FACTSHEET RISK ASSESSMENT AND MAPPING ACTIVITIES

High-resolution excess water hazard and risk mapping of agricultural areas

Where was it implemented?

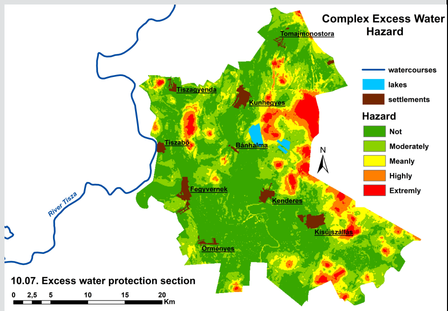
Hungary, Jász-Nagykun-Szolnok, Kunhegyes

10.07. Excess water protection section

Problem/background

The average annual precipitation may show extremely high territorial and temporal variability in Hungary because of three climatic effects (continental, oceanic, mediterranean). Under such conditions a considerable part of precipitation is lost by surface runoff, downward filtration and evaporation, but principally in the flat-land regions the excess waters cause several problems and damages mainly in the agricultural areas having basin-bottom character of Carpathian basin. The excess water is a form of temporary water inundation that occurs on flat lands due to extreme precipitation, sudden melting of snow, and high groundwater level, which can emerge on the surface (so called under flooding or water uprush). Damage caused by excess waters can be occurred about 1.8 million hectares, from which 60% is located in the arable-land in Hungary.

Map example:



Description of methodological background and outcomes

For modelling the complex relationship, we collected suitable and available spatial information on the predictor variables, which properly represent the influencing factors. Topography (relief) has a primary influence on runoff conditions. The position and type of the geomorphologic features determine the potential location of inland excess water occurrence. The topography was characterized by a high-resolution digital elevation model. In this case, we used the relevant part of the HYDRODEM provided by the General Directorate of Water Management. HYDRODEM is a countrywide digital elevation model (DEM) with 50 m spatial resolution and corrected for hydrological errors. The geomorphologic features were taken into consideration based on numerous derivatives calculated from the HYDRODEM by System for Automated Geoscientific Analyses (SAGA) GIS tools. The hydrometeorological conditions were described by long-term averages of yearly mean temperature, precipitation, evapotranspiration, aridity index, and a humidity index (HUMI). HUMI is used for the characterization of water stress periods; it was calculated by a 10% possibility of occurrence of root square of sum of monthly weighted precipitation and sum of monthly weighted potential evapotranspiration ratio. The geological conditions can affect the occurrence of inland excess water in two aspects. (a) The permeability of the surface and near surface horizons determines the speed of infiltration of the precipitation. The closer the uppermost aquitard is, the more the permeability of the near surface layers prevails. Additionally, the thickness of the uppermost aquitard also has an effect on the permeability. (b) The hydrostatic level of groundwater below surface has impact on the back-damming of infiltrating precipitation. The hydrogeology of the GHP was spatially represented and was taken into consideration by (a) the depth and the thickness of the uppermost aquitard, which data was provided by Geological and Geophysical Institute of Hungary, and (b) the standard depth of groundwater calculated on the average 10 highest values within the last 50 years. This groundwater parameter came from well observations provided by General Directorate of Water Management. The interpolation of the well data was carried out, taking into account major natural influencing factors of groundwater level. The applied method was co-kriging with the use of DEM, precipitation and evaporation data, soil texture, land cover (characterized by NDVI), and distance from surface water bodies. Soil properties also play a major role in the occurrence of inland excess water. The permeability and storage capacity of the soils are determined by soil texture, compaction, organic matter content, and soil depth. The effect of soil on the occurrence of inland excess water was modelled and spatially represented by the physical soil property layer of the Digital Kreybig Soil Information System (DKSIS, MTA ATK TAKI). Its categories were elaborated according to water retention capability, permeability, and infiltration rate. Land use also affects the formation and occurrence of inland excess water. The permeability of the total surface has a strong connection to land cover and land use, it has a

