Analysis of Lake Muhazi Marshland Degradation

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Abstract: Lake Muhazi is a long thin shallow flooded valley lake shared by Eastern, Northern Provinces and Kigali City of Rwanda but with a bigger part of it located in the eastern region. The analysis of Lake Muhazi marshland is the fundamental reason for this study through the detection of land use land cover in marshland of Lake Muhazi. Land covers classification through acquisition of Remote Sensing Imagery. Image classification to determine the nature and magnitude of marshland. This study uses GIS analysis, Remote Sensing Imagery and sampling method to successfully get sample size and enough data collection. Characterization of the marshlands of Lake Muhazi located in north east of Rwanda using Landsat TM data enabled an estimation of the rate at which disruption of water supply has led to the collapse of the ecosystem. Image classification techniques were used to estimate vegetation distribution using an NDVI image. Vegetation collapse appears to be linked to the completion of drainage projects that prevent the influx of nutrient rich spring flood waters to the marshes. The marshland change analysis determine how marshland was used from the year 2006 to 2016 in time range of 5 years. According to the maps showing the classification on land use and land cover near the lake is that the marshland, agriculture and built-up in this area was few in 2006 but forestry were as many as possible because this area was not built and there was few population. The results argues that the affected marshland must be protected for environment protection for a better use of the marshland to increase the productivity of marshland like agriculture production, touristic production, safe home for the aquatic species.

Keywords: Marshland, degradation, image classification, Remote Sensing Imagery

1. Introduction

Lake Muhazi is located in the eastern part of Rwanda, at Coordinates 1°51′S 30°24′E1.850°S 30.400°E, Primary outflows is Nyabugogo River, Catchment area is 829 km^2. The Muhazi constitute the more marshland ecosystem in the south, with environmental and socio-cultural significance. Critical problems and associated priority needs for the Muhazi Marshlands identified by the Rwanda authorities. Marshlands are low lying areas where water is always at or just below the surface. This marshland is the home to many species of plants and animals, such as fish and frogs, these species use marshlands to feed and have babies and can take the bad chemicals out of water in the lake, Muhazi marshland had a great area and it was not as much as potential due to human activities. In 20 years ago, Lake Muhazi and its marshland started to be affected by economic activities like agriculture at most, housing and rural settlement development and road construction. Thereafter, the erosion due to rainy water from the hills around Lake Muhazi became a major challenge to degrade that marshland. This level of degradation is periodically increasing because the human (both social and economic) activities increase due to development and the measures to stop this degradation were not yet set. To determine the level/rate of marshland degradation, GIS tool, image classification and Remote Sensing Imagery are applied to suitably detect land use and land cover marshland changes of Lake Muhazi.

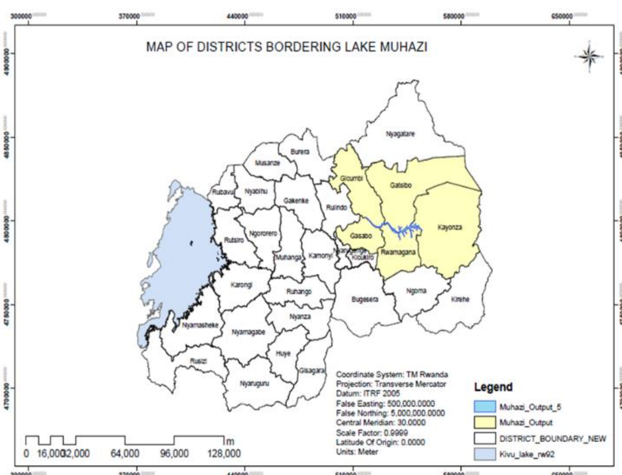
Lake Muhazi is one of lakes located in eastern province that is experiencing rapid degradation and conversion of marshlands. This is attributed to rapid urbanization that has characterized Rwanda's demographic structure in the past years. The degradation and conversion of Lake Muhazi marshland has resulted into regular flooding during the heavy rain season, this has led to seasonal displacement of people and destruction of properties, increase incidence of water related diseases all of which contribute to the impoverishment of the population.

The present study, therefore, seeks to: (1) analyze Lake Muhazi marshland degradation; (2) acquire Remote Sensing Imagery; (3) detect land use land cover change in marshland of Lake Muhazi over a decade; and (4) create land use land cover classification Maps. In the following sections, the authors elaborate on the methods and materials used (Section 2); the results obtained (Section 3); the discussion and analysis of results (Section 4); and, finally, the conclusion (Section 5).

