Digital Earth
AFRICA

BROADER PERSPECTIVES ON DIGITAL EARTH AFRICA

A follow-up study on the potential of Earth observation to address Africa's critical challenges

In collaboration with:

GEO GROUP ON EARTH OBSERVATIONS

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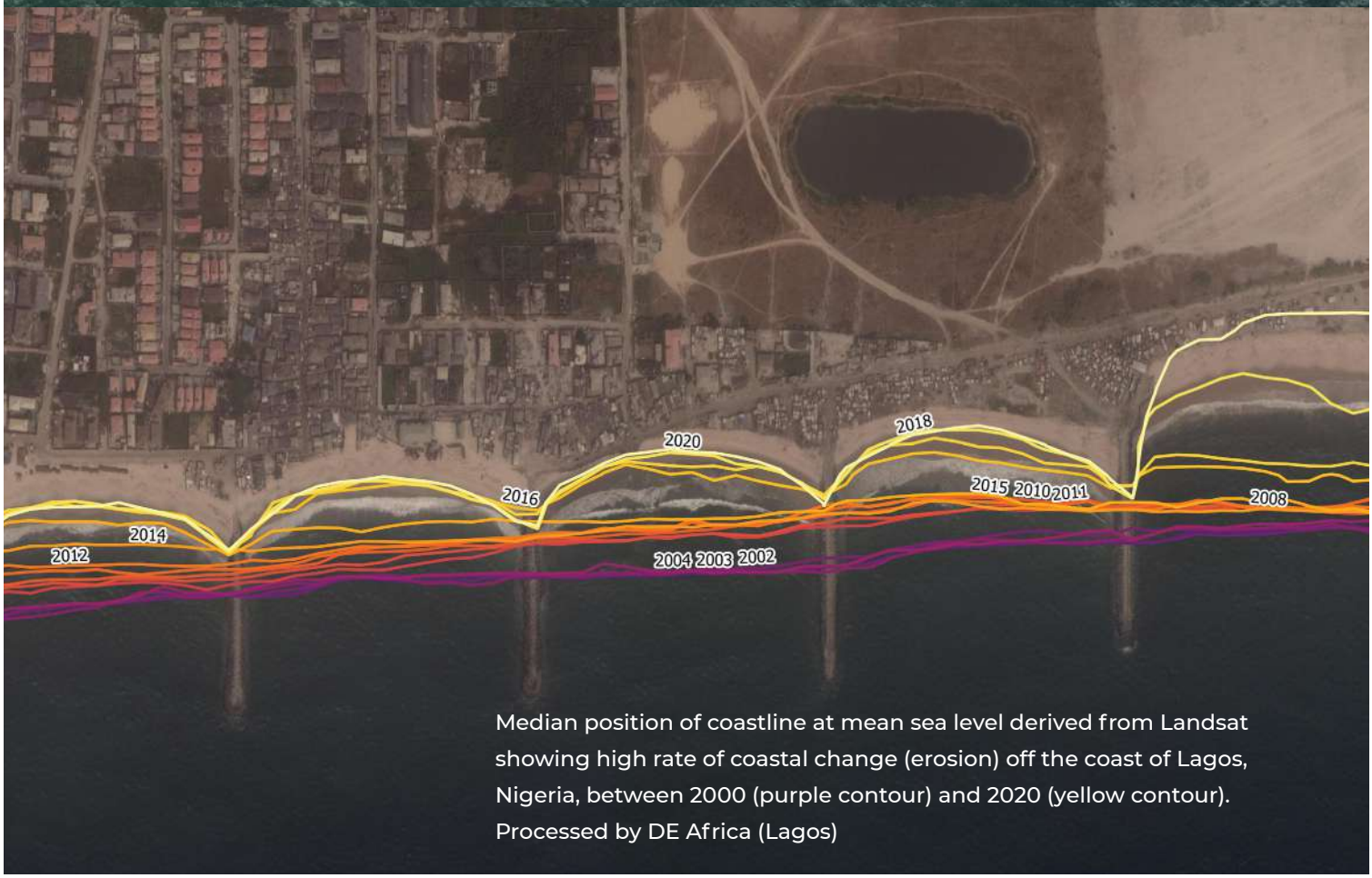


Median position of coastline at mean sea level derived from Landsat showing high rate of coastal change (erosion) off the coast of Lagos, Nigeria, between 2000 (purple contour) and 2020 (yellow contour). Processed by DE Africa (Lagos)

EXECUTIVE SUMMARY

We live on a planet that is continuously being recognised for having limited resources and overexploited ecosystems. Better information on our daily activities and the surroundings that host us can support mankind's existence and help preserve natural habitats. Earth observation (EO) data is a unique source of reliable and measurable information to help assess, mitigate and prevent negative outcomes, as well as explore new opportunities for social and economic development through improved efficiencies.

In 2021, Disal Consulting conducted research on the EO-based platform **Digital Earth Africa** (DE Africa) and discovered that a socio-economic impact of **USD 2 billion** per year can be achieved in three key areas by 2024.[1] The current report seeks to investigate the untapped potential of EO technologies and specifically DE Africa, to impact an additional **six industries** on the continent of Africa. The analysis estimates that an overall socio-economic impact of approximately **USD 540 million** could be achieved per year while keeping the conservative assumption of a 10% application. DE Africa deploys analysis-ready data (ARD) to facilitate more informed, strategic and inclusive information for better stakeholder decision-making.

"The analysis estimates that an overall socio-economic impact of approximately USD 540 million could be achieved per year while keeping the conservative assumption of a 10% application."

The areas of investigation include:

- **Marine Observation**
  $212 million
- **Disaster Risk Reduction**
  $74 million
- **Public Health**
  $113 million
- **Renewable Energies**
  $27 million
- **Oil & Gas**
  $15 million
- **Security and Civil Protection**
  $96 million

The examined industries were chosen based on expert inputs, data availability, and the scale of impact on Africa's economies and societies. To estimate the magnitude of the socio-economic benefits, the analysis explores three or four applications within each area.

1 World Economic Forum in collaboration with Digital Earth Africa. (2021, January) *Unlocking the potential of Earth Observation to address Africa's critical challenges*. Insight Report.

Africa's **Marine Observation** industry has the highest potential to benefit from DE Africa's services and other EO-based technologies with an estimated impact of nearly **USD 212 million** per year. Primary applications include sea transportation, fishery, ocean monitoring, and environmental preservation. Such technologies can help optimize shipping routes to save fuel costs and measure ocean currents to develop marine-based renewable energy projects. In fisheries, EO can enable more cost-efficient fishing methods by monitoring harvest activities and minimizing weather- and climate-related risks. Other applications, such as locating algal blooms and assessing fish stock populations can protect marine biodiversity and minimize trade disruptions. In terms of marine pollution, such technologies can detect plastic accumulation at sea, helping governments and other organizations secure clean waters to abide by environmental regulations and achieve **Sustainable Development Goals** signed by all UN member states.

Disaster Risk Management can benefit from DE Africa services and other EO-based technologies by contributing to an estimated cost-saving of **USD 74 million**. Many African countries experience floods, droughts, landslides, storms and cyclones, which cause fatalities, loss of livelihoods and severe damage to infrastructure. EO data can help prevent, prepare for, respond to, and recover from such environmental disasters by providing better risk management through improved predictive modeling, warning systems, early intervention tools, and crisis monitoring.

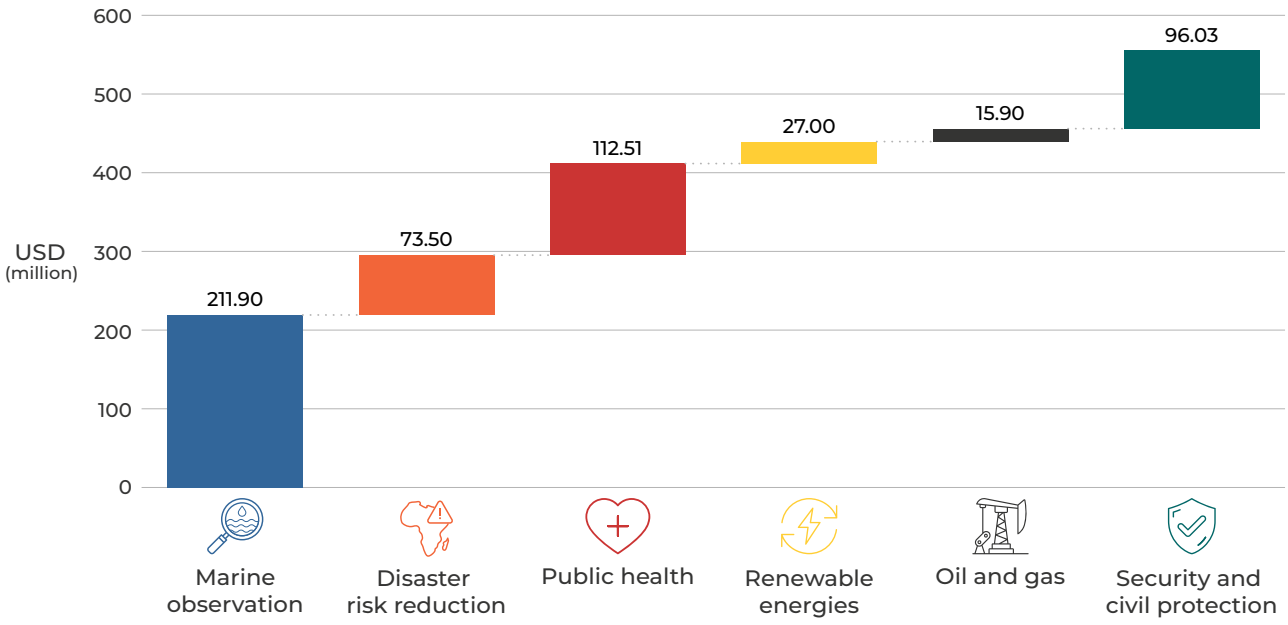
The **Public Health** industry is a vital player in Africa's developing nations, particularly in regions with accelerated population growth and rising urbanization levels. DE Africa and EO applications can bring an overall impact of **USD 113 million** by improving and monitoring waste management systems, disease outbreaks and air quality indices. EO tools are able to observe landfills and track waste disposal processes to help governments minimize illegal activity and aid intervention efforts with better policing. EO can also contribute to monitoring and responding quickly to disease outbreaks, such as Ebola, malaria and cholera, to aid policymakers in taking appropriate action to prevent or mitigate the emergence and spread of epidemics. In terms of air pollution, EO may help decrease hospital admissions due to poor air quality levels and reduce skin cancer deaths by using high-precision weather monitoring and improved warning systems.

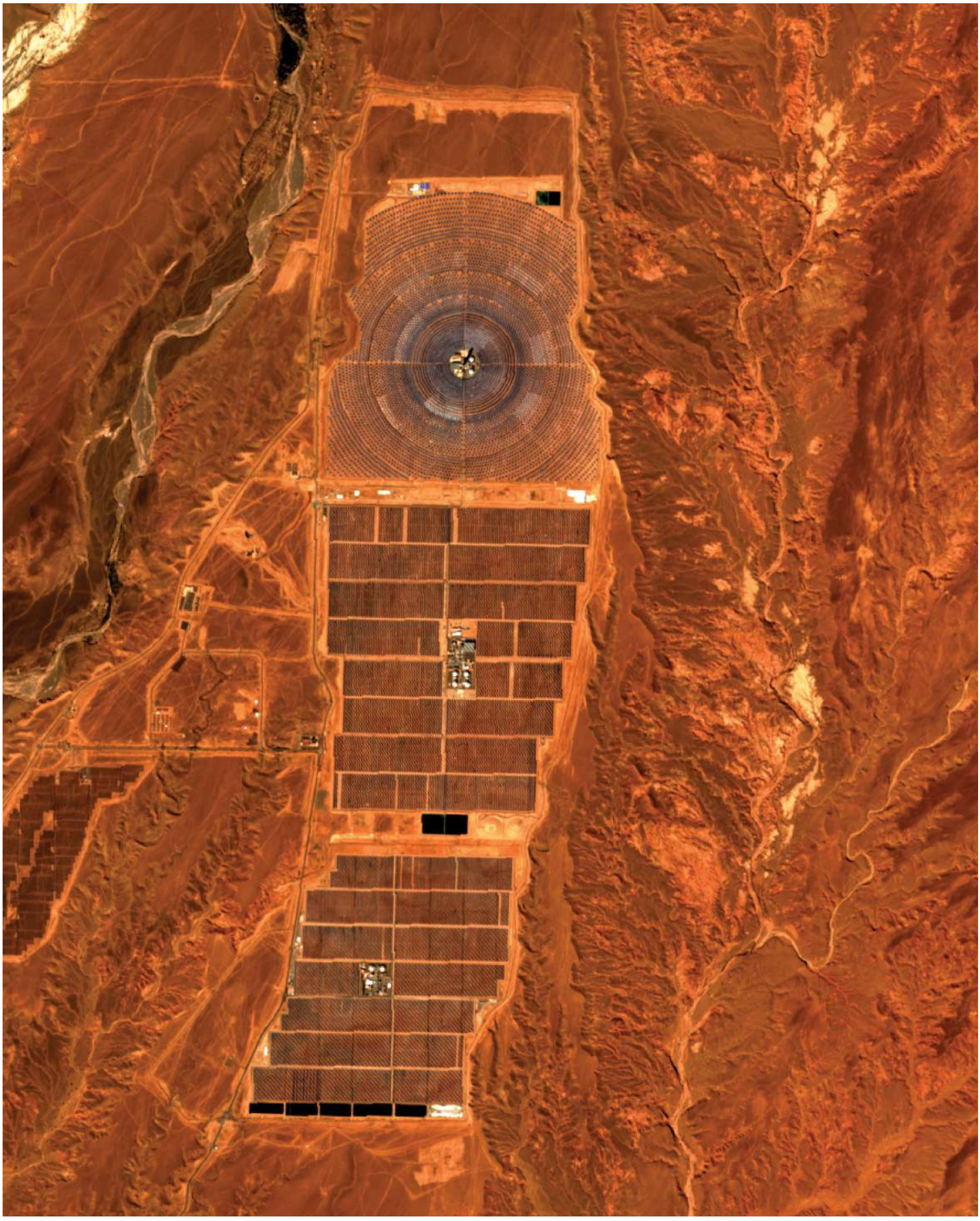
Africa's **Renewable Energy** industry contributes to the development and industrialization of the continent, particularly in terms of achieving green energy targets and UN Sustainable Development Goals. DE Africa and other EO-based technologies can provide an impact of roughly **USD 27 million** in three key areas that have the highest future potential: wind, solar and hydropower energy. EO can help identify viable sites and provide data points for optimal resource exploitation and production forecasting to reduce costs and ensure efficiencies.

Within the well-established **Oil & Gas** industry, DE Africa and EO applications can lead to more than **USD 15 million** in savings per year. Such technologies are able to promote better resource management to protect the earth's biodiversity and mitigate the negative effects through preventative measures. For example, by tracking severe weather patterns, offshore oil and gas operations can be powered down in a timely manner to avoid accidents, prioritizing the safety of the crew and protecting the infrastructure. EO data points can also forecast oil spill drifts and monitor natural gas pipelines to help governments and organizations protect their citizens and reduce environmental contamination.

In terms of **Security & Civil Protection**, DE Africa and EO tools can have an impact of more than **USD 96 million** focusing on three main sectors: land mine area identification, the illicit goods trade and illegal fishing. EO can help make demining operations safer, leading to 15 less fatalities per year and decreasing clearance costs. EO can also help detect unregistered vessels and monitor cross-border crimes to intercept illegal trade operations, contributing to making Africa a safer continent.

Impact of EO technologies, per year, assuming a 10% adoption rate in each of the sectors considered





Noor Ouarzazate Solar complex near Ouarzazate, Morocco, Sentinel-2 GeoMAD 2020, RGB, processed by Digital Earth Africa

INTRODUCTION

Source: *Digital Earth Australia*

Data is increasingly becoming the new soil from which businesses and economies can grow. Information accessibility and visualization are critical to unleashing the full potential of statistics and figures to bring tangible benefits to Africa. In this context, geospatial technologies can have a tremendous impact on socio-economic development, and Digital Earth Africa (DE Africa) provides a unique opportunity for African industry, policymakers and civil society to move forward in this direction.

DE Africa is a continental-scale data infrastructure that democratizes the ability to process and analyze satellite information on the continent of Africa. The platform provides analysis-ready data (ARD) to facilitate more informed, strategic and inclusive decision making, serving as a critical foundation to make the best use of advanced digital technology.[2] Although DE Africa currently does not leverage high-resolution imagery and datasets to provide the optimal use of geospatial technologies, the platform creates value by providing a unique opportunity for its users to add project-specific and high-resolution datasets where needed or available. This information, which includes continental datasets and other services, allows stakeholders to use such data to their advantage and bring real value to Africa.

