International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

The Impact of Urbanization on Wetland Pollution Case of Nyabugogo Wetland, Rwanda

Flora BAYIZERE
Dr. MUPENZI Christophe
Dr. NSHOGOZA Gilbert3
NKUNDIMFURA Juin Thierry4

Submitted: 20-05-2022 Revised: 28-05-2022 Accepted: 30-05-2022

ABSTRACT
This study presents the impact assessment of urbanization on wetland pollution in Nyabugogo wetland. The objectives of this study are to examine the urbanization status around Nyabugogo wetland and its catchments, to assess the water quality of Nyabugogo wetland and to establish the relationship between urbanization and wetland pollution, using both primary and secondary data. Six water parameters including pH, Zinc, Cromium, Total Suspended Solid (TSS), Total Nitrogen (TN) and Total Phosphorus (TP) were analyzed in laboratory of Research Center for Natural Resources and Environment, and they were compared to previous findings tested on Nyabugogo river, swamp, or wetland based on World Health Organisation (WHO) standards and Rwanda Standards Board (RSB) standard. Study findings show that urbanization in Kigali is increasing and reached at 75.9% in 2020, Gross Domestic Product (GDP) increases almost 3 times from 2010 to 2020, GDP per capita has reached 1.2 thousand US$/Cap, and people remain habituated in unplanned areas in Kigali city. For water quality, findings show that the maximum value of pH is 7.2, Zinc 0.22 mg/, Cromium (mg/l) 0.044, TSS (mg/L) 17, TN (mg/l) 55.7, and TP (mg/l) 0.34. These findings illustrate that urbanization has a positive impact to wetland pollution and that well planned urbanization led to the reduction of wetland pollution and vice versa.

Key words: Impact; Urbanization; Wetland; Pollution; Nyabugogo

I. INTRODUCTION

More than half of the world's wetlands have been reformed, corrupted, or lost in the last 150 years (Gardner et al., 2015) and human activities have globally changed wetland status (O'Connell, 2003). According to Shengjie et al. 2017 wetland damage and humiliation is a certain reality, and human activities are chiefly to blame as the main factors.

As Tengteng et al. (2016) pointed out, since the early 20th century, global wetland ecosystem has confronted great challenges including rapid economic development, intensive reclamation of farmland, overexploitation of biological resources, excessive use of wetland water, sedimentation, water pollution, tourism overdevelopment, and habitat destruction. Many wetland ecosystems have experienced severe pollution, including wetland area shrinking, water quality decline, biodiversity loss, and wetland function disorders (Tengteng et al., 2016). Agriculture and urbanization are two main human activities, directly cause wetland loss (Ehrenfeld, 2000; Gibbs, 2000; Gong et al., 2012; Niu et al., 2012).

Urban developments, including residential expansion, industrial and commercial activities have contributed to the pollution of Kigali's wetlands, especially in areas adjacent to Muhima Sector. The habitat's natural vegetation, dominated by C. Papyrus and a variety of Pennisetum, has been severely affected by industrial and household wastes. Industrial activities, such as brick making and sand mining, have contributed to the pollution of Kigali's wetlands (UN-Habitat, 2009). In Rwanda, despite its great importance in providing different values to surrounding community, Nyabugogo wetland is highly polluted so that it can be a good disease-ridden place. Nkuranga (2007) observed that Nyabugogo natural wetland (Kigali

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

City, Rwanda) receives all kinds of untreated wastewaters, including those from industrial areas. Many of these industries do not have onsite treatment plants. Therefore, they are discharging their wastewater into two small rivers, called Kibumba and Ruganwa, which discharge in the Nyabugogo wetland (Sekomo et al., 2011).

Objectives of the study: the main objective of this study is to assess the impact of urbanization on Wetland Pollution and come up with recommendations to protect and conserve the wetlands. And specific objectives were defied as follows:

1. To examine the urbanization status around Nyabugogo catchment.
2. To assess the water quality of Nyabugogo wetland.
3. To establish the relationship between urbanization and wetland pollution.

II. METHODOLOGY

Research Design: This study is descriptive design and correlative. It describes urbanization characteristics in Nyabugogo catchment area (Kigali City) and Nyabugogo water pollution parameters. The study is restrictively based on primary data and secondary data retrieved from long-term databases storing conservation and protecting wetlands. Other part of data, regarding the water and wetland pollution, were analyzed in laboratory of Research Center for Natural Resources and Environment located at University of Lay Adventist of Kigali. The study also is correlative as it ends up by examining the correlation between urbanization and water pollution on the case of Nyabugogo wetland.

Data collection and analysis methods: This study has used both primary and secondary data. Primary data are based on sampled points of water quality tests. Here 4 composite samples of water were taken to laboratory for water quality test. And the sample were taken in Nyabugogo wetland around the main catchments. Secondary data also were collected using documentation review. The main reviewed documents are reports of National Institute of Statistics (NISR) on urbanization and waste management in areas and households alongside of Nyabugogo wetland and its catchments. The second mainly used document is the Nyabugogo Catchments plan 2018-2024 in addition to papers and reports maid by other researchers (all sources were written in the document).

For water quality test, sample taken were taken to laboratory and results were analyzed as comparison to wetland water quality national RSB Standards (Rwanda) as officially by international agencies.

Time series of values for indicators of urbanization (economic indicators, poverty, population, infrastructure) and water pollution (waste handling and disposal in households, change of water chemical contents and physical contents, etc) were presented for last ten years where possible. And the researcher has made critical analysis from one year to another. Test of correlation was made using bivariate analysis model. This is analyzed with the correlation analysis showing r or Pearson correlation (always ranging between -1 to +1) and p-value of Sig. (2-tailed) which is statistically significant once the value is less or equal to 0.05.

III. RESULTS AND DISCUSSION

3.1. Urbanization in Nyabugogo wetland and its catchments areas

In this section urbanization level or characteristics in area surrounding Nyabugogo wetland and its catchments areas was made using population growth information, infrastructure (land cover change from 2010 to 2020) and natural disasters (floods, etc.).

Population growth in study area was marked from 2010 to 2020 where total population in Kigali city increased from 1 million to 1.3 million populations. This is due to the development of infrastructure, economic development in Kigali city, access to employment opportunities which increased migration of people from rural area to urban area (Antoine R., 2017).

Table 3.1: Kigali City Population Growth for the rea surrounding Nyabugogo Catchments.

