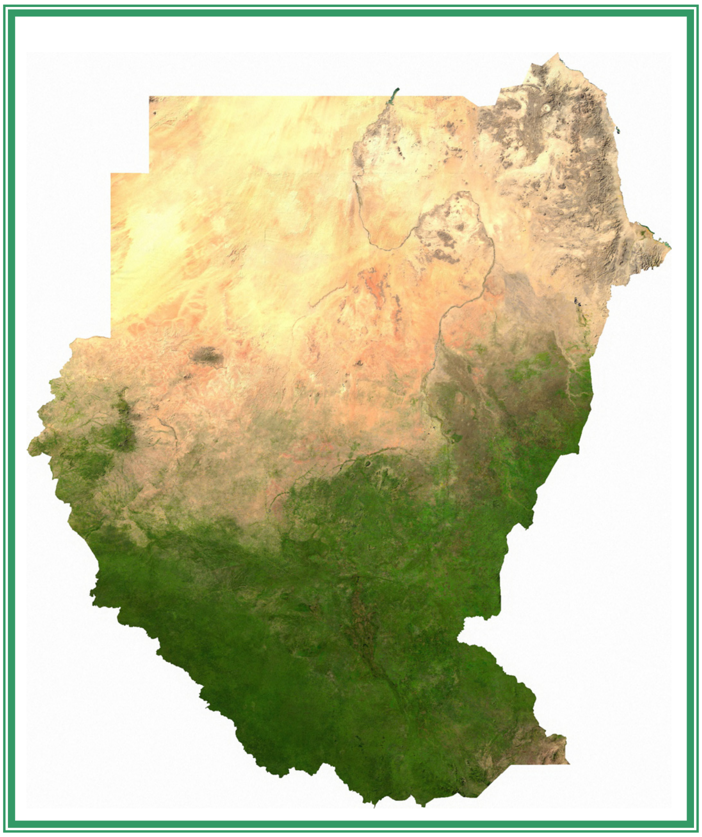
Sudan Institutional Capacity Programme

Food Security Information for Action

SIFIA



Satellite coverage evaluation and research for land cover mapping

Hot spots test analysis for land cover changes

Northern Sudan

Final Report

Rome, December, 2008

List of figures

Background

Sudan, the largest African country extends for a surface of 2.506.000 km2. It is comprised of 25 states (133 districts). The northern Sudan includes 15 states. The South has 10 states (figure 1).

Despite the enormity of its natural resources, the agricultural sector's development is well below its potential although it represents the major source of growth in the country's economy. International report states that several socio-economic, technical, and institutionally recognized constraints affect the attainment of sustainable development within the agricultural sector. The formulation of sound policies requires reliable information and accurate agricultural statistics. However, in Sudan there remains concern regarding the limited amount, timeliness and accuracy of the information available.

The Sudan Institutional Capacity Programme: Food Security Information for Action (SIFSIA) is a GOSS programme funded by the European Commission (EC) and executed by the Food and Agriculture Organization of the UN (FAO). The purpose of the programme is to build and strengthen human, physical and organizational capacities in the generation and utilization of information for the analysis, design, monitoring and evaluation of food security related policies and programmes in Sudan. SIFSIA is expected to contribute to food security decision making by supporting the strengthening of policy and planning initiatives through establishment of food security information system.

SIFIA is running two semi-independent projects SIFIA North and SIFIA-South to address the different and complex political situation. The main project component is related with the Crop Agricultural Production Estimation System (CAPES) which has three sub-components:

1. Agricultural Monitoring System
2. Agricultural Crop Yield System
3. Agricultural Production Information System

Natural Resources Climate Change and Environment – NRCE Devision is contributing to all three sub-components of the CAPES project in various ways:

For the above items 1 and 2, an updated land cover baseline is extremely helpful to support agricultural statistical analysis. In addition a land cover change survey to assess trends and patterns in land cover over time becomes an important input to policy options. The completion of a structured agricultural database should be also considered as a priority for item 3.

Moreover, a significant contribution can be made through training courses and the development of local capacity in methodology and applications required to undertaking, maintaining, archiving and disseminating land cover data and prepare information products.
NRCE has contributed significantly to this activity as well. NRCE is engaged in technical workshops at regional and national levels through its Global Land Cover Network project.

Figure 1 - Sudan administrative map.

Introduction

NRCE with its experience in land cover mapping could reinforce the data resources and information availability about agriculture and its trends. Upgraded and reliable land cover data can be also considered the primary input for accurate agricultural statistics. Therefore, future land cover/land use analysis can be undertaken utilizing satellite remote sensing products, the selection of which is the fist part of this consultancy. The Terms of Reference of the present consultancy are as follows:

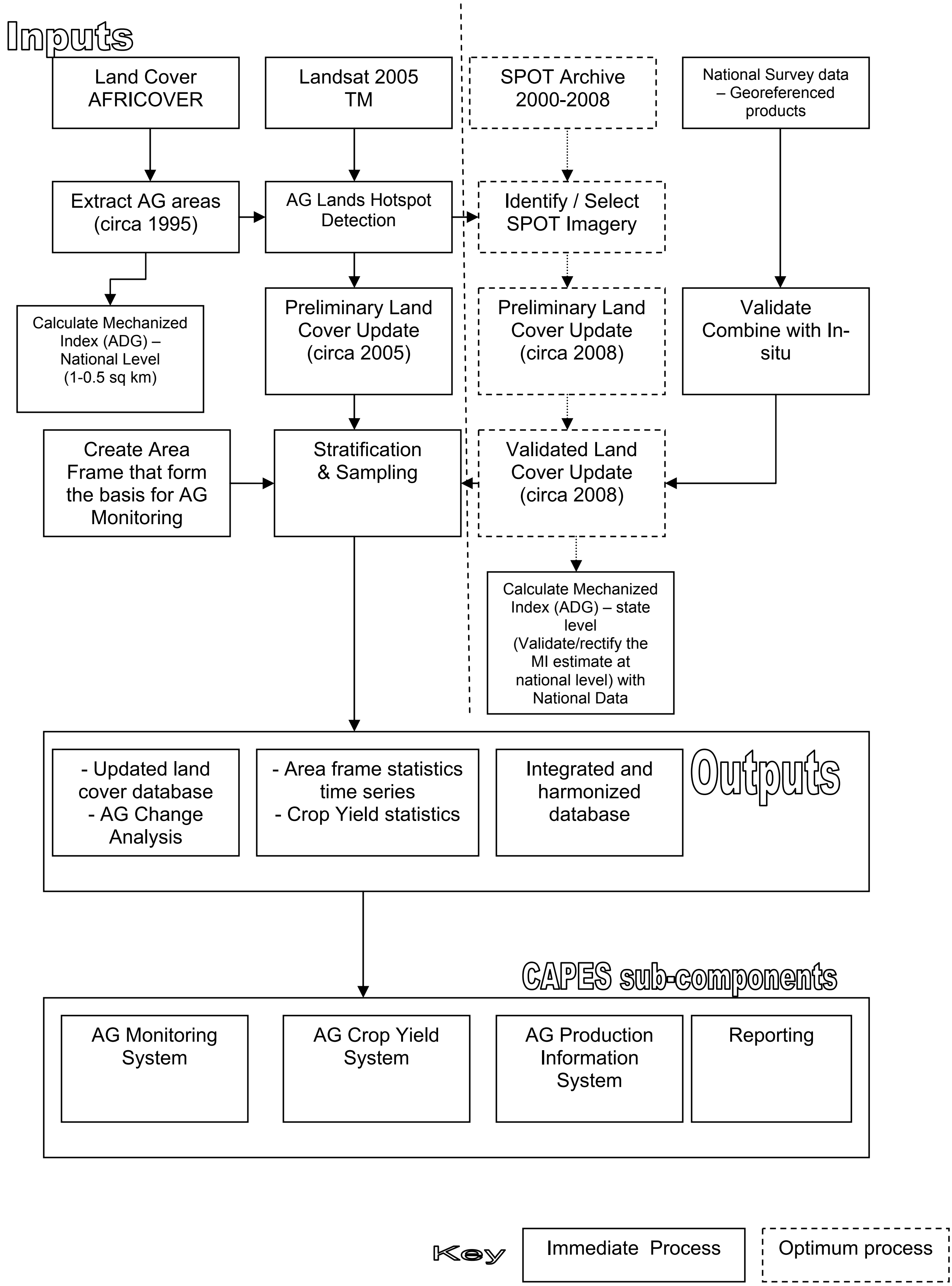
- Analyze the availability of Landsat/CBERS coverage for north-Sudan;
- Prepare Index of SPOT (archive) images 5, 10 and 20 m resolution, to obtain and assess the best coverage suitable for land cover mapping and according to the crop calendar;
- Analyze/review availability of other satellite imagery for the country;
- Draft of procurement plan to facilitate commencement of Land Cover activities in Sudan.
- Test and describe pros and cons of different methods for hot spots change land cover analysis in North Sudan.

The outcomes will give the basic issues to support the future activities.
For Northern Sudan project purposes, a survey about costs and availability of existing satellite coverage was conducted and results are presented in the report.

The image analysis and land cover / land cover change mapping will serve to update and upgrade the existing land cover database. The updating will highlight the changes over time in land cover and agricultural expansion/retraction patterns that have taken place since the last Africover assessment; in the mean time, the utilization of high resolution images will permit a revision (upgrading) of the agricultural/crop types information.

The flow diagram below summarizes the main proposed actions that can be modulated according with new inputs and agreements.

The present report is divided in two parts: in the first part, availability of several satellite products have been investigated and the existing coverage is listed and presented in the next paragraphs; in the second part, different methodologies for hot spots detection are tested; the methodology, results, details as well as advantages and disadvantages are also provided.


