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

→ EO4SD – EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Agriculture and Rural Development | Burkina Faso

Effective management and evaluation of rural development and sustainable land and forestry projects

agriculture and rural development
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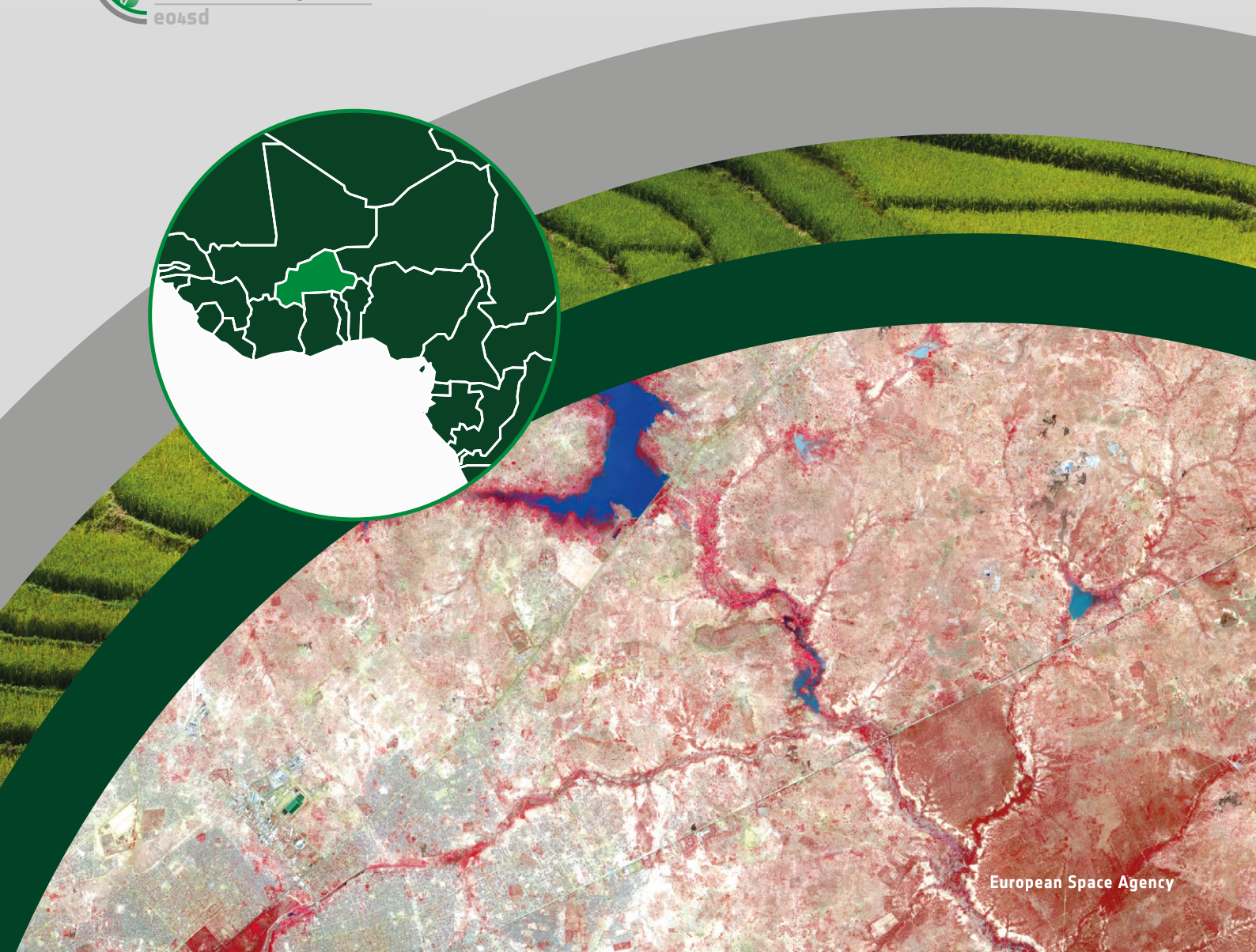

European Space Agency

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Cover image **Cover image shows that in the dry season active vegetation and agriculture can be mainly observed (in red) close to water bodies in Northern Burkina Faso. This image was acquired by Sentinel 2 on the last day of the year 2016 at 10 m spatial resolution. In fact, Sentinel-2 is the first optical Earth observation mission of its kind to include three bands in the 'red edge', which provide key information on vegetation state. Here, the bands 8, 4, 3 are combined to a 'false colour image' that highlights active vegetation cover in red.**
Credit: EO4SD Agriculture Cluster (GeoVille for ESA/IFAD/WB, 2017)

1. INTRODUCTION

Burkina Faso is a landlocked sub-Saharan country with limited natural resources. Its agro-ecological conditions are negatively impacted by climatic deterioration and increasing human pressure. Economically agriculture is the most important sector, providing of 80 percent employment of the active population. However as most of the agriculture is rainfed, changes in rainfall patterns and droughts severely affect the country's income and livelihoods. It has been estimated that besides natural factors, agricultural pressure (such as the overexploitation of the already limited natural resources through agricultural extensification of crop and livestock) increases environmental degradation.

EO4SD (Earth Observation for Sustainable Development) "Agriculture and Rural Development Cluster" supported several Multilateral Development Banks (MDBs) programs – in particular the World Bank and IFAD - regarding sustainable rural development in Burkina Faso. The objective was to provide them with up-to-date information that can guide land management decisions in order to halt land degradation, safeguard natural resources and improve agricultural productivity and food security. The potential of satellite EO technology to effectively manage and evaluate sustainable land and forestry management and how it was applied successfully is presented in this document. The purpose was to raise awareness and demonstrate to MDBs and their local stakeholders in Burkina Faso the added value of the state-of-art EO-based geo-spatial data products and services geared to information and capacity building requirements of the World Bank and IFAD's programs.

