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ENVIRONMENTAL SUSTAINABILITY IN KENYA

A case study in the Environmental Sustainability Gap Framework (ESGAP) and Strong Environmental Sustainability Index (SESI)

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Picture credits @Wilson Busenei. Rostchild giraffe or Rubian giraffe (*Giraffa camelopardalis rothschildi*) in Rukus sanctuary, an island in Lake Baringo. Main text images modified from Freepik.com.

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ACRONYMS AND ABBREVIATION

AFD	Agence Française de Développement
ASAL	Arid and Semi-Arid Lands
CBD	Convention on Biological Diversity
CIDP	County Integrated Development Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DCC	Directorate of Climate Change
EA	Environment Audit
EEZ	Extra Economic Zone
EMCA	Environment Management Coordination Act
EIA	Environment Impact Assessment
ESGAP	Environmental Sustainability Gap Framework
EU	European Union
FAO	Food and Agricultural Organization
GIS	Geographical Information System
GVA	Gross Value Added
HDI	Human Development Index
IMF	International Monetary Fund
IMO	International Maritime Organization
IUCN	International Union of Conservation of Nature
KNBS	Kenya National Bureau of Statistics
KEPI	Kenya Environment Performance Index
KFS	Kenya Forest Service
MEA	Multilateral Environment Agreement
MSY	Maximum Sustainable Yield
MTP	Medium Term Plan
MOW	Ministry of Water
NBI	Nile Basin Initiative
NEMA	National Environment Management Authority
NIMEs	National Impact Monitoring and Evaluation system

NEPAD	Kenya Secretariat
NSS	National Statistics System
NATCOM	National Communication
ODS	Ozone Depleting Substances
OHI	Ocean Health Index
PI	Poverty Index
SDGs	Sustainable Development Goals
SDI	Sustainable Development Index
SESI	Strong Environmental Sustainability Index
SOE	State of the Environment
UCL	University College of London
UNCCD	United Nations Convention on Desertification
UNESCO	United Nations Educational Scientific and Cultural Organization
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VNR	Voluntary National Reporting
WHO	World Health Organization

EXECUTIVE SUMMARY

The Environment Sustainability GAP (ESGAP) framework and the Strong Environmental Sustainability Index (SESI) provide a clear and easy-to-understand message to policy makers on a country's absolute performance against environmental standards that are linked to crucial environmental and natural resources areas. The ESGAP framework is underpinned by the concepts of 'strong sustainability' and 'critical natural capital', and it underlines how the assumption that the loss of nature can be fully compensated by increases in manufactured, human, or social capital can lead to misleading and poor decision making.

Kenya is one of the pilot countries implementing the ESGAP framework and SESI. This work was funded by the French Development Agency (AFD) in collaboration with University College London (UCL). To adapt the ESGAP framework to the Kenyan socio-ecological context, this project analysed the in-country environmental legislation landscape and existing environmental policy frameworks to determine challenges, gaps and opportunities for supplementing and strengthen existing processes. The technical application of the ESGAP framework to the Kenyan context was challenging due to data quality limitations, availability of adequate indicators and standards, and accessibility to data. The current Kenya ESGAP framework is composed of 12 indicators (in comparison with the 21 indicators used on the European SESI).

Our results suggest that the functioning of different elements of natural capital in Kenya, and their capacity to provide essential services in the long-term, **is highly impaired because of excessive environmental degradation.** Our results also show that **the human health and welfare function of Kenya's natural capital** exhibited the lowest performance, which highlighted that the capacity of natural capital to provide in the long-term services to humans, often non-economic, which maintain health and contribute to human well-being **is the most severely impeded in Kenya**. The most pressing environmental issues within this function were air quality and access to safe drinking water. We were not able to assess the life support function in Kenya due to the lack of suitable indicators with environmental science-based standards.

The ESGAP process has demonstrated to be a useful framework to highlight crucial data gaps and major current threats to environmental sustainability in Kenya. However, further components of natural capital need to be assessed, requiring efforts to improve the data underpinning the framework.

We also found that the use of science-based standards rather than policy targets as thresholds is challenging for developing countries like Kenya. Final users can be tempted to favor policy targets which are normally less ambitious and therefore more achievable than science-based standards. Therefore, there is a need to involve and engage with bodies like the Kenya National Bureau of Statistics and the Kenya National Bureaus of Standards and to effectively communicate with final users the relevance of the concepts of strong sustainability, critical natural capital, environmental functions, and science-based reference points to measure environmental sustainability of the nation to promote future usage and uptake.

The ESGAP framework could be used as an important tool to integrate data and indicators for natural capital and environmental sustainability into economic planning complementing and cross benefiting from other adopted national processes to support environmental planning and management.

1. INTRODUCTION

In 2006, Kenya developed a national blueprint for development for the next 30 years described as the Vision 2030[1]. Its aim is to transform Kenya into a newly industrialised and middle-income country providing a high quality of life to all its citizens. This blueprint was designed around three pillars: economic, social, and political stability. The social pillar aimed to provide a just and cohesive society with social equity in a clean and healthy environment. Kenya designed an implementation framework coordinated by the State Department of Devolution and Planning.

In 2016, spearheaded by the State Department for Devolution and Planning[2], Kenya mainstreamed the global Sustainable Development Goals (SDGs) into the country development agenda by designing a roadmap for implementation of the 17 SDGs. The framework involved various national government sectors, Government Departments and Agencies. The 17 SDGs came from the Agenda 2030 on Sustainable Development approved in Johannesburg in 2012[3]. Kenya ratified the Agenda 2030 which proposed 169 targets and 232 indicators to monitor progress.

The Vision 2030 is implemented in Kenya through Medium Term Plans (MTP), a 5-year implementation tool currently under the third cycle of implementation (MTP III 2018-2022). The incorporation of several SDG targets started in the second implementation cycle (MTP II 2013-2018). At the sub-national level, the SDGs are incorporated into the County Integrated Development Plans (CIDPs).

The implementation of the Vision 2030 was combined with flagship projects in addition to development initiatives. Specifically, there were five flagship projects which included (1) management of five major water catchments around five major mountains popularly known as 'water towers', (ii) securing wildlife corridors and migratory routes, (iii) development of solid waste management systems in five municipalities and cities, (iv) strengthening regulations on the production, use, and disposal of plastics, and (v) development of land use maps for Kenya.

The use of environmental indicators to monitor and report on the implementation of global and national development blueprints has been adopted in several institutions in Kenya, particularly those which are focal points to Conventions and Protocols for which Kenya is a Party. The State Department for Devolution and Planning adopted an indicator-based reporting framework for the SDGs supported by 93 indicators. Kenya submitted its voluntary National Review in 2017 and 2020. To support the process, the National Statistics System in Kenya mainstreamed some environmental indicators for regular data collection. These included indicators from different areas of natural resources and environment

including forest and land use, energy, manufacturing, tourism, environmental impact assessment (EIA) and environmental audits (EA).

In Kenya, there is political willingness to simplify environmental reporting through adoption and use of composite indices like what has been done in other sectors of the economy. Hence, the National Environment Management Authority (NEMA) in collaboration with University College of London (UCL) piloted the Environmental Sustainability Gap (ESGAP) framework and Strong Environmental Sustainability Index (SESI) to analyze the feasibility of using this framework as a reporting tool on national environmental sustainability performance[4]. The ESGAP is an environmental indicator-based framework that, unlike other indicators, measures strong environmental sustainability based on four essential environmental functions: source, sink, life-support and human health and welfare[5].

The source function refers to the provision of biotic and abiotic resources, the sink function refers to functional services that provide a neutralizing effect and stabilize the environment, the life-support function refers to ecosystems functions that support, for example, the food chain and hydrological systems, and the human health and welfare function refers to elements related to health and sanitation, natural and cultural heritage and aesthetic values which affect human wellbeing[5].

The SESI is a composite index that provides countries with a tool to analyse the integrity of their natural capital according to science-based standards. Data used in this project for computing SESI scores was collected mainly from international global platforms provided at national levels by national focal points.

This work presents the results of this analyses on assessing the state of natural capital functions in Kenya and piloting the ESGAP and SESI in the Kenyan context. This project was led by NEMA, an Environment Management Agency with the mandate of coordinating all matters related to the environment in Kenya.

1.1. Methodology

The methodology and approach for data collection and analysis used in this project to implement the ESGAP/SESI in Kenya followed the guidelines developed by the Institute of Sustainable Resources at UCL[5]. The ESGAP/SESI model was further adapted to the Kenyan national circumstances by analysing national policies, regulations, goals, targets, and other existing environmental approaches where applicable

The development of the Kenya SESI methodology used a protocol designed around four steps for data collection.

Phase 1 involved a literature review, national scoping, and data assessment. The literature review consisted of a desk study to analyse relevant environmental Conventions and Protocols that Kenya is signatory to, as well as national legislations and policies relevant to the ESGAP framework. Also, national environmental data custodians were identified to provide national data on the ESGAP and potential proxy indicators that could be used in the Kenya context. The Kenya ESGAP team followed up with the corresponding institutions and organisations to assess data availability, its spatial and temporal coverage and to gather relevant data available.

Phase II consisted of data compilation from published and verifiable national and international data sources. At the national level, the main data sources included the Kenya National Bureau of Statistics, which manages the national statistics systems. It regularly collects data (including environmental and sustainability related data) and collects and publishes various national statistical data reports such as the National Statistical Abstracts and the Economic Survey[6]. It also provides national statistics to global organizations such as the IMF and the World Bank and provides information on the National performance development and some agreed international indicators such as those used to assess progress on the SDGs. International data sources consulted included the World Bank, United Nation Statistics, Food and Agriculture (FAO), UNEP Geodata and the Ozone Global Environmental Monitoring systems (GEMs).

Phase III involved data organisation, cleaning and analysis following the established methodology for the ESGAP framework.

Last, Phase IV involved interpretation of the results with the lead agencies, the development of the Kenya ESGAP report and policy briefs, and stakeholders' engagement through the presentation of results with relevant national agencies and organisations.

2. KENYA'S ENVIRONMENTAL PROFILE

Kenya is a republic unitary state with two tier systems of government consisting of a National government and County governments[7]. The National government ensures that all multilateral environment agreements (MEAs) are fulfilled with support from the County governments.

Kenya has a total area of 582,646 km^2, of which 80% (571,416km^2) is classified as Arid and Semi-Arid Lands (ASALs) with pastoralism as the main land use[8].

Kenya has different landforms ranging from plains, escarpments such as the famous East African Rift Valley, high and low mountains to coastal areas. The country is middle-lower income with a GDP of 95,503,088.54 USD in 2019, a growth rate of 5.4% GDP and with agriculture, forestry and fishing gross added value (GAV) of 34.1% in 2019[6].

Although Kenya's economy is the largest and most developed in eastern and central Africa, it is a natural resource dependent economy. Kenya's population stands at 48 million people according to the 2019 population census[6], with 67% of the population residing in rural areas and relying on natural resources for their livelihoods. 36.1% of its population lives below the international poverty line[9]. The high percentage of rural population in Kenya, increasingly concentrated in small areas, and its dependency on natural resources make it challenging for the country to preserve environmental integrity and avoid severe environmental degradation.

Kenya has a varied climate with humid and wet coastal regions, dry and hot northern areas, and very humid conditions in the central highlands. This varied climate conditions influences the patchy population distribution, where 80% of the population is concentrated in 20% of the country land area, and 20% of the population occupies 80% of the arid and semiarid lands.

Kenyan natural capital is under severe threat due to human-induced biodiversity loss, forest degradation, unsustainable use of resources and governance[10].

Kenya's main ecosystems range from forest ecosystems, to wetlands, rangelands grasslands, alpine ecosystems, marine ecosystems, lakes, mangroves and human agricultural ecosystems or farmlands. These ecosystems provide crucial ecological functions and services that support the national economy. The tourism sector, which was once the number one foreign currency earner for the Country[11], is particularly highly dependent on biodiversity, coastal landscapes, and seascapes. Key natural environmental sources in Kenya include biodiversity, land and soils, water resources, forests, woodlands and bushlands, marine and freshwater wetlands, major river and lake basins, grasslands, and mountain ecosystems.

Biodiversity receives clear recognition as natural capital in Kenya as it underpins high tourism revenues for the national economy[11]. In addition, it provides major genetic resource base, goods, and related services.

12% of Kenya's territory is under legal conservation protection. This includes 24 parks, 27 national reserves, 203 forest reserves, 4 marine national parks, 6 marine reserves and 4 sanctuaries, all containing 30% of the national biodiversity[12]. Nevertheless, 70% of Kenya's national biodiversity is found outside protected areas[12]. The main threats to biodiversity in Kenya include habitat change through encroachment because of farming, settlement and grazing of livestock. Kenya ranks high in terms of biological diversity and endemism but biodiversity loss is an increasing threat for both plant and animal diversity[12].

Land and soils are a natural capital asset that offer in Kenya different opportunities for extraction of natural goods and services, agriculture and cattle rearing and maintenance of essential natural processes. Different landforms hold different biodiversity, and their unique richness are a source of medicinal use, food, and fiber. Land degradation in Kenya occurs under many different forms including increased soil erosion (with a consequent loss of soil fertility), increased salinity, reduced ground cover, loss of pasture and sediment loading in water bodies, such as evidenced in Lake Olbolosat, Winam Gulf and Lake Baringo. Kenya's land is highly vulnerable to soil loss by erosion given that 80% of its land area is classified as arid and semi-arid lands[12].

Water resources in Kenya are central to the provision of fundamental environmental goods and services, such as food production, and to the regulation of essential processes ranging from hydrological cycles, nutrient cycles, and temperature regulation[12]. Kenya's national water resource capital stands at 15.605 billion m^3 and 716 million m^3 for surface water and underground water respectively[10], distributed through the six major water basins in Kenya (i.e., Lake Victoria South and North, Rift valley, Tana, Athi and Ewaso Ngiro Water Basins). Among these, Lake Victoria is the most endowed in terms of water resources capital as it contains 54.1% of the total potential water availability in the country, followed by the Athi water Basin with 32.3%, and Rift Valley with the lowest percentage of national water resources capital with only 3.4% of the total national water potential[10].

Forests, woodlands, bushlands, and mountain ecosystems provide key goods and assets to the national economy. The main forests in Kenya comprise five water towers that constitute the water catchments and source of the main national rivers, and they are renowned for their abundant biodiversity and natural resources which constitute an essential pillar for economic growth. Kenyan forests

are important sources of local livelihoods. As of 2012, Kenya had 3.5 million hectares of forest cover (5.9% of land area) this figure was updated in 2010 to 6.1%[13] of which 1.8 million hectares or 3% of land is protected. 125,000 hectares are reserved for industrial forest plantations, and 475,000 hectares comprise bamboo plantations, moorlands, and glades[13]. Forests also provide essential recreational and spiritual benefits. The foreign demand for visiting wilderness areas motivated Kenya's Government to develop a strategy on ecotourism, which has been a major step in the forestry department. During 2008-2009, instruments for Ecotourism License Agreements were developed, including the identification of new ecotourism sites within Aberdares, Kakamega, Karura and Ngong forest reserves[12]. Forests also play a crucial role in regulating water quality and quantity, and in maintaining soil and genetic diversity of flora and fauna. Forests are also a crucial asset for climate change mitigation as nature-based solutions[12]. Main forests and mountain ecosystems are found in the humid and rainy moist areas mainly located in the highlands and around the high mountains of Mau, Cherengani, Mount Kenya, Mount Elgon, and Aberdare ranges[14]. Most forest reserves and parks are found in mountain ecosystems which contain typical alpine vegetation and sometimes are snow-capped like Mount Kenya. Particularly renown are the Kaya forests (The Kayas), unique coastal forests occupying an area of about 5056 hectares spanning 200 km along the Kenyan coastal stretch. The Kayas occur in patches ranging from 10 to 400 hectares in size and are found mostly on hilltops but also in the coastal plains. Currently 60 kayas have been identified and 40 of them are gazetted[12]. Some of the Kayas are either gazetted as forest reserve or game parks under Forest legislation. The National museums of Kenya has gazetted Kayas as national monuments, which has greatly improved their conservation status. The Kayas also form part of the country's natural heritage and are areas of great natural diversity with more than half of Kenya's rare plant species found within them. They have also been identified as important bird conservation areas.

In terms of grasslands and rangeland ecosystems, Kenya landscape is covered by over 80% arid and semi-arid lands, which form the major rangeland ecosystems and savannah grasslands. The rangeland is dominated by grassland and bush land including woody vegetation, and it is characterized by low rainfall, frequent droughts, and high incidences of food insecurity. The rangelands and savannah grasslands harbor enormous wildlife biodiversity for which Kenya is international renown as most of the game parks and game reserves are found in these ecosystems[12].

Marine and freshwater wetlands also contribute significantly to the national economy. The Kenya ocean waters are important carbon sinks and offer

important ecological services and habitat to national marine fisheries. Wetlands are a source of livelihoods to local communities and provide important ecological services acting as recharge areas to rivers and lakes. Kenya's wetland ecosystems are mainly found along the deltas and estuaries of the major rivers. Apart from the riverine swamps, there are lacustrine wetlands found in various parts of the country. Kenya has six gazetted Ramsar wetlands (Lake Baringo, Lake Bogoria, Lake Naivasha, Lake Nakuru and the Tana Delta, Lake Olbolosat and Lake Kanyaboli of Yala swamp). Mangrove ecosystems are found along the coastal area including the 200-mile Economic Exclusive Zone (EEZ) and form part of marine ecosystems that host unique coastal biodiversity including corals and sandy beaches. Kenya has four marine national parks and six marine national reserves rich in coral reefs[11,15] that provide important fishing resources for coastal communities. Wetland ecosystems are mainly found along the deltas and estuaries of the major Kenyan rivers. Apart from the riverine swamps, there are also lacustrine wetlands found in various parts of the country, many of which provide water recharge and discharge.

Major river and lake basins in Kenya include five drainage basins namely Lake Victoria south, Lake Victoria North, Rift Valley, Athi River Tana River and Ewaso Ngiro. These basins have water bodies such as lakes, rivers, wetlands, and springs. These water bodies are the sources of water for rivers flowing west of the Rift Valley to Lake Victoria and East of the Rift Valley into the Indian Ocean[16]. The main lakes include Lake Turkana with the largest surface area of water coverage estimated as 6,405 km² compared to Lake Victoria, which is estimated as 3,785 Km². It is the deepest lake in the country approximately 120m deep compared to 6.5m of Lake Victoria. Kenya is also endowed with several other smaller lakes found mainly in the Rift Valley, some of which are saline such as Lake Naivasha, Lake Elmentaita, and Lake Bogoria, while others are freshwater lakes such as Lake Baringo. Riverine and lake ecosystems found along river courses bear unique biodiversity and riverine vegetation. Lake ecosystems mainly comprise the Rift Valley lakes which are often brackish, some of which host an incredibly high bird biodiversity which contributes to the tourism industry[12]. On the western part of the country bordering Uganda, the Lake Victoria offers important fisheries resources for exports and local communities.

