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EU HORIZON 2020 Project

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Open Workshop
ICT tools for innovating Groundwater Management in a changing world

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Bakumivka River Catchment management through rural land use scenarios

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CENTRE D'INVESTIGACIÓ I DESENVOLUPAMENT 1967-2017

Taken from: http://travessa-pirineus.blogspot.com.es/2014/08/dia-15-de-lospitalet-al-refugi-de-juclar.html

Overview

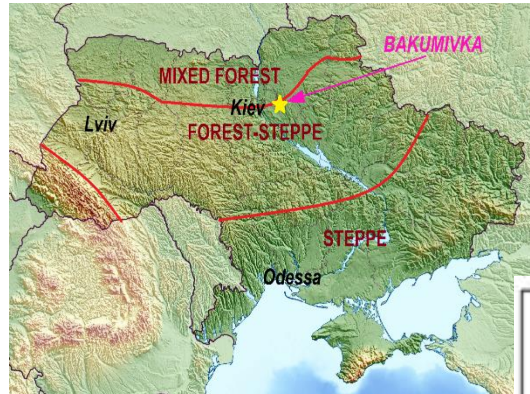
1. **General view of the case study:**
   location, conceptual model, objectives, methodological approach
2. **Main results of the simulation**
3. **Lessons learned**

The conductance of the river bed material (m^2/day)

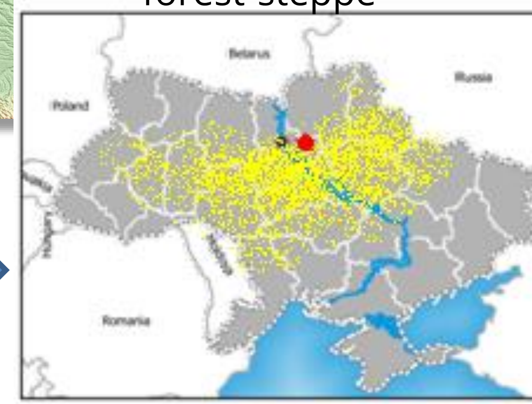
General view of the case study:
location and area

The catchment of Bakumivka River:

- is a part of Trubizh irrigation-drainage system;
- area – 64 km^2 of size;
- river network – 50 km of length;
- annual precipitation - 604 mm
- annual evaporation - 430 mm



The Bakumivka River's catchment lies within the ecotone between two natural zones: mixed forest and forest-steppe



The case study area is typical for central Ukraine with its natural conditions, landuse pattern and crops

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General view of the case study: *conceptual model*

Spatial Discretization

Model grid consists of 124 575 cells 30×30 m wide. Cells outside the catchment are excluded from the modelling, thus active domain includes 71 498 cells and is 64.348 km^2 wide

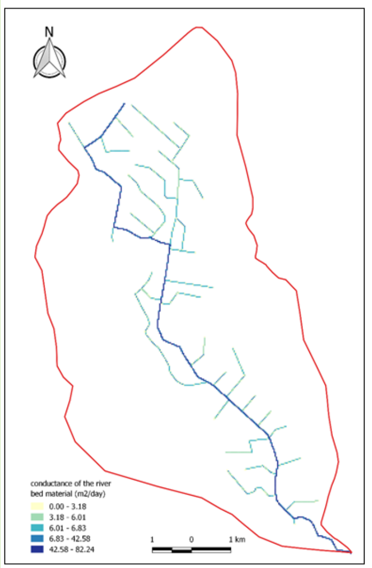
Temporal Discretization

The time unit - day.
Number of stress periods - 14,
SP 1 – steady state,
SP 2-14 – transient,
SP length – 15 days

Main hydrostrigraphic units

№	Thickness, m			Type	Hydrostratigraphic unit
	min	max	mean		
1	9.88	30.99	17.99	convertible	Sandy loam
2	1.0	20.41	11.02	confined	Clay
3	0.77	17.16	8.34	confined	Fine sand
4	0.38	8.45	4.11	confined	Gravelly medium sand

Surface streams



The conductance of the river bed material (m^2/day)

$$C^{RIV}_n = K_n L_n W_n / M_n$$

General view of the case study: *objectives*

Focus group logic:

- Currently in Ukraine we face with rapid and radical changes in land use and land cover – commercial crops replace traditional, agricultural fields change their size and shape, etc.