Inputs
Land Cover AFRICOVER
Landsat 2005 TM
SPOT Archive 2000-2008
National Survey data – Georeferenced products
Extract AG areas (circa 1995)
AG Lands Hotspot Detection
Identify / Select SPOT Imagery
Calculate Mechanized Index (ADG) – National Level (1-0.5 sq km)
Preliminary Land Cover Update (circa 2005)
Preliminary Land Cover Update (circa 2008)
Validate Combine with In-situ
Create Area Frame that form the basis for AG Monitoring
Stratification & Sampling
Validated Land Cover Update (circa 2008)
Calculate Mechanized Index (ADG) – state level (Validate/rectify the MI estimate at national level) with National Data
- Updated land cover database
- AG Change Analysis
- Area frame statistics time series
- Crop Yield statistics
Integrated and harmonized database
Outputs
CAPES sub-components
AG Monitoring System
AG Crop Yield System
AG Production Information System
Reporting
Key
Immediate Process
Optimum process

PART I

1. Africover database

The complete data base of land cover was realized by Africover project from 1998 to 2002. The data base is the first systematic attempt to describe the land cover resources in Sudan. (figure 2). A major achievement is the development of the whole country database which can be accessed by all stakeholders and users (www.africover.org). It is mapped to an equivalent scale of 200.000 using Landsat imagery dataset dated 1995-1999 (see paragraph 4.1.1) and contains digital georeferenced database with geodetic homogeneous referential, toponyms, roads and hydrograph data. In figure 3 the only agricultural land is extracted.
The lithology digital map is also available and can be downloaded from the Africover web site (www.africover.org).
The Land Cover Classification System LCCS developed by FAO-GLCN was applied for the cover description in the mapping activities.
LCCS is a comprehensive, standardized *a priori* classification system, scale independent method of classifying land cover. The approach can support all the types of land cover mapping and monitoring and it is designed to meet the requirement of all the users enables a comparison of land cover classes regardless of data source or sector.
Land cover classes are defined by a combination of a set of independent diagnostic criteria – the so called classifiers - that are hierarchically arranged to assure and high level of geography accuracy. This approach allows the use of the most appropriate classifies that are tailored to meet the specific land cover types and prevent the use of inaccurate classifier combinations ensuring standardization. The software assists the users to select the appropriate class using step-by-step process (i.e. classifier by classifier) reducing heterogeneity between interpreters and between interpretations over time.
The richness of detailed information of the LCCS existing database consent to deriving many different outputs for several applications and project purposes.
The Mechanized Index (MI) is an example of derived LCCS-based indices representing spatial relations with different land cover/land use types.
The Field Area Ratio is derived from the ratio between:

Areas classified “with dominance of Large-Medium sized fields (> 2 ha)” /
Areas classified “with dominance of Small sized fields (< 2 ha)”

and represents a value of areas characterised from lower probability (value: 1) of mechanization to areas with higher probability of mechanization (value: 9). Figure 4a shows the Mechanized Index derived from Africover data using a cell size of 2 km. In figure 4b, the MI is overlapped to a Landsat image in the Gedaref region. A cross-cutting with data field has shown a good correlation.
The index is calculated at the national scale using 2 km cell size. The detailed output can be increasing reducing the cell size to 1 - 0.5 km.

Figure 2 - Sudan Africover land cover.

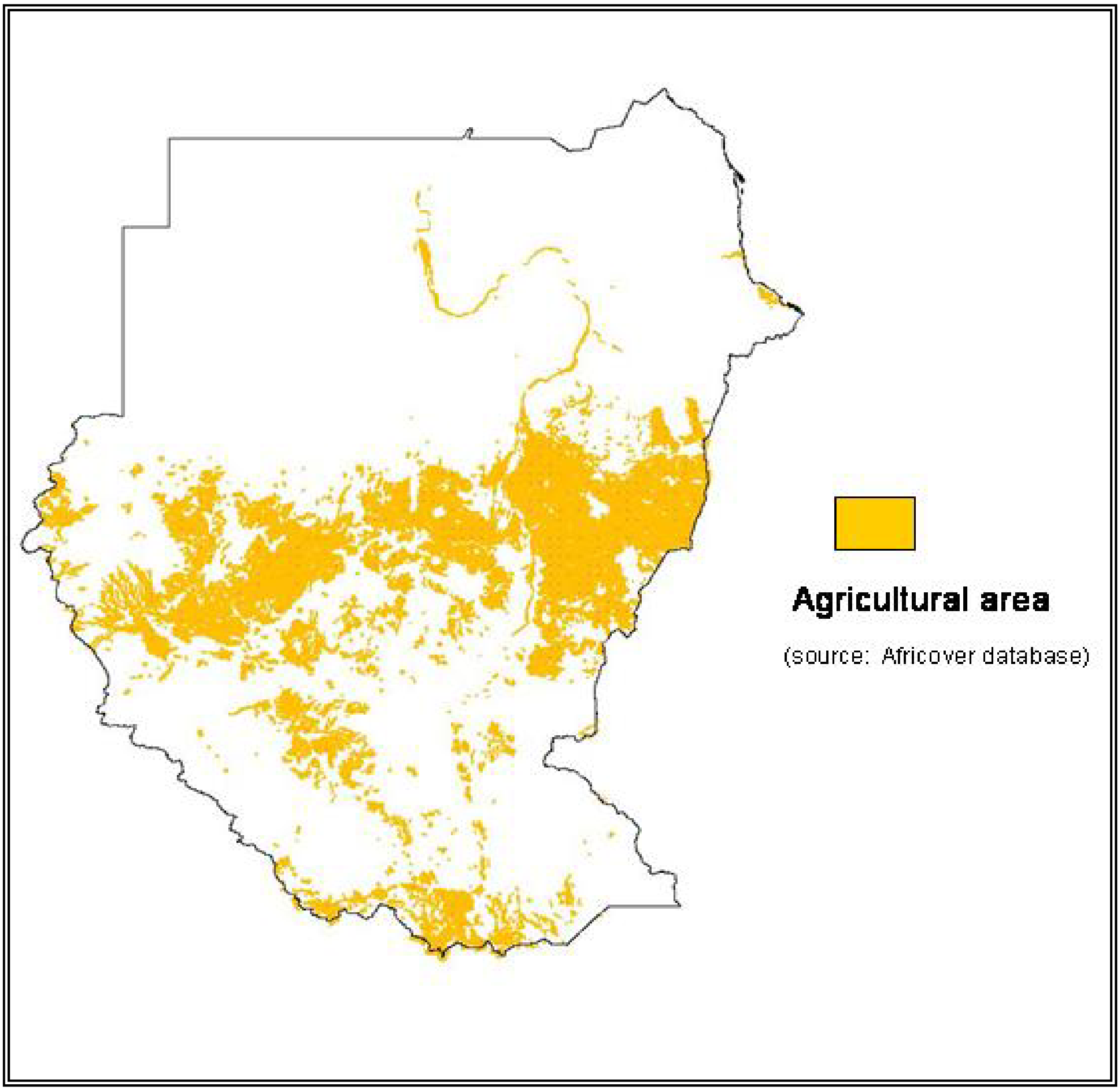


Figure 3 - Aggregated agricultural area from Sudan Africover database.

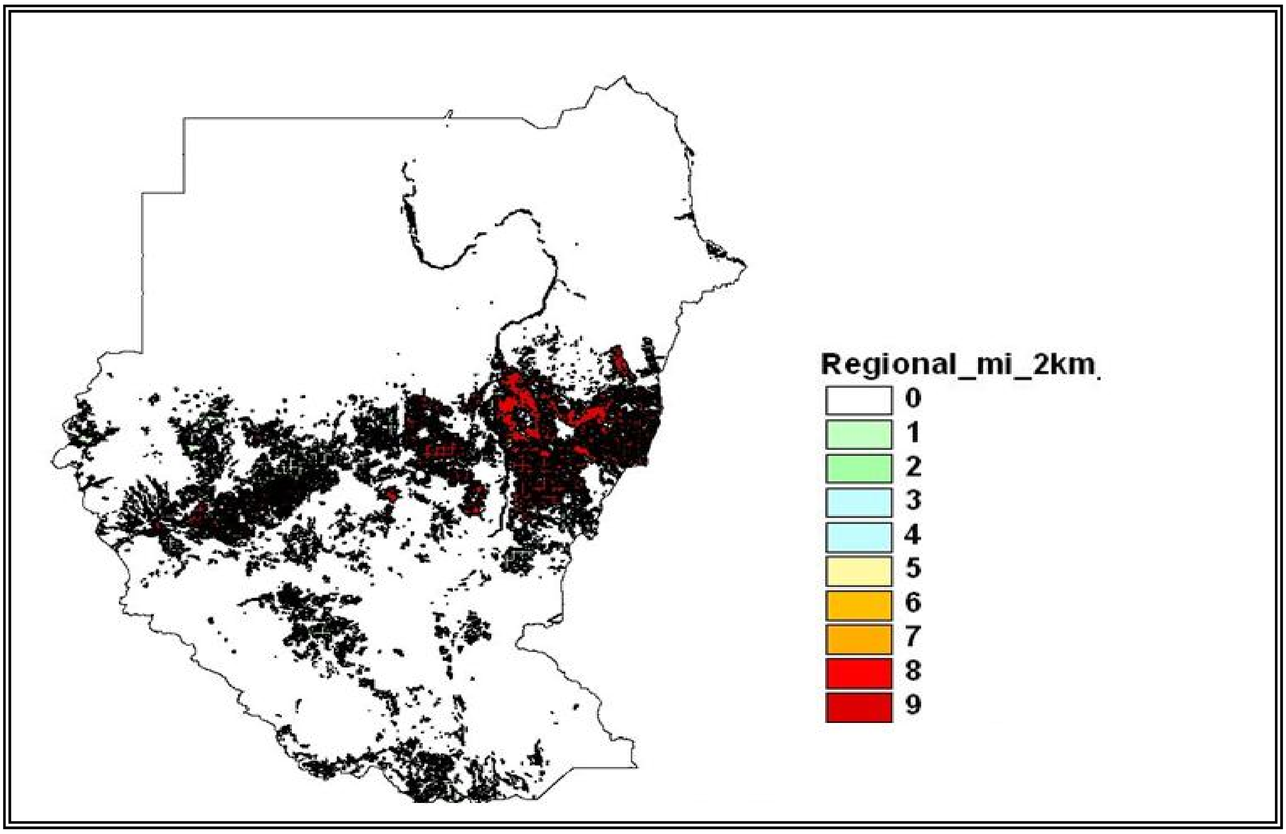
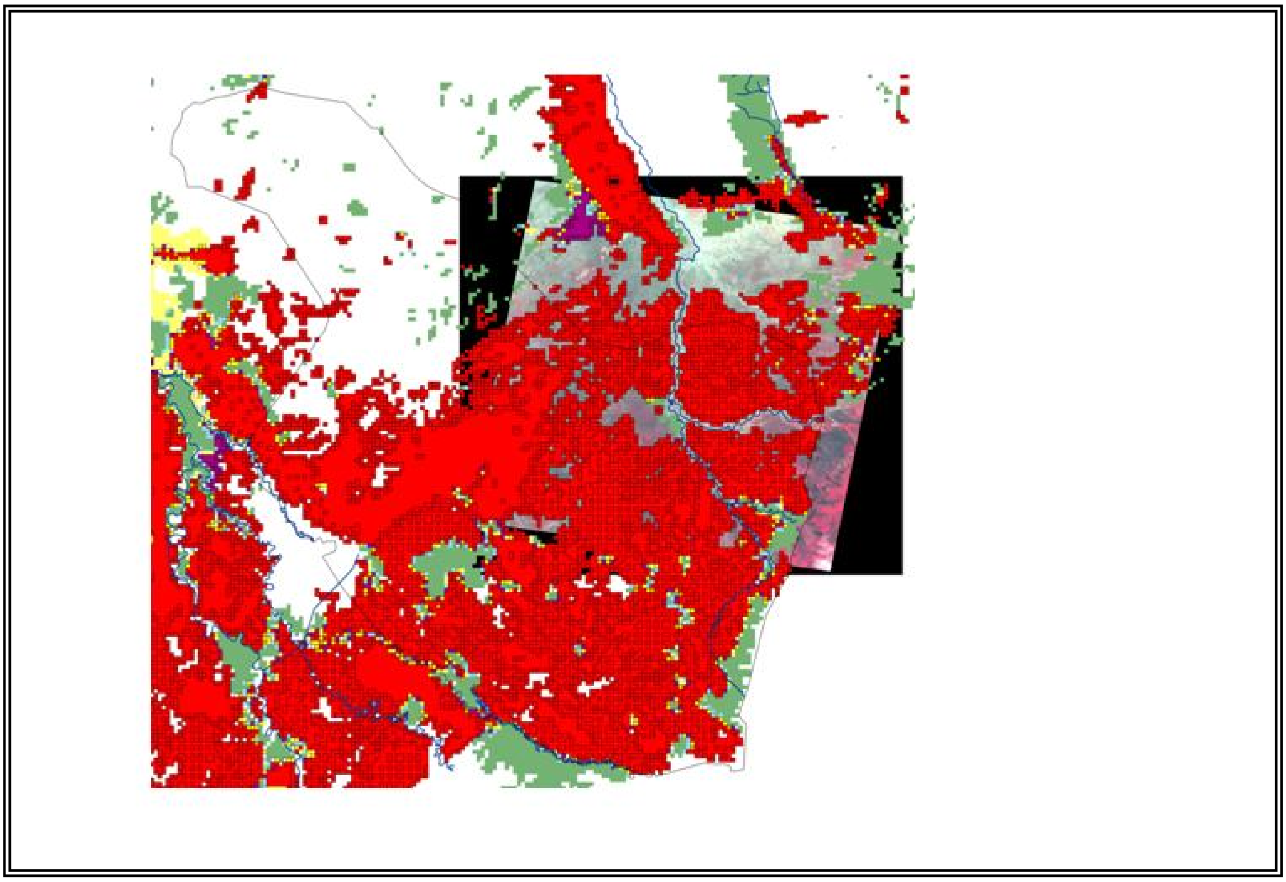


