

Africa's Hydropower Lifeline: The Congo River

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Abstract

The Congo, the world second-largest river, limitless water, rich fertile soils, a favorable climate, and underlain by abundant deposits of gold, copper, cobalt, diamonds, cobalt, uranium, coltan, and oil should make it one of the world's richest countries. However, it is one of the world's most hopeless. The interior of the Congo was opened by the British-born explorer Henry Morton Stanley in the late 19th Century. His dreams of free trading associations with communities he met were shattered by the infamous King of the Belgians, Leopold. According to historians, King Leopold ran a mercenary force that used murder and torture to force the native population to extract and export the region's ivory, rubber, and other natural resources. Historians estimate that from 1885 to 1908, approximately 10 million people in the region died at the hands of the Belgians. The primary objective of this study is to develop a master multi-country plan for more hydropower utilizing the Congo River's potential as the continent's energy lifeline while mitigating the loss of agricultural lands and reduced food security. In addition to trade, the river is a major energy source in Africa. With its tremendous flow rate, it can produce an immense amount of power. The Congo Basin alone accounts for 13% of the world's hydropower potential, which is more than enough to meet the needs of Africa.

Keywords

Congo, Hydropower, Navigation, Trade, Africa, King Leopold II, Colonial Rule

1. Introduction

The Congo River is Africa's second-longest river (about 4700 km), flowing through six countries in West-Central Africa, and is one of the world's longest rivers. The river meanders along the equator, crossing it twice before draining into

the Atlantic Ocean. It is the world's second-largest river by discharge volume, notable for its vast basin, which covers an area of about 4 million km² and 2nd only to the Amazon River in South America. This major African River is the world's deepest river. The many waterfalls along the course make the Congo difficult for long-distance navigation. However, many cities still use stretches of the river as a trade route. Commodities such as copper, sugar, cotton, and coffee are frequently traded via the Congo River. In addition to trade, the river is a major energy source in Africa. With its tremendous flow rate, it can produce an immense amount of power. The Congo Basin alone accounts for 13% of the world's hydropower potential, which is more than enough to meet the needs of most of Africa.

Agricultural development has generally lagged in Congo. The objective of this section is to describe the different soil types and their major constraints in the Congo basin, their management, the actual utilization types, and the impact of land use impact on food production. Agriculture in the Congo basin has a dualistic character [1]. One type is large commercial perennial crop plantations of rubber, Robusta coffee, oil palm, and cocoa. The other type is the traditional small-holder agriculture in forested areas based on shifting cultivation. Shifting cultivation uses almost no external inputs and characterized by low productivity. To increase community resilience and to ensure food security, agriculture must move from shifting cultivation to permanent agriculture that relies on agroforestry practices, a good knowledge of the soils, and the integrated land use management. However, in the Congo, farm-level detailed soil maps and information are non-existent. When this is coupled with other socio-economic constraints, it provides one explanation for the lack of progress in ensuring food security [1]. Proper utilization of soils is essential to economic development and sustainable agricultural production. In the Congo basin, 65% of the population is directly involved in agriculture and the majority lives in rural areas. Food production requires suitable soils for crop cultivation. Suitable soils for agricultural production are limited in the Congo basin. If soil characteristics and constraints are well understood, sustainable food production in the Congo basin can partly be attained.

Since 2003, the Democratic Republic of Congo (DRC) has been rebuilding its power grid as part of the war-torn country's reconstruction. Despite the millions of dollars of donor funding put into this, today only 9% of Congo's 70 million people have access to electricity—about 30% in urban areas and an alarming 1% in rural areas. Lack of access to modern electricity services impairs the education, health, and income-generating potential of millions of Congolese people. The Congolese government set an aggressive target to provide 60% of the population with access to electricity by 2025 but has failed to put in place plans to meet this target. Instead, the government plans to rehabilitate the existing power grid and develop new dam projects, primarily to power the mining industry and export electricity to neighboring countries. Investments in decentralized power supply projects, including small- and medium-scale hydro across the country, could more evenly reach the population and finally begin to close DRC's energy divide, but so far are not being developed.

UN population data show a population growth rate of around 3% per year, in the region of the Congo Basin [2]. Tyukavira *et al.* [3] “*Most of the population is low income and relies on rain-fed, subsistence agriculture with slash-and-burn cultivation. There is strong evidence that a significant proportion of the deforestation in the Congo is caused by small-scale agricultural clearance* [4]. *These practices are linked to a lack of equitable development and poverty rather than just a lack of development. The reasons behind this poverty are multifaceted and complex. International interests, colonial history, and armed conflict all play a role in holding back equitable development in the region*”.

However, international interest in the region is growing. Minerals are a well-known source of conflict in the region, leading to measurable impacts on sediment transport in this great river system and environmental degradation [5]. Timber extraction is growing because of complex global commodity chains. Recent research suggests that Chinese imports of timber from the Congo Basin is a result of US demand for Chinese furniture [6].

Alsdorf *et al.* [7] noted “*Energy and water within the Congo Basin are also now a strong focus of a variety of ‘visions’ of the basin’s future natural-resource potential. For example, the Grand Inga Dam has the potential to have twice the power output of the Three Gorges Dam in China. There is also the much-talked-about inter-basin water transfer from the Oubangui tributary to sustain the water resources in the Lake Chad Basin*”.

The primary objective of this study is to develop a master Africa plan for more hydropower utilizing the Congo River’s potential as the continent’s energy lifeline. If new dams are built, some communities will need to be resettled and their population might suffer from a lack of adequate compensation, loss of agricultural lands, problems with food security, and increased incidence of disease. Steps will have to be taken to prevent these problems to ensure that people’s livelihoods are restored.

2. Study Site

Ngongo *et al.* [1] found the “*Congo Basin forests support the livelihoods of more than 90 million people. Even today, a large portion of the population living in the Congo Basin forest is indigenous. In addition to those inhabitants, many others directly or indirectly rely on the forest for fuel, food, medicines, and other non-timber products. For the Congo Basin’s population, the forest is a major source of food. The contribution of forests to food security is very often overlooked, but rural communities in the Basin get a significant portion of protein and fats in their diets. Land use changes influence the fertility of the soil. Land use changes mostly focused on deforestation, cropland expansion, dry land degradation, urbanization, pasture expansion and agricultural intensification. In tropical regions, forest is cleared for the expansion of cropland, wood extraction or infrastructure expansion. Croplands expanded by 50% during the 20th century, from roughly 1200 million ha in 1900 to 1800 million ha in 1990. There are several interacting drivers*

for land cover change but the exponential growth in human population is important. Currently, 95% of the population growth takes place in tropical regions and soil fertility in tropical regions is affected by rapid land use changes. The effects of deforestation and grassland conversions as well as agricultural intensification have been well-documented but the spatial and temporal effects of soil fertility change and its interaction with land use change remains to be investigated”.

