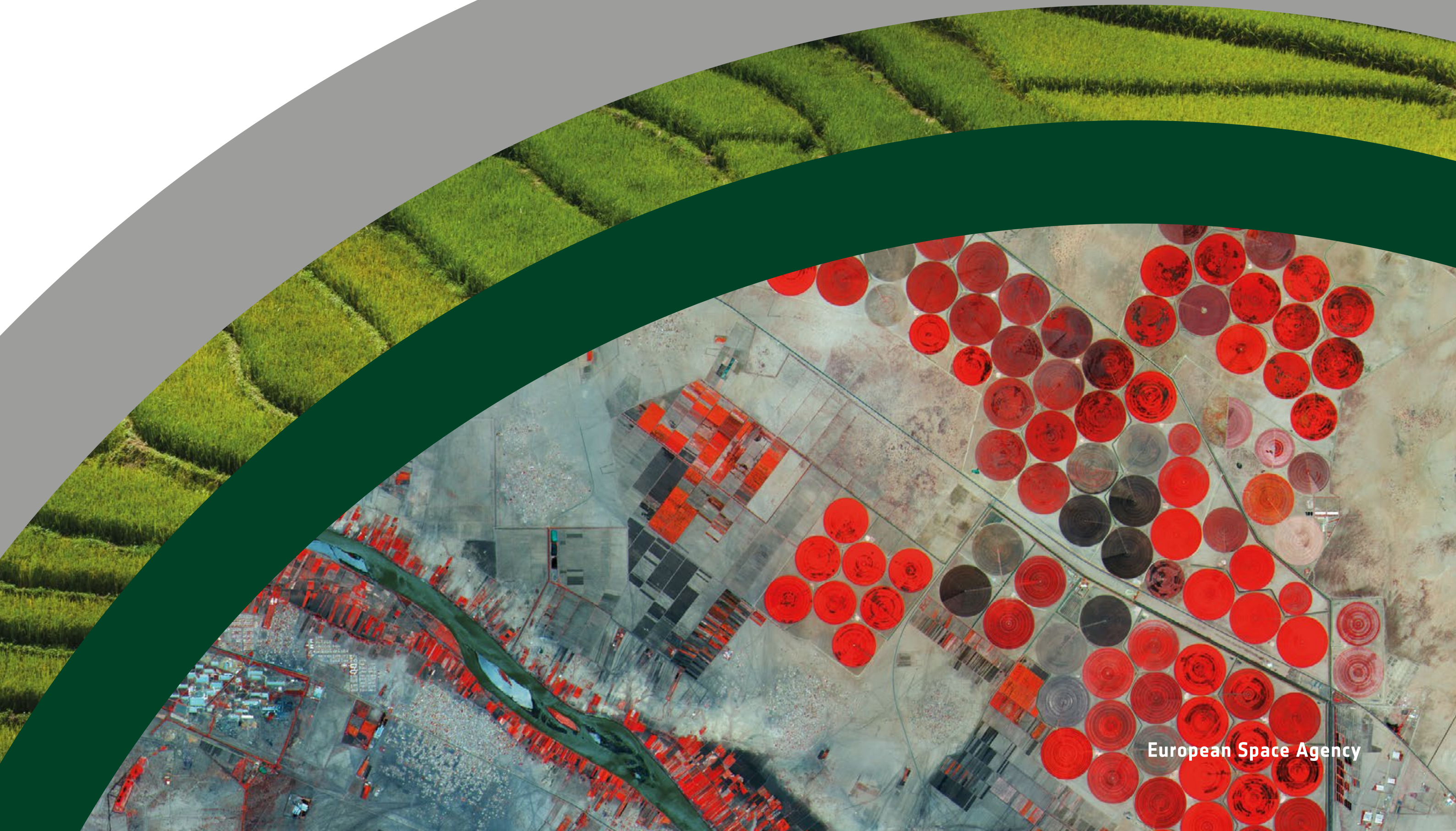
LARGE-SCALE EXPLOITATION OF SATELLITE DATA IN SUPPORT OF INTERNATIONAL DEVELOPMENT

→ EO4SD – EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Agriculture and Rural Development | Service Portfolio

agriculture and rural development
eo4sd



European Space Agency

TABLE OF CONTENT

DESCRIPTION

This service provides timely information on cropland distribution and status at various scales

USE

- › Agricultural census and crop statistics
- › Support sound spatial planning at a landscape scale
- › Screen for finance intervention planning
- › Assess the impact of program interventions
- › Assess crop loss and damage due to natural hazards
- › Assess the impact of value chains and agricultural commodities expansion on the environment
- › Monitoring of allocation of land, titling and concessions.
- › Monitor adherence to agricultural land titling and associated regulations

INPUT PRODUCTS

- › Cultivated area and crop distribution
- › Crop type, crop type area and distribution
- › Cropping intensity (number of times a crop is planted per year in a given agricultural area)
- › Irrigated or rainfed agriculture
- › Pasture area and distribution
- › Crop status: start, peak and end (harvest) of season dates, including management (ploughing etc)
- › Crop productivity (Leaf Area Index, Biomass)

SPATIAL RESOLUTION AND COVERAGE

- › Local/national (10-30m) and regional (250m) scale

BENEFITS

Improved strategy and decision making:

- › Prioritize actions
- › Select and upscale successful practices and interventions
- › Improved understanding of the context of crop production and performance at the landscape/ national scale
- › Monitor activities more effectively and effi ently ently

DELIVERY FORMAT

Depending on user needs, e.g.:

- › Vector and raster formats
- › Through a web portal
- › Statistics in tables and/or graphs

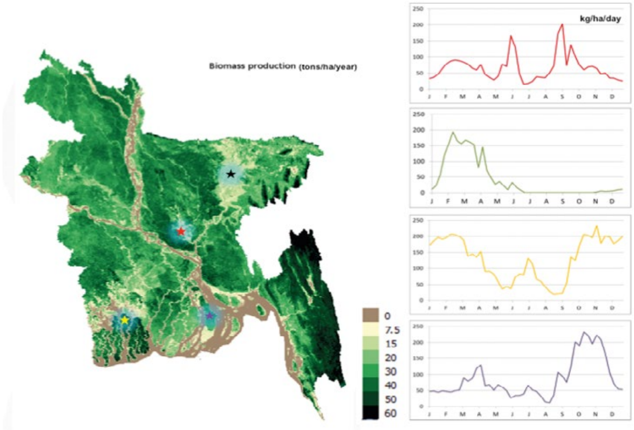
FREQUENCY

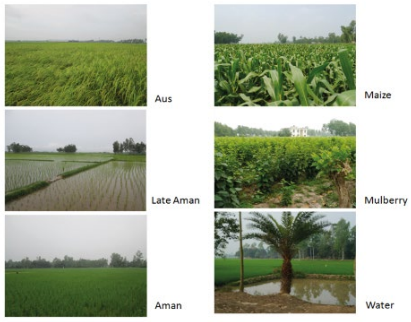
- › Single date for selected baseline year(s)
- › Up to near real-time (daily, weekly, monthly) for monitoring change at large scale

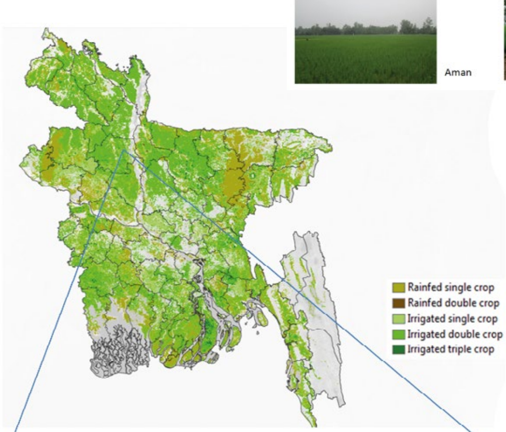
Satellite Earth Observation (EO) is a powerful technique for continuously assessing the status of agricultural production on a wide range of spatial and temporal scales. It provides historical to current global data and can rapidly reveal where change has happened in a consistent and repeatable manner.

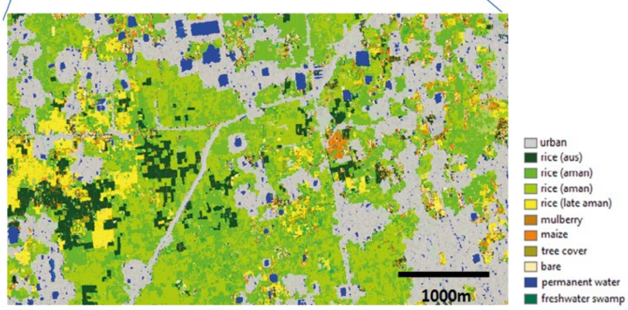
Information from Earth Observation is therefore very well suited to timely information on cropland distribution and status at various scales.

The impact of project interventions can be assessed via quantitative spatial crop distribution and productivity indicators, assisting the final programme or project evaluation.









→ CROP YIELD PROGNOSIS

Near real time yield prognosis statistical information is used as tool that helps to optimize production by providing quantified information of the in-season crop development. Information on expected crop yields during a growing season is of great importance to the public and private sector.

In the public sector there is a need to know the status of crop production at the regional scale in order to assess the food security and to update their crop statistical systems. Within the private sector, different players in the agricultural value chain are interested in yield prognosis. For farmers yield prognosis is of interest to estimate income. Food producers can streamline their logistical planning based on yield estimates and commodity traders need yield information as the basis for future buy-and-sell contracts. Yield prognosis models are available for the major crop types.

Most existing satellite based yield forecasting models are based on vegetation indices such as NDVI coupled with multi-year yield statistics. These models use an established correlation between NDVI-profiles and actual yield figures of the past years, sometimes decades. However, they have their limitations in areas where statistical datasets of historical yield are not available or reliable.

For areas without a historical yield database, an approach based on the biomass production is more suitable. To get from biomass production to yield forecast two main conversions are necessary. First the conversion from biomass to yield, and second the conversion from a current measurement to a future forecast. The expected biomass production until date of harvest is estimated using known crop growth patterns and weather data. Crop specific yield models combine the expected crop growth pattern, based on years of research, with the expected temperature for the period until harvest, based on long year averages for the specific region.

Relationships between EO observed biomass production and crop yield are area specific and need to be established using "in situ" yield measurements.

