AFRICA KNOWLEDGE PLATFORM

Mapping mines from space

Monitoring compliance of gold mines in Republic of Congo using earth observation

European Commission

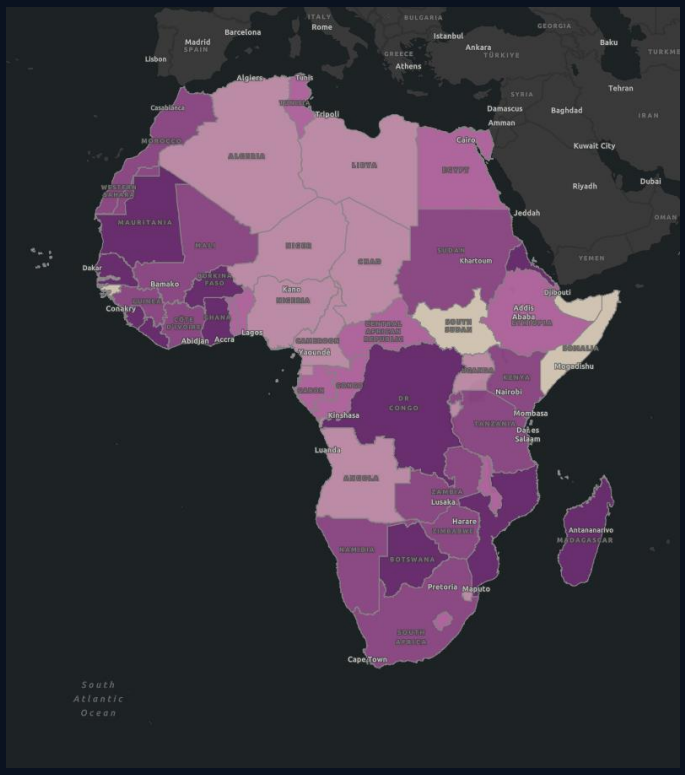
Mining contributes significantly to African economies, but mines impose pressures on ecosystems and are associated with illicit financial flows. Extractive industries are left unmonitored over large parts of Africa because of capacity constraints or the inaccessibility of remote regions. Earth observation offers high-resolution satellite imagery to monitor gold mines, increase transparency, and encourage responsible extraction.

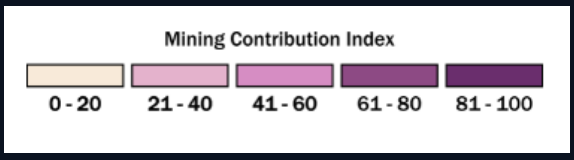
Mining in Africa

Mining is the cornerstone of many African economies as highlighted on the Mining Contribution Index.

This index aggregates mining's contributions to international exports and national Gross Domestic Product for African countries.

In the map below, darker shades of purple show how a country's economy is more dependent on mining. Click on the map to see index values for each country.





The five most mining-dependent countries in the world are all in Africa:

- Democratic Republic of Congo (96.2)
- Mauritania (95.6)
- Burkina Faso (94.0)
- Madagascar (91.7)
- Botswana (90.7)

Source: International Council on Mining and Minerals (2016) Role of mining in national economies: Mining Contribution Index.

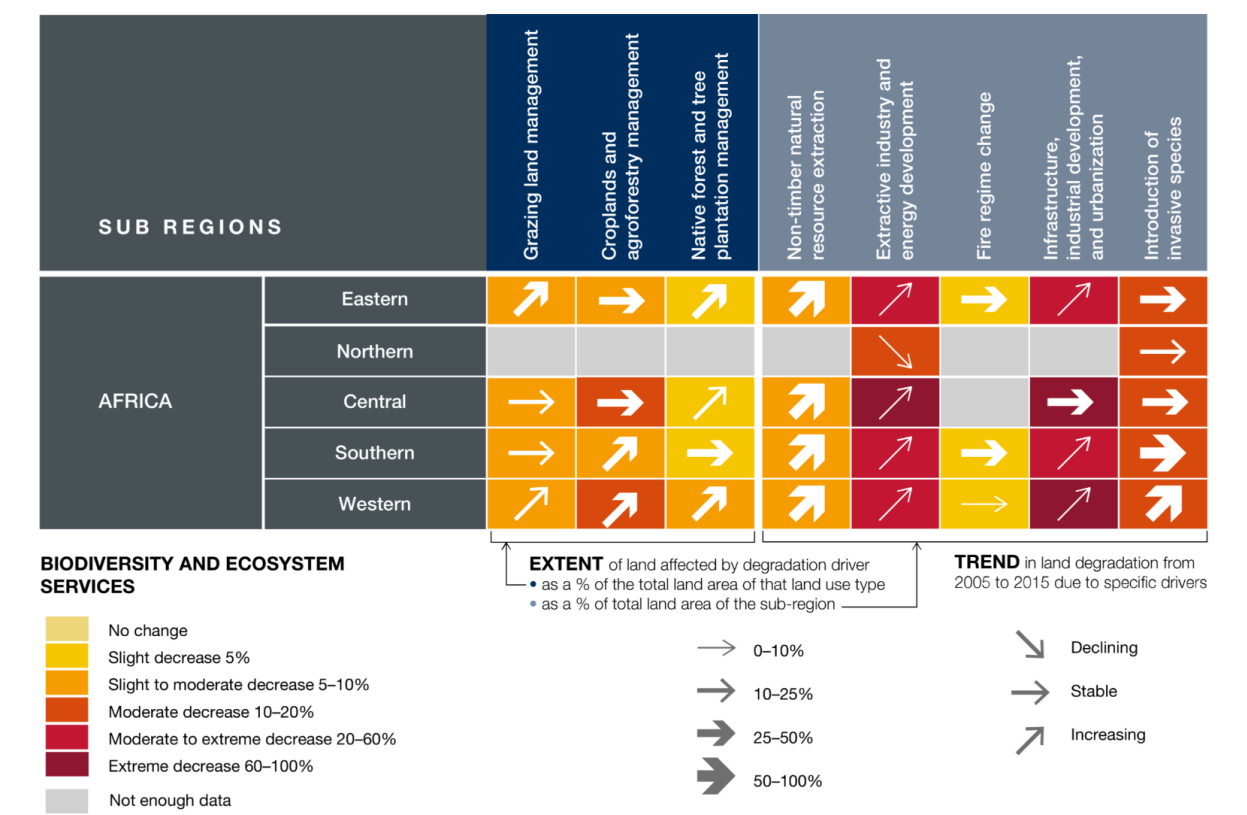
Mining's downside

Although mining is crucial for African economies, it is not without drawbacks.

The Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services reports that extractive industries and energy developments are most responsible for declines in biodiversity and ecosystem services.

In the figure below, deeper shades of red represent **greater declines in biodiversity and ecosystem services.**

The direction of arrows shows whether these pressures are increasing, stable or decreasing. Arrow thickness shows the extent of land affected by degradation.



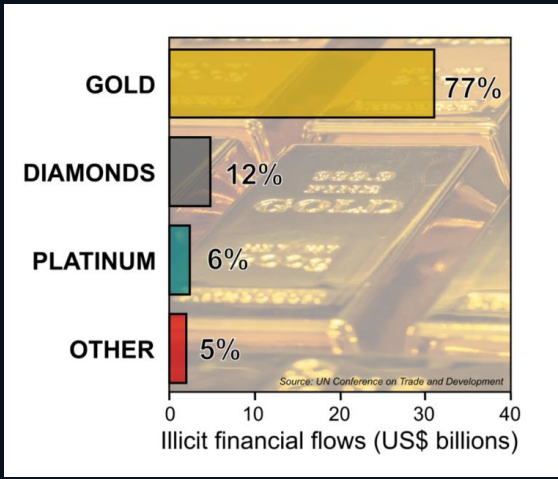
Focusing on the impacts of extractive industries shows how they are responsible for declines in biodiversity and ecosystem services across Africa.

Biodiversity and ecosystem services are most affected in central Africa. These pressure are increasing.

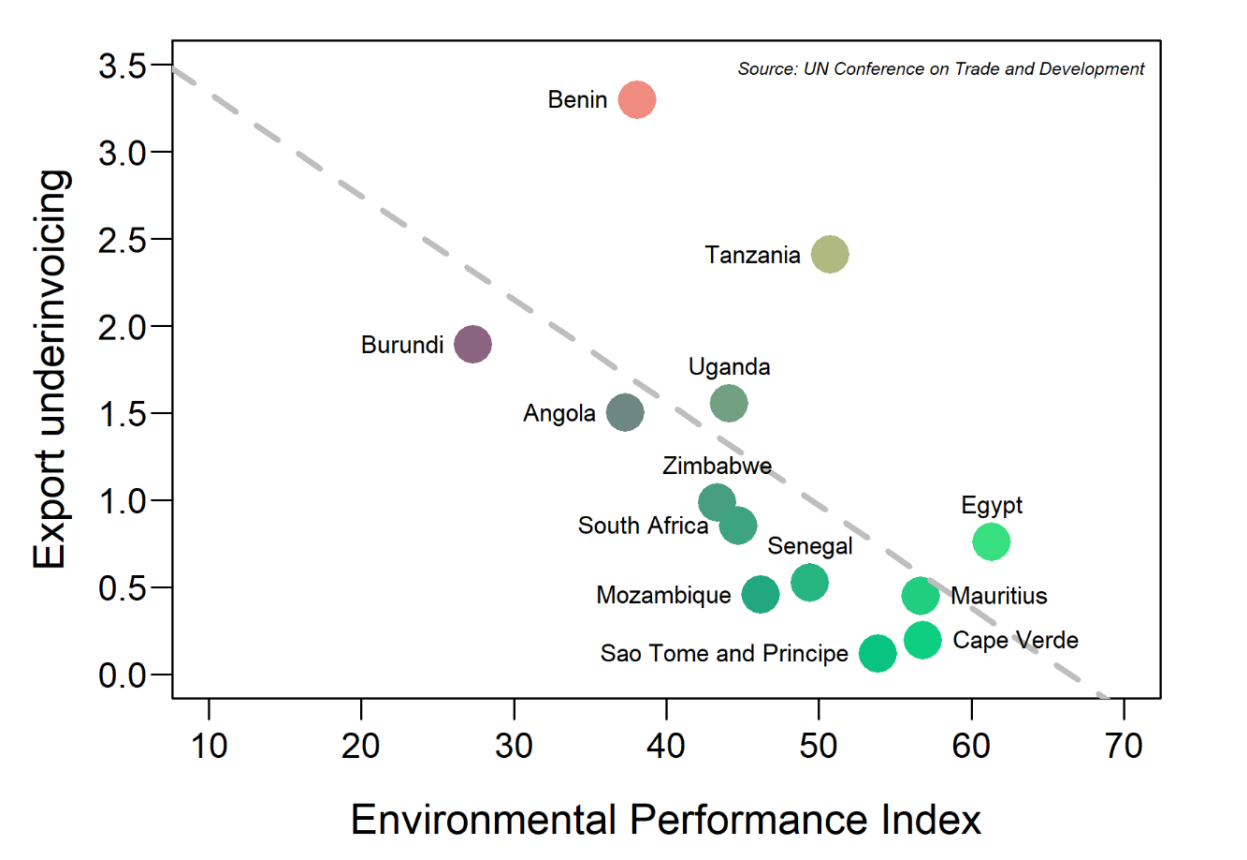
In eastern, southern and western Africa, mining pressures are moderate-to-extreme, and also increasing.

