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Economic assessment of landslide risk for the Waidhofen a.d. Ybbs region, Alpine Foreland, Lower Austria

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INTRODUCTION

This research aims to assess potential risk and estimate economic damage caused by landslides. The study area is located in the Ybbs valley, Lower Austria (Fig.1). Methodology consists of Arc GIS based spatial analysis and estimation of the potential monetary losses caused by landslides. Spatial analysis was used for defining elements at risk located in the risk zone of 100 m near landslides, and assessment of potential consequences. Results: calculated possible losses caused by the destruction of immobility and transport: costs for buildings demolition, restoration, roads rebuilding, debris transport, excavation and removal.

RESEARCH AREA

- The region of Ybbs valley (Fig.2) is located in mountainous Alpine Foreland, Austria. It covers a total area of 131.3 km².
- The environmental conditions of the the Ybbs valley are especially prone to landslides:
- Geology: deposits of gravel, sand, marl, conglomerate, calcareous sandstone and clay.
- Most of the region is used as pasture, agricultural land, and large forests.
- Climatic humid to continental. Intensive rainfalls in spring and autumn months.
- The region is attractive for tourists due to its environmental and historical value.

DATA

- Source: the data used in this research were generously provided by the Provincial Government of Lower Austria.
- Content: data include vector thematic layers covering the area, aerial imagery, topographic vector layers and maps.
- Organization: data have been organized in a ArcCatalog database and sorted according to their types (Tab.1).
- Compatibility: all data have been stored in the ArcGIS project in Austrian National grid Austria Bundesmeldenetz (BMN) M34.

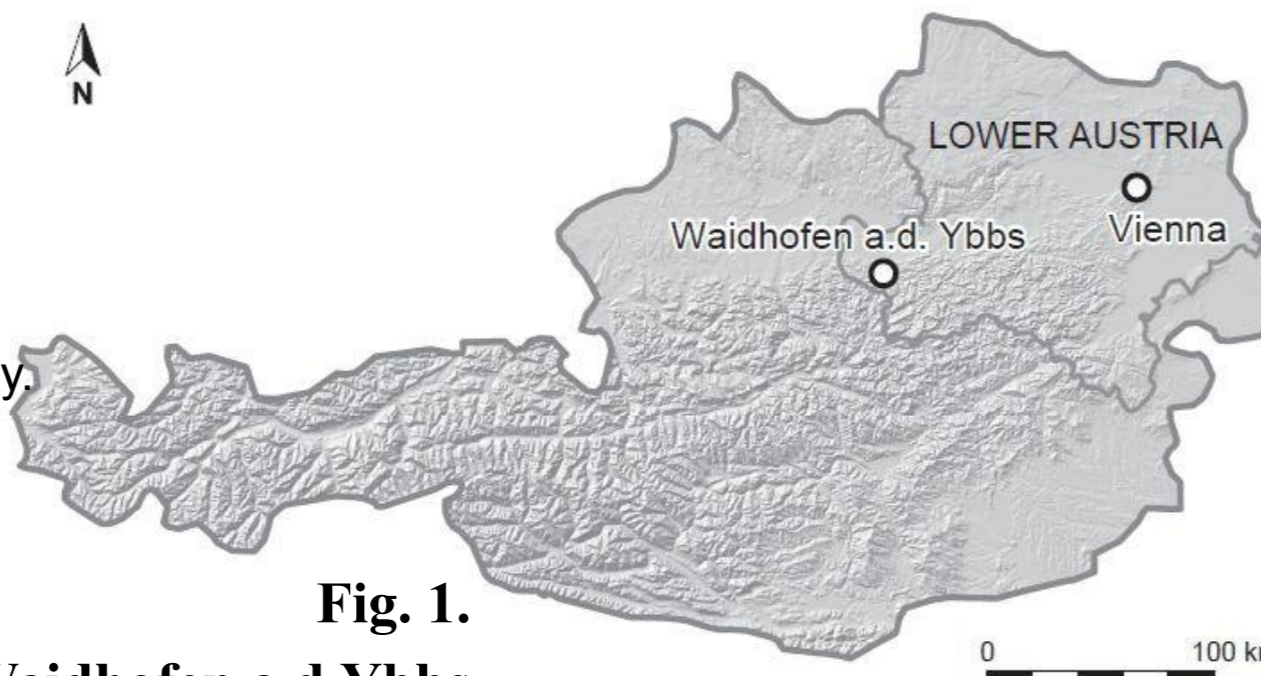


Fig. 1.

Geographic location of Waidhofen a.d.Ybbs.



