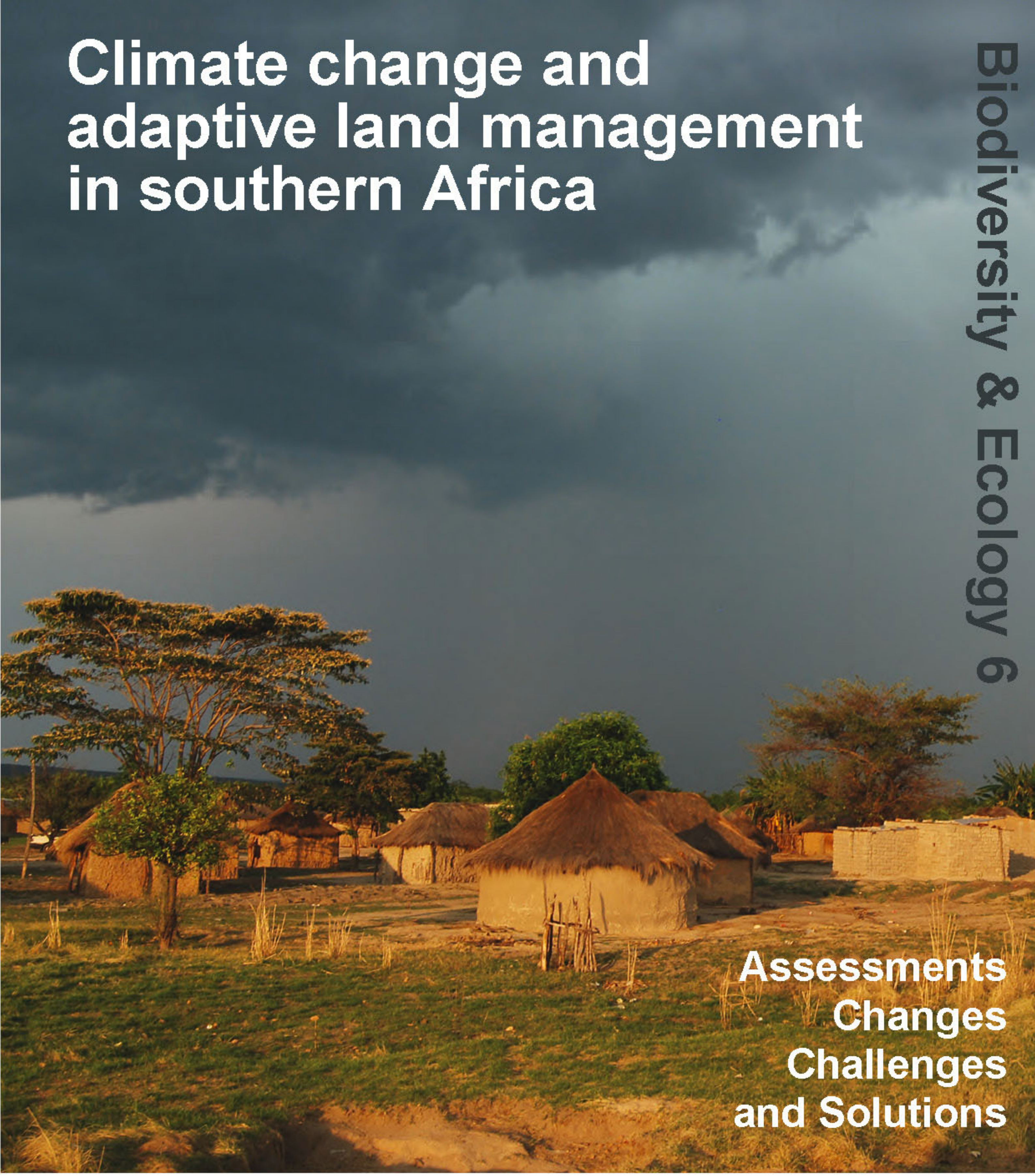
Climate change and adaptive land management in southern Africa

Biodiversity & Ecology 6



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Climate change and adaptive land management in southern Africa

Assessments, changes, challenges, and solutions

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Potential use of 3D-derived products generated from unmanned aerial vehicle (UAV) imagery for monitoring forest degradation and woodland structure changes in the Namibian dry woodlands

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Introduction

Woodlands in the SASSCAL region are variable in terms of species composition, density, and structure. Though many of the species are valued for their timber, management and effective monitoring of these woodlands pose several challenges, such as inaccessibility and limited funding for agencies to regularly monitor the woodlands (De Cauwer et al., 2018).

