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TRENDS IN THE DEGRADATION OF FRESHWATER URBAN WETLANDS IN KAMPALA, UGANDA: A CASE STUDY OF LUBIGI WETLAND

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ABSTRACT

Under advancing innovative policies and local solutions for community transformation, this study is aimed at determining the future of Lubigi wetland using satellite images. Wetlands, especially those within around cities are at a risk of being depleted. Most of the areas that ought to be conserved are facing several unregulated human activities (titling of such areas, farming, and developmental projects). There are many stakeholders that are vital to meeting developmental solutions for community transformation but these stakeholders need to work hand in hand with the stake holders that are responsible for natural resource conservation. Taking a leaf from Lubigi wetland, a critical water catchment area in Wakiso District, it has suffered several human activities such as the construction of the Northern bypass, there's a sewerage plant by National Water and Sewerage Corporation, human settlements to mention but a few.

Keywords: Stakeholders, Lubigi, Land degradation

1. INTRODUCTION

More human activities occur in Lubigi wetland than any other wetland in the country (Watebawa, 2010). Human induced land degradation has become one of the biggest threats to the natural resources (Rwakakamba, 2012). Eswaran reports that land degradation will remain an important global issue for the 21st century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life, thus accounting for 50% loss of yields in a given year (Eswaran, Lal, & Reich, 2001). Even though awareness of imminent effects of land degradation, wetland resources were noted to have reduced from 15% in 1994 to 10.9% of Uganda's area (Bwogi, 2012). Land degradation can be defined as a "Reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation" (UNCCD, 2012).

"The wetlands Management Department is mandated to manage wetland resources while putting efforts to sustain the biophysical and socio-economic values of the wetlands in Uganda for present and future generations. Wetlands are a source of livelihood to the majority of Ugandans and hence directly contributing to the national Development plan, vision 2040 and attainment of the Millennium Development Goals. However, wetlands are under a lot of pressure from conversion for industrial development, settlements, agriculture, sand and clay mining. Most of these degrading activities are perceived to be of greater importance than wetland conservation itself" (Ruffins, 2015).

2. LITERATURE REVIEW:

The rate of degradation at the only remaining wetland Lubigi has alarmed environmental conservationists with the degradation standing at 42% compared to the national average of 30 %" (Watebawa, 2010)."The invasion by people claiming to be army veterans has destroyed the wetlands, which shields the northern parts of Kampala from flooding. Lubigi wetland is threatened by farming, unregulated human activities and major development projects thus raising concerns about the future of Lubigi wetland as a major filter of waste water and flood control for various parts of Kampala. The swamp takes storm water from River Nsooba, whose flood plain at Bwaise has been destroyed after years of reclamation to pave way for settlement"(Lule, 2011). Undisturbed wetlands often function as active sinks of carbon. Wetland destruction ultimately releases carbon to the atmosphere. Wetland destruction poses a potential threat for accelerating the greenhouse effect.

Taking a leaf from Uganda, we have seen several wetland areas undergoing land degradation under human the influence of human activity. Wetlands in Uganda cover 11.9% of the country's total land surface area, down from 13-15% in the early 1990s (Kamuntu, 2013). Lubigi wetland is the largest remaining wetland in Kampala city and drains into River Mayanja in the Lake Kyoga basin. Lubigi wetland contains 16 mammals, 16 amphibians and 120 birds including papyrus endemics and the globally Endangered Hooded Vulture and Grey Crowned Crane, however Lubigi wetland is threatened by farming, unregulated human activities and major development projects (Asp, 2009).