Kenya also harbors unique UNESCO natural and cultural heritage sites. Particularly the coastal region is rich in historical, cultural, and archeological sites some dating back to the 8th century. At least over 120 important Swahili sites and monuments have been documented along the Kenyan coast from the border of Tanzania to Somalia. Some of the towns with these treasures include Witu, Pate, Lamu, Malindi, and Mombasa Fort Jesus in Mombasa and Gede ruins in Malindi[11]. Some of these

UNESCO heritage sites of international significance, even though gazetted as National heritage sites, face serious threats[12]. Some of these cultural sites, particularly the old town of Mombasa and Lamu town, face illegal demolition for construction development. Hence, there is an urgent need to raise awareness about the cultural and heritage significance of this areas. Additionally, the National Museum of Kenya is credited with some of the major archeological findings on evolution of humanity in the famous Olorgoseile and Kobi fora National reserve. These discoveries made by the famous anthropologist Richard Leakey catapulted Kenya into the global map of the theory of evolution. The National Museums of Kenya have added into its list of protected heritages the Kaya Forest as cultural forests. The National Museums also have many other historical sites gazetted and protected in many other parts of the country. Nevertheless, some of these historical sites are neglected and have been vandalized or encroached and require urgent protection. Also, some of the land parcels where these heritages are domiciled are under individual titled deeds which also makes their conservation challenging.

Even though Kenya is endowed with a vast and unique variety of natural resources, these resources are facing imminent threats. Biodiversity in Kenya is in decline, wetlands are being drained for agriculture and other major water bodies (i.e., lakes and main rivers) are facing unprecedented decline in water levels and are increasingly polluted. The National Forest cover stood at 6.1% against the 10% constitutional threshold in 2018 and the forests are severely threatened by encroachment, deforestation and charcoal burning.

Our analysis of Kenya's natural resources and their contribution to the national economy demonstrates that these resources play a critical role as sources, sinks and life support elements and they drive and support Kenya's economy and livelihoods. Nevertheless, the current severe threats to the Kenyan natural capital depict an unsustainable situation that can severely hinder socio-economic development. The ESGAP framework and SESI provide a unique opportunity for mainstreaming, measuring, and monitoring the integrity of Kenya's natural capital.

2.1. Policy framework on environment and natural resources in Kenya

We reviewed the main national environmental related legislation, policy, and national institutions to establish the feasibility of implementing an ESGAP assessment in Kenya and to identify gaps and opportunities to align with at the national level (

Table 1).

Kenya has adopted several environmental related legislations and sectoral laws. These range from regulations to maintain the integrity of Kenyan natural resources, to those defining how people relate and depend on natural resources and the environment, to the definition of environmental standards or regulations on environmental degradation.

The Constitution of the Republic of Kenya[7] elevated environmental integrity of natural resources into a constitutional matter. It further merged most of the government departments mandated with environment management and it introduced and clearly defined the roles of the two government Tiers, the National Government, and the County Governments. For example, pollution control and waste management are largely assigned to County Governments with the National or State Departments only maintaining oversight functions.

Table 1 represents some of the most relevant environmental legislations In Kenya[8].

Nevertheless, these legislations have not necessarily contributed to the sustainable use and exploitation of Kenya's natural resources. Pollution and degradation of natural resources, forest degradation, desertification (particularly in northern Kenya) and biodiversity loss continue to be major environmental challenges for the Kenyan Government. Main drivers include a low level of compliance and enforcement, inadequate human capacity, and financial resources. These also include issues around legal impunity and governance, where there is utter disregard of the laws in some cases driven by the urge of local communities to survive through harvesting of natural resources for example timber for charcoal.

One of major challenges as well within the current environmental policy scenario in Kenya is the overlap of roles and responsibilities between institutions addressing environmental issues. There is a need to strengthen management frameworks that coordinate operations.

Kenya is currently at the crossroads of legal reforms with many national and sectoral laws under revision to approve amendments necessary to harmonize and to respond to the mandates stated in the Constitution.

Table 1. Policy tools, national policies, and environmental sustainability regulations in Kenya relevant to the national implementation of the ESGAP framework.

Policy instrument	Date	Description
The Kenya Constitution[7]	2010	Chapter 5 on land and environment provides for the protection of natural capital and natural resources and recognizes the need to safeguard Kenyan natural resources and capital to achieve sustainable development. It resonates with ESGAP given its emphases on natural capital.
Environment Management Coordination Act 1999 cap 387[17]	2000	As a result of this Act, several institutions, including NEMA, were created with a strong environment compliance and enforcement mandate. This Act also mandates to measure and report on environmental integrity in the form of the Kenya State of the Environment (SOE) report. The law provides for the development and implementation and monitoring of environment through the process of National Environmental Action Plans and County Environment Action Plans and development of environmental standards to safeguard natural resources. These processes are environmental indicator and environmental standards driven and therefore offer an opportunity for application of the ESGAP and SESI in Kenya.
Energy Act[18]	2016	Primary legislation on Energy in Kenya. It was reviewed to align with the Constitution 2010 and Vision 2030. Part five of the Energy Act regulates on renewal energy and energy use and efficiency and gives the Minister powers to develop strategies on renewable energy technologies including biomass, biodiesel, solar, wind, hydropower, charcoal, fuelwood, and biogas. The Energy and Petroleum Regulatory Authority is mandated to collect energy data, maintain a central database, and publish energy statistics including data on renewable energy resources among others, which could inform relevant ESGAP indicators.
Other energy related policies		Sessional paper on Energy 2004 (legally recognized policy for energy in Kenya); National Bio-energy policy and strategy 2011 (it provides the National bio-energy strategy and policy in Kenya); Feed in tariff, December 2014 (revised feed in tariff to attract private capital and investment in the energy sector for biomass generated electricity); Agricultural Sector Development Strategy 2010-2020 (it defines the roll and intervention of various Kenyan ministries in the agricultural sector); Bio-ethanol Strategy 2010 -2020 (it defines the strategy for developing bioethanol industries and clean energy).
Water Act[19]	2016	It provides for regulations on water abstraction thereby controlling the volumes and permits for discharges into any water bodies. Procedures are provided in the Water rules. Within the ESGAP context, this Act provides the opportunity for comprehensive data collection and analysis.

Forest conservation and management Act No 34[20]	2016	It established the Kenya Forest Services and mandates for the development and maintenance of a database, and to collect, analyse and maintain data on forest use among many other mandates, including forest conservation in Kenya.
Wildlife Conservation and Management Act[21]	2016	It established the Kenya Wildlife Services to manage wildlife in the country. The mandate of the organization includes the formulation of policies related to conservation of wildlife; advising the Government on the establishment of National Parks, Reserves and Protected Wildlife Sanctuaries; the management of parks and research in the field of wildlife conservation; advice the Government and the custodians of treaties related to wildlife and the custodian of the Ramsar convention. This Act provides the framework for all data related to wildlife parks and reserves within the context of the ESGAP.
Kenya Fisheries Management and Development Act[22]	2016	The Act established the Kenya Fisheries Services (KFS), the main Government agency overseeing fisheries related activities in Kenya, both freshwater and marine, including development, exploitation, utilization, and conservation, as well as formulation of fisheries policies. The Act mandates the collection and management of fisheries statistics through stock assessment.
National Museums and Heritage Act[23]	2006	National Museums of Kenya is a state cooperation mandated with research, management and documentation of historical sites, archeological sites and sites of Natural and National heritages and monuments. National Museums of Kenya is involved in taxonomic and herbaria activities in Kenya.
Climate Change Act[24]	2015	In part IV of the Act, NEMA is mandated to monitor, investigate, and report on whether public and private entities are following climate change commitments. In addition, NEMA regulates, enforces, and monitors compliance on the level of greenhouse gas emissions, which is an essential element of the ESGAP framework.
Statistics Act[25]	2006	It established the Kenya Bureau of Statistics (KBS) and the National Statistics Systems with the following mandates: to plan, coordinate and supervise statistical programs in Kenya; to establish standards and promote best practices in the production of and dissemination of national statistics; to collect, compile, analyse and disseminate statistical information specified in the second schedule of the statistical Act 2006; and to coordinate population censuses and maintain comprehensive and reliable datasets. With the legal mandate and authority to supervise other organisations and the collection, analyses, and documentation of national statistics, the KBS also has a mandate on official national statistics on environment.
Water quality regulations[26]	2006	It provides regulations for the prevention of water pollution by ensuring compliance with standards provided in schedule III. Those national standards constitute the National threshold for water resources within the context of the ESGAP framework.

Water Rules[27]	2006	They regulate several issues related to environmental water quality ranging from providing conditions for discharge of wastewater into water resources, the need for permits to discharge into water resources, conditions for applying for discharge permits, issuance of permits and operations and effluent quality requirements of such discharges.
National Environmental Policy	2012	Highlights the diversity of Kenyan ecosystems and recognizes it as natural capital that provides social and supporting services and ecological services; it integrates poverty into all environment processes in Kenya and provides a foothold to green Economy, social inclusion, improving human welfare and employment creation.
Vision 2030[1]	2006	It provides a blueprint for development for the next 30 years with the aim to transform Kenya into a newly industrialised and middle-income country with a high quality of life to all its citizens by 2030. The blueprint was designed around three pillars: economic, social, and political stability. The social pillar aimed to provide a just and cohesive society with social equity in a clean and healthy environment

Kenya has several institutions involved in the management of natural resources and the environment (Table 2). They range from Government Departments to non-governmental organizations, private sector organizations and community-based organizations. The Government Agencies are created and governed by various legislations, policies, goals, objectives, and mandates. These Agencies are custodians of environmental related laws and are sometimes regulatory in their mandates.

Table 2. Major institutions managing environment and natural resources in Kenya.

Institution	Function
Ministry of Environment and Forest	It has the overall responsibility for environment policy formulation and direction and is structured into the State Department of Environment, the State Department of Forest, and the Directorate of Climate Change.
National Environment Management Authority (NEMA)	NEMA coordinates and regulates all environment matters in the country. Some of the regulations mandated by NEMA include Environment Impact Assessment and Environment Audit regulation 2006, Water quality regulation 2003, Wetland regulation 2006 and the Ozone depleting Substances regulations 2006, the latest being amended to ground circular economy in the country. It produces the State of Environment report and is custodian to the Ozone Depleting Substances Convention[28].
Kenya Forestry Services	It is responsible for the protection and management of gazetted forests and those under the county council under memorandum of understanding. The objective is to preserve forests, protect and conserve land resources and promote restoration. The service is responsible for maintaining national forest cover of at least 10%[20]. It undertakes forest cover assessments in collaboration with the Department of Resources, surveys and remote sensing work which has the capacity for aerial survey and photography. It maintains a database on forest and forest use.
Kenya Wildlife Services (KWS)	Manage wildlife in the country. Its mandate includes the formulation of policies related to conservation of wildlife and act as an advisory body for the Government on the establishment of National Parks, Reserves and Protected Wildlife Sanctuaries. KWS collects and stores all data related to wildlife parks and reserves[21].
National Museums of Kenya	It is a state corporation charged with research, management and documentation of historical sites, archeological sites, and sites of Natural and National Heritage and National Monuments[23]. It manages a biodiversity center, and it is involved in taxonomic and herbaria activities. It also keeps track of biodiversity state in the country, monitors flora and fauna biodiversity and supports the publication of the IUCN red list data.

Kenya Fisheries Services	Semi-autonomous government agency mandated to oversee fishing activities in Kenya including both fresh water and marine fisheries. Its core mandate is the formulation and implementation of fisheries policies.
Directorate of Climate Change	It is charged with the integration and mainstreaming of climate change actions and duties, including mainstreaming the National Climate Change Action Plan into County Integrated Development Plans. It also oversees the implementation and mainstreaming of climate change within the County Governments. County Governments shall submit an annual report on the implementation of climate change actions to the County Assembly and the Climate Change Directorate.
Kenya Ports Authority	It facilitates seaborne trade and the management of the port of entry to the country and all other ports. It overseas environmental protection through the implementation of Conventions for which Kenya is signatory and covers areas of oil spills, garbage disposal from vessels, sewage disposal from vessels, noxious chemical from vessels and disposal of plastics. It is also involved in regular beach cleaning activities.
Kenya Maritime Authority	Its mandate ranges from ensuring maritime safety through certification, ship registration and seafarers standards and training according to IMO requirements, and to regulate water transport. It is also mandated to provide protection of marine environment against sources of marine pollution. It is the focal point for ocean related disasters and its participation in the National Oil Spill Contingency Plan is crucial. It is also custodian of data related to marine water quality and data on sea going vessels.
Kenya National Bureau of Statistics	It provides a credible, reliable, and verifiable platform for national statistical data collection and documentation with a network of offices throughout the country to collect, analyse and document socio-economic statistics needed for planning and policy formulation in the country. This network includes county statistical offices in the 47 counties as data collection centers. The bureau collects and publishes various statistical data such as National Statistical Abstracts and the Kenya Economic Survey. It recently revised its mandate to include environmental statistics and statistics related to sustainable development. Some of the statistics included in the national statistics systems collected as national statistics include drinking water related statistics, sanitation, domestic energy consumption and energy efficiency. It also provides National statistics to global organizations such as IMF or the World Bank. The Bureau provides information on the National Agenda and agreed international indicators such as the SDG indicators.
State Department of Devolution and Planning	Government agency custodian of the Agenda 2030 on Sustainable Development in Kenya. The institution is mandated to track the indicators of the 17 SDGs including the 6 environmental SDGs indicators.

Water Resources Authority (WRA)	It is one of the institutions which was established during the water reform sector and its mandates relate to the collection, analysis and management of water related data and statistics, including quantitative and qualitative assessments of waterbodies, drinking water and sanitation.

According to our assessment, Kenya presents a good opportunity to implement the ESGAP and SESI at the national level given the relevance of the framework to the current national environmental policy landscape, and the institutions involved in environmental management in the country. Additionally, several institutions described above are focal points for MEAs for which Kenya is signatory, and for which the data mobilization required to implement the ESGAP framework is also relevant. For example, Kenya Wildlife Services is the custodian of CITES and Ramsar and it bears the responsibility of designating new Ramsar sites and managing its instruments and reporting mechanisms according to these Conventions. Also, the Ministry of Environment and Directorate of Climate change is the focal point for UNFCCC, NEMA is the focal point for ODS, and Kenya Fisheries Service is the focal point for fisheries related conventions.

Most of the institutions described in Table 2 are created by national legislations which mandate to oversee and be custodians of the respective sectors or resources. These legislations provide these institutions with statutory powers to collect, analyse, publish, and store data relevant to their sector. Some of these institutions have well developed technical infrastructures and human capacities and experiences built over time, such as the Kenya Fisheries Service (formerly the Fisheries Department) and the Kenya Wildlife Services, which have been involved in fisheries stock assessments and wildlife censuses respectively for many years. Some of those also host statistic departments with appropriate expertise and capacity to act as data custodians for their respective sectors and to maintain several infrastructures with networking capabilities and capacities, including spatial data management and analyses departments.

Kenya is signatory to several multilateral and regional environmental agreements[8] which provide an important framework for the conservation and effective management of shared resources, and that requires regional and international cooperation to make the most efficient use of scarce resources.

Kenya can benefit significantly by committing to trans-boundary agreements through increased funding from regional and international cooperation. Examples of such MEAs and regional instruments include the United Nation Human Development and Environment, United Nation Conference on Human Environment (UNCED)[29], the Convention on Biological Diversity (CBD), the

Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention), Convention on International Trade in Endangered Species (CITES), the Convention on Migratory Species (CMS), the World Heritage Convention, the Nairobi Convention, United Nations Framework Convention on Climate Change (UNFCC) and the United Nations Convention to Combat Desertification (UNCCD). Kenya is also an actor in UNESCO's Man and Biosphere Programme.

Regionally, Kenya plays a key role in both the New Partnership for Africa's Development (NEPAD) and the East African Community and associated Protocols. In addition, Kenya is cooperating with other riparian states under the Nile Basin Initiative (NBI) and East African Natural Resources Protocol to ensure sustainable use of the Lake Victoria waters. MEAs and regional instruments are not self-executing, and they cannot function in the absence and domestication into national polices and legislations. Kenya has done this even at the level of the Constitution of Kenya.

2.2. Linkages between Kenya's environmental policies and the ESGAP framework

Our analyses show that there are opportunities for implementation of the ESGAP and SESI at the national level. Most of the institutions involved in environmental sustainability have a role to play in providing national information and data relevant for the implementation of the ESGAP framework as data custodians or focal points of multilateral environment agreements, as well as through national legislation and policies (Table 3). Nevertheless, our analyses showed that there are also crucial gaps that need to be addressed to further implement the ESGAP in Kenya. There are numerous indicators already in use in Kenya, from different international Conventions that can be explored for domestication and potential use as ESGAP proxy indicators.

Some of the opportunities identified include:

- The Kenya Constitution 2010 recognizes that natural resources are Kenya's natural capital and provides for its protection.
- There are sectoral legislations that provide for overseeing enforcement of legislations for protection of natural resources including forests, biodiversity, water, fisheries, land and soils, wetlands, and air.
- Some institutions such as the Kenya Fisheries Services, Kenya Forest Services, or the Kenya Wildlife Services have policies, legislations and strategies for data collection, management, storage, and dissemination.
- Some policies and legislation provide for institutions as custodian of certain conventions, treaties and protocols and are mandated with data

collection and reporting duties, such as KWS which is a custodian for Ramsar and CITES.

- Some policies provide power to local institutions for the development of regulations, strategies, and environmental standards and to even legislate.
- Kenya National Bureau of Statistics is the national institution with a mandate to collect, manage, store, and disseminate all statistics in Kenya including environmental statistics.

Some of the gaps or challenges identified that require additional consideration to mainstream the use of the ESGAP framework in Kenya include:

- The lack of science-based standards for most of the national indicators (most indicators used policy-based targets as reference points).
- Data collection is inconsistent across time and depends on the availability of resources, which in many cases are not given priority consideration by the related organizations.
- Data analysis and interpretation require expertise and understanding of the national context to make those relevant and usable to inform decisions.

Table 3. Policies and national strategies relevant for the implementation of the ESGAP framework in Kenya.