2.1. Congo Basin Characteristics

Ngongo *et al.* [1] suggested that “Although agriculture is the main economic activity in the tropical regions, the proportion of cultivated land is virtually the same as in the temperate region: about 10 percent. There is a tremendous potential for expanding agricultural output in the tropics by bringing new lands into production with a reasonable degree of expected success. One of the factors presently limiting the utilization of tropical areas suited for crop production is inadequate knowledge of how to manage the highly weathered soils presently under rainforest or savanna vegetation. The proper management of soils in the tropics Congo Basin is considered one of the critical components in the worldwide race between food production and population growth. Despite the voluminous literature, comprehensive knowledge of the characteristics of soils in Congo Basin (the tropics) is still quite limited [8]. One of the reasons for this lack of integrated knowledge has been the development of strong local biases by full-time tropical soil scientists working only in a specific area or country. The lack of a common language has thus impeded the transfer of many important management findings from one area to another”.

2.2. Lack of Soil Information in Congo

In the Congo, the soil resource base for most developmental purposes is generally inadequate. The detailed soil maps and farm-level information are non-existent. When this is coupled with other socioeconomic constraints such as availability of capital for land management investments and land titling, it provides a reason for the lack of progress in food security and poverty alleviation [9]. In the Congo, large gaps in soil information persist.

2.3. Congo River

The Congo River is a significant river in Africa, celebrated and cherished in children’s songs and folklore, often regarded as a gift of God to humanity. Its majestic presence inspires stories and cultural narratives that highlight its importance to the people and ecosystems it nourishes. It flows through Cameroon, the Republic of the Congo, the Democratic Republic of the Congo, the Central African Republic, Equatorial Guinea, and Gabon (**Figure 1**). The river is divided into three sections—the Upper Congo, Middle Congo, and Lower Congo. The Congo originates in Eastern Africa, with its headwaters in the East African Rift highlands (**Figure 2**) [10]. The Lualaba River and the Chambeshi River are the major tributaries of

the Congo, with the former being fed by lakes Mweru and Tanganyika and the latter rising in Zambia. The river drains into the Atlantic near Moanda in the Democratic Republic of the Congo.

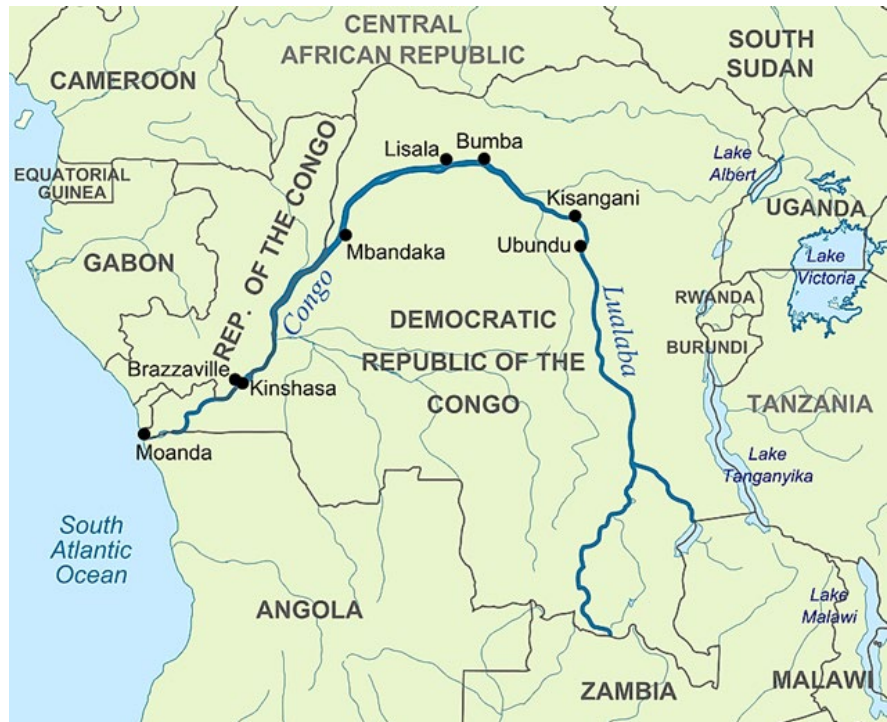


Figure 1. Congo map. From south Atlantic to Zambia (Lualaba River). Photo Credit: Wikipedia.

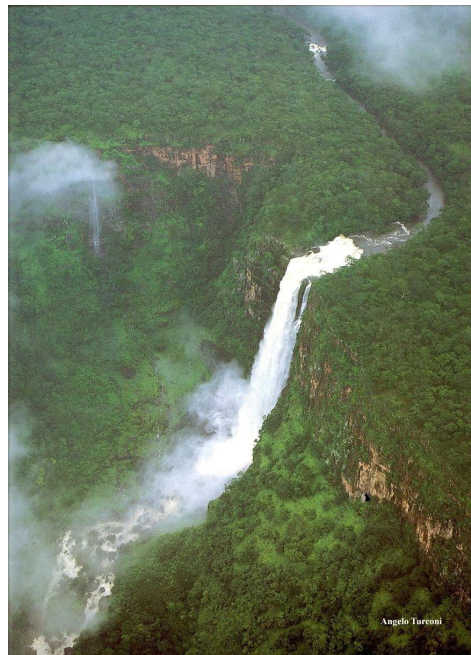


Figure 2. Congo river falls over an escarpment. Photo Credit: Angelo Turconi flanderimage.com.

With a length of 4700 km, the Congo-Lualaba-Chambeshi River system is the 9th longest river system in the world. The river also covers an immense basin size of 4,014,500 km², equal to 13% of Africa's Landmass. The river nourishes many ecosystems, such as wetlands, swamps, rainforests (**Figure 3**), floodplains, and more. Moreover, with its width spanning from 200 m up to 19,000 m, the Congo River is a major river system and one of the world's most unique habitat for diverse wildlife and exotic plant species.



Figure 3. Congo river meandering in rain forest. Photo Credit: kingo4.

3. Methodology

This study employed qualitative content analysis and visual data (pictures) to identify themes and insights for developing a master plan that harnesses the Congo River's hydropower potential while examining the socio-economic challenges of community resettlement due to new dam constructions. Peer-reviewed papers, reports and case studies on hydropower development, need for fish ladders to sustain fish migration and populations, community resettlement, and socio-economic impacts in the Congo River Basin among several other themes, were gathered and synthesized to identify best practices. Key metrics such as food security, compensation adequacy, and health outcomes were analyzed to establish a baseline for assessing the potential impacts of proposed hydropower projects. This methodology aimed to ensure that hydropower developments not only leverage the Congo River's energy potential but also prioritize the well-being and livelihoods of affected local communities.

