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Impacts of Human Activities on Biodiversity of the Simiyu Wetland, Tanzania

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Abstract
Human activities such as intensive agriculture, grazing and settlements have degraded the ecological integrity of biotic communities in the Simiyu wetland by altering niche in terms of quality and quantity leading to a loss of biodiversity. Monitoring of vegetation types, game animals and bird species was carried out to determine the impact of human activities in the wetland. Biodiversity monitoring of Simiyu wetland showed an increase of species richness, abundance and diversity. Granivorous bird species increased by 18% while waterbirds decreased by 6% between 2010 and 2016. Similarly, invasive plant species increased by 42%, heavy feeders by 55% and shallow feeders by 26% between 2010 and 2016. The increase in granivorous bird species, invasive and heavy feeders indicate degradation of the wetland. Restoration of ecological character and management measures to Simiyu wetland are required in order to restore the values and functions of the wetland.

Keywords: Biodiversity, Birds, Habitat, Human activities, Vegetation

Introduction

Wetlands are defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters" (Ramsar Convention Secretariat, 2013). They have been referred to as "kidneys of the landscape" because of their role in hydrological and chemical cycles, and as "biological supermarkets" because of the extensive food chains and rich biodiversity they support (Mitsch and Gosselink, 2000). Wetlands can be degraded or lost completely through human activities such as the cutting of aquatic vegetation for food and housing, commercial activities, overgrazing and cultivation, and illegal or improper fishing practices. Others causes include pollution by domestic sewage, industrial effluent and agro-chemicals, development of new human settlements and hunting of wildlife.

It is estimated that almost 10% of Tanzania's surface area (945,000 $km^{2)}$ is covered by wetlands making it particularly well-endowed for the continent (Mwakaje, 2009). The principal wetland systems are found in the Western and Eastern Rift Valleys, around Lake Victoria, and numerous minor lakes as well as in riverine flood plains, coastal systems with intertidal mudflats, and a number of artificial impoundments (Kamukala and Crafter, 1993). There are 422,000 ha of wetlands in the Lake Victoria basin and most are associated with major rivers such as the Kagera, Simiyu, Rubana and Mara rivers in Tanzania (Lake Victoria Environmental Management Project – Buffering Capacity Wetlands Studies Final Report, July, 2001). These wetlands include floodplains, ponds, small lakes, satellite lakes, fringing swamps, and river systems. They are important for the hydrological and ecological balance of the lake ecosystem, for their capacity remove pollutants, and

for the wide variety of flora and fauna that are adapted to waterlogged and seasonal hydric conditions (Balirwa, 1995). It is estimated that about 75% of these wetlands have been significantly affected by human activity, with about 13% being severely damaged.

The Simiyu wetland is located along the lower reaches of the Simiyu River where it flows into Lake Victoria at Magu Bay, Tanzania (Rwetabula *et al.*, 2007). The delta of the Simiyu is a marsh that starts just downstream from the town of Magu. The surrounding communities use the wetland for various purposes such as agriculture, horticulture, fishing, livestock grazing but as these activities are uncontrolled its biodiversity and ecological functioning has been heavily impacted by humans. The growing population is increasing pressure on this wetland, while degradation has been accelerated by extended drought and climate change. Intensive agriculture in the lower reaches of the Simiyu Basin results in the discharge of fertilizer and pesticides into the river (Rwetabula, *et al.*, 2006).

It was against this background that monitoring of biodiversity was carried out in the wetland, and associated rivers in its catchment to assess the human impact on vegetation, game animals and bird species. These data could be used to inform the planning of natural resources and environmental management decisions.

Methods

The study area included the Simiyu wetland core area in Magu district, Simiyu River and catchment in Busega, Kwimba, Maswa, Bariadi, Itilima and Meatu districts (Figure 1).

Vegetation communities were determined through line transects and plant identification guides (Mbuya *et al.*, 1994; Dharani, 2012) were used to determine the composition of the species in these communities. The frequency of each species was estimated visually and characterised as Dominant (D), Abundant (A), Frequent (F), Occasional (O), Rare (R) and locally abundant (L) following Causton (1988). The dominant species and their relative abundance were estimated using the Braun-Branquet cover scale (Greig-Smith, 1983). Invasive plant species were identified using plant identification field guide books (Mbuya *et al.*, 1994; Dharani, 2012) and their presence was estimated by formal interviews with people living along the wetland. Heavy and shallow feeder plants were determined by identifying their root system and root biomass.

