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Impact of Flood on Wetland Ecosystem Services in Rwanda

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Abstract

This study assessed the impacts of flood on urban wetland ecosystem with emphasis on Nyabugogo wetland. The study was a descriptive with a quantitative and qualitative survey approach. Purposive sampling methods identified 100 respondents from Gatsata, Gisozi, Muhima and Kimisagara sectors of Kigali city which surround the wetland. The structured questionnaire was used to collect data which were analyzed by using Microsoft Excel. The results indicated that the majority of respondents consider wetland as the main source of provisioning services, subsistence and commercial crops, and livestock feed and fresh water. Respondents also agreed on the fact that regulating and support services are important services provided by the wetland. However, it was noticed that flood occurrence declines ecosystem services at the Nyabugogo wetland. Lack of protecting the wetland's surrounding mountains from runoff and poor drainage systems were mentioned as key drivers to flood by 42% and 30% of respondents, respectively. Therefore, appropriate wetland protection measures are required to perform their functions and provide goods and services to sustain human life. This would lead to sustainable development and green growth resulting from the existing and delivery of ecosystem services.

Keywords

Community, Ecosystem Services, Flood, Nyabugogo Wetland, Kigali

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1. Introduction

In recent decades, there has been an upward trend in disaster loss, mainly driven by climate change and the increasing population growth rate and economic assets installed within flood-prone areas [1, 2]. Flooding affects millions of people worldwide each year. Between 1980 and 2012, the average annual reported losses and fatalities due to floods exceeded USD 23 billion and 5,900 people, respectively [3, 4, 5].

The process of urbanization is among the causes of continuous increase of flood hazard events and the associated losses worldwide; mainly due to the increasing impervious surfaces and the exposure of people and their wealth [3, 6]. Urban impervious surfaces, houses, roads, and many more reduce the infiltration capacity of the former rural catchment. This results into the upsurge in the flow of water available for runoff and leading to flash floods [4, 5, 7].

Due to its geographical features and climatic profile, Rwanda is prone to various hazards mainly localized floods and landslides [7, 8]. Due to its dense river network and large wetlands, the country is threatened very often by riverine floods. In Rwanda, mainly in Kigali City, heavy rainfall events cause rapid surges in the flow of rivers and drainage systems leading to floods downstream. Flooding in Kigali has been experienced since 1960s [9, 10, 11] and have increased with the city growth through years; its impacts got

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a huge intensity from 2000s till now. According to [10, 11], flooding in Kigali mainly happens during the long rainy season from April to June and September to December where intense rainfall is recorded.

The Nyabugogo wetland has been affected by flooding for several times. This is mainly due to its topography which is a lower land area where drainage systems of Kigali city are converging. The heavy precipitation associated with climate change combined with urban development in Nyabugogo flood plain increase the flood risk and flood damages in the wetland [11]. In the literature, many studies [8, 10, 11, 12] have been conducted on flood in Nyabugogo wetland and its ecosystem services. However, there is still a gap in connecting floods and Nyabugogo ecosystem services. This study comes in this framework to assess the impacts of flood on Nyabugogo wetland ecosystem, for a strong national disaster risk reduction and prevention. Therefore, the objective of this study was to assess the impact of flood on urban wetland ecosystem with emphasis on Nyabugogo wetland downstream.

2. Methods and Materials

2.1. Study Area

This study considered the Nyabugogo wetland located in the central eastern part of Rwanda. The catchment drains a total area of 1,647 km^2 dispatched into 8 districts: Rulindo, Gicumbi, Gatsibo, Kayonza, Rwamagana, Gasabo, Nyarugenge and Kicukiro. The climate of the catchment is mostly of temperate and equatorial type with an average temperature ranging between 16°C and 23°C, depending on the altitude of the area. Its annual rainfall varies between 800 mm and 1,600 mm [10, 11].