	Principle	Topic	Pressure/State	ESGAP indicator	Relevant Kenyan policies	Notes
Source function (Maintain the capacity to supply resources)	Renew renewable resources	Forest resources	Annual fellings	Forest utilization rate	Kenya Forestry Development Strategy 2016-2030 (in draft). Kenya National Biodiversity Strategy 1993. Forest Landscape Restoration Strategy 2020.	Kenya has committed to the Bonn challenge of planting 500 million trees by 2030.
		Fish resources	Condition of fish stocks	Fish stocks within safe biological limits	Kenya Fisheries Development Strategy 2015. Fisheries Policy 2016. National Blue Economy Strategy.	(1) Adopting a blue economy to harness marine and lake resources. (2) Strategy for exploiting marine fisheries in the Kenyan EEZ. (3) Strategy for the development of cage fisheries.
		Water resources	Blue water consumption	Surface water bodies not under water stress	National Water Master plan 2030. Strategy for the reform of water sector. EA Water Quality Regulation. Water Rules. Water Quality Regulation 2006.	(1) Water Resources have capacity and human resources for collection of water related data, including designated water monitoring points in all the six major country catchments.
			Status of groundwater bodies	Groundwater bodies in good quantitative status		
	Use non renewables prudently	Soil erosion	Soil erosion rate	Area with tolerable soil erosion	National Land Reform. Land and Environmental Court. National Spatial Plans	Current lack of operations of the soil and water conservation unit of the State Department of

	Principle	Topic	Pressure/State	ESGAP indicator	Relevant Kenyan policies	Notes
						Agriculture to monitor soil erosion.
Sink function (Maintain the capacity to neutralize wastes, without incurring ecosystem change or damage)	Prevent global warming, ozone depletion	Greenhouse gases	Greenhouse gas emissions	Emissions / Sustainable emissions	Green Economy strategy 2008. Nationally Determined Contributions (NDCs) 2020. Kenya National Climate Change Action Plan.	Kenya has committed to reducing emission by 32% below BAU by 2030.
		Stratospheric ozone depleting substances	Consumption of ozone depleting substances	Emissions / annual allowance	ODS Regulation gazette notice No.57.	Kenya has an active Ozone Secretariat.
	Respect critical loads for ecosystems	Load of pollutants in terrestrial ecosystems	Ozone pollution	Cropland area exposed to safe ozone levels	National Air Quality Regulations 2015.	Kenya's Government has regulations on air quality including the GHGs and has committed to monitoring and reporting on GHG emissions.
				Forest area exposed to safe ozone levels		
			Critical loads of heavy metals	Ecosystems not exceeding the critical loads of cadmium / lead/mercury	Water Quality Regulation 2006.	Heavy metals such as lead and mercury are parameters normally monitored by water monitoring stations. Kenya also participates in the global monitoring by UNEP.[45]

	Principle	Topic	Pressure/State	ESGAP indicator	Relevant Kenyan policies	Notes
			Eutrophication	Ecosystems not exceeding the critical load of eutrophication	Water Quality Regulation 2006. Water Rules. National Invasive Weeds Strategy.	A national invasive weeds strategy is in place, but implementation is not enforced.
			Acidification	Ecosystems not exceeding the critical loads of acidification	Water Quality Regulation 2006. Water Rules.	Designated surface water monitoring points by the Water Resources Authority.
		Freshwater ecosystems	Surface water pollution	Surface water bodies in good chemical status (fresh water and coastal water bodies)	National Strategy on Water Resources to 2020. Water Quality Rules. Water Quality Regulation 2006. EA Water Quality Standards.	Kenya has implemented regulations on water quality and EA water quality regulations.
			Groundwater	Groundwater bodies in good chemical status	National Strategy on Water Resources to 2020. Water Quality Rules. Water Quality Regulation 2006. EA Water Quality Standards.	The Water Resources Authority has officially designated ground water monitoring points.
		Marine ecosystems	Marine pollution	Coastal water bodies in good chemical status	Water Quality Regulation 2006.	The research institution KEMFRI regularly monitors and reports on ocean water quality and other parameters.

	Principle	Topic	Pressure/State	ESGAP indicator	Relevant Kenyan policies	Notes
Life support function (Maintain the capacity to sustain ecosystems health and function)	Maintain biodiversity (especially species and ecosystems)	Terrestrial ecosystems	Functional diversity	Terrestrial area with acceptable biodiversity levels	Kenya National Biodiversity Strategy (KNBS-1993).	Need to review the Kenya National Biodiversity Strategy (KNBS-1993).
		Freshwater ecosystems	Ecological status	Surface water bodies in good ecological status	The Water Quality Regulations cover standards for drinking water, bathing waters and discharge of effluents to water bodies.	The Water Resources Authority has officially designated ground water monitoring points.
		Marine ecosystems	Ecological status	Coastal water bodies in good ecological status	State of the Coast report. Ocean Health Index report.	The research institution KEMFRI regularly monitors and reports on ocean water quality and other parameters.
Human health and welfare function (Maintain the capacity to maintain human health and generate human welfare)	Respect standards for human health	Air pollution	Outdoor air pollution	Population exposed to safe levels of $PM_{2.5}$	Air Quality Regulation gazette notice No.34.	There is an air quality monitoring scheme in place, but it is not very active.
		Indoor air pollution	Concentration of air pollutants	Population using clean fuels and technologies for cooking	Air Quality Regulation gazette notice No.34	There is an air quality monitoring scheme in place, but it is not very active.
		Drinking water	Water samples	Samples that meet the drinking water criteria	The Water Quality Regulations cover standards for drinking water,	Drinking water quality monitored and reported by water monitoring

	Principle	Topic	Pressure/State	ESGAP indicator	Relevant Kenyan policies	Notes
					bathing waters and discharge of effluents to water bodies.	companies (e.g. Nairobi Water company and Kisumu Water company).
	Conserve landscape and amenity	Bathing water	Concentration of bacteria	Recreational water bodies in excellent status	The Water Quality Regulations cover standards for drinking water, bathing waters and discharge of effluents to water bodies.	The research institution (KEMFRI) regularly monitors and report on ocean water quality and other parameters.
		Natural and mixed world heritage sites	Conservation Outlook	Natural and mixed world heritage sites in good conservation outlook	National Heritage Policy with the National Museums of Kenya.	Reporting is implemented by the National Statistics System based on budget allocation to the institutions that manage Natural and World Heritage Sites.

2.3. Environmental Indicators-based Assessments in Kenya

Kenya has adopted several indicator-based processes with different frameworks for, i) tracking national development performance, ii) tracking performance against policy goals and targets, iii) measuring broad policy national performance on sectors such as the environment (e.g., the State of the Environment report) and sustainable development, or more specific sectors such as forestry, biodiversity, or the ocean.

Index-based performance processes are mostly implemented in social and economic sectors in Kenya. Some examples include the Multidimensional Poverty Index, Human Development Index etc. There are also few indices and indicator-based assessment processes in the environmental sphere currently under implementation in Kenya, namely the Kenya Environment Performance Index (KEPI), the Sustainable Development Goals Index (SDG Index), the Ocean Health Index, the Aichi biodiversity indicators, the National Statistics Systems (NSS), a statistical system that provides guidance in development, collection and management of National statistics, the State of the Environment Report (SOE) and the National Implementation Monitoring and Evaluation (NIMEs). Nevertheless, these environmental indices and processes are not well established yet in comparison to socio-economic indicators.

Indicators used under these assessments are often similar across frameworks with some exemptions of indicators specifically tailored to specific sectors, particularly those with a sole focus such as the KEPI, given that some of those indicators are customised to track national targets.

The SDG indicator framework offers a comprehensive indicator framework portfolio to measure and track sustainable development with over 244 indicators structured under 169 targets and 17 goals. Six of the 17 goals are considered environmental and therefore have associated environmental indicators (93 environmental indicators).

To implement the ESGAP framework in Kenya, and to adapt it to the national context, we assessed the environmental sustainability frameworks currently under implementation in Kenya to determine their relevance and potential alignment to the ESGAP framework (Table 4), and to identify data gaps and opportunities to supplement and strengthen the existing processes.

Table 4. Environmental indicator-based assessments processes in Kenya relevant for the Kenya ESGAP framework.

Indicator system	Sector, sector mandates and activities
National Statistics Systems	A range of indicators around different environmental sectors are now being followed through national surveys and sector statistical performance submissions. These include water resources, fisheries, forests, wildlife, mining, solid waste management, development control, energy, petroleum, environment economic accounting and manufacturing[6].
State of the Environment Report (SOE)	The first State of the Environment Report (SOE) was prepared in 2010. Kenya is now in its 2016-2018 cycle[14]. The SOE reporting has employed a system of indicator-based assessments. The process of National environment indicator (NIE) development was supported by UNEP in 2011. The process identified the main challenges and trends for implementation through time. This included deforestation, pollution of water sources, solid waste accumulation in urban centers, wetland degradation, poaching, growth of informal settlements, low compliance and enforcement, and governance. The process further assisted to determine whether the quality of the environment was improving or deteriorating.
National Implementation Monitoring and Evaluation (NIMEs)	A group of indicators for national development sectors are followed through national surveys and sector statistics performance submissions by the State Department of Planning and Devolution, and the Department of National Integrated Monitoring and Evaluation Systems (NIMES). The SDG and National indicators were used in the first Voluntary National Report (VNR) reporting in 2017.
Kenya Environment Performance Index (KEPI)	The Kenya EPI has been adopted as a performance assessment tool to guide in-country decisions on sustainable development[30].
Sustainable development Goals (SDG Index)	The Sustainable Development Goal Index (SDG Index) is an upcoming composite indicator with a focus on sustainability and it is built up based on an array of environmental indicators in addition to socio-economic indicators.
Ocean Health Index	The Ocean Health Index (OHI) is an upcoming composite indicator in Kenya with a focus on ocean and coastal marine health and marine resources.
Aichi biodiversity indicators	The Aichi biodiversity indicators are used to measure performance against the Aichi targets of the current biodiversity strategic plan of the CBD and its Parties.

Other sector-based performance measurements indicators such as i) forest indicators, ii) climate change indicators, iii) fisheries indicators, iv) water resources indicators and v) wildlife and biodiversity indicators	The Ministry of Environment and Natural resources and the Directorate of Climate change (DCC) is the focal point of UNFCCC. NEMA is the focal point of ODS and the Ozone secretariat of the Ministry of Environment and Forestry[29]. The Kenya Forest Service undertakes forest cover assessment reports on forest cover. Kenya Fisheries Service is the focal point of the fisheries related Conventions. The Fisheries Management and Development Act 2016 mandated on stock assessment and the creation of a data management unit[8]. The Water Resources Authority (WRA) is mandated to collect water related data and statistics. Data related to biodiversity is under the mandate of National Museums of Kenya as well as the Kenya Wildlife services (KWS). The National Museums of Kenya monitor plant biodiversity and supports the publication of the IUCN red list data. The Kenya Wildlife Services is also the custodian of CITES and Ramsar Conventions and is responsible for the designation and management of Ramsar sites and its instruments and reporting mechanisms using designated indicators for the corresponding sectors.

We assessed national data availability and suitability to implement the ESGAP framework (Table 5) based on four criteria[31]. These criteria included:

Update frequency. We selected regularly updated data to enables for environmental changes to be tracked over time. Data that is updated at least annually is preferable as this aligns to the normal frequency that national reporting occurs.

Most recent update. We selected data produced more recently over older datasets, as this enables reporting that more accurately reflects the current state of the environment. Datasets that do not have a recent update are likely to also not be frequently updated, so there is some overlap with the update frequency criteria.

Spatial coverage. We selected data available for the entire territory over data that is only available for certain regions or sites. Whole country datasets tend to be produced by satellite or modelling activities, whereas more localized data is produced by in-situ monitoring.

Spatial resolution. We also prioritized fine-scale resolution data over data that is only available at the country scale. Many of the environmental measures in the ESGAP, such as water quality and biodiversity, can vary spatially at local scales. High resolution data allows spatial differences in the state of the environment to be tracked and inform spatial environmental policies.

Table 5. ESGAP Indicator analysis for Kenya including proposed Kenya ESGAP indicators.

Indicator type (*) refers to 1 (same indicator and standard applied as in the European ESGAP framework), 2 (proxy state indicator supported by a science-based standard), 3 (proxy state indicator supported by a non-science-based standard), and 4 (proxy pressure indicator supported by an upper and lower limit reference value).

EU indicator	Proposed indicator for Kenya ESGAP	Indicator type*	Standard for Kenya	Baseline/Baseline year	Standard / Target / Target year	Reference	Notes	Comments
1.1.1 Forest utilization rate	% forested area as a proportion of total land area	3	10% forest cover	7.4% / 2018	10%: 2030[7]	Constitution of Kenya Vision2030 SNC National SDGs	Legislated in the National Constitution and the national target in the Vision 2030	10% forest cover (from SBSTA CBD and IV World Park Congress 1993[32])
1.1.2 Fish stocks within safe biological limits	% fish stock within biological sustainable levels	2	SDG threshold/standard of 0 to 100, with figures beyond 100 representing overexploitation, and sustainable fisheries between 0 to 100.		SDG threshold/standard of 0 to 100, with figures beyond 100 representing overexploitation, and sustainable fisheries between 0 to 100.	Fisheries Act Vision 2030 KEPI	Fisheries regulation 2016, Vision 2030	SDG, FAO[33]
1.2.1 Freshwater bodies not under water stress	% of freshwater withdrawal against the total freshwater renewal resources	2	Severe ≤20 %, FAO. Water abstractions permit regularly issued by WRA		Severe ≤20 %, FAO	National Water Master plan 2030 Water Act 2016 and Water regulation	Water Act 2016 and Water regulation which provides for Abstraction level for catchment National Water Master Plan 2030[10]	Derived from SDG indicators
1.3.1 Area with tolerable soil erosion	% land that is degraded against total land area	3	Areas of soil degradation documented by	Area not vulnerable to soil erosion	0.% 2030	National SDG framework SDG[2]	Requirement provided in	Derived from World standards by FAO &

			Agriculture department (Agriculture Act 2015, Vision 2030	27.17% in 2013 as in National Water Master plan[10]		FAO	Agriculture for soil conservation Agriculture Act 2015, Vision 2030)	Implementation of Agenda 2030 for sustainable development in Kenya, Ministry of Devolution and Planning (Voluntary National Report)[2]
2.1.1 Greenhouse gas GHG/CO2 emission annual allowance	Per-capita CO2 emissions	1	Same as EU standard	103Co2eq 2015	32% GHG reduction BAU 2030 (0.5-2.5 t/capita/yr. , IPCC)	NCCAP2018/2 NIR	NATCOMs Kenya 3rd Natcom NDC commitment of 30% GHG emission reduction below BAU Baseline year 2015	UNFCCC –IPPC standards requirement for 1.2-degree limit of CO_2 increase
2.1.2 Emission annual allowance Stratospheric ozone depleting substances	Consumption of HCFC	1	EU standard National Regulation on Ozone depleting substances (ODS)		Montreal protocol (52.3-47 ODs Units)[28]	Ozone report	Environment Management Authority Act Cap 387. Regulation on Ozone depleting substances (ODS) Issue permits for ODS imports in Kenya.	Report of Ozone secretariat and UNEP Ozone Secretariat[28]
2.3.1 Surface water bodies in good chemical status	Surface water bodies in good chemical status in terms of transparency, turbidity, dissolved oxygen, pH, salinity, pollution by priority substances and pollution by other substances identified as being discharged in significant quantities (% of monitoring stations of surface water with surface water that meets technical standards (good chemical status)	4	Water Quality Regulation 2006[26]. It provides for standards of nutrients in water bodies.	Water quality regulation 2006 [15]–water quality standards EA water standards SDG 80% of monitoring stations	National standards. Water Quality Regulation 2006[26] and EA standards	EMCA Water quality regulation 2006 and Air quality 2006 WHO SDG Indicator report	Environment Management Authority Act Cap 387. Water Act 2016	Derived from WHO standards. Regularly used for monitoring of water bodies

2.3.2 Groundwater bodies in good chemical status	Groundwater bodies in good chemical status in terms of oxygen content, conductivity, and nitrate (% of monitoring stations of ground water with surface water that meets technical standards (good chemical status)	4	Water quality regulation 2006. It provides for standards of nutrients in water bodies.	SDG 80% of monitoring stations	National standards and EA standards Water Quality Regulation 2006[26] and EA standards	EMCA Water quality regulation 2006 and Air quality 2006 WHO SDG Indicator report	Environment Management Authority Act Cap 387. Water Act 2016	Derived from WHO standards. Regularly used for monitoring of water bodies
4.1.1 Population exposed to safe levels of PM2.5	Outdoor air pollution % age of population exposed to P.M<2.5	1	EMCA cap 387-Air quality regulation 2015 Vision 2030	4.3% 2013	0% of population 2018	Air quality regulation 2006 WHO; Kenya Environment Performance Index (KEPI)	Environment Management Authority Act Cap 387	Derived from WHO standards [24]
4.1.2 Population using clean fuels and technologies for cooking	Indoor Air Pollution - % population with access to clean fuels	1	EMCA cap 387-Air quality regulation 2015 Vision 2030	84% of population 2013	0% of population (Agenda 2030)	National SDG framework Kenya Environment Performance Index (KEPI) WHO National Statistics System (NSS)	Environment Management Authority Act Cap 387	Derived from WHO standards[34]
4.1.3 Samples that meet the drinking water criteria	% of population with access to safe drinking water	1	Water quality regulation 2006 provides for drinking water standards Vision 2030	58% 2018	National target 80%, Vision 2030 100% population (WHO standards)	Vision 2030, Ministry of Water (MOW) WHO Water Quality Regulation 2006	Environment Management Authority Act Cap 387. Water Act 2016 Public Health Act	Derived from WHO standards. Regularly used for monitoring of water bodies[35]
4.2.2 Natural and mixed world heritage sites in good conservation outlook	Proportion of Natural and World Heritage sites in good status	4	Provision and regulations for preservation of monuments, Heritages sites and artefacts	100 % in good status	Good. Good with considerations, critical	National Water Master Plan (NWMP) National statistics System (NSS) IUCN World Heritage outlook 2014, 2017 and 2020 reports	Museums and Heritage Acts provides for protection and preservation of monuments, Heritages sites and artefacts	IUCN standards. IUCN World Heritage Outlook 2014, 2017 and 2020 reports[36]

The selection of final indicators and standards to implement the ESGAP framework in Kenya followed a three-tier decision tree approach as recommended by UCL (Figure 1) and it was also informed based on policy relevance (national regulations, strategies, targets), natural resources relevance and category, international obligations and therefore focal points or data custodians and national data availability.

We consulted the Kenya National Bureau of Statistics, which manages the National Statistics Systems and regularly collects data that includes environmental and sustainability related data. The Bureau collects and publishes various national statistical reports such as the National Statistical Abstracts and the Economic Survey [9]. The Economic Survey 2020 formed the main source of National Environmental statistics, which provided the most authoritative source of data for this work. Other National Institutions consulted included the Kenya Forest Service for forest coverage data, the Kenya Fisheries Service for fisheries related data, the Kenya Wildlife Services for biodiversity and marine related data, the National Museums for biodiversity and Natural and World heritage related data. The National Environment Management Authority was also consulted for ozone depleting substances consumption data[28].

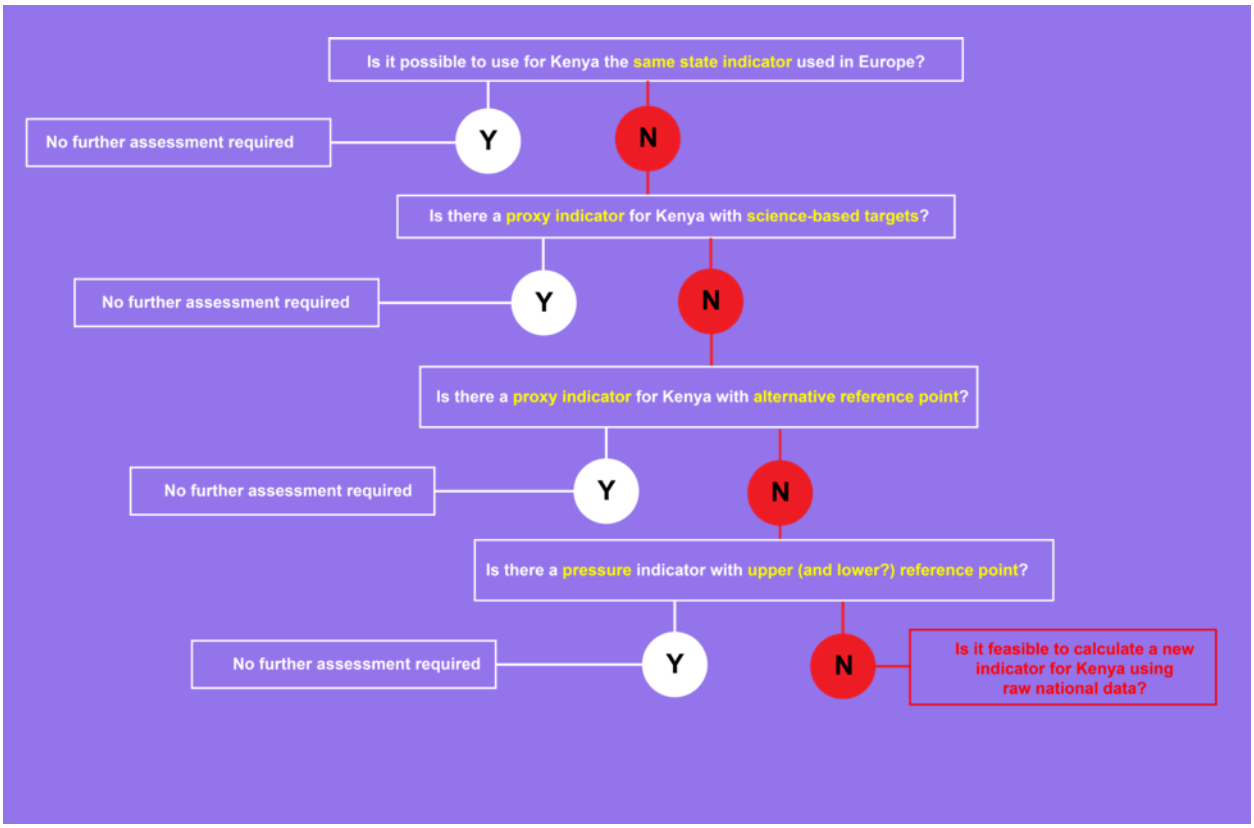


Figure 1. Decision tree used to select indicators for the Kenya ESGAP framework.