The major animal habitats were determined using combinations of topographic maps (1:50,000), questionnaires, binoculars (8 x 63,105mm) and focus group discussions with people living in and adjacent to the Simiyu wetland. Line transects and point count techniques were used for mammal counts, with species being identified using a field guide (Stuart and Stuart,1988, 2009).

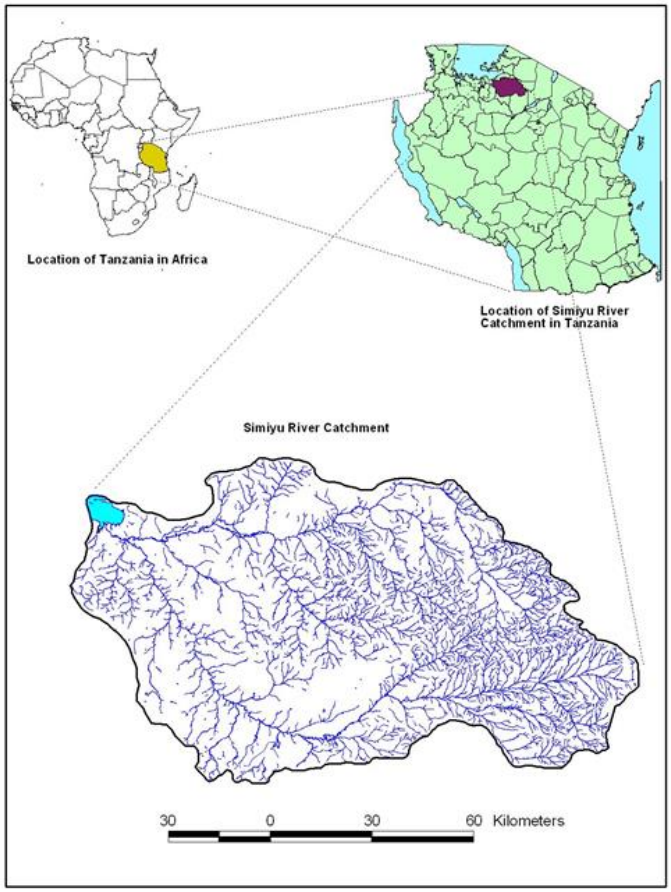

Figure 1: The location of the study area in Tanzania.

The number of birds was determined using the point count technique with the positions being located with a Geographical Position System. By walking within a radius of one kilometre from the identified stations it was possible to count birds seen and heard at the area; they were identified with field guides (Sinclair *et al.*,

1996; Stevenson and Fanshawe, 2002; Sinclair and Ryan, 2003). Focus group discussions with villagers living in and around the wetland were carried out to supplement collected information.

Results and Discussion

Vegetation communities and animal habitats

The major vegetation communities in the wetland were bushed-grasslands, swamps and riverine habitants. Efforts were being made to restore riverine habitats in some areas, such as around Itilima district in the Simiyu region by planting *Vachellia nilotica*, *Leucaena leococephala*, and some *Eucalyptus* species. In other areas these habitats had been largely destroyed by human activities, for instance in the villages of Meatu district, which has led to siltation of water habitats as a result of soil erosion from cultivated and grazed land.

Major vegetation communities and relative abundance

Seven major vegetation communities were identified in the 2010 field survey, dominated by the families Poaceae, Compositae, Amaranthaceae, Euphorbiaceae, Leguminoseae, Mimosaceae and Cyperaceae (Table 1). These communities extended from the banks of Simiyu River to about one kilometre from both sides of the river where species of Mimosaceae were mixed with shrubs and some dense grasses. There was little dense and tall riverine vegetation in permanent or seasonally wet areas close to river channels where cultivation was not extensive. Sedges, including *Cyperus papyrus*, dominated swampy areas and river patches, while short species such as *Cyperus iria*, *C. rotondus*, *C. teneristoma* and *C. esculenta* were found in non-intensively cultivated land. Species belonging to the Amaranthaceae, Compositae and Poaceae were observed in more intensively cultivated areas of the wetland.

The surveys carried out in 2013 and 2016 revealed that the area covered by the natural vegetation had decreased although the vegetation communities identified (Poaceae, Compositae, Amaranthaceae, Euphorbiaceae, Leguminoseae, Mimosaceae and Cyperaceae) were the same as those identified in 2010.

Table 1. Braun-Blanquet cover scale: major vegetation communities and their relative abundance in the Simiyu River wetlands.