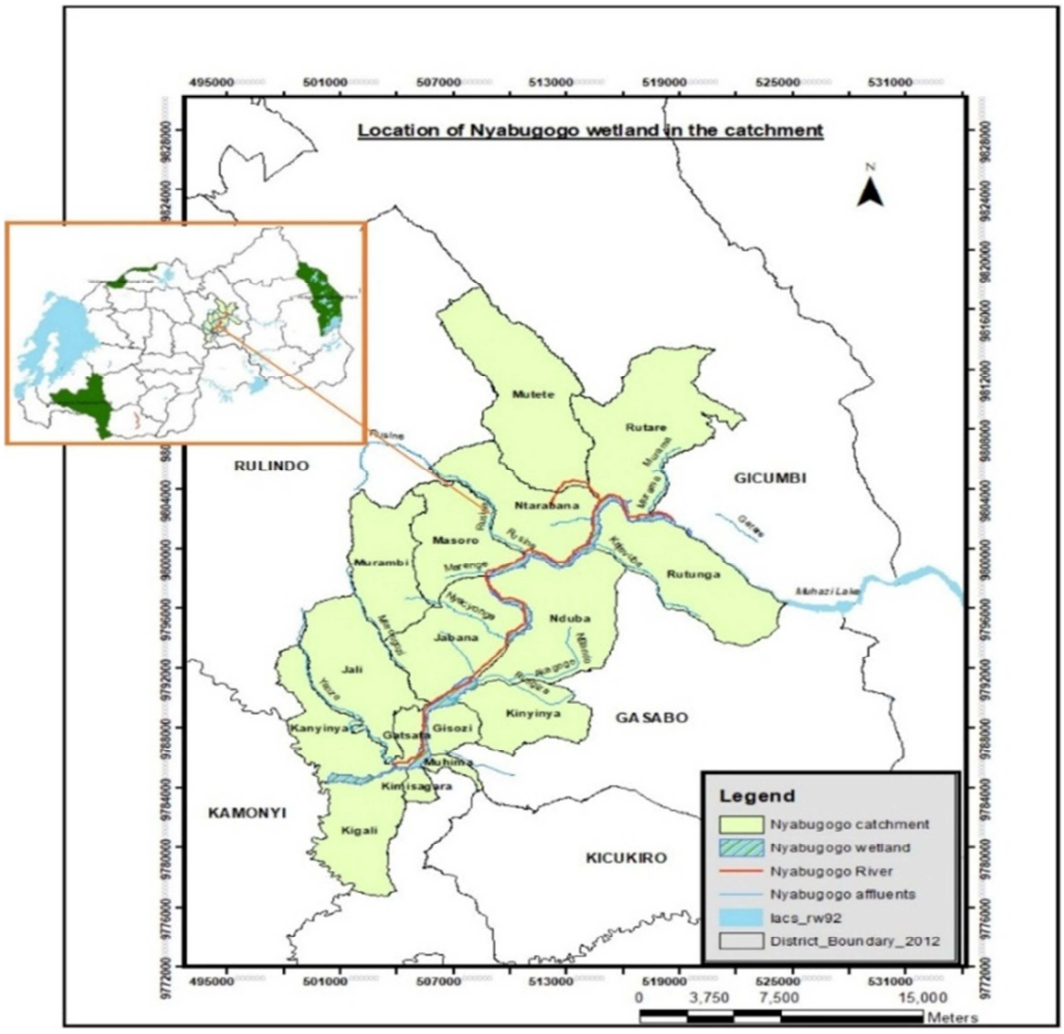

Figure 1. Location of Nyabugogo wetland in Nyabugogo catchment.

2.2. Data Collection and Analysis

For this study, the authors approached the wetland surrounding communities and analyzed their awareness on flood and its impact on Nyabugogo wetland ecosystem services. The considered study populations were from

Gatsata, Gisozi, Muhima and Kimisagara sectors. These sectors are populated by 186,468 residents as by 2019. These households were considered for this study based on two criteria namely: the location of settlements and other economic activities like shops and factories within the wetland.

However, the authors did not use all 186,468 residents. A sample was estimated from them by using the following formula as follows:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where n is the sample size, N is the study population in Gatsata, Gisozi, Muhima and Kimisagara sectors and e is the margin of error. Therefore, the sample was calculated as follows:

$$n = \frac{186{,}468}{1+186{,}468\ (0.1)^2} = 99.9 = 100 \quad (2)$$

To minimize the risk that the sample size will not represent the true population the margin error was fixed at 10%. Then, the sample size for the study was 100 informants. Thereafter, the authors calculate the sample per each sector considered by this study by employing the proportionate sampling method as follows:

$$ni = \frac{Ni*n}{N} \quad (3)$$

Where *ni* is the sample size proportion to be determined, *Ni* is the population proportion in the sector, *n is* the sample size calculated in equation 2 and *N is t*he total population considered by the study.