Northern Africa is the only part of the continent where mining pressures are decreasing. Here extractive industries have caused moderate decreases in biodiversity and ecosystem services.

Source: IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration.



The UN Conference on Trade and Development estimates that **illicit financial flows** from **extracted commodities** in Africa reach **US$40 billion per year**. These financial flows are associated with tax avoidance, corruption, and the trafficking in drugs, weapons, or people. Illicit financial flows can be tracked **through export underinvoicing,** which happens when the flow of raw materials leaving a country exceeds the payments entering the country. **High-value but low-weight commodities** are more likely to be linked to illicit trade. For instance, **77% of illicit financial flows in Africa can be attributed to gold mining**. It is comparatively easy to smuggle gold through organized crime networks. Once refined, the origin of smuggled gold is impossible to trace.



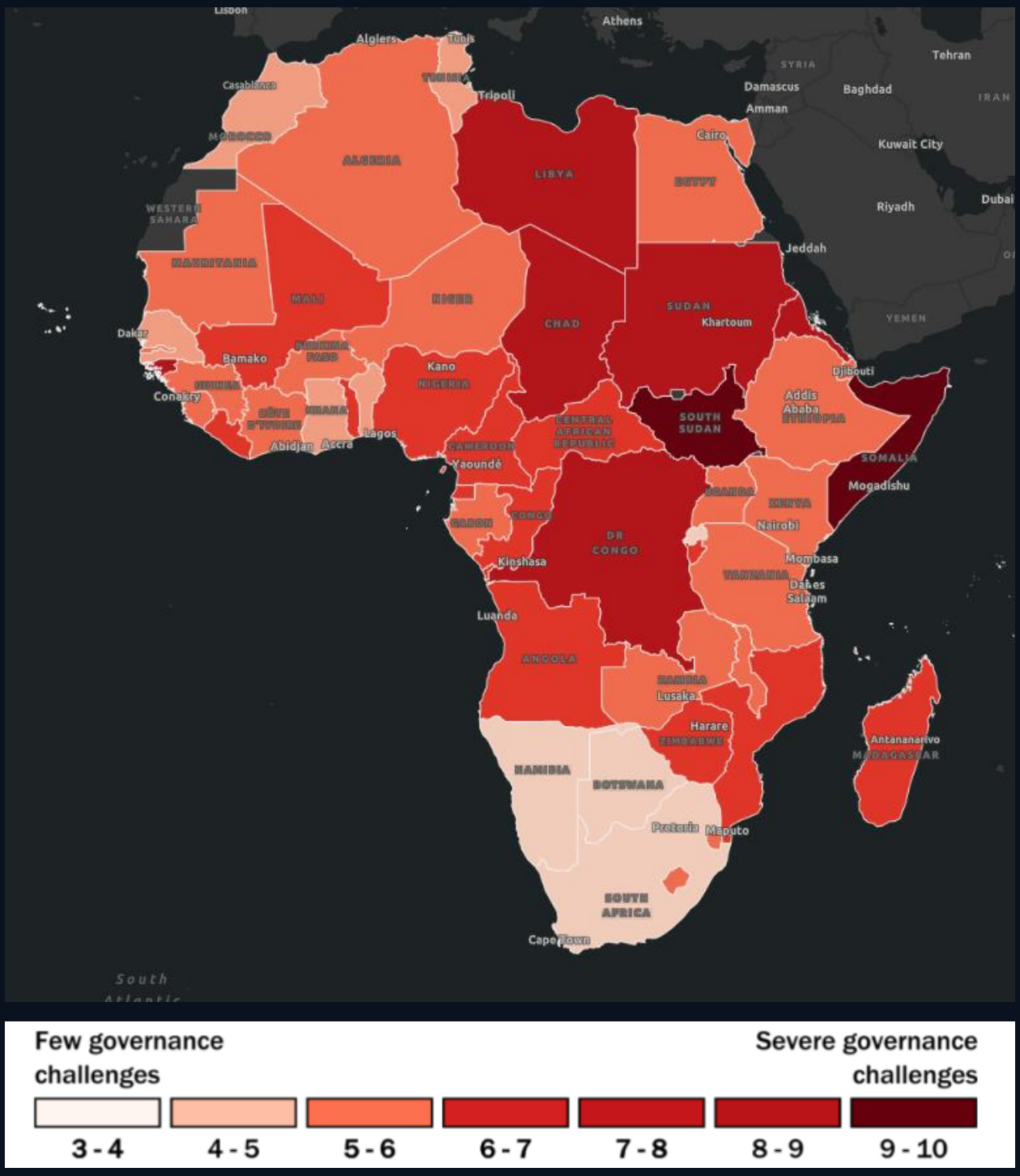
Countries with less export underinvoicing tend to score higher in the Environmental Performance Index, a metric that considers information on mining-related pollution and degradation. In the figure above, export underinvoicing is reported as the unaccounted exports as a percentage of national Gross Domestic Product.

Countries shown in green shades - like Egypt, Mauritius and Cape Verde - have low levels of export underinvoicing and good environmental performance. By contrast, countries is shades or red or purple - like Benin, Burundi and Tanzania - have more unaccounted for exports and lower environmental performance.**Improving compliance** in extractive industries can simultaneously tackle environmental pressures and illicit financial flows.

Source: UN Conference on Trade and Development, 2020 Tackling illicit financial flows for sustainable development in Africa .