4. Natural and Cultural Resources of the Congo River Basin

4.1. Congo River

Saulter and Pourtier [11] stated the “Congo River starts just south of Lake Tanganyika in the savannas. It picks up speed and gradually widens until it enters a 120 km long canyon of rapids often referred to as the ‘Gates of Hell’. Emerging from the canyon, it enters the tropical rainforest area known as the Lualaba. Its course through the rainforest crosses the equator twice. Because the watershed of the Congo drains from both the Southern and Northern Hemisphere, it does not have the significant seasonal fluctuations in water level as other great rivers. Its flow is relatively stable because part of its watershed is always in the monsoon season. The Upper Congo abruptly ends with Stanley Falls, a 96 km stretch of rapids.”

“Stanley Falls gives way to the Middle Congo, 1600 km stretch of navigable river, 14 km wide in some areas. Along this quiet stretch of river in the Democratic Republic of Congo the city of Kisangani. The first settlement of Henry Morton Stanley, Kisangani, is located where the Lualaba River becomes the Congo River north of the Boyoma Falls [12]. The Congo flows generally west from Kisangani. Just below the falls, the river bends southwest and flows by Mbandaka at confluence with the Ubangi River, and running into the Malebo Pool (Stanley Pool), an 80 km lake. The river slows to a virtual stand-still for 32 km. At this point, it is 24 km wide and is flanked by the capital cities of Brazzaville and Kinshasa.”

“Kinshasa (formerly Léopoldville) and Brazzaville are on opposite sides of the river at the Pool. The river narrows and falls (Figure 4) through several cataracts (Figure 5) in deep canyons (collectively known as the Livingstone Falls), running by Boma and Matadi, and into the sea at the small town of Muanda” [11].



Figure 4. Waterfalls on the Congo river. Photo Credit: World Atlas.



Figure 5. The Boyoma falls cataracts of the Lual rapids. Photo Credit: World Atlas.

Secon [13] noted *“The river then flows into Livingstone Falls, a series of rapids and cataracts 352 km. There are some 32 cataracts which have as much power as all United States falls and rivers combined. The final 160 km to the Atlantic Ocean from the end of the falls is fully navigable. The immense size, unique path, and Congo basin may be astonishing, but what truly sets the Congo River apart is its depth. This is because it is the deepest river in the world, with a maximum depth of up to 220 m. To put this into perspective, the famous Mount Rushmore stands tall at 18 m above ground which is 12 times less than the depth of the Congo River. Known as the Mesopelagic zone in water, minimal light can get through at this depth. So, the depths of the Congo River are home to some interesting sights and species rarely found in other rivers. Moreover, scientists are still trying to determine if the river is even deeper as it is yet to be fully explored.”*

“With such an expansive area and length, the Congo River is also home to a plethora of tributaries. Beginning from its source, the Luapula River and Chambeshi River provide a combined water flow of more than 900 m³. In addition to these, the Upper Congo (Lualaba to Boyoma Falls) has more than 10 tributaries, with the largest being the Lukuga and Luvua. These tributaries have a basin size of over 259 km². Moving up to the Middle Congo (Boyoma Falls to Kinshasa), there are about 20 tributaries ranging from the 35 km Irebu River to the massive Kasai River with its 884,370 km² basin size.”

“The Lower Congo (Kinshasa to River Mouth) has only four minor tributaries, which are M’pozo, Kwilu, Inkisi, and Djoué. In total, the Congo River has a major network of tributaries that account for its immense basin size across Africa. With the inflowing tributaries combined with its depth, the Congo River is also known for its high-water flow rate. Carrying more than 381,000 m³ of water into the Atlantic Ocean each second, it has the second-highest flow in the world. This is more

than the amount of water in 10 Olympic-sized swimming pools, making it a behemoth when it comes to water flow” [13].

4.2. Soils of the Congo Basin

According to the Soil and Terrain database of Central Africa [14], the main reference soil groups within the Congo basin are Ferralsols, Acrisols, Cambisols, Arenosols, Gleysols, Histosols, Lixisols and Nitisols, covering some 99% of the region. The main soil units are haplic Ferralsols (about 29%), haplic Acrisols (23%), xanthic Ferralsols (16%), umbric Ferralsols (5%), eutric Gleysols (4%), ferralic Cambisols (3%), haplic Lixisols (3%), ferralic Arenosols (2%), dystic Cambisols (2%), rhodic Ferralsols (2%), and haplic Arenosols (2%). In general, the Congo basin is dominated by highly weathered acidic soils but shows considerable diversity as a result of major differences in moisture regime, lithology, degree of weathering of parent materials, relief, and elevation above sea level [15]. The basic characteristics of the soils include red or yellow color, deep and highly leached (poor in bases), clayey texture, low activity clays (dominated by sesquioxides and 1:1 minerals, with only traces of weatherable minerals), very good drainage and permeability, strong cohesion of microaggregates, and strong aggregation and stability.

Soils in the Congo basin, alongside the humid climate, support a diversity of annual and perennial crops, including oil palm, cocoa, coffee, rubber, banana, plantain, cassava, cocoyams, maize, beans, a wide variety of fruits, cereal crops, and tubers. Major constraints to agricultural productivity, especially on the highly weathered ferralsols, include low cation exchange capacity, aluminium toxicity (extreme acidity), high phosphorus fixation, and high rates of soil organic matter decomposition. Given that soil chemical fertility declines very fast after few years of crop cultivation, farmers resort to slash-and-burn alternatives, which stands as one of the major drivers of deforestation in the Congo basin. Some studies have shown that humid forest soils of the interior are lacking in soil phosphorous, whereas the forest savannah ecosystems are more lacking in nitrogen, thus giving rise to the numerous nitrogen fixing trees such as *Acacia* [16]. The availability of a large number of nitrogen fixing tree species within the Congo basin forest makes it promising to develop sustainable agricultural practices such as agroforestry, which can go a long way to improve the soil’s fertility while minimizing deforestation.

