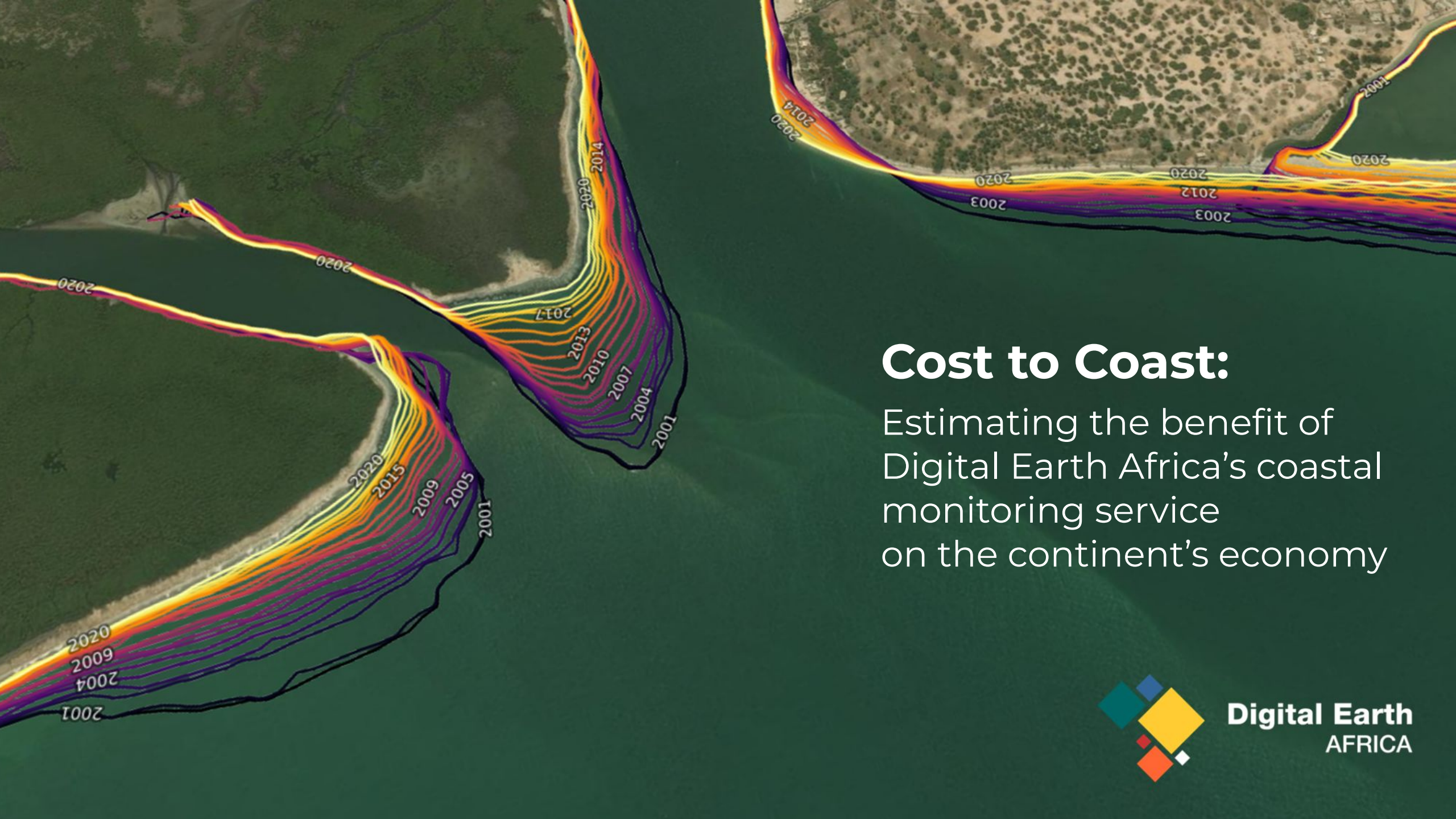


Cost to Coast:

Estimating the benefit of Digital Earth Africa's coastal monitoring service on the continent's economy

Digital Earth AFRICA

By mitigating coastal erosion risks in 3 key sectors, DE Africa could inject ~$600 mln per year into Africa's economy and change the lives of ~270 mln people

	Adverse effects of coastal erosion	DE Africa risk mitigation activities
Real Estate & Agriculture	• Degradation of **near-shore assets** • **People's relocation** away from the coasts Loss of **lives** due to water contamination & floods	• **Shoreline changes** assessment • Forecast and monitoring of **sea level** with integrated systems •Evaluation of **maritime security hazards**
Fishery	• **Housing losses** and resettlement • **Infrastructural problems** • **Vicious circle danger** related to measures to combat coastal erosion • **Aquaculture complications** (e.g. environment/ecosystem degradation)	• Supervision of **coastal water quality** • **Species niche habitat distribution** mapping • Forecast of **algal blooms** and monitoring of **water depth**, **winds** and **waves** • **Mangroves mapping**
Insurance	• Insufficient information about insurable risks lead to **inaccurate and generally high pricing** of insurance products • Landowners' willingness to pay is lower, and the price is reasonable only for high-risk parcels, thus causing **market failure**	• Risk modelling enhancement • Reduction of the **time spent to estimate losses** • Better monitoring of **insurers' risk portfolios** • **Support to clients** to facilitate more informed decisions about their assets

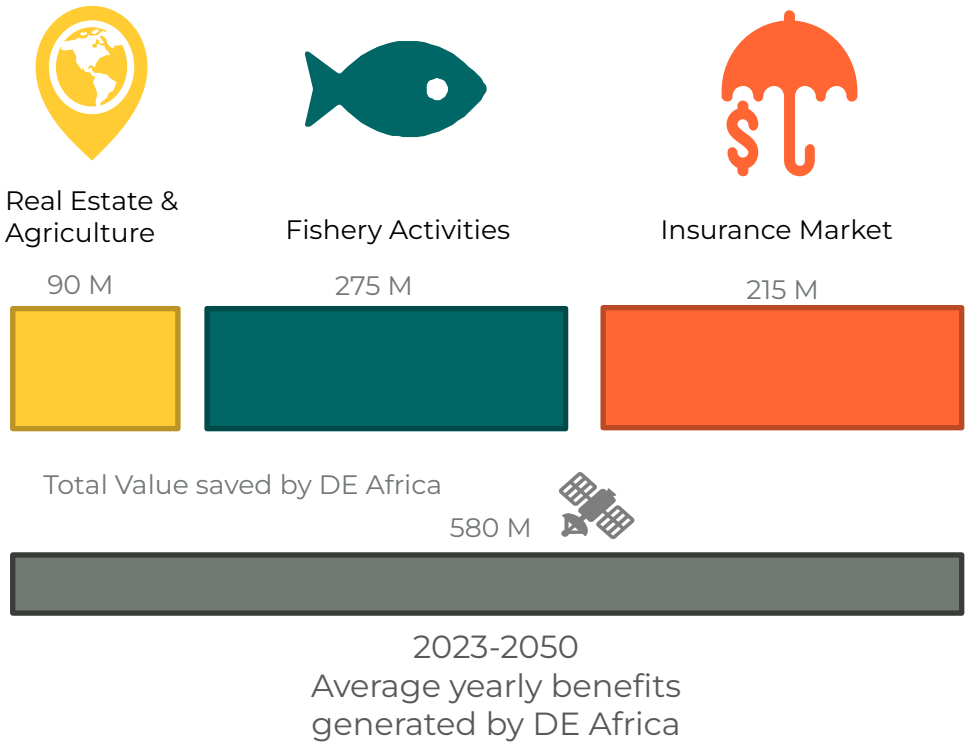
By mitigating coastal erosion risks in 3 key sectors, DE Africa could inject ~$600 mln per year into Africa's economy and change the lives of ~270 mln people

	Adverse effects of coastal erosion	DE Africa risk mitigation activities
Real Estate & Agriculture	• **$90 million** of asset value (land & buildings) per year	• DE Africa has the potential to positively affect **270 million people** who live in the proximity of coasts
Fishery	•**$144 million reduction in marine fish catches lost per year** by 2050 •**$131 million of salaries for indirect jobs** per year *(direct ones not included to avoid double-counting)*	•~**10,000 direct jobs** per year •~**20,000 indirect jobs** per year
Insurance	•**$54 million in insurance companies' profits** per year •**$56 million of salaries for direct jobs** per year •**$105 million of salaries for indirect jobs** per year	•Over **4,500 new direct jobs** •~**9,000 indirect jobs**

Executive Summary (1/3)

Introduction

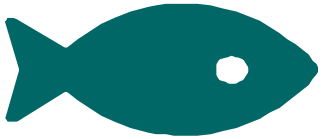
- Coasts serve as major **socio-economic hubs** for most African countries, and their importance is increasing with **population growth**.
- Coastal erosion hazards are threatening many areas of the continent.
    - In West Africa, for example, countries such as **Ivory Coast**, **Senegal** and **Togo** are experiencing an **average erosion rate of 1.8 meters per year**, whilst in **Benin,** 65% of coasts are suffering a **decline of about 4 meters per year**.
    - In East Africa, **Mozambique**'s average erosion rate lies between **0.4 and 1 meter per year.**
    - In the **Maghreb** (Northern Africa), the average rate of erosion is **1.58 meters per year**.
- Digital Earth Africa (DE Africa) services have the potential to **help policymakers identify coastal erosion hazards**.
- According to our analysis, **DE Africa can help Africa save $580 million per year with positive effects on around 270 million people** in three key sectors:
    - **Real Estate & Agriculture**;
    - **Fishery**;
    - **Insurance**.
- Due to insufficient data available to effectively estimate tangible socio-economic on the **Tourism sector**, the last section of this presentation includes a case study which provides a **foundational overview** on the **implications of coastal erosion** on this specific sector.



Executive Summary (2/3)

Real Estate & Agriculture

- The **rate of coastal erosion** represents a **pressing threat** for African real estate & agriculture and is putting these sectors at risk in many regions.
- Such a phenomenon has a **severe impact on African land** with estimated **losses of $7 billion per year**.
- DE Africa services can **save $90 million of asset value (land & buildings) per year**. Earth observation technologies can be implemented in procedures such as:
    - **Shoreline changes** assessment;
    - Examination of **total water level changes** on the coast;
    - Forecast and monitoring of **sea level** with integrated systems;
    - Evaluation **of maritime security hazards**.



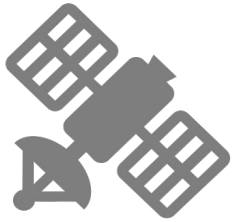
Fishery

- The fishing industry serves as a **critical source of income** and nutrition for millions of Africans.
- Coastal erosion has shown **dramatic consequences** for the livelihood of **fish population**, **marine ecosystems** and **local communities**, and negatively impacts a wide spectrum of **fishery-related areas** – e.g. aquaculture complications and infrastructural problems.
- By supervising coastal water quality, mapping distribution of fish, and **monitoring water depth, winds and waves**, DE Africa could **alleviate the loss of marine fish catches by $144 million per year** by 2050.
- Assuming that the amount of jobs lost across the industry is proportional to that of fish catches, DE Africa could also help save around **10,000 direct jobs per year** over the same period and over **20,000 indirect ones – amounting to an extra $131 million of yearly salaries for the latter** (direct ones not included to avoid double-counting).

Executive Summary (3/3)

Insurance

- Africa's non-life **insurance penetration rate is 1.8%**, about **half of the global average set at 3.3%.** This opens up **opportunities for market expansion**.
- Providing decision-makers with actionable information has the potential to **increase the efficiency of the insurance industry and create economic value**, as data availability is key to **avoid market failures**.
- By helping insurance companies calculate premiums more effectively and assess claims linked to damages caused by coastal erosion, DE Africa can generate **$54 million per year in additional profits** for the insurance sector.
- The **additional revenues** estimated at industry level could also lead to the creation of over **4,500 new direct jobs** and **around 9,000 indirect ones** in Africa, resulting in **$56 million** and **$105 million** in salaries, respectively.



Tourism

- Tourism in Africa secures **millions in jobs and revenues**, but it has lately **shrunk by more than 12%** due to COVID-19 pandemic.
- **Coastal erosion limits tourism income** and **reduces investments in infrastructures** connected to this industry.
- Across several African regions, the current and projected rate of erosion is resulting in **losses of revenues** and a **decreasing propensity to invest in tourist infrastructures**. It is therefore essential to assess how Earth observation technologies could help mitigate such effect.
- Due to insufficient data available, **tangible benefits of DE Africa on this area remain still to be defined**. Future research will be key to improve models with more accurate information and assumptions.

This document serves as a preliminary study which opens avenues for further research and welcomes future contributors to enrich models with additional data points and proofs of concept.

Introduction

Digital Earth
AFRICA

Coasts serve as major socio-economic hubs for most African countries

The importance of Africa's coastal areas is increasing with population growth

Globally, coastal regions represent **20%** of Earth's total surface.[1] They are also home and workplace for around **40% of the world's population** (3 billion people).[2]

Among the 54 African states, **38 are coastal**. This emphasises the importance of seaside settlements, especially taking into account that **half of the 15 African megacities** (with over 10 million inhabitants) expected to sprout in the continent by 2050 arise in near-shore areas.[3]

As African population is predicted to double in the next 30 years, reaching **2.5 billion people** on the whole continent, the health and efficiency of near-shore regions would be increasingly fundamental to sustain **socio-economic practices** within coastal zones.[4]

Coasts are major contributors to Africa's economic output

Coastal areas are critical for the development of a growing number of economic activities. For instance, the African **blue economy** – which comprises of all economic practices related to oceans, seas and coasts – is seen as a catalyst for growth and **is expected to be worth $405 billion and employ more than 57 million people by 2030**.[5]

Considering the importance of near-shore regions for both their social and economic benefits, coastal erosion implications could become an ever-increasing burden threatening to jeopardise Africa's socio-economic progress.

[1] Hegazy, I.R., *Towards sustainable urbanization of coastal cities: The case of Al-Arish City, Egypt*, Ain Shams Engineering Journal, 2021.
[2] *Kneller, S., Coastal Zones, Home to Forty percent of World Population, Medium, 2020.*
[3] *Africa's megacities a magnet for investors*, Africa Renewal, 2019.
[4] *Africa's population will double by 2050, The Economist, 2020.*
[5] *Ocean Decade: Blue economy presents vast opportunities for Africa, Africa Renewal, 2022.*

DE Africa services have the potential to help policymakers identify coastal erosion hazards

Digital Earth AFRICA

The advantages of using satellite images data over more traditional earth observation methods are prominent

Coastal erosion is a natural phenomenon which occurs due to the combination of the energy produced by waves, ocean and wind currents. However, an increase in **human activities**, a **decrease in sediment**, and the **implications of climate change** can accelerate the degree and exacerbate the consequent harmful effects of coastal erosion. Limiting the effects of coastal erosion, such as the loss of settlements and related maritime-oriented jobs, heavily depends on **prevention**. In order to understand future coastline changes stakeholders may use a combination of technologies and techniques which are often prohibitively expensive and therefore not always suitable options for simple and easily accessible monitoring activities.[1]

To track the rate of coastal erosion (or accretion) across the African continent in a more reliable, efficient and convenient way, **Digital Earth Africa has developed services that take advantage of available Landsat technology** – which is provided free of charge, therefore is more accessible than conventional methods such as field surveys, aerial photography, and LIDAR.[2]

DE Africa provides analysis-ready data (ARD) that can improve stakeholders' decision-making capabilities.[3]

DE Africa's new **Coastlines service** uses Landsat-extracted images with coverage of the entire content and provides practical functionality that can be used to inform African decision-makers to intervene promptly in the case of coastline change. The service provides:[4]

- Millions of kilometers of **satellite-derived annual shorelines** of approximately zero meters above main sea level;
- Millions of **change points across coastal Africa** (every 30 meters);

Coastal Change Hotspots.

[1] *Land Degradation and Coastal Erosion*, Digital Earth Africa.

[2] Sane, N.F., *Monitoring coastal erosion at Saly Portudal resort, Mbour-Senegal*, Digital Earth Africa, 2022.

