INTEGRATED METHODS AND A COMPLEX SOLUTION FOR FLOOD PROTECTION AND EROSION CONTROL – A CASE STUDY OF THE VILLAGE OF VRBOVCE, SLOVAKIA

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1 MOTIVATION

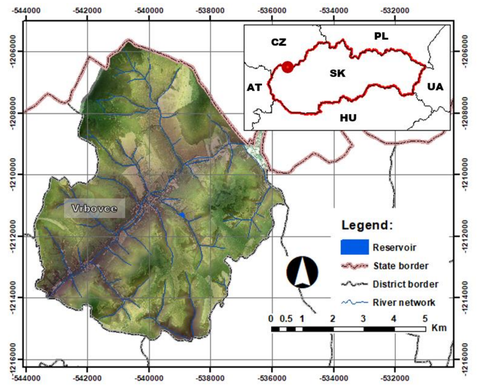
The landscape is an open system driven by interactions between natural and anthropogenic elements. Their long-term impact is responsible for the current form and status of the landscape. Integrated landscape management enables to implement particular solutions to mitigate the effects of threats to the ecological stability of the environment, to preserve and support the diversity of ecosystems, to improve ecologically less stable parts of the landscape and their spatial spread, as well as the possibility to maintain the cultural heritage of the landscape. Proper management of the landscape is especially important to serve spatial planning aiming at mitigation of problems caused by extreme runoff and erosion.

This study presents in support of such management through a complex of specific studies proposal of erosion control, flood protection, and eco-stabilization measures in the cadastral area of the village of Vrbovce. It is shown how can the ecological stability and recreational potential of the area be improved, when generally accepted robust quantitative methods for risk mitigation (which are simple enough, but are yielding reliable predictions) are integrated into a complex of mitigation measures.

The study has been divided into several topic parts:
Complex design of the **flood protection** and **erosion control measures** in the catchment
Revitalization of the inundation zone and adapting of the **Teplica river**
Assessment of the flow capacity of the Teplica river and flood protection measures
Proposal for the **Hydrometeorological warning system**

2 STUDY AREA

The cadastral area of the village of Vrbovce lies in the district of Myjava in the western part of Slovakia, on the edge of the flysch zone of the White Carpathians. The **total area** of the locality investigated is **5147 ha** and it lies in a hilly country, with an altitude ranging between **350 m a.s.l and 650 m a.s.l.** The area belongs to a moderately warm-climate region, with a mean annual **air temperature** of 7.5°C and mean annual **precipitation** totals ranging between 700-800 mm. The cadastral area of the village of Vrbovce belongs to the basin of the **Teplica river**.



◄ ***Fig. 1:*** *Position of the cadastral area of village Vrbovce in Slovakia.*

The typical character of the landscape in the first half of the 20th century was characterized by a mosaic of small. The collectivization of the agricultural land, which took place after the end of World War II, resulted in the loss of this stable landscape, which was replaced by a number of large cooperative fields. This transformation led to an increased **occurrence of flash floods** and significantly **intensified erosion processes**.

▲ ***Fig. 2:*** *The signs of erosion in the watershed of Haluznikov creek.*

3 METHODOLOGY

Universal Soil Loss Equation

For spatial erosion risk mitigation, the Universal Soil Loss Equation (USLE) was used to estimate soil loss with an emphasis on sheet and rill erosion, without taking into account the sediment transport and deposition:

$$E = R\ K\ LS\ C\ P$$

The USLE2D methodology was applied to calculate the LS topographical factor.

SCS-CN method

For the mitigation of flooding, we used the well-established SCS-CN method for the estimation of the direct runoff volume, and its changes for the current and alternative land uses. The design peak flows were calculated for the return periods of 5, 10, 20, 50 and 100 years based on rain intensities estimated by the simple scaling for the investigated locality.

Hydrodynamical modeling

For flood protection of the urbanised areas and proposal of room for river type river restoration, we created a 2D hydrodynamic model of the Teplica river, using the Mike 21 package, which is an industry-standard software package. It was used to assess the flow capacity of the main channel and the tributary channels of Teplica river, the carrying capacities of the bridge structures during extreme floods, and flood attenuation potential of inundation areas.

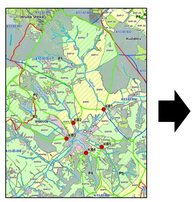
We selected five subcatchments of Teplica River basin, which are potentially dangerous on account of hight value of runoff – the watershed of Haluznikov creek – KB1 (9.3 km^2), Lulovský creek – KB2 (3.4 km^2), Záhutník creek – KB3 (2.3 km^2), Zápasečník – KB5 (3.3 km^2) and Vesník – KB4 (1.1 km^2).

