1	8	70,4	87,8	7	73,4	87,8	8	70,4	87,8
	2	9	55,0	68,7	11	50,9	70,4	8	56,8	68,7
	3	7	35,2	50,9	10	20,8	45,3	8	35,2	55,0
	4	5	18,3	33,1	6	5,8	18,3	8	10,9	33,1
	5	11	0,0	16,8	6	0,0	3,2	8	0,0	10,3
LakeCatchRatio	1	16	100,0	100,0	16	100,0	100,0	8	100,0	100,0
	2	2	62,2	65,2	2	62,2	65,2	8	100,0	100,0
	3	1	58,6	58,6	1	58,6	58,6	8	0,0	65,2
	4				1	0,0	0,0	8	0,0	0,0
	5	21	0,0	0,0	20	0,0	0,0	8	0,0	0,0
LakeRatio	1	1	7,2	7,2	1	7,2	7,2	1	7,2	7,2
	2				2	3,7	4,3	2	3,7	4,3
	3	2	3,7	4,3	1	0,5	0,5	1	0,5	0,5
	4				2	0,0	0,3	2	0,0	0,3
	5	37	0,0	0,5	34	0,0	0,0	34	0,0	0,0
MeanderRatio	1	1	89,4	89,4				8	89,4	92,8
	2	13	91,7	93,1	13	89,4	93,0	8	92,8	93,3
	3	16	93,3	95,0	11	93,1	94,1	8	93,4	94,1
	4	9	95,1	96,5	14	94,3	96,5	8	94,3	95,2
	5	1	98,8	98,8	2	96,5	98,8	8	95,3	98,8
NonForestedRatio	1	4	0,0	11,7	7	0,0	18,4	8	0,0	20,1
	2	11	15,1	27,4	17	20,1	33,0	8	24,3	28,9
	3	15	28,9	42,2	9	35,0	45,5	8	29,4	33,0
	4	8	43,7	54,7	5	46,8	54,7	8	35,0	43,8
	5	2	57,0	70,9	2	57,0	70,9	8	45,5	70,9
OrchVegRatio	1	24	0,0	2,1	16	0,0	1,0	8	0,0	0,0
	2	11	2,3	4,3	12	1,0	2,6	8	0,0	1,0
	3	2	4,9	5,0	8	2,7	4,9	8	1,0	2,1
	4	1	7,5	7,5	1	5,0	5,0	8	2,3	3,5
	5	2	10,6	11,4	3	7,5	11,4	8	3,5	11,4
RiverSlope	1	22	0,2	3,0	14	0,2	1,6	8	0,2	1,4
	2	9	3,7	5,9	9	1,9	3,7	8	1,4	2,3
	3	2	6,8	6,9	9	3,9	6,8	8	2,4	3,9
	4	4	9,2	10,9	4	6,9	10,7	8	4,4	6,8
	5	3	12,4	15,0	4	10,9	15,0	8	6,9	15,0
UrbanRatio	1	27	0,0	2,9	24	0,0	0,1	24	0,0	0,1
	2	9	3,3	6,2	3	1,0	2,9	3	1,0	2,9
	3	1	8,3	8,3	8	3,3	5,7	8	3,3	5,7
	4	2	9,8	11,3	3	6,2	9,8	3	6,2	9,8
	5	1	15,8	15,8	2	11,3	15,8	2	11,3	15,8
SoilErodibility	1	10	0,2	0,2	9	0,2	0,2	10	0,2	0,2
	2	4	0,2	0,2	4	0,2	0,2	4	0,2	0,2
	3	24	0,2	0,2	24	0,2	0,2	24	0,2	0,2
	4				1	0,2	0,2			
	5	2	0,2	0,3	2	0,2	0,3	2	0,2	0,3