When possible, the Kenya ESGAP framework used the same indicator applied for the European countries ESGAP with standards based on relevant international environmental agreements and scientific environmental standards that represents a sustainable reference point (and which were taken from the scientific literature when possible). If the same indicator applied for the European countries ESGAP was not available for Kenya, we then followed the decision tree approach represented in Figure 1 to select indicators. The results of this assessment are shown in Table 5.

2.4. The Kenya ESGAP indicator framework

The proposed Kenya ESGAP framework is composed of 12 indicators most of which are proxy indicators, including several SDG indicators. Most of these indicators used verified data sources provided by global data platforms. Some of those had similar data from national sources accessible through national data platforms of the statistics office and published in the latest Economic Survey and Statistical Abstracts for Kenya[6].

The Kenya ESGAP indicators are presented in Table 6. Further information on the indicators selected is provided in Appendix III.

Table 6. Comparison between the European ESGAP indicator framework and the Kenya ESGAP framework composed of 12 indicators.

Blue represents same indicators used in the European ESGAP framework, **orange** represents proxy indicators used in the Kenya ESGAP framework, and **red** represents data gaps in the Kenya ESGAP framework.

Function	Principle	Topic	Subtopic	Europe ESGAP indicator	Kenya ESGAP indicator
Source	Renew renewable resources	Biomass	Forest resources	Forest utilization rate	Proportion of forest area as proportion of land area
			Fish resources	Fish stock within safe biological limits	Proportion of fish stock within biologically sustainable levels
		Freshwater	Surface water resources	Fresh water bodies not under water tress	Freshwater withdrawal as proportion of total actual renewable water resources
			Ground water resources	Ground water bodies in good quantitative status	
	Use nonrenewable prudently	Soil	Soil erosion rate	Area with tolerable erosion level	Proportion of land with tolerable soil erosion
Sink	Prevent global warming and ozone depletion	Earth System	Greenhouse gases	Emissions / annual allowance	CO_2 emissions per capita
			Stratospheric ozone depleting substances	Emissions / annual allowance	Consumption of hydrochlorofluorocarbons (HCFCs)
	Respect critical levels and critical loads for ecosystems	Terrestrial ecosystems	Ozone pollution	Cropland and forest area exposed to safe ozone levels	
			Pollution by heavy metals	Ecosystems not exceeding the critical loads of cadmium / lead / mercury	
			Eutrophication	Ecosystems not exceeding the critical loads of eutrophication	
			Acidification	Ecosystems not exceeding the critical loads of acidification	

		Fresh water ecosystems	Surface water pollution	Surface waterbodies in good chemical status	Proportion of surface waterbodies with good ambient water quality (rivers and lakes)
			Ground water pollution	Ground waterbodies in good chemical status	Proportion of monitoring points showing ground waterbodies in good ambient water quality status
		Marine ecosystems	Marine pollution	Coastal water bodies in good chemical status	
Life support	Maintain biodiversity (especially species and ecosystems)	Terrestrial ecosystems	Functional diversity	Terrestrial area with acceptable biodiversity levels	
		Freshwater ecosystems	Ecological status	Surface water bodies in good ecological status	
		Marine ecosystems	Ecological status	Coastal water bodies in good ecological status	
Human health and welfare	Respect standards for human health	Human health	Outdoor air pollution	Population exposed to safe levels of $PM_{2.5}$	Proportion of population exposed to safe levels of $PM_{2.5}$
			Indoor air pollution	Population using clean fuels and technologies for cooking	Proportion of population with access to clean fuels and technologies for cooking
			Drinking water pollution	Samples that meet drinking wager criteria	Proportion of population with access to safe drinking water
	Conserve landscape and amenity	Amenity	Natural and mixed world heritage sites	Natural and world heritage sites in good conservation outlook	Proportion of natural and world heritage sites in good conservation status

3. DATA ANALYSES AND RESULTS

3.1. Source function

3.1.1. Proportion of forest area as proportion of land area

The European ESGAP framework uses the *forest utilization rate* as the indicator for forest resources, which represents the ratio between the annual fellings and the volume of annual net growth in the stock of living trees. In Kenya, spatial area of forest refers not only to natural forests but also to plantation forests, and no data exist on annual growth of wood stocks and annual feelings in natural forests.

Hence, the Kenya ESGAP framework uses as proxy indicator the *Proportion of forest area as proportion of land area* (SDG indicator 15.1.1), in which forest is defined by a tree coverage threshold of 0.3 hectares and a canopy of 10% coverage.

Standard

This indicator does not have a science-based standard for Kenya. Hence, we used a policy-based standard of 10% forest cover as defined in the Constitution of Kenya[7] and Vision 2030. The 10% forest cover target first appeared in the 4th World Park Congress report held in Caracas, Venezuela in 1992 [19] and the Aichi target II. This data is readily available for several years in Kenya (Table 7).

Data profile

Forest data is collected by the Kenya Forest Service, whose mandate covers forest management in the country. The data is provided to the National Statistics Office and other global data custodians such as the World Bank Development statistics office, and FAO.

Table 7. Percentage of forest area as a proportion of total land area in Kenya between 2005 and 2016.

YEAR	% forest area as a proportion of total land area
2005	7.1
2006	7.2
2007	7.2
2008	7.3
2009	7.4
2010	7.4
2011	7.5
2012	7.5
2013	7.6
2014	7.7
2015	7.8
2016	7.8

ESGAP Score calculation

We normalized the indicator as below,

$$\text{if} \quad I \geq gp_{max} \qquad NI = 100$$

$$\text{if } gp_{min} < I \leq gp_{max} \qquad NI = 100\,\frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

$$\text{if} \quad I \leq gp_{min} \qquad NI = 5$$

($gp_{min} = 0$; $gp_{max} = 100$)

ESGAP score = $\frac{\text{Forested area \% (year X)}}{100} * 100$

The Kenya ESGAP score for forest cover in Kenya is 78 for 2016.

Discussion

The Kenya ESGAP score for forest cover in Kenya is 78 for 2016.The ESGAP score for forest cover in Kenya indicates that Kenya's forest cover is on an upward trend from the lowest cover of 2.3% in the 1980's. This significant loss in forest cover was a result of nation-wide deforestation for charcoal and timber production and an unregulated expansion of settlements and croplands. The mandate of Kenya Forest Service targets, i) reducing forest degradation and deforestation, ii) reforestation of degraded forest, and iii) restoration of forest on degraded lands[20].

Forest loss, and natural forests loss, are a threat to the national economy since wildlife-based tourism which depends on biodiversity is one of the major revenue sectors for the country. The loss of forests, particularly around the country's main water towers in Kenya can lead to significant reduction of water recharge into rivers, particularly in the dry season. Forest loss also has an important impact on the energy sector and overall economic development[20].

However, there has been a marked recovery on forest land since 2000, particularly plantations. Kenya's Government is supporting a strong reforestation and afforestation programme with a target to restore 4,210,000 hectares and plant 50 million trees by 2030, in line with the Africa Forest Landscape Restoration Initiative (AFR100) and the Bonn Challenge. Nevertheless, there is an urgent need to strengthen and enhance surveillance, compliance and monitoring of forests and allocate more financial resources to afforestation and reforestation activities. Also, Kenya's Government needs to increase the country's ambition beyond a policy target of 10% of forest coverage.

3.1.2. Proportion of fish stocks within biologically sustainable levels

The European ESGAP indicator *Fish stocks within safe biological levels* relates to the biomass of fish stocks and the rate of recruitment through fish reproduction, and subsequently to the capacity to sustain fish harvesting. Most of the fisheries

data collected for Kenya is based on fish landings from which the proportion within biologically sustainable levels can be computed once reference points are determined.

The Kenya ESGAP framework uses the *Proportion of fish stocks within biologically sustainable levels* (SDG indicator 14.4.1*)* as proxy indicator[33].

Standard

This indicator adopts a standard of 100% of fish stocks within biologically sustainable levels, with figures below 100 representing overexploitation.

Before 2015, surveillance was not enforced and landings within the EEZ were not reported by the commercial fisheries vessels. Currently, there is data only for 2015 and 2017 (Table 8).

Data profile

Fisheries statistics are collected by the Kenya Fisheries Service and the Kenya Marine and Fisheries Research Institute. The Kenya National Bureau of Statistics and the National Statistics Office report this data in the National Economic Survey (latest from 2020). For this work the data used is not that generated at the Country level but at the level of fishing area, which is the Western Indian Ocean for Kenya, this is part of Kenya's EEZ.

This data adopted for this ESGAP work is global in nature and can provide representation of level of extraction from the Kenyan EEZ and hence Marine fisheries extraction.[43] Surveillance data from this area has been poor for Kenya, with offshore landings not recorded and only small artisanal landings recorded.

Table 8. Proportion of fish stock within biologically sustainable levels (%) for 2015 and 2017.

YEAR	% fish stocks within biologically sustainable levels
2015	66.67
2017	68.29

ESGAP Score calculation

We normalized the indicator as below,

$$\text{if} \quad I \geq gp_{max} \qquad NI = 100$$

$$\text{if } gp_{min} < I \leq gp_{max} \qquad NI = 100\frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

$$\text{if} \quad I \leq gp_{min} \qquad NI = 5$$

($gp_{min} = 0$; $gp_{max} = 100$)

$$\text{ESGAP score} = \frac{\%\ \text{fish stocks within biologically sustinable levels(year X)}}{100} * 100$$

The Kenya ESGAP score is 68.29 for 2017.

Discussion

Whilst the ESGAP score indicates that Kenya is exploiting its marine fish stocks in the marine area, which is part of the EEZ within sustainable levels, it also exhibits a tendency towards over extraction within the period that data was available for. Assuming that surveillance has been effective, what mainly determines the levels of marine fisheries within the EEZ in Kenya is the catch rate per unit of effort (CPUE), which has remained largely artisanal. However, an increase in exports and expanded technological capability of fishing efforts through commercial fisheries and exploitation by foreign industrial fishing vessels is emerging in the Kenyan marine waters. Large scale commercial fishing is becoming a common practice in Kenyan waters[33].

The unsustainable management of the country's coastal and marine resources can be explained from weak governance and high population growth rate. There is an increasing demand for fish by local populations, particularly Kenya's coastal communities, which are poor, have a narrow income base, and depend on marine fisheries for livelihoods.

It should be noted that this data does not include exploitation of inland fisheries where there is extensive fisheries extraction and is exhibiting severe signs of overexploitation.

The Government of Kenya (GoK) has devoted efforts to streamline marine fisheries within the EEZ and its international waters by developing a Marine Fishing Strategy and a Blue Economy Strategy. Also, Section 130(2) (b) of the Kenya Fisheries Development and Management Act 2016 stipulates for suspension of fishing if the current fishing rate poses a threat to fishing stocks[22].

Additionally, the GoK has established a coastal guard government unit, which should result into better reporting of the offshore catch, including foreign vessels. Nevertheless, there is still a need to strengthen, enhance and upscale surveillance, enforce compliance and monitoring of fisheries and implement fishing closed seasons to allow for stock recruitment. There is also a need for diversification of fisheries by leveraging sustainable aquaculture fisheries and improve partnership engagement within the coastal fisheries.

3.1.3. Freshwater withdrawal as proportion of total actual renewable water resources

The ESGAP indicator *Freshwater bodies not under water stress* was substituted with the proxy state indicator for Kenya *Freshwater withdrawal as proportion of total actual renewable water resources*, which measures total freshwater withdrawn each year expressed in percentage of the actual total renewable water resources (TRWR actual). This indicator provides information on the country's pressure on the renewable water resources.

Standard

OECD defines water stress as *a measure of the total annual average demand of a river basin (or a sub-basin) compared to the average water available annually (precipitation minus evapotranspiration) in that basin*. Water levels of stress are defined by a threshold level as follows; greater than 40% is severely water scarce, if the ratio lies in the range of 20-40% is defined as water scarce, if the ratio is in the range of 10-20%; moderate water scarce and less than 10%, low water scarcity. The goal is to maintain a level <40% which indicates adequate water availability, while >40% indicates threat of severe water scarcity[10,37].

We used 40% as the indicator standard for normalization, which is also the threshold recognized for every basin in Volume 1 of the Kenya National Water Master Plan[10].

Data profile

Data on freshwater withdrawal and renewal water resources is regularly collected by the Water Resources Authority, which maintains a database both at the national and catchment levels. This data can be accessed through the FAO Aquastat platform and KNOEMA (Table 9).

Table 9. Freshwater withdrawal data as a percentage of actual renewable water between 2002 and 2017.

YEAR	Freshwater withdrawal as % of total actual renewable water resources
2002	9.98
2007	13.6
2010	14.26
2015	15.55
2017	19.48

ESGAP Score calculation

We used a gp_{min} of 40 and a gp_{max} of 10.

If the country value => gp_{min}, the ESGAP score =5,

If the country value =< gp_{max}, the ESGAP score =100, otherwise

$$ESGAP_{score} = [(\text{Country value} - gp_{min}) / (gp_{max} - gp_{min})] * 100$$

The indicator's score is 68.4 for 2017.

Discussion

Kenya, officially classified as a chronically water-scarce country, has six major river basins, namely Lake Victoria North, Lake Victoria South, Ewaso Nyiro North and South, Tana River, and the Rift Valley catchments. Most basins in Kenya are considered water scarce, except Lake Victoria North Catchment area (LVNCA), as the country's natural endowment of freshwater is limited by an annual renewable freshwater supply. The annual freshwater withdrawals average below 40% and in the range of 10-20% for the period given indicates that the country is exploiting its freshwater resources within sustainable levels. Nevertheless, the 2013 National Water Master Plan forecasted extreme water stress ratios by 2030 for most of the river basins except LVNCA[10]. This is supported by this result in the ESGAP score which, despite it represents current sustainable levels, data between 2002 and 2017 shows an upward trend towards unsustainable use, with an increase of 9.5% between 2002 and 2017 and an average rate of 2.4% increase within that period.

Main pressures contributing to the forecasted extreme water stress conditions in Kenya include high population growth and poverty, which increases demand for water for economic needs, and the accelerating degradation of catchments and climate change derived impacts. The challenges derived from water scarcity and accessibility to water sources in Kenya are especially evident in rural areas and urban slums, where people are often unable to connect to piped water infrastructure. In rural Kenya, the average total coping costs for an unreliable or distant water supply are around seven times higher than the average water bill of a typical household in an urban area that is connected to a piped system. Water providers are unable to meet the demand in these areas, which makes water provision expensive. Hence, these limited freshwater resources place both a severe financial and health burden on the population of Kenya[38].

The response from the GoK requires improvement in water use efficiency and investment on alternative water sources, including groundwater extraction and rainwater harvesting, as well as an increased level of protection and better management of water catchments which determine the level of recharge of waterbodies[10].

3.1.4. Proportion of land area that is not degraded against total land area.

This Kenya ESGAP proxy indicator represents the *proportion of land area that is not degraded against total land area* and therefore the area with low risk of soil

degradation. These soils are less vulnerable to flood risks, landslides, erosion and are more productive.

Kenya Agricultural Research Institute in conjunction with the Ministry of Environment and Natural Resources published a study on Land degradation Assessment in 2017 [21]. This study on soil erosion mapping, which looked at data for a period of 29 years from 1990-2010, and classified land degradation in Kenya into very low, low, moderate, high, and high risk, the study found that 61.4 % of Kenya's land area was at high risk of land degradation, and 27.2% at very high risk of land degradation (Figure 2). The study also indicated that all counties in Kenya are at risk of land degradation.

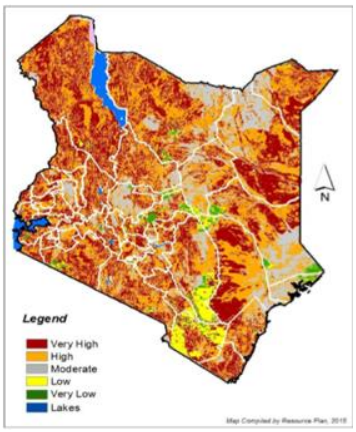
This has been reproduced in the Kenya Environment Performance Index report of 2019 [28]. Spatial analysis of Land use and Land cover change (LULC) showed that agriculture and cultivable lands increased by 7.3%, bare land by 3.6%, and 0.8% forest was lost.

Standard

KEPI 2019 adopted a target of 100% total land area that is not at very high risk of soil erosion. According to the Remote Sensing/GIS mapping, the extent of severity of erosion is categorized into very low, low, moderate, high, and very high. Very high severity, means having adverse impacts on agriculture, settlement, forestry etc. The target adopted is to ensure that no land area is at a "high risk" from soil erosion that is 0%.

Data profile

Data for this indicator has been derived from geographical information systems and remote sensing work categorizing land according to the degree of exposure or risk to soil erosion. We used the current proportion of area under high risk of soil erosion against the total land area, which was cumulatively reported as 72.83 (0.80+1.44+9.17+61.42). This data depicts the proportion of area that is not at high risk of being degraded against the total land area for 2017 and 2018 (Table 10). Therefore, the Kenya proxy ESGAP score for the indicator *proportion of land area that is not degraded against total land area is 72.83.* Since the data is expressed in % it therefore represents the ESGAP score. Figure 3 represents the most soil erosion prone counties.



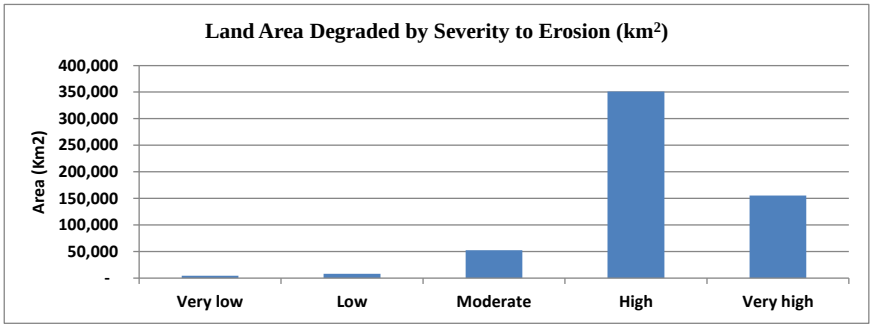


Figure 2. Left panel) Map of soil erosion prone areas in Kenya (KEPI 2019), Right panel) Distribution of land area by degree of soil erosion risk.