Table 1. Sample size determination per sector.

Sector	Number of residents	Sample size
Gatsata	43,898	23
Gisozi	52,052	28
Muhima	35,213	19
Kimisagara	55,305	30
Total	186,468	100

After setting up the study sample size, the authors collected field data among the respondents. The study considered (1) gender, age and education of respondents, (2) causes and occurrence frequency of flood at Nyabugogo wetland, (3) types of ecosystem services provided by Nyabugogo wetland and their importance to the livelihood of the surrounding community, and (4) recorded/observed changes on wetland ecosystem due to flood. The authors employed a structured questionnaire which was translated in Kinyarwanda in order to help respondents to easily understand the study purpose. Furthermore, the data collected were edited and analyzed by using Microsoft Excel.

3. Results

3.1. Identification of Respondents

Among the contacted respondents, the results in Table 2 showed that the majority of them (36 percent) are aged between 18 and 30 years old followed by 29 percent who are aged between 30 and 42 years old. And 58 percent of them are female while 44 percent and 32 percent attended secondary and primary schools, respectively.

Table 2. Description of respondents by age, sex and education.

Age	Age				
	18 - 30	31 - 42	43- 60	61 and above	Total
Frequency	36	29	21	14	100
Percentage	36	29	21	14	100

Gender	Gender		
	Female	Male	Total
Frequency	58	42	100
Percentage	58	42	100

Education	Education				
	Illiterate	Primary	Secondary	University	Total
Frequency	13	32	44	11	100
Percentage	13	32	44	11	100

3.2. Importance of Nyabugogo Wetland Ecosystem Services to Community Livelihoods

The results, as shown in Figure 2, all 100 respondents mentioned flesh water as a very important provisioning service derived by Nyabugogo wetland. This was followed by commercial and subsistence crops, asserted by 92 and 80 percent of informants, respectively. Whereas natural or plant derived medicines and ornamental plants were ranked at somehow important provisioning services derived from the wetland, as asserted by 76 and 67 percent of informants, respectively.

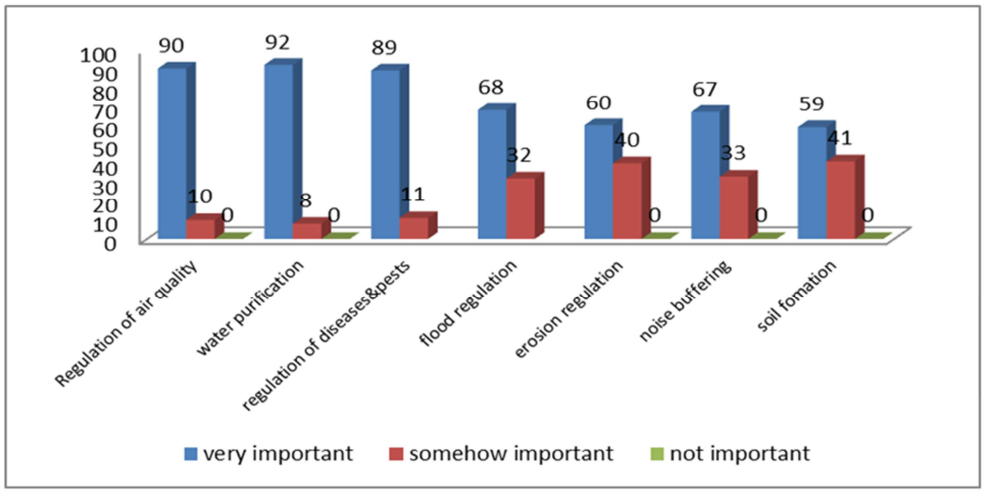

Figure 2. Importance of provisioning services.

