

HIPPOPOTAMI IN A LIMINAL SPACE: A MULTI-SPECIES ETHNOGRAPHY OF LAKE TANGANYIKA IN BUJUMBURA



UNIVERSITY OF CAPE TOWN
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Hippos open their muzzles facing each other at the abandoned flooded Kumase & Ange Beach - Lake Tanganyika in Bujumbura, 2021.

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DEDICATION

I dedicate this work to the Gisyo and Kibenga communities as well as the various experts to whom this research would have never been possible. I also dedicate this work to my wife Kassa Barakamfitye Maksudi, my son Idi Naqi Maksudi, my parents and siblings, my late mother Mariam and my late uncle Selemani, the whole Mashaka family, and my friends. I am very grateful for your encouragement, advise, and support throughout my entire educational process.

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ABSTRACT

This thesis explores how human encroachment has significantly altered Lake Tanganyika's freshwater ecosystem and riparian zone in Bujumbura, the capital city of Burundi, which affects the daily life and interactions between humans and hippopotami (hippo). Societal development agendas have favoured economic growth and infrastructural development with little regard for the well-being of multi-species communities. The study contrasts the ideas that drive economy-based approaches to development and environmental management with the many engagements with the lake, and how this in turn affects human-hippo relations on Lake Tanganyika's riparian zone. Environmental protection and management discourses are frequently portrayed as a unified, single, objectivist practice, however, their contextual enactment differs from discipline to discipline and across municipal interventions and service delivery. The study investigates how the current settlement developments affect human-hippo relations. Specific research questions include, what are the intersecting human-hippo interactions that exist in Bujumbura's lakeshore neighbourhoods? What impacts do these interactions have on people and hippos? What interventions can help restore the degraded environment and foster kinship? I respond to these questions by engaging with current debates in environmental humanities, cultural, and environmental anthropology on human-multi-species entanglements. Both grounded theory and multi-species ethnography approaches were used as data collection and analytic tools in this study. I trace nutrient and energy flows to foreground the interdependencies between the "human world" and "natural world", a separation that is no longer viable in the time of the Anthropocene. Triangulated data sets are used to narrate stories and critically discuss the current environmental challenges using ecocentric, and actor-network theory as the conceptual frameworks. Although population growth is considered a key factor in environmental degradation, I argue that the deterioration of the environment, particularly the coastal landscape, may be attributed to improper and unclear land-water management. The findings of this study indicate that land acquisition on the riparian zone for settlement development in the Gisyo and Kibenga is associated with power and affluence by some members of society. Potential land-water insights and spatial planning approaches for a human-and-hippo-friendly riparian zone are proposed.

Keywords: Ecosystem, Lake Tanganyika, Hippopotamus, biogeochemical, social ecology, riparian zone.

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INTRODUCTION

HUMAN-WILDLIFE RELATION: A MULTI-SPECIES INQUIRY APPROACH

"Each species on our planet plays a role in the healthy functioning of natural ecosystems, on which humans depend"

- William, H. Schlesinger (Citatis, 2021)¹.

"The environment and the economy are really both two sides of the same coin. If we cannot sustain the environment, we cannot sustain ourselves"

- Wangari Maathai (MDFE, 2021)².

The above quotes prompted me to reflect on the existing ecological conflicts between humans and hippopotami (hippos) on Lake Tanganyika riparian zone in Bujumbura, which is triggered by urban expansion, which in turn is understood to play a major role on the ecological degradation of the riparian zone. The increased settlement developments on the lake's riparian zone have altered its landscape consequently resulting in numerous environmental challenges for communities living next to the lake and city dwellers alike. Community members frequently encounter hippos in their backyards (literally), which is a major challenge for both species. There are several factors contributing to this, such as habitat degradation; human disconnection from the riparian land³; poor and limited access to water for human livelihoods; and reduced social welfare. In 2017, I witnessed a hippo in what Steffen and colleagues (2015b) termed a "zone of uncertainty" in their work titled "*planetary boundaries*". The zone of uncertainty has manifested itself in Bujumbura's coastal neighbourhoods along Lake Tanganyika, as urban development over the last two decades has contributed to an increase in the risk of species habitat loss. We should, therefore, focus on understanding the coastal land formation processes, understanding the historical dynamics of the

¹ Citatis, (2021). <https://citatis.com/a33345/27c44b/>

² Mount Dora Friends of the Environment, (2021). <https://www.mountdoraenvironment.org/what-we-do.html>

³ Referred in this text as the riparian zone, riparian area, coastal buffer system, buffer space or catchment area of the lake.

lake's hydrological cycle, and examining how the buffer corridor's physical boundaries affect species interactions, including hippos, rather than accumulating settlements along the coast. It was around 4 pm, in the northern part of the coastal area, while travelling from the northern suburbs of the lake to the city centre. I remember being startled by other passenger's sudden noises and screams which indicate that there was something strange running on the busy road ahead. When I looked outside the window, to my astonishment, I saw a huge hippo in the middle of the road, chased by city dwellers and police officers who tried to redirect it back to the lakeshore. It was my first time seeing such a creature outside water in such proximity. It was unusual to see hippos wandering on busy roads during the day, especially in such a densely populated and developed area. The sighting of hippos outside of their natural habitat has become common, particularly in more developed coastal areas. This is attributed to changes in land integrity as biodiversity loss is on the rise on the lakeshore, where vegetation cover has been steadily replaced by settlements (Steffen et al., 2015b). Both land integrity and biodiversity loss are somehow linked to current feedback in the local context associated with habitat loss and environmental degradation. The above reflection alludes to the need to find new ways of development planning for better in-situ management of the commons. I use the term commons to describe the shared resources such as the lake and the riparian zone in Gisyo and Kibenga. Due to the commodification of the riparian corridor, some people own more plots than others to benefit their own interests, without paying attention to the heterogeneity of other actants within the ecological landscape.

However, little research has been conducted to investigate the environmental effects of settlement activities along the lakeshores of Gisyo, Kibenga, and other coastal neighbourhoods throughout the Imbo plain's riparian zone, as well as the benefits gained from the natural life support systems provided by wildlife within this liminal⁴ space. For instance, the hippo's dual role in land-water nutrient transfer helps sustain the lake's chemistry, micro-organisms, and fish diversity, which I discuss in more detail in this thesis. This study aims to investigate the actions that lead to human-hippo conflict by stimulating debates on environmental humanities, cultural and environmental anthropology, and human-multi-species entanglements. Furthermore, the study attempts to suggest ways that address its social and environmental effects. This chapter will introduce the study by

⁴ For the purposes of this study, liminal space refers to both the riparian and littoral zones of the lake, and it is described by McCay (1947) as the space in-between, which is ambiguous due to shifting and contested boundaries.

first discussing the background/context of life in and around the lake, the research problem, the research aims, objectives, and the significance of the study, followed by a literature review, materials and methods, organisation of findings and limitation, and finally the chapter outline.

1. Background/Context

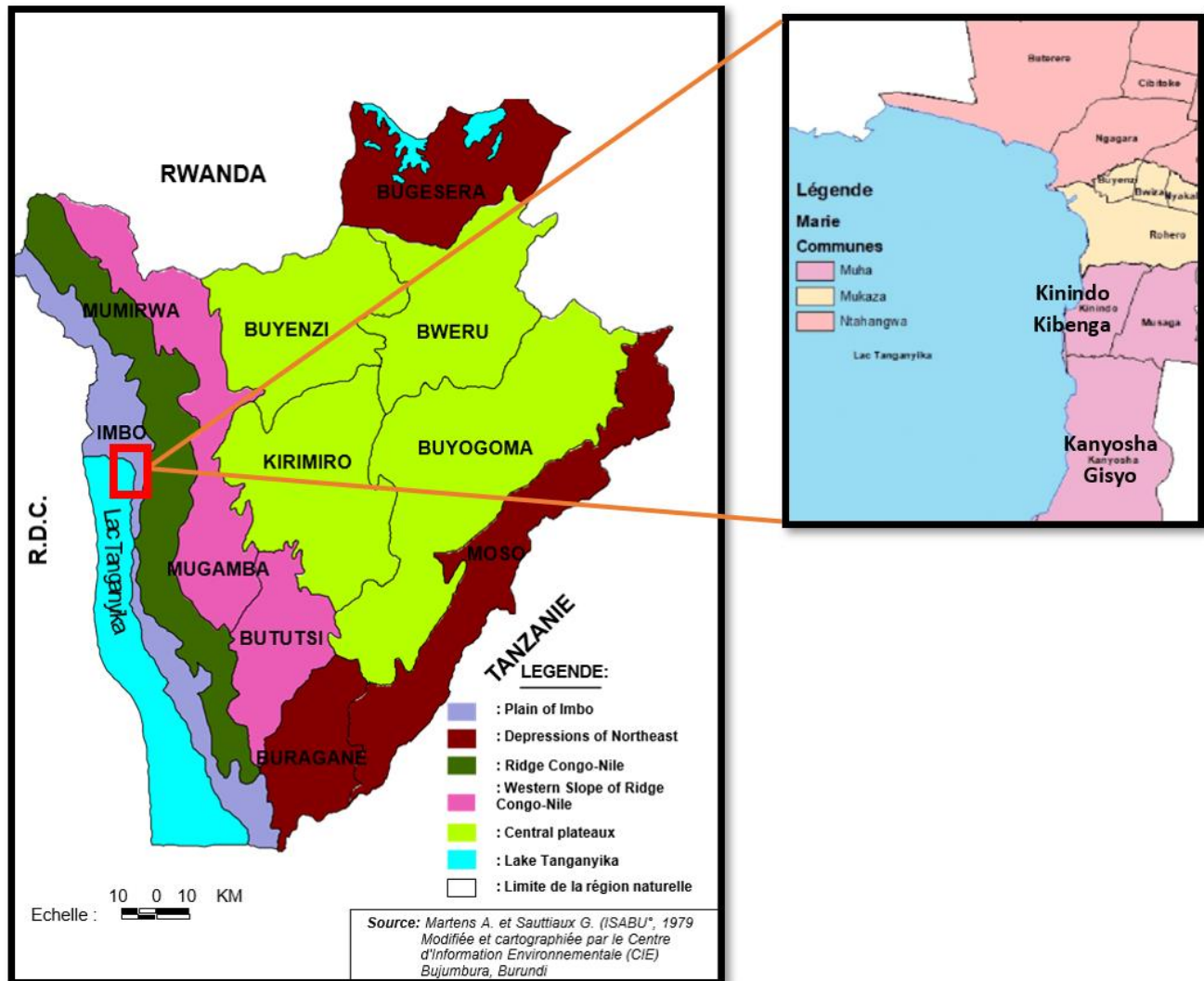


Figure 1: Map of the five ecological zones in Burundi (Left) and administrative communes of Bujumbura showing sampling sites (Right) (Nzigidahera, 2007; Kabanyegye et al., 2021).

Human activities have continuously altered the environment and transformed the coastal landscape in different communes adjacent to Lake Tanganyika in Bujumbura. There have been numerous prolonged and unchecked anthropogenic activities on the shores of Lake Tanganyika in Bujumbura (Burundi). The Lake Tanganyika Authority is mandated to safeguard the lake and its natural

resources (Secretariat, 2012), in their strategic action programme, has explained that disturbances and alterations to critical habitats are the main threats to the sustainability of the lake.

Burundi is a landlocked country situated in Southeast Africa and is also considered part of the central African region with a population of 12.3 million according to the United Nations Fund for Population Activities (2021) world population dashboard. 45.1% of the population are aged between 0-14, 54.4% between 15-64 and 2.5% are over 65. Women constitute 50.7% of the population (World Population Review, 2020). Bujumbura is the provincial and economic capital city of the country located in western Burundi with the province of Gitega as the political capital situated in the middle of the country. The country is one of the Great Lakes countries sharing borders with Tanzania to the east, Rwanda to the north, and the Democratic Republic of Congo to the west and south of Lake Tanganyika (see figure 1). Bujumbura is the largest city positioned at the North-Eastern shore of Lake Tanganyika with a population size of half a million inhabitants (Secretariat, 2012; World Bank, 2020; World Population Review, 2020).

1.1 Ecoregions and climatic Conditions

Lake Tanganyika is the second largest (32,600 km²) and second deepest (1470 m) freshwater ecosystem in Africa and the world starting in the North of Bujumbura ending in South in Mpulungu (Zambia) with a total distance of about 670 km and an average width of 48 km (Lowe-McConnell, 2003; Secretariat, 2012). The lake is estimated to have been in existence for 10 million years. Thus, it is considered by ecologists among the world's ancient lakes (Lowe-McConnell, 2003). It is home to over 2000 fish species, 500 of which are only found in that region of the world (McBride, 2016; Miriti, 2020). According to Jorgensen, Ntakimazi, and Kayombo (2005), the lake is home to the world's multi-colour fresh fish called Cichlids and hosts hundreds of different species of fish. The lake is one of the Rift valley lakes found in the Great Lake Region and is among the six ecoregions⁵ in Burundi with Great Lakes Freshwater as its biome.

⁵ Ecoregion: an area that cover land and water with distinct characteristics of it biodiversity of flora and fauna. (Also see: <https://www.definitions.net/definition/ECOREGION>).

Albertine Rift Montane Forests is another ecoregion covering the western part of Burundi with sub-tropical moist broadleaf forests as its biomes⁶ are the epicentre of the rainforest of Africa's mountains (World Atlas, 2021). The lake's basin has experienced unstable climate changes as described in Jorgensen et al. (2005) and McBride (2016), subsequently resulting in the lake's ecosystem becoming very sensitive to these changes. This is especially evident since the lake naturally experiences only two seasons, as it has a tropical humid Savana climate with only two seasons. The weather patterns in and around the lake consist of what is referred to as cool dry conditions of 25°C between May and September (sometimes considered dry season), and the wet season with temperatures reaching up to 28°C between October and April. The longest rain period occurs between March-April, whilst June-August mark the driest period of the dry season characterised by extreme heat with high temperatures on the surface. In Bujumbura alone, the average temperature in May and June is between 12.4°C to 21.3°C with average rainfalls of 114mm and 23mm respectively (Docquier, 2016; Weather Atlas, 2021).

1.2 Threats to the ecosystem and biodiversity

Lake Tanganyika shares boundaries with four riparian countries and its shoreline are split into parts between 8% Burundi, 45% DRC, 41% Tanzania, and 6% Zambia (Miriti, 2020). Besides climatic threats, the increase in anthropogenic activities near the lakeshore and riverbanks poses threats to both terrestrial and aquatic biodiversity ecosystems. Studies have shown that water pollution coming from the nonpoint source⁷ (NPS) and point source⁸ (PS) threatens the lake's aquatic ecosystems. The PS stems from human activities including discharged untreated sanitary and industrial/factory sewage, while NPS includes storm sewage, agricultural run-off, and sedimentation from deforestation and sand mining on rivers (Lowe-McConnell, 2003; Plisnier, 2018; Niyoyitungiye, 2019; Miriti, 2020). For instance, the agricultural runoff from Malagarasi River (Tanzania), Rusizi River (Burundi), and Kalambo River (Zambia & Tanzania) are said to be accompanied by agrochemical toxic waste (Jorgensen et al., 2005).

⁶ Biome: A large arear characterised by wildlife, soil, vegetation, and climate. (also see: <https://www.nationalgeographic.org/encyclopedia/biome/>).

⁷ Pollution that comes from different origins such as roads, development, farms, cities, and factories vessels.

⁸ Pollution from specific sources, such as industries/factories and sewage treatment plants



Figure 2: Sky view from Google Earth Pro showing two images (A & B) from sites (1 & 2), marking the transformation of the riparian zone in red, 2006 & 2021.

The threats to the coastal terrestrial ecosystem are similar to those of aquatic threats. The continued environmental degradation driven by encroachments for human settlements and the replacement of indigenous plants for agriculture has resulted in biodiversity and habitat loss, which consequently put unnecessary and added pressures on the coastal terrestrial ecosystem (see figure 2). These activities occur in cities or towns such as Bujumbura in Burundi, Uvira and Kalemie in the Democratic Republic of Congo, Kigoma in Tanzania and Mpulungu in Zambia which are adjacent to the lake. Bujumbura is the most urbanised and economically developed province over the above-mentioned cities or towns (Secretariat, 2012). These cities or towns are often considered the economic hubs in these countries' provinces which are characterised by large or small commercial industries and other human activities. Concerns have been raised about land-water quality, nutrient imbalance, and erosion from mountains as a result of these activities (Secretariat, 2012). Additionally, resource overuse and population growth are also known to pose threats to coastal biodiversity and ecosystem well-being (Miriti, 2020). Hence, amendments to current policies as well as the addition of new policies are pivotal in helping to mitigate these crises threatening these ecosystems. Burundi's law N° 1/02 of 26 March 2012 is a Water Code (Water Act)⁹ that protects coastal and riverbank environments by prohibiting any developmental activities

⁹ Water Code and Water Act will be used interchangeably - Water Act, N° 1/07 Burundi water code. § 2. Article 5 (2012). https://www.preventionweb.net/files/Le_Code_de_l_Eau_plumulgue_le_26_3_2012.pdf

from taking place between water bodies and human-disturbed lands. Under this law, article 5 stipulates the preservation of riparian zones as follows: 150m for Lake Tanganyika, 50m for other lakes, 25m for rivers and 5m for streams (Cabinet du Président, 2012; Ministry of Transport, Public Works, and Equipment, 2018). Although the Water Code of conduct is clear, people continue to build settlements along these restricted zones, which is especially common in coastal Lake Tanganyika communities.

2. Problem statement

The main driving forces of ecological threats in Bujumbura's riparian zone are linked to human settlement which begin in the north and extend to the basin's eastern riparian landscape. Resorts, hotels, restaurants, and small-scale agricultural activities are some examples of riparian zone encroachment. Manishatse (2017) quoted environmental activist Jacque Nkengurutse and the Office of Environmental Protection official Samuel Ndayiragije who admitted that these activities have significantly altered the riparian landscape, raising concerns about the safety of hippos and other species that rely on the riparian zone as their habitat. A local online newspaper reported on the effects of encroachment as seen and felt in certain parts of the city near the lakeshore (Manishatse, 2017; 2018). Members of communities have encountered hippos in their occupied habitats on numerous occasions, both at night and during the day, something that has become the new normal for residents in the affected areas. However, it is important to note that little work has been done to raise awareness about how human activities in the northern basin's riparian zone over the last two decades have impacted the natural habitat. These expanding settlements on buffer systems have replaced indigenous vegetation cover, resulting in a shortage of grazing land for hippos. The riparian zone is currently being ravaged by swift transformations caused by human non-compliance to the country's environmental code of conduct. This may be linked to a lack of historical knowledge or documentation of the natural structure of the coastal landscape and its biophysical processes, as well as poor urban development planning. The study examined how rapidly urbanising natural spaces threaten hippos in the Bujumbura lakeshore neighbourhoods of Gisyo and Kibenga. One might wonder what makes the riparian zone appealing to developers and how this has impacted hippos' life.

3. Research objectives and questions

The main objectives of this study are to highlight human-wildlife relations, particularly hippos as ecosystem engineers and to suggest some insights on interventions for cobecoming to protect both humans and hippos locally, nationally, and regionally.

Specific sub-objectives include:

- To investigate the interactions between humans and hippos in the coastal neighbourhoods of Bujumbura.
- To develop an understanding of how these interrelations influence nutrient and energy flows and suggest insights that may help restore coastal habitats.

This study, therefore, seeks to answer the following questions:

- What are the intersecting human-hippo interactions that exist on Bujumbura's lakeshore neighbourhoods?
- What impacts do these interactions have on people and hippos?
- What interventions can help restore the degraded environment and foster kinship?

4. Rationale: reimagining the city as part of nature

The study was conducted in the city of Bujumbura, simply because it is the largest city in Burundi, taking up a large percentage of the country's Lake Tanganyika shoreline. Furthermore, Bujumbura is the most developed city with the largest population in the country, it is also the city with the most human development near the lake. The encroachments that I have witnessed in the two coastal neighbourhoods are the result of a lack of land use planning and a disregard for the buffer corridor as prescribed in the Water Code of conduct, which has turned the area into a conflict zone. Human-nature relationships are complex and need to be understood and addressed beyond conservation because humans are fundamentally linked to nature rather than separate from it. This requires a multidisciplinary approach that incorporates aspects of culture, environmental anthropology (which includes social, historical, economical, and political ecology), multi-species ethnography, behavioural ecology, and chemistry. Additionally, Bujumbura is where the Lake Tanganyika Authority headquarters are located, thus taking the leading role in encouraging diplomacy and negotiation on transboundary solutions across all riparian countries is key for regional purposes.

This enquiry intends to help develop an understanding of the complexities of the human-nature conflicts in Gisyo and Kibenga. Findings gleaned from people's stories and ecological records will help to illuminate and inform society about their interconnectedness with nature. This is because they might aid in reimagining how diverse organisms such as hippos and humans, among others, are entangled in environmental processes. The transition from rural to urban lifestyles and habitats raises concerns about the process of modernity and conditions that affect human and hippo livelihoods. The livelihoods of coastal communities are gradually impacted in one way or another. For instance, farmers are being pushed out of their traditional way of life as cropland is being replaced by settlements, thus becoming outcasts as described by Bauman (2013), while fishers have reported a decline of catch especially in the littoral zone which may be linked to water pollution or a scarcity of food for predatory fish consumed by humans. Both explanations hold true, but the latter emphasizes the key role played by hippos in supplying nutrients to aquatic life subsequently sustaining the aquatic food web as explained by Witenberg (2019), which cannot be ignored. Therefore, bringing the hippo's voice into the picture is important, particularly in advocating for the species' protection beyond poaching and to ensure that its natural habitat, and the riparian zone where it finds its source of food, is not occupied nor destroyed by humans.

5. Literature review

This section reviews literature related to two conceptual frameworks used in this study namely ecocentrism, and the actor-network theory which are used to explore the agency of humans and non-humans. In addition to explaining how humans and hippos influence both the lake and its riparian zone. Their shared environmental impacts, particularly in relation to ecosystem services (life-support system). This review will engage with studies concerning the above themes and will illustrate how significant this study is both within the local and regional context.

5.1 Ecocentrism ideas and the centrality of life

The ecocentric approach places nature and ecology at the center of evolutionary processes as its priorities the earth system and the living things that make it, including humans (Washington et al., 2017). This approach views humans as part of nature rather than a separate entity and caution us about the decisions and actions we enact on the natural world. On the contrary, an anthropocentric

approach positions humans at the centre of nature and as the apex species on the planet (Cocks and Simpson, 2015). This simply means, from anthropocentric views, the lake and its riparian territory are regarded as instrumental resources for the use and survival of humanity. Similarly, Washington and colleagues' (2017), notion of ecocentrism suggests that it goes beyond biocentrism (ethical views that value all living things) and zoocentrism (views that value animals). While the two views value nature, they find the ecocentrism view to be more inclusive and can be used as an umbrella term as it encompasses the entire environment system including abiotic features, flora, and the context of living organisms (Keith et al., 2020). Furthermore, Washington and colleagues (2017), disagree with Smith (2014), on the view that the ecocentrism idea is anti-human or indifferent to concerns relating to social justice. Rather the authors support Rowe's (1994) assertions, that ecocentrism is not a discourse about equal value among all organisms, neither against the disputes on the existing homocentric challenges. Instead, these authors state that the ecocentrist's view highly supports both inter-human and inter-species.

