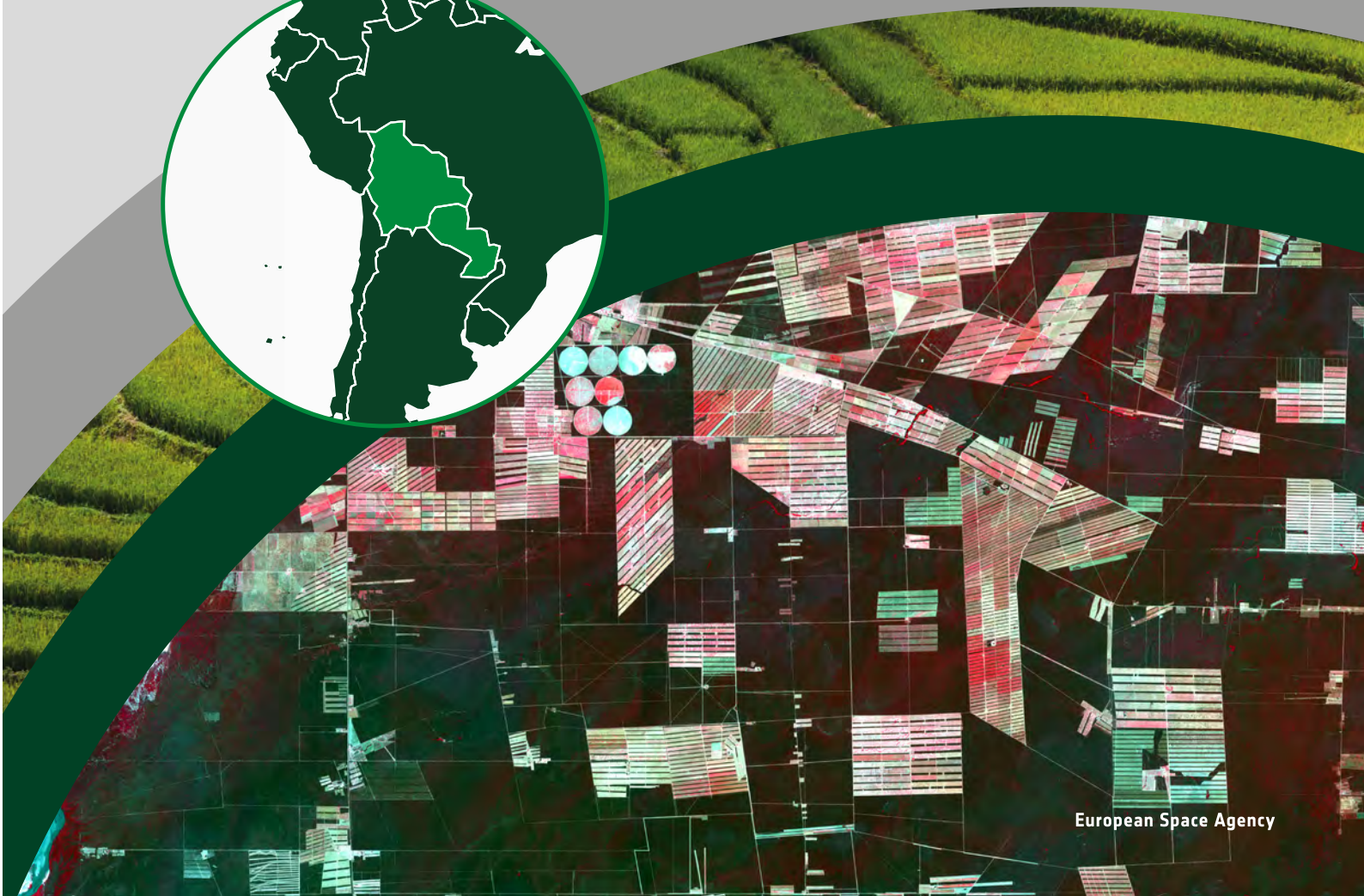


LARGE-SCALE EXPLOITATION OF SATELLITE DATA IN SUPPORT OF INTERNATIONAL DEVELOPMENT

# → E04SD – EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

## Agriculture and Rural Development | Bolivia and Paraguay

### Agriculture expansion impact on deforestation



**Cover image** Sentinel-1 image over Santa Cruz Region in Bolivia

Credit: ESA

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## 1. INTRODUCTION

In the last decade Bolivia has shown significant developments in agricultural production and the agro-food industry. The agriculture sector in Bolivia is of great economic and social importance as it accounts for 13% of GDP and is the main economic activity for 77% of the country's rural population. However the sector is dominated by farmers and indigenous family agriculture, characterised by small farms and low productivity. Yields from cereal and tuber crops in Bolivia average 57% and 39% of the South American total respectively, and the total productivity growth rate for these crops has remained below the average for Latin America and the Caribbean over the last two decades. This low productivity is reflected in low income for the rural population and in high levels of food insecurity.

In Bolivia, transgenic crops and quality seed have not been adopted as much as in neighbouring countries. On the other hand, poor agricultural practices, monocrops and excessive usage of agrochemicals results in soil erosion. In the meantime, the need for proper water management and irrigation has become a national priority, especially after the drought in 2016.

The Chaco dry forest region in the South of Bolivia and Eastern part of Paraguay is an important wilderness area. However, deforestation and land degradation due to uncontrolled expansion of soy and livestock are rampant. The region is experiencing one of the highest deforestation rates in the world.

Providing policymakers at the Multilateral Development Banks (MDBs) and government agencies, as well as farmers with the knowledge and tools to make better informed decisions on the basis of historical to current information habitat quality, deforestation and crop distribution and performance, can help design more sustainable policies and raise productivity and income in existing agricultural areas.

The testing, validation and maturity of the Earth Observation (EO) technologies now makes it feasible to deploy services for the benefit of smallholders, businesses, donors and (non) governmental organisations that strive to achieve sustainable supply chains and assess and increase productivity to investments as well as improve the livelihood of the smallholders. With the launch of the European Space Agency's (ESA) Sentinel satellites - carrying both optical and radar sensors and providing images at multiple spatial scales - an unprecedented amount of free and open-access data has become available. This will not only remove the barriers related to previously inadequate access to timely information but will also to solve the obstacles related to the operational adoption of information provision for various reporting obligations, especially if coupled with appropriate ground information and on-site validation using hierarchical field survey and sampling protocols.