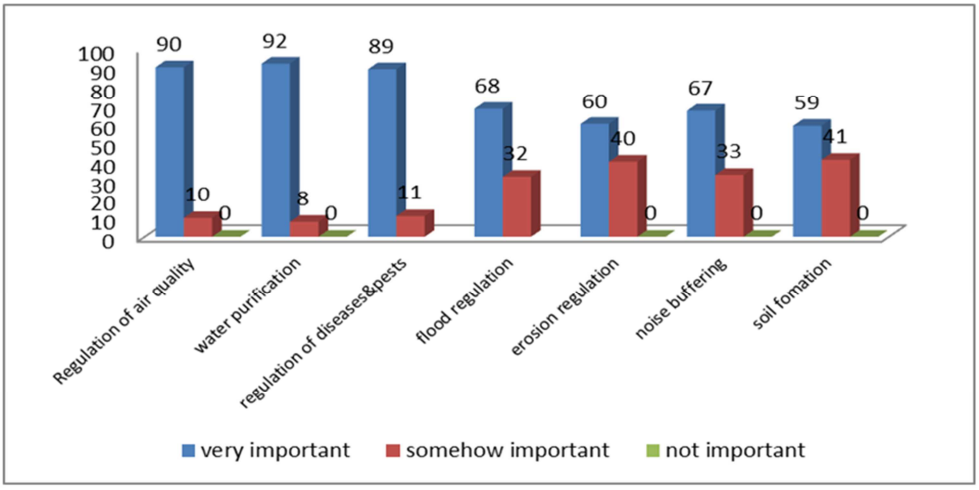

Figure 3. Importance of regulating and supporting services.

With regard to the regulating and supporting services provided by Nyabugogo wetland, the results in Figure 3 revealed that water purification (92%) regulation of air quality (90%), and regulation of diseases and pests (89%) are the very important regulating and supporting services offered by Nyabugogo wetland. Finally, the results in Figure 4, showed that education knowledge system was highly mentioned by respondents (85) compared to the remaining cultural services.

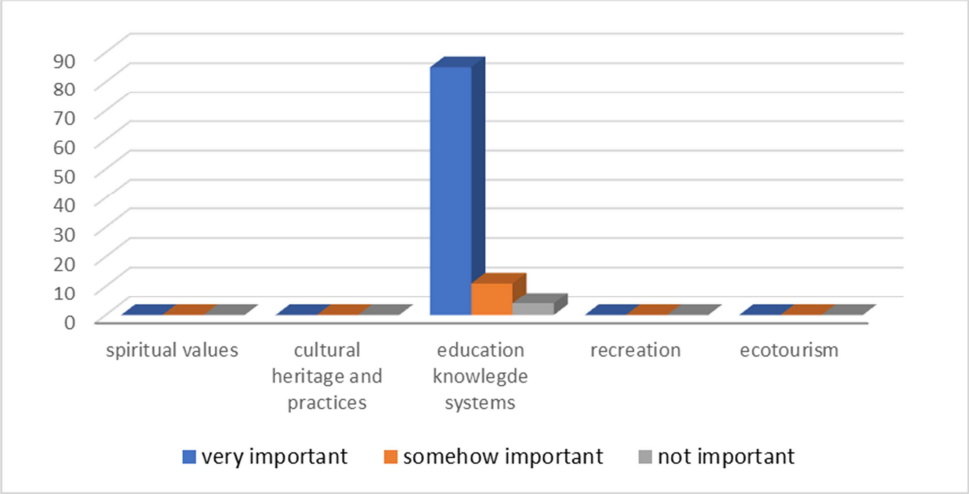

Figure 4. Importance of cultural services.

3.3. Floods Occurrence and Its Impact on Nyabugogo Wetland Ecosystem Services

The results in Figure 5, as asserted by 47 and 35 percent of respondents, showed that flood at Nyabugogo wetland occurs once a year and once in two years, respectively.

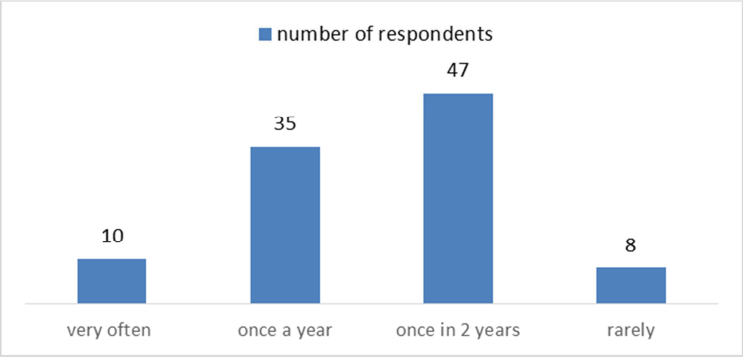

Figure 5. Flood occurrence in Nyabugogo wetland downstream.