Looking at the importance and function of all organisms and how they are embedded within an ecological system, the authors support the view of ecojustice for non-humans as ecology has been sacrificed to address minor and short-term social needs. Clearing hippo habitat for settlements, for example, may meet the short-term needs of humans but cannot resolve human-hippo conflict. To elucidate this, Washington et al. (2018), believes ecocentrism should be central in resolving environmental crises and therefore use multiple concepts within this view to underscore their reasons. Firstly, by considering the concept of being *ethical* which states that ecocentric ideas hold the views that all life deserves equal moral standing and consideration. Secondly, the *evolutionary* concept suggests that the ecocentrism view reflects on human evolution out of the ecosphere over the past three and half billion years. The authors stress that there is no rationale to suggest the beginning of intrinsic value and underline the recognition of biological kinship that others have conferred to all species. This recognition debunks human supremacy by suggesting that humans are part of nature rather than apart from nature. This is supported by Stengers (2010, cited in van Dooren, 2016) who uses the term 'reciprocal capture', where organisms' shared histories (coevolutionary process of becoming) and entanglement have determined their reciprocal relationship. The authors explain that becoming is concerned with organisms' "exchange and emergence of meanings, immersion in webs of signification that might be linguistic, gestural,

biochemical, and more” (van Dooren, 2016:2). Thirdly, the concept of being *spiritual* which speaks to a nature-based ecocentric piety that has helped change social behaviour towards the environment. In opposition to the concept of spirituality as ascribed by the ecocentric view, Tsing (2012), argued that human beings’ self-concept of exceptionalism has blinded us to the reality that we cannot survive on our own without the environment around us. The author explains that our perceived autonomy over nature has been further propelled by monotheistic religions.

However, this is not entirely true, as Islam, one of the world's largest monotheistic religions, teaches followers about their responsibilities and rights regarding the environment. Baharuddin and Musa (2017), state that Muslims are taught that nature provides both the material and spiritual needs of human beings. The Quran teaches humanity that they were created to serve God, servitude according to Baharuddin and Musa (2017: 161), refers to being the best to oneself, community, and environment, thus underpinning Islamic environmental ethics. Lastly, the *ecological* concept is where ecocentrism teaches us that humans and non-humans are all dependent on ecosystems (Leopold, 1986; Washington, 2013). The emphasis here is that ecocentrism takes us back to the evolutionary understanding of which all living organisms including humans, have gone through the same struggle for existence and reminded us that humans are the latecomers. Therefore, we should show empathy to our fellow earth inhabitants who have so far made it with us.

5.2 Actor Network Theory in the context of nature

Latour's actor-network theory (2016) proposes that we can effectively approach any system (natural, social, or technological) that we encounter by looking at all its elements as interacting and playing an equally active role within the system. It is worth noting that although the Actor Network Theory is termed a ‘theory’, it is not a theory in actual fact (Callon, 1999). According to Mol (2010), this is because the Actor Network Theory does not offer anything that “resembles a law of nature” (p.261), as it does not explain nor predict the cause and effect of phenomenon nor provide a robust methodological guide. Mol (2010), stresses that findings from studies using this approach cannot be applied to previous studies nor is there an attempt to link findings from a study using this approach to previous studies to create an “overarching explanatory framework” (p. 261). Instead, the author states that it “offers a form of repertoire” (p.261) where the researcher selects a research phenomenon that is different to past phenomena, with the aim of shifting from existing theoretical repertoires. Within the Actor Network Theory, the concept of locality will be used in

this study. Callon (2001), describes locality as both framed and connected. The interactions between humans and non-humans transpires in the frame that holds them (e.g., Gisyo and Kibenga).

Furthermore, this study uses the Actor Network Theory's concept of connectedness in conjunction with terms such as group formation, actants with agency, objects or things, networks, and translation to demonstrate the links between biotic and abiotic factors. Previous studies have shown that lakes and their coastal ecological landscapes are crucial to aquatic and terrestrial biotic and abiotic factors which all are part of natural ecosystem (Mentzer, 2018; Shoo, 2019; and McCann 2020). To contextualise the term group formation, I use the concept of locality to frame both aquatic, terrestrial, comprise of water, soil, rocks, and minerals as they form part of the abiotic factors. Biotic components fall under the major constituents of the ecosystem namely, plants/grass, animals (hippos), other organisms, and society composed of individuals, groups, and institutions (VanBaren, 2019). Both terrestrial and aquatic biotic factors are all living organisms classified into three sub-groups of actants with agency namely, (a) *producers* like plants, trees, phytoplankton (plankton), coral, algae, and bacteria which are responsible for producing energy through photosynthesis using sunlight and chlorophyll. (b) *Consumers* are categorifed under herbivores, carnivores, and omnivores which include mammals, reptiles, amphibians, insects, birds, and humans, among others. (c) *Decomposers* are fungi, worms, and bacteria, just to name a few (Brennan, 2018; Sohlden, 2019).

The differences between producers, consumers, and decomposers may be quite pronounced, however, their roles within ecosystems cannot be treated as independent as they are all interconnected and complement each other, subsequently, forming an actant-network or multi-species assemblages (Latour,1993). Abiotic factors such as water, the potential of hydrogen, air, temperature, rocks, sediment, and many others can be found under chemical and physical types of elements and are all referred to as non-living or inorganic components (Datta, 2019). The ecosystem may fail if nutrients and energy flow do not remain in balance. Thus, this study focuses on the neighbourhood communities of Gisyo and Kibenga, the lake and riparian zone flora and fauna as the collective to describe how the association between humans and non-humans is critical to the survival of all living organisms locally and regionally (Latour, 1993; Callon, 2001), as both

biotic and abiotic factors work in conjunction to balance the ecosystem (Shoo, 2019). The approach helps us understand the interdependence of actants as energy flow into the ecosystem and the biogeochemical cycle of nutrients in land-water ecology.

5.3 Human influence on the riparian zone and its environmental drawbacks

Over the past two decades, there has been growing land usage across the coastal area of Lake Tanganyika in Bujumbura. This is largely, due to the increased demand for land. These changes are observed on the riparian zone moving along southwestern Bujumbura adjacent to the lake. The riparian zone is the interface between land and the lake, it also serves as a habitat for hippos and other species. It provides a corridor between the body of water such as lakes, rivers and streams and neighbouring lands. This environmental space also provides conditions for the livability of both aquatic and terrestrial species including humans (Worm and Paine, 2016). The increase in riparian zone encroachments for human settlement expansion in different places adjacent to the lake around the city has impacted the hippo's access to food and has transformed the riparian landscape beyond the limit as shown in figure 2.

Some studies suggest that human encroachments in coastal Lake Tanganyika like Gisyo and Kibenga are associated with population growth and internal migration caused by conflicts (Allison et al., 2000; Secretariat, 2012; Azanga, 2016). Population growth can be defined as the variation or an upward growth trend of the number of people within a geographic location excluding immigration (World Population Review, 2020). This variation leads to an increase in social-ecological pressures as demands for land for personal or commercial use increases. For instance, in the social-ecological case of Bujumbura, it can be argued that the current development on the riparian zone is affected by urban expansions mostly led by commercial activities. Thus, acquiring a piece of land in such areas requires considerably large sums of money, as in some cases people buy a piece of land from its original owners and resell it a few years after at a higher price. However, little attention has been given to the environmental drawbacks associated with the disturbance of life support systems provided by ecosystem engineers like hippos classified as megafauna species. This study therefore aims to draw attention to hippo's role in transboundary waterscapes and landscapes.

5.4 Hippo's impact on terrestrial and aquatic biogeochemistry

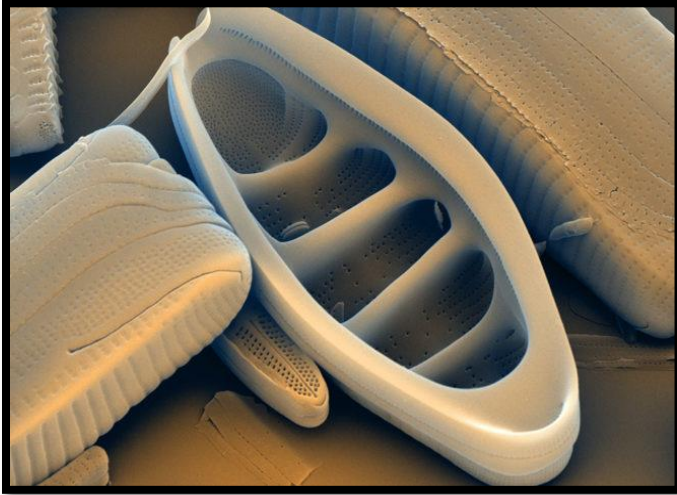


Figure 3: Diatoms (micro-organisms)

Human activities have greatly altered the fluxes of chemical elements from living and non-living factors and this interference has negative impacts on the life support system. Lakes need nutrients to regulate their ecosystems and it takes years for these processes to occur. The dominant presence of micro-organisms like diatoms¹⁰ (see figure 3) in the lake is important as they are key sources of energy and food for other organisms. Like

plants, diatoms are major producers in the aquatic ecosystem as they absorb carbon dioxide through photosynthesis and release oxygen¹¹. This raises the question, who benefits from the hippo's provision of energy transferred from land to water? The study by Schoelynck et al. (2019), shows that the role of hippos on the land-water metabolism is vital as these megafaunas contribute 39% of all biogenic silicon from grazing and defecating it into water. Chemical fingerprint analysis indicated that hippos were responsible for transporting over 76% of silicon, the total flux along the Mara River. Their results concluded that hippos convey huge amounts of silicon, making them key role players in the biogeochemical cycle of silicon in areas where these mammals are found. Silicon is important in energy supply, and it plays a crucial role in the marine and aquatic food web and acts as a water body regulator (Kristiansen and Hoell, 2002). Perhaps, the question that may arise is, what are the exact impacts that nutrients like silicon and other molecules have on the entire ecosystem? In answering this question, let me briefly analyse the hippo's role in this cycle. On land, hippos inhale oxygen, they graze on silicon, nitrogen, phosphorus and carbon dioxide-rich plants, the latter is also exhaled by the hippos. Whereas, in water, hippos recycle metabolised silicon through defecation, which is then consumed by diatoms to create new shells which then

¹⁰ Diatom: are microalgae live in a glass made with silica and found in ocean, freshwater, waterways an soil, they (also see: <https://diatoms.org/what-are-diatoms>)

¹¹ Sarah Spaulding: <https://diatoms.org/news/what-is-diatomaceous-earth>

allows them to reproduce. The hippo's role in this complex biogeochemical cycle is vital to coastal socio-ecological systems and beyond (Schoelynck et al., 2019).

5.5 Ecosystem services (life-support system) and economic factors

The term ecosystem services (ES) was developed in the 1970s to show interest in biodiversity conservation, the aim was to communicate to people about the significance of services provided by nature (Gomez-Baggethun, 2016). However, Burkhard and Maes (2017) points out that, in sustainable development discourse, the term was agreed upon by many authors in 1981 and became part of the mainstream professional literature, in the 1990s emphasis was placed on economic value of ES. The concept of ES was rooted in multiple aspects which firstly, looked at the ecological aspect in the late 1960s and early 1970s that focused on the functionality of the ecosystem through the description of its services and how they flow from nature to society (Gomez-Baggethun, 2016). Secondly, the socio-cultural aspect which draws attention to the value of nature for society apart from a conserved object. Thus, Burkhard and Maes (2017) suggest that its recognition of human dependency on nature in the early 1980s underscores non-material benefits like livelihood and cultural identity without taking away the intrinsic values from nature. Lastly, when talking about the economic aspect, they look at the historical natural value of humans from physiocrats and classical economics to neoclassical economics viewpoints.

Considering the above economic aspects, using the example of the coastal problems in Bujumbura, physiocrats with their notion of production values consider the coastal forest, vegetation, and agriculture as the source of wealth. Then, in classical economists lenses, humans developed the tendency of shifting away from using nature for its intrinsic values and turned their focus on the using nature for its extrinsic values where labour and capital gained momentum over the environment particularly land (Gomez-Baggethun, 2011). However, Gomez-Baggethun (2011) views ES as infinitely valuable and cannot be commodified. The author emphasises that the neoclassical emergence with its focus on capital accumulation, industrialisation and technology changed economic thinking, with an emphasis on supply and demand through mass production, the consumption of goods and services with emphasis on the use of the natural environmental to achieve the above-mentioned (Gomez-Baggethun, 2011; Kent, Kelly and Munichiello, 2021). However, Gomez-Baggethun (2011), stresses that there is a disagreement between neoclassical

and ecological economists on sustainability approaches. The former applies what is called the ‘weak sustainability’ approach under the assumption of replacing nature for manufactured capital while the latter uses a strong sustainability approach which upholds that natural and manufacturing capitals are complementary rather than substitutes (Gomez-Baggethun, 2011). According to Gomez-Baggethun (2011), neoclassical and ecological economists also differ on ES valuation, the classicists consider the exchange of goods and services, costs versus benefits, and monetary valuation. While the ecologists consider the inclusion of non-markets and services, and non-monetary approaches (Burkhard and Maes, 2017; Gomez-Baggethun, 2011). This study uses the term *life-support systems* instead of ecosystem services to describe some of the intangible benefits that humans receive from hippos and other lifeforms. As a result, the term is not used to support the exploitation or monetisation of the commons in the riparian region for settlements, as the anthropocentric approach could suggest. Rather, non-market incentives are used to encourage human-nature relationships as embedded in the ecological system.

6. Materials and Methods

This section provides details on the type of data collected and methods used to analyse them. Primary data included, key informant interviews (KIIs), focus group discussions (FGDs), participant observations, photographs, video recordings, memo notes from the field, Google Earth Pro maps, and a drone were used to assess the historical changes and retrieve sampled locations (latitude and longitude), organic matter such as grass on which hippos graze on and hippo dung, inorganic compounds such as water which was sampled and later analysed at the University of Burundi’s Natural and Environmental Sciences Research Centre (NESRC) laboratory also known as Centre de Recherche en Sciences Naturelles et Environnementales (CRSNE), however, the English acronym will be used for this paper. The research centre is under the faculty of Chemistry. Secondary data was in the literature which was used to analyse and explain soil and diatoms. These two specific matters were difficult to analyse due to budget and time constraints.

6.1.1 Data collection

This study used different empirical data collection methods in three categories. Focus group FGDs and KIIs were conducted, both of which were audio-recorded. FGDs involved two groups (A & B) of local inhabitants in Gisyo $n=6$ (group A) and Kibenga $n=5$ (group B) living near the lakeshore (see figure 4B). KIIs involved one-on-one interviews with $n=6$ candidates from diverse

backgrounds which included: a former government environmental official, a former journalist, biodiversity and aquatic ecologist, conservationist, biologist and chemist (one participant majored in both), and an environmental activist. Secondly, inorganic compounds (elements), as well as organic matter, were sampled and sent to the NESRC. Lastly, multiple site observations were conducted over six weeks.



Figure 4: (A) On-site water analysis potential of hydrogen in Gisyo and (B) Kibenga focus group B image, 2021.

I sampled two sites namely in Gisyo (site 1) and Kibenga (site 2) located in southeast Lake Tanganyika. Surface water sample parameters for both sites included the potential of hydrogen, total nitrogen, total phosphorus, and silicon/silica, which were collected twice at each site in two different timeframes in May and June 2021, this was to test if there were any changes in the above element readings within a month. While grass consumed by hippos and dung samples were collected once from site 1 because the purpose was to know if they contain silica, which was the same day in which water samples from sites 1 and 2 (the description of these sites will be provided in later chapters) were collected (see Table 1 below). The first round of water sample collection at site 1, occurred at 09:30 am inshore about 300m from the shoreline, whereas, at site 2, water samples were collected at 12:48 pm inshore about 20 metres from the shoreline. The second-round site 1 sampling occurred at 11:30 am inshore about 150 metres from the shoreline, while at site 2, water was sampled at 13:15 pm inshore about 30 metres from the shoreline. The on-site potential

of hydrogen measurements was conducted (see figure 4A) for both sites during the above times using a portable analyser device where 3-litres of water were collected per site in containers.



Figure 5: (A) Depiction of historical Google images, videos & places, (B) Hippo's pod surrounded by *Vossia Cuspidata* plants near Ange Beach in Kumase, and (C) hippo's footprints in Gisyo, 2021.

Observations were conducted with a combination of photographs (this included images of hippos, their footprints, trails, dung, pods and grass on which they graze) (see figure 5), videos (where hippo social behaviours and water level rise were observed) and memo writing (field notes). The use of multiple data collection methods is known as data triangulation (Guest et al., 2017), which has provided me with tools for better understanding and reflection on the phenomenon being investigated as well as increasing the reliability and credibility of the study (Abdallah et al., 2018; Shea, 2022). The triangulated data further instilled a deep sense of connection with the environment around me. Google Earth Pro maps and a drone were used for the historical and present visual representation of how the lakeshore landscape has changed over time, particularly from July 2000 to May 2021 (see figure 2). The combination of inorganic and organic samples, a collection of voice notes, images and footage of water, hippo's trails, footprints, grunts, pods, dung, and grass were used (see figure 5). The purpose of this was to create a narrative of a historically marginalised silent natural space with the help of participants to produce descriptions

of patterns of behaviour (Liebenberg et al., 2012). Additionally, these methods proved especially useful in tracing and assessing the presence of biotic and abiotic factors in and along the lakeshore. This subsequently improved our understanding of how these factors interact within both social and landscape ecologies. This has also been suggested by Bauer and Gaskell (2000) for better analysis of visual information with the sense of the real-time and real world.

6.2 Data analysis

Both grounded theory and multi-species ethnography was used to enquire and empirically analyse data gathered from the data collected. The variety of data was systematically used to answer the research questions. Grounded theory was used to collect empirical data through various strategies such as focus group discussions and interviews, observations, images and videos, memo writing, and the development of thematic themes (Sbaraini et al. (2011). An inductive process within grounded theory was used where I sought repeated themes through reviewing data during and after data collection. Thereafter, I coded emergent themes by using key words and phrases, later I grouped similar codes together in hierarchical concepts, finally I formed these concepts into themes and subthemes (Bowen, 2006) based on the everyday accounts of participants. Additionally, this inductive process was extended to the multi-species ethnographical analysis of the more-than-human networks which included hippos. Where focus was placed on historical data, cultural meaning, ways of understanding, subjective interpretation, and the chemical analysis. Locke and Munster's (2015), understanding of the more-than-human approach was used to trace the interrelation of human and non-human species' existence which has shaped the environment. First and second-order coding were conducted to develop themes using key points extracted from the data. The main inductive themes from both grounded and multispecies ethnography analyses were collated to develop a thematic map (see figure 6).

With regards to the organic materials and chemical elements analysed by the NESRC, several tools were used in the analysis process. On-site water analysis of the potential of hydrogen levels was done using a multiparameter meter method with a device called Consort C6010. Parameters that were used included total nitrogen, total phosphorus, and silicon to trace their level in the lake's littoral zone, and hippo dung and grass to trace silicon presence. Analyses were carried out in the laboratory using the molecular absorption spectrometry (MAS) method, the results are presented

in table 1. MAS is a spectroscopic technique used to measure the absorption of radiation as a function of wavelength. A sample was hit with photons from a light source and the frequency produced from the molecules was recorded for analysis (Butcher, 2013). It is worth noting that the discovered themes, organic and chemical results are unpacked in conjunction with the conceptual frameworks to discuss findings in this study.

7. Organisation of findings and limitations

7.1 Findings

The data analysis helped uncover three main themes which were accompanied by a further three sub-themes, respectively.

a. Developed themes from the datasets in figure 6 below.

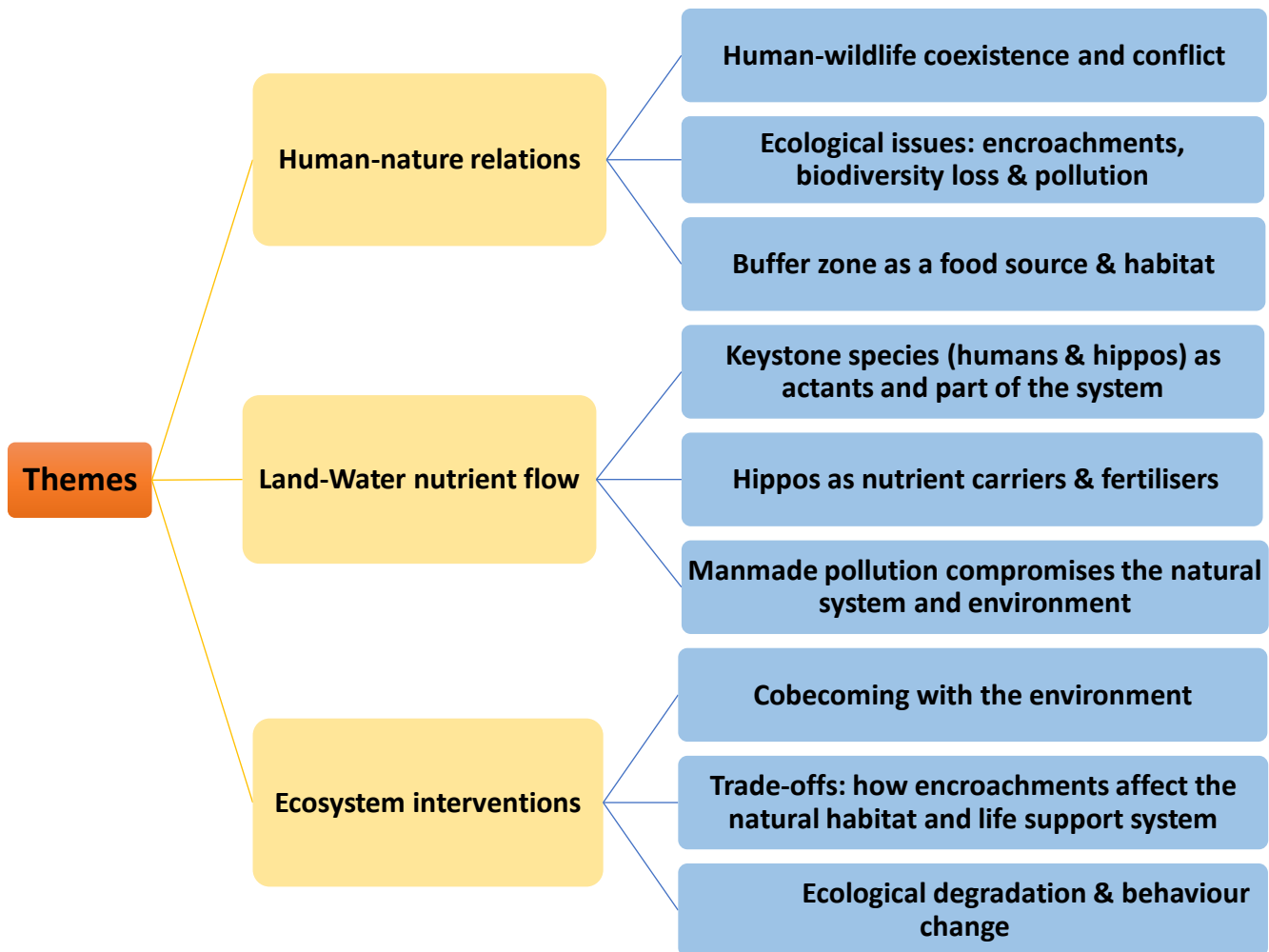


Figure 6: Main inductive themes and subthemes retrieved from grounded theory analysis 2021.

b. Analysis of organic materials and surface water chemical elements.

Table 1 below shows the results of water tests conducted in the Gisyo and Kibenga. Apart from the potential of hydrogen (pH) analyses, other sampled chemical elements parameters like total nitrogen (TN), total phosphorus (TP) and silicon (Si) from each site were measured in milligrams per liter denoted as mg/L (the unit used to measure the concentration of substances in water) at the given location (longitude and latitude) and daily temperature (°C)¹². Organic materials such as hippo dung and grass were only sampled once to determine the presence of silicon. The lake's potential of hydrogen ordinarily is at the standard level of between 8.5-9 (Niyoyitungiye, Giri, and Mishra, 2019), when this is found to be lower (e.g., below 5.0), it means that there is more than the natural level of acid in water. The potential of Hydrogen is critical for the survival of aquatic plants and animals, including humans that use the lake (Niyoyitungiye et al., 2019). I could not find the standardised local and regional levels for other parameters. However, in chapters two and four, I refer to the normal standardised freshwater eutrophication control level used in other studies to understand nutrient balance.

Table 2: Analysis of water (Lake Tanganyika), and organic matter (hippo grass & dung) conducted at the NESRC laboratory at the University of Burundi, 2021.