- The transformations in land cover pattern led to changes in water regime of the catchment (through the increased water demand and evapotranspiration of new crops, etc)

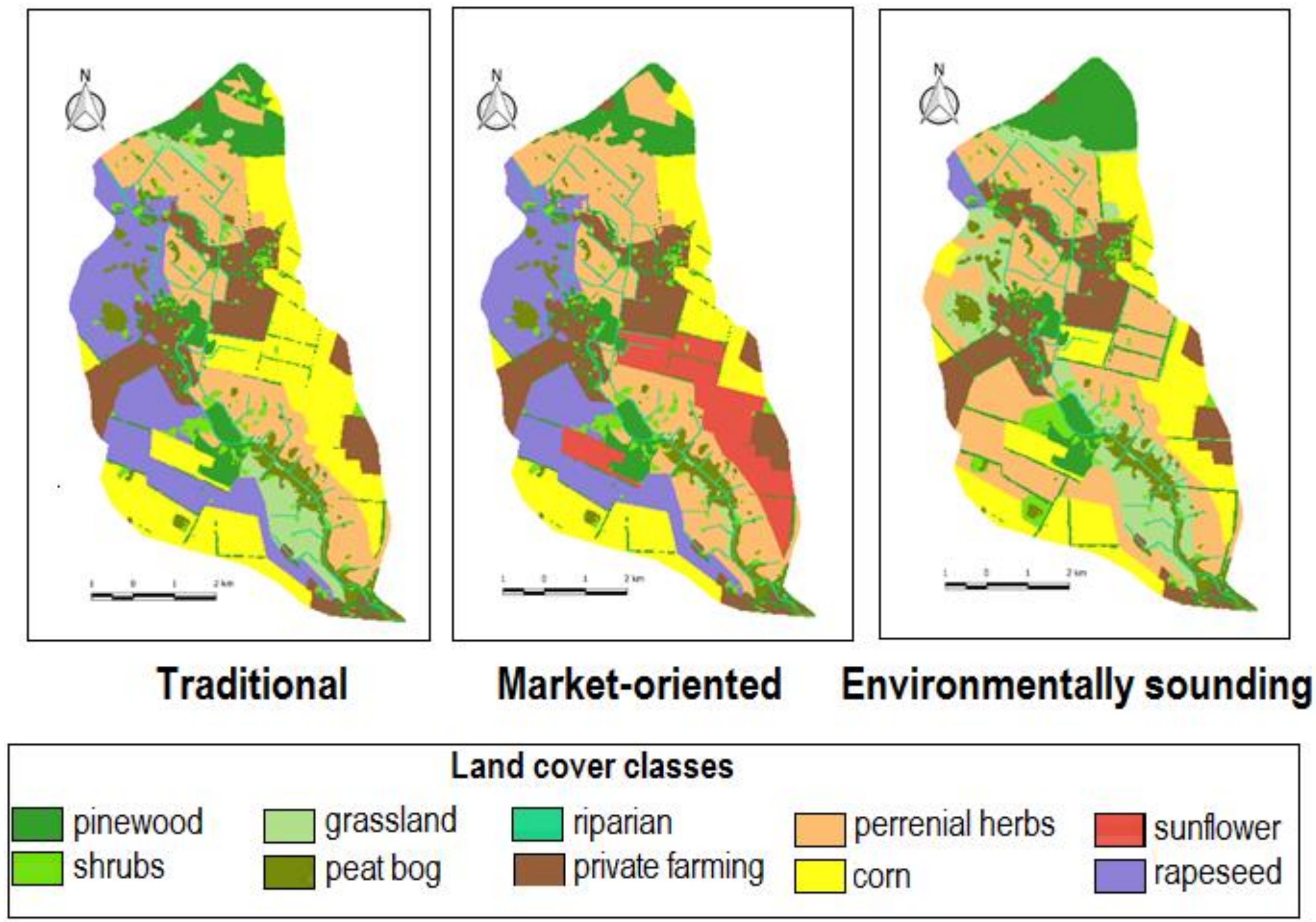
- Transformations of water regime and of landcover were simultaneous causing synergetic changes, such as peat fires, dehumification, wind erosion, loss of biodiversity.

