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EXAMINING THE STRENGTHS OF THE NIGERIAN NATIONAL BIODIVERSITY ACTION PLAN AND ENVIRONMENTAL POLICY IN ADDRESSING THE CHALLENGES OF THE COVID 19 PANDEMIC: THE PERSPECTIVE OF AQUATIC ECOLOGISTS

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ABSTRACT

Background: The biological resources of Nigeria are under increasing threat from natural disasters and human activities especially during the COVID-19 pandemic. There are ominous problems with the environment and visible scars associated with the destruction of the natural resources upon which all life depends. Although, Nigeria's National Biodiversity Strategy and Action Plan (NBSAP) was put in place to address these critical sectors however, the challenges have been with the implementation. This perceived difficulty creates an unending vacuum between the policy guidelines and implementation, especially in emergencies like the outbreak of the coronavirus. A novel disease, SARS-CoV-2 (formerly 2019 nCoV, isolated on 7th January, 2020) came to light, causing a contagious respiratory disease, and named coronavirus disease 2019, on 11th February, 2020 by the World Health Organization (WHO). The coronavirus disease 2019 (COVID-19), is a viral pneumonia with symptoms such as dry cough, fever, sore throat, dyspnea, body pain, and diarrhoea. This disease emerged in December, 2019 in Wuhan, in the Hubei province of China, and within three months, had spread globally, prompting WHO to declare it a threat to world health.
Objective: This review examined the strengths of the Nigerian National Biodiversity Strategy and Action Plan in addressing the challenges of the COVID-19 pandemic, given the bottlenecks associated with the implementation of the provisions of these policies
Methods: The instrument of the literature review was employed in the study.
Results: The pandemic has provided empirical evidence, to determining alternative and complementary activities, that can be deployed to mitigating socio-economic losses due to COVID-19, while ensuring the sustainability of aquatic ecosystem.

Keywords: Nigerian Environmental Policy, Biodiversity Action Plan, COVID-19 Pandemic, Aquatic Ecosystem

INTRODUCTION

Nigeria's biological resources are critically threaten from human activities and natural disasters (**NPE, 2016)**. There are certain ominous problems with the environment and visible scars associated with the destruction of the base (land, water and air) of natural resources upon which all life depends. The country's large population of about 170 million and its rapid growth rate of 2.8 percent are contributing to its environmental degradation (**NPE, 2016)**.

One of the key environmental issues facing Nigeria is aquatic pollution and the general degradation of aquatic ecosystem. Major sources of aquatic pollution include; urban wastewater, agricultural waste, and industrial effluents (Martins *et al*., 2014). Polluted aquatic environments are considered a human health threat that poses a lot of environmental health challenges (Elsamadony *et al*., 2021). The severity of pollution-related problems in the global aquatic environment has been widely and frequently reported in several studies (Kiani and Rahimpour, 2020; Kuroda and Kobayashi, 2021).

The intention of the Nigerian government in the National Environmental Policy (NEP) and Biodiversity Action Plan (BAP) is to achieve sustainable development through mechanisms and procedures spelt out in the respective documents. This was made possible due to the numerous contributions from and consultations with Federal and State Agencies, experts from Universities, and International Agencies. Ideally, environmental policy should guide the efforts towards the attainment of sound environmental management and sustainable utilization of natural resources (Gordon, 2012).

The United Nations Environment Programme (UNEP-WCMC, 2013) stipulates that a sound environmental policy must address four cardinal issues (energy, health, agriculture and population). Also, the United Nations Development Programme (UNDP, 2015) emphasised sustainable resource exploration and conservation of biodiversity. Despite the fact that Nigeria's National Policy on Environment addressed these sectors, the issues have been with the strategies for implementation. Because, the strategies adopted for implementation are deficient and have not been sufficiently wired to achieve the overall policy aims (FMEnv, 2015).This apparent difficulty creates a lacuna between the policy guidelines and implementation, particularly in emergency situations such as the challenges posed by the outbreak of the coronavirus.

Some years ago, scientists warned that the high rate of interaction and consumption of wildlife, particularly horseshoe bats in China, was a time bomb that could potentially cause the reemergence of severe acute respiratory syndrome (SARS) viruses or the appearance of unknown viruses (Culliton, 1990; Corman *et al*., 2018; Sharp *et al*., 2020). This warning was ignored, and subsequently, a novel coronavirus, SARS-CoV-2 (formerly 2019 nCoV, isolated on 7th January, 2020) came to light, causing a contagious respiratory disease, and named on 11th February, 2020 by the World Health Organisation (WHO) as coronavirus disease 2019 (COVID-19).

The coronavirus disease 2019 is a viral pneumonia with symptoms such as fever, dry cough, sore throat, body pain, dyspnea, and diarrhoea (WHO, 2020b). This disease appeared in December 2019 in Wuhan, Hubei province of China, and within three months, had spread across the globe, prompting WHO to declare it as a threat to world health (Andersen *et al.* 2020; Grant *et al*., 2020; WHO, 2020a). According to Hu *et al.* (2021) COVID-19 of the family Coronaviridae was in circulation within a family of four members, causing respiratory infections, and as at 14th April, 2020, there was a total of 1,978,769 confirmed COVID-19 cases and 125,196 deaths were reported in 213 countries (WHO, 2020a). The mortality rate of COVID-19 varied between countries,and in some countries, age has been shown to impact mortality; the older the population, the higher the rate of mortality (*Levin et al*., 2020; Liu *et al*., 2020). The severe form of coronavirus disease 19 occurs in three phases: the viral, pulmonary, and hyper-inflammatory, that could lead to severe acute respiratory distress syndrome (ARDS), impaired cardiac function, and eventual death (Levin *et al*., 2020). In the absence of comorbid conditions, the chance of surviving SARS-CoV-2 infection for those above 60 years is about 95%, and it decreases substantially if the patient has underlying health conditions (Levin *et al*., 2020).

Furthermore, because COVID-19 spread at a fast rate, individuals from vulnerable health and poor socio-economic backgrounds such as Nigerians are particularly at risk (WHO, 2020b).

A big concern is the medical waste resulting from the COVID-19 crisis, where COVID-19 patients are being treated, wastes from quarantine areas, in addition to the disposable personal protective equipment used by the health workers. Medical Waste and many disposable materials (such as gloves, facial masks, and shoes) are made of materials hardly decomposable in nature and can be harmful to all environmental elements. Another potential negative effect of COVID-19 stems from the production and extensive use of sanitization chemicals and disinfectants containing environmentally toxic materials.

Most of the wastes generated from the activities described above actually ended up in polluting aquatic environments, because many people erroneously believed that the aquatic environment has a limitless capacity to absorb any quantity of any waste type.