Sample Type	Site #	Date	Area (Zone)	Location (Long & Lat)	Temp (°C)	pH	TN (mg/L)	TP (mg/L)	Si (mg/L)
Water	1	20/5/2021	Gisyo (<i>Littoral</i>)	3°S, 29°E	27.3	8.92	123.8	4.36	6.45
	2		Kibenga (<i>Littoral</i>)	3°S, 29°E	27.3	8.87	139.2	9.92	6.31
Water	1	10/6/2021	Gisyo (<i>Littoral</i>)	3°S, 29°E	27.4	8.73	108.9	5.83	5.96
	2		Kibenga (<i>Littoral</i>)	3°S, 29°E	27.4	8.76	146.2	6.06	4.24
Grass	1	20/5/2021	Gisyo (<i>Riparian</i>)	3°S, 29°E	----	----	----	----	9.4
Dung	1	20/5/2021	Gisyo (<i>Riparian</i>)	3°S, 29°E	----	----	----	----	21.7

7.2 Limitations

This study only focused on two neighbourhood communities (Gisyo and Kibenga) in the city of Bujumbura which are both urbanised. This is because the scope of the study at a master's level was limited, however, going beyond one urban area would be an advantage as I will have access to in-depth information by spending more time engaging with participants (humans and non-humans)

¹² Also see World Weather: <https://world-weather.info/forecast/burundi/bujumbura/>

and accumulate various data set in a comparative study which may investigate the wider ecological issues across more than one city adjacent to the lake in Burundi as well as the region. Data was collected from a small number of marginalised coastal community members ($n=11$) to hear their narratives on the current human-wildlife conflicts as the basis for the study. Engaging with some local members whose livelihoods are dependent on small-scale farming and fishing in the two areas for the past 30 years played a fundamental role in understanding the history of the conflict between people and hippos. Additionally, only a small number of participants ($n=6$) from different affiliations with environmental interests were individually interviewed. Officials from the Lake Tanganyika Authority were not accessible after several attempts.

With regards to sampling of materials, only two rounds of chemical parameters as shown in table 1 from the two areas were analysed in the wet season to test the level of nutrients in lake water for the two neighbourhoods. It is important to conduct multiple water tests in both seasons (wet and dry) for better insights on transboundary risk assessment management of the lake and its catchment diversity. To understand the dynamics of social-ecological issues that are currently tied to urban expansion across all riparian cities, it is important to allocate enough time to assess both previous and actual settlement owners, and their motivation for building on the lakeshore. In addition to engaging with officials from the Lake Tanganyika Authority and environmental protection departments from more than one country.

8. Ethics

Ethical principles were observed during the study, particularly throughout the data collection process where informed consent was sought from all participants. For those participants who wanted to remain anonymous, I used pseudonyms and maintained confidentiality by attaching pseudonyms to their quotes. It is important to note that confidentiality and anonymity in the focus group discussions were limited however, participants were informed that they were not to share with people outside of the group what was said by others during the group discussions. However, most participants were mentioned by name in this study as they wanted their names published and voices to be heard. I did my best as a researcher to reduce harm to participants during data collection and made sure that interviews and focus groups took place in a safe and secure environment where they could freely discuss the research topic at length. To my knowledge, no

harm came to any of the participants during the data collection phase or so far, particularly those from the focus group discussions.

Prior to the commencement of all interviews and group discussions participants were informed of their right to withdraw at any time from the study and that nothing would happen to them because of their withdrawal, participation was completely voluntary. I read the informed consent form in the language that participants were most comfortable with (such as French, Swahili, or Kirundi) to participants informing them about the study's purpose. Each participant was asked to consent to the archiving of interviews at the end, and the release form was provided after the agreement (see appendix A for the English version). The two focus groups were held onsite (by the coastline in the riparian zone) to allow participants to reflect on everyday habits and practices, they were asked to share their experiences when responding to questions (see appendix B and C), only the candidates who participated in the study and the researcher had access to the digital recordings. Individual interviews were scheduled at a time and place that was convenient for each candidate (during the day) and in a comfortable and safe environment (at the office and in the garden). Both human and animal subjects were at low risk; all human subjects were over the age of 18, whilst animals (hippos) were seen, video filmed, and photographed from a distance in the lake. The CRSNE laboratory team from the University of Burundi assisted with the chemical analysis and sampling protocol. The University of Cape Town Research Ethics Committee and the Burundian Office for Environmental Protection both gave their approval to this study (see appendix D and E). All COVID-19 restrictions and regulations were adhered to in this study.

9. STRUCTURE OF THE THESIS

In this introduction, I present the study's background/context and problems, as well as how the current land clearing for settlements has impacted wild hippos' access to enough grasses, and how this change has impacted the coastal communities of Gisyo and Kibenga in Bujumbura. The research aimed to investigate human-nature interactions in order to answer the key questions raised above. Part of the literature was reviewed in relation to the conceptual frameworks used, namely ecocentrism and actor-network theory, and the effects of humans on the riparian zone and hippos on terrestrial and aquatic biogeochemistry cycles are explained. The concept of life-support systems and their intrinsic value were discussed in light of Gomez-Baggethun's (2011; 2016) views

on classical economists. The study materials and methods demonstrate how grounded and multi-species approaches were used to collect and analyse socio-ecological phenomena affecting humans and hippos. The organisation of empirical findings retrieved from the data set, as well as the study limitations, are presented.

In chapter one, literature on human-nature relations particularly that which emphasises ecocentric and actor-network theory (ANT) concepts to identify actants within the social system involved in the study and develop stories of human-hippo interactions linking this to ecological issues and the understanding of the coastal buffer zone are discussed. Additionally, it looks at how threats like pollution affect livelihoods and suggest a possible buffer zone structure that may create enough grassing space, regulate the flow of chemical substances and control flooding. These discussions are centred around study findings.

In chapter two, the existing literature on theme two land-water nutrient flows are reviewed. An additional review was conducted on ANT to identify and develop an understanding of the concept using the terms like locality, framing, and connect to demonstrate the impact of the hippo (keystone species) in the lake and terrestrial ecosystems in conjunction with the biogeochemical cycle. using the concept of ANT to demonstrate the hippo's importance in the aquatic food chains (web) and oxygen production. Moreover, the impacts of humans as the consumers or beneficiaries of natural services due to their deliberate disturbance of the buffer zone are explained.

In chapter three, the swift conversion of the riparian area into settlements in the city of Bujumbura is discussed. The need to adhere to the Water Act or Water Code of conduct (protocols) prescribed by the country's law and the significance of making legislation binding upon all people in the land. Suggestive transboundary insights for ecosystem interventions are developed and discussed concerning findings. Key strategies such as transboundary research and development across and preventing the use of riparian zone in the natural environment are proposed. Furthermore, the effects of urbanised natural land on the ecosystem are discussed to assist the entire country and region in restoring the affected riparian zones and continue to protect the natural environment adjacent to the lake.

Towards the end of chapter four, I sum up all previous chapters in an attempt to encourage humans to reconnect with nature, recognise the role of hippos and reconsider the importance of biotic and abiotic factors in resolving human-wildlife conflict. Furthermore, I argue that the current urban expansion may be attributed to people's affluence. I also cross-examine the agency of hippopotami, humans, and other species as equal actors/actants within ecosystem networks. As such, I urge all members of society to rethink and reframe our ecological role, particularly within an urban nature interface.



CHAPTER 1. HUMAN-NATURE RELATIONS: HIPPOS IN MY BACKYARD

"Many people have been injured by hippos as a result of houses built in their natural habitat. There have been reports of people being injured, even killed, by hippos. People believe that hippos eat humans, but they are herbivores. Perhaps we can tell that the hippos' behaviour is changing because they were attacked. They are aggressive due to a lack of grazing space, and their habitat is becoming increasingly scarce as people continue to build. It will be necessary to set aside at least a small area where they can be assured that no one will bother them, and perhaps they will stop being aggressive".

- Gaspard Ntakimazi¹³

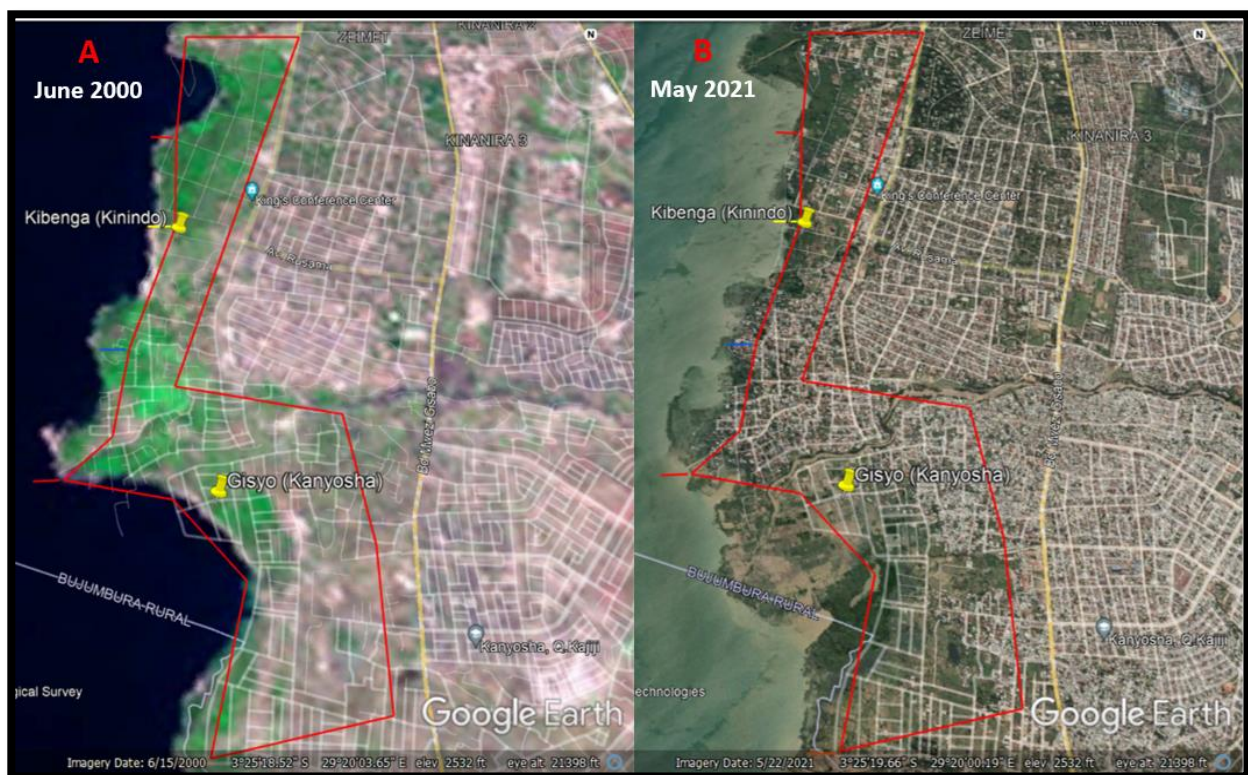


Figure 7: Google Earth Pro showing two images from sites 1 & 2, marking the transformation of the riparian zone for Kibenga & Gisyo for the years, 2000 & 2021.

¹³ Gaspard Ntakimazi, zoologist & aquatic ecologist at the University of Burundi, personal interview, May 2021

Introduction

This chapter aims to explore the first theme *human-nature relations* which is set in the neighbourhoods of Gisyo and Kibenga, forming the basis of the study. My argument here is that, the current land and water legislation fails to recognise the importance of the riparian zone, which is of paramount importance to the integrity of the land, while also addressing the socio-economic factors that contribute to its degradation. Thus, I explore how this has had an impact on multi-species interactions by studying how and why humans and hippos clash, as well as how hippos reclaim what has been taken from them. With the ecocentric concepts, a nature-centred approach is developed with an ecological community in mind. This chapter shares reflective stories on the human-environment relationships of coastal communities in Bujumbura. In response to the first question, what are the intersecting human-hippo interactions that exist in Bujumbura's lakeshore neighbourhoods? The focus is to understand human-wild animal relations and the impacts of their interactions as actants in terrestrial and aquatic ecosystems. This collection of stories resonates with Aldo Leopold's ecocentric ontological viewpoint as explained in (Erdős, 2020), to help us understand human-wildlife relations from stable connection with the natural space (riparian land and lake) and wildlife (hippos) to the drastic relationship over the shared commons.

The riparian zone is a unique and transitional space that connects local farmers and hippos. For example, in Gisyo, I observed hippos' footprints on rice farms, making the location critical for human and hippos' food sources. The stories detailed in this thesis are based on the struggles of local communities and wild hippos over the commons on Lake Tanganyika's coastland. The setting is of two neighbourhoods namely Kibenga and Gisyo (see figure 7) under the administration of the Muha commune, located on the southeast coast of the city of Bujumbura. In responding the above question, I will begin this chapter by *setting the scene* for which humans and the natural environment interact which highlight our impact on the environment. Thereafter it discusses the subthemes that accompany the theme Human-nature relations namely: *human-wildlife coexistence and conflict, encroachments & biodiversity loss, and buffer zone as a food source & habitat*.

Setting the scene

Human’s ability to root themselves anywhere they please have significantly reshaped the coastal landscape of Lake Tanganyika. The current increase in the occupation of the commons, due to urban expansion on the riparian zone has resulted in human-wildlife conflicts. The continued developments have drastically changed the landscape the lake’s riparian zone, which has led to the degradation of nature as well as the deterioration people’s well-being and livelihoods. It is important to understand that the lake and its riparian zone or catchment (see features in table 2 below) serve as placeholders, for Adam’s (2016) interpretation of the place as a sphere orchestrated by both human and non-human communication and engagement.

Table 3: Key features of Lake Tanganyika (Lowe-McConnell, 2003; Secretariat, 2012)

Water Type	Surface (km²)	Origin	Volume (km³)	Max. Depth	Altitude (m)	Age (mm)	Catchment (km²)	Shoreline (km)
Fresh	32600	Tectonic	17800 – 18880	1417-1470	773	10+	263000	1900
Basin Riparian Countries			Ecoregion		Biome		Climate	
Burundi, DRC, Tanzania, and Zambia			Lake Tanganyika		Great Lakes Freshwater		Tropical humid – Savana	

In this study the concept of actants is divided into human or social actants which include local community members of Gisyo and Kibenga (see table 3), as well as professionals from different backgrounds (see table 4). Non-human actants in this study are wild hippos (see figure 8) and other species that form part of the complex ecosystem of the lake. Other key actants within this study include: the BOEP¹⁴ and the Lake Tanganyika Authority who act as custodians of the lake. Both these actants’ strategic targets are to protect, restore, and the management of critical aquatic and terrestrial habitats; the MPCDFU¹⁵ and UNDP¹⁶ (2011) as promoters of the country’s vision 2025¹⁷; and the Water Act N° 1/02 of 26 March 2012 (Water Act, 2012), on Water Code in the protection of coasts and riverbank environments in Burundi. All members of society and

¹⁴ Burundian Office for Environmental Protection - Office Burundais pour la Protection de l’Environnement (OBPE)

¹⁵ Ministry of Planning and Communal Development/Forecasting Unit

¹⁶ United Nation Development Programme in Burundi

¹⁷ The Vision Burundi 2025 is government’s plan that describes action and goals for sustainable development.

organisations are referred to as actants, and they constitute the actant-network or assemblages within the social network. (Latour, 1993; Callon, 2001).

Table 4: Focus groups of the two coastal neighbourhoods along Lake Tanganyika, 2021.

Community	Grp.	No. of Cands.	Female	Male	Avg. yrs. in area	Identified by	Livelihood
Gisyo (Kanyosha)	A	6	1	5	36	Pseudo-nyms	Fishers & fish vendors
Kibenga (Kinindo)	B	5	2	3	36.2	Real names	Fishers & vendors

Table 5: List of individual interview candidates from different backgrounds, 2021.

Individual Interviews			
Candidate	Current Affiliation	Role/Function in Society	Gender
Mr Albert MBONERANE	ALUMA/Green Belt/GIZ (Former Minister of Environment)	Director of ALUMA & Environmental Activist	Male
Mrs Cecile GAKIMA	FAO United Nations (Former worker in the Env. Cabinet)	National Project Coordinator	Female
Dr Christophe NIYUNGEKO	University of Burundi (Faculty of Sci. Dept. of Chemistry)	Lecturer: Chemist	Male
Prof Gaspard NTAKIMAZI	University of Burundi (Faculty of Sci. Dept. of Biology)	Lecturer: Zoologist, Aquatic Ecologist (biodiversity of fish)	Male
Mr Jacque NKENGURUTSE	University of Burundi (Faculty of Sci. Dept. of Biology)	Lecturer: Biologist/Botanist	Male
Mrs Lorraine J. MANISHATSE	Independent journalist (Former IWACU Press journalist)	Report Environmental Issues	Female

Below I discuss the subthemes that accompany the theme human-nature relations in-depth. The first subtheme to be discussed is *human-wildlife coexistence and conflict* which is titled below as stories of human-wildlife coexistence and conflict in Bujumbura’s Lakeshore where a narrative approach is used to narrate stories of conflict between humans and hippos in people’s backyards. This is followed by the discussion of the second subtheme *Ecological issues: Encroachments, biodiversity loss and pollution* which discusses the ecological impacts of human settlement development on the riparian zone. Lastly, the subtheme *Buffer zone as a food source and habitat* is explained as an important part of both aquatic and terrestrial ecosystems.

Stories of human-wildlife coexistence and conflict in Bujumbura's Lakeshore



Figure 8: Drawing of large an adult hippopotamus, 2021

This subtheme discusses human-wildlife coexistence and conflicts, particularly in relation to hippos. Hippos have been present in Lake Tanganyika and the Rusizi river for centuries and have adapted to the ecosystem (Atkins, 2010)¹⁸. They are mammal herbivores with adults weighing between 1300 to 4500 kgs and live-in pods around lakes and rivers (Bradford, 2018). They are semi-aquatic and spend about 16 hours of their time in the water during the day and on land at night for grazing, consuming up to 40-50 kg of grass daily and have an average life span of up to 40 years (McCauley et al., 2015; Bradford, 2018; St. Lucia, 2021). The riparian area is the transitional space that connects hippo's life on land with life in the water (Bradford, 2018). Before the land degradation, the lake's littoral and its riparian vegetation were flourishing with flora and fauna elevated at almost every part, to keep the two systems going for thousands of years.

Human interaction with the riparian land was historically based on small-scale farming. However, because of the country's exposure to several systemic ethnic conflicts that resulted in the deaths of thousands of Burundians which saw prominent levels of internal displacement and refugeehood in the form of forced migration, the land tenure near the lake did not differ from other parts of the country (Kohlhagen, 2011; Couillard et al., 2009). The year 1962 marked the post-independence era, between 1965 and 1991 different events of ethnic massacres, and between 1993 and 2005 was the period of civil war (Kohlhagen, 2011). During these periods of conflicts, different land decrees were introduced, such as the N° 1/20 of 30 June 1977 which declared giving automatic full ownership of land to all occupants (illegal or otherwise) who had occupied land for at least fifteen years (Kohlhagen, 2011). The land prescription, code N° 1/008 of 1 September 1986 allowed members of the community to own land if they could cultivate or farm it (Couillard et al., 2009),

¹⁸ Atkins, C. 2010. *African Lakes and Rivers*. AuthorHouse.

something that benefited those living along Lake Tanganyika. Coastal communities in most parts of Bujumbura made a living from farming and fishing.

“...back then when I was a kid, my father was a farmer and he grew different types of food in this area, there were palm trees, guava trees and many other kinds of plants. We could farm and harvest a big quantity of crops...” (Kezakimana)¹⁹.

Here, Kezakimana reminded us of the importance of the land in their lives, the physiocratic belief described by Gomez-Baggethun (2011), as the wealth of nations which are tied to land for agricultural and development. This is the case of Burundi, where over 90 percent of livelihoods are derived from agriculture²⁰. Small-scale farmers, for example, in Gisyo valued coastal land as a source of income and food to support themselves, and this is how they are linked to place. However, Burundi’s land laws are complex, and its historical reform trajectory on land tenure is still questionable. Some pieces of land were earned through oral and customary law, the change to statutory law seemed to be confusing for some and resulted in land grabs by influential actants (Couillard et al., 2009; Kohlhagen, 2011; Claessens et al., 2021). The quote below by Bizimana refers to some community members who illegally grabbed land and then started farming activities, but later sold pieces of that land, which they turned into instrumental value.

“The truth is that people came and started farming on this land after they claimed that it was theirs and started selling those plots. This place where we are standing has been sold and every part has got its owners” (Bizimana)²¹.

The Land Code recognises the legitimacy of customary land rights and requires those rights to be registered. However, registration is costly, and no provision is made for poor and vulnerable people to acquire property rights. As a result, some people are forced to sell their plots (Prosper, 2021). The current change in land-use and land-cover may be attributed to a lack of a clear coastal management framework that integrates the well-being of humans, plants, wild animals, and water, which appears to jeopardise hippos' grazing space. Human-hippo interactions were relatively shaped by seasons (wet and dry) and vegetation cover before the new millennium. According to participants, conflicts between hippos and residents of Gisyo and Kibenga over the space were possibly low prior to the rise of large development activities. This is because there was enough

¹⁹ Kezakimana, a 26-year-old vendor, participated in a focus group B, April 2021

²⁰ Also see IFAD. <https://www.ifad.org/en/web/operations/w/country/burundi>

²¹ Bizimana, a 45-year-old fisher, participated in a focus group A, April 2021

grazing land, though the main activity of locals was small-scale farming. While onsite with participants, I asked them to reflect on changes that they have experienced and witnessed over the past two decades. Their explanation suggested that people's tendency to occupy the riparian zone is driven by the lake's fluctuation. As the lake level decreases over time, more space is created, and so does the increase in land occupation closer to the lake.

Bizimana and Bukuru²² reflect on the current shift of the shoreline, emphasising that flooded houses built near the lake should not have been there because the area was underwater 32 years ago. The same experience was echoed by Ciza²³, who stated that people capitalized on this gradual change by acquiring plots and building houses in the area. These participants are community members of Gisyo who rely heavily on fishing to survive, with some having lived in the area for more than three decades. When I asked them to give a general comparison of the number of hippos seen grazing in the area now as opposed to previous years. Their response seems to suggest that the number has increased. This makes sense as Gisyo is still less fragmented with more patches to graze than the neighbouring Kibenga. Thus, hippos' evolution of adaptive behaviour seems to have changed over time due to human-led land transformation resulting in scarce grazing patches which leaves them with fewer options making them heavily dependent on Gisyo's riparian corridor as a food source. Timbuka (2012) uses the concept of behavioural trade-off in his study in Tanzania's Katavi National Park to show how hippos prefer swards near their pods to optimise risks associated with long travel.

Like hippos, the majority of coastal communities were dependent on the lake and the land for their livelihoods and well-being. Growing crops, fetching medicinal plants, fishing, and consuming and swimming in lake water. These intersecting activities fundamentally illustrate our ongoing relationship with nature through the exchange and change of resources (land and water). Yet, our attitude toward using them is that of dominance, where we place ourselves as the apex species in charge and in control of this crucial resource. When members of communities were asked to share their lived experiences with hippos in the riparian space, they reported instances where hippos ate their harvested crops in the past without them retaliating against the hippos. These narratives

²² Bukuru, 42-year-old fisher, participated in a focus group A, April 2021

²³ Ciza, a 42-year-old fisher, participated in a focus group A, April 2021

illustrate coexistence with hippos on the shared commons which were based on mutual relations between locals and the hippos. During this time, the landscape was still in its “natural state” with enough space. Leopold referred to this as the ecocentric ‘golden rule’ on ecological (biotic) community states that “A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.” (Erdős, 2020).

“...you know when there were few houses here and no houses near the beach, hippos could go out for grazing and move around, there was no problem, and no one disturbed them because we knew that they are part of nature. Hippos ate our cassava (root crops). They did not prevent us from picking vegetables or plunking from trees” (Muhenure)²⁴.

“... you can have an encounter with hippo and pass one another, nothing could happen because this area was full of Urubingi (hippo grass), there were no animals that attack or kill people because there was enough space to graze” (Kezakimana).