2010		2013		2016	
Community	Rating	Community	Rating	Community	Rating
Poaceae	5	Poaceae	5	Poaceae	5
Compositae	3	Compositae	2	Compositae	1
Amaranthaceae	2	Amaranthaceae	2	Amaranthaceae	2
Euphorbiaceae	1	Euphorbiaceae	1	Euphorbiaceae	1
Leguminoseae	3	Leguminoseae	2	Leguminoseae	3
Mimosaceae	3	Mimosaceae	3	Mimosaceae	4
Cyperaceae	5	Cyperaceae	4	Cyperaceae	4
		Papilionoideae		Rutaceae	
		Scrophulariaceae		Scrophulariaceae	
		Arecaceae		Maliaceae	
		Musaceae		Arecaceae	
		Myrtaceae		Musaceae	
		Rutaceae	+	Myrtaceae	+
		Asteraceae		Cactaceae	
		Maliaceae		Asteraceae	
		Malvaceae		Malvaceae	
		Cactaceae		Papilionoideae	

Rating: + = Sparsely or very sparsely present with very small coverage; 1 = Plentiful, but of small cover; 2 = Very numerous, or cover 5-25%; 3 = Any number of individuals, cover 25-50 %; 4 = Any number of individuals, cover 50-75%; 5= Cover greater than 75%.

Invasive, heavy and shallow feeder plant species

Few invasive plants were recorded in the 2010 and 2013 surveys (Figure 2) with only seven being identified, namely *Eichhornia crassipes*, *Amaranthus spinosus*, *A. viridis*, *A. hybridus*, *Celosia trigyna*, *Opuntia* sp. and *Lantana camara.* Water hyacinth (*E. crassipes*) was the most abundant, possibly because raw sewage from residential areas was being discharged into the river and increasing the nutrient supply. The number of invasive plant species recorded in 2016 increased to 13, and water hyacinth in particular had become more abundant. Some species, such as *V. nilotica*, were deliberately introduced during restoration programmes, while species not recorded during earlier surveys included *Leucaena leucocephala, Thevetia peruviana, Albizia lebbeck, Azadirachta indica* and *Celosia trigyna.*

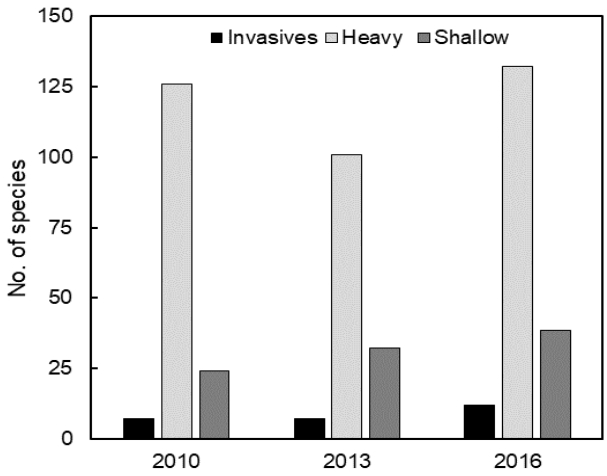

Figure 2: The number of invasive, heavy and shallow feeder plant species recorded in three surveys.

Plants with adventitious root system are heavy feeders while those with tap roots are shallow feeders and both types occurred in the Simiyu wetland. Most of the heavy feeder plants were grasses and sedges (Poaceae and Cyperaceae) and they take up moisture and nutrients quickly from soil compared to shallow feeders. Broad and narrow-leaved plants and deciduous shrubs are also heavy feeders owing to their shallow root systems as are vegetables grown in the wetland, such as cabbage, tomatoes, eggplant, pepper, cucumber, water-melon, pumpkin and okra as they also have fibrous root systems. Shallow feeders include deep-rooted plants, most of which are perennials such as trees, forbs and herbs and they were dominant at some survey sites. The same plant species were observed in all three years of surveys but the number of invasive species increased by 42%, heavy feeders by 5% and shallow feeders by 26% between 2010 and 2016 (Figure 2).

Large mammals and reptiles

Few large mammals or reptiles were identified during the 2010 survey with only three species, Hippopotamus *Hippopotamus amphibius*, otters *Lutra* or *Aonyx* spp. and Nile crocodiles *Crocodylus niloticus*, being reported. Most other species had disappeared mainly as a result of habitat destruction from logging, charcoal-making and fish smoking. In previous years, the major cause of species disappearance was the clearance of vegetation to open land for cultivation and livestock grazing. The development of the Magu District Headquarters in 1974 was found to be one of the factors that increased the rate of environmental degradation, especially deforestation, in the Simiyu wetland.