Consequently, this has resulted in a major biodiversity crisis in the aquatic environment. Additionally, it has been suggested that both surface and groundwater represent SARS-CoV-2 entry points through, possible contamination from health care facilities, sewage, and drainage water (Hata *et al*., 2020; Kitajima *et al*., 2020; Kataki *et al*., 2021).

Pollution and water flows are closely coupled given that concentrations of a pollutant equal its mass divided by the water volume. In economic terms, pollution decreases the supply of clean water and adds to the costs of water use. Water availability is a major determinant of human health, particularly in regions of the world like Nigeria where there is limited economic development (WHO, 2020b). The risk of waterborne diseases increases when encounters between aquatic vectors and humans are high, as occurs when water is scarce and people aggregate around limited water points or when water is abundant and aquatic vector populations (such as mosquitoes) are widespread (Gwenzi, 2021).
Besides, waterborne diseases have been known to emerge in the absence or compromised waste water management infrastructure (Guerrero-Latorre *et al*., 2020). However, Nigeria's long term vision for biodiversity management is to have a healthy living environment where people live in harmony with nature, and sustain the benefits of biodiversity, while integrating biodiversity into National programme to reduce poverty and ensure ecological sustainability (FMEnv, 2015). The major focus of this vision is the consideration of a fragile resource to be sustainably utilized, and more importantly, to be deployed as natural capital for socio-economic development of Nigeria.
Hence, in this review, the possibilities of achieving the aforementioned long-term vision as encapsulated in *National Biodiversity Strategy and Action Plan (*NBSAP) 2016-2020 and the objectives stated in the National Policy on the environment in emergencies, such as the case of coronavirus pandemic were examined.

The fragile state of the world's aquatic ecosystem

Recent changes in the world's aquatic systems are remarkably alarming such that adequate attention must be placed on strategies to better and correct these changes for aquatic ecosystem services to be sustainable (UNEP-WCMC, (2013). The major drivers of these changes include: climate change, human modification of water flows, land-use and cover alterations, chemical inputs, aquatic invasive species, human harvest and aquaculture.

Global Climate Change

Climate change has direct impact on aquatic ecosystem due to elevated temperatures, variability of precipitation and rising in sea level. Kubicz *et al*. (2021) observed increased precipitation over land north of 30°N since 1901, reduced precipitation over land between 10°S and 30°N after the 1970s, and increasing intensity of precipitation in some regions and droughts in other regions. Changing temperature and precipitation are linked with the decreased extent of glaciers and duration of ice cover, increased thawing of permafrost, and changes in evapotranspiration, streamflow and lake level (Van der *et al*., 2010).
Warmer water temperature reduces the availability of oxygen for respiration by aquatic organisms, and the processing of organic matter. It also reduced thermal niche and habitat availability for aquatic organisms that require cold water, such as salmonid fishes (Rahel, 2002).

Moreover, at higher latitudes and elevations, warming reduces the duration of the ice season and melts glaciers and permafrost, resulting to changing in the seasonality, magnitude, and sources of hydrologic flows. Additionally, the effects of rising sea levels on lowland rivers are worsened by decreased buildup of sediment due to siltation in impoundments upstream and decreased runoff due to irrigation (Shiklomanov, 2000; Van der *et al*., 2010).

The Hydrologic Change

Water resource development and management attempt to make water accessible for all human needs at all times. There is tendency to either store or divert water when it is present in excess or procure it when it is not enough, which is usually accomplished by irrigation, drainage, impoundment, inter-basin transfer among others (D'Aoust *et al*., 2009). These manipulations and climate change, have resulted in the alterations of hydrologic regimes of the world's aquatic ecosystems.

Noticeably, over large continental areas, human demand for freshwater approaches or exceeds the current supply, and about 2.4 billion people live in water-stressed environments (Oki and Kanae, 2006). Therefore, the provision of water to water-stressed regions for human needs is habitually done at the expense of aquatic systems.

Surface water storage in ponds and reservoirs is the most common strategy for ensuring a reliable water supply, because dam-building can also be used for electricity generation and flood control (Nilsson *et al*., 2005).

However, reservoirs have transformative impacts on rivers, including fragmentation, flow regime modification, enhanced evaporative loss, and increased water residence times.

In the past two decades, dam construction has shifted from developed to developing regions, particularly in India, China, and South America (Fujikura and Nakayama,2009).

Thus, hydrologic changes to rivers are continuing to increase both in spatial extent and degree of alteration and with increase of about 900% in some areas of Africa (D'Aoust *et al*., 2009).

The Change in Land-Use

The conversion of natural lands to human use and the modification of management practices on human-dominated lands, is a major driver of ecosystem change (Foley *et al*., 2005). Conversion of natural ecosystems to cropland or urban uses generally increases flood frequency and intensity, and reduces groundwater recharge. Comparatively, agriculture uses the greatest amount of freshwater (Foley *et al*., 2005), and releases the highest levels of greenhouse gases into the atmosphere (MEA, 2005).

Therefore, agricultural production will impact freshwater sources directly, through nutrient emissions, water withdrawals, and effects on riparian ecosystem, and also indirectly through climate change.

Chemical inputs into the aquatic system

The increase in chemical inputs to aquatic environment is a result of diffuse inputs from landscapes dominated by human use, atmospheric sources and from direct discharges of waste waters from industries, and municipal sewage (Pacini *et al.,* 2019). The chemicals added to aquatic systems includes organic compounds, heavy metals, acids, and alkalis, some of which are toxic to aquatic organisms. Additionally, the rapid urban population growth in developing countries interact to create water quantity and quality problems (Pacini *et al.,* 2019). Although, wastewater treatment mitigates nutrient and organic matter loading to aquatic systems however, the treatment of point-source effluents is more common in developed nations, as less than 20% of the population was connected to sewer systems in Africa and southern Asia (Shiklomanov, 2000).

The aquatic invasive species

The species invasion is now recognized as an important driver of global environmental change, and most aquatic ecosystems are especially vulnerable to species invasion and its effects (Mack *et al*., 2000). Although many aquatic invasive species were accidentally introduced, others have been deliberately stocked for aquaculture, pest control, aesthetic reasons, among others.

Aquatic invasive species have changed the physical, chemical, and ecological conditions of aquatic systems, thereby threatening aquatic ecosystems and biodiversity. For instance, the introduction of predatory sport fishes is the major threat to endemic fishes in the western United States (Minckley and Deacon 1991). The spread of non-native aquatic species is a key contributor to the ongoing biotic homogenization of aquatic ecosystems (Ross, 1991).

