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Assessment of provisioning and cultural ecosystem services in natural wetlands and rice fields in Kano floodplain, Kenya

Risper Ajwang' Ondiek*, Nzula Kitaka, Steve Omondi Oduor

Department of Biological Sciences, Egerton University, P.O. Box 536-20115, Egerton, Kenya

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ABSTRACT

This study assessed provisioning and cultural ecosystem services (ES) provided by natural wetlands and rice fields in two Kenyan wetlands; Ombeyi natural wetland and rice fields in Kore Irrigation Scheme. Data was collected through household questionnaire survey of 151 randomly selected farmers and 1 focus group discussion. The provisioning ES assessed included fibre; papyrus mats, reeds and thatching grass; fish and rice while cultural ES were religious/spiritual, eco-tourism, educational excursions and recreational use. The provisioning ES were quantified in terms of biophysical quantities and monetary value while cultural ES were graded per level of utilisation as low, medium and high. The study revealed that rice fields have enhanced food production (rice) in the area in addition to their higher value in terms of provisioning ES; rice (USD 602.49) and fish (USD 1039.50), and cultural ES (religious/spiritual and recreational use). In the natural wetland, both provisioning and cultural ES have declined over the past 20 years. The annual monetary value of USD 397.40 and 683.50 were observed for papyrus mats and fish production respectively in the natural wetland. Although rice fields seem to have higher value compared to the natural wetland sustainable utilisation of both systems is crucial in enhancing livelihoods.

1. Introduction

Floodplains in river basins are utilised globally for agricultural production due to their high fertility resulting from regular deposition of organic matter rich soil during flooding events (Verhoeven and Setter, 2009; Rouquette et al., 2011). Apart from agricultural systems, floodplains also have a variety of other ecosystems that perform multifunctional processes which ultimately provide a wide range of economic, social and environmental benefits to the society (Rouquette et al., 2011). Such gains derived from ecological activities of ecosystems are referred to as Ecosystem Services (ES) (MEA, 2005). The ES are typically generated when ecosystem components, functions and processes not only interact, but are actually used by people either directly or indirectly (De Groot et al., 2010) . Nevertheless, the use of floodplains primarily for agricultural production frequently lead to a compromise of ES derived from other ecosystems such as wetlands due to conflicting demands on water resources and land (Morris et al., 2009).

The consideration of ES as part of the benefits derived from ecosystems provides a suitable framework by which the society evaluates the importance of natural environments such as wetlands and provides a basis for informed decisions on conservation and sustainable management strategies of ES. The ES concept is a potential tool for linking human welfare and the benefits from natural ecosystems. This creates a common platform for communicating the value of ecosystems to stakeholders in the society (Carpenter et al., 2009; Grêt-Regamey et al., 2013).

Wetlands as one of the ecosystems which often occur in floodplains have been studied widely in many parts of world (Kanyiginya et al., 2010; Rongoei et al., 2013; Russi et al., 2013). The significance of their ES in support of livelihoods was one of the key components of the Millennium Ecosystem Assessment (MEA) and the Economics of Ecosystems and Biodiversity (TEEB) (MEA, 2005; TEEB, 2011; Russi et al., 2013). According to MEA (2005) and TEEB (2011), wetlands sustain the livelihoods of many people both directly and indirectly by supplying provisioning (e.g. fibre, water, food, fuel wood, natural medicines), regulatory (e.g. flood control, water quality improvement), supporting (e.g. nutrient cycling, primary production), and cultural services (e.g., recreation, aesthetics, education). In spite of the importance of these services to the society, wetlands globally have been identified as one of the most threatened ecosystems particularly due to demands for food production, through agriculture coupled with challenges in implementation of water management strategies. This is attributed to human population increase and the need for economic developments (MEA, 2005).

The Nyando River natural wetlands in Kano floodplain, Kenya

* Corresponding author.
E-mail address: ondiek.risper7@gmail.com (R. Ajwang' Ondiek).

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are threatened by degradation due to over-exploitation and conversion into farmland which may have compromised and even reduced in their ES functions (Owino and Ryan, 2007; Swallow et al., 2007). Furthermore, over the past five decades the area covered by the natural wetlands has largely declined through conversion into farmland especially paddy rice fields, sugarcane and most recently arrow roots (Swallow et al., 2007; Swallow et al., 2009; Obiero et al., 2012). The implication is that ES provided by these inland natural wetlands to local communities and the Lake Victoria ecosystem are lost or compromised. According to Foley et al. (2005) increase in agricultural land use practises may enhance food production in short-term but at the expense of losing ES from natural ecosystems in long-term, including many services that are important to agriculture. Conversion of natural wetlands into rice fields which is the focus of this study, has been taking place in Kano floodplain since 1960s Ong and Orego (2002) report 67% loss of Nyando wetlands into rice fields between 1960s and 1970s while Swallow et al., (2009) report a trade-off in area coverage between natural wetlands and rice fields ecosystems in entire River Nyando basin from the year 1991–2006. The area covered by the natural wetlands declined from 1.93% to 0.40% while rice fields increased by 0.45%. Although rice production of approximately 3 t ha^{-1} $year^{-1}$ has been recorded in the Kano floodplain, the extent to which these rice fields can provide ES is generally unknown (National Irrigation Board, 2014). The assumption is that development of rice schemes have occurred at the expense of ES provided by natural wetlands lack scientific information that needed to help improve existing knowledge and wetland management gaps in the natural wetlands and associated agro-ecosystems. Therefore, this study aimed to assess the current (2014–2015) delivery of provisioning and cultural ES in one of the Nyando Basin natural wetlands; Ombeyi and adjacent rice fields (Kore Irrigation Scheme) in the Kano floodplain. Selected biological (rice yields, reeds, thatching grass, papyrus mats and fish quantity) and socio-cultural (aesthetic value, recreation, ecotourism, educational excursions and religious/spiritual uses) indicators were used to measure the magnitude of ES supply in both the natural wetland and rice fields.