The loss of habitat is a serious issue for animals because it leads to the loss of their niche (Kingdon, 1997) and a small change in habitat condition can led to their death or, emigration, although some can adapt to a new situation (Estes, 1991). Adaptation may be a gradual process, however, which takes time and few animals can adapt to sudden change.

A total of 16 species were sighted in the 2013 survey. They included Bushbuck *Tragelaphus scriptus*, Sitatunga *Tragelaphus spekii*, Buffalo *Syncerus caffer*, Bush Pig *Potamochoerus larvatus*, Warthog *Phacochoerus africanus*, Hippopotamus, Elephants *Loxodonta africana*, Porcupine *Hystrix cristata*, Olive Baboon *Papio anubis*, Vervet monkey *Cercopithecus aethiops*, Riverine Rabbit *Bunolagus monticularis*, Leopard *Panthera pardus*, Spotted Hyaena *Crocuta crocuta*, African Clawless Otter *Aonyx capensis*, Nile Monitor lizard *Varanus niloticus*, and Nile crocodile. The increase in large animal species between 2010 and 2016 was a result of conservation measures. These include environmental education provided to villagers by the LVEMP II programme, the enforcement of a 60-m exclusion zone from the river, the restoration of the lost vegetation, and the provision of income-generating activities such as beekeeping in some areas.

A total of 17 large animal species were identified during the 2016 field survey but some, such as Bush Pigs, Hippopotamus and crocodiles were seen only occasionally Hippopotami and crocodiles were mostly confined to the river but sometimes occurred in deep water swamps and were very rarely seen in the wetland.

The density of animals was very low given the size of the area (Estes, 1991) and human activities, such as cultivation, livestock and deforestation, are the main cause of this low density and species diversity. The majority of the 49 respondents interviewed (60%) attributed the loss of game animals formerly observed in the Simiyu river basin to habitat loss, while 30% attributed it to direct hunting and 10% felt that environmental degradation and climate change were the cause.

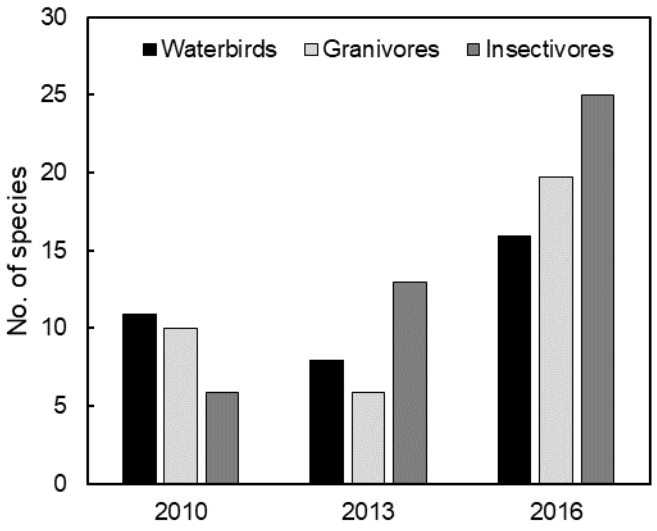

Figure 3: The number of bird species, in three major categories, identified during survey period.

Birds

A total of 27 bird species were identified during the survey but their diversity and abundance in and around the Simiyu wetland was relatively low. The two most numerous species were the granivorous Red-billed Quelea *Quelea quelea* and Village Weaver *Ploceus cucullatus* which made up 41.2% and 28.1%, respectively, of 1,111 birds counted. These birds were abundant because of the extensive cultivation of rice and sorghum in the area. Cattle Egrets *Bubulcus ibis* accounted for 5%, reflecting the fact that the area is used for grazing, as these birds feed on insects disturbed by grazing animals.

Only 27 species were sighted during the 2013 survey. The most common were the Little Egret *Egretta garzetta*, Black-headed Heron *Ardea melanocephala*, Yellow-billed Stork *Mycteria ibis*, Marabou stork *Leptoptilos crumenifer*, African Open-billed Stork *Anastomus lamelligerus*, Glossy Ibis *Plegadis falcinellus*, Egyptian Goose *Alopochen aegyptiacus and* Malachite Kingfisher *Corythornis cristatus* and while hundreds of passerine birds were seen and heard in the study area. Cattle Egrets and Yellow-billed storks were present in large numbers and the latter, along with Marabou Storks, were feeding on fish in temporary standing water. The numbers of waterbirds and granivorous species declined between the two surveys but insectivorous species increased (Figure 3).

