International Journal of Forest, Animal and Fisheries Research (IJFAF)
ISSN: 2456-8791
[Vol-5, Issue-1, Jan-Feb, 2021]
Issue DOI: https://dx.doi.org/10.22161/ijfaf.5.1
Article DOI: https://dx.doi.org/10.22161/ijfaf.5.1.2

Spatial and temporal dynamics of anthropogenic threats on the biodiversity of Virunga National Park

Kakule Thasi[1], Tchamba Martin[2], Daden Gueguim[3]

[1]PhD student in natural resource management in the Department of Forestry at Dschang University of Cameroon, attached to the Faculty of Health and Community Development of the Free University of the Great Lakes Countries, ULPGL -Goma Lakes in eastern of DRC.
[2]Professor in the Department of Forestry at the University of Dschang in Cameroon, Cameroon
[3]Dr in the Department of Forestry at Dschang University in Cameroon, Cameroon

Received: 07 Nov 2020; Received in revised form: 10 Jan 2021; Accepted: 21 Jan 2021; Available online: 03 Feb 2021
©2021 The Author(s). Published by AI Publications. This is an open access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/)

Abstract— *The Protected Area (PA) Network of the Democratic Republic of Congo represents 13% of the national area known for its rich biodiversity, but highly threatened. Virunga National Park (PNVi) one of these most important protected areas is also plagued by irrational use. The aim of this study is to analyze the spatial-temporal dynamics of threats to the biodiversity of PNVi. Two satellite images were used including landsat 2TM February 1980 and landsat 8 OLI February 2020 and documentary technique. As a result plant formations and wildlife have suffered a very considerable decline. The tree savannah reduced from 14.7% in 1980 to 8.9% in 2020. The loss of wildlife in Virunga National is worrying for hippos, buffaloes and elephants between 1981 and 2017.A small reconstruction of hippos between 2003 and 2006 and 2013. The annual loss rate of wildlife is very high for buffalo (7.8%), followed by hippos (6.7%) elephants (3%). Gorillas have suffered a relatively small loss over the past 4 decades (annual loss rate of 0.04%). All of these results are a response to the hypothesis that over the past forty years the anthropogenic threats to the biodiversity of PNVi have intensified in space and over time, three-fourths of the park has been destroyed, wildlife biodiversity has been halved including hippos, elephants, gorillas and buffaloes.*

Keywords— ***Dynamics, land use, threats, Virunga National Park, biodiversity, protected area, remote sensing, and satellite images.***

I. INTRODUCTION

Protected areas are territories that ensure the conservation of biological diversity and contain natural and cultural values (Keenleyside et al. 2013). They bring together a variety of ecosystems including the national park, nature reserve, wilderness area, wildlife reserves (IUCN, 2012). They are tools for conserving biodiversity nationally and internationally (Deshaies, 2018) and (UNEP-WCMC, 2016). Unfortunately, unsustainable recovery practices contribute to the loss of biodiversity in protected territories that are supposed to protect them from threats. The red list total of 10189 species including 3643 plants, 1024 invertebrates,540 marine fish, 506 freshwater fish, 280 mammals and 1,190 species of reptiles, this rate of species extinction is estimated at 28% (IUCN, 2019). This is evidence of unsustainable value for biodiversity (Garric et al. 2018). African wildlife is facing anthropoisation due to the cutting of energy wood, mining, crops, poaching... (Jacquemot,2018), which promotes the extinction of diversity in Africa. The large network of protected areas of the Democratic Republic of Congo (DRC) make up 13% of the national territory is a victim of these threats. According to the International Union for Conservation of Nature (IUCN) and the Congolese Institute for Conservation of Nature (ICCN) 4 out of 7 parks or about 57% of the protected areas of the DRC are in an alarming state of degradation and are on the list of protected areas at risk. These are Salonga National Park, Garamba, Kahuzi biega and Virunga. Virunga National Park in particular faces multiple threats. Poverty affects 40% of local

residents in the landscape, logging, poaching, agricultural pressure, demographic weight and unstable security climate contribute to the fragility of ecosystems (GVTC, 2015) and (Bakerethi, 2015). These issues degrade the park's natural resources globally; biodiversity in particular is highly threatened by anthropogenic activities. It is with this in mind that this study aims to analyze the threats of the spatial-temporal dynamics of threats to the biodiversity of Virunga National Park. The hypothesis is that anthropogenic threats to the biodiversity of Virunga National Park have intensified over time and space over the past 40 years, three-fourths of the park has been destroyed, wildlife biodiversity has been halved including hippos, elephants, gorillas and buffaloes.

