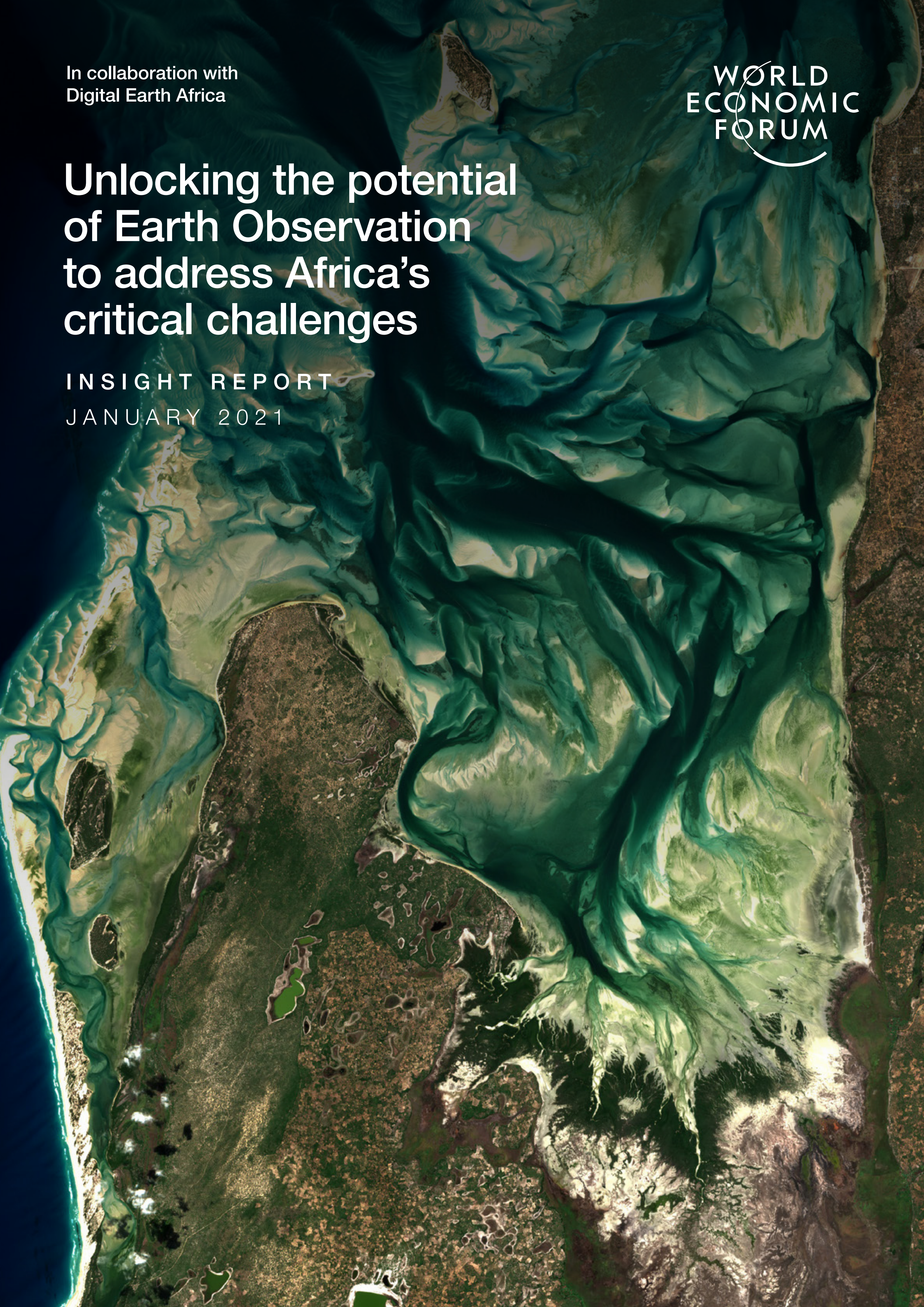
In collaboration with
Digital Earth Africa

WORLD ECONOMIC FORUM

Unlocking the potential of Earth Observation to address Africa's critical challenges

INSIGHT REPORT

JANUARY 2021



Cover: Digital Earth Africa

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Executive summary

Earth observations are fundamental to harness the innovations of the Fourth Industrial Revolution to support the public good.

We often hear that data and information is the 21st century's currency. This is why data democratization is so important, particularly in those countries whose economies suffer from a lack of relevant and available data. Big data is fundamental to building resilient systems, so when barriers to access and usage are removed, its potential for addressing development priorities and critical challenges will be unlocked.

With the global COVID-19 crisis threatening the African economy and livelihood of its citizens, governments and industry leaders, NGOs and CSOs are called on to utilize all the available data to respond, recover and advance hindered efforts towards the achievement of global development priorities. In this perspective, Earth Observation (EO) can be one of the most valuable assets Africa can rely on. EO, in fact, provides vast amounts of satellite data for monitoring and managing the Earth's natural resources, and the human and climate impact on them.

Digital Earth Africa (DE Africa) is an example of how Fourth Industrial Revolution technologies can enable widespread socioeconomic development. It is a continental-scale data infrastructure for all of Africa that democratizes the capacity to process and analyse satellite data. It provides analysis-ready information for more informed, strategic and inclusive decision-making by allowing detailed tracking of water, land, construction and vegetation changes across countries. The insights it offers can be used to tackle a wide range of issues, including water scarcity, land use and food security.

Even under conservative assumptions, the impact of DE Africa for the African industry could be higher than $2 billion a year. This report provides, for the first time, some quantification of DE Africa's potential impact, shining a light on three key areas:

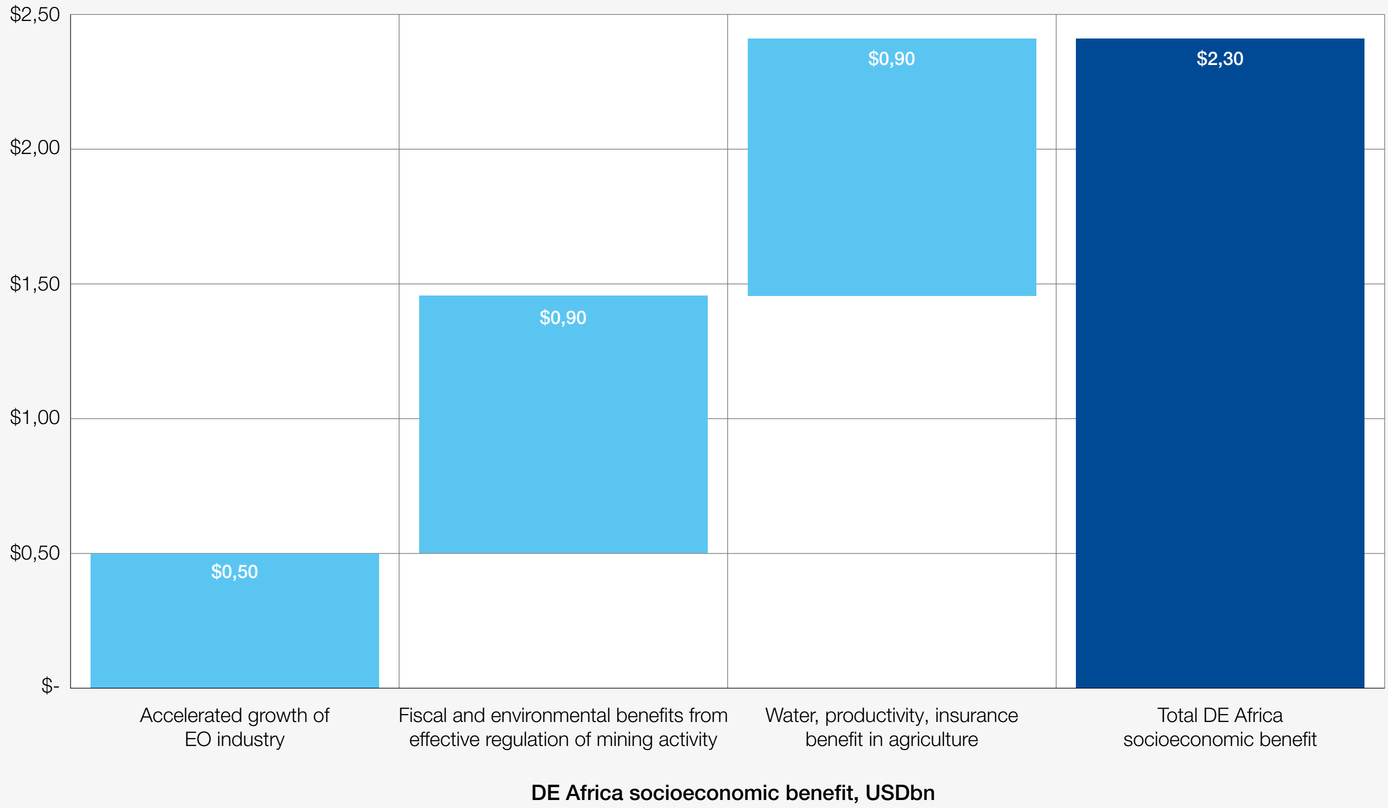
1. Accelerated growth of the EO industry, an extra $500 million of yearly sales with consequent externalities on employment and fiscal revenues