The World Bank information requirements were based on the implementation of the Third Community- Based Rural Development Project (PNGT-2) funded through the Sahel and West Africa Program (SAWAP). Underway since June 2013 it enhances the capacity of rural communities and decentralised institutions in the implementation of local development plans that promote sustainable land and natural resource management, and productive investments at the community level. In addition, PNGT- 2's monitoring and evaluation (M&E) activities are supported by the Sahara and Sahel Observatory (OSS) through the SAWAP's Building Resilience through Innovation, Communication and Knowledge (BRICKS) project.

> *"Burkina Faso's natural resources are being degraded primarily by deforestation, expansion of agricultural land, and grazing, all of these factors are being amplified by climate change.[1]"*
>
> **Ian Bannon, Acting World Bank Director for Sustainable Development in the Africa Region.**

Moreover, in order to define and implement its national REDD+ strategy, dedicated to reduce emissions from deforestation and forest degradation, Burkina Faso has benefited from the assistance of the World Bank and the African Development Bank (AfDB) to develop a Forest Investment Program (FIP) under Climate Investment Funds (CIF). Forests are impacted by rural development and agricultural activities, leading to deforestation and forest degradation. The CIF has selected eight developing countries as pilot areas to assess the effectiveness of REDD+ interventions. Reversing deforestation is of paramount importance for Burkina Faso because 7 million hectares of forest cover (representing about 25% of the country's surface) have been under heavy pressure with an estimated average annual deforestation rate of 1% between 1990 and 2015 (FAO, 2015)[2] . Burkina Faso has been chosen as the pilot country for the arid and semi-arid areas, given its tremendous replication potential in other countries with more than 500 million hectares of similar ecosystem around the world in Africa and South Asia.

[1] See the World Bank www.worldbank.org/en/news/press-release/2012/12/20/burkina-faso-boost-capacity-building-rural-development-sustainable-land-forestry-management

[2] FAO Global Forests Resources Assessment (2015).

On the other hand, the International Fund of Agricultural Development (IFAD) has been operating in Burkina Faso for three decades in poor rural areas. IFAD is implementing the Fostering Participatory Natural Resource Management project in the framework of the Participatory Natural Resource Management and Rural Development project (Neer-tamba project) which is funded by the Global Environment Facility (GEF) through the Integrated Approach Pilot Program on Food Security (IAP-FS). This project scales up activities defined in accordance with the strategic priorities of the Country Strategic Opportunities Programme (COSOP), focusing on building resilience to climate change in particular. This GEF-IAP project is being implemented over a period of eight years (2014-2022) and will contribute to the Burkina's second National Rural Sector Programme (PNSR2).

Target MDB's Projects and Programs

The Integrated Approach Pilot Program on Food Security in Burkina Faso

The Integrated Approach Pilot Program on Food Security (IAP-FS), an integrated approach pilot (IAP) initiative of the Global Environmental Facility (GEF), was designed to contribute to achieving the GEF 2020 vision and long-term strategy to impact the global environment. This is achieved by investing strategically in solutions targeting the underlying causes of environmental degradation. In Burkina Faso, the IAP is a sub-regional program that aims to improve food security through sustainable ecosystem management. It has the following three components: **(1)** institutional frameworks, **(2)** scaling-up practices for sustainability and resilience, and **(3)** the monitoring and assessment of ecosystem services, global environmental benefits, food security and resilience.

The Sahel and West Africa Program in Burkina Faso

The Sahel and West Africa Program (SAWAP) is the World Bank and GEF's contribution to the Great Green Wall Initiative. The vision is to foster sustainable land uses and community based land and water management practices. In Burkina Faso, the objective is to enhance the capacity of rural communities and decentralised institutions for the implementation of local development plans that promote sustainable natural resource management and productive investments at commune level.

The Forest Investment Program

The World Bank (WB) and the African Development Bank (AfDB) supported Burkina Faso's national REDD+ strategy by assisting in preparing the country for access to the international carbon market. The reduction of GHG emissions below their normal levels is an environmental service that could provide the country with compensation through a performance based mechanism. This plan, the so-called Forest Investment Program (FIP), aims to reinforce the carbon sequestration capacity of forests by reducing deforestation and forest degradation through improved governance, environment-friendly local socio-economic development, and sustainable management of forest resources and wooded areas.

2. OBJECTIVES

Burkina Faso is a recipient of a variety development programs and projects available through the MDBs financial instruments. They often target the environmental problems from different angles nevertheless what they have in common are key information requirements about the state and evolution of country's natural resources that can be supported effectively with Earth Observation data (through land cover mapping, development of tools to assess land degradation and environmental conditions as well as information systems that support monitoring and evaluation of investments.)

The objective of the World Bank project implemented in Burkina Faso as part of the REDD+ program is to improve tree cover in the woodland areas surrounding 12 selected gazetted forests. Participatory land use planning is aimed to improve woodland conservation. The project will use new methods to assess the overall effectiveness of the two main interventions: conditional conservation payments in the gazetted forests (the so-called Payments for Ecosystem Services (PES) scheme), and participatory forest management approaches in the surrounding woodland areas. The objectives for EO4SD project is to estimate the impact of PES and community-based forest management on forest conservation by monitoring land use and cover changes in forest ecosystems and nearby communities.

