

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

→ E04SD – EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Agriculture and Rural Development | Great Green Wall Initiative

Sahel and West Africa Program (SAWAP)

Building Resilience through Innovation, Communication and Knowledge Services (BRICKS)



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1. INTRODUCTION

Land degradation and desertification are major development barriers in the Sahel and threaten the livelihood of its population that heavily depends on agriculture and the natural resources, particularly soil, water and vegetation. Yet, concrete evidence on the extent, severity and its drivers is frequently weak. Land use changes are poorly documented precise causes and drivers of degradation such as population pressures (farming, grazing, human settlements development), extreme weather conditions and climate variability are still not fully understood and monitored over time.

Long term environmental and land degradation processes related to both climate change and anthropogenic causes can be difficult to evaluate. The lack of adequate assessment is a major impediment to identifying policies and investments that bring results in halting and reversing desertification.

Earth Observation-based technology is exceptionally well suited to support the implementation of long-term and large scale development programs by providing data and information concerning the status and change in land use, vegetation cover, agricultural production, and water productivity.

2. OBJECTIVES

The Great Green Wall for the Sahara and Sahel Initiative (GGWI) is the call from Heads of States from African countries to combat land degradation and desertification affecting the Sahara and Sahel countries, to boost food security and to support local communities to adapt to climate change.

In this context the World Bank and GEF partnered to develop the \$1 billion Sahel and West Africa Program (SAWAP). The World Bank Sahel and West Africa Program (SAWAP) is an investment umbrella with (i) 12 country-led investments operations in Benin, Burkina Faso, Chad, Ethiopia, Ghana, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan, and Togo and (ii) the BRICKS project, a regional knowledge hub project.

SAWAP was one of the target programs of the E04SD (Earth Observation for Sustainable Development) "Agriculture and Rural Development Cluster". The following SAWAP projects were primary partners of the E04SD technical assistance:

- The BRICKS project (Building Resilience through Innovation, Communication and Knowledge Services);
- The Sustainable land management project II (SLMP-II) in Ethiopia; and
- The third Community- Based Rural Development Project (PNGT-2) in Burkina Faso.

The objective of E04SD was to support development of long-term and large scale assessment and monitoring systems which provide independent and authoritative environmental variables in order to build up strong evidence how different SAWAP/GGWI investments are improving local sustainable land and water resources management (SLWM) and generating global environmental benefits.

For the demonstration, E04SD partners with:

- specialized regional organizations, such as Sahara and Sahel Observatory (OSS), mandated to improve geospatial monitoring and evaluation within the BRICKS project
- national implementing agencies and project Country Management Units (CMU) of the SAWAP program: the Ministry of Agriculture in Ethiopia as well as the National Coordination Unit (NCU) in Burkina Faso who are tasked to develop indicators for consistent and reliable SAWAP/GGWI M&E reporting for their specific national investment projects, and development organizations financing agriculture and rural development programs, projects, and interventions in the Sahel region such as the World Bank, the GEF, and others who are in need of environmental and program level M&E information.

Earth Observation for Sustainable Development (E04SD) is a European Space Agency (ESA) initiative to increase the use of Earth Observation information products and services for international development projects.

The Agriculture and Rural Development cluster within E04SD aimed at demonstrating the benefits of EO- based geo-information products and services to support agricultural monitoring and management tasks including:

- agriculture production assessment,
- identifying food security, and
- land degradation monitoring,
- irrigation management.
- soil erosion risk mapping,

3. OUTCOME

The E04SD project provided data, information and methods designed for monitoring land degradation/regeneration as well as desertification and land use trends. This included:

- (1) multi-scale agricultural monitoring** (EO-based products and services include agricultural production areas and biophysical variables),
- (2) tools to assess land degradation and environmental conditions** (EO-based products and services including indicators used for monitoring Land Degradation Neutrality such as land cover and land use change, land productivity indicators such as vegetation cover trends, biomass production, and Net Primary Productivity, actual evapotranspiration, precipitation, and soil erosion potential by water),
- (3) support to rural infrastructure investments planning and monitoring** (i.e. irrigation infrastructure planning (irrigation suitability), habitat quality, fragile habitats).

The delivered land information services – mapping and monitoring tools and training activities – contributed to the SAWAP Program Level Performance indicators (KPIs) such as increase in land area with sustainable land/water management practices (KPI1), changes in vegetation cover (KPI2), change in carbon accumulation rates in biomass and soil (KPI4). A multi- scale system of monitoring of land cover, land status, erosion potential, land productivity (vegetation cover and biomass production) and agriculture production catalyzes evidence- based implementation of country-level projects by providing a concrete and operational contribution to the program-level monitoring and evaluation (M&E) tools (Figure 1).