2 World Economic Forum in collaboration with Digital Earth Africa. (2021, January) *Unlocking the potential of Earth Observation to address Africa's critical challenges*. Insight Report.

Acknowledging the potential benefits of this approach, target beneficiaries and decision makers face various challenges in imagining or quantifying the impact of EO technologies on their businesses or countries. Such data-driven information could play a critical role in aiding investment decisions, such as whether or not to enter a new market, launch a start-up, develop a novel product, or design a specific training program. In this context, a new field of research attempts to assess the magnitude of such benefits and demonstrate the potential impact of EO technologies and services on African businesses and societies.

In Europe, EO technologies are widespread, yet the approach requires add-on interventions to fully reap the benefits. One viable application is to provide analysis-ready data (ARD) and make such information available to everyone. In the context of Africa, ARD through platforms like DE Africa make actionable data and in-depth training features readily available to the public. This creates the highest value for users and providers by removing any entry barriers to provide equitable access for all. By making EO data a public good through open data sources (such as open access offered by ESA, USGS, and JAXA), we can push forward infrastructure development in Africa for a more independent, innovative and thriving continent in a region filled with dynamism, drive and untapped capability. Although ARD is not yet widespread, the technology represents a major strategic and growth opportunity for the EO sector in the near future. DE Africa offers significant cost and time efficiencies, compared to the traditional approach to using EO data.

The initial report - first published in January 2021 by the World Economic Forum and in collaboration with Digital Earth Africa - focused on three areas: growth of the EO industry, an increase of agricultural productivity, and regulation of gold mining activity. **The study estimated an overall socio-economic impact of over USD 2000 million per year by 2024**.

This follow-up report aims to capture the unlocked potential within the African continent on six additional industries. Given the relevance of such findings and considering the groundbreaking nature of the project, further research may unveil new opportunities for the continent. The Australian Government and Digital Earth Africa commissioned Disal Consulting a follow-up study to provide further insights on six additional industries:

Marine Observation

Renewable Energies

Disaster Risk Reduction

Oil & Gas

Public Health

Security and Civil Protection

The six industries were prioritized based on two factors: (i) expert inputs and desk research on the magnitude of impact EO could have on Africa's economies and societies in such areas, and (ii) data availability, which remains a critical issue when conducting research in such countries.

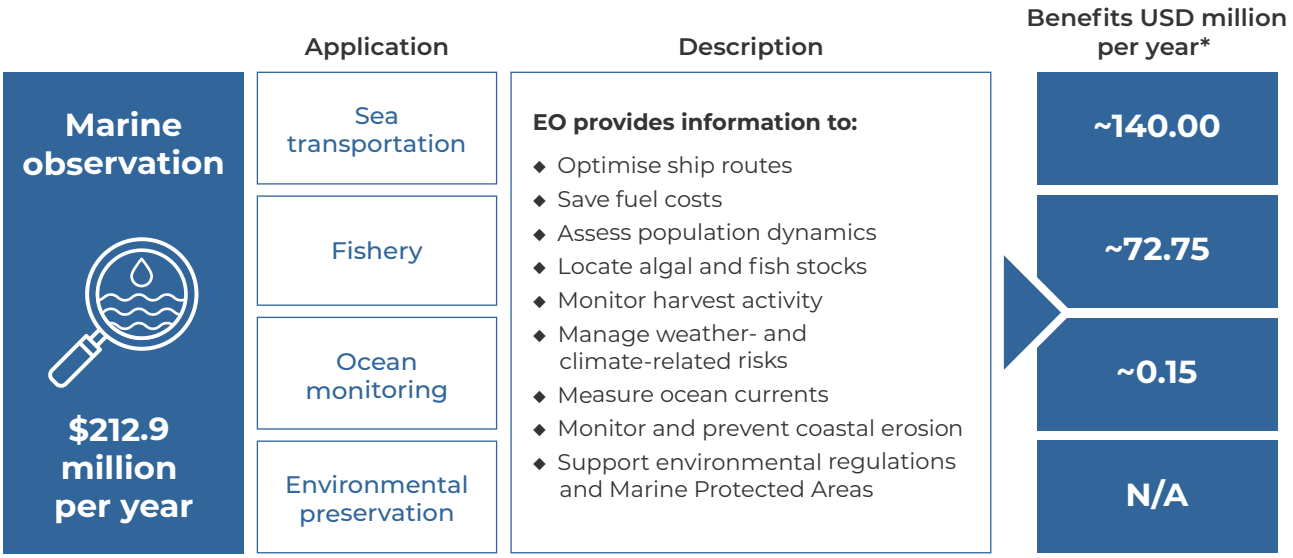
Taking into account the potential future impact EO will have on the six industries, the report focuses on three to four applications per industry that will be highly affected by the implementation of satellite technology. Each chapter will delve into one of the industries considered, summarizing the impact of EO technologies and estimating the potential benefits for each application.

This publication aims to quantify the forecasted impact that geospatial technologies and EO provided by DE Africa can have on the region's social-economic development. As a research pioneer in this field, the estimation figures should be taken not as exact and definitive numbers, but as an initial attempt to quantify the benefits of such innovation for African policymakers, businesses and society. This report marks an initial step towards more precise predictions that require additional time, data and effort. Nevertheless, it can help companies, entrepreneurs and policymakers gain insights into EO technologies and how they can be used to tackle a wide range of issues, such as risk reduction, public health issues and civil security.

"This publication aims to quantify the forecasted impact that geospatial technologies and EO provided by DE Africa can have on the region's social-economic development."

Angola Coast, Sentinel-2 GeoMAD 2020, RGB, processed by Digital Earth Africa

MARINE OBSERVATION



*assuming a 10% adoption rate

According to our analysis, EO services provided by DE Africa could substantially benefit the Marine Observation industry, which includes, but is not limited to, 38 coastal states in Africa that are critically dependent on maritime trade.[3] Up to 90% of the global imports and exports are conducted by sea on the continent and EO data observations can significantly aid maritime sectors, such as sea transportation, fishery, ocean monitoring, and environmental preservation.[4] This report provides in-depth observations on all these applications, demonstrating the various applications of EO technologies adjusted for different circumstances.

3 Economic Commission for Africa. (2016, March). *Africa's Blue Economy: A policy handbook.*
4 International Chamber of Shipping. (2020). *Shipping and world trade: driving prosperity | ICS.*

Sea transportation

Source: *Shutterstock*

EO can help African businesses and governments save approximately **USD 1.4 billion** per year within the sea transportation sector, making it the most beneficial application in the marine observation industry. EO technologies can aid in improving maritime logistics and provide detailed analyses of water depth, winds, waves, and currents to reduce navigation costs for large vessels. This approach optimizes ship routes, leading to significant fuel savings, cost reductions and minimizing the ecological impact of naval transportation. EO data can also boost the return on investment of transportation projects by optimizing its main cost drivers, as estimates show that developing countries pay a 40% to 70% premium to internationally transport imported goods compared to developed nations.[5]

Overall, improved network engagement and logistics through EO usage can decrease transportation costs by 13%.[6] These savings include reduced fuel costs and better port logistics services, which are the primary cost centers for naval vessels. Port logistics services point to better routing and ship arrival times, more efficient loading times, and a decrease in actual docking times. If considering the percentage change in expenses, multiplying the number by the costs of operating vessels covering all of Africa in one year, EO could save over USD 1.4 billion per annum, if applied to every marine transport, which is nearly equivalent to the GDP of Guinea-Bissau in 2020.[7]

To be conservative, assuming a 10% utilization rate, the result would still have roughly **USD 140 million** savings per year. Such savings could employ over 11,000 people in the fishery industry, as the average senior fisherman in South Africa earns a gross yearly salary of approximately USD 12,000, according to salaryexpert.com.[8]

5 Saggia, G. (2017, November 17). *About 90% of Imports and Exports in Africa Driven by Sea | SAP Africa News Center*. SAP East Africa.
6 Pwc. (2017). *Copernicus ex-ante benefits assessment | Copernicus*.
7 The World Bank Group. (2021) *Guinea-Bissau*.
8 ERI Economic Research Institute. (2021, August 29). *Salary Expert - Fisherman/Woman Salary South Africa | Salary Expert*. ERI.

"...improved network engagement and logistics through EO usage can decrease transportation costs by 13%."

Fishery

Source: *Unsplash*

Fisheries play a significant social and nutritional role in Africa, and EO has the potential to foster social welfare for coastal populations and support their businesses. With the increasing global demand for fish, EO can aid in promoting food, nutrition and job security.[9] Through dynamic population assessments and harvest activity monitoring, EO could also safeguard the sustainability of fishing grounds for future generations. Within the sector, locating fish stocks is a key success factor, as over USD 80 billion is lost each year due to overfishing.[10] EO can add value by providing fishermen and aquafarmers accurate, real-time information and forecasts on fish growth rates and health, which often depend on water conditions. Currently, real-time data is not offered by platforms like DE Africa, but the high potential of these datasets will drive future development in this direction.

"Fisheries play a significant social and nutritional role in Africa, and EO has the potential to foster social welfare for coastal populations"

9 The World Bank Group. (2020, June 8). *Africa Program for Fisheries | World Bank*.
10 Bacchi, U. (2017, February 14). *An end to overfishing could reap billions of dollars in global profits, study says | Reuters*. Thomson Reuters Foundation.

Based on an EO improvement rate of 2.5% in the fishery sector, the technology could contribute **USD 727.5 million** per year to Africa's overall GDP. According to a study by the Australian Government and APEC, impact between 2 and 3% can be assumed when applying EO in the fishery sector, thus this analysis uses a 2.5% impact rate to simplify calculations.[11]

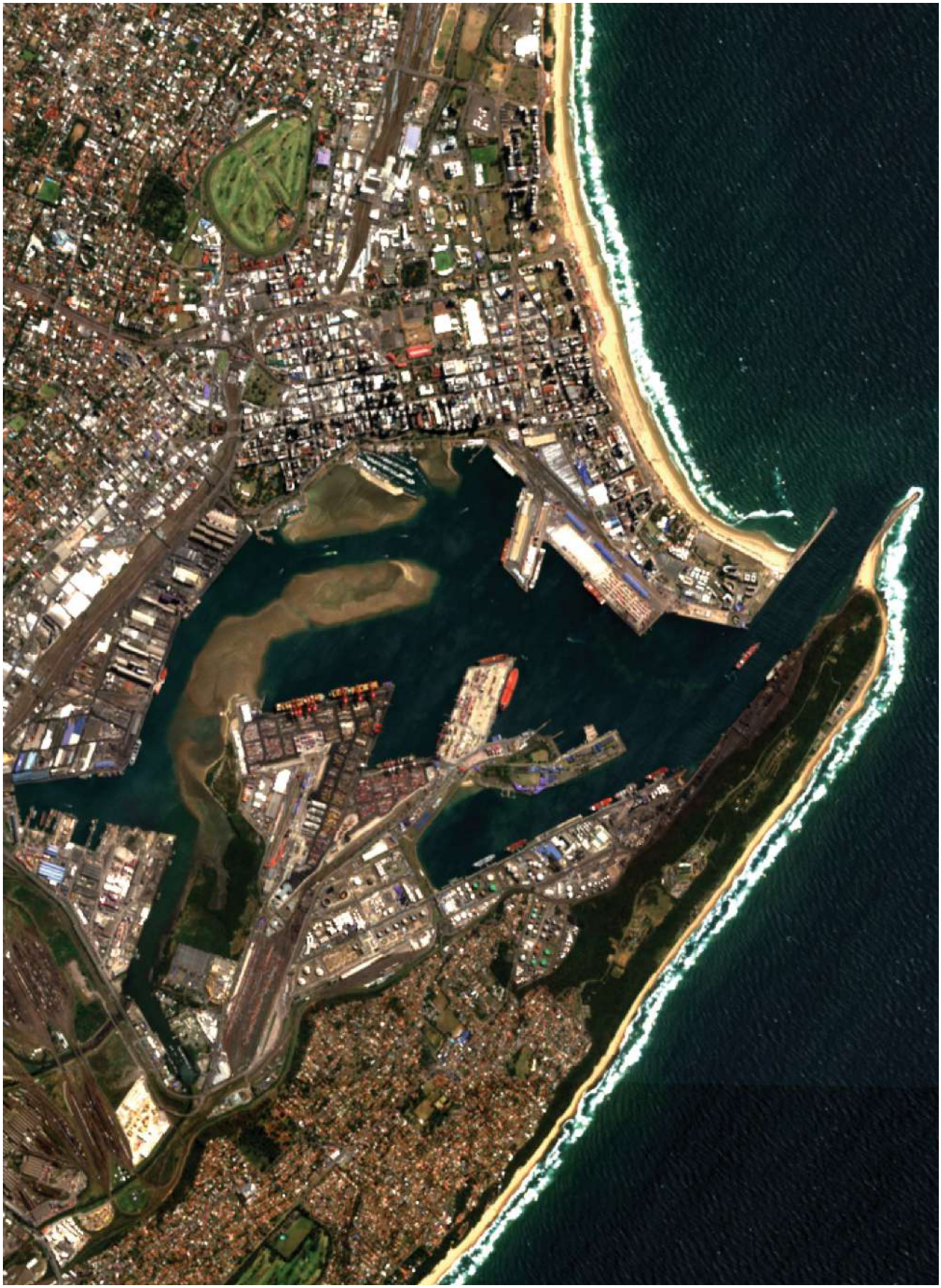
Africa can benefit from implementing satellite technology in the fishery sector in three ways. First, it has the potential to increase productivity by enabling more efficient fishing, mapping more accurate fishing zones, limiting the waste of contaminated shellfish, and facilitating the performance inventory of aquaculture. Second, it can improve fish stock sustainability by preventing overfishing with numerical modeling. Third, it could reduce the impact of harmful algal blooms through locating and monitoring their activity. The daily and in-depth observations by EO makes it possible to alert relevant authorities should there be a need for preventative, immediate or corrective action. Satellites such as Copernicus Sentinel-3 are already in use in West African countries (i.e., Ghana) for the management of ocean resources and maritime safety.[12]

As mentioned in the report published in January 2021 by the World Economic Forum, in collaboration with DE Africa, Copernicus found that EO can impact agriculture, forestry and fishery - accounting for 12% of the industry-derived value.[13] The share of fishery lies between 2 to 3%.

If applied to the whole market and assuming a mean of 2.5% of EO impact, satellite technology can add value to the annual African GDP by approximately **USD 727.5 million, USD 72.75 million** assuming 10% adoption per year. This amount is greater than two of the largest initiatives led by the World Bank to promote fishery and aquaculture development in Africa combined: the West Africa Regional Fisheries Program (worth USD 290 million) and the South West Indian Ocean Fisheries Governance and Shared Growth Program (worth USD 315.5 million).[14]

11 Australian Government, 2019. *Current and future value of earth and marine observing to the Asia-Pacific region.* Commonwealth of Australia.
12 EUMETSAT. (2020, September). *Monitoring the ocean and fisheries using Earth observation data | EUMETSAT*.
13 European Union, Pwc. (2019, February). *Copernicus Market Report.* Publications Office of the European Union. https://doi.org/10.2873/011961
14 The World Bank. (2020). *Africa Program for Fishery | World Bank*.