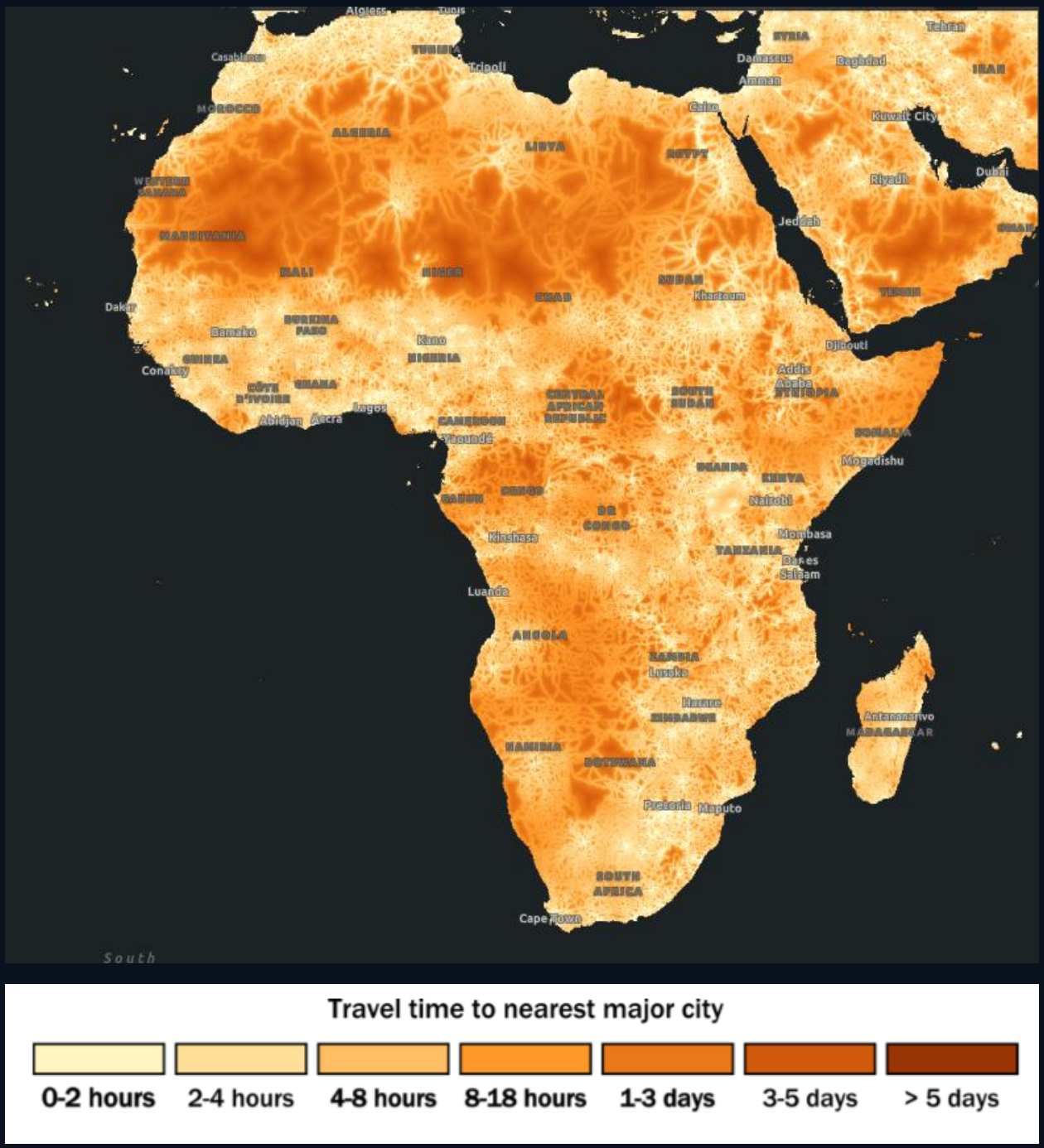
Obstacles to compliance

Many African countries perform poorly on the Governance Index , which combines **government effectiveness and corruption perception.**



Source: INFORM Risk models, Lack of Coping Capacity Index.

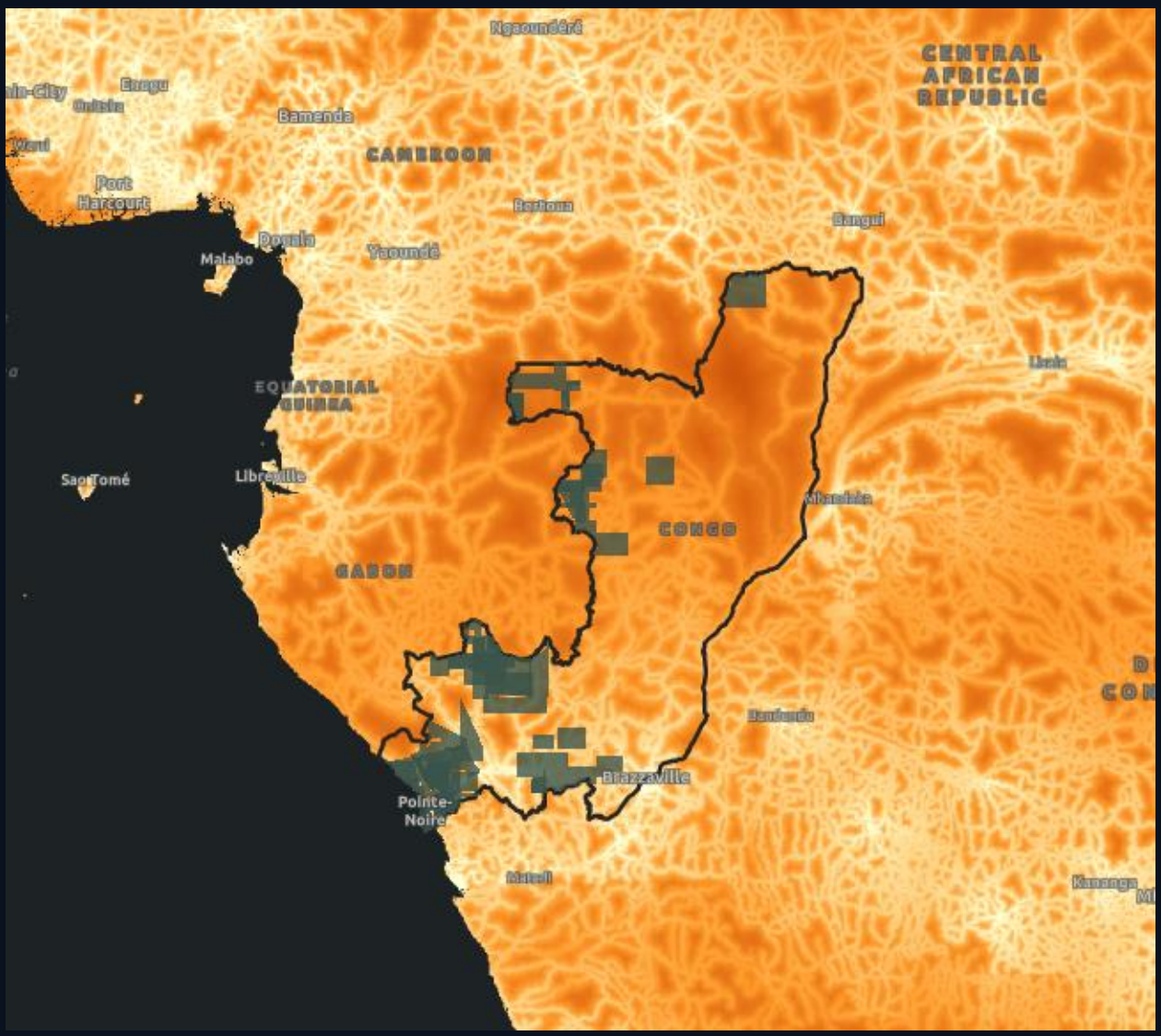
The Republic of Congo has a Governance Index score of 7.8, which makes it the 20th worst-ranked country in the world. This is because the country is considered the 14th most corrupt nation in the world according to Transparency International's Corruption perception Index . Without good governance, the current growth of gold mining in the Republic of Congo could worsen illicit financial flows. **Corruption in Congo's gold mining sector could be overcome through regular compliance monitoring.**



