Engineering Geology 101 (2008) 33–48

Contents lists available at ScienceDirect

Engineering Geology

journal homepage: www.elsevier.com/locate/enggeo

Probabilistic assessment of vulnerability to landslide: Application to the village of Lichtenstein, Baden-Württemberg, Germany

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ARTICLE INFO

Article history:
Received 12 September 2007
Received in revised form 3 March 2008
Accepted 28 March 2008
Available online 10 April 2008

Keywords:
Vulnerability
Landslide
Susceptibility
Intensity
Probabilistic assessment

ABSTRACT

Landslides are responsible for a considerable loss of buildings and infrastructure and often human lives. Although most of the studies concerning landslide disasters are concentrated on landslide risk assessment, zoning and monitoring, there are few studies focusing in its vulnerability component, particularly for inhabited areas. This paper explores the applicability of a new methodology for landslide vulnerability assessment that allows for a simplified probabilistic estimation of vulnerability to landslides. This is based on the First-Order Second-Moment (FOSM) approach, which allows for the quantification of uncertainty from the input parameters up to the vulnerability estimates. Results on the application of the method show vulnerability estimates for susceptible categories on structures and people for prescribed study areas. These are given in the form of expected values and ranges of variation, according to uncertainty measures given by intensity and susceptibility parameters. Due to the expert-based nature of the vulnerability methodology, fine judgement is expected to accompany the interpretations of results.

1. Introduction

Recent evidence shows that landslides are affecting more often and impacting more victims in Asia and America (Petley, 2006). In Europe these are significantly costly. In Central Europe, which is moderately threatened by natural hazards, landslides have considerable economic and ecologic consequences (NEDIES, 2003). The high standard of living, the accumulation of property, as well as the high population density makes society extremely vulnerable against natural hazards in general. Large mass movements are rare in Central Europe, however, small incidents that often occur together with intensive building activities at steep slopes, can be responsible for major economic damages. These mass movements have negative impacts on all kinds of buildings and infrastructure and cause high costs for rehabilitation, securing and maintenance. Losses are not only of economic nature, but also concern sensitive ecosystems and valuable cultivated land.

Current research on landslides focuses mainly on landslide zonation and modelling. Studies on vulnerability assessment to landslides have been focused in prone areas considering different priorities such as build environment, human life and local economy (Bell and Glade, 2004, Glade and Crozier, 2005, Gomes 2003, Shrestha, 2005). Studies on vulnerability communities subject to landslide related disasters are limited. In addition, the complexity in modelling landslide vulnerability is due to several factors. Glade (2003) identified several prominent factors contributing to such complexity: lack of accurate data for reliable hazard analysis; the strongly site-specific nature of landslide phenomena; the difficulty in quantifying spatial landslide hazard; the quantitative heterogeneity of vulnerability of different elements at risk for qualitatively similar landslide mechanisms; and the variability in temporal vulnerability. This is why it becomes relevant to introduce a measure of uncertainty on the vulnerability assessment.

The aim of this work is to explore the applicability of a methodology proposed by Uzielli et al. (in press) and Uzielli and Lacasse (2007), which simplifies the probabilistic vulnerability assessment to landslides. Their approach is based on expert judgement, and although it was inspired by scientific approaches such as HAZUS (2003), it relaxes risk well-defined probabilistic concepts for the sake of creating a tool (at the level of regional authorities) that can tackle the problem of estimating landslide vulnerability. Its application is relevant because it allows for integrating not only potential influencing factors on landslide vulnerability but also a systematic measure of their associated uncertainties. It is worth noticing

Abbreviations: FOSM, First-Order Second-Moment; COV, coefficient of variation.

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doi:10.1016/j.enggeo.2008.03.008

that this methodology captures only global landslide responses and is still open for further improvement. A description of the methodology key components is discussed in Section 2, and details of computations when applied to a real case study area are given in Section 3.