Table 10. Data on proportion of land degraded against total land area. The indicator is calculated as the % land that is not at very high risk (level 5) of degradation.

Total land area (km ²)		Area in km sq	% degraded
Level 1	Very low	4,548	0.80
Level 2	Low	8,225	1.44
Level 3	Moderate	52,383	9.17
Level 4	High	350,992	61.42
Level 5	Very high	155,268	27.17
Total area (km²)		571,416	100.00

ESGAP score calculation

We normalized the indicator as below,

$$\text{if} \quad I \geq gp_{max} \qquad NI = 100$$

$$\text{if } gp_{min} < I \leq \quad gp_{max} \qquad NI = 100\,\frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

$$\text{if} \quad I \leq \quad gp_{min} \qquad NI = 5$$

($gp_{min} = 0$; $gp_{max} = 100$)

$$\text{ESGAP score} = \frac{\%\ \text{land area that is not degraded against the total land area (year X)}}{100} * 100$$

The Kenya ESGAP score for *proportion of land area that is not degraded against total land area is 72.83* for 2018.

Discussion

Soil erosion vulnerability in Kenya is one of the main environmental challenges that requires urgent attention. According to the most recent data provided by the KEPI report 2018 drawn from the Land degradation Assessment in Kenya report[39],

the current proportion of land area degraded against the total land area is 61.42 % (about 350,992 Km² of Kenya), which is a worryingly high percentage.

In Kenya, soil erosion mostly affects the arid and semi-arid lands (ASAL), which represents around 80% of Kenya's land. Other areas, particularly those located in high altitudes and mountain slopes such as Mt. Kenya, Aberdares and Cheranganyi hills, also face high erosion risk levels. Nevertheless, protected areas and areas with flat terrain, including national parks and reserves, and the plateaus in Rift Valley and the Lake Victoria region, exhibit low risk levels to soil erosion.

The ASALs of Kenya, where approximately 30 percent of Kenya's human population and 50 percent of its livestock live, are at risk of degradation as their soils are also highly erodible. These areas have fragile ecosystems and storms occurring during the rainy period lead to huge runoffs because of low vegetation and soil biomass cover[40]. Land degradation leads to loss of soil fertility, because of wind and water erosion, that causes degraded rangelands, deforestation, and desertification. Land use in these areas is largely pastoral. Hence, are particularly vulnerable to land degradation which results in production losses to farmers and pastoralists and decline in ecosystem services such as drought and flood protection. Poor land management practices, including over cultivation, overgrazing, poor land husbandry and excessive forest conversion for charcoal making are the main human-induced causes exacerbating land degradation in Kenya, which is leading to an increased risk of food insecurity in the country.

Measures to tackle land degradation in Kenya require the development and implementation of strong soil and water conservation policies and interventions to stop soil erosion and maintain ecosystem services. This must include sound agricultural farm and rangeland management practices in ASAL, as well as water runoff harvesting and intensification of afforestation and reforestation practices.

At the national level, sustainable land management is under the mandate of the State Department of Agriculture and Fisheries, whilst at the country level it is distributed among county departments under agriculture and environment. The GoK has recently developed a forest landscape restoration strategy and is part of AFR100 (the African Forest Landscape Restoration Initiative), a country-led effort to bring 100 million hectares of land in Africa into restoration by 2030. AFR100 also contributes to the Bonn Challenge, the African Resilient Landscapes Initiative (ARLI), the African Union Agenda 2063, the Sustainable Development Goals, and other targets

3.2. Sink function

3.2.1. CO_2 emissions per capita

This indicator used in the Kenya ESGAP framework is the same used in the European ESGAP and it measures the average individual emission of CO_2 per person per year within the Kenyan population. It includes total emissions from all sources but mainly from cooking fuel, energy from electricity, transportation, manufacturing, and agriculture.

Standard

The emission allowance for every Party to the Paris Agreement is aimed at limiting the rise in global temperature to 1.5-2°C (67% and 33% chance respectively). The global standard is 0.5-2.5 tons/cap.

Data profile

National data on CO_2 emissions per capita (Table 11) is provided through the processes stated below, which are coordinated by the Kenya's Directorate of Climate Change, and can be accessed through the KNOEMA platform. These processes include:

- The National Climate Change Action Plan 2018-2022.
- The Biennial Update Report for Kenya (BUR) 2019-2020.
- The National Inventory Report (NIR) 2019.
- The Second National Communication 2015.

Table 11. CO_2 emissions per capita (tons per capita) between 2000 and 2017.

YEAR	CO_2 emissions per capita (tons per capita)
2000	0.326
2001	0.285
2002	0.236
2003	0.195
2004	0.214
2005	0.234
2006	0.254
2007	0.254
2008	0.257
2009	0.302
2010	0.29
2011	0.312
2012	0.283
2013	0.293
2014	0.309
2015	0.355

2016	0.365
2017	0.38

ESCAP Score calculation

We used a gp_{min} of 2.5 and a gp_{max} of 0.5.

If the country value => gp_{min}, the ESGAP score =5,

If the country value =< gp_{max}, the ESGAP score =100, otherwise

$ESGAP_{score}$ = [(Country value - gp_{min}) / (gp_{max}- gp_{min})] * 100

The indicator's score is 100 for 2017.

Discussion

Kenya's current population of 52 million people [9] is rapidly increasing and its economy transitioning towards a middle-income economy, with a derived rapid urbanization and industrialization. This sets Kenya under severe threat of increased CO_2 emissions in the next decade.

Whilst the ESGAP score suggest that Kenya is currently emitting under sustainable levels, the national CO2 emissions in tons/capita are on the increasing trend, although lower when compared to emissions from industrialized countries. The national total emission of CO_2 stands at 130M tons per year, which contributes around 0.1% to global warming. Hence, despite Kenya contributes minimally to the global greenhouse gas emissions, it is quite vulnerable to its effects. Climate disasters are on the rise and round 70% of climatic disasters in Kenya (i.e., droughts and floods, sea rise) are now climate related, which is up from around 50% from two decades ago.

Kenya is a signatory to the Paris Agreement and the GoK committed to the implementation of mitigation measures to achieve a 32% reduction of its 2015 GHG emissions by 2030, according to the Second National Communication[24] and the Nationally Determined Contributions (NDCs) submitted in 2015 and revised in 2018[41]. Nevertheless, increases in vehicle numbers caused by economic growth and the expansion of coal for energy generation might make it extremely hard for Kenya to achieve its emissions reduction targets.

The Kenya Climate Change Action Plan and NDCs identify agriculture (including livestock rearing) as the country's biggest emission source with industrial growth and engines burning fossil fuels adding to GHG emissions.

Kenya is on track with mainstreaming of climate change. The GoK has enacted climate change legislation to provide a regulatory framework for enhanced response to climate change, which also spells out the roles of both national and

county governments in applying the Action Plan in all sectors of the economy. The country has also embarked on a low carbon development pathway by adopting a green economy strategy for development. Nevertheless, there is still a need, both at the national and county levels, to allocate more resources towards reduction in CO_2 emissions, part of climate change resilience and mitigation such as investments in energy sectors to prioritize cleaner and green technologies.

3.2.2. Consumption of hydrochlorofluorocarbons (HCFCs)

The Kenya ESGAP proxy indicator used to measure sustainability on preventing ozone depletion is the *consumption of hydrochlorofluorocarbons* (HCFCs), which are one of the major ozone depleting substances. Ozone-depleting substances (ODS) are any substance containing chlorine or bromine that destroys the stratospheric ozone layer.

Standard

Kenya is a signatory to the Montreal Protocol and as such, it operates within the standard on the Ozone Depleting Substances Regulation 2009, stipulated as allowable limits of 47-52.2 tons of ODS.

Data profile

Data on ODS in Kenya (Table 12) is compiled by the Ozone Office of the Ministry of Environment and Wildlife and the Ozone Secretariat at UNEP and released annually[42].

Table 12. Consumption of HCFCs (tonnes) per year between 2014 and 2019.

YEAR	2014	2015	2016	2017	2018	2019
Consumption of HCFCs	24.8	20.6	15.07	5.66	4.49	6.36

ESGAP score calculation

We used a gp_{min} of 47 and a gp_{max} of 0.

If the country value => gp_{min}, the ESGAP score =5,

If the country value =< gp_{max}, the ESGAP score =100, otherwise

$ESGAP_{score}$ = [(Consumption of HCFCs (Year X) - gp_{min}) / (gp_{max}- gp_{min})] * 100

The indicator's score is 86.47 for 2019.

Discussion
ODS consumption in Kenya has steadily decreased between 2014 and 2018 at an average rate of 5.07% with an increase of 1.87 tonnes between 2018 and 2019.

Hence, despite the high ESGAP score indicates that Kenya is currently consuming ODS within sustainable levels, this upward tendency, which may be explained due to an increase on sales of refrigerators and air conditioners as result of a growing working-class population, needs to be monitored. Additionally, whilst compliance with the Montreal Protocol is set as the minimum ambition, a higher level of ambition on 0 emissions should be considered as target in the long term.

The GoK has made considerable steps to phase out ODS and to adopt cleaner refrigeration technologies in households and industries. This include the ratification of the Kigali Amendment to the Montreal Protocol to phase down production and consumption of hydrofluorocarbons in a joint enforcement comprising the Environment Ministry, National Environment Management Authority (NEMA) and Kenya Revenue Authority, which are working to ensure that substances that deplete the ozone layer are not imported into the country.

3.2.3. Proportion of surface waterbodies with good ambient water quality

The Kenya ESGAP framework uses as indicator the proportion of surface water monitoring stations in major river basins that meets the technical standards of good ambient water quality. The data presented for rivers.

Water quality parameters are regulated by the national water quality standards in the Water Quality Act 2006, and the EA Standards for water quality. Water quality parameters assessment in Kenya include dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD5), nitrate (NO3-), ammonium nitrogen (NH4+) and total phosphates (ph-), PH and alkalinity chloride ion (mg/l), sulphate ion (mg/l0 nitrate (mg/l), total hardness (mg/l), pH and total dissolved solids (TDS) (mg/l).

Standard
The indicator standard refers to ≥ 80% as threshold (i.e., ≥ 80% of stations with good ambient water quality). Nevertheless, we use as standard of 100% monitoring stations with good ambient water quality status.

Data profile
Water quality data is available through the UN SDG Water Monitoring Programme under GEM Stat, and it is collected in Kenya for a new indicator developed for SDG 6.3.2 and 6.3.1 (Table 13).

Table 13. Surface water bodies in good ambient water quality (rivers) in 2020.

YEAR	2020
Surface water bodies in good ambient water quality (rivers)	90.40

ESGAP score calculation

We normalized the indicator as below,

$$\begin{aligned} &\text{if} \quad I \geq gp_{max} && NI = 100 \\ &\text{if } gp_{min} < I \leq \quad gp_{max} && NI = 100\,\frac{I - gp_{min}}{gp_{max} - gp_{min}} \\ &\text{if} \quad I \leq \quad gp_{min} && NI = 5 \end{aligned}$$

(gp_{min} = 0; gp_{max}= 100)

ESGAP score = $\frac{\%\ \text{surface waterbodies in good ambient water quality (year X)}}{100} * 100$

The Kenya ESGAP score for the proportion of surface waterbodies in good ambient quality in Kenya is 90.40 for 2020.

Discussion

In Kenya, the Water Resources Authority is mandated by the Water Quality Act 2006 to monitor water quality in major rivers and lakes within the country, and there is a monitoring network and data collection infrastructure of reasonable quality equipped to collect water quality data for surface water bodies in all the six major catchments in the country (i.e., Lake Victoria North, Lake Victoria South, Ewaso Nyiro North and South, Tana River and Rift Valley).

Water Resources Authority (WRA) is mandated by law to monitor both surface water and groundwater quantity and quality. To this effect WRA has established permanent regular water monitoring stations (RGS) for both surface and some boreholes for ground water monitoring. A total of 223 stations are in operation with 188 dedicated to surface water and 140 dedicated to groundwater[10].

Out of the total established stations69% are operational for surface water and 61% are operational for groundwater of which 68% are operation for water quality monitoring. Some of the stations show inconsistency in water monitoring with an average of 68% for surface water and 67% for groundwater[10].

Data available for most station are inconsistent in terms of periodicity of collection and parameter range. There were many data gaps for different water quality parameters, data that was readily available were those of pH for example.

The ESGAP score that has relied on the SDG data indicates that a high proportion of rivers in Kenya (of those monitored) meet the technical standards of good ambient water quality 90.4, indeed a very high percentage, this is a surprise. However, this might have been due to dilution from rains since most rivers originate from 'Water towers' areas of pristine environment and with high rainfalls registered the rate of dilution is high. The water quality of open waterbodies is considerably lower than those of rivers since their waters are largely static

Small percentage of rivers run through urban centers with manufacturing industries, poor sewer management and poor garbage handling facilities. These urban rivers show poor water quality. Open bathing in rivers is common and therefore renders such rivers of poor ambient water quality.

Approved standards for effluent discharges exist but are not enforced. Additionally, the collapse of the sewage system in some urban centers as result of population growth has resulted into increased wastewater discharges into major water bodies, so water pollution from urban and industrial wastes continues to represent a major environmental threat to maintain water quality. In addition, pesticides and fertilizers used in agriculture deteriorate freshwater resources. Incidences of eutrophication have been reported in some of the main basins, including Lake Victoria.

Poor water quality is a major public health hazard so monitoring and enforcing water quality standards are a priority for the GoK.

3.2.4. Proportion of groundwater bodies in good chemical status

This indicator also represents the percentage of monitoring stations that meets the standards of good ambient water quality, but in this case of groundwater bodies. Ambient water quality is affected by both natural and anthropogenic influences, and it is an indicator of the potential of those water bodies to provide services such as the provision of drinking water and irrigation, or to preserve biodiversity (including sustaining fisheries).

The Kenya ESGAP indicator used is the *Proportion of groundwater monitoring points in major river basins that meets the technical standards of water quality*. Similarly, to the case of groundwater pollution assessments, reasonable data collection infrastructures are available in Kenya and attempts have been made to collect water quality data for groundwater in all the six major catchments of Lake Victoria North, Lake Victoria South, Ewaso Nyiro North and South, Tana River, and the Rift Valley catchments. Nevertheless, in this case data available is also inconsistent in terms of periodicity of collection and quality.

Water quality parameters are regulated in Kenya by the National Water Quality Standards of groundwater in the Water Quality Act 2006 and the EA Standards for water quality[43]. Parameters used for this study included oxygen content, conductivity, and nitrate levels. Nevertheless, the Water Resources Authority also regulates the monitoring of additional parameters including iron (mg/l), ammonium ion (mg/l), chloride ion (mg/l), sulphate ion (mg/l), nitrogen dioxide (mg/l), nitrate (mg/l), total hardness (mg/l), pH and total dissolved solids (TDS) (mg/l) but the implementation of these comprehensive assessments is not enforced.

Standard

This indicator is also derived from SDG indicators 6.3.2, and 6.3.1, which define as threshold ≥ 80% (i.e., ≥ 80% of stations with good ambient water quality). Nevertheless, we adopted a higher aspiration standard of 100%, with all the monitoring stations meeting the standard of good ambient water quality status.

Data profile

The data used for this indicator was drawn from SDG indicator documentation available through the UN SDG Water Monitoring Programme under GEM stat and included data collected for the new SDG indicators developed in Kenya SDG 6.3.2 and 6.3.1 (Table 14).

Table 14. Groundwater bodies in good chemical status in terms of oxygen content, conductivity, and nitrate levels in 2020.

YEAR	2020
Proportion of groundwater bodies in good chemical status in terms of oxygen content, conductivity, and nitrate	90.3

ESGAP score calculation

We normalized the indicator as below,

$$\text{if} \quad I \geq gp_{max} \qquad NI = 100$$

$$\text{if } gp_{min} < I \leq gp_{max} \qquad NI = 100\frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

$$\text{if} \quad I \leq gp_{min} \qquad NI = 5$$

(gp_{min} = 0; gp_{max}= 100)

$$\text{ESGAP score} = \frac{\%\ \text{groundwater waterbodies in good ambient water quality (year X)}}{100} * 100$$

The Kenya ESGAP score for the proportion of groundwater waterbodies in good ambient quality in Kenya is 90.3 for 2020.

Discussion

Like the case of surface waterbodies, there is a a monitoring network and data collection infrastructure of reasonable quality equipped to collect water quality data for groundwater aquifers in all the six catchments of Lake Victoria North, Lake Victoria South, Ewaso Nyiro North and South, Tana River and Rift Valley catchments. Nevertheless, we were also unable to access the data in a form that could be reported.

Groundwater water quality is partly influenced by anthropogenic activities occurring at the surface level including mining, agricultural activities and pollution of water areas which may have links to underground aquifers. Groundwater monitoring is often undertaken through designated groundwater monitoring boreholes and some studies have reported high heavy metal concentrations (such as mercury and arsenic) in intensive gold mining areas of Kakamega[44]. Similar results are reported for other mining areas of the country. However, the quality of groundwater in Kenya is still very good and compared to surface waterbodies which occasionally deteriorates during excessive drought, groundwater forms the future potential water source for the Country.

Nevertheless, relatively little is currently known about the extent, quality, recharge rates, and abstraction potential of much of Kenya's groundwater so there is a need for improved mapping and assessments of groundwater resources. Particularly, as this will become an increasingly important resource as the demand for water increases, so enhancing our understanding of the potential of groundwater resources in Kenya is a prerequisite for future sustainable water resource planning and management.

3.3. Life-support function

At the life-support function level, no indicator or data was available to use to measure Kenya's natural capital current capacity to sustain ecosystem health and functioning of crucial ecosystem services. The European ESGAP framework included for this function three indicators: the proportion of habitats in favorable conservation status, the proportion of surface water bodies in good ecological status, and the proportion of coastal water bodies in good ecological status. Nevertheless, there are not definitions nor data or standards for defining 'good ecological status' in Kenyan legislation based on biological, physicochemical, and hydro morphological parameters, neither data to define the ecological conservation status of terrestrial ecosystems based on range, area, structure and function. Further discussion about this function is provided in section 5.

3.4. Human health and welfare function

3.4.1. Population using clean fuels and technologies for cooking

One of the Kenya ESGAP indicators used to measure the extent to which the country is respecting standards for human health is the *Proportion of population using clean fuels and technologies for cooking*, which represents the number of households using clean fuels and cooking technologies.

This provides an indication of the proportion of the Kenyan population exposed to indoor air pollution and particulate matters of less than 2.5 mg/m³. Communities both in rural and urban low-income neighborhoods use charcoal, wood, and wood cooking stoves, which emit smoke and other climate pollutants.

Standard

We used a standard of 100% of the population with access to clean fuels and technologies for cooking.

Data profile

Kenya regularly undertakes demographic surveys and projections every ten years. The percentage of the population with access to clean fuels and technologies for cooking is included in the monitoring framework of the National Statistics Systems and data is available through the National Statistics Office (Table 15).

Table 15. Proportion of the population with access to clean fuels and technologies for cooking between 2005 and 2016.