Ocean monitoring



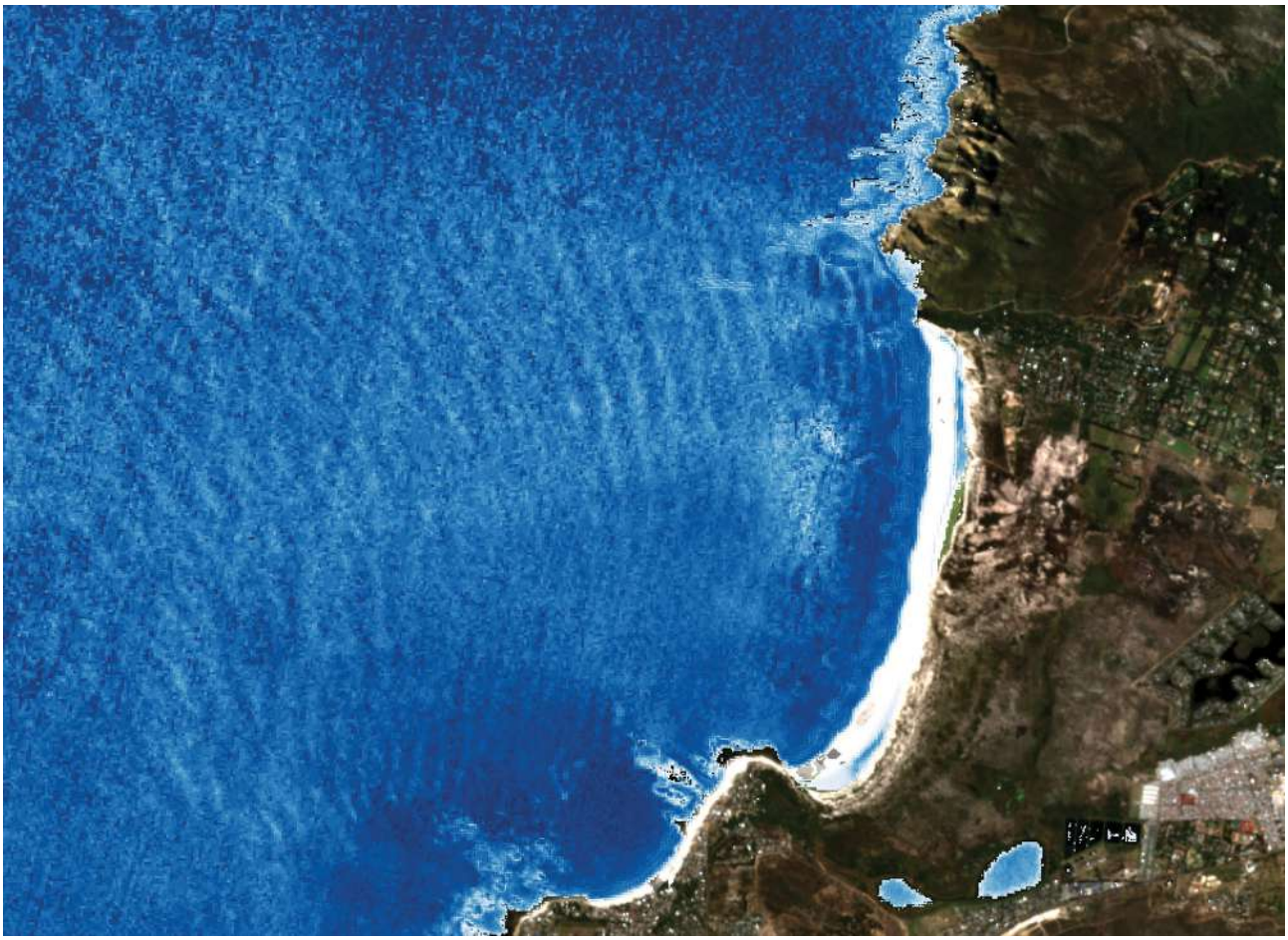
Durban Port, South Africa. Sentinel-2 GeoMAD 2020, processed by Digital Earth Africa

With a coastline of 30,500 kilometers, the African continent makes up 38% of the global length of coastlines, providing a unique opportunity to leverage the natural production of energy by waves.[15] If applied to all projects EO can add USD **1.46 million** per year to the African economy by introducing ocean monitoring via satellites andincreasing marine renewable energy production.

At 10% adoption rate, this equates to USD **0.15 million** per year.

The Power-Gen project on renewable maritime energy in South Africa estimated that waves along the country's coastline can produce enough energy between 25 and 50 MW/km, which results in an estimated total power of 56,800 MW available along the entire seashore.[16] As demonstrated by the Copernicus report, satellite technology supports the development and viability of the marine renewable energy market.[17] A 10% improvement in accuracy for monitoring ocean currents can lead to a 20% higher energy production.

"...an estimated total power of 56,800 MW available along the entire seashore."



Cape Town, South Africa, Sentinel-2 GeoMAD 2020, MNDWI, processed by Digital Earth Africa

15 Kröner, A., et al. (2020, October) *Africa* | *Encyclopedia Britannica*. Britannica.
16 Fourie, S.; Johnson, D. (2017). *The Wave Power Potential of South Africa*. Power-Gen Africa 2017.
17 European Union, Pwc. (2019, February). Copernicus Market Report. Publications Office of the European Union. https://doi.org/10.2873/011961

Environmental preservation

Source: *Unsplash*

In the past decade, plastic waste has been a leading topic for governments and NGOs. Non-recycled plastic pollution has increased exponentially over the years, particularly in terms of ocean contamination. Estimates show that more than 8.3 million tons of plastic waste enter the seas each year to threaten global ocean health.[18] The economic cost to marine natural capital alone ranges from USD 3,300 to 33,000 per ton of plastic each year.[19]

Africa is the second continent, following Asia, to emit the highest quantity of plastic into the ocean, representing 8% of overall ocean plastic pollution. Furthermore, five African countries are among the top twenty highest contributors to plastic marine debris in the world.[20] Plastic waste mismanagement affects the growing population in coastal areas and directly impacts marine life, especially the fishery sector.

"...five African countries are among the top twenty highest contributors to plastic marine debris in the world."

18 Alberts, E. C. (2020, May 1). *Satellite imagery is helping to detect plastic pollution in the ocean | Mongabay Environmental News*. Mongabay.

19 Biermann, L., & Clewley, D. (2020). Finding Plastic Patches in Coastal Waters using Optical Satellite Data. Scientific Reports. https://doi.org/10.1038/s41598-020-62298-z

20 Sambyal, S. S. (2018, May 23). *Five African countries among top 20 highest contributors to plastic marine debris in the world | DownToEarth*. DownToEarth

EO technologies could be utilized to locate and clean up polluted marine areas. Due to ocean currents, winds and vertical mixing, individual pieces of plastic aggregate and end up forming larger patches in the ocean. These accumulations are likely to be detected by high resolution satellite systems, such as Sentinel-2. It would, however, only detect plastic floating on the surface, which makes up only 1% of the overall plastic waste found in the ocean. On the other hand, case studies conducted by Dr. Lauren Biermann suggest an 86% success rate of such satellite systems identifying floating aggregations as plastic accumulations.[21]

We preferred not to estimate the actual monetary value of the impact of EO due to the lack of accurate and quantifiable case studies. Environmental preservation of coastal and maritime areas should be subject to further investigation when more data points become available. Nevertheless, mentioning such benefits provide a full image of EO's potential to bring benefits to the maritime observation industry.

21 Alberts, E. C. (2020, May 1). *Satellite imagery is helping to detect plastic pollution in the ocean | Mongabay Environmental News*. Mongabay.

Case Study - MESA (Monitoring for Environment and Security in Africa)

The MESA project is one of the first initiatives of the GMES (Global Monitoring for Environment and Security) and Africa joint program. This partnership seeks to support and advance the African infrastructure by leveraging Earth Observation data, technologies and services to complement environmental policies to achieve sustainable development. The approach involves developing the Copernicus Earth Observation Programme data and resources to benefit the African continent.[22]

MESA plays a crucial role in developing Africa's Capacity in Fishery Resource Management with the help of products from CMS (Copernicus Marine Service). Launched in 2012, the project received EUR 37 million (USD 43.66 million) in funding from the European Union and its list of beneficiaries include 48 countries across Africa, the Caribbean and the Pacific.[23]

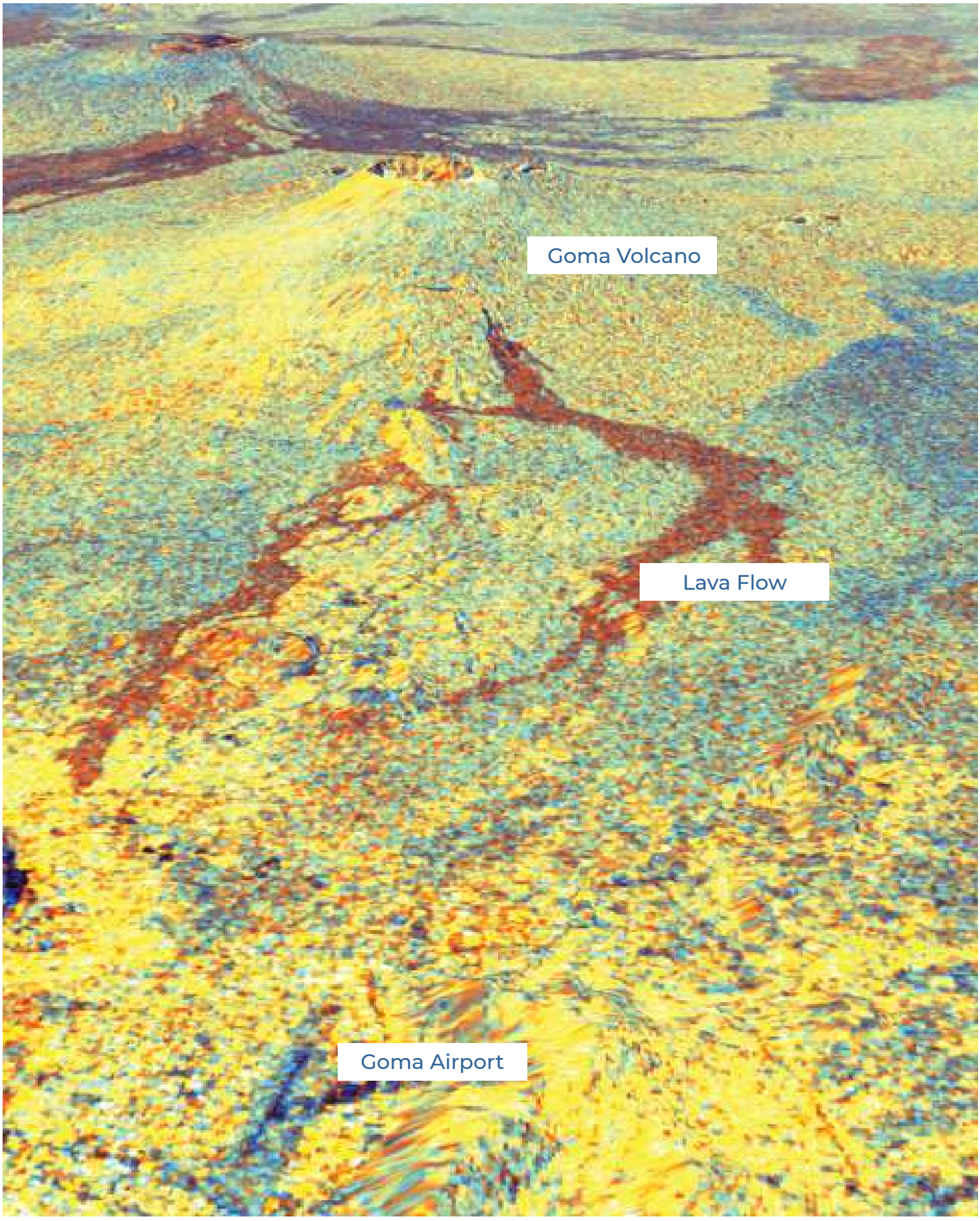
MESA offers two key services, which includes supporting fishery resource management and forecasting ocean conditions. To effectively provide solutions in these two areas, MESA relies on CMS to gather critical data points by measuring sea surface temperatures and currents, observing ocean color data, measuring nutrient acidity, and monitoring oxygen levels.

Four benefits emerge from analyzing the data inputs:

1. Free and regular updates on ocean parameters with scientific and accurate data
2. Better identification of fish stock recovery areas for common fishery policies
3. Improved planning related to aquaculture farm sitting and management
4. Enhanced knowledge of surrounding oceanic conditions for aquaculture farm siting[24]

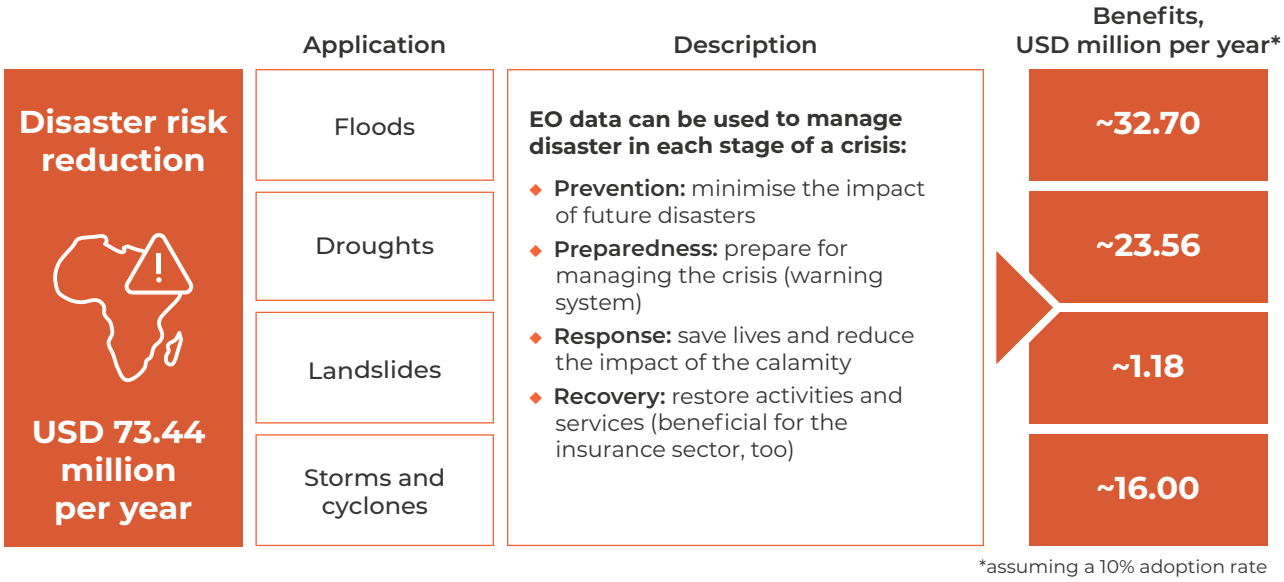
Within this context, EO aids NGOs, governmental and public agencies, private companies, and fishing-based livelihoods to monitor and manage fish stock levels and aquaculture farms. Such objectives and benefits can be fulfilled by cost-effectively utilizing analysis-ready Copernicus data facilitated by a successful partnership and alignment of GMES and DE Africa.

22 Mercator Ocean. (2021). *GMES and Africa programme | Eu4oceanobs*.
23 Copernicus. (2021). *Developing Africa's Capacity In Fishery Resource Management with MESA | CMEMS*. Copernicus.
24 Copernicus. (2021). *Marine Food | CMEMS*. Copernicus.



Goma Volcano, DRC, Sentinel-1 2021, processed by Digital Earth Africa

DISASTER RISK REDUCTION



Africa is a remarkably diverse continent in terms of climate, natural landscape, urbanization levels, and population density. The impact of natural disasters is felt to varying degrees depending on the challenges of the region. Areas with severe landscapes, volatile economies, underdeveloped infrastructures, political uncertainty, food insecurity, and rapid population growth are amongst the most vulnerable groups when a disaster occurs.

From 2008 to 2018, over 157 million Africans have been affected by natural disasters.[25] From a short-term perspective, this carries adverse economic repercussions due to productivity loss, damage to physical assets, and relocation and rehabilitation costs. With the help of EO, if it is applied on the whole market, there is a potential to save up to **USD 735 million** in costs per year. If EO data is adopted in 10% of cases would result in 73.5 million USD benefit per year. EO data can be deployed to prevent, prepare for, respond to, and recover from environmental disasters. It can also provide improved risk assessment, while protecting a robust insurance market, to aid the recovery efforts. To evaluate the impact EO can have on disaster risk reduction, we analyzed the four most frequent and devastating types of disasters that occur in Africa, which includes floods, droughts, landslides, and storms and cyclones.

Floods

Floods in Sub-Saharan Africa have a consequential impact on the economy, accounting for 42% of economic damages related to natural catastrophes.[26] Between 2008 and 2018, flood events in Africa represented 47% of the total disasters across the continent.[27]

25 UN Office for Disaster Risk Reduction, 2020. *Highlights: Africa Regional Assessment Report*.
26 GFDRR. (2020). *Striving Toward Disaster Resilient Development in Sub-Saharan Africa | GFDRR*.
27 UNDRR. (2020). *Highlights: Africa Regional Assessment Report 2020 | UNDRR*.

"...flood events in Africa represented 47% of the total disasters across the continent."

Globally, Africa is home to the top ten countries - in terms of share of the population - living in poverty with a high risk of flood exposure. When considering these two factors, the Sub-Saharan region represents one of the most vulnerable areas, according to the World Bank. Estimates indicate that at least 71 million civilians who live below the minimum wage threshold are situated in high-risk flood zones (according to USD 1.9 per day standard).[28] Furthermore, climate change is impacting the frequency and intensity of floods, generating greater unpredictability and threatening more livelihoods. The 2012 floods in Nigeria demonstrate the extent of the devastating impact, where the combined damages and losses amounted to USD 16.9 billion, representing 1.4% of the GDP of the country.[29]

Estimates show that EO can save up to **USD 328 million** per year by improving flood warning systems and emergency response mechanisms. This equates to a potential benefit of **32.8 million USD** per year assuming a 10% adoption of EO data. Overall, EO tools represent roughly 25% of all warning and emergency response systems employed, contributing to a 2% average of savings in terms of economic damages.