- Water planning and management should react on this synergism by integrating water management with land(scape) management (particularly the water regime could be

The main objective of the case study -
to find out the optimal spatial distribution of the water supplied to the farms by modifying the land cover pattern of the catchment.

General view of the case study:
methodological approach

To compare how different spatial patterns of land cover influence the water budget of the catchment three water management scenarios were developed. The scenarios represent continuum from market oriented pattern to environmentally sounding pattern of land cover.



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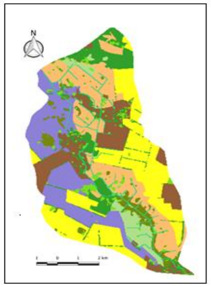
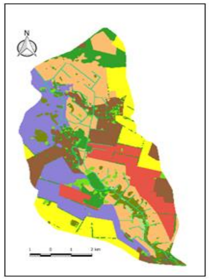
General view of the case study:

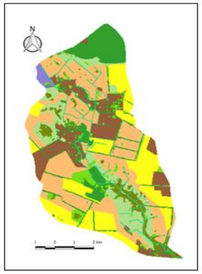
methodological approach



Traditional scenario is pattern of crops and other classes of land cover used in the recent five years in forest-steppe environmental zone of Central Ukraine. It is also the assumption that the technology of agriculture currently used in Bakumivka River's catchment will remain without serious transformations.



Market-oriented scenario is the assumption that currently most profitable crops (corn, sunflower and rapeseed) will occupy about 70% of the arable lands within the catchment; perennial herbs occupy only the floodplain; grasslands and shrubs mostly disappear; the spatial pattern becomes more homogenous.