YEAR	Proportion of population with access to clean fuels and technologies for cooking (%)
2005	4.28
2006	4.93
2007	5.65
2008	6.39
2009	7.24
2010	8.02
2011	8.95
2012	9.9
2013	10.74
2014	11.83
2015	12.76
2016	13.42

ESGAP score calculation

We normalized the indicator as below,

$$\text{if} \quad I \geq gp_{max} \qquad NI = 100$$

$$\text{if } gp_{min} < I \leq gp_{max} \qquad NI = 100\frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

$$\text{if} \quad I \leq gp_{min} \qquad NI = 5$$

(gp_{min} = 0; gp_{max}= 100)

$$\text{ESGAP score} = \frac{\%\ \text{population with access to clean fuels and technologies for cooking (year X)}}{100} * 100$$

The Kenya ESGAP score for the proportion of population with access to clean fuels and technologies for cooking in Kenya is 13.42 for 2016.

Discussion

The ESGAP score of 13.42 indicates that only a low percentage of the Kenyan population have access to clean cooking fuels and technologies, and therefore a high percentage of the population is exposed to critical levels of indoor air pollution. Communities both in rural and urban neighborhoods use charcoal, crop waste, dung, wood, kerosene, and low-quality cooking stoves. Rural communities and urban and sub-urban low-income neighborhoods commonly use 'unimproved' stoves or traditional three-stone fire pits for cooking. This contributes to ever increasing risk of respiratory diseases, including chronic illnesses, which also disproportionately harm women and children. Moreover, cooking with potentially dangerous and polluting modern fuels, such as kerosene, also imposes tremendous direct costs on economies and households in Kenya, and it contribute to a wide range of negative environmental and climate change derived effects.

Household air pollution is one of the greatest air pollution risks to the Kenyan population, and whilst considerable efforts has gone into improving cooking stoves among the most impacted communities, this has only realized low impact particularly in rural communities.

The Clean Cooking Alliance initiative, hosted by the United Nations Foundation, has distributed more than 115 million clean cookstoves to households since 2010, with a goal of achieving universal access to clean cookstoves by 2030[45]. The Alliance identified Kenya as one of eight priority countries for clean cookstove provision[45]. While this significant investment is important for reducing economic barriers, implementation should be paired with sufficient measures to enable uptake and retention. Hence, there is still an urgent need to popularize the use of clean cooking technologies and provide access to low-cost safe alternatives through microfinance institutions (MFIs), among others.

3.4.2. Population exposed to safe levels of $PM_{\geq 2.5}$

The ESGAP indicator *Proportion of population exposed to safe levels of* $PM_{2.5}$ represents the percentage of the population exposed to ambient air pollutants of fine particulate matter of ≥2.5mg/m^3.

This indicator is the same used in the European ESGAP framework. Kenya has deployed infrastructure to monitor ambient air quality in some major cities such as Nairobi, Mombasa and Kisumu and there are occasional reports on ambient air quality within those three major cities. The Meteorology Department also has a permanent air quality monitoring infrastructure supported by global partners and NEMA is developing a central monitoring system and an air pollution monitoring unit which should strengthen this databank.

Standard

We used the 2005 WHO Air quality guidelines on thresholds and limits for key air pollutants that pose health risks, which set averaged 24 h guideline exposure for PM2.5 at 25 µg/m3[34]. Three interim target levels were set by the WHO as an achievable roadmap for attaining their air quality guideline of an annual average fine particulate matter (PM2.5) concentration of 10 µg/m^3. The interim targets are set at progressively lower concentrations: IT-1, 35 µg/m^3; IT-2, 25 µg/m^3; and IT-3, 15 µg/m^3.

Data profile

Data (Table 16) is provided by the Kenya National Bureau of Statistics through the Economic Survey 2020 and the World Development Indicator of the World Bank.

Table 16. Population in Kenya exposed to levels exceeding WHO standards (% of total) between 2000 and 2017.

YEAR	Population exposed to levels of PM 2.5 exceeding WHO standards (% of total)
2000	100
2001	100
2002	100
2003	100
2004	100
2005	100
2006	100
2007	100
2008	100
2009	100
2010	100
2011	100
2012	100
2013	100
2014	100

2015	100
2016	100
2017	100

ESGAP score calculation

We normalized the indicator as below,

$$\text{if} \quad I \geq gp_{max} \qquad NI = 100$$

$$\text{if } gp_{min} < I \leq \quad gp_{max} \qquad NI = 100\,\frac{I - gp_{min}}{gp_{max} - gp_{min}}$$

$$\text{if} \quad I \leq \quad gp_{min} \qquad NI = 5$$

(gp_{min} = 0; gp_{max}= 100)

$$\text{ESGAP score} = \frac{\%\ \text{population exposed to safe levels of PM 2.5 (year X)}}{100} * 100$$

The Kenyan population exposed to levels exceeding WHO guideline value has been 100% between 2000 and 2017 (Table 16), which means that the proportion of the Kenyan population exposed to safe levels of PM 2.5 is 0. Hence, the normalized ESGAP score for this indicator is 5.

Discussion

The ESGAP score highlights the alarming fact that 0% of the Kenyan population is exposed to safe levels of $PM_{\geq 2.5}$. The Kenya economic survey 2019 reported that 21.8 million people suffered from respiratory diseases in 2018, which indicates that air pollution could be of major concern in Kenya.

According to the Kenya's NDCs[41], the transport sector is one of the leading emission sources responsible for outdoor air pollution. Air pollution is a visible problem in Kenya's major cities such as Nairobi, Mombasa, Kisumu and Eldoret, where major traffic congestions are of common occurrence.

The overall National GHG emission stands at 14.3 $MtCO^2$ with the transport sector reported to account for 30% of those emissions. Kenya witnessed a strong increase in the transport sector which resulted in a rapid increase of GHG emissions forecasted to reach 20 $MtCO^2$ equivalent by 2030 according to the Second National Communication[24].

Whilst the GoK mandated the Air Quality Regulation in 2018, the implementation of outdoor air pollution regulations is inhibited by lack of baseline on air quality measurements across the country and budgetary constraints, among others. Different measures to address urban air pollution through low carbon transport modes have been proposed, including bus rapid transit (BRT) corridor systems, light rail transit (LRT) systems and a shift of freight transport from roads to rails.

3.4.3. Proportion of the population with access to safe drinking water

The European ESGAP framework used the proportion of samples that meet the drinking water criteria as defined in European legislation based on microbiological, chemical, and other parameters. The Kenya ESGAP framework uses the proportion of the population with access to safe drinking water as proxy indicator. This indicator describes the portion of the country or county population with access to an improved drinking water source as the main water supply. Access is defined as at least 20 liters per person per day from an "improved" source within 1 km of the user's dwelling[46]. WHO defines an improved drinking water source as a facility or delivery point that protects water from external contamination, particularly from human fecal waste[43].

Standard

Whilst the Ministry of Water and Irrigation mandated to ensure gradual realization of universal access to safe drinking water in Kenya, with a target of ensuring 80% access by 2020, we used the global target for access to clean and safe drinking water of 100% of the population with access to safe drinking water[46].

Data profile

This data (Table 17) is collected by the National Statistics Office and shared internationally with global platforms such as the World Bank. In Kenya, drinking water standards are stipulated in the Water Quality Regulation 2006[26], under EMCA cap 387.

Table 17. National data on the proportion of the population with access to safe drinking water between 2002 and 2017.

YEAR	Proportion of population with access to safe drinking water (%)
2002	41.45
2003	42.55
2004	42.79
2005	43.05
2006	43.29
2007	43.55
2008	43.83
2009	43.83
2010	45.78

2011	46.82
2012	47.86
2013	44.89
2014	49.94
2015	50.99
2016	52.02
2017	53.25

ESGAP score calculation

We normalized the indicator as below,

$$\begin{aligned} &\text{if} \quad I \geq gp_{max} && NI = 100 \\ &\text{if } gp_{min} < I \leq gp_{max} && NI = 100\,\frac{I - gp_{min}}{gp_{max} - gp_{min}} \\ &\text{if} \quad I \leq gp_{min} && NI = 5 \end{aligned}$$

(gp_{min} = 0; gp_{max}= 100)

ESGAP score = $\frac{\%\ \text{population with access to safe drinking water (year X)}}{100} * 100$

The Kenya ESGAP score for the proportion of the population with access to safe drinking water is 53.25 for 2017.

Discussion

The Kenya ESGAP score for the proportion of the population with access to safe drinking water is 53.25 for 2017.Kenya has a national target of 80% of the population with access to safe drinking water by 2030 according to the Vision 2030. Nevertheless, according to the KEPI 2018 barely half of Kenya's population (58%) had access to improved sources of drinking water by 2016, an increase from 48% in 2010. The highest access to safe water is in urban areas where over 72% of the population have access to improved sources of water.

In developing countries such as Kenya, access to safe drinking water is a challenge. High population add pressure on limited water resources and inevitably, providing adequate safe drinking water becomes a major challenge when population densities are so high, particularly in dryland regions.

National data (Table 17) shows that there has been a steady increase of the proportion of the population of the country with access to safe drinking water through the years. Nevertheless, water quality and distribution infrastructure has not kept pace with Kenya's recent industrial expansion and social transformation.

Africa's cities are growing at an unprecedented rate with a population in Kenya estimated to be around 40 million by 2050. This rapid urbanization has huge implications for water use in the country's cities, which already face rising water and sanitation demands and problems, such as pollution and overexploitation. Kenya's natural water sources are increasingly being polluted by industrial and urban effluents, as well as agricultural chemicals. The dangers of polluted water supplies are made more severe because of the large numbers of people who are dependent on natural water sources for drinking water (although not all-natural sources are unsafe).

Achieving universal access to drinking water in Kenya by 2030 will be challenging given current levels of investment, projected population growth and climate change derived effects.

3.4.4. Proportion of natural and mixed UNESCO World Heritage sites on good conservation status

The Kenya ESGAP indicator of proportion of natural and mixed UNESCO World Heritage sites on good conservation status is the same used in the European ESGAP framework, and it provides a qualitative description of the status of the various natural and mixed UNESCO World Heritage sites by classifying them as good, good with some concerns, good with serious concerns and critical[36].

The three World Heritage sites in Kenya recognized by UNESCO are Mt. Kenya National Park, Kenya Rift Valley Lakes systems and Lake Turkana.

Standard

The definition of 'good conservation outlook' is based on three elements: i) the current state and trend of values, ii) the threats affecting those values, and iii) the effectiveness of protection and management.

Data profile

We used the data reported at the IUCN World Conservation Outlook[36] (Table 18) for this study.

Table 18. Proportion of natural and mixed world heritage sites on good conservation status (%).

YEAR	2014	2015	2016	2017	2018	2019	2020
Proportion of natural and mixed World Heritage sites on good conservation status (%)	0	-	-	0	-	-	0

According to the 2020 IUCN World Conservation Outlook, the Kenya Lake System in the Great Rift Valley is classified under 'significant concern', the Lake Turkana National Parks under 'critical concern' and the Mt. Kenya National Park/Natural Forest as 'good with some concerns'.

ESGAP score calculation

The proportion of natural and mixed World Heritage sites in good conservation outlook is zero for 2020, so the ESGAP score for this indicator is 5.

Discussion

While some concerns have been reported for Mt. Kenya National Park/Natural Forest, the Kenya Lake System in the Great Rift Valley have progressed from 'good with some concerns' to 'significant concerns' and the Lake Turkana National Parks has moved to 'critical concern'. These three World Heritage sites face climate change and anthropogenic induced effects that threaten their ecological integrity and may led to withdrawal of designation status.

Mt. Kenya is a gazetted national park with protection under wildlife conservation and the Protection Act 2016. Nevertheless, whilst the park is under protection it has faced environmental threats due to forest encroachment and human wildlife conflicts, which lead to the installation of an electric fence around most of the park.

The Rift Valley lakes are unique ecosystems in terms of water quality and biodiversity. Some of those, such as Lake Nakuru National Park, host exceptional biodiversity and it has been denoted by UNESCO as the single most important foraging site for the lesser flamingo anywhere in the world, with hundreds of thousands of lesser flamingos moving between Bogoria, Elementaita and Nakuru, the three shallow lakes lying in this section of the Africa's Great Rift Valley that cuts a fertile gash through Kenya's highlands. Nevertheless, Lake Nakuru faces threats of human encroachment, pollution from sewage discharges and runoff from Nakuru town, as well as climate change derived effects such as an unprecedented rise in the water level. Also, as Lake Turkana is one of the cross-border lakes between Kenya and Ethiopia, the management of water on the Ethiopian side is now of greater concern given that the lake is an important source of fisheries.

3.5. Kenya's Strong Environmental Sustainability Index (SESI)

We undertook aggregation at three different levels within the ESGAP framework. The first aggregation was undertaken at the level of topics, namely i) biomass, ii) freshwater, iii) soil, iv) earth system, v) freshwater ecosystems, vi) human health and vii) other welfare. The second level of aggregation was performed at the

principles level, namely i) renew renewable resources, ii) use non-renewables prudently, iii) prevent global warming, iv) prevent ozone depletion, iv) Respect critical levels and loads for ecosystems, v) Respect standards for human health, and vi) conserve landscape and amenity. The third level of aggregation was at the function level, namely i) source, ii) sink and iii) human health and welfare. Since we were not able to use any indicator to calculate the life support function for Kenya, we did not aggregate to the overall composite index (SES Index). The results of the different levels of aggregation are presented in

Table 19. Kenya ESGAP results. Summary of indicators and sub-indices scores at different levels of aggregation.

Function	Principle	Topic	Indicator	Indicator score (Year)	Topic score	Principle score	Function score
Source							71.7
	Renew renewable resources	Biomass	Proportion of forest area as proportion of land area	78.0 (2016)	73.0	70.1	
			Proportion of fish stocks within biologically sustainable levels	68.3 (2017)			
		Freshwater	Freshwater withdrawal as proportion of total actual renewable water resources	68.4 (2017)	68.4		
	Use non-renewables prudently	Soil	Proportion of land area not degraded against total land area	72.8 (2018)	72.8	72.8	
Sink							91.7
	Prevent global warming, ozone depletion	Earth system	$C0_2$ emissions per capita	100 (2017)	93.0	93.0	
			Consumption of hydrochlorofluorocarbons (HCFCs)	86.5 (2019)			
	Respect critical levels and loads for ecosystems	Freshwater ecosystems	Proportion of surface waterbodies with good ambient water quality	90.4 (2020)	90.3	90.3	
			Proportion of groundwater bodies in good chemical status	90.3 (2020)			
Life-support			-			-	-
Human health and welfare							8.7
	Respect standards for human health	Human health	Population exposed to safe levels of $PM_{2.5}$	5 (2017)	15.3	15.3	
			Population using clean fuels and technologies for cooking	13.4 (2016)			
			Proportion of the population with access to safe drinking water	53.3 (2017)			
	Conserve landscape and amenity	Other welfare	Proportion of natural and mixed UNESCO World Heritage sites on good conservation status	5 (2020)	5	5	

4. DISCUSSION

4.1. Application of the ESGAP framework to the Kenya context

The application of the ESGAP framework to the Kenyan context is challenging due to data quality limitations, availability of adequate indicators and standards, and accessibility to data. The Kenya ESGAP framework is composed by 12 indicators, three of which are the same indicators used in the European context, and 9 are proxy indicators relevant for Kenya (Table 19). Nine out of the 21 ESGAP indicators used in Europe did not have readily available data in the country. Five of those indicators were presumed to have data readily available according to our consultations with relevant stakeholders and data custodians. However, the team was unable to either access that data, or to use the data provided due to quality issues. Some of those indicators had data which would have required considerable time to clean, analyse and extrapolate missing data points. Particularly, some of the parameters on indicators related to water quality had serious data gaps, which made data unrepresentative. Three out of those nine ESGAP indicators had no data collected in Kenya, whilst one indicator with data readily available for Kenya for biodiversity and ecosystems, did not meet the conceptual requirements according to the theoretical framework, which reflects an accurate and restrictive vision on the concept of strong sustainability. Particularly, the indicator on protected areas coverage was not suitable to use within the ESGAP framework given that it is not linked to the life support function of natural capital (see below). See Table 5 and Appendix II for further information on the characteristics and robustness of the indicators used in the Kenya ESGAP process.

We were not able to gather data to inform the following indicators:

i) Proportion of cropland and forest area exposed to safe ozone levels. Data for this indicator does not exist in Kenya. However, the Meteorological Department seems to be implementing climate change monitoring efforts including the collection of data on emissions, so this could be potentially interesting for future applications of the ESGAP framework in Kenya

ii) Proportion of ground and coastal water bodies in good chemical status. Even though data is reported available with KEMFRI at the National level, the team was unable to access the data for analysis due to time constraints and the absence of data on aquifer recharges or water renewals that can be used to corroborate data on groundwater quantity status.

iii) Proportion of ecosystems not exceeding the critical loads of eutrophication and acidification. Data is nonexistent for Kenya on this

indicator. We also found challenges in the interpretation of the indicator and potential data sources.

iv) Proportion of habitats in favorable conservation status. Whilst there were some potentially suitable indicators that could be linked to this topic in Kenya, a closer look revealed that they did not match the theoretical underpinning of the ESGAP framework, so we were not able to use them.

v) Proportion of surface and coastal waterbodies in good ecological status. Whilst there was supposed to be data available from KEMFRI for this topic, at least for some waterbodies, for example, on the extent of invasive species such as water hyacinth or eutrophication based on phytoplankton levels, the Kenya ESGAP team was unable to access that data.

vi) Recreational waters in excellent status. Data was also presumably available through KEMFRI for coastal areas, and we reported that one study is available for the shoreline around Kisumu City with KEMFRI and JOUST University, although we were not able to access that information.

In terms of the use of standards, reference points, and data sources, eight out of nine of the proxy indicators used in the Kenyan context used science-based standards defined by recognized international organizations and sources including WHO, UNFCCC, UN, UNESCO/IUCN, Montreal protocol, FAO, or OECD. Only the indicator on forest coverage as proportion of total area used a national policy target (i.e., 10% of coverage) as defined in the Kenya Constitution. Normally, policy targets and some science-based standards differ, which makes it a potential controversial issue for application and uptake of the ESGAP framework by national countries given that some of the science-based standards may not be relevant to developing countries based on their socio-economic context and national circumstances. In Kenya, several indicators could not be used as proxy indicators given the lack of science-based standards. Nevertheless, the use of science-based standards is precisely one of the strongest features of the ESGAP framework, as its goal is to measure strong sustainability by reflecting on the conditions under which the functioning of natural capital is not altered in a way that threatens its capacity to provide essential ecosystem services in the long-term, so those essential environmental functions of natural capital should be defined by science-based standards not policy goals.

In summary, in terms of the methodological and technical process to apply the ESGAP framework to the Kenyan context, we conclude that:

i) There is a need to involve and engage with standard developing bodies like the Kenya National Bureau of Statistics (KNBS) to develop science-based environmental standards for future applications of the ESGAP

framework to the Kenya context. The KNBS has very limited experience in natural capital accounts and is unlikely to have the internal expertise to manage a process like this so support would be needed to ensure KNBS builds the capacity to produce these assessments in an accurate and reliable way.

ii) There is also a need to engage with environmental data developers and data custodians in Kenya to inform the development of relevant environmental indicators and design data collection and monitoring schemes that could inform more exhaustive and comprehensive assessments in the future on Kenya's performance against environmental standards intended to represent whether the capacity of the country's natural capital to provide ecosystem services is compromised in the long-term. This is particularly relevant for indicators related to the life-support function.

iii) It is important to effectively communicate with relevant national stakeholders and final users of the SESI that the concepts of 'strong sustainability' and 'critical natural capital' are at the core of the ESGAP framework, and how important the use of metrics on strong sustainability and environmental science-based standards is to avoid misleading and poor decision-making based on indicators that assume that the loss of nature can be fully compensated by increases in manufactured, human or social capital.