In 2005 the construction of the Northern Bypass started and there was a lot of in-filling with rock base to create the road surface at the fringes of the wetland. Road construction reached Bwaise in 2007 and was completed in 2008. At the beginning of 2010 new roads were also constructed through the wetland in Nansana and Nabweru. The road provided access to the wetland sections that could not be easily reached. As part of the Kampala sewerage Master Plan, the National Water and Sewerage Corporation established a sewerage treatment plant in the middle of Lubigi wetland to serve Northern Kampala. The plant has a combined treatment capacity of 5400 cubic meters of waste water per day ((NWSC), 2013). It receives and treats waste water from the piped network as well as fecal sludge that is brought by private cesspool emptier trucks. The Lubigi catchment area consists of Makerere, Katanga, parts of Mulago, Kalerwe, Bwaise and areas along the northern by-pass. A sewerage laboratory monitors ensures that effluent from this plant meets standards for discharge into water and land.

This raises concerns about the future of Lubigi wetland for biodiversity conservation and a major filter of waste water and flood control for various parts of Kampala. Disruption of the natural ecological values of Lubigi wetland is already being experienced by city dwellers as an increasing frequency and severity of flooding events (Mhonda, 2013b). Lubigi wetland is dominated by papyrus (Kansiime, Nalubega, van Bruggen, & Denny, 2003). Papyrus is known to increase action of nitrifying bacteria on waste water (Kansiime et al., 2003). However with the continued depletion of papyrus into other land covers poses a health risk to a large population due to contamination of the wetland by the sewage plant.

The main objective for this study therefore was to assess the level of land degradation, quantify trends in degradation of Lubigi wetland and provide probable solutions to the catchment area. The procedure relates the trajectories of wetland change using satellite images due to land degradation processes which in turn can affect the eco system provision while suggesting Sustainable Land Management options suited to reverse or mitigate the impact of land degradation.

3. STUDY AREA:

Lubigi wetland is the largest remaining wetland in Kampala city and drains into River Mayanja in the Lake Kyoga basin. The wetland is located on the northwest side of Kampala in Rubaga and Kawempe divisions about 7.02 km from the city center. It is part of a system in which water flows from north towards Lake Kyoga. Lubigi is fed by River Nsooba in the North East, River Nasero from the North West, River Nabisisasiro from the East, River Kigyankondo from the west, River Nalukolongo from the South East and it forms part of Mayanja-Kato system in the South-West.

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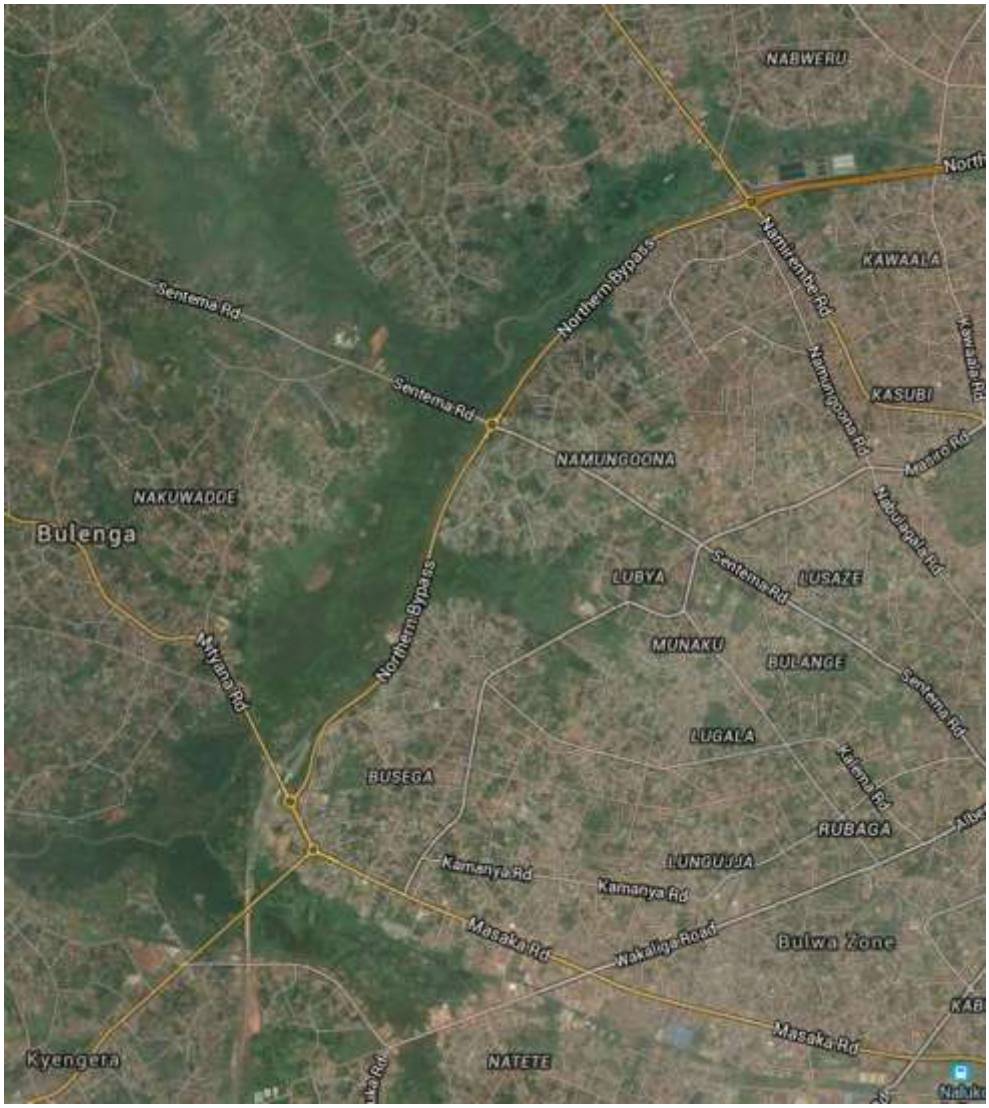