II. MATERIALS AND METHODS

2.1 Presentation of the study environment

Virunga National Park is one of the most important protected areas in Central Africa and eastern Democratic Republic of Congo (DRC) where biodiversity is very diverse (ICCN, 2018) and an extraordinary landscape ranging from wetlands to low- and high-altitude ecosystems. It is a cross-border park between the DRC, Uganda and Rwanda. Located in North Kivu province offers opportunities in terms of cross-border collaboration.

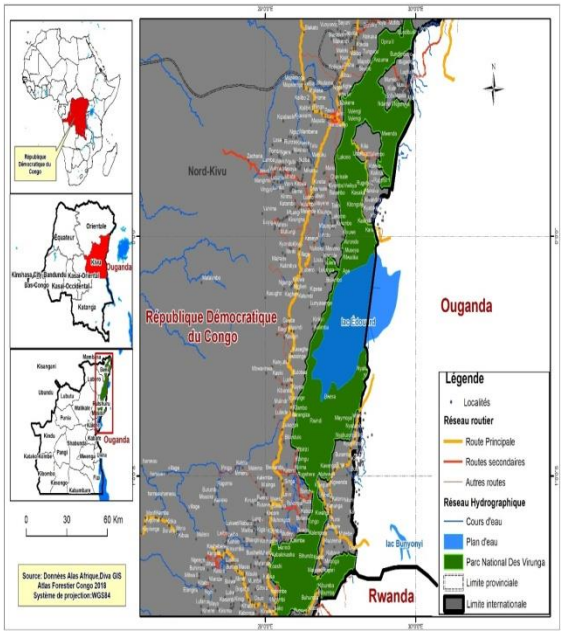


Fig.1: PNVi location maps

Virunga National Parc located in an environment made up of 5 administrative territories including Nyiragongo, Rutshuru, Masisi, Lubero and Beni which have socio-economic dominant agricultural activities. The territory of Lubero and Masisi are dominated by agro pastoral activities.The extraction of mineral resources in Masisi territory is fuelling tensions between local communities and mining companies, yet a natural potential to reverse poverty.The growing demography making pressure on the unsustainable withdrawal of natural resources from the PNVi (Ngongo, 2015), (IUCN, 2018), (ONFI, 2019) and (GVTC, 2015). Major vegetation of forest ecosystem in this landscape is located in the protected areas particular in Virunga National Park.

2.2 Data processing and analysis

This work was carried out through a methodology using the analysis of Landsat TM satellite images from February 1980 and Landsat 8 Oli images in February 2020 and bibliographic research. However, the processing and analysis of the satellite images took place as follows:

Acquisition of images: This step involves uploading satellite images to the image provider platform (www.Earth explorer.org). The images were acquired in the period from December to January due to the effect of clouds that hinder their analysis.

Pre-processing images: consists of collecting the sheets of the different images covering the area. In this case, we mosaiced 3 landsat sheets to cover the study area, other operations such as the colored compositions of the image strips were highlighted for the appreciation of the land use classes in the park. These are mainly the composition (2-4-1) and (6-5-3) respectively for the landsat 2TM sensor and the landsat 8 OLI.

Image Classification: This step involves using image processing algorithms that offer multiple categories of image classification with unsupervised and supervised classification. The one we used was the latter because we had a good command of the study area. It was as a result of this treatment that we had land occupancy classes proper using the ENVI 5.3 software.

Post classification: After supervised classification, we moved to post classification, which consisted of validating treatments based on observations. This step allowed the current land use of the study area to be used.

However, in order to determine the change we referred to the standardized formula proposed by Puyravaud et al. (2002) adopted to calculate the annual deforestation rate (Rakotomala et al, 2015).

$$\mathbf{Tdfa} = -\frac{\mathbf{1}}{\mathbf{t_2 - t_1}} \mathbf{ln}\left(\frac{\mathbf{A_2}}{\mathbf{A_1}}\right) * \mathbf{100}$$

Avec

Tdfa= Annual deforestation rate (Taux de déforestation annuel)

A_1= Forest area of the initial year

A_2 = Forest area of the final year

t_1 = Exact date of acquisition of the image for initial year

t_2= Exact date of acquisition of the image for the final year

This formula was also adopted in this work to calculate the annual loss rate of wildlife in Virunga National Park, in that it has similarities with that of calculating the annual rate of deforestation according to Puyravaud.