2. Methods and Materials

2.1. Study area

Lake Muhazi is one of 21 main lakes of Rwanda located in north eastern of the country. There are 5 districts that border Lake Muhazi which are Gasabo, Rwamagana, Kayonza, Gatsibo and Gicumbi; they are a lot of different marshland around Lake Muhazi that describes how Lake Muhazi marshland was degraded. Lake Muhazi outflows in River Nyabugogo which meets with River Akanyaru to form River Akagera which is the source of River Nile. Lake Muhazi marshland benefits to the population around in terms of agriculture, tourism and settlements. Lake Muhazi is methodically making, doing, or accomplishing something located at the eastern of Rwanda.



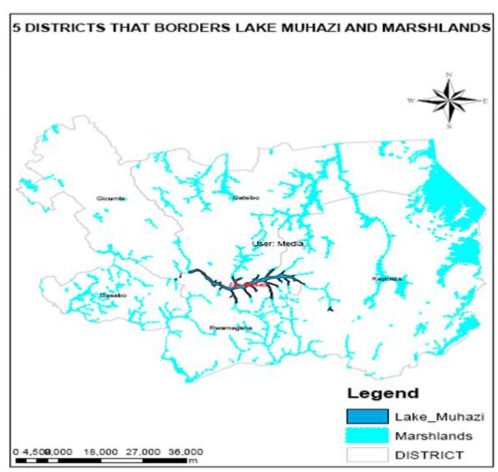


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Figure 1. Location of Lake Muhazi

2.2. Datasets

Data used for analyzing marshland degradation based on agriculture on the study area are land uses data, they have been derived from open source of United States Geological Survey (USGS) (https://www.usgs.gov). The Landsat images were downloaded from this open source as data to be used in the research. For this study, Landsat-5 TM image acquired in 2006; a Landsat-7 ETM+ image acquired in 2011; a Landsat-7 ETM+ image acquired in 2016 was used. All those images were acquired with a 30-m spatial resolution, as they deliver an appropriate and cost-effective source of information for a wide range of applications, including land change mapping. Shapefiles was used for describing the area of study downloaded from Rwanda Geo portal (http://geodata.rw). The Landsat images (raster data) are used to classify land use land covers of study area and the shapefiles (vector data) are used to describe the area of study.

2.3. Methodology

2.3.1. Remote Sensing Imagery

To plan for marshland protection and sensible coastal development, scientists and managers need to monitor the changes in coastal marshlands as the sea level continues to rise and the coastal population keeps expanding. Advances in sensor design and data analysis techniques are making remote sensing systems practical and attractive for monitoring natural and man-induced marshland changes. The objective of this research is to review and compare marshland remote sensing techniques that are cost-effective and practical and to illustrate their change in marshland degradation. The results of the case studies show that analysis of satellite and aircraft imagery, combined with on-the-ground observations, allows researchers to effectively determine long-term trends and short-term changes of marshland vegetation and hydrology. One of the software of remote sensing is ERDAS Imagine which is a raster-based software package designed specifically to extract information from imagery. ERDAS Imagine includes a comprehensive set of tools to create accurate base imagery. ERDAS Imagine provides a variety of tools such as image orthorectification, mosaicking, reprojection, classification and interpretation that allow the user to analyze image data and present it in formats ranging from printed maps to 3D models. It used for image data visualization, classification, modeling, analysis and interpretation. (Plascencia, 2015).

2.3.2. GIS Tool Analysis

The Geographic Information System (GIS) is a tool for better solution of environmental management in Rwanda. Rwanda's environmental resources can be categorized into land, marshlands, forests, and water resources. The major problem in the field of environmental protection in Rwanda is the imbalance between the population and the natural resources (land, water, flora and fauna and nonrenewable resources) which have been degrading for decades. This degradation is observed through massive deforestation, the depletion of bio-diversity, erosion and landslides, pollution of waterways and the degradation of fragile ecosystems, such as swamps and marshlands. Geographical information system is important tool to

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achieve goals of sustainability science which include understanding, integrating, and modeling nature and society for well-being of each nation citizens. (Nyesheja Muhire Enan 1, 2004). GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. This Software tools that automatically extract features from ERDAS Imagine.

3. Results

3.1. Monitoring Marshland Changes

To identify long-term trends and short-term variations, such as the impact of rising sea levels and hurricanes on marshlands, there is a need to analyze time series of remotely sensed imagery. The acquisition and analysis of time series of multispectral imagery is a difficult task. The imagery must be acquired under similar environmental conditions (e.g., same time of year and sun angle) and in the same or similar spectral bands, considering these images before classification. There are changes in both time and spectral content.