Ngongo *et al.* [1] found “There are eleven inherent soil constraints for food production in Congo basin. The characteristic soil limitations affecting soil fertility are in the Congo basin soil limitations: 1) Low cation exchange capacity: low capacity to retain added nutrients. 2) Aluminium toxicity: strong acidity. 3) High phosphorus fixation: a high level of ferric oxides in the clay fraction. 4) High decomposition rate of organic matter: The nitrogen in soil organic matter (SOM) remains the most important source of nitrogen for crop production in the Congo Basin. Organic matter (pH around 3.5 - 4) develops negative charges that contrib-

ute to the cation retention of the soil. 5) pH value less than 5.5 (high acidity). 6) Hydromorphy: poor soil drainage. 7) Soil-water relationship: Oxisols and other soils dominated by LAC have a low available water content compared with soils characterized by HAC. This may represent serious limitations especially under seasonally dry climates. 8) Low silt content (texture). 9) Porosity: Prolongated cultivation of annuals does not cause an important change of total pores but may be at the origin of a decrease of the macroporosity in the topsoil due to a decline in the organic matter content. This decrease in macroporosity may reduce root penetration. 10) Shallowness: rock or a rock-like horizon close to the soil surface. 11) Erosion hazard: a high risk of soil erosion, caused by steep slopes, or moderate slopes in association with erosion-prone soils”.

4.3. Natural History

Some of the more well-recognized and charismatic mammals in the region include forest elephants, lowland and mountain gorillas, chimpanzees (**Figure 6**), bonobos, kapi, leopards, hippos (**Figure 7**), manatees, and lions. Other rainforest species include the recognizable tsetse flies, African Goliath beetles, and Congo African grey parrots. Several animal species, including mountain gorillas, chimpanzees, and African wild dogs are endangered. This is due to recent increases in deforestation and wildlife hunting.

The rainforest provides crucial ecosystem services, such as regulating the climate, preventing drought, preserving unique species, and providing a source of food and medicine to local communities, said Alexandra Tyukavina, an assistant research professor of geographical sciences at the University of Maryland in College Park, Maryland [12]. The Congo Basin rainforest is so valuable for sequestering carbon dioxide and producing oxygen that scientists have called the rainforest the world’s “second lungs,” following the Amazon rainforest, according to the European Space Agency.



Figure 6. One of the more recognizable species is the bonobo, or pygmy chimpanzee. Photo Credit: Shutterstock.



Figure 7. Two hippos in Congo river. Photo Credit: World Atlas.

4.4 Geological and Cultural History

Sautter and Pourtier [11] determined “*The Congo River took millions of years to attain its current form. Some geologists theorize that the Congo River was once connected to the Amazon when the continents were part of the major landmass called Gondwana prior to the continental drift. Although, this would be many hundreds of millions of years before the Pleistocene period, making it hard to confirm. According to scientists, it began to form around 2 million years ago during the Pleistocene period when many upper tributaries merged to form the major river system. As time passed, the river grew, amassing an increasing number of tributaries.*”

“*Humans have lived in the Congo River Basin for 50,000 years, and the area is now home to approximately 75 million people, including 150 distinct ethnic groups, according to the World Wildlife Fund. It’s the home of prominent hunter-gatherer groups, often referred to as Pygmies: Ba’Aka, BaKa, BaMbuti, and Efe, among others. The groups in the area that aren’t hunter-gatherers have relied on subsistence agriculture and bartering for goods for thousands of years, according to a 2015 review published in the journal Current Anthropology.*”

“*Archaeological evidence suggests that some tribes began to form villages along the Congo River around 4700 years ago. Remnants of iron tools and pottery suggest that some of the groups settled along the river around 5000 years ago when populations of Bantu-speaking peoples migrated from the savannahs of West Central Africa throughout the Congo Basin—an event known as the Bantu expansion*”[11].

For the past 2500 - 3000 years, the Congo River has been a staple for many communities along the banks. The earliest confirmed reports date back to the Bantu peoples and local aboriginals who lived in the region around 500 BC for around 1000 years. Utilizing the Congo basin and nearby areas as habitats, these groups thrived until the Kingdom of Kongo formed in the late 14th century [12]. This kingdom developed along the left banks of Lower Congo and was a turning

point for the river's exploration. This is because of the European exploration of Congo. Explorers such as Diogo Cão made notable discoveries here. However, the true extent of the Congo River was only discovered many years later, in 1877, by the explorer Henry Morton [11].

4.5. Sanley's Expedition

This expedition was undertaken to confirm if the Lualaba River fed the Nile, Congo, and other rivers. It began at Zanzibar in late 1874 with more than 200 people who sailed in 23 canoes. Throughout the journey [17], the group encountered hardships. It took two years for the group to reach Boyoma Falls and discover that the Congo and the Nile were not linked. It took another few months to reach Boma, where the group was rescued. By this point, many had perished, and only 108 were left! In more recent times, the Congo came to the news for a tragic incident. On February 15, 2021, a ship with 700 people sank in the river near Kinshasa, with 400 people dead or missing [18].

4.6. Ecology

Due to its size and other key elements, the Congo River and its basin are crucial to the ecological balance of the entire African continent. The river's basin encompasses the world's second-largest contiguous rainforest, surpassed only by that of the Amazon. The region is biologically diverse and a huge watershed. The northern and southern parts of the basin are characterized by open grasslands and scattered trees. Wildlife is abundant along the river, which itself harbors more than two hundred species of fish [19].

The Congo River is rich in biodiversity. The Congo River Basin is known to house at least 800 fish species (Figure 8), including many endemics, one of the world's highest, and possibly more, given that large parts of the river remain unexplored. Interestingly, the river is also the world's first place where biologists have found genetically distinct animal populations divided by river currents [19]. For example, researchers found two populations of similar looking but genetically distinct cichlids living on opposite riverbanks divided by strong currents.

Some of the Congo River's dominant fish families are the Carp, Elephant Fishes, African Tetras, Squeaker Catfishes, and Cichlids. The river is also home to the carnivorous Giant Tigerfish, known for its aggressive behavior. One can also find some unique fish species (Figure 8), such as the Cavefish and *Heterochromis multidentis*, which are rarely found elsewhere. The rich fish diversity makes the Congo River a fishing hotspot, sustaining the livelihoods of thousands of people [20]. The river's depths are also home to some unique species, such as the *Lamprologus lethops*, which live below 160 m.

Apart from fish, the river also supports many endemic frogs, snails, turtles, dwarf crocodiles, and snakes. Aquatic mammals of the Congo include the manatee, otters, and hippos. The forests and wetlands of the river basin also support over 250 species of indigenous birds in addition to several migratory species.



Figure 8. Spotted Cong puffer (fish). Photo Credit: World Atlas.

Although the Congo water discharge levels were unstable throughout the second half of the twentieth century, the hydrologic balance of the river has provided some relief from the drought that has afflicted the river basin. In 1999, the World Commission on Water for the Twenty-First Century found that the Congo was one of the world's cleanest rivers, due to the lack of industrial development along its shores until that time [21]. However, the situation is changing. Major threats to the large tropical rainforests and savannas are occurring due to the increasing population and its demands. Uncontrolled hunting and fishing, illegal logging and the poaching of large mammals, deforestation, unplanned urban expansion, and unrestrained extraction of oil and minerals are some of the major economic and environmental issues confronting the region [22].

