Global Development Assistance

Water Resources

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Contents

What does ESA's Global Development Assistance (GDA) AID activity on Water Resources do?

The European Space Agency's Global Development Assistance (GDA) programme is a global partnership to mainstream the use of Earth Observation (EO) into development operations, implemented in co-operation with major International Financial Institutions (IFIs).

To foster adoption and accelerate impact, ESA GDA focuses on targeted Agile EO Information Development (AID) applied to thematic priority sectors.

For further context and more resources please see: https://gda.esa.int/thematic-areas/

The ESA GDA AID Water Resources activity (herein referred to as ESA GDA Water) has been established as part of this programmatic co-operation with IFIs and partners, specifically with the World Bank (WB), the Asian Development Bank (ADB), and the African Development Bank (AfDB) in partnership with the Climate Investment Funds (CIF), a global climate fund.

ESA GDA Water provides EO Information in response to requirements identified in the urban domain by IFIs and their Client Country governments in developing countries. The activity assists IFI teams and local authorities in making better location-based and planning decisions with regard to policies, regulations, or investments providing evidence using Earth Observation services.

This booklet provides a summary of ESA GDA Water services offered (Use Cases). It also presents examples of combining different EO Information to address various water-related phenomena.

For further information please see: https://gda.esa.int/thematic-area/water-resources

ESA GDA AID Water Resources Activity Rationale

Water, covering two-thirds of our planet, is essential for sustaining life and is crucial to our health, agriculture, industry, energy production, and environment. It regulates the Earth's climate through the water cycle and is involved in many natural processes. However, water can also cause severe disasters, and climate change and pollution are depleting usable supplies, increasing the risk of conflicts over this vital resource.

As a finite resource, water must be carefully protected and managed to ensure its future availability. Effective implementation and monitoring of Integrated Water Resources Management (IWRM), Disaster Risk Reduction (DRR), and water quality initiatives depend on reliable water-related data. The GDA AID Water Resources activity provides satellite-based Earth Observation information to meet the needs of IFIs and their client-country governments in developing countries, addressing key global water management challenges.

GDA AID Water Resources Activity Themes and Topics

Water availability

Water availability refers to the amount of freshwater, both groundwater and surface water, that is accessible for human use and other needs, such as agriculture, industry, and ecosystem support. Many regions around the world are experiencing water scarcity due to a combination of factors such as climate change, inefficient water management and rapid population growth. It is important to address this issue by promoting water conservation, improving water management practices, and increasing investment in water infrastructure. Balancing water supply and demand is a key challenge in water management, particularly in regions with limited water resources.

Water quality

Water quality refers to the physical, chemical, and biological characteristics of water that determine its suitability for a particular use or ecosystem. Water pollution is a major problem that can affect human health, aquatic ecosystems, and wildlife. It is important to strengthen water quality monitoring to support pollution reduction by implementing regulations and best practices for wastewater treatment, agricultural runoff, and industrial discharges.

Water governance

Effective water governance and integrated water resources management approaches are essential for managing this resource sustainably. This includes establishing clear policies and regulations, promoting stakeholder engagement, and ensuring that decision-making is based on sound scientific data. Overall, effective water governance and cross-boundary cooperation is critical for ensuring sustainable and equitable use of water resources and achieving the goals of sustainable development.

Water-related disasters

Water-related disasters such as floods and droughts can have devastating effects on communities and the environment. Facing altered climate conditions, it is important to build resilience to these events by implementing measures such as early warning systems, floodplain management, and drought preparedness to prevent or mitigate potential risks. This also includes monitoring river and delta morphology, protecting and restoring natural water resources by preserving wetlands, rivers and stream habitats, and promoting sustainable land use practices that protect and recharge groundwater resources.

Who runs ESA GDA AID Water Resources?

The activity is implemented by a consortium of seven European companies leading in the fields of Earth Observation, remote sensing, Geographic Information Systems (GIS), modelling and the integration of technology into international development contexts with a determined commitment to driving impactful and efficient transformations.

The consortium is led by EOMAP GmbH.

The consortium members are:

EOMAP GmbH (DE) - https://www.eomap.com/

BROCKMANN CONSULT GmbH (DE) - https://www.brockmann-consult.de/

GEOVILLE GmbH (AT) - https://www.geoville.com/

GMV S.L. (ES) - https://www.gmv.com/

GISAT SRO (CZ) - https://www.gisat.cz/

GRUNER AG (CH) - https://www.gruner.ch/

UFZ - The Helmholtz - Centre for Environmental Research GmbH (DE) - https://www.ufz.de/

Use Case Examples

Water Supply and Demand

The imbalance between water supply and demand, along with its uneven distribution, presents a critical challenge. International Financial Institutions (IFIs) rely on contextual data to strategically target and scale water accessibility projects and infrastructure. Earth Observation (EO) provides crucial insights into both current and historical water supply trends by monitoring surface water extents in rivers and lakes, changes in reservoir storage, groundwater fluctuations, and irrigation water use. This information aids IFIs in planning investments and assessing the impact of existing projects in client countries. Additionally, EO-based projections of water demand, which integrate EO-derived data into demand models, are essential for scaling IFI investments in urban and agricultural regions. These projections offer insights into crop water consumption, water stress, water use efficiency, and irrigation performance, supporting investments to enhance agricultural productivity and water resource efficiency.