In 2016 a total of 61 bird species were identified during the survey, amounting to 2,351 individual birds being counted. Of these, 34% were resident in the Simiyu River Basin while 66% were migrants. The number of waterbirds, granivores and insectivores were considerably higher than in the previous surveys with the latter being the dominant group (Figure 3). The insectivorous included the Cattle Egret, Common Bulbul *Pycnonotus tricolor*, plovers, swallows, swifts, and drongos.

The diversity and abundance of granivorous birds increased from 10 to 37 species between 2010 and 2016 and abundance increased from 37% to 55% of all identified species, with the most common species Red-billed and Cardinal *Q. cardinalis* Queleas and Village Weavers, along an increase in the numbers of some dove and francolin species. This increase in the number of bird does not necessarily indicate a recovery in the ecological integrity of the area (Fishpool and Evans, 2001). The increase of granivorous and insectivorous birds in the Simiyu wetland suggests that the wetland is becoming degraded by cultivation of cereal and oil crops such as maize, sorghum, and sunflowers. This in turn explains the lower percentage of waterbirds compared to non waterbirds during the 2016 survey.

Human activities

Most human activities in the Simiyu wetland and its catchment are uncontrolled and have resulted in

biodiversity loss and ecosystem degradation. The most threatening are agriculture, livestock grazing and vegetation clearance for various purposes. The extent of these activities was assessed through discussions with focus groups and village leaders living in and around the wetland to obtain more information on the impact of human activities in the wetland.

The increased intensity of agriculture is adversely affecting the wetland vegetation in some places. Vegetation is cleared to allow cultivation and charcoal making and there are no restrictions on access or use of the wetland. Cleared areas are used for both cash and food crops such as cotton, maize, rice, sorghum, yams, banana, sunflower, sugarcane, sweet potatoes, cassava, and chickpeas, mostly grown after the floods recede. Some permanent tree crops such as mangos, coconuts, oranges and guavas are also grown. Local communities use water from the river for watering vegetables.

Several herds of cattle, goats, and sheep were found roaming the wetland in order to avoid conflict with crop-growers. This has resulted in overgrazing, which has led to the loss of sponge qualities in the wetland and a consequent reduction of perennial flows. Animal trampling damages the wetland, compact the soils and reduces water retention and percolation in the wetland and during the dry season trampling reduces dry wetland surfaces to a powder like-condition making it susceptible to erosion.

Wetlands and their catchments are generally rich in forests and woodlands but the indiscriminate and unsustainable use of these resources charcoal and firewood, timber and poles (for construction) has led to deforestation in the Simiyu wetland and its catchment. Uncontrolled bush fires degrade the wetland forests, while deforestation along the river banks increases run-off rates causing flooding, soil erosion and siltation of the river and the lake.

Efforts made by LVEMP II to protect the Simiyu wetland

The Lake Victoria Environmental Management Project Phase II (LVEMP II) in collaboration with the Government of Tanzania has taken measures to restore and maintain the ecological integrity of the Simiyu wetland. It tried to strike a balance between the livelihoods of surrounding communities and conservation of wetland biodiversity through awareness creation and afforestation. Meetings, seminars and workshops at both local and national levels were held to create awareness on the importance of Simiyu wetland and the measures which can be taken to conserve and use the wetland sustainably. The importance of biodiversity conservation to poverty reduction and development was stressed by emphasising the linkages between biodiversity loss and poverty.

Tree planting programmes in most of the villages was one of the strategies for restoring degraded areas and more than 300,000 trees, including Mihale (*Vachellia nilotica*) and Migu (*Senegalia polyacantha*) have been planted. People in villages adjacent to the Simiyu River were educated on the importance of leaving a 60-m zone from the river banks free of human activities as required by the Environmental Management Act of 2004. In many places there were signs warning people not to carry out activities in the wetland while also informing them on the conservation activities which are taking place in that particular area.

Since some parts of the wetland will continue to be degraded as human activities increase, wetland conservation strategies should integrate the enforcement of laws and bylaws of local and central government to control destructive activities in the wetland. The provision of alternative water sources outside the river reserve and restricting livestock from drinking and grazing within the 60-m zone along the river should stimulate livestock-keepers to join efforts to construct dams and cattle troughs for their animals. Farmers and others living along the river should be encouraged to plant native trees as part of a capacity-building programme to enable people living in the Simiyu basin to conserve their own resources.

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