DESCRIPTION

Forecast yields of major crops

USE

› Optimize production in-season

› Anticipate to expected yield in post-processing agricultural chain

› Improve decision making related to the agricultural market

INPUT PRODUCTS

› NDVI

› Biomass production

› Weather

› Crop yield models

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) and regional (250m) scale

BENEFITS

Rapidly supply/derive reliable information on the crop prognosis and food security of the developing countries

DELIVERY FORMAT

Depending on user needs, e.g.:

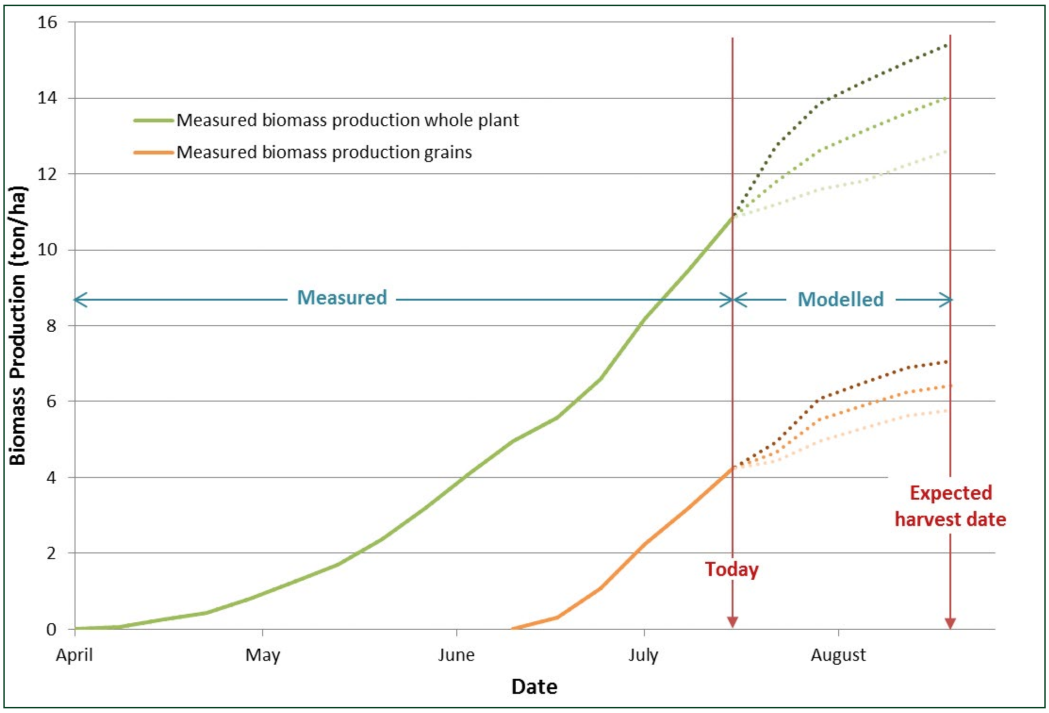
› Vector and raster formats

› Through a web portal

› Statistics in tables and/or graphs

FREQUENCY

Depending on user needs, most products can be updated regularly (daily at regional level, every 10 days at local/national scale)



The graph represents yield prognosis assessment based on satellite data and models.

DESCRIPTION

Land degradation assessments can be supported with additional information to better understand the factors contributing to degradation and ecosystem function

USE

Assessment and monitoring of environmental and climatic condition and input to comprehensive land degradation assessments

INPUT PRODUCTS

Project dependent and customisable:

- Climate variability
- Evapotranspiration
- Soil moisture
- Elevation and terrain slope
- Protected areas
- Burnt areas
- Water bodies
- Habitat heterogeneity
- Population density
- Infrastructure

SPATIAL RESOLUTION AND COVERAGE

Local to regional, yet climate variables come at rather coarse resolution (>1 km)

BENEFITS

Improved understanding of the spatial context of land degradation (synergies and trade- offs between causes and impacts)

DELIVERY FORMAT

Depending on user needs, e.g.:

- Vector and raster formats for integration into existing management systems
- Animations

FREQUENCY

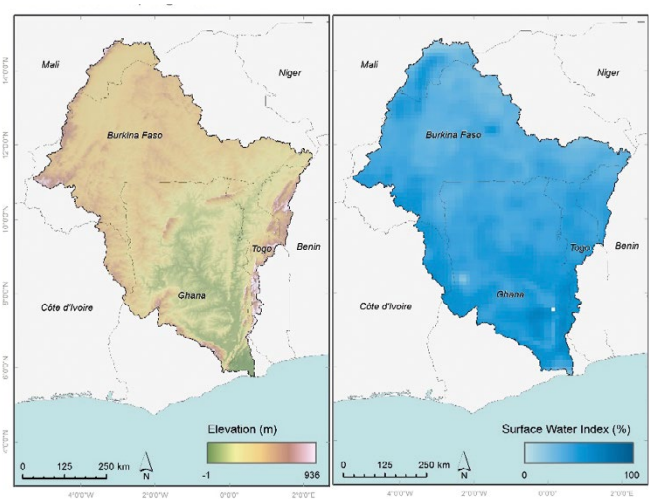
Annual, seasonal, monthly (depending on data availability)

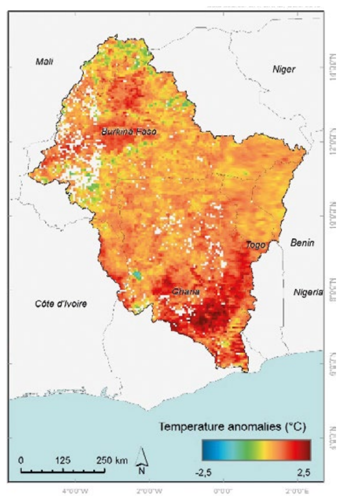
Several EO derived products (at different spatial scales, from regional to local) can jointly provide indication of a land status as effective tools for proper land use planning and natural resources management. Land use/land cover maps have become a standard service that provide information of basic land use types, major agricultural surface types, conservation areas, settlements, infrastructure, primary roads, bare soil, water bodies, rivers, wetlands following standard classifi ation schemes according to CORINE or FAO LCCS.

Land degradation assessments, which are often based on land productivity as the main indicator, can be supported with additional land status information, such as climate variables, soil moisture, elevation and terrain slope or population density to better understand the factors contributing to changes in land cover and vegetation productivity and finally ecosystem function.

In drylands, where water is the limiting factor for vegetation growth, the changing climate can often be the driver of a change in productivity, because of the direct link between precipitation and productivity. By relating long-term time series of precipitation with vegetation we can see this effect. The climatic effect can be removed by linking long term observations, thus revealing the impact of human activities such as changed land use practices on land productivity.

When assessing or monitoring land degradation, the supporting land status indicators service provides environmental information to get a more comprehensive picture of the status of the land and drivers behind changes in land productivity.





Supporting information for land degradation assessments for the Volta Basin - Spring 2016.
Data source: DHI GRAS, OMS 2016.

→ LAND DEGRADATION ASSESSMENT

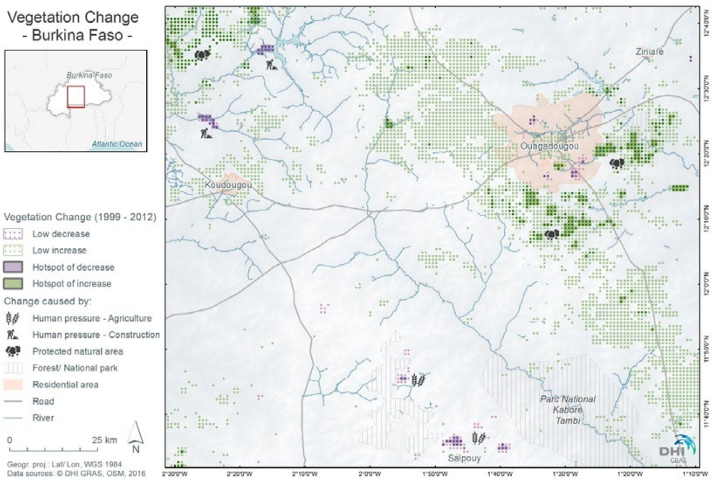
EO data provide synoptic, continuous and homogeneous views to monitor land degradation: from mapping land degradation drivers such as for instance land use and land use change, to assessing actual land degradation status, to identifying areas with higher susceptibility and land degradation. The service makes use of different resolution data in order to map land use and its changes at different scales to connect the regional dimension with national and local processes.

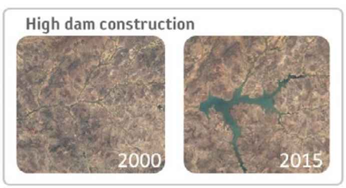
Land degradation conditions can be measured by a change in net primary productivity (NPP), whose EO proxies are vegetation indexes proportional to vegetation density, like the Normalized Difference Vegetation Index (NDVI). A Land Degradation Index can be obtained from a ratio of the NPP proxy (NDVI) to climate data (temperatures and precipitation) by exploiting a model (e.g. RUE – Rain Use Efficiency). Finally, identification of areas more prone to land degradation (Indicator of susceptibility to land degradation) takes into account soil degradation, land cover changes and climate dynamics over time.

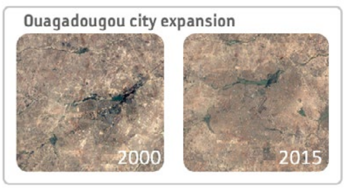
Determine extent and magnitude of land degradation

The land degradation assessment service provides spatial information of long-term change in vegetation cover to identify hotspots of major decrease or increase in land productivity. It is important to rely the assessment on long term observations because the processes behind degradation are generally slow. Once hotspots of change have been identified, they can then be further explored at local scale with more detailed EO information and expert knowledge as a basis for prioritizing both preventive interventions for the restoration or reclamation of degraded land and subsequent focal ground-based studies.

The combination of productivity change maps with other satellite-based information products, such as land cover/use change, carbon stock change or other supporting climatic and biophysical variables allows for a comprehensive assessment of the status of the land and follows the UNCCD Framework for land degradation indicators. The service can be extended with the land degradation monitoring service to follow short- term changes in vegetation productivity at a regular basis, for instance to evaluate the impact of interventions.