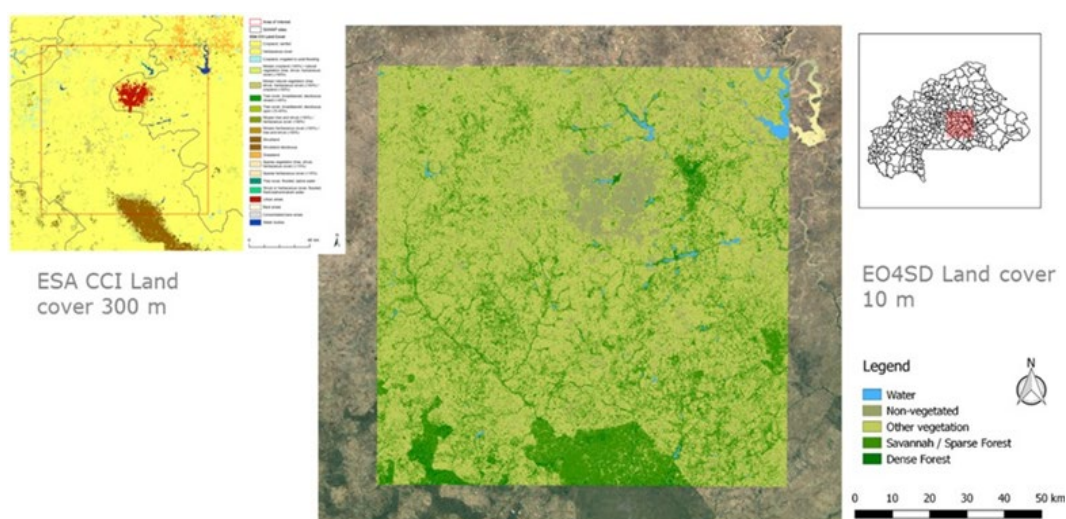


Figure 1 Evaluation of impact of interventions by mapping land cover at high spatial resolution (Burkina Faso).

Credit: E04SD Agriculture Cluster

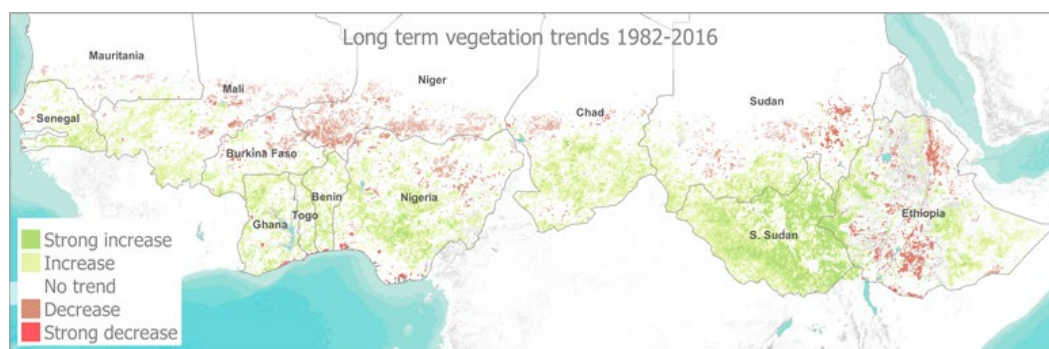


Figure 2 Long term vegetation trends 1982-2016 (corrected for precipitation as main variable).

Credit: E04SD Agriculture Cluster and the GIMMS team for providing the EO timeseries.

Earth Observation data, information products and services, available at the appropriate scales and timeframes, were made accessible to the users through the E04SD data and information delivery platform (E04SD.lizard.net). The Lizard site will go offline in October 2019, but most data will continue to be available through our partners ICRAF (<http://landscapeportal.org/projects/11>) and Conservation International (<https://foodsecurityiap.resilienceatlas.org/>).