$$\mathbf{Tapf} = -\frac{\mathbf{1}}{\mathbf{t_2 - t_1}}\mathbf{ln}\left(\frac{\mathbf{A_2}}{\mathbf{A_1}}\right) * \mathbf{100}$$

Avec

Tapf= Annual wildlife loss rate (Taux annuel de perte faune)

t_1 = Initial year

t_2= Final year

A_1= Amount of wildlife in the initial year

A_2 = Amount of wildlife in the final year

III. RESULTS

3.1 Land use from 1980 to 2020

The processing of the satellite images identified the following main classes of land use: low-lying dense forests, mountain forests, water surface, grassy savannahs, tree savannah, crops, bare soil, volcanic lavas and built spaces. Analyses show a regression of plant formation to grassy savannah, the appearance of crop fields and built-up spaces yet non-existent in the park more than 40 years ago**.**

Table 2 Percentage Land Occupancy Areas

Land use	Surfaces (%) 1980	Surfaces (%) 2020	Annual rate of deforestation
Low-lying dense forest	24,89	12,64	0,98
Mountain forest	9,68	6,20	0,40
Tree savannah	14,71	8,90	6,29
Grassy savannah	10,00	35,21	2,35
Fields of crops	0,00	5,69	
Sol right away	11,42	8,83	
Water surface	28,22	20,72	
Volcanic lavas	1,09	1,07	
Built space	0,00	0,74	

The analysis of the data in this table shows that in 1980 the park was more dominated in terms of plant formation, namely the dense low-lying forest estimated in 150950.5 ha (24.8%), followed by the tree savannah of about 89213 ha (14.7%), grassy savannah estimated at 60650 ha (10%), mountain forest estimated at 58711 ha (9.6%). In addition, the water class occupied an estimated 171125.8 ha (28%). Crop fields and built-up spaces are almost non-existent, reflecting a low anthropoisation of PNVi. Then the processing of the images showed the area occupied by the bare soil about 83711.5 ha (11%). This can be justified by the bushfire practices long used for pasture renewal. Unfortunately, dangerous practices that contribute to the loss of biodiversity by leaving the soil bare. Other bare spaces can mean rocks on the Kabasha escarpments or on much of Mount Mitumba visibly devoid of vegetation. However, volcanic lava occupied about 6584ha (1%) soil in the PNVi. This is presented on the figures below for a clear reading of the trend of degradation and deforestation.

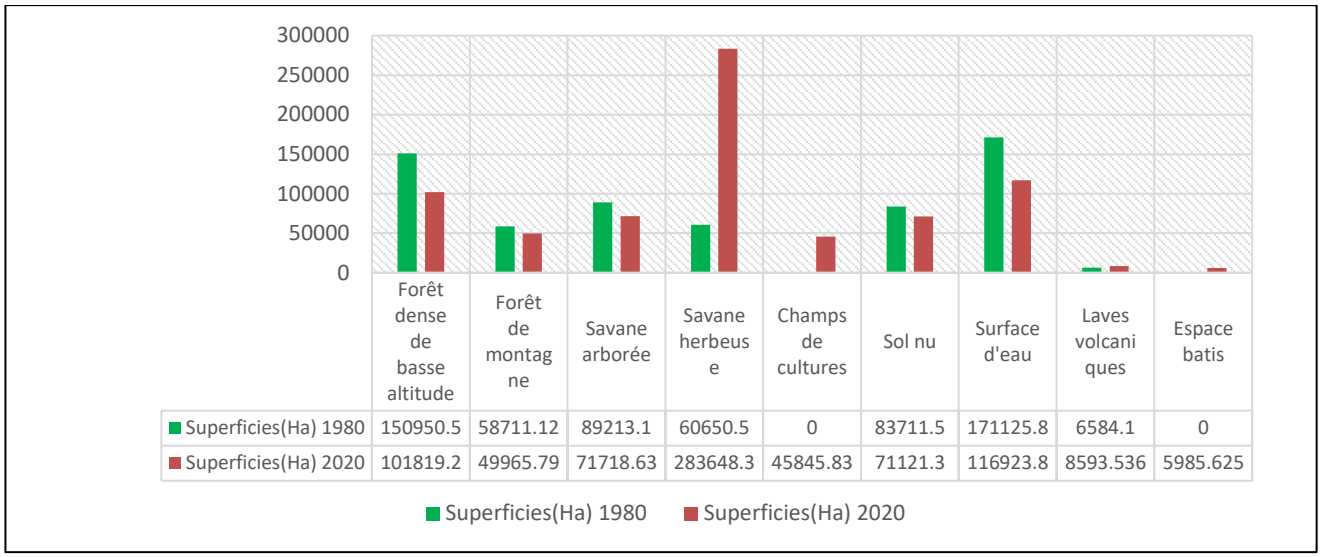


Fig.2: Areas modified in PNVi in hectares from 1980 to 2020

The ecosystems of Virunga National Park over time have experienced pervasive variations in the previous 4 decades. This shows the impact of human activities on the unsustainable use of natural resources of Virunga National Park's.