One way to approach this problem is to reduce the spectral information to a single index, reducing the multispectral imagery into one field of the index for each time step. In this way, the problem is simplified to the analysis of time series of a single variable, one for each pixel of the image,

3.2. Visualization of Classified Image

In order to fulfill the need for land cover and land uses in the study area, the land use land cover of Rwanda was produced in order to know the influence and impact of changes that can occur for the wetland as results of marshland degradation due to the land cover changes of the surrounding area by using remote sensing techniques and GIS. These maps provide a set of baseline conditions for comparing long-term changes.

The Landsat image provided from the United State Geological Survey (USGS) and they have been projected in Universal Transverse Mercator (UTM) coordinate system. Landsat satellites have the optical ground resolution and spectral bands to efficiently track land use. Those satellite images were obtained from the United States Geological Survey (USGS); the images were then subset to the border of the study area. The supervised maximum likelihood classification used in this study is the most common method in remote sensing image data analysis. It identifies and locates land cover types that are known through a combination of personal experience, interpretation of Landsat image, map analysis and fieldwork. It uses the means and variances of the training data to estimate the probability that a pixel is a member of a class.

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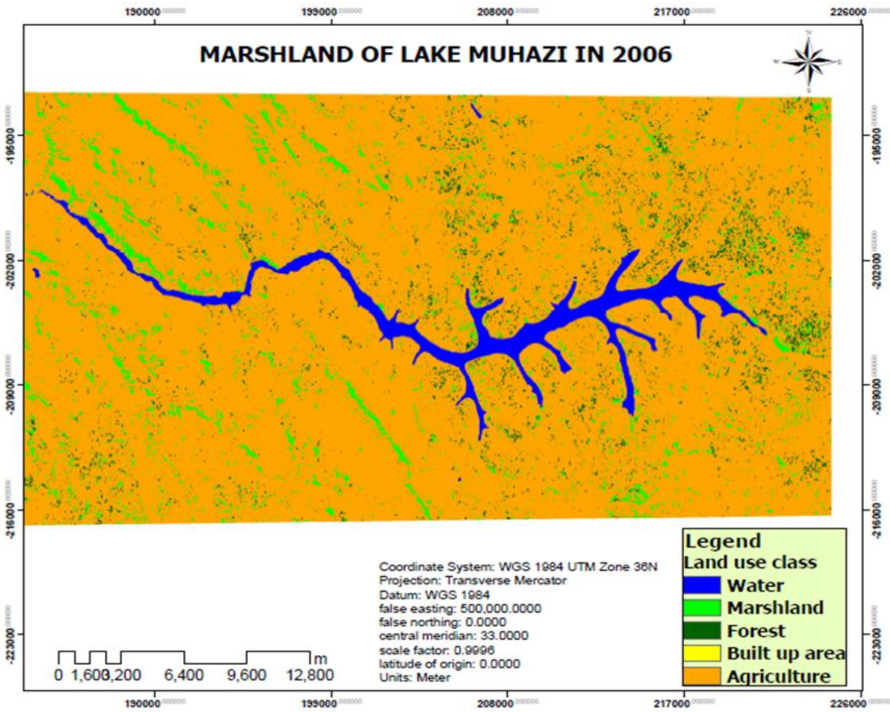

Figure 2. Classified map of Lake Muhazi marshland 2006

In 2006, it is observed that there is an abundance of vegetation around Lake Muhazi and small area of built up.