2. Boosting agricultural productivity, with water savings, productivity gains, insurance benefits and reduced pesticide usage in agriculture worth at least an extra $900 million a year

3. Effective regulation of gold mining activity, with savings of at least $900 million from reduced environmental damage and fiscal evasion

To shift the economic estimation to action at scale, the uptake and integration of data analytics practices and analysis-ready EO data into business models and political systems is required. An African-led ecosystem across diverse sectors and perspectives can see sustainable opportunities enabled by geospatial data and services. This requires collaboration and reinforcement with stakeholders. Drawing on existing frameworks and identifying gaps to make improvements will allow this data to be used to address Africa's critical challenges.

FIGURE 1 **Even under conservative assumptions, by 2024 DE Africa socioeconomic benefits could exceed $2bn per year**



Source: Team Analysis

Introduction

Digital Earth Africa translates Earth Observation into accessible data and services to inform strategic decision-making.

Africa is a large continent with a rich and diverse environment, resulting in many challenges such as access to drinking water, rapid urban development, active deforestation and food insecurity. At a time when these challenges are taking their toll on communities, the global COVID-19 crisis threatens the African economy and hinders efforts to achieve global development priorities. The United Nations Economic Commission for Africa (UNECA) reports that economic growth will slow from 3.2% to 1.8%, pushing 27 million people into extreme poverty[1]. Africa's ability to respond and recover connects directly to how well we understand the impacts on natural resources. Earth Observation (EO) data is the cornerstone to this information, and a key transition of the Fourth Industrial Revolution is the change in how we access and use this data to support a quick response to these critical challenges. Through the fusion of technologies, new possibilities for data analytics and visualizations are emerging. However, countries still face challenges of EO data availability, access, quality and usability in delivering its full potential.

Digital Earth Africa (DE Africa) is translating EO data into information and services that will democratize the capacity to use EO for a number of strategic purposes. DE Africa will improve our understanding of the continent's changing landscape, providing much-needed insights and analysis for more informed, strategic and inclusive decision-making. This information will support governments to monitor changes that relate to people and the environment as the COVID-19 crisis evolves, and to build resilience systems to underpin recovery. Furthermore, democratizing EO data will drive growth for Africa's economy by enabling more readily accessible satellite data for innovation and the creation of new products. This presents new opportunities for industry profitability and productivity in many sectors, such as land planning, agriculture and mineral exploration.

Below: Getty Images

1 Optimizing satellite data

Freely available and accessible satellite data is fundamental to addressing development priorities and global goals.

Satellites have taken images of Africa's land surface and coastlines for decades, providing a wide range of insights into land and water resources – from coasts and rivers to soil and crops and their changes over time. The availability of this information has boosted a growing demand by countries across the continent to use the data to address national development priorities and drive progress towards policy frameworks. This includes the Paris Agreement on climate change, the Sendai Framework for Disaster Risk Reduction, the United Nations Sustainable Development Goals (SDGs) and Agenda 2063. Now more than ever, the knowledge gained from EO can help continue the efforts required to achieve these development blueprints in the face of the global pandemic.

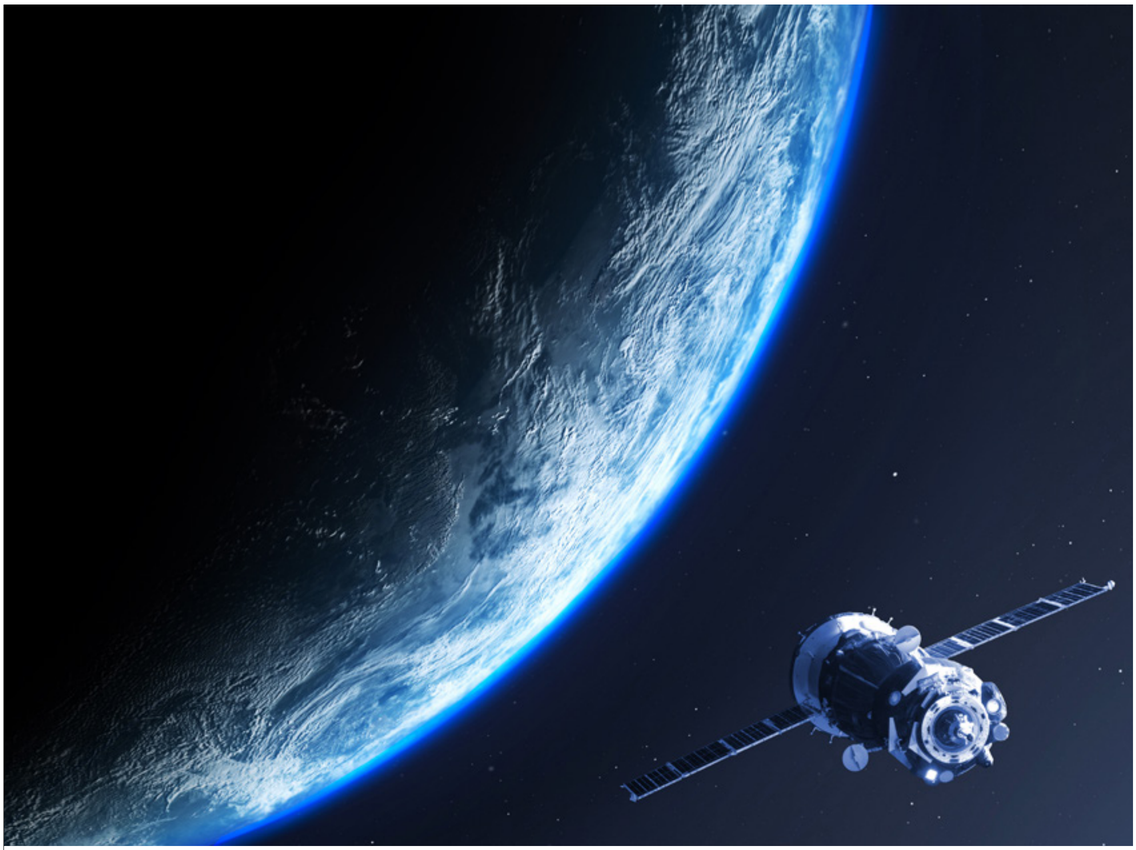
The challenge: Data for development

Satellite images are a rich source of information and freely available, but they are difficult to acquire, scale up, compute and analyse. If EO data was easier to access and use across the continent, countries could overcome a number of challenges in meeting the needs of their growing populations, from managing the environment to developing resources and unleashing agriculture potential. An analysis by Group on Earth Observations and the Committee on Earth Observation Satellites identified the specific SDG targets and indicators that EO can support (see Figure 2).