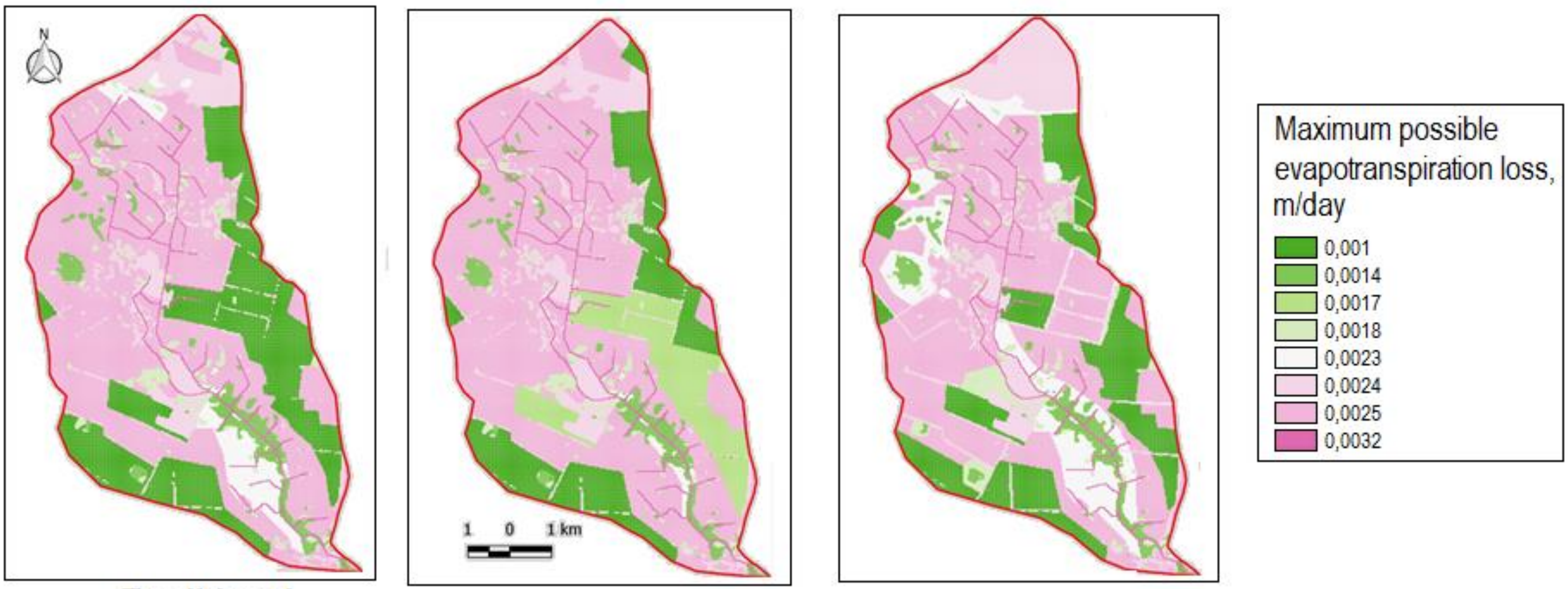


"Environmentally sounding" scenario - the landscape is spatially organized on the principles of landscape-ecological planning: rapeseed and suflower are removed; corn fields are reduced; perennial herbs predominate; patches with natural vegetation are connected with the eco-corridors creating local econet ecotones are introduced.

General view of the case study:

methodological approach

For the assessment of how the land cover type affects water budget during the growing season three separate evapotranspiration layers with the MODFLOW EVT boundary conditions were created. Each layer was assigned spatially distributed evapotranspiration parameters according to the spatial distribution of 10 land cover



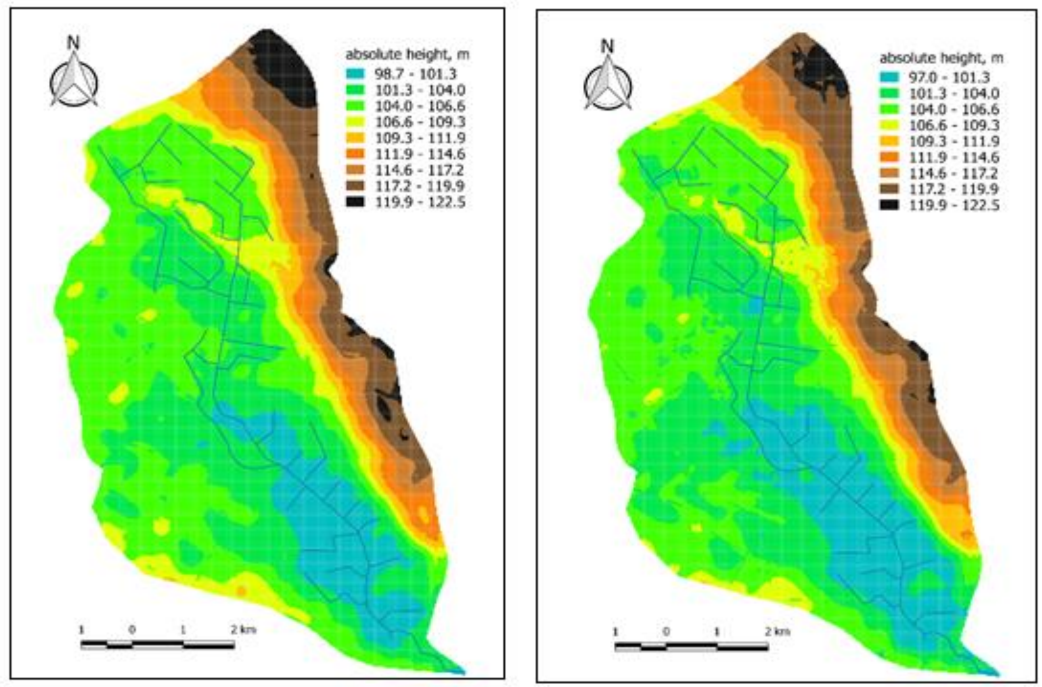
Traditional Market-oriented Environmentally sounding

