

The problem of mass movements in Polish cities – the example of Kraków city

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Kraków is located in the area of four tectonic units (**Fig. 1**): the Outer Carpathians on the south, the Carpathian Foredeep covering most of the city area, the Śląsko-Krakowska Monocline in the western and northwestern parts and a fragment of the Miechów Trough in the northern part. This causes the diversification of the topography and directly determines the occurrence and types of landslides.

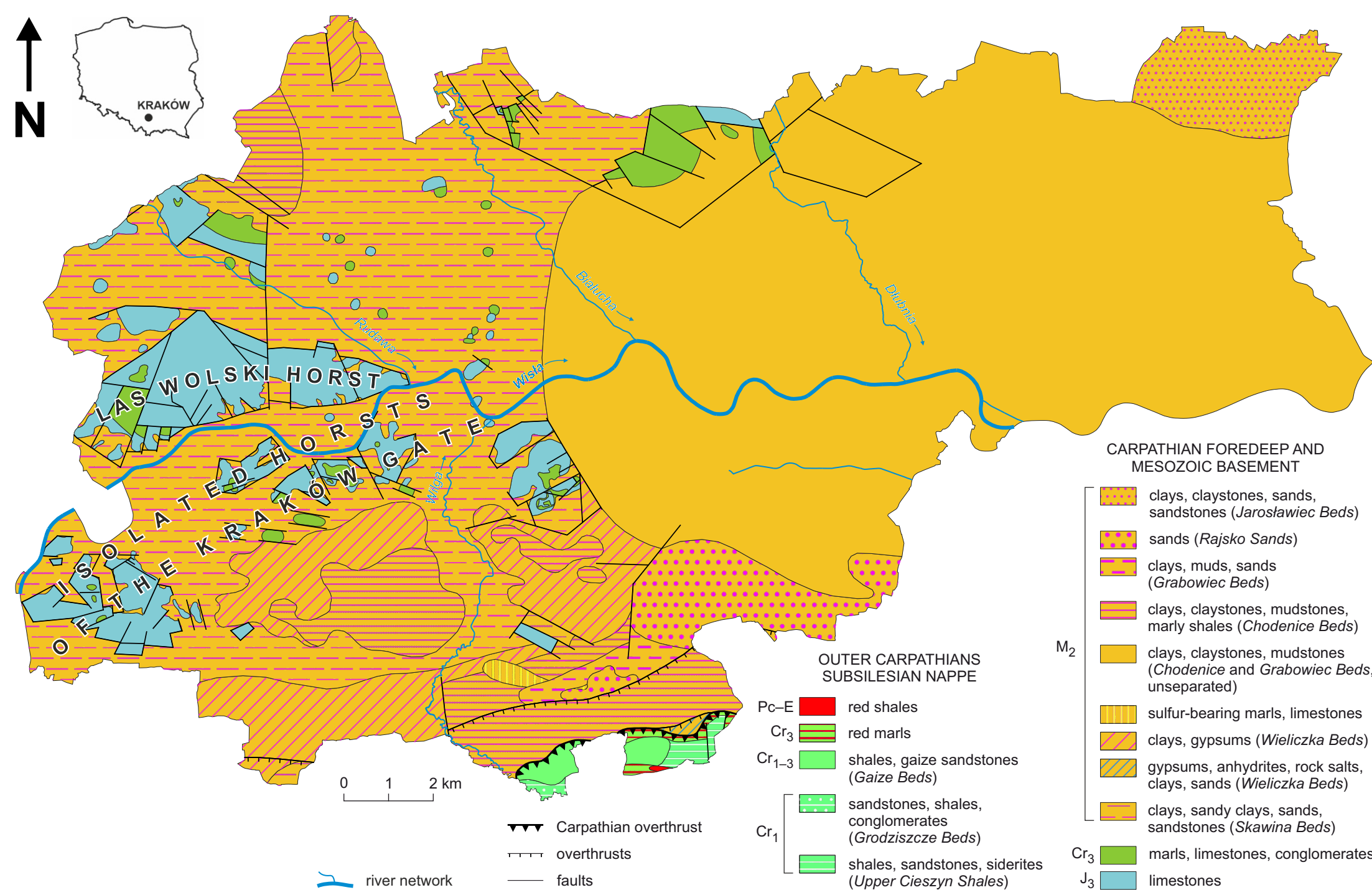


Fig. 1. Geological sketch of Kraków without Quaternary deposits

(Kmiotowicz-Drathowa, 1966; Rutkowski, 1993; Paul et al., 1996; Wójcik, 2007; Burtan, Wójcik, 2017; Wójcik, Lewandowski, 2021; Kamieniarz, 2021)

As part of the Landslide Counteracting System (polish acronym SOPO), 369 landslides were registered in Kraków (**Fig. 2**). There are over 600 buildings and 23.5 km of roads within their areas. Several landslides, where important buildings or infrastructure are located are monitored by a surface and subsurface monitoring systems (**Fig. 3**).