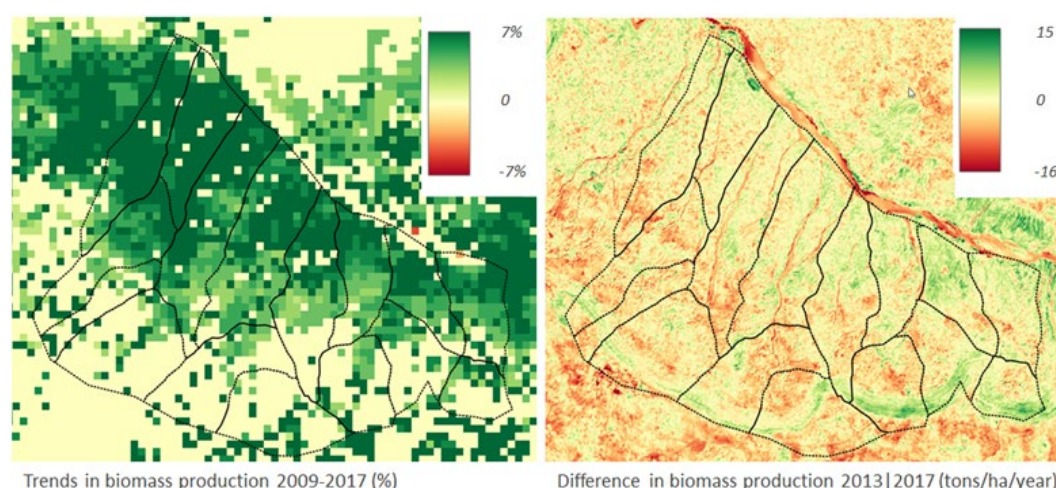


Figure 3 Changes in biomass production in a SLMPII watershed: trends based on the FAO WaPOR Above Ground Biomass Production dataset (250m) (left) and difference in biomass production based on Sentinel-2 and energy balance modelling (10m). Although the general trend is that the biomass production is increasing since 2009, the high resolution imagery shows there is significant variation at micro-watershed level and helps to prioritize restoration activities.

Credit: E04SD Agriculture Cluster

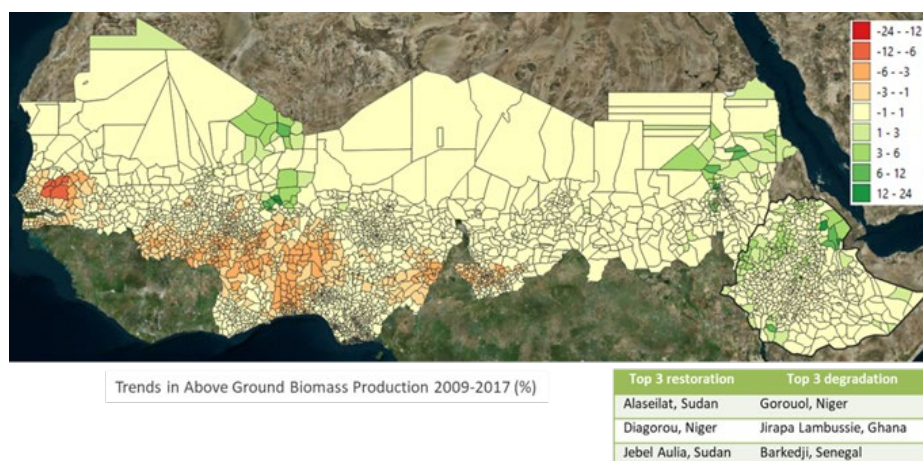


Figure 4 Trends in Above Ground Biomass Production based on the FAO WaPOR dataset

Credit: E04SD Agriculture Cluster

Table 1 List of multi-scale (regional and national level) indicators

Service level	Data	Spatial coverage	Temporal coverage	Spatial resolution	Description
Regional	Land cover	Continental	Yearly, 1992-2015	20-300m	ESA Climate Change Initiative datasets, including first continental Prototype Map for Africa based on Sentinel 2 at 20m (CCI+), 2015 Copernicus Global Land Cover (100m) based on ProbaV
	Land productivity	Continental	Yearly, 2009-2017	250m	Above Ground Biomass Production (AGBP) product from the FAO Water Productivity Open-access portal - WaPOR
	Biomass water productivity	Continental Africa	Yearly, 2009-2017	250m	Net Biomass Water Productivity (NBWP), in kg/m ³ , as available in the FAO WaPOR database
	Water consumption	Continental Africa	Yearly, 2009-2017	250m	Actual evapotranspiration (AET), in mm, as available in the FAO WaPOR database
Ethiopia	Land cover	(part of) North Shewa	2016/2018	10m	Customized land cover map based on Sentinel-2 data with detailed information on land cover in 2016 and seven land cover classes (water, build-up, bare soil, agriculture, grassland, shrubs, forest.) Baseline mapping for 2016 followed by near real time change mapping in 2018 with the aim to set up a Sentinel 2 based high resolution hot spot monitoring system
	Vegetation cover dynamics (trends)	(part of) North Shewa	1999 - 2018	30 m (National trends for 2000-2017 at 250m)	Long-term trends of vegetation cover showing areas of significant increase and decrease. Break points can be set at project start to see impact of intervention on vegetation development.
	Land productivity (biomass production)	(part of) North Shewa	2013&2017	30 m	Biomass production over time, in kilograms per hectare to derive input to carbon assessment product (combining carbon sequestration in biomass and in the soil).