Additionally, Mugisha²⁵ reflected on Kibenga's landscape before the transformation, stating, "All of Kibenga was just like a bush. "We used to come across hippos in different places...but they were never aggressive because there was enough food". Havyarimana²⁶, further suggested that the human-hippo conflicts were minimal or perhaps did not exist in the past. The above quotes show participants' sense of environmental consciousness, reflecting on the wanders of hippos in their backyards and how they co-existed with them, reminding us of Wordsworth's (2000)²⁷ text ‘*The Ruined Cottage*’ when he spoke about verities of lifeforms by paying attention to the symbolic value attributed to them and prevent disturbing the stillness of nature. Participants reflected on their encounters with hippos, which was a sign of co-habitation, where they made connections between human land acquisition and how it affects hippos' grazing space. This co-existential relationship began to deteriorate with the rise of settlements in the new millennium, dating to the year 2000, the year that marked the beginning of human-wildlife unstable relations. The repercussions of not respecting the golden rule started to manifest themselves as people living in Kibenga, Gisyo, and other coastal areas in the north started to realise the drawbacks of their dominance in the commons. Ruskin Bond's (1988) story reminds us about ecological imbalance

²⁴ Muhenure, a 70-year-old vendor, and farmer, participated in a focus group B, April 2021

²⁵ Mugisha, a 22-year-old fisher, participated in a focus group B, April 2021

²⁶ Havyarimana, fisher, participated in a focus group B, April 2021

²⁷ Wordsworth, W., 2000. *William Wordsworth: the major works*. Oxford University Press, USA.

(Giriya and Krishnaraj, 2021), and we should be mindful of the signs that might lead to species extinction. As the vegetated space started and continues to narrow towards the lake (also see figure 7), hippos started to be seen very often in people's backyards in search of food and became increasingly aggressive. This continuous development by developers encouraged the diminishing factor of ecology, creates an imbalance, and thus affects how humans, plants, and hippos relate in coastal areas.

“...there were problems reported in the past years, the constructions on riparian zone since the year 2000, that was the zone where hippos give birth and grew up there. But now their habitat has been invaded, they are unsettled, they don't know where to go, and become very aggressive, but before they were not. This is because their habitat was invaded” (Ntakimazi).

Again, here Ntakimazi echoes Wordsworth's (2000:33) sadness about human's disturbance of nature, when he said, “For them a bond of brotherhood is broken: time has been when every day the touch of human hand disturbed their stillness, and they ministered to human comfort”. When urban expansion accelerated, most community members were offered the opportunity to sell their plots at a lower price. This is when people's relationship with the land started changing as a form of classical economy emerged. This disconnect is referred to by Marx as a 'Metabolic Rift' because the land was no longer used for its intrinsic values; this disconnect between farmers and their land is influenced by the exchange values where labour and capital began to gain momentum overland (Clark and Foster, 2010). When Ntakimazi was asked about the other areas like Kabondo (a commune after Kinindo) which was developed before Kanyosha and Kinindo, his response was the same.

“People who lived there were farmers, then later, they were invaded by the city on the northern part. They sold their land and left. Their agricultural land was converted into building plots. Those who bought the plots earlier resell them and now the plots are very expensive” (Ntakimazi).

Ntakimazi resonates on how humans are endangering hippos by increasing land demand for construction, which is one of the factors affecting their habitat and putting their lives in danger. Kanga and colleagues' (2012) twelve-year (1997-2008) assessment of the human-hippo conflict driven by land use practices in Kenya warns us of the increase in human death by hippos' killings as a direct result of these human-hippo conflicts. As the transfer of land ownership continued in a form of investment for some, with the expectation of high returns in coming years. Land demand boomed, and the adoption of neoclassical ideas developed (Gomez-Baggethun, 2016; Burkhard

and Maes, 2017), more and more farmers were dragged out of the riparian land, as the rise of settlements for businesses became the dominant factor of habitat loss and scarcity of grassing land (patches) for hippos. This started raising community concerns about their safety when encountering hippos, highlighting that hippo's habitat degradation has been compromised by development programmes (Manishatse, 2017; 2018; Kanyange, 2018).

As witnessed on the ground, the landscape was changed by settlement activities from downtown to remote wildlands, to the lake. Figure 9 below depicts the current urban-nature convergence of the city of Bujumbura where agencies of humans and hippos as actants are placed at the centre. Communities and hippos cross paths in the shared riparian zone (commons) in Gisyo and Kibenga. A network of people, hippos, and other organisms has shaped this habitat found in the northern basin ecoregion of Lake Tanganyika. The change in urban political ecology, with the social processes in areas like Kibenga, Gisyo, and other coastal neighbourhoods has the common goal of building settlements on the shoreline. This cultural change in social class predominantly gives an advantage to the working and upper classes and undermines the moral concern of strengthening the relationship between society and nature.

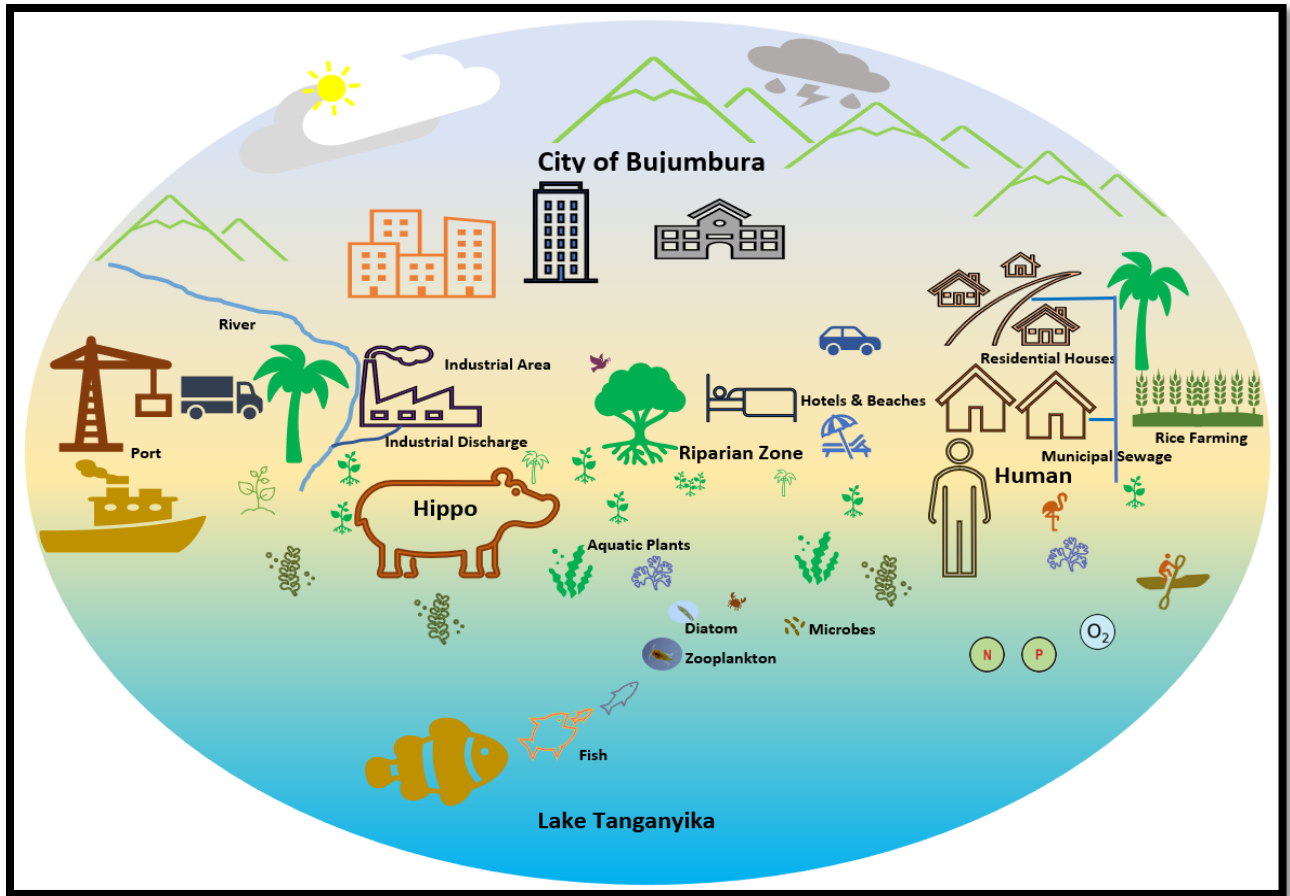


Figure 9: Depiction of actants in Bujumbura and the city’s metabolism, degraded riparian zone, and the biggest polluters of the Lake Tanganyika, 2021.

This implies that social, political, and economic meta-dimensions are merely focusing on certain individual aspects of life such as economic development and tourist attraction within the social system rather than the entire ecological community which Leopold (1986, cited in Erdős, 2020) considered to include soils, plants, waters, and animals. The rationale for this is that the society needs long-term agency from the nature to sustain itself. Participants acknowledge changes in human-hippos relations emerged post-2000 as a result of our systemic exclusionary behaviour towards nature. Their reflections reveal how their relationship with hippos is currently in limbo, caused by the current developments and expressions of concern over the possibility of being killed when encountering hippos.

“...nowadays hippos have become aggressive, you can hear that the hippo has killed three, four, five people because there isn’t enough grass...there is a lady there by Nicayenzi who were killed” (Kezakimana).

“I encountered a hippo on the street at night, I thought it was a mountain of trash. I heard a sudden hippo’s grunt, then when turning around I noticed that it was the hippo, then I start running (Kezakimana).

“I only meet hippos in the yard when they come to grazing our vegetables, destroying our plants, and sometimes we just wake up and hear that one of our neighbours is killed by a hippo. Some of our neighbours spent more than three days without seeing their brother not knowing that he was killed by a hippo” (Nduwabose)²⁸.

“I met hippos so many times. We have been attacked by hippos almost five times, they hit our boat and killed some members of the team but thanks God I survived all those attacks. And sometimes they find people in their homes, here we may say that the problem is from us humans who came to its place and made it our home” (Bukuru).

The anthologised poem ‘*Hawk Roosting*’ by Ted Hughes (1975²⁹, cited in Ghazzoul, 2021) asks us to consider other lifeforms as equally worthy of our attention. He uses the hawk as the speaker to remind us of the importance of understanding behavioural ecology, considering the power, beauty, and symbolic value attributed to creatures. Hughes (1975, cited in Ghazzoul, 2021:803) uses a predatory voice, using an imaginary quote of the hawk saying, “I kill where I please because it is all mine”; “No arguments assert my right: The sun is behind me”. In order to show us how animals, claim dominion in their territories as humans do. When participants discussed their fears and concerns when encountering hippos, they reminded us that hippos are territorial creatures and will claim dominion in their world. Like the hawk, the hippo’s assertion of power gives them the autonomy to graze and wander as they please because they believe that all coastal grasslands are theirs and no one should stop them in their territory. What the behaviours of both the hawk and hippo tells us here is, that as humanity believes they are supreme, they too believe they are supreme. A medical study conducted between 2017 and 2018 in one hospital (Arche Hospital) in Bujumbura reported 11 cases of people injured by hippos (Haddara et al., 2020). Therefore, these reports and testimonies suggest that biodiversity loss along the coast might lead to an escalation in human-hippo conflicts.

²⁸ Nduwabose, a 41-year-old vendor, participated in a focus group A, April 2021

²⁹ Hughes, T., 1975. *Hawk Roosting*. Department of Communication Design, Leeds Polytechnic Institute.

Ecological issues: Encroachments, biodiversity loss and pollution



Figure 10: Reflective image collection of hippo's presence on land (A), in water (B), in the neighbourhood (C), human-hippo encounter (D), coastal pollution (E), encroachments and agriculture (F), 2021.

Apart from safety concerns raised by members of the two communities, they have a sense of environmental ethics through the recognition of the deep history of the hippo's liminal space, and human and nature relation through the symbolic and intrinsic value of the commons (Tsing, 2012). Community members are cognizant of the hippo's symbiotic relationship with other wild species like birds in the ecosystem. Their understanding of the current conflict was far beyond just being anxious about their safety and for others, particularly the victims. Instead, they accepted and understood that hippos are vulnerable as classified in the IUCN³⁰ red list (Lewison, 2017). They admitted that the current crisis is the result of human behaviours toward nature. Will this be what Leopold (1986 cited in Erdős, 2020) experienced as the "turning point"³¹? His work focuses on morality as he believes that protecting the biotic community yields to a sustainable healthy natural ecosystem. Leopold's work asserts the human and non-human connectedness with the land, stressing that humans are not responsible for selective resources but for the entire landscape. Thus, his land ethics does not focus solely on individuals and places, instead he focuses on the entire biotic communities.

³⁰ International Union for Conservation of Nature

³¹ Leopold realise the importance of larger animal in nature and their crucial role for the ecosystem.

Perhaps this environmental record should change how people see nature, inculcating within us a belief that, nature without hippos means nutrient imbalance in the lake and fewer diatoms (planktons), zooplankton and fish reproduction (impact on aquatic food web) of which we all depend on for the supply of fresh water and fish protein (Hildebrand et al., 2018; Frame and George, 2020). This interspecies relation is broadly discussed in chapter two. With the help of the above-mentioned materials, I have managed to document the direct interaction of the two systems (land and water) and show the current intersection within a framed ecosystem. This fieldwork was conducted during the wet season, the lake level was high, going through its cyclical period which has an impact on the riparian zone structure, the lake chemistry, and the mobility of hippos and humans. When Professor Gaspard Ntakimazi was asked about the state of the lake, he echoed that, the current record is not new as in the past there were similar scenarios.

The lake fluctuates, the average is between 774 and 775 m of altitude above sea level. When it is lower, it decreases between 772 m and 773 m. In 1999, 2000, and 2001, this is where the lake was lower, and we had periods when the level was high, between 776 m (dry season) and 777 m (wet season) which is today. Finally, the area where the people are looking to build is between 772 m and 777 m, which is a band of 5 meters high in the riparian zone” (Ntakimazi).

The reality I observed on the ground was overwhelmingly worrisome, the two neighbourhoods, as well as other coastal neighbourhoods surrounding the lake, were negatively affected by flooding. This outcome could have been easily minimised or even avoided if people did not build on the riparian zone as prescribed in the Water Act (see figure 10F). The entanglement between fishermen and hippos occurred in uncomfortable proximity, representing the struggle of two different lifestyles in a shared resource (see figure 10D). I also observed that hippo lives revolve around the shoreline in Kumase beach adjacent to the industrial area, and the residential settlements built on the riparian zone in Gisyo and Kibenga (see figure 10A, B & C respectively). Human impacts on the deteriorating health of the lake also included the addition of water pollution, which saw the coastline littered with the city’s solid waste, which was dominated by plastic bottles, the lake retaliated by vomiting the waste back onto the surface (see figure 10E). One can only hope that the realities faced by community members will draw our attention to how the earth’s systems operate. It is not about the selected few of those that are negatively affected by natural disasters, but about humanity as a whole, our survival depends on our interactions, respect for and proper use of this planet and seeing ourselves as part of the land (earth) community (Erdős, 2020). An

important concept where we are framed and connected as actants of ecological diversity (Latour, 1993).

The natural state in both neighbourhoods exhibits unhealthy riparian zone dominated by settlements, with little to no vegetation density in some areas to stabilise the lake bank whose soil is eroded. Agricultural runoff from upstream and the transfer of nutrients from fertilisers drained from NPS and watershed easily canalised through the rivers and ends up in the lake have a substantially negative impact on water quality. Some community members, mostly local inhabitants and dwellers use the lake water without treatment. Pollution could have been reduced or controlled if the riparian zone was in a good structure with native plants and vegetation (Solitude Lake Management, 2021).

Buffer zone (BZ) as a food source and habitat

The riparian zone or catchment is the transitional area between a highland dry zone and the lake known as the shoreline zone. It is a strategic resource, rich in biodiversity and productive as it serves the double purpose by providing critical habitat and an essential feeding area for hippos, trees on the bank provide the shade to aquatic insects and fish (Trout Unlimited Canada, 2021). While for human's direct impact, it serves as a buffer system setting up a corridor that regulates flooding through the absorption and dissipation of water (Trout Unlimited Canada, 2021). Like the riparian zone, the littoral zone transitions from aquatic to terrestrial and is the most productive area of the lake in terms of the lake's food web (Solitude Lake Management, 2021). Thus, it solely depends on landscape patches like the riparian zone not only for the protection of external pressures but also, if well filled with wildlife and flourishing plants, it adds value to the shoreline and the surrounding neighbourhoods (Solitude Lake Management, 2021). Environmental activist and director of the Green Belt Movement in Burundi Mr Albert Mbonerane stresses that our responsibility should strive to keep the relationship with the buffer zone ensuring it is safe, and natural, and avoiding any activities that will lead to its degradation that might affect the provisions that we get from nature.

“... If we have a good habit, a good riparian zone, well-built according to norms, tomorrow we'll have healthy fish to consume and perhaps even enough to export. There is a scientist who told us that some types of fish like Tilapia have adapted to toxic water, so consuming such fish knowing that are good fish, might increase the

risk of contracting diseases like cancer which might take up to 15 years to discover”
(Mbonerane)³².

The current water legislation does not clearly define the demarcation points from which the riparian zone should be considered. It is important for Burundi to develop a legal framework that defines the riparian zone in the context of humans, land, animals, plants, and water (the lake) in Burundi, that may to protect the biodiversity of the riparian zone and to reduce the risk human-hippo conflict. Mbonerane’s insights account for the conservation of the buffer zone, in an attempt to allow the flow of energy from the terrestrial into the lake’s littoral zone, the reproductive area for phytoplankton (diatoms) and zooplankton. His linkage of vegetation and aquatic life between the two systems, shows that a healthy buffer zone is central to the functioning of natural life support systems. He then reflected on the risks of consuming toxic fish as a result of the degraded lake and the unbalanced ecosystem. Environmental activists like Rachel Carson (2002)³³ in her paper '*Silent Spring*' and Vandana Shiva (2019)³⁴ in her paper '*Defending Traditional Agriculture*' cited in Erdős (2020), as well as Rob Nixon’s (2011) paper on '*Slow Violence*' which explain that chemical substances like pesticides and fertilisers are created by humans and have long-term negative effects on our environment for decades. The authors argue that the misuse of chemical substances harm both humans and animals alike, due to their long-term persistence in soil, plants, and water. As a result, these authors promote traditional non-chemical agricultural practices. Furthermore, Nixon (2011) pleads with us to examine incremental toxicity violence that occurs slowly over time ultimately altering the environment (terrestrial and aquatic systems). In Mbonerane's opinion, a well-structured buffer zone may support the lake by regulating the flow of NPS chemical substances, which leads to a healthy lake, thereby enhancing the reproduction of fish.

A study by Hou et al. (2019), identified vegetation within high-efficiency purification for total nitrogen and phosphorous from water discharge, pattern IV (coniferous species) from 0 m to 4 m and pattern I (broad-leaved species) from 4 m to 10 m were suggested (see figure 11) to have the highest-efficacy. The study demonstrates the structured diversification of the vegetation which includes both indigenous grass and three other species with biological purification

³² Albert Mbonerane, environmental activist & director of ALUMA, personal interview, May 2021

³³ Carson, R. 2002. *Silent spring*. Boston: Houghton Mifflin Company.

³⁴ Erdős, L., 2019. Vandana Shiva–Defending Traditional Agriculture. In *Green Heroes* (pp. 187-192). Springer, Cham.

properties. Apart from regulating the environment, a well restored buffer zone with indigenous plants may enhance the hippo's habitat. Hou and colleagues (2019) study can be used as a guide for the restoration and promotion of natural processes that shape the riparian zone. This guide will be extremely useful in helping to restore and promote the natural processes the shape the riparian zone in Gisyo and Kibenga. Largely, because the riparian zone in these two neighbourhoods is found within an urban setting exposed to human interference. For this to happen, a spatial monitoring system needs to be implemented that will be used to monitor and evaluate vegetation density on the riparian zone in these neighbourhoods.

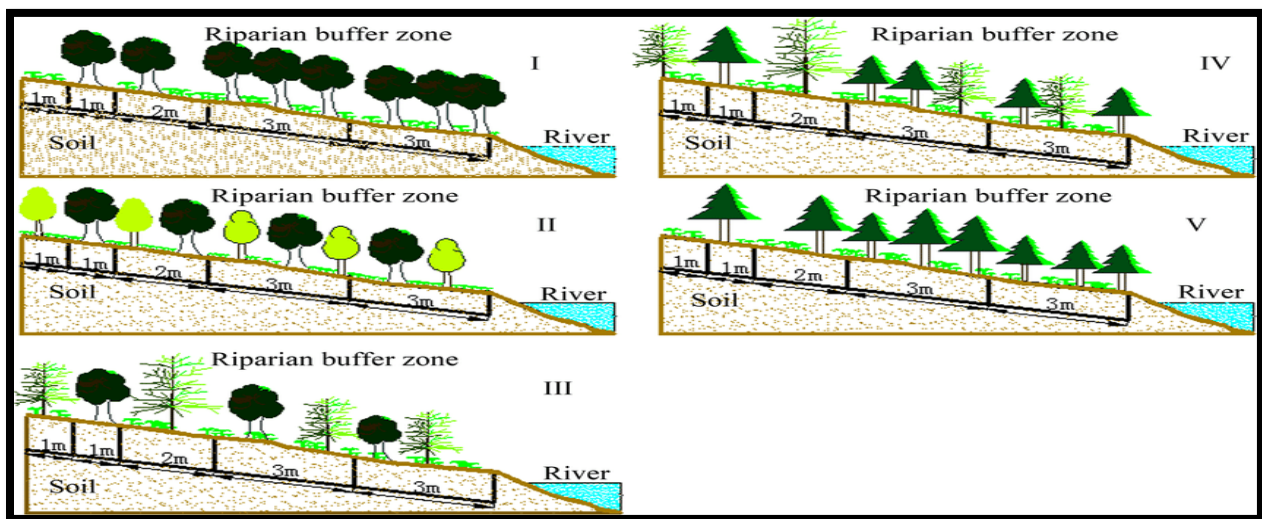


Figure 11: Vegetation configuration patterns for runoff purification (Hou et al., 2019).

Conclusion

This chapter examined the relationships between humans and the environment in Gisyo and Kibenga. These two neighbourhoods are separated by Ntakangwa river and are among the most fragmented areas as they continue to experience a non-stop rise in settlement development. These developments put pressure not only on the human residents of these neighbourhoods but as well as hippos which contest the degradation of their natural the habitat. Understanding residents' relationship with hippos is extended beyond just how they share the riparian zone. This zone is critical as it is characterised as a space of transition that serves as the commons. Human dominance has taken advantage of the current ambiguous and unenforced land and water legislation and continues to commodify or privatize the land through development processes. It is difficult to

overlook hippos and other life forms' existence in the riparian zone. Testimonies from participants and literary contributions by Leopold (1986), Hughes (1975), Wordsworth (2000), and Tsing (2012), encourage us to assess our historical and cultural entanglement with nature and consider ourselves as part of the ecosystem. There is a need for Burundi to put in place a legal framework that defines the riparian zone in the context of humans, land, animals, plants, and water (the lake) to protect biodiversity and reduce the risk associated with human-hippo conflict. As the riparian zone is important for both humans and hippos, this chapter, discusses the first theme and its accompanying subthemes in-depth. It also urges developers and urban planners to reconsider the current feedback and develop a well-designed spatial risk management framework that may assist in maintaining the buffer space and minimise some drawbacks like human-hippo killings and water pollution due to nutrient flow.



CHAPTER 2. LAND-WATER NUTRIENT FLOW: THE SEEN AND UNSEEN REALITIES OF THE LAKESIDE

“...just a few Burundians understand the importance of wild animals. I am pretty sure that among them, some who are educated don’t understand what the role of those wild animals is, I doubt that people understand and even if some do, there is always personal interest that everyone has”.