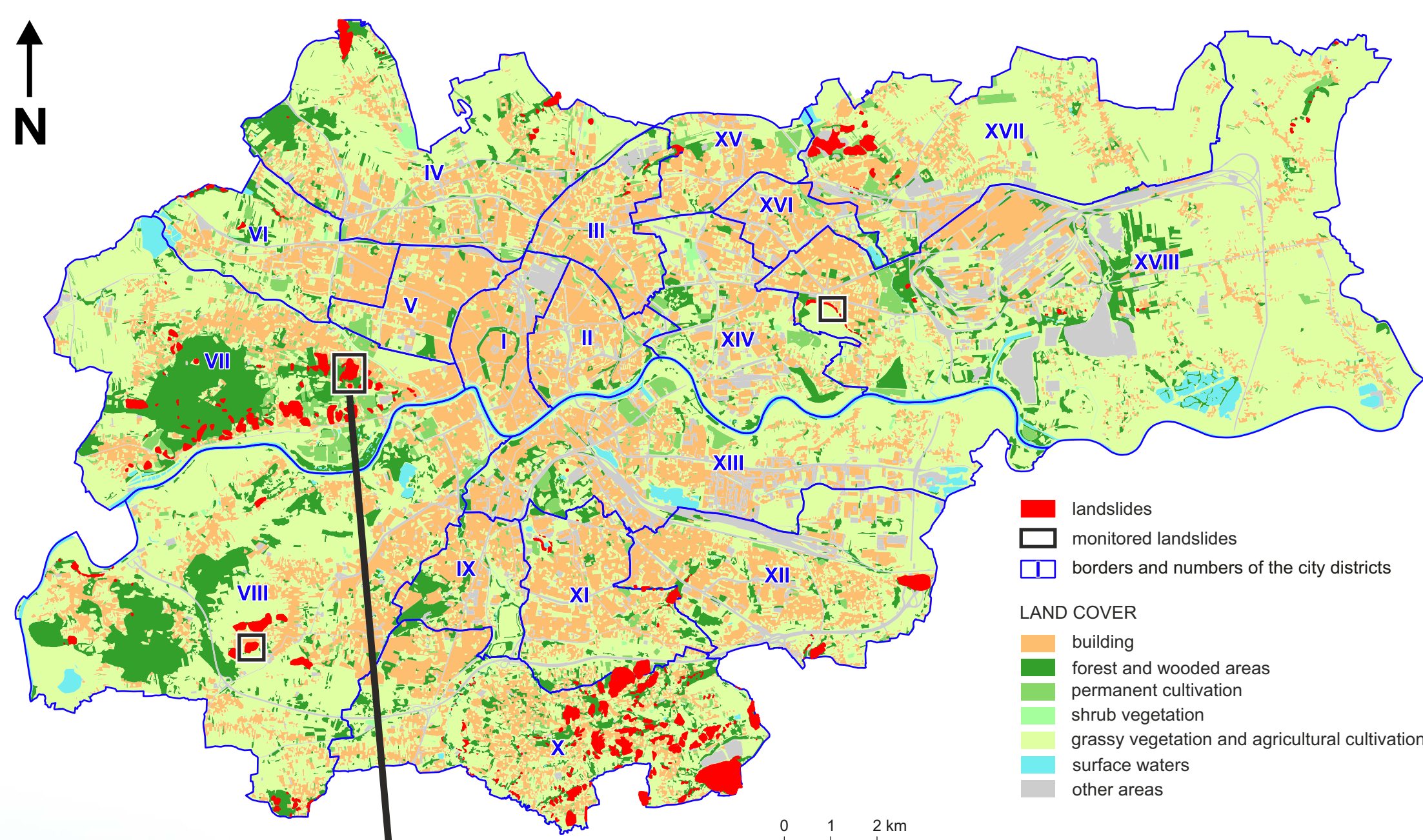


Fig. 2. Distribution of landslides in Kraków

(Kamieniarz et al., 2018; Kamieniarz, 2021)