FIGURE 2

SDG targets and indicators that can be supported by EO[2]

Target: Contribute to progress on the Target, not necessarily the indicator									Goal	Indicator: Direct measure or indirect support to the indicator					
							1.4	1.5	1. No poverty	1.4.2					
						2.3	2.4	2.c	2. Zero hunger	2.4.1					
					3.3	3.4	3.9	3.d	3. Good health & well-being	3.9.1					
									4. Quality education						
								5.a	5. Gender equality	5.a.1					
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6. Clean water & sanitation	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1	
					7.2	7.3	7.a	7.b	7. Affordable & clean energy	7.1.1					
								8.4	8. Decent work & economic growth						
					9.1	9.4	9.5	9.a	9. Industry, innovation & infrastructure	9.1.1	9.4.1				
						10.6	10.7	10.a	10. Reduced inequalities						
	11.2	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11. Sustainable cities and communities	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1	
				12.2	12.4	12.8	12.a	12.b	12. Responsible consumption & production	12.a.1					
					13.1	13.2	13.3	13.b	13. Climate action	13.1.1					
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14. Life below water	14.3.1	14.4.1	14.5.1			
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15. Life on land	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
								16.8	16. Peace, justice & strong institutions						
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17.Partnerships for the goals	17.6.1	17.18.1				

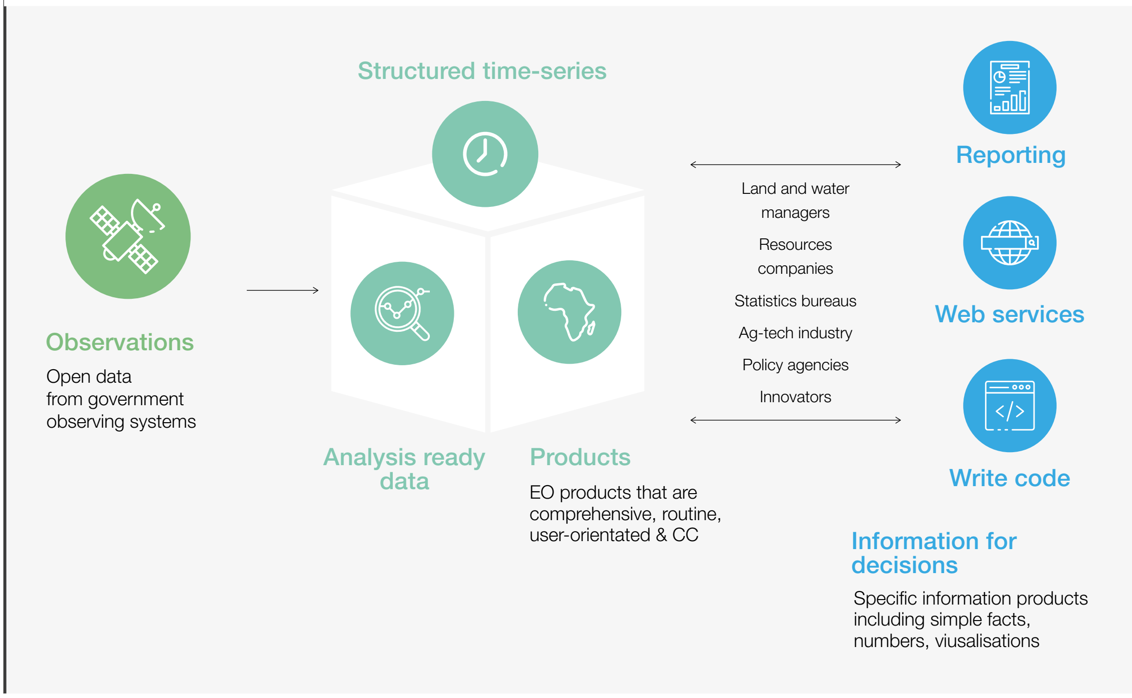


The solution: A data cube for all of Africa

Open-satellite data policies and analysis-ready data, coupled with cloud infrastructure and open-source technology, are creating transformational opportunities. The Open Data Cube (ODC) concept allows for the provision of information at continental scales and encompasses a thriving online community focused on advancing its core capabilities. DE Africa has scaled up ODC technology to the entire African continent to provide a platform where algorithms can be rapidly developed and applied to generate new information, from simple facts to the visualizations of trends. Policy-makers, scientists, the private sector and civil society can all have ready access to EO insights to address social, environmental and economic changes across the continent.

FIGURE 3

Connecting users with observations through a data cube architecture



Source: Digital Earth Africa

Note: In the DE Africa approach, freely available satellite observations are pre-processed to analysis-ready data, thus producing time series of images which can be readily analysed to reveal rich new information products covering the entire continent – such as crop masks or surface water maps. A wide range of users can access these openly available products, bringing new information to bear on key problems, on their own terms

The impact: Building resilience systems

Encompassing a land area over 30 million square kilometres, DE Africa will be the world's largest open data cube to provide insights into a range of issues, which includes flooding, droughts, soils, coastal erosion, agriculture, forests and land use and land change, water availability and quality, and changes to human settlements. In particular, the use of EO within Africa will be directly relevant to SDG 2 (zero hunger), SDG 6 (clean water and sanitation), SDG 9 (industry, innovation and infrastructure), SDG 11 (sustainable cities and communities), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land).

Valuable insights from EO are already aiding COVID-19 response and recovery in Africa by enabling countries to monitor changes that relate to people and the environment. For example, simply identifying water resources provides greater access to where clean water and good hygiene are the absolute minimum required to combat the spread of the virus. Additionally, concerns about food shortages can be addressed through regularly mapping food crops to support decision-making on agricultural development issues. Democratizing EO data through the use of ODC technology ultimately provides government and industry with the tools to build the required systems for managing natural resources on the continent. This will help support Africa's economic recovery post-COVID-19 through the stimulation of the digital economy and acceleration of innovation using DE Africa's free and open products and services.

FIGURE 4

Illustrative application of Earth Observation to specific United Nations Sustainable Development Goals

2. Zero hunger	Farmers can monitor their land vegetation to improve outlooks on crop production, ensure that anticipation of food volumes are accurate and identify potential food shortages early.
6. Clean water and sanitation	Communities can better understand changes of water extent and quality in dams, wetlands, rivers and other water bodies due to floods and droughts to improve water management.
9. Industry, innovation and infrastructure	Companies, small business and entrepreneurs will have access to analysis-ready EO data to develop new applications, many of which are yet to be realized.
11. Sustainable cities and communities	City planners can track the movement of people based on land settlement changes over time to understand where urbanization is occurring.
13. Climate action	Countries can measure and monitor the environment to develop and implement climate action adaption and mitigation plans.
14. Life below water	Communities can monitor water quality and assess the conditions and impact on marine life to improve inshore management.
15. Life on land	Countries can monitor, track and report on forest cover for more sustainable forest management.

Source: Digital Earth Africa.