- Cecile Gakima³⁵

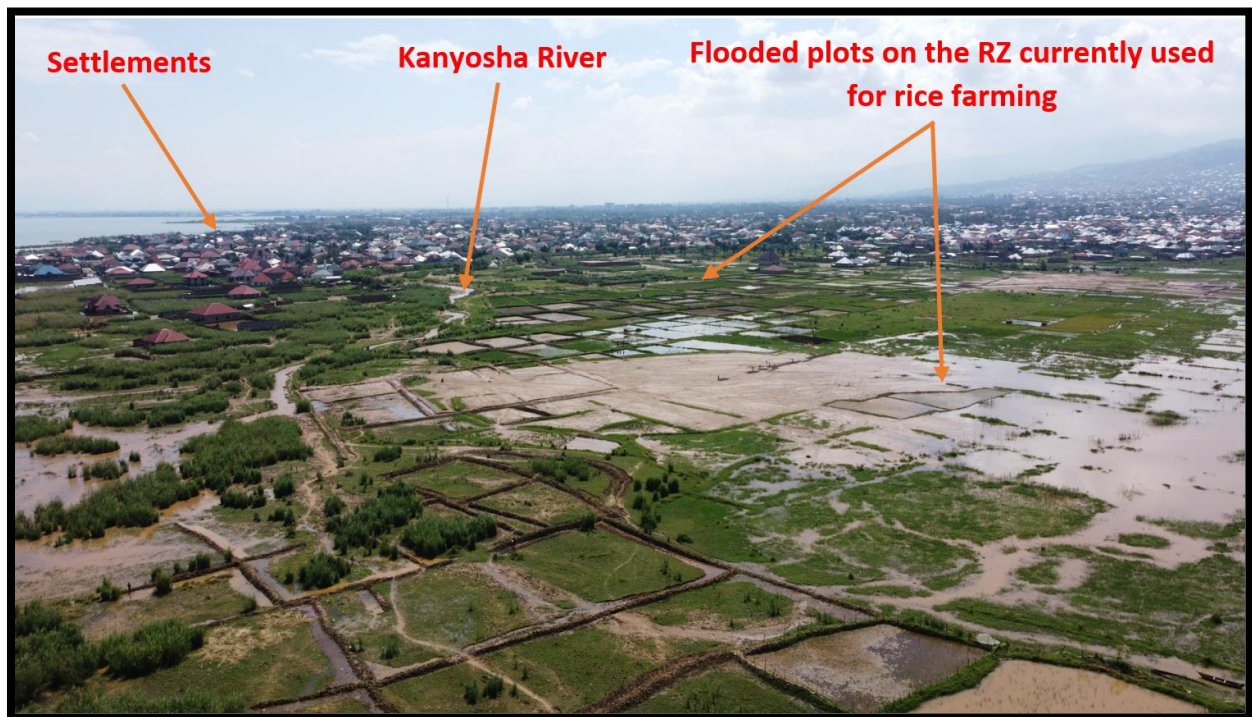


Figure 12: Sky view depicting encroachments of settlements and small-scale farming in the coastal Giso’s riparian zone, 2021.

³⁵ Cecile Gakima, project coordinator at FAO & former OBPE officer, personal interview, May 2021

Introduction

In the previous chapter, I discussed the theme human-nature relationships whilst I focused on the interrelation between Gisyo and Kibenga residents and hippos in the complex riparian zone. In addition, I also described the riparian zone as a liminal space that is transitional for both humans and hippos. In this chapter, I examine the second theme *land-water nutrient flow* showing the interconnections between life forms using Latour's (1993) actor-network theory. It is a key aspect that provides analytical tools for understanding how humans and non-human elements collaborate to create action. This chapter focuses on the concept of locality, which is defined as framed and connected. I extend the socio-economic argument to demonstrate how the lack of collaboration among actants (actor-network) or assemblages, as well as failure to incorporate the ecological context into the riparian zone, has impacted the society. The purpose of this chapter is to draw emphasis on ecological consciousness, articulating the notion of locality using interspecies relationships and their interdependence on terrestrial and aquatic ecosystems. I begin with a brief reflection on the observed realities of the lakeside, and the discussion of interrelation among the living and non-living actants, followed by an exploration of the second theme by discussing each of the subthemes namely *keystone species as actants and part of the system*, *hippos as nutrient carriers and fertilisers*, and *natural system and human made pollution* and conclusion.

The biosocial reality of the coastal landscape

Tsing (2012) describes her concept of the 'art of noticing' as a 'new alliance' in which we can commit to conducting immersive observations and fieldwork where we understand and examine how humans have damaged or destroyed the natural environment. To do this, we need to understand the histories and entanglements of both humans and nonhuman participants (coevolution) (Tsing, 2012). This is especially important as, this study helped me understand the historical destruction of the riparian zone in the two neighbourhoods and what it means for humans, hippos and other species.

On June 10th, 2021, my team and I went to the coastal neighbourhood of Gisyo, and I observed the reality of the lakeside using what Tsing (2012) refers to as the 'art of noticing' to provide details of my observation. The landscape below was completely flooded as my team and I were descending

from the highland neighbourhood of Musama. As we looked down from the hill, the terrain looked unappealing. The landscape had changed completely within a one-week period due to the significant amount of rain that had fallen in a few days. What we first saw when we conducted the first set of analysis was drastically different to what we had seen on this specific day. On this day we barely saw any dry land, Musama was flooded there was water everywhere with a few patches of land revealing some greenery (also see figure 12). As we walked through, I reflected on the Google Earth images and related them to the reality on the ground. As shown in figure 12, on my left and right, I could see completed and incomplete houses, and demarcated plots which were being used as small farms. I heard multiple sounds of frogs croaking, birds chirping, and I could see small fish trapped in the small pools trying to find their way back to the lake, the signs of the flooding aftermath. We walked through the encroached wetland filled with rice farms which used traditional irrigation methods. We found ourselves walking in knee high and at times shallow bodies of water in the rice farms, the rain boots we had come with were no match for the water levels we came across. Some members of the community particularly those who were severely affected decided to retreat and had sought accommodation elsewhere, many of them stayed with family and friends. Others, mostly those living further away from the shoreline and less affected survived the flooding, remained in the area. It was worrying to see how people, domestic animals and wildlife coped with the expansion of the lake. Largely, because of the fact that floodwater is often contaminated by pollutants such as debris, sewage, and agricultural runoff negatively affecting the health of humans, animals and plants (de Man et al., 2014). Additionally, floods cause loss of life in both humans and animals, soil erosion and also causes damage to infrastructure and habitat loss (Doocy et al., 2013).



Figure 13: Fishers floating at Gisyo's nearshore as part of their daily life, 2021.

From across the city, I heard the lyrics "Tanganyika has reclaimed its territory" as a reminder to those occupying the buffer zone that it belongs to the lake. The aesthetic text titled '*Mont Blanc*' by Shelley (2010)³⁶, depicts nature as being majestic, powerful, violent, limitless, and instilling fear and wonder. The author went on to say that all these characteristics are beyond human comprehension. Her characterisation of nature gives us a glimpse of how we should view nature. While approaching the lake within about 200 metres, the wind abruptly blew toward me, I could smell geosmin in the air and felt the lake breeze. As we walked through the farmlands, stepping on top of the bumps on land created by rice farmers to conserve irrigated water from the Kanyosha River which separates the Gisyo and Kibenga.

Farmers spend the whole day working on their farms at the same time using noisemaker dolls to scare birds away from rice crops. As we walked into the riparian zone filled with water, about 70 metres to the coastline, I observed different features of the landscape, plants, and vegetation predominantly on my left side while on my right-side settlements had taken over. I detected hippo's pathways, footprints and excrement marking their presence in the space. We arrived at the

³⁶ Shelley, P.B., 2010. *Mont Blanc. Exit: imagen y cultura*, (38), p.128.

shoreline, facing the reality of the lakeside as I spotted the physical aspect of the water quality through its colour composition. Figure 13 depicts a lake with two different colours, with the littoral zone having a brownish appearance. While about 2 km inshore the lake appeared crystal clear. Additionally, the lake edge had shifted from where the plants known as *Vossia Cuspidata* are seen behind the fishermen to where we stood. Small-scale farming (rise farming) and fishing are two major activities observed in Gisyo that connect the riparian community and the natural environment. These are what I describe as, the seen and unseen realities of the lakeside. Some of which we can see like living organisms (biotic) and non-living (abiotic), things we interact with or encounter daily, which include water, hippos and other animals, plants/vegetation, rocks, and people.

There are also other living and non-living things that are unseen which constitute nutrient elements such as nitrogen, phosphorus, and silicon; micro-organisms such as bacteria, viruses, and diatoms; as well as molecules like oxygen and carbon dioxide (Datta, 2019). All of which can be found in the soil, water, and air while some are transported by animals across aquatic and terrestrial systems. To understand the role of both the seen and unseen in the ecosystem, this chapter will focus on nutrient and energy flow and land-water nutrient cycles, showing the importance of hippos and other organisms in the two systems (terrestrial and aquatic). The emphasis is drawn on ecological consciousness by making the case for the interconnectedness of lifeforms and the concept of interspecies relations. This chapter attempts to answer the second question, what impacts do these interactions have on people and hippos? I use actor network theory to show how humans, hippos, and other lifeforms are framed as interdependent.

This study's limnological analysis revealed higher levels of nutrients in the lake's littoral zone in Gisyo and Kibenga. Table 1 analysis shows the potential of hydrogen at the ordinary level which is between the normal standard (8.5-9). But high concentrations of total nitrogen and total phosphorus were all reported in a unit (mg/L). The results also revealed that there is silicon presence in water, hippo grass and dung sampled in Gisyo which gives hope to energy flow and nutrient cycle from primary producers to primary consumers helping to support and maintain the ecosystem as explained by Brennam (2018) and Sohlden (2019). Similar findings were found in studies by Falkowski (2015), De La Rocha and Conley (2017), Stears et al. (2018) and Schoelynck

et al. (2019) which revealed the interconnections between different living organisms and how they interact, develop, and maintain the ecosystem.

This process may perhaps constrain and sustain what Mentzer (2018), and McCann (2020) referred to as a balanced ecosystem Schoelynck et al. (2019) found that when natural processes are well-engineered through habitat restoration, in all parts of the urban coast, energy can flow from the sun to plants, to hippos, to diatoms, to fish, to humans, and finally to bacteria. Using Latour's (1993) actor-network theory in this chapter demonstrates how the seen and unseen actants supports, interacts, and add up to assemblages of the land-water ecosystem and what could happen if the cycle is disrupted. Using this notion as cited in Callon (2001), we can examine that each actant has a metaphysical relationship with nature and society within the ecosystem. Using locality and framing to raise awareness about the interdependence of living and non-living things and to call for a radical shift through the understanding of the underlying causes of current environmental issues that affect both humans and wildlife.

Interrelations among the living and non-living actants

Though our dependence on nature differs, it does not mean that we are less dependent on it. Cities are dependent on nature and thus they need larger natural surroundings to sustain themselves (Gomez-Baggethun, 2016). Lake Tanganyika and its catchment provide habitats for hippos, at the same time, hippos through their dual lifestyle supply nutrition and energy facilitated by sophisticated physical structures connecting multiple species (actants) which systematically cleans and revives itself, ultimately sustaining biodiversity, which we benefit from in the form of food (fish) and water. An ecosystem network connected and engineered by energy flow and nutrient cycles across both the living and non-living is connected to hippos. Their role in transboundary ecosystems prompted us to realise our direct and indirect connection with the biotic (living) community and abiotic (non-living) factors that shape the environment that we all depend on (McCauley et al., 2015; Stears et al., 2018; and Schoelynck et al., 2019).

This ecosystem entanglement is extended from single-celled to multi-cellular organisms and vice versa through nutrients and energy flow that keeps all actants connected with the system. According to van Dooren and colleagues (2016), this is possible because of what Stengers (2010,

cited in van Dooren, 2016) termed ‘reciprocal capture’, where organisms’ shared histories (coevolutionary process of becoming) and entanglement have determined their reciprocal relationship. The authors explain that becoming is concerned with organisms’ “exchange and emergence of meanings, immersion in webs of signification that might be linguistic, gestural, biochemical, and more” (van Dooren, 2016:2). By considering the lake and its riparian zone as an intersecting place as described by Adams (2016), I use Latour’s notion of the locality as an attempt to analyse how the natural world as a collective can help us understand the laws of nature. This conceptualisation illustrates how the heterogeneous connections of actants are embedded in what Leopold’s land ethics considered as the enlargement of boundaries of the community which includes water bodies, soils, plants, and animals (Erdős, 2020). Thus, figure 14 below can be used as the analytical tool that involves the abiotic structure and biotic community explaining how Latour’s idea extends to how we should contextualise social and natural systems as framed and connected biogeochemical cycles in the two neighbourhoods, locally, and transnationally. Starting with the *black* connectors, the sun is the major source of the earth’s energy supply, providing energy to plants and diatoms through the process of photosynthesis to make glucose, a sort of sugar they need for survival. Like plants on the surface, diatoms stock carbon dioxide (CO₂) and produce oxygen (O₂) in the lake on which the aquatic community like fish rely to survive (Datta, 2019). Both hippos and humans benefit greatly from oxygen supplied by plants and diatoms (Schoelynck et al., 2019). The energy that flows into the ecosystem is conserved, and nutrients transferred are recyclable and reused. Thus, the dynamics and structure of the ecosystem are shaped and defined by both energy movement and chemical cycling (Brennam, 2018).

The *red* connectors allude to a network which begins with members of society who will need to use their agency to help restore the damaged riparian structure and maintain it. People in Gisyo and Kibenga consume plants for their medicinal properties as well as fruits, vegetables, and other crops as food for protein that grow on their riparian zone. These very plants need nitrogen, phosphorus, and silica from soil supplied by dung beetles. At the terrestrial chain, dung beetles collect dung deposited by hippos while grazing at night and ventilate them in a different location through infestation which sustains the soil, ultimately benefitting microbes that are dependent on the hippo dung (Falkowski, 2015). Falkowski’s (2015), work on ‘*Microbes Made the Earth Habitable*’ reminds us how microbes rule both the land and lake. Like plants and diatoms,

microbes purify the soil by absorbing carbon dioxide and producing oxygen. In the aquatic chain, hippos fertilise the lake through their metabolised food (grass) and deposit dung containing silica into it. Diatoms (phytoplankton algae) use this silica to build their cells, besides being the energy producer, they are also food for other organisms like zooplankton (Hildebrand et al., 2018). Zooplanktons are the prey to small fish, then small fish, which are also preyed on by larger fish. With the help of fishermen in Gisyo or Kibenga, the wider society is supplied with fish as a form of food. Latour (1993) referred to this network of interdependences between humans and non-humans as a collective. The translation of this network comes into play since it is mediated by communities, hippos, plants/grasses, nutrients, energy, and other biotic and abiotic components discussed above. The interaction between them is crucial to maintaining the connection. (Callon, 2001).

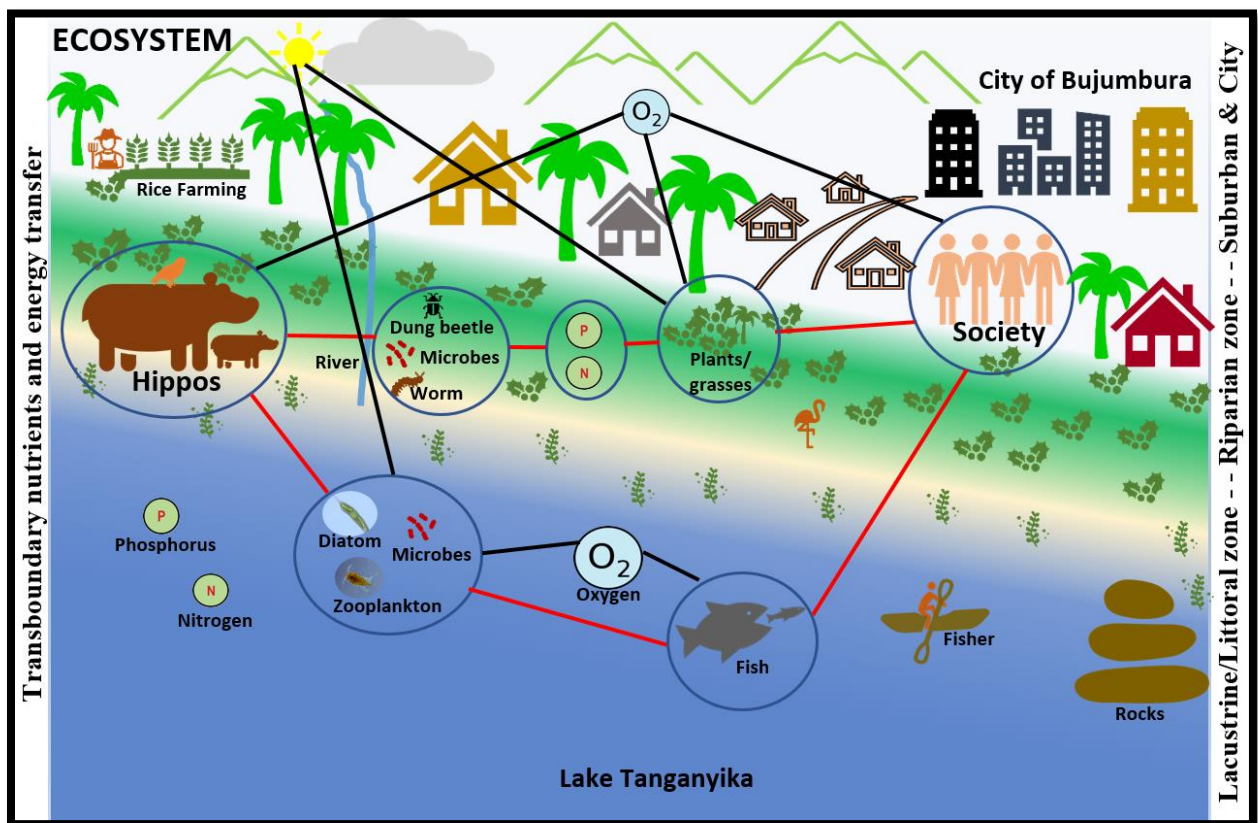


Figure 14: Description of framed and connected energy and nutrients flow. *Abiotic* (sun, lake/water & riparian/land) and *biotic* includes producers (plants & diatoms); decomposers (dung beetle, microbes, worms); primary consumers (hippos & zooplankton); secondary consumers (fishes); and primary & third consumers (society), 2021.

The works of Schoelynck and colleagues (2019) and Stears and colleagues (2018), demonstrated that Latour's (1993) notion of locality employs that the hippos in Gisyo and Kibenga are entangled, framed, and connected across assemblages (actants). Hippo's interactions that keep terrestrial and aquatic ecosystems balanced through the transfer of nutrients called silica. Overturning their population or altering their behaviour will affect their interaction with other actants. Schoelynck and colleagues warn that this could lead to the collapse of an entire ecosystem. This is due to hippos being regarded as keystone species with a significant impact on terrestrial and aquatic trophic levels. The process involving the transboundary circulation of nutrients and energy is found to balance water chemistry, according to McCann and colleagues (2020). As a result, any social-economic development policy that seeks to undermine this framed and linked natural ecosystem, particularly in coastal riparian cities, may aggravate the above mentioned social-ecological issues.

Keystone species as actants and part of the system

Figure 14 above depicts a proposed structural system composed of a network of actants (natural and social) within the ecosystems that might assist in alleviating the current ecological conflict, protecting the hippo's habitat, and providing them with food. It also suggests a consolidated urban ecological plan that seeks to promote coexistence between human and non-human agents in the two coastal neighbourhoods. Humans and hippos are both keystone species and they play an important role within their network. But the role of humans tends to be more dominant, as described by Worm and Paine (2016), in their study on human interaction with the terrestrial and aquatic system and the impact it has on the trophic food chain. They describe humans as "hyper-keystone species" as our behaviour as dominant actants outsize the ecological structure. The empirical results gathered in the form of testimonies from participants, water analysis, and physical observations from this study suggest that humans are at the centre of habitat loss which has contributed to human-wildlife conflict. Prominent feedback on the riparian zone is an example that can also be described as the direct impact on people's transformation of the terrestrial commons for personal use, which directly crowds hippos' habitats and narrowed their grazing space.

Seeing that the hippo's place of transition is continuously being degraded, they find themselves on the threshold as their lifestyle seems to be halted. This complex interaction has changed the hippo's

behaviour and their feeding patterns. Instead of grazing at night, they have adopted an unusual behaviour and that has resulted in them foraging for food during daylight in these coastal neighbourhoods. The environmental degradation associated with the social activities underestimates the role of wild hippos in keeping the ecosystem of African lakes and rivers healthy. Unlike other grazers, Schoelynck et al.'s (2019), findings exceeded their expectations on the role of this semi-aquatic herbivore. Hippos subsidise the aquatic system with high volumes of silicon, with which diatoms are dependent for reproduction in Lake Victoria. The supply of silicon by hippos in the lake facilitates the balance of total nitrogen and total phosphorous (Schoelynck et al., 2019). Hippos perform these processes everywhere, including those in Bujumbura and across Lake Tanganyika.

Hippos as nutrient carriers and fertilisers

It was difficult to observe hippos in the Gisyo neighbourhood as indicated in St Lucia (2021), they mostly spend the day in the water and graze on land at night. However, their existence was traced through footpaths, footprints, dung, hearing wheezing and honking in the water, and testimony from participants on their encounter with hippos at night. I managed to observe hippos during the day in the densely developed areas of the shoreline in Kibenga, Kumase and Kajaga (northern parts of the lake). Focusing on hippo's agency as nutrient carriers in the system, their role is appreciated by Zoeller and Bond (2013) on how they engineered the landscape by creating grazing lawns. Their study suggested that hippos as the biological force were responsible for contributing to the transforming lawn. Their terrestrial behaviour may help shape the riparian zone by revitalising the soil as they recycle nutrients. Though this process can be assisted by dung beetles through the manipulation of dung as part of their feeding process. In this case, the dung beetle's agency in the ecosystem service ranges from the dispersal of seed to nutrient cycle and biological parasite suppression. Dung beetles depend on hippos' dung as much as hippos need them to re-engineer the soil for the production and growth of new grass (Slade et al., 2015). This symbiotic relation instigates the network between the two organisms in the riparian land. Within the same land, a well-structured farming system on upland as displayed in figure 14 will benefit from the spread of the seeds and the fertilisation of the soil.

Schoelynck and colleagues' (2019) experimented on the Mara River in Kenya integrate large fauna actants like hippos into the biogeochemical cycle of terrestrial and aquatic systems while focusing on a single element called silicon. Their goal was to study how this organic matter is transferred from the terrestrial to the aquatic system and in what quantity. Their study revealed that hippos account for at least 32% of biogenic silicon (BSi) flux and 76% of total silicon flux along the river. This makes hippos the biggest contributor to the transfer of organic matter. However, they suggested that the continuous decline in the hippos population will relatively impact the Mara ecosystem and because it is affluent to Lake Victoria, this decline may impact the nitrogen silicon (N:Si) and phosphorous silicon (P:Si) ratios. They also explained the geological impacts, stating that if all hippos in Mara River get extinct, and the supply of biogenic silicon stops, this will impact the total silicon transfer which may, in turn, create an imbalance between the volcanic lithology and silicon concentration of the underlying bedrock of the river basin. Furthermore, this imbalance will also limit the reproduction of diatoms in Lake Victoria as the result of a lack of an optimal nutrient ratio. This change had already been documented in other Rift valley lakes like Lake Tanganyika (Tierney et al., 2010), where human use of nitrogen and phosphorous in the watershed and climate change contributed to the increase in nitrogen silicon and phosphorous silicon ratios. This transition affected the water chemistry as diatom growth was depleted and resulted in other phytoplankton species using up excess nitrogen and phosphorus.