Area	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Rwanda	**10,127,674**	**10,305,157**	**10,482,641**	**10,739,766**	**10,996,891**	**11,262,564**
Kigali City	1,094,331	1,113,508	1,132,686	1,160,469	1,188,253	1,216,959
Nyarugenge	274,925	279,743	284,561	291,541	298,521	305,733
Gasabo	511,629	520,595	529,561	542,550	555,540	568,961
Kicukiro	307,777	313,170	318,564	326,378	334,192	342,266
Area		**2016**	**2017**	**2018**	**2019**	**2020**
Rwanda		**11,535,932**	**11,809,300**	**12,093,905**	**12,378,511**	**12,663,116**

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

Area	2010	2011	2012	2013	2014	2015
Kigali City		1,246,498	1,276,036	1,306,789	1,337,541	1,368,294
Nyarugenge		313,154	320,574	328,300	336,026	343,752
Gasabo		582,771	596,581	610,959	625,336	639,714
Kicukiro		350,573	358,881	367,530	376,179	384,828

Source: (NISR, Fourth Population and Housing Census, Rwanda, 2012; Thematic Report: Population Projections , 2014)

As seen from table 3.1, population in Kigali and in districts areas of Nyabugogo catchments is increasing from 2010 to 2020. From 2010 Kigali city population was increased from 1.09 million 2010 to 1.37 million population in 2020. In Nyarugenge in the same period of range was changed from 0.27 million to 0.34 million, Gasabo changes was taken from 0.51 million of population to 0.64 million and for Kicukiro the changes were from 0.31 million of population to 0.38 million. Population growth in areas of Nyabugogo wetland catchments also increase effects to water quality mainly waste generation and later due to human activities water get polluted.

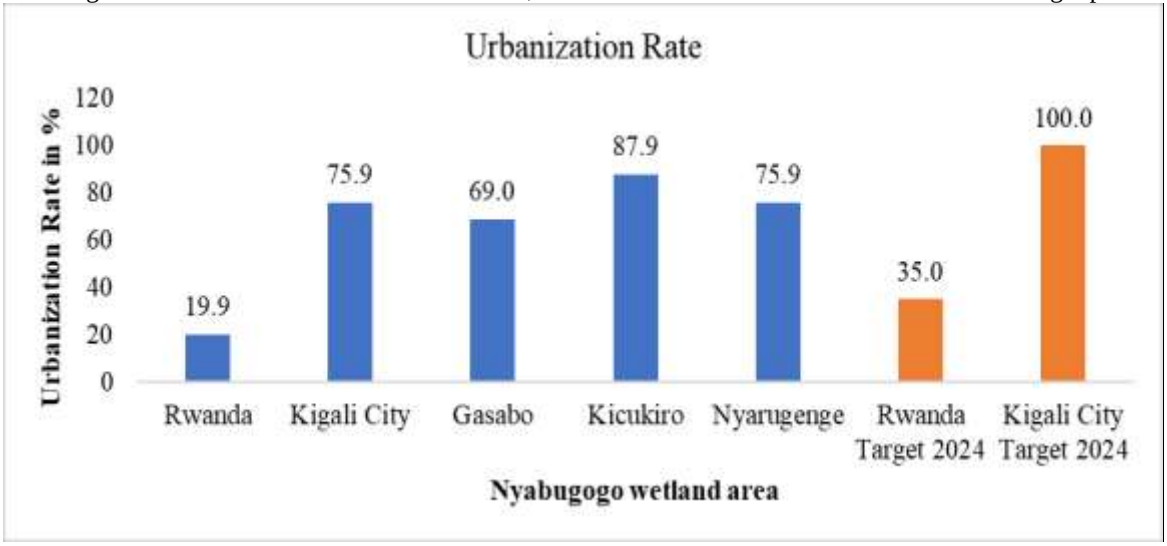

Figure 3.1: Urbanization rate in Nyabugogo wetland area 2017.

Source: NISR (EICV5 2016/17)

Figure 3.2: Land Cover of Kigali city in 2010

Source: Google Earth,2020

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

As see from figure 3.2, Kigali city was having different free places (unused) which has plants, trees, and some of them were cultivated by people. Urban planning (Kigali Master Plan) was started in this period, where people prevented to use land as they want except if they get approval of the sector, district, or Kigali City authority (each level is consulted based on the capacity of land user need from small project to big project or based on the project impact).

One may confirm that, in 2010 Kigali city was with less infrastructure (roads, offices, industries, etc.), less buildings, and less population compared to 2020 population, but this population were not organized in terms of habitation, most of them were in high-risk zones around Nyabugogo wetland catchments and they used to accumulate wastes in the area. All these are the factors for poor water quality observed in that period.

Figure 3.3: Land Cover of Kigali city in 2020

Source: (Google Earth, 2020)

The figure 3.3 explains well the changes happened in Kigali for settlement and infrastructure development. Kigali city is high rated changing city for 5 years, beautiful infrastructure, planned settlement, good buildings, water distribution channels, waste collection centers and landfills were developed. In Kigali city, the journey is still long to achieve the category of city in middle income countries as planned for 2030. It is in that context in different areas of Kigali city activities were separated, residential areas were separated from industrial area, leisure area and all residents in marchlands were removed. Different works are still at initial stage, like construction of sufficient residential and affordable houses, construction of all connecting roads, construction in all places of electricty distribution networks and water distribution networks are still have long way to travel. As people move plants in favour of houses and unfractured, they reduce the capacity of water management. Construction of more houses also lead to the accumulation of water which falls the city dominated by hills to the Nyabugogo wetland with all materials taken in the way. However, Kigali of 2020 and today (2021) is being developed with measures of waste management, rainwater management, industries in one zone and separation of zones by main activities (industries, business, agriculture, sport, culture, etc.) all these are good however some people remain not compromising to the measures in place.

By 2020 the management of Kigali city has made free area (removed all people and economic activities) in wetland of Nyabugogo or other wetland inside Kigali City. Infrastructure also was measured through how GDP is increasing, however the researcher failure to get disaggregated data on GDP growth specific to Kigali city. GDP shows the added values recorded per year.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

