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Participatory scenario development process in addressing potential impacts of anthropogenic activities on the ecosystem services of Mt. Marsabit forest, Kenya

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ABSTRACT

The Marsabit Forest Reserve (MFR), a green island in an arid environmental setting, generates multiple ecosystem goods and services (ES) to the local community critical for their livelihoods. The forest has been experiencing substantial land conversion for town expansion, agriculture production and settlements threatening long-term ES provision. Sustaining the forest ES under increasing anthropogenic pressures is one of the great challenges of the Marsabit forest community. We used focus group discussions in the thirteen locations around the forest and individual key informant's interviews in the identification of drivers of change and their potential impacts on ES in MFR. We used the scenario development process (SDP) in coming up with four divergent but plausible exploratory scenarios. The study established that the main ES provided by the forest was, water, fuelwood, forage (dry season grazing resource), medicinal plants and timber for construction. Stakeholders identified population pressure, unsustainable utilisation of forest resources, institutional barriers to effective resource management, land use and climate change as the main drivers impacting ES provision in the forest. Land use change and climate change were considered the most significant drivers yet the most uncertain in the future impacting ES provision in the MFR. The SDP identified four alternative future scenarios for the MFR by the year 2044 with the Marsabit we want scenario identified as the most desirable future for the sustainable supply of ES with adequate adaptation to observed changes. Stakeholders came up with a joint action plan implementation matrix for the identified scenario while mitigating the negative aspects of the alternative scenarios. The results support the need for participatory land use planning that takes into to account the growing threat of climate change to natural forest systems.

1. Introduction

The Millennium Ecosystem Assessment (MEA) defines ecosystem services (ES) as the goods and services local communities obtain from an ecological system for their wellbeing (Reid et al., 2005). These ES were further broken down into four distinct categories: provisioning services, regulating services, supporting services and cultural services (Díaz et al., 2006).

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Environmental stresses have caused untold deterioration of terrestrial, freshwater, and marine environments (Butchart et al., 2010). Anthropogenic intervention in various ecosystems causes habitat loss, degradation, and fragmentation, and is, therefore, a leading cause of terrestrial biodiversity loss, impairment of ecosystem functioning, and loss of ecosystem services (IPCC, 2007). According to most researchers, the assessment of ES demands an integrative approach that considers ecological, economic and social evaluation criteria (Burkhard et al., 2009).

The Marsabit Forest Reserve (MFR), a dry tropical forest in the middle of a semi-arid region, is of critical importance to sustaining life not only within the forest but also in the surrounding areas harbouring a diverse range of ecosystems and associated biodiversity. The forest is experiencing anthropogenic pressures through illegal extractive activities, increasing human population in the surrounding areas, conversion of lands around the forest to other land uses, and human encroachment from Marsabit town – all these threaten the sustainability of the forests' ES provision (Githae et al., 2008). Reid et al. (2005) recommend an integrated approach to establishing the status and threats to ES in different jurisdictions, factoring both scientific, economic and social aspects of ES assessment. The participatory scenario development process (SDP) which was used in this study is a systematic method for thinking creatively about dynamic, complex and uncertain futures, and identifying strategies to prepare for arranging of possible outcomes (IPCC, 2014). They can be used to (1) enable managers to understand better the forces driving landscape change and work with landscape stakeholders, as well as to (2) improve adaptive capacity, not only by responding to landscape changes but also by anticipating them. Scenarios may be developed with little participation from stakeholders but may be participatory, given their capacity to influence decisions that may have wide-reaching implications for a range of stakeholders (Reid et al., 2005). SDP has been applied to various issues including; community forest management (Wollenberg et al., 2000); rural funding policy in mountainous landscapes (Bayfield et al., 2008); deforestation in Brazil (Soler et al., 2012); forest management impacts on livelihoods (Kassa et al., 2009); future environmental changes Lake Victoria basin (Odada et al., 2009); management of natural parks (Daconto and Sherpa, 2010); and changes to freshwater resources (van Vliet et al., 2010). Given the dynamic complexity and unpredictability of socio-ecological systems, as they respond to drivers such as climate change, scenarios are increasingly being developed at various temporal and spatial scales to help people prepare for change (Eames and Skea, 2002).

It is, therefore, necessary to study how future anthropogenic pressures might affect human-environment interactions in the Marsabit Forest Reserve and the effects of forest destruction on ES provision. This will inform possible future interventions about mitigation and adaptation efforts for sustainable ES provision by the Marsabit forest. Our study aimed to (i) to identify ecosystem services and how they are perceived by local communities (ii) assess the impact of anthropogenic activities on ecosystem service provision (iii) identify through the scenario development process the most plausible outcome that will sustain ecosystems service provision and (iv) develop an action plan for the favored scenario outcome to build resilience to related changes in the Marsabit forest community.

2. Materials and methods

2.1. Study site

Mount Marsabit is a unique dry forest system in Kenya which is ecologically and socio-economically important to the people of Marsabit County (Githae et al., 2008). It is located between latitude 01°15′North and 04°27′ North and longitude 36°03′ East and 38°59′East (Fig. 1). It was established in 1948 (Synott, 1979) and is the only government gazetted forest in Marsabit County under the management of Kenya Wildlife Service and Kenya Forest Service (Kenya Wildlife Service, 2016).

The MFR covers approximately an area of 157 square kilometres with the highest point on the mountain at 1836 meters above the sea level. It is an isolated area in the semi-arid region of northern Kenya in Marsabit County, about 560 kilometres from Nairobi, Kenya's capital city. Being an extinct volcano, the MFR has rich and well developed volcanic soils (mainly Cambisols) which have a high-water retention capacity (KFWG, 2001). Some areas have moderately deep clay loams while others are stony or rocky. The soils are suitable for crop farming in areas of sufficient rainfall. It experiences a bimodal rainfall pattern with mean annual rainfall ranging between 600 and 1000 mm per year (Bake, 1984). The long rains (March–May) are brought by southeasterly winds. Most rainfall is experienced in the March to May and October to December rainy seasons. The intervening periods are dry. Highest temperatures usually are experienced in February, ranging between 30° and 35 °C while lowest temperatures are experienced in March and July and range between 22° and 25 °C.

The floristic composition of Marsabit forest is a mosaic of mature and transitional forest types, deciduous woody shrublands and wetland communities (Githae et al., 2008). The vegetation clusters depict a combination of climax, remnant and or regenerating and colonising species. There is an evergreen to semi-deciduous bushland type vegetation that is most extensive on the southern and southeast sides of the mountain. The evergreen forest is dominated by *Cassipourea malosana, Podocarus gracilior, Olea africana, Juniperus procera* and, *Croton megalocarpus*. The MFR is located in Saku constituency with a population of 46,502 persons with a third (16,213) of them residing around the MFR (Wiesmann et al., 2014). It consists of thirteen locations namely, Hula Hula, Karare, Dirib-Gombo, Songa, Kituruni, Leyai, Sagante, Qilta-korma, Gabra Scheme, Dakabaricha, Nagayo, Jirime, and Mountain central in the urban set up (Fig. 2). The communities surrounding the study area are predominantly Rendille (in Karare, Hula Hula, Leyai, Kituruni and Songa locations) Gabbra (in Jaldesa location) and Borana (in Jirime, Jaldesa, Mountain central, Dakabaricha, Qilta-korma and Nagayo locations). The other smaller ethnic groups of Burji, Turkana, Samburu, Sakuye, Somali, Ameru and other migrants also occupy these locations around the MFR. Pastoralism is the main economic activity in the study area, accounting for 80% of the economic activities, while subsistence agriculture