The potential of satellite EO technology for effectively monitoring the agricultural production as well as expansion impact on deforestation in Bolivia and Paraguay is presented in this document. The purpose is to raise awareness and demonstrate to the MDBs and their local stakeholders the added value of EO information products and services for implementation of their ongoing development projects and programs.

The Inter-American Development Bank (IDB) and the Global Environment Facility (GEF) are currently providing financing and technical assistance for the following ongoing key projects in Bolivia and Paraguay:

- **IDB Rural Land Regularization and Titling Program** (Land Administration Program II – IDB BO-L1113). This project does focus on both the lowland and highland areas.
- **GEF Taking Deforestation out of Commodity Supply Chains** (Integrated Approach Pilot (IAP) Commodities program), implemented by UNDP's Green Commodities Programme. This project covers part of the dry forest across the border in Paraguay.

The Land Administration Program II project supports setting up an environmental cadastre to address land tenure control issues resulting from unbridled soy and livestock expansion causing deforestation and ecosystem degradation. Improving the estimation and availability of land pricing information and informed land allocation can help promote sustainable agricultural expansion in less vulnerable areas.

The GEF IAP Commodities program promotes an integrated supply chain approach to tackle the underlying root causes of deforestation from agriculture commodities, such as beef in Paraguay. Partners include the government of Paraguay, the private sector and civil society organisations to enable lasting, transformative change throughout the key global beef supply chain. Led by the UNDP's Green Commodities Programme, the partnership will be implemented in collaboration with Conservation International, the International Finance Corporation, UN Environment and World Wildlife Fund.

## 2. OBJECTIVES

The ongoing initiatives supported by IADB and GEF (**The Land Administration Program II and Taking Deforestation out of Commodity Supply Chains**) are target projects in Latin America for the E04SD (Earth Observation for Sustainable Development) "Agriculture and Rural Development Cluster". The main objective is to demonstrate that the effectiveness of technical assistance and financial investments in the agriculture sector can be measurably enhanced by using Earth Observation-derived information.