Figure 4a – Mechanized Index derived from Sudan Africover database for 2 km cell size.
Figure 4b – Mechanized Index derived from Sudan Africover database for 2 km cell size in the Gedaref region.



2. GLOBCOVER

The GlobCover product v 2.2 released to the public in late September 2008 is the Earth's global land cover map dated 2005-2006. It is mainly based on ENVISAT satellite, Medium Resolution Imaging Spectrometer (MERIS) Level 1B data acquired in full resolution mode with spatial resolution of 300 meters over the full year 2005. The Advanced Synthetic Aperture Radar is also collected to generate data for GLOBCOVER.

This new product is intended to update and to complement the other existing comparable global products, such as the global land cover map at 1 km resolution for the year 2000 produced by the Joint Research Center (JRC). It is also expected to improve on such previous global products, in particular through a finer spatial resolution (300 m).

The thematic legend of the final product are labellated using according to the FAO-UNEP Land Cover Classification System (LCCS); 24 main land cover classes are extracted using LCCS, see figure 5. The digital database with Legend and explanation note is available in NRCE and can be delivered to the CAPES project.

The GLOBCOVER product is developed with an international network of partners, in particular, FAO, GOFC, IGBP, EEA, JRC and UNEP. Further information about ENVISAT MERIS mission is available at the MERIS home page ENVISAT MERIS Mission (http://envisat.esa.int/object/index.cfm?fobjectid=1665).

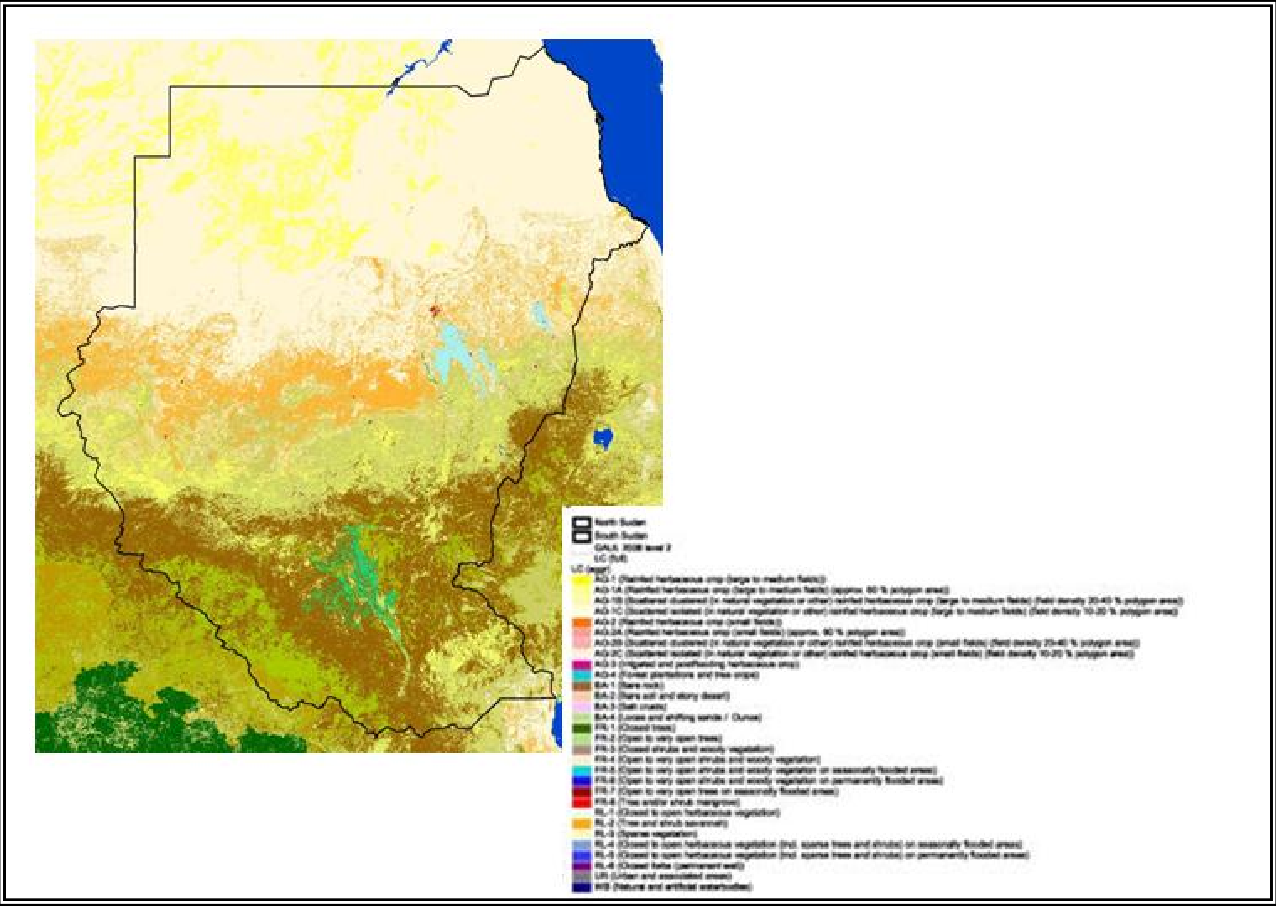


Figure 5 – Globcover data base.

3. Area of Interest

The AoI (Areas of Interest) utilised for the imagery selection was delineated according with the total Africover extension of agriculture cropland that means that no geographic/administrative boundaries have been taken in to account see yellow area in the figure 6a.

It extents in the southern parts of the country where agricultural activities are concentrated (total agricultural surface of Sudan is about 344,000 km^2 - source Africover). A simplified sub-zone has been delineated to limit the area for imagery research and to match the best coverage for the project requirements.

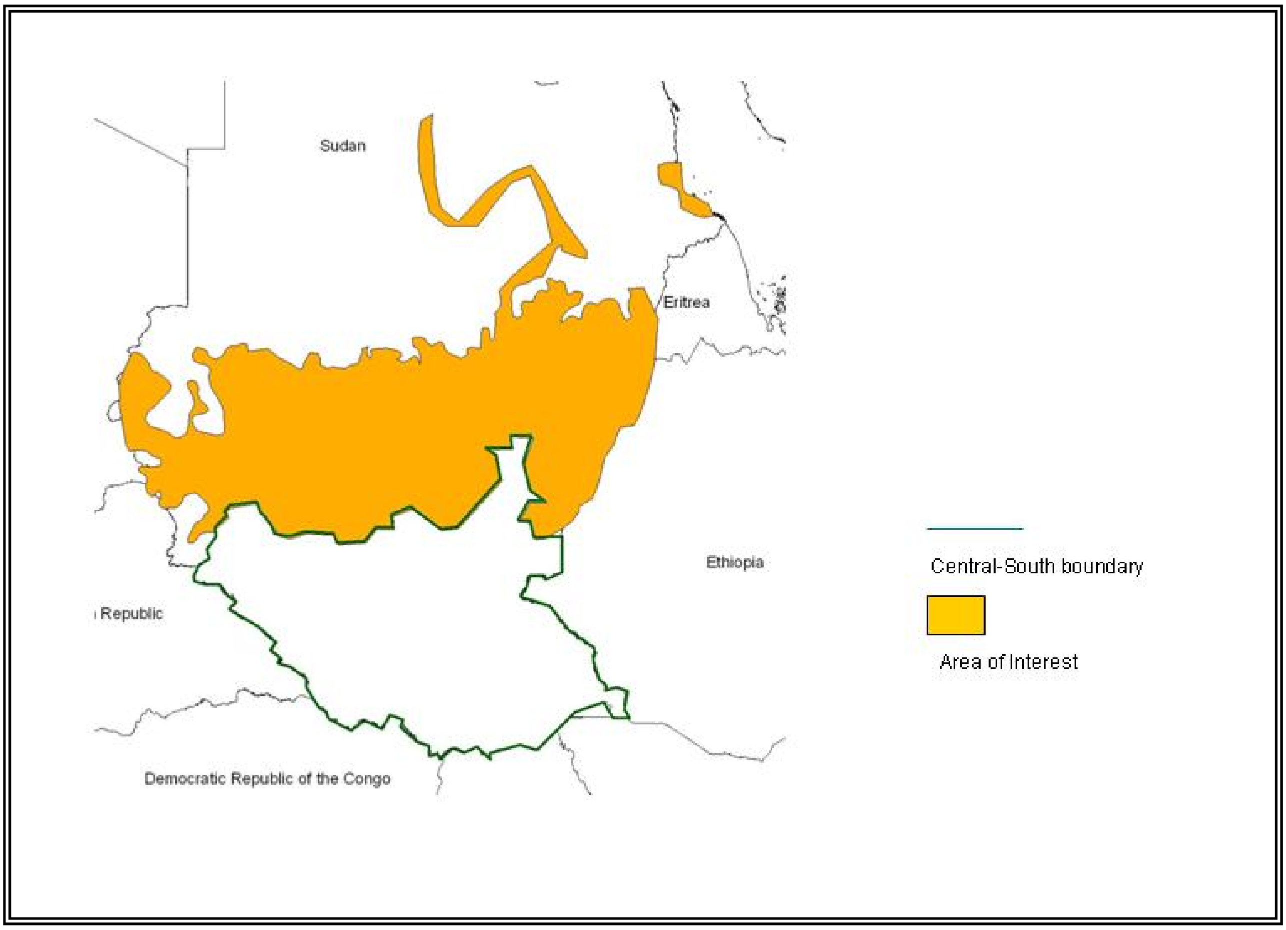


Figure 6a - North Sudan AOI.