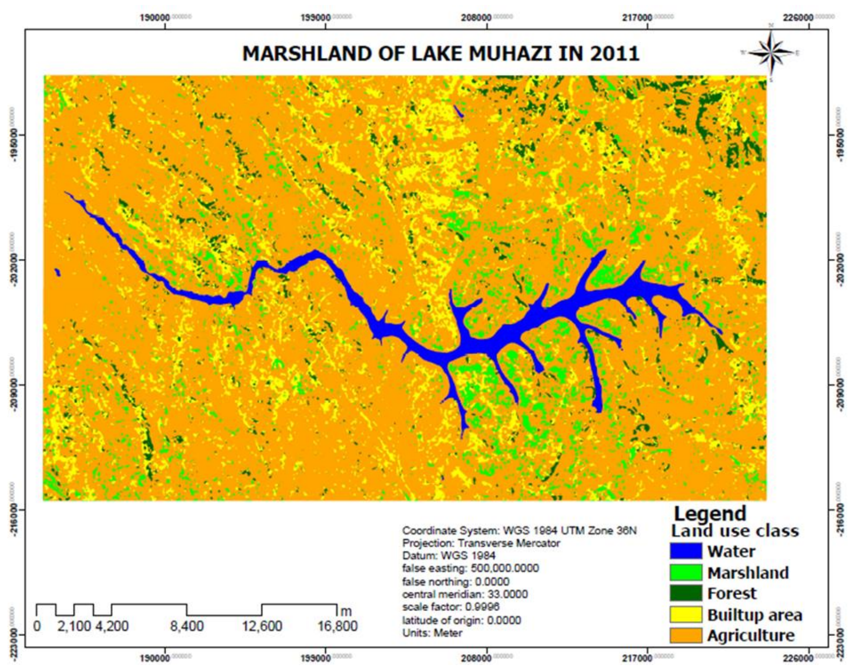

Figure 3. Classified map of Lake Muhazi marshland 2011

From the observation of figure [3], it shows that the agriculture is still in abundance but

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also there is an increase of marshland area and built up.

As this study was considering the data ranging from 2006, 2011 and 2016, here is another classified image.

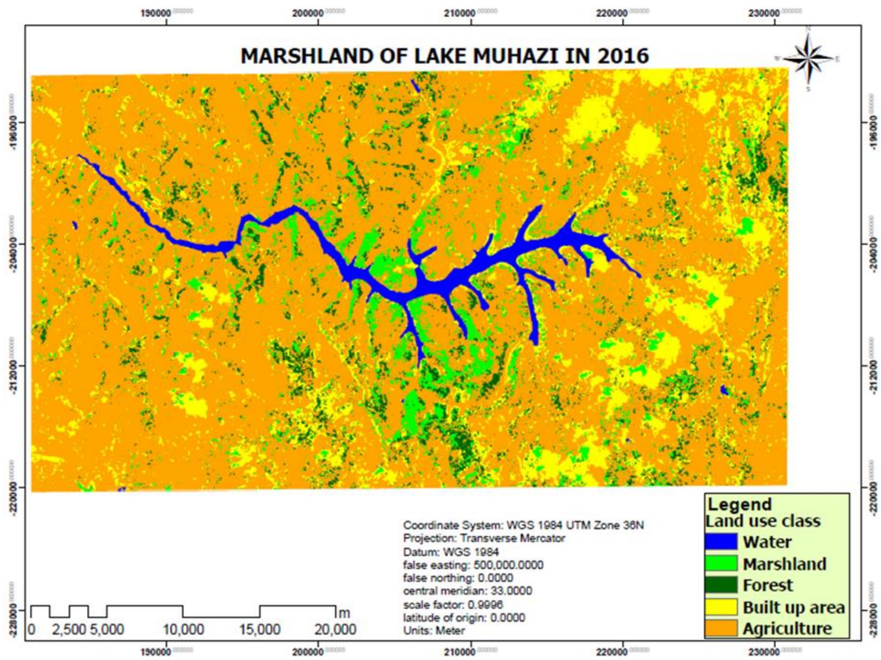

Figure 4. Classified map of Lake Muhazi marshland 2016

Figure [4] shows how after 5 years from the previous classified image, there is a big change where we can observe that not only marshland have increased but also built up area is increasing in terms of area which implies that there is a human growth around Lake Muhazi.

One disadvantage in the image classification of marshland is that every error in the individual data classification maps is also present in the final change detection map.

3.3. Land Use Change Analysis

Ranging from 2006, 2011 to 2016 there are some changes that have been observed, those changes can be represented in terms of area and analyze them.

Table 1. Changes in area of the classified land use (figures in sqkm)

Land use	**2006**	**2011**	**2016**
Water	57	42	38
Marshland	21	46	70
Forest	18	34	77

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Build up	82	117	194
Agriculture	684	734	981

This table above show the difference in areas of the features presented in the figures [2], [3] and [4] of Lake Muhazi marshland including water of Lake Muhazi, marshland of Lake Muhazi, forests, built up area and agriculture.

From the values of table [1] data can be visually illustrated through the graph below showing the relationship between them.