In the context of Bolivia and Paraguay, the E04SD project will contribute with information on:

- Crop type and performance
- Deforestation
- Land cover status
- Habitat quality and suitability mapping

E04SD - Agriculture and Rural Development Cluster project - aims at demonstrating the benefits of EO-based geo-information products and services to support agricultural monitoring and management tasks including:

- agriculture production assessment,
- deforestation-free commodity monitoring, and
- land cover and habitat quality

Paraguay and Bolivia currently monitor deforestation on an annual basis using optical imagery, but for agricultural production area licensing and commodity monitoring more frequent observation is needed.

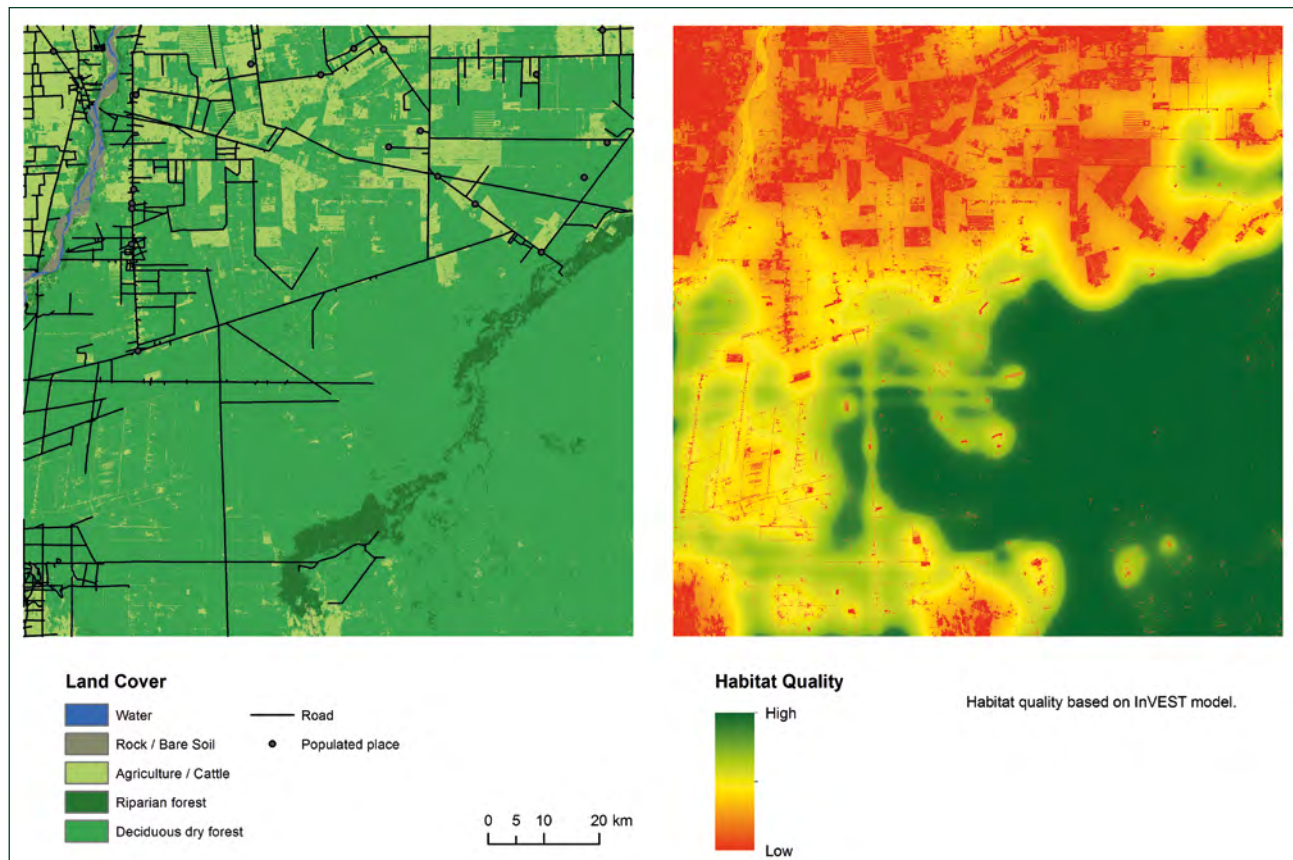
Key questions to be answered by IADB "Land Administration II" project include how land titling does affect the forest. To answer this, E04SD would provide information services in the form of mapping and monitoring tools which include:

- Opportunities for producing baseline, piloting and post-implementation evaluation,
- A new database on deforestation and land use change, combined with existing land titling boundary data to see what the impacts of deforestation are, and develop suitable mitigation measures,
- Analytical tools to determine historical trends and to forecast future changes.

