# Assessment of the interaction of land-cover change on shallow landslide occurrence: an automated object-based approach

*"Land-cover change could contribute to enhanced shallow landslide susceptibility"*

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**Publication date**
2016

**Document Version**
Final published version



**Citation for published version (APA):**
Kamps, M., Seijmonsbergen, A. C., & Bouten, W. (2016). *Assessment of the interaction of land-cover change on shallow landslide occurrence: an automated object-based approach: "Land-cover change could contribute to enhanced shallow landslide susceptibility"*. Poster session presented at GEOBIA 2016, Enschede, Netherlands.

# Assessment of the interaction of land-cover change on shallow landslide occurrence: an automated object-based approach

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"Land-cover change could contribute to enhanced shallow landslide susceptibility"

## Motivation

Shallow landslides are geomorphological processes occurring in mountainous regions. Shallow landslide susceptibility depends on several factors such as topography, changing land cover and characteristics of subsurface material. Detailed knowledge of fine-scale past and present land cover change (LCC) is a prerequisite for modelling and analyzing landslide susceptibility.
The aim of this research is:
(**Aim 1**). To develop a robust and up-scalable workflow for automated object-based LCC detection using high resolution orthophotos in the Laternser valley, Austria (Fig. 1).
(**Aim 2**). To analyze the correlation between LCC and the temporal occurrence of rainfall triggered shallow landslides.

## Analysis approach

**Aim 1:** Land-cover is classified using four sets of high resolution orthophotos (198x, 2001, 2006, 2009; 0.25 m spatial resolution). Classification consists of two routines:
(1) Stratified membership classification based on feature space optimization.
(2) Fuzzy-logic improvements based on context, geometry and spectral characteristics.
Land-cover change detection is performed using post-classification image differencing (Gutierrez et al., 2012; Zhou et al., 2008).

**Aim 2:** A multi-annual landslide inventory developed as part of the C3S-ISLS project (Zieher et al., 2016) is used as reference dataset for the location of shallow landslides (Fig. 2). Derivation of LCC trends is utilized for interpretation of LCC in the vicinity (<25m) of shallow landslides to assess the effect of LCC on rainfall induced landslide occurrence (Begueria, 2006).

