One first use case addresses the lack of transparent land tenure information services, which deters sustainable investment in land resources by smallholders, communities and the local private sector, and disempowers them in their current internal operations and in their relations with urban and international investors. A second use case addresses the inability to cost-effectively recognize cultivated species in smallholder fields, which protracts the prediction and valuation of seasonal agricultural production, and prevents equitable access to physical and financial inputs and markets by smallholders and agro-dealers.
Goal
Enhance smallholder food security, income generation and future livelihoods through imagery-supported agricultural information services.

Objectives
1. Develop sustainable, subscription-based rural land tenure and agricultural information services supported by very high-resolution satellite imagery.
2. Develop digital libraries and algorithms for smallholder crop recognition and management support at scale.

Approach
Objective # 1 develops an imagery-based “container”, a land information service building on mLocGov™, an existing platform proposed by MANOBI S.A. and on an imagery parcel backbone. This service is grounded in the local context through participatory research led by Association Malienne d'Eveil au Développement Durable in Koutiala district (Mali) and by the Center for Dryland Agriculture / Bayero University Kano in Bebeji LGA (Nigeria). Scientific backstopping also involves the Groupe d'Etudes et de Recherche en Sociologie et Droit Appliqué (Univ. Bamako).

Objective # 2 develops an imagery-based “content” for agricultural decision making through participatory on-farm trials and spectral, temporal and textural crop profiling. Trials led by Institut d'Economie Rurale (Mali) and CDA/BUK (Nigeria) involve fertility windows on dominant crops, pure or mixed, over 150+ smallholder fields. Farmers explore with scientists and other boundary partners various uses of field-level remote sensing for insertion in a future agricultural information service.

Biweekly overflights of Unmanned Aerial Vehicles (UAVs) are overseen by the Agence Nationale de l'Aviation Civile (Mali) and by the National Space Research and Development Agency (Nigeria) through its Zonal Advanced Space Technology Applications Laboratory, with significant data post-processing undertaken locally. Development of libraries and algorithms for crop recognition involve a task force composed of ICRI-SAT, ITC / Univ. Twente (the Netherlands), Univ. Catholique de Louvain (Belgium), Univ. de Sherbrooke (Canada), and Wageningen University & Research Centre (the Netherlands).

Sites
- The Molobala subdivision in Mali and the Bebeji local government area in Nigeria for the development of a subscription-based land & agricultural information service built on an imagery backbone
- The communities of Sukumba (Mali, 12.172°N, 5.189°W) and Kofa (Nigeria, 11.555°N, 8.268°E) for the development of libraries and algorithms for crop recognition and management support
Anticipated outcomes

**Objective 1:** local governments accelerate the rural cadaster production process, leading to the ability to raise levies in exchange for land tenure securement tools and use; smallholders capitalize on increased tenure security to invest in improved land management practices, eventually leading to higher, more sustainable agricultural productivity; agro-dealers benefit from information about the distribution of land assets and farm typologies at the community scale, and valuate that information base to connect smallholders to input/output and financial markets; improved market integration progressively capacitates smallholders to satisfy commercial demand for food products, particularly from growing urban areas, and to derive new sources of income for enhanced livelihoods.

**Objective 2:** recognizing crops within smallholder field boundaries allows agro-dealers to quantify planted areas per crop and to ignite a cascade of spatially disaggregated services for the optimization of resource use (land, fertilizer, seed, pest control), agronomic operations and harvest management; this allows for the development of field typologies, the profiling of communities, clients and suppliers, for improved yield forecasting, and for a reduction in agricultural investment risk by various stakeholders; a larger portfolio of finance and input options is liberated for smallholders, leading to a strengthened market infrastructure and to agricultural intensification.

**Tools**

- **Mobile-to-web applications** to optimize value chains, including emergent imagery value chains with JotBi™, for geo-referenced field-level data collection, validation and visualization, mAgri™ for agronomic advisory streaming, mLocGov™ for land tenure management by local governments, and STARS ONE™ for imagery supported optimization services. Precursor applications are developed on ODK platforms and sqlite to facilitate data sharing, curation and storage;

- **Multispectral, very-high resolution imagery** from satellite: DigitalGlobe (WorldView2-3, QuickBird) and BlackBridge (RapidEye) and UAVs: SenseFly eBees with NIR cameras and GeoKonzept GEO-X8000 with TetraCAM 6-band MiniMCA camera, with in each country a biweekly target acquisition frequency for crop growth monitoring over 100km² (satellite) and 1km² (eBee) and yearly revisits for parcel database updates over 1,000km² (satellite);

- **Harmonized protocols** for coordinated air-ground data collection, dissemination and stakeholder engagement to streamline the analyses of imagery and ground data through metric scale maps of vegetation indices and digital surface models of plant height for varied environmental and management conditions.