E04SD will also help strengthen agricultural land use policies and land allocation to support GEF "Commodities" IAP with near real-time deforestation monitoring adding frequent Sentinel-1 imagery. The radar sensor carried by Sentinel-1 is a remote sensing tool capable of capturing images of the Earth's surface through rain and clouds. This enables monitoring information to become available also during the cloudy wet season.

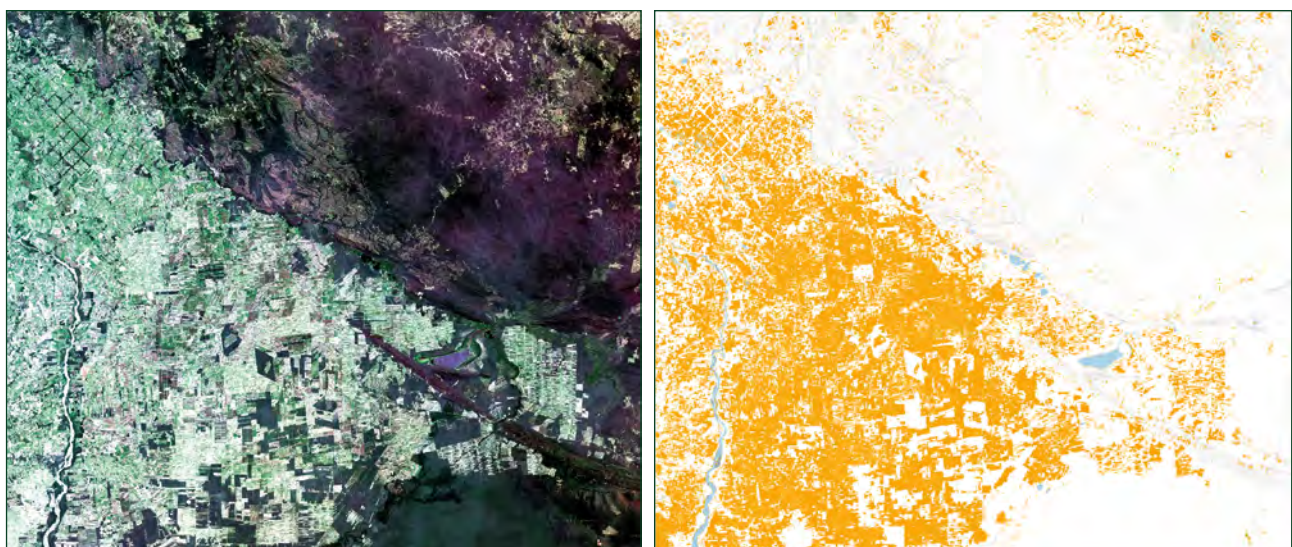


Overall E04SD will help support governments to fortify their assistance to small-scale farmers and strengthen land use policies using historical fact-based land cover information. It will also focus on raising awareness to influence the local to global demand of sustainably produced agricultural commodities and supply chain transparency in addition to engaging the finance sector with new opportunities for investment.



