
Food and Agriculture
Organization of the
United Nations
SOUTH SUDAN
LAND COVER MAPPING
To support natural resources assessment and conflict mitigation strategies

BACKGROUND

The use, distribution and temporal dynamics of natural resources as well as human activities is fundamental information needed for sustainable land management, particularly in zones with protracted crises and severe environmental challenges (e.g. inefficient management of natural resources, frequent natural hazards and displacement of people).

Competition for natural resources like water, grassland and wood among different stakeholders with multiple visions and interests is not only responsible for land degradation but often a driver of tensions and violent conflicts.

Working with Geographic Information Systems (GIS) remote sensed imagery and thematic maps, supports a participative process where different stakeholders and communities are invited to discuss their needs and develop an understanding of the causes and dynamics of conflicts in a transparent and inclusive environment.

Mapping land cover is essential baseline information to support and promote this participative approach throughout South Sudan and its boundaries. The objective is to address the increasing concerns related to food and nutrition security by improving the resilience of livelihoods to threats and crises in a changing climate. Mapping South Sudan is however challenging: the total surface is about 620 thousand square kilometers, the landscape is complex and fragmented, field data collection is often difficult since many areas remain insecure or inaccessible during a large part of the year and satellite imagery is often unusable due to cloudy weather, dust and smoke.

In 2011, FAO published the "Land Cover Atlas of the Republic of South Sudan", based on the integration of Landsat (dating from circa 2000 and circa 2005-2007) and SPOT images (circa 2006-2008). The dataset, developed within the "Sudan Institutional Capacity Programme: Food Security Information for Action" (SIFSIA) funded by the European Union, in collaboration with the Government of South Sudan, received a positive consensus but it was rarely used for effective national land use planning.

RATIONALE

In November 2017, FAO decided to develop an updated land cover dataset, with the objective to produce baseline georeferenced information to serve applications within a portfolio of projects:

- Strengthening the Livelihoods Resilience of Pastoral and Agro-Pastoral Communities in South Sudan's cross border areas with Sudan, Ethiopia, Kenya and Uganda.
- Strengthening the resilience of households to food insecurity in South Sudan.
- Sustainable Agriculture for Economic Resilience.

The reasons for updating land cover mapping in South Sudan are numerous. Although no systematic work has been conducted in recent years, displacement of people related to civil unrest is frequent and commonly results in increased pressure on natural resources, with deforestation and degradation of woodlands for biofuel production and land conversion to agriculture. The area under investigation will now include 10 km around South Sudan's country boundaries to better understand transboundary patterns (e.g. livestock movements) not mapped in previous assessments.

Recent Earth observation missions have meant that multi-temporal and multi-spectral analyses of land cover over time can be carried out more effectively than ever before. This, combined with online cloud-computing platforms will allow improved thematic and spatial accuracy combined with time and cost-effective results.

A new International Standard on land cover classification means that the dataset has a legend that better meets the needs of rigorous land cover 'formalization' required for cartography, with the user-friendliness and flexibility required by end users. This will overcome some of the limitations of the previous land cover mapping, where the high number of mixed classes made the use of the dataset challenging.

APPROACH TO LAND COVER MAPPING

The FAO approach to land cover mapping combines innovative technologies, multi-temporal high-resolution imagery, standards and tools developed specifically to assess land characteristics.