Regarding the World Bank led SAWAP/OSS project, PNGT-2, its objective is to expand sustainable land and water management (SLWM), and improve the productive capacity of rural resources. EO4SD supported the monitoring of the following key performance indicators: biomass production, vegetation cover state and change dynamics as well as land cover change.

The objective of the IFAD-led GEF-IAP project is to ensure that the Government of Burkina Faso adopts and scales up food security policies and activities that build in resilience and sustainable management of the environment. The development objective is to ensure, within the framework of the Neer-Tamba project, that the agro-ecosystems that are providing food security in the North region are managed sustainably. The project involves three technical components: (i) enhancing the decision-making capacities of national and regional multi-stakeholder platforms to set sector policy and intervention priorities; (ii) improving food security in the North region through sustainable ecosystem management; (iii) monitoring and evaluation of environmental risks linked to achieving sustainable food security. EO4SD supported the IAP in Burkina Faso on two levels: by providing a detailed and updated map (a baseline) of the North region land and water resources, and by monitoring "land under sustainable & integrated management" to support institutional partners and actors at local level in their decision-making and investments effectiveness evaluation at the project level. This study also assessed the erosion risk for selected sites. The erosion risk factor furthermore serves as an indicator for the project to prioritise GEF-IAP investments by identifying where erosion risk is highest. Monitoring over time showed where 'regreening' has happened, lowering the erosion risk and verifying the effectiveness of the land management practices.

The EO4SD project aims to answer key development questions in relation to IFAD and World Bank activities in Burkina Faso:

- Have Payments for Ecosystem Services (PES) been effective in forest ecosystems and surrounding communities?
- Have project investments led to a "regreening" in selected sub-watersheds?
- What is the status of natural resources?
- Which areas are most prone to water-based soil erosion?
- Which areas are most degraded?

3. IMPLEMENTATION PLAN

EO4SD defined and developed a cluster of land information services that were delivered to IFAD, the World Bank and their stakeholders. These services incorporate mapping and monitoring tools as well as training activities in order to enhance the success of the GEF-IAP, SAWAP and REDD+ programs in Burkina Faso. This includes:

(1) Land cover change mapping and ecosystem services (EO-based products and services to identify agricultural production areas and tree cover)

(2) Tools to assess land degradation and environmental conditions (EO-based products and services to identify water-based soil erosion, and provide vegetation trend analyses, land degradation assessments)

(3) Environmental and Social Safeguards (Monitoring and Evaluation) (EO-based products and services as well as geo-information products to identify the effectiveness of investments)

The target partners are:

- **IFAD** as the implementing agency for the GEF-IAP Participatory Natural Resource Management and Rural Development project (Neer-tamba Project),
- **The World Bank** as a lead agency of a Third Community-Based Rural Development Project (PNGT-2) as a part of the Sahel and West Africa Program (SAWAP), as well as the Forest Investment Program (FIP),
- **the Ministry of Agriculture and Water Resources** (*Ministère de l'Agriculture et des Aménagements Hydrauliques*), and
- **Ministry of Environment and Sustainable Development** *(Ministère de l'Environnement et du Developpement Durable (MEDD)*) the **Division for the Development of Competences, Information and Monitoring in the Environment** (*Division du Développement des Compétences, de l'Information et du Monitoring en Environnement, DCIME*), which is part of the Permanent Secretariat of the National Council for the Environment and Sustainable Development (*Secrétariat permanent du Conseil National pour l'Environnement et le Développement Durable, SP/CONEDD*), responsible for the management of environmental information.

Earth Observation data, information products and services, available at the appropriate scales and timeframes, are made accessible to the users through the EO4SD data and information delivery platform (EO4SD.lizard.net). The Lizard platform was used as a hub for data sharing and visualisation. The communication with Lizard was available both via the web-interface (where the services and data products will be shown at different regions and scales) and through direct communication via an Application Programming Interface which will be available for continuous communication between the technical partners and the ESA consortium.

In addition to the EO4SD generated data, the system also included open access data from ESA, such as a datasets developed under ESA Climate Change Initiative (CCI+), including high-resolution land cover dataset for the entire African continent, which is currently under production in the framework of the ESA and Copernicus Program Initiatives.

The ESA Sentinel-2 for Agriculture (Sen2-Agri) tool offers the user communities validated algorithms to derive EO products for crop monitoring. Over twelve different test sites are currently implemented including locations in Burkina Faso, Mali, and South Africa to generate four key products: monthly composites, dynamic cropland masks, crop type maps and leaf area index (LAI) products.

Service level	Data	Spatial coverage	Temporal coverage	Spatial resolution	Description
Regional	Land cover	Continental Africa	Yearly, 1992-2015	20-300m	• ESA Climate Change Initiative datasets, including first continental Prototype Map for Africa based on Sentinel-2 at 20 m (CCI+) as well as annual land cover change products • Global Urban Footprint (GUF, GUF+), • 2015 Copernicus Global Land Cover (100m) based on ProbaV
	Land productivity	Continental Africa	Yearly, 2009-2017	250m	Above Ground Biomass Production (AGBP), in kg/ha/year, as available in the FAO Water Productivity Open-access portal WaPOR
	Biomass water productivity	Continental Africa	Yearly, 2009-2017	250m	Net Biomass Water Productivity (NBWP), in kg/m3, 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