Description

Inland water bodies are detected, including their seasonal variability and changing extent.

Use

Water extent mapping and monitoring is crucial for managing limited water resources.

Input data

Sentinel-1 and Sentinel-2

Spatial resolution and coverage

10m, global

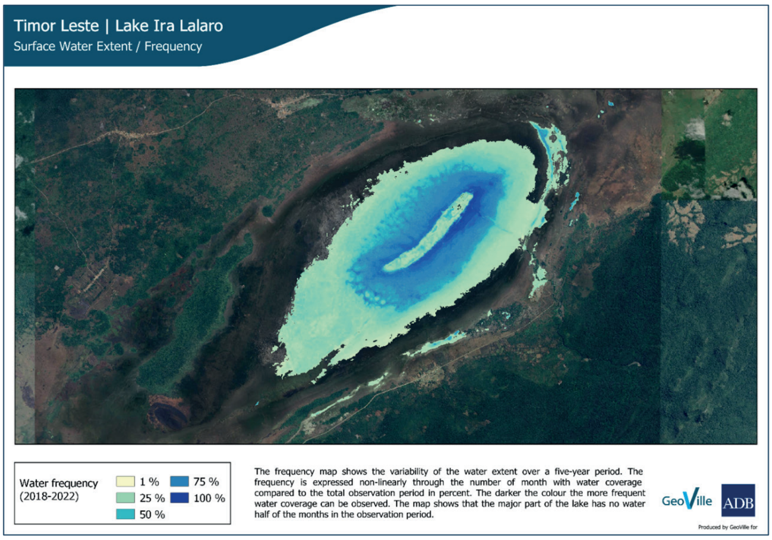
Benefits

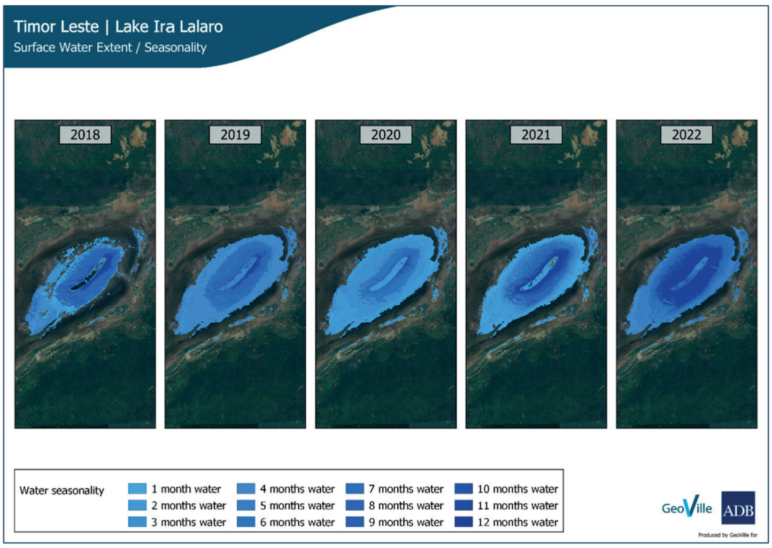
Large-scale assessment and monitoring

Dense and uninterrupted timeline

Frequency

Monthly, on-demand





Use Case Examples

Infrastructure Planning

Reservoirs and dams serve multiple purposes, including irrigation, flood protection, and hydropower production. Infrastructure projects and construction in these areas are highly dependent on environmental conditions, making access to reliable information essential for defining fundamental characteristics. A major challenge for hydropower and similar developments is the lack of early-stage data on environmental factors like hydrology and water quality. EO data provide valuable insights to support the planning, monitoring and maintenance of large infrastructure, such as dams and reservoirs, as well as to assess their environmental impact, particularly on downstream ecosystems. EO data can be used by the IFIs to evaluate potential sites for sand dams, assess sediment-related safety factors, address dam safety concerns (e.g., populations at risk), and monitor changes in river flows and habitats downstream.

Description

EO-based products on water quality, sediments, water extent, and land use, combined with DEM, GIS and hydrological forecasts, support cost-effective planning and monitoring and optimise infrastructure and hydropower projects.

Use

Characterise environmental conditions for ecological assessments analysing upstream and downstream dynamics and evaluate erosion risk potential.

Input data

Sentinel-1, Sentinel-3, Sentinel-2, SuperDoves, Landsat 5-9, external modelling data, DEM