With regard to flood occurrence conditioning factors at Nyabugogo wetland, the majority of respondents (42%), as illustrated in Figure 6 mentioned that lack of protecting the wetland's surrounding hills causes runoff which stands as the main driver to flood occurrence at Nyabugogo wetland. This was followed by poor drainage systems in the wetland, as asserted by 30% of the respondents.

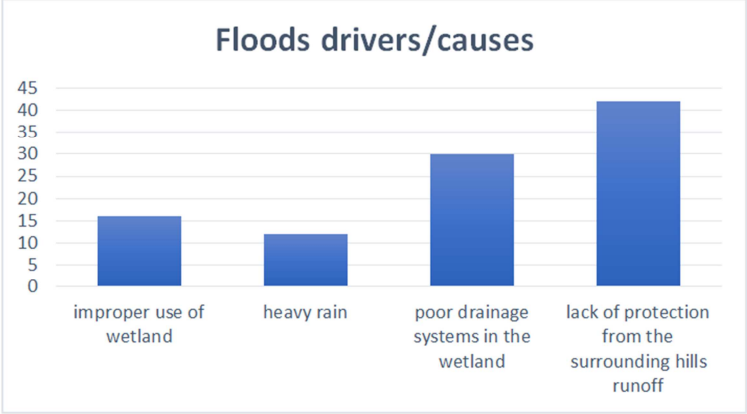

Figure 6. Flood drivers/causes.

The results in Figure 7 showed that flood occurrence leads to decline in provisioning services mainly fresh water, commercial crops and natural/plant derived products.

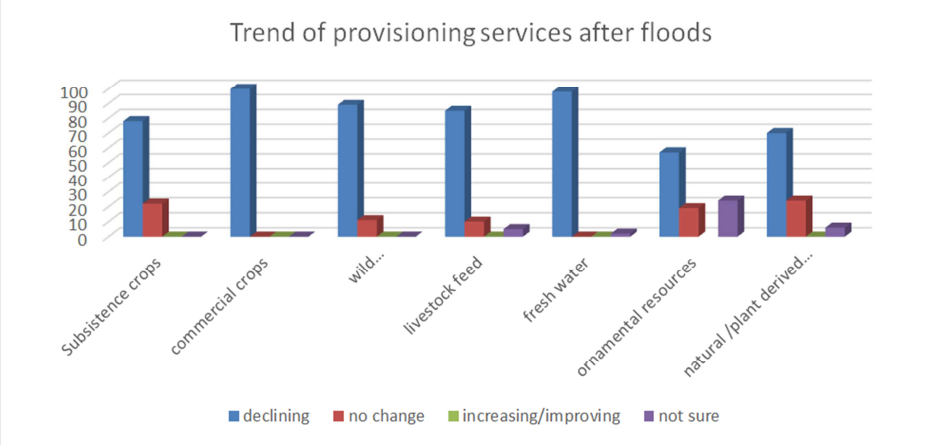

Figure 7. Trend of provisioning services after flood.

In addition, based on the results in Figure 8, all informants confirmed that the regulating and supporting services record decreasing trend as a result of flooding.

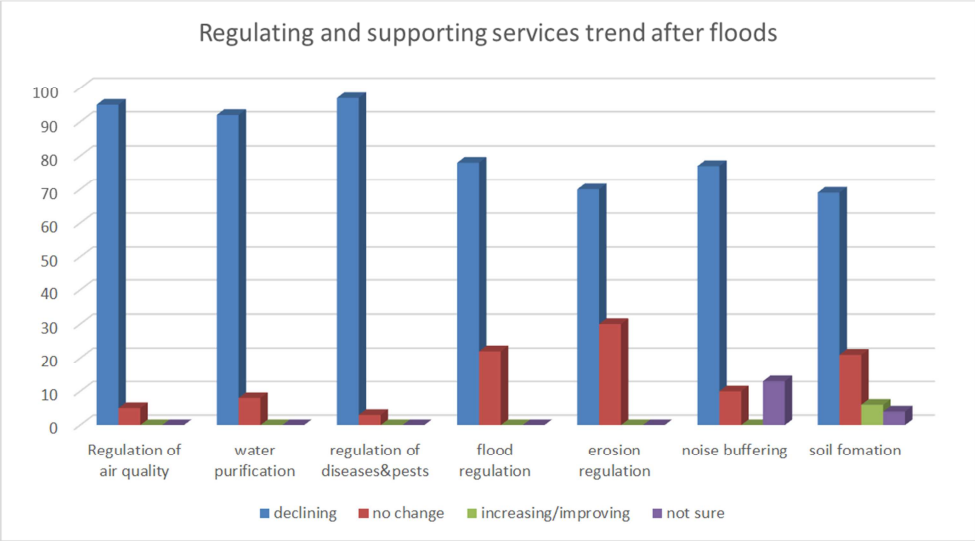

Figure 8. Regulating and supporting services trend after flood.

