Effective catchment management of soil erosion for long-term improvement of surface water bodies quality

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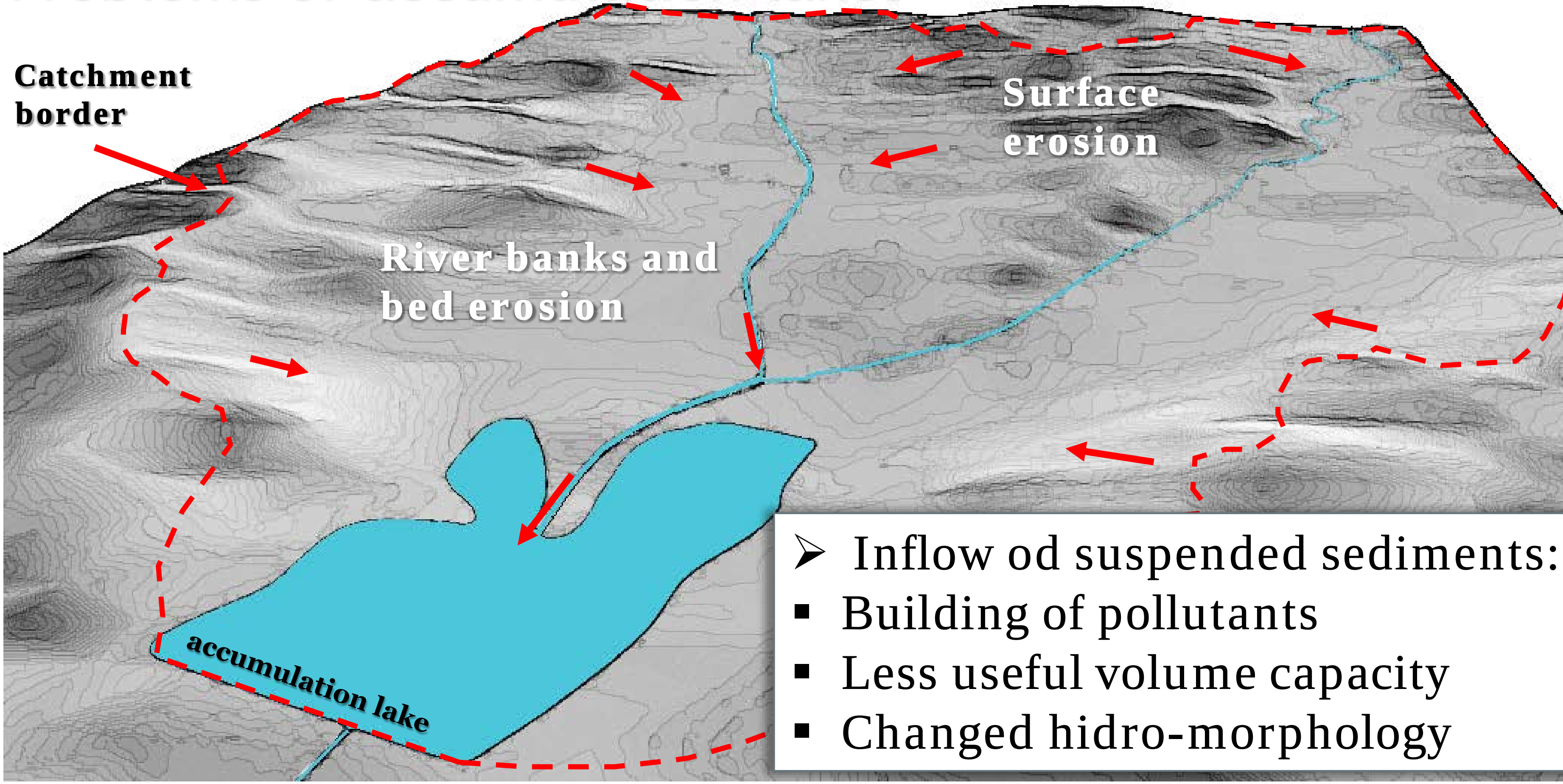
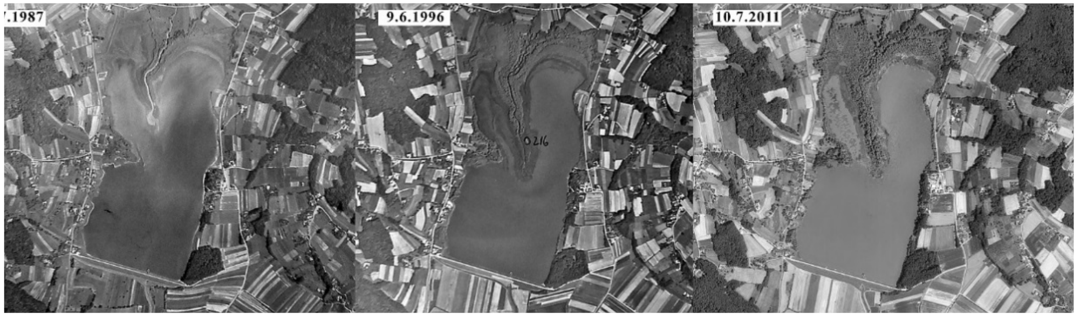
INTRODUCTION

Problems of accumulation lakes



- ➢ Inflow od suspended sediments:
  - Building of pollutants
  - Less useful volume capacity
  - Changed hidro-morphology