[3] Andreula N., et al., *Broader perspectives on Digital Earth Africa*, Digital Earth Africa, 2020

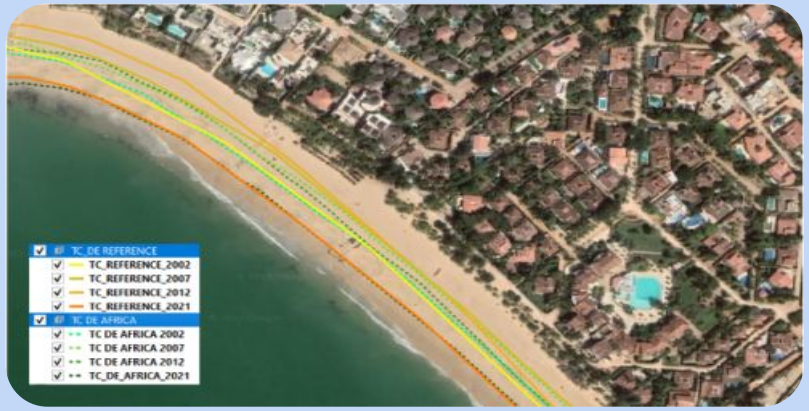
[4] Digital Earth Africa – preliminary information for stakeholders

[5] Sane, N.F., *Monitoring coastal erosion at Saly Portudal resort, Mbour-Senegal*, Images source Digital Earth Africa, 2022.

DE Africa technology has been used to monitor Senegal's Saly Portudal Resort shoreline [5]

In the Saly Portudal resort's coastal area, the impact of the receding shoreline has forced **hotels to close** and caused **beaches to disappear**. Breakwaters have been placed to combat the adverse consequences of erosion, helping key industries such as tourism and fishing to resume in the area. The CSE team used **DE Africa services** to assess the state of coastal retreat finding an underlying erosion rate of **3 meters per year** on the southern part of the seaside resort.

Thanks to DE Africa Coastlines, it was possible to detect that **coastal accretion** occurred in other areas that have benefited from improved protection, breakwaters installations, and beach replenishment.



DE Africa can help Africa save ~$600 million per year in three key sectors [1]

The present study aims to quantify the benefits generated by DE Africa when considering **coastal erosion implications** on the African economy. The analysis focuses on **three sectors***:

1. **Real Estate & Agriculture**
2. **Fishery**
3. **Insurance**

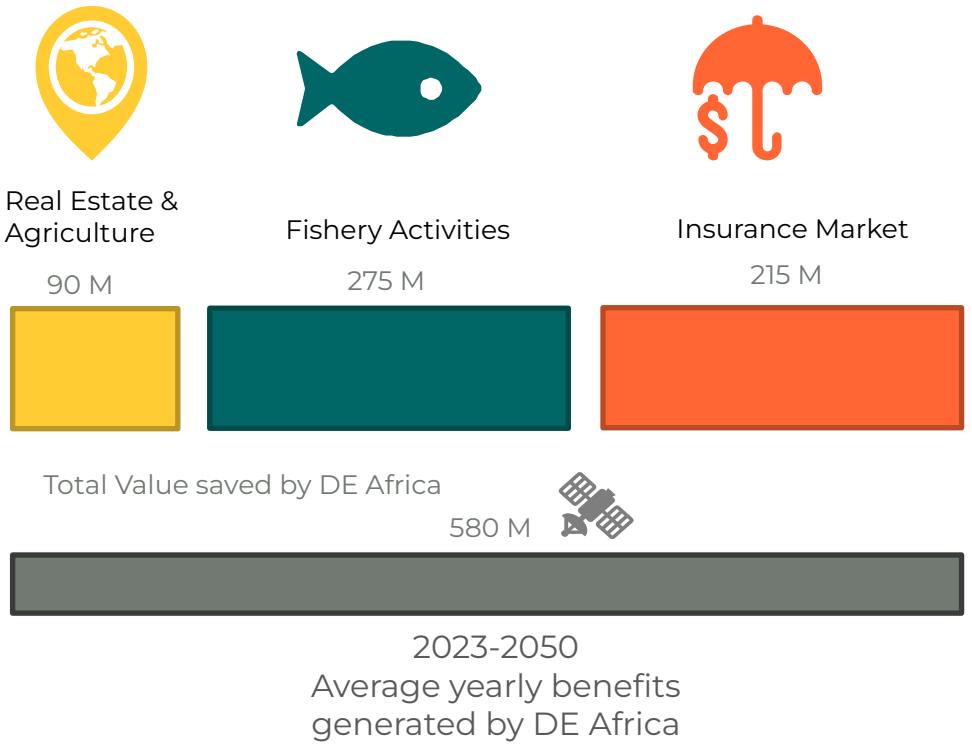
Our estimations reveal a total potential socio-economic benefit of **$580 million per year** within the African continent, with positive effects for around **270 million people**.

In addition to the areas listed above, extensive research on the African tourism sector has also been made. Due to insufficient data available, tangible benefits of DE Africa on this area remain undefined. The dedicated section includes a case study which provides a foundational overview of the implications of coastal erosion on this specific sector.

This presentation serves as a **preliminary study** which opens avenues for further research and welcomes future contributors to enrich models with additional data points and proofs of concept.

**The three sectors* were *selected* based on two factors:
(i) Expert inputs and desktop research on the magnitude of Earth observations' impact on Africa's economies and societies in such areas;
(ii) Data availability, which remains a critical issue when conducting research in many African countries.

Average yearly benefits generated by Digital Earth Africa



[1] Team analysis.

Real Estate & Agriculture

Sentinel-1 2020 shows Tunis, Tunisia

Digital Earth
AFRICA

The rate of coastal erosion represents a pressing threat for African real estate & agriculture

The real estate market is expected to grow significantly in the coming years; agriculture remains one of the driving sectors of the African economy

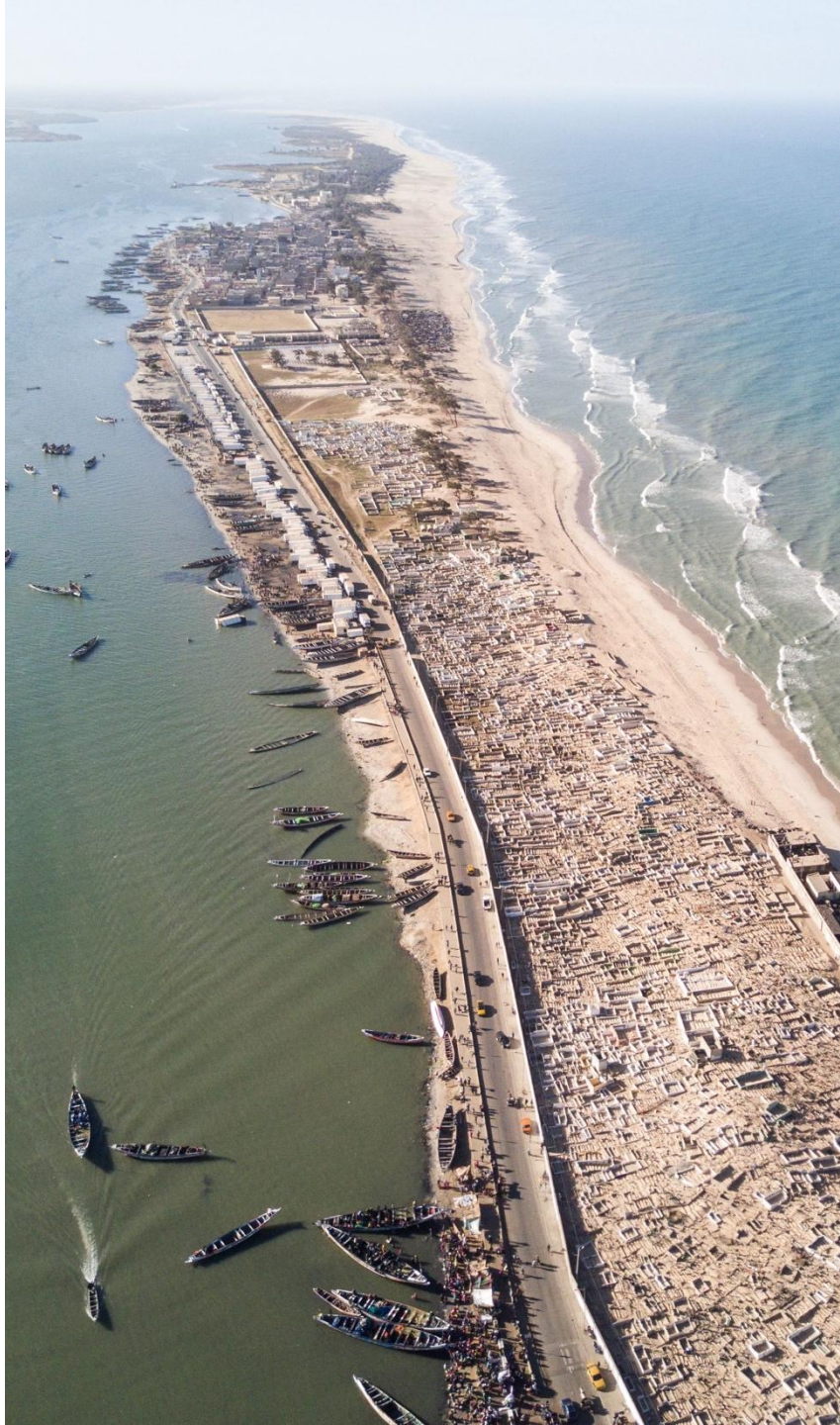
Real estate is a vector of growth in a context of demographic expansion.[1] Thus, with an estimated **population expected to double over the next 30 years**, the **housing market in Africa is anticipated to surge significantly**.[2] In Ghana, for instance, the real estate contribution to GDP **increased by 39%** from 2013 to 2020 highlighting the positive growth trend of the sector.[3]

On the other hand, agriculture is one of the leading industries in Africa, employing almost half of the continent total labour force and contributing to roughly **15% of its total GDP**.[4]

The current rate of erosion is putting the real estate and agriculture sectors at risk in many regions

The development of real estate and agriculture is seriously jeopardized by the implications of coastal erosion hazards which are threatening many areas of the continent. In West Africa, for example, countries such as **Ivory Coast**, **Senegal** and **Togo** are experiencing an **average erosion rate of 1.8 meters per year**. Coastal retreat is quite severe in **Benin**, where 65% of coasts are suffering a **decline of about 4 meters per year**.[5]

Coastal erosion can also be witnessed in other areas of the continent. For instance, in **Mozambique** (East Africa) the average erosion rate lies between **0.4 and 1 meter** per year [6]. The northern part of the continent is also threatened with data showing that in the **Maghreb** the average rate of erosion is **1.58 meters per year**.[7]



[1] *Africa's Population Boom: Will It Mean Disaster or Economic and Human Development Gains?*, World Bank, 2015.
[2] *Real Estate in Africa and its growth prospects*, Amri, 2021.
[3] Sasu, D.D., *Contribution of real estate to GDP in Ghana from 2013 to 2020*, Statista, 2021.
[4] *Agriculture in Sub-Saharan Africa: Prospects and challenges for the next decade*, OECD, 2016
[5] Croioru, L., Miranda, J.J., Sarraf, M., *The Cost of Coastal Zone Degradation in West Africa: Benin, Cote d'Ivoire, Senegal, and Togo*, World Bank, 2019
[6] Palalane, J., et al., Coastal Erosion in Mozambique: Governing Processes and Remedial Measures, BioOne, 2016.
[7] Heger, M.P., Vashold, L., *Disappearing coasts in the Maghreb: Coastal erosion and its costs*, World Bank, 2021

Coastal erosion has a severe impact on African land, with estimated losses of $7 billion per year [1]

Digital Earth AFRICA

The costs of land loss in Africa are a severe burden to its economies

For instance, in 2017 Benin, Ivory Coast, Senegal, and Togo alone lost **$3.8 billion** – corresponding to **5.3% of the four countries' GDP** – due to the severe implications of coastal erosion, flooding and pollution [2]. The adverse consequences of such a phenomenon affect also the **Maghreb region**, which faces significant costs related to the loss of near-shore assets (*see Figure 1*).

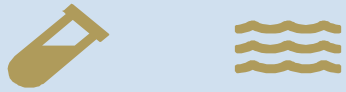
Erosion affects the lives of millions of Africans

As entire villages and towns are destroyed across the continent, people are losing homes and livelihoods (*see Figure 2*). In fact, coastal erosion forces them to **retreat** further away from the shore or **relocate to entirely new areas** [5].

The true cost of land loss[4]

In West African countries, such as Benin, Ivory Coast, Senegal and Togo, **coastal degradation causes over 13,000 deaths a year**

The main reasons are:



Water contamination

Floods

Figure 2

In Africa, such a phenomenon has the potential to affect around **270 million people** who live in the proximity of coasts [6]. **West Africa** is one of the most heavily impacted regions, with some areas encountering erosion rates of **23-30 meters per year**. The effects of coastal erosion on people could be even more menacing in this region, considering that **31% of its total population** and **51% of its urban population** lives in near-shore areas.[7]

Annual asset destruction cost (as share of GDP) due to coastal erosion in the Maghreb region[3]

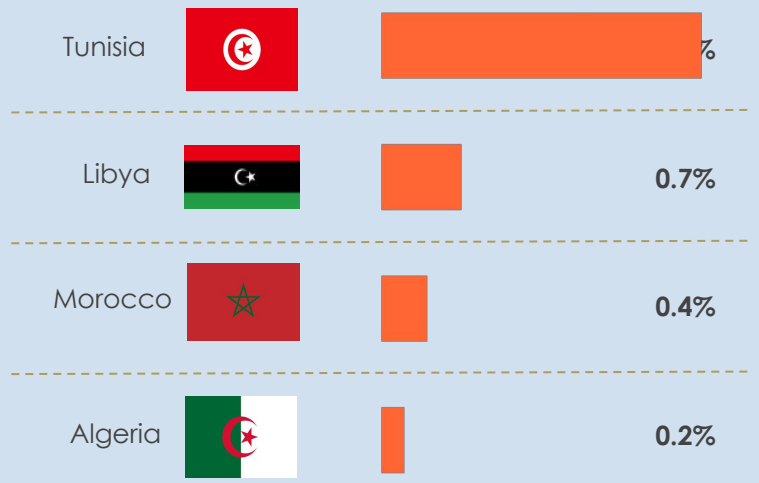


Figure 1

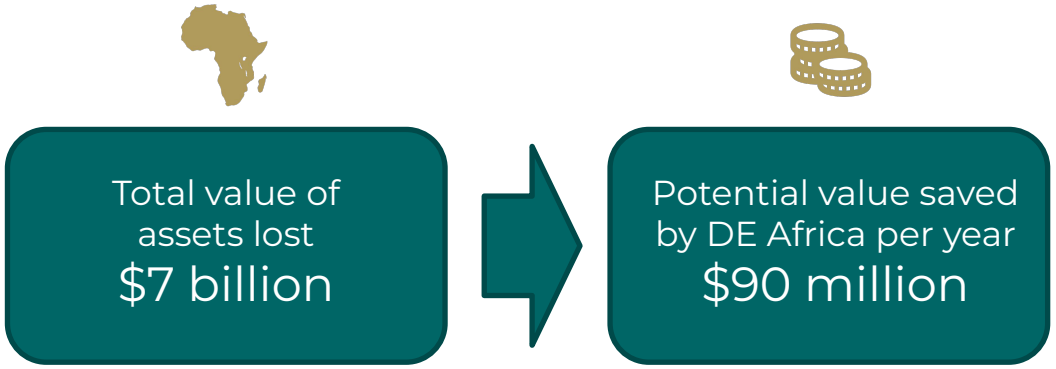
[1] Team analysis
[2] Croioru, L., Miranda, J.J., Sarraf, M., *The Cost of Coastal Zone Degradation in West Africa: Benin, Cote d'Ivoire, Senegal, and Togo*, World Bank, 2019.
[3] Heger, M.P., Vashold, L., *Disappearing coasts in the Maghreb: Coastal erosion and its costs*, World Bank, 2021.
[4] *West Africa's Coast: Losing Over $3.8 Billion a Year to Erosion, Flooding and Pollution*, World Bank, 2019.
[5] Heger, M.P., Vashold, L., *Disappearing coasts in the Maghreb: Coastal erosion and its costs*, World Bank, 2021
[6] Team analysis
[7] Kennedy-Walker, R., et al., *Living on the edge: Saving West Africa's coastal assets*, World Bank, 2015.