Below: Getty Images

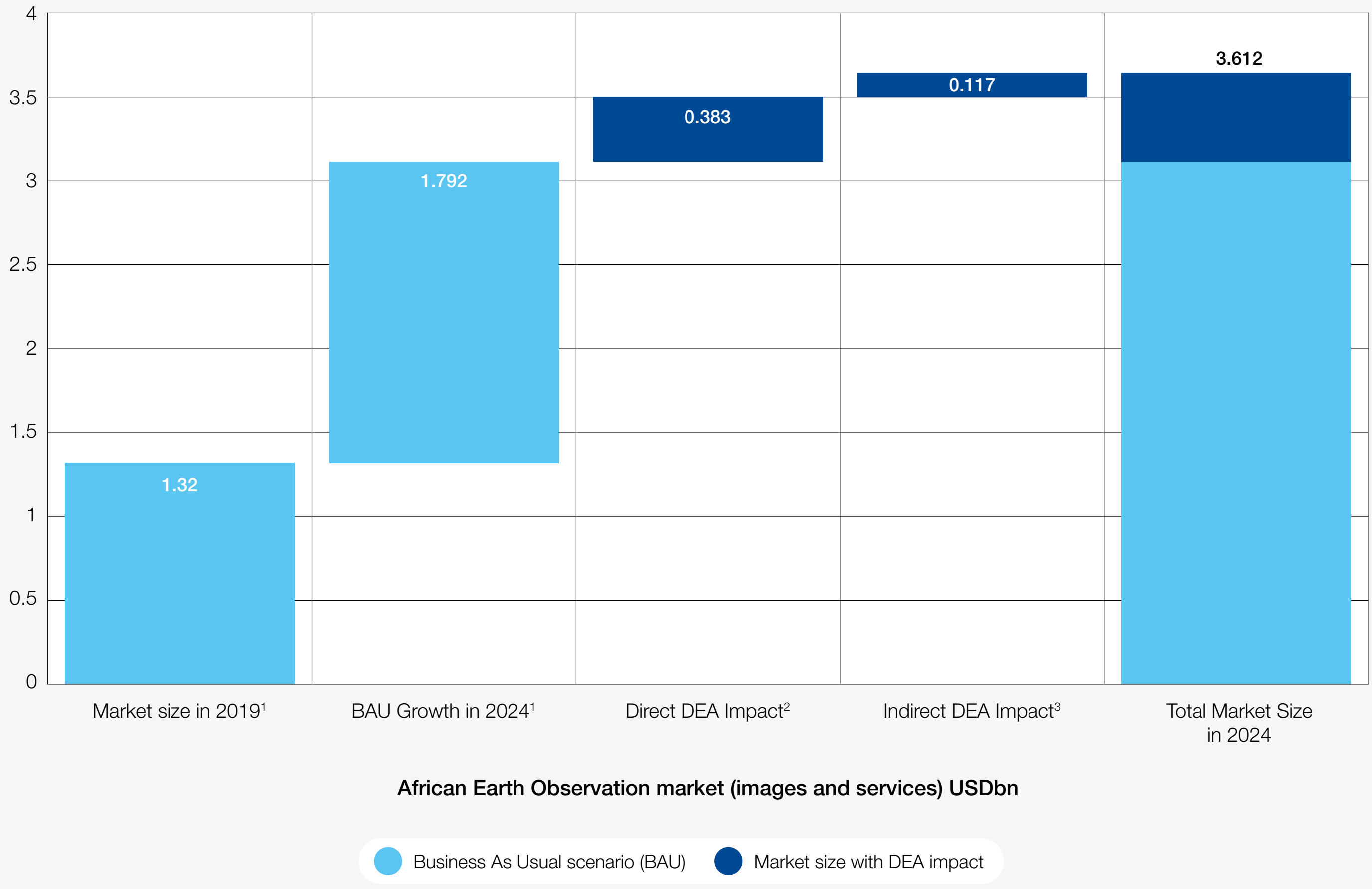
2

Accelerated growth of Africa's Earth Observation industry

Industry growth and capability within Africa is vital to fully realize the benefits of Earth Observation data.

DE Africa is estimated to accelerate the growth of Africa's EO industry by $500 million a year from 2024. This is based on the forecast that Africa's EO industry will increase from $1.32 billion in 2019 to $1.8 billion by 2024. In comparison to a scenario where DE Africa does not exist, it will be directly responsible for an increase of approximately $385 million in yearly revenues of the downstream African EO industry. Furthermore, if Africa adopts the best practices of top-performing countries (see Appendix), by 2024 DE Africa's contribution to Africa's EO industry revenues will increase by an additional $117 million a year.

FIGURE 5 **DE Africa could increase the size of Earth Observation market in the region by $500m**



Notes:

[1] As estimated by Geobuiz – Geospatial Industry Outlook & Readiness Index, 2018 and 2019.

[2] We have observed that there is direct correlation between a Geobuiz index of institutional quality and the size of EO market in several regions of the world; a multivariate regression, controlling for some measures of GDP levels, confirms the significance of this driver; we assume that DEA will raise the quality of African Data Infrastructure (ie, availability of EO images in the region), by halving the distance between Africa and Australia (where a similar project is in full force) by 2024. Details can be found in the Appendix.

[3] On top of improving the quality of Data Infrastructure, we assume that DE Africa could also stimulate African countries to improve other policy-related indicators. As such, we assume that by 2024 Africa will be able to reproduce the best practices adopted in different areas by the top performing countries (as indicated by Geobuiz), in particular: Nigeria for policy framework; South Africa for institutional capacity and industry fabric; Ghana for user adoption level.

The hypothesis that DE Africa will improve image availability, quality and frequency has also led to the key assumption that by 2024 it will halve the gap in the data infrastructure index between Africa and Australia, where the ODC concept was first operationalized. The reduction in Countries Geospatial Readiness Index (CGRI) distance between the two regions is calculated as a round number to avoid a false sense of accuracy, as it is difficult to estimate this effect with precision.

Below: Getty Images

3

Boosting agricultural productivity

The use of Earth Observation across the globe has shown dramatic improvements in agricultural practices and access to water.

Agriculture is the lifeblood of many African economies, employing over 40% of its total working population and accounting for almost one-tenth of gross domestic product (GDP)[3]. Yet, productivity rates are often far from global best practices and local farmers are frequently missing accurate information such as water availability and crop development. Through the provision of EO data products for African agriculture, DE Africa has the potential to generate an impact of up to $1 billion a year. These economic benefits would be generated by exploiting EO technologies in four areas already demonstrated in other parts of the world and applicable to Africa[4].

Water savings

86%
of water withdrawals in Africa are used for agricultural purposes

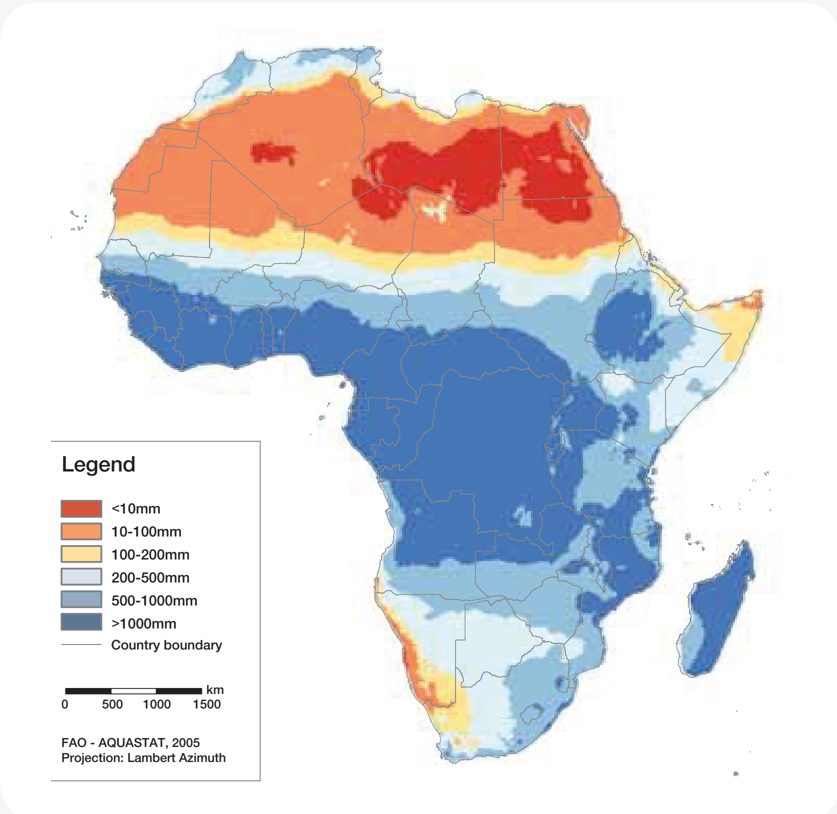
Water is a limited resource in Africa and needs to be managed wisely to ensure a sustainable food supply. Africa's share of global freshwater resources is only 2% less than its share of world population (10% vs 12%), yet rainfall (as shown in the figure below) is unevenly distributed, since 86% of water withdrawals in Africa are used for agricultural purposes and "the share is even higher in the arid and semi-arid part of the continent"[5]. The main consequence is a significant reduction in crop yield.