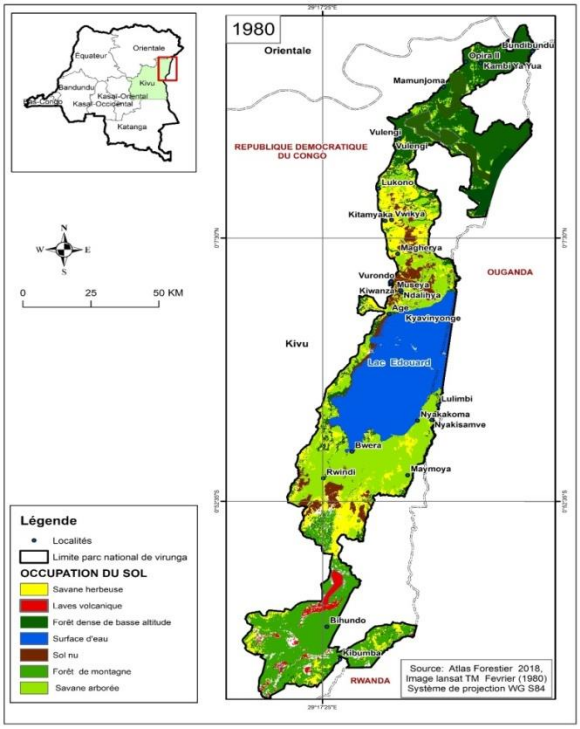


Fig.3: Land occupation of Virunga National Park at 1980

By contrast, in 2020, low-lying dense forests account for 101819ha (12.6%), dense mountain forests 49965.7ha (6.2%). At the same time the tree savannahs decreased to 71718.6ha(8.9%) turning into grassy savannah 283648ha (35%), which reflects a sharp degradation of the protected area. However, the annual deforestation rate is high (6.2%) in the tree savannahs, 2.3% in grassy savannahs, (0.9%) in dense low-lying forests and (0.4%) mountain forests. A sharp change in the forests with tree and grassy savannah over the large expanse of the park whereas in 1980 were so dominated by dense low-lying and mountain forests. This is a testament to the strong involvement of human activities in the destruction of PNVi. In addition, for the other classes, crop fields were intensified in 2020 by occupancy of 45845.8ha (5.6%. Bare soil has decreased to 71121ha (8.8%), which may mean a slight improvement in vegetation cover in ancient volcanic lava areas and on some rocks. Water surfaces decreased to 115923.8ha (20.7%), which is a consequence of climate change due to deforestation of the Park and its borders. Volcanic lava did not experience an increase of 8593.5ha or 1.07%. In the end, the built-up spaces grew to 5985.6ha or 0.7%.