Fig. 2. Surroundings of the Ybbs valley. Photo: H. Petschko

METHODS

The geographic location of landslides within the Ybbs valley was defined by H.Petschko. We used these results (Fig.3) for defining risk zones. 1) Risk zone: 100-meter buffer area surrounding all landslides downwards, as a landslide with volume of 1 km³ may reach 100 meters while moving. 2) Elements at risk: The objects located in the 100 meter distance downwards the landslides are regarded as elements at risk. 3) Estimation of the economic losses: The methodology is proposed by Giacometti (2005) was applied for Ybbs valley using real estate prices for common goods (immobility, roads). Calculations of the economic losses (in €) was done based on the average real estate prices for various aspects of renovation, reconstruction and rebuilding of the destroyed objects.

RESULTS

Defining elements at risk
The elements at risk were selected in 100-meter buffer area near the landslides (Fig. 4). The length and number of the elements at risk within the distance of 100 m near landslides totals to **20.9 km of railway lines, 13.5 km of roads and 641 buildings.**

Calculation the economic losses
The calculation of the real estate losses is computed from the calculation of five different types of costs (Tab. 3): 1) demolition, 2) transport and disposal debris, 3) restoration of inner walls, 4) furniture restoration and 5) house construction. The average volume to demolish damaged buildings indicated the dimensions of the losses of ca. **13.65 M €.**

The estimated price for the debris removal is approx. **3.6 M €**, in case buildings are totally affected and covered. The restoration of the inner walls is based on average prices for building restoration and approximate surface of the walls, which totally estimates **2.73 M €.** Using approximate prices of the furniture costs (Giacometti, 2005) in a typical house the costs for furniture renovation is **€ 190,500.** Cost for house construction is computed using real estate prices and average house area in m² which sums up to **€ 349,250.** The losses for transport (Tab. 2) include costs to rebuild a road, a railway, and a restoration of the roads. A total of almost **140 M €** would have to be invested for the renovation of the Ybbs valley in case of a landslides disaster (Tab.3).

Tab. 1. Data Structure

Type of factors	Thematic layers
Anthropogenic	Roads (railway, highways)
	Areas of demolishing & dismantling
	Areas of construction work
	Settlements
Topographic	Orthophotos
	DEM (1m and 3m resolution), DTM
	Vector relief map
Environmental	Watershed areas
	Water catchment areas
	Landscape protected zones
	Areas of NATURA-2000
	Geological vector map
	Natural protected zones; forests; parks.

Tab. 2. Estimation of possible monetary losses for transport.

Type of investment	Construction cost	Length (m)	Total losses (€)
Railway tracks, (€/m) restoration (*)	4,200	20,953	A = 88,005,204
Road rebuilding, €/m (**)	4,131		
Debris excavation (a)	17	13,541 (length in Ybbs valley)	B = 55,948,749
Debris removal (b)	25		
Transportation & storage (c)	26		
Roads restoration, (a)+(b)+(c), €/m ² (***)	68.0		C = 927,590
Total possible direct damages (A+B+C) =			144,881,544

(*) Source: Zischg et al., 2005 (**) Source: Giacometti, 2005. (***) Source: Sterlacchini et al., 2007

Tab. 3. Real estate destruction losses, Ybbs valley, as for average market value (Source: Giacometti, 2005).

Types of investment	Construction cost, €/year, one house	Total costs, all houses (*)
Demolition cost (concrete masonry), €/m³ (a)	87	-
Average volume to demolish, m ³ (b)	189,32	-
Mechanical excavation costs, €/m ³ (c)	25.5	-
Total (€) to demolish walls, concrete masonry = (a*b)+(c*b)	21,298	13,652,338
Transport and disposal debris, €/m² (**)	26	3,608,462
Inner walls restoration costs (€/m²)	7	-
Average surface of inner walls (m ²)	607	-
Average charge to restore inner walls (€)	4,252	2,725,852
Average price to restore furniture, €/m² (x)	600	-
Average house base area, m ² , (y)	317	-
Total average charge (€) to restore furniture (x*y)	190,500	122,110,500
Average house base area, m ² , (y)	317	-
Average cost to build a house (€/m³)	1,100	-
Total average charge to build a house, €	349,250	223,869,250
Total complete average charge (demolition + restoration), €	216,051	138,488,691