3.1 Gedaref Area pilot project

A pilot project to apply the change analysis methods has been undertaken in the Gedaref region. The area covers about 58.314 km^2 and it is one of the most productive and mechanized agricultural areas in the Central-South Sudan.

The Gedaref State conducts a regular annually up-dating process of the List Frame hence many field data could be available for interpretation validation.
Figure 6b below the Gedaref state area is sketched and overlapped to the Lansdsat mosaic (Radex).

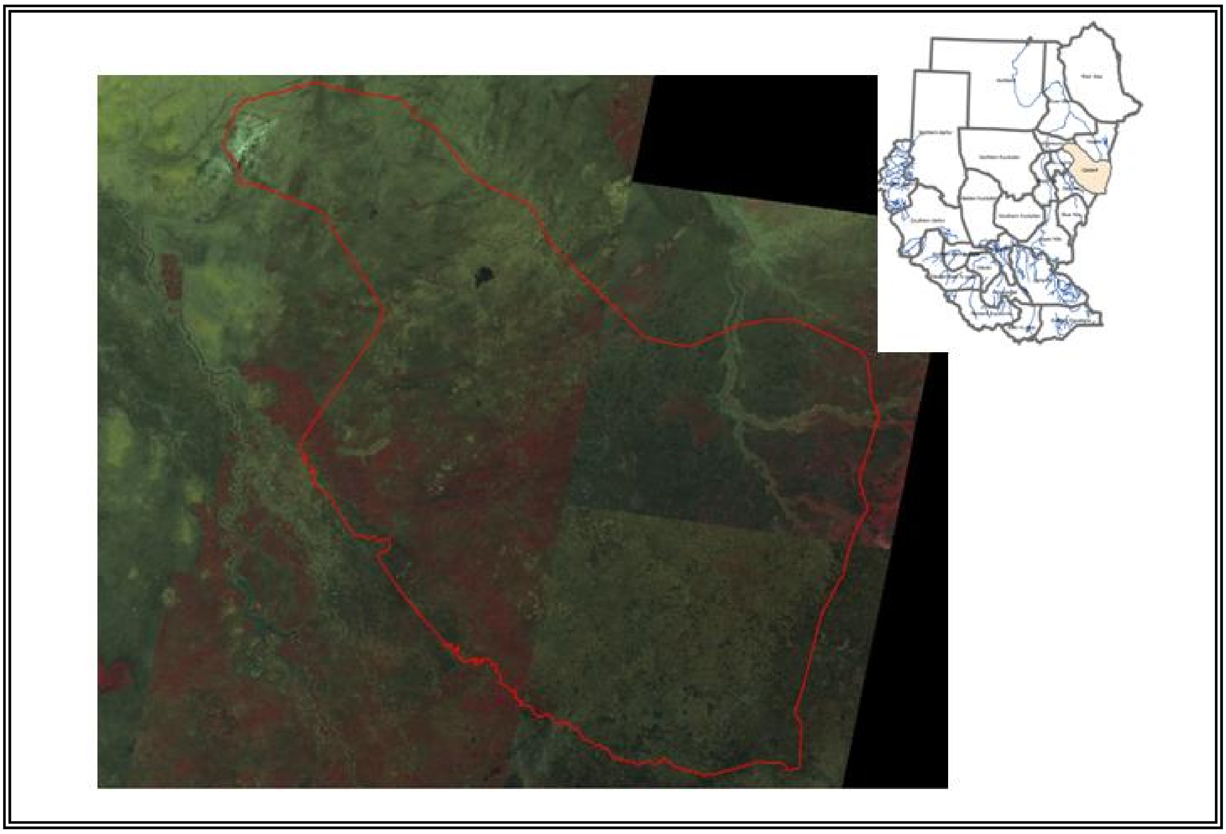


Figure 6b – Gedaref state - AOI.

4. Imagery coverage research

4.1 Landsat imagery

4.1.1 Archive

The full coverage of the Landsat imagery dated approximately 2002, 1997, 1984 and 1972 is available in the Tecproda data repository in NRCE department.
The Landsat database 1997 for the whole country actually span from 1994 to 1998 was acquired for the Africover land cover mapping activities.
In the Annex I is listed the image inventory with the acquisition dates. For the mapping purpose using remote sensing, the best period for image acquisition is 1-2 months after the rainy season. For images selection, this condition should be followed, however, for such large territory it is difficult to determine (in July the moist air reached Khartoum and in August it extends to its usual northern limit around Abu Hamad). In addition, cloud cover and technical constrains re-directed the choice to other available dates.

4.1.2 New Product - GLS 2005

GLS2005 Global Land survey is new product from USGS, U. S. Geological Survey and NASA has developed this new global dataset with core acquisition dates of 2005-2006. The Landsat 7 ETM+ and Landsat 5 TM were incorporated into the GLS2005 imagery, making GLS 2005 the first-ever global data set built with data from two sensors. Data recorded in 2004 and 2007 will be used as needed to fill areas of low image quality or excessive cloud cover.

The available coverage for whole country was downloaded, free of charge and it is now available in NRCE; both Landsat dataset can be delivered to the CAPES project.The figure 7 shows the existing images of the GLS5 dataset. In the Annex II is listed the image inventory with the acquisition dates.

For the coverage in the AOI, several images are not yet processed by USGS, in particular, 179/051,176/051, 173/050,171/047, 171/046, 171/051, 171/052, 175/052, 175/053, 177/053 but USGS continuously updated the list and in the near future it is possible fill the gaps.

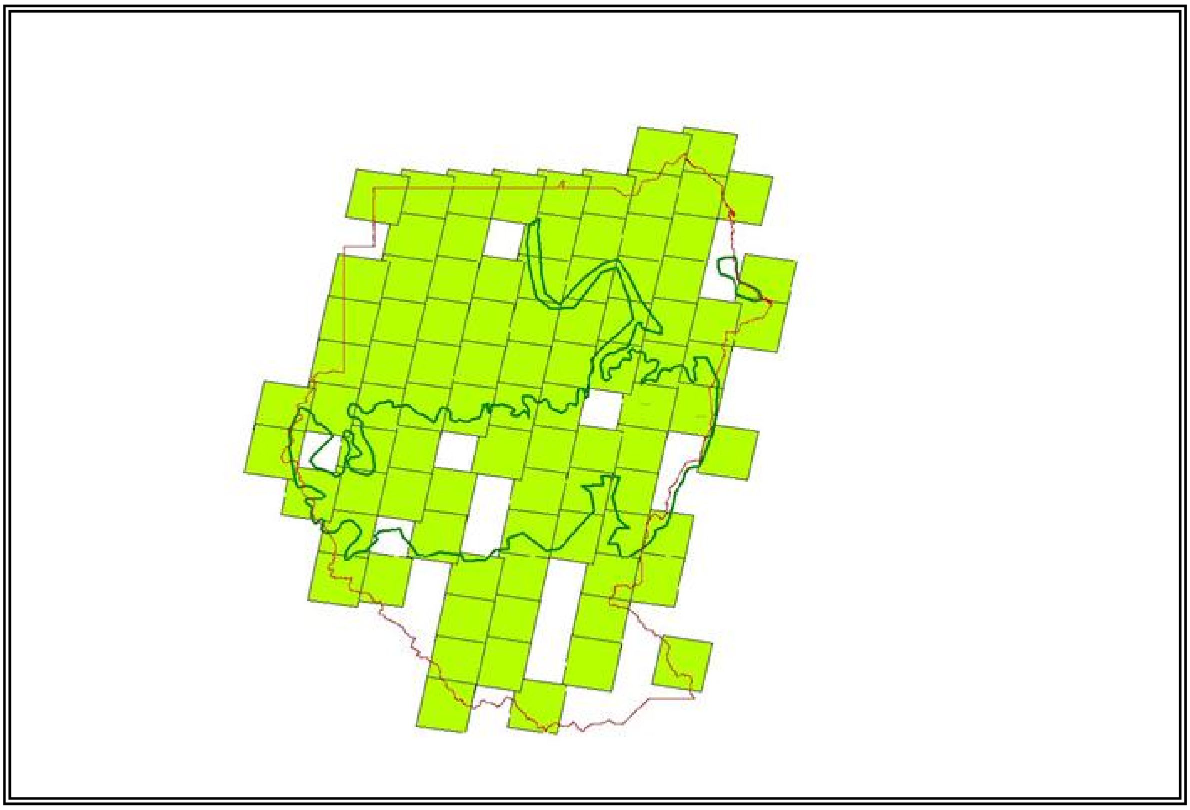


Figure 7 - Landsat GLS2005 coverage.

4.2 INPE-CBERS imagery

In order to fill the Landsat GLS5 gaps, the availability of the CBERS satellite imagery has been checked. CBERS is a new Chinese-Brazilian satellite system with all images fully cost free. The resolution is 20 m comparable with the Landsat imagery (30 m). Using the recording capability available on board CBERS-2B, the acquisition over Sudan, was planned for this year (May-September) taking into account that the company has previously received a further request from Sudanese GIS Office.
FAO-NRCE has requested an alert for this area therefore, in the next few months as soon new images are acquired, INPE - Istituto Nacional de Pasquisas Espaciais will suddenly communicate. However, the present downloadable coverage, dated 2006, is shown in figure 8 and is now available in NRCE.

For the complete list see ANNEX III.

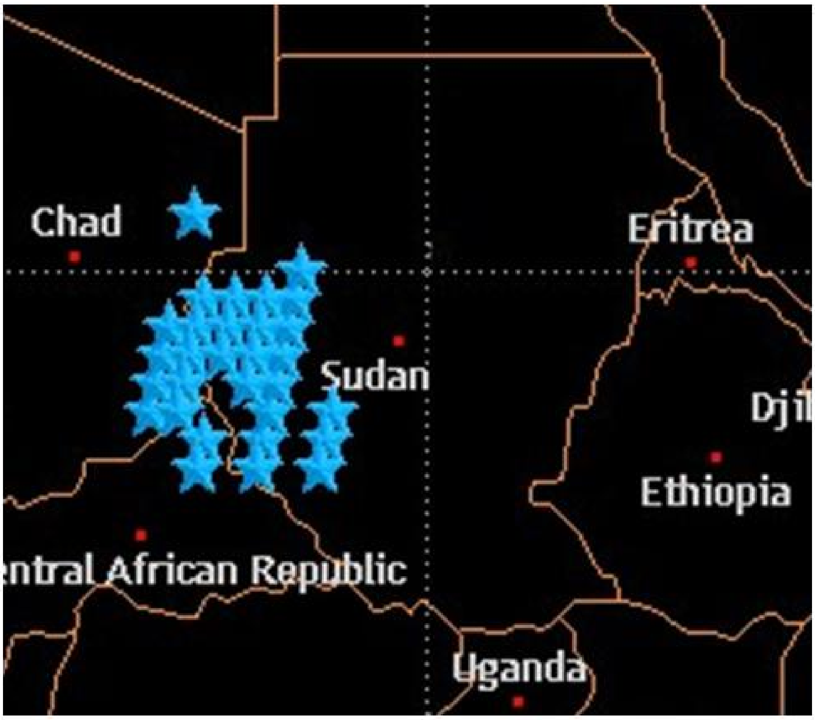


Figure 8 – Current CBERS coverage.