Spatial resolution and coverage

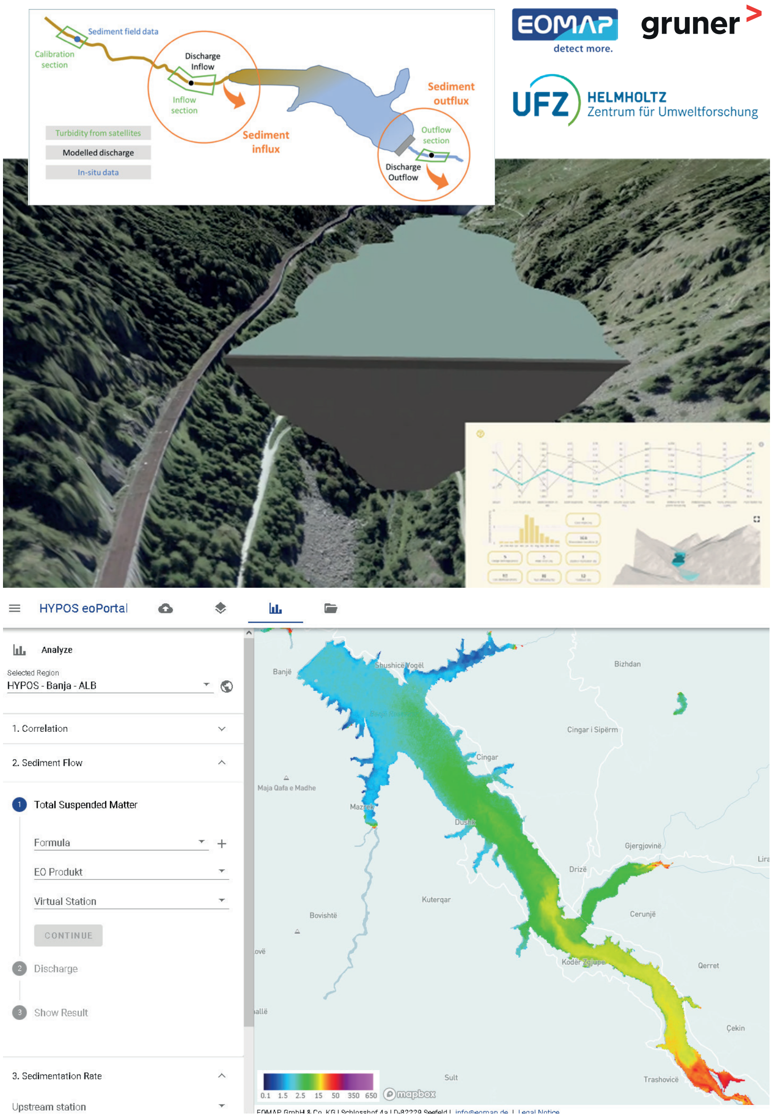
3-300m, global

Benefits

Back-date to the early 80ties, catchment-wide information, monitoring trends

Frequency

Monthly, on-demand



Use Case Examples

Groundwater Monitoring

Groundwater is the largest source of freshwater, accounting for over 97% of the planet's non-liquid freshwater. Globally, it provides 36% of drinking water, 42% of irrigation water, and 24% of industrial supply, with these proportions increasing in remote and arid areas. Aquifers' large storage capacities and retention times give groundwater resources exceptional drought resilience and enhance water security. Groundwater also plays a crucial role in sustaining river base flows and dependent ecosystems such as lakes and wetlands. Consequently, groundwater depletion often reduces runoff, weakens riparian vegetation, and alters dependent habitats. Despite its importance, groundwater monitoring remains limited due to the high cost of drilling and maintaining wells, a lack of digitised systems, and restricted data access for geopolitical reasons. Remote sensing technology, through initiatives like GRACE and GRACE-FO, has revolutionised groundwater assessment by providing information on water content via changes in the Earth's gravity field, offering valuable insights for water management.

Description

Groundwater monitoring and large-scale groundwater recharge estimates by combining data assimilation systems with Earth Observation data.

Use

Understand groundwater dynamics over time and quantification of groundwater recharge and abstractions. Sustainability assessment of groundwater resources.

Input data

GRACE & GRACE-FO Terrestrial Water Storage Anomaly (TWSA) + GLDAS

Spatial resolution and coverage

0.25° x 0.25°, Global

Benefits

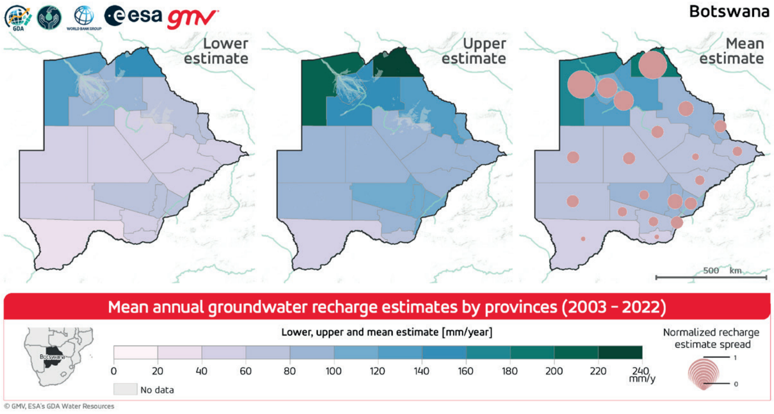
+20 years of large-scale EO-based groundwater monitoring products