Service level	Data	Spatial coverage	Temporal coverage	Spatial resolution	Description
Burkina Faso	Land cover/ use and change with focus on forest ecosystems	Region Nord (IFAD), central Burkina Faso (SAWAP), western Burkina Faso (FIP forests and surrounding communes)	Baseline mapping 2017 and change for 2018	10 m	Land cover/use map depicting - Dense tree cover - sparse tree cover - other vegetation - non-vegetated - water
	Soil erosion mapping (water based)	Region Nord (IFAD), central Burkina Faso (SAWAP)	One coverage, depending on input data	30 m	Identification of areas prone to water-based soil erosion based on terrain, vegetation cover, rainfall and soil type
	Agricultural production	National	Yearly / seasonal mapping	20 m	Detection of cultivated and irrigated agricultural areas (identification of the area location and extent). Sentinel-2 for Agriculture (Sen2-Agri) tool components will be applied. Crop type mapping will depend on quantity and quality of available field data
	Vegetation dynamics (trend analysis)	National	2000-2018	250 m	Large scale assessment of vegetation cover trends to reveal hotspots of change; impact assessments before and after project interventions

Service level	Data	Spatial coverage	Temporal coverage	Spatial resolution	Description
Burkina Faso	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)	Region Nord (IFAD), central Burkina Faso (SAWAP), western Burkina Faso (FIP forests and surrounding communes)	Baseline mapping 2017	30m	Biomass production over time, in kilograms per hectare to derive input to carbon assessment product (combining carbon sequestration in biomass and in the soil)
	Support to MDBs environmental and social safeguard frameworks/ M&E service - Monitoring and Evaluation	Region Nord (IFAD)	Baseline mapping 2017 and trends for 2018	10-30 m	Assessment of erosion risk/re-greening for selected sites where project investments have taken place

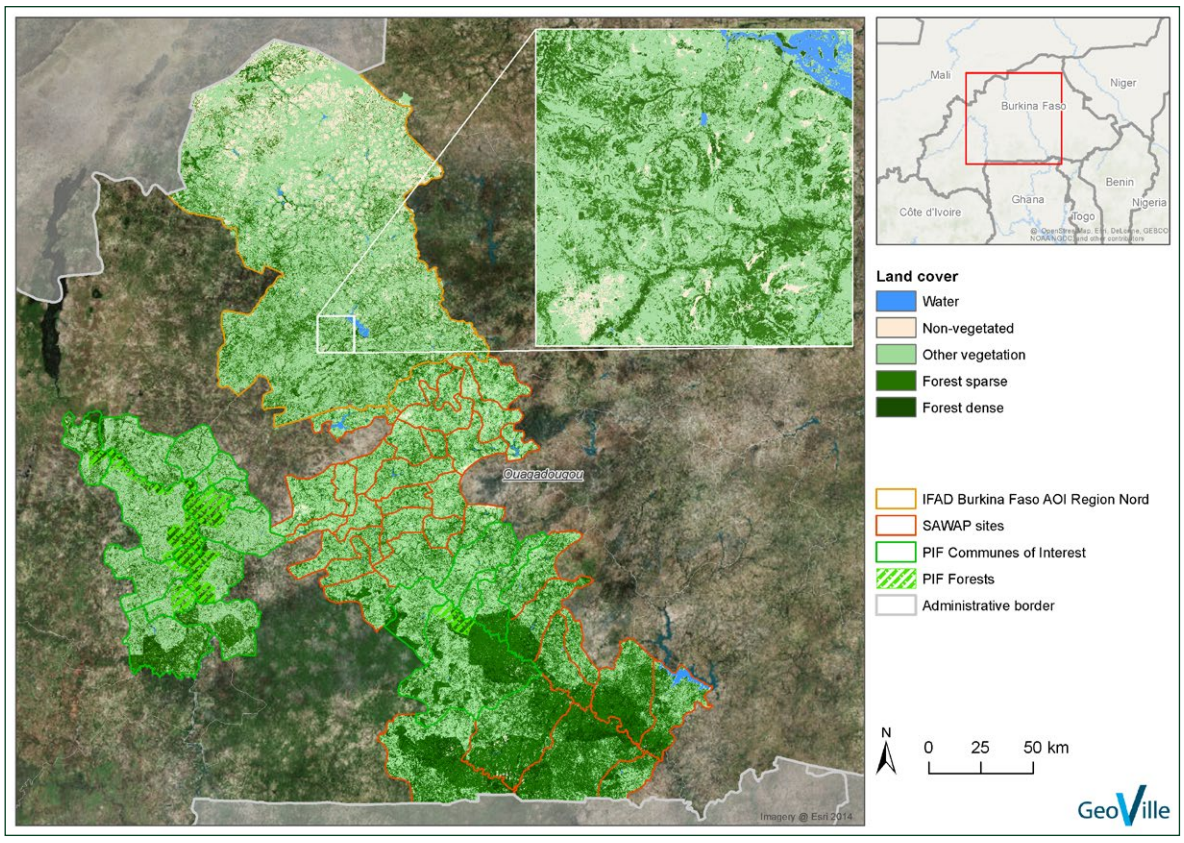


Figure 1 Detailed land cover/use mapping for 2016/2017 for different areas of interest throughout Burkina Faso based on a time series analysis of more than 400 Sentinel-2 images.
Credit: EO4SD Agriculture Cluster (GeoVille for ESA/IFAD/WB, 2017).