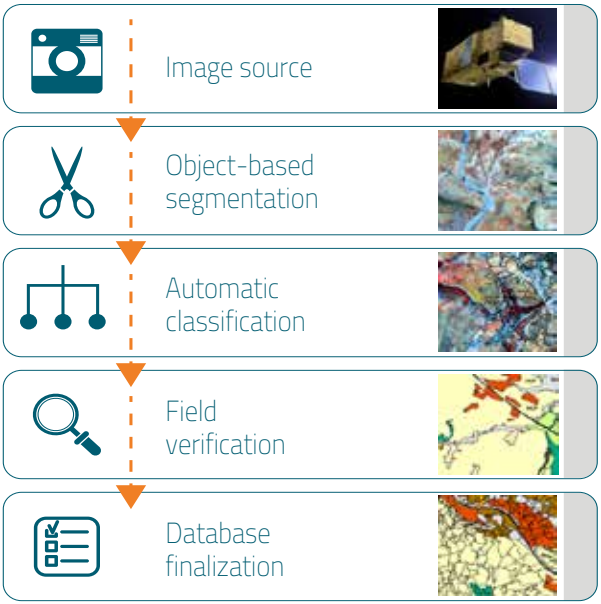

Figure 1 - FAO Land Cover Mapping process

1. Standards

With the objective to describe the land in a non-ambiguous way, the approach ensures interoperability and comparability of national, regional and global land cover classification systems. FAO has contributed significantly to the development of the Land Cover Meta Language (LCML) which became a joint FAO / ISO standard (ISO 19144-2:2012) and is based on the original FAO Land Cover Classification System (LCCS).

LCML is used to standardize the process of classifying land, rather than providing a fixed classification system. It creates a set of standard diagnostic attributes (biotic and abiotic basic objects, their properties a characteristics) spatially and temporally arranged.

Figure 2 - South Sudan - Satellite-2A image, Nov. 2017

2. Imagery

Sentinel-2 is the primary source of remote sensed imagery. It is a polar-orbiting, multispectral high-resolution imaging mission for land monitoring equipped with an optical Multi-Spectral Instrument with a spatial resolution of 10 meters. Its high revisit time (5 days in total), coupled with a wide swath, ensures free cloud coverage of the whole area of study. Time series images for the whole of 2017 (January to November) have been pre-processed (geometric, radiometric and atmospheric corrected) to have a comparable time series for analysis. Sentinel-1 images are being used to provide additional information to support land cover interpretation, in particular to assess temporal dynamics of water resources. The mission comprises of a constellation of two polar-orbiting satellites, operating day and night and performing C-band synthetic aperture radar imaging, enabling them to acquire imagery regardless of the weather.

3. Analysis

Object-Based Image Analysis (OBIA) will be applied to delineate and classify land cover features. Multi-temporal optical and radar images will be used to characterize the land cover across an entire year, including patterns of vegetation growth, fire occurrence and water dynamics. OBIA provides several advantages to traditional raster-based analysis, in terms of improved accuracy and ability to identify complex and heterogeneous, functional land cover classes. Sample training data for each class will be entered into a machine-learning algorithm (i.e. random forest classifier) to provide an initial interpretation of the "object-features". Validation of the preliminary interpretation is necessary to ensure the integrity, consistency and accuracy of the final dataset. Such validation procedures result in a significant reduction of the initial image interpretation errors, leading to a more reliable product. The identification of a team of national experts is critical in this phase to ensure that the local knowledge in the field supports the validation process, and at the same time provides the necessary information to the national experts on the use and interpretation of the dataset.

4. Capacity building

A first workshop to enhance capacity on land cover mapping, geospatial management and field data collection was organized in Juba in February 2018 for local geospatial experts and Natural Resource Officers. Capacity building is a critical component of the land cover mapping activity. The use of innovative imagery and technologies requires that the country receive adequate training to use, interpret and analyse the information produced. Training will also support the validation of the land cover dataset to ensure that it is endorsed and used in the region to develop land applications.

APPLICATIONS

The new land cover dataset will allow mapping of natural resources, human settlements and human activities in South Sudan and within neighboring countries. It will represent the most innovative and updated dataset developed for South Sudan, integrating high-resolution multi-temporal imagery, object-based image analysis and machine-learning algorithms and LCML to support the Natural Resource Management strategy and land use planning. The national land cover dataset will allow upscaling and extrapolating observation on test pilot areas (i.e. field data observation or sub-meter Remote Sensing analysis) at national level for many potential applications:

- Identification and suitability of livestock migratory routes
- Estimation of charcoal production and impact on natural wood biomass
- Participatory and community mapping for development of conflict mitigation strategies
- Assessment of Socio-Economic Systems
- Assessment of landscape complexity and hotspot mapping (e.g. cropland/grassland interspersion)
- Supporting crop monitoring

Related Links:

LC Atlas of the Republic of South Sudan 2012
http://www.fao.org/geospatial/resources/detail/en/c/1024738/

FAO in South Sudan
http://www.fao.org/south-sudan/en/

Geospatial information in FAO
www.fao.org/geospatial

Figure 3 - Community mapping exercise in Kapoeta North, South Sudan

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