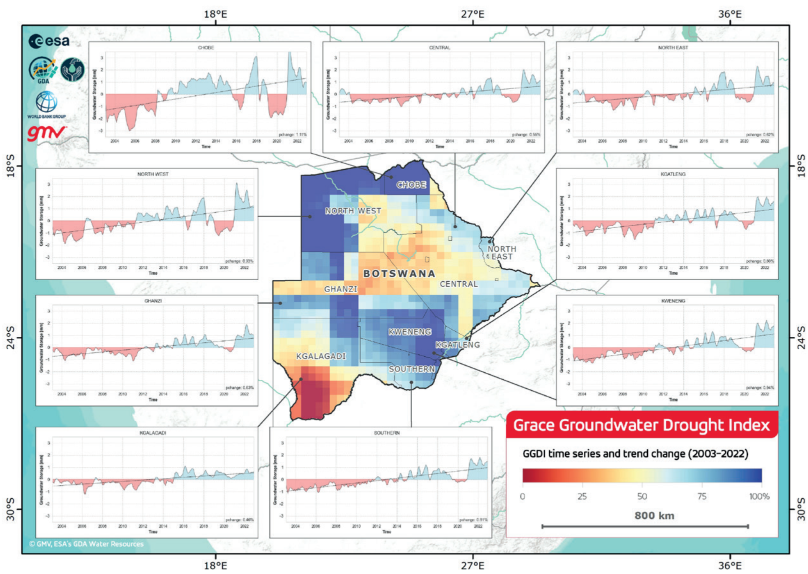
Enhanced knowledge on groundwater resources availability and consumption

Large-scale groundwater recharge and abstractions quantification

Frequency

Monthly long-term time series & trends on-demand





Use Case Examples

Drought Monitoring (meteorological drought)

As climate change intensifies, the frequency and severity of meteorological droughts are increasing, impacting water resources and agriculture worldwide. Meteorological drought is defined by a lack of precipitation relative to a typical baseline, with key monitoring indices including the Standardized Precipitation Index (SPI), which uses precipitation data alone for simplicity and broad climate applicability, and the Standardised Precipitation Evapotranspiration Index (SPEI), which incorporates temperature to reflect its role in water balance. Both indices support regular or on-demand drought assessments, enabling more responsive monitoring. The service empowers IFIs to detect significant drought anomalies early, supporting climate risk management. Integrating data on precipitation, soil moisture, surface water, and vegetation water content is essential for developing models that predict droughts and provide early warning in hotspot areas. Earth Observation data is crucial in producing Combined Drought Indicators (CDI), which consolidate multiple drought metrics for a holistic view of drought conditions. .

Description

Provides time-series information and analyses precipitation, evapotranspiration patterns, soil moisture anomalies, decreases in the extent of water bodies, total water storage anomalies, and climate combined drought indexes.

Use

Provides monitoring and forecast on meteorological drought over time and its trends.

Input data

Meteo and EO datasets

Spatial resolution and coverage

10m-25km, global

Benefits

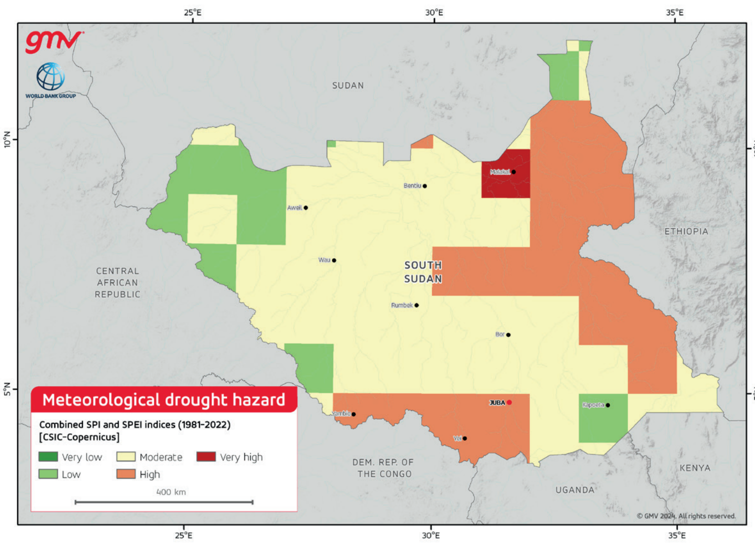
Climate risk monitoring and assessment

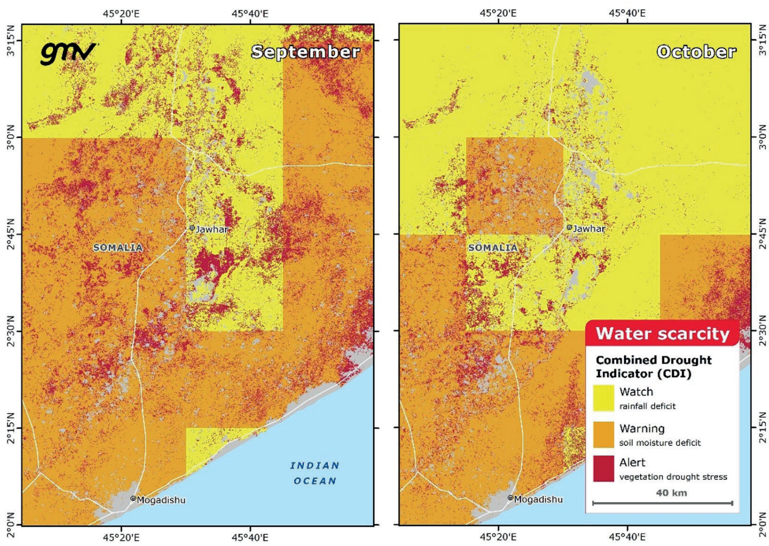
Food security support, potential crop damages assessment