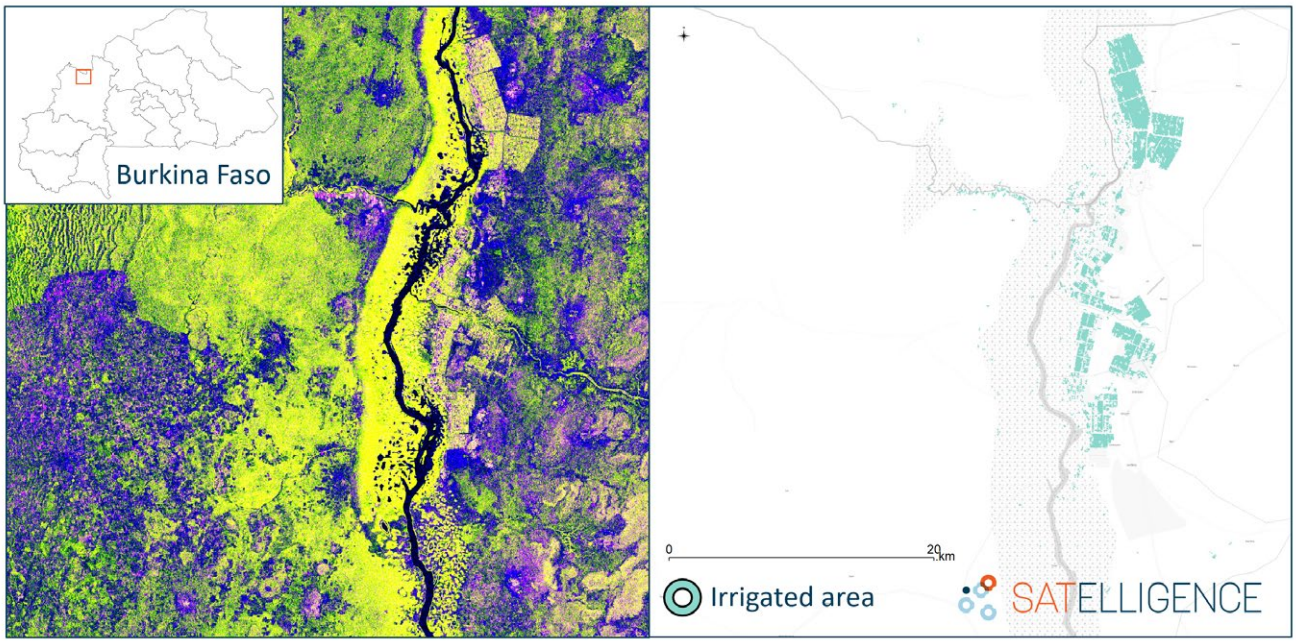


Figure 2 Left: example of one of the Sentinel-1 radar images used in the irrigated area analysis (image 2 February 2017). Right: irrigated area map based on multi-temporal Sentinel-1 radar imagery (April 2015 to February 2017). Location: agricultural area surrounding the Ramsar site La Vallée du Sourou, Burkina Faso[3].
Credit: EO4SD Agriculture Cluster (GeoVille for ESA/IFAD/WB, 2017).