Even where states do have the capacity to regulate extractive industries, **expertise is often concentrated in urban centres.**

The map above shows the average overland travel times to the nearest major city. Darker shades of orange correspond to **longer travel times.** When mines are in remote regions, compliance officers need to travel for several hours, possibly even days, to reach the sites they are meant to monitor.

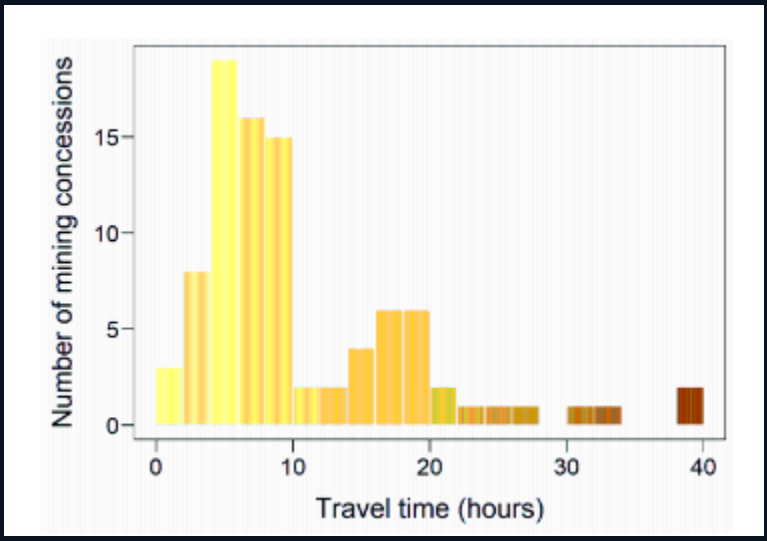
Source: *Travel time to major cities - A global map of Accessibility*



Despite governance obstacles, the Congolese Ministry of Mines and Geology, with support from the World Resources Institute, has mapped the **spatial locations of issued mining permits.**

These permit areas are shown as grey shapes in the map above.

The trouble is, government authorities are based in **Brazzaville in the south-east of the country** while most mining permits are issued in areas that can only be reached after **several hours of land travel.** This makes regular compliance monitoring difficult.