DESCRIPTION

Mapping of status and trends of land degradation indicators

USE

› Baseline mapping

› Identificate hotspots of change

› Decision support for interventions

INPUT PRODUCTS

Depending on assessment

› Land productivity status and long term change

› Land cover and land cover change

› Carbon stocks

› Other land status indicators include land surface temperature, evapotranspiration, precipitation, soil moisture, terrain slope, erosion potential, protected areas, habitat heterogeneity, burnt areas, water bodies and so on

SPATIAL RESOLUTION AND COVERAGE

Local to regional, based on long-term (decadal) time-series with spatial resolution between 30 m and 8 km, depending on the scope of the assessment. The assessments of hotspots is based on high resolution data, in-situ data and local interpretation

BENEFITS

Improved strategy and decision making:

› Large scale overview of trends and extent of degradation indicators

› Prioritize actions

› Improved understanding of the context of land degradation

› Linking of multiple indicators for a comprehensive assessment

DELIVERY FORMAT

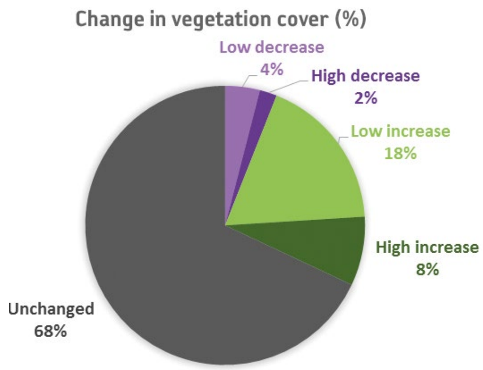
Depending on user needs:

› Vector and raster formats for integration into existing management systems

› Statistics in tables and/or graphs

FREQUENCY

› Annual, seasonal



→ LAND DEGRADATION MONITORING

DESCRIPTION

Quantitatively mapping of the change in status, drivers and impacts of land degradation at different spatial and temporal scales

USE

› Evaluate impact of interventions

› Identify and evaluate hotspots

INPUT PRODUCTS

Land cover and land cover change

› Land productivity

› Carbon stocks

› Other land status indicators include land surface temperature, evapotranspiration, precipitation, soil moisture, terrain slope, erosion potential, protected areas, habitat heterogeneity, burnt areas, water bodies and so on.)

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) and regional (250m) scale

BENEFITS

Improved strategy and decision making:

› Prioritize actions

› Select and upscale successful practices and interventions

› Improved understanding of the context of land degradation (synergies and trade-offs between causes and impacts)

› Monitor activities more effectively and effi ently

DELIVERY FORMAT

Depending on user needs, most products can be updated regularly (daily at regional level, every 10 days at local/national scale)

FREQUENCY

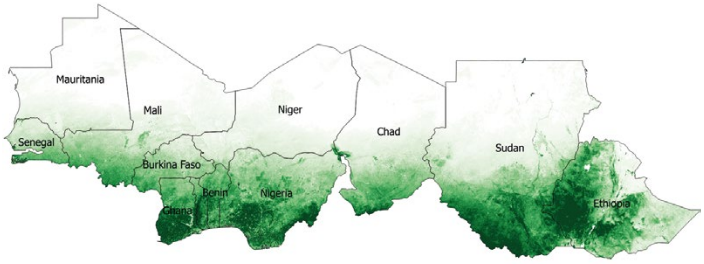
Depending on user needs, most products can be updated regularly (daily at regional level, every 10 days at local/national scale)

Satellite Earth Observation (EO) allows for a regular inventory of land degradation on a wide range of spatial and temporal scales. It is a cost-effective method offering up-to-date global data that rapidly reveals where change has happened in a consistent and repeatable manner.

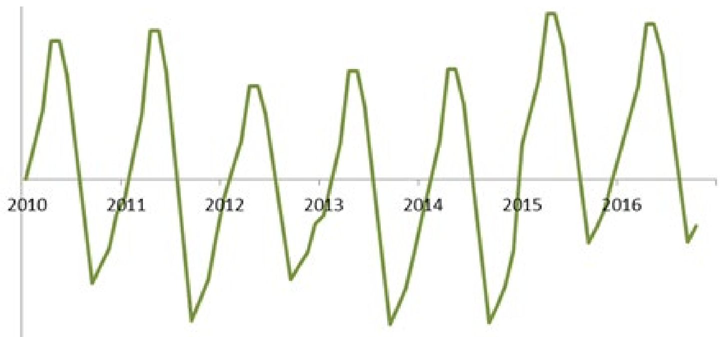
The land degradation monitoring service provides up-to-date information products to address the three main indicators of land degradation at various spatial and temporal scales: land cover and land cover change, land productivity, and carbon stocks. The service can be extended with land status indicators to early identify the factors contributing to land degradation and ecosystem function.

Data can be provided in form of maps in raster or vector format for easy integration within existing GIS systems and/or web portals or the service is accessed via a web portal inclusive online mapping and basic analytical tools. Furthermore, summaries of information, such as statistics per administrative unit, can be provided in tables or graphs which can directly be imbedded in regular reporting obligations.

Regreening of the Sahel



Relative land productivity over time



→ SOIL EROSION MAPPING

The use of satellite Earth Observation (EO) for the identification and assessment of the extent and severity of water related soil erosion has gained prominence in recent years as it can be used to establish baselines, to track change over time, and to monitor soil erosion mitigation measures.

Identifying erosion prone areas

Earth observation is helpful to get an overview over the extent and severity of areas with soil erosion potential. The potential of erosion is linked to environmental factors of a site, such as terrain slope, soil type, land cover/use and amount of precipitation. With satellite Earth Observation and advanced GIS analyses we can determine these parameters and combine them to a map showing areas prone to soil erosion due to water. Applications related to sustainable land and water management (SLWM) are for instance assisting in the prioritization of restoration or rehabilitation measures and monitoring of critical locations. The service could be combined with the land degradation assessment service to get a more complete picture of the condition of the land.

DESCRIPTION

This service helps to identify areas prone to water erosion and to determine their extent

USE

› Baseline mapping

› Prioritization of interventions

› Mapping

INPUT PRODUCTS

Precipitation

› Elevation, terrain slope

› Soil type

› Land cover and land cover change

SPATIAL RESOLUTION AND COVERAGE

The resolution depends on the input data, the resulting product will be a merge of input data resolutions

BENEFITS

Get an overview of erosion prone areas and their severity to plan interventions and monitoring activities more effectively

DELIVERY FORMAT

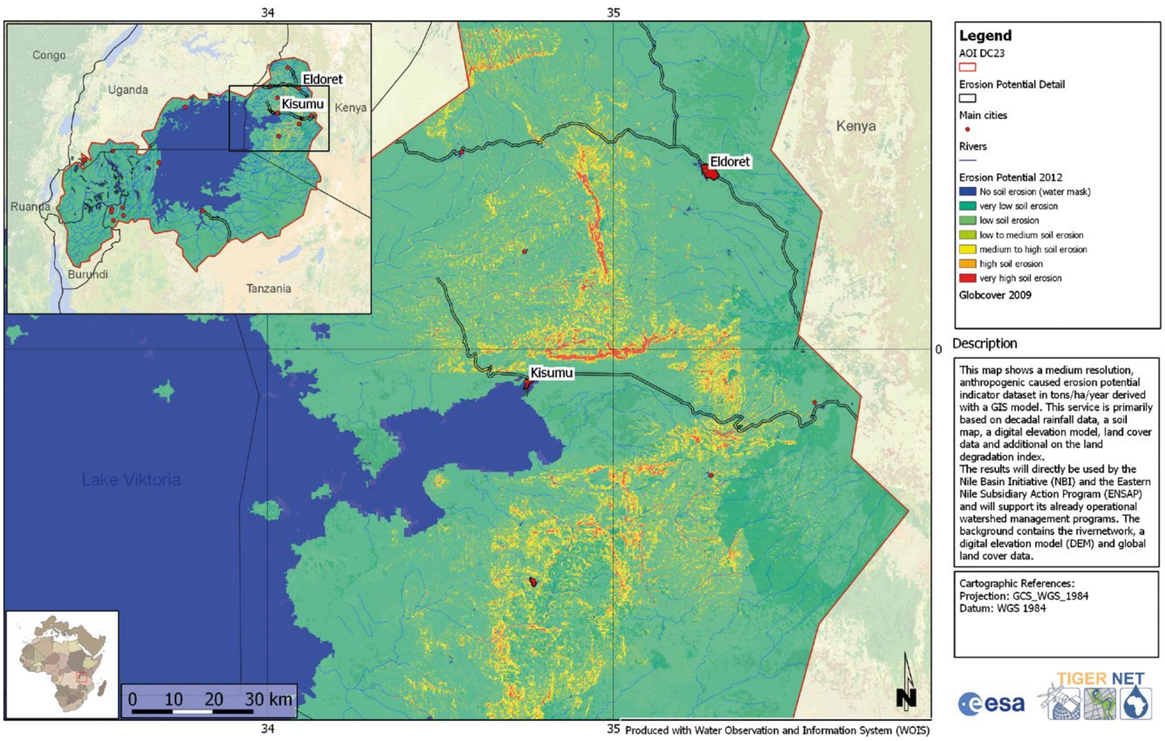
Depending on user needs, e.g.:

› Vector and raster formats for integration into existing management systems

FREQUENCY

Depending on user requirements and input data availability

Water soil erosion potential for the Nile Basin (2012)
The map shows a anthropogenic caused erosion potential indicator dataset in tons/ha/year. Source: GeoVille for ESA TIGERNET project. The product is derived with a GIS model and includes decadal rain- fall data, soil information, digital elevation model, land cover information and additional information on land degradation index.



→ AGRICULTURE COMMODITY PRODUCTION RISK MONITORING SERVICE

DESCRIPTION

This service provides independent and timely information on commodity (soybean, palm oil, beef) production area distribution and impact on ecosystems at regional to local scales

USE

Risk screening:

› Baseline mapping

› Monitor performance

› Evaluate impact of interventions

› Inform public debate

INPUT PRODUCTS

› Plantation type and area

› Ecosystem type

› Infrastructure

› Carbon stocks

› Supporting land status indicators (licensed concessions, protected areas)

› Deforestation and ecosystem degradation

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) and regional (250m) scale

BENEFITS

Improved strategy and decision making:

› Prioritize actions

› Select and upscale successful practices and interventions

› Independent and neutral information in support of engagement and public debate

› Monitor activities more effectively and effi ently

DELIVERY FORMAT

Depending on user needs, e.g.:

› Vector and raster formats

› Through a web portal

› Statistics in tables and/or graphs

FREQUENCY

Depending on user needs, most products can be updated regularly (every week at local/ national scale)

Satellite Earth Observation (EO) is a powerful technique for continuously assessing the status and changes of agricultural production and environmental conditions on a wide range of spatial and temporal scales. It provides historical to current global data and can rapidly reveal where change has happened in a consistent and repeatable manner.

Information from Earth Observation is therefore very well suited to help assess and reduce risks associated with the environmental and social impact of commodity (palm oil, soy, beef etc.) production. This includes land titling, the location and extent of industrial and smallholder production areas versus other land use, in particular vulnerable ecosystems (peatlands, wetlands and natural grassland), trends and patterns of deforestation and ecosystem loss and degradation.