The example of spatial distribution of evapotranspiration for different scenarios during the stress period 5

General view of the case study:
methodological approach

The criteria of evaluation of scenarios is the difference (in meters) between the actual water head and the optimal water head for particular land cover class.
The water level was considered as optimal if it falls within the range of minimal and maximum permissible levels.

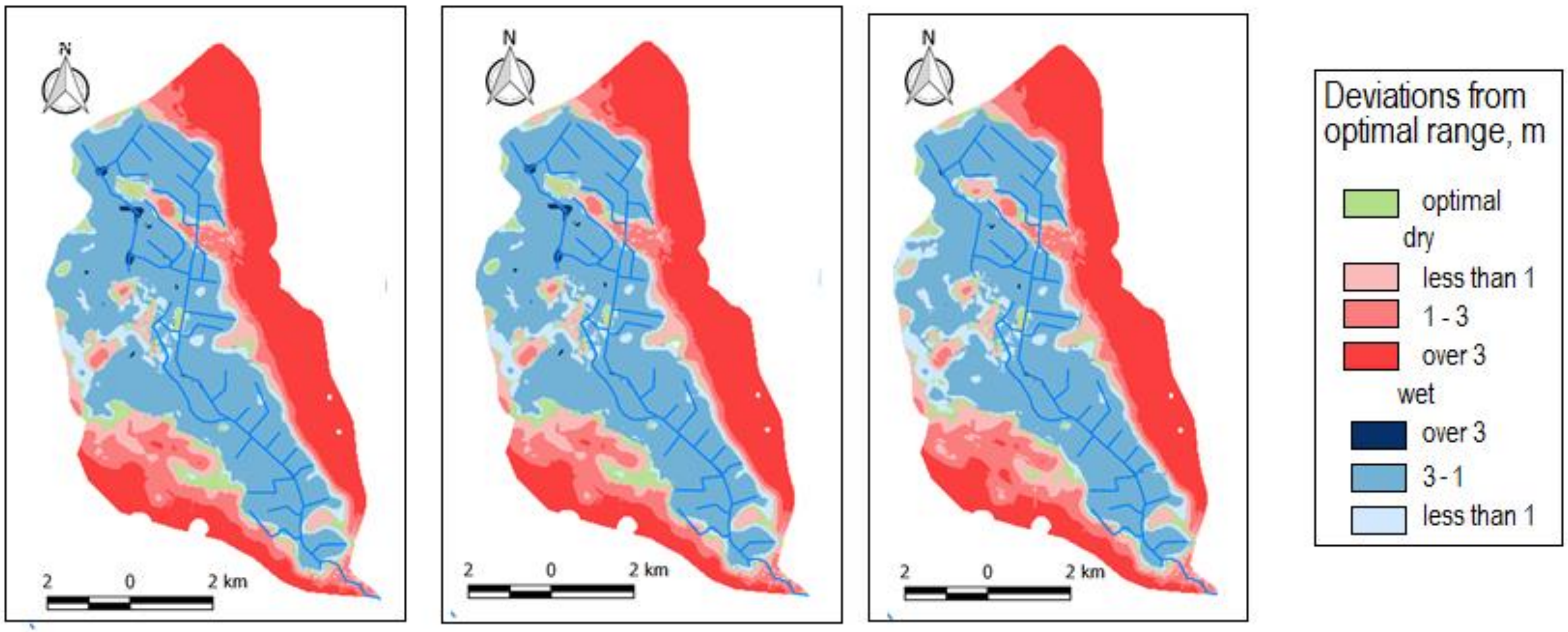
The maximum permissible level is the extinction depth plus the capillary fringe; the minimal permissible level is the extinction depth plus 0,5 of the capillary fringe.
The range of optimal water head were defined for each particular landcover class for each stress period. Using these data, two surfaces of minimal and of maximum optimal water head were created for all scenarios