Figure 1 Location of Lubigi map

4. MATERIALS AND METHODS:

High resolution satellite images of 2003, 2005, 2007, 2010 and 2015 were used in this study. The images were geo-referenced to the Uganda National Coordinate System - Universal Traverse Mercator (UTM) Projection and Arc 1960 datum using Arc GIS 10.2.2 software. The images were processed and sharpened using Adobe Photoshop CS6 software to produce such images as seen below.

Figure 2 showing a processed map

A folder was created on drive F:\project\final project into which a database was created using ArcCatalog. Datasets were created. The feature dataset will accept only the features that have their coordinates between the minimum and maximum values defined for the *x*, *y*, *z* and *m* values of spatial domain extent. Feature classes that are representations of the real-word objects; grouped in classes based on their common components, shape (geometry) and attributes. These were created inside the datasets in the geodatabase of the main degradation agents where created as seen in the table below.

Datasets	Feature Class	Subtypes	
		Code	Description
D2003	Interested Boundary Area		
D2005			
D2007	Remaining Swamp area		
D2010	Human induced land degradation activities	0	Gardens
		1	Settlements
		2	Clay mines
D2015		3	Road Network
		4	Fish pond
		5	NWSC plant

Table 1 showing the Geo database design

The Lubigi wetland boundary of 2003 was digitized and taken as the base line onto which each of the subsequent years were superimposed in Arc GIS 10.2.2 software and the changes analyzed. The main degradation agents like road networks, settlements and farming were digitized and the areas they occupied in the wetland were calculated for each image and the rate of degradation was determined. For determining the trends, we used the idea of interpolation and extrapolation to determine the future of the wetland. With the areas of the remaining swamps acquired we took two areas at certain years and extrapolated it to find out the future of the wetland after an estimated number of years.

5. RESULTS:

The earliest photo used for this study was for the year 2003. Most parts of the wetland especially in Nabweru and Nansana were intact, except for settlements in Bwaise where population explosion from the catchments had pushed the settlements into the wetland. Currently, there is also pressure on the wetlands for settlements in Nabweru and Nansana.