Table 1, continuation List of multi-scale (regional and national level) indicators

Service level	Data	Spatial coverage	Temporal coverage	Spatial resolution	Description
Burkina Faso	Land cover/ use and change	SAWAP western AOI	Baseline mapping 2017 and change for 2018	10 m	Customized land cover map based on Sentinel 2 with detailed information on land cover in 2016 with five land cover classes (dense tree cover, sparse tree cover, other vegetation, non-vegetated and water) Baseline mapping for 2017 followed by rapid change mapping in 2017/2018 with the aim to set up a Sentinel 2 based high resolution hot spot monitoring system
	Vegetation cover dynamics (trend analysis)	National	2000-2018	250m	Large scale assessment of vegetation cover trends to reveal hotspots of change; impact assessments before and after project interventions
	Climate-normalised vegetation trend (vegetation dynamics not related to climate)	National	2000-2018	250 m	Reveal changes in vegetation cover related to climate and/or human activities
	Land productivity (biomass production)	SAWAP western AOI	2017	30m	Biomass production over time, in kilograms per hectare to derive input to KPI4 carbon assessment product (combining carbon sequestration in biomass and in the soil)

Some prototypes and refined data products for the Sahel region already existed. They were developed under Land Cover Component of the ESA Climate Change Initiative, as well as different on-going Copernicus and Sentinel data exploitation programs. This includes datasets released in 2017 such as the 300m annual global land cover series for 1992-2016 with 22 classes (based on FAO classification) and 1 km land cover change product with enhanced urban layer (based on the Global Urban Footprint) resolving land cover seasonality and water bodies information. In addition, a high resolution land cover dataset for the entire African continent at 20 m resolution was produced within the framework of the ESA Climate Change Initiative (+), along with the system for systematic monitoring of the human settlements in Africa region and globally (under the ESA Urban Thematic Exploitation Platform).

Moreover, annual Above Ground Biomass Production (AGBP) data from 2009 to present from the FAO Water Productivity Open-access database WaPOR was also assimilated to the BRICKS portal. Finally the ESA Sentinel 2 for Agriculture (Sen2-Agri) tool will offer the SAWAP user community validated algorithms to derive Earth Observation products for crop monitoring and generate four key products: monthly composites, dynamic cropland mask, crop type map and leaf area index (LAI) products.

The proposed data offered stronger baseline assessment for the GGWI, linking multiple datasets, spanning multiple scales, and consolidating and contributing to existing databases. Moreover, the indicators listed in Table 1 are following the FAO LADA¹, GM-UNCCD reporting guidelines, the Convention on Biological Diversity (CBD) and the 2020 Aichi targets.

The followed approach was also a practical way of monitoring and reporting progress towards the Sustainable Development Goals (SDGs) target 15.3 where Member States agreed to restore degraded land and soil, and achieve land degradation neutrality by providing information on 1) land cover and land cover change, 2) land productivity, and 3) carbon stocks above and below ground, according to the Framework and Guiding Principles for a Land Degradation Indicator.

The E04SD system of data collection and integration offered improved analysis of links between environmental and land degradation indicators as well as deeper understanding of trends and drivers to guide policies and future GGWI directions. In particular it ensured more effective monitoring and reporting of policies and GGWI investments, including stronger capacity among regional and national expert communities that rely on credible and reliable data for monitoring environmental, climatic and other regional development trends to use and work with Earth Observation data and services. Overall the project also enabled monitoring of adoption of sustainable land management practices as part of the pan-African commitment to the Great Green Wall initiative and provided an improved large- scale assessment of land degradation and related challenges to support better-informed policy and investment outcomes.

1 Land Degradation Assessments in Drylands (www.fao.org/nr/lada)

4. CAPACITY BUILDING

Many countries of the Great Green Wall Initiative and SAWAP are currently taking steps to enhance their sustainable land and water (SLWM) monitoring systems. Following the increasing availability of ICT, mobile networks, and Big Data analytics, the countries are increasingly open to incorporate satellite technology solutions to their national environmental monitoring systems.