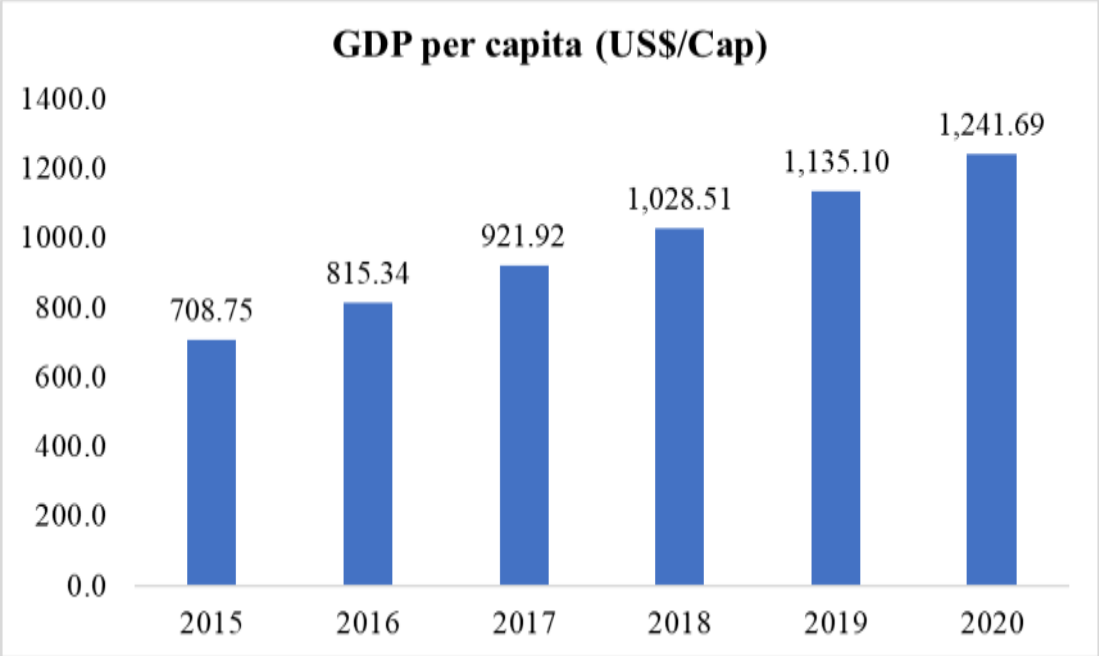

Figure 3.4: Growth of Rwanda GDP Per Capita 2015 to 2020.

As explained in the figure 3.4, GDP is the main indicators for monitoring national economy development and urbanization. However, GDP growth or characteristics specific to Kigali City as the area surrounding Nyabugogo wetland catchments were not found separate, and they include in the total nation's compilations. Currently an increase in GDP per capita mean changes in living conditions of people.

Once income increase also people use money to buy more items and have capacity to replace goods or items at any time are not properly or no longer useful. All these are waste increased. In one way or another GDP growth also increase in the proportion of waste generation and associated poor management of waste also lead to environmental pollution the case of Nyabugogo wetland.

Table 3.2: Types of habitats (Imidugudu, etc.), by district (EICV5, EICV4).

Year and District	Umudugudu	Unplanned clustered rural housing	Isolated rural housing	Unplanned urban housing	Small settlement	Modern planned area	Total Nber of HHs (000s)
EICV5 (2016/17)							
Rwanda	**58.9**	**6.5**	**16.8**	**14.2**	**0.7**	**2.8**	**2,708**
Nyarugenge	6.6	0.0	0.4	91.9	0.2	0.8	81
Gasabo	2.8	0.3	1.2	71.2	0.2	24.3	230
Kicukiro	4.8	0.0	0.2	79.7	0.4	14.9	98
EICV4 (2013/14)							
Rwanda	**49.2**	**8.7**	**25.6**	**12.8**	**2.2**	**1.6**	**2,493**
Nyarugenge	0.0	0.0	0.0	100.0	0.0	0.0	73
Gasabo	4.1	4.4	26.8	62.0	0.2	2.5	147
Kicukiro	2.6	0.0	0.3	91.8	0.0	5.3	76

Source: (NISR, Household Living Condition Surveys (EICV2 2005/06; EICV2 2010/11; EICV4 2013/14 and EICV5 2016/17, 2018)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

A seen from table 3.2, according to EICV 4 and EICV 5 as published by NISR (2018), from 2013/14 to 2016/17 people living in Umudugudu were increased from 49.2% to 58.9% all over the country. Unplanned housing rate in district or areas of Kigali city remain high, where 14.2% households in Rwanda live in unplanned urban housing, 91.9% for Nyarugenge district, 71.2% Gasabo and 79.7% in Kicukiro all information for the year 2016/17. This is the problem for urbanization effects on water and other environmental impacts. It is in that context some people remain living in high-risk zone and sometimes may lose their life mainly in rainy seasons. Once people live in unplanned urban housing area, also meaning that, there is insufficient infrastructure and protection against diseases is still at low level.

Figure 3.5: Floods caused by natural disasters in Nyabugogo wetland and catchments areas.
Source: (City of Kigali, 2020)

Figure 3.5 gives information on how natural disasters affect people in Kigali city and contribute to Wetland pollution a case of Nyabugogo wetland. Image A shows how when it is raining and wind moving building roofs accumulate water and follow the hills to the down relief. Down, there is image B, C and D showing movement water after rainfall in downstream and catchments of Nyabugogo (this every year cost lives and assets of people and government). For image E and F, shows how water accumulate waste (all forms) to the Nyabugogo wetland. With example to the car in Image E both engine and fuels were taken water in Nyabugogo river, however more waste remain in wetland for long and others are taken by water till the main rives (Nyabarongo).

3.2 Water quality of Nyabugogo wetland

For dependent variable (wetland pollution), water quality parameters such as pH, Zinc, Cromium (cr6+), Total Suspended Solid (TSS), Total Nitrogen (TN) and Total Phosphorus (TP) were analyzed. In addition to water pollution characteristics, the researcher also has assessed and explored different areas where waste accumulated alongside where Nyabugogo rive catchment meet the main river and waste management characteristics within the area of Nyabugogo catchment.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

Table 3.3: Water management for households surrounding Nyabugogo catchments.

Area/Years	Total % of HHs with rainwater harvesting system	Type of rainwater catchment system					Total	Total no. of HHs (in 000s)
		Rainwater tank	Ditch	Piped away	Other	No measure		
EICV5 (2016/17)								
All Rwanda	**14.5**	**2.2**	**9.4**	**1.6**	**1.3**	**85.5**	**100**	**2,708**
Nyarugenge	20.2	3.5	15.2	0.3	1.2	79.8	100	81
Gasabo	25.7	2.7	20.2	2.0	0.7	74.3	100	230
Kicukiro	49.7	8.7	33.9	6.7	0.5	50.3	100	98
EICV4 (2013/14)								
All Rwanda	**17.4**	**2.1**	**13.4**	**1.8**	**0.3**	**82.5**	**100**	**2,493**
Nyarugenge	22.9	3.1	17.6	2.1	0.0	77.1	100	73
Gasabo	31.8	4.6	25.6	1.5	0.0	68.3	100	147
Kicukiro	53.7	5.5	41.8	6.4	0.0	46.3	100	76

Source: (NISR, Household Living Condition Survey, EICV5 2016/17, 2018)

Table 3.3 shows that, in area surrounding Nyabugogo catchments only 20.2% managing water from the roofs meaning that 79.8% leave water cooling in the places to reach Nyabugogo wetland from Nyarugenge, 74.3% in Gasabo and 50.3% in Kicukiro. Rainwater from rooftop can wash different types of contaminants into the water you collect (for example, bird poop on roof could end up water barrel or tank). Rainwater can carry bacteria, parasites, viruses, and chemicals that could make you sick, and it has been linked to disease outbreaks.

