Object-based Image Analysis Using VHR Satellite Imagery for Monitoring the Dismantling of a Refugee Camp after a Crisis: The Case of Lukole, Tanzania

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Abstract

The use of HR and VHR (high/very high spatial resolution) imagery and OBIA (object-based image analysis) offers new possibilities for monitoring activities in and around refugee camps to manage, understand, and assess developments and impacts of the camp on its environment (see for example TIEDE et al. 2013, HAGENLOCHER et al. 2012). Here we demonstrate how VHR imagery in combination with OBIA can be used to retrieve and create valuable information about a remote refugee camp and its surroundings before, during, and after the dismantling and the repatriation process. Feature extraction approaches for single dwellings and further information retrieval, as well as land cover classification for the refugee camp Lukole in Tanzania were combined for an integrated monitoring approach.

1 Introduction

The Lukole refugee camp is located in the Ngara District in the north-west of the United Republic of Tanzania, close to the borders of Rwanda and Burundi. The twin camp (Lukole A/B) was erected in 1994 to host refugees that fled due to political and ethnical motivated unrests, as well as genocides between different tribes. The United Nations High Commissioner for Refugees (UNHCR) managed the camp until its dismantling in 2008 (TURNER 2006). At its climax in the year 2000, it hosted more than 129,000 people. Since then, the number of refugees declined slowly but steadily, and in 2006 the official repatriation process started (TURNER 2010). The presence of refugees over this long period has had a considerable impact on the environment, especially on the surrounding forests (UNHCR 2008). Thousands of refugees were in need of timber for construction, as well as firewood for cooking. This led to deforestation processes not only within but especially around the camp. UNHCR started to plant more than 14 million tree seedlings in refugee host areas in north-western Tanzania in 1995 to respond to the damage caused by deforestation (UNHCR 2008). The impact of these counteractions as well as the overall land cover change and development of the camp itself have not yet been investigated with remote sensing methods. Our study for monitoring the camp and its environment using VHR data and an object-based analysis approach has been conducted within the EU FP7

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project G-SEXTANT (Geospatial services in support of EU external action), where different indicators are being developed to monitor the repatriation process after a crisis.

2 Input Data and Data Processing

For this study, three multi-temporal VHR images from three sensors with different spatial resolution were used (see table 1). The image from 2000 is an IKONOS scene, which was pan-sharpened to a ground sample distance of 1.0 m. The image from 2005 is a QuickBird scene, pan-sharpened to a ground sample distance of 0.6 m. Finally, the 2013 image is a Pléiades 1A scene, pan-sharpened to a ground sample distance of 0.5 m. All image data were co-registered.

Satellite sensor	**Acquisition Date**	**Spatial resolution (pan-sharpened)**	**Spectral resolution**
IKONOS	24/09/2000	1.0 m	4 bands (B,G,R,NIR)
QuickBird	16/12/2005	0.6 m	4 bands (B,G,R,NIR)
Pléiades 1A	26/06/2013	0.5 m	4 bands (B,G,R,NIR)

Tab. 1: Overview of the available satellite data

3 Methods

In the last decade, advances in computer technology and Earth observation (EO) sensors have led to the field of object-based image analysis (OBIA, see BLASCHKE 2010). OBIA techniques were successfully used for camp monitoring using VHR data (TIEDE et al. 2013, LANG et al. 2010). In our research, expert rule-sets using OBIA for feature extraction (i.e. dwellings) and land cover classification (LCC) were developed within CNL (Cognition Network Language, implemented in eCognition, Trimble Geospatial Imaging). A rule-set proposed by TIEDE & LANG (2008) for IKONOS was adapted for the other sensors. Dwellings were extracted by their spectral properties, and also taking into account relations to neighbouring objects, as well as using form indices for improved classification. For the LCC, vegetation was roughly pre-classified using an NDVI threshold. Since the focus of the LCC analysis was set on re-/deforestation activities, and to compensate for the problem of image acquisition in different seasons, the vegetation classes (trees, bushes, low vegetation) were refined based on the extracted shadow and shadow size of vegetation objects instead of spectral values or texture. Overall, seven different land cover classes were extracted (see Figure 1).