DE Africa can provide actionable information to save $90 million of asset value (land & buildings) per year

DE Africa services can help African countries monitor and assess coastline movement

Using **DE Africa services and data** is helpful to inform intervention in Africa's degraded coastal zones and monitor potential coastal areas at risk of retraction. More specifically, Earth observation technologies can be implemented in procedures such as[1]:

- **Shoreline changes** assessment;
- Forecast and monitoring of **sea level** with integrated systems;
- Evaluation of **maritime security hazards**.



Team Analysis

[1] Melet, A., et al., *Earth Observations for Monitoring Marine Coastal Hazards and Their Drivers*, 2020.

Visualising coastal erosion: The case of the Fuveme village[1,2]

Squeezed between the Keta lagoon and the Gulf of Guinea, in Ghana's Volta region, the **Fuveme village** has been drastically affected by the **severe consequences of coastal erosion** over the past years.

On November 5, 2021, the intensity of tidal waves hit the shore of the Volta region, reportedly leaving thousands of homes submerged and residents homeless, forcing many families to move inland. The magnitude of coastal change in Fuveme seems to worsen as the village has already been **transformed into an island** and will soon become **uninhabitable**.

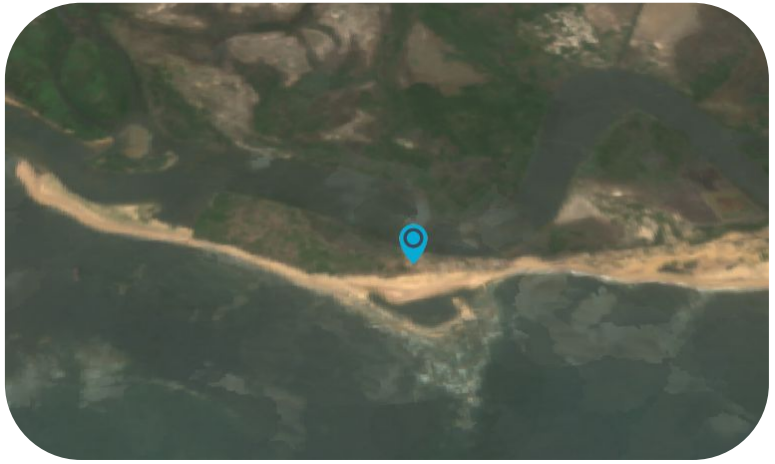
These consequences could have been largely anticipated. For example, the **Fuveme RC Basic School**, destroyed by coastal erosion in 2016 and subsequently rebuilt, faced the **second destruction** due to the impact of tidal waves shortly after.

The Ghanaian government has tackled the adverse consequences of coastal erosion in the region by **implementing breakwaters** and **seawalls**. The local communities saw positive effects as many coastal communities benefited from the increased protection. Yet, the 2.8km Atorkor sea defense project left some parts of the coastline **unprotected and exposed** to the adverse consequences of coastal erosion and high tides.

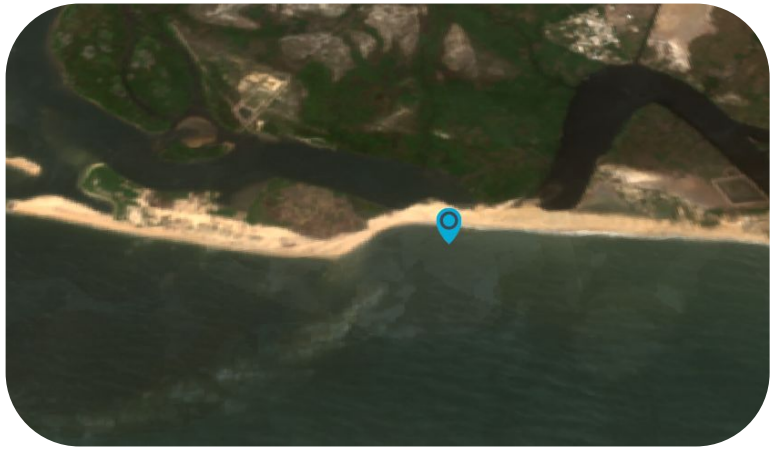
DE Africa services can be crucial in monitoring the coastal change in areas of Africa with little to no protection, **informing policymakers and local governments on how and where to intervene promptly**, thus limiting catastrophic consequences like the ones experienced in the Fuveme village. The **DE Africa interactive map** – as shown in the pictures on the right – makes it is possible to visualise the **change in coastal morphology and magnitude of shoreline retraction** in Fuveme over time.[3]

[1] Bokpe, S., J., *Fuveme: Before and after the destructive tidal waves*, The Fourth Estate, 2021
[2] Schwikowski, M., *Climate change drowning West African coastline*, DW, 2022.
[3] Digital Earth Africa Map

Digital Earth AFRICA



Fuveme village in January 2017



Fuveme village in January 2022

Fishery

Digital Earth
AFRICA

The fishing industry serves as a critical source of income and nutrition for millions of Africans

Fish as a source of life and revenue

Fish is an **important source of food and nutrition for over 400 million Africans**, providing 22% of overall protein intake in Sub-Saharan Africa while exceeding 50% in the poorest countries (e.g. 62% in the Gambia and 63% in Sierra Leone).[1]

The fishing industry is crucial for many African economies, as it **employs over 12 million people** and contributes to **1.26% of the continent's GDP**.[2,3]

More specifically, when it comes to coastal ecosystems, the African fishing sector comprises two kinds of players – **industrial fisheries** and **small-scale fishers**.[4]

The value of this industry is probably significantly underestimated, since **unreported and unregulated fishing activities are potentially equivalent to 40-65% of the reported legal ones** in West Africa – thus implying that more people than what is officially stated rely on this sector as a source of income.[5]

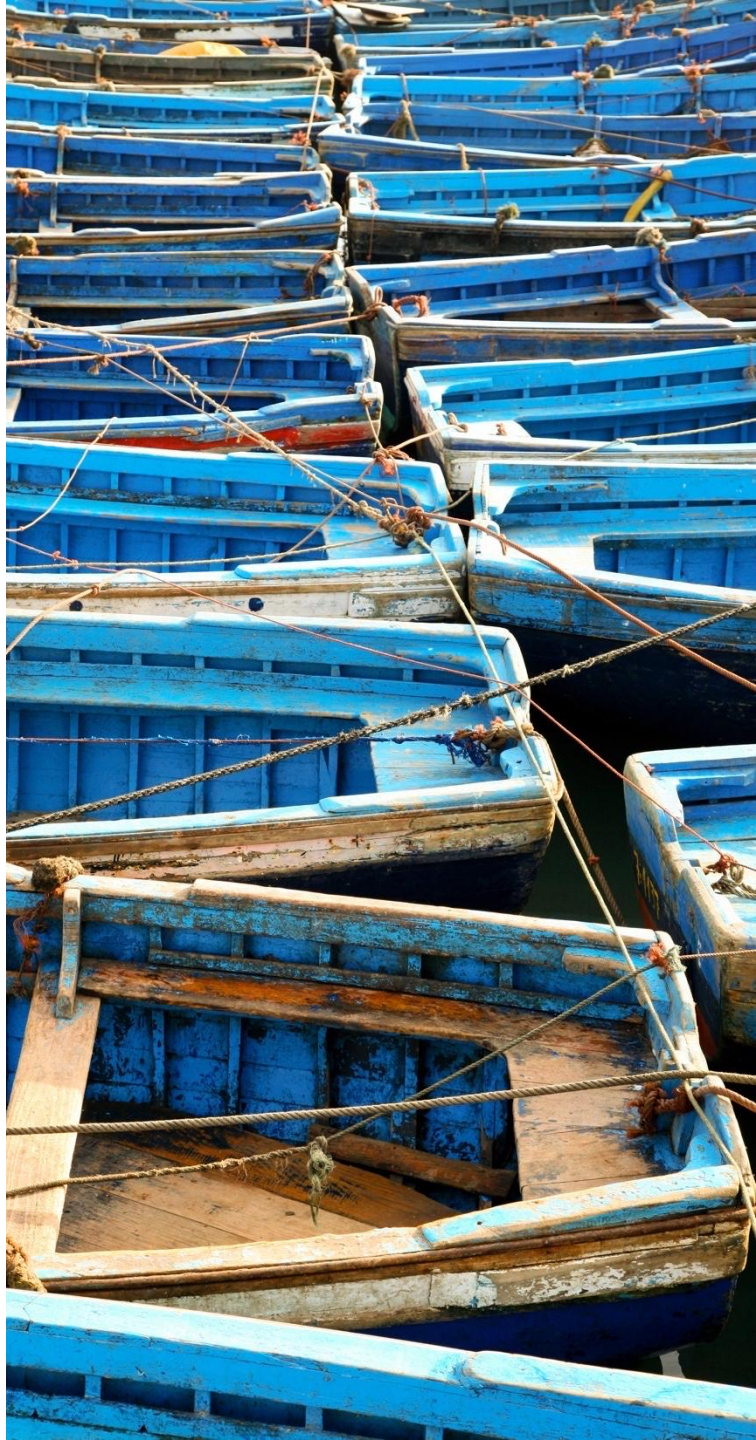
Number of additional jobs created for every fisherman's job[6]

Mauritania 1.04

Guinea 3.15

When talking about the fishing industry, the **employment multiplier effects** are remarkable in many African economies, demonstrating the prospect of the fishing industry value chain

[1] Johnny, M.K., Espoir, K.H. and Paul, C.M., *Determination of the Protein Content of Smoked Fish Sold in the Markets of the Town of Mbuji-Mayi (Democratic Republic of the Congo)*, 2020.
[2] De Graaf, G., Garibaldi, L., *The Value of African Fisheries, Food and Agriculture Organization*, 2014.
[3] Hamady, D., et al., *African Fisheries and Aquaculture in The Macro Economy*, African Union Development Agency, 2016.
[4] Hamady, D., et al., *African Fisheries and Aquaculture in The Macro Economy*, African Union Development Agency, 2016.
[5] Doverty, P.D., et all., *Threats of illegal, unregulated, and unreported fishing to biodiversity and food security in the Republic of the Congo*, 2021.
[6] Lovei, M., *Climate Impacts on African Fisheries: The Imperative to Understand and Act*, 2017.



Coastal erosion has shown dramatic consequences for the livelihood of fish population, marine ecosystems and local communities

Digital Earth AFRICA

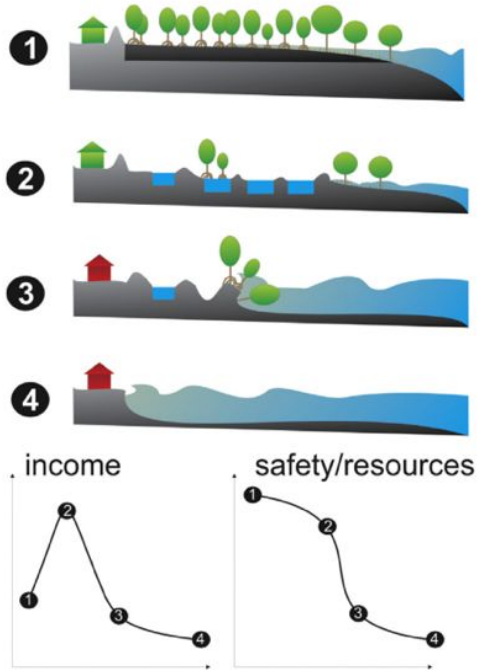
Coastal erosion can impact a wide spectrum of fishery-related areas

The fishing industry significantly relies on coastal areas as **95% of all commercially important fish species depend on coastal habitats** and fish density is much higher near the shore than on the high seas.[1] The problems related to the impact of coastal erosion on fishery activities can be witnessed extensively in **four main areas**:

- **Housing losses and resettlement:** adverse effects of coastal erosion cause local fishing communities to either **retreat** further away from the coast or **relocate** to an entirely new area. [2]
- **Infrastructural problems:** coastal erosion, sea level rise, and flooding have a detrimental effect **on fishing infrastructures** (e.g. harbours and coastal markets)and **post-harvest infrastructures** (e.g. docks and storage facilities).[3]
- **Vicious circle danger:** measures to combat coastal erosion could hinder fishing activities. For instance, the construction of **dykes** prevents fisherman from bringing their nets on shore.[4]
- **Aquaculture complications:** large scale mangrove cutting amid **intensive aquaculture practices** sets off cascading effects which further contribute to coastline erosion. The consequences include:
    - Rise in **salinity levels**, which jeopardise the efficiency of previously installed aquaculture practices.
    - Loss of the **nursery functions** of mangroves, causing fish stocks to further decline.
    - Increase in water **turbidity levels**, which lead to a loss of biodiversity connected to damaging of coral reefs and seagrasses.

Once aquaculture practices are no longer commercially viable, local communities are left behind in a **ruined landscape** (*see figure*) and are often forced to revert to **small-scale offshore fishery activities**.[5]

Impact of aquaculture on coasts[6]



Development of income, flood safety and resources for communities along mud-mangrove coasts**1.** Natural mangrove forest with small fishing or agricultural communities **2.** Large-scale mangrove cutting and intensive aquaculture **3.** Reduction of pond yield and start of coastal erosion **4.** Large-scale coastal erosion and increasing salinity intrusion.

[1] *Fisheries, Mapping Ocean Wealth.*
[2] Barman B., *Effects of coastal Erosion on the fishing community livelihoods: a Focus on the East Midnapore coast*, West Bengal; India.
[3] Monnereau, I., Oxenford, A.A., *Impacts of Climate Change on Fisheries in the Coastal and Marine Environments of Caribbean Small Island Developing States (SIDS)*, Commonwealth Marine Economies Programme, 2017.
[4] *Coastal erosion threatens the existence of small-scale fishing communities*, Agri, 2020.
[5] Van Wesenbeeck, B.K., et al., *Aquaculture induced erosion of tropical coastlines throws coastal communities back into poverty*, Ocean & Coastal Management, 2015.
[6] Van Wesenbeeck, B.K., et al., *Aquaculture induced erosion of tropical coastlines throws coastal communities back into poverty*, Ocean & Coastal Management, 2015.

By alleviating the loss of fish catches, DE Africa could generate potential benefits of $275 million per year

Satellite imagery helps mitigate the devastating consequences of coastal erosion

It is estimated that **total fish catches will decrease by 26% in West Africa by 2050**, with peaks of 53% in Nigeria and 60% in Ghana.[1] Such a decline in fish availability would negatively affect millions of people that rely on this industry.

The DE Africa team estimates that their monitoring services could **reduce the impact of coastal erosion on marine fish catches by 10%** by:

- Supervising **coastal water quality** [2]
- Mapping **distribution of species niche habitat** [3]
- Forecasting **algal blooms** and monitoring **water depth, winds and waves** [4]
- **Mangroves mapping**.