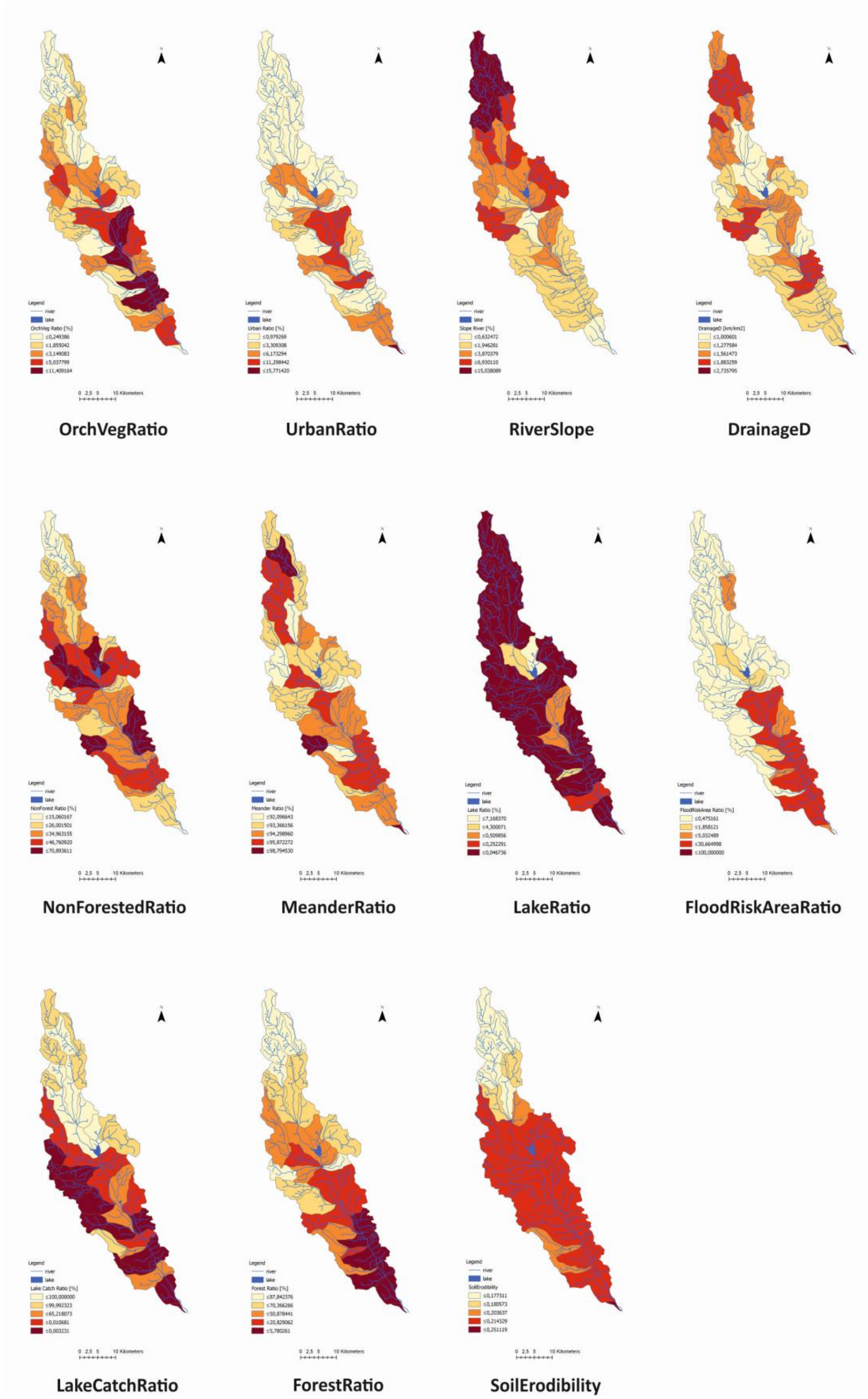


Fig. 11 Indicator values maps

4.6. Weights assignment

(In each subchapter create maximum of 6 maps (division method: ranges of equal width, natural breaks (Jenks), quantile); Due to the number of variants in these analyzes, I suggest change the weights only for one goal - which is most important for pilot catchment)

The weights for indicators analyses were calculated through conditional analyses in the software Excel (MsOfiice 2016 Profesional Plus, Windows 10) by using the Solver tool using the goals identified for SPUs in the goals map. It was used the standard workflow described in the chap. 6 Example how calculate weight indicator value of Manual.