4.7. Economic Importance of The Congo River

Factmonster [22] noted *“Covering a large portion of Africa, the Congo River also has immense economic significance for the region. While the many waterfalls along the course make the Congo difficult for long-distance navigation, many cities still use stretches of the river as a trade route (Figure 9, Figure 10). Commodities such as copper, sugar, cotton, and coffee are frequently traded via the Congo River. Apart from trade, the river is also a major energy source in Africa.”* *“With its tremendous water flow rate, it can produce an immense amount of power. The Congo River boasts an estimated hydropower potential of approximately 100,000 megawatts (MW), making it the highest in the world, yet only a small fraction of this potential is currently harnessed. According to scientists, the Congo Basin alone accounts for 13% of the world’s hydropower potential, more than enough needed for most of Africa. So, to extract this potential, there are currently 40 hydropower plants in the basin that power many local cities. The most significant hydropower initiative on the river is the Inga Dam Complex, which includes Inga I (commissioned in 1972 with a capacity of 351 MW), Inga II (commissioned in 1982 with a capacity of 1424 MW), and the proposed Inga III expansion, which*

aims to add 4800 MW and is currently under discussion and development. Moreover, plans are in place to develop and grow more hydropower plants to further utilize the Congo's energy potential."

"Thus, the Congo River is a lifeline for many African countries. It nourishes land through which it flows, keeps ecosystems like the massive Congo rainforest alive, provides hydroelectricity, allows trade, helps meet agricultural and industrial water requirements, and attracts tourism. While this river's length and breadth have been well-explored, much needs to be known about its great depths and the life that exists there" [22].



Figure 9. Container cargo ships in the Congo river. Photo Credit: World Atlas.



Figure 10. Vessel with passengers on Congo river. Photo Caption: World Atlas.

5. Results

5.1. The History of the Congo

Sautter and Pourtier [11] noted *“The region first became known as the ‘Congo’ in the late 1300s, from the kingdom of Kongo, an independent state, that ruled the area around the mouth of the river from the late 1300s through the 1800s, according to the Encyclopedia Britannica. In the late 1400s, Portuguese explorers arrived in the Kongo kingdom and established trade outposts along the Congo River, according to the BBC [23]. By that time, the slave trade had existed in Africa for centuries—historians estimate that African kingdoms sold captive prisoners of war to other African and Arab groups starting around 1000 B.C., according to the Encyclopedia of Migration’s ‘Trans-Saharan Slave Trade’. Portuguese traders quickly entered into the slave trade and began to send African slaves to plantations that other Portuguese traders had established on islands off the African coast, including Madeira and the Canary Islands, according to the United Kingdom’s National Archives. A couple hundred years later, throughout the 1600s and 1700s, European traders from other countries, including Denmark, England, the Netherlands, Scotland, and Sweden, came to the Congo region to seize African slaves for the trans-Atlantic slave trade.”*

“In 1885, King Leopold II of Belgium took control of the Congo region after signing a treaty with other European nations at the Conference of Berlin, according to the Encyclopedia Britannica. He called the region the ‘Congo Free State’. According to historians, Leopold ran a mercenary force that used murder and torture to force the native population to extract and export the region’s ivory, rubber, and other natural resources. Historians estimate that from 1885 to 1908, approximately 10 million people in the region died at the hands of the Belgians. History Today reported [23] and the legacy of Leopold’s cruel regime has haunted the region ever since. It was only about 110 years ago when this (King Leopold’s rule) ended, so there are still people in the region whose grandparents were directly affected by this.”

“After Leopold’s death, the region was annexed by the government of Belgium and ruled as the Belgian Congo from 1908 until 1960. The Belgian Congo leaders forced Congolese people to build road and railroad infrastructure for free, plantations and mining companies used indentured laborers, or forced laborers, who were later able to buy their freedom, according to the Encyclopedia Britannica. Congolese resistance movements had been challenging European colonial rule since the 1920s, but it wasn’t until 1958 that the nationwide Congolese political party, the Congo National Movement, rose to prominence. Skirmishes between Belgian forces and the Congolese broke out over the next year, and Belgium yielded to the nationalist forces.”

“In 1960, the country became independent, and political leader Joseph Kasavubu became the first president of the Democratic Republic of the Congo (then called the Republic of the Congo), serving from 1960 until 1965, according to the Encyclopedia Britannica. The fledgling independent government was divided and

weak, and became a proxy conflict (called the ‘Congo Crisis’) amid the Cold War between the United States and the Soviet Union, with each country supporting opposing Congolese political factions, according to the Atomic Heritage Foundation.”

“In 1965, Mobutu Sese Seko, a Congolese military officer, seized power through a coup, using his command of the Congolese army. He developed a totalitarian regime, amassed a large personal fortune, and became notorious for giving his corrupt friends and allies important positions in government. He was finally ousted more than 30 years later, in 1997, by a rebellion in the eastern part of the country. At that point, a civil war broke out and lasted until 2003. In 2006, the newly instated government held democratic elections.”

“But the region is still not entirely peaceful. The area continues to be haunted by ethnic conflicts, economic inflation, political corruption, European colonialism, and the Ebola virus. Because of so much political unrest, traveling along the Congo is unsafe in some areas. In January 2020, the Democratic Republic of the Congo issued a do-not-travel warning for certain provinces around the river due to the threat of ambush, armed robbery, and kidnapping which is prevalent around eastern DRC”[11].

5.2. Results Agriculture and Land Use

The Congo Basin is marked by a dominance of highly weathered soils (HWS), having an oxic or a kandic (argillic) horizon (**Figure 11**). According to Soil Taxonomy, Ultisols and Oxisols are the most common soil resource [15]. In their natural state, these HWS often maintain highly productive and diverse ecosystems that are dependent on efficient resource utilization. A characteristic of these systems is their reliance on SOM to cycle nutrients from the soil through the plant and hence back to the soil through plant debris. Soil organic matter (SOM) effectively acts as a slow-release nutrient delivery system that mediates the cycling of nutrients and chemical attributes of soils. However, when these ecosystems are disturbed through continuous cultivation, the productivity of many HWS often declines rapidly due to a loss of SOM, accelerated soil acidification, and a reduction in the CEC thereby limiting the ability of the soil to hold basic cations (nutrients), which are rapidly lost through leaching. It has however, been shown that intensive continuous cropping with annuals is possible with adequate use of fertilizers after annulation of the phosphorus fixation capacity and Al-saturation.