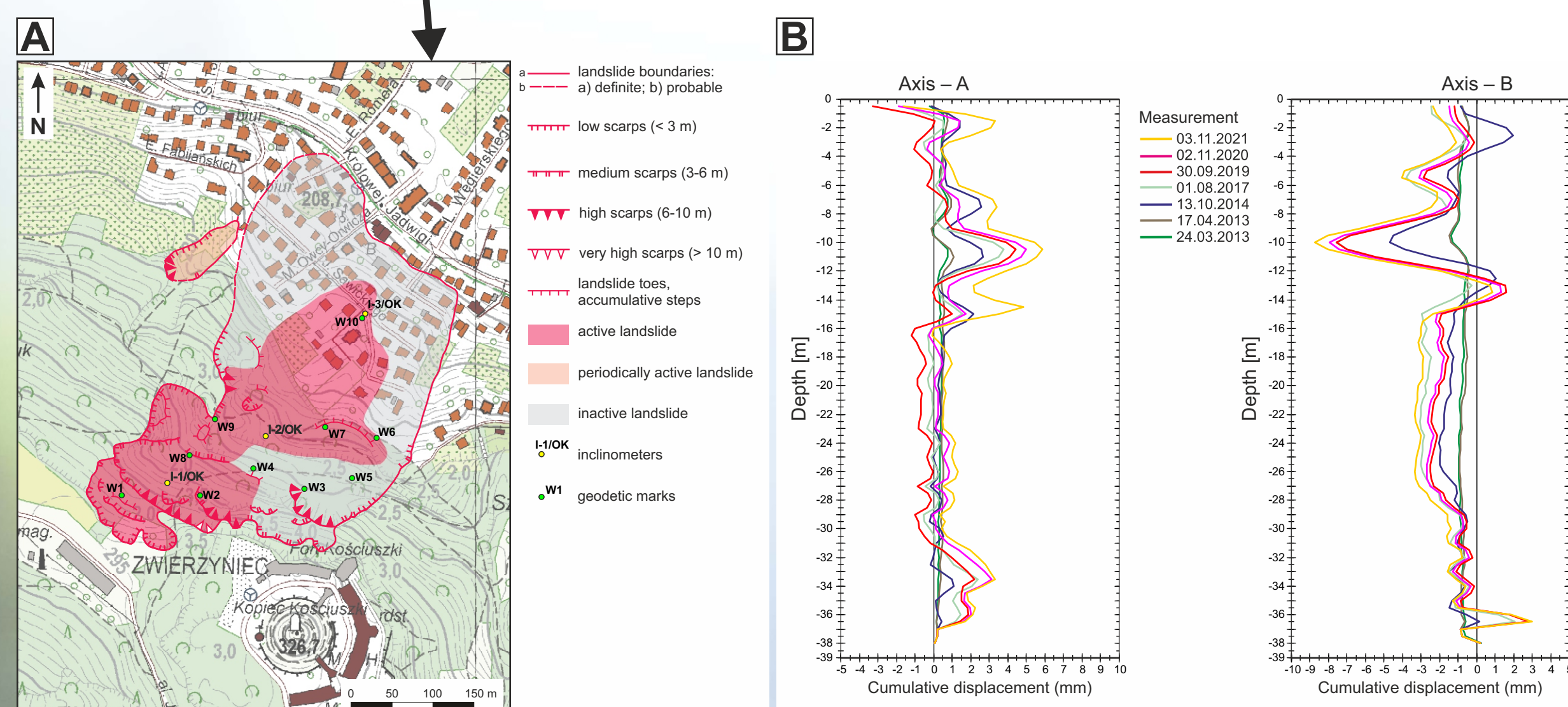


Fig. 3. Landslide on the St. Bronisława Hill: A – monitoring system arrangement; B – cumulated ground displacements in the I-3/OK inclinometer

(Kamieniarz, Kos, 2020; Forýš et al., 2021)

Due to the intensive development of the city, simple landslide identification and the heuristic risk assessment are insufficient. Due to planning of new investments there are more and more questions about the implementation of recommendations and restrictions for landslide areas and their legitimacy raised from the side of local government administration. In order to answer these questions the landslide susceptibility and hazard maps were developed by the PGI – NIR. The landslide susceptibility map presents the possibility of a landslide occurrence in a given place due to the specific environmental conditions (**Fig. 4**). The hazard map shows the probability of a landslide occurrence within a specified period of time and a given place (**Fig. 5**). These maps were developed using artificial neural networks and geostatistical methods.