This service provides independent and timely information on commodity production area distribution and impact on ecosystems at regional to landscape scales. It consists of 3 components:

Commodity baseline mapping:

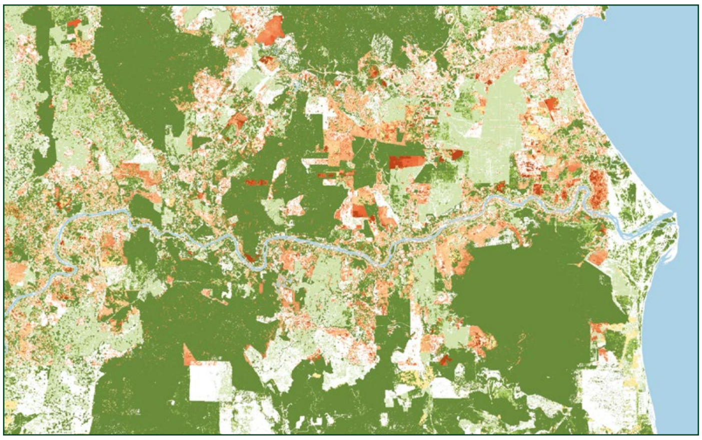
- Spatial distribution and area of agricultural commodities (palm oil, soy and beef) and other land use
- Mapping of highly biodiverse grasslands, high carbon stock areas, infrastructure etc.
- Allocation of land for licensed concessions (if local cadastral data is available)

Forest, land use and land cover change monitoring:

- Land use and land cover change: deforestation, changes in extent of peatlands, wetlands, natural wetlands, high conservation value area and high carbon stock area

Additional environmental impact monitoring:

- Infrastructure development mapping and monitoring
- Carbon footprint: GHG emissions from farm operations
- Water footprint: Water quality monitoring



Deforested areas detected weekly from satellite data are visible in shades of red .

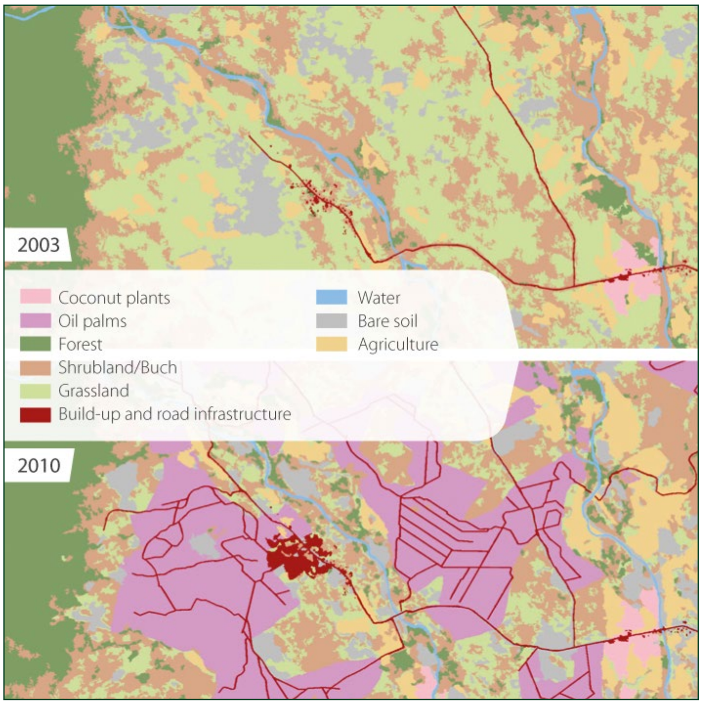
→ AGRICULTURE ECOSYSTEM MAPPING AND MONITORING

Sustainable agricultural management practices are critical to realising the benefits of ecosystem services from agricultural activities. Earth Observation (EO) data supports integrated ecosystem management by determining the spatial extent and condition of agroecosystems, associated trends and changes over time.

A major contribution is the mapping of detailed, large-scale land cover and land use and its changes at watershed or sub- watershed level. This service helps to identify how farm and landscape management impact on the flow of ecosystem services to and from agroecosystems and can also enhance the understanding of the environmental benefits that this sector can provide if agricultural production is well-managed.

Impacts of farm and landscape management on the flow of ecosystem services to and from agroecosystems can be detected directly or as a proxy with EO products such as satellite based land cover, land use and change as provided in this service.

The EO mapping service consists of maps describing changes in agriculturally dominated ecosystems over a user-defined time, providing targeted analyses of the country's natural capital and substantial flows (this includes greenhouse gas emissions, biomass, crop status and diversity, as well as ecosystems fragmentation, erosion potential, potential nutrient runoff, sedimentation of waterways, etc.). Maps are provided in raster or vector format for easy integration within existing GIS systems and/or webportals. It is also possible to access the service (maps and analytical tools) via a webportal. Furthermore, summaries of information, such as statistics per administrative unit, can be provided in tables or graphs and included in email reports.



Satellite-based detailed land cover/use information shows changes in agricultural ecosystems. In this case, natural vegetation was transformed into oil palm plantations leading to increased sedimentation in a catchment of southern Palawan, Philippines. Such information supports integrated ecosystem management. Copyright: GeoVille for ESA/World Bank WAVES.

DESCRIPTION

Quantitatively and qualitative mapping of the change in agricultural ecosystems at different spatial and temporal scales

USE

- Baseline mapping
- Detect ecosystem extent, condition and changes that can be related to services
- Identify hotspots and evaluate impact of interventions

INPUT PRODUCTS

- Land cover/use and change (incl. forest, wetlands, riparian areas, crop status and diversity)
- Fragmentation and change
- Erosion potential
- Soil moisture

SPATIAL RESOLUTION AND COVERAGE

Local/national/regional (10-250m)

BENEFITS

Improved strategy and decision making:

- Prioritise actions
- Select and upscale successful practices and interventions
- Improved understanding of agricultural ecosystems (trade-offs between ecosystem services and disservices)
- More effective and efficient Sustainable Land Management

DELIVERY FORMAT

Depending on user needs, e.g.:

- Vector and raster formats
- Through a web portal
- Statistics in tables and/or graphs

FREQUENCY

Depending on user needs but can vary from customised high frequency information to single date for the selected baseline year

→ RURAL INFRASTRUCTURE & SUPPLY CHAIN MAPPING

DESCRIPTION

Mapping of rural infrastructure helps to enhance rural-urban linkages and access to markets. This service provides spatially explicit analytics of land use and natural resources distribution (e.g. settlements, roads, cropland, forest, energy sources) in relation to the transport network as well as irrigation schemes

USE

› Planning
› Assessment of rural infrastructure status and change
› Assessment of the impact of irrigated areas development
› Access to infrastructure and travel times to assets
› Evaluate impact of investments

INPUT PRODUCTS

› Rural infrastructure (roads, settlements, rivers, waterbodies)
› Distance to markets (e.g. travel time) from production / storage facility
› Land cover/use
› Infrastructure risk assessment (e.g. flood) based on terrain information
› Irrigation infrastructure

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) scale

BENEFITS

Improved strategy and decision making:

› Prioritize investments
› Select and upscale successful rural investments
› Improved understanding of the rural – urban linkages and value chain
› Monitor rural development activities more effectively and efficiently

DELIVERY FORMAT

Depending on user needs, e.g.:

› Vector and raster formats
› Printable maps
› Through a web portal
› Statistics in tables and/or graphs

FREQUENCY

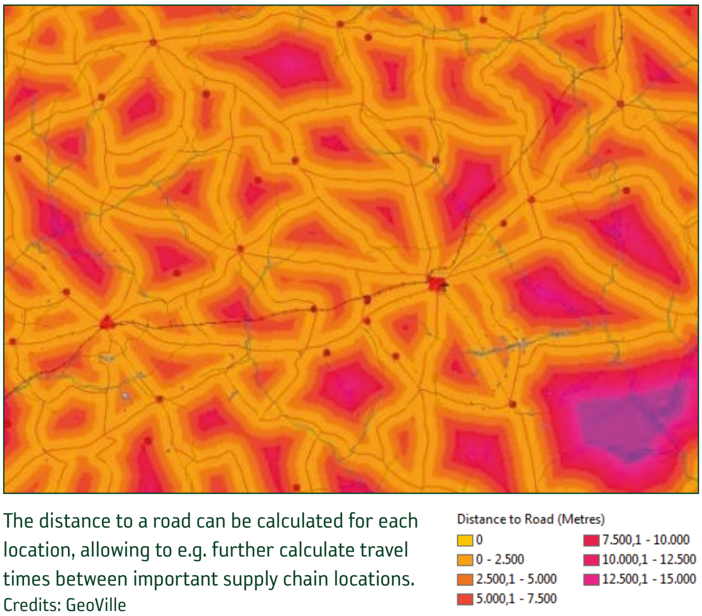
Depending on user needs, most products can be updated regularly (user define time intervals)

Rural infrastructure mapping helps to devise policies and programs to meet specific rural development and market access objectives. It can support the assessment of needs in rural infrastructure investments, and identification of lagging / underdeveloped areas - future breadbaskets - if investment in infrastructure is stimulated.

Satellite Earth Observation (EO) is a powerful technique to map rural infrastructure assets and physical supply chain infrastructures such as the road network and other transport infrastructure, storage facilities, markets and irrigation schemes. Analyses enhanced with local data can provide information on travel times to market centers or support emergency planning in case of natural hazards, such as floods.

The service consists of maps identifying the road networks as well as other transport and critical agriculture infrastructure elements (like irrigation systems). Land cover and use maps focus on agricultural production centers, rural settlements, and potential markets, as well as indicators resolving distance to markets (e.g. travel time from production or storage facilities) which are used for supply chain assessments. Also, the impact of rural infrastructure investments can be identified by mapping land cover change related to new developments including impact on settlements growth or ecosystems degradation. Furthermore, maps assessing the risk of infrastructure to e.g. floods can be provided, including satellite based terrain information.

The service typically consists of the original maps in raster or vector format for easy integration within existing GIS systems and/or webportals. It is also possible to receive the service (maps and analytical tools) in a webportal. Furthermore summaries of information, such as statistics per administrative unit, can be provided in tables or graphs and included in email reports.