Compensation support and subsequent control

Frequency

Monthly, on-demand





Use Case Examples

Drought Monitoring (agricultural drought)

Agricultural drought assesses the impact of meteorological or hydrological drought on agriculture by examining precipitation shortages, evapotranspiration deficits, and soil water shortages that can lead to crop failure. Crop canopy development relies heavily on climate variables such as air and soil temperature, soil moisture, and precipitation, with temporal climate variations causing significant shifts in crop growth. Satellite data offer large-scale, high-frequency monitoring of crop conditions, using vegetation indices to assess crop health. General vegetation vigour and canopy water content are captured by normalised EO based indices, which correlate with key biophysical characteristics of crop canopies, including leaf area, biomass, canopy closure, chlorophyll, and water content. Analysing temporal profiles of these indices provides valuable insights into changes in crop health over time, aiding in drought impact assessments on canopy water status and productivity.

Description

EO-based products on crop status and evolution. assessment based on long-term analysis of time-series of EO datasets

Use

Assessment of actual crop status and identification of anomalies from long-term average conditions. Identification of agriculture drought impact on productivity.

Input data

Sentinel-1, Sentinel-2, Landsat 5-9, Planet

Spatial resolution and coverage

10m, global

Benefits

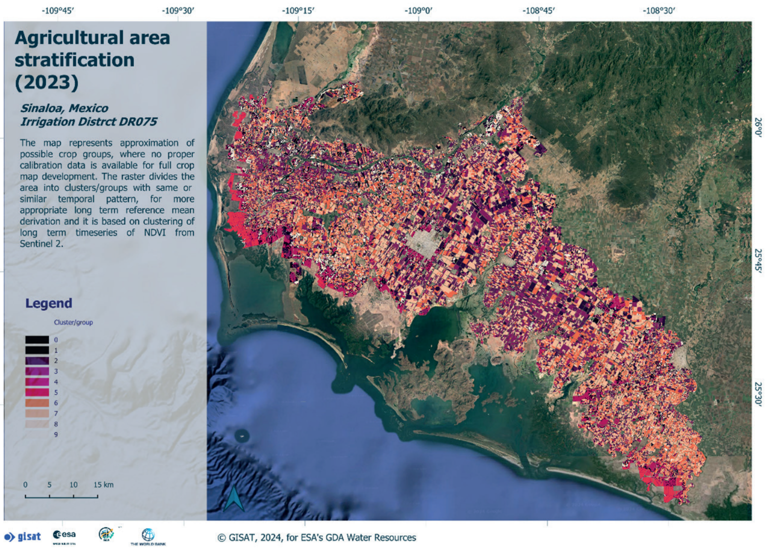
Detailed crop status analysis

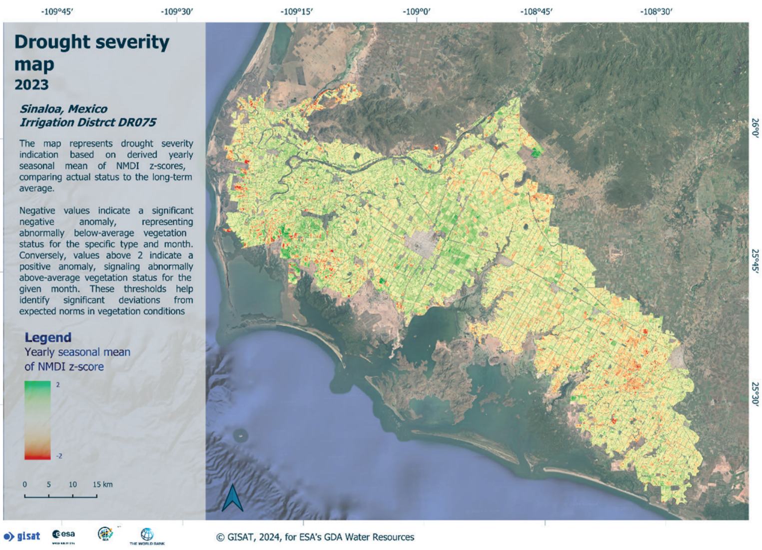
Detection of the crop damage risk - climate risk monitoring and assessment

Applicable on local (parcel) or regional (grid) level

Frequency

On-demand





Use Case Examples

Flood Detection, Forecasting and Risk Assessment

Floods are among the most frequent natural disasters, with climate change, agricultural intensification, urbanisation, and soil sealing increasing flood risks by reducing drainage capacity. Detecting and monitoring floods is essential for assessing at-risk populations and building resilience based on local hydrological conditions. Leveraging advanced EO applications in flood detection, forecasting, and risk assessment can improve data accuracy and frequency, enhancing countries' resilience to water-related disasters. Priority should be given to planning activities supported by IFI development assistance projects, which aim to strengthen resilience to extreme flood events.

Description

On demand flood mapping provides timely support for analysis of flood related impacts. Risk assessments can help mitigating the impact of floods. Combination with modelling can help to estimate different flood zones.

Use

Quantification of areas affected by floods, inclusion of historical flood data and flood risk assessments for spatial analysis and management.