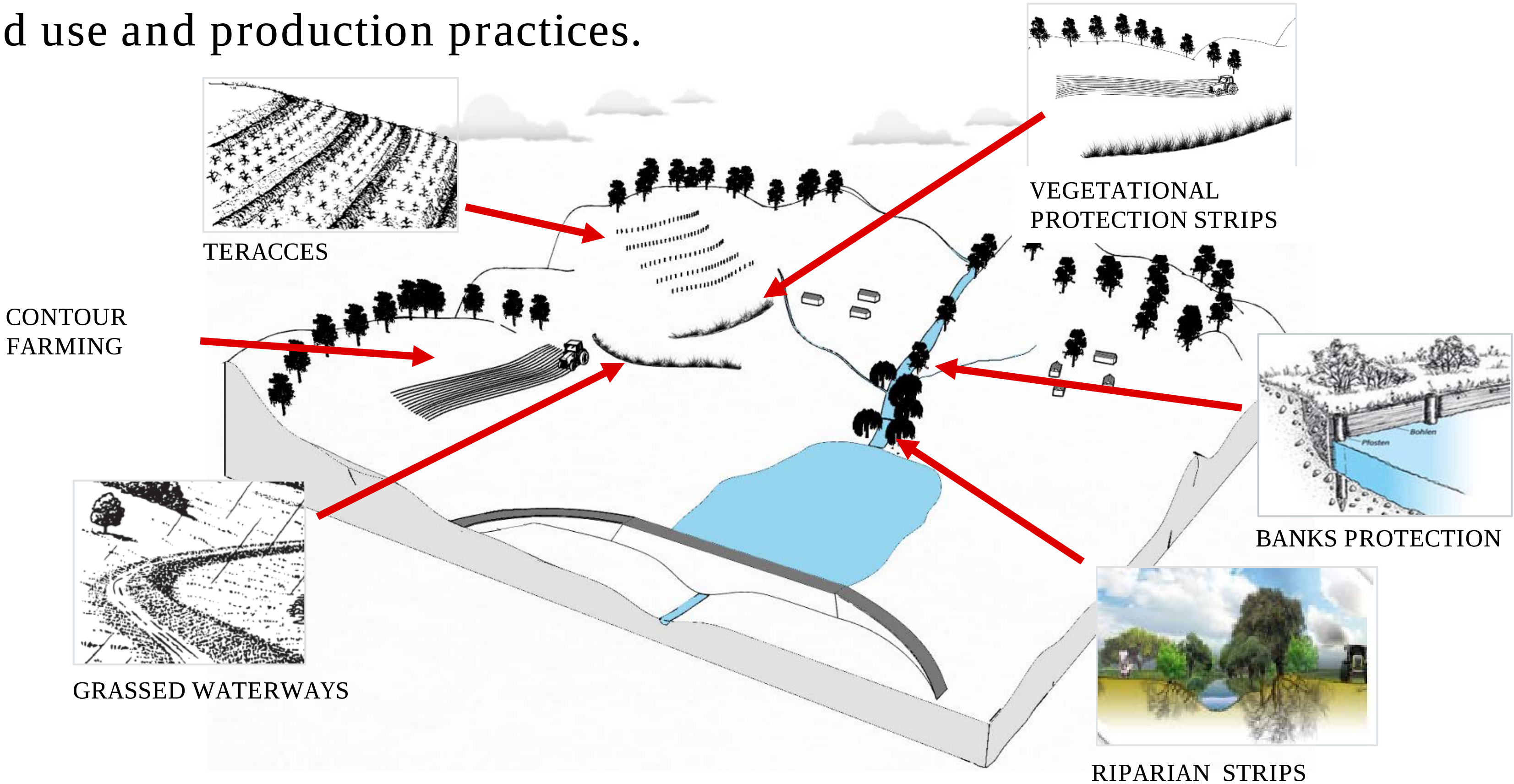


Ecoremediation(ERM) measures

Ecoremediation - use of ecological engineering, i.e. physiology and morphology of plants, including soil cultivation and other interventions in the area of reconstruction and protection (i.e. remediation) of the environment.

ERM measures – Constructional and non-constructional

Efficiency depends on topography, soil characteristics, climatic conditions, land use and production practices.



INTRODUCTION

Aim

Develop a **set of proven effective measures** and determine the **extent and location of their placement** in the river catchment area in order to improve and preserve the ecological potential of the accumulation lakes.

Objective

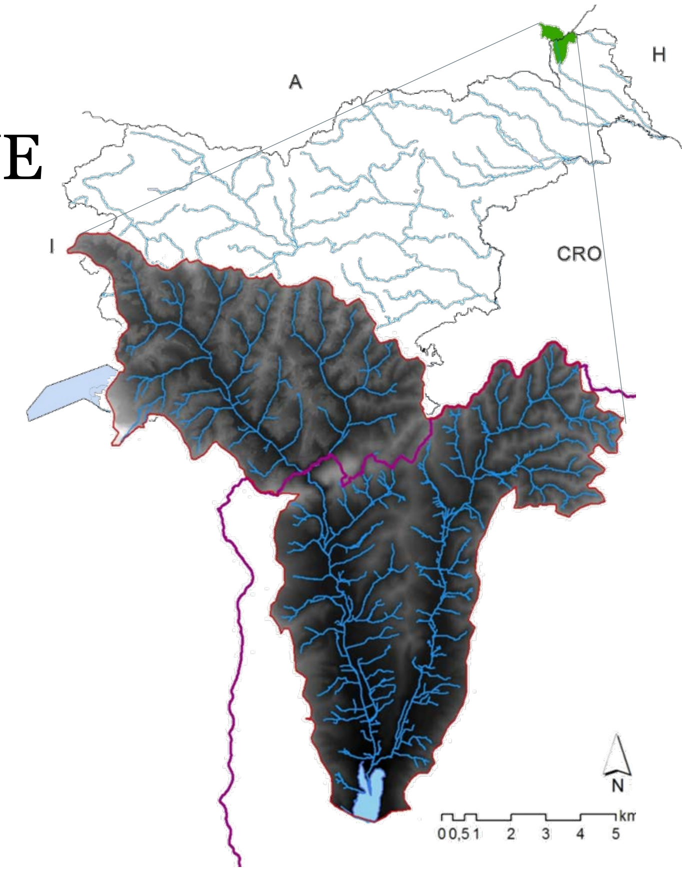
Develop a tool to support decision-making in the selection and placement of ERM measures into the space of the river-catchment area to reduce the load on the accumulations.

Accumulation Ledava Lake

- W-part of Landascape Park Goričko, in NE of Slovenia
- Catchment area of 105.25 km^2 (33.7 km^2 in Austria)
- Useful capacity of accumulation: 2.42 x 10^6 m^3 (at level 220.9 m.a.s.l.).)