Digital Earth Africa can therefore potentially **decrease the loss of marine fish catches by $144 million per year by 2050**. Assuming that the amount of jobs lost across the industry is proportional to that of fish catches, DE Africa could also help save around **10,000 direct jobs** and over **20,000 indirect ones per year** over the same period **– amounting to an extra $131 million of yearly salaries for the latter** (direct ones not included to avoid double-counting).[5]

Yearly contribution to Africa's GDP of fish catches in marine waters
$40.7 billion

Potential average value saved by DE Africa per year
$144 million
(2023-2050 average)

Indirect salaries saved potentially save due to DE Africa
$131 million
(by 2050)

[1] *Living on the frontline: Climate change will first impact African coastal fishing communities*, Coalition for Fair Fisheries Arrangements, 2022.
[2] Politi, E., et al., *Earth observation applications for coastal sustainability: potential and challenges for implementation*, Anthropocene Coasts, 2019.
[3] Politi, E., et al., *Earth observation applications for coastal sustainability: potential and challenges for implementation*, Anthropocene Coasts, 2019
[4] Earth Observation for Marine and Maritime Applications, Cloudeo.
[5] Team analysis

From orbit to the ocean: the importance of safeguarding mangrove ecosystems & how Earth observation can help

Mangrove forests refer to a group of trees and shrubs located in the coastal intertidal zone.[1] Their dense roots help to bind and build soils, slow down water flows, and therefore reduce coastal erosion.[2]

In Bangladesh a study on the *Sonnoretia Apetala* – a species of mangrove tree – found that the mangroves decrease the rise in seawater levels by **4-16.5 centimetres** and water inflow speed by **29-92%**.[3]

As a result, mangroves are fundamental in **sustaining coastal sites**, and their contribution is critical in areas such as:

- **Flood effects:** globally, mangrove forests protect people and real estate from flooding. To understand their positive impact consider that if today's mangroves were lost, the annual property damage **would increase by 16%** – equivalent to **$82 billion**. A study conducted in the Philippines indicated that without these forests, the **yearly flood impact on people and properties** would increase by **~25%** – with negative consequences on some of the most socially vulnerable communities of the archipelagic country.[4]
- **Marine ecosystems:** mangrove forests serve as **nursery grounds** for most aquatic organisms and coastal fisheries. It has been estimated that these salt-tolerant trees produce **11% of marine organic matter**, which may contribute to aquatic food webs and fish production.[5]

Although the importance of such ecosystems and their positive impact on coastal sites are widely recognised, around **6.6% of mangrove forests were lost** worldwide between 1996 and 2016.[6]

Thanks to Earth observation technologies, DE Africa services can help many African economies **identify the causes of mangrove reduction and track restoration progress** effectively by providing policy and decision-makers with remote sensing data and tools.[7] The effectiveness of such practices has already been proved – for instance – in **Sierra Leone**, where Landsat data was found to be **95% more accurate** than pre-existing information in analysing coastal mangrove evolution.[8]

[1] *What is a mangrove forest?*, National Ocean Service
[2] *Mangroves for coastal defence guidelines for coastal managers & policy makers*, Wetlands International and The Nature Conservancy, 2014.
[3] Mangroves and coastal protection: A potential triple-win for Bangladesh, World Bank, 2020
[4] Brck, M.W., et al., *The miracle of mangroves for coastal protection in numbers*, World Bank, 2018

[5] De Silva, W., et al., *Potential Use of Mangroves for Coastal Protection: A Case Study from Sri Lanka, 2021*
[6] *How satellites save mangroves from space*, ESA, 2021
[7] *How satellites save mangroves from space*, ESA, 2021
[8] *Facilitating Mangrove Restoration through Technology*, WA BiCC, 2018.

Insurance

Sentinel-1 2020 shows Tunis, Tunisia

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Africa's non-life insurance penetration rate is 1.8%, about half of the global average set at 3.3% [1]. This opens up opportunities for market expansion

The insurance market landscape in Africa

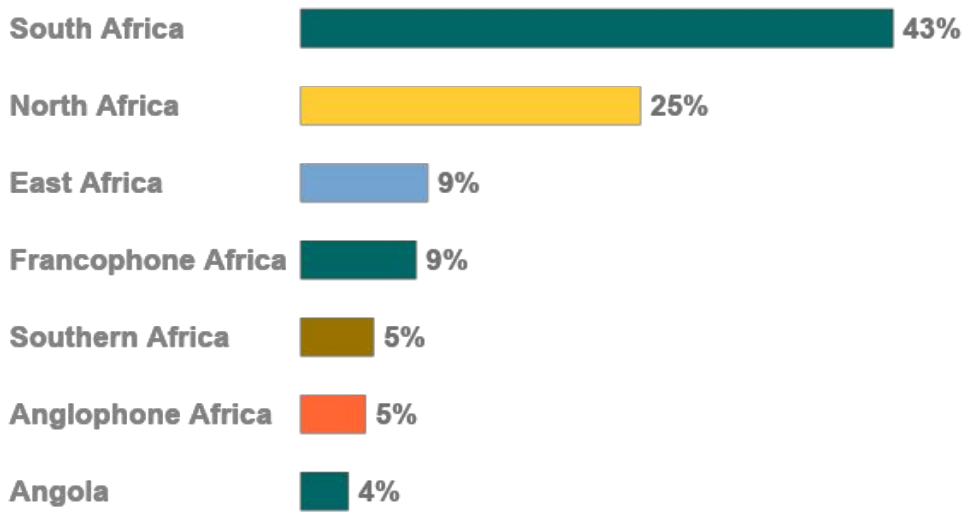
Globally, Africa accounts for 17% of the population, 3% of the GDP, and just **1% of non-life insurance premiums**.[2] The main reasons affecting the **systematically low adoption rate of insurance products** in Africa may be connected to:

- **Market dynamics:** the continent lacks policies aimed at fostering industry growth and at making insurance more accessible at the consumer level.[3]
- **Cultural misconceptions:** mistrust and lack of confidence in the often depicted "thief-insurer".[4]
- **Absence of comprehensive information:** a shortage of data may prevent insurers from offering appropriate coverage on specific events, as well as from pricing it correctly.[5]

Still, Africa remains the **second most promising continent** with regards to growth potential for its insurance market.[6] A McKinsey study portrayed how Africa's' compounded annual growth rate is set to **7% per year**, nearly twice as fast as North America and higher than Asia's 6%.[7]

The share of non-life insurance premiums is led by South Africa and North Africa, with little expansion in other regions[8]

Non-life insurance gross written premium (GWP) in Africa by region in 2018 (as share of Africa total)



[1] Reinsurance News, 2022.
[2] *Why is non-life Insurance not taking off in Africa?*, Addactis, 2021.
[3] Toesland, F., *Insurance: Africa's sleeping giant*, New Africa, 2021.
[4] *Why is non-life Insurance not taking off in Africa?*, Addactis, 2021.
[5] *Tackling America's flood risk problem*, Swiss Re, 2018.
[6] *Why is non-life Insurance not taking off in Africa?*, Addactis, 2021.
[7] Bagus, U., et al., *Africa's insurance market is set for takeoff*, McKinsey, 2020.
[8] Team analysis based on: Bagus, U., et al., *Africa's insurance market is set for takeoff*, McKinsey, 2020.

Providing decision-makers with actionable information has the potential to increase the efficiency of the insurance market and create economic value

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The drivers of the insurance market growth are not the same across Africa

While the insurance sector is expected to grow considerably, research shows that only in Morocco and Ghana such surge is mainly tight to **higher market penetration rather than economic growth**.[1]

Data availability is key to reduce inefficiencies and avoid market failures

Theoretically, when insufficient information about insurable risks connected to coastal erosion is available, the **pricing of insurance products is inaccurate and generally high**. This negatively affects the economic ecosystem as:

- Landowners' general willingness to pay is lower than said prices.
- The price is reasonable only for parcels at high risk of erosion □ **adverse selection bias**;
- Predicting adverse selection bias, insurers may not find convenient to offer coverage.

This mechanism leads to **market failure** and prevents the insurance industry from thriving.[2]

Using Earth observation data to inform insurance decision-making: The case of Australian residential properties [3]

Australia's property wealth is mainly concentrated on the Eastern and South-Eastern seaboard, with a general **increase in the value of coastal properties** due to a higher demand also driven by the shift to remote work.

Australian coasts are eroding at rates higher than the global average. Such phenomenon has **repercussions on the overall property market and on supporting financial sectors**, including insurance. Homeowners are encountering **inflating insurance premiums and restricted coverage** connected to the challenge of understanding the **coastal risk** associated with their properties.

Geoscience Australia's **satellite imagery** from 1988 to 2021 has been used to **assess the impact of shoreline movements** on coastal properties and mitigate the effects explained above. This was assessed by measuring the change in distance from the shore and using an **algorithm** that calculates the coastal retreat rate to identify the **remaining time** before a property is likely to "**fall into the water**".

It has been estimated that coastal hazards can impact **$25 billion** of residential properties. These properties were classified by assigning a **risk rating** that considers both gradual erosion and storm surge. This rating was then translated into a scoring system – as shown in the table on the right.

Thanks to **satellite information**, insurers have the opportunity to precisely quantify the **impact of coastal erosion**, enhance **risk management** and make **data-led decisions** that would eventually create opportunities for market expansion and benefit customers.

Value of dwellings at risk

Coastal Risk Score	Value at risk (AUD billion)
Very High	5.3
High	19.6
Medium	109.0
Low	718.6
Total	**852.6**

[1] Bagus, U., et al., *Africa's insurance market is set for takeoff*, McKinsey, 2020.
[2] Ruan, K., *Chapter 10 - Case Study: Insuring the Future of Everything*, Digital Asset Valuation and Cyber Risk Measurement, 2019.
[3] *$25 billion in Australian residential property exposed to high coastal risk*, CoreLogic, 2022.

DE Africa can help generate $215 million per year in additional profits & jobs for the insurance industry

DE Africa can boost the commercialisation of non-life insurance products

DE Africa can help insurance **companies calculate premiums more effectively and assess claims** linked to damages caused by natural disasters such as the effects of coastal erosion.[1]

In addition, DE Africa could make the African insurance market more efficient by:[2]

- Enhancing **risk modelling**, making insurance processes more efficient and reliable
- Reducing the time spent to **estimate losses**
- Helping to better price and **monitor insurers' risk portfolios**
- Assisting clients in **making more informed decisions** about their assets.

Furthermore, historical Earth observation data can be used to model flooding more effectively, thus expanding the insurability to many previously uncovered homes and assets.

Finally, DE Africa can boost insurance companies' profits with a **total value creation of $54 million per year**. Such figure does not include consumer surplus or all the positive spillovers connected with the **additional revenue** estimated at industry level – equal to approximately **$1.1 billion per year** – which could generate more than **4,500 new direct jobs** and **around 9,000 indirect jobs** in Africa, resulting in **$56 million** and **$105 million** in salaries, respectively.[3]

In addition, insurance companies help lower borrowing costs within the economy by investing in municipal bonds with premiums collected in advance of claim payments. This would lead to even **greater investments**, **more employment and higher economic growth** also outside of this specific sector.[4,5]

[1] Baqus, U., et al., *Africa's insurance market is set for takeoff*, McKinsey, 2020.
[2] Mitchell, M., *Can satellites help insurers to grow by closing protection gaps, and improve sustainability?*, Swiss Re, 2021.
[3] Team Analysis
[4] Ul Din, S.M., et al., *Does insurance promote economic growth: A comparative study of developed and emerging/ developing economies*, Cogent Economics & Finance, 2017
[5] Weisbart, S., *How insurance drives economic growth*, Insurance Information Institute, 2018.

Tourism

Digital Earth
AFRICA

Tourism in Africa secures millions in jobs and revenues, but it has recently shrunk by more than 12%

Tourism is a central industry for many African economies

As of 2019, tourism sector employed more than **24 million people** across Africa and contributed to **7.1% of the continent's GDP**. Morocco and South Africa had the highest amount of visitors per year, with around 13 and 10 million respectively.[1]

When the COVID-19 pandemic hit, the tourism sector witnessed a severe crisis. It is estimated that in the first three months of the pandemic, Africa lost **$55 billion in trade and tourism revenue and 2 million in jobs**. Moreover, the International Monetary Fund stated that the GDP among African countries that heavily depend on **tourism shrunk by 12% in 2020**. The high dependence on foreign tourists is one reason that explains the hardships of the tourist industry during the pandemic. Out of the all the continents, the Africa region has the **lowest percentage of domestic tourists** (*see figure below*). Therefore, tapping into the domestic demand would be crucial in alleviating the impact of COVID-19 and projecting the African tourist industry into a more sustainable future.[2]

[1] JTB Tourism Research & Consulting Co., 2020.
[2] *A Ticket to Recovery: Reinventing Africa's Tourism Industry*, IFC, 2021.
[3] *A Ticket to Recovery: Reinventing Africa's Tourism Industry*, IFC, 2021.

Coastal erosion limits revenues and reduces investments in tourism infrastructures

Surveys conducted in other countries reflect the close relationship between coastal erosion and tourism

Areas around the world are at risk of **foregone revenue linked to the impact of coastal erosion on tourism**. In **Barbados** more than 3 out of 4 visitors surveyed were reluctant to return for the same price should beaches largely disappear – with an associated **46% drop in tourism revenues**. Along the **Australian coastline**, tourists interviewed stated that significant land erosion events would lead them to choose other destinations, with losses equal to **$75 million per year**.[1]

Losses are expected to increase in Africa's coastal areas

Coastal erosion's impact on the tourism industry is witnessed across Africa. It has been estimated that shore degradation and rising sea level could impact coastal areas on the **Red Sea in Egypt** (such as Sahl Hasheesh and Makadi Bay), with expected **lost revenues that could exceed $350,000 per day** in 2050.[2] In the **Gambia** – a country with just 80 km of coastline – all **15 coastal hotels are at risk**.[3] In other areas such as West Africa, the current and projected rate of erosion regions is resulting into a **decreasing propensity to invest in tourist infrastructures**.[4]

[1] Heger, M.P., Vashold, L., *Disappearing coasts in the Maghreb: Coastal erosion and its costs*, World Bank, 2021.
[2] Heger, M.P., Vashold, L., *Disappearing coasts in the Maghreb: Coastal erosion and its costs*, World Bank, 2021.
[3] Brice, M., *Coastal erosion washes away beaches, threatens tourism in Senegal*, Reuters, 2015.
[4] Kemper, K., *Swallowed by the Sea…Where coastal infrastructure and jobs meet climate change*, World Bank, 2017.
Image source

The effects of erosion on tourism: the case of the Tetouan coast[1]

The **Tetouan coast** in Morocco (*see Figure 1*) stretches for more than 20 km of primarily **sandy shores**, and is served by **infrastructures** such as hotels, highways, marinas and ports. The area heavily relies on tourism as its leading economic activity. Attendance on M'Diq beach can reach **more than 150,000 tourists a day**, exceeding the total local population of 134,000 residents.
The studied beaches are increasingly impacted by **coastal hazards**. It is estimated that **more than 70% of the coast** is subjected to severe erosion. An economic approach based on the **overnight stays of tourists** was adopted to evaluate the impact of such phenomenon on tourism income, assuming that **decreasing beach quality and width would reduce the demand for coastal tourism**.

The difference between the income of overnight stays without beach retreats (using 2016 as reference year) and income with beach retreats has been used to determine the foregone revenue of tourism activities in the region by 2054 – the year in which all beaches are expected to disappear.

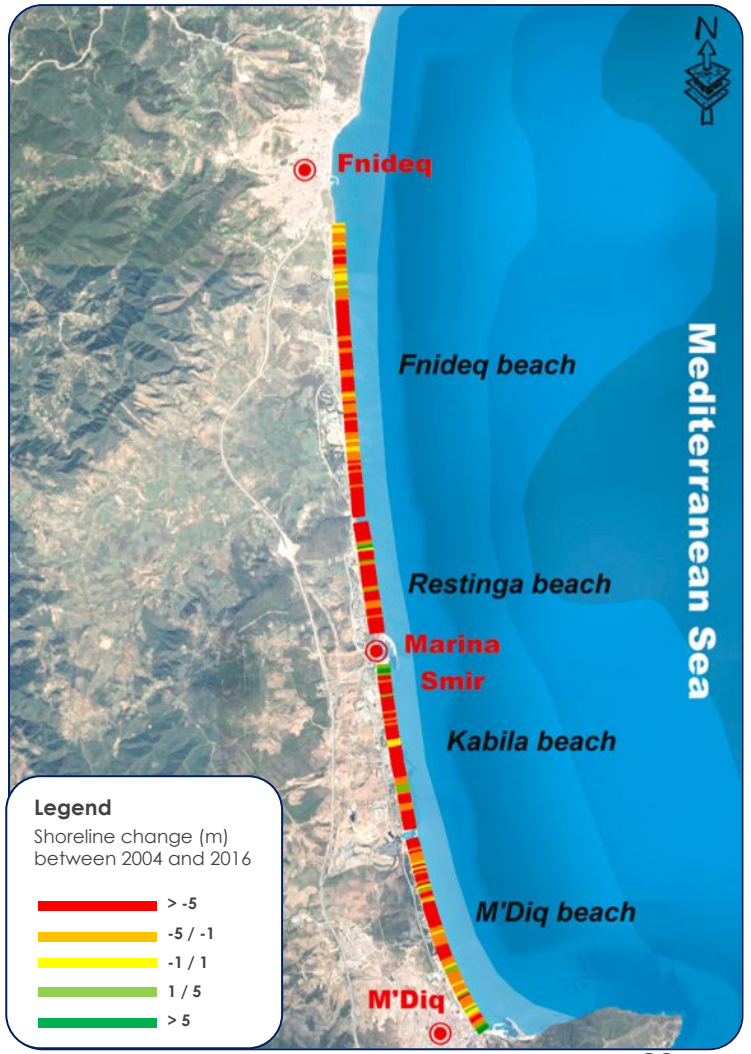
The **total expected value lost** due to the impact of coastal erosion on tourism within the Tetouan coast is estimated to be **$71.5 million per year**.