Table 3.4: Waste management facilities in households surrounding Nyabugogo wetland and its catchments.

Area/Years	Compost heap	Thrown in bushes / fields	Rubbish collection service	Dumped in river /lake	Publicly managed refuse area	Burnt	Other	Total	Total Nber of HHs (in 000s)
EICV5 (2016/17)									
All Rwanda	**42.5**	**46.5**	**8.3**	**0.2**	**2.0**	**0.1**	**0.4**	**100**	**2,708**
Nyarugenge	12.7	29.2	55.7	0.9	1.5	0.0	0.0	100	81
Gasabo	14.9	37.3	43.4	0.8	2.8	0.1	0.6	100	230
Kicukiro	11.4	28.2	56.2	0.4	3.0	0.9	0.0	100	98
EICV4 (2013/14)									
All Rwanda	**51.6**	**40.2**	**6.2**	**0.1**	**1.5**	**0.1**	**0.2**	**100**	**2,493**
Nyarugenge	14.4	24.0	59.9	1.4	0.3	0.0	0.0	100	73
Gasabo	23.1	34.6	39.9	0.2	1.8	0.3	0.0	100	147
Kicukiro	21.7	29.4	46.5	0.0	0.7	0.0	1.8	100	76

Source: (NISR, Household Living Condition Survey, EICV5 2016/17, 2018)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

As mentioned in the contents of the study topic, there is a need to assess the impact of urbanization Wetland pollution a case of Nyabugogo in Kigali city catchments. So that, here the above table analyze and check if some waste from Kigali households is well or poorly managed so that, they can reach Nyabugogo wetland bed or flow channel of the catchments or the river itself. As seen from the table, it is clear that based on recent data of EICV5, only 55.7% of households in Nyarugenge deposing waste to rubbish collection service, 43.4% in Gasabo and 56.2% in Kicukiro all other households are deposing waste on compost heap (12.7%, 14.9% and 11.4% respectively), thrown in bushes/fields (29.2%, 37.3% and 28.2% respectively Nyarugenge, Gasabo and Kicukiro), dumped in river/lake (0.9%, 0.8% and 0.4% respectively), publicly managed refuse area (1.5%, 2.8% and 3% respectively), burnt waste (0%, 0.1% and 0.9% respectively) and 0% in Nyarugenge, 0.6% in Gasabo and 0% in Kicukiro are using other methods of waste management not identified in the above categories (see table 3.4).

Water samples have been collected in Nyabugogo wetland then after analyzed in laboratory located Research center for Natural Resources and Environment located at UNILAK Headquarter. Six parameters including pH, Zinc, Cromium, Total Suspended Solid (TSS), Total Nitrogen (TN) and Total Phosphorus have been analyzed.

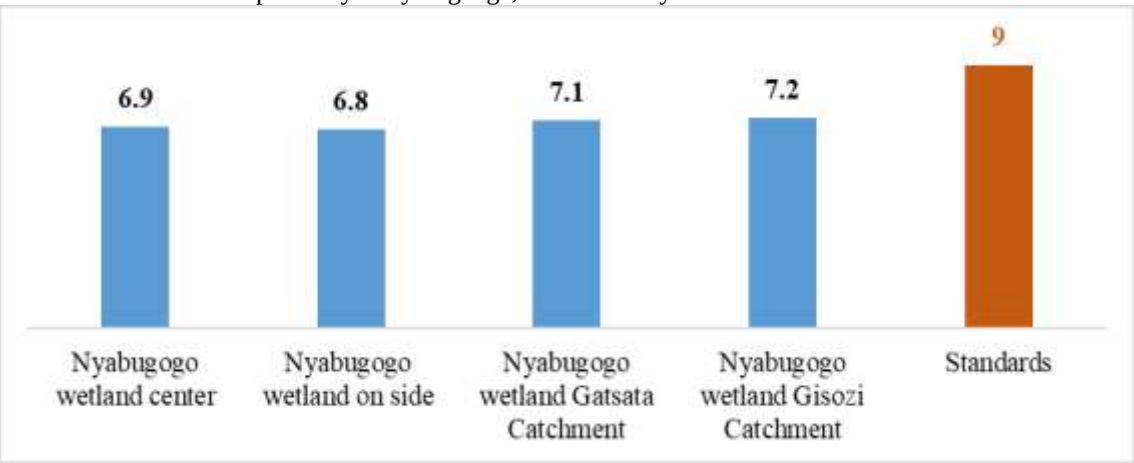

Figure 3.6: pH

Source: Primary data, 2020

As seen from figure 3.6 for all 4 samples taken of water taken from Nyabugogo wetland catchments, pH tested results meet national standards (means for all points of sample). Currently the standards limit for wetland water quality in Rwanda is ranged from 5.5 to 9 and the lowest value for the samples taken is 6.8 while the highest is 7.2 all less than 9 and greater than 5.5. Once pH is too high or too low, the aquatic organisms living may die. Currently pH shows the acidity but is measuring the potential activity of Hydrogen ions in the sample.

Laboratory test results for samples taken in 2020 (taken and tested by the author) pH test results are less than that observed by Omara T. & Papias N., et al., (2019) for the sample taken in December (pH was 8.2 with the sample taken at Gitikinyoni) (Omara T. & Papias N., et al., 2019). The primary data test results also are less than these taken and tested by Rwanda Natural resources in the study conducted 2018-2019 where phase one of test taken November 2018 and the second was made in February 2019. Respectively the pH test results were 8.2 to 7.8 for samples taken at Nyabugogo River downstream and 7.5 to 7.5 for Nyabugogo River upstream (RNRA, 2019). It is consistent that, from 2018 to 2020, pH contents of Nyabugogo wetland remain in standard range not less than 5.5 and not greater than 9.5. This also is in range of WHO (World Health Organization), standards which is ranged to 6.5-8.5 (WHO, 2019). As seen from the assessment made by (Christian B. et al, 2011) pH of Nyabugogo river was 7.02 as resulted by the test made to water taken in Nyabugogo swamp and for Nyabugogo river in the same period pH was 6.82.