Input data

Sentinel-1 Sentinel-2, Landsat 5-9, modelling data, DEM

Spatial resolution and coverage

10m, global

Benefits

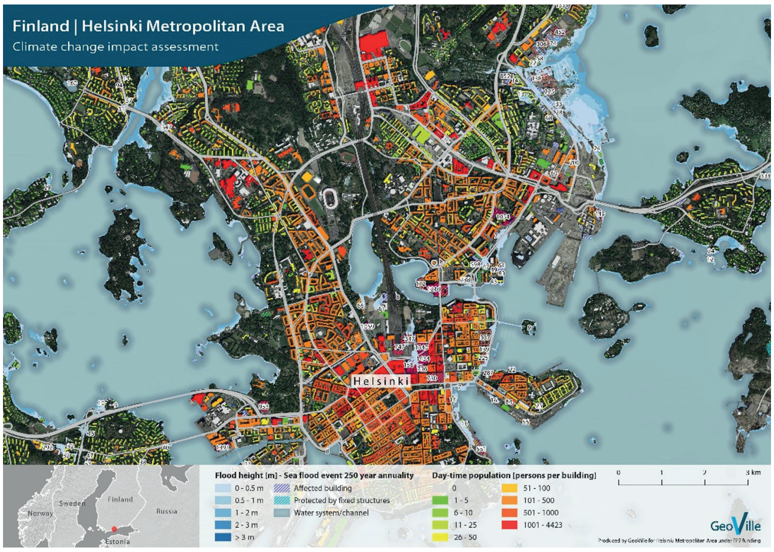
Timely assessment of flood events

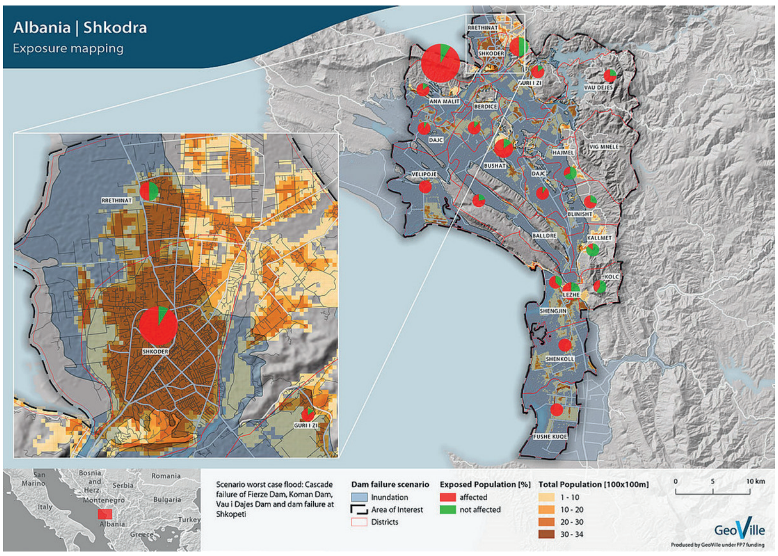
Elaboration of action plans for mitigation

Delineation of risk areas

Frequency

3-5 days (depending on the location), on-demand





Use Case Examples

Monitoring of Freshwater Quality

Freshwater resources are increasingly pressured by population growth and climate change, making aquatic ecosystem protection essential. Satellite monitoring provides large-scale assessments of freshwater quality, measuring key parameters such as turbidity, chlorophyll-a, cyanobacteria, Secchi depth, sediment levels, and water surface temperature. This data offers insights into drinking, bathing, and wastewater quality in rivers and lakes, identifying areas impacted by Harmful Algal Blooms (HABs) and high phytoplankton biomass. EO data also highlight regions prone to algal blooms, supporting targeted in-situ efforts and cost efficiency. Client countries and IFIs use EO insights for sustainable water management, precisely identifying interventions while reducing mobilisation, health risks, and impacts of IFI-supported projects.

Description

Monitoring key water quality parameters such as turbidity, chlorophyll-a, harmful algae blooms or surface water temperature with a broad range of satellite sensors.

Use

Providing environmental evaluation, government reporting and impact assessment for drinking, bathing and wastewater topics.