high impact on the infiltration/runoff ratio. Land use also provides some kind of information on anthropogenic driving forces of inland excess water inundations. The effect of land use was characterized and spatially represented by a numeric coefficient based on the National CORINE Land Cover 1:50,000 database (CLC50). The CLC50 categories were parameterized with expert-based land use indices characterizing their role in the formation of inland excess water. According to our method, the lower the values of land use factor (i.e., artificial areas 0.6–1.0; arable lands 0.3–1.0; permanent crops 2.5; pastures 0.6; forest and natural vegetation 1.0–5.0; wetlands 0.1; etc.), the more significant their role in IEW development is. In the present case, we have built up the regression kriging model as follows. The target variable of the modelling was the inland excess water inundation frequency. The multiple regression analysis was carried out on the generated inundation frequency point data (as dependent variables) and the influencing factors (soil, agro-geology, relief, groundwater, land use, and hydrometeorology) of inland excess water (as independent variables). A 5% significance level was applied. The explanatory variables used by the multiple regression, were selected by a stepwise method. Regression residuals were calculated from the resulted models and the original data set, which were subjected to exploratory analysis. Semivariogram models were fitted to the calculated empirical semivariograms by a semi-automated method provided by SAGA GIS environment. The vectors of the kriging weights assigned to the original point data set were determined by the semivariogram models. An interpolation was carried out to spatially extend the local residuals made by ordinary kriging. The final result of inland excess water inundation was derived by the integration of the regression model and the kriged residuals. Besides the predicted map, its spatial reliability was also obtained in the form of kriging variance map. By the validation of the map results, the overall accuracy of the prediction was checked by the validator data set. The predicted inland excess water inundation frequency and reference values were compared in 5,000 points. The following error parameters were calculated: mean error, mean absolute error, root mean square error (RMSE), and root mean normalized square error. The best performing model was selected based on the smallest RMSE value.	
Area and event characterisation	
Area type Rural	**Topography** Lowland
Land cover/land use distribution Mainly arable land with plough, agricultural and meadow territories	**Event** Not event-based
Receptors Agricultural land, damage potential to crops	**Flood type** Pluvial flood (inland excess water)
Specifications of method/measure and data demands and outputs	
Level of complexity	2
Adressed SPRC element	Source, pathway, receptor, consequence
Method group	Empirical/geostatistical approach
Spatial scale(s) of application	Regional, national
Time scale/resolution	No timely dynamics/long term averages
Input datasets (type and scale/resolution)	Weather station data: monthly average (sum of monthly weighted precipitation and sum of monthly weighted potential evapotranspiration ratio) Digital Elevation Model: Raster, 50 m Soil data: Vector, 1:25,000 Geological factor: Vector, 1: 100,000 Groundwater: Raster, 50 m Land use: Vector, 1:50,000
Output datasets (type and scale/resolution)	High-resolution excess water hazard and risk mapping of agricultural areas

<table>
<tr><th colspan="3">Description of implementation</th></tr>
<tr><td>Implementation
• 10/2018 to 5/2019</td><td colspan="2">Users (reported/designated)
• Farmers</td></tr>
<tr><td>Initiator/responsible
• Csaba Bozán, Harsányi Gábor</td><td colspan="2">Involved stakeholders
• -</td></tr>
<tr><th colspan="3">Lessons-learned</th></tr>
<tr><td>Main success factor:
• The quality of data has the greatest influence on the results.</td><td colspan="2">Main challenge:
• A very important factor in pluvial flood is the farming methods. The appropriate farming methods can decrease the pond effects after heavy rain on flat lands. The main challenge how can we build the farming methods in the model.</td></tr>
<tr><td>Synergies/beneficial aspects:
• Raising awareness for farmers.
• We can harmonize the flood issue with the drought issue. We can identify which territory worth implementation the water retention.</td><td colspan="2">Conflicts/Constraints:
• Harmonizing the flood issue with the drought issue.</td></tr>
<tr><th colspan="2">Key message to others starting with a similar task</th><th>Contact</th></tr>
<tr><td colspan="2">“The quality of data has the greatest influence on the results.”</td><td>Middle Tisza District Water Directorate (KÖTIVIZIG)
Csaba Bozán, Harsányi Gábor
harsanyi.gabor@kotivizig.hu</td></tr>
<tr><th colspan="3">References</th></tr>
<tr><td colspan="3">Integrated spatial assessment of inland excess water hazard on the area of the Middle Tisza District Water Directorate (KÖTIVIZIG) - Nemzeti Agrárkutatási és Innovációs Központ</td></tr>
</table>