Land use	
Arable:	37.8 %
Forest:	36.7 %
Grassland:	12.1 %

Avg. annual rainfall:	800 mm
Avg. annual temperature.:	11.2°C

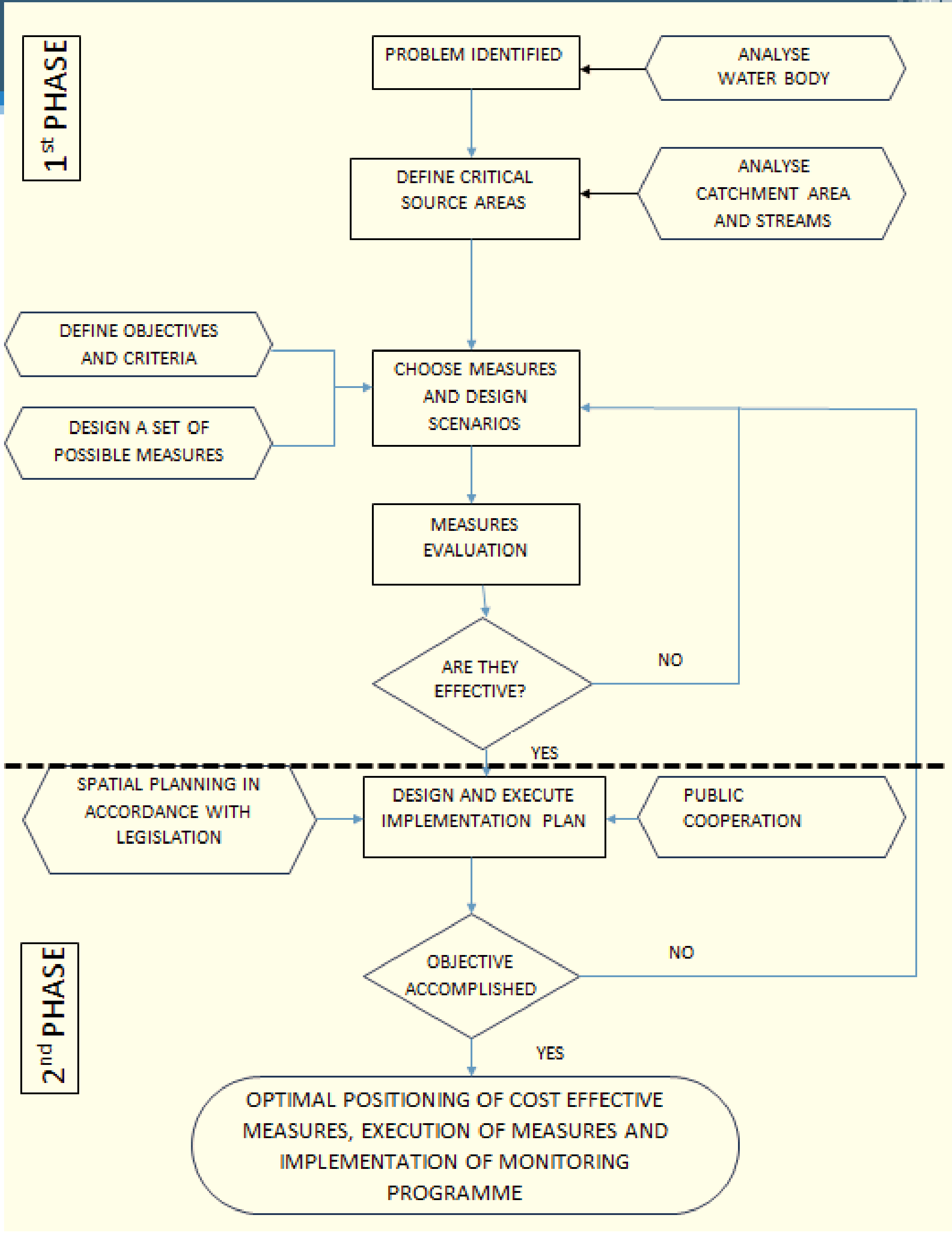


- Environmental Agency (ARSO): Accumulation does not reach good ecological state (WFD)

MATERIALS & METHODS

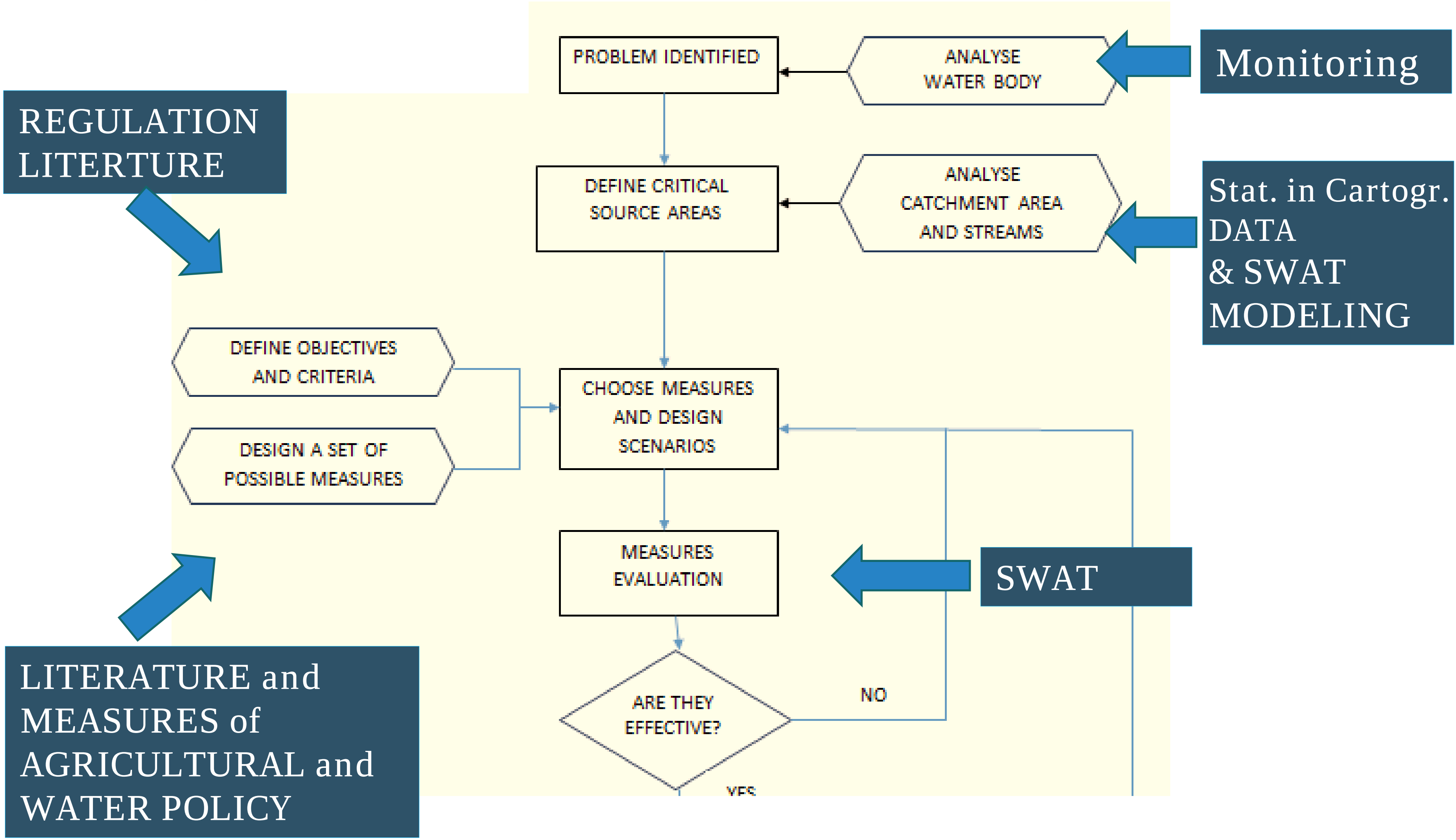
Tool for optimal Selection and Allocation of the ERM measures (TSA)