Input data

Sentinel-3, Sentinel-2, SuperDoves, Landsat 5-9

Spatial resolution and coverage

3m-300m, global

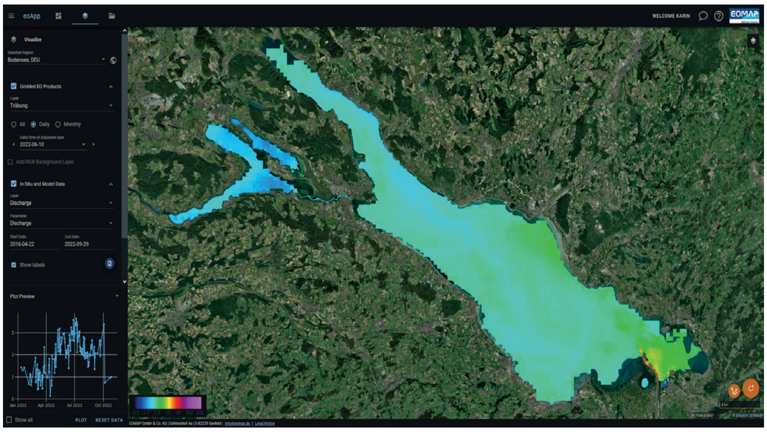
Benefits

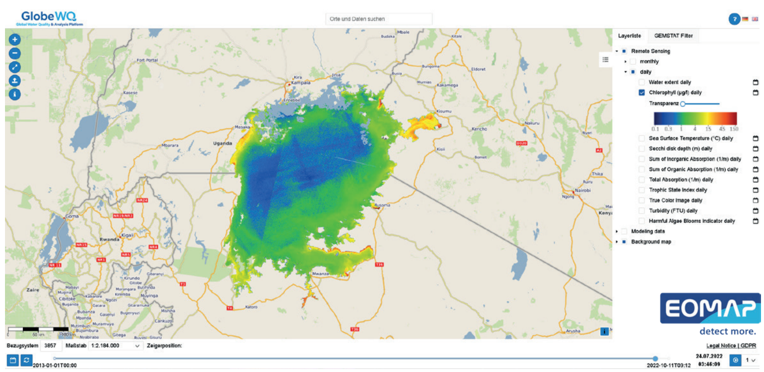
Knowledge about trends on a temporal and spatial water quality dynamics over large areas based on 40 years of data.

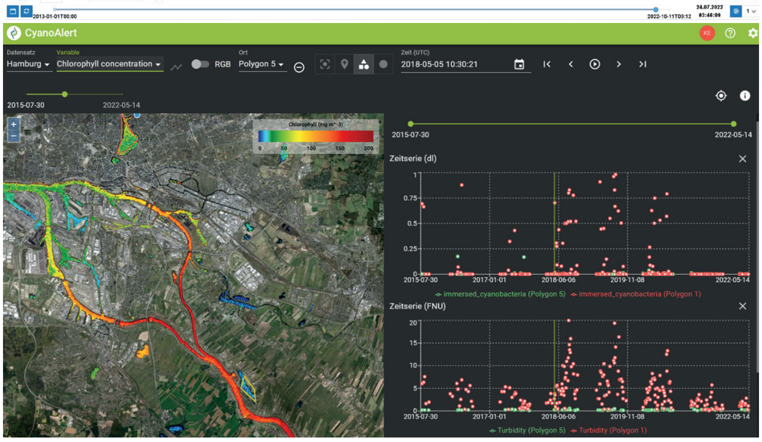
Easy access to solid EO-based measurements for water quality parameters.

Frequency

Up to daily, on-demand







Use Case Examples

Freshwater Biodiversity Monitoring

Freshwater biodiversity is essential for sustaining ecosystem health and functionality, providing critical ecosystem services such as water purification, flood regulation, and nutrient cycling. It also underpins various human activities, including fishing, agriculture, and recreation, while offering significant cultural and aesthetic value. Despite this importance, freshwater ecosystems are among the most threatened globally. Since 1970, freshwater biodiversity has declined by more than 80%, a rate surpassing that of the most impacted terrestrial ecosystems. This decline, driven by factors such as water pollution, altered water regimes, and habitat degradation, underscores the need for rigorous monitoring. IFI activities in this domain can be effectively supported by proxy indicators derived from EO data, enhancing monitoring and conservation strategies.

Description

Providing information on the spatial and temporal dynamics of freshwater habitats.

Use

Supporting several EBVs (Essential Biodiversity Variables) with EO input to biodiversity monitoring and assessment.

Input data

Various EO sensors

Spatial resolution and coverage

10m-300m, global

Benefits

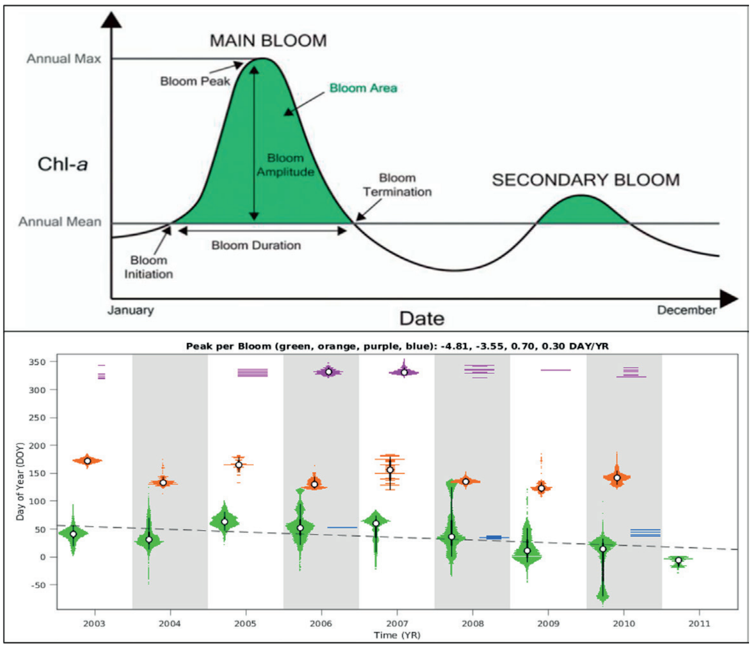
Monitoring a key environmental variables.