The final results are shown in Figure 2, with Restinga and Kabila experiencing the most losses. M'Diq is the narrowest beach and will therefore disappear sooner, causing a lower total potential loss.

Estimated loss of overnight income for tourism due to erosion of the studied beaches

Beach	Loss of overnight income ($, million)
Fnideq	17.5
Restinga	19.3
Kabila	19.2
M'Diq	15.6
Total	**71.5**

Figure 2



[1] Flayou, L., Snoussi, M., Raji, O., *Evaluation of the economic costs of beach erosion due to the loss of the recreational services of sandy beaches - The case of Tetouan coast (Morocco)*, Journal of African Earth Sciences, 2021.

Acknowledgments

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Disal Consulting is a boutique advisory firm specialized in strategy, public policy and impact studies for large corporations, innovative startups, national governments and multilateral organizations. 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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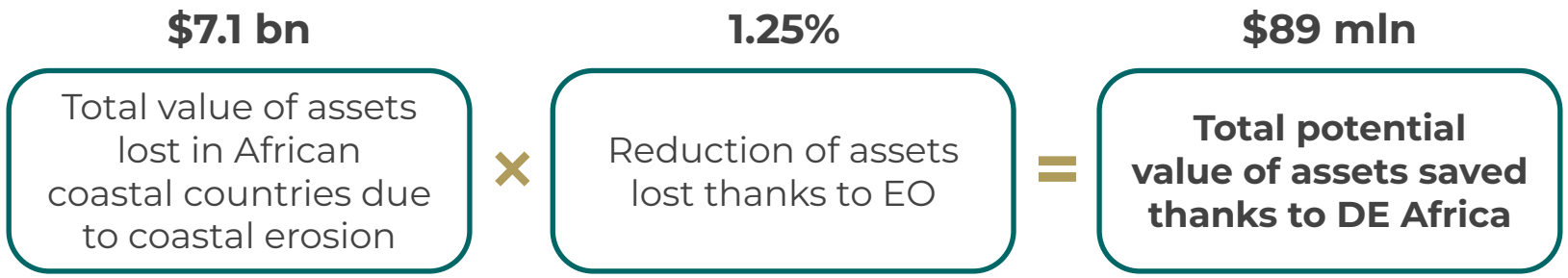
Appendix

Real Estate & Agriculture

General approach

The calculation of the potential benefits in terms of value of **land and buildings saved** from the effects of coastal erosion thanks to DE Africa requires:

- the quantification of the **value of assets at risk** within the African coastal countries;
- the estimation of the **total potential reduction of assets at risk** thanks to Earth observation technologies.



For the purpose of this model, the value of assets includes that of buildings and land on the coast:

$$\boldsymbol{Value\ of\ assets} = value\ of\ buildings\ + value\ of\ land$$

Our analysis refers to a London Economics paper, which argues that **satellite-derived Earth observation can reduce land lost to coastal erosion by 1.25%**.[1] The following slides present the calculations used to obtain the value of assets lost in African coastal countries.

[1] *Value of satellite-derived Earth Observation capabilities to the UK Government today and by 2020*. LE, 2018. As seen in the notes section (note number 77) on page 24.

Calculation of the value of assets lost in the Maghreb (1/3)

As comprehensive data related to the value of assets lost is not available for most of African coastal countries, the analysis starts from the **Maghreb** due information availability.

The table below shows the **actual value of assets lost** (according to the World Bank) in each country in the region – namely Algeria, Libya, Morocco, and Tunisia.[1]

Country		Value of buildings lost		Value of land lost
Algeria	$	3,000,000.00	$	310,000,000.00
Libya	$	1,000,000.00	$	272,000,000.00
Morocco	$	8,000,000.00	$	425,000,000.00
Tunisia	$	29,000,000.00	$	1,078,000,000.00
Total (Maghreb)	**$**	**41,000,000.00**	**$**	**2,085,000,000.00**

$$\textbf{\textit{Total value of assets lost in the Maghreb}} = Total\ value\ of\ buildings\ lost + Total\ value\ of\ land\ lost =$$
$$= \$41{,}000{,}000 + \$2{,}085{,}000{,}000 = \mathbf{\$2{,}126{,}000{,}000}$$

[1] *Disappearing coasts in the Maghreb: Coastal erosion and its costs*, World Bank, 2021.

Calculation of the value of assets lost in the Maghreb (2/3)

The total value was then divided by the Maghreb's coastal GDP, which was obtained multiplying the GDP by the share of coastal population – under the assumption that the coastal zone share of GDP equals that of coastal population. The share of coastal population represents a good proxy for that of coastal GDP, as cross-referenced data reported by two sources show that in West Africa these two values are almost equal (55% vs 56%).[2,3]

Description		Value
Maghreb's GDP[1]	$	389,427,981,000.00
Coastal population in Maghreb	$	61,302,200.00
Total population in Maghreb	$	85,060,000.00
% coastal population in Maghreb		72.07%
Maghreb's coastal GDP	$	280,658,264,482.23
Value of assets lost as share of coastal GDP		**0.76%**

$$\textbf{Value of assts lost as a share of coastal GDP} = \frac{Value\ of\ assets\ lost\ in\ the\ Maghreb}{Maghreb's\ coastal\ GDP} =$$

$$= \frac{Value\ of\ assets\ lost\ in\ the\ Maghreb}{Maghreb's\ GDP\ *\ Share\ of\ coastal\ population\ in\ the\ Maghreb} = \frac{\$2{,}126{,}000{,}000}{389{,}427{,}981{,}000 * 72.07\%} = \mathbf{0.76\%}$$

This percentage was then multiplied by each coastal country's coastal GDP to imply the **value of assets lost due to erosion**.

[1] *World Bank*

[2] Resource Watch (2010)

[3] A Partnership for Saving West Africa's Coastal Assets, WACA, 2016.

Calculation of the value of assets lost in the Maghreb (3/3)

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Coastal countries	Share of coastal population	Total GDP[1] (USD)	Coastal GDP (USD)	Value of assets lost (USD)
Algeria	71.00%	$ 167,983,141,000.00	$ 119,268,030,110.00	$ 903,461,127.30
Angola	29.00%	$ 72,456,985,000.00	$ 21,012,525,650.00	$ 159,170,903.50
Benin	58.00%	$ 17,785,640,000.00	$ 10,315,671,200.00	$ 78,141,710.92
Cabo Verde (no data, average % of coastal population in coastal countries)	34.26%	$ 1,936,174,000.00	$ 663,258,131.68	$ 5,024,212.60
Cameroon	20.00%	$ 45,238,613,000.00	$ 9,047,722,600.00	$ 68,536,938.63
Comoros (no data, average % of coastal population in coastal countries)	34.26%	$ 1,327,964,000.00	$ 454,908,970.77	$ 3,445,957.57
Congo, Dem. Rep.	2.00%	$ 53,958,573,000.00	$ 1,079,171,460.00	$ 8,174,776.28
Congo, Rep.	21.00%	$ 12,523,961,000.00	$ 2,630,031,810.00	$ 19,922,618.84
Cote d'Ivoire	39.00%	$ 69,764,827,000.00	$ 27,208,282,530.00	$ 206,104,063.12
Djibouti	100.00%	$ 3,371,000,000.00	$ 3,371,000,000.00	$ 25,535,488.91
Egypt, Arab Rep.	44.00%	$ 404,142,000,000.00	$ 177,822,480,000.00	$ 1,347,013,932.33
Equatorial Guinea	69.00%	$ 12,269,392,000.00	$ 8,465,880,480.00	$ 64,129,456.28
Eritrea	69.00%	$ 2,065,001,000.00	$ 1,424,850,690.00	$ 10,793,313.26
Gabon	60.00%	$ 18,269,350,000.00	$ 10,961,610,000.00	$ 83,034,728.74
Gambia, The	78.00%	$ 2,078,070,000.00	$ 1,620,894,600.00	$ 12,278,355.41
Ghana	44.00%	$ 77,594,279,000.00	$ 34,141,482,760.00	$ 258,623,391.98
Guinea	30.00%	$ 15,850,520,000.00	$ 4,755,156,000.00	$ 36,020,537.91
Guinea-Bissau	95.00%	$ 1,638,517,000.00	$ 1,556,591,150.00	$ 11,791,253.65
Kenya	8.00%	$ 110,347,079,000.00	$ 8,827,766,320.00	$ 66,870,759.11
Liberia	63.00%	$ 3,486,741,000.00	$ 2,196,646,830.00	$ 16,639,706.55
Libya	88.00%	$ 41,879,579,000.00	$ 36,854,029,520.00	$ 279,171,065.58
Madagascar	51.00%	$ 14,637,400,000.00	$ 7,465,074,000.00	$ 56,548,298.53
Mauritania	32.00%	$ 8,227,580,000.00	$ 2,632,825,600.00	$ 19,943,781.94
Mauritius (no data, average % of coastal population in coastal countries)	34.26%	$ 11,156,657,000.00	$ 3,821,838,056.72	$ 28,950,609.11
Morocco	66.00%	$ 132,725,261,000.00	$ 87,598,672,260.00	$ 663,564,201.71
Mozambique	56.00%	$ 16,095,828,000.00	$ 9,013,663,680.00	$ 68,278,940.65
Namibia	6.00%	$ 12,236,250,000.00	$ 734,175,000.00	$ 5,561,411.32
Nigeria	23.00%	$ 440,776,971,000.00	$ 101,378,703,330.00	$ 767,948,607.10
Sao Tome and Principe	100.00%	$ 547,092,000.00	$ 547,092,000.00	$ 4,144,248.50
Senegal	78.00%	$ 27,625,388,000.00	$ 21,547,802,640.00	$ 163,225,652.72
Seychelles (no data, average % of coastal population in coastal countries)	34.26%	$ 1,320,053,000.00	$ 452,198,968.95	$ 3,425,429.18
Sierra Leone	60.00%	$ 4,200,380,000.00	$ 2,520,228,000.00	$ 19,090,849.64
Somalia	63.00%	$ 7,292,721,000.00	$ 4,594,414,230.00	$ 34,802,911.19
South Africa	38.00%	$ 419,946,428,000.00	$ 159,579,642,640.00	$ 1,208,823,552.30
Sudan	3.00%	$ 34,326,058,000.00	$ 1,029,781,740.00	$ 7,800,646.75
Tanzania	19.00%	$ 67,775,101,000.00	$ 12,877,269,190.00	$ 97,545,940.25
Togo	45.00%	$ 8,413,200,000.00	$ 3,785,940,000.00	$ 28,678,679.59
Tunisia	85.00%	$ 46,840,000,000.00	$ 39,814,000,000.00	$ 301,592,985.89
			Total	**$ 7,143,811,044.82**

[1] World Bank

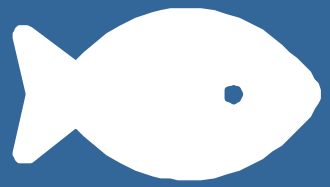
Share of coastal population in African coastal countries

The **share of coastal population** has been calculated by adding the urban and rural coastal population of each of the 38 African coastal countries and then dividing it by the respective country's total population. The table below shows the calculations for each country.

Coastal countries	Total population[1]	% of coastal urban population[2]	% of coastal rural population[3]	Urban coastal population	Rural coastal population	Total coastal population	Share of coastal population
Algeria	35,980,000.00	42%	29%	15,111,600	10,434,200	25,545,800.00	**71.00%**
Angola	23,360,000.00	23%	6%	5,372,800	1,401,600	6,774,400.00	**29.00%**
Benin	9,199,000.00	27%	31%	2,483,730	2,851,690	5,335,420.00	**58.00%**
Cabo Verde*	492,644.00	n.a.	n.a.	n.a.	n.a.	n.a.	34.26%
Cameroon	20,340,000.00	13%	7%	2,644,200	1,423,800	4,068,000.00	**20.00%**
Comoros*	689,696.00	n.a.	n.a.	n.a.	n.a.	n.a.	34.26%
Congo, Dem. Rep	64,560,000.00	1%	1%	645,600	645,600	1,291,200.00	**2.00%**
Congo, Rep.	4,274,000.00	19%	2%	812,060	85,480	897,540.00	**21.00%**
Cote D'Ivoire	20,530,000.00	22%	17%	4,516,600	3,490,100	8,006,700.00	**39.00%**
Djibouti	840,194.00	74%	26%	621,744	218,450	840,194.00	**100.00%**
Egypt	82,760,000.00	20%	24%	16,552,000	19,862,400	36,414,400.00	**44.00%**
Equatorial Guinea	943,640.00	16%	53%	150,982	500,129	651,111.60	**69.00%**
Eritrea	3,170,437.00	16%	53%	507,270	1,680,332	2,187,601.53	**69.00%**
Gabon	1,624,000.00	52%	8%	844,480	129,920	974,400.00	**60.00%**
Gambia, The	1,793,000.00	49%	29%	878,570	519,970	1,398,540.00	**78.00%**
Ghana	24,780,000.00	25%	19%	6,195,000	4,708,200	10,903,200.00	**44.00%**
Guinea	10,190,000.00	16%	14%	1,630,400	1,426,600	3,057,000.00	**30.00%**
Guinea Bissau	1,523,000.00	33%	62%	502,590	944,260	1,446,850.00	**95.00%**
Kenya	42,030,000.00	3%	5%	1,260,900	2,101,500	3,362,400.00	**8.00%**
Liberia	3,891,000.00	18%	45%	700,380	1,750,950	2,451,330.00	**63.00%**
Lybia	6,100,000.00	68%	20%	4,148,000	1,220,000	5,368,000.00	**88.00%**
Madagascar	21,150,000.00	5%	46%	1,057,500	9,729,000	10,786,500.00	**51.00%**
Mauritania	3,494,000.00	10%	22%	349,400	768,680	1,118,080.00	**32.00%**
Mauritius*	1,250,000.00	n.a.	n.a.	n.a.	n.a.	n.a.	34.26%
Morocco	32,340,000.00	34%	32%	10,995,600	10,348,800	21,344,400.00	**66.00%**
Mozambique	23,530,000.00	18%	38%	4,235,400	8,941,400	13,176,800.00	**56.00%**
Namibia	2,119,000.00	4%	2%	84,760	42,380	127,140.00	**6.00%**
Nigeria	158,500,000.00	12%	11%	19,020,000	17,435,000	36,455,000.00	**23.00%**
Sao Tome and Principe	180,372.00	72%	28%	129,868	50,504	180,372.00	**100.00%**
Senegal	12,680,000.00	42%	36%	5,325,600	4,564,800	9,890,400.00	**78.00%**
Seychelles*	89,770.00	n.a.	n.a.	n.a.	n.a.	n.a.	34.26%
Sierra Leone	6,416,000.00	22%	38%	1,411,520	2,438,080	3,849,600.00	**60.00%**
Somalia	12,040,000.00	12%	51%	1,444,800	6,140,400	7,585,200.00	**63.00%**
South Africa	51,220,000.00	23%	15%	11,780,600	7,683,000	19,463,600.00	**38.00%**
Sudan	34,550,000.00	1%	2%	345,500	691,000	1,036,500.00	**3.00%**
Tanzania	44,350,000.00	9%	10%	3,991,500	4,435,000	8,426,500.00	**19.00%**
Togo	6,422,000.00	37%	8%	2,376,140	513,760	2,889,900.00	**45.00%**
Tunisia	10,640,000.00	51%	34%	5,426,400	3,617,600	9,044,000.00	**85.00%**

* For Cabo Verde, Comoros, Mauritius and Seychelles no information on the percentage of coastal population was available. We therefore used the average value of African coastal countries (34.26%)

[1] World Bank (2010)
[2] Resource Watch (2010)
[3] Resource Watch (2010)



Fishery

General approach

The calculation of the potential total benefit connected to the **reduction of the loss of fish catches** from the effects of coastal erosion thanks to DE Africa requires:

- the quantification of the **annual value of fish catches saved by DE Africa**;
- the estimation of the value of **salaries for jobs connected to the fishing industry saved by DE Africa annually**.

