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Assessing forest change in a priority West African mangrove ecosystem: 1986–2010

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ABSTRACT

This study examines the areal extent and status of mangrove forests in a West African region prioritized in contemporary conservation, climate change, and livelihood initiatives. The focus is the transnational region of the western coastal section of The Gambia and Senegal located between the Gambia and Casamance Rivers. Remote sensing applied to Landsat images of the interfluvial region in 1986 and 2010 indicates a 35% decline in overall mangrove coverage for the study area with sub-regions of pronounced loss. There was a 12% decline along the south bank of the lower Gambia River and a 43% decrease in coverage between the Gambian border and the Casamance River. Mangrove loss reached 92% in the northern section of Casamance south of the international border between Senegal and The Gambia. Fieldwork suggests that the mangrove decline over the study period is in part driven by the growing firewood demand of urban centers. The remote-sensing analysis, complemented by fieldwork in the region, attributes the negative trends to the Gambian demand for firewood, political instability in Casamance, and a porous international border that facilitates illegal cutting and smuggling.

1. Introduction

Mangrove forests are at the forefront of contemporary scientific and conservation concerns. They are repositories of biodiversity and provide vital habitats for a vast range of reptiles, birds, mammals, and aquatic species (Alongi, 2002; Nagelkerken et al., 2008). Mangroves also protect coastal areas from erosion (Mazda et al., 2002). The bio-shield function of mangroves is likely to assume greater importance with anticipated sea level rise this century (IPCC, 2007; Alongi, 2008; Gedan et al., 2009). Threats to the mangrove ecosystem place many species at risk, including human populations who live along coasts and river estuaries. Satellite images, available since the 1970s, provide an important tool for accurately assessing mangrove coverage and the effects of conservation programs (Freiss and Webb, 2011). They bear witness to a global decline in mangrove forests, which are being cleared for shrimp ponds, tourist infrastructure, roads, building poles, and firewood. The United Nations' Food and Agriculture Organization (FAO) estimates that since 1980 an alarming 20% of the world's mangroves, or 3.6 million hectares, has been lost globally (FAO, 2007). Other estimates place the reduction in coverage over this period as high as 35% (Giri et al., 2011). It is now the case that "approximately 75% of the world's mangroves are found in just 15 countries, and only 6.9% are protected under the existing protected areas network" (IUCN I–IV in Giri et al. (2011:154)).

Mangrove loss in Africa—home to nearly 20% of mangroves found worldwide (2.7 million of 13.7 million total hectares) (Comín, 2010; Giri et al., 2011)—follows the pattern of global decline with more than half a million hectares destroyed since 1985 (FAO, 2007; Saenger, 2003). Current conservation initiatives in West Africa prioritize mangrove forests of ecological significance and strategically seek their protection. The mangrove forest situated along Atlantic estuaries from Senegal to Guinea is one such area. It fronts one of the world's most biologically diverse and economically important marine habitats and fishing zones, known by the IUCN as the West African Marine Eco-Region (WAMER).[1] Three-quarters

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[1] The West African Marine Eco Region (WAMER), designated by the International Union for the Conservation of Nature (IUCN), is home to dolphins, whales, manatees, several endangered turtle species, and over 1000 species of fish. It is also a globally significant breeding and over-wintering site for numerous migratory birds. WAMER spans 3500 km of the Atlantic coast from Mauritania to Senegal, The Gambia, Guinea-Bissau, Guinea, and includes the offshore Cape Verde archipelago. It is circumscribed by the Atlantic's Canary Current; the upwelling of cold water delivers nutrients to the sea-beds and rocky reefs that support productive fishing grounds from the coasts of Mauritania southward to Guinea. Some eight million people currently live along this Atlantic African coastline (http://wwf.panda.org).

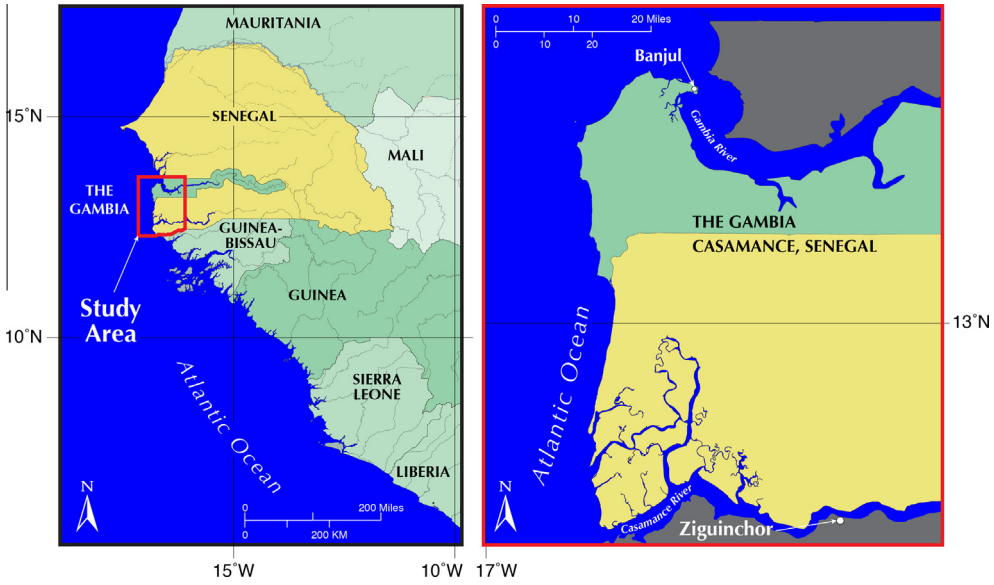

Fig. 1. WAMER study area.