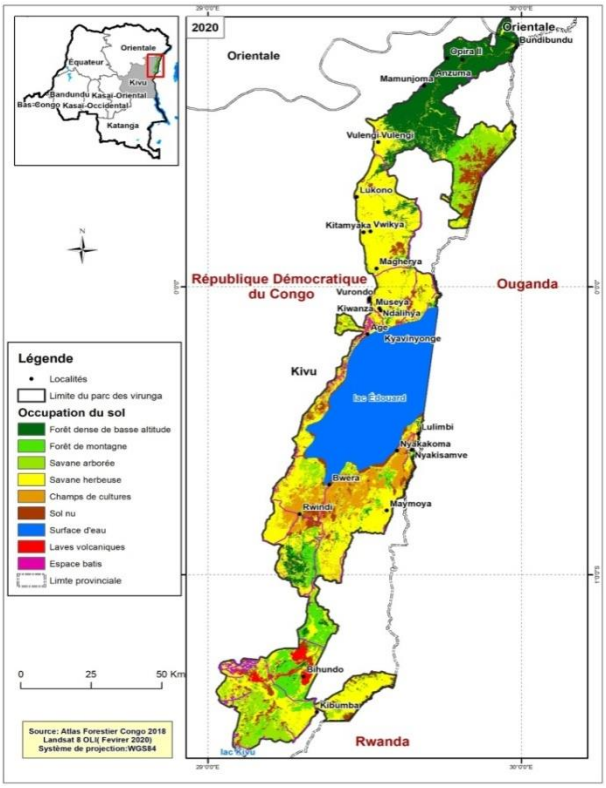


Fig.4: Land occupations in and around the PNVi at 2020

Over the past forty years, forests have been degraded and transformed to savanicole formations, especially the growing grassy and tree-lined savannahs. Built-up spaces grew to 5985, 6ha or 0.7%.

Fig.5: Grassy savannah of the extreme south sector PNVi

In view of all this, land use in the PNVi is a very important and worrying dynamic from the point of view of the conservation of this park. Since human activities have contributed significantly to the degradation of the entire territory of the protected area over the past forty years. The analysis from Figures 3 and 4 is that in 2020 the Virunga National Park (PNVi) experienced an unprecedented ground-use dynamic. Two classes of land use in the Park have experienced significant growth momentum. These are the classes of cultures (5.6%) and built spaces 0.7%. On the other hand, five classes experienced a dynamic in the direction of regression, including mountain forests; wooded savannah, bare soil and water surface, and dense low-lying forests northwest of the park towards Beni were almost halved. However, the tree savannas have given way to grassy areas, which in turn have given way to crop areas. Bare soils decreased slightly while built-up spaces increased significantly in 2020. This forest loss exceeds the annual deforestation rate of 0.31 ± 0.042% in the DRC between 1990 and 2010 (DIAF, 2015) cited by MECNDD-DRC (2016). But it is below the rate of deforestation inside of Virunga National Park (10.6% (82,302 ha) in 2019, higher than the annual rate of deforestation (0.39%) (ONFI,2019). This reflects continued forest destruction through carbonization. These results corroborate those of Unesco Commission criticising threats across the PNVi (IUCN, 2018), Kasolene et al.(2019),Dranginis (2016), WWW (2014),Mathe et al. (2015), PAMEV-DRC (2016), ONFI (2019) WWF/Dalberg, (2013) showing that deforestation is one of the causes of ecological disturbance in Virunga National Park. However, the loss of forest cover in Virunga National Park is less than the loss of forest ecosystems (60%) Africa due to agro-industrial crops (FAO, 2016). In the regional context, this forest loss in the PNVi's savanicole areas is greater than the area that burns per year (02.28 ± 3.56%) in the Mbam and Djerem National Park in Cameroon (Jiagho, *et al.* 2019).

Several factors contribute to anthropogenic threats in Virunga National Park. Repeated use of bushfires in improving wildlife grazing and unsustainable use of charcoal or firewood from PNVi. The Rwandan Liberation Forces (FDLR) has been major agents of destruction for more than 26 years. The estimated population increase of more than three million in the landscape and poverty have a negative impact on the biodiversity of the park. There are similarities with those revealed in Virunga National Park by Ngongo (2015), IUCN (2018), Dranginis (2016), Arjuna (2017), Mikanda et al. (2018). (GVTC, 2015) and (Bakerethi, 2015). The expansion of crop areas in the park favoured by the non-support of local communities by sustainable agricultural production techniques that reconcile social, economic and ecological. Then the built-up areas are located in Masisi territory, a central area in Lubero territory dominated by the extension of fishermen's villages and northern sector in Beni territory by village constructions in Lubirihya and Mayangose. Disputes in the human-fauna territories are common in the PNVi and its periphery. Hence the need for an approach that integrates the park and bordering realities for the sustainable

exploitation of natural resources. This leads to the integration of sustainable approaches to forest production and agriculture in the peripheral area of national parks (Kormos et al. 2017), cited by Chardonnet (2019). Issues upsetting the sustainability of natural resources in and around Virunga National Park.

3.2 Virunga National Park Wildlife Dynamics from 1981 to 2017

The analysis of wildlife dynamics in Virunga National Park is based on the data from the following table, obtained by consultation with mission reports from UNESCO, the Congolese Institute for Conservation of Nature and nature conservation. The periods during which the data are missing correspond to the time of the political turbulence of Zaire before 1997 and the Democratic Republic of Congo after 1997 with numerous wars of liberation making the abandonment of the count of wildlife. The difficulty of collecting the numbers of species motivated the taking of the less represented data by placing them in the more stocked columns. Thus the 305 gorillas taken up in 1981 are data from 1983 and the 586 buffaloes taken up in 2017 are data from 2014.

