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Conference Paper · June 2019

DOI: 10.5593/sgem2019/3.2/S13.053

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SOIL EROSION AND FLOOD MITIGATION IN CZ AND UK – COMPARISION, DISCUSSION AND LESSON LEARNED

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ABSTRACT

Both the United Kingdom as well as Czech Republic have seen increased impacts due to flooding in recent years. Rural flooding is due to intense and heavy rainfall-runoff events. Runoff brings with it soil erosion and sediment transport, so called 'muddy floods,' which causes serious onsite and offsite damages in the landscape or even in settlement area and infrastructure. Long-term observation and measurement is crucial step for understanding of complexity of processes involved in the generation of muddy floods and a requirement for and further calibration and validation of predictive models. In addition, such flooding has a significant impact to the agricultural in both countries. There are differences in initial conditions but similarities in consequences, which leads to degradation of sources (soils) and costs in billions EUR each year.

Both countries are investing in research and three complementary projects are highlighted here, as examples. The 'Quantifying the likely magnitude of nature-based flood mitigation effects across large catchments (Q-NFM)' project funded by the UK Natural Environment Research Council is dealing with the question "How much can natural measures reduce flooding at large scales?". The project includes direct measurement of landscape management effect to inform modelling, which can then be used to assess of flood protection and landscape management methods. Mitigation measures may have a synergistic effect and significantly lower the soil erosion and sediment transport, risk of drought or even floods. Modelling of these risks and scenarios of protection has been one of goals of two projects within Czech Rep. First is called Saxon-Czech flood risk management where soil erosion, sediment transport and scenarios of protection on 150km^2 catchment is evaluated. Second is called "Erosion losses - increased risk to the inhabitants and water quality" where large scale risk assessment of flash floods was carried out and 150,000 potential risk points identified over area of 79,000 km^2.

Keywords: soil erosion; sediment transport; flash flood; flood mitigation; landscape management

INTRODUCTION

Intense rainfall-runoff events and subsequent soil erosion are a global problem that disrupts and damages resources in the landscape (degradation of arable land and water resources). Soil erosion and sediment transport by water is one of the main degradation processes on agricultural lands both countries Czech Republic and United Kingdom.

At the same time, these events can cause extensive damage to the infrastructure of municipalities and can even directly endanger the life of their inhabitants [1]. In one third of the OECD (Organisation for Economic Co-operation and Development) member states, more than 20% of the agricultural land is threatened by moderate to intense erosion [2]. The average rate of soil loss by sheet and rill erosion in Europe is 2.46 Mg ha^{-1} yr^{-1} [3]. On the territory of the Czech Republic, 50% of the agricultural land is threatened by erosion [4]. Development of landscape in post-soviet union countries deal with similar problems and consequences like sediment transport from arable land regions [5].

Llasat points out that flash floods are major annual events that occur in unpredictable locations and impact the lives of a significant part of the local population [6]. They disturb everyday life and cause minor damage almost every year. Recently, however, heavy damage has been caused by pluvial flows accompanied by massive sediment transport. The damage to the affected areas is inflicted not only by the flowing water, but also by soil particles [7]. These events have their source mainly in farming (arable) land, but they also occur in forests and in other intensively-used areas.

Due to the dense population in Central Europe, there are frequent interactions between sediment and human infrastructure or water resources, and great damage is done. In the Czech Republic and in the EU there are documents dealing with protection of the population against floods [8]. The protection of agricultural land against erosion is coordinated under Cross-Compliance [9] and CAP [10]. However, the policies do not include protection of the population from erosion and transported sediment especially into urban areas. Specifically, in the Czech Republic and the United Kingdom the owner or the user of the land is not yet held directly responsible for off-site damage caused by surface run-off from his land.

This issue therefore is important to municipalities and state government. An early warning system would be welcomed to reduce risk from floods and excessive sediment transport [11]. Pluvial floods occur over relatively small areas, and are mostly inflicted by torrential rainfall. These events are impossible to predict reliably in real time and in advance. The damages can be mapped and even visible by historical imagery [12]. There is great interest in creating at least maps of potential risks in passive mode.

Soil loss by water erosion on arable land together with following sediment transport and its settling in the water system remains big issue. Various anti-erosion measures can decrease the amount of soil particles transported to the river-network and mitigate the water quality problems connected with sediment load. Process description and quantification are essential tools in soil-protection but computer modelling provides the power to quickly assess various areas and point out the endangered ones.

In the England, the quantifiable soil degradation costs ranged between £0.9 bn and £1.4 bn per year, with a central estimate of £1.2 bn, mainly linked to loss of organic content of soils (47% of total cost), compaction (39%) and erosion (12%). Eighty percent of costs occur off-site and, as such, are often of limited concern to those whose actions may be causing soil degradation. The findings confirm that control of soil degradation has implications for a number of key policy areas such as flood risk management and climate change mitigation [13].