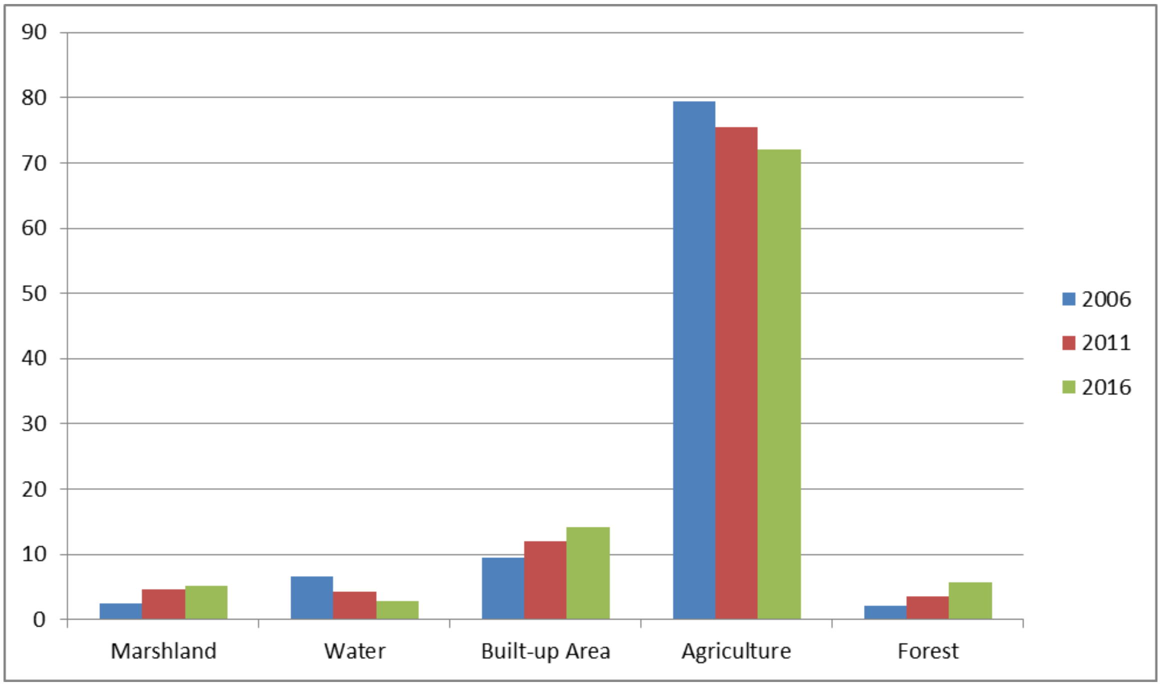

Figure 5. The graph of features in different years

4. Discussion

4.1. Land Use Change between 2006 and 2011

Detecting changes between two registered and corrected images [2] and [3] from different years 2006 and 2011 respectively can be accomplished by employing one of several techniques, including post classification comparison and spectral image differencing (change detection). In post classification comparison, two images from different years are independently classified. The two maps are then compared pixel by pixel. This avoids the difficulties in change detection associated with the analysis of images acquired at different times at different years or by different sensors, thereby minimizing the problem of radiometric calibration across years.

Considering these two maps of Lake Muhazi marshland of 2006 and 2011 with the difference of 5 years, there is a great change after classifying all these images we can detect comparing pixel by pixel that the volume of water of Lake Muhazi has reduced while the Lake Muhazi marshland has increased which has been caused by the projects of irrigation and watering of plantations in the areas near Lake Muhazi and erosions in 2008 which affected the sectors of Munyiginya and Gishali.

4.2. Land Use Change between 2011 and 2016

In these two images [3] and [4] of the years 2011 and 2016 respectively not only Lake Muhazi and the marshland also the built up areas and the forests show a great change while comparing them on each map pixel by pixel due to the land consolidation for the built up areas where citizens where moved to the villages, and through the tree planting program which has been launched in Rwanda in 2003 and published in Eastern province in 2012 where they planted many trees in districts of Rwamagana, Kayonza and Gatsibo and those trees have led to large and great forests in those areas. In terms of marshland and Lake Muhazi there is a great change as the volume of water as reduced and the marshland has increased in terms of volume and area due to the causes mentioned above of irrigation, watering of plants and erosion.

5. Conclusion

A number of factors influence marshland degradation and these include political, economic, social and cultural factors. In this study the rate of change of marshland on Lake Muhazi and how it has degraded over the years it has been observed from the findings that the marshland were not degraded but increased due to the decrease of water which resulted from irrigation and agriculture that are the results of human activities. Lack of employment opportunities and alternative sources of income among most respondents neighboring Lake Muhazi this has left them with no other choice except agriculture and fishing which led to the reduction of biological diversity of animal species. In the study, data shows that there have been a population growth in the area of study and those people are the one who were involved in crops cultivation, while others wanted additional income to meet family requirements have to use fisheries which result in the decrease of water. Thus local communities living near the marshland depend heavily on it for survival and this result into its degradation. It was further noted and concluded that increases in population densities coupled with limited land and declining yields, also influences marshland degradation. In order to supplement the diminishing crop yields on land, farmers on Lake Muhazi have been to the marshland which was fertile soils leading to its degradation. Increased awareness and education are therefore required for efficient management and sustainable of marshlands. Furthermore it can be concluded that marshland have the most delicate ecosystems compared to any type of the existing ecosystems.

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