Meaning that from 2011 to 2019 the water quality was changed however the changes were not exceed the WHO organization limits or that of RSB standard. Again by 2011 as reported by (Banadda N. et al, 2011), Nyabugogo river water tests were resulted pH which is between 7.04±0.69 and is in range of the standards as include between 5.5 to 9 values. Nyabugogo wetland at Gitikinyoni was

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

displayed in 2020 as the highest with pH from all tests taken which is linked to the urbanization characters in the area where more households' wastes are deposited in non-protected area.

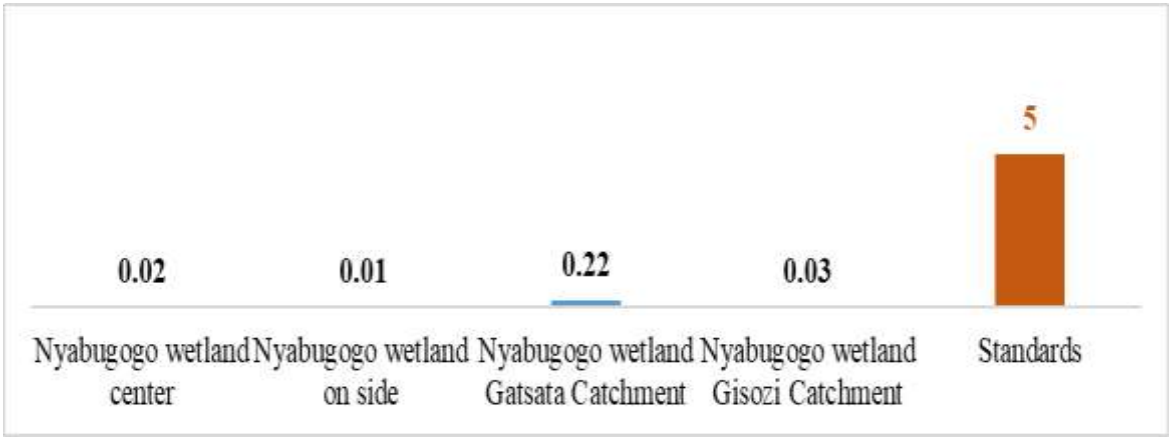

Figure 3.7: Zinc (mg/l)

Source: Primary data, 2020

As seen from the figure 3.7, Zinc contents in Nyabugogo wetland is in range of the standards as all values for tests taken are less than 5mg/l. They are also less than the value obtained December 2019 (0.43 mg/l). This is significant based on the change in season where the contents quantity increases or reduce based on the season. This again is in range of the range of WHO as limited to 3mg/l (RNRA, 2019). In the test made by (Banadda N. et al, 2011) Nyabugogo river water shown Zinc ranged 0.00±0.00 which also less than the standard value but also less than the four tested values in 2020. (Omara T. et al, 2019) tests shown Zinc 0.43±0.058 which is always less than the standard but greater than all values optioned by the researcher. Meaning that, water quality of Nyabugogo wetland were good from 2011 and later by 2019 was somehow polluted and by 2020 quality was improved.

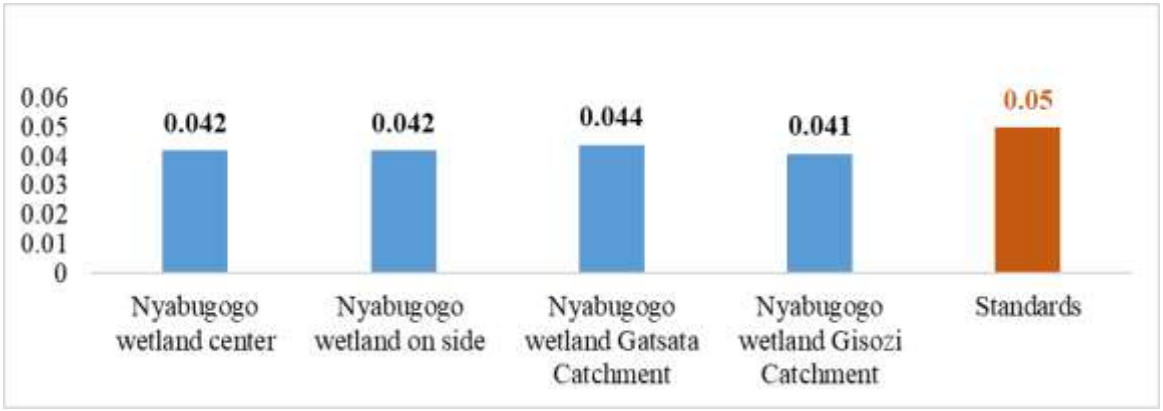

Figure 3.8: Cromium (mg/l)

Source: Primary data, 2020

In figure 3.8, sample tested results is in range of RBS (Rwanda Bureau of Standards) and were reduced from the sample taken in December 2019 (0.15mg/l) which was beyond RBS and WHO standards (all fixed to 0.05mg/l). This shows that from 2019 to 2020 chromium contents was varied reducing, however also this may be affected by seasons (RNRA, 2019). Nyabugogo wetland at Gatsata was show high number of Cromium compared to other catchments. As studied or tested by (Banadda N. et al, 2011) Nyabugogo wetland tested Cromium was (0.10±0.07) which shows a level beyond the standard (poor quality) and this was later improved to 2019 where tested Cromium (Mg/l) 0.15±0.00 to 0.05 suggested by WHO (Omara T. et al, 2019). All these values were greatly but not strongly improved to 2020 where all

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

values from 4 tests remain significant to the WHO standard.