4.3 SPOT

SPOT data can be considered the step ahead for the CAPES objective project. Be it for improving the whole mapping coverage of the AOI agricultural area and updating and upgrading the agricultural/land cover database, the high resolution of the SPOT satellite images can give statisticians, technicians, decision-makers and stakeholder the correct detailed information they need to support the food security information system.

4.3.1 SPOT coverage

The main characteristics are listed below:

SPOT 4

Spatial resolution

Panchromatic : 10 meters
Multispectral : 20 meters

Spectral Range

Panchromatic : 0.61 – 0.68 µm
Multispectral : 0.50 – 0.59 µm (Band 1-Green)
0.61 – 0.68 µm (Band 2-Red)
0.78 – 0.89 µm (Band 3-Near Infrared)
1.58 – 1.75 µm (Band 4- Short-wave Infrared)

Temporal resolution : 26 days
Recommended Scale : 1:50,000 - 1:100,000

SPOT 5

Spatial resolution

Panchromatic : 2.5 - 5 meters
Multispectral : 10 meters

Spectral Range

Panchromatic : 0.48 – 0.71 µm
Multispectral : 0.50 – 0.59 µm (Band 1-Green)
0.61 – 0.68 µm (Band 2-Red)
0.78 – 0.89 µm (Band 3-Near Infrared)
1.58 – 1.75 µm (Band 4- Short-wave Infrared)

Temporal resolution : 26 days
Recommended Scale : 1:20,000 - 1:50,000

The figure 9 shows the acquisition points of SPOT imagery over the AOI covered by about 330 images.

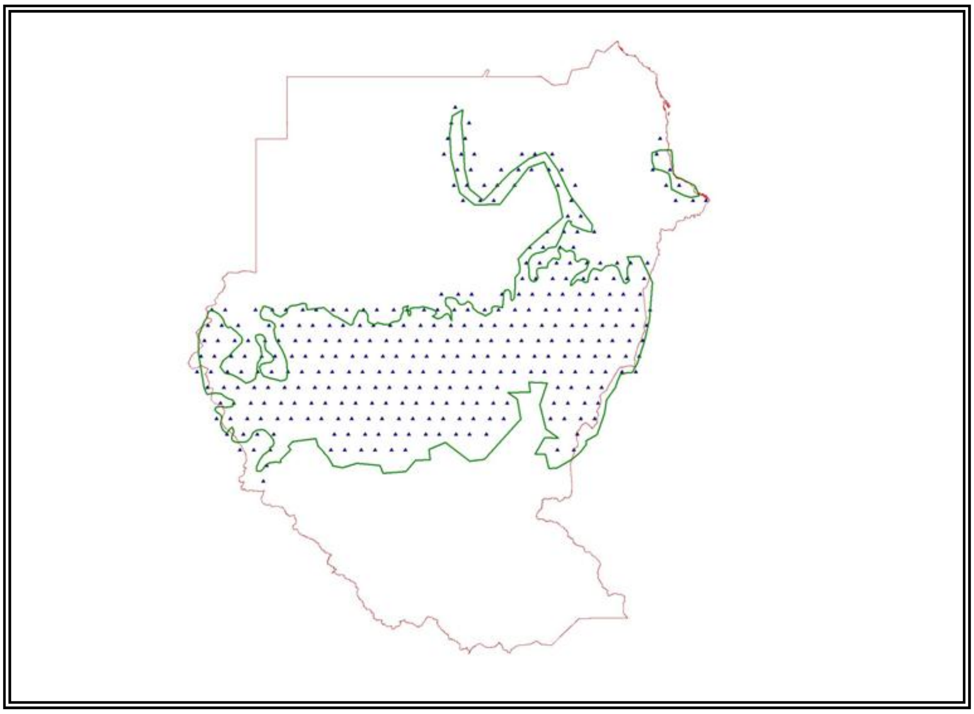


Figure 9 – SPOT acquisition points.

4.3.2 SPOT Archive

The SPOT coverage from Archive SPOTIMAGE has been investigated.
With the application of the high resolution SPOT5 product (e.g. res. 5 m), the existing agricultural data base can be updated and upgraded giving an important contribution to the land management and planning. However costs of such imagery will be significantly higher and there has to be a review of resolution vs increased information content vs cost before a final decision is made on optimum dataset.

The acquisition is not always completed, not homogeneous in dates, seasonality and sensors depend on different periods. The figure 10 shows the SPOT coverage for years 2008, 2007 and 2006. Attached the shape file with all the details of the images (it is also included a word file "SPOT scene description.doc with all the keys). As shown, in the year 2006 the coverage is almost complete (308/330 images).

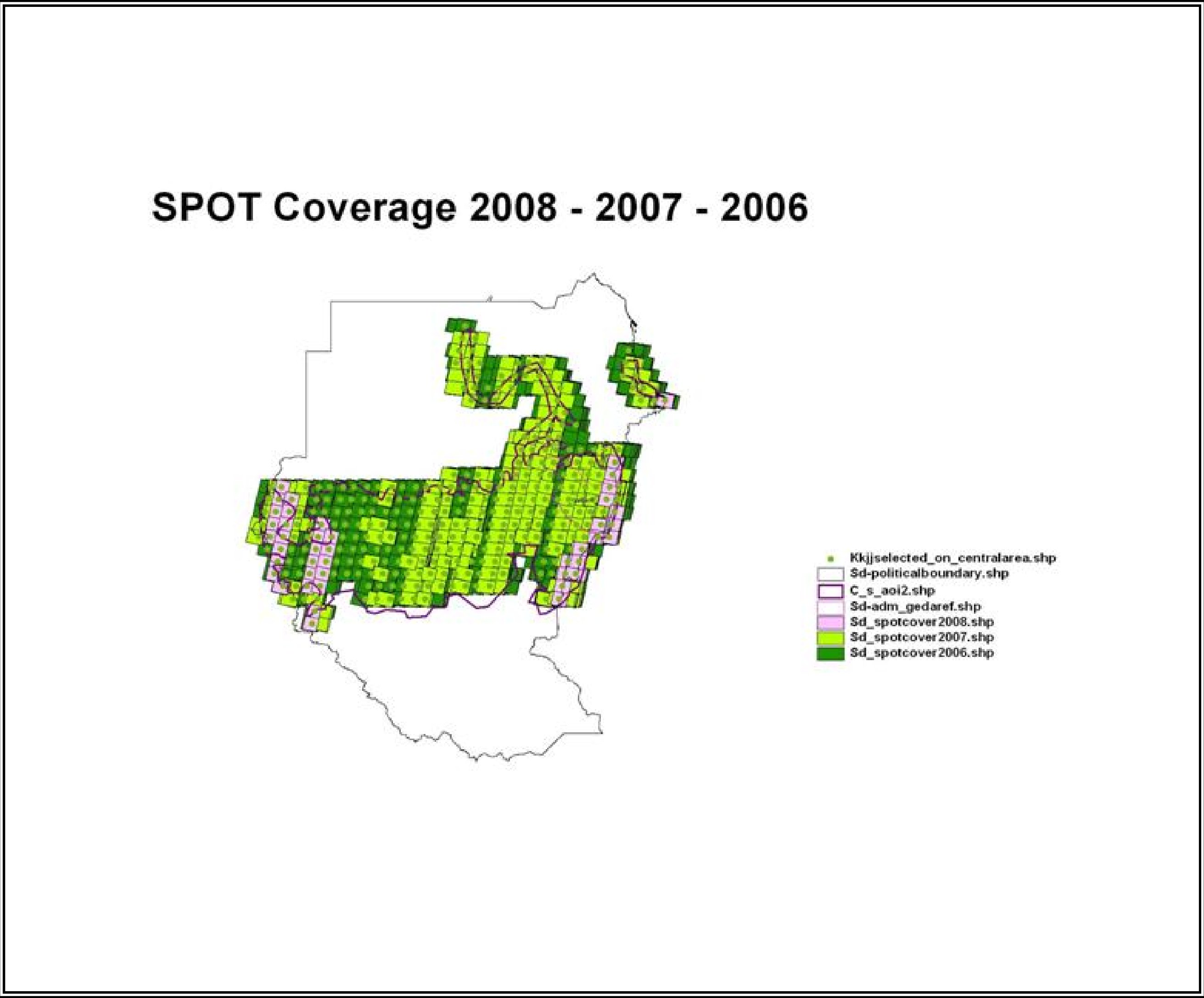


Figure 10 – SPOT5 coverage available from SPOTIMAGE archive years 2006 -2007-2008.

Figure 11a shows the coverage for the AOI available in the year 2006 available at 5m resolution.
Figure 11b shows the coverage for the AOI available in the period June-October 2006.