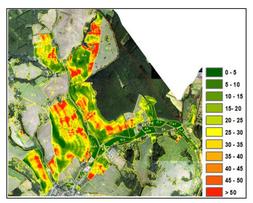
4 RESULTS

Flood protection and erosion control measures

The erosion and direct runoff calculations were performed for present and alternative land-uses including the evaluation of a set of measures, i.e., flood detention polders, infiltration trenches and agrotechnical measures on the arable land for the reduction of the extreme runoff and accelerated soil erosion (Fig. 3 - 5).

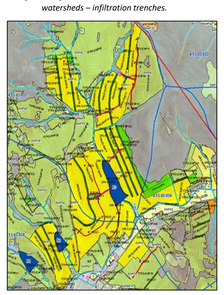
▼ ***Fig. 3:*** *Identification of the critical points - KB.*

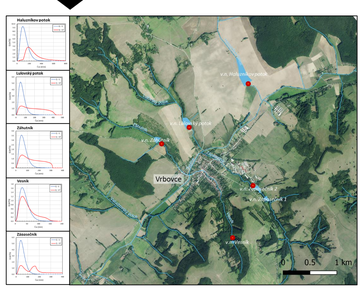




▲ ***Fig. 4:*** *Annual value of soil loss in the basin of Haluznikov creek.*

▼ ***Fig. 4:*** *Designed erosion control measures on selected watersheds – infiltration trenches.*



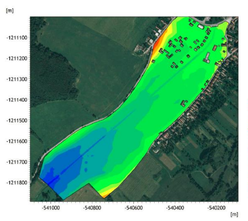


In each creek, we propped a small reservoir (polder), the function of which is to accumulate water in a flooded state in the creek temporarily. A drainage ditch was designed for parts of the arable land, especially the land most endangered by accelerated soil erosion.

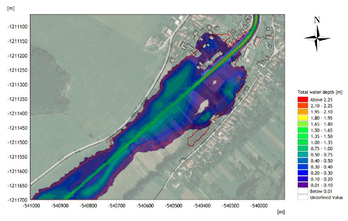
◄ ***Fig. 5:*** *Designed flood protection on selected watersheds – polders, transformation of flood wave with 100 years return period in the capacity of the polder.*

Assessment of the capacity, flood protection measures and the revitalization of Teplica river channel

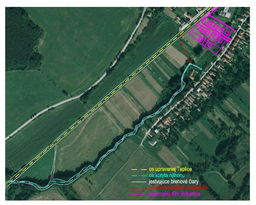
Ichthyological and dendrological research was implemented in riverine areas and, using 2D hydrodynamical modelling, we submitted a proposal for the revitalization of the inundation zone of Teplica river and devised new areas suitable for housing (Fig. 8).



▲ ***Fig. 6:*** *Digital elevation model of the Teplica river.*

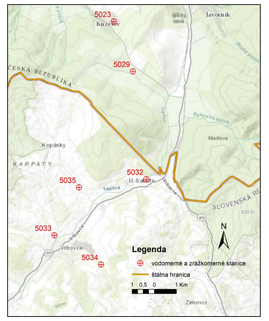


▲ ***Fig. 7:*** *: Hydrodynamic modelling - 2D hydrodynamic model of the Teplica river, using the Mike 21 package.*



▲ ***Fig. 8:*** *Proposal for an increase of space for inundation and housing.*

Hydrometeorological warning system



▲ ***Fig. 9:*** *Proposal of a hydrometeorological warning system as a part of the flood protection measures.*

5 CONCLUSIONS

- Generally accepted quantitative methods for risk mitigation were selected, which are simple enough, but are yielding reliable predictions.
- A set of measures, i.e., polders, an infiltration trench and agrotechnical measures on the arable land, was designed outside the built-up areas of the village of Vrbovce for the reduction of the extreme runoff and accelerated soil erosion.
- The effectiveness of the proposed measures showed that we were able to reduce the amount of soil erosion to permissible values.
- Measures for the Teplica river revitalisation in the village were proposed.
- Proposals for the mitigation of the particular risks were integrated into an eco-stabilisation system which will be the bases of spatial planning on a local scale in the future.

6 ACKNOWLEDGEMENTS

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