Natural systems and human made pollution

Nutrient fluxes caused by human activity adversely affect the environment. Any attempt to control them naturally may reduce pressure on natural systems and enhance the sustainability of urban ecosystem processes. With reference to Figure 14, it is important to reconsider the natural structure as depicted and recognise how Earth systems do not operate in silos. Instead, it is a cohesive network of interconnected natural forces that self-regulate. The problem is that we [humans] disrupt the system with our aggressive behaviours, forgetting that we are the end-users of nature's services. In the previous chapter, we discussed how pollution affects coastal communities and to an extent city dwellers whose livelihood is dependent on nature. The present acceleration of coastal settlement expansion in the natural space by certain members of the society particularly those believed to be wealthy has led to the current ecological problems, which Moore (2016), referred

to as Capitalocene. He argued that the Anthropocene epoch tends to include actants from the entire society while the current ecological crises are driven by capital, which in this study's context most settlement activities near the lake are for private businesses. Thus, in Moore's terms, the current issues faced by the environment like habitat loss at the expense of settlements for businesses and the mass pollution from the circular economy must be branded as the *'Age of Capital'* rather than the *'Age of Man'* which the Anthropocene referred to.

The current nutrient imbalance caused by high total nitrogen, total phosphorus as well as liquid and solid waste from the city has already shown signs of pressure on the aquatic system, causing excessive growth in algal Blooms and a drop in reproduction of diatoms (Bacillariophyceae) and other species of diatoms. Looking at the study conducted by Niyoyitungiye and colleagues (2020) on the assessment of Lake Tanganyika's phytoplankton populations in four communes namely Kajaga, Nyamugari, Rumonge, and Mvugo. Their study revealed phytoplankton (diatom) diversity in Kajaga was 50 species and 1025 individuals, Nyamugari (Bujumbura) was 42 species and 446 individuals, and Rumonge (province in the south coast) was 50 species and 1354 individuals. For nutrients parameters, total nitrogen found was 0.379 mg/L⁻¹, 0.1502 mg/L⁻¹, 0.1079 mg/L⁻¹ for Kajaga, Nyamugari, and Rumonge respectively. While total phosphorus was 1.572 mg/L⁻¹, 1.671 mg/L⁻¹, 0.786 mg/L⁻¹ in the same order as above (Niyoyitungiye et al., 2020). Even though only two sites in Bujumbura were investigated, these findings suggest that the aquatic diversity on Bujumbura's littoral zones is under threat from anthropogenic NPS and PS pollution. If we compare diatom diversity in Kajaga and Rumonge, evidence shows that there is a higher concentration in Kajaga with low numbers of individual diatoms. While less concentration in Rumonge revealed higher numbers of individual diatoms. The reproduction of primary producers (phytoplankton) and primary consumers (zooplankton) in the food chain appears to be low in abundance in the northern basin of the city of Bujumbura due to high pollution pressure from chemical and organic matter.

“Several works have found that there are high concentrations of nitrogen and phosphorus originating from fertilisers used by farmers in the mountain. These nutrients get drained into the rivers during the rainy season and then end up in the lake. The solution is to plant trees to limit them at a normal level” (Niyungeko)³⁷.

³⁷ Christophe Niyungeko, chemist at the University of Burundi, personal interview, May 2021

Niyungeko who is a researcher in soil chemistry admitted that the water quality of the lake is under threat due to the use of chemical substances like fertilisers and pesticides from hill farming. He stressed that there is improper management of natural systems which could possibly help intercept high flows of nutrients from upland during the rainy season. In addition to Niyungeko's suggestion, there is widespread agreement that other types of pollution (sewage and solid waste) discharged into the lake has had an impact on both aquatic life and society, as evidenced in Table 5 statement G in the following chapter. Bujumbura has only one water treatment facility which does not have the capacity to treat the city's municipal sewage. The water treatment facility is currently unable to handle the high influx of waste material, leading to dangerous wastewater material being discharged into the lake. Niyoyitungiye and colleagues' (2020), study also suggests that eutrophication is caused by the excessive influx of total nitrogen and phosphorus which promotes the development of algal blooms and invasive species, which threatens the water quality, endangering fish diversity and public health of coastal communities. According to Carson (2002) and Nixon's (2011) humans can only live within an environment, the authors stress that human destruction of the environment has long-term consequences for many generations to come (Erdős, 2020). Nixon (2011) refers to the '*environmentalism of the poor*' as it affects the livelihoods, health, and culture of some of the most marginalised people along the lakeshore. Rethinking land-water as an intersectional system of assemblages, networks of nutrient and energy flow, interdependence intensity, and movement of life forms is critical to understanding how the biophysical and metaphysical world's function.

The chemical analyses of surface water in the littoral zone in this study also show a stable potential of hydrogen, but a high concentration of nutrients. Table 1 highlights the first round of water tests, which show sites 1 and 2 have a stable potential of hydrogen of 8.92 and 8.87, respectively, and the acceptable level is between 8.5-9 (Niyoyitungiye et al., 2020). Other analyses found that the total nitrogen levels of 123.8 mg/L and total phosphorus levels of 4.36 mg/L sampled about 300 meters inshore at site 1 (Gisyo). While total nitrogen was 139.2 mg/L and total phosphorus was 9.92 mg/L in site 2 (Kibenga). Site 1 results show that as we moved further inshore at the tropic, the concentration level decreases, whereas site 2 results show that the concentration level increases as we moved closer to the lake bank, The milligrams per liter (mg/L) determines the amount of nutrient units that are found, which revealed high concentration on both sites. Although the

acceptable nutrient levels were not found in this study, Niyoyitungiye et al. (2020) study as discussed above suggests that some diatom species population rates were relatively affected by the increase in total nitrogen and phosphorus. However, Nikolaidis et al. (2022) study provides a good or moderate target boundary that may control eutrophication in large lakes. The authors suggest that total nitrogen and total phosphorus concentration should not exceed 0.7 mg/L and 0.02 mg/L respectively. They further underlined that these nutrients are an important criterion for water quality assessment and regulation in ensuring that there is no harm to the environment and the public. Water pollution has posed a serious threat to communities, especially those living near the lake. This is the case that affects coastal communities, something as a Mugisha stressed below.

“In some cases, people get sick or even die due to the contamination of this water. Years ago, we could go directly to the lake, fetch some water, and drink it without any problem. In the present day, if you do that, it's like you intend to commit suicide”
(Mugisha).

The preceding statement highlights yet another issue that coastal communities face because their use of lake water. As a Kibenga youth, Mugisha reflects on how pollution directly affects their livelihoods because they daily interactions with the lake (swim, drink, fish). This demonstrates how pollution affects people's culture and overall well-being.

Conclusion

This chapter began with the use of an ethnographic reflection that focused on the realities surrounding the urban coastal environment using the seen and unseen actants that constitute our biosocial network. Then I further demonstrated how the two terminologies namely social and natural are interconnected using the notion of locality in conjunction with the two research sites to address the current ecological challenges affecting hippo's habitat. The importance of hippo's agency in silica transboundary transference that keeps the balance of terrestrial and aquatic systems was framed and connected to the two neighbourhoods of Gisyo and Kibenga. I argue that the ecological meaning of the riparian zone has not been properly defined in the Water Code in a manner that helps people understand the multi-species entanglement of the land-water system (see chapter three). Lastly, I used the actor-network theory to demonstrate the importance and promotion of different natural techniques that help sustain the environment, while in addition highlighting why restoring the hippo's habitat is urgent. Reciprocity between humans and non-humans, as well as non-human interrelationships, are critical to the ecosystem and the

sustainability of the environment. In contrast to reciprocity and interdependence, humans tend to instrumentalise and categorise nature, species, and other life forms. The next chapter is a purposeful challenge to cultural value change caused by human's dominion over the riparian zone, as a result of the contested environmental code of conduct.



CHAPTER 3. ECOSYSTEM INTERVENTIONS: INSIGHTS ON COASTAL MANAGEMENT

“Since 2005, the 2nd of July is a year where we celebrate the National Day of Lake Tanganyika. We spread the message of the importance of protecting the lake’s biodiversity. There is a theme that says, we need the lake, and the lake needs us. ... People have the mindset that, if you build next to the lake or ocean, you’ll attract tourists and gain a lot of money, but you never thought of what you’ll give to that lake or ocean ...”.

- Albert Mbonerane³⁸

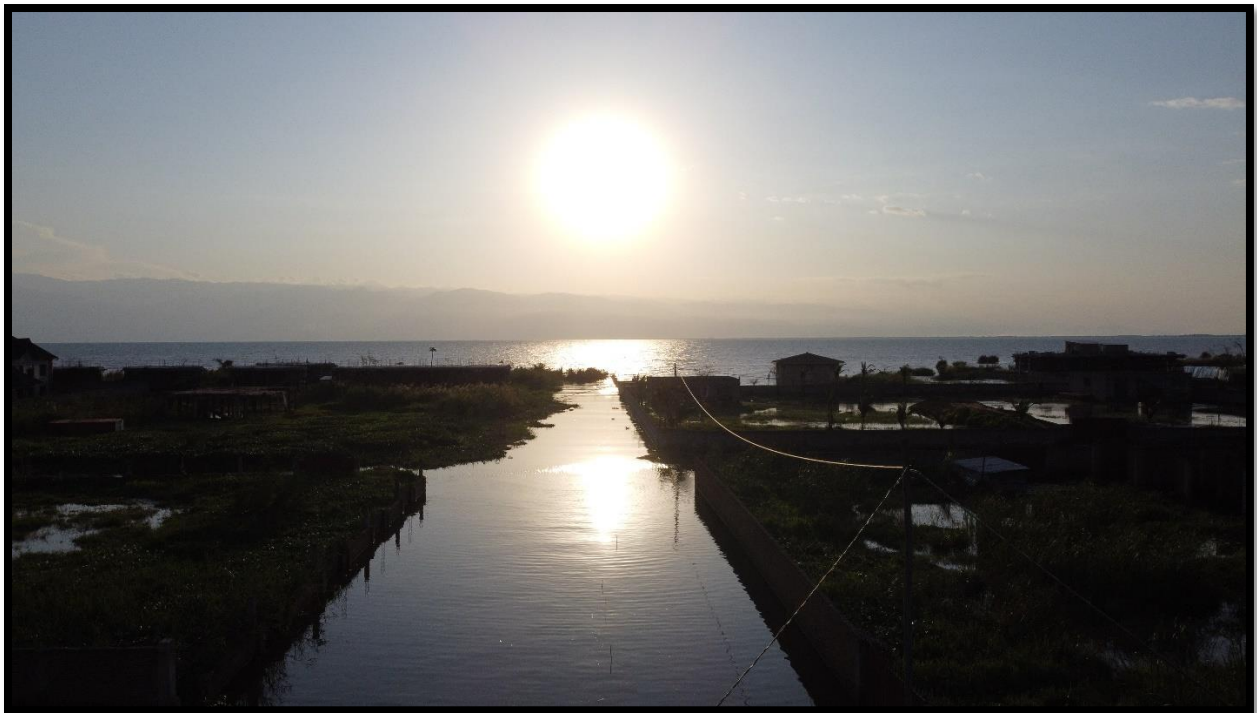


Figure 15: *Sunset in one of Kibenga’s nearby communities under development, where the roads turned into lagoons while houses were flooded in 2021.*

³⁸ Albert Mbonerane, environmental activist & director of ALUMA, personal interview, May 2021

Introduction

Drawing on Latour's actor-network theory, in the previous chapter, I described the interaction between biotic and abiotic actants in an ecosystem, and how their interconnectedness enables them to play important and complimentary roles in ecosystem sustainability. I also highlighted that the growth of the population along the banks of the lake and in turn exponential increase of infrastructure in the riparian zone places a risk not just on the well-being of the hippos, but also to multiple species that are reliant on nutrient transfer between the land and water. This begs the question, what efforts are being made or can be made to strengthen the protection of the riparian zone from the current unchecked infrastructural development which are largely based on logics of economic growth and development above all else. This chapter focuses on the theme *ecosystem interventions* by providing insights on coastal management. It discusses the current water legislation and looks for gaps that weaken its enforcement, leading to its contestation. I argue that the Water Act is a piece of legislation governing the environment which needs to be supplemented with a legal framework that fully incorporates coastal geomorphology in order to protect the riparian zone and the lake. I begin with a reflective account of residents' fears and concerns, followed by a description of the law and its shortcomings. In response to the third question, what interventions can help restore the degraded environment and foster kinship? This is where the subthemes *local and transboundary interventions, encroachment trade-offs which negatively affect the natural habitat, ecological degradation, and behaviour changes* are discussed. The chapter concludes with insights on the implementation of the current provision for the protection, conservation, and sustainable use of the coastal environment.

Social fear as nature strikes

In the late afternoon, human activity on the streets of Bujumbura along the coast decreases, while hippos appear on the streets of Gisyo and Kibenga as the sun sets. Witnessing hippos out and about, creates anxiety and overwhelming fear in people, a fear of not knowing whether the hippos will just pass by or attack pedestrians in the streets. People pace about carefully keeping an eye out for any aggressive behaviour from these large herbivores which many misguidedly believe are capable of eating them. They close their businesses speedily, whilst others return home with caution before the sun sets completely for the day in fear of encountering these massive mammals up-close by accident. The same goes for those attending functions in halls situated in Kibenga like

the King Conference Centre. I had attended a wedding, however, to my surprise many of the attendees began showing signs of distress as the sun began to set. Many began packing and leaving stating that they feared for their safety and did not want to encounter a hippo on their way home. We were in the wet season which saw the lake elevated to a height of 776 meters above sea level, streets become temporary rivers and lagoons, shaping the behaviour of hippos to easily shift their pods closer to the neighbourhoods. At night they wander around construction sites in search of grassland shifting from one site to the next until sunrise. You could notice that local people were concerned about encountering hippos at night while walking in the dark as neighbourhoods were without streetlights, as discussed in the first chapter. Water levels are rising in Lake Tanganyika as depicted in figure 15, which serves as a reminder that the lake boundaries should be respected as this cyclical event has been recorded since the 1960s. Despite being warned that this lake would reclaim its banks that have been built on, stakeholders involved in the development of these areas paid no attention to its history or natural cycles of water rising and receding at different points in time. It is essential to pay attention to the Lake's history as this gives us insights into how to manage and plan with this urban-nature interface, as a sole focus on conservation fails to acknowledge the complexities that include droughts, floods, chemical flows social and economic priorities of the day.

In situ conservation of the riparian system

In the revised decree No 1/02 of 26 March 2012 of the water code, the government provides guidelines on protecting coasts and riverbanks by prohibiting any development activities between water bodies and human-disturbed land. Under this law, article 5 paragraph 3 stipulates the preservation of buffer zones as follows: 150 metres for Lake Tanganyika, 50 metres for other lakes, 25 metres for rivers and 5 metres for streams (Water Act, 2012:13). In my view, this approach might be characterized as in situ conservation since it attempts to prevent the degradation of the lake and its catchment area or riparian area while conserving wildlife such as fish, reptiles, avifauna, and endangered megafauna such as hippos in their natural habitats. I have discussed in the introduction and Chapter One how humans interact with wild hippos, both living and non-living, and how they play an integral role in the coastal eco-system of Lake Tanganyika. In the context of this study, the land and the lake form a complex urban metabolism as a result of the flow of materials (Thomson & Newman, 2018).. The concept of urban metabolism is useful in

understanding human relationships to the environment as it highlights the material and energy flows in cities, including how economic, social and environmental forces shape and create a complex system. In this study, I argue that these forces have a geological effect (Solomon, 2021), which form a local expression of what some scholars have called the Anthropocene, discussed in the introduction of this thesis (Crutzen, 2006). The importance of the riparian zone vegetation, as part of the urban metabolism, in maintaining the bank's stability by providing a habitat for hippos and other species, cannot be overlooked as it is vital part of the metabolic exchanges necessary for well-being of multispecies communities, including the human. The riparian zone helps to control the inflow of nutrients into the lake by maintaining sophisticated temporal and spatial biophysical connections adjacent the lake and upland systems (Dècamps, 2009). The author explains that sediments, water and nutrients enter the riparian zone from the adjacent lake and upland by reacting and mixing the above-mentioned through surface and subsurface flow paths that are strong. Under normal flow conditions riparian zones retain a significant portion of these materials and generally return chemically purer water to streams and rivers. At the same time riparian zones are important sources of energy to both upland and aquatic systems in the form of plant and insect tissues. However, through viewing Google Earth's spatial images, it is clear that the riparian zone is at risk due to infrastructural development, which leads to the fragmentation of the vegetation, interrupting the flow between land and Lake.

The contestation on environmental regulation (the Water Code) is deeply embedded in logics of economic growth which leads to unclear coastal management weakened by the failure to strengthen and promote just approaches to environmental governance, particularly on the restoration of the riparian system in coastal Bujumbura for the benefit of multispecies communities and people dependent on the lake for their livelihoods.

Are gaps in the water Act failing to address nature and urban divide?



Figure 16: Lake level rise causing flooding, (left) the lake swallowed settlements reclaiming its territory in coastal Kibenga, (right) hippos occupying Kumase beach reclaiming their territory, 2021.

The Lake Tanganyika Authority's strategic action programme pointed out that disturbances and alterations to critical habitats are the main threats to the sustainability of the lake and its catchment. The key driving forces of these ecological threats are tied to poor urban planning that results in prolonged and unchecked settlement developments, pollution linked to the poor waste management systems, and use of agrochemicals products, as reported in (Lowe-McConnell, 2003; Beck et al., 2010; Secretariat, 2012; Plisnier, 2018; Niyoyitungiye et al., 2020; Miriti, 2020). The settlement activities have greatly transformed the riparian landscape at an alarming rate, putting pressure on the earth system processes (Steffen, 2010). Both the Lake Tanganyika Authority and BOEP's strategic targets are to protect, restore, and manage critical aquatic and terrestrial habitats. Burundi's development plan was released in the year 2011 in the document titled '*Vision Burundi 2025*', after conducting a national study dating back to 2003 which consulted participants from diverse social-professional sectors of societies. Its eight vision pillars include (1) good governance and capacity-building for the state, (2) human capacity, (3) economic growth, (4) regional integration, (5) demographics (6) social cohesion, (7) management of territory and urbanization, and (8) partnership. However, it also acknowledges some cross-cutting issues such as gender, the youth, other vulnerable people, science and technology, and the environment (MPCDFU and UNDP, 2011).

For this section of the chapter, I will draw attention to the 7th pillar and discuss the management of urban territory particularly the coastal environment in relation to the environment. The 7th pillar's policy highlights the vision of accelerating rural development and urbanisation at the rate

of 40% by 2025, promising that the development will improve social aspects, income generation, and economic infrastructures, provide employment, and manage the territory through the control of population and urbanisation. The document states that all social-economic policies will consider environmental factors and promise to implement an aggressive environmental policy as enshrined in its sustainable development to ensure sustainable management of natural resources. Although, the document neither specified what mechanisms will be used to implement these policies nor referred to any environmental code of conduct. As discussed above, the Water Act of 2012 is plagued with contradicting interpretations and the implementation of the buffer zone demarcation between the shoreline and zone of development. Thus, this study suggests that the act needs to be reviewed to dispel any ambiguity, as was highlighted during discussions with my interlocuters which I refer to below:

“Our job as civil society is to advocate for anything that goes wrong with the environment. We are government partners, when there is a misinterpretation of the law, we alert the government, telling them what has been done as opposed to what the law says. The water code states that we need to protect the riparian zone considering periods when the lake levels were high like in 1938, 1963, 1964, and 1978. Surprisingly people build at 25-50 m from the shoreline” (Mbonerane).

“We have observed the way the lake has invaded the city of Bujumbura in places like Kibenga, Gatumba, Kajaga, and Kanyosha; all this is to show that there will come a time when the lake will be back to its origin. In those places, you find that so many houses have been abandoned due to the flood” (Gakima).

“I think the space provisioned for animals should be given back, destroy all that was built in that area but for that, we will need serious decisions and people in power must be very rigorous and I think it is easy, the laws are there it is just the matter of applying them” (Nkengurutse)³⁹.

Like in some other coastal settings, it can be seen that the riparian buffer of some parts of Gisyo (mostly undeveloped) is still covered with vegetation that creates an interface that extends between the edge of the lake and the edge of the upland suburban residential zone. Most of the buffer system, however, is privately owned by individuals because the land has already been demarcated with plot pickets a few meters away from the shoreline, as shown in figure 12. According to Grebner and colleagues (2021), the required buffer zone width and structure are defined in local and provincial laws that serve as a guideline for best practice. Managing the buffer zone, however,

³⁹ Jacque Nkengurutse, biologist/botanist at the University of Burundi, personal interview, May 2021

can be difficult due to its physical transitional nature. Mbonerane’s suggestion to consider the Water Code that was adopted in the year 2000 which makes provision for the protection of lakes and their catchments to consider historical cyclical periods where the lake’s level was recorded at the highest altitude notably 1938, 1963, 1963, 1964, and 1978. During our conversation, Mr Mbonerane reiterated that one of the issues that have thus far led and continues to lead to the violation of the 150-meter buffer is the misinterpretation of the law. He went on to say that the 150-metre line should be drawn from the highest altitude point recorded in the past. (Ntakimazi, for example, indicates 777 meters altitude above sea level.) heading upland rather than demarketing from the lake's edge during the dry season when the lake level is low. Mbonerane's perspective on demarcation provides insight into how semi-terrestrial and aquatic buffer systems, such as the one in Lake Tanganyika, can be dealt with. Figure 16 also depicts social-ecological issues that could have been avoided if boundaries had been observed.

Table 6: Joint statements combined showing the number of time implicated (NTI) in focus groups (FGs) and personal interviews (PIs) with 17 candidates between May and June, 2021.

Key statements and concerns from 22 questions representing views from participants	PIs (NTI) (n=6)	PIs %	FGs (NTI) (n=11)	FGs %
<i>(A) Settlements on the lakeshore threaten hippo’s habitat</i>	6	100%	7	64%
<i>(B) Views on hippos as threats (people’s fear of hippo)</i>	2	33%	8	73%
<i>(C) Understanding hippo’s role in the environmental</i>	4	67%	3	27%
<i>(D) Considering hippos as part of tourist attraction</i>	3	50%	6	55%
<i>(E) Believes that hippos are protected</i>	5	83%	3	27%
<i>(F) People building on the riparian zone are wealthy & elites society</i>	6	100%	5	45%
<i>(G) Pollution (sewage and solid waste) drained in the lake</i>	6	100%	8	73%
<i>(H) Water quality affects the fish diversity</i>	5	83%	8	72%
<i>(I) Lack of adherence to environmental/water/forest acts</i>	6	100%	2	18%
<i>(J) Role of riparian/catchment zone on water purification</i>	3	50%	--	--
<i>(K) Worries of the rising lake level (flooding)</i>	4	67%	10	91%

Mbonerane, Gakima and Nkengurutse's above remarks, as well as the joint statements in Table 5 (F), all seem to indicate that the Water Act is neither enforced nor incorporated into the coastal development plan. This may be arguably linked to historical changes in land law, which resulted in land grabs in which people are known to have bent the law or purchased plots from locals (Couillard et al., 2009; Claessens et al., 2021). In addition to the ecological aspect, the interventional approach of this study is to draw attention to the social aspect at the local level, as

they are all intertwined with the ecosystem. Furthermore, when some members of society engaged in destructive activities on the riparian zone, their actions had an impact on them and the larger community, either directly or indirectly. Some key statements presented in Table 5 above in relation to current environmental issues are intended to assist urban planners, developers, coastal managers, and decision-makers. It represents some societal concerns, ideas, and opinions to consider when assessing the social-ecological impacts of local and national coastal development plans. The key aspects to consider for better management of the buffer system can range from the legal, ecological, social, and economic levels.

The answer to whether there are gaps in the water code is based on how the role of the coastal buffer system has been defined. The legal concept of the buffer zone/system, in my opinion, is not well defined in the water code for two reasons. Firstly, its legal aspects only gives provision for size (width) at the local and national levels, with no reference to policy and legislative documents that provide detailed measures about execution or management. For example, for Lake Tanganyika, a 150-metre buffer between the edges/shores and where social activities must be restricted. The same article refers to article 159 of the constitution, as noted below.