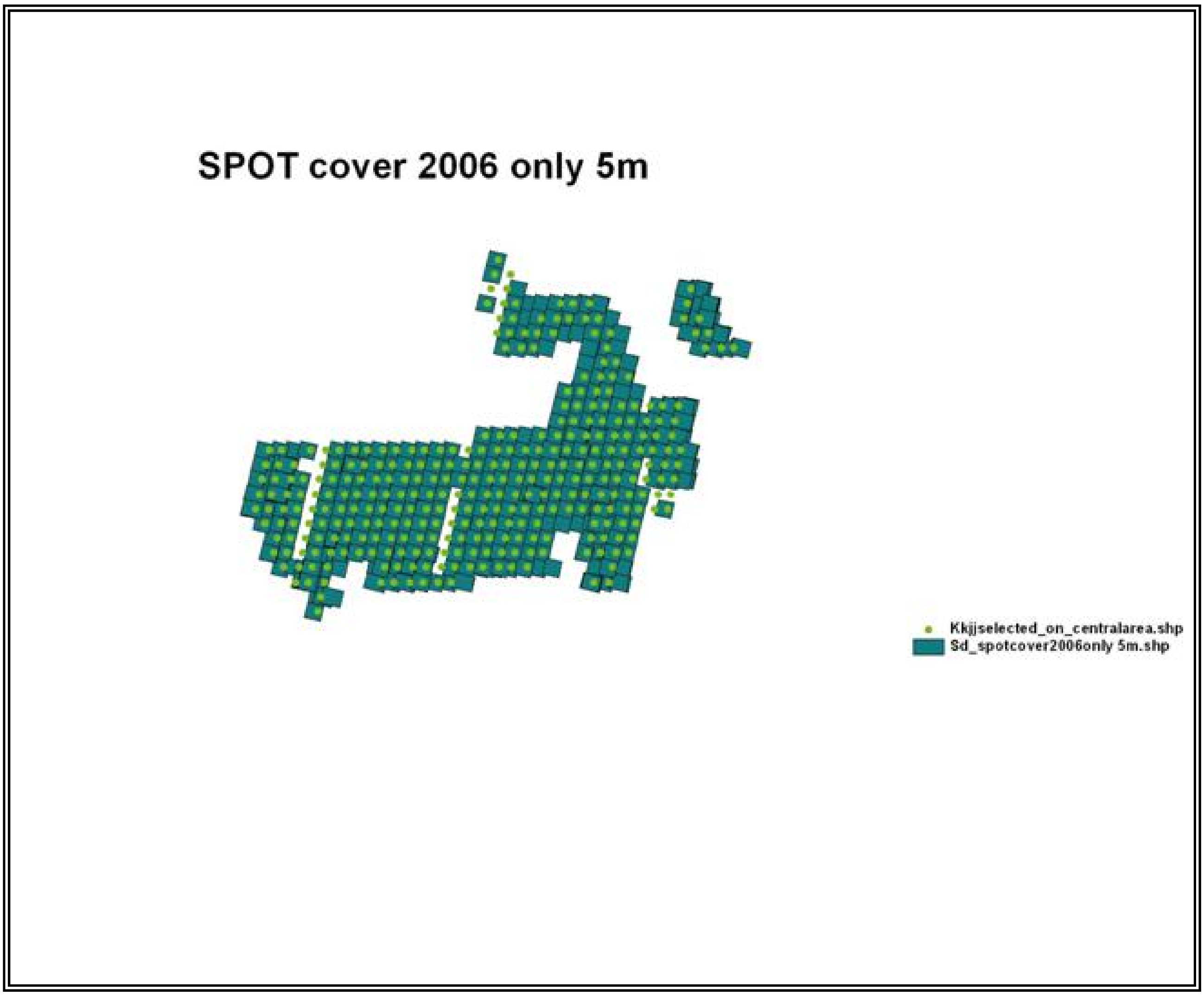


Figure 11a –SPOT5 coverage available from SPOTIMAGE archive year 2006 5m resolution.

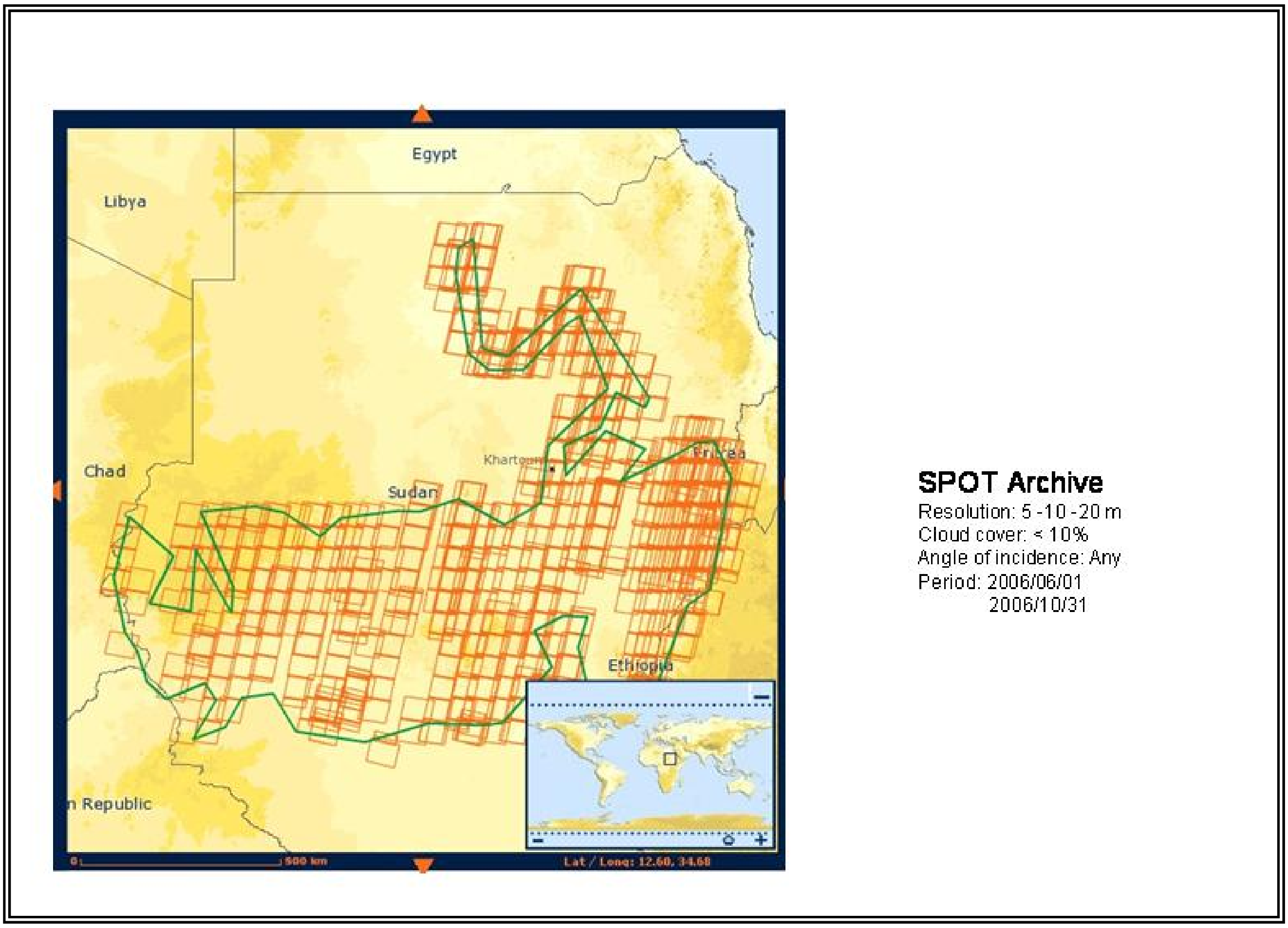


Figure 11b –SPOT5 coverage available from SPOTIMAGE archive dated June-October 2006.

SPOT coverage 5m resolution can be visualized with Google Earth using the following files: Soudan_5m1anee_081036.kmz and Soudan_5m1ete_081036.kmz are files with detailed information about images. Example of the year 2006 coverage is given in the figure 12.

4.3.3 Programmed acquisition for SPOT coverage

A new acquisition has been programmed. For the project purpose, in this period, an official request to the ground station in Cairo – Egypt has been transmitted to start a programmed acquisition over the Area of Interest. This acquisition has no commitment for the project to procure the imagery.

Costs for programmed and archive imagery are included in the table in the Annex VI.

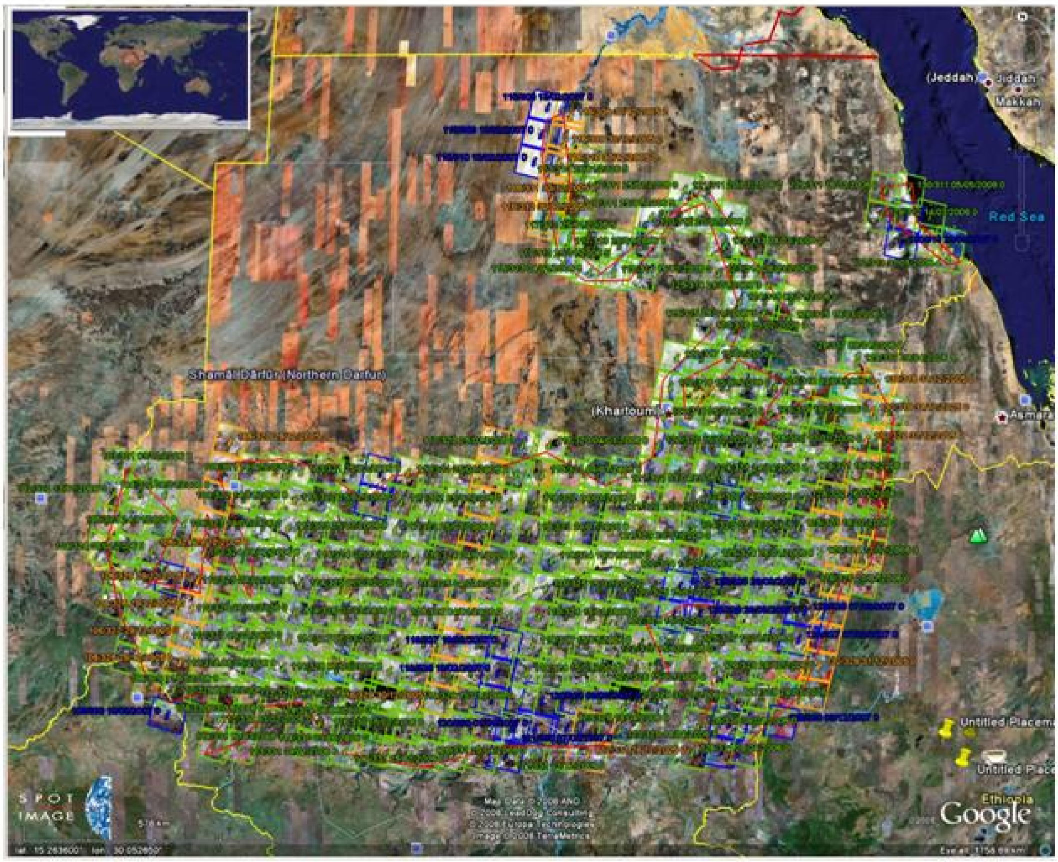


Figure 12 –SPOT5 coverage available from SPOTIMAGE archive dated June-October 2006 shown using Google Earth.

4.4 Other sources

4.4.1 MODIS

The MODIS (or Moderate Resolution Imaging Spectroradiometer) instrument is operating on both the Terra and Aqua spacecraft. It has a viewing swath width of 2,330 km and views the entire surface of the Earth every one to two days. Its detectors measure 36 spectral bands between 0.405 and 14.385 µm, and it acquires data at three spatial resolutions -- 250m, 500m, and 1,000m. More info in http://modis.gsfc.nasa.gov/data/.

GLCF provides access to imagery collected from the Terra MODIS sensor, in a product that is a composite of sixteen days worth of images. This composite has the benefit of eliminating most cloud cover found in daily images. Note: the Collection 3, 32-day composites will remain online until replaced by the Collection 4 and Collection 5 edition, 16-day composites.

Some data set are available in NRCE but new updated can be downloaded from: http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp

PART II

Introduction

Land cover mapping can be undertaken using different satellite images. Obviously, the accuracy of the final output is linked with the resolution of the satellite image utilised. The existing Africover database realised with Landsat 30m pixel resolution is a good compromise at the country level; however, it can considerably improved using SPOT imagery 5-10 m pixel resolution. The updating and upgrading of the agriculture information baseline can be also an important source of information for the statistical analysis and future estimation system.