The amount of free and open-access satellite data has increased immensely with the launch of the Sentinel satellites. However national GIS and remote sensing centers or user organizations often lack the capacity to develop and use the data for monitoring and reporting activities. The developed portfolio of the tailored information services and consistent capacity building activities helps them to sustainably build up their decision-making capabilities as well as knowledge in EO data exploitation.

The training under the E04SD umbrella is aimed to prepare the SAWAP/GGWI stakeholders for the increased data availability and its usefulness to SLWM investments planning, monitoring and evaluation. The training was delivered with the technical support of the ITC Faculty of Geo-Information Science and Earth Observation of the University of Twente: a global leader in training and capacity building in the field of geo-information science, earth observation and GIS.

The training component of E04SD involved a contribution to the SAWAP/BRICKS regional workshop in Benin and four capacity building workshops in Morocco (including the Burkina Faso teams) and Ethiopia. Furthermore the project organized an awareness event at the World Bank to demonstrate how satellite earth observation to share knowledge and enhance capacity on satellite Earth Observation applications in agriculture and rural development.

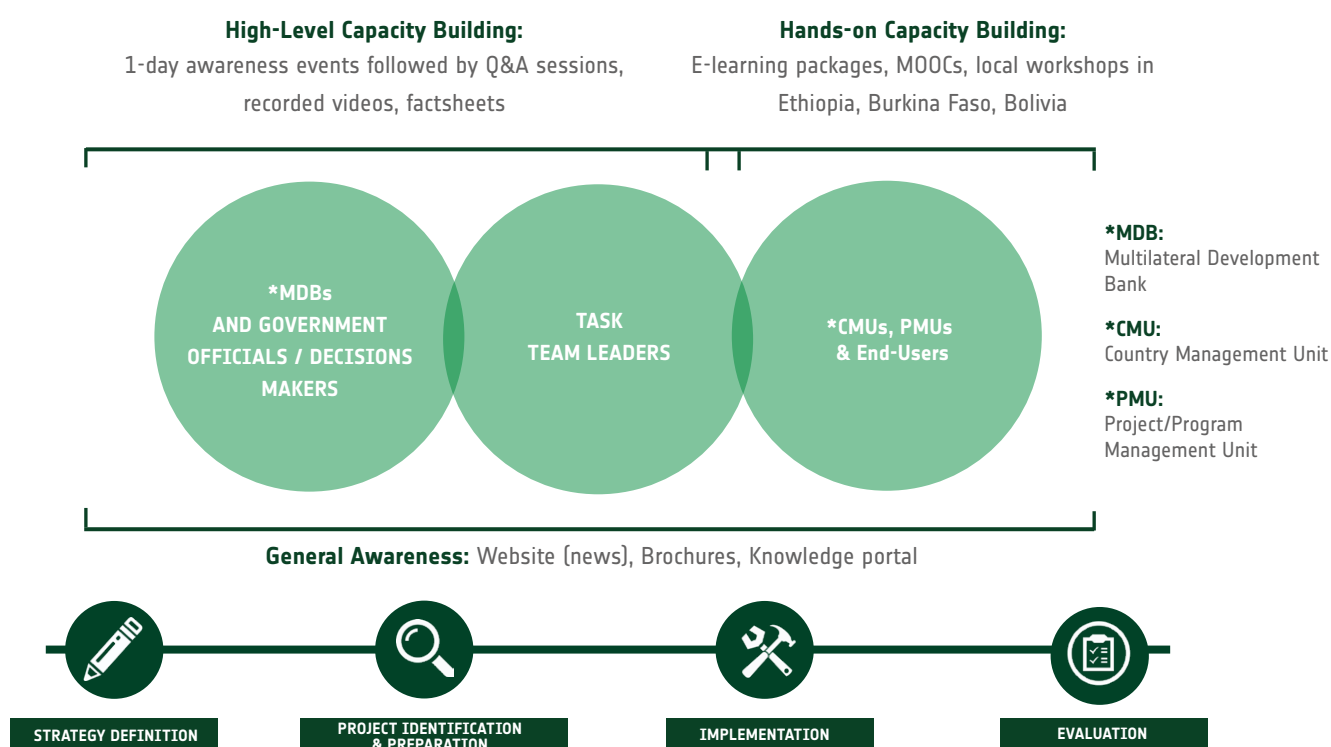


Figure 5 E04SD capacity building plan.

Partners of the Agriculture Cluster



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