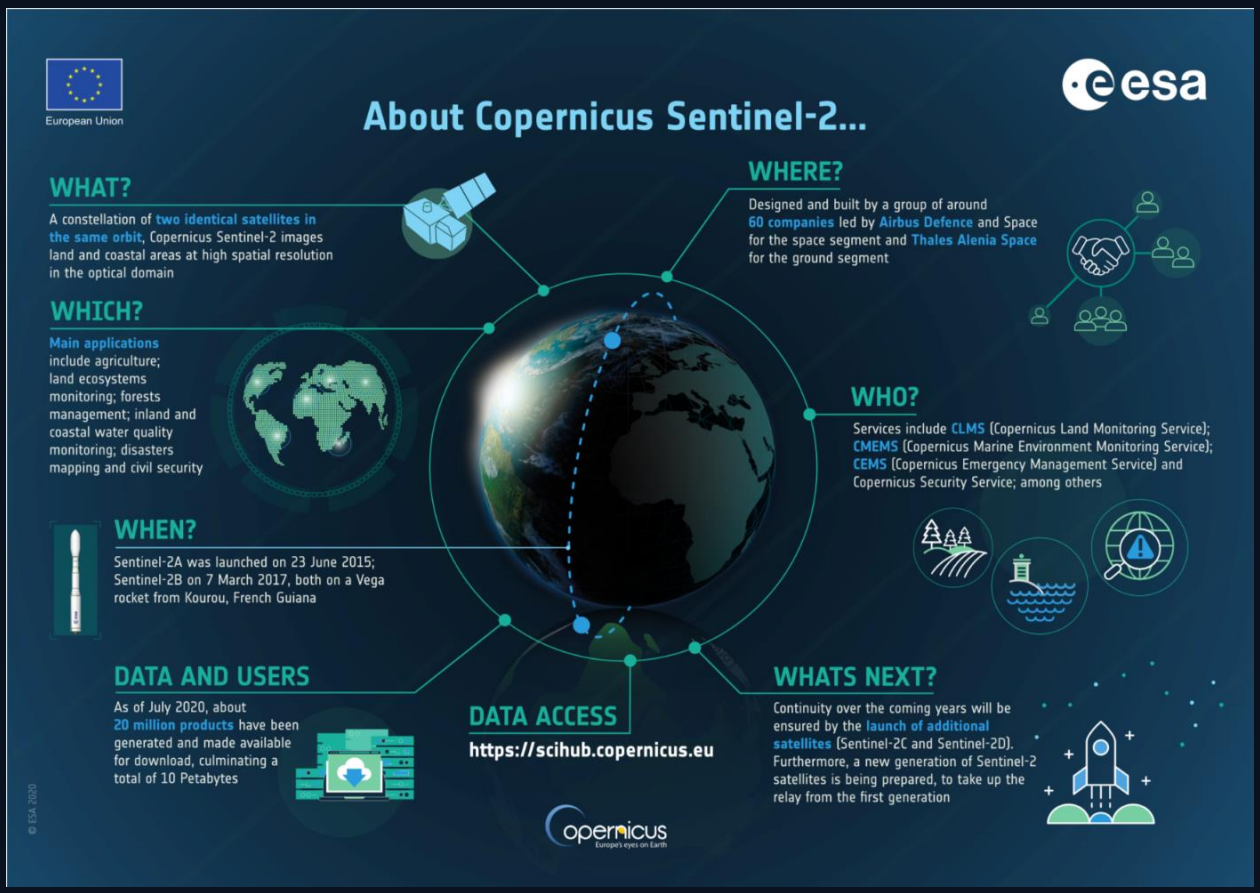


The distribution of travel-times to mining concession areas in the Republic of Congo

Monitoring from space

Modern satellite technology can be used to monitor whether mines in remote areas comply with mining permits. Copernicus is the European Union's program for earth observation. It supplies many freely available earth observation products generated from several Sentinel missions . Each Sentinel mission includes includes two satellites that orbit the planet and provide imagery for earth observation.

Sentinel 2 provides **multispectral optical images** that include both visible and invisible parts of the light spectrum. Combining different spectra can be used to classify land-cover, estimate vegetation productivity , or quantify soil water balances. A downside of Sentinel 2 sensors is that they can be blocked by clouds.



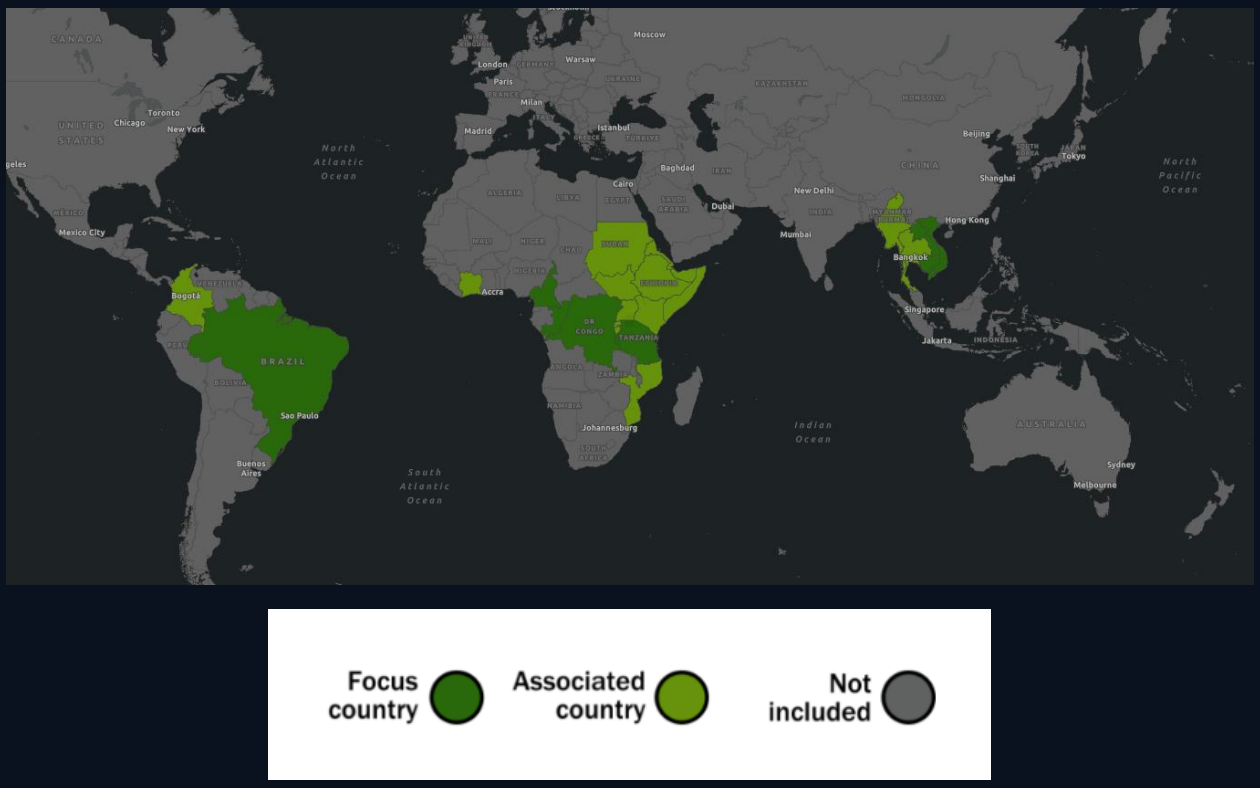
Another satellite mission, Sentinel 1 , captures RADAR imagery. RADAR is impervious to cloud cover, so can be used to fill in the gaps caused by overcast days.

