



Reprint of “Assessing urban growth and rural land use transformations in a cross-border situation in Northern Namibia and Southern Angola”[☆]



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ABSTRACT

The Okavango catchment is a hot spot of accelerating land use change. In particular, climate predictions, demographic developments and a growing utilization of ecosystem services and functions are expected to increase pressure on resources and land. Land use conflicts, the sustenance of precarious livelihoods, deforestation of woodland savannahs, upstream–downstream water issues and human–wildlife conflicts are among the processes that are characteristic of policy and management challenges in the region. In the Eastern and Western Kavango regions of Namibia and the Cuando–Cubango province of Angola, a unique cross-border situation exists that allows assessing how the combination of local traditions, regional land management and national policies determines spatial patterns of land use and land cover transformation processes.

To map major land use types and change processes we used a set of multi-temporal Landsat-5 TM and Landsat-7 ETM+ data sets, support vector machine (SVM) classification and iterative spectral mixture analysis (ISMA) on images covering the period from 1990 to 2010. Integrating satellite imagery with literature reviews, interviews, census and household survey data, we assessed the contrasting development of resource utilization on both sides of the Okavango River. We investigated if and how policies and regulations at different levels drive land use decisions, and how these decisions manifest spatially.

We found a strong and interconnected urban growth on both sides of the river. The area around Rundu has constantly been evolving to become Namibia's second largest city, also functioning as a hub of development and transborder commerce with opposing Calai. This trend was found to affect adjacent settlement areas and cause widespread conversion of woodland savannahs to agricultural land or their utilization for timber extraction. The conversion of woodland savannah to arable land was by far the dominant land use change process on both sides of the river, with a total conversion area of 460 km² (Namibia) and 293 km² (Angola) observed during the observation period. Strong spatial change gradients occurred in relation to determining factors, such as accessibility, proximity to water, urban centres, etc., while relations to settlements were less obvious. Assessing results by country illustrated the difference in land use intensity and resource consumption between Angola and Namibia, which relate directly to historical developments, with a long period of stability in Namibia standing opposed to the recent and ongoing recovery from civil war in Angola. These are added to by statutory and traditional policy frameworks, the national endowment with natural capital (e.g. oil, uranium, diamonds, zinc) and the integration into global markets, which strongly affects national economies of both countries at large.

Underlying land use decisions were found to be largely driven by individualized perspectives on growth ideologies, consumerism and wealth-aspirations connected to globalization processes. However, at present the result of these perspectives is still mainly a small-structured conversion to rainfed agriculture as a component of subsistence strategies of local livelihoods, and thus stands opposed to other regions of the world, where change processes are much more driven by large companies or follow national regulations and result in more intensive uses.

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Introduction

The recent acceleration of land use transformations, coupled with an increasing global population has manifested in an alteration of almost all terrestrial ecosystems (Millennium Ecosystem Assessment, 2005). In particular, the extension and intensification of agricultural and pastoral uses has supported unprecedented rates of population growth (Ellis and Ramankutty, 2008). However, this stands opposed to increased greenhouse gas emissions, declining biodiversity, declining air quality and increasing soil degradation, being reflected in the general reduction in ecosystem services and functions (Banwart, 2011; Butchart et al., 2010; Lal, 2013; Sala et al., 2000). Such global change processes are to a large degree driven by land-use transformations or modifications (Foley et al., 2005). These are in turn a result of the complex interaction of factors playing out at different scales, varying from global market dynamics through national policies to regional planning and local traditions (Hein et al., 2006). Conceptually, these may be differentiated into proximate causes of change, including for instance immediate human actions at the local level, and underlying driving forces that incorporate political, economic, cultural, technological, and natural driving forces (Bürgi et al., 2004; Geist and Lambin, 2002).

The Okavango Basin represents a highly complex social-ecological system, where the variation in physio-geographic characteristics is reflected by manifold livelihood strategies in the three adjacent countries Angola, Namibia and Botswana. In mostly rural areas, small-scale subsistence agriculture, livestock-keeping and the utilization of natural resources such as thatch grass, timber, fruits, etc. have traditionally formed the basis for human well-being. These strategies are juxtaposed by recent urban and transportation infrastructure developments, the expansion of commodity markets, the creation of commercial irrigated farming schemes and dams for energy production, or the growing role of tourism, in particular in the Delta region, as a major source of income generation.