For example, in 2017, the total costs caused by floods in the United Kingdom amounted to GBP 796.3 million (USD 1,095 billion). However, in the same year, EO helped avoid incurring an additional GBP 17.2 million (USD 23.7 million) in costs, which represent 2.16% of the total potential losses. Similarly, in Australia, effective warning systems and emergency response management helped avoid incurring 8% of the overall damages. In Africa, the estimated losses due to natural disasters amount to USD 39.2 billion per annum, of which 42% are flood-related occurrences. Assuming that EO will save 2% of the overall costs, added in with a 10% adoption rate, we find that EO will be able to deliver USD 32.8 million per year in flood-related cost savings. This amount is about 2.7 times the budget allocated by IFRC (International Federation of Red Cross and Red Crescent Societies) for flood-related emergency appeals, which targets 564,000 people.[30, 31, 32, 33]

28 IFRC. (2021) *African floods* | *Reliefweb*.
29 UNDRR, CRED. (2019). Human cost of disasters | *UNDRR*.
30 Caribou Space. (2020) *Adoption and Impact of Earth Observation for the 2030 Agenda for Sustainable Development*.
31 Australian Bureau of Meteorology. (2017). *A study of the economic impact of the services provided by the Bureau of Meteorology.*
32 GFDRR. (2019). *Disaster Risk Country Profiles* | *GFDRR*.
33 IFRC. (2021) *African floods* | *Reliefweb*.

Droughts

Source: *Unsplash*

The absence of rains during one season or more represents a key threat for Africa, causing recurring droughts throughout the region. Droughts affect Africa more than any other continent, as 41% of the global droughts occur in the area.[34] The Emergency Events Database (EM-DAT) recorded 136 events between 1995 and 2015, of which 77 droughts affected East Africa alone.[35] From 2008 to 2018, droughts were responsible for 78% of all disaster-related deaths.[36] Drought vulnerability in Africa is caused by the considerable climate variation across the continent and throughout the seasons, exacerbated by the lack of financial resources for mitigation efforts and high dependency on rains for agricultural activities.

> *"Droughts affect Africa more than any other continent, as 41% of the global droughts occur in the area."*

The economic impact of droughts can be gauged by studying Kenya, one of the most severely impacted African countries. The drought between 2008 and 2011 caused damages and losses worth approximately USD 12.1 billion and slowed down the country's GDP growth by an average of 2.8% each year.[37]

34 UNDRR, CRED. (2019). Human cost of disasters | *UNDRR*.
35 CRED, UNDRR. (2015, March). *The human cost of natural disasters 2015: a global perspective* | *Reliefweb*.
36 UN Office for Disaster Risk Reduction. (2020). *Highlights: Africa Regional Assessment Report*.
37 USAID Center for Resilience. (2018, January). *Economics of resilience to drought* | *USAID*.

Estimates show that for every dollar spent on early intervention through the African Risk Capacity's tool called the Africa RiskView (ARC's ARV), USD 4.5 is saved in post-event crisis management.[38] This results in a 77% cost reduction in the disaster recovery phase, providing not only monetary benefits but also saving lives and livelihoods. ARC's ARV tool achieves this outcome by combining EO technologies and population vulnerability data to provide an early warning model that measures food insecurity and estimates the response costs. This enables decision-makers to plan and respond to drought stresses in an efficient and immediate way.

The total response cost in Africa for droughts stands at USD 3.06 billion per year.[39] With the cost savings of using ARC's ARV tool and an estimated 10% contribution of EO to ARC, the total impact of EO results in cost savings of up to **USD 235.6 million**. Assuming a 10% adoption rate, the final contribution of EO to drought management would amount to **USD 23.6 million** per year, which is enough funding to construct over 780 deep wells with motorized pumps to serve 2.3 million residents.[40]

Landslides

From 2008 to 2018, landslides in Africa affected up to six million people.[41] This phenomenon creates many challenges in vulnerable areas, such as Equatorial Africa. The deadliest landslide in recent years occurred in Sierra Leone in 2017, where over a thousand people were found dead or declared missing.[42] The high vulnerability of this region is caused by steep slopes, intense rainfalls and deep soil profiles. Every year, landslides cause fatalities, structural and functional damage to infrastructure, and serious organizational disruptions, such as food supply interruptions that affect local livelihoods.

"...landslides in Africa affected up to six million people."

38 ESA. (2019a). *EO4SD - Earth observation for sustainable development | eo4sd*.
39 African Risk Capacity. (2019). *The cost of drought in Africa | African Risk Capacity*.
40 The Water Project. (2021). *Digging Water Wells in Africa - How it Works | The Water Project*.
41 GFDRR. (2019). *Disaster Risk Country Profiles | GFDRR*.
42 Bruce, I. (2019, May). *A preventable disaster: Landslides and flooding disaster in Freetown, Sierra Leone | World Bank Blogs*. World Bank Group.

According to an ESA study, satellite-based landslide monitoring can save up to 10% of costs by 2020. This can be achieved by improved and routine monitoring of vulnerable areas in order to reduce the damage from landslides and minimize the risk of harming the local population. Currently, landslides lead to USD 118 million in damages per year.[43] This number was derived from the disaster risk profiles of 13 African countries, scaling up the impact of landslides to all of Africa as a percentage of the GDP EO can reduce damages by 10%, resulting in **USD 11.8 million** in savings.[44] Therefore, with a 10% adoption rate, the final savings amount to roughly **USD 1.2 million** per year.

Storms and cyclones

Storms and cyclones represent the second most frequent disaster in Africa and may be a primary driver for triggering floods, which can have a severe impact on communities. Such events affect populations in two ways: first, the devastation causes large-scale food insecurity by impacting the ability to cultivate subsistence crops; second, storms and cyclones lead to an increase in waterborne diseases, such as cholera.

"Storms and cyclones represent the second most frequent disaster in Africa..."

In 2019, cyclone Kenneth in Northern Mozambique caused the displacement of nearly 670,000 people.[45] The storm's effects are still felt in the form of food insecurity, extensive displacement of people and loss of livelihoods. Based on the disaster risk profile of 13 African nations, storms and cyclones contribute to USD 3.2 billion per year in estimated damages.[46] The implementation of EO services has the potential to save 5% of these costs if the effectiveness levels of Australia are matched.[47] This results in **USD 160 million** in savings, which translates to **USD 16 million**, assuming a 10% adoption rate. This amount is sufficient to meet half the funds required for hydro-meteorological modernization efforts in Uganda in accordance with the Uganda Modernization Plan.[48]

43 ESA, Copernicus. (2013, September). *Landslide warnings from satellites save lives* (No. 13) | Copernicus.
44 London Economics. (2016, November). *A study of the economic impact of the services provided by the Bureau of Meteorology* | bom.gov.eu.
45 Reliefweb. (2021). *2 years since Cyclone Idai and Mozambique has already faced an additional 3 cyclones.*
46 GFDRR. (2019). *Disaster Risk Country Profiles* | GFDRR.
47 London Economics. (2016, November). *A study of the economic impact of the services provided by the Bureau of Meteorology* | bom.gov.eu.
48 UNSP. (2016). *A NEW VISION for Weather and Climate Services in Africa* | thegef.

Case Study - DE Africa[49]

Using satellite data to combat drought: Monitoring Lake Sulunga, Tanzania

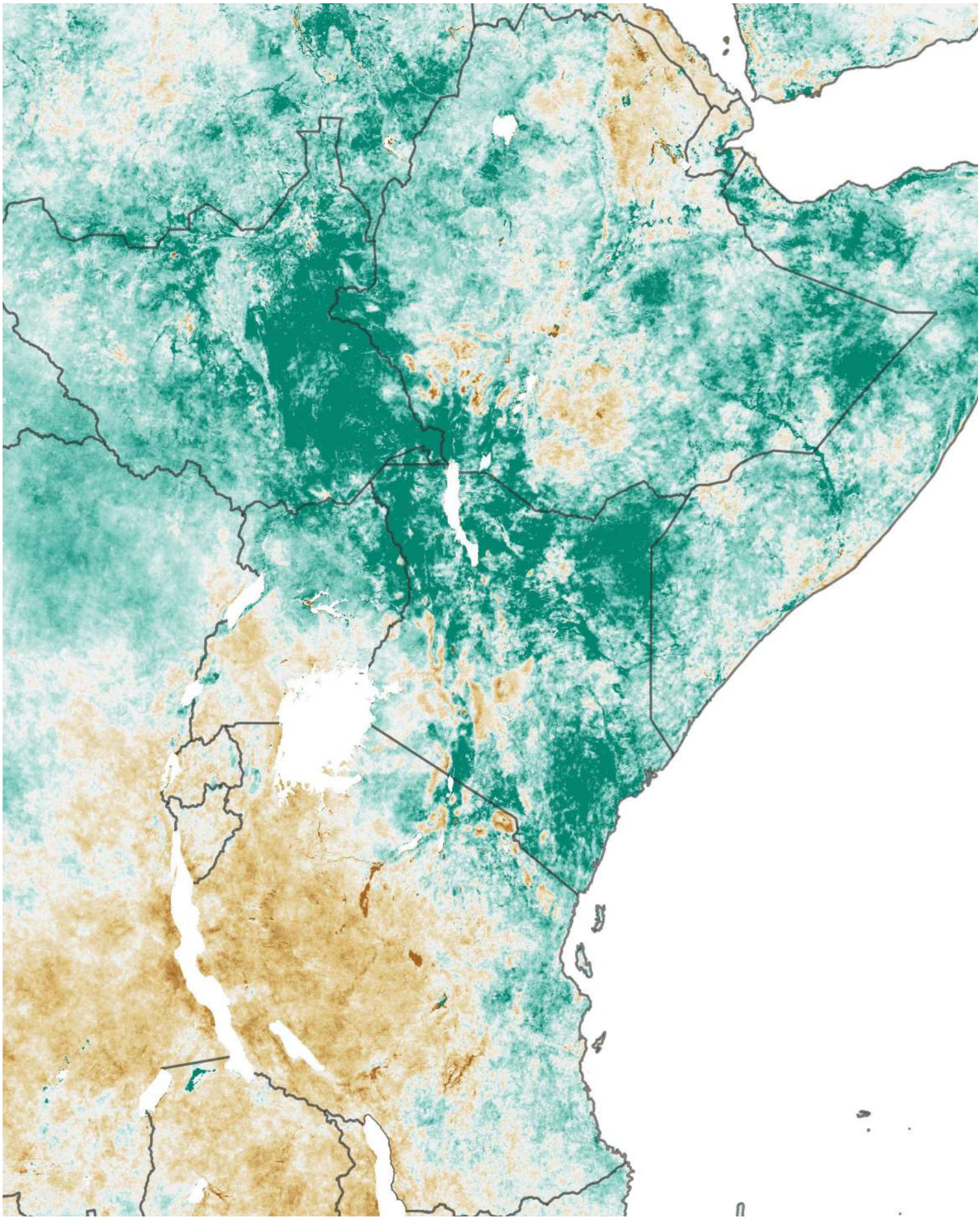
DE Africa water observations from space data layer shows changes in water levels, providing valuable insights for planning, https://www.digitalearthafrica.org/why-digital-earth-africa/impact-stories/using-satellite-data-combat-drought-monitoring-lake-sulunga

Lake Sulunga located in Tanzania measures roughly 25 km wide and 42 km long, and lies 45 km west of the capital, Dodoma. The surrounding communities rely on the lake to support their livelihoods, including fishing and animal husbandry.

In collaboration with local agencies, DE Africa conducted further analysis of Lake Sulunga using the Water Observations from Space (WOfS) available both in the DE Africa Map portal and DE Africa Sandbox interface for advanced analysis. By monitoring the lake over a six-year period from 2013 to 2019, DE Africa was able to plot the minimum and maximum water extents.

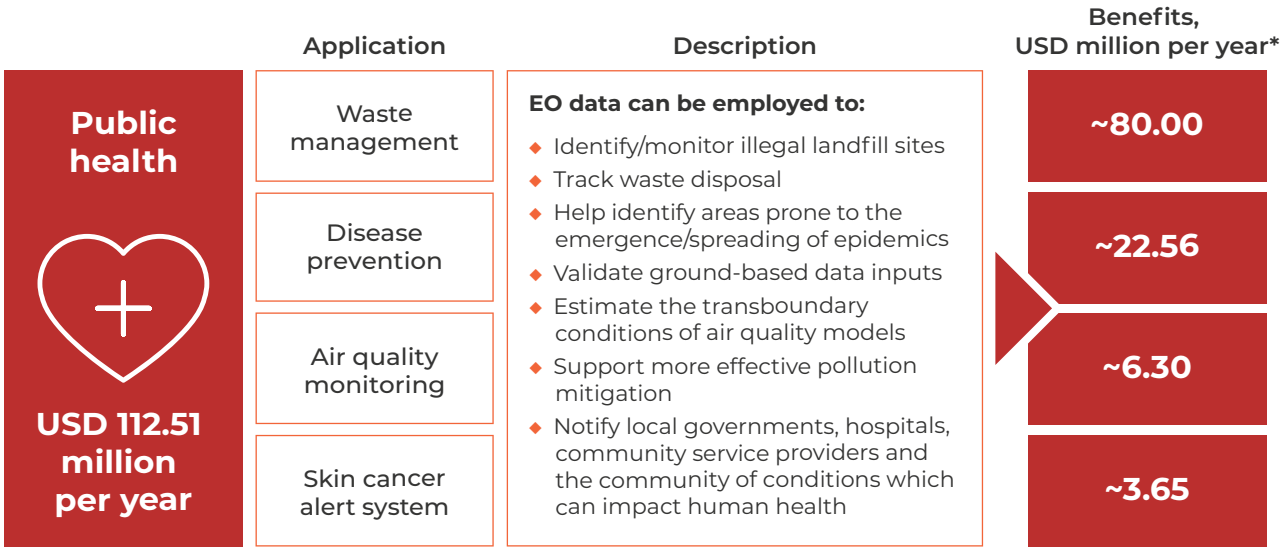
The research indicated that 55.4% of the region was never covered by water, 44.6% of the region was sometimes holding water, and none of the regions had water at all times. This analysis can detect and forecast variations of lake volume and depth in order to plan and organize activities, such as fishing and agriculture. The information is also a critical input to water accounts and modeling, which includes forecasting, to aid the government in making informed decisions on water planning and policies, prioritizing the people's interests and the environment, and contributing to SDG achievements.

49 Digital Earth Africa. (2020, November 17). *Using satellite data to combat drought: Monitoring Lake Sulunga, Tanzania* | Digital Earth Africa.



NDVI anomalies reveal how much healthier (greener) vegetation is than normal. Greener areas are usually wetter, suggesting better habitat for mosquitoes.
Source: NASA Earth Observatory maps by Lauren Dauphin, using NDVI anomaly data from Terra MODIS.)
Link this website - https://earthobservatory.nasa.gov/features/disease-vector

PUBLIC HEALTH



*assuming a 10% adoption rate

A society's health and healthcare system are hallmarks to a functioning and thriving social community. Health factors affect both the public's well being and the overall economic activity. As the Covid-19 crisis has demonstrated, failures in disease prevention and under-equipped hospitals can cause millions of deaths and become extremely costly for any state or region.

EO could support public health issues and save over **USD 1.125 billion** per year if EO benefits applied on the whole market, on the African continent by monitoring disease outbreaks, weather conditions, air quality, and other important applications. Estimated benefit is is **USD 112.51 million** per year if EO benefit is adopted in 10% of the cases

In the near future, health will become a relevant issue in Africa due to the exponential population growth and rapid increase in urbanization. These trends will cause contagious diseases to spread faster, shifting the attention to problems of waste accumulation and air pollution. Such concerns will primarily affect citizens in larger metropolitan areas, such as Lagos and Kinshasa. As these concerns rise, communities will hold local, regional and national stakeholders accountable to take action and prevent harm.

This chapter focuses on how EO technologies can help improve waste management, disease prevention of malaria, cholera, Ebola and skin cancer, as well as air quality.

"In the near future, health will become a relevant issue in Africa due to the exponential population growth and rapid increase in urbanization."

Waste Management

Source: *Unsplash*

EO could contribute up to **USD 800 million** per year assuming EO services applied in all cases, to the African economy by properly managing waste and improving recycling activities. This would be the most beneficial usage of EO in the sector if cost savings of 10% are assumed when using EO. Assuming 10% adoption of EO services would result in **USD 80 million** benefit per year.

The benefit brought about by EO is not surprising considering the 125 million tonnes of municipal solid waste (MSW) generated in Africa in 2012 - a number which is expected to double by 2025.[50] The average collection rate of MSW lies at only 55%, and around 60% of waste is dumped openly.[51]

"...benefit brought about by EO is not surprising considering the 125 million tonnes of municipal solid waste (MSW) generated in Africa..."

Through the data provided by EO, policymakers can improve waste management and combat illegal practices, such as the use of non-registered landfill sites.
The European Space Agency (ESA) confirmed an 80% accuracy rate in monitoring similar activities after launching the Wastemon project in Southern Italy.[52]
The technology monitors the entire disposal process from source to destination and ensures that legal landfills do not exceed or violate the provided boundaries.