- Support for decision-making in selection and placement
- A systematic approach that is divided into two phases:
  1. professional basis
  2. plan for placement and setting up

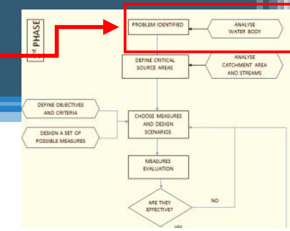


MATERIALS & METHODS

TSA Phasa 1



RESULTS Analyse water body - Monitoring



Analysis of Ledava lake and Ledava River

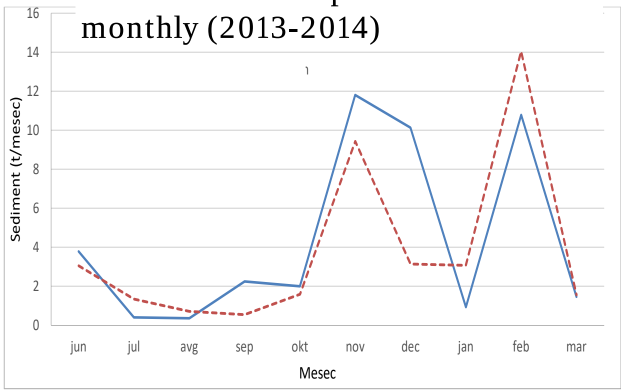
Year	LEDAV. LAKE Month	Total N [TN mg/l]	Nitrate [NO_3 mg/l]	Total P [TP mg/l]	Orto-P [PO_4 mg/l]	DO [O_2 mg/l]	Susp. S. [TSS mg/l]
2013	June	1.09	1.32	0.05	0.000	10.45	84.12
	July	1.25	0.00	0.05	0.000	5.98	134.11
	August	1.17	0.00	0.09	0.015	4.95	87.00
	Septemb.	1.68	0.15	0.07	0.039	4.48	68.00
	October	2.66	1.48	0.18	0.028	10.25	104.63
	Novemb.	2.21	5.07	0.25	0.017	8.10	85.67
	Decemb.	2.90	7.84	0.18	0.032	10.80	97.22
2014	January	2.01	5.82	0.12	0.010	10.84	91.98
	February	1.31	9.57	0.57	0.009	10.39	129.13
	March	1.29	6.72	0.18	0.011	11.76	74.27
	April	1.27	1.83	0.19	0.000	10.97	90.28
	May	1.17	2.94	0.15	0.000	9.37	158.00
Average:		**1.67**	**3.56**	**0.17**	**0.01**	**8.92**	**98.32**

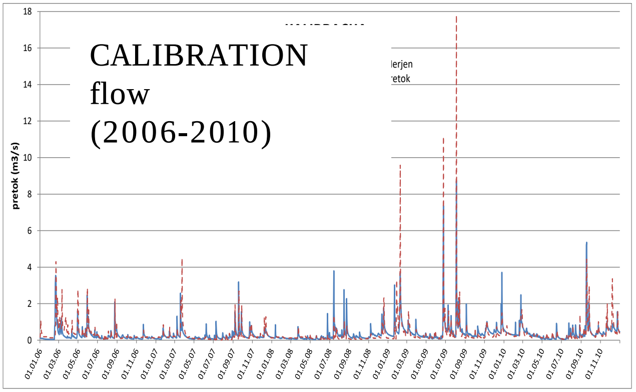
Year	River LEDAVA Month	Total N [TN mg/l]	Nitrate [NO_3 mg/l]	Total P [TP mg/l]	Orto-P [PO_4 mg/l]	Susp. S. [TSS mg/l]
2013	June	2.14	7.35	0.11	0.000	91.17
	July	1.58	3.69	0.12	0.000	43.33
	August	0.99	1.17	0.07	0.039	48.75
	Septemb.	1.71	5.36	0.07	0.068	46.75
	October	2.05	6.48	0.18	0.026	50.56
	Novemb.	3.27	11.79	0.37	0.024	62.63
	Decemb.	2.88	9.48	0.18	0.047	47.06
2014	January	2.76	9.11	0.16	0.013	53.66
	February	4.50	15.33	0.87	0.038	67.75
	March	2.94	9.95	0.18	0.064	44.21
	April	2.77	7.23	0.26	0.000	41.67
	May	3.86	13.12	0.79	0.000	55.50
Povprečje:		**2.62**	**8.34**	**0.28**	**0.03**	**53.50**

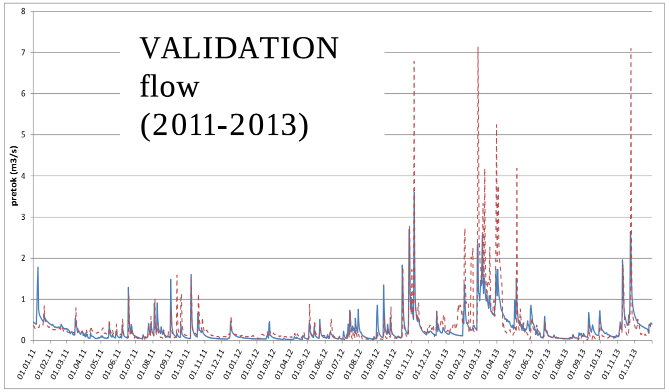
Calibration and Validation of the SWAT model

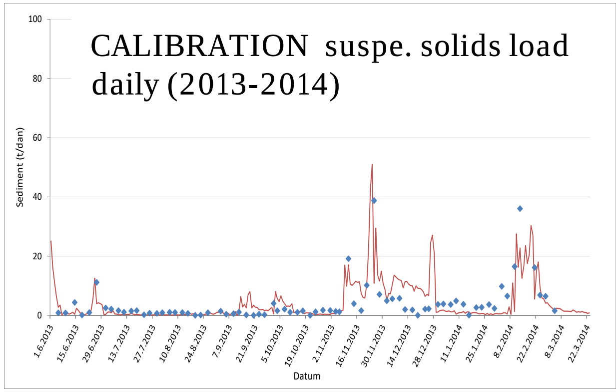
Objective function	CALIBRATION - FLOW			VALIDATION - Flow	CALIBRATION SUSPEND. SOLIDS load		Accaptable values (Moriasi; van Liew)
	year	month	day	day	month	day	
E_{NS}	0.996	0.493	0.571	0.5	0.57	0.38	0 – 1; 1 = optim.
PBIAS	-5.29	-5.19	-5.29	14.08	-14.09	17.69	0 = optim.. ± 25% for flow ± 50 % za TSS
R^2	0.701	0.618	0.571	0.525	0.64	0.39	0.5; 1 ali -1 = optim.