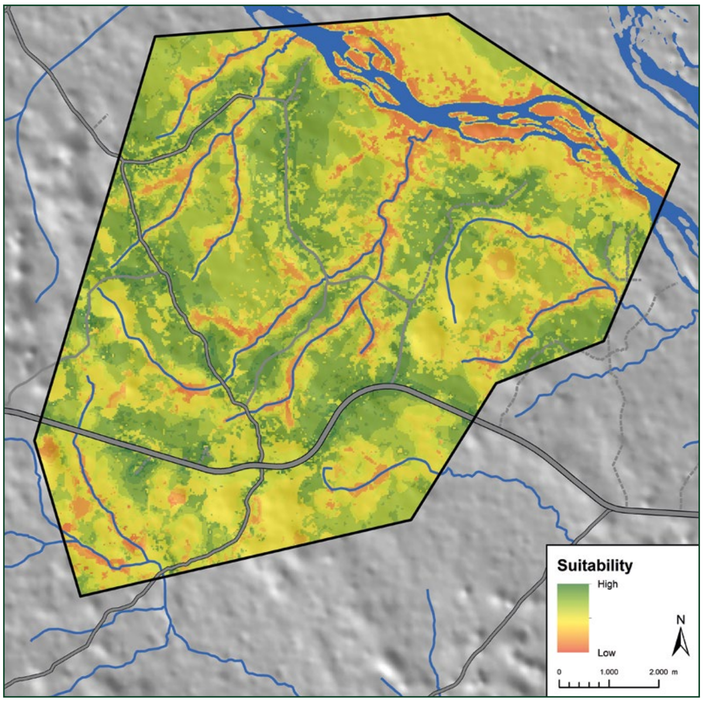
The distance to a road can be calculated for each location, allowing to e.g. further calculate travel times between important supply chain locations.
Credits: GeoVille

→ LAND SUITABILITY MAPPING

Development of rural areas often requires identification of potentially suitable investment sites and information on their environmental characteristics. Satellite Earth Observation (EO) is a powerful technique to answer various land management questions to estimate future land use demand and manage potential land use conflicts. For example, estimating where suitable land for agricultural activities, livestock grazing, forest resources and new infrastructure is available provides the baseline for an efficient and sustainable resource use and can mitigate adverse impacts of rural development on the environment.

The land suitability service provides a land use inventory of a project site based on user identified suitability criteria that helps significantly in investment strategy definition. The service is based on EO and ancillary products such as road network, settlements, land cover and use, soil and terrain information, and climate data. When these information products are jointly analysed based on criteria identified by the user, the best suited areas for the respective activity e.g. the expansion of crop land or the building of new roads can be identified and mapped. Planning of irrigation infrastructure requires a good understanding of the need (water shortage), feasibility (availability of water, slope, drainage etc.), and potential (distance to requirements, terrain, soil properties, climate, etc.), which can also be provided by this service.

The service consists of the original maps in raster or vector format for easy integration within existing GIS systems and/ or web portals. It is also possible to receive the service (maps and analytical tools) in a web portal. Furthermore summaries of information, such as statistics per administrative unit, can be provided in tables or graphs and included in email reports.



The suitability (low to high) of a site for agricultural or rural development can be mapped in detail for large areas. Relevant criteria such as flood risk, distance to roads, land cover and slope can be defined by the user and weighted according to their importance for the agricultural or rural infrastructure development project.
Credits: GeoVille

DESCRIPTION

Mapping of suitable areas for rural development supports the correct allocation and administration of resources through data-driven planning and monitoring

USE

› Assessment of suitable sites for rural infrastructure and agricultural production

› Planning

INPUT PRODUCTS

› Land suitability mapping (based on user criteria the relevant input information will be selected)

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) scale

BENEFITS

Improved strategy and decision making:

› Prioritise investments

› Upscale successful rural investments

DELIVERY FORMAT

Depending on user needs, e.g.:

› Vector and raster formats

› Printable maps

› Through a web portal

› Statistics in tables and/or graphs

FREQUENCY

Depending on user needs and the update frequency of the input data

DESCRIPTION

This service provides timely information on predicted and actual crop production figures at various scales. It is an operational service with regular updates on crop and vegetation performance and production conditions (weather)

USE

› Assessment of agricultural production and risks
› Assess market situation
› Early warning to act upon food scarcity
› Determine impact of natural hazards on food production

INPUT PRODUCTS

› Cropping area
› Crop type
› Crop production
› Biomass production
› Water productivity
› Irrigated area
› Precipitation
› Weather data

SPATIAL RESOLUTION AND COVERAGE

Regional scale for daily semi real-time services and long-term time series with spatial resolution of 250m, local (10-30m) scale

BENEFITS

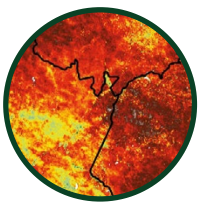
Improve decision and action making to better target and monitor the distribution of aid

DELIVERY FORMAT

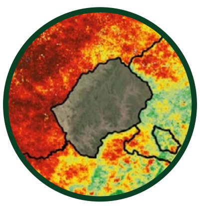
Depending on user needs, e.g.:
› Vector and raster formats
› Through a web portal
› Statistics in tables and/or graphs

FREQUENCY

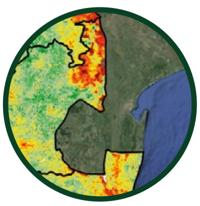
› Up to near real-time (daily, weekly, monthly)



Vaalhaarts -20%



Free State -50%



Kruger Park -37%

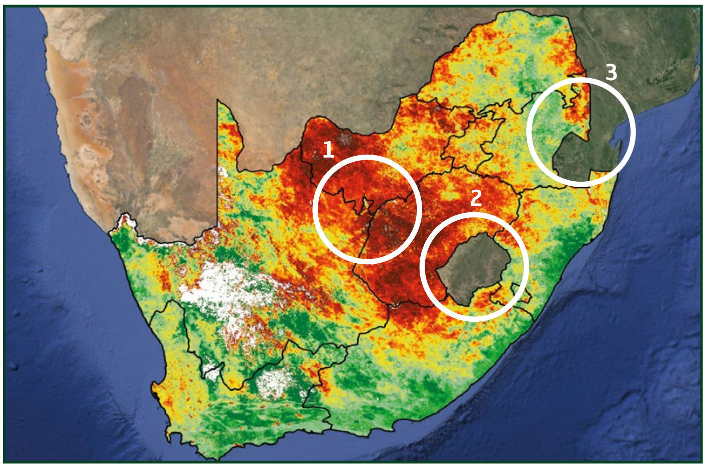
Early warning, monitoring and understanding the causes of natural hazards and associated agricultural risks with satellite Earth Observation.

Traditionally agricultural monitoring systems rely heavily on in-situ measurements and agricultural statistics, while standardization of methodologies and coordination of data acquisition between and within countries are missing. Recent EO missions such as ESA's Sentinels, offer the opportunity to establish an effective, semi real-time and large-scale agricultural monitoring system which supports government agencies and international organisations to collaborate and coordinate their response.

EO services provide valuable information on crop biophysical, soil and climate characteristics, but also on the occurrence, duration and intensity of natural disasters such as heat stress, droughts, and floods that strongly influence production figures.

Large-scale EO observations of meteorological and growth conditions allow the continuous monitoring of crop production trends and changes. Crop production can be expressed as water productivity ("crop per drop") that not only indicates where production has obtained its full potential and where not, but that also reveals distinct patterns of change as upcoming risks or prosperity. Also, satellite data can be used to determine the onset and development of the rainy season and the status of crops and rangelands across countries and to generate situation bulletins. The service could include a webportal or email service that provides alerts when production figures are lower as usual or other anomalies are detected.

Combining the different EO data products such as water productivity and meteorological data helps in the assessment of climate risk, rainfall and drought impact, and consequently possible effects of plant water stress and water deficits on crop growth at the regional level. Traditional cropping patterns and farming methods may need to be adapted in the future to accommodate changes in rainfall patterns and increasing extreme and erratic weather events caused by climate change. A better understanding of the spatial variations and the scope for improvement can help to plan for agricultural production systems which are more resilient to climate change influences.



Percentage of Actual Biomass Production lost over the period Aug 2015 to Jan 2016 when compared to the same period during the 2014-2015 agricultural season.

→ INDEX INSURANCE SERVICE

Index insurance schemes base their insurance premiums and indemnity payouts on a pre-determined index derived from Earth Observation (EO) data rather than on actual crop and livestock losses. The insurance pays upon the occurrence of a triggering event, with EO data providing measurable indices (e.g. precipitation, vegetation index NDVI, biomass production, relative evapotranspiration, soil moisture) of the event. Given that this eliminates loss verification costs, an index insurance approach has substantial potential for scale up, even if sales and education of sales agents and insurance takers remain critical for effective insurance take-up.

Index insurance is used as a risk management tool in agriculture, food security and disaster risk reduction. Index insurance is important for development because it helps stabilise income for smallholders when yields are affected by weather. It is one of the tools MDBs have to reach their goal of reducing extreme poverty.

A key challenge for delivering relevant EO services to index insurance schemes is to construct indices that closely correlate to farmer's losses (i.e. yields, forage scarcity) and/or key yield reducing hazards like droughts. For such schemes to be effective, indices should account for monitoring the land use of interest, and also for the seasonality of crop production. A common index used for input to insurance schemes is spatially- and temporally-aggregated NDVI, but also agrometeorological input variables like soil moisture, precipitation, solar radiation and temperature can be used as input.

DESCRIPTION

This service provides indices that closely correlate to farmers losses and/or key yield reducing hazards that can be used as input to index insurance schemes

USE

Index insurances

INPUT PRODUCTS

› Precipitation

› Vegetation index NDVI

› Biomass production

› Relative evapotranspiration

› Air temperature

› Soil moisture

SPATIAL RESOLUTION AND COVERAGE

Long-term time series with spatial resolution of 10-25km

BENEFITS

The elimation of loss verification costs and the potential for scaling up are the greatest benefits of using a pre-determined index based on EO information for the insurance of crop and livestock losses. Index insurance is one of the tools MDBs have to help stabilise income for smallholders when yields are affected by weather

DELIVERY FORMAT

Depending on user needs, e.g.:

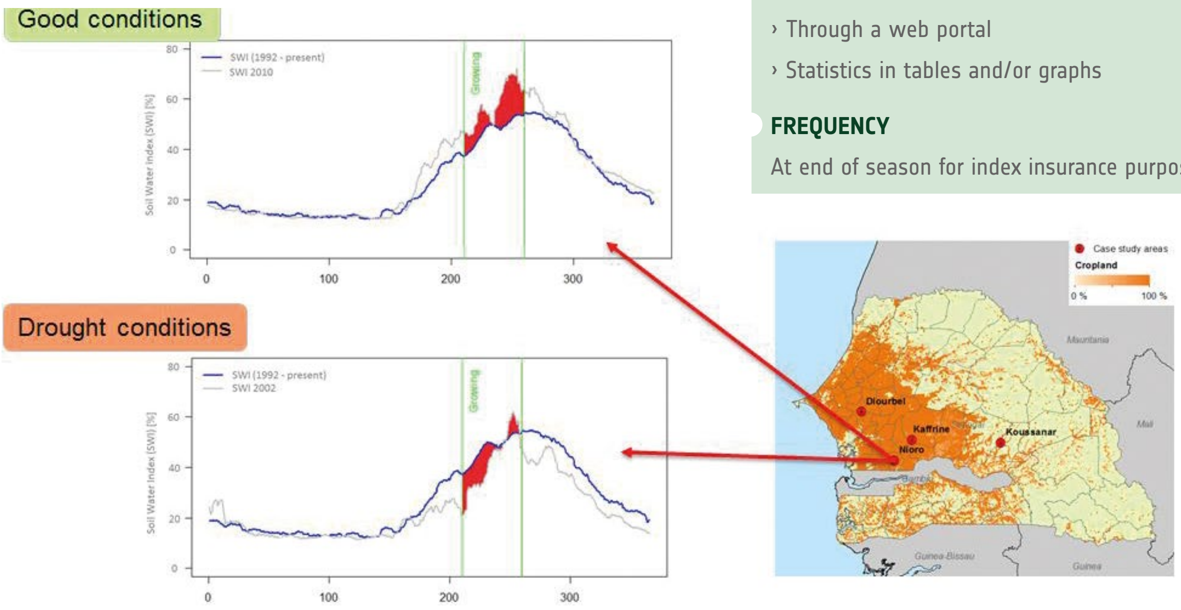
› Vector and raster formats

› Through a web portal

› Statistics in tables and/or graphs

FREQUENCY

At end of season for index insurance purposes



Example of a satellite soil moisture based index insurance indicator that can be related to payouts to farmers in Senegal.
Source: GeoVille for IFAD

