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Floods and mangrove forests, friends or foes? Perceptions of relationships and risks in Cameroon coastal mangroves

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ABSTRACT

Faced with the growing influence of climate change on climate driven perturbations such as flooding and biodiversity loss, managing the relationship between mangroves and their environment has become imperative for their protection. Hampering this is the fact that the full scope of the threats faced by specific mangrove forests is not yet well documented. Amongst some uncertainties is the nature of the relationship/interaction of mangroves with climate driven perturbations prevalent in their habitat such as coastal floods. We investigated the relationship between coastal flooding and mangrove forest stabilization, identify perceptions of flood risk and responses to offset identified effects. Random household surveys were carried out within four communities purposively sampled within the Cap Cameroon. Coastal changes were investigated over a period of 43 years (1965–2008). Seasonal flooding improved access to mangrove forests and hence promoted their exploitation for non-timber forest products (NTFPs) such as fuel wood and mangrove poles. 989 ha of mangrove forests were estimated to be lost over a period of 43 years in Cap Cameroon with implications on forest resources base, ecosystem stability, and livelihoods. Alternative livelihood activities were found to be carried out to moderate interruptions in fishing, with associated implications for mangrove forest dynamics. Respondents were of the opinion that risks associated with floods and mangrove deforestation will pose a major challenge for sustainable management of mangroves. These locally relevant perceptions and responses should however enable the identification of pertinent needs, challenges and opportunities to inform and orient effective decision-making, and to facilitate the development and participation in adaptive management strategies.

1. Introduction

Faced with the growing importance of issues of environmental change such as climate change and loss of biodiversity, the protection of mangrove forests has become imperative (Gilman et al., 2008; Heller and Zavaleta, 2009; Butchart et al., 2010). Mangroves are salt-tolerant evergreen forests that often form monospecific communities at inter-tidal or transitional zones between dry lands and the open ocean in tropical and sub-tropical regions found between 25°N and 25°S (Mitsch and Gosselink, 2000). Previously considered only as 'inferior forests' and passed up during forest debates, mangroves are increasingly gaining recognition for the indispensability of their ecosystem services. They perform valued regional and site-specific functions (e.g. Ewel et al., 1998; Gilman et al., 2008). These include provisioning for human well-being and development, regulation (e.g. sedimentation, climate and aquatic ecosystems), habitat, and protection of communities and terrestrial ecosystems during hurricanes, coastal floods and tsunamis (Duke et al., 2007; Suratman et al., 2008). Mangroves are efficient natural carbon sinks which are important in mitigating climate change (Donato et al., 2011). Despite their importance, mangroves are amongst the most threatened forests of the world, yet the full scope of the threats faced by specific mangrove forests is not yet well known. Amongst some of the biggest uncertainties is the nature of the relationship/interaction of mangroves with climate driven perturbations prevalent in their habitat such as coastal floods (Gilman et al., 2008; Polidoro et al., 2010).

Mangrove forests are facing increasing degradation owing to established threats from human activities (WWF, 2001; UNEP, 2007). Over the past 50 years, 50% of the 181,390 km^2 of global mangrove forest has been lost worldwide and it is estimated that

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70% of Africa's present total mangrove area of 34,266 km^2 will be lost if current trends of mangrove loss are not arrested (IPCC, 2007; Duke et al., 2007).

In Africa mangrove loss is driven by agriculture, aquaculture, deforestation (e.g. for fuel wood, charcoal and salt production), oil exploration, drilling and production, fishing and hunting, and urban and tourism development. Fuel wood for fish smoking is the main driver behind the loss of Cameroon's mangrove, with deforestation rates of 8.28% per year (Feka, 2005; Ajonina et al., 2008; Alongi, 2008; Feka and Manzano, 2008; Feka et al., 2009; Feka and Ajonina, 2011).

Based on the unique physiological, reproductive and respiratory characteristics of the mangrove trees that make them ideally suited to live in partially inundated salt water environments, it has generally been suggested that mangroves are resilient to climate change (IPCC, 2007; Alongi, 2008). However, sea level rise is acknowledged as the greatest impact of climate change on mangroves (Field, 1995, McLeod and Salm, 2006; Lovelock and Ellison, 2007). Relative sea-level rise is a substantial cause of recent and predicted future reductions in the area and status of mangroves and other tidal wetlands (Ellison and Stoddart, 1991; Nichols et al., 1999; Ellison, 2000; Cahoon and Hensel, 2006; McLeod and Salm, 2006; Gilman et al., 2006, 2007a,b), although, to date, it has likely been a smaller threat than anthropogenic activities (Primavera, 1997; Valiela et al., 2001; Alongi, 2002; Duke et al., 2007). With the associated possibility of more frequent and intense coastal floods, how wetlands will be affected is increasingly becoming an important question (Church et al., 2004). In addition, inundation may result in significant land loss in Cameroon's coastal or small island settlements (Folack and Gabche, 2001). However, little inquiry has been made on the nature of the relationship/interaction between coastal inundation and the mangrove forests surrounding these settlements (Munji, 2010). Therefore, we investigated in this paper how people adapt to a dynamic and challenging mangrove ecosystem. It provides a useful baseline for a follow up study after some of the phenomena detected cause significant changes in the ecosystem observed. The paper also presents the results of a survey of flooding which has not been widely investigated in other mangrove ecosystems.