This video shows the **orbit of Sentinel 1 around planet earth**. Its flight path was designed to collect imagery from terrestrial parts of the planet in a systematic

and efficient way. The video shows how **images are captured in 250km-wide swaths across the continents.** Sentinel imagery provides data over large parts of Africa every 5 days. These images are at resolutions from 10 to 20 meters, which are detailed enough to identify logging, road clearing or artisanal mining.

The European Commission, along with its partner organisations, has developed the ReCaREDD project (Reinforcement of Capacities for REDD+). This project has developed **earth observation methods** and **software tools** for assessing tropical forest cover and degradation across 24 tropical countries.

The map below shows the **8 focus countrie**s and 16 associated countries in the ReCaREDD project.



Gold mines in the Republic of Congo

In the Republic of Congo, the ReCaREDD project has **monitored the impacts of gold mine**s in the north-west of the country.

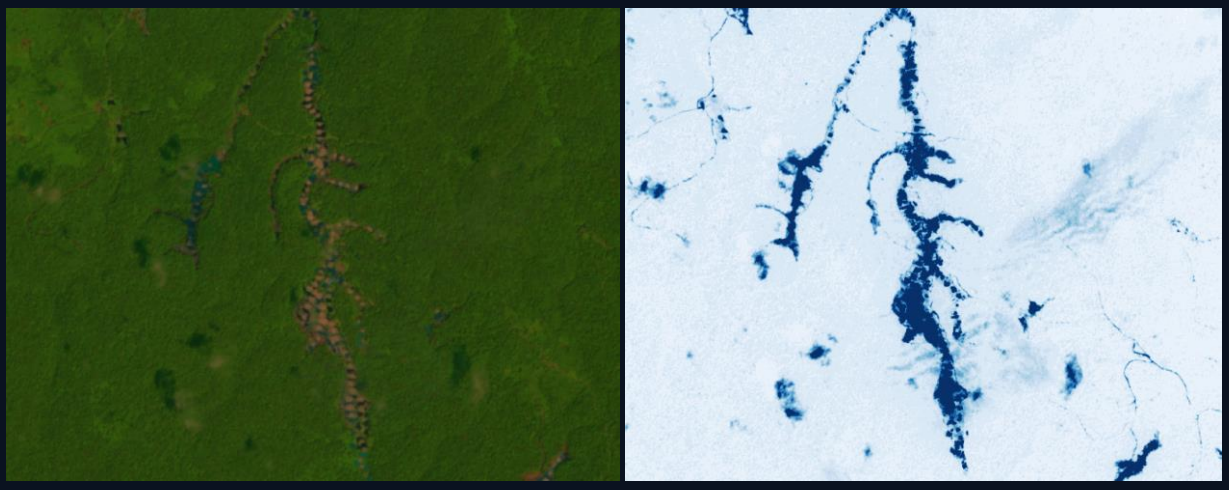
This area in the Cuvette-Ouest Province is more than 1,000 km from the capital, Brazzaville. Its remoteness makes **on-the-ground monitoring difficult**.

Gold mining takes place along the **river network.** Water flow is blocked by barrages, riverine forests are cleared, and the riverbed is dredged for ore. You can see the **ponds created in the river from aerial images**. Exposed sandbanks are also visible from space. This form of alluvial mining uses heavy machinery to clear roads and physically separate the sand fraction containing gold, from the larger mineral fraction.

Heavy machinery used to clear forest in Cuvette-Ouest

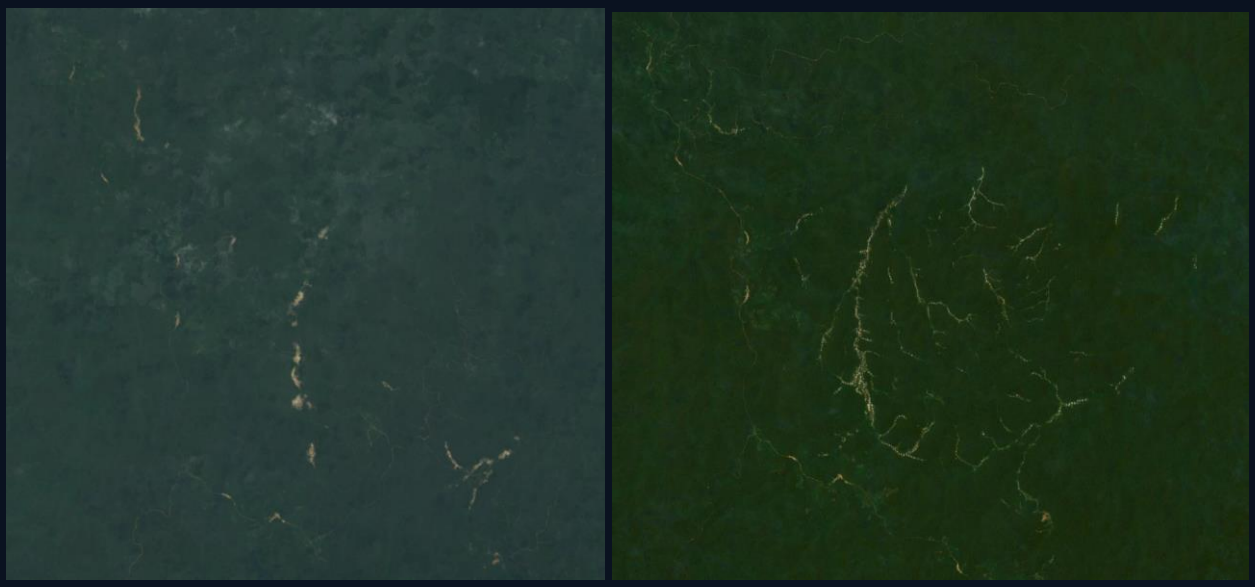
The mining process leaves clear spatial signs, which **can be monitored by satellites. Large pools of water and the clearance of trees** along riverbeds are visible from space.

