Driving forces of land-use change in the Taita Hills, Kenya

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INTRODUCTION

The Eastern Arc Mountains (EAM) of Kenya and Tanzania maintain some of the richest concentration of endemic animals and plants on Earth. Although this region is among the most important areas for the biological conservation in the world, it has already lost approximately 80% of its original forest area (Hall et al., 2009). One of the EAM sections most affected by the agricultural expansion is the Taita hills, which is the northernmost part of the EAM. Between 1955 and 2004, the indigenous forest areas in the Taita hills decreased by 50% (Pellikka et al., 2009). Today, only 1% of the original forested area remains.

The improvement of models and computer capacity during the past decades allowed an increasing number of studies aiming at the sustainable use of natural resources and land use planning. For instance, land use and land cover change (LUCC) simulation models provide robust frameworks to cope with the complexity of land use systems (Veldkamp and Lambin, 2001). Moreover, geospatial technologies, such as remote sensing and geographical information systems (GIS), have made available an unprecedented opportunity for new studies in terms of data collection, availability and processing capacity.

The presented research aimed to evaluate the role of landscape attributes and infrastructure components as driving forces of agricultural expansion in the Taita Hills. In order to achieve this objective, remote sensing, GIS techniques and a LUCC simulation model were integrated to identify and evaluate the driving forces of LUCC.

STUDY AREA

Taita Hills is the northernmost part of the EAM biodiversity hotspot, situated in the middle of the Tsavo plains of the Taita-Taveta District in the Coastal Province, Kenya (Figure 1). Taita Hills cover an area of 1000 km^2. The indigenous cloud forests have suffered substantial loss and degradation for several centuries as abundant rainfall and rich soils have created good conditions for agriculture.

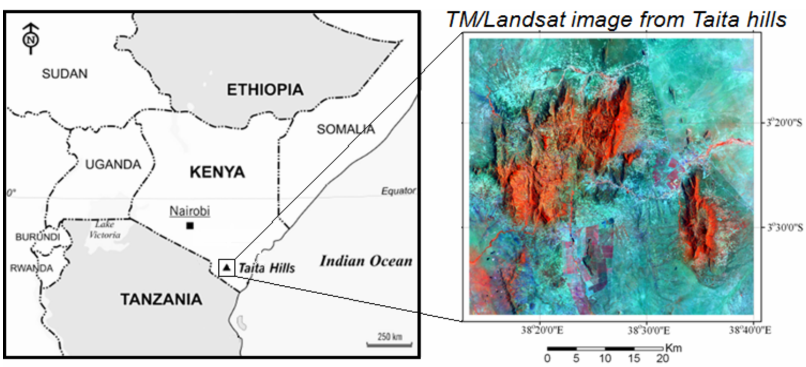

Figure 1: Geographic location of the study area.

MATERIAL AND METHODS

This study integrated remote sensing, GIS techniques and a spatially explicit simulation model of landscape dynamics, DINAMICA-EGO (Soares-Filho et al., 2002), to assess the agricultural expansion driving forces in the study area. The model receives as inputs land use transition rates, landscape variables and landscape parameters. The model is driven by land use and land cover maps (LULCM) from two selected dates: 1987 (initial landscape) and 2003 (final landscape), which are used as inputs to represent the historical land use transitions in the study area.

In total, ten landscape attributes (parameter/variables) were used as inputs for the model: distance to roads, distance to rivers, distance to markets, soil type, protected areas, elevation, slope, mean annual precipitation, distance to croplands and insolation. All attributes were represented by raster images with a 20 m spatial resolution.

The transition probability in each cell was calculated in DINAMICA-EGO using the weights of evidence (WoE) method. The WoE is a Bayesian method, in which the effect of each landscape attribute on a transition is calculated independently of a combined solution (Soares-Filho et al., 2002). The weight of evidence for a determined landscape variable range, defined by the following equation:

$$W+ = \log_e \frac{P\{Vi/T\}}{P\{Vi/\bar{T}\}}, \quad (1)$$

where:

P{Vi/T} = probability of occurring variable *Vi* in face of the previous presence of transition T, given by the number of cells where both *Vi* and *T* are found divided by the total number of cells where *T* is found;

P{Vi/ } = probability of occurring variable *Vi* in face of the previous absence of transition T, given by the number of cells where both *Vi* and are found divided by the total number of cells where *T* is not found.