50 UN environment. (2018). *Africa Waste Management Outlook | UNEP*.
51 UN environment. (2018). *Africa Waste Management Outlook | UNEP*.
52 Caribou Space, *Adoption and Impact of Earth Observation for the 2030 Agenda for Sustainable Development*, Farnham, Surrey, United Kingdom. Caribou Space, 2020.

This approach could be significant for Africa as 19 of the world's 50 largest dumpsites are located in Sub-Saharan territories.[53] More than 90% of generated waste on the continent is discarded in unsupervised dumpsites, often by open burning.[54] Municipal solid waste will increase with the growing population, and governments could leverage EO support to divert waste away from dumpsites and landfills towards a circular economy approach, such as reuse, recycle and recovery. The UN Environment Program found that these activities could inject an additional USD 8000 million every year into the African economy.[55] With EO's potential during these activities, an additional **USD 800 million** could be allocated towards cost savings. Such savings would be enough to build roughly 40 recycling plants with a capacity to process 20,000 tons of blue and white plastic per year.[56]

Landfill in Lagos, Nigeria, Sentinel-2 GeoMAD 2021, RGB, processed by Digital Earth Africa

53 UN environment. (2018). *Africa Waste Management Outlook* | UNEP.
54 UN environment. (2018). *Africa Waste Management Outlook* | UNEP.
55 UN environment. (2018). *Africa Waste Management Outlook* | UNEP.
56 GLI. (2020). *Africa Recycling Feasibility — GLI* | Globallivingston.

Disease Prevention

Our analysis focuses on three diseases that are widespread throughout the African continent: malaria, cholera and Ebola. Within this context, EO could lead to savings of **USD 226 million** per year assuming EO services are applied on the whole market, by reducing cases through outbreak prediction and disease monitoring.

Satellites can identify areas prone to the emergence and spread of epidemics. This insight provides policymakers the opportunity to monitor and respond quickly to outbreaks, and to take action to prevent or mitigate the occurrence of such diseases. With a total of nearly 210 million cases and approximately 500,000 deaths caused by malaria, cholera and Ebola, a reduction of overall cases and a decrease in deaths would be beneficial for any newly occurring outbreak or epidemic.

"...a total of nearly 210 million cases and approximately 500,000 deaths caused by malaria, cholera and Ebola..."

The NASA Malaria Early Warning System (MEWS) used satellite observation to obtain data covering a broad geographical area in Sub-Saharan Africa, including remote or sparsely populated regions with limited ground-based measurements. Using this approach, cases could be lowered by 660,000 or 1.15% of the total number of cases.[57] Cost savings of USD 138 million could be achieved using EO technologies to monitor malaria cases. This figure is obtained by taking into account the total number of cases and the costs per case multiplied by the reduction rate of cases due to EO. The savings could fund the construction of over 2,500 small clinics capable of serving a wide range of ailments in Africa.[58]

57 NASA. (2016). *Measuring Socioeconomic Impacts of Earth Observations. A Primer* | NASA.
58 The Borgen Project. (2015). *Clinic-In-A-Box Helps Bring Healthcare to Africa* | The Borgen Project.

https://www.nasa.gov/sites/default/files/files/Malaria_Early_Warning_508.pdf

Another successful approach is the cholera outbreak observation project in Yemen by NASA, which proved a 92% accuracy rate in forecasting the spread of the disease.[59] Our analysis indicates cost savings of USD 11.5 million when using EO to monitor cholera cases. The lower EO impact (in comparison to malaria and Ebola) is related to the marginal amount of existing cases. Nevertheless, Sub-Saharan Africa did report more cholera cases and deaths in the past 20 years than any other region in the world, which makes the application of EO relevant. Cholera also has an estimated economic burden to Africa of USD 1000 million, making its cost per case comparably high.[60]

Lastly, with a fatality increase of 26 percentage points (from 40% to 66%) in the most recent Ebola outbreak occurring between 2018 to 2020, monitoring this disease with EO would lead to savings of USD 76 million, following the same calculations used for malaria and cholera.[61]

59 Northon, K. (2018, March 17). *NASA Investment in Cholera Forecasts Helps Save Lives in Yemen | NASA*.
60 Mogasale V., et al. (2021, September). *Model-based estimation of the economic burden of cholera in Africa | BMJ Open*.
61 Statista. (2021, May 10). *Chronology of Ebola virus disease outbreaks 1976–2020 | Statista*.

Air Pollution

Source: *Unsplash*

EO could reduce the cost of air pollution in Africa by more than **USD 63 million** per year assuming EO services applied on the whole market. By validating ground-based data and estimating transboundary conditions. Assuming a 10% adoption of EO services would result in **USD 6.3 million** benefit per year.

In 2016, 4.2 million premature deaths worldwide were attributed to ambient air pollution.[62] About 88% of these deaths occur in low- and middle-income countries.[63] One of the deadliest air pollution spots is located in Eastern South Africa, an area that is over-proportionally infected by nitrogen dioxide.[64] Frequent and long-term exposure to low-quality air can cause serious harm to citizens, particularly in terms of health and well being. As witnessed in other countries, such as China, air quality has suffered due to the exponential growth in population, GDP, industry and urbanization.

To avoid such consequences, African countries can take immediate and preventative action. EO could support more effective pollution mitigation and help reduce air quality-related emergencies and hospital admissions. This could be done by providing monitoring capability such as plume dispersion, areas subject to particulate deposition and exposed habitats/population centres nearby to governments and citizens. Especially when air pollution is extremely high, providing data will help to increase awareness of pollution concerns, and support decision-making through accessible information.

"EO could support more effective pollution mitigation and help reduce air quality-related emergencies and hospital admissions."

62 World Health Organization. (2019, July 30). *Air pollution | WHO*.
63 World Health Organization. (2014). *Burden of disease from Ambient Air Pollution for 2012 | WHO*.
64 Greenpeace Africa. (2018, October 29). *New satellite data reveals the world's largest air pollution hotspot is Mpumalanga - South Africa | Greenpeace*.

The United Kingdom adopted an "Air Quality Hotspot Mapper", which draws on Copernicus MACC II data.[65] By integrating this information with other sources, the tool provides local authorities with better insights to enhance decision-making capabilities, mitigating the negative consequences resulting from poor air quality, which generated a cost savings of GBP 4.3 million (equivalent to USD 5.9 million). If a similar approach was applied to the African continent, cost savings of 9.5 times this amount could be achieved, considering the cost of air pollution and EO impact.

Skin Cancer Alert System

Finally, EO could be used to prevent more than 42 deaths each year caused by skin cancer, which would save roughly **USD 36.5 million** per year based on the value of statistical life in Africa equaling USD 850,000.[66] Assuming 10% adoption of EO services would result in **USD 3.65 million** benefit per year.

This would be achieved by notifying local governments, hospitals, community service providers, and the general population when conditions are hazardous for human health. Such notification systems would reduce the public's exposure to the sun and prevent skin cancer-related deaths.

The SunSmart program implemented in Australia uses a combination of grassroots tactics and mass media campaigns and advocacy to influence the population's attitude, knowledge and behavior regarding sun protection. The SunSmart program increased cost savings by 7.44%, of which 5% were directly related to EO contribution.[67]

As skin cancer causes 11,299 deaths in Africa every year, reducing such figures even by 0.4% would carry a significant impact.[68] In regions with the highest level of direct sun exposure, such as Northern and Southern African territories, skin cancer is the most common form of cancer. In South Africa, for example, there are roughly 20,000 reported cases and 700 deaths annually.[69]

"As skin cancer causes 11,299 deaths in Africa every year, reducing such figures even by 0.4% would carry a significant impact."

65 London Economics. (2018, July). *Value of satellite-derived Earth Observation capabilities to the UK Government today and by 2020* | London Economics.
66 Roy, R. (2016), *The cost of air pollution in Africa*, OECD Development Centre Working Papers, No. 333, OECD Publishing, Paris, https://doi.org/10.1787/5jlqzq77x6f8-en.
67 London Economics. (2016, November). *A study of the economic impact of the services provided by the Bureau of Meteorology* | bom.gov.au.
68 World Health Organization. (2020, December). *Melanoma of skin* | The Global Cancer Observatory. and World Health Organization. (2020b, December). *Non-melanoma skin cancer* | The Global Cancer Observatory.
69 CANSA. (2010). *Fact Sheet - Skin Cancer 2010* | CANSA.

Case Study - NASA[70]

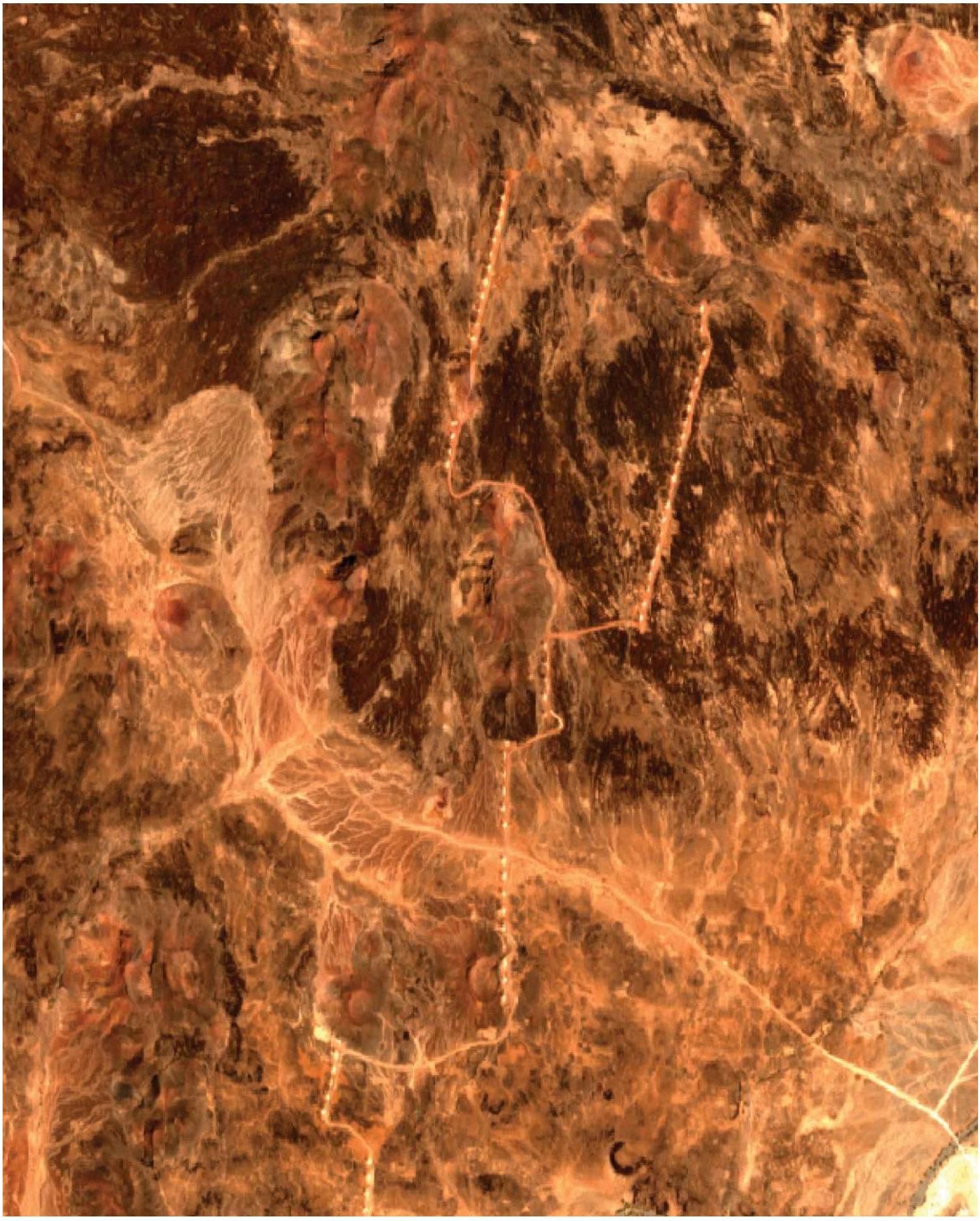
"Using remote sensing and Earth system models to improve air quality and public health in mega cities."

In 2020, a study conducted by NASA in collaboration with George Washington University aimed to monitor air quality and public health estimates in urban concentrations. The objective was to improve and verify the figures of harmful gas emissions and particulate matter in several pilot cities using NASA satellite data from MODIS, MISR, CALIPSO, OMI, TROPOMI and GEOS-Chem. One of the five chosen cities was Accra, Ghana. The study also estimated exposure trends for the next 15 years, which included associated mortality rates and morbidity burdens in cities.

The science team collaborated with municipal governments and NGOs to ensure the most accurate results. The project raised air quality awareness, encouraged stakeholder engagement, increased the use of analytical tools, and integrated air quality systems into urban climate action planning for the C40 cities.[71] The research team also faced several challenges, including obstacles in obtaining local health data, handling different geopolitical interests of the stakeholders, as well as pandemic-related difficulties in supporting cross-border communications.

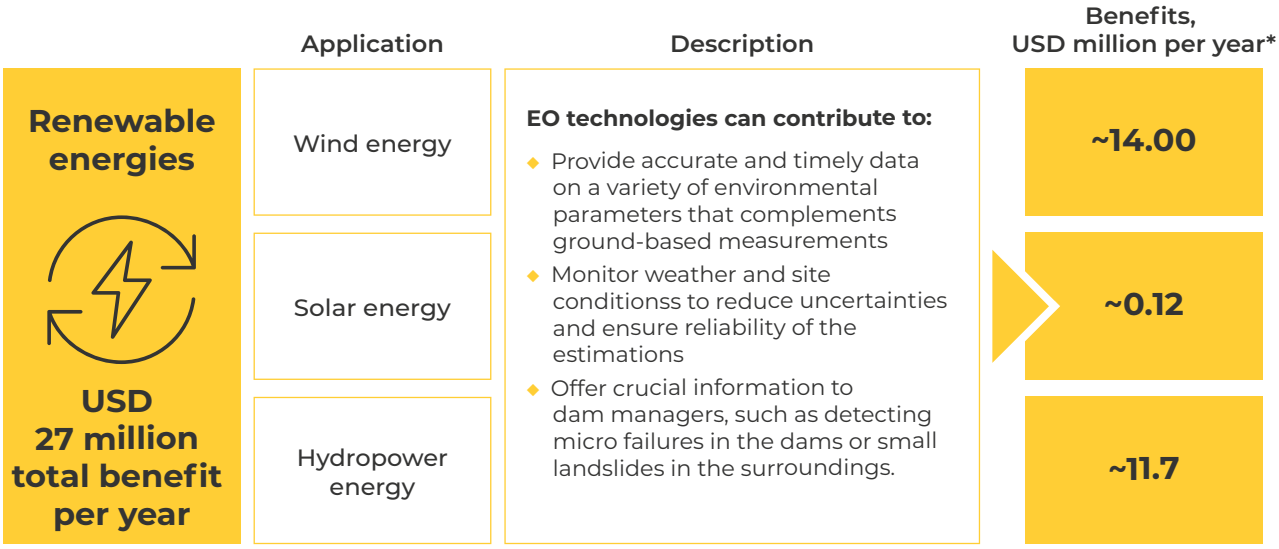
Nonetheless, there is a need to provide scientific support for stakeholder policy analyses, and the research team would value the opportunity to conduct such a breakthrough study to further improve air quality in municipalities around the world. The goal is to reduce pollution-related diseases, achieve Paris Agreement goals, and avoid climate change in its most severe form. By implementing air quality monitoring, sustainable industrialization can be achieved within the new global regulatory frameworks.

70 Dr. Ahnenberg, S. (2020, September). *Using remote sensing and Earth system models to improve air quality and public health in mega cities | NASA*.
71 C40 Cities Climate Leadership Group, Inc. (2021). *C40. C40 Cities | C40 Group*.



Wind Farm at Lake Turkana, Kenya, Sentinel-2 GeoMAD 2020, RGB, processed by Digital Earth Africa

RENEWABLE ENERGIES



Africa's wealth of renewable energy resources puts the continent in a unique position to create viable alternative energy solutions for the future. The continent has the potential to meet 25% of its energy needs from renewable energy sources by 2030 and further increase this fraction to approximately 66% by 2050.[72]

Africa is the fastest-growing continent both in terms of population and GDP, emphasizing the need to develop clean and sustainable energy sources. In this perspective, the Sustainable Development Goal on energy (SDG 7) is incorporated in the social, economic and sustainability objectives of Africa's Agenda 2063, indicating its priority and importance. Furthermore, 48% of Africa's population has no access to electricity.[73] The remaining population has access to power but faces frequent blackouts, power cuts and other issues related to power quality. Such shortages combined with high energy tariffs cost approximately 2 to 4% of the annual GDP.[74]

Renewable energy sources can help overcome such challenges. EO plays a crucial role in setting up renewable energy production plants by identifying suitable sites and aiding in plant design. The use of EO is critical in running the plants efficiently by providing data points for optimal resource exploitation, efficient monitoring and forecasting of production levels. We focused our analysis on the scope of EO on Africa's three largest sources of renewable energy: wind, solar and hydropower.