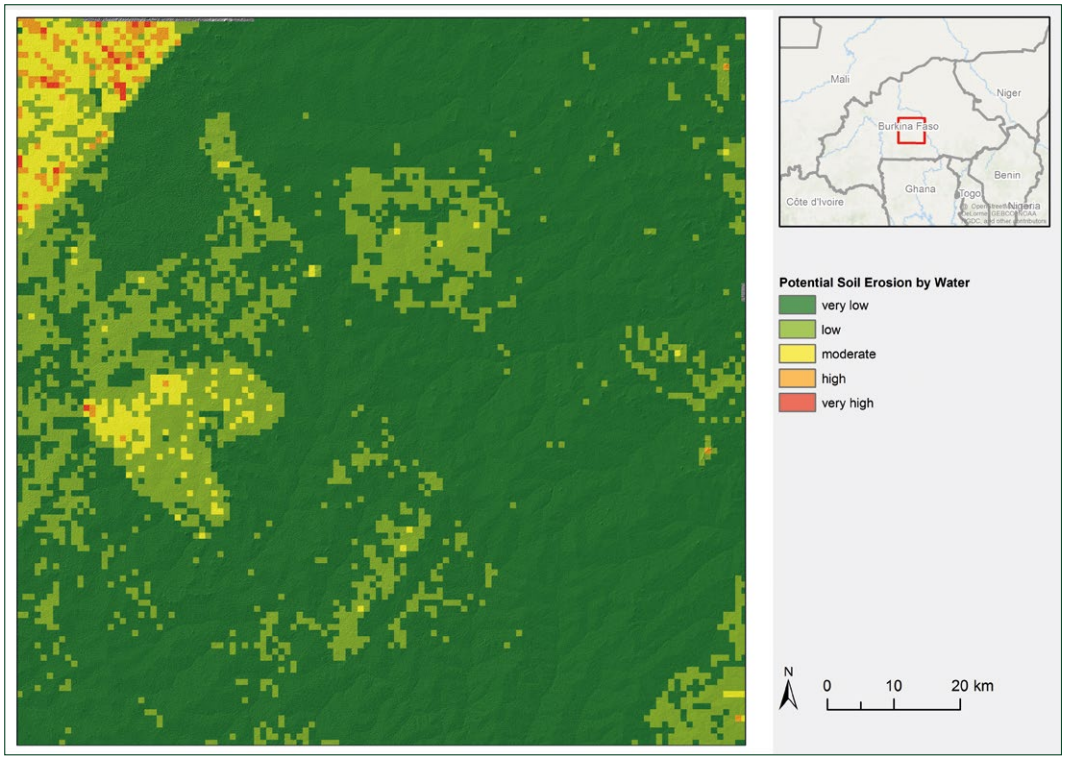
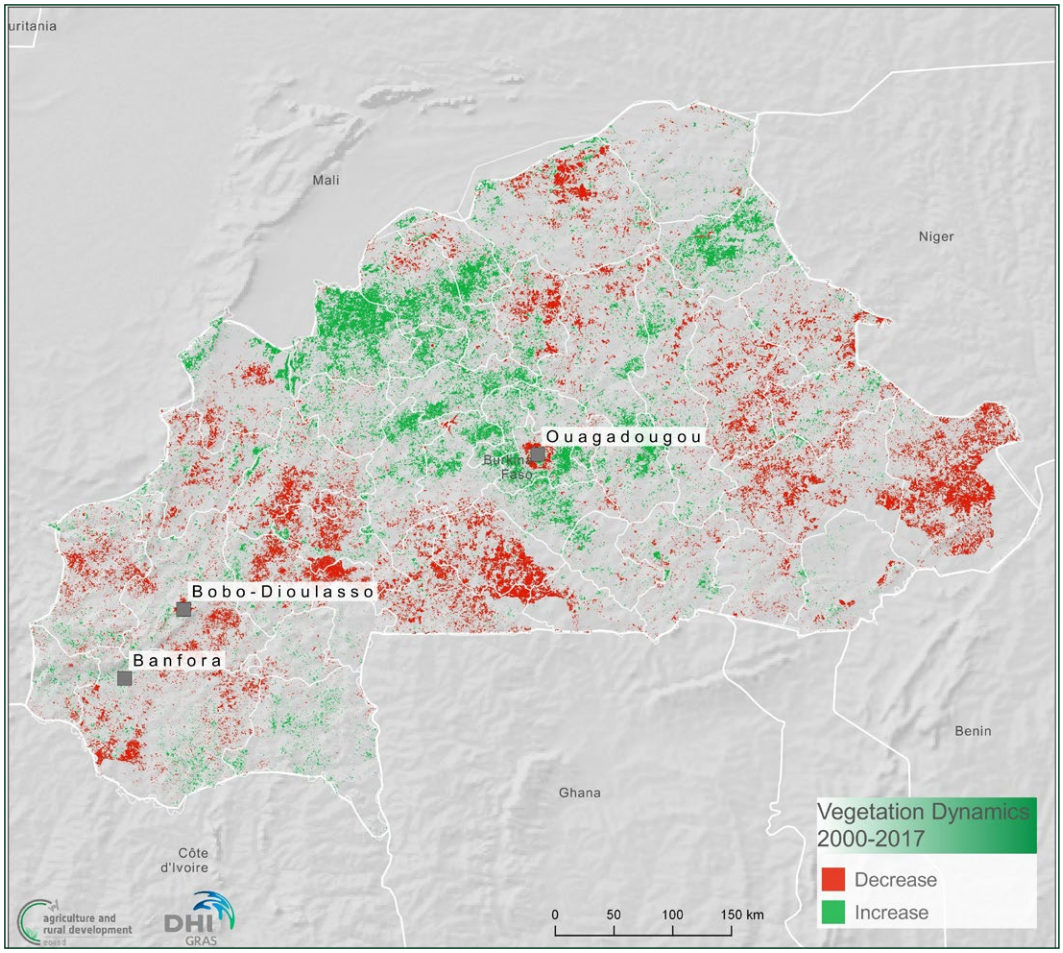


Figure 3 Water-based soil erosion potential is derived from satellite-based digital terrain information, rainfall and land cover data as well as a digital soil map. Areas prone to soil erosion can be identified and further assessed, supporting recovery activities.
Credit: EO4SD Agriculture Cluster (GeoVille for ESA/IFAD/WB, 2017).

[3] Background map data copyright: OpenStreetMap contributors and available from www.openstreetmap.org



