# Space for Climate Observatory, Climate change in the LAc Chad region (ECLAT)

## Summary note

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The Space Climate *Observatory (*SCO) is a global initiative to study and monitor the complex impacts of climate change in order to adapt to them. The objective of the SCO ECLAT project is to provide automated decision support tools from space-based imagery to observe, assess and predict climate change impacts in the Lake Chad region.

The genesis of the project comes from ESA's *Earth Observation for Sustainable Development* (EO4SD) project on Fragility, Conflict and Security (FCS), which selected the Lake Chad region as one of the priority areas for assistance, after consultation with the World Bank and the United Nations Development Programme (UNDP). The recurrence of extreme weather events in recent years has had serious consequences in terms of pressure on natural resources and population displacement, increasing food insecurity and conflict.

The Lake Chad Basin Region is bordered by 4 countries: Chad, Cameroon, Niger and Nigeria and covers an area of approximately 33 km². Following the interest expressed by other stakeholders such as the Centre de Suivi Écologique (CSE) in Senegal and the African Union, 2 other study sites were also analysed: the Tocc Tocc Park in Senegal with an area of about 12 km² and the W Park straddling Benin, Niger and Burkina Faso with an area of about 42 km².

The methodology can be broken down into 3 main steps:

(i) Identification, evaluation and selection of calibration and validation databases
(ii) Production of land use maps
(iii) Development of sustainable development indicators

The databases were used for the calibration of the classification models, validation and correction of the resulting land cover maps. This step consists of 3 sub-steps: a) survey of existing databases b) evaluation c) selection.

25 open access databases available on the African continent and covering the 3 study areas were analysed.

The following 6 land use classes were given special attention:

- Artificial surfaces
- Water surfaces and wetlands
- Bare ground
- Cultivated land
- Vegetation
- Forest

For the Lake Chad region, the database evaluation consisted of implementing an unstratified and unweighted random sampling design (due to time and budget constraints) with the selection of 325 Primary *Sample* Units (PSUs) of 2 km × 2 km. 10 Secondary *Sample Units* (SSUs) were then selected within each PSU and photo-interpreted with free online validation tools Open Foris Collect Earth, using available background maps (Google Earth, Bing Maps, Sentinel-2) and Google Earth Engine for the calculation of annual NDVI indices on Sentinel-2, Landsat-8 and Modis time series

The databases were harmonised with the SCO ECLAT project nomenclature (see Table 1) and compared with the reference samples by means of statistical indices, such as producer, user, global and F1-Score precision.

The evaluation of the databases is based on a 5-criteria scoring: spatial resolution, reliability, last update date, genealogy/depth of the data set and F1-Score obtained.

The best databases were selected for each site and each thematic or land use class (see Table 1 below).

Table 1: Selection of the best databases by theme for the 3 study areas

| Thematic | Lake Chad Region | Tocc Tocc Park Senegal | Park W Niger |
|---|---|---|---|
| Artificial area | Global Human Settlement | Global Human Settlement | Global Human Settlement |
| Water surface | Global Surface Water | Global Surface Water | Global Surface Water |
| Wetland | G3WBM Yamazaki | Global 1sec Water Body Map | Global 1sec Water Body Map |
| Cultivable land | FROM-GLC | GFSAD30AFCE | GFSAD30AFCE |
| Vegetation | FROM-GLC | FROM GLC & ESA CCI Land Cover Africa 20m | FROM-GLC |
| Forest | | | FROM-GLC |
| Bare ground | MODIS Bare soil layer | Copernicus Global Land Service Land Cover | Copernicus Global Land Service Land Cover |

The earth observation data used to produce the land cover maps are the Sentinel-2 time series for the years 2018, 2019 & 2020, freely available (open-data) at the L2A pre-processing level, corrected for atmospheric effects using the MAJA algorithm.

The land cover maps were then produced with the open-source iota-2 chain based on Orfeo Toolbox (OTB), developed by the Centre d'études spatiales de la biosphère (CESBIO), in partnership with the Centre national d'études spatiales (CNES). The Random Forest supervised classification algorithm, which has been widely tested in the literature, was selected. The maximum overall accuracy obtained is 72%, 82% and 69% for the Lake Chad region, the Tocc Tocc Park in Senegal and the W Park, respectively, after correction using auxiliary databases (see example in Figure 1).