Mapping the Earth's cover is a sensitive and time-consuming work. It implies specific procedures and precise standard steps. According the new technologies, NRCE has developed new mapping tools, free of charge for FAO projects, which can be widely implied in the all cartography activities. LCCS, GeoVis/Map, MadCat, ADG, radex-mosaic and VEDAS are software, tools, mapping criteria and standards generally presented in national training courses dedicated to the national capacity building (for detail see http://www.fao.org/gtos/doc/2007-LCCS6/GLCN-brochure.pdf).
A correct and harmonised approach on the methods and know-how required to produce and manage land cover data is the key factor for a successful outcomes on which FAO-NRCE dedicated time and resources, taking into account the different national situations and approaches and with the awareness that adoption of international standards is a long process that needs the involvement and endorsement of numerous national institutions.

The activities are normally organized in a first phase dedicated to a preliminary training courses in support to the land cover mapping production and change analysis; after that, in a second stage, through the development of regional and national networks of collaborating institutions and individuals with the assistance of national focal points. This interchange process of ideas and actions between FAO-NRCE and all the national entities has been considered crucial.

5. Land Cover change analysis in the Gedaref region

The interpretation process can start from a systematic description of the present features followed by a comparison process from which the changes occurring in the area are extracted. Change characterization must be carried out throughout the identification, intensification or reduction of features, and evaluation of types and the main peculiarity of features. Characterizing change implies:

- Definition of change of interest

Change can range from short phenomena such snow cover or flooding to long term such urban fringe development or desertification. Long-term changes are the task of the present project related mainly to extension/reduction agricultural features. No other land cover types are of interest.

- Product selection

Accordingly with the time frame of the phenomena analysed, product utilised must contain the information desired. Landsat ETM, TM and MSS are time series dataset that cover 4 decades and, therefore, suitable for the aim of the project. However, to have output suitable for agricultural statistical analysis a more detailed time satellite images should be utilised.

- Types of analysis

When reliable and update data are available, the present features can be compared with the previous images to identify the changes that have occurred. However, areas of change can be detect following different approaches, for example classifying independently two or more images and then compare the results or analysing a multi-date image containing various bands from each date. Detailed description in the next paragraphs.

- Detect area of changes

When identifying changes that have occurred, the area of changes must be delimited in order to define the exact extension and the correct location of changes in the study area. Moreover, it should be define the specific nature of the changes involved.

- Magnitude of change

Together with the extension, the intensity of change could be indicated. Magnitude is quite difficult to quantify but for simplicity two main categories can be identify:

Change. It signifies a drastic conversion from an activity to another. A passage from natural vegetation to agriculture is a clear, recurrent example.
Variation. The same natural vegetation or agricultural pattern can undergo more modest modifications (e. g. size or density of the fields).

From a technical point of view, mapping change in land cover is a complex exercise. Different methods and procedures have been international proposed but not a fully harmonised approach exists. Considering specific objectives, accuracy and time, users place different emphasis on different methodologies. The analysis can be carry on in automatic, semi/automatic and with manual interpretation with a statistical approach or with "wall to wall" mapping procedures.

Therefore, to determine the best modus operandi in an implementing phase, a pilot test in the Gedaref state has been carrying out. For a complete overview and to furnish key elements for a correct evaluation of the most suitable methods, certain criteria are considered and listed for each procedure. Criteria include:

- Able to detect changes.
- Comprehensive and replicable.
- Accurate.
- Timely.
- Cost-effective;
- Sustainable; the methods and data output must be manageable by local staff.
- Flexible; results must be and useful for different applications.
- Comparable; results can be used among years without massive re-mapping.

Finally, a summarized table is presented (see table 1).
The proposed methods can be used standard-alone or in cascade: detailed analysis can be re-directed in specific areas of interest.

Vantages and disadvantages are inherent in each method. To evaluate their effectiveness and value it must keep in to account that the changes of interest include mostly the agricultural expansion to the detriment of natural vegetation. The detection of changes within of the agricultural areas is not the matter of the analyses but strongly influence the interpretation especially using automatic/semi-automatic methods.

5.1 Method 1 – Hot Spots

It refers to a visual and fast indicator of the changes. It is useful to apply at the first phase of the analysis in order to locate the main areas of changes (Hot Spots); it could be also useful to address the research of the high resolution images, inside the Area of Interest.

Procedure

The first step is the grid characteristics set up and its generation. The grid should be generated according with the Minimum Mappable Units of the changes. This depends on the original MMU dataset as well as the pixel resolution of the images utilised.
For this test, a grid 250 x 250 was generated using ArcGIS and the comparing analysis was undertaken considering the main classes in the legend below:

N - 0-10% No modification/change
NN - 0-10% No modification/change /No agriculture features in the analysed cells
L - 10-30% Low modification/change
M - 30-60% Medium modification/change
H - > 60% High modification/change

Obviously, a finer grid can be generated to provide a more detailed output.

Output

A vector layer representing the grid with the attributes related to the above legend.

Time

Depending on the grid cell size, but it can be considered relatively fast. In this case, to generate the grid and complete the analysis for the Gedaref AoI it was necessary 2/3 working days.
The result is shown in figure 13. In figure 13a, a zoom in a high modification cell (red colour) is presented.

Cost

Costs are reduced to the man/days work.

Advantages and disadvantages

Advantages

- Fast;
- Easy for a non-expert photo-interpreter;
- Clear representation of the Hot Spots;
- Performable also with low-medium resolution imagery data set;
- Output useful for image selection.
- Not expensive.

Disadvantages

- No precise extension of the changes;
- No indications about types;
- No possibility to generate “from” – “to” table;
- No precise statistical features.

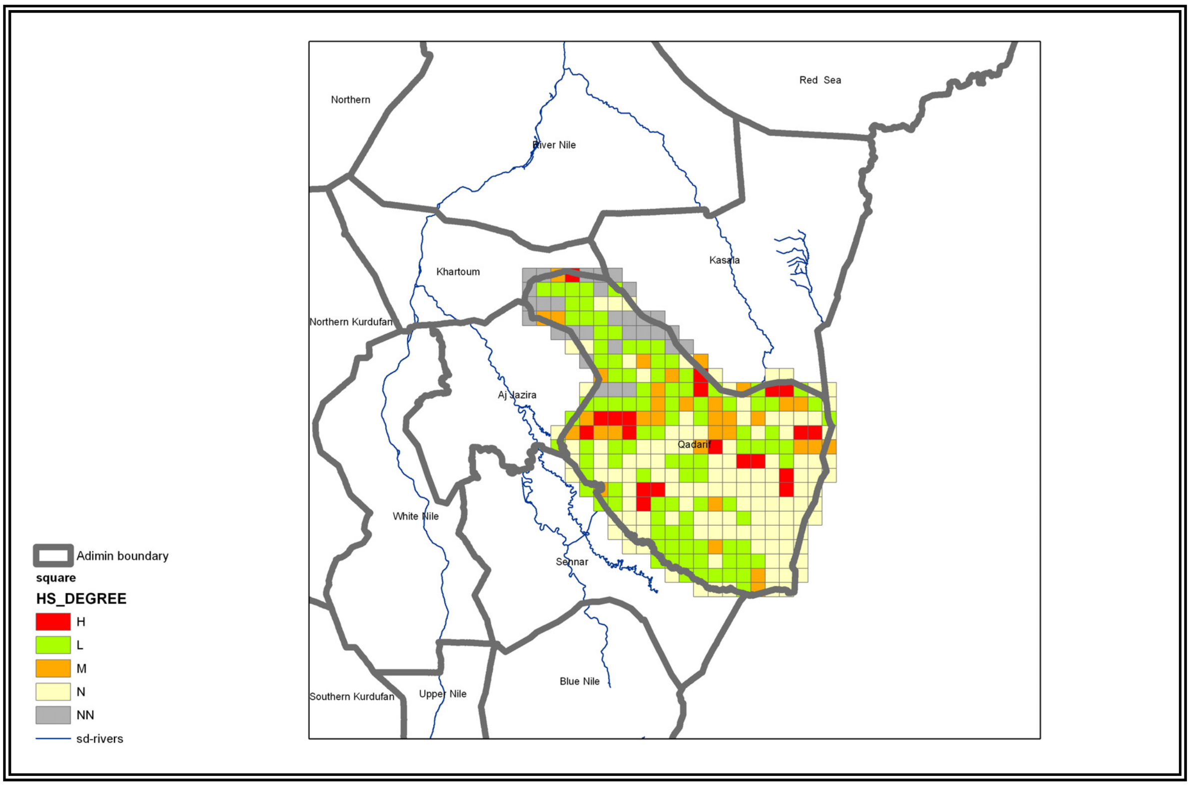


Figure 13 – Hot spots grid.

Figure 13 – Hot spots grid cell – High modification.

5.2 Method 2 – "Wall to wall" analysis

The canonical method to map the whole surface of interest is normally called "wall-to-wall" in order to signify that, not only the randomly selected portions of the territory is analysed but its total extension. When the analyses concerns the changes, On screen" manual interpretation can also be considered the best way to detected and highlight land cover features (expansion/reduction). Land cover can be mapped using manual interpretation or semi-automatic vector object based method. In each case, the interpretation is fully supervised by the users. It can be considered one of the best approaches to adopt. No massive pre-processing is required as well no specific anniversary imagery date is necessary: the expert users can detect only changes of interest.

On the other hand, to carry on the mapping exercise, skill and expert photo-interpreters are required, able to manage also multi-layers database.

Procedure

The identification of the features present in one date can be considered the first step in the analysis of changes. In our example, the analysis started with the visual interpretation of the oldest images (Landsat ETM, 1997) from which a vector shapefile was obtained (Africover database). This layer has been overlapped to the new recent scene (ETM 2005) and modified according with the new indications of images. A new vector shape-file is obtained. From the intersection of the two layers the changes can be extracted.

Using FAO software, images of two dates are synchronized and visualized in multiple windows. The existing land cover is overlapped on top of the two images. An example is shown in figure 14.