Tab. 6 Weights assigned to indicators for flood goal

Short name indicator	Calculated by Weight Solver		
	Equal width	Natural breaks	Quantile
DrainageD	0.2	0.3	0.4
FloodRiskAreaRatio	0.4	0.1	0.1
ForestRatio	0.4	0.4	0.1
LakeRatio	1.0	1.0	1.0
LakeCatchRatio	0.1	0.1	0.1
MeanderRatio	1.0	1.0	1.0
NonForestedRatio	0.8	1.0	1.0
OrchVegRatio	0.1	1.0	0.7
RiverSlope	1.0	0.1	0.9
UrbanRatio	0.1	0.1	0.1

5. ANALYSIS OF VARIANTS

5.1. Valorisation for flood mitigation purpose (5 classes)

In the following figure there are shown valorisation map for flood goal differentiated by constant weight and variable weight for all three classification methods equal width (EW), natural breaks (NB) and quantiles (Q).

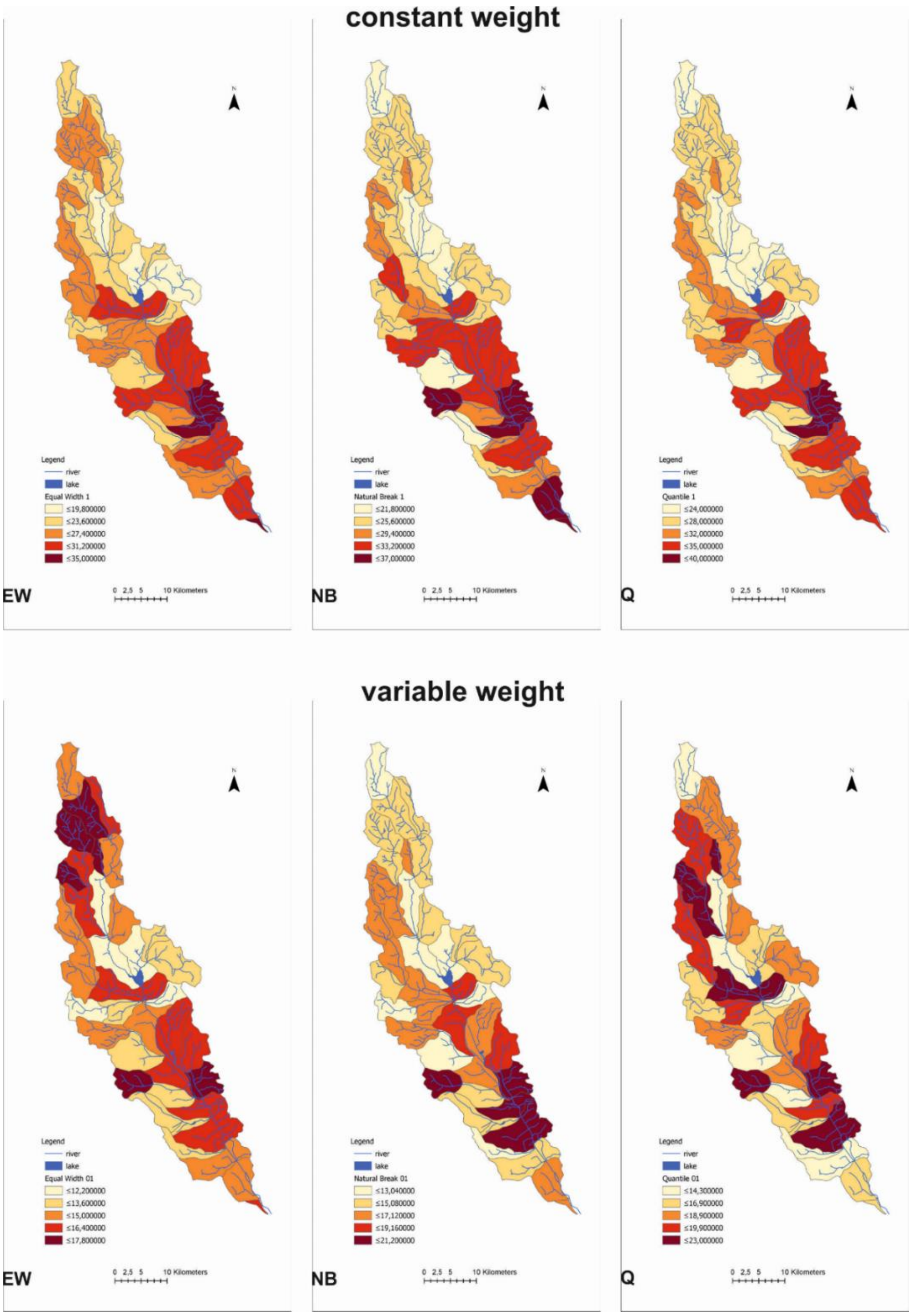


Fig. 12 Final valorisation map for flood goal differentiated by weight and by the methods of division into classes (EW- equal width, NB- natural breaks, Q- quantiles)

There have been also calculations for the **general goal** promoted, but due to the fact, that we have not available yet the official data on discharges from national authority, whole the process from selection of available indicators to production of valorization maps gave the same results. It is due to the fact, that using of "demo data of discharges available at SWME" gives bad correlations and particular indicator should be eliminated. Afterwords the set of available indicators was the same for flood goal and general goal too.

5.2. Valorisation for sediment mitigation purpose (5 classes)

In the following figure there are shown valorisation maps for sediment goal for constant weight also for all three statistical methods equal width (EW), natural breaks (NB) and quantiles(Q).