Harvest of aquatic resources

Aquatic resources, particularly fish, invertebrates, birds, reptiles, and amphibians, are harvested for local subsistence, commercial use, recreational use, or pet trade.

The "global fisheries crisis" has focused almost exclusively on marine ecosystems, while the impacts of recreational fishing and overfishing of inland waters have garnered increased attention (Post *et al*., 2002; Allan, *et al*., 2005). Declining fish stocks and increasing demand for fish have led to sharp increases in aquaculture production in recent decades, and has led to increase in the harvesting of wild fish for feed, water pollution, altered hydrologic flows, and the accidental release of non-native species (Carpenter and Biggs, 2009).

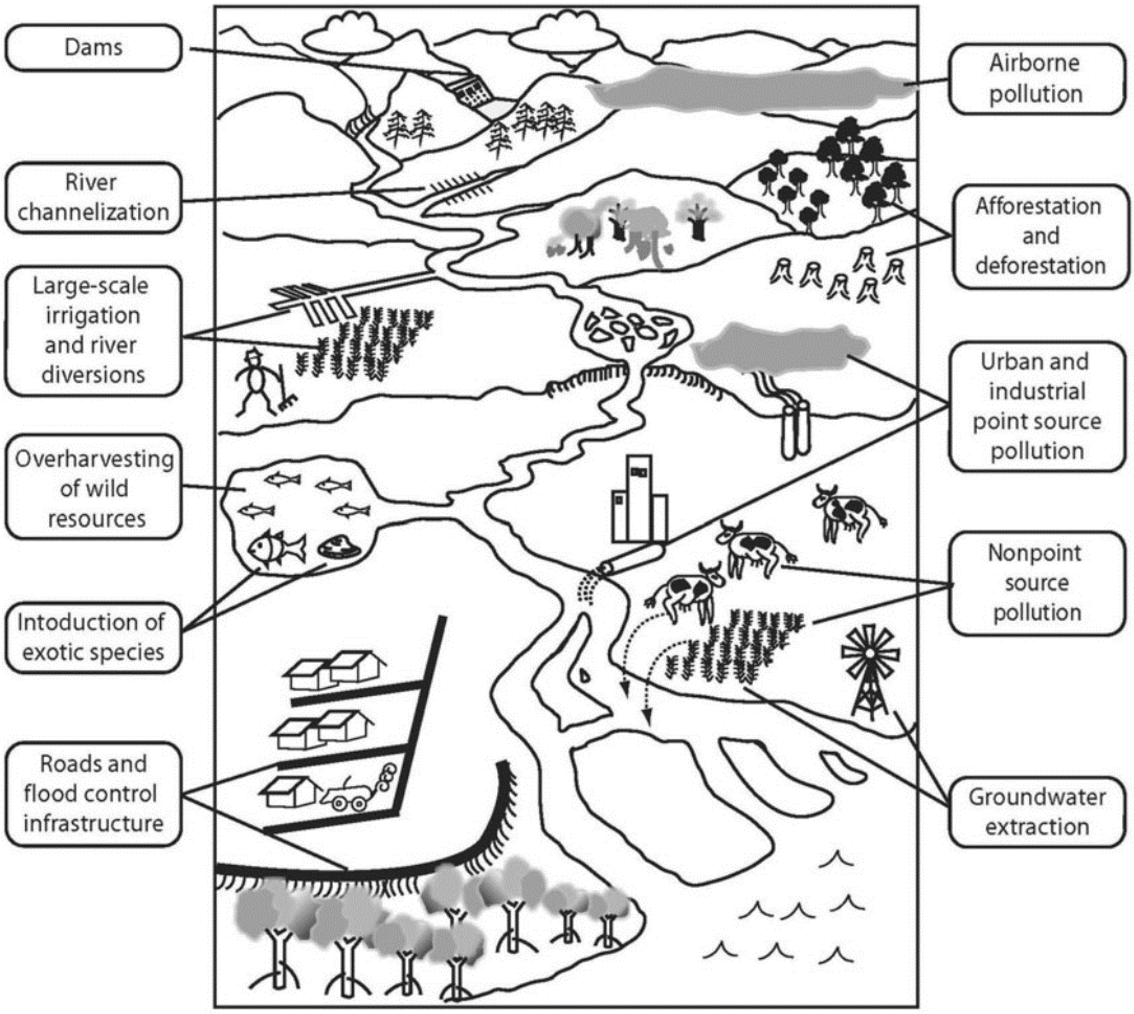

Fig. 1. Many interacting drivers, and interacting responses, affect the condition of freshwaters on any particular landscape. Source: Carpenter and Biggs (2009).

Nigeria houses a cornucopia of aquatic plants and animal species, making it very rich in aquatic biodiversity (FMEnv, 2015).

The four major drainage systems in Nigeria are:

• The Niger River Basin Drainage System
• The Lake Chad Inland Drainage System
• The Atlantic Drainage System at the east of the Niger.
• The Atlantic Drainage System at the west of the Niger

Nigeria has a population of over 100 million, spread unevenly over a national territory of 923,770 km^2 (Ekubo and Abowei, 2011). The expanding human activities have extensively altered the aquatic systems, with modifications impacting the physical, chemical, and biological features (Fig. 1).

Water pollution in Nigeria occurs in both rural and urban areas. In rural areas, drinking water from natural sources such as rivers is usually polluted by organic substances from upstream users. The most common form of stream pollution is forestry activities which result in increased concentrations of soil particles washed into the stream by land disturbance. Studies have shown that the suspended matter can obstruct the penetration of light and limit the photosynthetic zone to less than 1 m depth (Adedeji and Adetunji, 2011).

Many factories in Nigeria are located on river banks and use the rivers as open sewers for their effluents. The major industries responsible for water pollution in Nigeria include petroleum, mining, wood and pulp, pharmaceuticals, textiles, and plastics (Kanu and Achi, 2011). Additionally, from time to time accidental oil spillages occur which endanger local sources of water supply. The most affected tend to be the urban and landless poor. Also, of major environmental concern is the direct discharge of raw faces into aquatic systems (Kanu and Achi, 2011) . In the future, the present level of environmental degradation could create health problems from waterborne diseases for most of this population.

Aquatic ecosystem services and human well-being

Aquatic ecosystem services are the gains that humans derive from nature (UNEP-WCMC, 2013, Álvarez-Ruiz and Pico, 2020) (Table 1). Ecosystem services from the aquatic environment include fishes, plants and flows that are withdrawn for irrigation and municipal use (Brauman *et al*., 2007).

The disease can be regulated by ecosystem processes, such as the association of cholera outbreaks with phytoplankton blooms).

The ecosystems also provide cultural benefits in areas of education, recreation, disease regulation and spiritual values (Ayeni, 1995; Borokini, 2014).