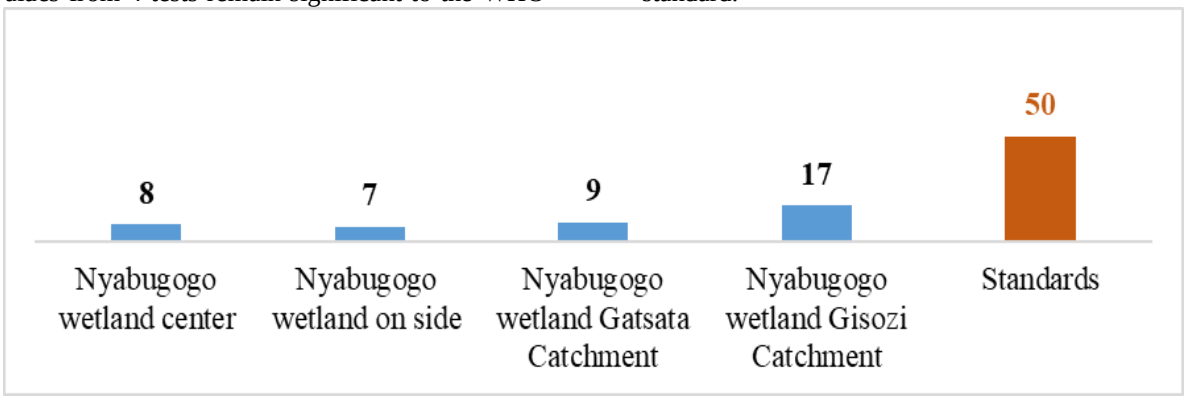

Figure 3.9: Total Suspended Solid (mg/l)

Source: Primary data, 2020

With figure 3.9, total suspended Solid in Nyabugogo wetland is changing over the season where by November 2018 was 314mg/l to 168 mg/l in February 2019 for samples taken at Nyabugogo river downstream, was too much to the RBS standards and again change for the samples taken at Nyabugogo river upstream where by November 2018 TSS was 4mg/l and in February was 6mg/l the later samples test results are in range of the RBS standards. This is changing with seasons and incremental factors.

During rainy seasons, water have capacity of transporting materials to the downstream of river and create high value of TSS in the wetland (RNRA, 2019). The capacity of water for transporting materials up to the downstream is given by the quantity of water and the speed which increased by the relief, or the accumulation of non-roof captured water from buildings as well as roads which are the main components of urbanization also.

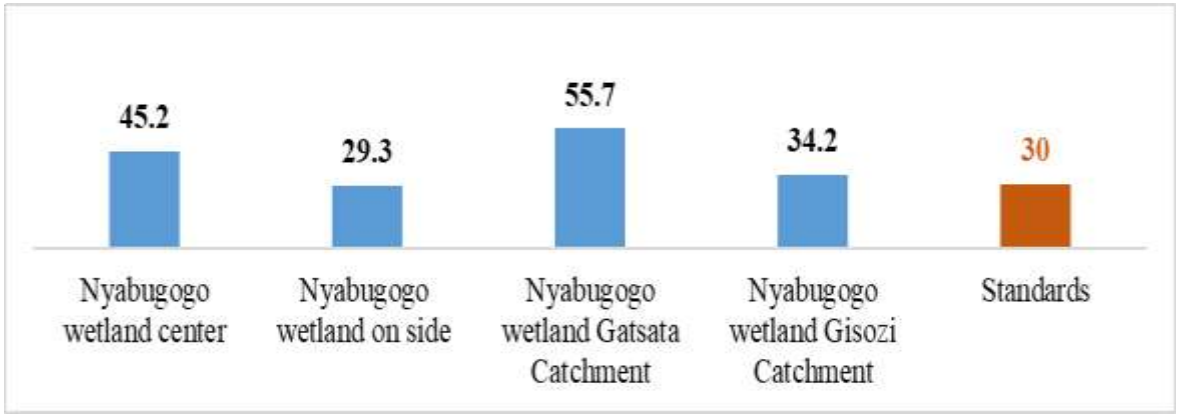

Figure 3.10: Total Nitrogen (mg/l)

Source: Primary data, 2020

Reference to results in figure 3.10, Nyabugogo Wetland is with higher total nitrogen with a comparison to the RBS standards (results of author's sample tested 2020). However, this was increased with a comparison to that obtained December 2019 12.81mg/l. By November 2018 to February 2019 TN test results shows that it was 6mg/l to 7.9mg/l for samples taken at Nyabugogo river downstream and this changed to 5.1mg/l to 8.8mg/l for samples taken at Nyabugogo river upstream. Both results strictly higher than WHO limit which is 3mg/l (RNRA, 2019).

Total Nitrogen is an essential nutrient for plants and animals. However, an excess amount of nitrogen in a waterway may lead to low levels of dissolved oxygen and negatively alter various plant life and organisms. Sources of nitrogen include wastewater treatment plants, runoff from fertilized lawns and croplands, failing septic systems, runoff from animal manure and storage areas, and industrial discharges that contain corrosion inhibitors. All these engines or sources TN contents are mainly from urban areas. Nyabugogo wetland catchment of Gatsata and that of center to Gisozi

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

need improvement of the urbanization factors in the rea as the total Nitrogen is higher than the standard. (Omara T. et al, 2019) tests were shown TN (mg/l) 12.81±9.51 to 30.0 suggested by WHO for the test taken at Nyabugogo river (Gitikinyoni side). This was in range of standards.

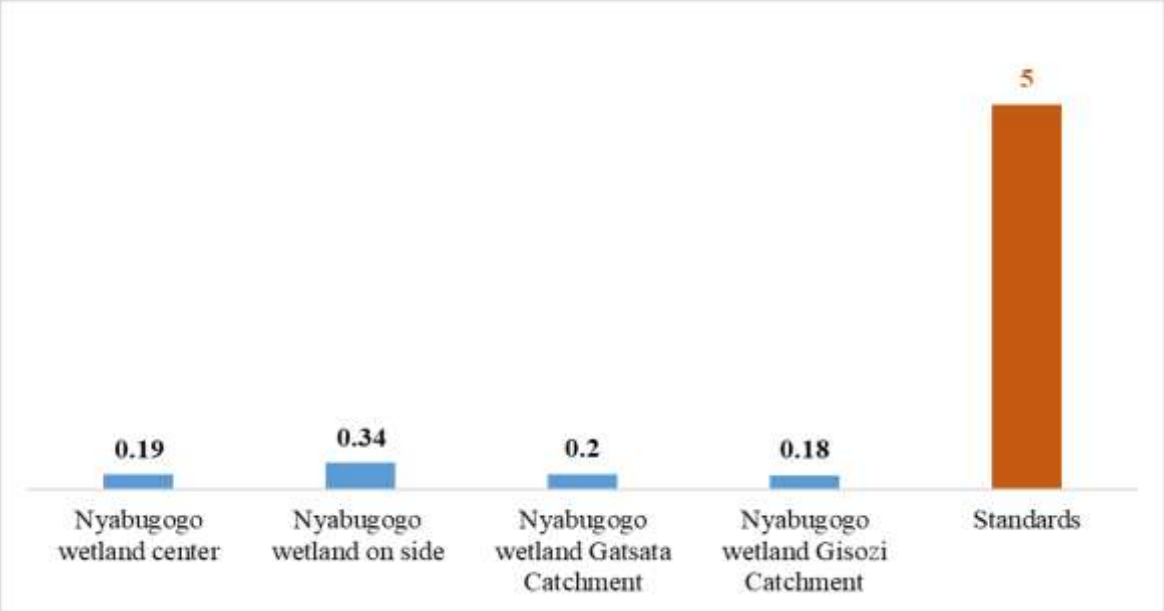

Figure 3.11: Total Phosphorus (mg/l)

Source: Primary data, 2020

Learning from primary sampled test results as shown in figure 3.11, Nyabugogo wetland water are under the limit of RBS total phosphorus standards (mg/l). The same good quality was observed for the sample taken by RNRA (2019) on Nyabugogo river downstream where results show TP of 0.7mg/l by November 2018 and 0.8mg/l by February 2019 and good results again were obtained by the same institution at Nyabugogo upstream where results show 1.5mg/l by November 2018 and 1.4mg/l by February 2019. This shows that from 2018 to 2020 Nyabugogo wetland water total phosphorus meets the limit of RBS (RNRA, 2019).