Furthermore, for the cultural services, the analysis in Figure 9 indicated that the education knowledge systems have been argued by most of the respondents (more than 80) to be declined by flood compared to other cultural services.

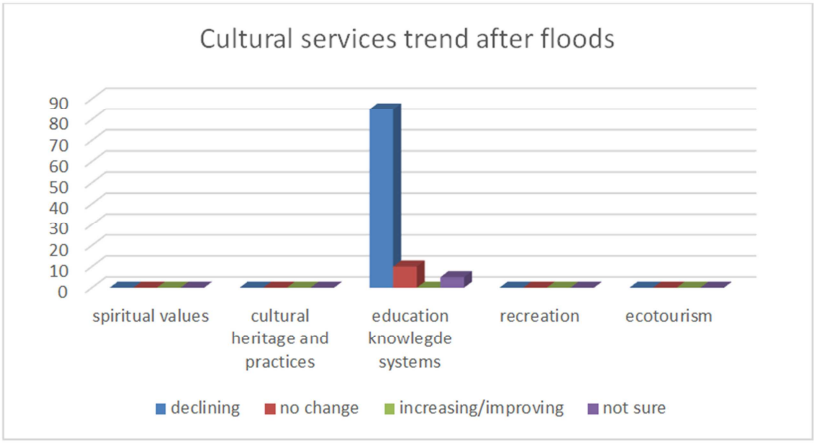

Figure 9. Cultural services trend after flood.

4. Discussion

Urban flooding is becoming an increasing problem in Kigali City. In the past few years, major flood events have led to infrastructure damage, landslides, soil erosion, environmental degradation, injuries, and fatalities [13, 14]. This is mainly aggravated by the increasing unplanned urban growth, occupation of floodplains, and poor drainage systems characterizing the city [13, 14, 15]. This study indicated that Nyabugogo wetland surrounding communities are aware of flood occurrence and the associated consequences. As highlighted by respondents in Figure 5, flood occurs once a year or within two years at the wetland. However, this occurrence affects the regulating, supporting, provisioning and cultural wetland ecosystem services (Figures 7, 8 and 9). The results in Figure 6 indicated that this occurrence of flood is mainly driven by poor protection of hills surrounding the wetland and poor drainage system along with heavy rain recorded in this area.

Nevertheless, the results in Figures 2, 3 and 4 indicated that respondents value the wetland ecosystem services at varied ranks. Consequently, this can cause the wetland surrounding community not to fully protect the wetland due to the importance they attach to its existence. Therefore, further community mobilization and skills development (education/training) on the types of ecosystem services and their role on their wellbeing would be important among these

people. The results of this study agree with previous reports [16, 17, 18] that poor community awareness on the role wetland ecosystem services leads to flood occurrence since the wetland surrounding hills are not protected. These reports also call for community engagement and training to develop their wetland management skills and ownership as well.

Thus, as long as flood is occurring at Nyabugogo wetland and damages it ecosystem services, more polices should be envisaged to ensure its sustainable protection. This requires both public and private engagement, but particularly the local community involvement since they are the ones exploring the wetland on daily basis and exposing these services to flood risk as well.

5. Conclusion

This study assessed the impact of flood on wetland ecosystem services. The respondents (100) were selected from all residents of the sectors surrounding Nyabugogo wetland considered as the case study. The authors employed a structured questionnaire to collect the data among respondents. The results indicated that the communities understand the types of ecosystem services provided by the wetland to them. These are provisioning, regulating, supporting and cultural services. However, it was noted that as long as flood is occurring at the wetland, ongoing decline on these services is under record mainly due to high rainfall intensity, poor draining system and unprotected hills surrounding the wetland. Based on the fact that the community values the Nyabugogo ecosystem services at different scales, it is suggested to policy makers to ensure that people are approached to enhance their awareness and participation on ecosystem management.

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