Table 1. Examples of ecosystem services

Provision Services	**Crops, livestock, capture fisheries, aquaculture, wild plant and animal products, freshwater etc.**
Regulating services	Regulation of climate, water, erosion, diseases, pests, air quality, natural hazards etc.
Cultural services	Spiritual and religious values, recreation and tourism, educational values etc.
Supporting Services	Soil formation, primary production, nutrient and water cycling.

Emergence and Transmission of Diseases in Aquatic systems

The risk of waterborne diseases is elevated when there is a high encounter between aquatic vectors and humans such as when people aggregate around limited water points or when water is abundant and mosquitoes are widespread (Edinger *et al*., 1998; Corpuz *et al*., 2020). Also, contamination of domestic water supplies with feaces increases the risk of cholera, and a range of parasitic infections. Likewise, impoundments increase the spread of diseases such as schistosomiasis and malaria by creating a the habitat for aquatic diseases vectors such as snails and mosquitoes (Foley *et al*., 2005).

Biodiversity loss frequently increases the incidence of human and wild-organism diseases (Morens *et al*., 2008; Guerrero-Latorre *et al*., 2020). Also, pathogenicity, host susceptibility, and disease spread can be affected by the trophic status of an infected water body (UNEP-WCMC, 2013). In addition, eutrophication in conjunction with agrochemicals often increases infection risk that weakens host resistance (Van der *et al*., 2010).

The aquatic ecosystem as a transmission route for COVID-19

Aquatic environments have been linked to the SARS-CoV-2 virus (Liu *et al*., 2020; Lodder and Husman, 2020; *Meyerowitz et al., 2021*). Water pollution problems were heightened during the period of coronavirus disease. Also, it has been established that the Corona virus can remain active for some time in waste waters from hospitals, and faecal discharge from individuals infected by the virus (Hata *et al*., 2020; Juan-Reyes *et al*., 2021). However, based on the SARS-CoV pandemic in 2003, it was reported that the virus can multiply within a short time if disinfection is not done and can be contagious (Kiani and Rahimpour, 2020). Accordingly, studies have shown that the survival of coronavirus in the aquatic environment depends on the following factors, which include temperature, organic matter, exposure to light and antagonistic microbes (Farkas *et al*., 2020; Kitajima *et al*., 2020).

The following are some important facts about COVID-19 in freshwater, wastewater and its management (WHO, 2020c):

COVID-19 virus in the stool of infected patients: A high concentration of coronavirus in the stool of hospitalized patients with COVID-19 has been reported by Wölfel *et al*. (2020).

The genetic material of the COVID-19 virus found in sewage water: The virus was first detected in sewage, when samples from 7 cities and an airport were tested during the outbreak in the Netherlands (Medema *et al*., 2020).

Access to good water supply and sanitation can reduce the occurrence of infectious diseases including COVID-19*:* A technical guide published by the World Health Organization (WHO, 2020c) on the use of water, water sanitation, and management of wastes from health care facilities could be useful in preventing coronavirus disease.

Household water treatment can remove viruses from water*:* There is suitable technology for water treatment at homes against viruses, which include boiling, chlorination, and ultrafiltration. Also, the World Health Organization has published two reports (Round I and II) on the various household water treatment procedures and their effectiveness in the removal of viruses (WHO, 2020c).

The transmission of the COVID-19 virus through the toilet and other surfaces*:* The health facilities treating cases of COVID-19 patients have been reported to be the most contaminated areas. Also, it has been reported that human coronaviruses such as SARS and MERS, or HCoV can persist on metal, glass, or plastic for up to 9 days (Culliton, 1990; Corman *et al*., 2018; Corpuz *et al*., 2020). Surface disinfection with 62–71% ethanol or 0.5% hydrogen peroxide was recommended to inactivate coronaviruses within one minute.

The spread of the virus through surfaces can be effectively prevented by regular washing of hands with soap*:* There are guidelines on hand hygiene in health care situations published by the World Health Organization (WHO, 2020).

The coronavirus spreads through water droplets from sneezing, coughing or on contaminated surfaces*: Studies* during the COVID-19 outbreak in Wuhan city, China, on six family members after visitation to a hospital in the city revealed that, person-to-person transmission of the virus is very consistent in family settings, hospitals, and infected travelers from other regions (WHO, 2020a).

Effects of substances used for the control and treatment of coronavirus on the aquatic systems

In the United States, guidelines for the treatment of wastewater were released by the Occupational Safety and Health Administration (OSHA) to protect the public and aquatic ecosystem from the coronavirus. The procedure involves the processes of oxidation of wastewater with chlorine and the use of ultraviolet radiation for virus inactivation (OSHA, 2020).

Chlorine disinfectants: The use of chlorine for disinfection remains the best economical solution for the inactivation of the virus however, chlorine treated wastewater may find its way into aquatic environment thereby, causing secondary infection and threatening the survival of aquatic biodiversity (Zhang *et al*., 2020). It can harm aquatic organisms by damaging their cell walls or their protein through oxidation and the chemicals in the disinfectant can bond with other materials to form injurious compounds in water.

Bleach as disinfectant: Bleach is a very strong disinfectant that inactivates bacteria, viruses, and fungi with active ingredient sodium hypochlorite. It is recommended at 0.5% for surface cleaning in household and hospital facilities. Its limitations are that it can irritate the mucous membranes in humans and react easily with other chemicals in the water (WHO, 2014).

Alcohol as disinfectant*:* The use of 70% ethyl alcohol is very effective in fighting against the influenza virus. It is very flammable and can be used to disinfect external surfaces of equipment. If used repeatedly on a particular surface, it may result in hardening, discoloration, or cracking of such surfaces (WHO 2014)

Impact of COVID-19 on the health and management of aquatic ecosystems

The COVID-19 pandemic affected virtually all sectors and the biodiversity conservation sector at all levels. Some of the major effects are as follow:

Municipal solid wastes discharged into the aquatic environment*:* The COVID-19 pandemic has created a new form of pollution in the environment. To control and avoid the spread of this contagious virus, WHO has advised the health workers, front liners, and the public to wear personal protective equipment such as wearing face masks and gloves, particularly in the infected area (WHO, 2020b). However, there is a lack of adequate information and guidance to the public on how to properly dispose this equipment.

Healthcare waste in the aquatic environment: The use of pharmaceuticals and drugs to combat the COVID-19 pandemic is unavoidable. Pharmaceuticals compounds from different classes such as chloroquine, hydroxy chloroquine, azithromycin, remdesivir, lopinavir, ribavirin, and ritonavir have been widely used to treat the patients with coronavirus infection (Baron *et al*., 2020; Fanin *et al.,* 2020) (Table 2). Therefore, there is a concern about the elevated level of pharmaceutical residues that might end up in the aquatic environment due to the increasing number of pharmaceuticals and drugs used in medical facilities (Table 2).