CALIBATION suspe. solids load monthly (2013-2014)

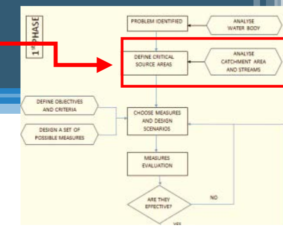






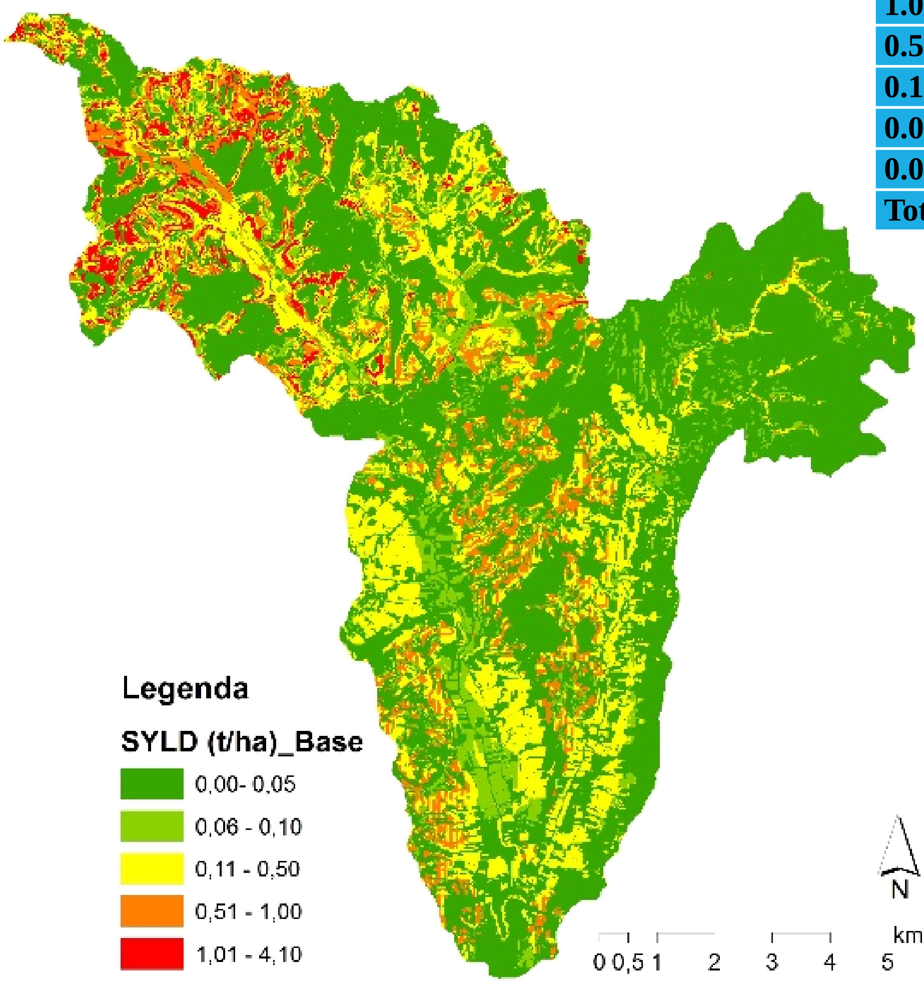


SWAT Soil & Water Assessment Tool



Critical source areas (CSA)

Transport Class (t/ha/year)	Area (ha)	Percent of total area (%)	Transport of Suspended Solids (t/ha)
1.01 - 4.10	355.06	3.37	1.72
0.51 - 1.00	905.32	8.60	0.69
0.11 - 0.50	2245.50	21.33	0.23
0.06 - 0.10	855.62	8.13	0.08
0.00 - 0.05	6163.80	58.56	0.01
Total:	**10525.31**	**100.00**	**0.28**



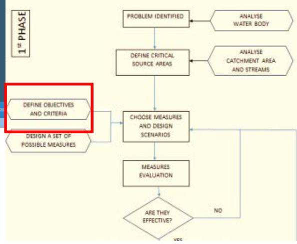
CSAs account for 31.1% of all arable fields, or 12.1% of all land use.

The most erodible are:

- gley and pseudogley soils;
- the slope between 11 and 24%
- fields and fields with drainage ditches

CRITERIA for allocation

RESULTS Defining objectives and criteria



OBJECTIVES:

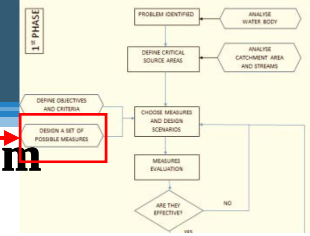
- improve ecological potential and to maintain a useful value (WFD for HMWB)
- Reduce soil loss and thus:
  - ➢ reduce the inflow of suspended solids or to maintain a useful volume
  - ➢ to preserve fertile soil

CRITERIA:

- to reduce the concentration of suspended solids below 25 mg TSS/l*
- Reduce the loss of soil where it exceeds 0.5 t/ha/year**

* Decree on the quality of waters for the life of freshwater fish species (Ul. RS, št. 46/2002)