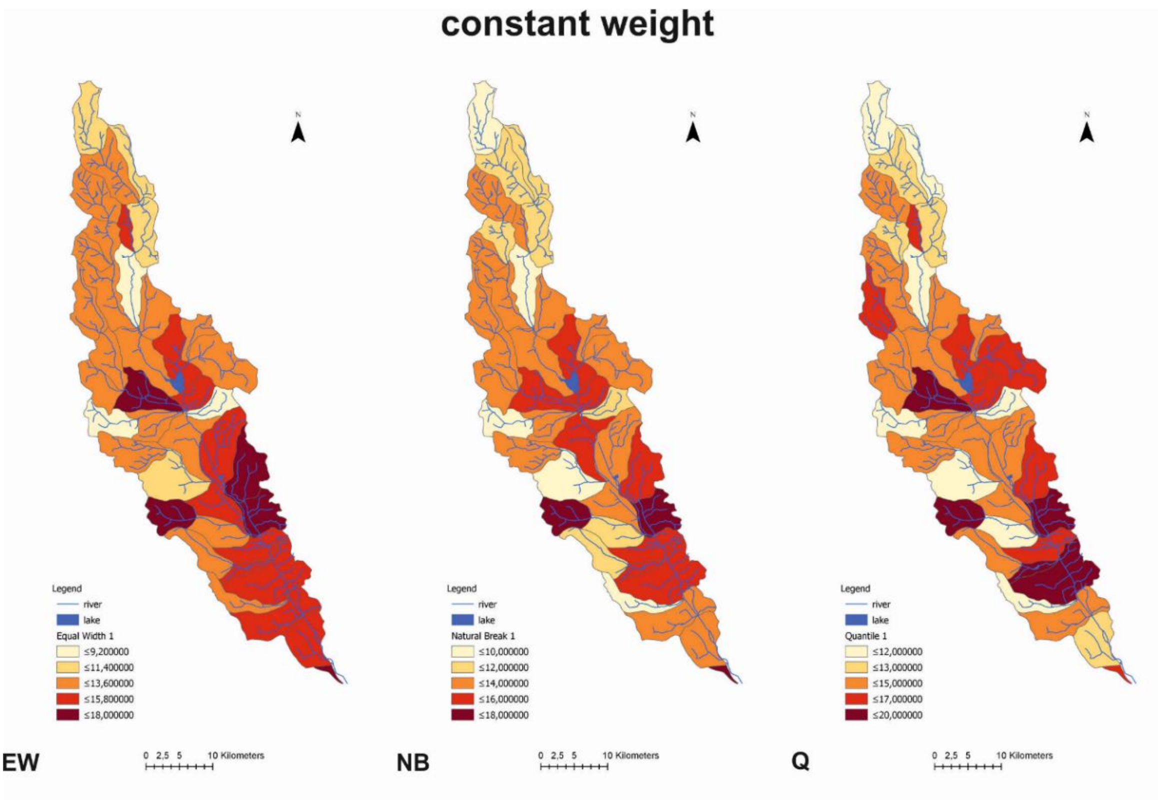


Fig. 13 Final valorisation map for sediment goal with constant weight (Wht1) differentiated by the methods of division into classes (EW- equal width, NB- natural breaks, Q- quantiles)

6. COMPARISON AND DESCRIPTION OF RESULTS

(create table present differences between results of variants maps and maps created in the chapter 3.5)

The results of all three classification methods classification methods equal width (EW), natural breaks (NB) and quantiles(Q) were compered between each other's. Based on comparison of differences of variants calculated for variable weight (Wht1 – Wht01), the method Equal Width serves with best results. The difference are huge – up to 42% (see Tab. 7). This could be due to the fact:

- of less number of available indictors used for calculations or
- of using the classification of indicators into 5 classes (instead 3) in the subcatchment divide into a minimum number of SPUs (40 SPUs) necessary for proper calculations in the FroGIS.

Reason of to high differences between variants Wht1, Wht01 and Goal we are not able to indicate yet and should be further examined. For the method Equal width we assume that changing the goals in the goal map for particular SPUs will lead to better results within the variant Goal vs Wht01.

Tab. 7 Variant validation for flood mitigation goal

	Equal width			Natural breaks			Quantiles		
Errors	VarA.Wht01-VarA.Wht1	Goal-VarA.Wht1	Goal-VarA.Wht01	VarB.Wht01-VarB.Wht1	Goal-VarB.Wht1	Goal-VarB.Wht01	VarC.Wht01-VarC.Wht1	Goal-VarC.Wht1	Goal-VarC.Wht01
MAD	0,73	1,90	1,70	0,83	2,30	1,80	0,93	2,30	1,90
MSE	1,08	4,90	3,90	1,18	7,30	5,00	1,63	7,30	5,10
RMSE	1,04	2,21	1,97	1,08	2,70	2,24	1,27	2,70	2,26
MAPE	26,58%	143,33%	123,33%	40,42%	175,00%	133,33%	41,96%	175,00%	130,00%

7. SUMMARY