Different remote sensing approaches (in terms of data and analysis) have been demonstrated to be efficient mechanisms for monitoring changes in woodland cover. The use of optical remote sensing in monitoring dry woodlands has proved challenging and resulted in underestimating the cover and distribution of open woodlands (Bastin et al., 2017). With the use of an integrated LiDAR and SAR approach, Mathieu et al. (2018) have demonstrated an effective means to assessing the distribution and fractional woody cover of savanna forests (including the dry woodlands of Namibia). For regional scales, this method is likely to pave the way for future monitoring of dry woodlands. Such regional-scale monitoring, however, will not enable forest managers to capture and monitor localised changes that occur in the dry woodlands as a result of forest degradation caused by extraction of timber for construction and carving, firewood collection, etc. Strohbach (2018) has been able, with the use of UAV technology, in particular by combining a UAV-derived digital surface model (DSM) and RGB imagery, to compare the degree of deforestation and forest degradation, at a small scale, in the Omusati region (Fig. 4-6 in Strohbach, 2018). Here we wish to present an approach for analysing UAV-derived 3D products, generated during processing, to quantify structural properties of woodlands, which could then be used to monitor small-scale forest degradation.

Methods

Using the same flight planning parameters outlined by Strohbach (2018), imagery was acquired on March 21, 2017 (between 13h37 and 14h29) taken over the paired SASSCAL long-term observatories of Mile 46 and Mutompo (Jürgens et al., 2010), located in the dry woodlands of the northern Kalahari. Mutompo is a communal grazing land, and Mile 46 is a site located at the Alex Muranda Livestock Development Centre. A total of 411 images, with a spatial resolution of 5 cm (resampled to 25 cm to facilitate faster processing), were acquired over an area of approximately 325 ha covering these two sites.

Basic pre-processing outlined in Strohbach (2018) was done with Pix4DMapper Pro (Pix4D, Lausanne, Switzerland). From this pre-processing, a mosaicked RGB image and an *x, y, z* point cloud dataset were obtained (RMSE error (m): $x = 0.14, y = 0.19, z = 0.47$). To enable the generation of this point cloud data set for 3D modelling, sufficient overlap (long track 60–85%, across track 30–70% [Pix4D, 2018]) between the different images is needed. In this case there were more than five overlapping images covering each location within the study area (60% by 75% across/long track overlap). Using the ENVI-LIDAR tool in ENvironment for Visualizing Images (ENVI) software version 5.4 *(Exelis Visual Information Solutions, Boulder, Colorado)*, both a digital elevation model (DEM) and digital surface model (DSM) were generated from the point cloud data. Based on the difference between the DEM and the DSM, one can calculate the heights of individual trees (Fig. 1), assess woody

Table 1: The structural breakdown of woody cover in the two management units at Mile 46 and Mutompo derived from analysis of derived point cloud tree height classifications.

Cover	Mile 46 – ha (%)	Mutompo – ha (%)	Total – ha (%)
Non-woody	120 (84.8)	112 (86.1)	233 (85.4)
Shrub (1–1.5 m)	7 (5.0)	5 (3.5)	12 (4.3)
Tree (1.5–5 m)	11 (7.8)	9 (7.2)	20 (7.5)
Tree (5–10 m)	3 (2.3)	4 (2.8)	7 (2.5)
Tree (> 10 m)	0.3 (0.2)	0.5 (0.4)	0.8 (0.3)