Table 1 Wildlife evolution in the PNVi from 1981 to 2017

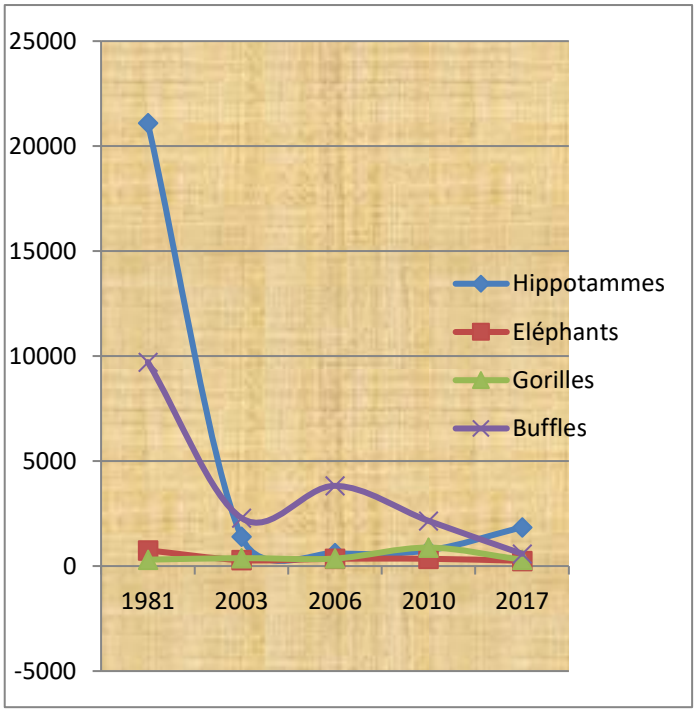
Year	Hippos	Elephant	Gorillas	Buffaloes
1981	21095	751	305	9715
2003	1399	286	380	2292
2006	629	348	360	3822
2010	753	348	880	2154
2017	1850	250	300	586
TAPF	6,76	3,05	0,04	7,80

Légende : TAPF= Annual Wildlife Loss Rate (Taux Annuel Perte Faune)

Source: Developed based on inventory reports, annual IUCN and ICCN missions.

Analysis of the results of Table 1 shows a significant decline in all of the park's iconic species. This means a strong threat to the biodiversity of the PNVi. Hippos yet dominating the fauna 21095 individuals in 1981 were reduced to 1850 individuals or an annual loss rate of 6.7%. Which is very alarming in the disappearance of this amphibian in this park. This loss of hippos has increased since 2003 to 2010. Nevertheless, there was a small increase after 2010 until 2017. This is the result of relative stability in the area and intensified surveillance. Then elephants were reduced from more than half of 751 individuals in 1981 to 250 individuals in 2017, with an estimated annual loss rate of 3%, a slight stability in 2003 to 2010. This shows that elephant poaching has been intensified over the past four decades. On the other hand gorillas behaved relatively stable, only 5 gorillas in the past forty years were lost from 305 individuals in 1981 reduced to 300 individuals in 2017, for an annual loss rate of 0.04%. Gorilla poaching is low due to heavy surveillance in the southern sector of the PNVi ecological niche of gorillas. In the end the dominant wildlife buffaloes in terms of 9715 individuals in 1981 were reduced to 586 individuals in 2017, for an estimated annual loss rate of 7.8%. More than three-quarter of the buffaloes have been heavily poached in the park over the past forty years. This is evidence of a strong anthropogenic nature of the park exposing wildlife to extinction. This regressive wildlife trend in Virunga National Park is included in the following figure in the context of clarifying the extent of biodiversity loss in Virunga National Park.

Table 3 Wildlife Dynamics Trend from 1981 to 2017



The loss of more than three-fourths of wildlife including hippos, buffaloes and elephants in Virunga National Park is linked to the political instability of the 1990s to the repeated wars and armed conflicts in the park and its landscape. Despite the regression of hippos in recent decades, a slight repopulation was observed between 2006 and 2013 and 2017, which corresponds to the post-conflict period when surveillance was intensified. The M23 war in Virunga National Park in 2012 and 2013 contributed significantly to the collapse of biodiversity. This has made

wildlife monitoring difficult over much of the park and contributing to wildlife movements to nearby parks including Qeen Elizabeth Park in Uganda and Volcanoes National Park in Rwanda.