Clearance of trees and exposed bare soil



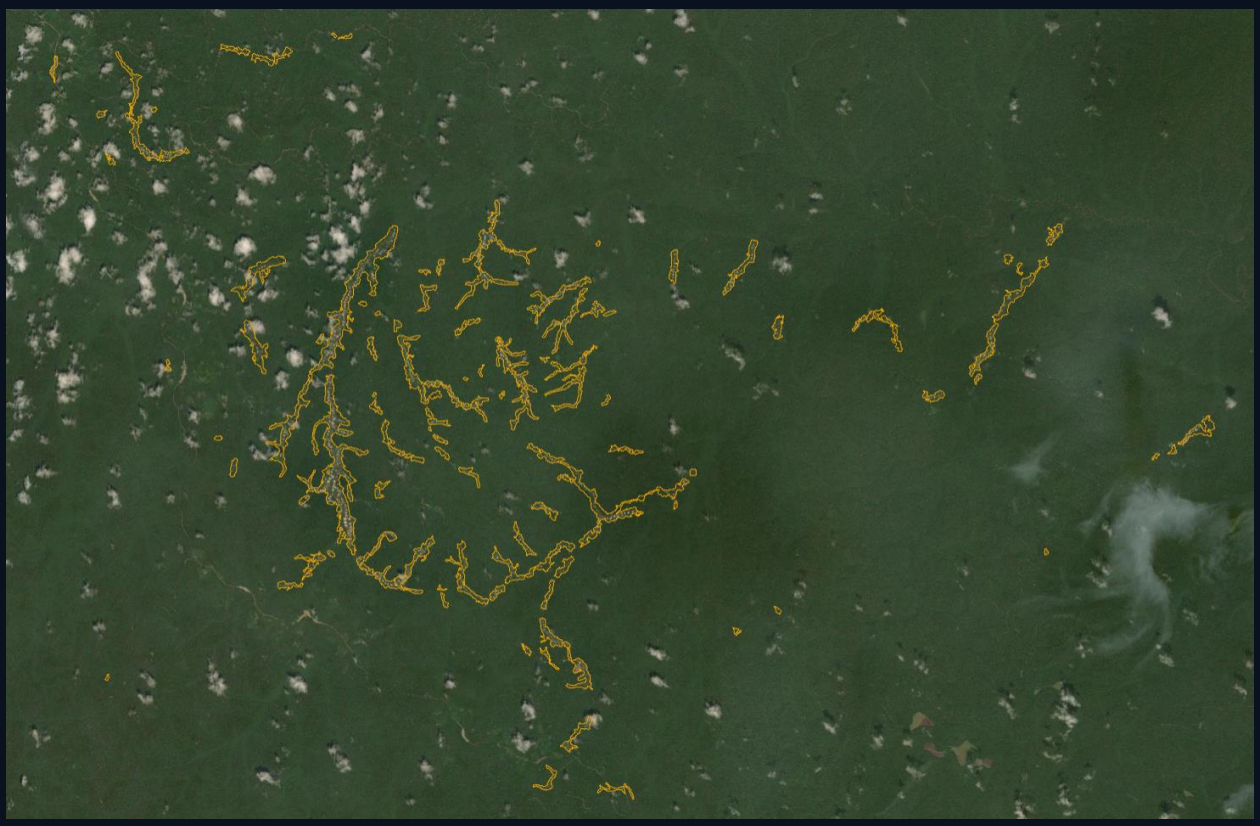
The images above allow comparing the visible light spectrum of a Sentinel satellite image (left), with the blue part of the light spectrum for the same imaging (right). The blue spectrum also identifies cloud cover. This is why the whole light spectrum, including parts invisible to the naked eye, is combined to paint a more accurate picture of land-cover.

Sentinel imagery also makes it possible to to track the growth of gold mines through time.



The images above allow comparing the mines in Cuvette-Ouest between 2016 (left) and 2020 (right). You will notice how mines appeared along the river network in recent years. From space, the ponds and sand banks look like strings of beads. But these beads are often more that 200 m wide, and can extend down the river for dozens of kilometers.

The ecological damage is significant, not to mention the risks to downstream communities who rely on these rivers for water.



The orange shapes in the map above show **the most recent boundaries of gold mines**. These boundaries were identified using **automated methods.** These automated methods provide valuable information on:

- Geographic localities of mines
- Number and extent of the mines
- Year when mining started
- Growth in mines through time

This information can be **cross-validated with mining permits** to monitor compliance.

The way forward

Earth observation can be **incorporated into a monitoring system** that allows authorities to link mining permits with on-the-ground mining expansion thousands of kilometers away.

This can **reduce underinvoicing and illicit financial flows** because the extent of gold extraction is monitored more accurately. Environmental impacts can also be monitored in near-real-time, increasing transparency and leading **to tighter enforcement of mining regulations.**

Monitoring using satellites supports the European Commission's EU Biodiversity Strategy for 2030 by **"raising the level of ambition and commitment worldwide**". Specifically, earth observation contributes to much stronger implementation, monitoring and review of country's biodiversity strategies while also creating an enabling framework to bring the ambition to life, across areas such as finance, capacity, research, innovation and technology.

Earth observation also contributes to the African Union's Africa Mining Vision by **improving the capacity to manage mineral wealth**. Using satellites for monitoring will ensure that industry players comply with the highest environmental standards.

https://africa-knowledge-platform.ec.europa.eu/

This document has been originated from a StoryMap compiled in the context the European Commission's Africa Knowledge Platform.

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