Plastic pollution in the aquatic environment: The increase of single-use plastics during the COVID-19 pandemic is inevitable. Frontliners use plastics as their protective gear and people have been taking takeaway food using plastic containers. Many grocery stores and restaurants have also prohibited their customers from bringing their containers or shopping bags to avoid cross-contamination. Praveena and Aris (2021) reported that massive plastic waste was generated in many capital cities in South East Asia countries such as Kuala Lumpur, Bangkok, and Singapore.

Greywater runoff into the aquatic environment Greywater is the wastewater produced from houses such as bathtubs, hand basins, dish washers, and laundry machines. Urban runoff from greywater consists of body care products, food residue, oil, and bleacheswhich develop into pollutants such as organic carbon, total solid, total suspended solid, and nutrients (Noutsopoulos *et al*., 2018). Greywater channelled into the urban runoff is usually discharged into the stream network and usually carries some amount of dissolved nutrients which may lead to low dissolved oxygen in aquatic systems (Liang et al. 2019). The stay at home policy during COVID-19, made the amount of greywater produced to increase, and which further perturbed aquatic systems.

Zoonotic diseases in fish and marine mammals: World Health Organization define zoonoses as diseases or infections that are naturally transmitted from animals to human.

Coronaviruses such as COVID-19 are common pathogens of the respiratory system and gastrointestinal tract in domestic animals and wildlife. Concern has been raised about whether this virus will contaminate the fish as the main protein source of maritime countries. The five genera of coronavirus that usually infect only birds and mammals do not belong to the family Coronaviridae therefore, fishes are not susceptible to this virus (Hemida and Abduallah, 2020).

Table 2. Classification of healthcare wastes

Non-hazardous or general waste	**The types of waste that do not pose any biological, chemical, physical or radioactive hazard.**
Infectious waste	These are wastes contaminated with blood and other bodily fluids, cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animal), or waste from patients with infections.
Pathological waste	These are human tissues, organs or fluids, body parts and contaminated carcasses
Chemical waste	Disinfectants, Solvents and reagents, and heavy metals contained in medical devices and batteries.
Cytotoxic waste	Waste with genotoxic properties such as cytotoxic drugs used in cancer treatment and their metabolites.
Radioactive waste	These are products contaminated by radionuclides or radiotherapeutic materials
Pharmaceutical waste	These include expired, contaminated drugs and vaccines.

Source: Compiled by Authors based on WHO (2014)

General impact of Covid-19 on Global Economy

Shortage of Skilled Personnel and loss of funds: Economically, pandemic imposed high financial loss on both government and conservation organization. The loss of trained staff to the pandemic is devastating in developing countries where conservation capacity is limited. For example, 40 Rangers lost their jobs in the Mara Nabisco Conservancy in Kenya due to the drastic reduction in tourism revenues which was used to pay their salaries (UNWTO, 2020).

Ineffective and Lukewarm attitude of Staff: Psychologically, staff members preferred to care for their relatives that are sick than going to work. For examples, many protected areas in Africa, Latin America and other parts of Asia experienced poor attendance by workers due to the outbreak of the COVID-19. This attitude led to an increased number of poaching incidents, deforestation, and wildlife loss in Uganda and Cambodia during the lockdown period (Waithaka, 2020).

Weakened Performance in the Protected Area: Practically, there was no supervision of patrols in protected areas, because the superior officers are all home because of the lockdown. Therefore, making it possible for poachers to gain unhindered access to wildlife resources (Waithaka, 2020).

Reduced Revenue and Staff Strength during the pandemic: Revenue from tourism is the major source of funding for most government agencies responsible for administration of protected areas. Loss of revenues from tourism in protected areas also lead to staff dismissal (Weaver and Makiwa, 2020). According to UNWTO (2020), 100% of countries with tourism destinations, introduced travel restrictions during the pandemic,which caused a drastic decrease in number of tourist (290 – 440 million) at a rate of 20–30% during 2020 globally.

Resource conflict: The effect of pandemic associated factors resulted in conflicts and destruction of natural resources. For example, the shortage in supply of resources led to scarcity of foods and other materials, bringing about suffering among the populace. According to the World Bank (2020), the COVID-19 pandemic has worsened the poverty of 176 million people globally. This high poverty rate increased the dependence of vulnerable communities and households on natural resources.

***Increase in local exploitation of wildlife*:** The pandemic resulted in heightened exploitation of the physical environment. The pandemics have also aroused the interests of local people with biodiversity-rich ecosystem in land clearing, and illegal logging (McCauley et al., 2013; McNeely, 2021). This new interest contributed to the overexploitation of biodiversity resources for their survival during the period.

Reduction in Research, Assessment, and Monitoring Activities during pandemic: The lockdown and social distancing because of the pandemic inhibited rangers and other conservationists to provide information on the trends in primary species and other aspects (Waithaka, 2020. Researchers could not conduct field-based social research that requires interviews or focus group because of the disease transmission. The continuing shortage of funds can be the fundamental barrier to biodiversity assessment and more effective monitoring programmes in Africa (Weaver and Makiwa, 2020). In the absence of such informative data, the missed research means missed opportunities to identify conservation priorities, monitor the health of endangered species and ecosystems, and provide practical solutions for the protection and sustainable use of resources on which human well-being depends (World Bank, 2020).

National environmental policy and biodiversity action plan as instruments for the conservation of aquatic systems

The COVID-19 pandemic presented huge environmental challenges, arising from the emergence of different arrays of wastes, that eventually find their way into aquatic systems, thereby constituting hazard to aquatic biodiversity.

The Nigeria National Policy on Environment was formulated in 2001 and reviewed in 1999. The policy which also underwent review in 2014 places the mandate to coordinate environmental protection and natural resource conservation on

the Federal Ministry of Environment (FMEnv, 2015) and has the following strategic objectives:
The Ministry has the mandate to coordinate environmental protection and conservation of natural resource for sustainable development; and precisely, to secure a quality environment adequate for:

- Good health, wellbeing and promote sustainable use of natural resources;
- Restore and maintain the ecosystem and ecological processes to preserve biodiversity;
- Raise public awareness and promote understanding of linkages between environment and development; and cooperate with government bodies and international organisations on environmental matters.