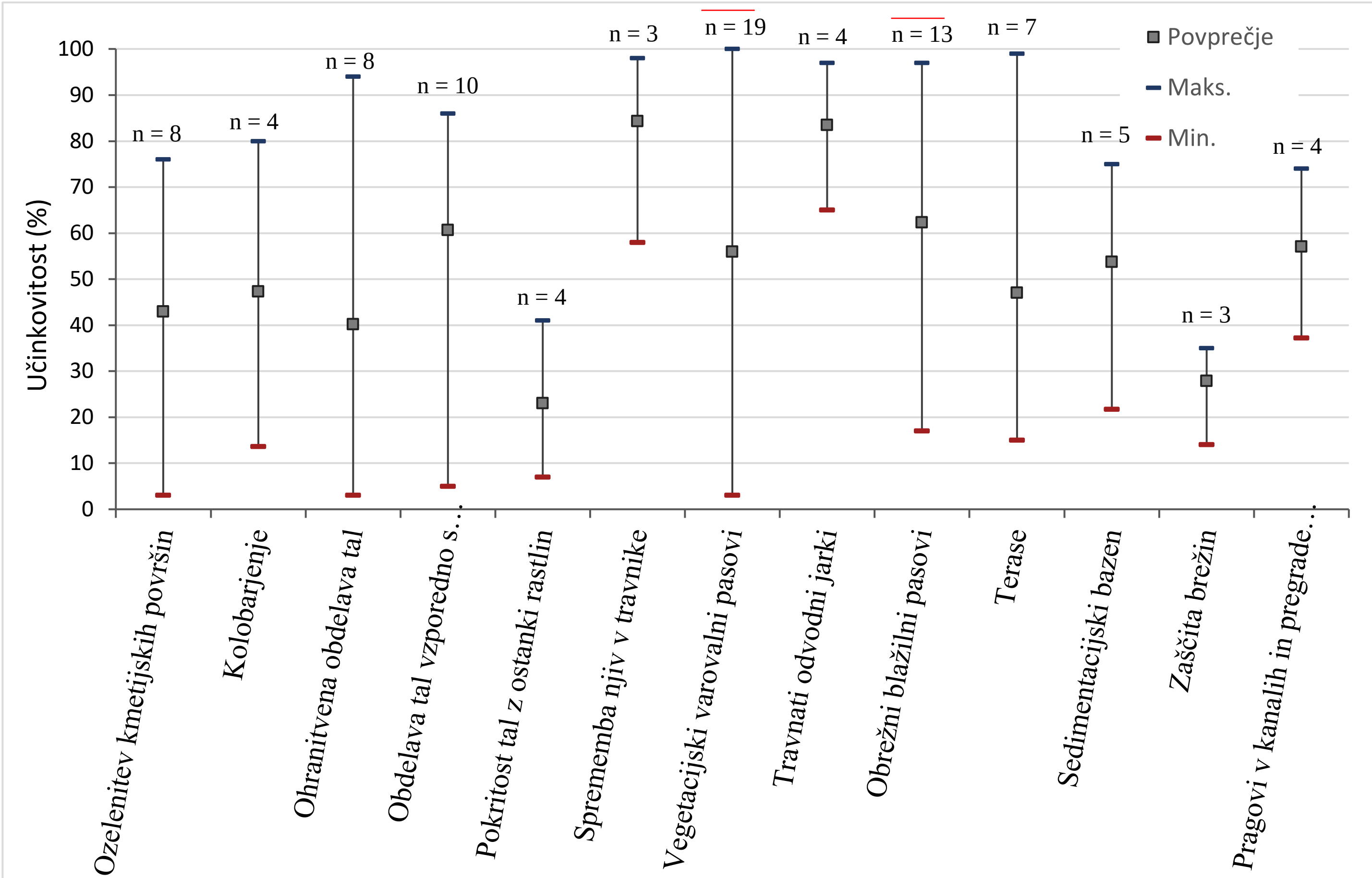
** On the basis of literature, the area is strongly subjected to the action of external forces, due to badly fished sediments there are frequent avalanches and landslides. The European Center for Soil Research estimates 1 t/ha/year as natural erosion. (http://eusoils.jrc.ec.europa.eu)



ERM measures to mitigate the transport of suspended solids from agricultural land and in the watercourses :

- USDA* lists 164 measures for different types of load, of which approx. 22 for erosion;
- Agri-Envi-Climate measures (CAP RDP) –10 requirements to reduce erosion and improve the soil structure;
- 3 RBMP measures to reduce erosion and improve the hydromorphology of watercourses

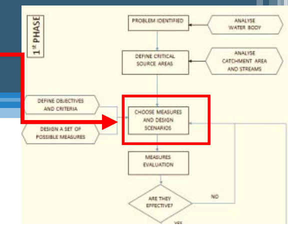
13 ERM measures based on **92 published** results from **43 sources** of literature



* U.S. Department of Agriculture

RESULTS

Designing scenarios



The set of 13 measures

CRITERIA:

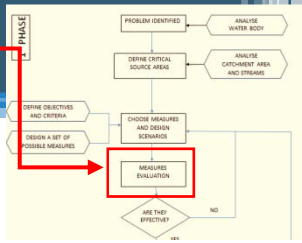
- characteristics of CSA
- existing measures CAP RDP (in implementation 3)
- high efficiency against load
- adaptation to actual use, technology of cultivation….
- capacity of the numerical model

1. Vegetation buffer strips
2. Conservation tillage
3. Contour farming
4. Terracing
5. Greening of arable land (Catch crop)

1. S1: Vegetation buffer on a slope of 0-11%
2. S2: Vegetation buffers on slope of 11-24%
3. S3: Vegetation buffer on slope of 0-11% and from 11 to 24%
4. S4: Conservation tillage
5. S5: Contour farming on slope between 11 and 24%
6. S6: Terraces on slopes between 11 and 24%
7. S7: Crop rotation without winter catch crop
8. S8: Crop rotation with winter catch crop