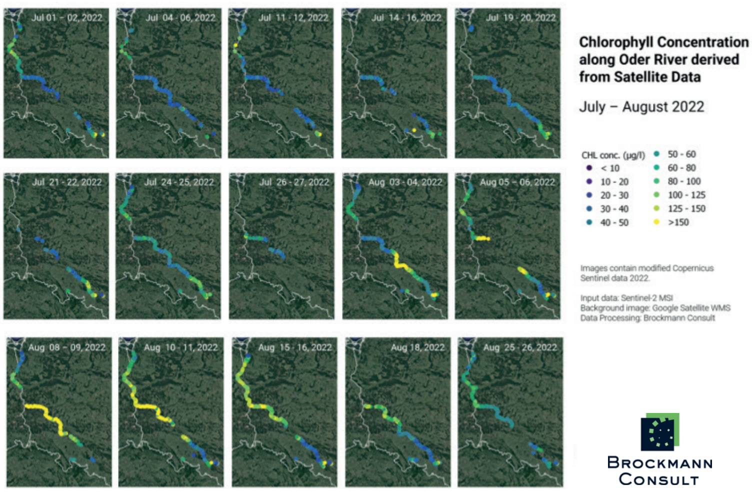
Input into biodiversity models.

Fills gaps where ground monitoring is challenging.

Frequency

Various frequencies are available, from daily to yearly. Trend analyses over several years.





Use Case Examples

Monitoring of River and Delta Morphology

Rivers and deltas are highly prone to morphological changes, especially when no structural measures prevent natural development. River sediment load is typically balanced with runoff and slope; however, changes in sediment load can trigger erosion and accumulation processes. When sediment load decreases, riverbed erosion occurs, while excess sediment leads to accumulation. Causes of these changes include both natural factors and human activities, such as sand mining and dam construction. Sand mining impacts sediment load directly by creating ponds or indirectly by altering erosion patterns. Understanding the temporal evolution of these morphological changes helps predict future river behaviour and identify areas at risk of erosion. Results can be provided through maps, datasets, or tabulated information, supporting IFIs in planning and managing infrastructure projects. For instance, hydropower dams significantly influence river runoff, impacting riverbed dynamics and sediment distribution.

Description

Positions of rivers and deltas are determined in different satellite acquisitions and changes over time are visualised.

Use

Helpful information for monitoring morphological changes and related ecosystems, coastal and riverbank erosion and accretion.

Input data

Sentinel-1 Sentinel-2, Landsat 5-9, modelling data, DEM

Spatial resolution and coverage

10m, global

Benefits

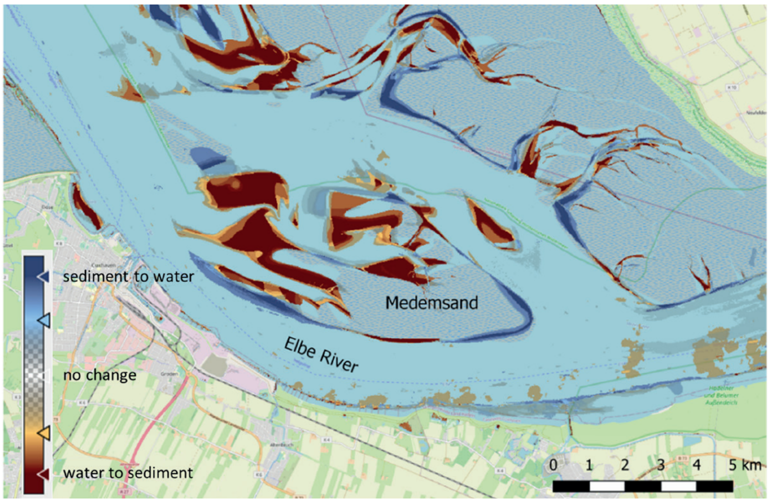
Visualisation and accounting of current and past status of riverbanks

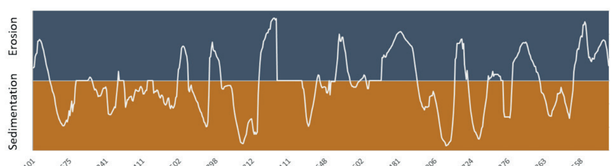
Visualisation and accounting of changes

Assessment of future development

Frequency

Yearly, on-demand





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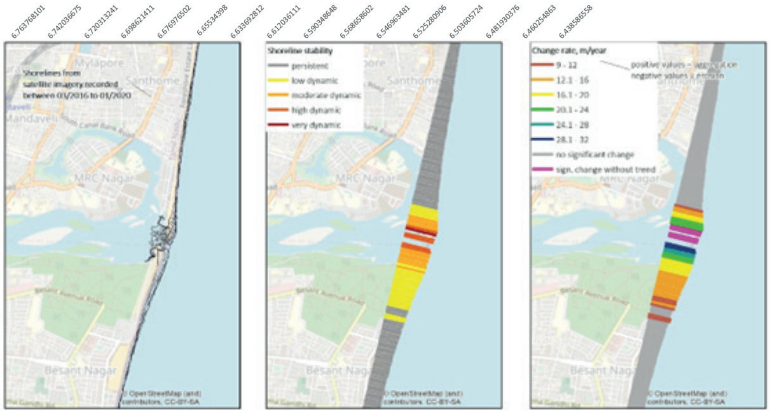

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