Furthermore, Nigeria became a Party to the Convention on Biological Diversity (CBD) in 1994 and thus committed itself to the convention's three objectives (UNDP, 2015): the conservation of biological diversity; the sustainable use of its components; and the equitable sharing of benefits arising from the utilization of genetic resources.
Parties to the Convention on Biological Diversity (CBD) are required in Article 6 to prepare and implement a National Biodiversity Strategy and Action Plan (NBSAP).
The Strategic Plan is a ten-year framework for action by Parties to the CBD to save biodiversity and enhance its gains for people.
The NBSAP is a national instrument for identifying, documenting and addressing the threats to biodiversity in order to ensure its sustainability (FMEnv, 2015). Its objectives are to:

- address the underlying causes of biodiversity loss and reduce the direct pressures on biodiversity and promote sustainable use;
- improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity and enhance the benefits of ecosystem services to all and sundry.
- enhance implementation through participatory planning, knowledge management and capacity building.

Nigeria reaffirms its commitment to ensuring that it delivers on these obligations through positive action at home, which will promote biodiversity conservation and sustainable livelihoods.

Challenges Facing The Implementations of Nigerian National Biodiversity Action Plan and Environmental Policy in Pandemic Situations

Nigeria ranked very low in terms of its environmental performance rating, despite efforts to tackle the of environmental problems.
In 2016, the country's Environmental Performance Index (EPI) was 58.27, ranking it as number 133 out of 190 countries surveyed in the world (Hsu *et al*., 2016). A value of 58.27 indicates that Nigeria has not been able to significantly reduce its high rate of air, land and water pollution (FMEnv, 2015).
Some of the major bottlenecks responsible for the poor environmental performance rating particularly during COVID-19 pandemic are:

- There was lack of management structures for implementation of the NBSAP, and low level of awareness creation at Federal, State and Local governments during its preparation.
- Targets and Actions were not set to address identified major challenges although challenges were identified.
- The strategies for mainstreaming biodiversity into different sectors were weakly analysed in the first NBSAP.
- The weak and fragmented environmental governance remains a major bane of environmental sustainability in the country.
- There is inadequate environmental education and awareness, hence National efforts to address environmental issues have not been broad-based.
- There is dichotomy between environment and growth, and environment and poverty alleviation, therefore environmental degradation and intractable poverty have become more complex.
- There is limited private sector participation in environmental management, hence the cost of environmental mitigation is not incorporated into the capital outlay as part of the Corporate Social Responsibility (CSR) of every private establishment.
- There are conflicts over control and management of shared resources in many parts of Nigeria. Hence, there is need for a harmonized and common approach to the conservation and management of such shared resources.

CONCLUSION

The socio-economic systems are interlinked with ecosystems dynamics. The effects of the COVID-19 pandemic on human societies corroborated the need to recognize that thriving human societies are linked and dependent on the health of ecosystems.

The mass experiment of COVID-19 should provide empirical insights into determining alternative and complementary activities that can be fostered to define a sustainable future while averting or mitigating socio-economic losses.

To succeed, humans will need to reconcile the conservation of nature with its rational use and profitability while preventing further environmental degradation.

Moreover, it is fundamental to understand, and communicate the dependencies between interlinked human activities and the natural world in order to achieve the United Nations Sustainable Development Goals (UNSDG).

In addition, the sustainable use of aquatic resources is essential for the well-being of present and future human generations, as it is clearly recognized by the UNSDG 14 'Life below water' with the statement 'that the world's oceans drive global systems that make the Earth habitable for humankind.

Likewise, clean water, and good hygiene together form the foundation that underpins almost all of the Sustainable Development Goals. Therefore, sustainable ecosystem services, are indispensable elements in the current efforts to avert the spread of the COVID-19 pandemic.

References

Adedeji O.B., & Adetunji V.E. (2011). Aquatic pollution in Nigeria: the way forward. *Advances in Environmental Biology*, 5(8):2024-2032.

Allan JD, Abell R, Hogan Z, Revenga C, Taylor BW, Robin L. Welcomme, Kirk Winemiller. (2005). Overfishing of inland waters. *BioScience*, 55:1041–51.

Álvarez-Ruiz, R., Picó, Y. (2020). Analysis of emerging and related pollutants in aquatic biota. *Trends Environ. Analytical Chemistry* 25: e00082.

Andersen KG, Rambaut A, Lipkin WI, Holmes EC, Garry RF (April 2020). "The proximal origin of SARS-CoV-2". *Nature Medicine*. 26 (4): 450–452.

Ayeni, J.S.A. 1995. Conservation of Natural Resources. The Dynamic of Vanishing Species and their Habitats In the Nigerian Environment: Ecological Limits of Abuse, Proceeding of the Annual Conference of the Ecological Society of Nigeria held in Port Harcourt, Nigeria. Eds. Nokoe. 17-38.

Baron, S.A., Devaux, D., Colson, P., Raoult, D. & Rolain, J.M. 2020. Teicoplanin: An alternative drug for the treatment of coronavirus COVID-19. International Journal of Antimicrobial Agents 55(4): 105944.

Borokini, TI. (2014). A Systematic Compilation of Endemic Flora in Nigeria for Conservation Management. *Journal of Threatened Taxa,* 6: 6406-6426.

Brauman KA, Daily GC, Duarte TK, Mooney HA. (2007). The nature and value of ecosystem services: an overview highlighting hydrologic services. *Annu. Rev. Environ. Resour.* 32:67–98

Carpenter SR, Biggs R. (2009). Freshwaters: managing across scales in space and time. In Principles of Ecosystem Stewardship, ed. FSI Chapin, GP Kofinas, C Folke, pp. 197–220. New York: Springer.

Corman VM, Muth D, Niemeyer D, Drosten C, (2018). Hosts and sources of endemic human coronaviruses. *Adv Virus Res* 100: 163–188.

Corpuz MVA, Buonerba A, Vigliotta G, Zarra T, Ballesteros FJ, Campiglia P, Belgiorno V, Korshin G, Naddeo V (2020) Viruses in wastewater: occurrence, abundance and detection methods. *Science of the Total Environment,* 745, 140910.

Culliton BJ, (1990). Emerging viruses, emerging threat. *Science* 247: 279–280.

D'Aoust PM, Mercier E, Montpetit D, Jia J-J, Alexandrov I, Neault N, Baig AT, Mayne J, Zhang X, Alain T, Langlois M-A, Servos MR, MacKenzie Lohse KA, Brooks PD, McIntosh JC, Meixner T, Huxman TE. (2009). Interactions between biogeochemistry and hydrologic systems. *Annu. Rev. Environ. Resour*. 34:65–96.

Edinger, E.N., Jompa, J., Limmon, G.V., Widjatmoko, W. Risk, M.J. (1998). Reef degradation and coral biodiversity in Indonesia: Effects of land-based pollution, destructive fishing practices and changes over time. *Marine Pollution Bulletin* 36(8): 617-630.