72 IRENA. (2020, January). *Scaling up renewable energy deployment in Africa | IRENA*.
73 The World Bank. (2019). *Access to electricity (% of population) - Sub-Saharan Africa | Data*. World Bank Group.
74 IRENA. (2020, January). *Scaling up renewable energy deployment in Africa | IRENA*.

Wind

Source: *Unsplash*

To assess the wind power potential in Africa, a study commissioned by the International Finance Corporation (IFC) in 2020 found that 59,000 GW of energy could be produced per year, which is equivalent to 250 times the current domestic demand.[75] According to the Global Wind Energy Council, Africa has tapped into only 0.01% of its potential wind power resource and accounts for less than 1% of global wind power production.[76] The future for wind power is optimistic as the study discovered that 66% of Africa's total wind potential is located in areas with optimal wind conditions for turbines with average wind speeds of over 7.5 meters per second.

> *"...59,000 GW of energy could be produced per year, which is equivalent to 250 times the current domestic demand."*

Another key discovery of the research was the wide geographical distribution of wind potential. The study identified viable pockets in places that were previously considered unfavorable for harvesting wind energy. Those regions include areas in Namibia, Botswana, Côte d'Ivoire, Cameroon, Mauritania, Madagascar and Tunisia. In many cases, the best wind resources are located in areas close to cities and towns, which are primary demand centers. In such territories, the wind blows strongest when electricity demand is the highest - i.e., early in the

75 Largue, P. (2021, March 8). *Africa has more than 59,000GW wind potential, says the GWEC report |* Power Engineering International.

76 Pek, A. (2021, March 3). *Africa is only tapping into 0.01% of its wind power potential |* Global Wind Energy Council.

morning and early in the evening. Therefore, wind energy could complement solar energy, which generates most of its power during the day. It is important to note that the costs of wind projects have declined by 50 - 60% from 2010 and 2019, making such solutions more accessible and feasible.[77]

EO can play a pivotal role in implementing both onshore and offshore wind energy solutions across Africa, as it can provide accurate and timely information on a variety of environmental parameters, such as wind and waves, weather conditions, topography and vegetation cover, which are critical inputs for modeling wind energy. This data can help ensure that wind turbines are placed in the right locations to benefit society without impacting regional biodiversity.

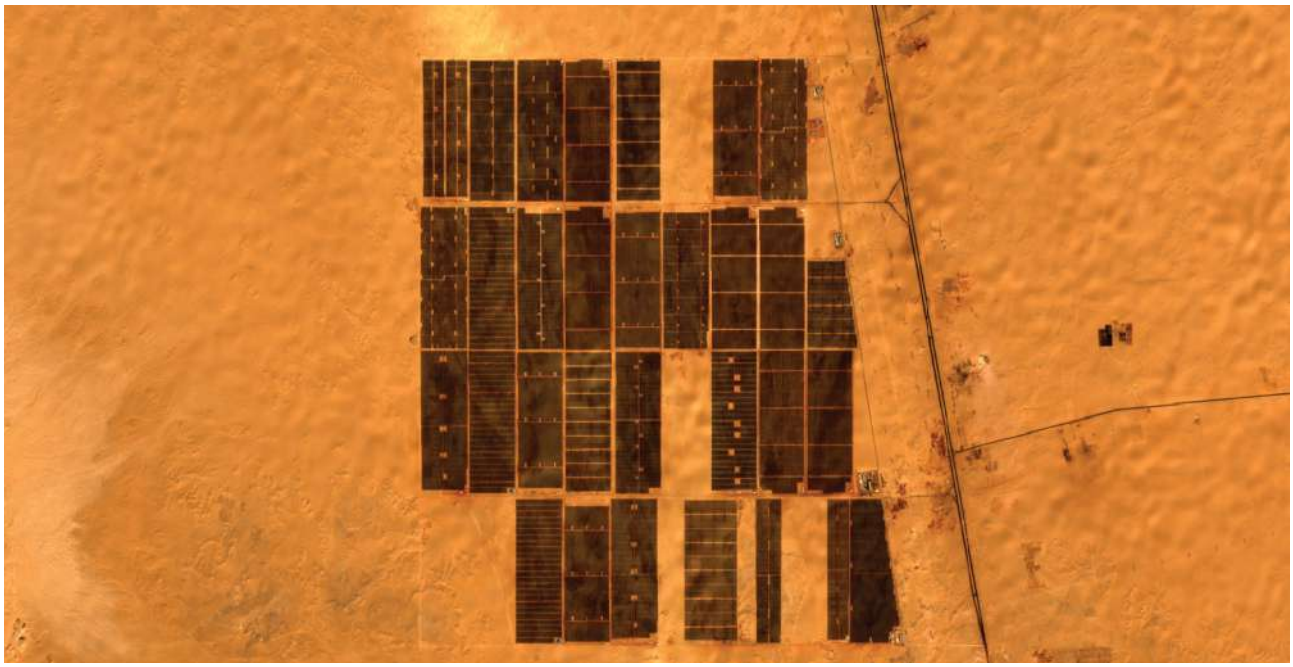
To understand the potential impact of EO on wind power, we looked at the extensive analysis undertaken by Vortex.[78] The study used ERA 5 climate reanalysis data and measurements shared by Vortex users from more than 1,500 sites across the world. The results indicate a 1 to 3% decrease of project uncertainty, hence 2% can be assumed to be the average reduction.

Generally, a 1% reduction in the project uncertainty implies an increase of the project feasibility by USD 1.18 million for a typical 100 MW wind farm project. Assuming a 2% average uncertainty reduction every 100 MW - which amounts to USD 2.38 million - and considering that the African wind capacity stands at 5,900 MW, the project returns could total **USD 140 million** if applied to all wind farms.[79] If we assume a 10% adoption rate, the total benefits generated by EO would amount to **USD 14 million** per year.

The wind capacity in Africa is expected to reach 51 GW by 2030, which implies that under the same assumptions, the total benefit due to EO could be USD 1200 million or USD 120 million with a 10% adoption rate. These savings would allow the set up of roughly 92 wind turbines and add 92 MW of energy to the electricity supply. [80]

77 Obonyo, R. (2021, January). *Push for renewables: How Africa is building a different energy pathway* | *Africa Renewal*. UN.
78 European Union, Pwc. (2019, February). Copernicus Market Report. Publications Office of the European Union. https://doi.org/10.2873/011961
79 IRENA. (2020, January). *Scaling up renewable energy deployment in Africa* | *IRENA*.
80 Weather Guard Lightning Tech. (2021). *Wind Turbine Cost: Worth The Million-Dollar Price In 2021?* | *Weather Guard Wind*.

Solar



Benban Solar Farm, Egypt, Sentinel-2 GeoMAD 2020, RGB, processed by Digital Earth Africa

Africa has excellent conditions for solar energy as sunshine is both more abundant and reliable when compared to other regions. Solar PV in Africa can generate an annual electricity potential of 660,000 TWh, which is 900 times the power generated today.[81],[82] Additionally, the costs for power generated from utility-scale solar photovoltaics (PV) fell by 82% between 2010 and 2019. Solar PV tariffs fell below USD .04, making it the most cost efficient source of electricity generation and a logical choice for increasing power generation capacity.

Technological innovations and sustainability initiatives have driven the adoption of solar power in Africa. For example, more than 33% of Morocco's electricity comes from clean sources generated by the Noor Quarzazate Solar Power Station, the world's largest concentrated solar power farm. The African continent has shown great progress in the development of its solar power capabilities over the past few years. The region experienced a growth of over 1.8 W of new solar installations, driven primarily by five countries: Egypt, South Africa, Kenya, Namibia and Ghana.[83]

"The region experienced a growth of over 1.8 W of new solar installations..."

81 Hermann, S., Miketa, A., Fichaux, N. (2014). *Estimating the Renewable Energy Potential in Africa*. IRENA-KTH working paper, International Renewable Energy Agency.
82 Aboagyeac, B., & Gyamfi, S. (2021, March). *Status of renewable energy resources for electricity supply in Ghana* (No. 11). ScienceDirect. https://doi.org/10.1016/j.sciaf.2020.e00660
83 UN. (2021) *Push for renewables: How Africa is building a different energy pathway | UN*.

EO can contribute to the development of solar power in Africa by monitoring weather and site conditions, thereby reducing uncertainties and ensuring estimation reliability. EO could also assist in understanding the origins of productivity losses at solar plants, such as dirt collection on panels to help maintain optimal efficiency.

To illustrate the versatility of EO applications in solar power development, we look to PowerHive as a leading example. PowerHive is a US-based microgrid solutions provider licensed to generate, distribute, and sell electricity in Kenya, which uses a proprietary tool called SWARM for microgrid site selection.[84] SWARM leverages on EO data to identify potential customers and create preliminary microgrid designs for viable sites. The benefit of EO can be quantified by the Copernicus report, which studied solar power production by Reuniwatt.[85] The findings show an average 2% increase of photovoltaic electricity producers' remunerations due to EO technology.

The African solar energy capacity accounts for 1.23% of the global market, which is estimated to be USD 50,000 million.[86] Applying a 2% benefit to the entire African solar power market brings the potential revenue gain to roughly **USD 12.3 million** per year. If a 10% adoption rate is assumed, the economic benefit generated by EO can be approximated to reach **USD 1.2 million** per year.

With the size of the solar power market in Africa expected to reach USD 10,500 million by 2030, EO could potentially provide total benefits of up to USD 210.8 million.[87] A 10% adoption rate would bring this number to approximately USD 21.1 million. This figure is equivalent to powering 28,000 homes with their own solar panels in Sub-Saharan Africa.[88]

Hydropower

Hydropower accounted for more than 43% of the world's renewable energy in 2020.[89] Compared to other renewable sources, such as wind and solar energy, hydropower has the lowest carbon emissions in terms of end-to-end lifecycle, which includes the construction, operation and decommissioning of such projects.

84 Powerhive Inc. (2020). *Powerhive | STORY*. Powerhive. https://powerhive.com/
85 European Union, Pwc. (2019, February). *Copernicus Market Report*. Publications Office of the European Union. https://doi.org/10.2873/011961
86 Our World in Data. (2020). *Installed solar energy capacity.* https://ourworldindata.org/grapher/installed-solar-pv-capacity
87 IRENA. (2015). *Africa 2030: Roadmap for a Renewable Energy Future* | IRENA.
88 Madamombe, I. (2006, October). *Solar power: cheap energy source for Africa* | Africa Renewal. UN.
89 Irena.org. (2021, April). *World Adds Record New Renewable Energy Capacity in 2020* | IRENA.

"Hydropower accounted for more than 43% of the world's renewable energy in 2020. "

As of 2020, Africa has an installed hydropower capacity of over 37 GW, which represents only 11% of its capacity, making the region one of the highest untapped potential areas in the world. On average, hydropower contributes to 70% of all renewable energy use and accounts for 16% of total electricity generation on the continent. The share of hydropower in total electricity generation may potentially increase to more than 23% by 2040 as part of the ongoing efforts towards renewable energy transition and universal energy access in Africa. In some countries, such as the Democratic Republic of Congo, Ethiopia, Malawi, Mozambique, Uganda, and Zambia, the share of hydropower in electricity generation already exceeds 80%.[90]

The use of EO in the hydropower sector is similar in its versatile application to solar energy, which includes locating and monitoring potential sites. For example, with the help of Geographic Information Systems (GIS) platforms, such as ArcGIS, the Australian National University found 22,000 suitable sites for pumped hydro energy storage. One of the largest proposed projects, Snowyhydro 2, will have a storage capacity of 360 GWh.[91]

As with the other renewable energy industry, we assumed a 2% increase in revenues for the hydropower sector. Africa accounts for 2.9% of the global hydropower capacity, which is valued at USD 202.4 billion. With a 2% increase in revenues due to EO, the value of the benefits is approximately **USD 117.5 million** per year, if applied to the entire market. With an adoption rate of 10%, the increase in revenues would amount to **USD 11.75 million**. This is equivalent to the cost of producing 235 GWh of hydroelectric power assuming a levelized cost of electricity of USD 0.05/KWh.[92]

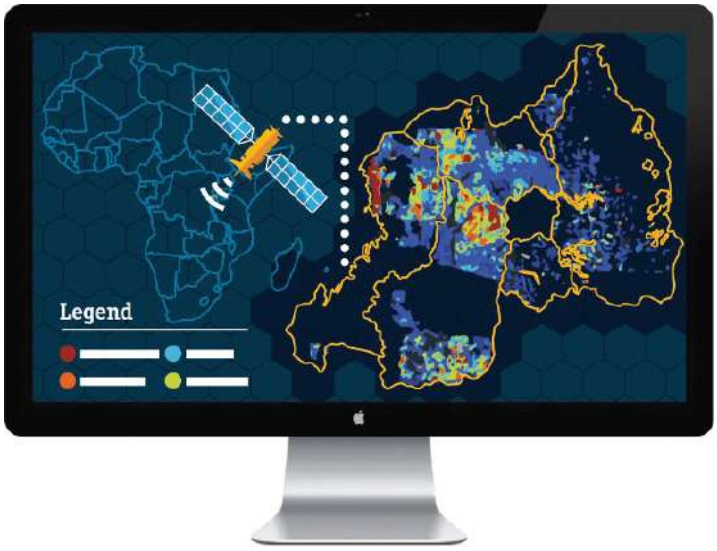
90 IEA. (2020, June). *Climate Impacts on African Hydropower* | IEA.
91 Blakers, A. et al. (2017, September). *An atlas of pumped hydro energy storage* | ARENA.
92 IRENA. (2021). *Hydropower Costs* | IRENA.

Case Study - Powerhive[93]

Powerhive is a US-based microgrid solutions provider licensed to generate, distribute and sell electricity in Kenya. The company aims to provide stable electricity and fast internet connection to remote communities by offering more convenient utility services. These objectives also help national and regional governments reach their electrification and renewable energy targets.

Powerhive offers various technologies to their customers, including a proprietary tool called SWARM for microgrid site selection. SWARM leverages EO data to identify potential customers and create preliminary microgrid designs for viable sites, which allows the company to provide renewable energy options in a cost-efficient way. SWARM conducts the analyses based on financial, technical and geospatial data. Such information is used to calculate optimal mini-grid solutions by factoring design, system size and site feasibility.

By partnering with project developers, utility services, government agencies and other organizations, a full-scale service can be provided before, during and after the project deployment.

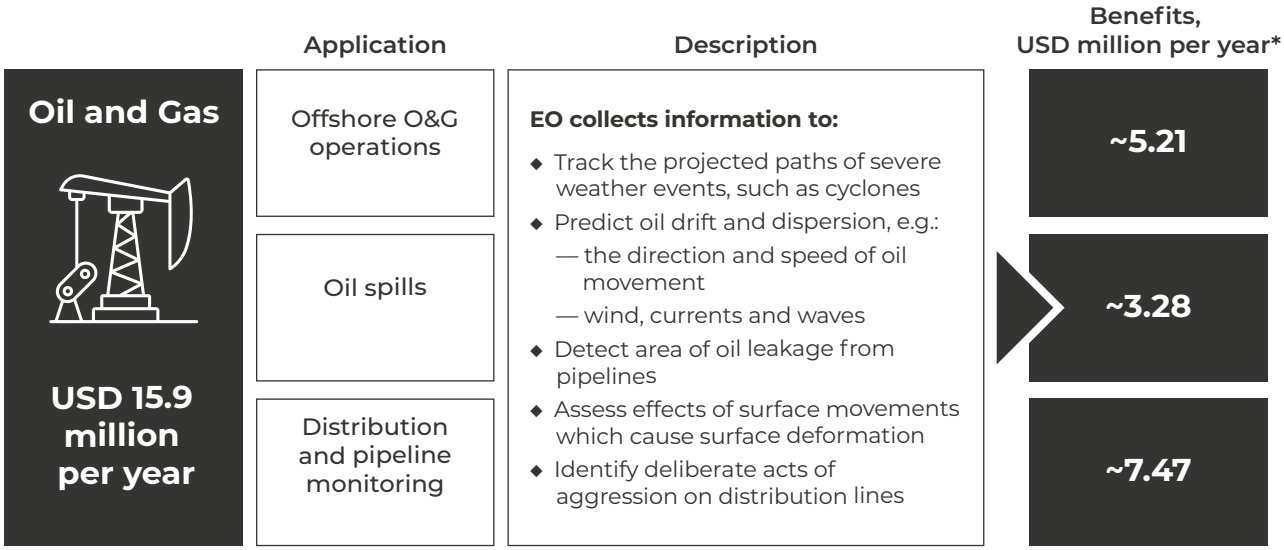


Exemplary image of the SWARM technology, https://powerhive.com/our-technology/

93 Powerhive Inc. (2020). *Powerhive - STORY* | Powerhive.Com.

Oil and gas fields near Ras Lanuf, Libya, Sentinel-2 GeoMAD 2020 RGB, processed by Digital Earth Africa

OIL AND GAS



Africa is endowed with abundant fossil fuel resources as five of the world's top 30 oil and gas producing nations are located on the continent. The region accounts for 8.8% of global oil production and approximately 6.1% of natural gas production.[94] These resources are largely concentrated in the Sub-Saharan territories, which hold nearly half of Africa's oil and gas reserves. Countries located in this zone heavily rely on oil and natural gas outputs to meet their domestic energy needs. When faced with global uncertainties, such as the ongoing Covid-19 pandemic, any shift in the market (e.g., the decrease in demand and prices) has an immediate and devastating impact on the livelihoods in the region.