The primary cause of water waste in the African agricultural business is through evaporation, caused by high temperatures, inefficient storage of water reserves and non-optimal irrigation plans. Satellite imagery can help smooth this problem. In combination with meteorological and spatially explicit training data and hydrological modelling, it can be used to derive information about the past and current state of main crops to make future predictions. Hence, it would improve water procurement and water allocation before and during irrigation, reducing water shortages[6,7].

In Salinas, California, for example, NASA trials demonstrated that satellite images can reduce water used to grow lettuce and broccoli crops by up to 33% relative to standard practice[8]. Even assuming a conservative 20% impact on African cultivations and extending such benefits to all cultivations, the results may be very significant.[9]

By improving irrigation plans and adjusting timing and resource allocation, DE Africa could save 176 billion cubic meters of water a year, equivalent to a $880 million reduction in water abstraction costs[10]. The water savings DE Africa could realize in only one year would be enough to meet eight years' water requirement from African households[11]. If every African farmer could rely on geospatial services, the continent would save over 175 trillion litres of water every year, a quantity which is roughly equal to the dimension of the Turkana Lake in Kenya and Ethiopia.

FIGURE 6 **Average annual precipitation**



Source: New,M., Hulme,M. and Jones, P.D. (1999) Climate Research Unit of the University of East Anglia, UK

Increased crop yields

African farmers are net buyers of food, with $43.64 billion of food imports vs $41.84 billion of food exports in sub-Saharan Africa

African farmers are net buyers of food, with $43.64 billion of food imports vs $41.84 billion of food exports in sub-Saharan Africa[12]. They spend more than 60% of their disposable income on food, highlighting the fact that domestic production is unable to keep up with household requirements.[13]

Due to insufficient production, sub-Saharan African economies spend $30 billion-$50 billion a year to import food. If domestic production does not catch up with domestic food requirements, Africa could spend more than $150 billion on food imports by 2030. Several studies demonstrate that increasing agricultural productivity helps to boost rural incomes and increases food availability. However, the productivity levels of many cultivations and food staples produced in Africa are below international averages. This is due to a lack of knowledge of up-to-date technologies and practices, low use of chemically improved and hybrid seeds[14], as well as inadequate irrigation plans.

EO can be used to improve crop monitoring at field and farm level and could be the basis of accurate models set up to identify and remove factors causing lower yields – for example, sowing too late vis-à-vis current season weather, and making informed decisions of when to irrigate. EO data can also provide a rapid, standardized and objective assessment of the biophysical impact of agricultural practices in terms of vegetation cover, calling for restoration interventions when most needed[15].

EO data in India, for example, was crucial in understanding that the sowing date of wheat should be anticipated by a week, given the change in seasonal weather. This led to an overall yield gain of 5%, higher than the total yield increase in India over the past decade[16]. Satellite data is particularly useful in regions where ground-based measures of sow date are lacking, such as Africa. Optimizing sowing dates, DE Africa can raise yearly wheat production (10% effect) by 136,000 tonnes, bringing a benefit of at least $35 million to the African economy.

Reduced insurance costs

A key hindrance to the insurance industry is information asymmetry, which causes moral hazard[1] and strongly shrinks the growth margins of the sector. Usually, insurers have little information about their insured farmers, no insights in how they run their business and no control of their actions. This results in huge risk borne by providers and is reflected in the high premium they set for farmers. The problem is even more relevant in Africa, where insurance penetration (2% on average) is far below the threshold of developed economies (6%)[17].

Satellite data can improve transparency on agricultural activity and output as it helps assess crop conditions and environmental risks. This enables insurance companies to develop index-based insurance products to compensate farmers for their loss. EO data may also help develop algorithms to assess farmers' creditworthiness, allowing access to necessary resources to improve production. Evidence in Thailand has demonstrated that EO data has been used effectively to benefit the insurance sector where the UK Space Agency estimates a 25% increase in insurance penetration and an average decrease in premia of 10% in the next years[18].

It is estimated that developing sustainable financial products based on increased transparency in Africa will reduce costs and help create new tailor-made solutions, allowing farmers to save $20 million in premiums and expanding the insurance market by at least $25 million. Furthermore, if farmers are properly insured, they can rebuild more effectively if hit by disasters instead of risking the loss of their main source of income.

Reduced pesticide usage

Despite several benefits in agricultural practices, such as productivity improvements and protection of crop yields, pesticides can often have severe consequences for both public health and the environment.[19] Global deaths and cases of chronic disease due to pesticide poisoning amount to 1 million a year.[20]

Through the implementation of best practices and the prevention of the spread of natural diseases, the use of pesticides could be reduced. EO data can play a focal role in setting up development models aimed at monitoring the evolution of diseases and the massive movements of insects. Such models would be crucial in forecasting how much and where these phenomena spread, to focus and limit pesticide intervention instead of resorting to broad, spray-all campaigns.

Evidence from China has demonstrated the use of space-based technology in contributing to the fight against yellow rust, a plague that affects wheat and reduced yield by between 5% and 30% of annual crops. The use of EO alongside meteorological and vertical looking radar (VLR) assisted the Chinese government to reach its goal of a 0% increase in pesticide use by the end of 2020[21].

Below: Getty Images

4 Effective regulation of mining activity

Effective governance of resource extraction captures revenues while protecting the environment and preventing harm to people.

$9bn

Estimated total economic damage from unregulated gold mines

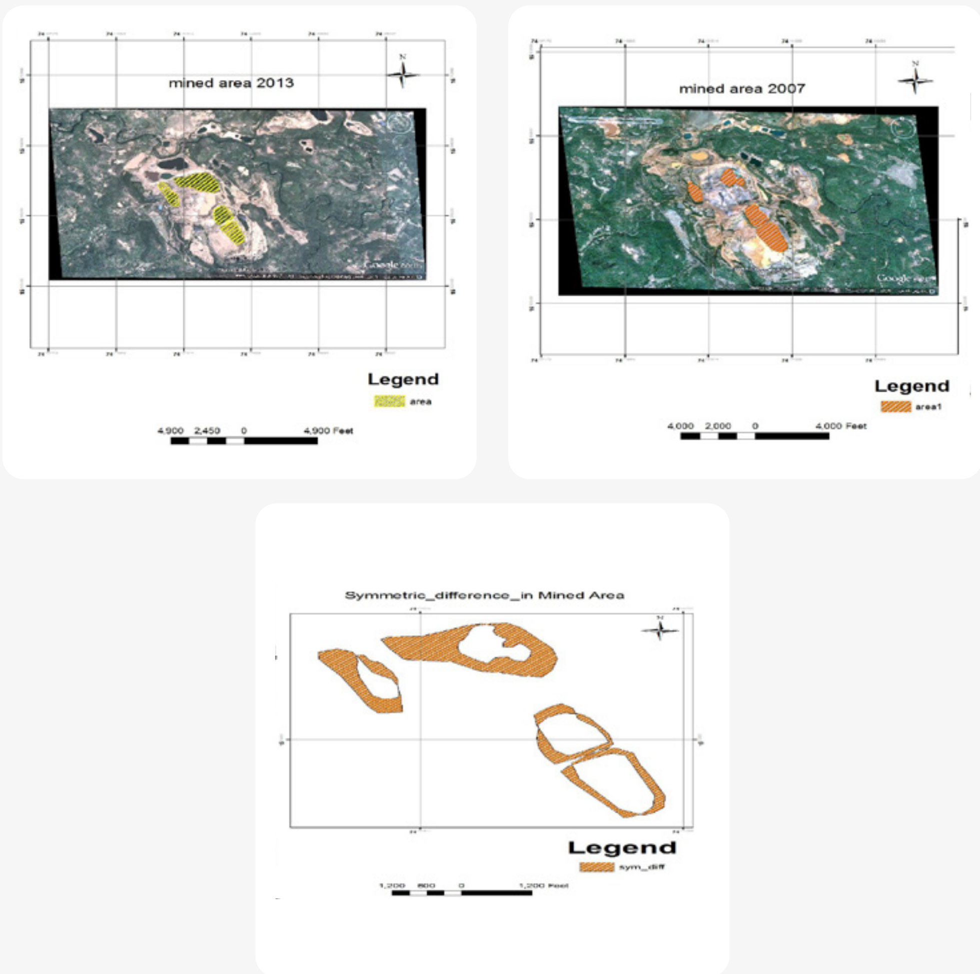
Over one fifth of global gold production takes place in Africa[22]. However, this precious metal is often extracted illegally, causing financial, environmental and health-related damage. The ability to generate a time series using satellite images can provide a much-needed solution to regulate mining activity. In situations of rapid and often unrecorded land use, EO provides meaningful insights into how the landscape is used to monitor and manage natural resources and into environmental changes from the onset of mining[23].