Ekubo, A.T. and Abowei, J.F.N. (2011). Aspects of Aquatic Pollution in Nigeria. Research Journal of Environmental and Earth Sciences 3(6): 673-693.

Elsamadony M, Fujii M, Miura T, Watanabe T (2021). Possible transmission of viruses from contaminated human feces and sewage: Implications for SARS-CoV-2. *Science of the Total Environment,* 755, 1425-75.

Fanin, A., Calegari, J., Beverina, A. Tiraboschi, S. (2020). Hydroxychloroquine and azithromycin as a treatment of COVID-19. *Internal and Emergency Medicine* 15: 841-843.

Farkas K, Walker DI, Adriaenssens EM, McDonald JE, Hillary LS, Malham SK, Jones DL. (2020). Viral indicators for tracking domestic wastewater contamination in the aquatic environment. *Water Research,* 181, 11592-6.

FMEnv. (2015). Nigeria National Biodiversity Strategy and Action Plan. Available at https://www.cbd.int/doc/world/ng/ng-nbsap-01-en.pdf

Foley JA., DeFries, R., Asner GP., Barford C., Bonan G., Carpenter SR., Chapin FT., Coe MT., Daily GC., Gibbs HK., Helkowski JH., Holloway T., Howard EA., Kucharik CJ., Monfreda C., Patz JA., Prentice IC., Ramankutty N., Snyder PK. (2005). Global consequences of land use. *Science* 309:570–74.

Fujikura R, Nakayama M. (2009). Lessons learned from the world commission on dams. *Int. Environ. Agreements Polit. Law Econ.* 9:173–90.

Gordon (2012). Environmental Justice: Concepts, Evidence and Politics. London and New York: Routledge. 256 pp.

Grant MC, Geoghegan L, Arbyn M, Mohammed Z, McGuinness L, Clarke EL, Wade RG (2020). The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries. *PLOS ONE*. 15 (6): 2347-65.

Guerrero-Latorre L, Ballesteros I, Villacrés-Granda I, Granda MG, Freire-Paspuel B, Ríos- Touma B (2020). SARS-CoV-2 in river water: Implications in low sanitation countries. *Science of the Total Environment,* 743, 140832.

Gwenzi W. (2021). Leaving no stone unturned in light of the COVID-19 faecal-oral hypothesis? A water, sanitation and hygiene (WASH) perspective targeting low-income countries. *Science of the Total Environment,* 753, 141751.

Hata A, Hara-Yamamura H, Meuchi Y, Imai S, Honda R. (2020). Detection of SARS-CoV-2 in wastewater in Japan during a COVID-19 outbreak. *Science of the Total Environment, 758*, 143578.

Hemida MG, Ba Abduallah MM. (2020). The SARS-CoV-2 outbreak from a one health perspective. One Health. 2020 Dec;10:100127. doi: 10.1016/j.onehlt.2020.100127.

Hsu, A. et al. (2016). 2016 Environmental performance index, New Haven, CT: Yale University. Available: www.epi.yale.edu.

Hu B, Guo H, Zhou P, Shi ZL (March 2021). Characteristics of SARS-CoV-2 and COVID-19. *Nature Reviews. Microbiology*. 19 (3): 141–154.

Juan-Reyes S, Gomez-Oliv LM, Islas-Flores H. (2021). COVID-19 in the environment. *Chemosphere,* 263, 127973.

Kanu, I., Achi, O.K., (2011). Industrial Effluents and Their Impact on Water Quality of Receiving Rivers in Nigeria. *Journal of Applied Technology in Environmental Sanitation*, 1 (1): 75-86.

Kataki S, Chatterjee S, Vairale MG, Sharma S, Dwivedi SK. (2021). Concerns and strategies for wastewater treatment during COVID-19 pandemic to stop plausible transmission. *Resources, Conservation & Recycling* 164, 105156.

Kiani MR, Rahimpour MR. (2020). Aquatic/ water environment contamination, treatment, and use. In: Alberto Figoli, Yongdan Li and Angelo Basile (Eds.), Current Trends and Future Developments on (Bio-) Membranes. pp: 213-238. Elsevier Inc.

Kitajima M, Ahmed W, Bibby K, Carducci A, Gerba CP, Hamilton KA, Haramoto E, Rose JB. (2020) SARS-CoV-2 in wastewater: State of the knowledge and research needs. *Science of the Total Environment* 739, 139076.

Kubicz, J, Lochynski P, Pawełczyk A, Karczewski M. (2021). Effects of drought on environmental health risk posed by groundwater contamination. *Chemosphere,* 263, 128145.

Kuroda K, Kobayashi J. (2021). Pharmaceuticals, Personal Care Products, and Artificial Sweeteners in Asian Groundwater: A Review. In: M. Kumar et al. (Eds.), *Contaminants in Drinking and Wastewater Sources, Springer Transactions in Civil and Environmental Engineering.* pp: 3-36. Springer Nature Singapore Pte Ltd.

Levin AT, Hanage WP, Owusu-Boaitey N, Cochran KB, Walsh SP, Meyerowitz-Katz G (2020). Assessing the age specificity of infection fatality rates for COVID-19: Systematic review, meta-analysis, and public policy implications. *European Journal of Epidemiology, 35 (12): 1123–1138.*

Liang, X., Cui, S., Li, H., Abdelhady, A., Wang, H. Zhou, H. (2019). Removal effect on stormwater runoff pollution of porous concrete treated with nanometer titanium dioxide. *Transportation Research Part D: Transport and Environment,* 73: 34-45.

Liu D, Thompson JR, Carducci A, Bi X. (2020). Potential secondary transmission of SARS-CoV-2 *via* wastewater. *Science of the Total Environment,* 749: 142358.

Lodder W, Husman AMR. (2020). SARS-CoV -2 in wastewater: potential health risk, but also data source. *Lancet Gastroenterol. Hepatol*. 5 (6), 533–534.

Mack RN, Simberloff D, Lonsdale WM, Evans H, Clout M, Bazzaz FA. (2000). Biotic invasions: causes, epidemiology, global consequences, and control. *Ecol. Appl*. 10:689–710.

Martins VV, Zanetti MOB, Pitondo-Silva A, Stehling EG. (2014). Aquatic environments polluted with antibiotics and heavy metals: a human health hazard. *Environ. Sci. Pollut Res.* 21, 5873-5878.

McCauley, M., Minsky, S., and Viswanath, K. (2013). The H1N1 pandemic: media frames, stigmatization and coping. *BMC Public Health* 13:1116. doi: 10.1186/1471-2458-13-1116.