For the purpose of this model, direct jobs within the fishing industry saved by DE Africa are not included to avoid double-counting issues. In fact, the value of fish catches has been calculated starting from the contribution of the industry to the GDP (Gross Value Added method), which in this case should include salaries.

The following slides present a comprehensive breakdown of the two elements of the equation proposed above.

Calculation of the contribution to Africa's GDP of fish catches in marine waters (1/3)

In order to calculator the v**alue of fish catches saved by DE Africa**, the model started by estimating the **total contribution of Africa's GDP of fish catches in marine waters**. As the analysis aims to quantify DE Africa's benefits connected to coastal erosion, it focuses on marine catches and does not consider aquaculture nor island fisheries.

$$\textbf{\textit{Fish catches in marine waters}} = \textit{Marine artisanal fishing} + \textit{Marine industrial fishing}$$

The contribution to Africa's GDP of fish catches in marine waters is calculated starting by estimating the **impact of marine artisanal & industrial fishing on the overall fishing industry in terms of contribution to GDP**, using data of an FAO report:[1]

	Gross Value Added	Contribution to GDP
Marine artisanal fisheries	$ 5,246,000,000.00	0.24%
Marine industrial fisheries	$ 4,670,000,000.00	0.27%
Total fisheries and aquaculture	$ 24,030,000,000.00	1.26%
Share of marine fisheries / total fisheries and aquaculture	41.27%	40.48%
Conservative assumption		**40%**

The value obtained (40%) was multiplied for the **share of fishing industry on GDP** in selected countries – depending on data availability – and used to imply the **regional average** for Northern, Southern, Eastern, and Western Africa. Such percentages were then used to quantify the **marine fishing contribution to GDP** for every African coastal country, as shown in the next two slides.

[1] De Graaf, G., Garibaldi, L., *The Value of African Fisheries, Food and Agriculture Organization*, 2014.

Calculation of the contribution to Africa's GDP of fish catches in marine waters (2/3)

Digital Earth AFRICA

Region	Country	Share of fishing industry on GDP	Marine fisheries contribution to GDP	Marine fisheries contribution to GDP *(regional arithmetic Average)*
North	Lybia	9.0%[1]	3.60%	**2.26%**
	Morocco	2.3%[2]	0.92%	
South	Namibia	3.0%[3]	1.20%	**0.78%**
	South Africa	0.9%[4]	0.36%	
East	Kenya	0.8%[5]	0.32%	**0.44%**
	Somalia	2.0%[6]	0.80%	
	Sudan	0.2%[7]	0.08%	
	Tanzania	1.4%[8]	0.56%	
West	Angola	4.6%[9]	1.84%	**2.03%**
	Cote D'Ivoire	0.8%[10]	0.32%	
	Gambia, The	12.0%[11]	4.80%	
	Ghana	4.5%[12]	1.80%	
	Nigeria	3.5%[13]	1.40%	

[1] University of Benghazi
[2] Salon Halieutis
[3] International Trade
[4] SADC-EU EPA
[5] Ministry of Agriculture, Livestock and Fisheries, Kenya
[6] SATG Filsan
[7] FAO
[8] USAID
[9] FAO
[10] FCWC
[11] The Point, 2022
[12] Republic of Ghana Fisheries and Aquaculture Sector Development Plan
[13] WorldFish, 2021

Calculation of the contribution to Africa's GDP of fish catches in marine waters (3/3)

Digital Earth AFRICA

Region	Country	Total GDP (USD)[1]	Marine fishing contribution to GDP (using regional arithmetic average)
North	Algeria	$ 167,983,141,000.00	$ 3,796,418,986.60
	Egypt	$ 404,142,000,000.00	$ 9,133,609,200.00
	Lybia	$ 41,879,579,000.00	$ 946,478,485.40
	Morocco	$ 132,725,261,000.00	$ 2,999,590,898.60
	Tunisia	$ 46,840,000,000.00	$ 1,058,584,000.00
South	Mozambique	$ 16,095,828,000.00	$ 125,547,458.40
	Namibia	$ 12,236,250,000.00	$ 95,442,750.00
	South Africa	$ 419,946,428,000.00	$ 3,275,582,138.40
East	Comoros	$ 1,327,964,000.00	$ 5,843,041.60
	Djibouti	$ 3,371,000,000.00	$ 14,832,400.00
	Eritrea	$ 2,065,001,000.00	$ 9,086,004.40
	Kenya	$ 110,347,079,000.00	$ 485,527,147.60
	Madagascar	$ 14,637,400,000.00	$ 64,404,560.00
	Mauritius	$ 11,156,657,000.00	$ 49,089,290.80
	Seychelles	$ 1,320,053,000.00	$ 5,808,233.20
	Somalia	$ 7,292,721,000.00	$ 32,087,972.40
	Sudan	$ 34,326,058,000.00	$ 151,034,655.20
	Tanzania	$ 67,775,101,000.00	$ 298,210,444.40
West	Angola	$ 72,456,985,000.00	$ 1,472,325,935.20
	Benin	$ 17,785,640,000.00	$ 361,404,204.80
	Cabo Verde	$ 1,936,174,000.00	$ 39,343,055.68
	Cameroon	$ 45,238,613,000.00	$ 919,248,616.16
	Congo, Dem. Rep	$ 53,958,573,000.00	$ 1,096,438,203.36
	Congo, Rep.	$ 12,523,961,000.00	$ 254,486,887.52
	Cote D'Ivoire	$ 69,764,827,000.00	$ 1,417,621,284.64
	Equatorial Guinea	$ 12,269,392,000.00	$ 249,314,045.44
	Gabon	$ 18,269,350,000.00	$ 371,233,192.00
	Gambia. The	$ 2,078,070,000.00	$ 42,226,382.40
	Ghana	$ 77,594,279,000.00	$ 1,576,715,749.28
	Guinea	$ 15,850,520,000.00	$ 322,082,566.40
	Guinea Bissau	$ 1,638,517,000.00	$ 33,294,665.44
	Liberia	$ 3,486,741,000.00	$ 70,850,577.12
	Mauritania	$ 8,227,580,000.00	$ 167,184,425.60
	Nigeria	$ 440,776,971,000.00	$ 8,956,588,050.72
	Sao Tome and Principe	$ 547,092,000.00	$ 11,116,909.44
	Senegal	$ 27,625,388,000.00	$ 561,347,884.16
	Sierra Leone	$ 4,200,380,000.00	$ 85,351,721.60
	Togo	$ 8,413,200,000.00	$ 170,956,224.00
		Total marine fishing contribution to GDP	**$ 40,726,308,247.96**

[1] World Bank

Calculation of the annual value of fish catches saved by DE Africa (1/2)

Once the initial value of African fish catches in marine waters was identified (i.e. the contribution to Africa's GDP of fish catches in marine waters), it was possible to estimate the value of fish catches **saved by DE Africa**. This has been done by formulating some **assumptions**:

1. A research by the Coalition for Fisheries Arrangements argues that a **26% reduction of available fish due to an increase in CO_2 levels will occur in West Africa by 2050**.[1] The model uses **West Africa as a proxy**, assuming that fish catches will decrease at the same rate in the whole continent.
2. Coastal erosion implications explain **25% of the decrease** in fish catches attributable to an increase in CO_2.
3. The DE Africa team estimates that monitoring services could **reduce the impact of coastal erosion on marine fish catches at least by 10%**.

Starting from *assumption 1*, it was possible to imply the **annual reduction of fish catches within 2050** by performing a **CAGR** calculation. The resulted (negative) **compounded annual growth rate** is **-1.07**% per year.

The difference between the **contribution to Africa's GDP of fish catches in marine waters** ($40.7 bn) and the **annual value with CAGR reduction** would determine the **annual value of fish catches lost** in Africa.

Multiplying the **annual value of fish catches lost** by the **reduction of fish catches attributable to coastal erosion** (*assumption 2*) and the **potential value saved by DE Africa** (*assumption 3*), we derived the **annual value of fish catches saved by DE Africa** (*see next slide for breakdown*).

See next slide		**25%**		**10%**		***See next slide***
Annual value of fish catches lost	×	Reduction of fish catches attributable to coastal erosion	×	Potential value saved by DE Africa	=	**Annual value of fish catches saved by DE Africa**

[1] *Living on the frontline: Climate change will first impact African coastal fishing communities*, Coalition for Fair Fisheries Arrangements, 2022.

Calculation of the annual value of fish catches saved by DE Africa (2/2)

Year	N. of year	Initial value of fish catches	Annual value considering CAGR reduction	Difference	Value saved by DEA per year
2023	1	$ 40,726,308,247.96	$ 40,290,536,749.71	$ 435,771,498.25	$ 10,894,287.46
2024	2	$ 40,726,308,247.96	$ 39,859,428,006.49	$ 866,880,241.48	$ 21,672,006.04
2025	3	$ 40,726,308,247.96	$ 39,432,932,126.82	$ 1,293,376,121.14	$ 32,334,403.03
2026	4	$ 40,726,308,247.96	$ 39,010,999,753.06	$ 1,715,308,494.90	$ 42,882,712.37
2027	5	$ 40,726,308,247.96	$ 38,593,582,055.70	$ 2,132,726,192.26	$ 53,318,154.81
2028	6	$ 40,726,308,247.96	$ 38,180,630,727.70	$ 2,545,677,520.26	$ 63,641,938.01
2029	7	$ 40,726,308,247.96	$ 37,772,097,978.92	$ 2,954,210,269.04	$ 73,855,256.73
2030	8	$ 40,726,308,247.96	$ 37,367,936,530.54	$ 3,358,371,717.42	$ 83,959,292.94
2031	9	$ 40,726,308,247.96	$ 36,968,099,609.67	$ 3,758,208,638.29	$ 93,955,215.96
2032	10	$ 40,726,308,247.96	$ 36,572,540,943.84	$ 4,153,767,304.12	$ 103,844,182.60
2033	11	$ 40,726,308,247.96	$ 36,181,214,755.74	$ 4,545,093,492.22	$ 113,627,337.31
2034	12	$ 40,726,308,247.96	$ 35,794,075,757.86	$ 4,932,232,490.10	$ 123,305,812.25
2035	13	$ 40,726,308,247.96	$ 35,411,079,147.25	$ 5,315,229,100.71	$ 132,880,727.52
2036	14	$ 40,726,308,247.96	$ 35,032,180,600.37	$ 5,694,127,647.59	$ 142,353,191.19
2037	15	$ 40,726,308,247.96	$ 34,657,336,267.95	$ 6,068,971,980.01	$ 151,724,299.50
2038	16	$ 40,726,308,247.96	$ 34,286,502,769.88	$ 6,439,805,478.08	$ 160,995,136.95
2039	17	$ 40,726,308,247.96	$ 33,919,637,190.24	$ 6,806,671,057.72	$ 170,166,776.44
2040	18	$ 40,726,308,247.96	$ 33,556,697,072.31	$ 7,169,611,175.65	$ 179,240,279.39
2041	19	$ 40,726,308,247.96	$ 33,197,640,413.64	$ 7,528,667,834.32	$ 188,216,695.86
2042	20	$ 40,726,308,247.96	$ 32,842,425,661.21	$ 7,883,882,586.75	$ 197,097,064.67
2043	21	$ 40,726,308,247.96	$ 32,491,011,706.63	$ 8,235,296,541.33	$ 205,882,413.53
2044	22	$ 40,726,308,247.96	$ 32,143,357,881.37	$ 8,582,950,366.59	$ 214,573,759.16
2045	23	$ 40,726,308,247.96	$ 31,799,423,952.04	$ 8,926,884,295.92	$ 223,172,107.40
2046	24	$ 40,726,308,247.96	$ 31,459,170,115.76	$ 9,267,138,132.20	$ 231,678,453.31
2047	25	$ 40,726,308,247.96	$ 31,122,556,995.52	$ 9,603,751,252.44	$ 240,093,781.31
2048	26	$ 40,726,308,247.96	$ 30,789,545,635.67	$ 9,936,762,612.29	$ 248,419,065.31
2049	27	$ 40,726,308,247.96	$ 30,460,097,497.36	$ 10,266,210,750.60	$ 256,655,268.76
2050	28	$ 40,726,308,247.96	$ 30,134,174,454.14	$ 10,592,133,793.82	$ 264,803,344.85
				Total	**$ 4,025,242,964.64**

$$\textbf{Average annual value of fish catches saved by DEA between 2023 and 2050} = \frac{Total\ value\ saved\ by\ DEA}{Number\ of\ years} =$$

$$= \frac{\$4{,}025{,}242{,}964.64}{28} \approx \$144\ mln$$

Calculation of direct jobs saved by DE Africa annually

In order to calculate the **indirect jobs saved by DE Africa**, our model starts by estimating the total **number of direct jobs saved by DE Africa per year**.

The following ratio assumes that the **number of jobs lost is proportional to fish catches lost**, and is used to estimate the **number of jobs saved by DE Africa** every year *(see next slide)*:

$40.7 bn		***See next slide***		**2,777,000**		***Value to be calculated***
Initial value of fish catches	÷	Annual value of fish catches saved by DE Africa	=	Initial number of fishers	÷	Annual number of direct jobs saved by DE Africa

$$\textbf{Annual number of direct jobs saved by DEA} = \frac{\textit{Annual value of fish catches saved by DEA} * \textit{Initial number of fishers}}{\textit{Initial value of fish catches}}$$

The initial number of fishers in Africa was given by:

$$\textit{Number of fishers working in marine artisanal fisheries}^{1} + \textit{Number of fishers working in marine industrial fisheries}^{2}$$
$$= 1{,}876{,}000 + 901{,}000 = \mathbf{2{,}777{,}000}$$

[1] De Graaf, G., Garibaldi, L., *The Value of African Fisheries, Food and Agriculture Organization*, 2014.

[2] De Graaf, G., Garibaldi, L., *The Value of African Fisheries, Food and Agriculture Organization*, 2014.