Shifting cultivation is by far the most widespread tropical soil management system [1]. The role of fallow in humid tropical areas is to regeneration of soil organic matter; immobilization of mineral elements; and elimination of weeds. The efficiency of a forest fallow depends mostly on its ability to create in a short time a vegetation which protects the soil against erosion [1]. The regeneration of the soil in organic matter is quite rapid. A forest fallow can rebuild the original organic matter level in about 10 years. The most essential function of the fallow, the accumulation of mineral elements in the aerial parts of the plants, is also gradual but

achieved in a later stage. The length of the fallow period depends on the quality of the soil and the fertility status when the field was abandoned. In the Congo basin, 12 - 14 years fallow was necessary on a Hapludox to regenerate the soil after a 2 - 3-year rotation including maize, rice, cassava and bananas [24]. On better soils the length of fallow remains similar, but the cropping period may be longer (5 - 6 years).

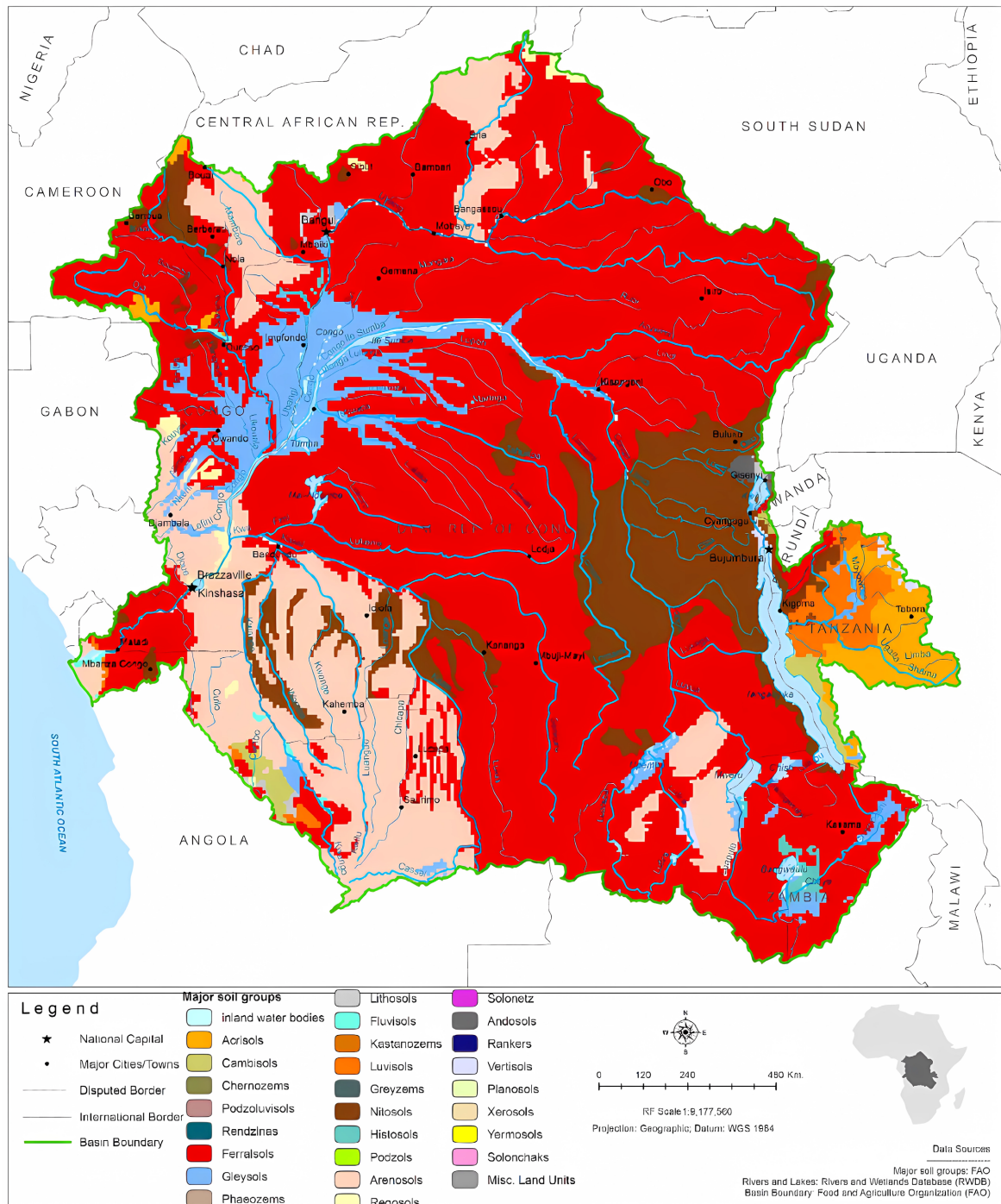


Figure 11. Soils map of the Congo Photo Credit: appsoilutelydigital.com.

The purpose of liming is primarily to neutralize the exchangeable Al, and this is normally accomplished by raising the pH to 5.5. When Mn toxicity is suspected, the pH should be raised to 6.0 (Mn is very soluble at pH values lower than 5.5. If this element is present in sufficient amounts, Mn toxicity can occur along with Al toxicity at pH values up to about 5.5 to 6.0). However, to increase the soil pH to 6, large inputs of lime are required which is inefficient because of the high buffering capacity in these HWS and may result in micronutrient deficiencies. The well-established practice of liming to neutrality is not effective in most of the HWS of the tropics. Often, liming to pH 7 causes more harm than good. Most plants grow well within a pH range of 5.5 - 6.5 and therefore a liming program should be aimed at maintaining the pH in this range [25]. Kamprath [26] reviewed the consequences of over liming in tropics are yield reduction; soil structure deterioration; and decreased availability of phosphorus, boron, zinc and manganese. Increasing the organic matter content is difficult to achieve under warm and humid conditions when the soil is regularly cultivated. Even if increasing the actual CEC is not feasible, current levels of exchangeable cations should be closely monitored to ensure there is no further decline because of decreasing organic matter levels under increasing cropping intensity or diversification into more demanding crops. In the tropical soil, the behavior of P fertilizers is very complex, because it is influenced by the solubility of different possible constituents and the pH.

5.3. Military History

The region surrounding the Congo River held an abundance of valuable resources, from freshwater to ivory to rubber to timber [23]. Governments have long fought for control of the Congo. The brutal colonial regime of the infamous King Leopold II of Belgium (Figure 12) from 1885 to 1908, memorialized in the 1899 novella, "Heart of Darkness," by Joseph Conrad [27], was one of the bloodiest.

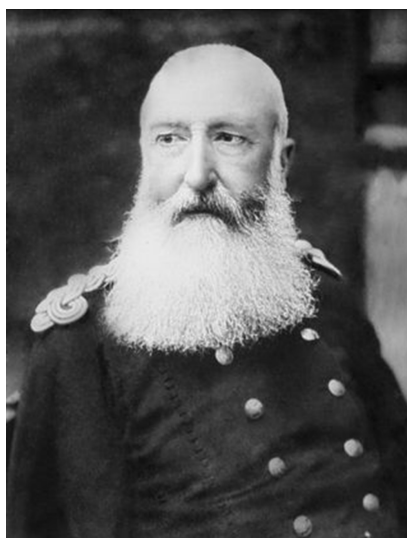


Figure 12. King Leopold II of Belgium. Leopold's brutal rule of the Congo was responsible for an estimated 10 million deaths. Photo Credit: Shutterstock.