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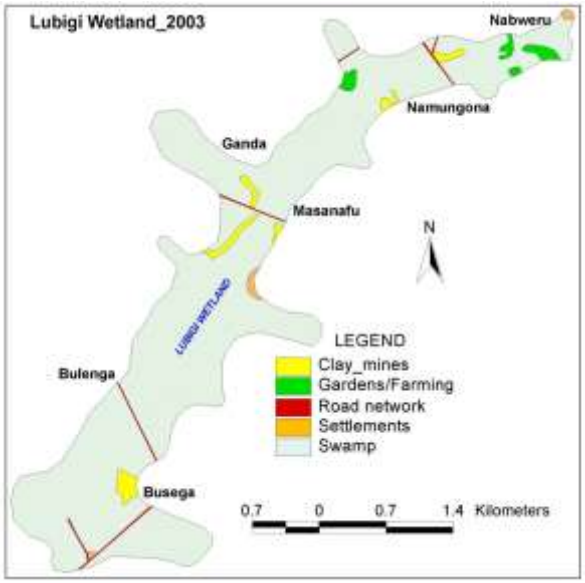

Figure 3 Lubigi wetland degradation agents in 2003

In 2003, 94.71% of the wetland was still intact. Only 5.29% of the wetland had been taken up by clay mines, road network, settlements and gardens as shown in table below.

Degrading agent	Area Sq_km	Percentage
Clay_mines	0.17	2.43
Road network	0.06	0.90
Settlements	0.04	0.55
Gardens/Farming	0.10	1.41
Remaining swamp	6.65	94.71
Total	**7.02**	**100**

Table 2 The status of Lubigi wetland in August 2003, area in sq km

The construction of the Northern Bypass started in 2005 and there was a lot of in-filling with rock base to create the road surface at the fringes of the wetland as seen below.

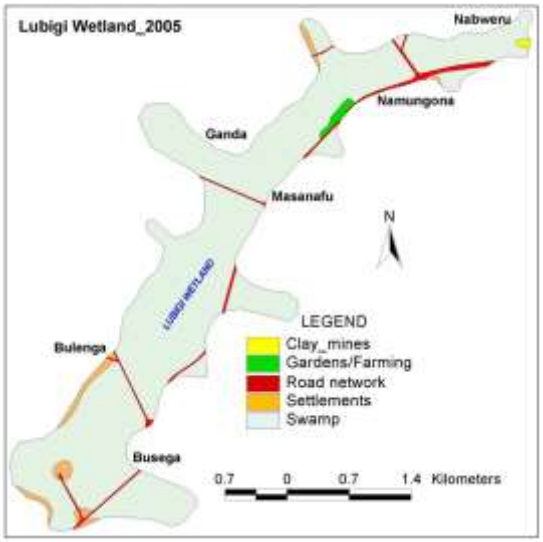

Figure 4 Lubigi Wetland degradation agents in 2005

The aerial photograph of 2005 was taken during the construction of the Northern bypass. At this time the road network occupied only 2.9%, gardens had come down to 0.6% compared to 1.41% in 2003. Settlements had increased from 0.55% in 2003 to 2.7% and 93.71 % of the wetland was still intact as shown in table below.

Degrading agent	Area Sqkm	Percentage
Clay-mines	0.01	0.1
Road network	0.20	2.9
Settlements	0.19	2.7
Gardens/Farming	0.04	0.6
Remaining swamp	6.58	93.7
Total	7.02	**100**

Table 3: The status of Lubigi wetland in August 2005

Road construction reached Bwaise in 2007 and was completed in 2008 as we shall see in the aerial photograph below.