DESCRIPTION

Quantitative mapping of the biophysical baseline in an area where agricultural development is to take place

USE

› Baseline mapping

› Identify hotspots and evaluate impact of interventions

› Assist with post-approval monitoring

INPUT PRODUCTS

› Baseline maps

› Project overlays

› Graphical presentation of predicted outcomes

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) and regional (250m) scale

BENEFITS

Better design of projects:

› Present environmental baseline in graphical format

› Assist with impact "scoping", so as to focus on issues of key importance

› Assist proponents to minimise risk in program and project design

› Monitor activities more effectively and effi ently

DELIVERY FORMAT

Depending on user needs, e.g.:

› Vector and raster formats

› Through a web portal

› Statistics in tables and/or graphs

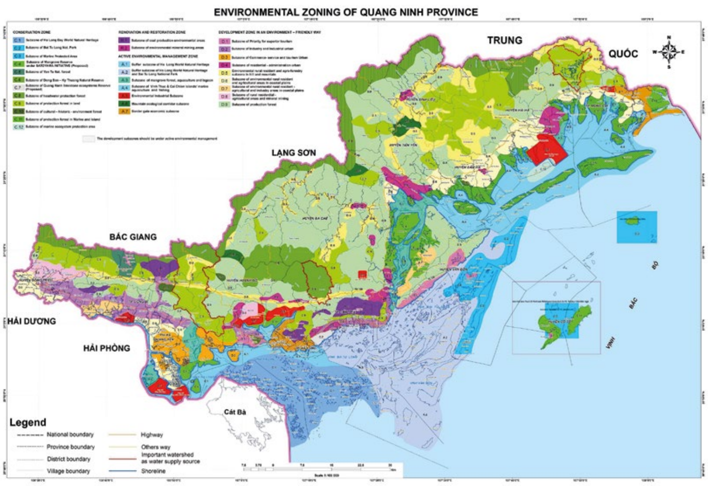
FREQUENCY

Depending on user needs, most products can be updated regularly (daily at regional level, every 10 days at local/national scale)

Most significant agriculture sector programs or projects financed by MDBs will have a requirement for either strategic environmental assessment (SEA), or environmental impact assessment (EIA) to take place prior to MDB Board approval. EIA has been a standard safeguard requirement for MDBs for decades, and is now consistently applied by partner countries. SEA is a newer initiative, the purpose of which is to assess the environmental implications of policies, programs, and plans (PPPs). Both SEA and EIA attempt to predict the likelihood of environmental impacts emanating from development proposals. Satellite Earth Observation (EO) is a powerful technique for understanding the biophysical baseline existing in a given geographic space. Understanding the nature of the baseline state is a necessary pre-condition for effect SEA and EIA.

SEA and EIA studies associated with agricultural programs or projects require information on issues such as land cover, productivity, population distribution, water sources, areas of degraded lands, rivers, lakes, wetlands, groundwater vulnerability, protected areas, and many other environmental components that might be affected by a new development.

The service can consist of maps that layer to present a "baseline scenario" in place before the initiation of an agricultural program or project. The service could consist of the original maps in raster or vector format for easy integration within existing GIS systems and/or webportals. It is also possible to receive the service (maps and analytical tools) in a webportal.

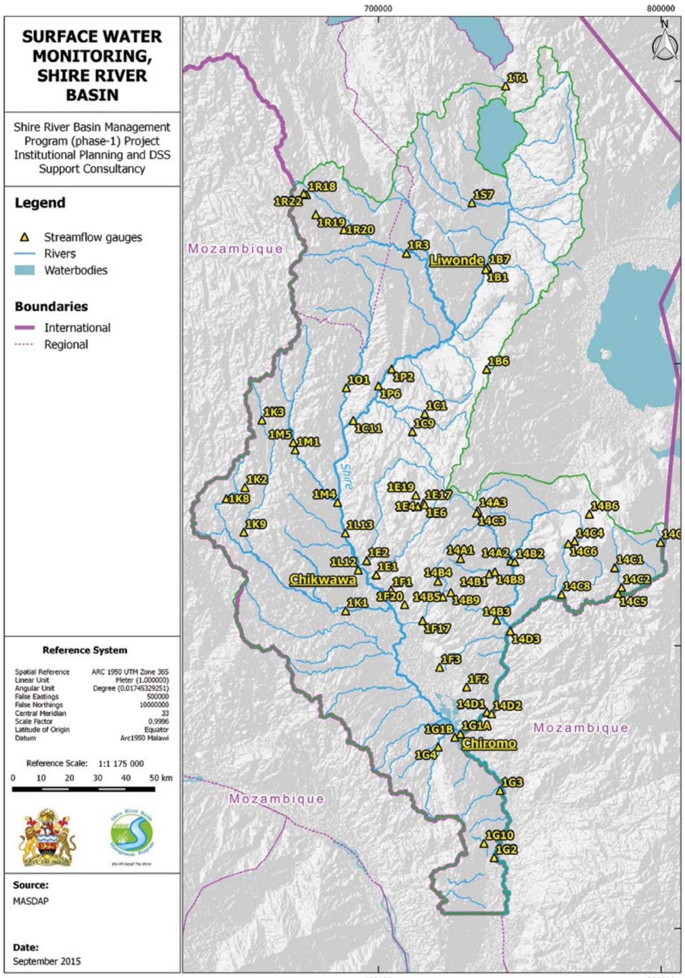


This map was produced using multiple GIS layers. It presents different land use zones in a Province of Vietnam, and can be used to decide the best location for different types of agricultural development.

→ MONITORING AND EVALUATION FOR ENVIRONMENTAL AND SOCIAL SAFEGUARDS

Most significant agriculture sector programs or projects financed by MDBs will have a requirement for environmental and social impact assessment (ESIA) to take place prior to MDB Board approval. ESIA has been a standard safeguard requirement for MDBs for decades, and is now consistently applied by partner countries. Both the immediate and long-term benefits from undertaking monitoring as part of EIA are widely recognised, although not always realised. Satellite Earth Observation (EO) is a powerful technique for assisting with the monitoring component of environmental management plans (EMPs).

ESIA studies associated with agricultural programs or projects require information on issues such as land cover, productivity, population distribution, water sources, areas of degraded lands, rivers, lakes, wetlands, groundwater vulnerability, protected areas, and many other environmental components that might be affected by a new development. The service can consist of maps that layer to present a "baseline scenario" in place before the initiation of an agricultural program or project. This would then be followed up with replicated maps that show the condition of specific environmental components post- approval, and during the operation of a project. The service could consist of the original maps in raster or vector format for easy integration within existing GIS systems and/or webportals. It is also possible to receive the service (maps and analytical tools) in a webportal.



DESCRIPTION

Quantitative mapping of the biophysical baseline in an area where agricultural development is to take place, complemented by follow-up during project operation

USE

- › Baseline mapping
- › Identify hotspots and evaluate impact of interventions
- › Check compliance with agreed conditions and standards
- › Facilitate impact management
- › Determine the accuracy of impact predictions and the effectiveness of mitigation measures

INPUT PRODUCTS

- › Baseline maps
- › Project overlays
- › Graphical presentation of predicted outcomes
- › Project performance monitoring

SPATIAL RESOLUTION AND COVERAGE

Local/national (10-30m) and regional (250m) scale

BENEFITS

Better design of projects:

- › Present environmental baseline in graphical format
- › Assist proponents to minimise risk in program and project design
- › Monitor activities more effectively and effi ently
- › Present post-approval monitoring of critical environmental components in compelling form

DELIVERY FORMAT

Depending on user needs, e.g.:

- › Vector and raster formats
- › Through a web portal
- › Statistics in tables and/or graphs

FREQUENCY

Depending on user needs, most products can be updated regularly (daily at regional level, every 10 days at local/national scale)

The map represents surface water monitoring sites in the Shire River Basin in southern Malawi. EO services can be used to pinpoint monitoring sites, and can enable real-time presentation of water quality data that would allow for evaluation of the impact of new agriculture projects.

→ IRRIGATION DEVELOPMENT SERVICE

DESCRIPTION

This service helps to identify areas suitable for irrigation expansion and select areas needing irrigation rehabilitation

USE

Selection of suitable areas for irrigation development

INPUT PRODUCTS

› Irrigated area
› Land cover
› Actual evapotranspiration
› Biomass production
› Elevation
› Soil maps
› Air temperature
› Relative humidity
› Precipitation

SPATIAL RESOLUTION AND COVERAGE

From local (field-level) up to regional scale (irrigation scheme level)

BENEFITS

Add spatial detail to irrigation rehabilitation and irrigation expansion plans at low costs

DELIVERY FORMAT

Depending on user needs, e.g.:

› Vector and raster formats

FREQUENCY

Single date for selected baseline year(s), longer time series for the weather data

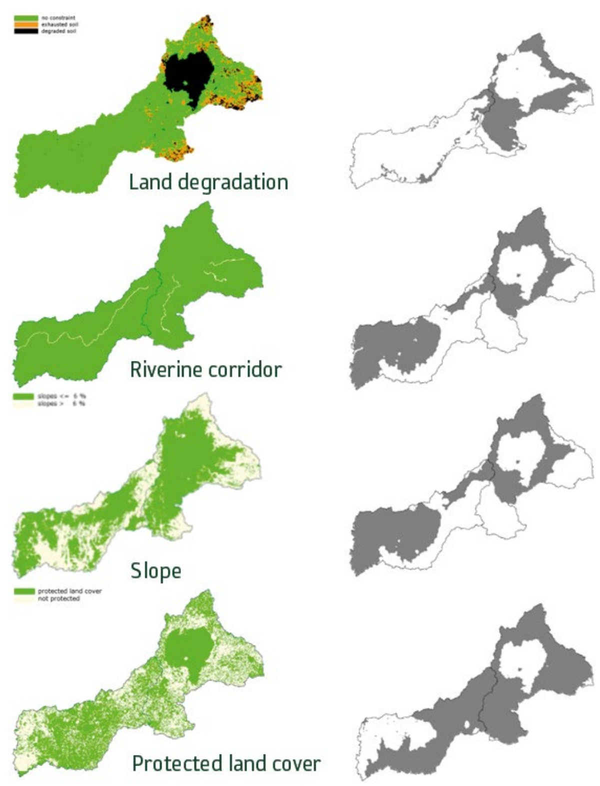
Satellite Earth Observation (EO) technologies provide a low cost methodology to plan irrigation development. It helps in selecting target areas for irrigation development by quantifying water stress and identifying under-performing areas in both rainfed and irrigated agriculture. Once areas have been selected, EO data can assist in determining land and irrigation suitability as well as (potential) impact of irrigation development on the water balance.