The Great War of Africa, a conflagration that has sucked in soldiers and civilians from nine nations and countless armed rebel groups, has been fought almost entirely inside the borders of one unfortunate country—the Democratic Republic of Congo. The world’s bloodiest conflict since World War II is still rumbling on today. It is a war in which more than five million people have died, millions more have been driven to the brink by starvation and disease and several million women and girls have been raped [19].

5.4. Slavery

Secon [13] determined *“In the late 15th Century, an empire known as the Kingdom of Kongo dominated the western portion of the Congo, and bits of other modern states such as Angola. It was sophisticated, had its aristocracy, and had an impressive civil service. When Portuguese traders arrived from Europe in the 1480s, they realized they had found a land of vast natural wealth, rich in resources—particularly human flesh. The Congo was home to a seemingly inexhaustible supply of strong, disease-resistant slaves (human resources). The Portuguese quickly found this supply was easier to tap if the continent’s interior was in anarchy. They attempted to destroy any indigenous political force capable of curtailing their slaving or trading interests. Money and modern weapons were sent to rebels, Congolese armies were defeated, kings were murdered, elites slaughtered, and secession was encouraged.”*

“By the 1600s, the once-mighty kingdom had disintegrated into a leaderless, anarchy of mini-states locked in endemic civil war. Slaves, victims of this fighting, flowed to the coast and were carried to the Americas. About four million people were forcibly embarked at the mouth of the Congo River. English ships were at the heart of the trade. British cities and merchants grew rich on the back of Congolese resources they would never see. This first engagement with Europeans set the tone for the rest of the Congo’s history. Development has been stifled, government has been weak and the rule of law non-existent. This was not through any innate fault of the Congolese, but because it has been in the interests of the powerful to destroy, suppress, and prevent any strong, stable, legitimate government. The Congolese had threatened to interfere before, with the easy extraction of the nation’s resources. The Congo has been utterly cursed by its natural wealth [23]. The Congo is a massive country, the size of Western Europe” [13].

5.5. Natural and Human Resources

Snow [23] suggested *“Limitless water, from the world’s second-largest river, the Congo, a benign climate, and rich soil make it fertile, beneath the soil abundant deposits of copper, gold, diamonds, cobalt, uranium, coltan, and oil are just some of the minerals that should make it one of the world’s richest countries. Instead, it is the world’s most hopeless. The interior of the Congo was opened in the late 19th Century by the British-born explorer Henry Morton Stanley, his dreams of free trading associations with communities he met were shattered by the infamous*

King of the Belgians, Leopold, who hacked out a vast private empire.”

“The world’s largest rubber supply was found when bicycle and automobile tires and electrical insulation made it a vital commodity in the West. The Victorian bicycle craze was enabled by Congolese rubber, collected by slave laborers. To collect the rubber, Congolese men were rounded up by a Belgian officer security force, and their wives were interned to ensure compliance and were brutalized during their captivity. The men were then forced to go into the jungle and harvest the rubber. Disobedience or resistance was met by immediate punishment—flogging, severing of hands, and death. Millions perished.”

“Tribal leaders capable of resisting were murdered, Indigenous society was decimated, and proper education was denied. A culture of rapacious, barbaric rule by a Belgian elite who had no interest in developing the country or population was created, and it has endured. To end the brutality, Belgium eventually annexed the Congo outright, but the problems in its former colony remained. Mining boomed, and workers suffered in appalling conditions (Figure 13), producing the materials (Figure 14) that fired industrial production in Europe and America.”

“In World War I men on the Western Front and elsewhere did the dying, but it was Congo’s minerals that did the killing. The brass casings of allied shells fired at Passchendaele and the Somme were 75% Congolese copper. In World War II, the uranium for the nuclear bombs dropped on Hiroshima and Nagasaki came from a mine in southeast Congo. Western freedoms were defended with Congo’s resources while black Congolese were denied the right to vote, or form unions and political associations. They were denied anything beyond the most basic of education. They were kept at an infantile level of development that suited the rulers and mine owners. They made sure that when independence came, there was no home-grown elite who could run the country. Independence in 1960 was, therefore, predictably disastrous [13]. Parts of the vast country immediately attempted to break away, the army mutinied against its Belgian officers. Within weeks the Belgian elite who ran the state evacuated leaving nobody with the skills to run the government or economy” [23].



Figure 13. Girl walking through garbage in the Congo River. Photo Credit: aa.com.tr.



Figure 14. Two men in a boat surrounded by floating plastic garbage. Photo Credit: bornebulletin.com.bn.

Secon [13] noted *“Of 5000 government jobs pre-independence, just three were held by Congolese and there were no Congolese lawyers, doctors, economists, or engineers. Chaos threatened to engulf the region. The Cold War superpowers moved to prevent the other from gaining the upper hand. Sucked into these rivalries, the struggling Congolese leader, Patrice Lumumba, was horrifically beaten and executed by Western-backed rebels. A military strongman, Joseph-Desire Mobutu, who had a few years before been a sergeant in the colonial police force, took over. Mobutu became a tyrant. In 1972, he changed his name to Mobutu Sese Seko Nkuku Ngbendu Wa Za Banga, meaning ‘the all-powerful warrior who, because of his endurance and inflexible will to win, goes from conquest to conquest, leaving fire in his wake’. The West tolerated him if the minerals flowed, and the Congo was kept out of the Soviet orbit. He, his family, and friends bled the country of billions of dollars, a \$100 m palace was built in the most remote jungle at Gbadolite, and an ultra-long airstrip next to it was designed to take Concorde, which was duly chartered for shopping trips to Paris”*.

