OBJECT-BASED LANDSLIDE MAPPING ON SATELLITE IMAGES FROM DIFFERENT SENSORS

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Introduction

Several studies have proven that **object-based image analysis (OBIA)** is suitable for landslide mapping using **Earth observation (EO)** data. However, many of the existing OBIA approaches for **landslide mapping** are rather complex and are tailored to specific imagery. These restraints lead to a lack of transferability and applicability of OBIA mapping routines.

Assuming that **event-based landslides** cause a significant vegetation loss, they can be automatically detected by considering the distinct spectral contrast between landslides and their surroundings. Such contrasts can especially be observed for landslides occurring in densely vegetated regions such as Taiwan. In this study we present an automated OBIA approach for the **detection of landslide affected areas** (incl. debris flows and debris filled river beds) using **spectral indices** and **optical satellite images from various sensors**.

Objective

The objective of this study is to assess the performance of selected **spectral indices derived from optical satellite images from different sensors** with different resolutions for the **rapid identification of landslide affected areas in Taiwan using OBIA**.

Following spectral indices have been tested and compared:

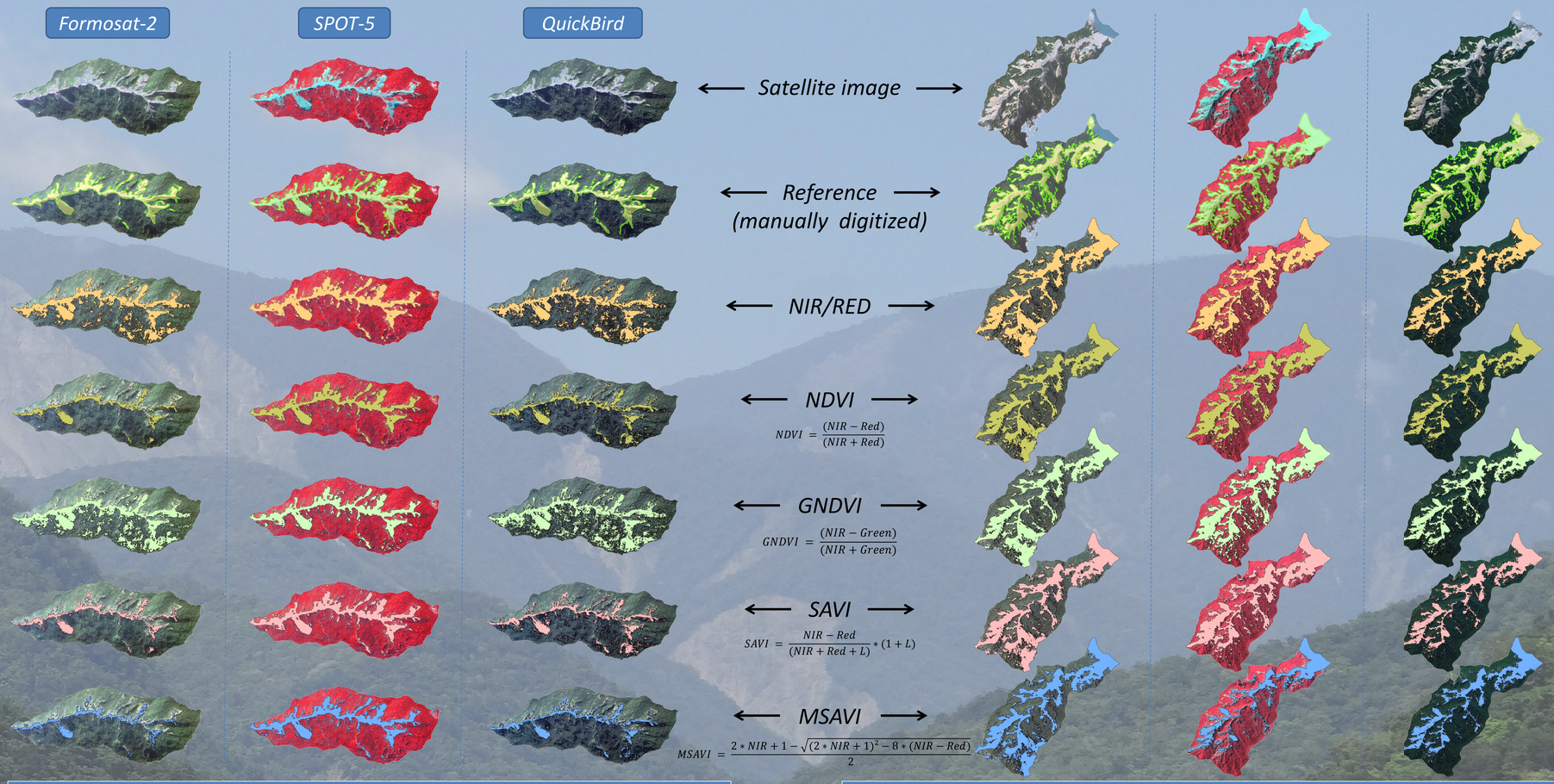
- Near Infrared/Red ratio (**NIR/RED**)
- Normalized Difference Vegetation Index (**NDVI**)
- Green Normalized Difference Vegetation Index (**GNDVI**)
- Soil-Adjusted Vegetation Index (**SAVI**)
- Modified Soil-Adjusted Vegetation Index (**MSAVI**)

Study area & data

Two study areas in **Taiwan** were selected: Study area one (~4.6 km²) is a tributary of the **Huaguoshan** catchment in the southern-central part of the island, study area two (~5.2 km²) is a tributary of the **Taimali** watershed in Taitung County near the south-eastern Pacific coast. Both areas are regularly affected by severe landslides.