(*) Number of houses at risk in Ybbs valley = 641

(**) Total area of buildings at risk, m² = 138

CONCLUSION

The research focuses on the monetary estimation of the possible losses caused by landslides. Estimation of the economic damages is performed using existing simplified methodologies. Calculations were based on real estate and market price of the elements at risk. While assessing potential damage of landslides confusion arises due to these factors. 1. First, the temporal probability of the landslides occurrence is highly difficult to assess: it can only be estimated based on the reliable and obtainable data. This includes historical data continuously reporting the occurrence of the landslides. 2. Secondly, difficulties arise by estimation of the indirect losses and partially damaged objects. The amount of the damages can be assessed based on elements vulnerability, which is very uncertain to estimate exactly. Thus, the vulnerability may differ depending on object location, individual characteristics and external factors. 3. The term "landslide" is not differentiated between debris flows and shallow or rotational landslides. This is an important source for uncertainty, as movement characteristics of these landslides are different. 4. Confusing over different method approaches in the risk assessment may generate various results: difference in magnitude and occurrence of landslides, risk perception and vulnerability assessment. The estimation of landslide risk should be based on complex investigations. The data about landslide probability should be gained from monitoring programmes. The elements at risk are defined based on spatial analysis and infrastructure inventory. The vulnerability estimation should include census data and social questionnaire. The real-life situations may vary depending on the exact price of the individual object.

PERSPECTIVES AND RECOMMENDATIONS

In view of the uncertainties in risk assessment, flexible combination of research approaches is desirable: landslide hazard modeling and application of various methodologies to study area. Buffer zones have to be validated and empirically tested during fieldworks. Data from cadastral and statistical information sources could enable vulnerability assessment.

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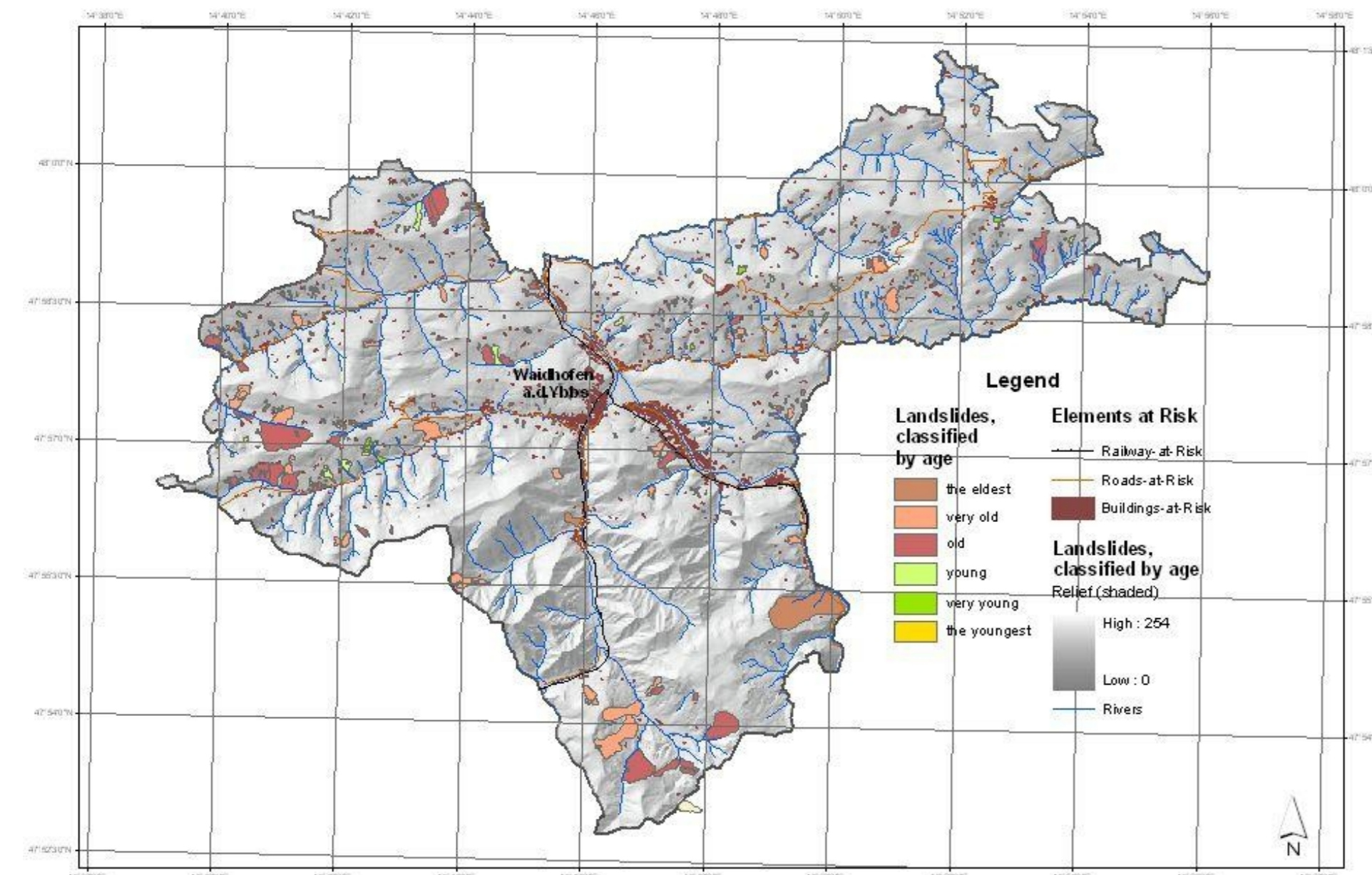