RESULTS

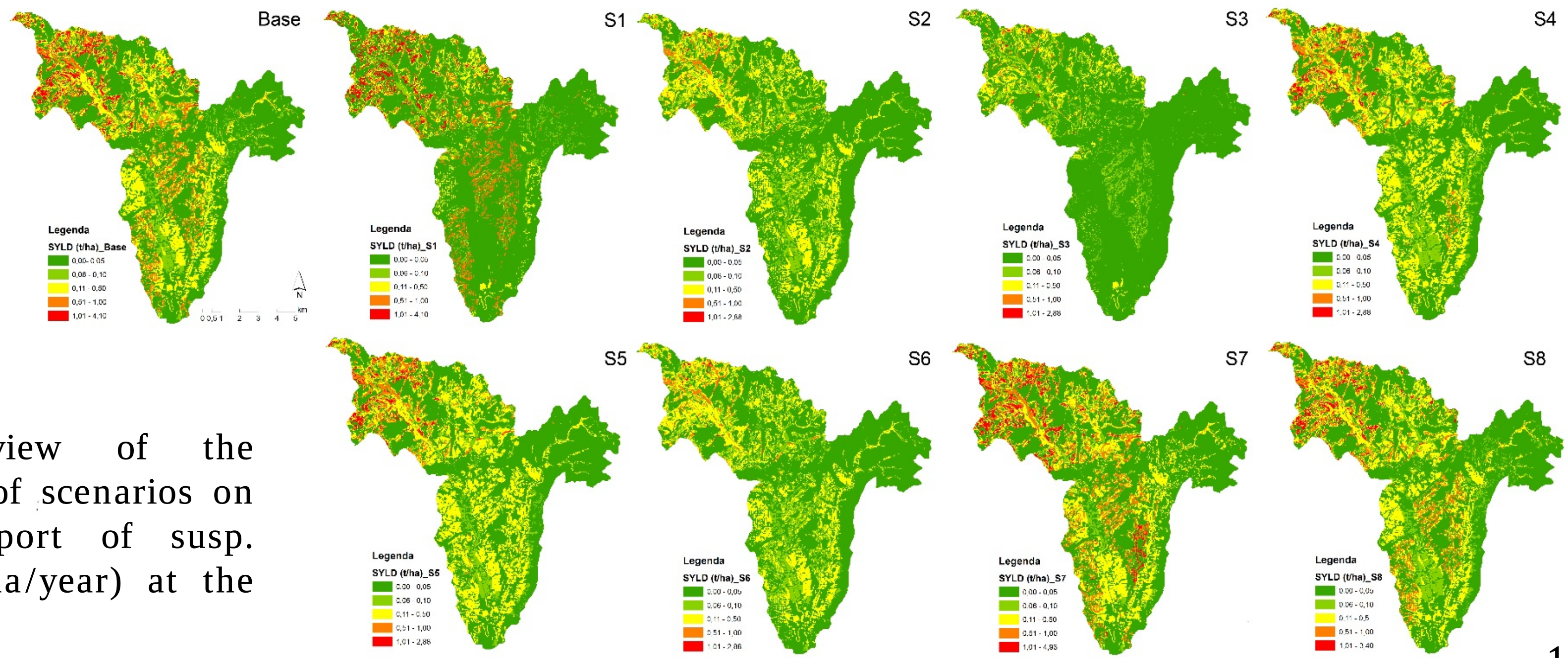
Evaluation of mesures



Scenario	Area (ha)	% from agri. land area	% from total area	Efficiency (%)			
				Load of susp. solids at inflow to lake	Transport susp. solids from HRU	Concentration susp. solids in the river Ledava	Half life period of accumulation
S1 - veg. strip 0-11%	32.8	0.6	0.3	**13.3**	12.8	4.2	**15.1**
S2 - veg. strip 11-24%	36.4	0.7	0.4	6.8	**43.4**	**11.7**	7.5
S3 - veg. strip 0-11-24%	69.2	1.2	0.7	**8.5**	**56.1**	**13.1**	9.7
S4 – conservation tillage to 24%	3422.9	60.8	32.5	7.9	20.3	3.3	8.6
S5 – contour farming 11-24%	1453.8	25.8	13.8	8.2	18.9	2.8	8.6
S6 - terraces11-24%	1453.8	25.8	13.8	**30.5**	**42.4**	**5.8**	**44.1**
S7 – no winter catch crop	3422.9	60.8	32.5	**-24.7**	**-11.5**	**-1.3**	**-19.4**
S8 – with winter catch crop	3422.9	60.8	32.5	7.7	11.9	1.0	8.6

$$r = \left(\frac{y_1 - y_2}{y_1}\right) \times 100$$

r ... efficiency (%)
y_1 ... base scenario
y_2 ... test scenario



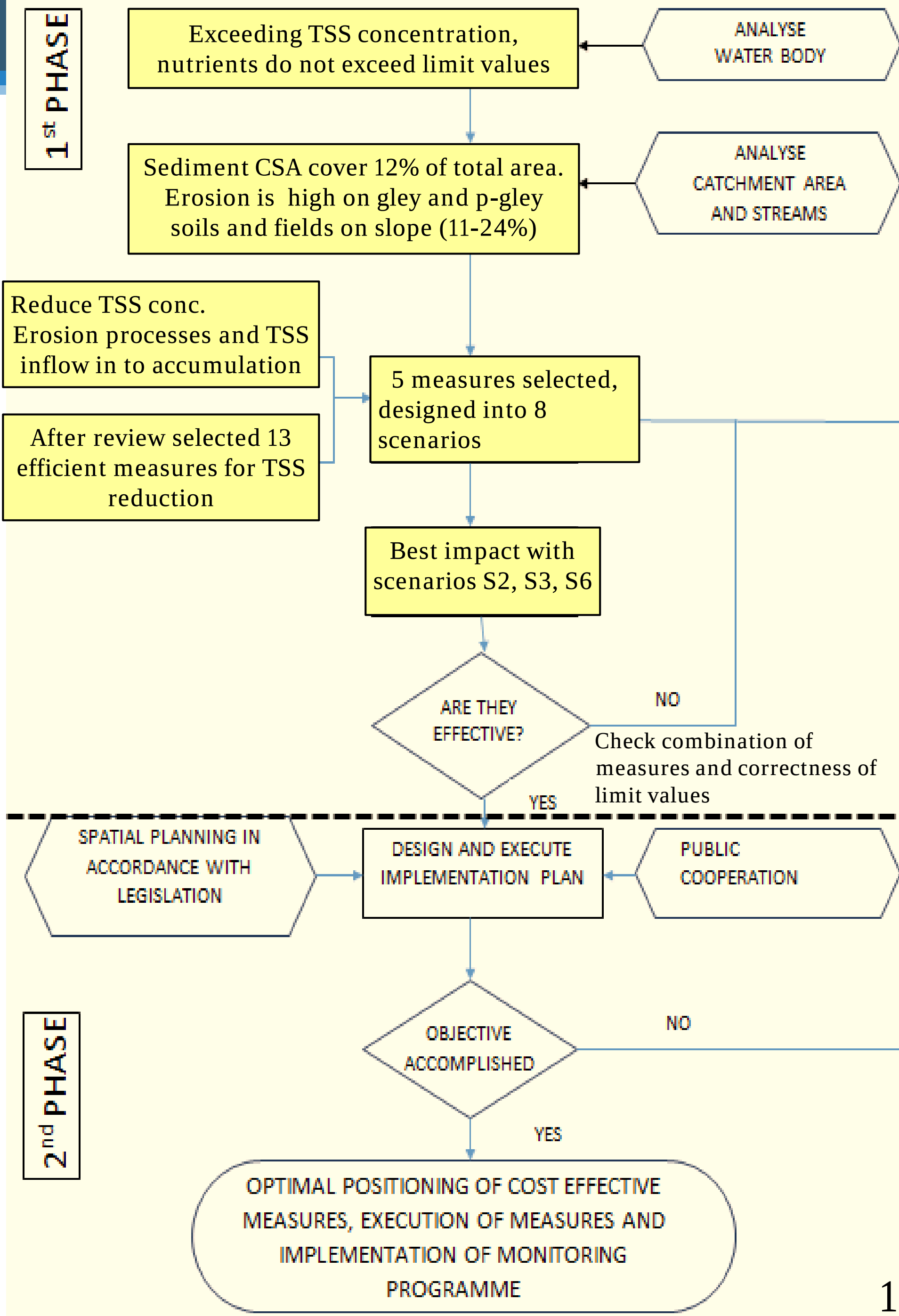
Spatial view of the influence of scenarios on the transport of susp. solids (t/ha/year) at the HRU level.