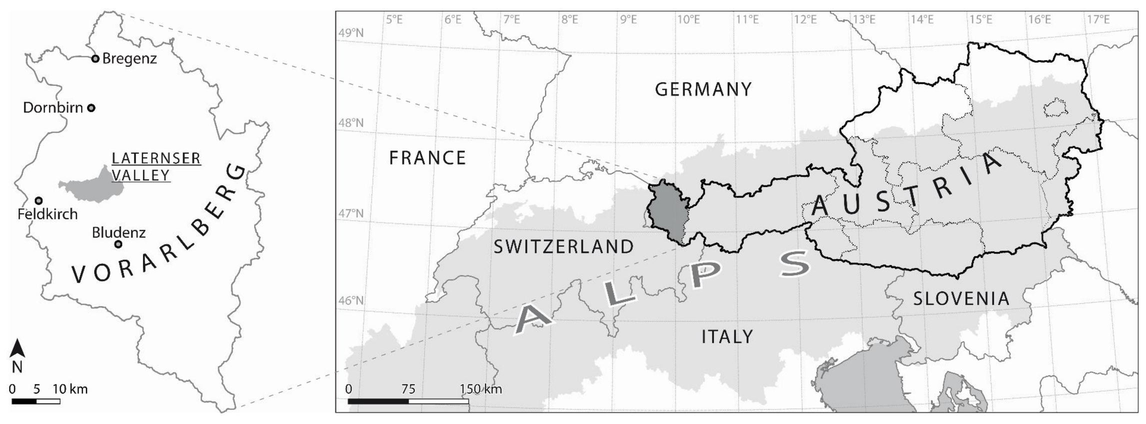


**Figure 1. Location of the Laternser Valley in Vorarlberg, western Austria.**

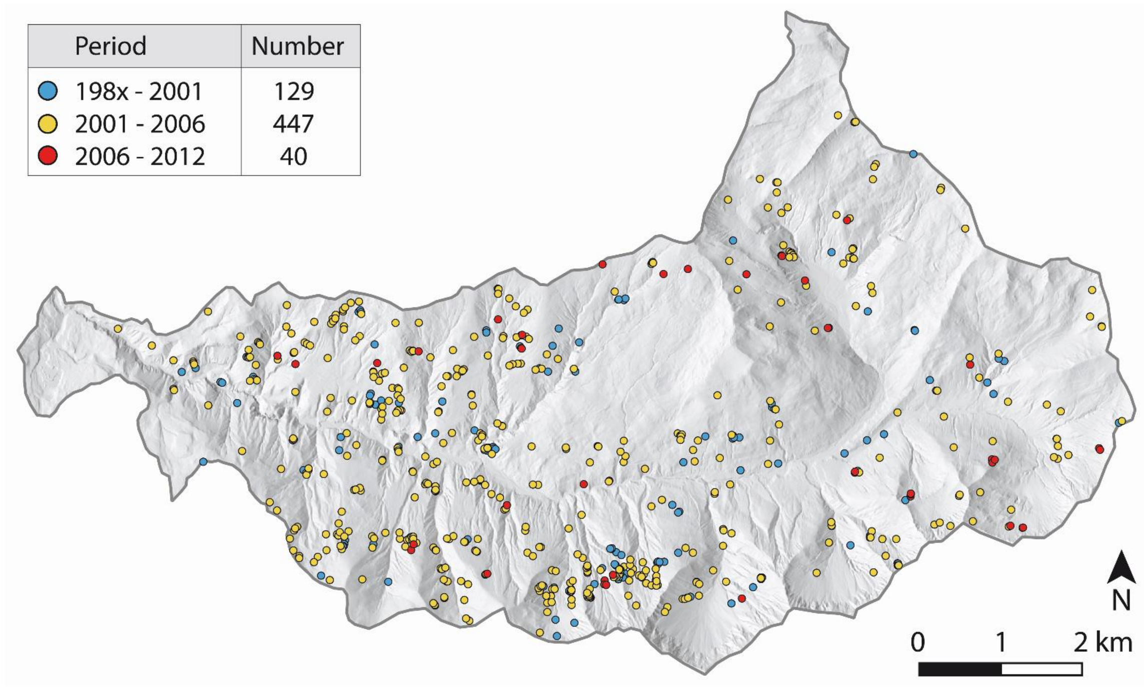


**Figure 2. Mapped shallow landslides in the Laternser valley by C3S-ISLS project.**

## Main results

### 1. Land Cover Change Analysis (Fig. 3)

**Accuracy:**
Classification accuracies are: 76% (198x), 83% (2001), 78% (2006) and 88% for the 2009 orthophotos (Congalton, 1991). The context-based classification ruleset improved 52% of all accurately classified samples in 198x and only 39% in 2009 due to better image quality and reduced overlap in the feature space in the more recent years.