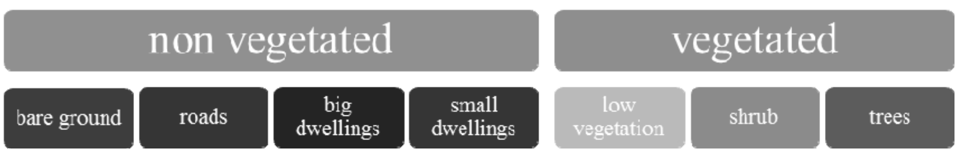

Fig. 1: LCC scheme applied in this study

4 Results and Conclusion

The results of the dwelling extraction show high overall accuracies (> 90 % overall accuracy for each of the images) for all three images compared to visual assessments for randomly selected areas. This result is in line with results from GIADA et al. (2003) and TIEDE & LANG (2008) for the year 2000. Especially the permanent structure of the dwellings account for this; the buildings, mostly covered with corrugated iron roofs facilitate the automated extraction process compared to camps with small and/or non-permanent dwelling types. The development of dwelling numbers, camp extent as well as dwelling density shows the dismantling of the camp over time (see Figure 2). More than 23,000 dwellings were extracted using the image from 2000, around 6,000 for 2005, but only few major buildings are left in 2013. Density calculations depict density shifts within the camp. The area of the camp which was calculated based on density values of the dwellings is reduced from 13.176 km² in 2000 to 7.617 km² in 2005 and only 0.267 km² was left in 2013.

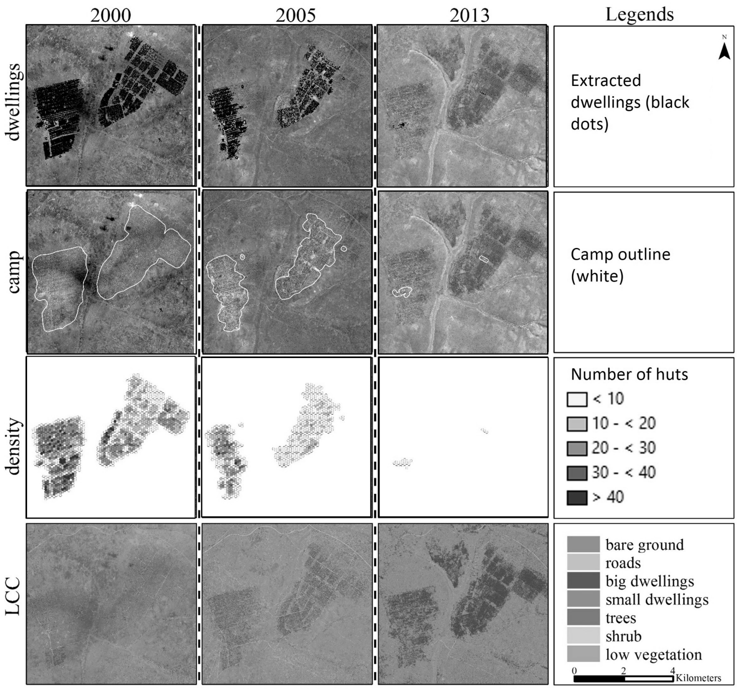

Fig. 2: Results of the camp development over time: The first row shows the results from the dwelling extraction (background: satellite imagery as false colour composite). The second row represents the camp extent over the years. Dwelling density is shown in the third row and the LCC in the last row (trees are shown in dark green).

The LCCs depict an increase of high vegetation (trees, shrubs) over the years. In 2000, tree coverage concentrates on the south west area of the camp, while the results from 2005 revealed an increase of trees within the camp as well as changing spatial patterns and tree densities. In 2013, almost the whole initial camp area was covered by trees. This growth of trees is also detectable outside the camp, especially in the northern part. Opposed to this, the class open bare ground is decreasing, which can be linked to the declining number of refugees as well as the overall increase in vegetated area.

The object-based dwelling extraction has proven to be highly accurate for this type of refugee camp. In combination with the LCC, the derived information can be helpful for monitoring the dismantling process and to represent the progress of counteractions (here: reforestation) on the surrounding environment in a spatially explicit manner. The LCC clearly indicates that the counteractions taken by UNHCR against deforestation have been quite effective in this area. The usage of form parameters and object neighbourhood relations in the object-based LCC could be successfully applied, especially to differentiate the vegetated areas into trees, bushes and low vegetation. Thus, the problem of different seasonal acquisition times of the images could be compensated.

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