In the Czech Republic, there are no such as studies published yet. Based on reports for Common Agricultural Policy plans, due to the soil loss, there is more than €0.7 bn of financial losses. Almost 75% are costs for sanitation and restoration (and off-site damages) and 25% are loses of most rich top soil. In the same time, due to the soil erosion in the EU, agricultural productivity is endangered. The 12 million hectares of agricultural areas in the EU that suffer from severe erosion are estimated to lose around 0.43% of their crop productivity annually. The annual cost of this loss in agricultural productivity is estimated at around €1.25 billion [14].

RESULTS

Three projects described are dealing with introduced issues. Mitigation measures may have a synergic effect and significantly lower the soil erosion and sediment transport, risk of drought or even floods. Modelling of these risks and scenarios of protection are one of goals of two projects within Czech Rep. Project called “Saxon-Czech flood risk management - STRIMAII” is focused on the lower flood risk in Czech Rep. and Germany. In the Germany, main problems are close to the rivers (Elbe) by high water level and flooding near-river areas, especially in the cities and residential areas. In the Czech Rep., main problem is with soil erosion and sediment transported during the flash flood event in the small basins from the field directly into the settlement areas and close urban zones. Small catchment (171 km^2) was chosen to soil erosion and sediment transport study done by model WaTEM/SEDEM (Fig. 1).

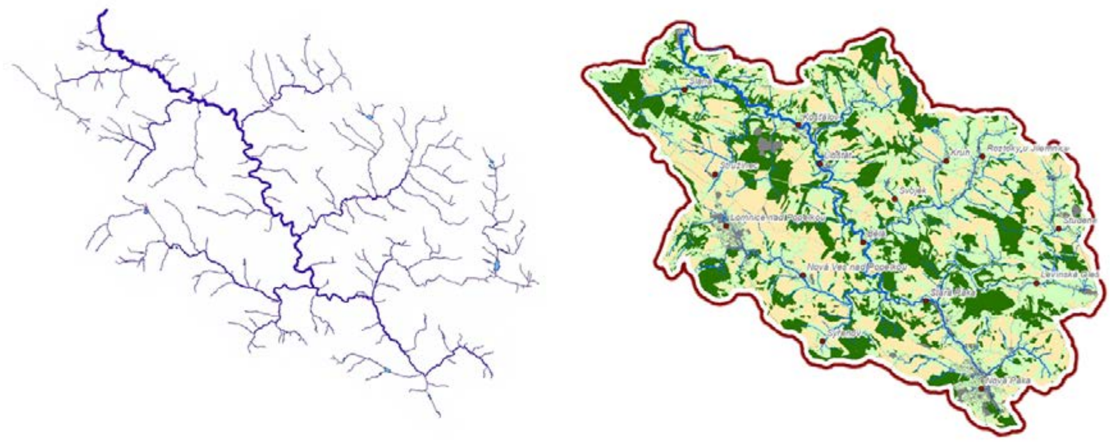

Fig. 1 River net and LandUse for the case study pilot area „Oleška“

As can be seen from the results (Tab. 1), most of the eroded material is deposited before reach the river net. This amount is important for soil degradation, changes the soil structure and soil profile. Only 22% in this study area reach river net which mean soil completely lost and transported out of the basin. There is amount (7%) of the soil loss sedimented in the reservoirs.

Tab. 1 Soil loss and sediment transport case study results

Soil erosion/sediment transport			
Soil erosion	t/year	45 600	100 %
Deposition		35 700	78 %
River net input		9 900	22 %
Reservoir deposition		3 100	7 % (31%)

Future steps in the project progress are implementation of natural base flood measures. This all have synergic effect for the flood protection and drought in the same time and for sure there are very effective in soil loss and sediment transport protection.

The 'Quantifying the likely magnitude of nature-based flood mitigation effects across large catchments (Q-NFM)' project funded by the UK Natural Environment Research Council is dealing with the question "How much can natural measures reduce flooding at large scales?". The project includes direct measurement of landscape management effect to inform modelling, which can then be used to assess of flood protection and landscape management methods.

The core task of the whole Q-NFM project is: What are the flood mitigation benefits of NFM from feature-scales to large catchment scales in Cumbria? Here is the combination of the acceptable models of observed river discharge records with shifts in the model parameters based on our NFM evidence base, and with a range of spatially-distributed NFM scenarios set previously (Fig. 2).