However, buffaloes despite being among the animals in strict protection in DRC have experienced a very worrying drop by estimate of more than 90% is decimated in virunga National Park. The results are almost similar to those of IUCN (2018) showing an alarming loss of buffaloes, hippos and elephants between 1990 and 2016. This loss of biodiversity justifies the irrational use of natural resources (PAMEV-DRC, 2016). The armed groups identified in this disorderly levy contribute to the loss of biological diversity in Virunga National Park (IUCN, 2018) and (Dranginis, 2016) (UNESCO, 2017). This joins Eburnie(2018) demonstrating poaching of cynegetic and ivory interest for elephants. The results of this study reveal the relevance of the Democratic Republic of Congo to protect endangered wildlife including Hippos (hippopotamus amphibius), forest elephant (Loxodonta africana cyclotis) and mountain gorilla (Gorilla berengei berengei), lowland gorilla (Gorilla beringei graueri (WWF-DRC, 2017). The particular contribution of this work is the determination of the annual loss rate of wildlife in the PNVi , which is very high for buffalo (7.8%) followed by hippos (6.7%). These results are in line with those of Jane (2019) and Courchamp (2018), who have been critical of threats to African wildlife, including lions, leopards, elephants, African buffaloes and rhinos. The anthropization of Virunga National Park shows that the global approaches published in the Summits of Stockohlm, Rio 1992, Convention on Biological Diversity, Rio-20, also the African Convention on Nature and Natural Resources and regional frameworks including the Commission for Forests of Central Africa (COMIFAC), the Network of Protected Areas of Central Africa (RAPAC) ... are far from being reached. This gives rise to a new beginning in the management of Virunga National Park from the perspective of sustainable development and the Aichi goals.

IV. CONCLUSION

Analysis of the spatial-temporal dynamics of threats to biodiversity in Virunga National Park shows that plant formations and wildlife declined significantly between 1980 and 2020. Grassy savannahs expanded into the park in 2020 while dominated by dense low-lying forests, tree-lined savannah and dense mountain forests in 1980. This is due to the intensified human activities in the protected area over the past four decades. In particular, the expansion of crops and village occupations in the park increased in 2020 while non-existent in 1980. This is justified by two classes that have ariseened, notably the classes of cultures and built spaces. This reflects the intensity of the park's anthropoization. It is appropriate to accept the assumption that over the past forty years more than three-quarter of the park has suffered massive destruction, characterized by forest degradation and deforestation. Then the confirmation of the loss of biodiversity of the park of more than 3/4 in the past 40 years, when the assumption was that half of the biodiversity was halved for hippos, elephants, gorillas and buffaloes. The loss of wildlife in the Virunga National is worrying between 1981 and 2017 for hippos, buffaloes and elephants. Gorillas have suffered a relatively small loss over the past 4 decades. The major concern in the context of biodiversity conservation in this protected area is the implementation of sustainable natural resource development alternatives in and around this park.

REFERENCES

[1] Arjuna, D. e. (2017, October). Virunga Park: between nature conservation and population development. (A. Fischer, Ed.) Consulted on May 20, 2019,on http://www.justicepaix.be/IMG/pdf/2017.

[2] Aubertin. (2008). Protected areas, sustainable spaces? Consulted on September 03, 2020, on https://www.researchgate.net/profile/Catherine_Auberti n/publication/280636027_Aires_protegees_espaces_durabl es/links/563097d008ae432a022c87ca/Aires-protegees-espaces-durables.pdf.

[3] Bakerethi, E.M. (2015). BNS "Basic Necessities Survey" Survey on Basic Needs in the Virunga Landscape Year 2014-2015. Goma: WWF.

[4] Deshaies, C. e. (2018). The conservation of national parks beyond their borders. The Canadian Naturalist, 142(1), 50 63. https://doi.org/10.7202/1042013ar. , 142 (1), 3-96.

[5] Dranginis, H. (2016). The Mafia in the Park: A charcoal syndicate is threatening Virunga, Africa's oldest national park.

[6] Dranginis, H. (2016). The Mafia in the Park: A charcoal syndicate is threatening Virunga, Africa's oldest national park. Viewed on December 20, 2018, on enoughproject.org: https://enoughproject.org/files/Charcoal Virunga_June2016_FRENCH.pdf.

[7] Eburnie, T. (2018, September 02). Trafficking in protected species on the rise. Consulted on May 17,2019,on http://eburnietoday.com/: http://eburnietoday.com/le-trafic-des-especes-protegees-en-hausse/.