Surfaces of optimal range of the water head for the traditional scenario of land/water management: maximum (left) and minimum (right) limits of optimal water head

General view of the case study:
methodological approach

Subtraction of surfaces of water head and of optimal water head produces the map which shows the optimal areas (water head falls within the limits of optimal range), permissible areas (the difference between the head and its optimal limits does not exceed 3 meters), and critical areas (the water head is above or below its optimal range for more than 3 meters).



Traditional **Market-oriented** **Environmentally sounding**

Deviations of water head from its optimal ranges during the stress period 5

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Main results of the simulation

• Changing spatial landcover pattern could be effective measure to reduce water supply to the farms, however it does not prevent water logging in the flood-plains as well as drying of lands on sandyloam soils;

• the elevated lands with sandy soils characterized by the risk of soil drought should not be used for crops with high transpiration coefficients (above 250-300); they have to be replaced with the perennial herbs;

• irrigation in the Bakumivka River's basin should be excluded in the areas with sandy and sandyloam soils;

• the flood plain with peat bogs despite the high water head in spring and late summer should be irrigated to protect the peat bogs and prevent peat fires;

• introducing eco-corridors and ecotones to the landscpe (environmentally sound scenarios) is profitable from ecological point of view but has little influence on the ground water of the watershed. Moreover, the eco-corridors could prevent drainage causing water logging in the arable lands.

Main results of the simulation

The measures propopsed could rise crop productivity, and to protect the environment of the Bakumivka River's catchment from water logging, peat fires, soil degradation and other undesirable processes.

An important outcome of the realization of the set of scenarios is that **no single one but few types of hypothetic land cover patterns with few schemes of spatial distribution of water attached to each of them could be regarded as optimal. The variety of optimal decisions is the ground for adaptive water/land(scape) management and planning.**

Lessons learned

Current modeling approach and obtained results can be improved in several ways:

- there is a need for more adequate representation of the layers with complex geometry that contain lenses and inclusions. For this purpose, model layers' depth and quantity can be reduced (for example, 2-3 aquifers of total thickness of about 15 m)
- River stage parameters could be varied in time and space (on the segments between slices), in order to simulate storage and discharge of water from the river network. This will help to understand the role of the channel network in the maintenance of the optimum groundwater table level.
- Further developments could include simulation of the groundwater pumping in the area.
- The more advanced modelling scenarios are needed fort better understanding the relations between the water storage in the river and channel network and groundwater heads and flows.
- In the context of rural management more attention should be given to the soil properties. For example, MODFLOW-OWHM suggest only 3 types of soils and describe them with limited parameters, while such soils properties like pH, salinity, humus are neglected.

Lessons learned

- The application of the FREEWAT needs experience wide experience in the fields of hydro(geo)logical modeling, plant physiology, agronomy, soil science, geoinformatics, geospatial data analysis. It means that the intermediate-level managers of water resources as well as end-users of these resources could hardly be able to use the FREEWAT in their activity. It is too complicated for them.
- The consulting centres or research groups composed of experts in abovementioned fields could be established in order to provide service to potential stakeholders in solving their needs using the FREEWAT platform. It could both create jobs and improve evidence-based decision-making.
- Another efficient measure is training the experts in FREEWAT instruments.

BAKUMIVKA: the case study where land and water meet

Thank you for your attention !

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