Surface mining operations are typically characterized by the removal of overburden to expose the mineral for extraction. The process of setting up a new gold mine involves the generation of detectable artificial ponds to allow the sedimentation of solids from the water[24]. Finding these ponds can help governments and specialists to identify gold mining sites and monitor the progression of other disturbances caused by complementary activities such as identifying and tracking reclamation sites and assessing land-cover changes. However, simply searching for newly cleared land can produce false positives and give misleading results as people clear lands for agriculture or other general productive purposes. Due to the typical activities necessary to pave the ground for the development of mines, the surface tends to be significantly altered according to patterns, which are clear and easily observable over time. Some examples are river diversions and the building of new roads to access coal seams.[25]

It is estimated that the total economic damage for Africa due to unregulated gold mines is approximately $9 billion a year. This takes into account Ghana and South Africa's gold data, representing one third of the continent's production. The data provided by DE Africa will be available for analysts and specialists to interrogate, representing a huge opportunity for Africa. For example, the NASA Langley Research Center is creating an algorithm for mining regulation in Ghana that can automatically detect changes in geographic features of the landscape that suggest the presence of illegal mines[26]. Even if DE Africa can prevent 10% of unregulated mining, the use of its analysis-ready EO data will result in savings of at least $900 million a year.

FIGURE 7

By analysing the systematic differences of the Earth's surface over time, it is possible to detect the onset of unregulated sites of gold extraction



Source: Research gate.

Increased fiscal revenues

Illegal mines are neither registered nor regulated. Hence, they evade taxes both in paying workers, whose working conditions are unsafe and often alienating, and in trading metals. By their nature, illicit activities are not amenable to accurate statistics. However, based on estimates, more than 14,000 people in South Africa alone are involved in illegal mining activities[27]. These miners enter mostly abandoned wells, digging and threading up to 4km underground, where they spend several days at a time and risk their lives for an income that is not contributing to the growth of their country.

It is easy to appreciate the potential of DE Africa's intervention in such a scenario. Scaling up the empirical evidence from South Africa and Ghana, with a financial loss of $550 million and $2.2 billion respectively from uncollected taxes in 2016 alone, it is estimated that on average $7.6 billion per year of fiscal losses is experienced for the whole African continent[28]. Even if DE Africa could help prevent only 10% of unregulated gold mining activity, the estimated economic benefits in this area exceed $750 million a year.

Safeguarded environmental resources

Mining poses serious and highly specific threats to environmental resources and affects biodiversity. Illegal mines do not comply with minimal environmental requirements and regulations and can have even worse impacts. The direct impacts of mining extraction are seen in chemical emissions of mercury or cyanide used to extract gold, and acids are released from oxidized minerals when some ores are exposed to the air[29], along with physical dust and aerosols. Indirect impacts occur when illegal mining facilitates additional biodiversity loss. For example, mining development can attract human populations, which cause new threats of deforestation and river diversion, and exacerbate pre-existing threats such as over-exploitation from hunting and fishing, invasive species and habitat loss for other land uses.

In 2018 alone, Ghana saw a 1.13% of primary forest loss and 3.7% of farmland destroyed in addition to unquantified losses of water bodies. The Ghanaian government spent $250 million in 2016 to recover lands and water bodies destroyed by unregulated mining just in the previous year. Scaled up to the continental level, the damages from these activities would amount to $1.4 billion a year. If DE Africa can prevent just 10% of that, the result would see benefits of $140 million a year.

“ Mining development can attract human populations, which cause new threats of deforestation and river diversion and exacerbate pre-existing threats

Improved public health

Mining practices in Africa have a detrimental impact on public health and are one of the most harmful occupations in the world. Deleterious effects range from short-term injury to long-term impacts such as cancers and respiratory conditions to loss of life.[30] The drivers include water and air pollution, which dramatically facilitate the spread of diseases. In areas near illegal sites for gold extraction, for instance, there is a much higher incidence of malaria, skin disease and fever with diarrhoea than in areas where mines do not exist.[31]

Water is considered mining's most common victim[32]. Huge amounts of water are used to process minerals and mining waste, and seepage from tailings and waste-rock impoundments are discharged in natural basins. Impacts on water quality can include acid mine drainage, heavy metal contamination and leaching, pollution from chemicals' processing, erosion and sedimentation.[33] Air pollution arises from heavy-duty vehicles on dusty gravel roads, and chemical gases, smoke and fine dust can be generated during ore processing and blasting.[34]

If DE Africa can prevent some illegal mining activity, the benefits for the health of African communities could be significant, improving the quality of livelihood in all the countries. Unfortunately, the lack of reliable data makes it impossible to estimate such benefits at scale but is a target for future research.

Call to action

We must seize this moment to harness the potential of Earth Observation data to make data-driven decisions for more efficient, inclusive and equitable outcomes.

Africa has a unique opportunity to address its critical challenges through the use of DE Africa's data and services. The estimated $2 billion economic value that DE Africa can bring the African EO industry is just the beginning. Removing the barriers to accessing open and free analysis-ready satellite data will have a transformative impact on the continent, and through an African-led ecosystem of governments, private business, international investors and non-government organizations, ongoing investment can be sustained. Dialogue between industry and government can see the geospatial data integrated into business models and translated into political systems. It will enable innovation from local entrepreneurs with a forward-looking perspective and international investors willing to bet on profit-making business opportunities enabled by geospatial data and services.

This report has demonstrated some areas where real impact can be seen from the use of EO products, but it will be the African ecosystem of industry sectors and government institutions that need to drive this change.

If your organization would like to get involved in the adoption of DE Africa data and products, you are encouraged to contact community@digitalearthafrica.org and visit www.digitalearthafrica.org.

Appendix

The numbers used in this report leverage available empirical evidence, adapted to an Africa context under conservative assumptions.

Accelerated growth of Earth Observation industry

A vast array of research agrees that **Earth Observation (EO) is already a multi-billion-dollar industry**. We have chosen GeoBuiz figures since it has the latest estimates, forward-looking predictions and it allows us to select only the segment associated with DE Africa. The GeoBuiz report, in fact, clearly divides the market into industrial segments and provides more updated estimates than those from AlphaBeta and Euroconsult.