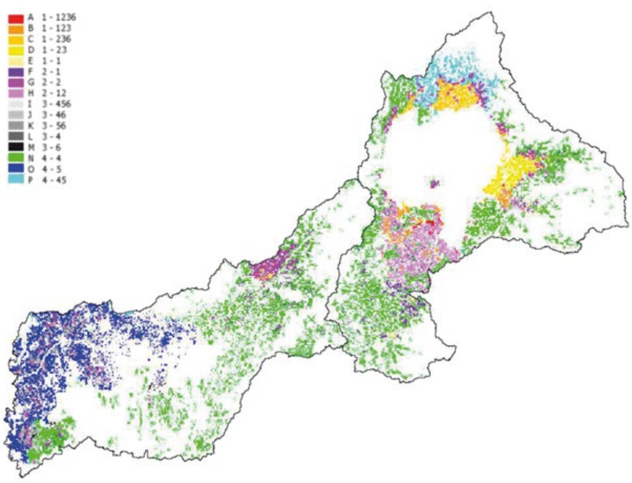
Suitable areas for irrigation development and their potential

The presence of green vegetation during the dry season and its temporal variation is a good indicator of irrigation activities, especially when actual evapotranspiration exceeds rainfall. Maps of actual evapotranspiration, water deficit and water productivity help to quantify irrigation performance. Actual evapotranspiration data gives spatial insight in water distribution within an entire irrigation system. The transpiration deficit is the difference between actual and potential evapotranspiration and shows the occurrence of water stress. Water productivity data shows the production per unit of water ('Crop per Drop') and is a measure of water use efficiency.

Earth Observation is also helpful to identify which areas are suitable for new irrigation activities and the impact on the water balance. In the example for the Tana-Beles catchments in Ethiopia maps of land degradation, slope and protected areas constraints are combined with maps on crop suitability (taking into consideration soil and climate), resulting in a map depicting the ideal crop and irrigation type (the irrigation suitability map).

Constraints **Suitability for 4 crop classe**





Irrigation potential in the Tana-Beles catchment

→ IRRIGATION SYSTEM DESIGN

Satellite Earth Observation (EO) is a powerful technique for collecting spatial information relevant for irrigation system design. It adds spatial detail on soil, crop and topography to basic design criteria, such as water application, irrigation frequency and operation restrictions. For example using satellite data we can map the land cover prior to investment, identify areas of importance needing protection, assess the suitability taking into account weather and soil, and assess risks such as floods.

Irrigation system design does not only involve the construction of new systems but also extensions, rehabilitations, and upgrades of existing systems. Changing environments require constant redesign to conserve water and improve services.

Suitable areas for irrigation development and their potential

The service consists of maps that show which areas are relevant and suitable for interventions while at the same time indicating which areas need to be protected. Insight in the spatial variability helps to prioritize investments and select the most appropriate irrigation techniques and practices. For example land cover maps give valuable insight of the landscape as it is, and the ecosystem functions present. Evapotranspiration maps – the current water consumption – help to calculate the impact of interventions on the water balance, determine best practices in physical irrigation design and irrigation water management for sustainable water use, and allows more effective sampling and placement of probes. Water productivity maps show the spatial variation to determine fitting solutions and prioritize actions.

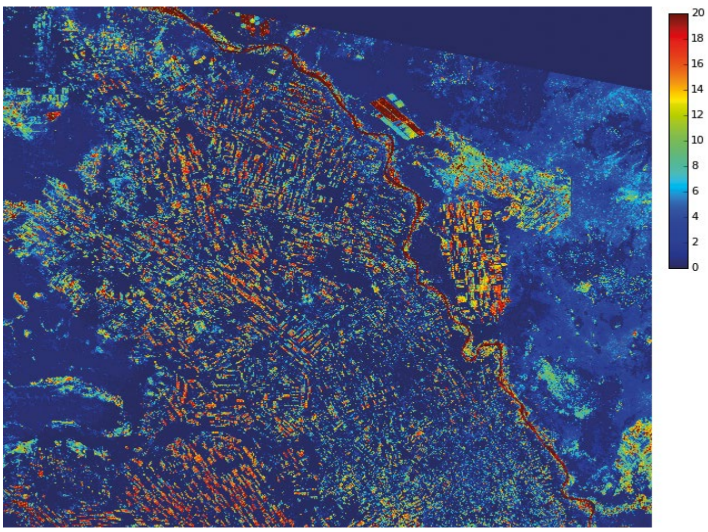


Image shows crop water consumtion in the Gezira scheme in Sudan.

DESCRIPTION

This service assists irrigation system design by mapping spatial variation of land cover, water consumption and water productivity

USE

› Irrigation system design
› Irrigation management
› Probe placement
› Sampling strategy

INPUT PRODUCTS

› Irrigated area
› Land cover
› Actual evapotranspiration
› Potential evapotranspiration
› Transpiration deficit
› Water productivity
› Elevation
› Soil maps
› Air temperature
› Relative humidity
› Precipitation

SPATIAL RESOLUTION AND COVERAGE

From local (field-level) up to regional scale (irrigation scheme level)

BENEFITS

Make decisions in planning and design for site specific conditions

DELIVERY FORMAT

Vector and raster formats

FREQUENCY

Single date for selected baseline year(s)

DESCRIPTION

This service provides regular updates on the actual water use to help irrigation agencies improve irrigation system operations and thus reduce water consumption and increase production

USE

In-season information to water managers at all levels – from farmer to irrigation agency – to improve irrigation system operations, i.e.

› Planning of irrigation volume and timing
› Compare actual water use against water allocation
› Improve distribution of water over an irrigation scheme by identifying water stressed areas during the season

INPUT PRODUCTS

Actual evapotranspiration

› Potential evapotranspiration
› Transpiration deficit
› Precipitation
› Irrigation planner
› Water auditing

SPATIAL RESOLUTION AND COVERAGE

From local (field-level) up to regional scale (irrigation scheme level)

BENEFITS

Improved water management from farm to scheme level using up-to-date area-specific information on crop water use

DELIVERY FORMAT

Depending on user needs, e.g.:

› Vector and raster formats
› Through a web portal
› Statistics in tables and/or (interactive) graphs
› Regular notifications through SMS or email

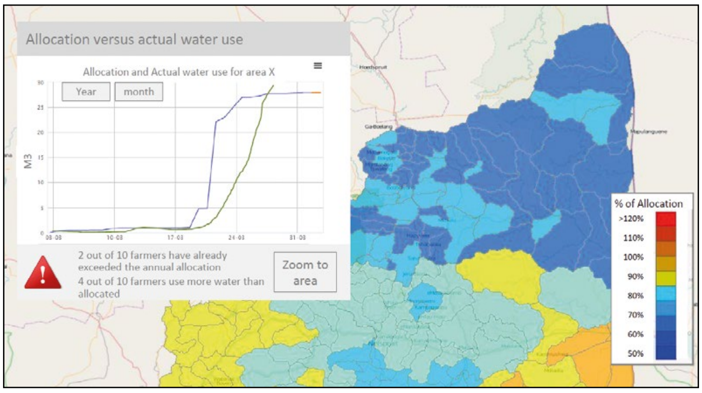
FREQUENCY

In-season (weekly) up to once a season (retrospective)

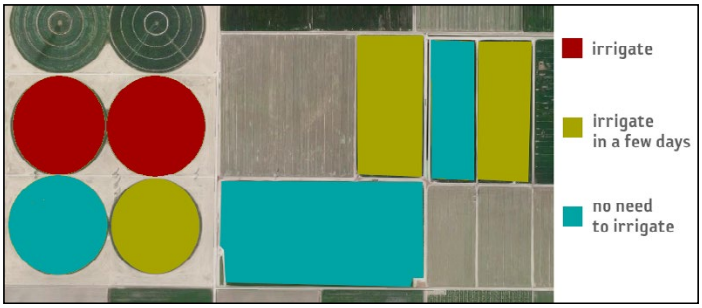
Regular and consistent monitoring of water distribution over large areas has become possible with satellite technology. Satellite derived evapotranspiration and precipitation data are used to calculate water use. Together with weather forecasts it allows timely identification of upcoming water stress and/or exceedance of the allocated water.

Irrigation performance can be enhanced by (1) optimising water distribution (rehabilitation of the physical irrigation infrastructure); and (2) by improving the irrigation water management (sufficient and timely application). This service focusses on the latter – improving water management- and is valuable to water managers at different levels, from irrigation agencies to irrigation scheme managers to the farmer. Regular updates on water use in-season allow irrigation schedules and water distribution to be adjusted and provides valuable insights on how water management can be improved.

The irrigation operations service can send timely notifications when predicted soil moisture drops below a set threshold in the coming 5 days and irrigation is essential to sustain optimal crop growth (irrigation planning). Another service application is the comparison of actual water use to the water allocated, allowing farmers to better distribute their water resources over time and managers to distribute the water fairly (water auditing). Knowing how much and when to irrigate within the limits of crop requirements for optimum growth can save substantial amounts of water and other irrigation related inputs such as fuel and fertilizer while at the same time improve production.



Water auditing service.



Irrigation planner service.

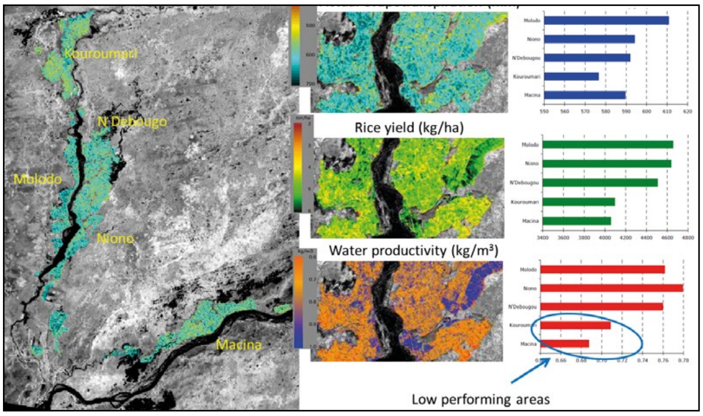
→ IRRIGATION PERFORMANCE SERVICE

Increased water scarcity -brought on by climate change, a growing population and food demand, and an increased competition of other sectors - calls for improving water productivity and achieving more crop per drop.