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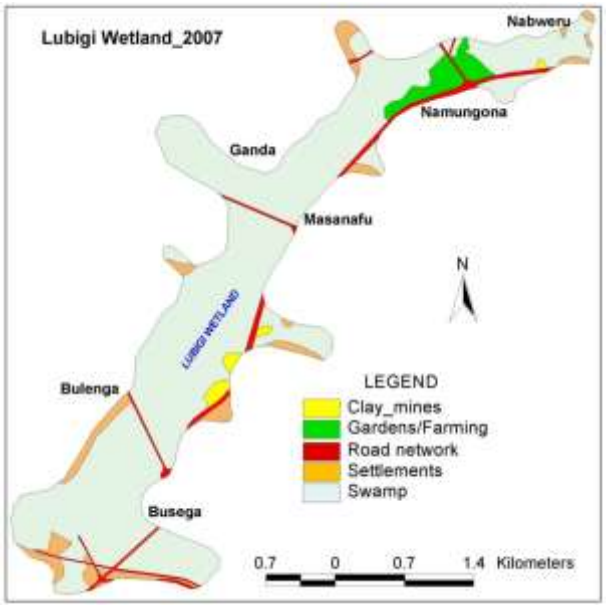

Figure 5: Lubigi Wetland degradation agents in 2007

Analysis of an aerial photograph of the wetland in 2007 after the construction of the Northern Bypass had been completed showed that the road network had taken up 4.2% of the wetland. At the time, the remaining swamp occupied 84.5% and the other degrading agents are shown in table

Degrading agent	Area Sq km	Percentage
Clay mines	0.08	1.1
Road network	0.30	4.3
Settlements	0.47	6.7
Gardens/Farming	0.24	3.4
Remaining swamp	5.93	84.5
Total	**7.02**	**100**

Table 4: The status of Lubigi wetland in August 2007

At the beginning of 2010 new roads were also constructed through the wetland in Nansana and Nabweru. The road provided access to the wetland sections that could not be easily reached as we shall see in the aerial photo below.

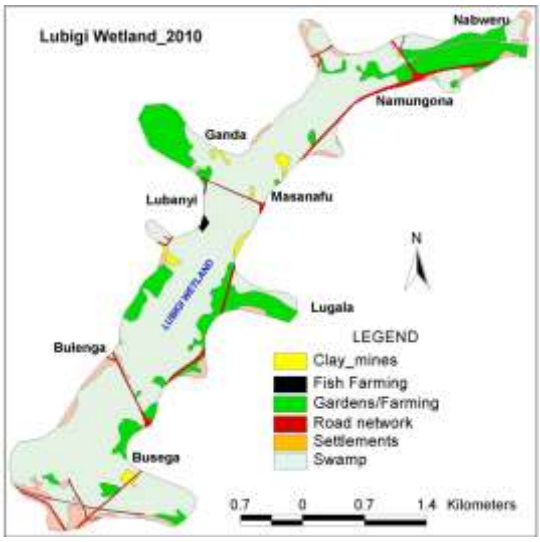

Figure 6: Lubigi Wetland degradation agents in 2010

The biggest threat to Lubigi wetland emanates from gardens and farms which were occupying about 18.7% as of August 2010 as shown in table 4. At this time about 30% of the wetland had been degraded.

Degrading agent	Area Sqkm	Percentage
Fish Farming	0.01	0.2
Clay_mines	0.1	1.3
Road network	0.22	3.1
Settlements	0.42	6.1
Gardens/Farming	1.31	18.7
Remaining swamp	4.96	70.6
Total	7.02	**100**

Table 5: The status of Lubigi wetland in August 2010

As part of the Kampala sewerage Master Plan, the National Water and Sewerage Corporation established a sewerage treatment plant in the middle of Lubigi wetland to serve Northern Kampala. The plant has a combined treatment capacity of 5400 cubic meters of waste water per day (NWSC 2015). It receives and treats waste water from the piped network as well as fecal sludge that is brought by private cesspool emptier trucks. The Lubigi catchment area consists of Makerere, Katanga, parts of Mulago, Kalerwe, Bwaise and areas along the northern by-pass.