RESULTS

The most effective measures and critical source areas (CSAs) are the basis for the TSA Phase 2 allocation plan.

Future challenges:

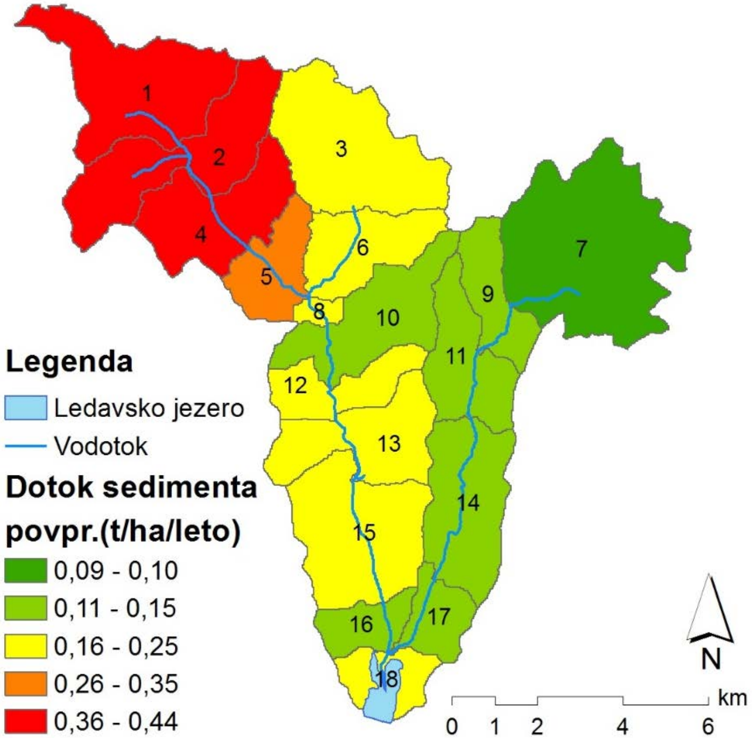
- More precisely to define the limit values of the quality parameters for water accumulations and soil loss criteria;
- Design a set of measures for different types of loads;
- Define CSA on aggregate agricultural land use;
- Using evolutionary algorithms to a greater number of combinations of measures;
- Upgrade SWAT or other programmes to assess measures to protect river banks;
- TSA tool design into a software tool for easy use.



CONCLUSIONS

- We have **developed the TSA tool**, which makes it possible to **optimize the selection and allocation of ERM measures** in the river catchment area for the restoration and protection of accumulations.
- Based on the results of **previous research**, it is possible **to collect data on the effectiveness of ERM measures** according to the type of load and the characteristics of the area of concern.
- **Criteria for ERM measures allocation into the space can be determined** in order to achieve their optimum efficiency and distribution. **On the basis of critical source areas (CSA) we were able to set criteria and place measures where they are most needed** and effective.
- With the integration of the SWAT numerical model in the TSA tool, **we evaluated the impact of measures on reducing the inflow of suspended solids** into the Ledava Lake accumulation, the maintenance of useful volume, the concentration of suspended solilds and the soil loss.


Thank you for your attention!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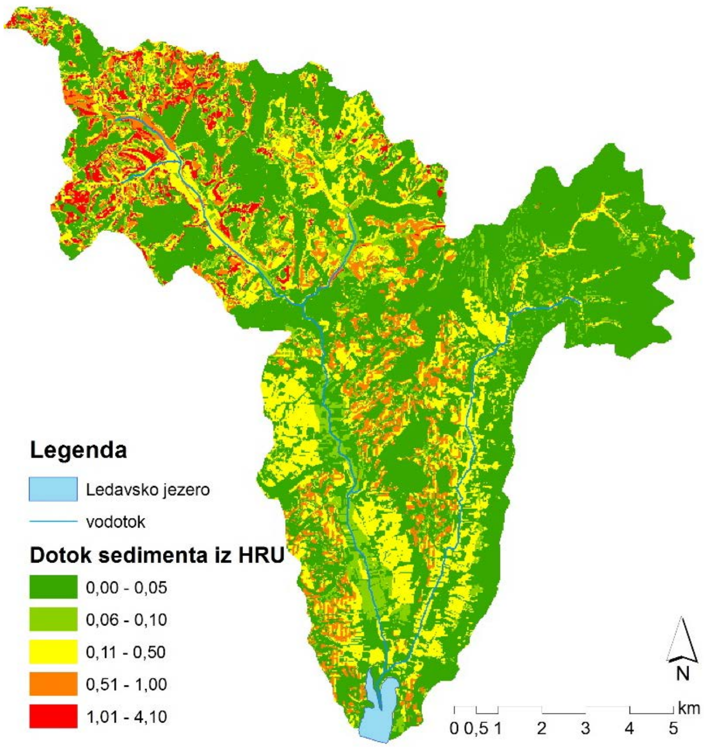
Legenda
Ledavsko jezero
Vodotok
Dotok sedimenta povpr.(t/ha/leto)
0,09 - 0,10
0,11 - 0,15
0,16 - 0,25
0,26 - 0,35
0,36 - 0,44
N
0 1 2 4 6 km


Legenda
Ledavsko jezero
vodotok
Dotok sedimenta iz HRU
0,00 - 0,05
0,06 - 0,10
0,11 - 0,50
0,51 - 1,00
1,01 - 4,10
N
0 0,5 1 2 3 4 5 km