	Data	Acquisition date	Spatial resolution	Spectral resolution
Huaguo-shan	Formosat-2	21/11/2010	8 m	4 bands (b, g, r, nir)
	SPOT-5	20/03/2011	2.5 m (pan-sharpened)	4 bands (g, r, nir, swir)
	QuickBird	28/11/2010	2.8 m	4 bands (b, g, r, nir)
Taimali	Formosat-2	20/08/2009	2 m (pan-sharpened)	4 bands (b, g, r, nir)
	SPOT-5	09/09/2013	2.5 m (pan-sharpened)	3 bands (g, r, nir)
	WorldView-2	29/09/2010	0.5 m (pan-sharpened)	8 bands (coastal, b, g, yellow, r, red edge, nir 1, nir 2)

Results



Study are one (Huaguoshan)

	Formosat-2					SPOT-5					QuickBird				
	Classifi-cation (in ha)	Reference (in ha)	Correctly classified (in ha)	UA (%)	PA (%)	Classifi-cation (in ha)	Reference (in ha)	Correctly classified (in ha)	UA (%)	PA (%)	Classifi-cation (in ha)	Reference (in ha)	Correctly classified (in ha)	UA (%)	PA (%)
NIR/RED	136,55	77,31	63,90	**46,80**	**82,66**	105,99	96,87	90,33	**85,22**	**93,25**	153,97	85,06	71,87	**46,68**	**84,49**
NDVI	54,11	77,31	44,14	**81,57**	**57,09**	100,46	96,87	88,46	**88,06**	**91,32**	87,18	85,06	58,25	**66,82**	**68,48**
GNDVI	158,05	77,31	59,95	**37,93**	**77,54**	105,64	96,87	88,20	**83,49**	**91,06**	196,66	85,06	72,13	**36,68**	**84,80**
SAVI	54,08	77,31	44,11	**81,56**	**57,05**	100,61	96,87	88,52	**87,98**	**91,38**	87,56	85,06	58,34	**66,63**	**68,59**
MSAVI	40,88	77,31	36,42	**89,08**	**47,11**	98,08	96,87	87,45	**89,16**	**90,28**	63,28	85,06	57,41	**90,73**	**67,49**

Study area two (Taimali)

	Formosat-2					SPOT-5					WorldView-2				
	Classifi-cation (in ha)	Reference (in ha)	Correctly Classified (in ha)	UA (%)	PA (%)	Classifi-cation (in ha)	Reference (in ha)	Correctly classified (in ha)	UA (%)	PA (%)	Classifi-cation (in ha)	Reference (in ha)	Correctly classified (in ha)	UA (%)	PA (%)
NIR/RED	263,44	181,78	176,59	**67,03**	**97,14**	221,82	186,93	183,31	**82,64**	**98,07**	193,69	189,28	178,89	**92,36**	**94,51**
NDVI	251,80	181,78	174,55	**69,32**	**96,02**	214,85	186,93	182,25	**84,83**	**97,50**	174,45	189,28	167,54	**96,04**	**88,52**
GNDVI	254,68	181,78	173,48	**68,12**	**95,44**	246,37	186,93	182,44	**74,05**	**97,60**	202,31	189,28	176,42	**87,20**	**93,21**
SAVI	251,79	181,78	174,55	**69,32**	**96,02**	215,22	186,93	182,26	**84,69**	**97,50**	174,23	189,28	167,36	**96,06**	**88,42**
MSAVI	247,28	181,78	173,59	**70,20**	**95,50**	121,69	186,93	121,43	**99,79**	**64,96**	171,49	189,28	165,30	**96,39**	**87,33**

Methodology

Image analysis was conduced in eCognition (Trimble) software. First, the **spectral indices** were calculated. Next, a **threshold value per index** was automatically computed by combining the homogeneity criterion of multiresolution segmentation and histogram-based methods. These threshold values were then used for **multi-threshold segmentation** for separating landslides from vegetated areas. Finally, landslide objects with less than 3 pixels were removed.

Computation of spectral indices → Automatic threshold calculation → Multi-threshold segmentation → Remove objects < 3 pixel → Landslide affected areas

Discussion

The **results were compared to results from visual image interpretation** (i.e. manually digitized reference polygons for each image). By that, the performance of the spectral indices in relation to each sensor was assessed, whereby the **highest user's and producer's accuracies** were reached by the **MSAVI** and by the **NIR/RED** ratio, respectively. Overall, **SPOT-5 and WorldView-2** seem to be most **suitable for landslide mapping**. However, the influence of pre-processing steps and of the spectral/spatial resolution of optical imagery should be evaluated in more detail in future studies.

Conclusion

Automated landslide mapping routines that are based on transferable parameters can **complement traditional manual mapping efforts** (e.g. by applying a "hybrid approach"), especially for rapid assessment after major events. This study gives **indications which spectral indices and which optical sensors might be preferable for landslide mapping**. The presented method may also contribute to an increased efficiency of change detection approaches that use multi-sensor optical data.

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