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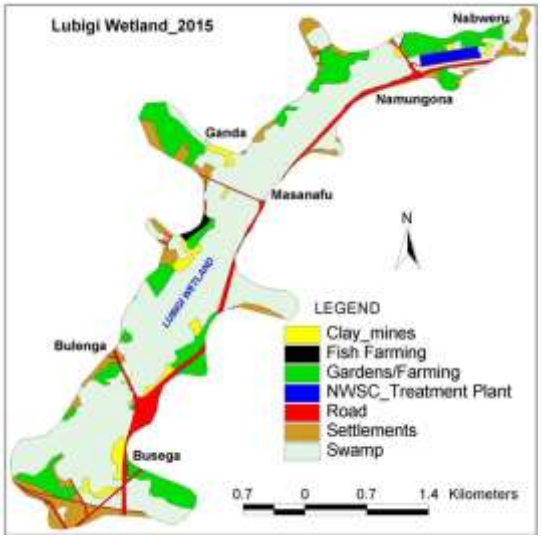

Figure 7: Lubigi Wetland degradation agents in 2015

By January 2015, the sewerage treatment plant of National Water and Sewerage Corporation had been constructed and it occupied 1.16% of the wetland. The road network had increased from 3.1% in 2010 to 6.47% due to expansion of the Northern bypass and construction of part of Entebbe express highway that enters into the Lubigi wetland however most of the road network was constructed through the infringes of the wetland. In 2015, fish farming had also increased from 0.2% in 2010 to 0.36% in 2015.

As of January 2015, the wetland covered 4.38km^{2}which is 62.4% of its original area.

Degrading agent	Area Sqkm	Percentage
Fish Farming	0.03	0.36
NWSC_Plant	0.08	1.16
Clay mines	0.22	3.13
Road network	0.45	6.47
Settlements	0.67	9.53
Gardens/Farming	1.19	16.95
Remaining swamp	4.38	62.4
Total	7.02	100

Table 6: Status of Lubigi wetland in January 2015

Using the trend function in Microsoft excel, extrapolation was carried out to the year 2050 so as to see with the vision 2040, what will be of the wetland. Below is the outcome when forecasted to 2050.

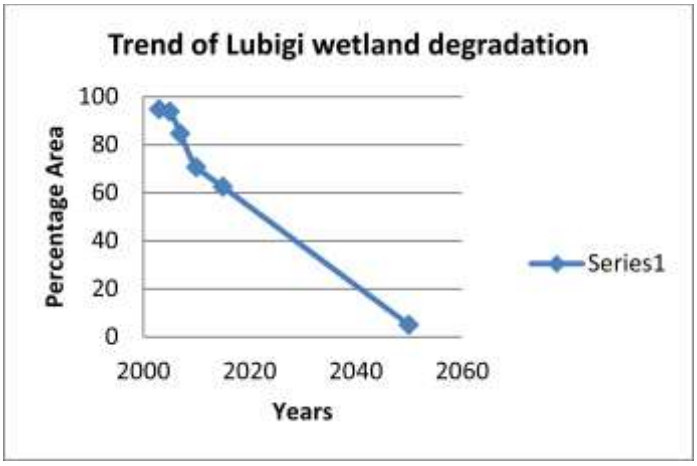

Figure 8: Lubigi Wetland degradation curve between 2003 and 2050

6. DISCUSSION:

Lubigi wetland reduced from 7.02 km^2 to 4.38 km^2 with only 62.4% of the wetland still intact in 2015 (Mhonda, 2013a), down from 94.7% in 2003. During this time road construction increased greatly (including Kampala's Northern Bypass) as did settlements within the wetland. A surge in settlements occurred between 2005 and 2007. By 2010 some 30% of the wetland had been degraded. Fish farming was introduced in the wetland in that year accounting for 0.2% but the most degrading agent was farming/ gardens (18.7%). By January 2015, the wetland covered just 62.4% of its original area, the biggest losses being to gardens and farms occupying 16.95%. A sewerage treatment plant constructed in the wetland occupied 1.16% and road construction had increased to 6.47%. Fish farming had also increased to 0.36%. The percentage area occupied by electricity pylons was too small to quantify during the analysis though their impact on the site is substantial. Currently, an estimated area of 0.74sq km (10.62%) of Lubigi wetland is allocated as private land titles.