1.1. Impacts of mangrove forest reduction

Reduced mangrove area and health increase the threats from coastal hazards (e.g. erosion, flooding, storm waves and surges, and tsunami) to human safety and development (Danielsen et al., 2005; Kathiresan and Rajendran, 2005; Dahdouh-Guebas et al., 2005a,b, 2006). Mangrove loss also reduces coastal water quality and biodiversity, eliminate fish and crustacean nursery habitat, adversely affect adjacent coastal habitats, and eliminate a major resource for human communities that rely on mangroves for numerous products and services (Din et al., 1997, 2001, 2002; Ewel et al., 1998; Din and Ngollo, 2002; Mumby et al., 2004, Nagelkerken et al., 2008; Walters et al., 2008). Potentially, coastal floods can cause environmental degradation and disruption of ecological balance. Subsequent impacts include migration of mangrove forest inland or seaward, sedimentation, extinction of migratory bird species, and threats to inhabiting species (IPCC, 2007). Mangrove destruction can also release large quantities of stored carbon and exacerbate global warming and other climate change trends (Kristensen et al., 2008). Accurate predictions of changes to coastal ecosystem area and health (e.g. in response to projected relative sea-level rise and other climate change outcomes), enable site planning with sufficient lead time to minimize and offset anticipated losses (Titus, 1991; Hansen and Biringer, 2003; Gilman et al., 2006, 2007a).

1.2. Natural-human system interactions

Understanding the interaction between natural and human systems must be considered to effectively assess vulnerability of the systems, and the likelihood of transformation of those systems (De Lange et al., 2010). The lack of inquiry into the cumulative effects of climate driven perturbations such as flooding with other drivers of ecosystem destabilization such as deforestation is of particular pertinence in coastal areas. In Cameroon for instance, despite the growing consensus that floods and an increasing concentration of forest-dependent populations are the most prevalent phenomena in the mangrove forests (Molua, 2011), the nature of the relationship between floods, livelihoods and mangrove forests is not well studied (Munji, 2010). While science has an established efficacy in the identification of critical drivers of climate change and risks, impact and vulnerability modeling and analysis, establishing linkages between nature and society is an area where science falls short (Rahmstorf and Zickfeld, 2005). To understand these interactions in a changing environment, there is a need to identify local perceptions of change, risk, and responses (Adger, 2006; Grothmann and Reusswig, 2006).

Grass root level information provides insights into the perceptions and responses to adaptations by the local communities who are directly affected by the changes in the environment. This information is vital to better comprehend, analyze and offer sustainable solutions to the problems related to climate change (Dolan and Walker, 2006).

We aimed to investigate the relationship between coastal flooding and mangrove forest stabilization, identify perceptions of risk, and responses to offset identified effects. Specifically, we investigated the following questions: Does flooding change the physical and biological characteristics of a mangrove forest? Does flooding affect mangrove forest recruitment and regeneration? Does flooding influence sedimentation in mangroves? How do inhabitants of the study area perceive risks related to observed changes? What are the responses taken to protect mangroves?

1.3. Study area

The coastal mangrove forest zone of Cameroon is located in the extreme South West of the country. It stretches discontinuously along the Cameroonian coastline, which is located in the northeastern end of the Gulf of Guinea and measures 402 km from the Equatorial Guinea border to the Nigerian border (Fig. 1) (Din et al., 2002; Feka and Ajonina, 2011). The mangrove forests extend from the low tide mark to about 30 km inland, covering an area of about 1957 km^2. More than 90% of the mangrove occurs in two estuarine complexes flanking the volcanic horst; the Douala estuary and the Rio-del-Rey estuary (Din et al., 2001; Folack and Gabche, 2001; WWF, 2001).

The climate is of the equatorial type which is characterized by abundant rains (3000–4000 mm per year), and generally high temperatures with monthly mean day temperature of 24–29 °C. Rainfall is generally high during the rainy season that lasts for about 7 months (April–October), with the most rainfall occurring between June and October (Ajonina, 2008). The ecosystem is normally inundated by a tidal variation of about 2 m in the rainy season and 1 m in the dry season (WWF, 2001). The propagation of waves and ebb-tides is enormous, though poorly known (Folack and Gabche, 2001). Historically, settlements within this ecosystem experienced intense floods about once every 5–7 years. The lag time between two successive floods reduced consistently until presently intense flooding occurs within the area every year. Peak flood periods occur within the months of July, August, September, and October (Munji, 2010).