4.2. Strong environmental sustainability in Kenya

Our results suggest that the functioning of different elements of natural capital in Kenya, and their capacity to provide essential services in the long-term, is highly impaired because of excessive environmental degradation.

Kenya scores 71.8 points in the source function, 91.7 on the sink function and has a very low score (under 10 points) in the human health and welfare function. Given lack of data on life support functions we were not able to calculate the overall SES index. It is evident that the gap between the current and sustainable environmental conditions is very high in Kenya. In particular, and considering data limitations, we can highlight that Kenya faces a particular critical situation in relation to human health and welfare (see below).

It is important to bear in mind that only a score of 100 reflects compliance with the environmental standards of each of the 12 indicators selected to represent environmental functions of natural capital in Kenya.

In terms of the source function, the principle of using non-renewables prudently obtained a score of 72.8 points (Table 19), based solely on the indicator of

Proportion of land area not degraded against total land area. Land degradation, accelerated due to soil erosion and due to climate-change derived effects, is currently the major challenge and is a severe environmental threat to ecosystem functions and agricultural productivity for Kenya. Kenya's soils are highly erodible (Table 10). An estimated 12 million people, close to 25% of the Kenyan population, subsist on land that is highly degradable, the ASAL taking up approximately 85% of Kenya's land area[47]. The dominant processes of land degradation in Kenya include the loss of soil fertility in agricultural lands through wind and water erosion, poor land management practices, deforestation, and desertification. Degradation affects majority of the rural people (smallholder farming and pastoralism), who primarily depend on land for their livelihoods, food, water, and economic development. Livestock production is highly vulnerable to the impact of land degradation, and yet it is a crucial factor in Kenyan agriculture as it accounts for approximately 50 percent of the agriculture share of the national GDP[48].

On relation to Kenya's renewable natural capital assets, whilst the ESGAP performance was relatively high (i.e., 70.1 points, see Table 19) particularly driven by the biomass topic which scored 73 points, a closer look shows environmental challenges under this area in the country. On relation, to Kenya's forests, between 1982 and 2006, 46 percent of Kenya's forestland degraded[47]. This decrease is also partly responsible for land degradation. Whilst in recent years there has been some recovery (as highlighted by the relatively high score of the proportion of forest area indicator of the biomass topic) and Kenya' s forest cover currently stands at 7.3%, forests have not yet returned to baseline levels of 1990. It is also worth mentioning that the ESGAP score for this indicator was based on a policy target of 10% coverage, which arguably represents a low level of ambition. Additionally, data on the extent of Kenya's forest cover generally uses a criterion of 10% canopy cover to determine forested areas. Nevertheless, the percentage of 'closed forests' (i.e., tree canopies of 60–70% coverage) currently stands at about 2% of the total land area, compared to the African average of 9.3%[48]. Hence, the overall value of Kenya's values may be overestimated.

In terms of the other component of the biomass topic, fisheries, Kenya also faces sustainability challenges. Whilst according to the ESGAP score fish stocks in Kenya seem to be exploited within biologically sustainable levels, it is important to highlight that the data used is not generated at country level, but at the level of fishing area. For Kenya, this is the Western Indian Ocean and therefore only considers marine areas. At National level marine fisheries data available is on the EEZ and is mainly from artisanal fisheries. Hence, there is a need to update data and analysis of Kenya's marine fisheries potential as data on marine fish stocks are

decades old. Nevertheless, Kenya is currently compiling national level data to develop the SDG indicator 14.4.1. Whilst data on marine fish stocks is scarce and old, there is evidence that inland fisheries, particularly in Lake Victoria are severely threatened by overexploitation. Illegal, unregulated, and unreported fishing is threatening the survival of Lake Victoria's fish stocks and is putting local livelihoods at risk. Illegal fishing and overexploitation however are not the only reasons for the drop in Lake Victoria's fish populations. The other drivers are a high population growth rate, pollution, agriculture, and invasive species.

The fisheries sector's contribution to the country's GDP is around 0.8%, with the inland fisheries subsector making up about 95 % of contributions[48]. The GoK has prioritized the blue economy as a key pillar of its Vision 2030 development agenda, and fisheries is an important component of the blue economy. However, a greater barrier to sustainable management of the country's fish stocks is weak governance. Hence, a strong, functional, and uncorrupted response is still needed to tackle major drivers of unsustainable use of fish stocks in Kenya.

In terms of the sink function, an ESGAP score of around 91.7 points highlights that Kenya is meeting environmental standards to maintain the capacity of its natural capital to neutralize wastes without incurring ecosystem change or damage in the long-term. The principle of respecting critical levels and loads for ecosystems performed reasonable (90.3 points, see Table 19). It is worth noting that three ecosystem related indicators were not reported due to unavailability of appropriate data. Those included data on the proportion of ecosystems not exceeding critical loads of heavy metals, ecosystems not exceeding critical loads of eutrophication and ecosystems not exceeding critical loads of acidification. Hence, the ESGAP framework has highlighted an important national data gap to be able to adequately assess the state of the sink function of Kenya's natural capital.

Water quality has presented problems for Kenya for many years. The causes are complex but together with water scarcity and water conflict, it is generating a water crisis in Kenya with poor management of water supply, water contamination (particularly in slums), as well as droughts, forest degradation, floods, and population growth as main contribution factors[48]. Kenya's natural freshwater sources are increasingly being polluted by agricultural chemicals and industrial and urban effluents. The dangers of polluted freshwater sources not only represent a severe threat jeopardizing the capacity of Kenya's natural capital to neutralize wastes without incurring ecosystem change or damage in the long-term, but it represents a major public health hazard which is made more severe because of the large numbers of people who are dependent on natural water sources for drinking water.

One of the main barriers is that the enforcement of water quality standards is weak enforcement. Water degradation costs Kenya around US$82.9 million every year, which is the cost of maintaining water quality (as well as quantity) and the increased cost of maintaining reservoirs. However, these costs do not fully account for the cost attributable to other threats such as the management of invasive species (e.g., water hyacinth). There are government policy initiatives that target the rehabilitation of Kenya's water catchment zones and water towers[48]. However, the lack of compliance with policies remains a serious concern, with common cases of wetlands converted to agricultural land or use for industrial development. Also, as way forward and whilst regulations exist, there is a need to monitor and enforce water quality standards in Kenya.

On relation to the earth system topic, Kenya scored highly (93.0 point, see Table 19). Nevertheless, CO_2 emissions deserve a particular mention. The ESGAP score suggests that Kenya is currently emitting under sustainable levels. It is important to mention through that whilst Kenya contributes minimally to the global greenhouse gas emissions (the current national total emission of CO_2 stands at 130M tons per year, around 0.1% contribution to global warming), it is quite vulnerable to its effects. In any case, the national CO_2 emissions in tons/capita are on the increasing trend. The GoK committed to the implementation of mitigation measures to achieve a 32% reduction of its 2015 GHG emissions by 2030. Nevertheless, increases in vehicle numbers caused by economic growth and the expansion of coal for energy generation might make it extremely hard for Kenya to achieve its emissions reduction targets. Even though Kenya is on track with mainstreaming of climate change, and it has embarked on a low carbon development pathway by adopting a green economy strategy for development, there is still a need to scale up investments on climate change resilience and mitigation measures such as energy sectors that prioritize cleaner and green technologies.

The human health and welfare function of Kenya's natural capital exhibited the lowest performance. A score of 8.7 points (Table 19) highlights that the capacity of natural capital to provide in the long-term other services to humans, often non-economic, which maintain health and contribute to human well-being in different ways to those represented by the source and sink function, **is severely impeded in Kenya.**

One of the most pressing environmental issues is indoor air quality. In Kenya, even though life expectancy is rising, environmental pollution still causes large numbers of deaths and most of these deaths and illnesses are linked to household air pollution (HAP), together with unsafe water and sanitation health. In Kenya, the population using solid fuels for cooking is exposed to high HAP levels that are on

average over 10–60 times the WHO guideline levels. Hence, the GoK needs to enforce interventions including education and public awareness strategies to make the severe health risks of HAP apparent.

There is also a need for subsidies to promote adoption of energy-efficient alternatives to wood fuel, especially at the household level, such as biogas energy from organic waste materials, uptake of efficient and improved cooking stoves, and improved ventilation of cooking and heating areas. In terms of outdoor pollution, virtually 100% of Kenya's population is exposed to unsafe levels of $PM_{2.5}$ although the availability of monitoring data focused on urban areas may render this result biased (Table 19). Air pollution is a highly visible problem in Kenya's major cities, where major traffic congestion is a common occurrence. The implementation of outdoor air pollution regulations is inhibited by a lack of baseline data on air quality measurements across the country and budgetary constraints, among others.

The accessibility to safe drinking water is another major environmental problem in Kenya. There is an increasing trend on overall access to safe drinking water, but over 45% of the population is still exposed to risk. In developing countries such as Kenya, access to safe drinking water is a challenge and high population growth rates also add pressure on limited water resources. The water distribution infrastructure has not kept pace with Kenya's recent industrial expansion and social transformation. In the future, Kenya faces an even greater water deficit situation, with climate change likely to exacerbate the situation with rainfall variability projected to increase. Hence, there is still a need in Kenya to explore innovative markets as financing sources for water resources management. This is particularly important given that the current level of investments allocated to water resource management are inadequate not only to enhance accessibility to safe drinking water sources, but to also meet the challenge of chronic and increasing water scarcity in the country.

We are not able to assess the life support function in Kenya due to the lack of suitable indicators with environmental science-based standards. This highlights a crucial data gap that the process of applying the ESGAP framework to the Kenyan context has identified. Hence, the ESGAP framework has also demonstrated to be a useful tool to guide and inform the development of national level indicators in Kenya to effectively assess the Kenya's natural capital capacity to maintain ecosystems health and function.

In terms of biodiversity, Kenya is committed to global biodiversity goals as a Party to several biodiversity-related MEAs including CITES, CBD and Ramsar. Also, the GoK has committed to wildlife conservation for a long time, which may date back

to the colonial era when Kenya designated its first protected areas. Protected areas in Kenya are surveyed, demarcated, and gazetted through a legal process as national parks, national forests, or forest reserves. Terrestrial protected areas in Kenya host a unique biodiversity richness that is essential for food security, human health and wellbeing, livelihoods, and economic development. These also include critical services such as watershed protection (a critical service in a water-scarce country) and tourism, which is a major industry in Kenya. Currently, around 12% of Kenya's territory is under legal protection including 24 national parks, 27 national reserves, 23 forest reserves, 4 marine national parks, 6 marine reserves and 4 sanctuaries, all those hosting around 30% of national biodiversity [11], while the remaining 70% is found outside protected areas [50] and exposed to severe threats linked to human encroachment because of farming, settlement and grazing of livestock. Approximately 40% of the North and North-Eastern (NNE) regions are classified as a biodiversity hotspot. But Kenya's biodiversity is under risk, evidenced by an increased rate of loss of biodiversity. Sixty-eight percent of wildlife was lost over the last 40 years and Kenya is ranked the 5th worst country in Africa in terms of numbers of threatened species.

Wildlife and biodiversity are arguably Kenya's key economic assets and therefore the cornerstone of national revenue. Nature-based tourism is the key tourism attraction to Kenya. The nature-based tourism sector is highly integrated into Kenya's economic fabric, and safari-based tourism has been found to stimulate the national economy where it is most needed, in rural areas[47]. Nevertheless, there is a growing recognition that the current approach to managing nature-based tourism may be contributing to degradation of the actual assets it relies on. Many of Kenya's nature attractions are under pressure with clear signs of degradation, including long-term declines of many of the charismatic big mammal species[47].

A system of national parks and reserves are key for conservation of biodiversity, nevertheless, protected areas coverage is not per se a good indicator of conservation outcomes and often, protected areas are not ecologically representative. Hence, this indicator is not suitable within the theoretical framework of the ESGAP. Another indicator proposed as proxy for the principle of maintaining biodiversity and ecosystem health was the Red List Index. Nevertheless, this indicator was not suitable given that it lacks scientific-based standards. Normally, environmental standards for biodiversity indicators are commonly missing so their inclusion in the ESGAP framework is challenging. In Kenya, the indicator 'proportion of species under threat' is supported by EMCA 387 and the Regulation on Biodiversity section 5-7, which covers biodiversity conservation, access to genetic resources and access and benefit sharing.

Another indicator is the 'proportion of area covered by invasive species against the total land area' although it also currently lacks science-based standards for these indicators. In any case, there are other indicators of ecosystem condition measuring different parameters that are suitable to determine whether an ecosystem is in good condition or not, but considerable efforts need to be devoted to including those in future ESGAP processes in Kenya. The European ESGAP framework uses the proportion of habitats in favorable conservation status based on range, area, structure and function, as well as the proportion of surface and coastal water bodies in 'good ecological status', as defined in European legislation based on biological, physicochemical and hydro morphological parameters.

4.3. Conclusion and recommendations

Kenya has a range of progressive policies and institutional arrangements to manage environmental issues. Particularly, the Vision 2030 provides a development blueprint aiming to transform Kenya into a newly industrialized middle-income country, whilst recognizing that the environment and natural capital are critical to achieve the socioeconomic and political development goals that it sets out.

Natural capital accounting provides a way to mainstream the value and conservation of natural resources into national economic policy planning. The ESGAP framework provides a framework to flag essential and irreplaceable natural capital functions (i.e., critical natural capital) currently at unsustainable levels that, if current rates continue, can jeopardize the maintenance of crucial environmental functions underpinning socio-economic development and human well-being. The National Treasury could use this information to generate an analysis on key policy questions, and to inform further assessments to allocate public expenditures to these sectors.

Based in our experience of implementing the ESGAP framework in the Kenyan context, we conclude that:

The ESGAP process has demonstrated to be a useful framework to highlight crucial data gaps and major threats to environmental sustainability in Kenya. However, its effective implementation requires strong guidance and/or the development of policies or regulations to enforce indicator-based data collection, analysis and sharing. Responsibilities of data collection among relevant institutions is low because of lack of policies, regulations, guidelines for implementation, internal capacity, and budgetary constraints (and therefore lack of resources and adequate infrastructure for regular and standardized data collection procedures). Hence, the development of policies or regulations may strengthen

planning and budgeting for indicator-based data collection and monitoring efforts, analysis and documentation between relevant institutions and data custodians.

Further natural capital assessment processes need to be leveraged in the country to assess local functions and their indicators. Nevertheless, future implementation processes of the ESGAP framework in Kenya can also benefit from other environmental-based assessment processes such as the Ocean Health Index, Water Stress Index, and Environmental Performance Index and so on. This also includes assessing the potential alignment to other MEA processes in Kenya, and the use of 'Conventions indicators' as proxy indicators. Developing countries such as Kenya are constrained by budgetary and capacity limitations for the monitoring and reporting for these processes. Hence, exploring the use of indicators widely accepted by Parties for reporting to different MEAs could be a potential lever to avoid the 'burden of reporting' and promote uptake and usage of the ESGAP framework. Indeed, the application of the ESGAP framework to Kenya relied largely on SDG indicators and international data sources for its implementation.

The effective application of the ESGAP framework to the Kenya context requires further efforts to improve the data underpinning the indicators used to inform the framework in terms of robustness and accuracy. Also, indicators with science-based standards used in different sectors should be explored to assess feasibility of adoption within the ESGAP theoretical framework. This also includes the development of science-based targets for indicators with data collected in Kenya but that currently lacks science-based reference points. Nevertheless, **we have also found that the use of science-based standards and not policy targets as thresholds is challenging for developing countries** like Kenya, as final users can be tempted to favor policy targets which are normally less ambitious and therefore more achievable than science-based standards. Hence, there is a need to involve bodies like the Kenya National Bureau of Standards on these processes and effectively communicate with final users the relevance of the concepts of strong sustainability, critical natural capital, environmental functions, and science-based reference points to measure environmental sustainability of the nation.

The crucial role of natural capital in the Kenyan economy is well recognized by the GoK. Nevertheless, the government still needs to continue developing natural capital accounts for key natural assets in the country such as forest resources, fisheries, water, or wildlife among others, to identify potential cross-sector linkages, and to improve available data to guide economic planning. The ESGAP framework could be used as an important tool to integrate data and indicators

for natural capital and environmental sustainability into economic planning complementing and cross benefiting from other adopted national processes such as the State of Environment Report to support environmental planning and management.

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6. APPENDIX I. INDICATOR ANALYSES FOR THE KENYA ESGAP FRAMEWORK.

Function	Principle	Topic	Subtopic	Pressure / State	Standard	Reference	ESGAP indicator	Data source
Source	Renew renewable resource	Biomass	Forest resources	Annual felling	Felling/net annual increments	EEA (2017)	Forest utilization rate	EEA (2017)
			Fish resources	Condition of fish	Fishing mortality consistent with maximum sustainable yields Spawning stalk biomass consistent with maximum sustainable yield.	EC (2010)	Fish stock with safe biological limits	EEA (2018b,2019b)
		Freshwater	Surface water resources	Blue water consumption	Blue water consumption/ mean quarterly flows	Raskin et al (1997)	Fresh water bodies not under water tress	EAA (2028a)
			Ground water resources	Status of ground water consumption		EC (2009)	Ground water bodies in quantitative status	EAA (2018b)
	Use non-renewables prudently	Soil	Soil erosion rate	Soil erosion	Tolerable erosion level	Jones (2024) Huber (2008) Vieijhe (2009)	Area with tolerable erosion level	Borelli et al (2017)
			Greenhouse gases	Greenhouse gas emission	Per capita GHG emissions consistent with global set target	See annex	Emission annual allowance	Eurostat (2012)
			6reenhouse gases	Greenhouse gas emission	Per capita GHG emission consistent with global climate targets	See annex	Emission/annual allowance	Eurostat (2019)
Sink	Prevent global warming and ozone depletion	Earth system	Stratospheric ozone depleting gases	Consumption of ozone depleting substances	Per capita ODS consumption consistent with reducing ozone hole	See annex one	Emission/annual allowance	Ozone secretariat UNEP

	Respect critical levels and critical loads of ecosystems	Terrestrial ecosystems	Ozone pollution	Concentration of air pollutants in terrestrial ecosystems	Critical levels of stratospheric ozone	Karlson et al 920030	Cropland and forest exposed to ozone levels	Horelak et al
			Pollution by heavy metals	Load of air pollutants in terrestrial ecosystems	Critical loads of heavy metals	Hertelink et al 2015 Hertelink et al 2017	Ecosystems not exceeding the Critical load of cadmium/lead/mercury	Hertelink et al 2015
			Eutrophication	Load of air pollutants in terrestrial ecosystems	Critical loads of eutrophication	CLR (TAP 2017)	Ecosystems not exceeding the Critical load of eutrophication	Hertelink et al 2017
			Acidification	Load of air pollutants in terrestrial ecosystems	Critical loads of acidification	CLR (TAP 2017)	Ecosystems not exceeding the Critical load of acidification	Hertelink et al 2017
		Fresh water ecosystems	Surface water pollution	Chemical status	Good chemical status as defined in European legislation	European parliament & Council	Surface waterbodies in good chemical status	EEA (2018c) EEA (2018c)
			Ground water pollution	Chemical status	Good chemical status as defined in European legislation	EC (2009)	Ground waterbodies in good chemical status	EEA (2018c) EEA (2018c)
		Marine ecosystems	Marine pollution	Chemical status	Good chemical status as defined in European legislation	EC (2009)	Coastal waterbodies in good chemical status	EEA (2018c)
Life support	Maintain biodiversity Ecosystems and species	Terrestrial ecosystems	Functional diversity	Local biodiversity intactness index	Local biodiversity intactness index	Steffan et all (2015)	Terrestrial area with acceptable biodiversity level	Usubiaga-Liaño (2019)
		Fresh water ecosystems	Ecological status	Ecological status	Good ecological status as defined in European legislation based on biological physiochemical and hydro morphological parameters	EC (2003	Surface waterbodies in good ecological status	EEA (2018c)

		Marine ecosystems	Ecological status	Ecological status	Good ecological status as defined in European legislation based on biological physiochemical and hydro morphological parameters	EC (2003	Coastal waterbodies in good ecological status	EEA (2018c)
Human health and welfare	Respect standards for human health	Human health	Outdoor air pollution	Concentration of air pollutants	Critical level of air pollutants	WHO (2005)	Population exposed to safe level of PM5	Harakel et al (2015b) Harakel et al (2017)
			Indoor air pollution	Concentration of air pollutants	Critical level of air pollutants	WHO (2005)	Population using clean fuels and technologies	WHO (2018)
			Drinking water pollution	Water samples	Safe drinking water criteria as found in European legislation based on microbiological, chemical & other parameters	European levels (1998)	Samples that meet drinking wager criteria	EC (2016)
			Bathing waters	Concentration of bacteria	Excellent quality criteria as defined in European as defined in European legislation based on concentration enterococci and *Escherichia coli* in bating waters	EC (2002)	Recreational water in excellent status	EAA (2019 a)
	Conserve landscape and amenity	Amenity	Natural and mixed UNESCO World Heritage	Conservation outlook	Good conservation based on 3 elements, the current state & trend of values, threats affecting those value The effectiveness of those values and management	Osipova et al	Natural and world heritage sites on good conservation status	Osipova et al (2014) Osipova et al 2017)

7. APPENDIX II. COMPARATIVE ANALYSIS BETWEEN THE PROPOSED ESGAP/SESI INDICATORS AND NATIONAL INDICATOR-BASED PROCESSES IN KENYA.