Number of direct jobs saved by DE Africa

Year	N. of year	Initial value of fish catches	Annual value considering CAGR reduction	Difference	Value saved by DEA per year	N, of jobs saved by DE Africa (assuming that the number of jobs lost is proportional to fish catches lost)
2023	1	$ 40,726,308,247.96	$ 40,290,536,749.71	$ 435,771,498.25	$ 10,894,287.46	743
2024	2	$ 40,726,308,247.96	$ 39,859,428,006.49	$ 866,880,241.48	$ 21,672,006.04	1,478
2025	3	$ 40,726,308,247.96	$ 39,432,932,126.82	$ 1,293,376,121.14	$ 32,334,403.03	2,205
2026	4	$ 40,726,308,247.96	$ 39,010,999,753.06	$ 1,715,308,494.90	$ 42,882,712.37	2,924
2027	5	$ 40,726,308,247.96	$ 38,593,582,055.70	$ 2,132,726,192.26	$ 53,318,154.81	3,636
2028	6	$ 40,726,308,247.96	$ 38,180,630,727.70	$ 2,545,677,520.26	$ 63,641,938.01	4,340
2029	7	$ 40,726,308,247.96	$ 37,772,097,978.92	$ 2,954,210,269.04	$ 73,855,256.73	5,036
2030	8	$ 40,726,308,247.96	$ 37,367,936,530.54	$ 3,358,371,717.42	$ 83,959,292.94	5,725
2031	9	$ 40,726,308,247.96	$ 36,968,099,609.67	$ 3,758,208,638.29	$ 93,955,215.96	6,407
2032	10	$ 40,726,308,247.96	$ 36,572,540,943.84	$ 4,153,767,304.12	$ 103,844,182.60	7,081
2033	11	$ 40,726,308,247.96	$ 36,181,214,755.74	$ 4,545,093,492.22	$ 113,627,337.31	7,748
2034	12	$ 40,726,308,247.96	$ 35,794,075,757.86	$ 4,932,232,490.10	$ 123,305,812.25	8,408
2035	13	$ 40,726,308,247.96	$ 35,411,079,147.25	$ 5,315,229,100.71	$ 132,880,727.52	9,061
2036	14	$ 40,726,308,247.96	$ 35,032,180,600.37	$ 5,694,127,647.59	$ 142,353,191.19	9,707
2037	15	$ 40,726,308,247.96	$ 34,657,336,267.95	$ 6,068,971,980.01	$ 151,724,299.50	10,346
2038	16	$ 40,726,308,247.96	$ 34,286,502,769.88	$ 6,439,805,478.08	$ 160,995,136.95	10,978
2039	17	$ 40,726,308,247.96	$ 33,919,637,190.24	$ 6,806,671,057.72	$ 170,166,776.44	11,603
2040	18	$ 40,726,308,247.96	$ 33,556,697,072.31	$ 7,169,611,175.65	$ 179,240,279.39	12,222
2041	19	$ 40,726,308,247.96	$ 33,197,640,413.64	$ 7,528,667,834.32	$ 188,216,695.86	12,834
2042	20	$ 40,726,308,247.96	$ 32,842,425,661.21	$ 7,883,882,586.75	$ 197,097,064.67	13,439
2043	21	$ 40,726,308,247.96	$ 32,491,011,706.63	$ 8,235,296,541.33	$ 205,882,413.53	14,038
2044	22	$ 40,726,308,247.96	$ 32,143,357,881.37	$ 8,582,950,366.59	$ 214,573,759.16	14,631
2045	23	$ 40,726,308,247.96	$ 31,799,423,952.04	$ 8,926,884,295.92	$ 223,172,107.40	15,217
2046	24	$ 40,726,308,247.96	$ 31,459,170,115.76	$ 9,267,138,132.20	$ 231,678,453.31	15,797
2047	25	$ 40,726,308,247.96	$ 31,122,556,995.52	$ 9,603,751,252.44	$ 240,093,781.31	16,371
2048	26	$ 40,726,308,247.96	$ 30,789,545,635.67	$ 9,936,762,612.29	$ 248,419,065.31	16,939
2049	27	$ 40,726,308,247.96	$ 30,460,097,497.36	$ 10,266,210,750.60	$ 256,655,268.76	17,501
2050	28	$ 40,726,308,247.96	$ 30,134,174,454.14	$ 10,592,133,793.82	$ 264,803,344.85	18,056
				Total	**$ 4,025,242,964.64**	**274,469**

$$\textbf{Average annual number of direct jobs saved by DEA} = \frac{Total\ number\ of\ direct\ jobs\ saved\ by\ DEA}{Number\ of\ years} =$$

$$= \frac{274{,}469}{28} = \mathbf{9{,}802}$$

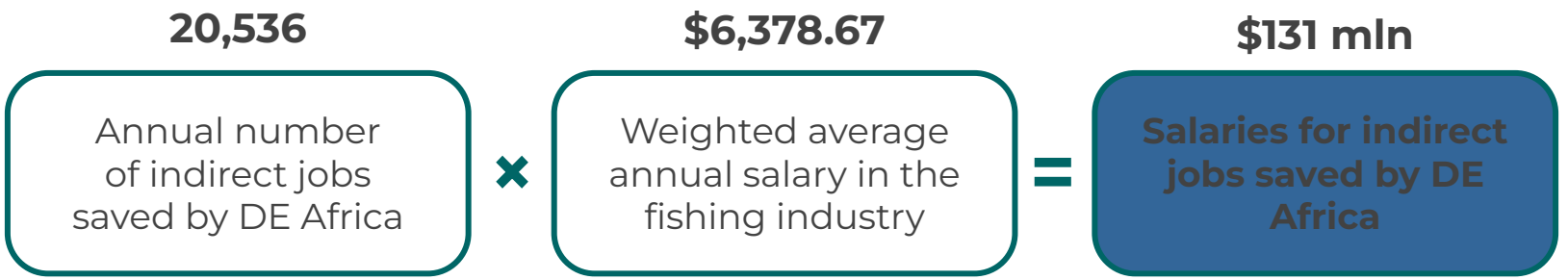
Calculation of indirect jobs saved by DE Africa annually

Once the number of direct jobs saved by DE Africa has been calculated, the **number of indirect jobs saved by DE Africa** has been implied by using the **employment multiplier** found in two African countries (Mauritania and Guinea):

Country	Employment multiplier [1]
Mauritania	1.04
Guinea	3.15
Average	**2.095**

$$\textbf{\textit{Annual number of indirect jobs saved by DEA}} =$$
$$= \textit{Annual number of direct jobs saved by DEA} * \textit{Average employment multiplier}$$
$$= 9{,}802 * 2.095 = \mathbf{20{,}536}$$

By multiplying the **number of indirect jobs saved by DE Africa** by the **weighted average annual salary in the fishing industry** (*see next slide*), it was possible to estimate the salaries for indirect jobs saved by DE Africa.



[1] World Bank, 2017..

Weighted average annual salary in fishing industry

The weighted average annual salary in the fishing Industry has been calculated by taking into consideration the annual salary within the fishing industry of 12 African countries and the industry-specific GDP. Countries have been selected according to information availability.

The “Weight” column is the result of : $\frac{\textit{Fishing industry GDP of selected country}}{\textit{Total fishing industry GDP of the countries considered}} = \frac{\textit{Fishing industry GDP of selected country}}{\$36{,}074{,}027{,}913.00}$

Country	Local currency	Average salary per month in fishing industry (local currency)[1]	Conversion rate local currency/USD	Average monthly salary in fishing industry (USD)	Average annual salary in fishing industry (USD)	Share of fishing industry on GDP	Total GDP (USD)[15]	Fishery GDP (USD)	Weight	Weighted average annual salary in fishing industry
Angola	AOA	157,000.00	0.0023 $	361.10	$ 4,333.20	4.6%[2]	$ 72,456,985,000.00	$ 3,333,021,310.00	0.092393933	$ 6,378.67
Cote D'Ivoire	XOF	203,000.00	0.0016 $	324.80	$ 3,897.60	0.8%[3]	$ 69,764,827,000.00	$ 558,118,616.00	0.01547148	
Gambia. The	GMD	9,580.00	0.018 $	172.44	$ 2,069.28	12.0%[4]	$ 2,078,070,000.00	$ 249,368,400.00	0.006912685	
Ghana	GHS	3,050.00	0.096 $	292.80	$ 3,513.60	4.5%[5]	$ 77,594,279,000.00	$ 3,491,742,555.00	0.096793809	
Kenya	KES	88,400.00	0.0083 $	733.72	$ 8,804.64	0.8%[6]	$ 110,347,079,000.00	$ 882,776,632.00	0.024471252	
Lybia	LYD	1,380.00	0.2 $	276.00	$ 3,312.00	9.0%[7]	$ 41,879,579,000.00	$ 3,769,162,110.00	0.104484094	
Morocco	MAD	11,700.00	0.091 $	1,064.70	$ 12,776.40	2.3%[8]	$ 132,725,261,000.00	$ 3,052,681,003.00	0.084622682	
Namibia	NAD	10,500.00	0.056 $	588.00	$ 7,056.00	3.0%[9]	$ 12,236,250,000.00	$ 367,087,500.00	0.01017595	
Nigeria	NGN	204,000.00	0.0023 $	469.20	$ 5,630.40	3.5%[10]	$ 440,776,971,000.00	$ 15,427,193,985.00	0.427653769	
Somalia	SOS	156,000.00	0.0018 $	280.80	$ 3,369.60	2.0%[11]	$ 7,292,721,000.00	$ 145,854,420.00	0.004043198	
South Africa	ZAR	18,800.00	0.056 $	1,052.80	$ 12,633.60	0.9%[12]	$ 419,946,428,000.00	$ 3,779,517,852.00	0.104771163	
Sudan	SDG	22,000.00	0.0017 $	37.40	$ 448.80	0.2%[13]	$ 34,326,058,000.00	$ 68,652,116.00	0.00190309	
Tanzania	TZS	760,000.00	0.00043 $	326.80	$ 3,921.60	1.4%[14]	$ 67,775,101,000.00	$ 948,851,414.00	0.026302896	
						Total		$ 36,074,027,913.00		

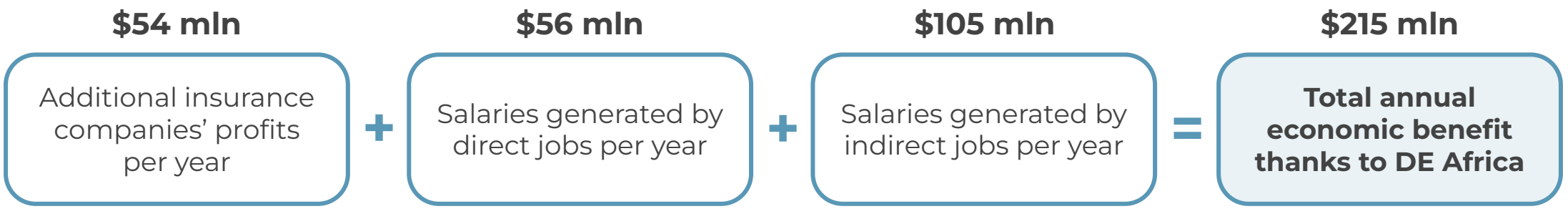
[1] Salary explorer.
[2] FAO
[3] FCWC
[4] The Point, 2022
[5] Republic of Ghana Fisheries and Aquaculture Sector Development Plan
[6] Ministry of Agriculture, Livestock and Fisheries, Kenya
[7] University of Benghazi
[8] Salon Halieutis
[9] International Trade Administration, 2021
[10] WorldFish, 2021
[11] SATG Filsan
[12] SADC-EU EPA
[13] FAO
[14] USAID
[15] World Bank

Insurance

General approach

The calculation of the potential **total annual economic benefit that DE Africa can provide to the insurance sector** in Africa when dealing with coastal erosion implications requires:

- The estimation of the **additional profits** generated per year by insurance companies thanks to DE Africa services.
- The calculation of the annual value of **salaries for direct jobs** created.
- The calculation of the annual value of **salaries for indirect jobs** created.



The following slides present a comprehensive breakdown of the three elements of the equation shown above.

The missing piece would be a calculation of consumer surplus, i.e. = (willingness to pay) – (price paid); but the Willingness to pay is quite hard to estimate, so we exclude such factor from the equation.

Calculation of insurance companies' profits (1/4)

In order to calculate the **additional profits** generated by insurance companies in Africa thanks to DE Africa services, our analysis uses the breakdown of the insurance premium, which is generally divided into three components.

A PwC article shows the cost distribution for insurers:[1]

- **Policy management & claims (i.e., reimbursement expenses)**: **40%**;
- **Overhead costs (SG&A, marketing, etc.): 60%**.

According to CSIMarket, the most recent average profit margin for Property & Casualty insurance is of 7.8%, whereas other sources report an average profit margin of 3%.[2,3] Following experts' inputs, our analysis opts for a conservative value:

- **Profits: 5%**.

Description	Share of premium (%)
Costs related to policy management & claims (i.e., reimbursement expenses)	~38%
Overhead Costs (G&A, marketing, etc.)	~57%
Profits	~5%

The model is based on **West Africa**'s data included in two West Africa Coastal Areas Management Program reports:

- **Cost of erosion as a share of West Africa's GDP: 1.4%**;[4]
- **Coastal zone's share of West Africa's GDP: 56%**.[5]

According to cross-referenced data reported in two sources, the coastal zone's share of West Africa's GDP is almost equal to that of coastal population (56% vs 55%).[6,7] We will assume that this relationship is true for all the African coastal countries.

$$\textbf{Share of coastal GDP} = \textbf{Share of coastal population}$$

[1] Braasch, T., Getting more for less: How insurance companies can squeeze the full benefit from general and administrative costs, Strategy&, 2021.

[2] CSIMarket

[3] Investopedia, 2021

[4] Croitoru, L., et al., *The cost of coastal zone degradation in West Africa: Benin, Cote D'Ivoire, Senegal and Togo*, WACA, 2019.[5] A Partnership for Saving West Africa's Coastal Assets, WACA, 2016.

[6] A Partnership for Saving West Africa's Coastal Assets, WACA, 2016.

[7] Resource Watch (2010)

Calculation of insurance companies' profits (2/4)

Coastal erosion mainly affects the economic activities that depend on the shoreline. It is therefore necessary to estimate the **impact that this phenomenon has on coastal GDP**. To do so, we will use West Africa as proxy:

$$\textbf{Cost of erosion as a share of coastal GDP} = \frac{Cost\ of\ erosion\ as\ a\ share\ of\ GDP}{Coastal\ zone's\ share\ of\ GDP} = \frac{1.4\%}{55\%} = \mathbf{2.55\%}$$

In the next slide, a chart will show the calculations of **coastal GDP** and **cost of erosion** for every African coastal country.

$$\boldsymbol{Expected\ cost\ of\ erosion} = Coastal\ GDP\ *\ Cost\ of\ erosion\ as\ a\ share\ of\ coastal\ GDP\ (West\ Africa\ as\ a\ proxy)$$

Calculation of insurance companies' profits (3/4)

Digital Earth AFRICA

Coastal countries	Share of coastal population	Total GDP (USD)[1]	Coastal GDP, using share of coastal population (USD	Cost of erosion (USD)
Algeria	71.00%	$ 167,983,141,000.00	$ 119,268,030,110.00	$ 3,035,913,493.71
Angola	29.00%	$ 72,456,985,000.00	$ 21,012,525,650.00	$ 534,864,289.27
Benin	58.00%	$ 17,785,640,000.00	$ 10,315,671,200.00	$ 262,580,721.45
Cabo Verde*	34.26%	$ 1,936,174,000.00	$ 663,258,131.68	$ 16,882,934.26
Cameroon	20.00%	$ 45,238,613,000.00	$ 9,047,722,600.00	$ 230,305,666.18
Comoros*	34.26%	$ 1,327,964,000.00	$ 454,908,970.77	$ 11,579,501.07
Congo, Dem. Rep	2.00%	$ 53,958,573,000.00	$ 1,079,171,460.00	$ 27,469,818.98
Congo, Rep.	21.00%	$ 12,523,961,000.00	$ 2,630,031,810.00	$ 66,946,264.25
Cote D'Ivoire	39.00%	$ 69,764,827,000.00	$ 27,208,282,530.00	$ 692,574,464.40
Djibouti	100.00%	$ 3,371,000,000.00	$ 3,371,000,000.00	$ 85,807,272.73
Egypt	44.00%	$ 404,142,000,000.00	$ 177,822,480,000.00	$ 4,526,390,400.00
Equatorial Guinea	69.00%	$ 12,269,392,000.00	$ 8,465,880,480.00	$ 215,495,139.49
Eritrea	69.00%	$ 2,065,001,000.00	$ 1,424,850,690.00	$ 36,268,926.65
Gabon	60.00%	$ 18,269,350,000.00	$ 10,961,610,000.00	$ 279,022,800.00
Gambia, The	78.00%	$ 2,078,070,000.00	$ 1,620,894,600.00	$ 41,259,135.27
Ghana	44.00%	$ 77,594,279,000.00	$ 34,141,482,760.00	$ 869,055,924.80
Guinea	30.00%	$ 15,850,520,000.00	$ 4,755,156,000.00	$ 121,040,334.55
Guinea Bissau	95.00%	$ 1,638,517,000.00	$ 1,556,591,150.00	$ 39,622,320.18
Kenya	8.00%	$ 110,347,079,000.00	$ 8,827,766,320.00	$ 224,706,779.05
Liberia	63.00%	$ 3,486,741,000.00	$ 2,196,646,830.00	$ 55,914,646.58
Lybia	88.00%	$ 41,879,579,000.00	$ 36,854,029,520.00	$ 938,102,569.60
Madagascar	51.00%	$ 14,637,400,000.00	$ 7,465,074,000.00	$ 190,020,065.45
Mauritania	32.00%	$ 8,227,580,000.00	$ 2,632,825,600.00	$ 67,017,378.91
Mauritius*	34.26%	$ 11,156,657,000.00	$ 3,821,838,056.72	$ 97,283,150.53
Morocco	66.00%	$ 132,725,261,000.00	$ 87,598,672,260.00	$ 2,229,784,384.80
Mozambique	56.00%	$ 16,095,828,000.00	$ 9,013,663,680.00	$ 229,438,711.85
Namibia	6.00%	$ 12,236,250,000.00	$ 734,175,000.00	$ 18,688,090.91
Nigeria	23.00%	$ 440,776,971,000.00	$ 101,378,703,330.00	$ 2,580,548,812.04
Sao Tome and Principe	100.00%	$ 547,092,000.00	$ 547,092,000.00	$ 13,925,978.18
Senegal	78.00%	$ 27,625,388,000.00	$ 21,547,802,640.00	$ 548,489,521.75
Seychelles*	34.26%	$ 1,320,053,000.00	$ 452,198,968.95	$ 11,510,519.21
Sierra Leone	60.00%	$ 4,200,380,000.00	$ 2,520,228,000.00	$ 64,151,258.18
Somalia	63.00%	$ 7,292,721,000.00	$ 4,594,414,230.00	$ 116,948,725.85
South Africa	38.00%	$ 419,946,428,000.00	$ 159,579,642,640.00	$ 4,062,027,267.20
Sudan	3.00%	$ 34,326,058,000.00	$ 1,029,781,740.00	$ 26,212,626.11
Tanzania	19.00%	$ 67,775,101,000.00	$ 12,877,269,190.00	$ 327,785,033.93
Togo	45.00%	$ 8,413,200,000.00	$ 3,785,940,000.00	$ 96,369,381.82
Tunisia	85.00%	$ 46,840,000,000.00	$ 39,814,000,000.00	$ 1,013,447,272.73
	Total		**$ 943,071,312,148.12**	**$ 24,005,451,581.95**

* For Cabo Verde, Comoros, Mauritius and Seychelles no information on the percentage of coastal population was available. We therefore used the average value of African coastal countries (34.26%)

[1] World Bank

Calculation of insurance companies' profits (4/4)

Once the cost of erosion is implied, our model assumes that **1.8% of it will be insured** - this figure was chosen as it equals Africa's average insurance penetration rate.