Hence, the *W*+ values represent the attraction between a determined landscape transition and a certain variable. The higher the *W*+ value is, the greater is the probability of a certain transition to take place. On the other hand, negative *W*+ values indicate lower probability of a determined transition occurring in the presence of the respective variable range.

RESULTS AND DISCUSSION

The most relevant *W*+ values obtained during the model calibration are showed in Figures 2. This information represents the attraction between a determined landscape transition and a certain landscape attribute. Distance to rivers, insolation, distance to croplands, DEM, distance to roads and distant to markets were particularly associated with the land-use transitions. The distance to croplands is an important driving factor for all transitions indicating that the proximity to previously established croplands is a key factor for agricultural expansion in this region.

Although areas close to rivers did not retrieve high positive *W*+ values, the importance of water bodies for croplands is clearly reflected in regions distance to rivers, where high negative *W*+ values are observed. Hence, the results indicate that patches further than 1 km from water bodies have lower probability of being converted to cropland. Distance to roads also demonstrated a clear pattern in influencing the transition from shrublands to croplands. The distance to markets, here represented by the Euclidean distance to the main villages, was the most representative driving force for the agricultural expansion.

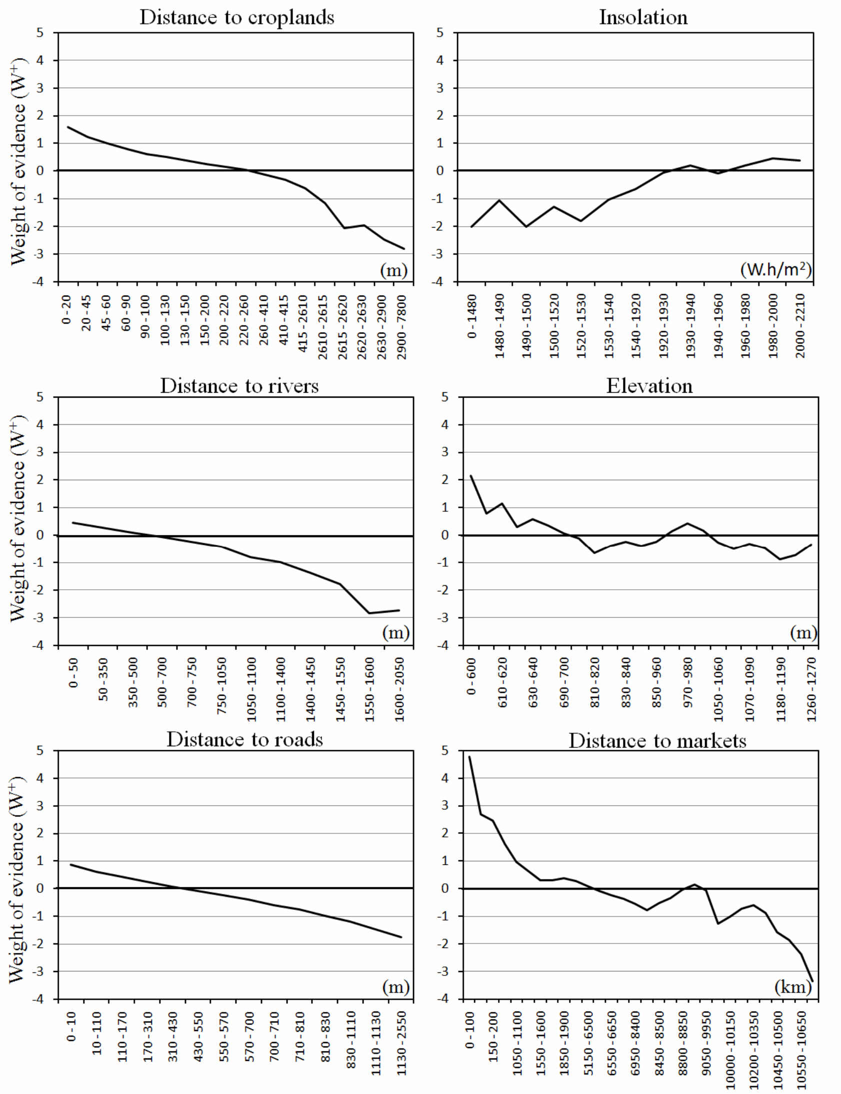

Figure 2. *W+* values attributed for each range of six landscape attributes most related to the "shrublands to croplands" transition.

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