McNeely, J. A. (2021). Nature and COVID-19: the pandemic, the environment, and the way ahead. *Ambio* 50, 767–781. doi: 10.1007/s13280-020-01447-0.

Medema, G., Heijnen, L., Elsinga, G., Italiaander, R., Brouwer, A., (2020). Presence of SARS-Coronavirus-2 in sewage. *medRxiv,*

Meyerowitz EA, Richterman A, Gandhi RT, Sax PE (2021). Transmission of SARS -CoV-2: A Review of Viral, Host, and Environmental Factors. *Annals of Internal Medicine. 174 (1): 69–79.*

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-Being: Scenarios. Washington, DC:

Minckley WL, Deacon JE, (1991). *Battle Against Extinction: Native Fish Management in the American West*. Tuscon: Univ. Arizona Press.

Morens DM, Folkers GK, Fauci AS, (2008). Emerging infections: a perpetual challenge. *Lancet Infect Dis* 8: 710 –719.

Nilsson C, Reidy CA, DynesiusM, Revenga C. (2005). Fragmentation and flow regulation of the world's large river systems. *Science* 308:405–408.

Noutsopoulos, C., Andreadakis, A., Kouris, N., Charchousi, D., Mendrinou, P. Galani, A. (2017). Greywater characterization and loadings - Physicochemical treatment to promote onsite reuse. *Journal of Environmental Management* 216: 337-346.

NPE (2016). https://leap.unep.org/countries/ng/national-legislation/national-policy-environment-revised.

Oki T, Kanae S. (2006). Global hydrological cycles and world water resources. *Science* 313:1068–72.

OSHA (2020). Standards and directives for COVID-19, United States of America Occupational Safety and Health Administration.

Pacini, N., Pechar, L., Harper, D. M. (2019). *Chemical determinands of freshwater ecosystem functioning*. In: *Freshwater Ecology and Conservation: Approaches and Techniques*. Edited by Jocelyne M. R. Hughes: Oxford University Press. DOI: 10.1093/oso/9780198766384.003.0005

Post JR, Sullivan M, Cox S, Lester NP, Walters CJ, Eric A. Parkinson, Andrew J. Paul, Leyland Jackson and Brian JS. (2002). Canada's recreational fisheries: the invisible collapse? *Fisheries,* 27:6–17.

Praveena, S.M. Aris, A.Z. (2021). The impacts of COVID-19 on the environmental sustainability: A perspective from the Southeast Asian region. *Environmental Science and Pollution Research International*, *28*(45), 63829–63836.

Rahel, F.J. (2002). Homogenization of freshwater faunas. *Annu. Rev. Ecol. Syst.* 33:291–315.

Ross, S.T. (1991). Mechanisms structuring stream fish assemblages: Are there lessons from introduced species? *Environ. Biol. Fishes* 30:359–68.

Sharp PM, Plenderleith LJ, Hahn BH, (2020). Ape origins of human malaria. *Ann Rev Microbiol* 74: 39–63.

Shiklomanov IA. (2000). Appraisal and assessment of world water resources. *Water Int*. 25:11–32.

UNDP (2015). Biodiversity and Ecosystems Global Framework 2012 to 2020, available at http://www.undp.org/content/undp/en/home/librarypage/environment-energy/ecosystems_and_biodiversity/biodiversity-and-ecosystems-global-framework-2012-to-2020.html

UNEP-WCMC (2013). Incorporating Biodiversity and Ecosystem Services Values into NBSAPS, Guidance to support NBSAP practitioners, produced as an output of a joint UNEP-WCMC and IEEP project, funded by Defra, and in collaboration with the Secretariat of the CBD to examine the 'Lessons learnt from incorporating biodiversity and ecosystem service values into NBSAPs'.

UNWTO (2020). The COVID-19 pandemic prompted all destinations worldwide to introduce restrictions on travel, https://www.unwto.org/news/covid-19-travel-restrictions.

Van der Bruggen B, Borghgraef K, Vinckier C. (2010). Causes of water supply problems in urbanized regions in developing countries. *Water Resour. Manage.* 24:1885–902.

Waithaka, J. (2020). The Impact of Covid-19 Pandemic on Africa's Protected Areas Operations and Programmes: https://www.iucn.org/sites/dev/files/content/documents/2020/report_on_the_impact_of_covid_19_doc_july_10.pdf.~Pp44.

Weaver, C., and Makiwa, T. (2020). Covid-19 Threatens the Legacy of Long-Term Investment and Success in the Community-Based Conservation Programme of Namibia. Available online at: http://www.ccf-namibia.org/urgent-appeal-for-support-for-community-game-guards.

WHO (2014). Infection Prevention and Control of Epidemic- and Pandemic-Prone Acute Respiratory Infec-tions in Health Care. Geneva: World Health Organization; Annex G, Use of disinfectants: alcohol and bleach.

WHO (2020). Hand Hygiene: Why, How & When? https://www.who.int/gpsc/5may/Hand_Hygiene_Why_How_and_When_Brochure.

WHO (2020a). Novel Coronavirus-Japan (Ex-China). https://www.who.int/csr/don/17-january-2020-novel-coronavirus-japan-ex-china/en/ (accessed 21.04.2020).

WHO (2020b). World Coronavirus Disease (COVID-19) Dashboard. https://COVID19.who.int/?gclid=CjwKCAjwwYP2BRBGEi-wAkoBpApqSYnC_7CfA-c2jptAfCg38TEzlK-BiY2Zl_GLcxi_aIpJdUm7L-qBoC-dUQAvD_BwE.

WHO (2020c). Water, sanitation, hygiene, and waste management for the COVID-19 virus: interim guid-ance. COVID-19: Infection prevention and control / WASH Published on 23 April, 2020. WHO REFERENCE NUM-BER: WHO/2019-nCoV/IPC_WASH/2020.3.

Wolfel, R., Corman, V. M., Guggemos, W., Seilmaier, M., Zange, S., Muller, M. A., et al. (2020). Virological Assess-ment of Hospitalized Patients With COVID-2019. *Nature* 581 (7809), 465–469. doi: 10.1038/s41586-020-2196-x.

World Bank (2020). *Projected Poverty Impacts of COVID-19 (coronavirus) [online]. Washington, DC*. Available online at: https://www.worldbank.org/en/topic/poverty/brief/projected-povertyimpacts-of-COVID-19.

Zhang, Y., Chen, C., Zhu, C., Wang, D., Song, J., Song, Y., Zhen, W., Feng, Z., Wu, G., Xu, J., and Xu, W. (2020). Isola-tion of 2019-nCoV from a stool speci-men of a labora-tory-confirmed case of the coronavirus disease 2019 (COVID-19). *China CDC Weekly,* 2(8), 123-124.