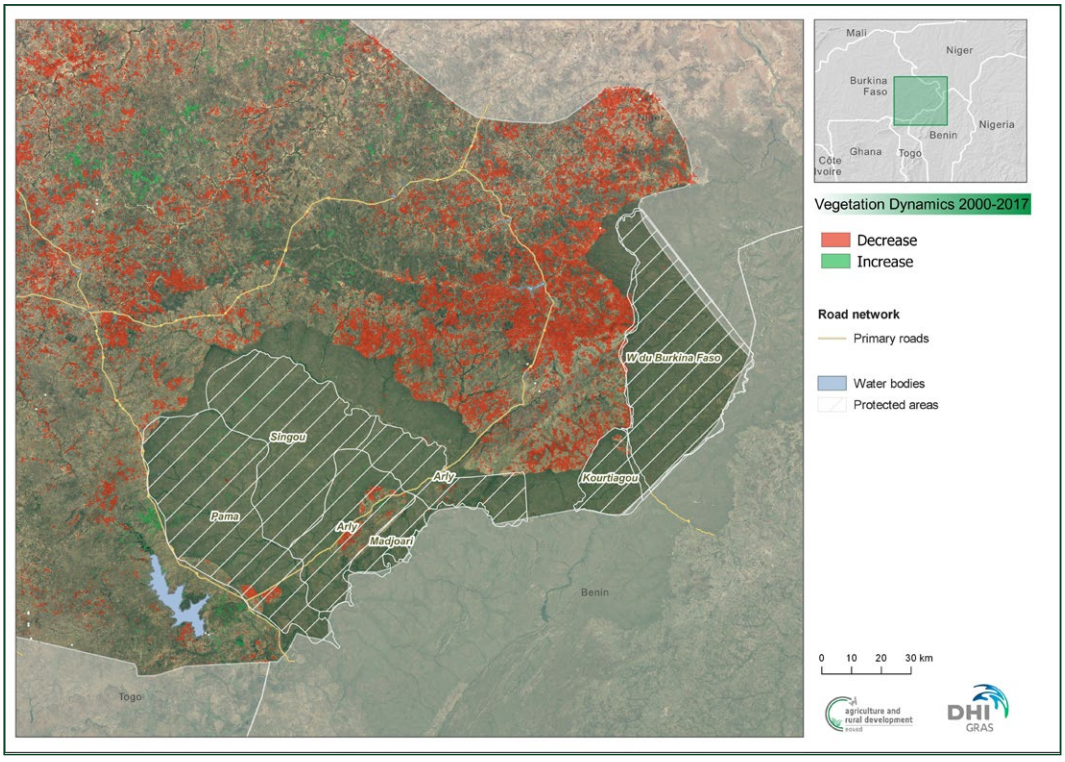


Figure 4 Significant change in vegetation cover (increase and decrease) from 2000-2018 in Burkina Faso. Decreasing vegetation cover is very obvious around Ouagadougou, reflecting the city expansion and in areas with agricultural expansion. In the national map some major areas stand out without any significant changes, e.g. in the south east of the country. These areas often fall together with protected areas, as can be seen in the bottom figure.

Credit: EO4SD Agriculture Cluster (DHI GRAS for ESA/IFAD/WB, 2017).

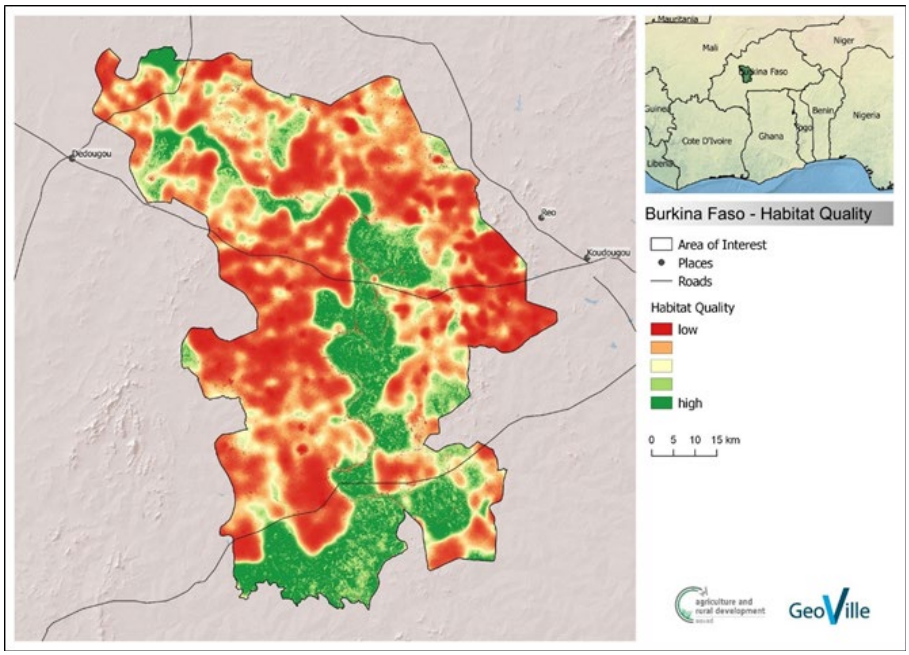


Figure 5 Habitat Quality derived from land cover data (2018) and additional layers (e.g. cultivated areas, settlements, OSM, 2018) which represent the threats to the health of the habitats.
Credit: EO4SD Agriculture Cluster (DHI GRAS for ESA/IFAD/WB, 2017).

4. CAPACITY BUILDING

The amount of free and open-access satellite data has increased dramatically with the commissioning of the Sentinel satellites. However, national GIS and remote sensing centres or user organisations often lack the capacity to develop and use the data for monitoring and reporting activities. Developing a portfolio of tailored information services and ad hoc capacity building activities would help them to sustainably build up their decision-making capabilities as well as skills in EO data exploitation.

The training under the EO4SD umbrella aimed at demonstrating the opportunities and benefits of using EO-based information services so that they become an integral part of the planning, operational, monitoring and evaluation phases of projects. This plan was implemented 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. It aimed at developing the skills set of the remote sensing professionals and the user organisations alike and included - as necessary - practical exercises concerning data application and use, lectures, and independent EO research by the participants. It also specifically leveraged free, open access Earth Observation data and programs.

This dedicated training component (see Figure 5) involved the organisation of awareness raising sessions with MDBs and other development partners and national training workshops organised for the French-speaking stakeholders in Marrakech, Morocco. The duration was 5 days and stakeholders from different targeted projects were gathered together.