2. Materials and methods

2.1. Description of the study area

Kano floodplain is located in the larger River Nyando Basin; one of the sub-catchments of the Lake Victoria Basin in Kenya which covers an area of 3600 km^2 and situated between longitudes 34° 47′ 00″ E and 35° 44′ 00″ E, and latitudes 0°07′ 00″ N and 0° 20′ 00"S (Swallow et al., 2009; Raburu et al., 2012a). The floodplain covers approximately two thirds of the lower half of the basin (Raburu et al., 2012a) and it extends from Miwani, Nyando, Lower Nyakach and Kisumu East sub-County. The topography of the plain varies with highest point (altitude of 1801 m above the sea level) in Muhoroni and lowest point having the same altitude as Lake Victoria at 1134 m above the sea level (Raburu et al., 2012b).

Kano floodplain is frequently inundated by floods as a result of River Nyando overtopping its banks. The river originates from the Mau Forest Complex situated on the eastern part of the Kenyan Rift Valley (MWENR, 2012; Raburu et al., 2012b). It passes through the floodplains before draining into Lake Victoria. The flooding in the plains is an annual evident attributed to the high discharge of the river in April and May as a result of accumulation of run-off in the upper reaches coupled with the alluvial soil that has poor drainage. River Nyando is also laterally confined in the southern end of the floodplain at Ahero. In addition, the Kano floodplains are surrounded by steep hills such as Tinderet Hills to the East and Nandi Escarpment to the North (MWENR,[1] 2012).

This study was conducted in two sites within Kano floodplain in Ombeyi location. The location is situated between latitudes 00° 10′ 00″ S and 00° 07′ 00″ S, and longitudes 34° 58′ 00″ E and 34° 54′ 00″ E in western part of Kenya, Nyando sub-County. The sites include; Ombeyi natural wetland and Kore Irrigation Scheme. Ombeyi natural wetland is a small swamp which covers an area of approximately 176 acres (Fig. 1). It is located between latitudes 00° 08′ 00″ S and 00° 07′ 00″ S, and longitudes 34° 57′ 00″ E and 34° 56′ 00″ E. It is adjacent to the Kore Irrigation Scheme which is fed by River Ombeyi that drains through heavily populated Bwanda and Kobura plains and ends into Lake Victoria shore wetlands. River Ombeyi on the other hand is fed by Oroba and Nyakoko streams which in turn derive their waters from the upper Nandi escarpment (MWENR, 2012). The wetland vegetation is dominated by *Cyperus papyrus*. Other macrophytes found in the wetland are *Phragmites australis, Cyperus* sp. and *Typha domingensis* among others. The wetland is also inhabited by birds, reptiles, amphibians and fish.

Kore Irrigation Scheme is the largest farmers managed irrigation scheme in Kano floodplain started in 1991 through farmers' own initiative. The scheme is located between latitudes 00° 08′ 00″ S and 00° 07′ 00″ S, and longitudes 34° 57′ 00″ E and 34° 55′ 00″ E. It lies adjacent to the Ombeyi natural wetland (Fig. 1). The area covered by the scheme is 2340 acres with approximately 700 farmers (pers. comm. with Joseph Kenye (Chairman of Kore Irrigation Scheme). However, the size of the scheme is likely to increase with time due to continuous conversions of Ombeyi natural wetland into rice fields (personal observation).

The Kore Irrigation Scheme has three "blocks" or segments; Kore 1A, Kore 1B, and Kore II. However, the sizes of the three "blocks" are unknown due lack of delineation. Rice varieties grown in the scheme are IR 2793 and Basmati 370 with rice yield of 5.5 t ha^{-1} (Ong and Orego, 2002). The irrigation scheme practises less intensive farming whereby only farmers who can afford fertilizers do apply it in their farms. The source of water for irrigation is River Ombeyi which is partly diverted via a canal into the irrigation scheme. The drainage and irrigation canals are poorly designed and maintained with most rice fields getting water either from adjacent rice plots or from the drainage canals.

2.2. Data collection

Data was collected for a period of four months running from December 2014 to March 2015 using published literature on wetlands ES, field observations, household questionnaire survey and focus group discussion targeting farmers in Kore Irrigation Scheme. The study was conducted during rice harvest season to enhance reliability on the production information. The provisioning and cultural ES was identified according to MEA (2005) and Russi et al. (2013) and field observations. Semi-structured questionnaire survey listing all the provisioning and cultural ES identified was first administered face to face to 60 randomly selected farmers consisting of both men and women in the irrigation scheme. The questionnaire was meant to elicit information on the provisioning and cultural ES that were actually derived from both ecosystems. The responses obtained from the farmers on various ES in both systems were later used to identify and develop indicators of ES measurements as shown in Table 1. The indicators were in turn used to develop the second set of questionnaires for both Ombeyi natural wetland and rice fields. A sample size of 88 people was obtained (Israel, 1992), 100 questionnaires were administered and 91 used for the analysis. No attempt was made to

[1] MWENR stands for Ministry of Water, Environment and Natural Resources