Figure 3.12: Waste accumulated by Nyabugogo wetland catchments.

Source: Primary data, 2020

As observed from figure 3.12, image A and B shows how water deposits waste in wetland for Nyabugogo river. Waste deposited are these from different sources either industry, service

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2552-2566 www.ijaem.net ISSN: 2395-5252

centers, in fields and some others from households and these are the main factors for increasing pollution level.

Based on the findings of the study conducted by United Nations (2014), people and their activities are the part of Wetland pollutants. The sample example was taken to mining activities in Nyabarongo river, Nyabugogo wetland water polluted by the people dumping waste inside etc. From this point, the study assessment has confirmed that in Kigali city only average of 51.8% households from three sampled districts paying waste collection fees to consigned companies to collect waste from their households all others are not using this method which facilitate them to ensure poor deposit of waste mainly in the areas to be taken by rainwater and being deposited in Nyabugogo wetland. In other case, this also was confirmed by the extent to which, 80.9% urban population in Rwanda are living unplanned urban settlement. So that, they ensure contribution in Wetland.

3.3 Relationship between urbanization and Wetland Pollution

The test of relationship or correlation was made with reference to the secondary collected data. Independent variable (urbanization was presented by the rate of urbanization counted for Kigali city as an area of Nyabugogo wetland catchments) and dependent variable was presented by share of households who ensure poor domestic (solid and wastewater) handling (it was assumed that these are taken by rainwater to the Nyabugogo wetland, or the processes is supported by other means like small animals and people themselves:

Table 3.5: Test of correlation between urbanization and Wetland pollution

Correlations

		Urbanization growth	**Poor household waste handling**
Urbanization growth	Pearson Correlation	1	.371**
	Sig. (2-tailed)		.081
	N	**2**	**2**
Wetland Pollution	Pearson Correlation	.371**	1
	Sig. (2-tailed)	.081	
	N	**2**	**2**

**. Correlation is significant at the 0.05 level (2-tailed).

Source: Statistical Analysis, 2020

With table 3.5, test of urbanization growth with its correlation to share of households which ensure poor waste handling in Kigali city areas of Nyabugogo wetland catchments has resulted Pearson correlation (r) which is equal to 0.371 and p-value or Sig. (2-tailed) which is equal to 0.081. It means that there is a positive correlation or relationship between urbanization and Wetland pollution however this correlation is not statistically significant at 0.05 confidence interval. P-value is greater than the level of significance ($p=0.081>0.05$). Urbanization growth has 37.1% contribution to wetland pollution as from our case, it was assumed that poor waste handled contribute to wetland pollution. However, this contribution is limited to 37.1% meaning that remaining 62.9% of wetland pollution could be delivered from other factors not concerned by this study.

The correlation between urbanization and wetland pollution is not statistically significant, means that, it is not always positive for urbanization growth and wetland pollution, well implemented urbanization with proper measures of environmental and waste management could not lead to wetland pollution. With this regard the researcher failure to confirm that the increasing urbanization in Kigali city pollutes and degrades the Nyabugogo wetland. It depends on how urbanization policies and projects were implemented.

IV. CONCLUSION

The findings show that, Rwanda urbanization rate is increasing from 2010 to 2020, GDP also is increasing, population density also increasing. However, housing characteristics are not suitable to modern urbanization category as

they do not have mechanism for rainwater management (only 32.9% average for all three districts have water catchment system), houses are not deposing waste in proper landfills so that they are taken by rainwater to the Nyabugogo wetland, in other case more 80% of houses in urban area are not respected modern urban planning scheme. The assessment of water quality has been shown that around 86% indicators (water quality contents) feet the range of water quality RSB Standards in Rwanda and only 14% beyond the range.

The test of correlation between urbanization and Wetland pollution also has shown that, there is positive but weak impact of urbanization to Wetland a case of Nyabugogo wetland and catchments. Urbanization impact 37.1% to Wetland pollution while remaining 62.9% is signified by other factors not captured by this study.

This impact between study variables is not statistically significant, meaning that increasing urbanization is not always increasing Wetland pollution, so that it depends to the urbanization process and quality of urbanization as well as location of the urban area to the Wetland. In other case, once urban planning is ensured, Wetland pollution contributions will be reducing.

Based on the study findings, the quality of Nyabugogo wetland is not good for use (drink, cooking or washing cloths), we recommend authority to protect their population against this use with supply of good water. In other case, the authority in charge of land management and environment protection as well as urbanization, they are encouraged to increase and supervise the implementation of Kigali master plan. Create water flow channels in hills landsides and encourage people to handle waste properly. All activities also in Nyabugogo marchland could be controlled.

REFERENCES

[1]. Ansoms, A. & McKay, A. (2010). A quantitative analysis of poverty and livelihood profiles: The case of rural Rwanda. Food Policy, 35(6), 584-598.

[2]. Antoine R. (2017). Note 1: Urbanization and the Evolution of Rwanda's Urban Landscape. Kigali City: World Bank Group.

[3]. Ashley, B. (2017). What is Urban Development? bizfluent.com. Retrieved from https:// bizfluent.com/ about-4728387- what-urban-development. html.

[4]. Assessment, M. E. (2005). Ecosystems and human well-being (Vol. 5, p. 563). Washington, DC Island press.

[5]. Bairoch, P. (1988), Cities and Economic Development from the Dawn of History to the Present. University of Chicago Press, Chicago.

[6]. Barney, C. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. Technology in society.

[7]. Barney, G., & Al-Sharif, L. (2015). Elevator traffic handbook: theory and practice. Routledge.

[8]. Bidogeza, J. C., Berentsen, P. B. M., De Graaff, J., & Lansink, A. O. (2009). A typology of farm households for the Umutara Province in Rwanda. Food Security, 1(3), 321-335.