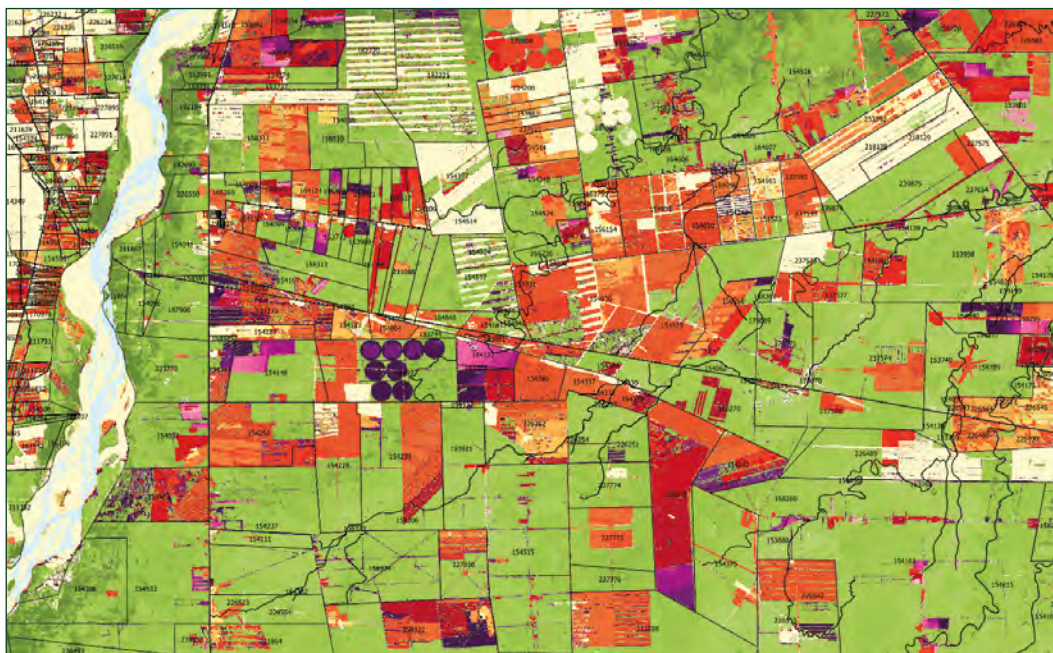
**Figure 1** Habitat quality model derived with the Integrated Valuation of Ecosystem Service and Tradeoffs (InVEST) tool. Example from Santa Cruz, Bolivia.

Credit: E04SD Agriculture Cluster (Geoville for ESA/IDB, 2017).



**Figure 2** Left: MODIS satellite image. Right: cultivated area derived from time-series analysis of Sentinel-2 and Landsat. Example from Santa Cruz, Bolivia.

Credit: E04SD Agriculture Cluster Satelligence for ESA/IADB, 2017).



**Figure 3** Deforested areas derived from time-series analysis of Sentinel-1 radar and optical Sentinel-2 and Landsat imagery. Black lines: land title database courtesy of INRA Bolivia. Example from Santa Cruz, Bolivia.

Credit: E04SD Agriculture Cluster (Satelligence for ESA/IDB, 2017).

### 3. IMPLEMENTATION PLAN

E04SD will work with partners in Bolivia, including IDB Bolivia, INRA (National Agrarian Reform Institute of Bolivia), SENASAG (National Service for Animal and Plant Health and Food Safety of Bolivia), and Bolivian Ministry of planning and CAO (*Camara Agropecuaria del Oriente* – Farmer Association). Partners in Paraguay include the Ministry of Forestry of Paraguay, UNDP Paraguay, and the GEF.

In support of the abovementioned actors, and in order to enhance the success of their respective projects in Bolivia and E04SD has defined and will develop a cluster of forest, land cover/biodiversity and agriculture mapping and monitoring services and training activities in order to enhance the success of the respective projects in Bolivia and Paraguay. This includes:

- (1) **multi-scale agricultural monitoring** (EO-based products and services include crop area, crop type, as well as biomass production),
- (2) **monitoring of the environmental impact of expansion of soy and livestock commodity production on Chaco dry forest and other ecosystems**

The Land Administration project has collected a large agricultural parcel database of almost 500,000 land titles in Bolivia, in particular, the cities of Santa Cruz and Cochabamba. Santa Cruz Farmer's association (CAO - *Camara Agropecuaria del Oriente*) indicated its willingness to share planting and harvesting information (including yields). Data generated by E04SD will be delivered for direct inclusion in existing geographic data platforms supporting the cadastres (Table 1).