Gondola [18] found *“Dissidents were tortured or bought off, ministers stole entire budgets, and the government atrophied. The West allowed his regime to borrow billions, which was then stolen, and today’s Congo is still expected to pay the bill. In 1997, an alliance of neighboring African states, led by Rwanda—which was furious Mobutu’s Congo was sheltering many of those responsible for the 1994 genocide—invaded, after deciding to get rid of Mobutu. A Congolese exile, Laurent Kabila, was dredged up in East Africa to act as a figurehead. Mobutu’s cash-starved army imploded, its leaders, incompetent cronies of the president, abandoning their men in a mad dash to escape. Mobutu took off one last time from his jungle Versailles, his aircraft packed with valuables, his unpaid soldiers firing at the plane as it lumbered into the air.”*

“Rwanda had effectively conquered its titanic neighbor with spectacular ease. Once installed, however, Kabila, Rwanda’s puppet, refused to do as he was told. Again, Rwanda invaded, but this time they were just halted by her erstwhile African allies who now turned on each other and plunged Congo into a terrible war. Foreign armies clashed deep inside the Congo as the paper-thin state collapsed totally and anarchy spread. Hundreds of armed groups carried out atrocities, and millions died. Ethnic and linguistic differences fanned the ferocity of the violence, while control of Congo’s stunning natural wealth added a terrible urgency to the fighting. Forcibly conscripted child soldiers corralled armies of slaves to dig for minerals such as coltan, a key component in mobile phones, the latest obsession in the developed world, while annihilating enemy communities, raping women, and driving survivors into the jungle to die of starvation and disease” [18].

5.6. Threats to the Congo River Basin

Deforestation, primarily as part of modern agricultural practices, is the main environmental threat to the Congo River Basin and its rainforest (**Figure 15**). According to New World Encyclopedia [19], *“It’s mainly slash-and-burn agriculture, when people clear back and forth manually and clear-cut down the trees. And then they burn those logs to fertilize the soil with the ashes and grow crops there. Industrial logging is another driver of deforestation in the region”.*



Figure 15. Rain forest along the Congo river. Photo Credit: blogspot.com.

In addition, as the population in the region has grown at a rate of about 1.7 million people each year, according to the World Wildlife Fund, so has the demand for food. Bushmeat, or meat from wild animals like bats, monkeys, rats, and snakes, which hunter-gatherer groups have traditionally relied upon as their main food source, now faces a new threat: overhunting.

“Bushmeat is a good, important source of protein for people throughout the

Basin”Tyukavina said. However, commercial hunters have increasingly targeted animals like monkeys and antelope for the commercial bushmeat trade [13]. These midsize mammals did not reproduce fast enough to compensate for the high rate of hunting, causing their populations to decline. Elephants are also at risk from poachers looking to profit from the international ivory trade.

To encourage the development of a comprehensive master plan for hydropower utilization from the Congo River, several strategies can be employed. Despite its immense potential, the Congo River has been marred by a history of exploitation that has left local communities vulnerable. Congo should be one of the world’s richest regions with an abundance of mineral deposits, rich soil, and the immense potential of the Congo River to meet the overarching energy demands of the rest of the world. The ongoing conflict and legacy of colonial exploitation has resulted in profound socio-economic challenges. According to qualitative reports, a complex web of domestic and international rivalries continues to destabilize the region, with local populations often marginalized and left without adequate support.

To this end, it is critically important to conduct extensive feasibility studies that assess not only the hydropower potential but also the social, environmental, and economic impacts of large-scale projects [28]. Polido *et al.* [29] emphasized *“Integrating environmental and social considerations into energy planning, suggesting that thorough environmental impact assessments (EIAs) can identify potential risks to local ecosystems and communities while fostering stakeholder engagement. Incorporating the insights of local populations and environmental experts into the master plan will help minimize adverse effects and maximize community benefits”*.

Moreover, regional cooperation among Central African nations is crucial for successful hydropower development. Collaborative frameworks can facilitate the sharing of technology, resources, and funding, enhancing energy security and economic integration [30] [31]. By leveraging existing infrastructure and investing in cross-border electricity trade, countries can optimize the hydropower potential of the Congo River while fostering sustainable development across the region.

Lastly, innovative financing mechanisms such as public-private partnerships (PPPs), blended finance, green bonds, crowdfunding, social impact bonds, and results-based financing etc. must be incorporated into the master plan to attract investment for hydropower projects. Public-private partnerships (PPPs) have proven effective in mobilizing capital for infrastructure projects [19]. Governments can stimulate private sector participation by offering incentives such as subsidies for renewable energy investments or tax breaks. These combined approaches can position the Congo River as a key asset in Africa’s energy landscape, driving sustainable economic development and growth while ensuring that the well-being of local communities and livelihoods are safeguarded.

6. Summary

The primary objective of this study was to encourage the development of a master

Africa plan for more hydropower utilizing the Congo River's potential as the continent's energy lifeline. However, when new dams are built within the Congo, existing communities will require resettlement. The population might suffer from a lack of adequate compensation, loss of productive agricultural lands, loss of fish habitat, problems with reduced food security, and increased incidence of disease. Steps will have to be taken to reduce environmental impacts to ensure that people's livelihoods are restored.

As population for Congo basin increases and demand for food rises, there will be increasing demand for suitable agricultural land to provide the agricultural products. Farmers will have to decide if they are more concerned with short-term yields or long-term sustainability and soil management [1]. Their decisions may be detrimental to preventing global climate change since recent research has shown that tropical forests have been converted to sustainable agriculture. We need detailed information from soil maps to translate soil characteristics into agronomic constraints and land use suitability. There are some substantial data limitations to the sources used. The reliability of some of the maps and data is known to be relatively low. Soil degradation and the decline of soil chemical fertility are major concerns in relation to sustainable management of land and food production in Congo Basin. Conserving soil nutrients and organic matter are practices that must be followed if sustainable agriculture is to continue to meet increasing global demand.

According to Holly Secon [13], *“A deeply flawed; partial peace was patched together a decade ago. In the far east of the Congo, there is once again a shooting war as a complex web of domestic and international rivalries see rebel groups clash with the army and the UN, tiny community militias add to the general instability. The country has collapsed, roads no longer link the main cities, and healthcare depends on aid and charity. The new regime is as grasping as its predecessors. Trainloads of copper, straight from foreign-owned mines to the border, and on to the Far East, rumbling past shanty towns of displaced, poverty-stricken Congolese. The Portuguese, Belgians, Mobutu, and the present government have all deliberately stifled the development of a strong state, army, judiciary, and education system, because it interferes with their primary focus, making money from what lies under the Earth. The billions of pounds those minerals have generated have brought nothing but misery and death to the very people who live on top of them while enriching a microscopic elite in the Congo and their foreign backers and underpinning our technological revolution in the developed world. The price of that myopia has been human suffering on an unimaginable scale”*.

The Congo River is a lifeline for many African countries. It nourishes land through which it flows, keeps ecosystems like the massive Congo rainforest alive, allows trade, provides hydroelectricity, helps meet industrial and agricultural water requirements, and attracts tourism. While this river's length and breadth have been well-explored, much needs to be known about the existing population. In addition to trade, the river is a major energy source in Africa. With its tremendous

flow rate of about 41,000 m³/s, it can produce an immense amount of power. The Congo Basin alone accounts for 13% of the world's hydropower potential, which is more than enough to meet the needs of most of Africa.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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