“In accordance with article 159 of the constitution, the distance provided for point 3 (referring to paragraph 3) of the previous paragraphs may be extended, depending on the imperatives of strengthening the protection of the hydraulic public domain”
(Water Act, 2012:13).

The fourth point in article 159 reads *“The protection of the environmental and the conservation of natural resources”*⁴⁰. In the case of Gisyo and Kibenga, the above law makes provision for the extension of the 150-meter limit to protect coastal communities by reducing the risk associated with human-hippo conflicts and flooding. Secondly, while the law specifies the width of the buffer system for all bodies of water across the country, it does not stipulate the physical boundaries in relation to the space required by flora and fauna. This study’s findings suggest that the legislative document (Water Act) does not clearly spell out the legal status of the riparian zone. There is also no mention of other legal documents for a more detailed policy. These gaps may erode local and national interventions for current land-use restrictions.

⁴⁰ Burundi’s constitution of 2005. https://www.constituteproject.org/constitution/Burundi_2005.pdf

Cobecoming with the environment

The logic of organism's interdependency reminds us that all actants have an important role in the ecosystem and their interconnectedness within an ecological setting does not happen in isolation, as van Dooren et al. (2016: 1) highlight,

“All living beings emerge from and make their lives within multispecies communities... Life cannot arise and be sustained in isolation. But relationships also have histories. Beyond a static ecological exchange, like the energy circuits mapped by early ecologists, organisms are situated within deep, entangled histories”

The ecosystems of the Lake and land have been co-created and co-constituted of thousands of years, even before humans settled in the region, shaping and being shaped by how energy and nutrients flow between the spaces. I argue that for sustainable management of the two ecosystems (terrestrial and aquatic) to occur, one needs to take seriously these deep entangled histories of multi-species lives into account, particularly through paying attention to what Isabelle Stengers refers to as “reciprocal capture” for instance, when there is a change (rises or falls) in the population of one organism, how this change will affect the rest of the ecosystem. For van Dooren et al. (2016), when an organisms existence shapes the way another one exists, it forms a rich process of cobecoming, which in turn creates diverse forms of exchange, meanings and ways of relating.

In the local context, the development pressure on grassy spaces of Kibenga is very high, thus, the relationship between the hippos and the riparian land shifts, forcing hippos to seek new ways of relating to the landscape, hence they are seen in numbers coming out of the water in the evening in the neighbouring Gisyo. This is because the latter still has some open grassy space along with some agricultural activities that are taking place in the area. The struggle for life as described in Juniper (2019), over the shared resource with scarce grass makes hippos even more vulnerable in Kibenga and other fragmented areas on the north coast. This practice also raises questions on the behavioural ecology of hippos, the impact on the “reciprocal capture” as their ecological niche is also seemingly under threat. When participants in Gisyo were asked about their observation of the decline of hippos in the area, the answer seemed to be simple.

“Not at all, they never decreased, instead they have increased in number just that they are always found in places where there are not a lot of people, in quiet places where they graze” (Bukuru).

In most cases, the hippo’s presence was recorded in the strip of land along the shoreline in the low-lying areas. This is because the city is adjacent to the lake making it attractive for future development. This is the case for DRC, Tanzania, and Zambia. There is human-wildlife competition over the commons, where the focus should be on encouraging kinship for co-existence between humans and wildlife particularly hippos. To co-exist, we should not be intrinsically considered more valuable than other organisms based on the interdependence that binds all actants (Callon, 2001; Shoo, 2019) As demonstrated in chapter two, a well-managed ecosystem in Kibenga and Gisyo will yield positive results in the neighbouring areas.

While working as an intern at the Rondvlei Natural Reserve for three months (December 2021 to February 2022), a time where I benefited immensely from understanding conservation and its challenges spatially in the urban setting. I used the internship as an opportunity to observe hippo movements through pathways and how they mark their territory. Before the internship, I had the opportunity to discuss hippo grazing patterns with Mr Gibbs⁴¹ and Mr Zungu⁴², where I learned that they systematically rotate their grazing spaces to allow the grass to grow.

⁴¹ Dalton Gibbs, Regional Manager False Bay Natura Reserve, personal conversation, November 2020

⁴² Bongani Zungu, Biodiversity Area Coordinator, False Bay Natura Reserve, personal conversation, January 2022



Figure 17: Hippo's walkway on a drained swamp, Rondevlei Nature Reserve, 2022

walkways is passed on from generation to generation. Figure 17 shows hippo footprints on the drained swamp in the reserve, the same walkway has been used for generations even when that area was filled with water. Mr Khan underlined that any change in the hippo's routine will take generations to adapt to these changes naturally, it takes about forty years for their existence in the wild, which again highlights the intricate process of cobecoming within environments.

This means that the bull (alpha male) is the leader who passes on this knowledge of walkways to calves. In the transboundary context of the lake within the country, attending to the intimate relationship between the hippo and the land, the adherence to a 150 metres buffer at the given demarcated altitude (referring to the lake's highest level recorded) when restored with rich vegetation will promote a healthy ecosystem. However, the 150 meters buffer system legislation is only applicable in Burundi at the national level and not in DRC, Tanzania, and Zambia, which is a problem since multispecies communities and material flows do not recognise transnational boundaries. A well-maintained buffer zone in Gisyo and Kibenga will allow not only the hippo's

⁴³ Shihabudeen Khan, Conservation Manager at Rondevlei Natural Reserve, personal conversation, February 2022.

transition of nutrients in those areas but also sequester total nitrogen and total phosphorus in those areas and beyond. Therefore, Gibbs and Zungu's above explanation of hippo's feeding patterns, cannot be limited to one neighbourhood. In context, the transboundary concept means hippos systematically graze in Kibenga and alternate in Gisyo or beyond. The same thing may occur across the Lake's borders. Hippos from Burundi may cross the conventional boundaries and wander for fresh grass in the neighbouring DRC or Tanzania. By doing so, according to Zoeller and Bond (2013), they are shaping the terrestrial zones of neighbouring countries. Some analogy may be applied for hippos subsidising other aquatic organisms with silicon in the lake. Zoeller and Bond (2013) and Schoelynck et al. (2019) works have contributed to the understanding of interspecies relations. The increased reproduction of diatoms in the littoral zone will result in more fish and oxygen production ultimately producing cleaner water. The Northern basin fishers in the city of Bujumbura will not have to travel a long distance to get fish in the rural area of Bujumbura, or, in extreme cases, fish being abundantly transported from Rumonge (located on the southern province's coast) to Bujumbura. The degradation of natural habitats for settlement activities is attributed to biodiversity loss and hence ineffective terrestrial to aquatic material flow.

Encroachment trade-offs hinder natural habitats

If we reconsider our relationship with nature and acknowledge each one's role in keeping it functional, we should not ignore the provisions that we benefit which come from the collective ecosystem. Our understanding of nature should not be narrowed to the prospect of ecotourism and economic development. Figure 16 displays yet another historical record that should remind us about the cyclical events of the lake's movement and how this movement reshapes the riparian zone. This is another milestone in environmental history that shows the repercussions of not considering ecological records in development policy which led to thousands of residents, mostly those vulnerable, being displaced. Although some studies (Secretariat, 2012; Azanga, 2016; Allison et al., 2000; Miriti, 2020), suggest that the current coastal settlement expansions are the result of population growth. One can argue that people who are involved in settlement activities on the shoreline have different needs.

“... there is a need for many of us to stay in the capital city, but those who have built houses there do not need their first shelter; it's all about fortunes, I mean rich people, just look at the type of buildings that can be found there” (Gakima).

According to Gakima's statement, there may be some settlements (residential) belonging to residents as their first homes. While many of the houses along the shoreline are owned by people who already own property elsewhere, mostly for business purposes such as for renting, hotels, restaurants, public halls, and resort owners. For this reason, I argue that the key variable we should not underestimate here is that of people's affluence, i.e. the role and flow of capital in the space. The acquisition of commercial settlements has driven the increase in land consumption along the coast over the last two decades. However, in most cases, all these facilities were built without respecting norms, even the ones built after the year 2012. As discussed in chapter one, the decrease in lake levels with the lack of the demarketing signs of the highest altitude dictates people's movement toward the riparian zone.

"...there were banana trees everywhere in such a way that some parts had water during the rainy season and water run out during the dry season, so, there was movement. Now the banana trees are cut down, that zone has been made ready for construction (developed) and it is the government that did that, some people have financed the state for the roads that will be underwater. I did warn them that the lake will come back, but they continued with development. Now they have underwater roads, it was clear that this will happen again. This was done by the state, which is where people build houses now" (Ntakimazi).

"What I can tell you is that people who are building there are the most knowledgeable about the law; they know exactly what they are doing is wrong; it's just a matter of economy and profit maximization for their business" (Nkengurutse).

In my discussion in chapter two, I have explained the role of the social agency in the ecological network where all actants must work collaboratively. Testimonies by Ntakimazi and Nkengurutse above have revealed that there is no collaboration between state organs such as the BOEP, the MPCDFU, and the Lake Tanganyika Authority. As actants within the social network, they should equally cooperate through knowledge sharing of the historical records of the buffer zone and its critical areas by looking at the broader context from local, national, and across borders. However, there is insufficient data to speculate on the levels of cooperation among the above organs because it is beyond the scope of this study. Findings in Table 5 statement (I) suggest that all respondents from the individual interviews believe that the contestation of the environmental/water/forest acts stems from the non-adherence to the provision of the protection of the environment. Mbonerane suggests that, although there are penalties associated with the violation of the environmental decrees, there is no environmental tribunal for the prosecution of any misconduct.

"...the problem is that there is no tribunal that deals solely with environmental cases, and there is no place to report or complain about any misconduct." (Mbonerane).

Non-compliance can also be attributed to the lack of environmental law enforcement because those involved in misconduct cannot account for their own actions. Mbonerane's account emphasises that environmental protection is the responsibility of every citizen. He then admitted that this responsibility can be shared across the administration spectrum, from residents to high-profile officials and figure. Therefore, he reiterates that good governance of the coast needs a bottom-up approach as the best solution to misconducts that contravenes the Water Act. Participants reported that this bottom-up approach should flow from residents to the counsellors, to the city council.

Ecological degradation and behaviour change

Managing threats from upland



Figure 18: *Kanyosha River flowing downstream under the R.N.3 bridge, sediment turbidity, encroachment of residential houses and bricks manufacturing (right), vegetable garden (left), and littering (left & right) threaten the water quality of the lake, 2021.*

Yu and colleagues (2018) study on water quality in seven tributary rivers along Lake Tanganyika in the province of Bujumbura revealed that the Rusizi, Mutimbuzi, Kinyankonge, Muha, Kanyosha, and Mugere rivers all had high nutrient concentrations. These rivers are located in the

northern basin of the lake and play a vital role in the water cycle of the lake. As a first step in addressing the threats outlined in figure 18, the city's environmental management system should engage in projects that promote not only the restoration of riverbanks with native plants that cover a 25 meters buffer as prescribed in the Water Act but also the promotion the importance of the buffer for water quality and safety from erosion caused by flooding affecting communities living nearby. Additionally, the waste management system should also consider the use of litter booms and litter traps tied to all bridges across National Road 3 (N.R.3) and the (N.R.4) in the north.

Managing threats from lowland

The constant changes in the landscape including water and land degradation affect the ecological system. However, this can be mitigated firstly, by adopting a developmental plan that incorporates the role of the buffer zone in terms of natural coastal processes and dynamics relative to specific species (flora and fauna). This approach accommodates the coexistence of hippos and other organisms including humans whose lives are dependent on the riparian zone and the lake. As explained by Mr Khan, hippos are the dominant species understanding their behaviour is key to any coastal development, particularly in their dominant areas. Secondly, in dealing with pollution the treatment of municipal and industrial sewage before discharge into the lake and implementing projects that support solid waste management systems by working with local NGOs. The environmental assessment conducted between the years 2007, 2012, and 2016 in the northern basin near the harbour revealed that water was dangerously contaminated with harmful substances and heavy metals such as copper, cadmium, zinc, lead, and arsenic (ADBG⁴⁴, 2019).

It is important to rethink sustainable town planning, reliable and environmentally friendly waste management, and the protection of the riparian zone by understanding the historical lake levels fluctuation as the benchmark as well as a protection for homeowners. Statements (A), (G), (H), and (K) in Table 5 illustrate the strong views held by community members and professionals on the current ecological issues. Thus, conservation strategies concerning social-economic development need to internalise the social-ecological aspects to avoid commodification of the commons which may lead to cohabitation between humans and hippos, and among local community members especially those whose livelihood and well-being has been affected.

⁴⁴ African Development Bank Group

Considering Matose’s (2016) contribution to the co-management of natural resources suggests that, the denial of property rights to some members of the community (marginalised) may lead to hidden conflicts. This means that the Water Act can serve as a legislative document that guides in reference to the land and water frameworks that inform the relationship between humans and non-humans for a healthier environment and social well-being. Table 6 below illustrates the relationship between life-support systems and human well-being indicating how we, directly and indirectly, benefit from natural services. Any developmental plans that are not informed by respecting and understanding environmental norms might lead to the violation and compromise of the intrinsic value of nature.

Table 7: Relationship between life-support system and human well-being, 2021.

<i>Human well-being components (Freedom and choice)</i>	<i>Hippos, Riparian (plant/grass) and Lake Supporting Services</i>		
	<i>Provisioning Services</i>	<i>Regulating services</i>	<i>Cultural Services (values)</i>
Material for a good life	Freshwater (lake) and food (fish)	Fertilise (hippo), local climate and carbon storage (plant/grass)	ecotourism, aesthetic, enjoyment
Health	Medicine (plants), food	Waste-water treatment (plant/grass)	Recreation, physical & mental health
Good social relations		Biological control (species),	Inspiration, Spiritual, heritage connections
Security	Impact on food chain (hippo), flood risk (plant/grass)	Erosion and fertility (plant/grass)	

Proposed coastal management framework

Figure 19 illustrates the proposed coastal management framework, highlighting the connection between society and nature within the urban coastal ecosystem in Bujumbura and other cities adjacent to the lake. Reiterating the importance of the buffer zone for both humans, hippos and other lifeforms and their interdependence and connection. It uses the prescribed buffer distance of 150 m as stipulated in article 5 of the Water Act N° 1/02 of 26 March 2012, to suggest where the natural demarcation (use of trees, plants and grass) may be positioned (e.g., starting from 776 m altitude above sea level). It also shows how actants (humans and hippos) from the two systems (terrestrial and aquatic) are interconnected at the intersected riparian zone. Efforts need to be made

to investigate and monitor hippo populations and their pods to help us better plan for how much vegetation is needed for them to feed. Knowing hippo's pathways on land and water will help fishers and other people to understand where in the lake and the riparian zone it is safe for fishing, and walking. This framework also makes provision for the riparian zone as the natural habitat that protects coastal communities against conflict related to human-hippo (wildlife) competition over resources. Additionally, the buffer system will regulate nutrient fluxes from upland and protect communities against devastating floods in the inevitable event where the lake level rises.

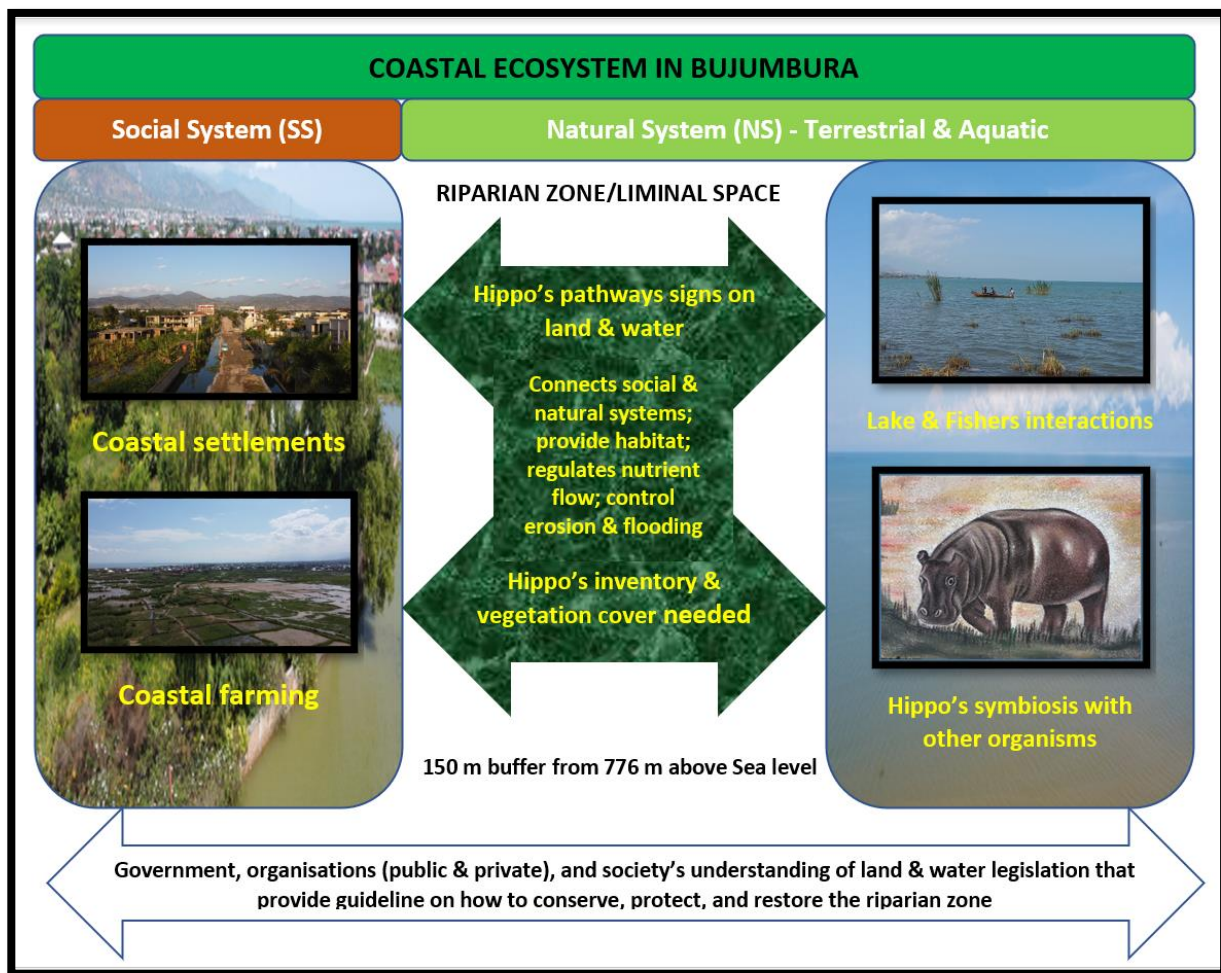


Figure 19: Proposed coastal management framework that incorporate social and natural systems

Conclusion

The framed system discussed in chapter two may be sustainable if the guidelines on coastal settlement growth are managed and boundaries for urban development are put in place and are defined. This chapter provides insights on the contested Water Code legislation by identifying some gaps that could have been incorporated in the act and calls for an informative coastal geomorphology framework that incorporates the riparian zone with regards to flora, fauna, and abiotic factors. This may assist in maintaining the places that are still unaffected by settlement developments in the two neighbourhoods and gradually upheld to the extent until it covers the entire 8% of the lake boundary that Burundi occupies. Maintaining the lake's chemistry and the physical features of the riparian zone at the local level, as discussed in Mentzer (2018), Shoo (2019) and McCann (2020), this is critical for ecosystem balance. These authors' emphasis on the interconnectedness of biotic and abiotic factors takes us back to our two opening quotes in the introduction. William Schlesinger (Citatis, 2021) reminds us that all lifeforms on this planet have a role as an actant in the life support system that helps sustain our ecosystems. Similarly, Wangari Maathai (MDFE, 2021), prompts us that we cannot overemphasise the socio-economic advantages of commercial settlements while forgetting that the riparian zone that they were and still build on has an important role in the functioning of the lake through its interconnectedness of flora and fauna, which also reduces risks of flooding. Both Schlesinger and Maathai remind us to reflect on Leopold's (1986) ontology of ecological community by considering all components of coastal ecosystem as discussed in chapter one; Latour's (1993) notion of the locality explains that all components are entangled within a framed ecosystem as discussed in chapter two, we need to rethink human-nature interdependency within an urban ecology setting that may lead to an effective kinship as discussed in chapter four.



CHAPTER 4. DISCUSSION AND CONCLUSION: RETHINKING HUMAN-NATURE INTERDEPENDENCE

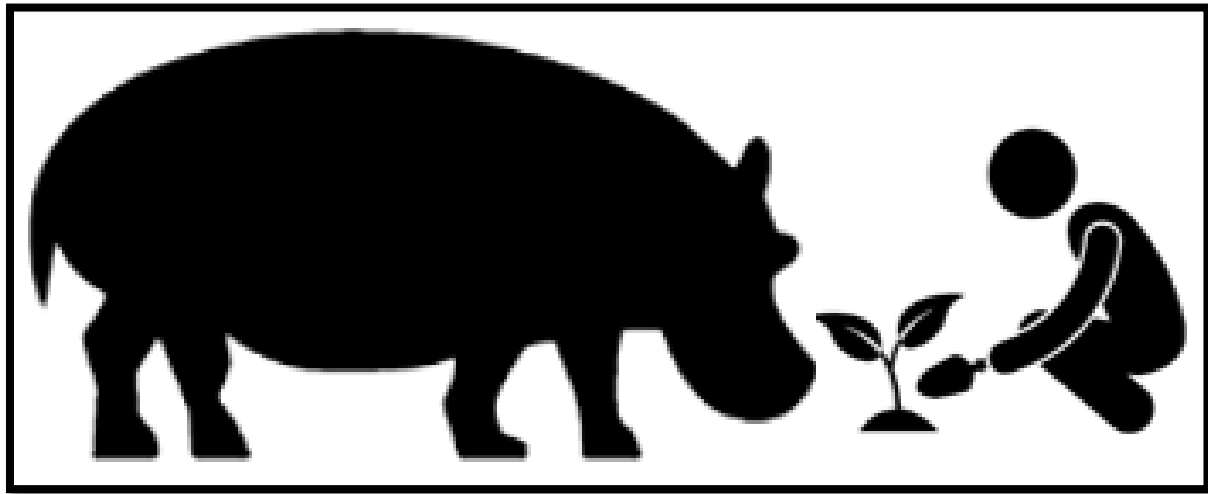


Figure 20: Depiction of symbiosis, kinship, and cohabitation

INTRODUCTION

In previous chapters, I examined the cohabitation between humans and wild hippos in the intersecting liminal space (buffer zone). It was noted that human dominance in occupying this transitional space has impacted both human livelihood and the hippo's habitat. We also learned about multi-species entanglement by examining hippo transboundary agency at the ecosystem ecology level through nutrient and energy flow. Thus, because humans cannot live in isolation, some insights for encouraging coexistence between humans and non-human species in a riparian urban landscape like Bujumbura were proposed. In this chapter, I focus on the key aspects of human-nonhuman species relationships and how we (humans) can rethink nature as a part of ourselves. The first section deals with the discussion which begins with a review of the objectives of the study and the research questions, followed by highlights of key findings and a discussion of the results. The second section presents the study's overall conclusion highlighting why the current struggles in the coastal city of Bujumbura are deeply embedded in lack of improper and unclear land-water management.

