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Mapping of ecosystem services flow in Mida Creek, Kenya

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ABSTRACT

The concept of ecosystem services (ES) and its application in natural resources management decision making is a new conservation paradigm. A better understanding of ES in resource-rich developing countries can contribute to poverty alleviation and sustainable development, while at the same time conserving natural resources. This study assessed the flow of ES in Mida Creek, a marine reserve in Kenya, with the aim of characterizing land use/land cover (LULC) classes, spatially mapping distribution of ES, identifying important ES, and establishing the opinions of experts on ES flow. A qualitative and quantitative assessment was carried out coupling expert scores and LULC maps in a matrix structure. A participatory approach was used to engage and raise awareness with the community groups who actively participate in conservation activities in the creek, together with researchers/academics/managers who also are involved with the management of the reserve. The study was carried out between July and October 2015 and a total of 65 participants were involved. Datasets were collected using questionnaires in which ecosystem service flow was scored based on expert estimates per LULC class against the selected ES. Data were assessed using statistical and spatial analysis techniques. Results for the flow of provisioning services showed that, while palm trees were the main source of firewood (68%), other vegetation types were also an important source for wood products, including charcoal (46%), construction poles (54%) and fishing gear (68%). There was also a high flow of provisioning services (sea food and bait organisms) from water bodies (82%) and mangroves (80%). Flow for regulating services was mainly from mangroves, and for cultural services from beaches, mangroves and water bodies. Saline bare areas and sand flats scored least for all the ES. There were statistically significant differences in the scoring of the LULC against the different categories of provisioning, regulating and cultural services between the local communities and the other stakeholders. The method shows both the location of the resources utilized by the communities and, also, facilitates communication between these communities and the decision makers, thereby providing an example of a management strategy at the local scale for other coastal regions of Kenya and elsewhere.

1. Introduction

Marine and coastal ecosystems provide an extensive range of services to human society including supporting, regulating, cultural and provisioning services (UNEP-WCMC, 2011). However, many of these ecosystems are under increasing threat from human-related exploitation, both for direct (e.g. fishing) and indirect (e.g. tourism) consumption. Increasing societal demand for marine resources has led to substantial alterations in the flow of ecosystem services (ES) and even loss of services e.g. flood protection and water quality (Small et al., 2000; Small and Nicholls, 2003). The Millennium

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Ecosystem Assessment (M.E.A, 2005a, b), a synthesis of scientific knowledge about global ecosystems and their capacity to support human well-being, showed that human use of marine and coastal ecosystems is expanding, commensurate with the growth of coastal human population and expansion of consumption. With many competing uses of marine and coastal ecosystems and their services, there is a need to formulate and improve policies that will catalyse management efforts to reverse their continued decline.

Formulation of policy and implementation of management decisions to reduce, or even reverse ecosystem decline, will require a consideration of ES. Recently, studies have suggested that incorporating ES information into environmental policies and management can lead to environmental decisions that secure a broader set of desired future outcomes (Daily et al., 2009; Turner and Daily, 2008; Arkema et al., 2015; Schaefer et al., 2015). Managing natural capital from an ES perspective is useful in establishing priorities for the management of essential functions of ecosystems (Balmford et al., 2002), thus enabling natural resource managers to focus on the areas and habitats that deliver the greatest amount and/or the highest value of ES (Kremen, 2005). Alternatively, priorities can also be based on the most critical threats to the delivery of ES from the most valuable areas (Leslie and McLeod, 2007). Thus, scientific understanding of ES will provide basic information that will enable resource managers to take adaptive management measures; thereby, ensuring that the supply and capacity of an ecosystem to provide services is not degraded (Leslie and McLeod, 2007; Palomo et al., 2013; Arkema et al., 2015).

Managing natural capital to maintain ecosystem structure and function requires evidence to demonstrate how the incorporation of natural capital and ES into decision making can lead to better outcomes for improving human well-being (Guerry et al., 2015). This evidence also requires a multidisciplinary approach that can integrate the data on the physical, economic and social aspects of ecosystems. Policy makers and resource managers have begun to apply the ES perspective into marine and coastal policy and management, although it is not yet a usual practice. Most assessments and mapping of ES are still focused on large scales, hindering the use of such assessments for decision making at the national, and sub-national scale (M.E.A, 2005a, b; Turner and Daily, 2008). Therefore, there is a need to increase assessments and mapping of ES at smaller geographical scales, consistent with capturing all the relevant effects of the biophysical and social processes (Lovell et al., 2002; Perrings et al., 2011) necessary for decision makers to address impacts on biodiversity and ecosystem change at the local level.