[9]. Bolund, & Hunhammar. (1999). Ecosystem services in urban areas. Ecological Economics.

[10]. Brander, L. M., Florax, R. J., & Vermaat, J. E. (2006). The empirics of wetland valuation: a comprehensive summary and a meta-analysis of the literature. Environmental and Resource Economics, 33 (2), 223-250.

[11]. Buliva A. (2010). Kigali Genocide Memorial Centre: How to Visit & What to Expect. Kigali City.

[12]. Christian et al. (2019). IWRM Programme Rwanda: Water quality monitoring in Rwanda final report. Kigali: Rwanda Water and Forestry Authority.

[13]. City of Kigali. (2020). Rwanda climate change: Kigali homes built near wetlands are destroyed. Kigali: BBC.

[14]. Cohen B., (2006), Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability, Technology in Science, 28, 63-80

[15]. Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Lévêque, C. & Sullivan, C. A. (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. Biological reviews, 81(2), 163-182.

[16]. Ezeani, E.O. & Elekwa, N.N. (2001). Issues in urbanization and urban administration in

[17]. FA, U.M., Nhapi, I., Wali, U., Banadda, N., (2010). Assessment of Wastewater Management Practices in Kigali City, Rwanda. Open Environmental & Biological Monitoring Journal 3, 21-28.

[18]. Finlayson, C. M., & van der Valk, A. G. (1995). Classification and inventory of the world ‘s wetlands; A summary. Classification and inventory of the world ‘s wetlands.
[19]. Gardner, A. M., Allan, B. F., Frisbie, L. A., & Muturi, E. J. (2015). Asymmetric effects of native and exotic invasive shrubs on ecology of the West Nile virus vector Culex pipiens (Diptera: Culicidae). Parasites & vectors, 8(1), 329.
[20]. Habitat, U. N. (2009). Planning sustainable cities: global report on human settlements 2009. Earthscan, London.
[21]. Kayitesi, M., (2008). Improving Sanitation Systems: Technical and Socio-Economic Perspectives.
[22]. Mc Donnell, & Pickett. (1990). Ecosystem structure and function along urban rural gradients. New York, EPA, (2018).
[23]. McDonnell, M. J., & Pickett, S. T. (1990). Ecosystem structure and function along urban-rural gradients: an unexploited opportunity for ecology. Ecology, 71(4), 1232-1237.
[24]. McPhearson, T. e. (2014). Resilience of and through urban ecosystem services. Ecosystem service,
[25]. MINIFRA. (2015). National Urbanization Policy. Kigali: Ministry of Infrastructure.
[26]. MININFRA, (2015), National Urbanization Policy, Ministry of Infrastructure, Kigali.
[27]. MININFRA, R. O. (2019). Urbanization Sector Overview .Kigali: MININFRA.
[28]. Mukundwa Ntakiruta, D. (2011). Causes of insufficient cost recovery of the health care services provided to the members of the community-based health insurance in Rwanda: case of Kabusunzu Health Center from 2009 to 2010 (Doctoral dissertation, National University of Rwanda).
[29]. United Nations (2014), World urbanization prospects: The 2014 revision, highlights. department of economic and social affairs. Population Division, United Nations, 32. Nigeria. Enugu, Jamoe Enterprises
[30]. NISR. (2014). Fourth Population and Housing Census, Rwanda, 2012; Thematic Report: Population Projections. Kigali: National Institute of Statistics of Rwanda.
[31]. NISR. (2018a). Household Living Condition Survey, EICV5 2016/17. Kigali: National Institute of Statistics of Rwanda.
[32]. NISR. (2018b). Household Living Condition Surveys (EICV2 2005/06; EICV2 2010/11; EICV4 2013/14 and EICV5 2016/17. Kigali: National Institute of Statistics.
[33]. NISR. (2020). GDP (Gross Domestic Product)-National Accounts (Fiscal Year 2019/20). Kigali: National Institute of Statistics of Rwanda.
[34]. Nkuranga, E., (2007). Heavy metal removal and accumulation by an Urban Natural wetland: The Nyabugogo Swamp, Rwanda. MSc Thesis, UNESCO-IHE Institute for Water Education.
[35]. Omara T. & Papias N., et al. (2019). Physicochemical Quality of Water and Health Risks Associated with the Consumption of the Extant African Lung Fish (Protopterus annectens) from Nyabarongo and Nyabugogo Rivers, Rwanda. Nairobi, Kenya: Moi University.
[36]. Ouyang, W., Kolls, J. K., & Zheng, Y. (2008). The biological functions of T helper 17 cell effector cytokines in inflammation. Immunity, 28(4), 454-467.
[37]. REMA, (2009). Rwanda State of Environment and Outlook, 2009: Our Environment for Economic Development. Rwanda Environmental Management Authority.
[38]. Satterthwaite, David (2010). Urban Myths and the Misuse of Data that Underpin Them. UNU-WIDER Working Paper, No. 2010/28. Helsinki: World Institute for Development Economics Research.
[39]. Secretariat, R. (2016). An Introduction to the Convention on Wetlands (previously The Ramsar Convention Manual). In Ramsar Convention Secretariat, Gland, Switzerland.
[40]. Sekomo, C.B., Nkuranga, E., Rousseau, D.P., Lens, P.N., (2011). Fate of heavy metals in an urban natural wetland: the Nyabugogo Swamp (Rwanda). Water, Air, & Soil Pollution 214, 321-333.
[41]. Tengteng, et al. (2016). Wetland ecosystem health assessment through integrating remote sensing and inventory data with an assessment model for the Hangzhou Bay, China. Science of the Total Environment, 566, 627-640.
[42]. Umuhoza Mbateye, F. A., Nhapi, I., Wali, U. G., & Banadda, N. (2010). Assessment of Wastewater Management Practices in Kigali City. Rwanda, August 26.
[43]. UNDP, (2016). Sustainable urbanization strategy. New York

[44]. UNFPA, (2016). Urbanization, UNFPA, New york.
[45]. Verdoodt, A., & Van Ranst, E. (2006). Environmental assessment tools for multi-scale land resources information systems: A case study of Rwanda. Agriculture, ecosystems & environment, 114 (2-4), 170-184.
[46]. Wirth, L. (1938). Urbanism as a way of life. American Journal of Sociology Vol. XLIV pp8
[47]. World Bank. (2019). Urban development. Washington D.C: The world bank.
[48]. Zedler, J. B., & Kercher, S. (2005). Wetland resources: status, trends, ecosystem services, and restorability. Annu. Rev. Environ. Resour., 30, 39-74.