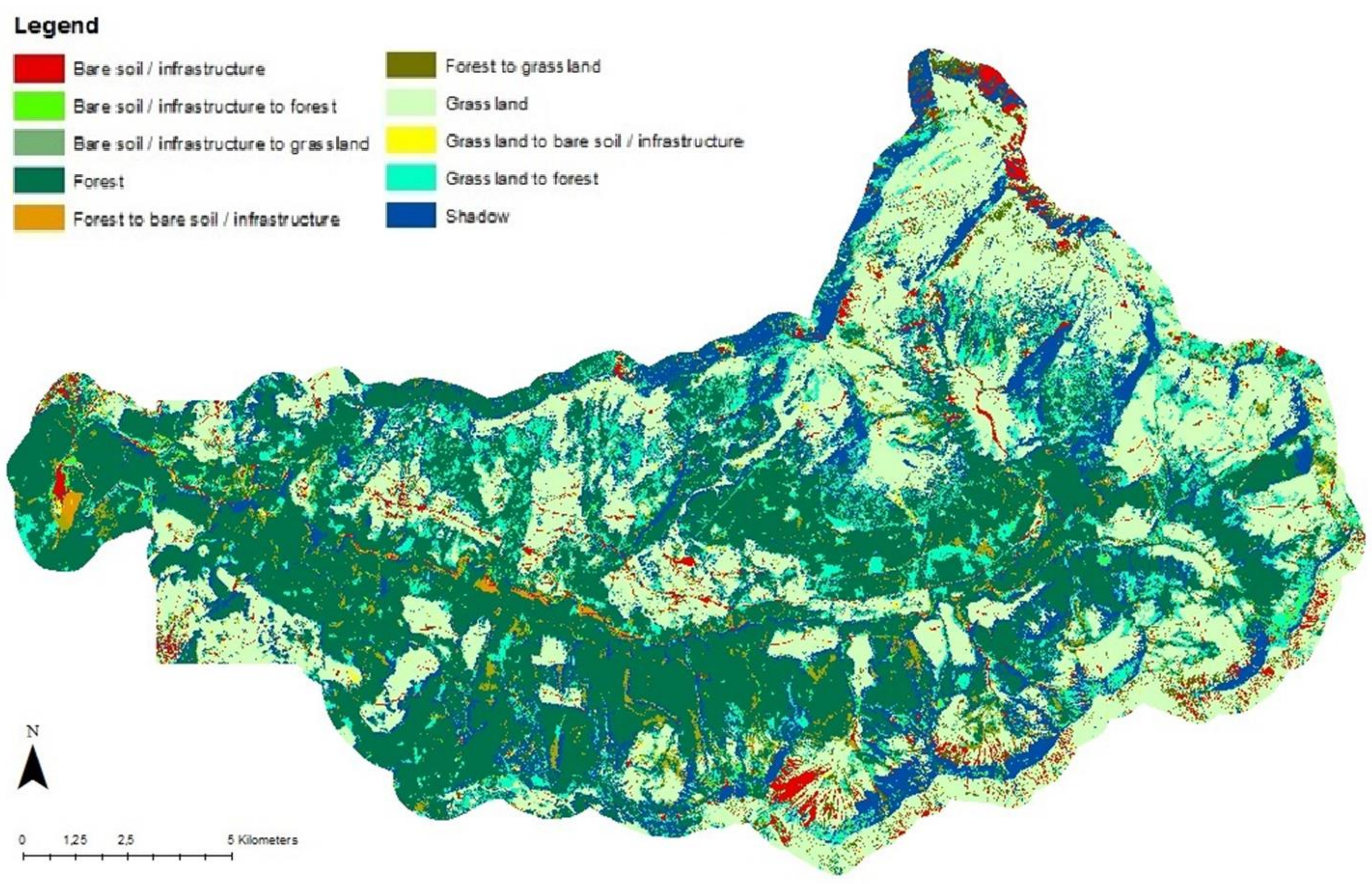


**Figure 3. Land cover change results 198x-2009.**

**LCC trends:** (Fig. 4)
1. A general increase in forest is observed while grassland decreases in the whole Laternser Valley.
2. 18% of the total area has undergone LCC between 198x and 2009.
3. The biggest LCC is the shift from grassland to forest.

### 2. Change Detection and Landslides

**LCC trends:** (Fig. 5 - 6)
1. A general decrease in forest is observed while grassland increases in the vicinity of landslides.
2. 34% of the area in the vicinity of landslides has undergone LCC between 198x and 2009.
3. The biggest LCC is the shift from grassland to bare soil / infrastructure, and a shift from forest to grassland.

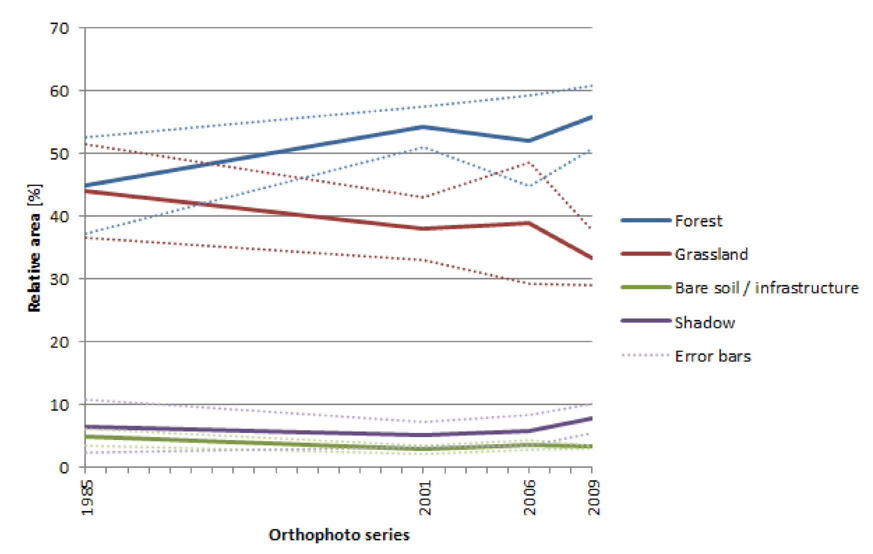


**Figure 4. LCC trends: Relative land cover change for the four classes per orthophoto series in the whole Laternser valley. Error bars are derived from the average user/producer accuracy per land-cover class.**

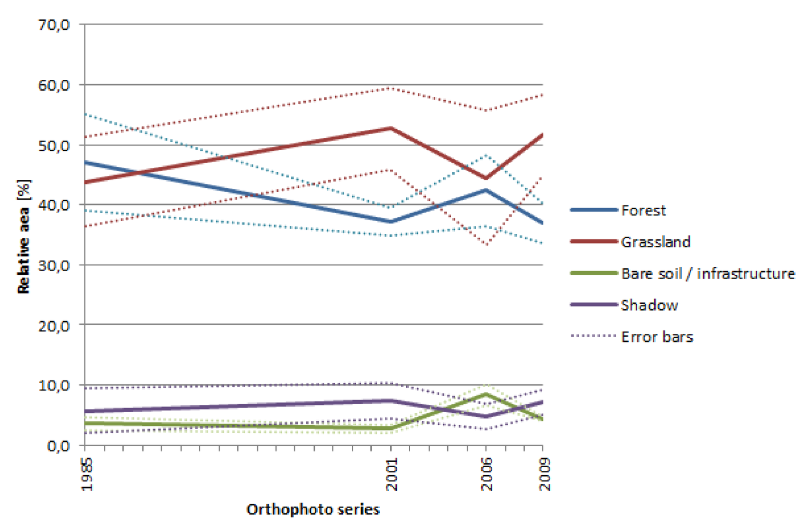


**Figure 5. LCC trends: Relative land cover change for the four classes per orthophoto series in the vicinity of landslides. Error bars are derived from the average user/producer accuracy per land-cover class.**