Traditionally, irrigation performance has been expressed in terms of efficiencies of observed flows, with a focus on the amount of irrigation water applied on the field. However, not all of the water applied will be consumed by the crop, and some of the losses in the irrigation system are actually re-used elsewhere downstream. Advanced energy balance algorithms together with satellite earth observation data are used to estimate actual evapotranspiration, i.e. the water consumed by the crop. Satellite derived data on water consumption and crop growth estimates irrigation performance at scales not achievable with conventional methods.

Irrigation performance can be expressed by a number of satellite derived indicators, providing spatial insight in water distribution both in the field and within an entire irrigation system. An insightful indicator of water distribution is the actual evapotranspiration, the quantity of water that is actually removed from the land surface through evaporation of water from the soil, plant canopies, and open water bodies plus transpiration by the plant (all together constituting the actual water consumption). The (biomass) water productivity is calculated by dividing the biomass production or the yield by the actual evapotranspiration, it shows biomass or crop production per unit of water. Another useful indicator is the crop water deficit, which can be expressed using the difference between potential and actual evapotranspiration, and shows where water stress occurs.

Satellite derived information on irrigation performance helps irrigation managers – both at farm and scheme level - to monitor their water management on a real-time basis but also to look at accumulated figures from an entire season and analyze spatial patterns from year to year.The consistent and objective measurement of progress, outcome and impact of agricultural water management provides opportunities to determine the reasons for success and failure of development activities, and how to use this understanding to improve future action.



Actual evapotranspiration, yield and water productivity in the Office du Niger irrigation scheme (Mali).

DESCRIPTION

This service provides irrigation performance indicators to (1) assist in developing water management strategies responding to climate change and an increasing water demand; and (2) provide valuable input to monitoring and evaluation (M&E)

USE

Measure project and programme progress, outcome and impact of agricultural water management

› Understand reasons for success and failure of development activities

› Define water management strategies

INPUT PRODUCTS

› Irrigated area

› Actual evapotranspiration

› Potential evapotranspiration

› Transpiration deficit

› Biomass production

› (Biomass) water productivity

SPATIAL RESOLUTION AND COVERAGE

From local (field-level) up to regional scale (irrigation scheme level)

BENEFITS

More productive and sustainable agriculture by improving irrigation services (water distribution and timing of application) at both farm and scheme level

DELIVERY FORMAT

Depending on customer needs, e.g.:

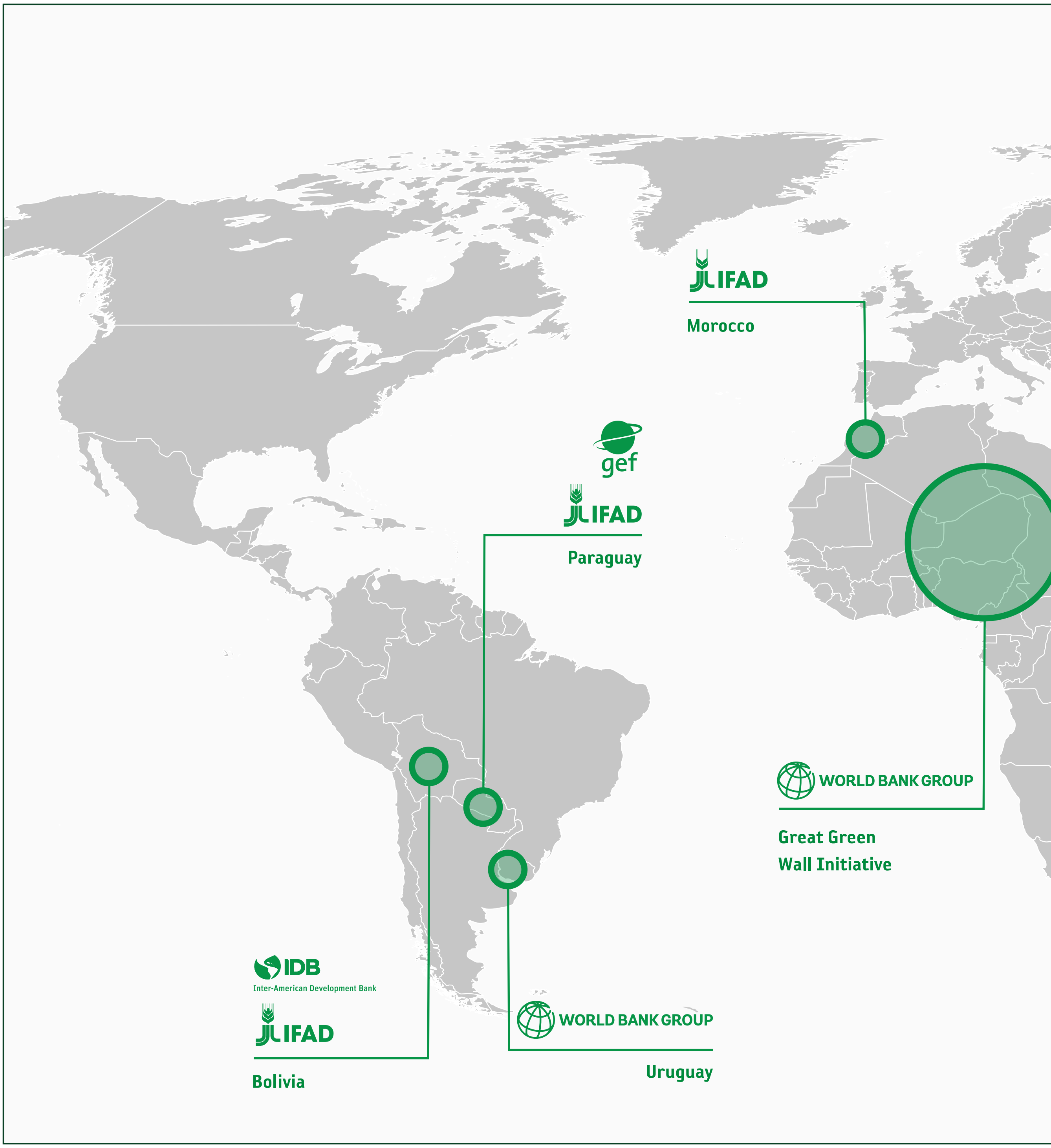
› Vector and raster formats

› Through a web portal

› Statistics in tables and/or (interactive) graphs

FREQUENCY

In-season (weekly) up to once a season (retrospective)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Morocco
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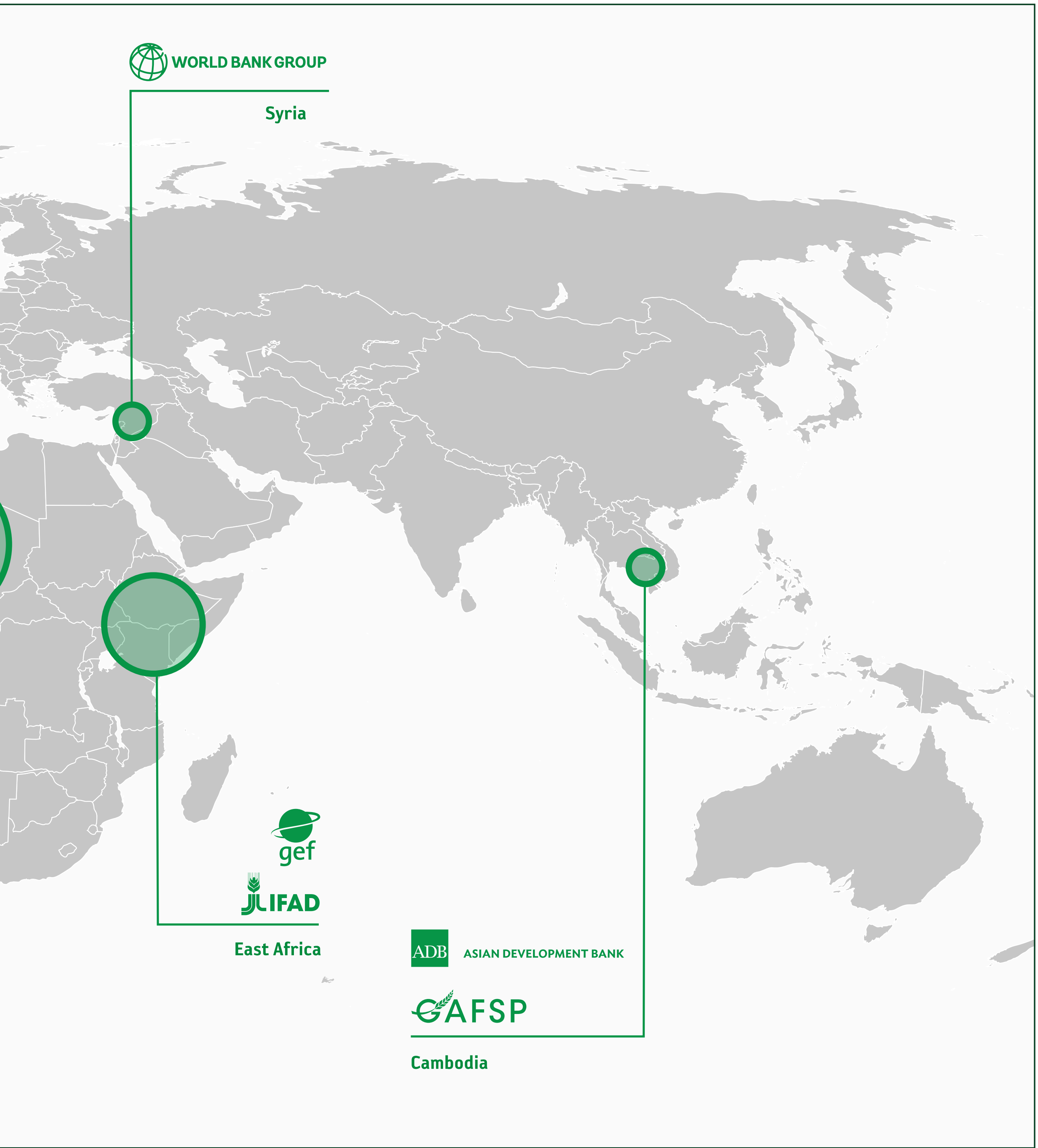
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