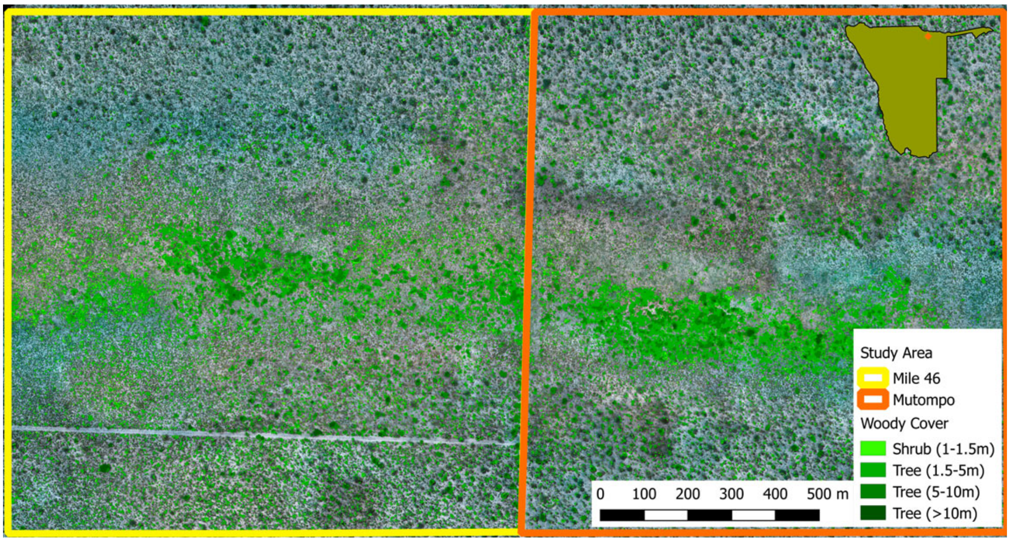
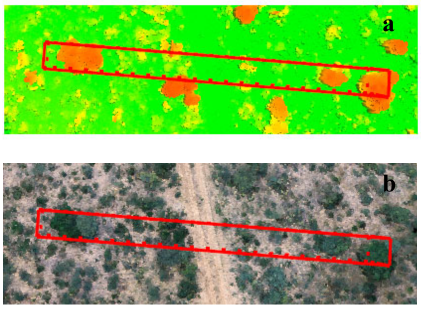


Figure 1: Woody cover height classification derived from processing of UAV imagery point clouds

cover (Tab. 1), determine woody cover per height class (Tab. 1), and generate 3D transects (Fig. 2).

3D Product Outputs

The interpretation of Figure 1 and Table 1 would provide similar outputs to those generated by Strohbach (2018), but with the additional accuracy provided by combining the DEM and DSM in the modelling process. The 3D modelling has the advantage of enabling the analysis of small-scale changes in woody vegetation structure, as shown in the 3D image transect examples (Fig. 2). The image transect analysis could either be done based purely on the height classification (Fig. 2a,c) or combine both the height information and the spectral information (Fig. 2b,d). Oldeland et al. (2017) have recently demonstrated the feasibility of identifying abundant species in Namibian savanna woodlands based on RGB UAV imagery. Combining a woody species map with structural information derived from 3D modelling could thus provide a means to studying the variation in structure of the canopy understory (Fig. 2c,d). Such an analysis would be a valuable contribution to forest management monitoring of selective harvesting of canopies, but this technique still has to be explored to determine its potential applicability in an operational setting (i.e., cost versus value, potential to upscale, skills and requirements).



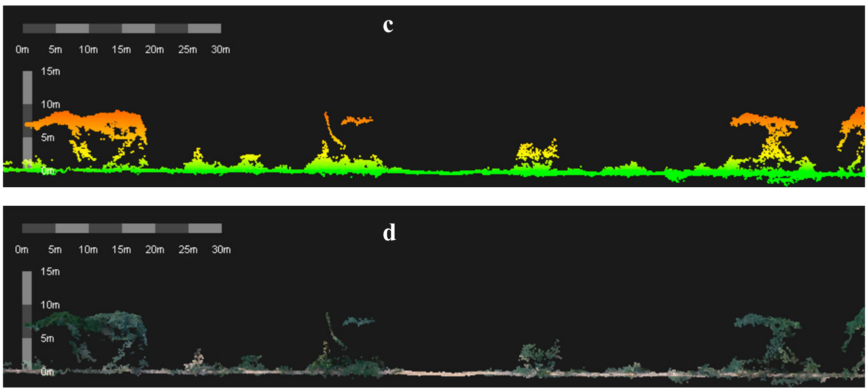


Figure 2: 3D transect analysis of dry woodlands, based on (a) and (c) height-scaled transect and (b) and (d) true-colour imagery (RGB) transect (the transect profile has been stretched to aid interpretation).

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