



Land cover changes and landscape pattern dynamics in Senegal and Guinea Bissau borderland



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ABSTRACT

Different levels of climatic, agricultural, demographic, political and socioeconomic change have been detected in West African countries. For many years the human impact on the region was negligible, due to the low population density. However, in the last decades, demographic increase has accelerated exploitation of the natural resources and consequently the degradation of the ecosystems. Land cover degradation and landscape changes are more or less pronounced according to politic and socio-economic conditions of each country. In this study, a region located on the borderland of north Guinea-Bissau and south Senegal, is analyzed with regard to land cover and landscape trends, considering the socio-economic factors that drive them and the borderline effect. In this analysis, remote sensing data (Landsat TM, ETM+ and OLI data) were used to obtain four land cover maps for the years 1990, 2002, 2010 and 2015. The results show a similar landscape behavior in both countries, directly related to similar socio-economic practices. Forest area increase in both countries and there is a reduction in Agriculture/Bare soil areas until 2010. Main causes may be associated to the rural exodus, resulting from the conflict for independence of Casamance, which affects the borderland region of Senegal and Guinea Bissau, or to the conversion of agricultural areas into cashew orchards. In opposition, between 2010 and 2015, Forest area decrease and Agriculture/Bare soil increase, due to the recent trend of conversion of old cashew orchards into traditional fields of cereals and peanut. An increase in landscape fragmentation is observed in the period under analysis, revealing a heterogenization trend, which can be related to the adoption of similar human practices, in the last decades.

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1. Introduction

West African countries, such as the Republic of Senegal (SN) and the Republic of Guinea Bissau (GB), are experiencing an environmental and social decline characterized by an acceleration in degradation of the natural resources, expansion of agricultural area, rapid population growth, and deterioration in the quality of life (Tappan, Sall, Wood, & Cushing, 2004; Vasconcelos, Biaí, Araújo, & Diniz, 2002). Both natural and human factors are appointed by Brink and Eva (2009) to explain the important changes of natural vegetation in sub-Saharan Africa, mainly driven by the expansion of croplands. Natural biotic resources in these countries have

undergone severe changes as a result of demographic growth and the consequent increased demand for food and goods, associated with the regional climatic conditions of a long dry season, and high variability of annual precipitation, with frequent periods of drought. Some of the more affected ecosystems are the forests and the savanna woodlands, which represent an important source of goods for rural families and are mainly used to satisfy domestic needs and increase family income. Preserve these ecosystems, promoting its sustainable use, is extremely important in West Africa and particularly in GB, where the products they provide contribute to improve significantly the livelihoods of the poorest households (Barry, Creppy, Gacitua-Mario, & Wodon, 2007, p. 83; Lundy, 2009, p. 479, 2012). Moreover, ecosystem management and political state functions seem to be limited and very diverse, depending on the country, thus influencing landscape development and community life differently. This can be particularly critical in

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borderland regions, such as those located in GB and SN, where different management policies, adopted by each country, lead to different landscape behaviors. As these differences are a function of the time that the processes or factors are operating, it is extremely important to analyze the evolution of the landscape, in each country, which will, in turn, contribute towards understanding the planning measures to be adopted (Roder, Propper, Stellmes, Schneibel, & Hill, 2015) in order to establish a similar sustainable management system on both sides of the border.

The GB border divides the territory of some ethnic groups, in neighboring countries, thus creating a large cross border affinity in ethnic, cultural, religious and linguistic terms. These social factors, associated with favorable topographic conditions, in particular the flat landforms and the absence of deep valleys in the borderland, allow for a high cross border mobility of populations and goods. Given these social and natural conditions, the GB border does not constitute an effective barrier to the development of agro-livestock activities, commercial transactions, service procurements, or ethnic and religious relationships. In addition, it has even promoted the demand for health care and other services, as well as trading, in the borderlands, due to the more advantageous transactions or more adequate services in the neighboring countries.

The sector north of the border that divides GB and SN, which is analyzed in this study, is subject to regular movement of people, mainly associated with the weekly local markets that take place in both Casamance (SN) and in the GB borderland. These markets are extremely important, due to the peripheral location of these regions relative to the main cities and allow for the development of the local economy by increasing the economic power of traders and the local population (Fanchette, 2001). Moreover, due to proximity, accessibility and quality of services, health care providers in SN, such as the hospitals of Ziguinchor and Kolda, are much sought by the population of GB, that reach about 10% of the cases and hospitalizations (Dione, 2013, p. 247). With regard to territory planning, several concerted actions were carried out in 2005 and 2006 (Arragain & Salliot, 2006, p. 35) for management of the borderland valleys which led to implementation of hydraulic infrastructures and contributed to expansion of the area used for rice cultivation, which is the main agricultural production in both countries.

