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The flood risk assessment in cities as an element of a flood risk management: A Case study of Krakow, Poland

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INTRODUCTION

Urbanization comes with a variety of environmental problems for both the local and downstream ecosystems. The loss in permeable surfaces reduces the infiltration into soil; the introduction of artificial drainage alters or replaces natural pathways. Soil sealing-related impervious surfaces inflict the risks of augmented runoff and lower infiltration rate. Transformation of natural, semi-natural and peri-urban ecosystems to artificial impervious surfaces, can bring about a number of adverse consequences (Lepeška et al. 2020). The riverside towns are particularly at risk due to surface water flooding as well as riverine flooding – fig 1. One of the main problems that influences flood risk in the Krakow is urbanisation – fig. 2
The aim of the work was to assess the risk of flood in urban area on the example of Krakow. Krakow is a city located in the highland climate region of Poland and has high impervious cover. The analysis was performed for watersheds that are main tributaries to the Vistula river – fig. 1.

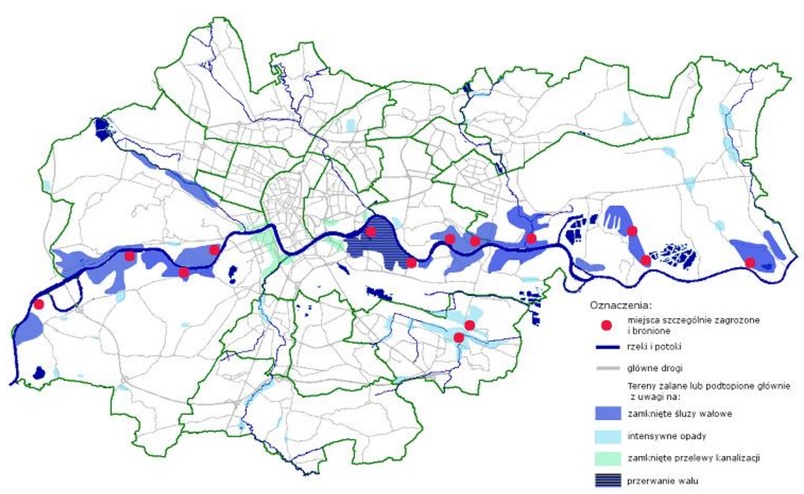

Fig 1. Flood in Krakow – May 2010

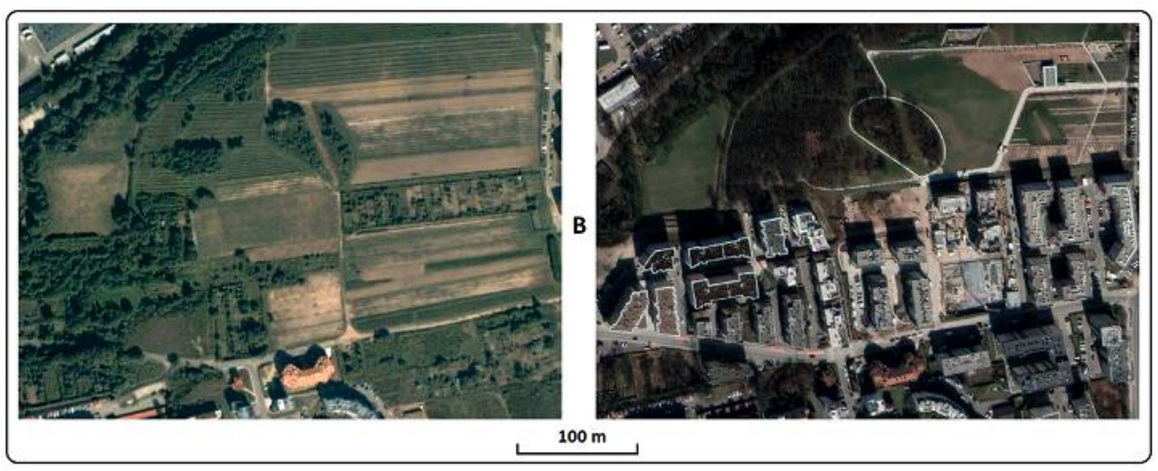

Fig. 2. Example of land cover changes between 1990 and 2018– the Prądnik river (Wojkowski et al. 2022)

MATERIAL AND METHODS

Flood risk assessment was carried out for 100 yr annual maximum flow. Because almost all of analyzed watersheds are ungauged, the peak discharges and flood hydrograph were calculated based on rainfall-runoff model based on Nash cascade of linear reservoirs, according to the guidelines recommended by Association of Polish Hydrologists (Banasik et al. 2017). To determine the flood areas and wave movement, a one-dimensional model was used, based on the Saint-Venant equations. The calculations were performed with the use of MIKE11 program – fig. 3.