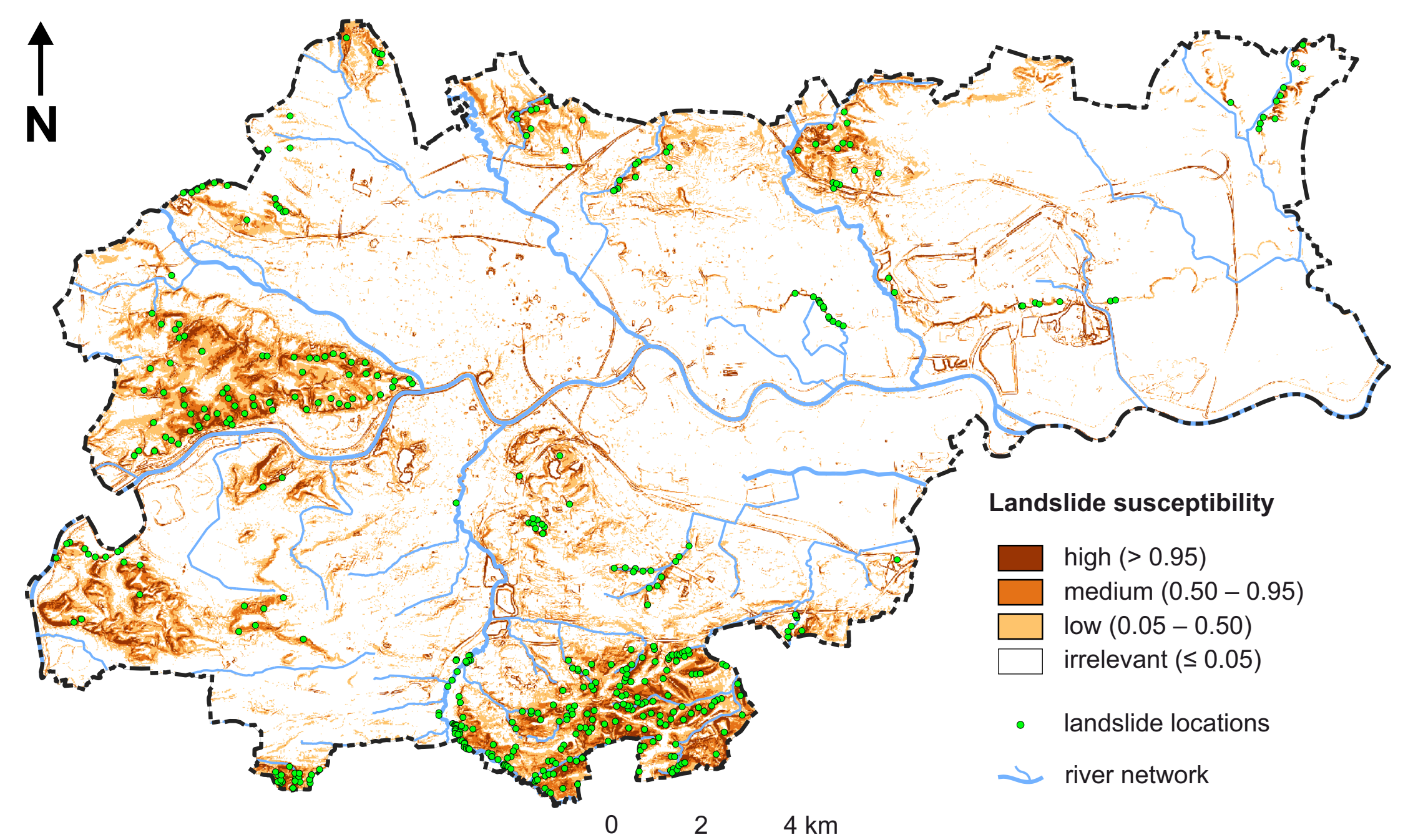


Fig. 4. Landslide susceptibility map of Kraków

(Kamieniarz, 2021)