Function	Subtopic	ESGAP indicator	Proxy indicator	Alternative Indicators/KEPI	SOE indicator	SDG	SDG /VNR indicator	National Statistics System	Aichi indicators	Data custodian/ Focal Institution
Source	Forest resources	Forest utilization rate	Forest cover	Tree cover loss (%) (KEPI 2018)	Proportion (%) of land cover area under forests	Forest area as a proportion of total land area	Forest area as a proportion of total land area	Forest area as a proportion of total land area	Forest area as a percentage of total land area	Kenya Forest Services
	Fish resources	Fish stock with safe biological limits	None	% of fisher's population that use inappropriate fishing methods (Proposal)	Total and per capita marine fish catch Total and per capita aqua culture fish	Proportion of fish stocks within biologically sustainable level freshwater and marine	Proportion of fish stock within biological sustainable levels	Proportion of fish stock within biological sustainable levels	Proportion of fish stocks within biologically sustainable levels	Kenya Fisheries Services
	Surface water resource	Fresh water bodies not under water Stress	Water abstraction	Water stress index - % of water demand <40% of total available water resources (KEPI 2018)		A freshwater stress: freshwater withdrawal as a proportion of available freshwater resources			Water Quality Index for Biodiversity	

	Soil erosion rate	Area with tolerable erosion level	None	% land area degraded that is in extremely high severity of erosion. (KEPI 2018) % of farmers adopting improved soil management and soil erosion control practices	Proportion of arable land that is protected from soil erosion	Proportion of land that is degraded over total land area			Proportion of land that is degraded over total land area	MOA – Ministry of Agriculture /KALRO/-Kenya Agricultural and Livestock organization NAL - National Agricultural Laboratories
Sink	Greenho use gases	Emission/annu al allowance (per capita GHG/CO2 emission	None	CO2 emission per unit of value added	None	None				MOT/Ministry of Transport
	Stratosph eric ozone depleting gases	Emission/annu al allowance	None	None	None	None				NEMA - National Environment Management Authority KRA - Kenya Revenue Authority
	Surface water pollution	Surface waterbodies in good chemical status	Good chemical status in terms of transparency, turbidity, dissolved oxygen, pH, salinity, pollution by priority substances and pollution by other substances identified as being discharged in significant quantities.	Proportion of bodies of water with good ambient water quality	Biochemical oxygen demand (BOD) and COD in selected water bodies Presence of heavy metal					WRA/ -Water Resources Authority NEMA National Environment Management Authority
	Ground water pollution	Ground waterbodies in good chemical status	Groundwater bodies in good chemical status in terms of oxygen content,	Proportion of bodies of water with good ambient water quality	Biochemical oxygen demand (BOD) and COD in selected water bodies Concentration of Fecal coliforms/ pathogens					WRA/-Water Resources Authority NEMA National Environment

			conductivity, and nitrate		Presence of heavy metal Ground water levels by potential/volumes No. of boreholes sank and yields in urban and rural are					Management Authority
	Ecological status	Surface waterbodies in good ecological status	Surface water bodies in good ecological status in terms of oxygenation, salinity, nutrient status, acidification status and phytoplankton (medium and large-sized lakes only	Proportion of bodies of water with good ambient water quality	Biochemical oxygen demand (BOD) and COD in selected water bodies Concentration of fecal coliforms/ pathogens Presence of heavy metal Ground water levels by potential/volumes No. of boreholes sank and yields in urban and rural areas	Proportion of bodies of water with good ambient water quality				WRA/-Water Resources Authority KMFRI-Kenya Marine and Fisheries Officers /DA - Development Authorities UON/University of Nairobi
Human health and welfare	Outdoor air pollution	Population exposed to safe level of PM5	None	Annual mean levels of fine particulate matter (e.g., PM2.5 and PM10) in cities (population weighted) Average % population exposure to PM<2.5 (i.e., fine particulate matter) as a health risk factor, measured in micrograms per cubic meter µg/m3 (KEPI 2018)						NEMA/ National Environment Management Authority UON/ - University of Nairobi MOT - Ministry of Transport
	Indoor air pollution	Population using clean fuels and technologies for cooking	Proportion of population with primary reliance on clean fuels and technology	Indoor Air Pollution - %age of total households using wood fuel as energy for cooking (KEPI 2018)						

				Indoor Air Pollution - %age of total households using paraffin for indoor cooking and lighting (KEPI 2018) % age of population exposed to P.M<2.5 (KEPI 2018)						
	Drinking water pollution	Samples that meet drinking water criteria	Samples that meet the drinking water criteria for E. coli	% age of population having access to safe drinking water (KEPI 2018)	Proportion of population in urban / rural using (safe drinking water, improved water source portable) water		Proportion using safely managed drinking water services	Proportion using safely managed drinking water services	Percentage of population using safely managed drinking water services	WRA/ Water Resources Authority Water companies/ NEMA/ National Environment Management Authority
	Natural and mixed world heritage	Natural and world heritage sites on good conservation status	None	Mountain Green Cover Index; 15.5.1 Endangered species			Total expenditure per capita spent on cultural heritage conservation	Total expenditure per capita spent on cultural heritage conservation		NMK/National Museums of Kenya NEMA/ National Environment Management Authority

8. APPENDIX III. DETAILED MATRIX ON INDICATOR SUITABILITY ANALYSIS TO THE KENYAN CONTEXT.

Indicator	Proposed ESGAP Indicator	Is this possible?	Standard to be used	Data quality score	Indicator	Standard	Data description
1. Same state indicator as EU ESGAP framework		[Yes or No. If No, provide explanation for why not]	Same as EU	Total: Freq. of dissemination: Timeliness: Time coverage: Temporal comparability:	1. Same state indicator as EU ESGAP framework		
1 Same state indicator as EU ESGAP framework							
2.1.2 allowance (per capita GHG/CO2 emission	allowance (per capita CO2 emission	Yes: data readily available (This EU indicator applies for Kenya)	Data readily available through NATCOMs Kenya in its 3rd Natcom (DC30% GHG emission reduction commitment	Total: 2 Freq. of dissemination:1 Timeliness: 2yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years	Same state indicator as EU ESGAP framework	UNFCCC	Data available SNC, NDC KNCCAP
2. Proxy state indicator with science-based standards		As above	Description and value of standard	As above	2. Proxy state indicator with science-based standards		
2. Proxy state indicator with science-based standards							
2.1.1 Total greenhouse gas emissions per year	Co2 tons per capita	Yes level 2: data readily available (proxy Indicator with scientific standard)	Data readily available through NATCOMs Kenya in its 3rd National NDC30% GHG emission reduction commitment	Total: 2 Freq. of dissemination:1 Timeliness: 2yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years	Same state indicator as EU ESGAP framework	UNFCCC	Data available SNC, NDC KNCCAP
2.1.2 Emission/annual allowance (stratospheric ozone)	Consumption of HFCs	Yes level 2: data readily available (proxy Indicator with scientific standard)	Data available from Ozone secretariat office regularly	Total: 3 Freq. of dissemination:1 Timeliness:1yr Time coverage: ≥2 years in periods of <5 and 5-15 years		UNFCCC	Satellite data through Geostat

			generated through ODS permits by ODS regulation Global data through ODA satellite analysis	Temporal comparability: All years			
3. Proxy state indicator with alternative reference point (non-science based)		As above	Description and value of standard	As above	3. Proxy state indicator with alternative reference point (non-science based)		
3. Proxy state indicator with alternative reference point (non-science based)							
1.1.1 % Forest utilization rate	Forest area as proportion of total land area (No. data not readily available)	No level 2: data readily available (proxy Indicator with scientific standard)	Data regularly reported by KFS 10% forest cover (National constitution & Vision 2030 target	Total: 3 Freq. of dissemination:1 Timeliness:1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years	Proxy indicator non-EU	WHO, Vision 2030 FAOSTAT, KNOEMA	Data published locally and Internationally Great variation of published data from local and international sources National data published in KNBS
1.1.2 Fish stocks within safe biological limits	% fish stock exploited within maximum sustainable yield (MSY)	Yes level 2: data readily available –fish landings (proxy Indicator with scientific standard)	Fish landing within available stock and biomass renewal (fisheries regulation 2016, vision 20300)	Total: 3 Freq. of dissemination:1 Timeliness: 1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years	Proxy indicator Non-EU	Vision 2030, CoK FAOSTAT, KNOEMA	Time series published data by FAO, Data also available in KNBS National data published in KNBS
1.2.1 Fresh water bodies not under water Stress	% of freshwater withdrawal against the total freshwater renewal resource.	Yes level 2: data readily available (proxy Indicator with scientific standard)	Water abstractions permit regularly issued by WRA Water Act 2016)	Total: 3 Freq. of dissemination:1 Timeliness: 1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years	Proxy indicator non-EU	Vision 2030, MWI, NWMP KNOEMA	Current and projected Data available from NWMP

4. Proxy pressure indicator with upper (and lower) reference point(s)		As above	Description of standard with values of upper and lower reference points	As above	4. Proxy pressure indicator with upper (and lower) reference point(s)		
Proxy pressure indicator with upper (and lower) reference point(s)							
1.3.1 Area with tolerable erosion level	% land that is degraded against total land area	No level 3: data not readily available (proxy Indicator with national reference point)	Areas of soil degradation documented by Agriculture department (Agriculture Act 2015, Vision 2030)	Total: 3 Freq. of dissemination:1 Timeliness:1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years	EU indicator	SDG 2030	National data available
2.3.2 Ground waterbodies in good chemical status	Groundwater bodies in good chemical status in terms of oxygen content, conductivity, and nitrate	No level 2: data readily available (proxy Indicator with scientific standard	Data regularly reported through Water quality regulations 2006, NEMA, WRA	Total: 3 Freq. of dissemination:1 Timeliness: 1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years		WHO	Data regularly reported through Water quality regulations 2006, NEMA, WRA. Development Authorities
4..1.1 Population exposed to safe level of	PM2.5 Outdoor air pollution %age of population exposed to P.M<2.5 (KEPI 2018)	No level 2: data readily available (proxy Indicator with scientific standard	Data not regularly reported through ERC, MOT	Total: 1 Freq. of dissemination: 0 Timeliness: ≤1yr Time coverage: not comparable		Vision 2030, CoK EMCA regulation (Air quality standards)	National data published in KNBS?
4.1.2 Proportion of population with primary reliance on clean fuels and technology	Indoor Air Pollution - % of total households using wood fuel as energy for cooking (KEPI 2018) Indoor Air Pollution - %age of total households using paraffin for indoor cooking and	No level 3: data readily available (proxy Indicator with national reference point	Data regularly reported through National statistics systems (NSS)	Total: 3 Freq. of dissemination:1 Timeliness:1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years		Vision 2030, CoK EMCA regulation (Air quality standards	National data published in KNBS

	lighting (KEPI 2018)						
4.1.3 Samples that meet the drinking water criteria for E. coli	% of population having access to safe drinking water (KEPI 2018)	No level 2: data readily available (proxy Indicator with scientific standard	Data regularly reported through Water quality regulations 2006, NEMA, WRA. KEMFRI	Total: 3 Freq. of dissemination:1 Timeliness:1yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: All years		Vision 2030, MWI	% of population having access to safe drinking water National data published in KNBS?
4.2.3 Natural and world heritage sites on good conservation status	Natural and world heritage sites on good conservation status	No level 3 data readily available (proxy Indicator with national reference point)	Data regularly reported by IUCN	Total: 3 Freq. of dissemination:3 Timeliness:2yr Time coverage: ≥2 years in periods of <5 and 5-15 years Temporal comparability: (2014,2017 & 2020)		No standard	Data regularly reported by IUCN

9. APPENDIX IV. DIGITAL REFERENCE LIST FOR DATA SOURCES AND STANDARDS USED FOR THE KENYA ESGAP FRAMEWORK.

Indicator	Data sources
Forest coverage	Search - Kenya Data Portal (opendataforafrica.org) SDGs National Indicator Framework June 2019 - Kenya National Bureau of Statistics (knbs.or.ke) Kenya Forest area as a share of land area, 1960-2020 - knoema.com The Constitution of Kenya, 2010 (wipo.int) Ref: IUCN 1992 park congress report pg
Proportion of fish stock within biological sustainable levels	Environmental Performance Index, 2016 - Knoema Data Appliance (opendataforafrica.org) FAO. Fisheries and Resources Monitoring System (FIRMS). 2020 http://www.fao.org/cwp-on-fishery-statistics/publications/sessionsofthecwp/en/ World Development Indicators (WDI) | Data Catalog (worldbank.org) ECONOMIC SURVEY 2020 - Kenya National Bureau of Statistics (knbs.or.ke)
Fresh water bodies not under water stress	http://www.wra.go.ke/national-water-master-plan/ http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en Kenya Freshwater withdrawal, 1960-2020 - knoema.com AQUASTAT database Query Results (fao.org)
Proportion of land area degraded against the total land area	ECONOMIC SURVEY 2020 - Kenya National Bureau of Statistics (knbs.or.ke) https://esdac.jrc.ec.europa.eu/content/global-soil-erosion
CO_2 emissions per capita	Kenya CO_2 emissions per capita, 1970-2020 - knoema.com linked to Standard Kenya CO_2 emissions per capita, 1970-2020 - knoema.com, and EDGAR - The Emissions Database for Global Atmospheric Research (europa.eu)
Emission annual allowance (Total Ozone depleting substances stratospheric ozone)	Kenya | Ozone Secretariat (unep.org) https://knoema.com/atlas/Kenya/topics/Environment/Stratospheric-Ozone-Depletion https://ozone.unep.org/countries/data/standard Kenya | Ozone Secretariat (unep.org) https://knoema.com/atlas/Kenya/topics/Environment/Stratospheric-Ozone-Depletion
Surface waterbodies in good chemical status	https://sdg6data.org/indicator/6.3.2 Indicator | SDG 6 Data https://sdg6data.org/indicator/6.3.2 Indicator | SDG 6 Data
Ground waterbodies in good chemical status	https://sdg6data.org/indicator/6.3.2 Indicator | SDG 6 Data https://sdg6data.org/indicator/6.3.2 Indicator | SDG 6 Data
Population using clean fuels and technologies for cooking	Kenya National bureau of statistics. Economic survey 2020 http://www.knbs.or.ke PM2.5 air pollution, mean annual exposure (micrograms per cubic meter) - Kenya | Data (worldbank.org) ken_en.pdf (who.int) >>S (nema.go.ke) AIR QUALITY REGULATIONS (nema.go.ke) http://nema.go.ke https://apps.who.int/iris/bitstream/handle
Population exposed to safe level of ≤PM2.5	http://www.knbs.or.ke

	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter) - Kenya | Data (worldbank.org) Standard http://nema.go.ke ken_en.pdf (who.int) https://apps.who.int/iris/bitstream/handle/
Proportion of the population with access to safe drinking water.	Kenya National bureau of statistics. Economic survey 2020 http://www.knbs.or.ke People using safely managed drinking water services, rural (% of rural population) | Data (worldbank.org) People using safely managed drinking water services, rural (% of rural population) | Data (worldbank.org) **Standard** People using safely managed drinking water services, rural (% of rural population) | Data (worldbank.org) http://nema.go.ke https://knoema.com/atlas/Kenya/topics/Water/Water-Supply-Total-Population/
Proportion of natural and mixed UNESCO World Heritage sites on good conservation status	https://portals.iucn.org/library/sites/library/files/documents/2020-035-En.pdf Home page | World Heritage Outlook (iucn.org) http://www.wra.go.ke/national-water-master-plan/ Home page | World Heritage Outlook (iucn.org)

About Agence française de développement

AFD Group implements France's policy in the areas of development and international solidarity. The Group includes Agence Française de Développement (AFD), which finances the public sector and NGOs, as well as research and education in sustainable development; its subsidiary Proparco, which is dedicated to private sector financing; and Expertise France, a technical cooperation agency. The Group finances, supports and accelerates transitions towards a fairer, more resilient world.

With our partners, we are building shared solutions with and for the people of the Global South. Our teams are at work on more than 4,000 projects in the field, in the French Overseas Departments and Territories, in 115 countries and in regions in crisis. We strive to protect global public goods – promoting a stable climate, biodiversity and peace, as well as gender equality, education and healthcare. In this way, we contribute to the commitment of France and the French people to achieve the Sustainable Development Goals (SDGs). Towards a world in common.

ENVIRONMENTAL SUSTAINABILITY IN KENYA

A case study in the Environmental Sustainability Gap Framework (ESGAP) and Strong Environmental Sustainability Index (SESI)

To adapt the ESGAP framework to the Kenyan socio-ecological context, this project analysed the in-country environmental legislation landscape and existing environmental policy frameworks to determine challenges, gaps and opportunities for supplementing and strengthen existing processes. Challenges included data quality limitations, availability of adequate indicators and standards, and accessibility to data.

The current Kenya ESGAP framework is composed of 12 indicators (in comparison with the 21 indicators used on the European SESI). Results suggest that the functioning of different elements of natural capital in Kenya, and their capacity to provide essential services in the long-term, is highly impaired because of excessive environmental degradation. The capacity of Kenya's natural capital to provide critical services to maintain health and contribute to human well-being is the most severely impeded in Kenya.

The ESGAP process has demonstrated to be a useful framework to highlight crucial data gaps and major current threats to environmental sustainability in Kenya. However, further components of natural capital need to be assessed, requiring efforts to improve the data underpinning the framework. The ESGAP framework could be used as an important tool to integrate data and indicators for natural capital and environmental sustainability into economic planning complementing and cross benefiting from other adopted national processes to support environmental planning and management.

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