TABLE 1 **A vast array of research agrees that Earth Observation is already a multi-billion dollar industry**

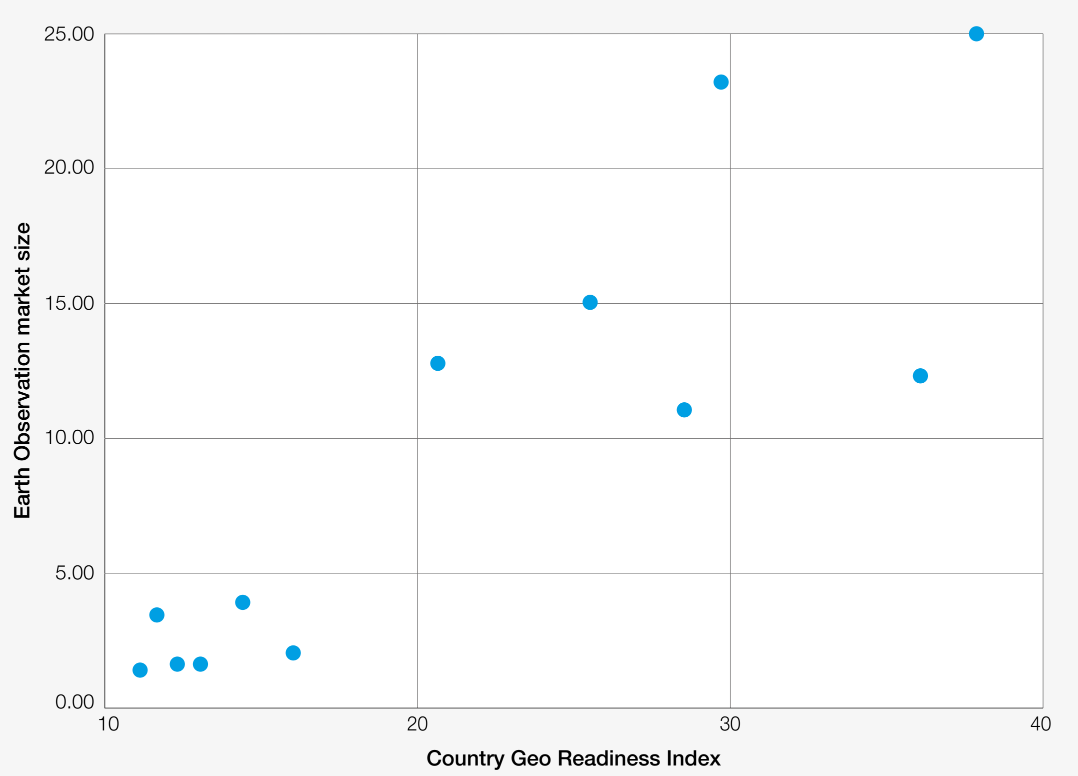
Source	Global EO industry, *USDbn (year)*	African EO industry, *USDbn (year)*	Research scope considerations for our analysis
GeoBuiz – *Geospatial Industry Outlook & Readiness Index*	**66.0** (2019)	**1.91** (2019)	The GeoBuiz report **clearly divides the market** into industrial segments and provides **up to date estimates**.
AlphaBeta – *The economic impact of geospatial services: how consumers, businesses and society benefit from location-based information*	**55.0**[1] (2016)	**2.45**[1] (2016)	The AlphaBeta figures **do not provide a distinction** between EO services and other non-EO technologies and services. Moreover, even within EO industry, they do not distinguish between the revenues coming from satellite manufacturing sector and data elaboration. They will be used as an **upper bound**.
Euroconsult – *Earth Observation: State of play and future prospects*	**4.6** (2017)	**0.138** (2017)	The Euroconsult numbers will serve as a **lower bound** since they take into consideration just commercial data and value added services.

[1]Estimated considering the size of the Human data and Environmental data subsegments, the only two related to the EO industry.

GeoBuiz has also produced a time-series of indices of institutional quality which is directly correlated with the size of the EO industry in several regions. More specifically, the Countries Geospatial Readiness Index (CGRI) is aimed at providing a framework for decision-makers to formulate inclusive geospatial ecosystem strategies. Since 2017, GeoBuiz has assigned a CGRI score to more than 50 countries and world regions.

FIGURE 8

GeoBuiz has also produced a time-series of indices of institutional quality, which is directly correlated with the size of the EO industry in several regions



Source: GeoBuiz - Geospatial Industry Outlook & Readiness Index, 2018 Edition.

This score synthesizes the assessment of several parameters that represent the key areas necessary to develop effective and efficient geospatial capabilities. The score is based on five pillars, whose weights are assigned by GeoBuiz depending on the relative importance of each dataset. They are: data infrastructure (20%); policy framework (10%); institutional capacity (20%); user adoption level (20%); and industry fabric (30%).

FIGURE 9

The CGRI score is based on five pillars, including one on data infrastructure that could be directly influenced by the DE Africa project

1 Data Infrastructure 20%

Topographic and Earth Observation Infrastructure

Positioning infrastructure such as GPS or GLONASS

Platforms and Portals like the Centralized Analytical Platform

Standards (Geospatial Data Quality Standards: ISO 19157)

2 Policy Framework 10%

Geospatial Policies and Enabling Polices

National Geospatial Policy

Open Data Policy

Space, EO, and GNSS Policy

S&T Policy, Innovation Policy

ICT Policy

3 Institutional Capacity 20%

Institution and Courses

Research and Post-Graduate courses

Graduate, Diploma and Certificate courses

4 User Adoption Level 20%

User Adoption at Functional Level

Mapping or Service Level (digital map-based visualization)

Asset Management (asset mapping and management)

Analytics and Workflow Level (location information for process management)

System Integration Level (customized solutions integrating multiple platforms)

Enterprise Level (adoption in all business processes)

5 Industry Fabric 30%

Industry Capacity, Industry Networks, and Venture Creation

Geospatial industry capacity

Geospatial innovation promotion

Geospatial industry networks

Source: GeoBuiz - Geospatial Industry Outlook & Readiness Index, 2018 Edition.

Moreover, a multivariate regression shows that the institutional framework plays a strong role in driving EO, even controlling for GDP levels. Indeed, when controlling for various indicators of GDP measures, the one that works best both in terms of R-squared and coefficient significance is GDP expressed in purchasing power parity PPP terms. This is probably due to the fact that the cost of domestic resources (e.g. salaries) is an important factor in the development of the EO industry.

This conclusion is in line with the fact that, for instance, one of the key competitive factors in the development of the IT industry in emerging markets (e.g. India) is the relatively lower wages of skilled engineers and developers[3]. In our analysis, the coefficient we assign to CGRI is 10%, not 13%. We do it for three reasons: to be conservative; to take into account results of the other regressions (that even without 95% statistical significance confirm our hypothesis); to round up to and avoid a false sense of accuracy.

Geobuiz indicates the top-performing countries using policy-related indicators, in particular: Nigeria for policy framework; South Africa for institutional capacity and industry fabric; and Ghana for user adoption level. Based on the multivariate regression, it is estimated that in the scenario that Africa adopted the best practices of these countries, by 2024 DE Africa's total contribution to Africa's EO industry revenues will raise up to $500 million a year. This also sees significant effects on the creation of well-paid job opportunities for Africa's youth, investment in advanced technology and fiscal revenues for local tax authorities.

FIGURE 10 **Besides having a direct effect on data infrastructure, DE Africa could encourage policy-makers to bring other pillars to current best-practice level**

Policy Framework

Best Practice
NIGERIA[1]

Africa score	Country score
11.61	16.66

Nigeria's Vision 2020 is a document that targets the long-term developmental objectives of the country. The strategy is about encouraging production of tech components, providing incentives for telecommunication services, and establishing a national (spatial) ICT bone Connectivity and Bandwidth Aggregation Solution.

The **National ICT Policy** seeks to create a knowledge-based globally competitive society by 2020. The strategy is aimed at using information and communication technologies for the economic development of the country, ensuring the availability of ICT services and promoting research in the ICT sector.

Institutional Capacity

Best Practice
SOUTH AFRICA

Africa score	Country score
0.14	0.47

Although in many African countries institutional efforts are just beginning, South Africa has **a developed research and educational system** for creating geographic data expertise and a tradition of using this information in administrative and economic contexts.

South Africa has acknowledged that science capacity can contribute to economic competitiveness, and for this reason the **Stellenbosch University** is promoting the use of geographic information in Africa with its satellite launched in 1999 with NASA, the only one in the world built and managed by a university.

User Adoption Level

Best Practice
GHANA

Africa score	Country score
3.53	13.54

The Ghanaian Government recognized that **partnering with the private sector** would ease the provision of the investments needed to promote ICT growth. In 2016, the Lands Commission entrusted **Sinergise** and **Airbus Defence and Space** with the implementation of the Ghana Enterprise Land Information System.

ICT and geospatial information policy promote **economic development through a people-centered, inclusive framework**. Ghana has incorporated geospatial information policy into broader ICT strategy, which is often well funded. This could provide a **firm and broad-base commitment** to its implementation.