(Based on the maps from chapter 3.1. & 3.2 and expert knowledge development of up to five maps showing needs and possibilities of water retention (in SPU units) only for real catchment problems (goals): general, flood, drought, quality, sediment transport (recommended division of needs into 2 or 3 classes. These maps will show severals SPUs having high needs and possibility for water retention recognized by the expert (also in the field). These maps will be used to verify the valorization method in the chapter 6.

During the testing of developed GIS tool FroGIS in the Blh catchment it was find out that the best results are given by using the classification method of Equal Width. The next two methods Natural breaks and Quantiles are serving with approximately similar values.

We can assume that the differences could be diminished by:

- using the classification into three classes instead five classes
- division of Blh subcatchment into more SPUs than 40 or
- re-evaluation of goals within goal map

Further potential improvements in goals definition in the near future coul be based on:

- the improvement of drought goals through application of the results of the DriDanube project ongoing within DTP (close to be finished)

The DriDanube project is focused on drought management in the SR, real-time online tool for drought monitoring and national network of drought impacts reporting.

8. OTHER COMMENTS

(specify any problems that occured or encountered difficulties)

The pre-processing of data, e.g. from global datasets, is quite time consuming, as it necessary to resample the data more times with the aim to find the most appropriate scale, as for example for DEM from 10x10 squares to 100x100 m squares lead to faster calculations in FroGIS.

It is necessary to make more instructions for potential users of FroGIS, how to e.g. prepare SPUs in the way they are also suitable for calculations on FroGIS.