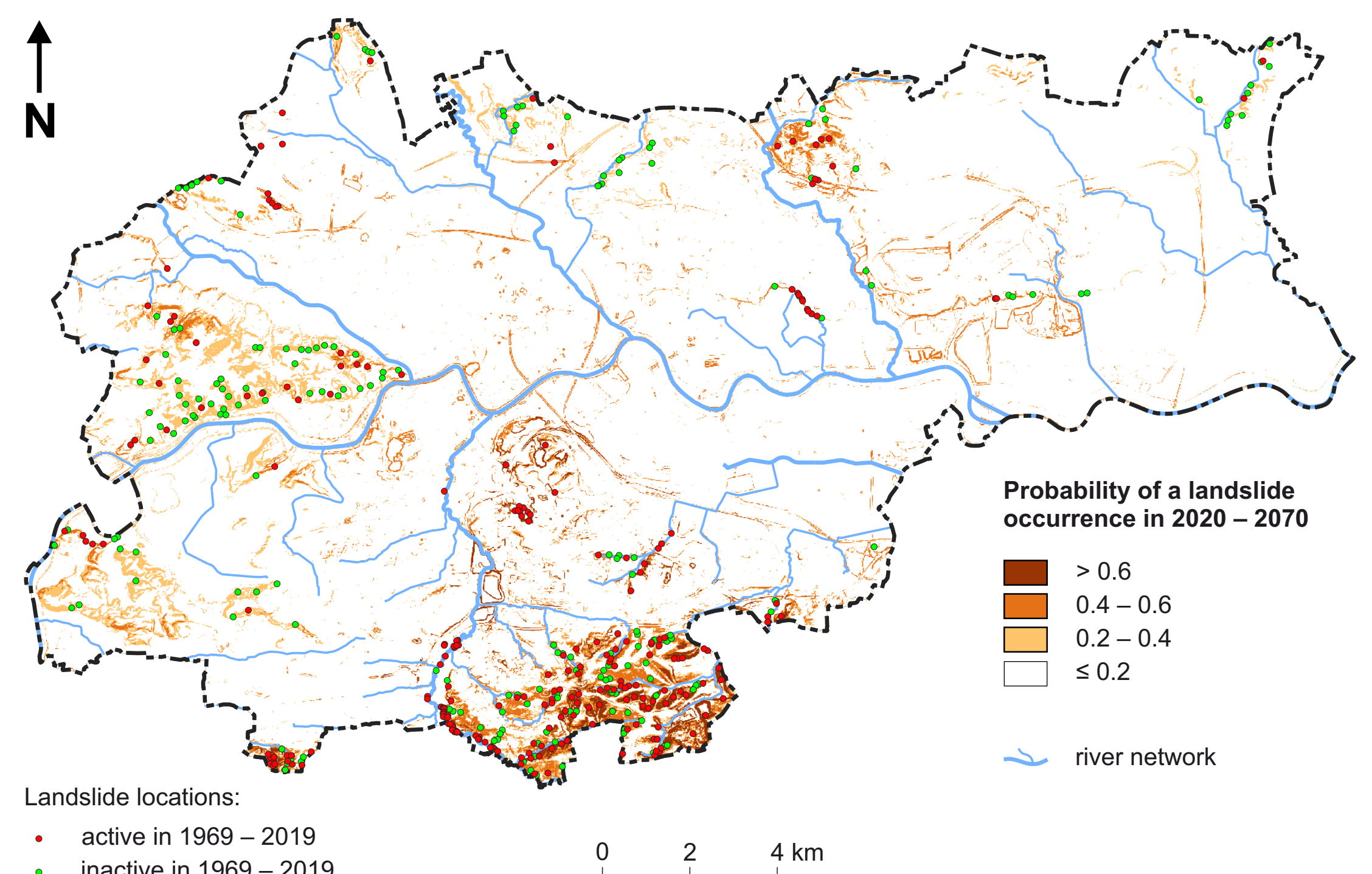


Fig. 5. Landslide hazard map of Kraków

(Kamieniarz, 2021)

Both maps can be successfully used in urban planning when selecting corridors for infrastructure (e.g. road, rail, technical networks), determining general directions of urban development and defining recommendations related to the foundation of new buildings.