2. Methodology

This work explores the applicability of a probabilistic methodology for the probabilistic vulnerability assessment to landslides (Uzielli

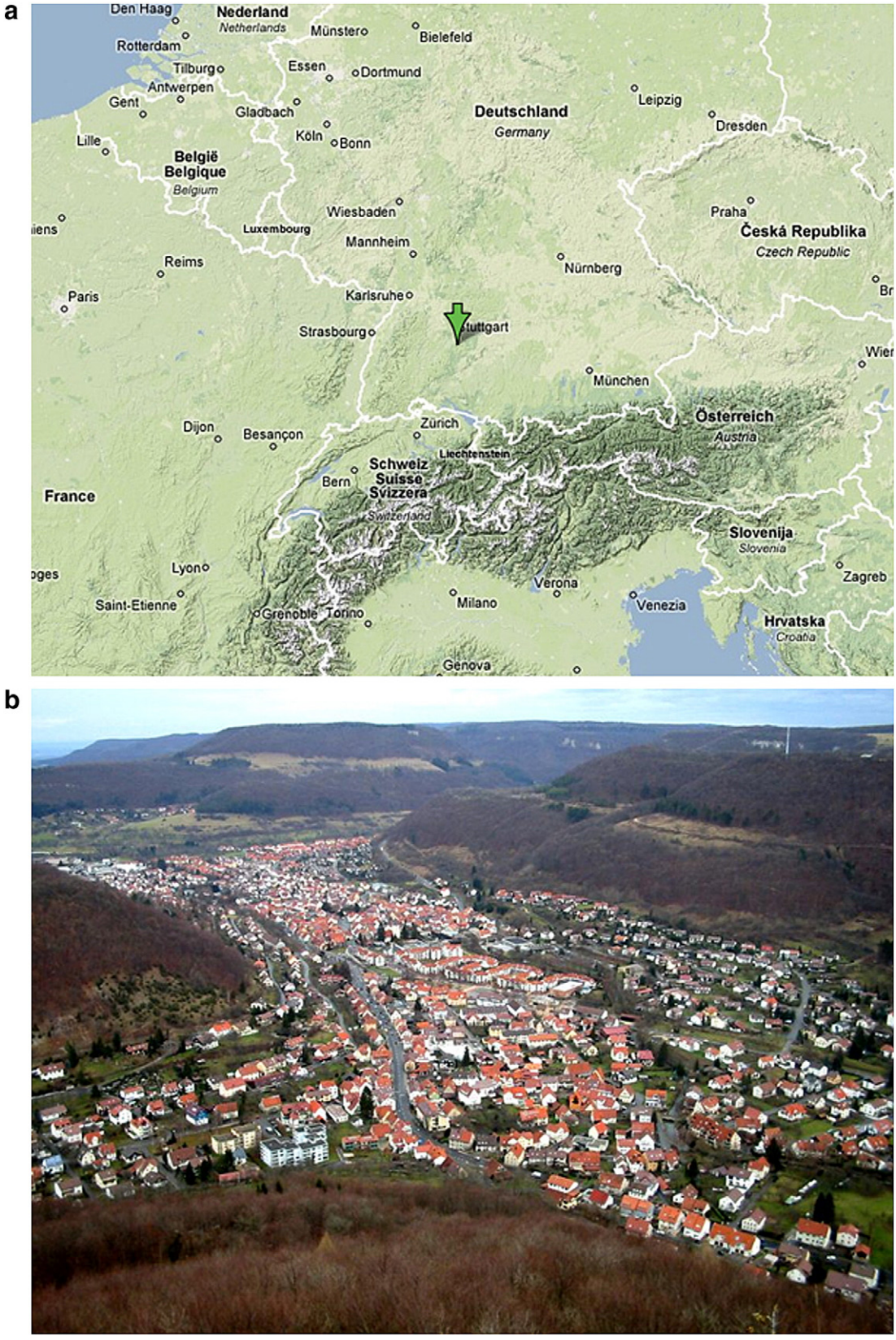

Fig. 1. Location (a) and picture (b) of the Village of Lichtenstein (Baden-Württemberg).