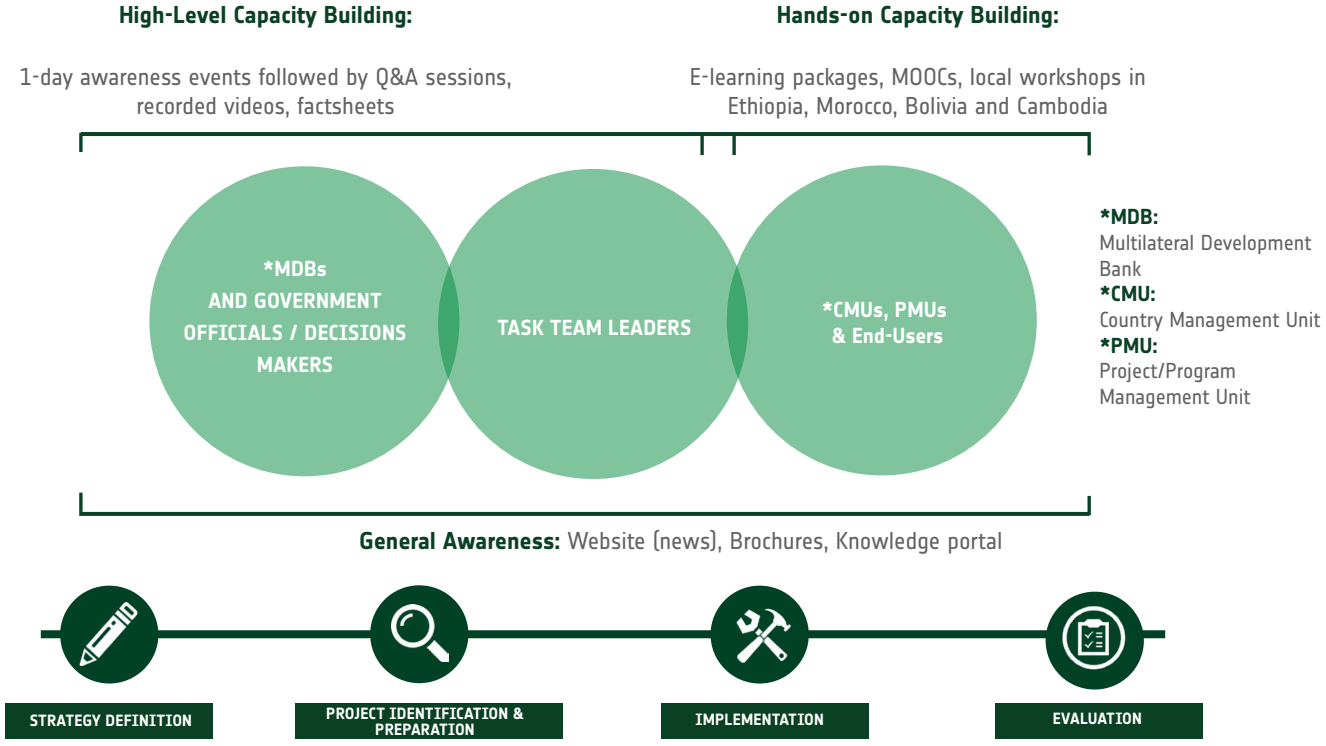


Figure 6 EO4SD capacity building plan.

Figure 7 outlines how national training workshops were organised aiming at supporting organisational capabilities to use EO data and services to fulfil their operational functions.

The Agriculture and Rural Development cluster organised the first local workshop in Marrakech (Morocco) at the Direction Regional de l`Agriculture (DRA) from 12 to 16 March 2018. For this event, attended by 20 participants from MDBs and governmental agencies, the focus was on projects implemented in Burkina Faso and Morocco and funded by the UN`s International Fund for Agriculture Development (IFAD) and the World Bank (WB). This training did not only present the state-of-art EO capabilities for the agriculture and rural development sector to local stakeholders but it also provided the project implementation teams with a refresher training on GIS and EO technology and data.

Moreover, a roadmap towards an integrated approach to the development of EO-based indicators for Monitoring and Evaluation purposes was discussed during the workshop. Attendants from different backgrounds and with different roles in regional projects, organisations, and ministries benefited from the various components of the training, showed keen interest for the next round of local workshops, and proposed topics and areas of interest to be covered in future EO4SD capacity building events.

A second workshop was held in Marrakech (Morocco) from 23 to 26 April 2019 that aimed at French-speaking stakeholders in the frame of the EO4SD initiative. While the first workshop targeted the first interaction and use of the products and services this second workshop had the aim to see how these services are used in the projects and to formulate a roadmap with each of the stakeholders.

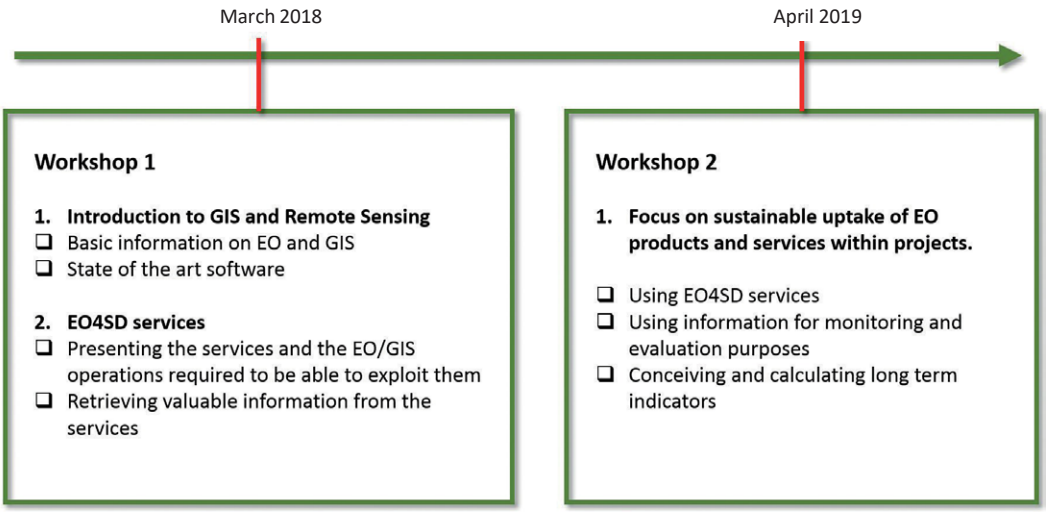


Figure 7 Outline of customised national training workshops.

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For more information, please contact:

ESA Technical Officer: Anna Burzykowska - Anna.Burzykowska@esa.int

Project Lead: Remco Dost - Remco.Dost@eleaf.com

eo4sd.esa.int/agriculture