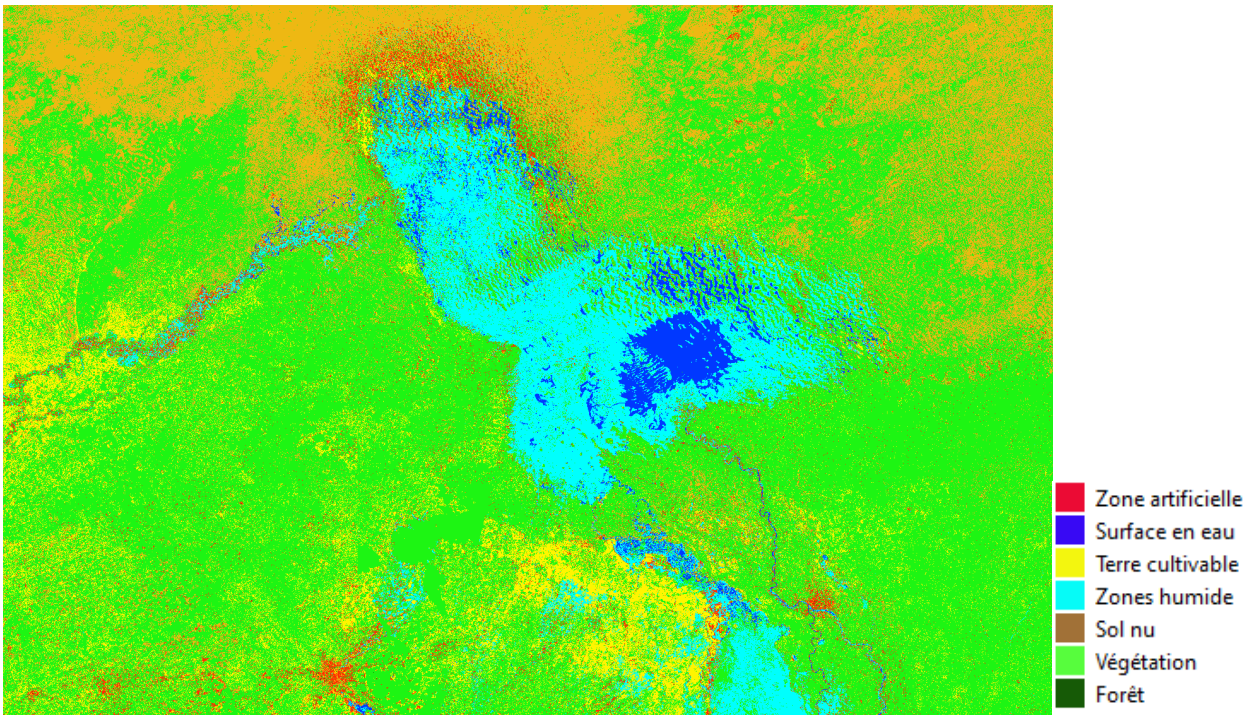


Figure 1: Land use mapping in the Lake Chad region in 2020

The 3ème step consisted in the development of 3 sustainable development indicators, responding to several United Nations Sustainable Development Goals (*SDGs*). These indicators were of interest to the Agence Française de Développement (AFD) and should be used in the future.

- **The Agricultural Development Indicator** is based on the Dynamic Habitat Index (DHI) for which the minimum, cumulative and standard deviation values of the NDVI time series over the observed period (6 months to 1 year) are calculated. The DHI makes it possible to distinguish crops between the rainy season from January to June and the dry season from June to December. Due to the large amount of agricultural land in the Senegalese region, this indicator has proven to be very useful according to the SSC for monitoring fallows, salinisation and leaching of plots, as well as possible overexploitation of agricultural land.
- **The Water Ecosystems Development Indicator** aims to study the evolution of urban pressure on water ecosystems. Permanent and seasonal water surfaces are strategic resources subject to pollution from built-up areas. The most important pollution comes from dirty water from homes, businesses and industries that is discharged and not treated and can cause serious disturbances in the quality of water ecosystems. The indicator makes it possible to analyse the spatial distribution of urban areas with regard to permanent and seasonal water and to observe its evolution. The study carried out within a perimeter of 500 m (then 1000 m) reveals a greater and increasing presence of urban areas near temporary waters between 2018 and 2020.
- **The development indicator on urban dynamics**, which consists of comparing the evolution of artificialisation with that of the population, has made it possible to identify a trend towards regular densification in the city of N'Djamena and its surroundings (within the limit of 50 km) over the 2000-2020 timeframe, and in particular over the 2018, 2019 and 2020 study period.

The SCO ECLAT project used Earth observation data to monitor the dynamics of land use change, as well as the detection of abrupt, cyclical and long-term changes, with a view to setting up a warning system.