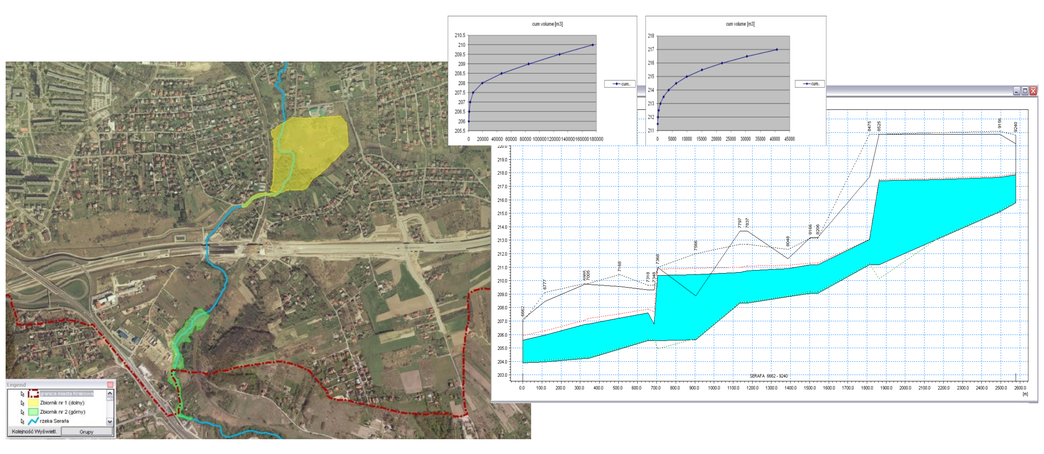

Fig. 3. Example of the detention reservoirs included in hydraulic model

RESULTS and CONCLUSIONS

The analyses showed that in the Krakow agglomeration, there are 45 areas where flood hazard is identified, of which 39 are located on the tributaries of the Vistula and 6 - within the range of the direct influence of the Vistula River. The main problems of flood risk are linked to the following causes: 1) backwater effect occurs in the tributaries to the Vistula – fig. 4, 2) The limited capacity of the rivers – fig. 5. 3) obstruction of culverts or bridges, which influences the capacity of the rivers – fig. 6. One of of the ways to flood risk reduction is rising of water storage in cacthments – fig. 7.

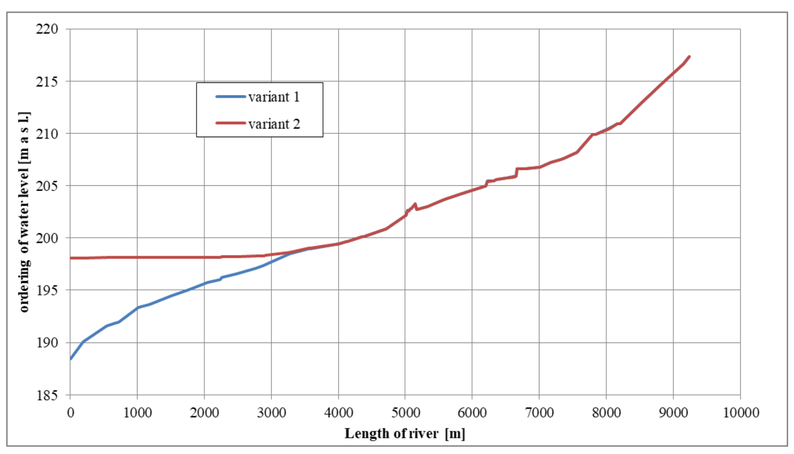

Fig. 4. The running of water table's ordiantes for the 100 yr flow on the Serafa river in the conditions of a free water flow into the Vistula river (variant 1) and in the conditions of dyke lock closed (variant 2)

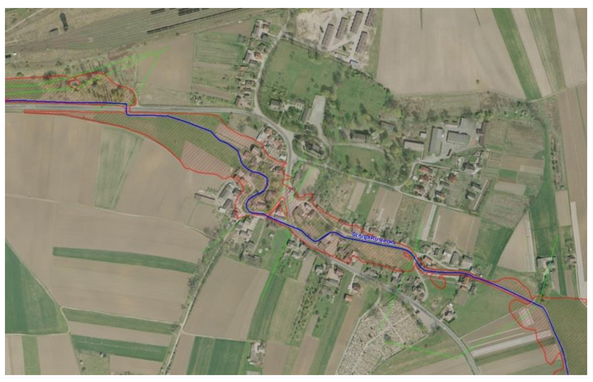

Fig. 5. The flood area in the Struga Rusiecka stream as a result of too small bed capacity

Fig. 6. The flood area in the Drwinka river as a result of a culvert obstruction

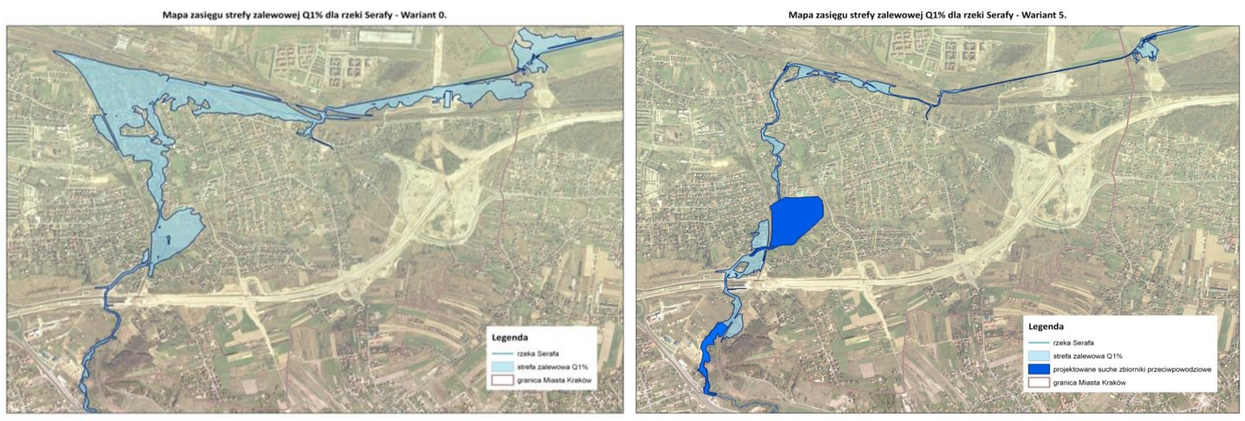

Fig. 7. Effect of water retention of flood mitigation – example of Serafa river

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