There are several components of ES delivery that can be assessed including capacity, demand, ecological pressure and flow (Villamagna et al., 2013; Burkhard et al., 2014). Flow is defined by Burkhard et al. (2014) as a set of ES currently consumed or used in a particular area over a given period of time. In Kenya, like in other African countries, most of the communities' livelihoods revolve around natural resources (Egoh et al., 2012). Therefore, there is need to understand how people interact with the environment in order to identify sources of problems (Stedman-Edwards, 1997). The ES approach is one way to promote conservation of marine resources because it focuses on the social, ecological and economic aspects of a system (M.E.A, 2005a, b). Mapping of flow enables the evaluation of ES sustainability using different scenarios. It also gives information on the current and future biophysical capacity of an area to produce ES (Villamagna et al., 2013). Understanding of the flow of ES and their spatial distribution should support adaptive management of Marine Protected Areas (MPA) in Kenya. Managers can then take adaptive measures to ensure that supply and capacity of the ecosystem to provide services is not degraded (Burkhard et al., 2012; Palomo et al., 2013).

In Kenya, there are two types of MPA. The first category comprises Marine National Parks (MNP), where there is total protection from any type of direct consumption, although indirect activities such as tourism can take place for a fee (Tuda et al., 2014) and, the second is Marine National Reserves (MNR), which allows traditional harvesting of resources, as well as research and tourism (Tuda and Omar, 2012). Extending the work of Kirui et al. (2013), who focused on mangrove land cover changes at a large scale along the Kenya coast, this study has characterized land use/land cover classes of a mangrove area at the local scale of the Mida Creek MNR. Despite being a resource-rich area, poverty levels in the study area and its surroundings is still high (Government of Kenya, 2009), and degradation of natural resources is on the rise through illegal activities that have led to the loss of biodiversity (Muthiga et al., 2000; Muthiga, 2009). Through this study, a matrix approach has been used to develop spatial maps of ES flow, to identify important ES, and to establish opinions of experts on ES flow (Burkhard et al., 2009; Jacobs et al., 2015). The findings of this study on the assessment of ES flow using mapping techniques will inform better management strategies for the Kenyan coast, as well a raising awareness and educating the community about ES. The results will also add to the literature on mapping of ES in developing countries at local scales.

2. Study area and methods

2.1. Description of Mida Creek

Mida Creek is part of the Watamu Marine National Reserve in Kenya. It covers an area of 31.6 km^2 (Dahdouh-Guebas et al., 2000), and is situated 100 km North of Mombasa in Kilifi County (Fig. 1). Watamu Marine reserve is part of the Watamu-Malindi Marine Reserve complex (Fig. 1), which in 1979 was recognized and designated as a Biosphere Reserve (Kairo et al., 2002). The study area is under the jurisdiction of the Kenya Wildlife Service (KWS) who take planning and management decisions (Weru, 2001), and the Kenya Forest Service (KFS) who are responsible for the mangrove forest reserve. Mangrove forest is the dominant habitat in the Creek, occupying 1746 ha, and supporting 7 of the 9 mangrove species found in Kenya (Kairo, 2001). The extensive sand flats in the area also form important habitats for shorebirds (Kairo, 2001), which has led to its global recognition as an Important Bird Area. It is an important Social Ecological System (SES) for the local community who can access the reserve for fishing, tourism and conservation activities. However, to access and cut mangroves, community members require licenses from KFS while fishing licences are obtained from the Fisheries department. The different mandates have sometimes led to confusion and even conflict among resource users; for example, disagreement between sport and artisanal fishers over the collection of 'bait' organisms from the reserve by sport fishers (Weru, 2001). The other issues facing the area are overexploitation of fish stocks, use of destructive fishing methods and poaching. These various conflicts indicate a need for a renewed integrated natural resource management strategy that will provide a management framework for the sustainable use of these natural resources (Vrebos et al., 2015).

2.2. Methods

This study tested the land use/land cover (LULC) matrix approach developed by Burkhard et al. (2009). Local knowledge and expert views were integrated with LULC data in a qualitative and quantitative assessment. The methods that were used in the study included: (1) selection of ES using literature review and expert knowledge; (2) use of a matrix approach for scoring flow of