SN has a very positive trade balance with all West African countries, with exportations reaching about 47% and importations only 14% (ANSD, 2012–2013). However, its trade balance is negative with Europe (41% importations and only 27% exportations) and Asia (23% importations and 16% exportations) (ANSD, 2012–2013). Many of the European and Asiatic products arrive at GB markets by sea, mainly through the ports of Dakar (SN) and Banjul (Gambia), as well as by land, crossing the northern border. According to Catarino, Menezes, and Sardinha (2015), 90% of the GB exportations are focused on cashew nuts, mainly to India, being the main source of income in rural areas. Cashew trade is particularly relevant in the economy of GB and the main generator of national revenue (Lundy, 2012). GB occupies the sixth place of the most important world producers of cashew and SN the eleventh position. In GB the cashew higher production occurs in northwest regions, although plantations cover all country (Barry et al., 2007; Catarino et al., 2015). In SN most of cashew plantations are located in Casamance, mainly in communes nearer GB (Warrington, 2012).

The regular cross-border population movements between these two countries, have an impact on human settlements and road network development, as well as, on land cover, land use changes and landscape patterns, which can be assessed through comparing existing maps, satellite imagery and field surveys. Several studies, using remote sensing technologies and/or field observations have been developed for SN and GB to assess land cover/land use changes and vegetation composition. In Senegal, Wolf (1998)

analyzed the floristic structure, physiognomic characteristics and diversity of the existing woody vegetation, and evaluated the typology, taking into account the two major environmental variables, precipitation and topography. Moreover, Woomeer, Tieszen, Tappan, Touré, and Sall (2004) described the effects of climate and land use changes on terrestrial carbon stocks, and Liu, Kairé, Wood, Diallo, and Tieszen (2004) explored a model to simulate carbon dynamics, in south Central Senegal, incorporating land use change data into the model, and discussed management options from the perspective of potential carbon sequestration and sustainable regional development. In the Cacheu and Orango protected areas, in the north borderland of GB, Vasconcelos et al. (2002) quantified and spatially characterized land cover changes between 1956 and 1998. As a contribution to the establishment of a deforestation baseline and to the assessment of the carbon stocks in the above-ground biomass, Oom et al. (2009) quantified GB's deforestation rate and documented spatio-temporal forest changes between 1990 and 2007. Focusing on mangrove species, Vasconcelos et al. (2015) quantified carbon stock dynamics and the expected returns if their deforestation were avoided. From the socio-economic point of view, Temudo, Figueira, and Abrantes (2015) developed an analysis to understand the complex interaction between agro-ecology and socio-political history of GB and the associated drivers of land use/cover changes. Given the relevance of cashew in GB after the mid-1980's, many authors studied the socio-economic impact of the accelerated conversion of large agricultural areas into permanent cashew orchards, referring an annual rate of 12% in cashew production and 8% in cultivated area (Barry et al., 2007, p. 83; Catarino et al., 2015; Lundy, 2009, p. 479; 2012; Temudo et al., 2015).

Despite the existing studies, few have focused on landscape modification and the associated anthropogenic factors over time and no studies were found comparing the regions located on the north borderline between SN and GB. This type of information is extremely important in this critical border area since, in the last decades, it has suffered severe disturbances and armed conflicts with impacts on the livelihood of the rural population and subsequent consequences on land cover and landscape patterns (Robin, 2006). One of the conflicts that persisted for several decades was associated with the struggle for independence of the Casamance region (SN). Its beginning can be confused with the Casamance resistance to the Portuguese arrival in the region, continuing throughout the French colonial period and during SN's independence (Tandia, 2010). The conflict, clearly related to local ethnic specificity and of a deeply socio-economic, political and cultural nature, was in the origin of the Movement of Democratic Forces of Casamance (MFDC) in March 1947.

MFDC only had sporadic activities until 1982, but rebellious activities increased, in the 90s, when Dakar implemented a development policy in urban centers, and Casamance, as a peripheral region, became only human and natural resources provider. As a consequence, there were several public manifestations in Casamance, repressed by the governmental military forces which led to loss of human lives and growth of the ideal of separatism (Diallo & Fernandes, 2011). The conflict spread to the neighboring countries, namely GB, where MDFC deployed military bases, until the end of the last century. Repeated military activities from the Senegalese forces and uprisings of the armed MFDC group led to displacement of the population in the borderlands of GB, and consequently the economic infeasibility of the northern part of the country (Tandia, 2010). Involvement of GB in the Casamance independence issues, led to a conflict in the country, resulting from a disagreement between the Bissau government and its military forces, in 1998, and in 2000 the government stopped supporting the MFDC, participating in peace negotiations between Senegalese government and this

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