Fig. 3. Landslides classified by age. Ybbs valley (Source: Petschko et al., 2011)

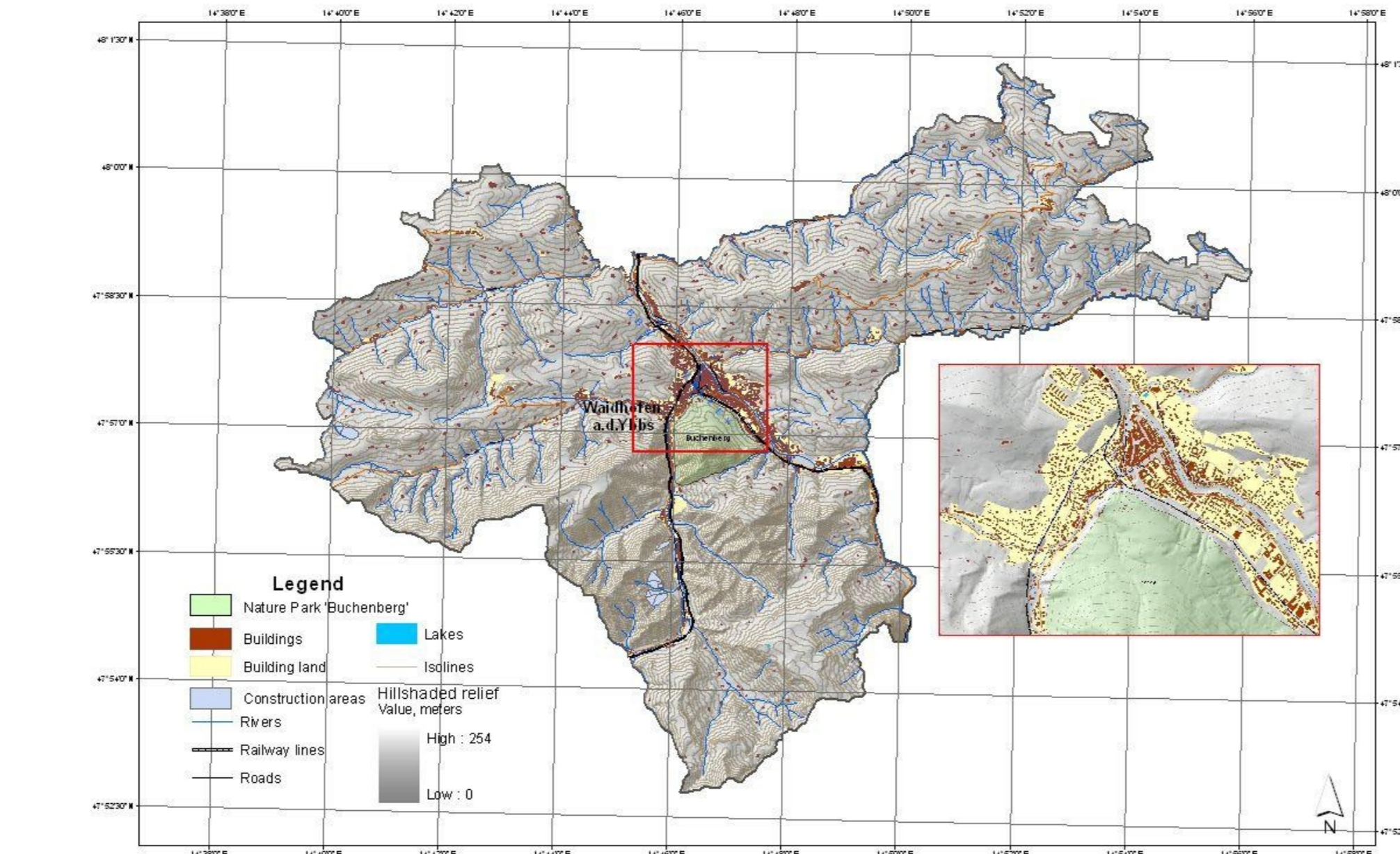


Fig. 4. Elements at risk: buildings, roads and railway lines. Enlarged: city centre (Data source: Provincial Government of Lower Austria)