[8] FAO. (2016). Sustainable forestry and wild faune management in africa: Improving the value of benefits and services. Accra: FAO Regional Office for Africa. Foundations. (2019, May 25-26). Ecology emergency. Consulted on March 23, 2020, on EUROPEAN ELECTIONS: https://urgence-ecologie.fr/wp-content/uploads/2019/04/Fondations-Urgence-Ecologie.pdf

[9] GVTC. (2015). Annual State of Conservation Report. Consulted on July 4, 2020, on http://192.64.33.156/IMG/pdf/2015_acsr-_french.pdf.
Iccn. (2018). Report. ICCN, Directorate General. Kinshasa: ICCN.

[10] Idea. (2017, July). Improving the governance of natural resources in Africa. Consulted on March 11, 2020, at https://(IDEA/sites/default/files/publications/improve-the-governance-of-natural-resources-in-Africa.pdf.

[11] IPBES. (2019, May 4). Press release: The dangerous decline of nature: An "unprecedented" and accelerating species extinction rate. Consulted on March 23, 2020, on Ipbes.net: https://ipbes.net/news/Media-Release-Global-Assessment-Fr
Jacquemot, P. (2018). What future for African protected areas? Consulted on March 7, 2020, on https://www.willagri.com/wp-content/uploads/2018/11/Dossier-Willagri-les-menaces-sur-les-aires-protegees-africaines.pdf.

[12] Ngongo, R. (2015, March). The vulnerability of the DRC's protected areas: Virunga National Park case. (P. Institute, Ed.) Consulted on May 1, 2020,on http://www.pole-institute.org/: http://www.pole-nstitute.org/sites/default/files/aires%20protegees_draft_%20rene_corrections_ones.pdf.

[13] ONFI. (2019, May). Assessing the impact of a decade of efforts to reduce deforestation in and around Virunga National Park, North Kivu province, DRC. (WWF, Ed.) Consulted on May 2, 2020, on https://wwf.be/assets/IMAGES-2/PROJETS/Ecomakala/Evaluation-10-ans-ECOmakala-ONFi-rapport-final.pdf.

[14] PAMEV-DRC. (2016, September). Alliance of Green Livelihoods-Country-DRC Programme. Consulted on July 8, 2020, on https://aidstream.org/files/documents/A2_DRC_Inception_Report-20171005121029.pdf.

[15] IUCN. (2018, April 28). Reactive monitoring mission to Virunga National Park, April 23-28, 2018. Consulted on March 23, 2020, on whc.unesco.org: file:///C:/Users/HP/Downloads/mis63-2018-Report%20Final%20mission%20WHC%20IUCN%202018-Virunga%20(1).pdf

[16] IUCN. (2012, December). News of protected areas in Africa. Consulted on September 03, 2020, on https://papaco.org/fr/wp-content/uploads/2015/07/lettreNAPA-59-1212-FR.pdf.

[17] IUCN. (2019). Annual report:70 years. (U.E. Natural, Ed.) Consulted on July 10, 2019, on IUCN 70 years: International Union for Nature Conservation annual report 2018: https://portals.iucn.org/library/sites/library/files/documents/2019-007-Fr.pdf .

[18] IUCN. (2018). Report of the Joint Reactive Monitoring Mission World Heritage Centre/IUCN Virunga National Park. Consulted on 12 31, 2019, on Report%20Final%20mission%20WHC%20IUCN%202018-Virunga%20(1).pdf.

[19] UNEP-WCMC. (2016). The State of Biodiversity in Africa: A mid-term review of progress towards the Aichi Goals. (UNEP-WCMC, Ed.) Cambridge, UK. Consulted on January 02, 2020, on outlook africa: https://www.cbd.int/gbo/gbo4/outlook-africa-fr.pdf.

[20] UNESCO. (2017, May 17). REPORT ON THE STATE OF CONSERVATION OF DRC'S WORLD HERITAGE LIST IN PERIL. (UNESCO, Ed.) Consulted on March 18, 2020, on http://whc.unesco.org/: http://whc.unesco.org/archive/2017/whc17-41com-7A-fr.pdf

[21] WWF (2018). Living Planet Report 2018: Let's be ambitious. Gland, Switzerland: Grooten, M. and Almond, R.E.A. (Eds). Wwf.

[22] WWF-DRC. (2017, APRIL). Why do we protect the environment. Goma, North Kivu, DRC: WWF-DRC Goma office.