The result obtained represents the policy management & claims (i.e. reimbursement expenses):

An equation is then used to find the other components of the premium. The profits represent DE Africa's potential value creation in the insurance market.

$$\textbf{Costs related to policy management \& claims} = Cost\ of\ erosion * 1.8\%$$
$$= 24{,}005{,}451{,}581.95 * 1.8\% = \mathbf{\$432{,}098{,}128.48}$$

Description	Share of premium (%)	Value (USD)
Costs related to policy management & claims (i.e., reimbursement expenses)	~38%	$432,098,128.48
Overhead Costs (G&A, marketing, etc.)	~57%	$648,147,192.71
Profits	~5%	**$54,012,266.06**
Total value of the premiums		$1,134,257,587.25

[1] Reinsurance News, 2022.

Calculation of direct jobs & salaries generated thanks to DE Africa (1/2)

To calculate **the salaries generated for direct jobs in Africa's insurance sector**, the analysis focused on selected African insurance companies and implied their **Gross Written Premiums (GWP) in relation to the number of employees**. The companies have been selected considering availability of information.

Company name (non-life insurance)	Country	Gross Written Premiums (million), 2021 Currency	GWP ($)	Number of employees, 2021	GWP/Employees
Santam	South Africa	R	$ 2,852,335,815.84		$ 473,416.73
The Hollard Insurance	South Africa	R	$ 817,855,314.83		$ 189,406.05
Old Mutual Insure	South Africa	R	$ 1,078,334,461.75		$ 233,002.26
Misr Insurance	Egypt	$	$ 611,000,000.00		$ 92,575.76
				Average	**$ 247,100.20**

Currency conversion rate: $1 = R14.77[9]$

The **average ratio between GWP and number of employees** was then used to calculate the **potential number of direct jobs that DE Africa services can help create** in each country, which was then multiplied by the average industry-specific wage to imply the **economic value of the corresponding salaries** (*see next slide*).

[1] Santam, 2021 Integrated Report
[2] Hollard, 2021 report
[3] Old Mutual 2021 Annual Report
[4] Fitch Ratings
[5] Santam, 2021 Integrated Report
[6] Craft
[7] Old Mutual Limited, 2021 Annual Financial Statements
[8] Misr Life Insurance
[9] Fairfax

Calculation of direct jobs & salaries generated thanks to DE Africa (2/2)

Digital Earth AFRICA

Coastal countries		Coastal GDP, using share of coastal population (USD)	Local currency	Average annual salary in Insurance industry (local currency)[1]	Conversion rate local currency/USD		Average annual salary in insurance industry (USD)	Weight, calculated using coastal GDP		Share of insurance companies' revenues to which the country contributes (calculated using weight)	Direct jobs created by DEA		Salaries generated for direct jobs
Algeria	$	119,268,030,110.00	DZD	2,160,000.00	0.0071	$	15,336.00	0.126467669	$	143,446,912.58	581	$	8,902,873.63
Angola	$	21,012,525,650.00	AOA	3,140,000.00	0.0023	$	7,222.00	0.022280951	$	25,272,337.67	102	$	738,634.86
Benin	$	10,315,671,200.00	XOF	4,090,000.00	0.0016	$	6,544.00	0.010938379	$	12,406,939.09	50	$	328,575.25
Cabo Verde	$	663,258,131.68	CVE	2,460,000.00	0.0087	$	21,402.00	0.000703296	$	797,718.64	3	$	69,092.52
Cameroon	$	9,047,722,600.00	XAF	5,530,000.00	0.0015	$	8,295.00	0.00959389	$	10,881,942.73	44	$	365,300.05
Comoros	$	454,908,970.77	KMF	3,630,000.00	0.002	$	7,260.00	0.00048237	$	547,131.43	2	$	16,075.16
Congo, Dem. Rep	$	1,079,171,460.00	CDF	5,710,000.00	0.00049	$	2,797.90	0.001144316	$	1,297,948.95	5	$	14,696.59
Congo, Rep.	$	2,630,031,810.00	XAF	8,970,000.00	0.0015	$	13,455.00	0.002788794	$	3,163,210.99	13	$	172,241.88
Cote D'Ivoire	$	27,208,282,530.00	XOF	4,060,000.00	0.0016	$	6,496.00	0.028850716	$	32,724,143.44	132	$	860,282.74
Djibouti	$	3,371,000,000.00	DJF	3,310,000.00	0.0056	$	18,536.00	0.003574491	$	4,054,393.64	16	$	304,136.70
Egypt	$	177,822,480,000.00	EGP	111,000.00	0.051	$	5,661.00	0.188556769	$	213,871,946.40	866	$	4,899,749.53
Equatorial Guinea	$	8,465,880,480.00	XAF	5,750,000.00	0.0015	$	8,625.00	0.008976925	$	10,182,145.34	41	$	355,406.45
Eritrea	$	1,424,850,690.00	ERN	82,300.00	0.0666667	$	5,486.67	0.001510862	$	1,713,706.78	7	$	38,051.54
Gabon	$	10,961,610,000.00	XAF	6,650,000.00	0.0015	$	9,975.00	0.01162331	$	13,183,827.30	53	$	532,207.90
Gambia, The	$	1,620,894,600.00	GMD	191,000.00	0.018	$	3,438.00	0.00171874	$	1,949,494.14	8	$	27,124.06
Ghana	$	34,141,482,760.00	GHS	61,000.00	0.096	$	5,856.00	0.03620244	$	41,062,892.45	166	$	973,144.90
Guinea	$	4,755,156,000.00	GNF	84,200,000.00	0.00011	$	9,262.00	0.005042202	$	5,719,155.81	23	$	214,369.80
Guinea Bissau	$	1,556,591,150.00	XOF	4,110,000.00	0.0016	$	6,576.00	0.001650555	$	1,872,154.63	8	$	49,823.06
Kenya	$	8,827,766,320.00	KES	1,770,000.00	0.0083	$	14,691.00	0.009360656	$	10,617,395.31	43	$	631,242.53
Liberia	$	2,196,646,830.00	LRD	864,000.00	0.0065	$	5,616.00	0.002329248	$	2,641,967.05	11	$	60,045.63
Lybia	$	36,854,029,520.00	LYD	27,500.00	0.2	$	5,500.00	0.03907873	$	44,325,346.41	179	$	986,601.41
Madagascar	$	7,465,074,000.00	MGA	15,800,000.00	0.00024	$	3,792.00	0.007915705	$	8,978,448.09	36	$	137,783.28
Mauritania	$	2,632,825,600.00	MRO	239,000.00	0.026	$	6,214.00	0.002791757	$	3,166,571.15	13	$	79,631.96
Mauritius	$	3,821,838,056.72	MUR	559,000.00	0.022	$	12,298.00	0.004052544	$	4,596,628.86	19	$	228,770.93
Morocco	$	87,598,672,260.00	MAD	234,000.00	0.091	$	21,294.00	0.092886584	$	105,357,312.18	426	$	9,079,226.19
Mozambique	$	9,013,663,680.00	MZN	484,000.00	0.016	$	7,744.00	0.009557775	$	10,840,979.14	44	$	339,751.01
Namibia	$	734,175,000.00	NAD	210,000.00	0.056	$	11,760.00	0.000778494	$	883,012.30	4	$	42,024.35
Nigeria	$	101,378,703,330.00	NGN	4,080,000.00	0.0023	$	9,384.00	0.107498449	$	121,930,931.37	493	$	4,630,509.65
Sao Tome and Principe	$	547,092,000.00	STD	84,100,000.00	0.000039	$	3,279.90	0.000580117	$	658,002.47	3	$	8,734.04
Senegal	$	21,547,802,640.00	XOF	4,210,000.00	0.0016	$	6,736.00	0.02284854	$	25,916,129.90	105	$	706,478.79
Seychelles	$	452,198,968.95	SCR	236,000.00	0.074	$	17,464.00	0.000479496	$	543,872.03	2	$	38,438.58
Sierra Leone	$	2,520,228,000.00	SLL	68,600,000.00	0.000065	$	4,459.00	0.002672362	$	3,031,146.95	12	$	54,697.99
Somalia	$	4,594,414,230.00	SOS	3,120,000.00	0.0018	$	5,616.00	0.004871757	$	5,525,827.30	22	$	125,588.92
South Africa	$	159,579,642,640.00	ZAR	375,000.00	0.056	$	21,000.00	0.1692127	$	191,930,788.38	777	$	16,311,385.26
Sudan	$	1,029,781,740.00	SDG	439,000.00	0.0017	$	746.30	0.001091945	$	1,238,546.58	5	$	3,740.70
Tanzania	$	12,877,269,190.00	TZS	15,200,000.00	0.00043	$	6,536.00	0.013654608	$	15,487,842.85	63	$	409,665.96
Togo	$	3,785,940,000.00	XOF	6,340,000.00	0.0016	$	10,144.00	0.004014479	$	4,553,453.29	18	$	186,929.15
Tunisia	$	39,814,000,000.00	TND	47,100.00	0.31	$	14,601.00	0.04221738	$	47,885,383.64	194	$	2,829,518.10
										Total	**4,590**	**$**	**55,752,551.03**

Calculation of indirect jobs & salaries generated thanks to DE Africa (1/2)

To calculate the **number of indirect jobs created thanks to DE Africa**, the number of direct jobs created by DE Africa in each country was then multiplied by the **insurance carriers employment multiplier in the US, equal to 1.894**.[1] This choice was made due to lack of data referred to Africa.

The **total value of salaries generated for indirect jobs** in Africa was then obtained by multiplying the number of indirect jobs created by DE Africa in each country by the average yearly salary (*see next slide*).

[1] Economic Policy Institute, 2019

Calculation of indirect jobs & salaries generated thanks to DE Africa (2/2)

Digital Earth AFRICA

Coastal countries	Local currency	Average annual salary (local currency)[1]	Conversion rate local currency/USD	Average annual salary (USD)	Direct jobs created by DE Africa	Indirect jobs created by DE Africa	Salaries generated for indirect jobs
Algeria	DZD	2,150,000.00	0.0071 $	15,265.00	581	1,100 $	16,783,977.64
Angola	AOA	3,130,000.00	0.0023 $	7,199.00	102	194 $	1,394,519.10
Benin	XOF	4,080,000.00	0.0016 $	6,528.00	50	95 $	620,799.95
Cabo Verde	CVE	2,450,000.00	0.0087 $	21,315.00	3	6 $	130,329.27
Cameroon	XAF	5,520,000.00	0.0015 $	8,280.00	44	83 $	690,627.16
Comoros	KMF	3,620,000.00	0.002 $	7,240.00	2	4 $	30,362.47
Congo, Dem. Rep	CDF	5,690,000.00	0.00049 $	2,788.10	5	10 $	27,737.85
Congo, Rep.	XAF	8,940,000.00	0.0015 $	13,410.00	13	24 $	325,135.07
Cote D'Ivoire	XOF	4,040,000.00	0.0016 $	6,464.00	132	251 $	1,621,349.02
Djibouti	DJF	3,300,000.00	0.0056 $	18,480.00	16	31 $	574,294.63
Egypt	EGP	110,000.00	0.051 $	5,610.00	866	1,639 $	9,196,520.88
Equatorial Guinea	XAF	5,740,000.00	0.0015 $	8,610.00	41	78 $	671,969.13
Eritrea	ERN	82,000.00	0.0666667 $	5,466.67	7	13 $	71,806.90
Gabon	XAF	6,630,000.00	0.0015 $	9,945.00	53	101 $	1,004,970.17
Gambia, The	GMD	191,000.00	0.018 $	3,438.00	8	15 $	51,372.97
Ghana	GHS	60,800.00	0.096 $	5,836.80	166	315 $	1,837,093.36
Guinea	GNF	84,000,000.00	0.00011 $	9,240.00	23	44 $	405,052.00
Guinea Bissau	XOF	4,090,000.00	0.0016 $	6,544.00	8	14 $	93,905.68
Kenya	KES	1,760,000.00	0.0083 $	14,608.00	43	81 $	1,188,818.69
Liberia	LRD	861,000.00	0.0065 $	5,596.50	11	20 $	113,331.54
Lybia	LYD	27,400.00	0.2 $	5,480.00	179	340 $	1,861,828.08
Madagascar	MGA	15,800,000.00	0.00024 $	3,792.00	36	69 $	260,961.53
Mauritania	MRO	239,000.00	0.026 $	6,214.00	13	24 $	150,822.93
Mauritius	MUR	557,000.00	0.022 $	12,254.00	19	35 $	431,741.90
Morocco	MAD	233,000.00	0.091 $	21,203.00	426	808 $	17,122,567.00
Mozambique	MZN	482,000.00	0.016 $	7,712.00	44	83 $	640,829.37
Namibia	NAD	209,000.00	0.056 $	11,704.00	4	7 $	79,215.09
Nigeria	NGN	4,060,000.00	0.0023 $	9,338.00	493	935 $	8,727,194.18
Sao Tome and Principe	STD	83,900,000.00	0.000039 $	3,272.10	3	5 $	16,502.93
Senegal	XOF	4,200,000.00	0.0016 $	6,720.00	105	199 $	1,334,892.52
Seychelles	SCR	236,000.00	0.074 $	17,464.00	2	4 $	72,802.67
Sierra Leone	SLL	68,400,000.00	0.000065 $	4,446.00	12	23 $	103,295.96
Somalia	SOS	3,110,000.00	0.0018 $	5,598.00	22	42 $	237,103.02
South Africa	ZAR	374,000.00	0.056 $	20,944.00	777	1,471 $	30,811,380.31
Sudan	SDG	438,000.00	0.0017 $	744.60	5	9 $	7,068.74
Tanzania	TZS	15,200,000.00	0.00043 $	6,536.00	63	119 $	775,907.33
Togo	XOF	6,330,000.00	0.0016 $	10,128.00	18	35 $	353,485.38
Tunisia	TND	46,900.00	0.31 $	14,539.00	194	367 $	5,336,350.98
					Total	**8,694 $**	**105,157,923.40**

[1] salaryexplorer