At present, the three countries bordering the river have individual legislations governing the use of natural resources, which usually originate at central institutions and are implemented in different ways at subordinate levels. Commonly, communities make their own decisions regarding the use of natural resources within the framework of statutory and traditional governance and national legislation. The Permanent Okavango River Basin Water Commission (OKACOM) has been created between Angola, Namibia and Botswana to deal with transboundary issues and facilitate informed policies. Developing such informed policies is even more urgent given demographic and climatological predictions. The African population is expected to almost double by the end of the century (Haub, 2012), while climate predictions indicate an overall increase in average temperatures, added to by an increase in dry spells during the wet season and overall decreases in precipitation (IPCC, 2013). This will result in increasing demands for food, paralleled by less favourable production conditions.

The appropriation of resources in the wider region is therefore characterized by various, potentially conflicting demands that are likely to accumulate in space and time (Röder et al., 2013). A particular constraint draws from upstream–downstream issues, with a predicted increase in upstream water utilization for drinking and irrigation, while the Delta region relies on regular flood pulses of clean water to sustain its biodiversity, to which the tourist sector as a major source of national income is linked. This is threatened by the increasing concentrations of pesticides and herbicides used in the frame of irrigation schemes, and the disruption of flood pulse cycles through damming projects (Lindemann, 2009).

Besides national policies and regional planning programmes, an equally important element in understanding the utilization of

natural resources is the individual perspective of actors that may range from the conservation of traditions and cultures to stronger market integration and consumerism (Pröpper et al., 2013) that result from rapidly changing social and environmental framework conditions (Weber et al., 2012).

In this manuscript we seek to integrate knowledge on determining factors at different levels with remote sensing techniques to understand how existing and previous framework conditions and actors' decisions have shaped the present-day land use systems, which may serve as a baseline for future integrated policies. We do evaluate both, underlying political and environmental drivers, but analyze the apparent land use change pattern as a direct consequence of the cumulative effect of actor's decisions at the local level, thus aligning our study with the Actor-Land Change conceptual model suggested by Hersperger et al. (2010). However, while our interviews are happening at a clearly defined local level, linking them to land change data from remote sensing images allows a generalized interpretation for a larger area with a consistent social and ecological framework.

A special focus will be set on the unique cross-border situation in Northern Namibia and Southern Angola, which share physio-geographic properties on both sides of the Cubango River, but vastly differ in respect to their recent history. While Namibia has experienced a period of stability since its independence in 1990, Angola is still recovering from the civil war that, with some interludes, lasted from 1975 until 2002.

Specifically, we try to answer the question on how land use has evolved in the past 20 years in this cross-border region, and which ecological, policy-, planning-, and human-related drivers and causes have contributed to this development. This includes addressing the question which changing values and decisions spatially manifest in the landscape, and what are the decisions behind visible moves and transformations.

From this, three specific objectives emerge:

- Map land use and its change between 1990 and 2010.
- Provide a characterization of emerging patterns in relation to spatially explicit driving factors.
- Analyze which underlying socio-economic factors are responsible for these trends and patterns.

We will use remote sensing and geoinformation techniques to characterize land use and land cover dynamics during the observation period, while the interpretation will be based on an evaluation of existing literature and documentation on land use-related policies, as well as on recent surveys of livelihood strategies in the region (Kowalski et al., 2013; Pröpper et al., 2013).

Test area

Physical environment

The test area is located in the middle reaches of the Okavango River (in the following, "Cubango" will be used as the established term for the central part of the river) that runs along a distance of 1860 km from the highlands of Angola to the wetlands of the Okavango Delta. It comprises an area of 171,000 km² upstream of the Delta and the mean annual runoff of the Cubango at Rundu has been 165 m³ s⁻¹ during the period 1945–2000 (Steudel et al., 2013). The region is based within the Eastern and Western Kavango provinces (Namibia) and the Cuando-Cubango province in Angola and encompasses a total area of 15,000 km² (Fig. 1). Climate in the region is semi-arid, with annual rainfall of approx. 570 mm received mostly during the wet season from November to March and a high inter-annual variability (Weber, 2013). The landscape

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