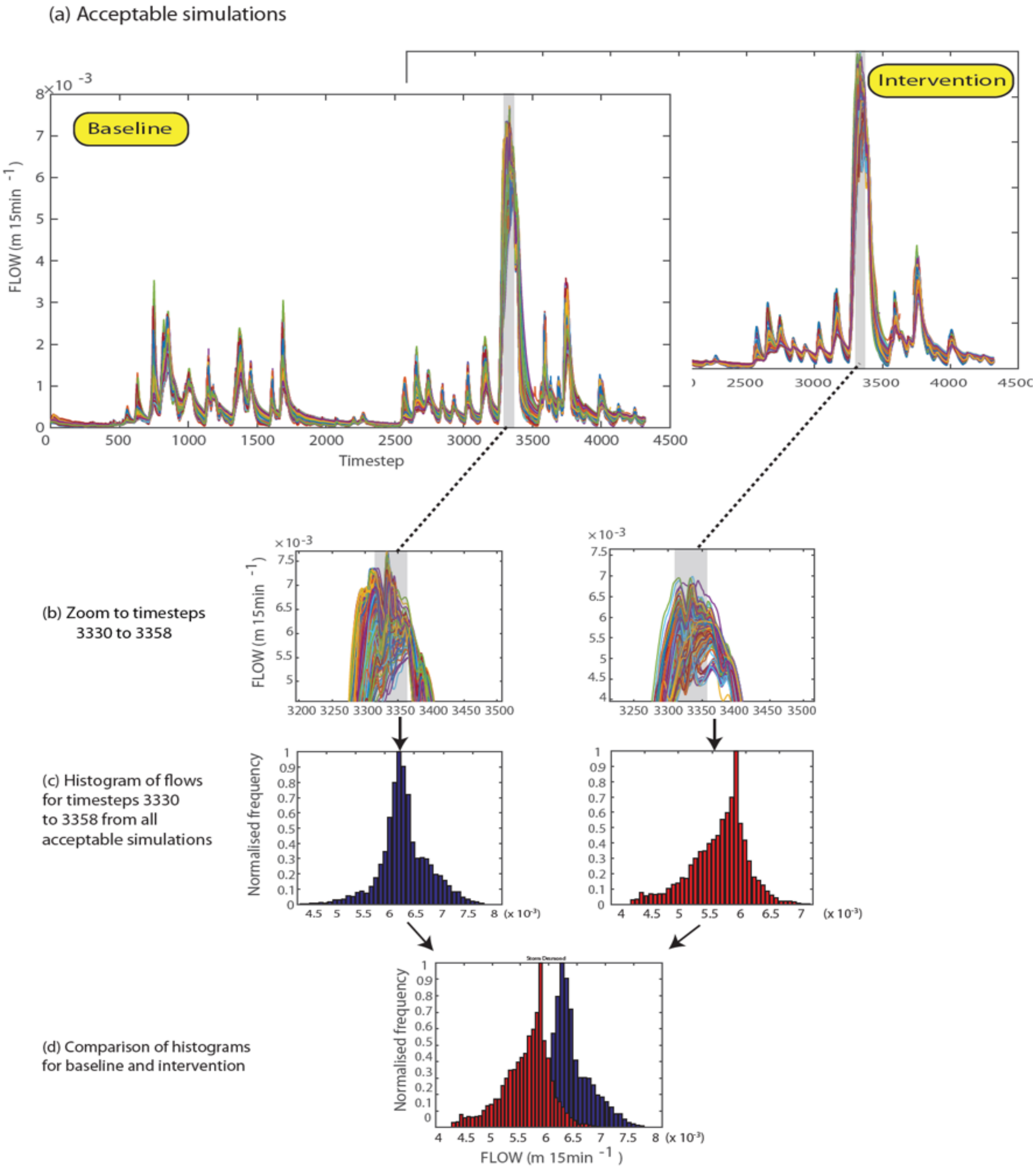

Fig. 2 Q-NFM simulation methods

In the third project, totally more than 150,000 risk points were identified by GIS morphology and land-use analysis. The threat, the vulnerability, and the resulting risk category were determined for each of these points. The WaTEM/SEDEM model was used to assess the threat with 10 m data resolution. The summarized vulnerability of real objects on individual runoff trajectories was combined with the threat of sediment transport, resulting in the overall risk represented by a 5-degree scale, from lowest (1) to highest (5). The output of the project lies stored in the WEB application. 19% of the sites in the Czech Republic, i.e. more than 23,000 sites, have been assigned to categories 4 and 5, with a high level of risk. 34 % of cadastral units are classified as the high risky (4,416 cadasters, with a total area 24,707 km^2).