of WAMER fish species spawn in the stilt-root mangrove waters. Several mammalian and amphibian species—including the endangered West African manatee and five species of turtle—depend on the ecosystem for breeding (Nagelkerken et al., 2008). The habitat is home to hundreds of resident and migrating bird species, making it a globally significant avian flyway (Bos et al., 2006). WAMER mangroves also provide critical ecosystem services to local populations, such as protein from fish and shellfish, firewood, building materials, tannin, dyes, honey, and medicines (Cormier-Salem, 1999).

WAMER mangrove landscapes have long been inhabited. Historical records reveal that people were already living and securing food and livelihood in the mangrove forests of West Africa when Portuguese caravels arrived in the mid-fifteenth century (Cormier-Salem, 1999; Carney and Rosomoff, 2009). A testament to the importance of WAMER mangroves and associated fisheries is the actual word *mangrove* itself. Mangroves are found in tropical and sub-tropical areas the world over, but the origin of the word derives from the Wolof language of Senegal and The Gambia (Senegambia). When Portuguese mariners first encountered the mangroves of West Africa—an environment unknown in Europe—they adopted the Wolof *mangue* for these forests, from which mangrove in English is derived (Vannucci, 1989). Until the 1960s mangroves did not elicit much conservation interest except among those who traditionally inhabited them (Vannucci, 1989). This has profoundly changed over the past fifty years with recognition of the support mangrove forests provide to marine fisheries, as sinks for carbon storage, and for protection of coastal areas from erosive forces.

This study isolates one critical section of WAMER that is vital to conservation objectives in the region: the mangrove-forested lowland extending inland from the West African Atlantic littoral zone and bounded to the north and south respectively by the Gambia and Casamance Rivers. The interfluvial lowland is crisscrossed by channels and intertidal mud flats that are interspersed with areas of higher ground. The study area includes portions of two West African countries, The Gambia and Senegal. This WAMER region contains one of West Africa's most intact mangrove ecosystems as well as some of its most degraded. As a result, it has attracted in recent years a significant number of mangrove reforestation projects and conservation initiatives.

Remote-sensing techniques are indispensable for monitoring the world's ecosystems and especially suitable for assessing those, such as mangroves, that are often inaccessible, at risk, and comparatively less studied (Giri et al., 2011; Kuenzer et al., 2011; Heumann, 2011; Fatoyinbo and Simard, 2013). Satellite imagery assists in the detection of forest change over time and in targeting critical areas for protection and reforestation. There is general consensus that the mangrove forests of Senegal and The Gambia experienced die-back in the aftermath of the 1968–1974 Sahelian drought (Saenger and Bellum, 1995; Spalding et al., 2010; Aizpuru et al., 2000). More controversial is whether there has been natural regeneration and ecosystem recovery in the decades since. Valiela et al. (2001) estimated that between 1982 and 1995 mangrove coverage in the two countries decreased by more than half, from 5000 to 2352 square kilometers. However, a remote-sensing study by Conchedda et al. (2008) determined that mangrove coverage of the lower Casamance estuary in Senegal increased 6% between 1986 and 2006. Nonetheless, a declensionist perception continues to guide contemporary environmental policies being implemented in Senegambia. Several European food and utility companies now sponsor reforestation projects in Senegal in exchange for carbon credits under REDD+ (Reduced Emissions from Deforestation and Forest Degradation+) climate-mitigation mechanisms. In 2009 the French dairy giant *Danone* began funding reforestation projects to plant 70 million mangrove seedlings on degraded floodplains (Down to Earth, 2013). National and international NGOs and the U.S. Peace Corps are involved in similar regional initiatives. Mangrove reclamation projects are also being established along tributaries of the Gambia River (Sandbrink and van Meijeren, 2010). In response to lobbying by international conservation organizations, the Gambian government in 2007 placed the Tanbi Wetlands Complex (Ramsar, 2013), which holds the largest intact WAMER mangrove forest, under protective status. The following year it was incorporated within the 6300-ha Tanbi National Park.

This article contributes to ongoing research on mangrove forests of Senegambia. We assess changes in mangrove coverage in the study area and discuss broader factors that have contributed to the observed trends. Building upon the remote-sensing and livelihoods approach of Conchedda et al. (2008), this study similarly employs a regional scale of analysis to clarify patterns of change. However, instead of framing the region within the political borders of a single country (Senegal), we consider a transnational region of Senegambia bounded by the Gambia and Casamance rivers. The