When imagining Africa's energy transition towards a greener and more sustainable future, one significant challenge is to reduce the environmental impact caused by the extraction and transportation of fossil fuels. EO technologies can help address these problems by actively monitoring the natural environment and transportation routes, potentially bringing benefits of up to **USD 159.5 million** to the industry. This minimizes the damage caused by natural hazards and accidents by identifying leakages to ensure optimum efficiency. To analyze the potential impact, we focused on the following three areas: offshore operations, oil spills and pipeline monitoring.

94 Pwc. (2020). *Africa Oil and Gas Review 2020*.

Offshore operations

Source: *Unsplash*

In 2018, the production of oil and gas in Africa generated over USD 130 billion in net income. Africa's proven reserves stand at 125.7 billion barrels of crude oil with 41% of these sites located offshore, and its proven gas reserves are estimated to be 527 trillion cubic feet with 34% of these operations located offshore. The ten most significant resource discoveries in 2019 have all been offshore, further highlighting the future importance of such facilities.[95] These offshore plants are highly susceptible to severe weather patterns, such as cyclones, which can cause harm to crew members and critically damage infrastructures.

EO can help reduce 10% of costs incurred due to natural phenomena by accurately tracking the projected path of storms and cyclones and enabling timely disconnection and powering down of FPSO operations (Floating Production Storage and Offloading), which on average can take up to 12 hours depending on the conditions.[96] Integrating EO technologies will mitigate such risks to ensure the safety and security of both the crew and facility.

95 Pwc. (2020). *Africa Oil and Gas Review 2020*.
96 Acil Allen Consulting Pty Ltd. (2015, December). *The value of earth observations from space to Australia* | CRCSI.

"EO can help reduce 10% of costs incurred due to natural phenomena by accurately tracking the projected path of storms and cyclones and enabling timely disconnection and powering down of FPSO operations..."

A study conducted in Western Australia by Acil Allen Consulting calculated both the economic cost of severe weather on offshore oil and gas (O&G) operations and the EO economic benefit in terms of cost savings.[97] In 2014, the total revenue from offshore O&G operations in the region amounted to USD 20.7 billion. While the annual cost of severe weather (primarily due to storms and cyclones) amounted to USD 86 million. EO contributed to saving USD 8.55 million, equivalent to 10% of downtime costs.

The African offshore O&G revenues are 3.52 times greater than those in Western Australia, and the annual costs of severe weather on offshore operations adjusted for Africa is approximately **USD 148 million**. With a 10% cost benefit due to EO and a 10% adoption rate, the total savings are estimated to be **USD 5.21 million** per year, which equates to roughly 11.35 million liters of crude oil that could be purchased at a price of USD 73 per barrel.[98]

Oil spills

Oil spills can have a detrimental effect on human life and cause irreversible damages to the natural environment by polluting water sources and adversely impacting marine biodiversity. Multiple oil spills occur in Africa each year, with the Niger Delta being one of the most affected regions. On average, over 40 million liters of crude oil are leaked into the ocean in this zone every year, resulting in human fatalities and severe destruction of local ecosystems.[99] A 2018 research conducted by the *Journal of Health and Pollution* revealed that more than 12,000 oil spill incidents have occurred in the Niger Delta between 1976 and 2014. Although the amount of "dispersed oil per oil spill incident" area is shrinking each year, the frequency of oil spills continues to rise. To monitor and contain these disasters, aerial surveillance requires at least a five- to six-hour recognition flight that costs roughly USD 1.18 per km^2, which is 150 times the cost of satellite imagery.[100]

97 Acil Allen Consulting Pty Ltd. (2015, December). *The value of earth observations from space to Australia* | CRCSI.
98 MWV. (2021). *Average monthly Brent crude oil price from January 2020 to August 2021 (in U.S. dollars per barrel)* | Statista. Statista Inc..
99 Bukola Adebayo, C. (2019, March). *Major new inquiry into oil spills in Nigeria's Niger Delta launched* | CNN.
100 ESA, Copernicus. (2013b, September). *Space technology reveals where oil pollutes the oceans* (No. 21) | Copernicus.

"Oil spills can have a detrimental effect on human life and cause irreversible damages to the natural environment..."

EO can play a vital role in controlling the damage extent of oil spills, as the technology allows for more timely and cost-effective observations. Between April 2007 and January 2011, 72 authorized users in 24 coastal states leveraged EO data provided by the CleanSeaNet (CSN) initiative of the European Maritime Safety Agency (EMSA), which is an agency combating sea pollution operations (i.e., oil spills) with the help of Sentinel-1 c-band SAR.[101] Over this four-year period using EO data, approximately 8,800 possible oil spills were detected, of which 2,800 events were inspected on-site. Roughly 740 of the on-site checks confirmed the danger of a potential spill.

EO enables EMSA to monitor over 1,000 million km² (a geographic operational area equal to 11.46 million km²) at an operational cost of approximately USD 3.18 million per year, which is roughly ten times more cost-effective than aircraft-based modeling, saving USD 29.5 million per year. As the potential operational area in Africa is 11% greater than the area CSN currently surveys, the total cost savings would amount to **USD 32.75 million** if the EO adoption rate is 100%. If we assume a 10% adoption rate, the savings would amount to **USD 3.28 million** per year.

Pipeline monitoring

Natural gas is a key component of Africa's energy mix and plays a significant role in fueling the region's growing economies. Such resources contributed to 36% of the additional energy consumed in 2019. In the power sector, gas-fired generation experienced an increase from 22.8% to 23.3% in the same year.[102] Natural gas is often transported with the help of pipelines, with the West African Gas Pipeline (WAGP) as one of the longest pipeline corridors on the continent. This infrastructure represents a significant fossil fuel undertaking in Africa, which includes a 681 km high-pressure gas transmission system built to export Niger Delta gas from the Lagos Beach terminal in Nigeria to Ghana.[103]

Satellites, such as the Sentinels of the European Copernicus programme, are high precision tools for detecting changes and anomalies in natural gas pipeline structures. Sentinel-1 radar data is effective in detecting disruptions across vast territories with pipeline corridors.[104] EO can help increase the efficiency and reduce transmission losses of distribution channels in three ways: detecting

101 ESA. (2021). *Sentinel-1 Mission Operations Concept* | ESA.
102 Snam, International Gas Union, BloombergNEF. (2021). *Global Gas Report 2020* | IGU.
103 Verdict MediA Lmtd. 2021. *West African Gas Pipeline (WAGP)* | Hydrocarbons Technology.
104 ESA. (2017, May 25). *Sentinels bring solutions to pipeline monitoring* | Sentinel Online.

the area of oil leakage in pipeline structures, assessing the effects of surface movements that can cause area deformation, and detecting deliberate acts of aggression on distribution lines.

"EO can help increase the efficiency and reduce transmission losses of distribution channels..."

To understand the impact of EO on pipeline monitoring, we studied its implementation in the Netherlands. Stedin is a Dutch gas and utilities company that began developing its pipeline replacement strategy by taking into account surface deformation data delivered by SkyGeo, a Dutch EO-based service company.

By integrating such technology, Stedin significantly reduced its replacement costs and failure rate, and provided an economic benefit of USD 15 million to citizens.[105] As gas consumption in Africa is 4.81 times the overall consumption in the Netherlands, the total potential benefits could amount to **USD 74.7 million**. If a 10% adoption rate is assumed, the resulting benefits are around **USD 7.47 million** per year.

105 EARSC. (2016, May). *Copernicus Sentinels' Products Economic Value: A Case Study* | EARSC.

Case Study - REMPEC (Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea)

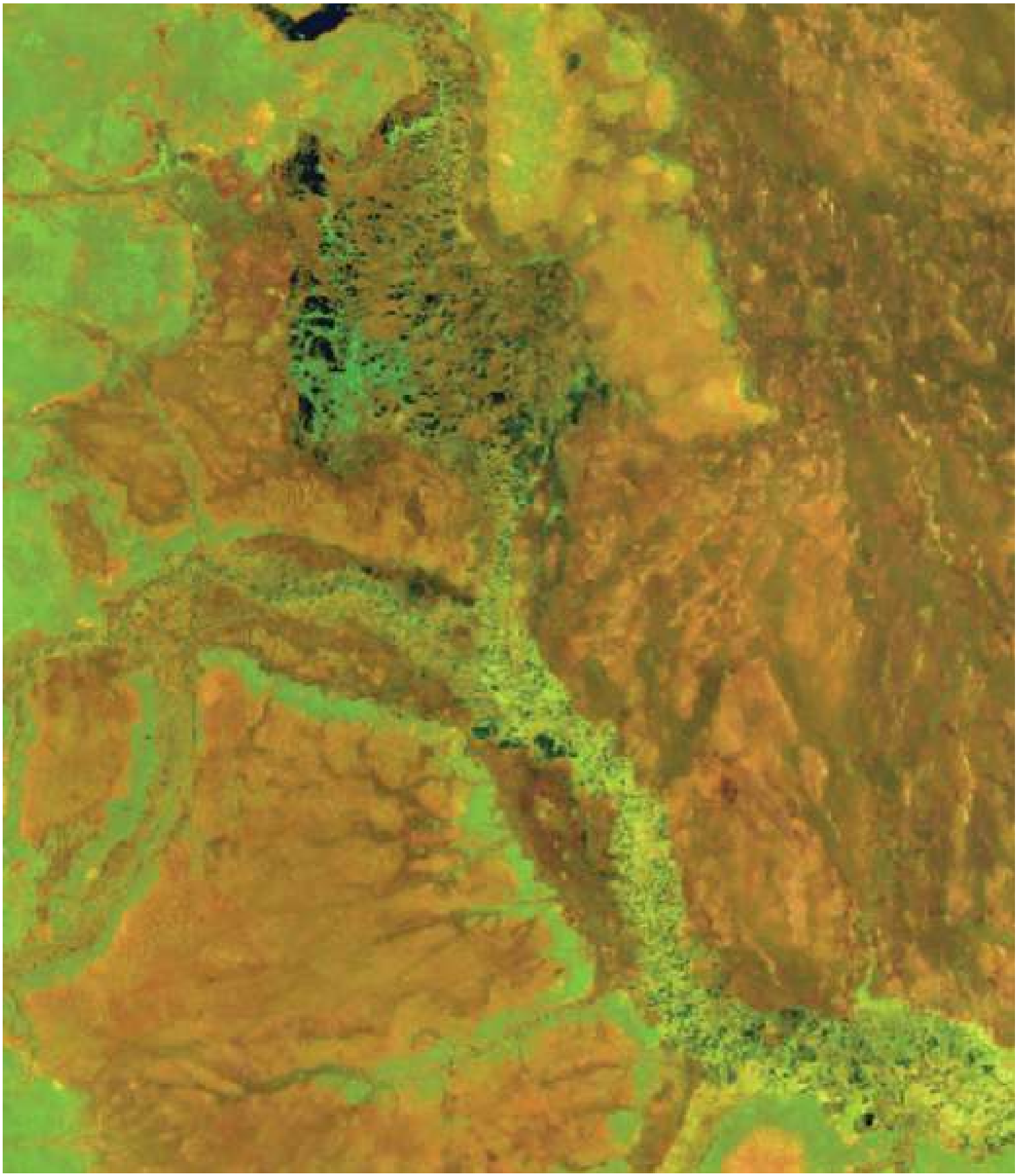
REMPEC established MONGOOS (Mediterranean Operational Network for the Global Ocean Observing System) to coordinate a multi-platform observation framework (in situ and remote sensing) to monitor the entire Mediterranean basin and create a high-resolution forecasting system. CMEMS (Copernicus Marine Environment Monitoring Service) aided the project by providing EO-based technologies and services to supplement the analysis efforts.

To carry out the initiative, MONGOOS set up an emergency response arm called ERO (Emergency Response Office) to provide a quick and immediate response system during an environmental hazard. In the event of an oil spill, for example, ERO provides critical information, including forecasting the oil drift range and detecting the coastal areas that would likely be affected by the spill. The speed and accuracy of this intelligence helps neighboring countries define and develop a cost-effective and proactive response strategy.

Following an armed attack on the oil port of Es Sider in Libya in March 2017, REMPEC commissioned MONGOOS to simulate a worst-case scenario plan in the event of an oil spill. The simulation was created using data provided by CMEMS, with inputs from the Italian Meteorological Office, the Euro-Mediterranean Center on Climate Change, and the Italian National Group of Operational Oceanography. The simulation was visualized through SeaConditions, a web and mobile application developed by CMCC (Euro-Mediterranean Center on Climate Change) to make EO data easily available and user-friendly.

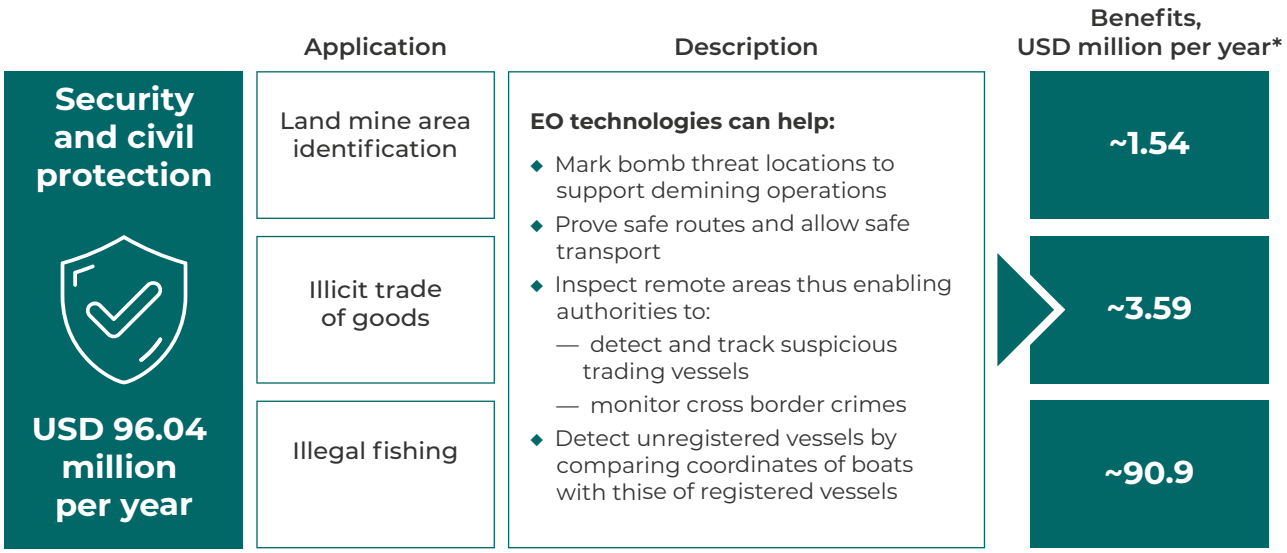
The information from CMEMS included ocean current forecasts, which were predicted to be weak and headed north-westward along the Libyan coast. The analysis also included other ocean parameters, such as wind speed and direction, and led to the conclusion that approximately 44% of the oil spill could reach the Libyan coastline within 24 hours after the incident occurred. This information proved essential in aiding REMPEC and public authorities to prepare for a potential spill and implement appropriate countermeasures in a timely way.[106]

106 Copernicus. (2017). *Copernicus assists in monitoring risks and planning for response to marine pollution*.



Okavango National Park, Botswana, Sentinel-2 GeoMAD 2021, False Colour, processed by Digital Earth Africa

SECURITY AND CIVIL PROTECTION



Africa is still considered one of the most dangerous continents in the world. Newly elected governments and public institutions are prioritizing the issue of safety and security by searching for ways to enhance civil protection. Such endeavors are costly and difficult to implement given the minimal resources available and rampant corruption schemes.