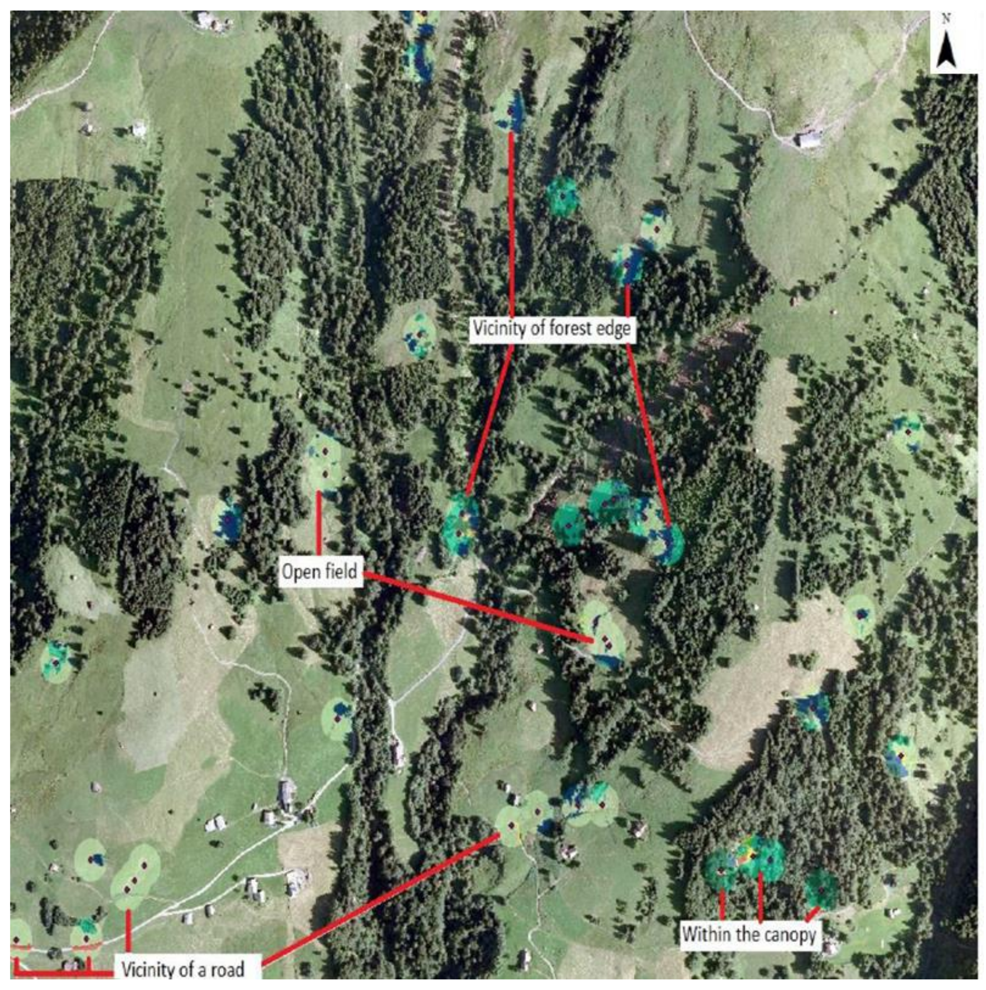


**Figure 6. LCC (198x – 2009) in the vicinity of landslides. Legend same as Fig 3. Dots represent landslide the scar points based on the C3S-ISLS project.**

## Outlook

Further analysis will incorporate topographic LiDAR data to optimize segmentation and classification and integrate additional explanatory variables for shallow landslide susceptibility such as slope angle, aspect, curvature and lithology to strengthen the analysis.

## Main Conclusions

1. This research shows the effectiveness of utilizing context to improve classification accuracy after initial membership-based classification in an object-based workflow to deal with overlap in the feature space.
2. In the Laternser valley 18% of the total area has undergone LCC between 198x and 2009, while in the vicinity of landslides its 34%.
3. Overall LCC trends indicate a shift from grassland to forest for the Laternser valley, the opposite is observed near shallow landslides. However, so far, a clear correlation between LCC and landslide occurrence could not be established. The question remains whether the observed LCC actually caused the landslides or was the eventual effect of the landslides.

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