Industry Fabric

Best Practice
SOUTH AFRICA

Africa score	Country score
4.60	6.76

Even if still relatively small, the South African space sector is well positioned for **significant growth** in future. Since 2015, the **Research Institute for Innovation and Sustainability** has identified more than 70 innovators and has supported them through partnerships with companies such as **Airbus** and **DigitalGlobe**.

South African National Space Agency's ambition is for South Africa to grow as a global in the next ten years. Mandated in 2008 by the country's government, it is the **primary implementer** of South Africa's National Space Programme to direct the government's investment in space science and technology.

Source: Literature review and press search

[1] Despite South Africa was the top performing country, we included Nigeria in our analysis in order to provide cross-regional best practices.

TABLE 2 **Regression coefficients for EO market size estimation**

Standard errors in parentheses
***** p<0.01, ** p<0.05, * p<0.1**

We have performed a **regression** in order to assess the impact of the CGRI on a country's geospatial market size.

Data: Geobuiz 2017 and 2018 data aggregated at regional level: Africa, Asia Pacific, Europe, Middle East, Latin America and North America;

Dependent variable: region Earth Observation market size;

Main dependent variable: CGRI;

Control variables: GDP; GNP; GDP Expressed in Purchasing Power Parity.

Analysis: panel data regression. Control for region-specific effects.

	EO Market Size	EO Market Size	EO Market Size
CGRI	**0.130***** (0.0185)	0.0887 (0.0639)	0.0866 (0.0636)
GDP (PPP)	**0.000429***** (5.74e-05)		
GDP		0.000823* (0.000330)	
GNP			0.000829* (0.000327)
Constant	**-1.821** (0.904)	-3.022 (3.133)	-3.119 (3.117)
Observations	**12**	12	12
R-squared	**0.989**	0.933	0.934
Number of regions	**6**	6	6

Preferred regression – highest R-squared

Water savings, productivity boosts, insurance benefits and reduced pesticide usage in agriculture

FIGURE 11 **By helping African farmers better plan irrigation and manage water supplies, DE Africa can save 176bn m³/year water, equivalent to $880m savings in abstraction costs**

882
billion m³/year
Total water used for crops in Africa

x

20%
Improvement due to DEA impact

x

0.05
USD per m³
Cost of groundwater abstraction

=

$8.82bn
Potential monetary value of savings in water extraction

Source: Claro Energy for water requirements per kilo of sugarcane (average values) in peak periods. The analysis takes sugarcane values (2250 liters /kg) as a benchmark to scale up to all the other cultures and finally come up with a result at regional level. Computations are based on FAOSTAT conversion table for water needs of different crops in peak periods

Source: NASA trials on lettuce and broccoli states a 33% reduction of water needs. This analysis assumes a more conservative value of 20% to hold for each kind of crop

Source: FAOSTAT, conservative value. Some estimates arrive also at 0.015 dollars per m³

assuming DEA/EO services applied by every African farmer

Assuming 10% adoption of DEA / EO services → **$882m**

Source: Team analysis

This result is obtained conservatively assuming a 10% adoption of DE Africa/EO services. Sugar cane, which has a water intensity of 100% in peak periods, needs 2,250 litres per kg and is used as starting point of this analysis[35]. Then, based on FAOSTAT conversion tables, it was possible to scale up groundwater requirements for all crop production in Africa, according to some specific FAO coefficient (see the table below for more detailed information)[36].

TABLE 3 **Close-up on water savings**

	Potential water savings, (assuming 100% DEA application) *billion m³/year*	**Total potential economic benefit,** (assuming 100% DEA application) *$ million/year*	**Water savings** (10% application), *billion m³/year*	**Economic benefit** (10% application), *$ million/year*
Sugarcane, paddy rice, banana 2,250 litres per kg	67	$3,400	6.7	$340
Wheat, tobacco, soybean, sorghum, potatoes, peas, millet, lentils, tomato, cotton, flax, maize, beans 90% conversion coefficient for water needs 2,025 litres per kg	95	$4,800	9.5	$480
Carrots, crucifers (broccoli, cauliflowers), lettuce, melons, onion, peppers, spinach, tea, cocoa, coffee 80% conversion coefficient for water needs 1,800 litres per kg	9.5	$473	0.95	$47
Cucumber, marishes, squash 70% conversion coefficient for water needs 1,575 litres per kg	1.4	$71	0.14	$7
Citrus, olives, grapes 60% conversion coefficient for water needs 1,350 litres per kg	3.7	$185	0.37	$18
Total	**~176**	**~$8,800**	**~17.6**	**~$880**

FIGURE 12 | **By helping wheat farmers optimize sowing dates, Digital Earth Africa can raise production by 136k tonnes, equivalent to $35m**

27.2
million tonnes
Total wheat production in Africa

Source: FAOSTAT, 2017 data

x

5%
Improvement due to DE Africa impact

Source: Lobell et al. (2013)

x

263
USD per tonnes
Economic value of wheat ton

Source: FAOSTAT, 2017 data (derived from economic value and quantity of production)

=

$350m
Potential economic value of increase in wheat production

assuming DEA/EO services applied by every African farmer

Assuming 10% adoption of DE Africa / EO services → **$35m**

Source: Team Analysis

FIGURE 13 | **By helping develop more sustainable products based on transparency, DEA will decrease premia paid by farmers by $20m and expand market size by $25m**

200
USD million
Agricultural premium volume

Source: The World Bank

x

10%
Decrease in premia (DEA impact)

Source: UK Space Agency

x

1.25
Increase in mkt size for higher penetration

Source: UK Space Agency

=

$25m
Total economic benefit

assuming DEA/EO services applied by every African farmer

Source: Team Analysis

FIGURE 14 **Ghana and South Africa gold production data has been used to scale up and approximate at $9bn for the damage figure per region**

Country	Evidence at country level *millions*	Country Share of African gold production	Scale up at regional level *billions*
Ghana Fiscal damage	$2200	~18%	~$12.1
Ghana Environmental damage	$250		~$1.4
South Africa Fiscal damage	$550	~18%	~$3

Total damage of illegal gold mining in Africa = **~$9bn** *per year*

~$7.6bn in fiscal damages *(average of Ghana and SA scale-up)*

~$1.4bn in environmental damages *(Ghana scale-up)*

Health damages at regional level

Source: Team Analysis

Contributors/Acknowledgements

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Lead authors

Nicolò Andreula
Founder and Managing Director, Disal Consulting

Tessa Robinson
Program Communication Officer, Digital Earth Africa

Eniola Mafe
Lead 2030Vision Technology and Sustainable Development, World Economic Forum

Other contributors

Mario De Pinto
Associate, Disal Consulting

Luciano Di Loreto
Management Engineering Graduate, Politecnico di Milano

Margherita Serena Ferrara
Economics and Social Sciences Graduate, Bocconi University

We are also grateful to Digital Earth Africa Governing Board and Technical Advisory Committee (TAC) and specialist contributors:

Adam Lewis
Managing Director, Digital Earth Africa

Aditya Agrawal
Senior Advisor, Digital Earth Africa and Founder, D4DInsights

Anne Marie Engtoft Larsen
Former Lead, World Economic Forum

Elise Kanza
Head of the Regional Agenda, Africa; Member of the Executive Committee, World Economic Forum

Lisa Hall
Director, Digital Earth Africa

Nicholas Davis
Professor of Practice, Thunderbird School of Global Management and Visiting Professor in Cybersecurity, UCL Department of Science, Technology, Engineering and Public Policy

Nikolai Khlystov
Community Lead, Aerospace Industry; Co-Lead, Global Future Council on Space Technologies, World Economic Forum

Philip Thigo
Senior Adviser, Data, Innovation and Open Government, Office of the Deputy President of Kenya

Trevor Dhu
Co-chair, Digital Earth Africa Technical Advisory Committee

Steven Ramage
Head of External Relations at Group on Earth Observations (GEO)

Endnotes

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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744
contact@weforum.org
www.weforum.org