Ideally, all of the wetland should be preserved but according to figure 9 below, most of the middle part of the wetland has already been acquired (titled) by the public while according to figure 7, the northern part of the wetland is already infested with settlements, cultivation and the NWSC treatment plant. This leaves us with the southern part of the wetland which is fairly intact.

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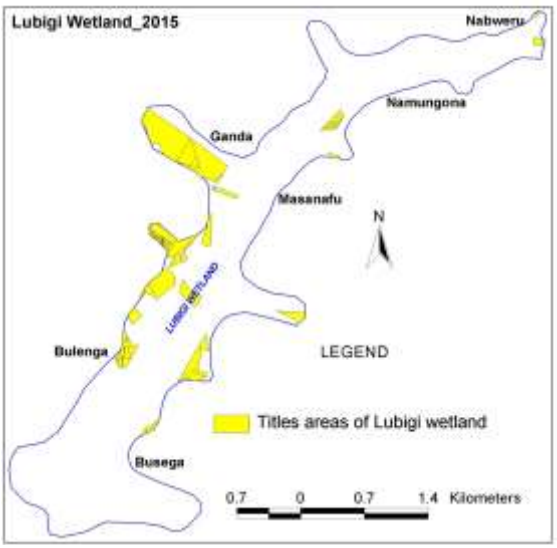

Figure 9: Titled land in Lubigi wetland 2015

The biggest threat to Lubigi wetland is from gardens and farming activities (26.48% in 2015) followed by settlements (9.5% in 2015), Table 6. The wetland is not benefiting from any active conservation (Pomeroy, 2006). This allows the surrounding local communities to easily access and use resources in it. Encroachment has also been fuelled by acquisition of land titles in the wetland.

Lubigi wetland is dominated by papyrus (Kansiime et al., 2003; Pomeroy, 2006). Papyrus is known to increase action of nitrifying bacteria on waste water (Kansiime et al., 2003; Kansiime, Oryem-Origa, & Rukwago, 2005). However with the continued conversion of papyrus into other land covers, there is need to establish how the sewage plant in the wetland will work knowing that contamination of Lubigi wetland will pose a health risk to a large population along the catchment on its way to Lake Kyoga.

Although the sewage plant construction took up only 1.16% of wetland coverage, the Papyrus Gonolek, a papyrus specialist bird, could not be found in areas where it was recorded in previous years, presumably because its habitat had been destroyed.

The area occupied by the road network has steadily increased over the years despite the fact that most of the road network has been constructed along the fringes of the wetland. These areas have previously been used as sources of medicinal plants.

7. DISCUSSION:

In order to save Lubigi wetland for the biodiversity therein, surrounding community and the whole of Kampala in general, the following is steps are recommended:

1. The Lubigi wetland boundary should be demarcated (surveyed) and the boundary should be plotted on the cadastral sheets in Entebbe. This will stop people acquiring titles within this wetland in future
2. The boundary should also be gazetted
3. The already acquired titles as seen in figure 8 above; should be cancelled by the Ministry of Lands, Housing and Urban Development as recommended by Parliament MINUTE 114(CT 2014)- CANCELLATION OF LAND TITLES ISSUED IN WETLANDS AS ONE OF THE MEASURES TO ADRESS THE PROBLEM OF WETLANDS DEGRADATION.
4. In order to enable the sewage treatment plant work properly, the papyrus which is essential for sewage treatment should be replanted in areas where other land covers have already taken place. NWSC should consider funding papyrus replanting activities
5. NEMA and WMD should guard against illegal constructions and cultivations within the wetland.
6. The last detailed biodiversity survey in the wetland was conducted almost 10 years ago (Pomeroy, 2006). There is now need to carry out an extensive biodiversity survey of the wetland to document species richness, abundance and monitoring in relation to what was observed in 2006. Also, monitoring of species like avian fauna, amphibians and small mammals gives an indication of ecosystem health.

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