An Interpol report in collaboration with RHIPTO (a UN-collaborating rapid response center) details the various types of activities in which criminal groups in Africa are involved in, including drug trafficking, fraud, illegal trade (ivory and rhino horns), and human trafficking. Additionally, the report states that the proceeds of environmental crime – which encompasses not just wildlife crime but also smuggling and illicit mining of gold, diamonds and other precious minerals and resources – have become the largest source of income for non-state armed groups and terrorist organizations.[107]

EO could aid in enforcing laws and legal practices by supporting governmental programs and improving socio-economic development. Such technologies could thereby save Africa approximately **USD 960 million**. By considering the most relevant and data-backed applications, our analysis focused on three main criteria: land mine area identification, illicit trade of goods and illegal fishing.

107 Interpol, RHIPTO. (2018). *World Atlas of illicit flows* | Interpol.

Land mine area identification

EO contribution to land mine area identification can help save **USD 15.4 million** per year if EO services are applied 100%. by reducing the costs of demining operations and improving the training of deminers to boost job safety and security. Assuming 10% adoption of EO services this would equate to **USD 1.54 million** benefit per year

Land mines are still a common threat in nations facing ongoing civil conflict or in countries considered post-war territory. Such dangers impede socio-economic development, hinder the construction and maintenance of infrastructure, and obstruct the achievement of Sustainable Development Goals. Land mines also make agricultural land unusable, restrict water access, and prohibit schools from being built, inhibiting students and teachers from attending classes for education.[108]

Globally, estimates show that 110 million landmines are still active today and an equal amount remains in stockpiles waiting to be planted or destroyed. According to the International Campaign to Ban Landmines network, more than 4,200 people, of whom 42% are children, fall victim to landmines and explosive remnants of war (ERWs) on an annual basis in countries affected by war or in post-conflict regions around the world. In 2020, the UN reported 2,630 landmine casualties in Africa alone.[109]

"In 2020, the UN reported 2,630 landmine casualties in Africa alone."

Currently, the continent has approximately 41 million active mines with a majority located in Egypt and Angola. The cost of removing one explosive mine ranges between USD 300 to USD 1,000. For every 5,000 successfully removed land mines, one deminer is killed and two retain injuries.[110]

In this context, EO can help accurately track the search area coverage and mark threat locations to support planning and traceability of demining operations. This approach will contribute to making demining operations safer, more efficient, cost-effective, auditable, and more autonomous. EO can help save lives by offering virtual training opportunities for deminers without needing to enter dangerous territories or requiring physically buried targets. Finally, EO can ensure transportation safety using proven routes by monitoring safe zones and pinpointing potentially hazardous areas.

108 Dorn, A.W.. (2019). *Eliminating Hidden Killers: How Can Technology Help Humanitarian Demining?*. Stability: International Journal of Security and Development, 8(1). DOI: http://doi.org/10.5334/sta.743
109 United Nations. (2021). *Interactive Dashboard of the UN Mine Action Strategy* | Mineaction.
110 United Nations. (2021). *Interactive Dashboard of the UN Mine Action Strategy* | Mineaction.

For example, the MIDAS program introduced by ESA uses satellite technologies as an enabler for new services to make demining operations safer. MIDAS brings the same value add to its users as mentioned in the previous sections, and assures that the demining equipment is set up and used safely, correctly and effectively.

Our analysis considers two cost factors to measure the potential EO impact of land mine area identification: land mine clearance costs and lives saved during demining operations. The first factor assumes an average cost of removing a land mine of USD 600 and a 10% EO contribution to safer demining operations, which leads to a total impact of USD 2.53 million. The second part of the calculation assumes that EO would decrease the death rate of deminers from 1 death per every 5,000 successfully removed mines, to 1 death for every 6,000 successfully removed mines, which would save 15 lives each year.[111] If this number is multiplied by the statistical value of life in Africa, a monetary savings of **USD 12.9 million** could be achieved. Assuming a 10% EO adoption rate, both factors combined would lead to USD 1.54 million savings in land mine area identification.

Illicit trade of goods

By increasing the efficiency of governmental agencies, EO could contribute to detecting illicitly traded goods and decrease revenues stemming from illegal activity by more than **USD 35.59 million** per year. Assuming a 10 % adoption rate, this would equate to **USD 3.59 million** benefit per year.

Africa remains a key area for illegal trade due to the rampant exchange of unauthorized goods, such as the criminal sale of wildlife, and the lack of law enforcement, which continues to cripple many nations. The presence of high criminal activity can also be attributed to the continent's central location between Asia and Europe. The Mediterranean Sea, the Suez Canal and the Cape of Good Hope provide direct maritime access and fast shipping routes to connect Africa with the rest of the world, such as common trade lanes between Spain and Morocco.

This analysis includes land and sea trade of products that we found to be main sources of illicit activities, such as illegal drugs, vehicles, and wildlife, including the sale of elephant tusks and rhino horns. Due to a lack of data on the rosewood market, expired medication and aloe gum, such products are not included in the impact analysis, although relevant for the African continent. Thus, these goods could be subject to further investigation in follow-up reports.

111 Minesweepers. (2019, March 20). *Facts About Landmines | Landminefree*.

Africa is almost exclusively the only region where elephant tusks and rhino horns are illegally poached. The estimated economic value of ivory and rhino horn seizures amounts to nearly USD 24 million and USD 34 million respectively.[112] Furthermore, the total amount of illicit drugs intercepted through sea operations is estimated to be greater than 17,000 kg in 2020 alone.[113]

EO can help increase the amount of seized illegal goods by allowing regular oversight of remote areas, enabling authorities to detect suspicious trading vessels and monitor cross-border crimes. The European Border and Coast Guard Agency - also known as Frontex - integrated EO tools into its services to achieve the highest level of situational awareness in any given and predefined area, which enabled observation of pre-frontier regions to detect and anticipate suspicious activities.[114]

"EO can help increase the amount of seized illegal goods by allowing regular oversight of remote areas, enabling authorities to detect suspicious trading vessels and monitor cross-border crimes."

By considering an EO impact of 7% on maritime-based confiscations, and 3% on overland seizures, a total revenue of **USD 35.59 million** stemming from criminal activity could potentially be avoided.[115] In general, the ramifications of illegal maritime trade in Africa are higher due to direct shipping routes, resulting in greater frequency in sea trading compared to overland trafficking. Assuming a 10% adoption rate of EO services, illicit trades valuing up to USD 3.6 million could be avoided. This sum is roughly 43% of the investment made by the African Union to the Multi-Donor Action program in 2020 to combat illicit financial flows on the African continent, a project that collaborated with the European Union and the German Federal Ministry of Economic Development and Cooperation.[116]

112 Milliken, T.. (2014). *Illegal Trade in Ivory and Rhino Horn: an Assessment Report to Improve Law Enforcement Under the Wildlife TRAPS Project | TRAFFIC*. USAID and TRAFFIC.
113 UNODC. (2021, January). *Annual Report 2020 | UNODC*. United Nations.
114 European Union, Pwc. (2019, February). *Copernicus Market Report*. Publications Office of the European Union. https://doi.org/10.2873/011961
115 European Union, Pwc. (2019, February). *Copernicus Market Report*. Publications Office of the European Union. https://doi.org/10.2873/011961
116 Africa Renewal. (2021) *Tackling illicit financial flows to secure Africa's future, curb conflict | UN*.

Illegal fishing

Source: *Unsplash*

Within the security industry, EO contribution to detecting illegal fishing activities has a success rate of more than 90%, which leads to cost savings of roughly **USD 909 million**.[117]

117 Booz & Co. (2014, March). *Evaluation of Socio-Economic Impacts from Space Activities in Europe | OP Europa*.

Illegal fishing affects economic and tax revenues by jeopardizing the sustainability of fishing grounds and endangering the jobs of legal fishermen. In the past 20 years, the occurrence of Illegal Unreported Unregulated (IUU) fishing has grown exponentially in West Africa. In some areas, the amount of illegal catch nearly equates to the amount of legally caught fish. Statistics show that every one in four fish on the continent are categorized as unlawful catch.[118]

EO is able to detect coordinates of boats and compare them to registered vessels. This approach helps authorities identify unlicensed ships and reduce the occurrence of illegal fishing. Such technologies also minimize environmental costs attributed to illegal marine activity, such as the destruction of marine ecosystems, trade disruption, drastic fall of fish stocks, and job losses from the collapse of fishing structures.

In 2004, France deployed EO satellite data to monitor an exclusive economic zone in the South Indian Ocean. This led to a reduction of illegal fishing activity in that area by 90% within one year.[119] INSURE, an end-to-end system using visible light and SAR to detect shipping activity in the Ghanaian Exclusive Economic Zone, also integrated the technology to identify both legal and unregistered vessels, as well as other logistical information. With such technology, INSURE was able to obtain results within one hour of ingestion time and results showed a 91% success rate.[120]

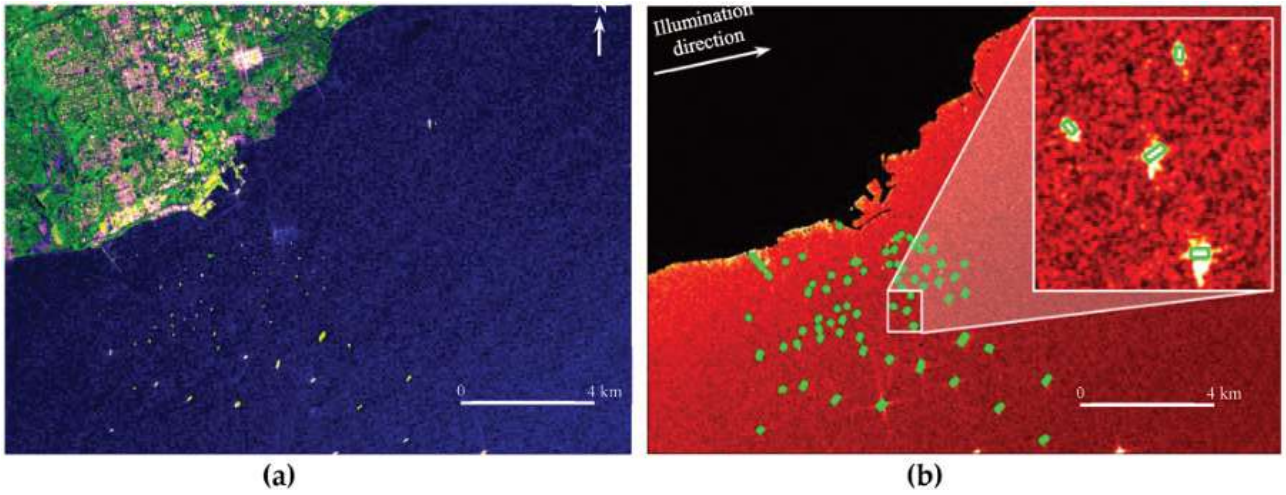
"...France deployed EO satellite data...This led to a reduction of illegal fishing activity in that area by 90% within one year."

Taking into consideration the costs stemming from illegal fishing activities in Africa, juxtaposed with the decrease of these activities neutralized by law enforcement actions, and an assumed 25% EO contribution, the analysis shows an overall cost savings of USD 909 million. The figure represents approximately 15.7% of Africa's total fish export value and 0.7% of the global value of fish trade.[121]

118 FAO, GEF, UNEP. (2020). *Fight against illegal, unreported and unregulated fishing in West Africa* | FAO.
119 Booz & Co. (2014, March). *Evaluation of Socio-Economic Impacts from Space Activities in Europe* | OP Europa.
120 Kurekin, A. A. (2019, February 1). *Operational Monitoring of Illegal Fishing in Ghana through Exploitation of Satellite Earth Observation and AIS Data* | MDPI. MDPI.
121 Interafrican Bureau For Animal Resources. (2019). *Linkages and Inter-connectedness between Cross-border Fish Trade Corridors in Africa* | AU IBAR.

Case Study – INSURE[122]

INSURE is an integrated system that uses visible light and SAR to detect maritime transportation in the Ghanaian Exclusive Economic Zone to disrupt illegal fishing activities, resulting in a 91% success rate.



Automatic vessel detection: (a) vessels at the entrance to Port Tema, Ghana (example Sentinel-1 pseudo-colour scene); (b) automatic vessel detection; (b), inset—estimated vessels dimensions and orientation, https://www.mdpi.com/2072-4292/11/3/293/htm

Illegal fishing threatens wildlife conservation and jeopardizes the equilibrium of the aquatic ecosystem in which communities depend on. The Integrated System for Surveillance of Illegal Unlicensed and Unreported Fishing (INSURE) is an efficient and cost-effective approach to monitor IUU fishing in the Ghanaian waters. INSURE makes use of real-time earth observation data from a synthetic aperture radar instrument on Sentinel-1 and the Multi-Spectral Imager on Sentinel-2, identifying objects that deviate markedly from their direct background using a continuous false alarm rate test. Detections are matched and verified by the Automatic Identification System (AIS) data, which displays the location and dimensions of ships that are legally operating in the region. Matched and unmatched data are then presented on a web portal for application by coastal management authorities in Ghana. The system has a detection success rate of 91% for AIS-registered vessels and is prompt throughout the process, delivering information within two hours of collecting the satellite overpass. Within the 17-month analysis period, 75% of SAR detections have no equivalent in the AIS record, which implies the high level of unregulated marine activity in Ghanaian waters, including vessels potentially involved in IUU. The INSURE system demonstrated its effectiveness in Ghana's Exclusive Economic Zone and can be integrated into other countries within the Gulf of Guinea or other geographical areas that require maritime surveillance.

122 Kurekin, A. A. (2019, February 1). *Operational Monitoring of Illegal Fishing in Ghana through Exploitation of Satellite Earth Observation and AIS Data | MDPI*. MDPI.

Source: *Shutterstock*

FUTURE OUTLOOK: NEXT STEPS

The purpose of this report is to estimate the socio-economic benefits of Earth Observation technologies in six key industries. The research analyzed the potential initiatives and services EO could provide and support, including DE Africa's Data Cube, which has lowered the entry barriers to access EO data. Although such technologies could generate USD 5.4 billion per year if EO services are applied 100%. This calculation does not aim to be an exact figure or a definitive estimation, as there are numerous assumptions considered to reach this result, and many unquantifiable levers due to scarce reliable data points.

Nonetheless, initiating with conservative assumptions that EO images and data would be applied in 10% of cases, **USD 540 million** per year illustrates a considerable amount of savings that could aid Africa to accelerate its socio-economic progress to achieve UN Sustainable Development Goals.

The calculated cost savings demonstrates to every African citizen, entrepreneur and policymaker that satellite services can create and add value for both businesses and societies alike. For example, estimates show that the average cost of the Covid-19 vaccine per person in Africa is approximately USD 16.[123] Such savings of USD 540 million per annum could be redeployed to assist almost 34 million citizens to obtain a vaccine shot or treat 18 million severe cases of malaria (assuming a cost structure of USD 30 per person).[124]

In addition to the visible economic benefit, EO technology and analysis-ready data can boost community and social developments. By introducing this approach to entrepreneurs and policymakers, many processes will increase in efficiency and undergo simplification. This means improved disaster and disease outbreak prevention and heightened environmental protection through fish stock and oil operation observations.

123 Jison Yoo, K., de Francisco Serpa, N., & Gordillo-Tobar, A. (2021, May 11). *Calculating Sub-Saharan Africa's COVID vaccination financing gap | World Bank Blogs*. World Bank Group.

124 National Center for Biotechnology Information. (2017, September 1). *Evaluating the Treatment Costs for Uncomplicated Malaria at a Public Healthcare Facility in Nigeria and the Implications | NCBI*. PubMed Central (PMC).

What are the next steps needed to unlock the potential of such innovations? Based on our analysis, there are **three key steps** that policymakers, researchers and entrepreneurs can take:

- First, public and private sector institutions can increase visibility and awareness of the efficacy of such technologies through training programs, information workshops and other educational means.
- Secondly, more research should be conducted on other industries, supplemented with further studies into the applications that have already been analyzed. This also means leveraging available information on open Data Cubes, such as information found on DE Africa.
- Thirdly, investing in the growth potential of EO and ARD services provides a first mover's advantage to reap the future benefits of this technology.

This report uncovers the untapped potential of EO data and services. The groundbreaking insights demonstrate that African entrepreneurs, policymakers and civil society have the unique opportunity to leverage the technology offered by platforms, such as DE Africa, to drive lasting socio-economic benefits to the continent. The objective is to inspire and encourage further exploration into the possibilities of EO to promote the achievement of UN Sustainable Development Goals towards a thriving and sustainable Africa.

Senegal Coast, Sentinel-2 GeoMAD MNDWI 2020, processed by Digital Earth Africa

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Disal Consulting is a boutique advisory firm specialised in strategy, public policy and impact studies for large corporations, innovative startups, national governments and multilateral organisations. We help people and institutions survive and thrive in the Fourth Industrial Revolution. For more information about methodology and assumptions behind figures as well as about our team and projects please visit www.disalconsulting.com.

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