Discussion

The current pursuit of urban expansion in the city of Bujumbura, particularly in the last two decades has resulted in an upsurge in encroachments of human settlements along the coast of Lake Tanganyika. The encroachments include residential houses, resorts, hotels, restaurants, halls, and small-scale agricultural farming (Secretariat, 2012). These activities have played a role in altering the coastal landscape, reducing grazing space for species such as hippos which have resulted in conflicts over land between local communities and wild hippos (Manishatse, 2017; Kanyange, 2018). This conflict in the case of wild hippos is for reclaiming the grazing space. This study's objectives were to investigate human and non-human relationships, understand hippos and their role in terrestrial and aquatic ecosystems; their interrelationship with other non-human species through nutrient and energy flow; and review the contested water legislation and its provisions to protect the lake, riparian landscape, hippos, and coastal communities. Throughout the discussion, I attempted to answer the following questions to better understand these relationships: *(1) What are the intersecting human-hippo interactions that exist in Bujumbura's lakeshore neighbourhoods? (2) What impacts do these interactions have on people and hippos? (3) what interventions can help restore the degraded environment and foster kinship?*

Spatial analyses of vegetation cover in Gisyo and Kibenga revealed that human settlement activities have resulted in the loss of vegetation along the shorelines of the two neighbourhoods. However, the majority of Kibenga appears to have had extensive land clearing. Figure 7 depicts the land transformation over the past two decades, illustrating that there was still enough vegetation cover until the year 2000. The clearing of natural land which was previously designated for traditional small-scale farming at the interface of the riparian zone covered with grass, shrubs, and trees has an impact on the natural processes that regulate nutrient influx from urban environments (Solomon, 2022). However, there has been a constant insurgence on the land characterised by the clearing of vegetation for settlements. This has impacted community's everyday life as evidence from participants in both neighbourhoods attests that their cohabitation with hippos is currently unstable as the grazing space shrinks over time. This has resulted in conflicts which have seen the deaths of community members or injuries caused by hippos. While others who depend on land for everyday life were forced to sell their small farms for developmental purposes. The ecological

impacts include a continuous increase in biodiversity loss; human dominion over the riparian zone may force hippos out of the coastal ecosystem or lead to an extension in the long-run due to food shortages; thus, the study by Schoelynck et al. (2019) suggests that this change may affect the nutrient and energy flow cycle of the lake. I conducted chemical analyses trace silica's presence. For example, in hippo's grass at 9.4 mg/L and dung at 21.7 mg/L, and in the first round of sample of water in Gisyo 6.45 mg/L; and Kibenga 6.31 mg/L; and high levels of total nitrogen and phosphorus in both sites as shown in Table 1.

These human-hippo conflicts over the past two decades have also been witnessed by many participants including Bizimana, Bukuru, Ciza, Havyarimana, Kezakimana, Muhenure, Mugisha, and Nduwabose. While describing the physical transformation of the riparian zone, participants admitted that there was a sense of cohabitation with hippos when there was enough grazing space. However, this relationship changed over time and turned into clashes between inhabitants and hippos over the liminal space. This indicates that agents involved in developing coastal Bujumbura did not consider the ecological aspects of the buffer zone as described by Leopold's (1986) land integrity. Washington and colleagues (2017) and Rowe (1994), stress the concept of ecocentrism which denotes that humans are a part of nature and that there is intrinsic value in all of nature, we cannot exist and thrive on our own without others in nature. Furthermore, the authors explain that ecojustice for non-humans like hippos in the case of Bujumbura has sacrificed the "well-being" of humans, which now places hippos as problematic and an annoyance disturbing our peace and safety. With little to no consideration as well as ignorance of the role, they play in the ecological system.

The urban expansion from on the shoreline has shown several negative consequences on both society and the environment. This study found that community members of Gisyo and Kibenga are anxious about encountering hippos, this was supported by Manishatse's 2017 media report which reported that Kibenga residents felt anxious about encountering hippos. This fear of hippos is brought about by community members' encounters with hippos which have resulted in injuries or deaths. Participants like Ntakimazi, Kezakimana, Nduwabosa, and Bukuru all revealed that there have been instances of people who were killed by hippos in the two neighbourhoods. For instance, in places like Gisyo, where I observed small scale rice farming, it was revealed that

hippos come onto the farms to graze after sunset. Participants acknowledged that hippo behaviours have increasingly become aggressive, which has resulted in people's fear of hippos, especially as both man and hippo struggle for space. Hughes's (1975) anthologised text reminds us of animals claiming dominion in their territories. Thus, as explained in chapter one, hippo's aggression toward people can be described as the form of claiming back its habitat. Beck (1992) proposes that we live within modernity which is defined and redefined as a risk society, he argued that risks associated with modernity must be admitted, assessed, planned, and documented by government and organisations to avoid detrimental consequences for both society and nature. Additionally, another social impact of modernity in Bujumbura is that social constraints were not considered in the context of the buffer zone and everyday life. Therefore, Burkhard and Maes (2017) assert that in communities like Gisyo, some farmers are victims of the neoclassical economy. This is because they were forced to give up some of their lands for settlement projects where they were paid very little for their land. In Gisyo, Kibenga, and other coastal communities, uncontrolled urban development and commodification are driving traditional (classical) economies. The land transactions of people like Muhenure and many others who were forced to sell a portion of their land were unfortunate. The reason for this was because the production used to determine the value of the land. Instead of focusing on profit, the price of land should have been determined by social and historical analysis. Neoclassical ideology, on the other hand, emphasizes that landowners are concerned with the supply and demand for plots close to the lake, as well as the profits that will accrue over time (Gomez-Baggethun, 2011). The shift in land ownership in Gisyo and Kibenga has caused an ecological crisis. This crisis threatens not only the safety of hippos and their habitat but also the safety of current settlement owners and inhabitants. This type of exchange creates what Marx called a rift, which Foster and Clark (2010) describe as enriching private individuals at the expense of public wealth. Costanza (1996⁴⁵, cited in McNeill, 2016) speaks about ecological economics, which views man as part of the ecosystems. It focuses on equitable distribution and efficient allocation of resources (land) by linking ecological and economical systems to develop effective policies (Costanza, 1996 cited in McNeill, 2016). In our context, using this approach may assist with the partial distribution of land within certain limits in order to not only meet the demand for developmental purposes but to provide land to accommodate natural processes. In promoting

⁴⁵Costanza, R., 1996. Ecological economics: reintegrating the study of humans and nature. *Ecological Applications*, 6(4), pp.978-990.

environmental justice and human well-being, the question that arises is, how can this be achieved without affecting lives of marginalised people and degrade the environment? Perhaps the reasonable answer in relation to the current pressures on the riparian zone is to avoid what Costanza (1996, cited in McNeill, 2016) referred to as prestige economies, which can be related to the commodification of the buffer zone. He also talks about peer pressure, which can be linked to the competition of settlements for businesses. Atwood (2009⁴⁶, cited in Suchostawska, 2020:104), in her novel titled *'The Year of the Flood'* expands on human civilisation, greed, and development, she further poses the question “why do we think that everything on Earth belongs to us, while in reality, we belong to Everything?”, reminding us that we belong to nature, we are not the owners of nature. Also, Gómez-Baggethun and Ruiz-Pérez (2011) explained that the land is a limited resource, informing us that once the pursuit of space for development becomes scarce or no more, then settlements will stop.

The ecological debate on urban settlement expansion in the two neighbourhoods needs to consider the current human-hippo conflicts, the high level of anthropogenic total nitrogen and phosphorus from upland, and municipal pollution (untreated sewage and the dumping of solid waste, and plastic bottles) discussed in previous chapters, and to an extent how the above-mentioned affects humans, which is integral to modernity. According to Beck (1992) and Bauman (2013), risk and waste are integral to the process of modernity as both tend to discriminate among species. Apart from risks linked to conflict, other socio-ecological risks have been raised by the study. Such socio-ecological risks include the discharge of pollution (liquid and solid) into the environment. This has resulted in hippos' proclivity to consume dumped trash near houses due to a lack of grassland and contract disease, while people get sick from drinking polluted lake water. Consequently, as modernisation continues, certain species, including humans and hippos have become marginalised. In Bauman's (2013) terms, they become outcasts. In context, as the riparian zone continues to experience settlement activities, some members of society particularly those relying on the land for their livelihoods will continue to be marginalised. Similarly, the hippo's entitlement to grazing space for existence will continue to be taken away. Bauman's (2013) intervention in his piece *'Wasted Lives: Modernity and Outcasts'*, talks about how industrialisation and development

⁴⁶ Atwood M. *The Year of the Flood*. New York: Nan A. Talese; 2009

have increased risk in certain segments of society. The present example is related to the commodification of the riparian zone, leading to discriminatory practices that systematically classify society based on their wealth. All individual participants admitted that most people involved in settlement activities at the edge of the lake are wealthy. Ntakimazi pointed out that some of the people who owned and worked the land for their livelihoods for over three decades have been forced out of the area. In one case, Muhenure, a widow and mother of six, admitted to selling part of her plot at a cheap price.

According to Borman (2013), people like Muhenure are modernity outcasts because their lives have become socially insignificant, unproductive, and at some point, subject to labour surplus. Bauman (2013) argued that all these are natural outcomes of the process of modernisation as they are integral to the pursuit of modernity. Similarly, Carson (2002) argues that all environmental damages are attributed to humans, not animals. An example of this is the result of the circular economy in Bujumbura, the rise in bottled water industries, and the lack of waste management resources has resulted in the mass dumping of empty bottles and garbage disposal into rivers that ends up being transported to the lake. While dumping spots were observed closer to the lake. The role of the buffer zone and the local environmental conditions were not adequately considered by developers. Considering Shelley's (2010) personification of nature as powerful, violent, and limitless, and Hughes's (1975) use of the animal's voice to claim its territory, it is empirical to remember that, the current complex challenges of conflict and risks discussed above are minimised. Green's (2013) provocative text on contested ecology echoes us on effective environmental governance suggesting that decisions have to come from the collective in marginalised members of the community. Thus, the coastal management in the city of Bujumbura needs to contextualise and incorporate all aspects of the riparian zone (ecological, socio-economic, and legal) as discussed above in its broader definition. Referring to Mbonerane's suggestion in the previous chapter, the current challenges could have been prevented if all parties involved in decision-making collaborated and conducted the environmental impact assessment adopted under the Water Act of 2000. This could have allowed developers and other stakeholders to classify ecological and social risks before any development project took place.

Conclusion

Our [human] embedding in nature, places us in an unassailable position to argue that we are part of nature and that we cannot survive in isolation. Hence, our dynamic understanding of the lake and its riparian zone or corridor is inextricably linked to our everyday biosocial reality. The general agreement by Leopold (1986), Latour (1993), Rowe (1994), Locke and Munster (2015), and Washington et al. (2017) directs our attention to rethinking how we interact not only among ourselves (inter-human), but also with non-humans (inter-species) in complex coastal urban environmental settings like Gisyo and Kibenga. Locke and Munster's (2015) insights on multi-species inquiry indicate that we should pay closer attention to the current social and cultural situation (switch of lifestyle from traditional to the modern economy) as well as the agency of hippos and other life forms. Hence, this thesis developed an understanding of the relationship between society and the environment, and further demonstrates the agency of the social and natural actants. I applied Latour's (1993) notion of locality which defines society and nature as framed and connected, where all organisms on the riparian zone are interconnected and interdependent. Using grounded and ethnographic datasets, I have cross-examined different actants (humans, hippos, grass, water) agencies by framing the flow of energy and nutrients across connected habitats in the complex adaptive systems (riparian zone and littoral zone) of Lake Tanganyika in the context of coastal urban expansion in Bujumbura's Gisyo and Kibenga.

In chapter one, I used the ecocentric concept of land ethics coined by Leopold (1986) to explore the trend of land cover patterns using historical Google Earth images over a twenty-year period and used participants' testimonies and insights to understand the impact of human-hippo interactions on the riparian zone. Like humans, hippos need the riparian zone as it is part of their habitat, for this reason, I used the term liminal space to demonstrate that it is transitional and part of their lives. Thus, developers and city planners need to understand the riparian zone is the home (habitat) of hippos, which helps to sustain and protect them. Protection with regards to the riparian zone can be seen as a dual concept, where hippos are protected from humans (i.e. poaching, habitat loss etc) and humans are protected from hippos as they are considered dangerous animals capable of killing or injuring them, especially in coastal communities where grazing space is contested. Allowing encroachment on hippo's habitat has shown that the riparian zone's role was not defined

in terms of coastal geomorphology on how humans, hippos, plants, water, and land interact and co-exist.

In chapter two, I extended the notion of land ethics to Latour's (1993) actor-network theory where I focused on the concept of locality, in order to explain and demonstrate the hippo's influence on the two systems and their agency as they subsidise nutrients (silicon) on land and in water through defecation when marking their territory. This process assists in sustaining the soil and water chemistry as demonstrated by Schoelynck and colleagues' 2019 study. I then discussed interspecies intercedence, showing hippo's agency on transboundary interactions has a critical impact on the chemistry of the lake and is a major source in the food web as energy flows. Where energy flows from diatoms (plankton) to zooplankton to fish and humans who consume fish as a source of protein (Frame and George, 2020). The link between society and hippos appeared to show coexistence as both actants effectively intersect in the liminal space within the actant-network. This is what Latour (2013) referred to as translation. Meaning the network of the two actants is translated through their mutual understanding of the boundaries of each actant within the shared buffer space.

In chapter three, I examined the current water legislation and suggested that it needs to be informative or have a legal framework that provides details to define the riparian zone in the legal context of interspecies histories and relations for better coastal management. I argue that the contested legislation is tied to a lack of translation across social actants as there is no collaboration to connect the role of the riparian zone in terms of flora, fauna, lake sustenance, and coastal community protection. In other words, settlement expansion plans do not take into account the entire ecological community (Leopold, 1986) as well as the history of their cobecomings, but more specifically, the entire ecological system, which includes abiotic features, flora, and other living organisms (Washington et al., 2017).

Encouraging kinship as one of the strategies in managing socio-ecological issues in a complex coastal urban network/system could be challenging. Social actants need different ways of knowing and understanding at ecosystem ecology levels, the dynamic forces that lead to their success and failure. Drawing from this study's analyses, this research findings suggest that the increase in

settlements in the locality of Gisyo and Kibenga's riparian zone is unjustifiably linked to population growth alone. Evidence suggests that affluence is a major factor in these two neighbourhoods as plots on the shoreline are extremely expensive and Table 5 statement (F) suggests that only people with financial means can afford them. Therefore, a kinship plan may raise awareness and collectively educate or guide all actants in the social network to acknowledge the subjective agency of hippos as sentient, territorial, and dominion. In addition to considering their historical existence in the terrestrial and aquatic space; their contribution to society (source of protein as we get from fish) and ecological (energy flow and nutrient cycling) aspects that connect and provide support to human lives. In other words, understanding their interaction and contribution as one of the life support systems actants that keep our environment in balance.

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PARTICIPANT INFORMATION LETTER

Hippopotami in a Liminal Space: A Multi-species Ethnography of Lake Tanganyika in Bujumbura

Dear participant,

I, Bakenga Maksudi a Masters in Environmental Humanities student at the University of Cape Town, would like to ask for your participation in the above research.

My research aims to understand the complexities of rapidly urbanising spaces that pose a threat to the survival of hippos in the natural environment along Tanganyika lakeshore in Burundi. The increase in encroachments on the lakeshore around the city of Bujumbura has raised alarming issues on land-water ecosystems. Hippos' behaviours are significant to the coastal ecosystem due to their impact on nutrient flows from terrestrial to water. Data collection consists of individual or focus groups interviews which will be recorded.

Participation is voluntary and all information provided by participants will be confidential. Participants will be asked for their consent for the archiving of interviews at the end of the interview session and the release form will be provided if agreed. You may withdraw your participation from this research at any time.

Please fill in the slips below to indicate your consent to participate in the study. You are welcome to ask any questions regarding this research using the following contact details:

Researcher: Bakenga Maksudi - mksbak001@myuct.ac.za or +27822915993

Supervisors:

- Nikiwe Solomon – nikiwe.solomon@uct.ac.za
- Prof Frank Matose – frank.matose@uct.ac.za

Yours sincerely,

Bakenga Maksudi

Participant Consent form (for individual & focus group interviews)

Hippopotami in a Liminal Space: A Multi-species Ethnography of Lake Tanganyika in Bujumbura

Name: _____ (Print)

_____ (Signature)

_____ (Date)

I consent to	Yes	No
1. Take part in the research		
2. Being interviewed		
3. Audio-recording of the interview		

(Tick ✓)

I understand that my participation is voluntary and that confidentiality will be maintained. I can withdraw my participation at any time.

Participant Consent form (Archiving of interview)

Hippopotami in a Liminal Space: A Multi-species Ethnography of Lake Tanganyika in Bujumbura

Name: _____ (Print)

_____ (Signature)

_____ (Date)

(Fill X)

I consent to	Yes	No
1. Take part in this research		
2. Agree to the release and archiving of my interview		
3. I prefer the use of pseudonyms		

(Tick ✓)

I understand that my participation is voluntary and that confidentiality will be maintained. I can withdraw my participation at any time.

INDIVIDUAL INTERVIEW SCHEDULE

Introduction

Thank you for volunteering to take part in this individual interview. You have been asked to participate as your personal experiences are important and will add value to this study. This discussion is designed to gather your **professional experiences** on issues surrounding coastal ecosystem, humans and hippos along Lake Tanganyika.

Confidentiality: If you consent the interview will be voice recorded. But I would like to assure you that confidentiality is maintained as the report will be written in such a manner that findings will not be associated with specific individuals. To ensure confidentiality, the voice recordings will be transcribed verbatim and archived if the participant agree. In case the participant does not agree, I will use pseudonyms. Please try to answer as accurately and as truthfully as possible. Before we start, I would like to request for your permission to tape the discussion in order to facilitate a true reflection or recollection of what was discussed in the session, I will also be taking photographs where possible.

DISCUSSION QUESTIONS

A: General information

1. What organisation do you currently work for?
2. How long have you worked at the organisation?
3. What role/function does your organisation play in civil society/ or environmental policy?
4. What is your role or function at the organisation?

B: Experiences with the environment

5. Who is building along the lakeshore? (probe about socie-economic status of people along the lakeshore)
6. What are some of the leading causes for the increase in settlement along the lake?
7. What impacts of increased settlement have you/or your organisation observed over the past 10-15 years on the environment along the lakeshore?

C: Experiences with water

8. How has settlement along the lakeshore impacted on the water quality of the lake?
9. How has the water quality of the lake affected humans both directly and indirectly?
10. What policies are in place to mandate where settlements are built along lakeshore? (probe if people are aware of these policies?)
11. How would you describe people's adherence to current policies?

D: Experiences with hippos

12. How has the increased in human settlement affected hippo populations?
13. What are the main conflicts occurring between humans and hippos along the lakeshore?
14. What is the public's understanding of the role of hippos in the ecosystem?
15. What interventions or policies are present that seek to provide safer spaces for both human and hippos?
16. In your opinion are these interventions or policies adhered to or working?

Conclusion

Thank you for participating. This has been a very successful discussion with you. Your experiences will be invaluable to this study. I hope you found the interview enlightening and interesting. If there is anything you would like to discuss, please feel free to speak to me. I would like to remind you that your contributions will be anonymous in the research report.

Thank you

FOCUS GROUP GUIDE

Introduction

Thank you for volunteering to take part in this focus group discussion (FGD). You have been asked to participate as your personal point of view is important and will add value to this study. I am conducting this study for my masters thesis. This discussion is designed to gather your **personal experience(s) or opinions** on issues surrounding coastal ecosystem, humans and hippos along Lake Tanganyika. No personal or sensitive questions will be asked.

Confidentiality: If you consent the interview will be voice recorded. But I would like to assure you that confidentiality is maintained as the report will be written in such a manner that findings will not be associated with specific individuals. To ensure confidentiality, the voice recordings will be transcribed verbatim and archived if participant agree. In case the participant does not agree, I will use pseudonyms. Please try to answer as accurately and as truthfully as possible. Before we start, I would like to request for your permission to tape the discussion in order to facilitate a true reflection or recollection of what was discussed in the session, I will also be taking photographs where possible.

Ground rules

- Only one person should speak at a time. Please do not interject while a group member is speaking, wait until they have finished speaking before you jump in.
- There are no right or wrong answers.
- You do not have to speak in a specific order.
- All your opinions and experiences matter so it is important that each of you participate. When you have something to say please feel free to speak.
- If you disagree with someone's point of view please do so respectfully. You do not have to agree with the opinions of other group members.

Before we start, I would like to request for your permission to tape the discussion in order to facilitate a true reflection or recollection of what was discussed in the session.

A: General information

17. How long have you lived in this neighbourhood for?
18. How large is your family?
19. What is the size of your house and property?

B: Experiences with the environment

20. What changes have you witnessed over the years in the neighbourhood (in terms of settlement and subsequent changes)?
21. What changes have you noticed on the water quality of the lake?
22. How has the water quality affected fish supply over the years?
23. What other changes have you witnessed on the land along the lakeshore?

24. How have these changes impacted on your life and that of others in the community?
(probe on the health consequences i.e. increase in malaria outbreaks, cholera etc)

C: Experiences with hippos

25. How often have you come across hippos? (probe on where and what times people come across hippos)
26. What interesting stories do you relate with regards to your interactions (or other people's interactions with hippos)?
27. What has impacted on conflicts between people and hippos, particularly hippo killings?
28. Have you noticed any changes linked between hippo population decline and other animals (birds, fish etc).
29. What role do you think hippos play on the environment?

Conclusion

Thank you for participating. This has been a very successful discussion. Your opinions will be invaluable to this study. We hope you found the discussion enlightening and interesting. If there is anything you would like to discuss outside of this meeting please feel free to speak to me after the meeting has been dissolved. I would like to remind you that your contributions will be anonymous in the research report.

Thank you

APPENDIX D



Environmental Humanities South

School of African and Gender Studies, Anthropology and Linguistics
University of Cape Town
Private Bag X3, Rondebosch 7701, Cape Town, South Africa
Telephone: +27 (0)21.650.9111
Email: nikiwe.solomon@uct.ac.za

03 December 2020

Re: Confirmation of Research Ethics Approval -Mr Bakenga Maksudi (EHS008)

This is to confirm that Mr Bakenga Maksudi's research proposal, "Hippopotami in a liminal space: A grounded theory multi-species inquiry of Lake Tanganyika in Bujumbura" under the supervision of Ms N. Solomon has been reviewed by the EHS department. Mr Maksudi presented his proposal to the department on the 27 November 2020.

The department is satisfied that the research carries no significant risk of harm to human subject. We are further satisfied that appropriate informed consent and confidentiality data protection mechanism are in place. It is a condition for the acceptance of Mr Maksudi's proposal that he complies consistently with strict ethical standards. This will entail proceedings only on the basis of the consistently informed consent of interviewees and will require regular monitoring of ethical issues which may emerge as the project develop.

Please contact the department should you have any questions or concerns regarding the above.


Regards,

Nikiwe Solomon
Lecturer
Department of Anthropology
Upper Campus
University of Cape Town
RONDEBOSCH 7700

APPENDIX E


Gitega, le 18/13/2021

REPUBLIQUE DU BURUNDI



MINISTRE DE L'ENVIRONNEMENT,
DE L'AGRICULTURE ET DE L'ELEVAGE

N. Réf.: 710-06/815/001-0/0BPE/2021



Office Burundais pour la Protection de
l'Environnement

A Monsieur BAKENGA Maksudi, Candidat à la Maîtrise
à
UNIVERSITÉ DE CAPE TOWN
AFRIQUE DU SUD

Objet: Autorisation de Recherche.-.

Monsieur,


Faisant suite à votre demande d'autorisation d'effectuer un travail de recherche sur la cohabitation entre les hippopotames et les riverains du Lac Tanganyika dans le cadre de votre travail de Maîtrise intitulé: ***l'Hippopotame dans un endroit liminal: une théorie fondée sur une enquête multi-espèce au Lac Tanganyika à Bujumbura, Hippopotami in a liminal space: A grounded theory multispecies inquiry of lake Tanganyika in Bujumbura***, j'ai l'honneur de vous informer que je marque mon accord et le Conservateur en Chef du Parc National de la Rusizi, qui me lit en copie, est prié de vous faciliter le travail.

Toutefois, **Monsieur**, je vous invite à partager les résultats de votre travail avec l'Office Burundais pour la Protection de l'Environnement qui en a besoin pour l'accomplissement de sa mission des protection de l'Hippopotame.

Veillez agréer, **Monsieur**, l'expression de ma considération très distinguée..

LE DIRECTEUR GENERAL DE L'OBPE
Ir. HATUNGIMANA Berchmans

CPI à :
Monsieur le Conservateur en Chef du
Parc National de la Rusizi



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