Service level	Data	Spatial coverage	Temporal coverage	Spatial resolution	Description
<b>Regional (Bolivia and Paraguay)</b>	Deforestation	Santa Cruz, Cochabamba (Bolivia), Norte (Paraguay)	2000 – May 2019 Jan 2018 – May 2019	10 -30m	Deforestation on an annual basis for impact monitoring, on a weekly basis for recent years for environmental enforcement
Bolivia	Crop type	Cochabamba Santa Cruz	Jan 2017 – May 2019	250m 20m	Main crop types (e.g. soy, maize, sorghum, sunflower, quinoa)
	Leaf Area Index (LAI)	Cochabamba Santa Cruz	Jan 2017 – May 2019	250m 20m	Green cover index, per hectare per bi-weekly interval
	Basic land cover	Selected areas Cochabamba Santa Cruz	2016	10-30m	Land cover baselines, with classes including forest, wetland, agriculture etc.
	Habitat quality	Selected areas Cochabamba Santa Cruz	2016	10-30m	Evaluation of biodiversity using the habitat quality model of the Integrated Valuation of Ecosystem Service and Tradeoffs (InVEST) tool, which models habitat quality as proxy for biodiversity

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

In addition, the ESA Sentinel 2 for Agriculture (Sen2-Agri) tool will offer the project partners in Bolivia and Paraguay validated algorithms to derive EO products for crop monitoring. Sen2-Agri is a software platform integrated with open source QGIS and ESA SNAP image processing software, to enable large area image processing in the cloud. Over twelve different test sites are currently implemented, including areas in Brazil and Argentina, to generate four key products: monthly cloud reduced image composites, dynamic cropland masks, crop type maps, and leaf area index (LAI) products.



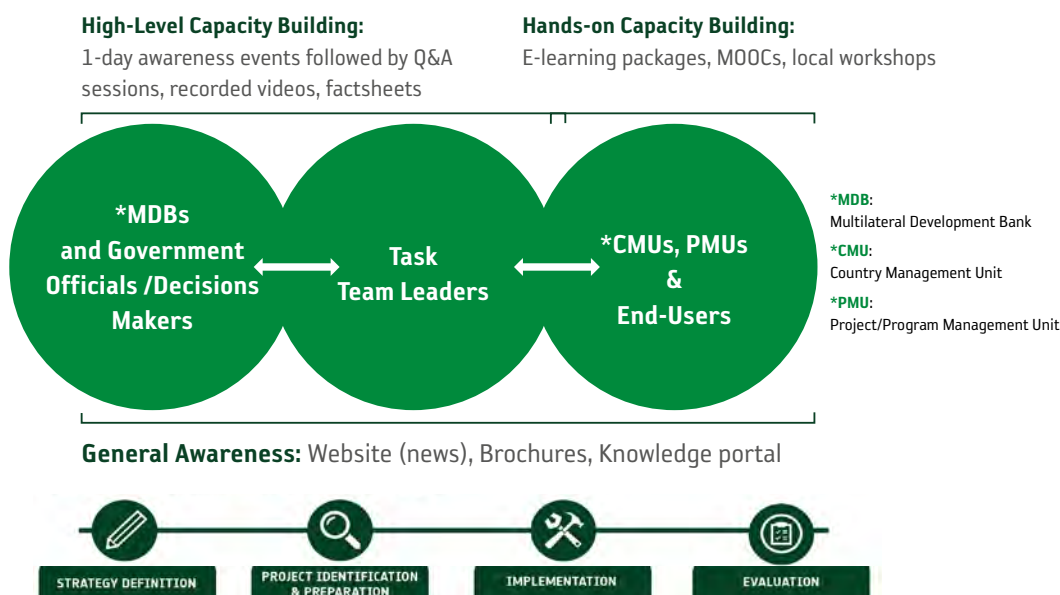
## 4. CAPACITY BUILDING

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 IDB has a keen interest in understanding geospatial and EO techniques, to be able to service its clients better. The Bolivian Ministry of Rural Development (including INRA and SENASAG), the Ministry of Environment (forestry and biodiversity departments), Space Agency, and the Ministry of Forestry of Paraguay expressed a clear interest in further enhancing their capacity to develop and use the information for monitoring and reporting activities. Enhancing the capacity for processing Sentinel-1 radar imagery is a priority identified. Consistent capacity building activities would help them to sustainably build up their knowledge in EO data exploitation.

The training under the EO4SD umbrella is 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 will be 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 will be aimed at developing the skill-set of the remote sensing professionals and the user organisations alike and include - as necessary - practical exercises concerning data application and use, lectures, and independent EO research by the participants. It will also specifically leverage free, open access Earth Observation data and programs.

This dedicated training component will target staff from IDB, as well as national actors.



## Partners of the Agriculture Cluster

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