Tab. 2 Representation of risk categories for the territory of the Czech Republic

	Low risk	Slight risk	Moderate risk	High risk	Extreme risk	TOTAL
total number of points in the cat.	54,706	27,914	21,456	14,908	8,500	127,484
%	43%	22%	17%	12%	7%	

Approximately 30% of the population of the Czech Republic live in high-risk cadastral areas. Four scenarios of protection were modeled. To reduce the high-risk and very high risk sites (category 4 and 5), the most effective solution is the implementation of technical measures or conversion to grassland within the contributing watersheds. This could reduce the number of high-risk sites from 23,400 to 3,700 [15]. Methods of sediment transport modelling and risk evaluation, based on presented USLE input data and documented WaTEM/SEDEM model, can be used worldwide.

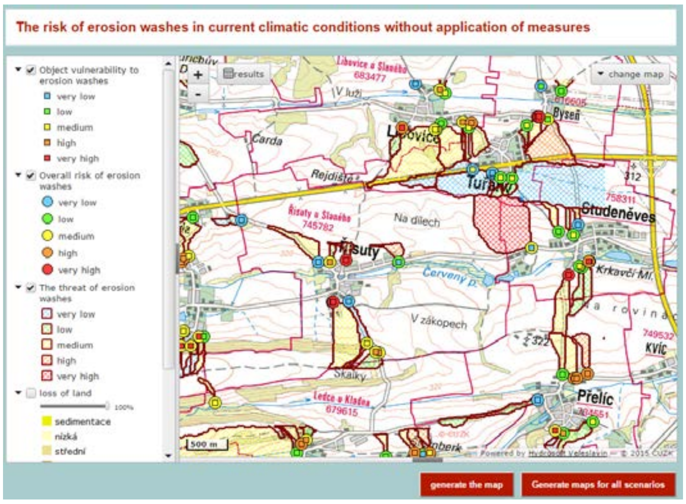

Fig. 3 Geoportal interface with an overall presentation of risk points

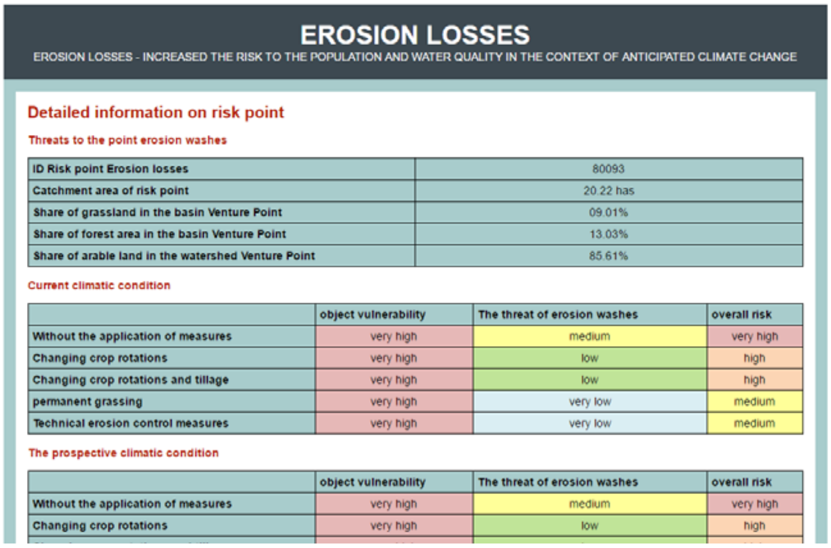

Fig. 4 Detailed information about a selected risk point

In the context of making the data available to the general public and to territorial self-government, the data have been presented in relevant magazines, workshops and especially in the form of a freely available GIS application on a geoportal https://heis.vuv.cz/data/webmap/datovesady/projekty/eroznismyv/www/index.php. In this application (Fig. 3), it is possible to select any territory in the Czech Republic, to locate trouble spots and to model simple variants for implementing protective measures and assessing their effectiveness for each site.

The result is targeted at individual municipalities, landowners and landusers, the administrator of the territory, the administrator of watercourses, farmers, state administration, and self-government and details of each risk point can be displayed and investigated one by one from the initial risk and potential future risk as well as effectivity of sugested and recomended measures (Fig. 4).

CONCLUSION

As it was describe and documented in three projects, in EU context, presented in UK and CZ case studies, soil loss, sediment transport are serious problem in the EU. It is one of the major challenges for future generation – to deal with climate change and related issues concerning extremity of lack of water on one hand and flooding and flash floods (to much of water) on the other hand.

Complex of natural base landscape system of measures can help to solve climatic changes we are dealing with and help to adapt by infiltration waters, protecting of the soils as well as lower sediment transport and nutrients to the river systems and reservoirs.

The risk for inhabitants and its sources can be lowered significantly by proper land management, quality observation and support models for early warning, adaptation and decision-making.

ACKNOWLEDGEMENTS

This paper has been supported by projects SGS17/173/OHK1/3T/11, NERC NE/R004722/1 and STRIMAII – 100282105.

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