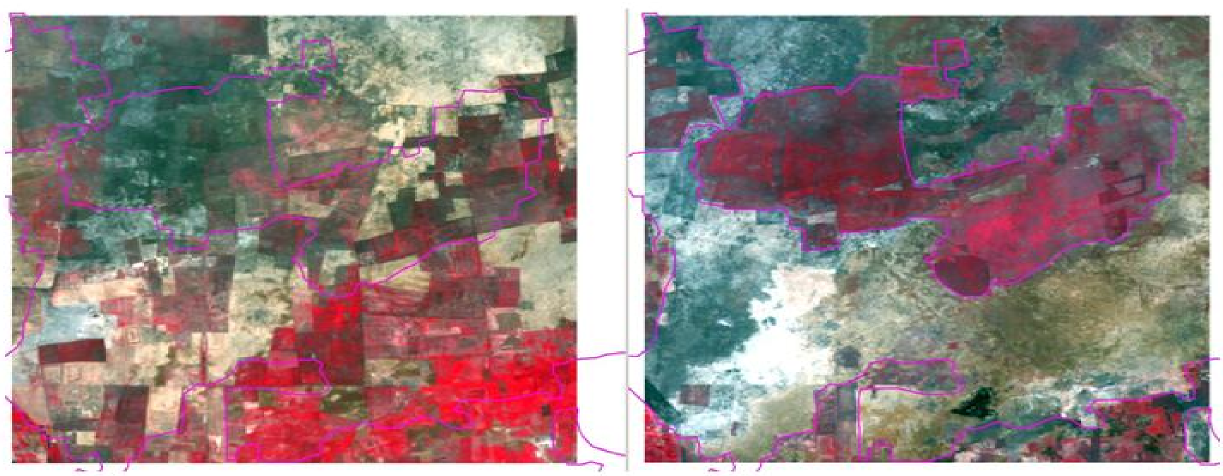


Figure 14 – Africover database overlapped on Lansat images (left 2006, right 1996).

The process involves the following phases:

- Examine a polygon area;
- Recognize land cover class;
- Perform a comparative analysis with previous images to determine if the polygon can be recognized an area(s) of change;
- If no change occurs:
    - leave unchanged the land cover code and delete polygon:
- If change can be recognised, define type or category of the change, through the following steps:
    - according to the evidence on the images re-classify the old polygon if changes have occurred in the same area;
    - create new polygons and labels, if change has occurred in an area not previously interested by agriculture;
    - re-shape old polygon boundaries and labels if change occurs in a portion of an old polygon.

Figure 14a and 14b give an example of the described procedure. Polygon 1022 black arrow) is examined. In figures there are, on the left side, images 1996 and, on the right the new one, 2006; on top the Africover database (red line). The polygon indicated is labelled as 2SVJ67 (Natural Vegetation –Very open shrubs with closed to open herbaceous and sparse trees). However, the same polygon boundary doesn't fit the right image where it is visible a colonization of agriculture. In the new image, the old polygon is split and the agriculture feature re-labelled according (HL4/HM14 Rainfed Herbaceous crop(s) Large-Clustered Medium fields).

Figure 14a – Africover database overlapped on Lansat images (left 2006, right 1996).

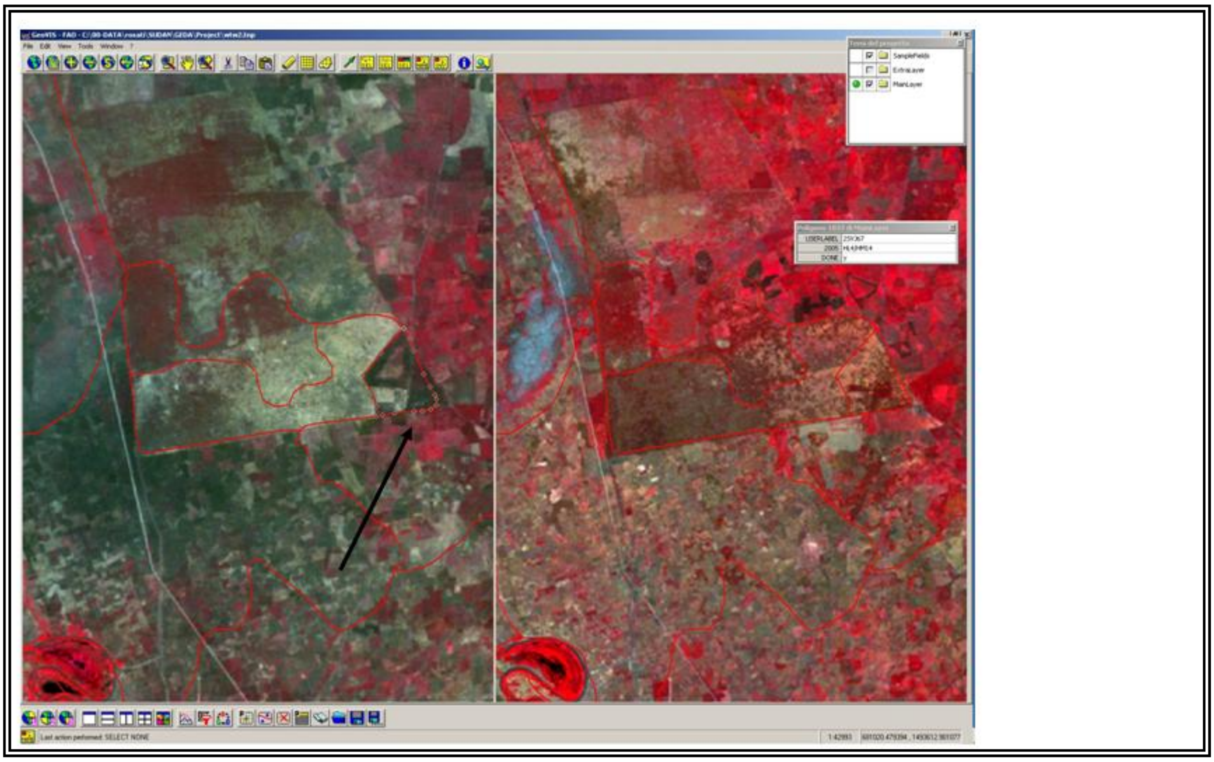


Figure 14b – Modification (reshaping and labelling) of polygon 1022.

Finally, the table "from-to" is created for the polygons where changes occurs In figure 14c, the only polygons where changes occurs are shown, they are extracted from the interpreted land cover layers. The linked table "from-to" is also presented.

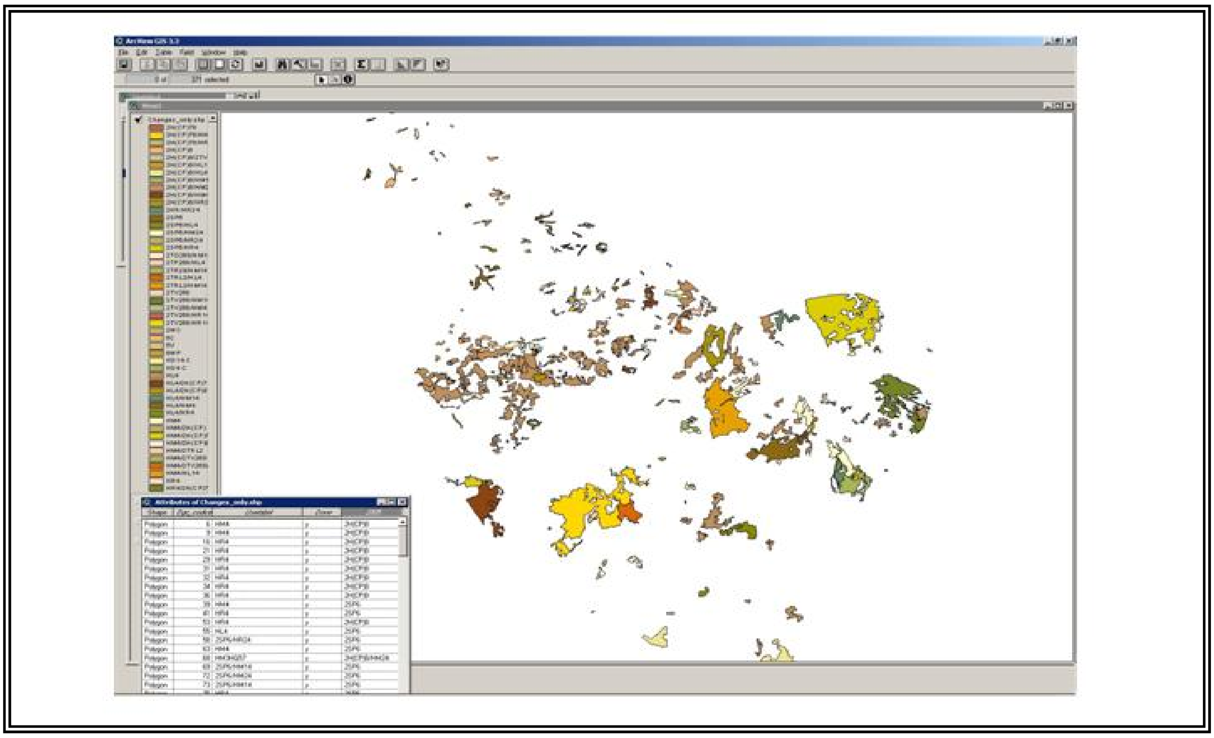


Figure 14c – Shape file with change areas with the table " from-to".

In the manual exercise, the most important task is the delineation of homogeneous areas (polygons) that can be afterwards labelled using the chosen classification method. This first step is very important and must be done with accuracy and consistency because from it, depend the other outputs. Furthermore, if the first "polygonization" is inaccurate the re-process work is long and it is required a most accurate review instead, errors in labelling are more easy and fast to correct later on.

The new technology offers software for automatic vector polygon generation. In this case, there is an overshoot of homogeneous polygons (based on pixel values) that, soon after, will be classified and merged together. That procedure is very useful in such cases when a previous land cover doesn't exist.

Very often, because of the mapping scale and the pixel resolution, it is necessary introduce mixed (or mosaic) classes. In such cases, the delineation of single classes could produce a too complex final map due to too many and too small polygons. When possible, mixed units could be limited to two classes. However, there were cases where the delimitation using only two classes was actually not possible.

Final GIS procedures (merge, bordering matching etc.) as well field works can be considered

Output
Vector files linked with an attribute table "from-to".

Time
Work long and complex to achieve the result. To examine the Gedaref area (1021 initial polygons were necessary 4 full days).

Cost
Mainly man/days.

Advantages and disadvantages
Advantages

- exact discrimination of changes;
- accurate delimitation;
- exact location of changes;
- exact extension of change;
- table "from-to" immediately available;
- no strong pre-processing is necessary even so it is recommended;
- no anniversary date images must be employed even so it is recommended;
- the analyst can re-fine and review the final output as soon new information are available and nor strong re-processing it is required.

Disadvantages

- the interpretation is a time-consuming work;
- it is linked to the skill of the analyst and the information available;
- an interpreter arbitrary decides what and where a difference or a variation is of interest and if it is mappable or not;
- subjectivity is the main characteristic of visual interpretation and it must be minimized when several photo-interpreters work together.

5.3 Method 3 - Dot grid analysis

The dot grid method is vector/raster hybrid approach, based on the idea that the changes can be highlighted using a discrete classification attributes that touch each the dot grid generated on the raster files.
For this approach two different software can be utilised:

- ArcGIS - RLCM Rapid Land Cover Mapping tool by ESRI

- MadCat – dot grid tool by GLCN-FAO

Both tools are powerful; they can facilitate the definition and generation of the grid, aids the selection of dot and/or the block of dots and applies the classification attribute to them.
However, using LCCS classification system, the management of the codes, classes defined in the field "Userlabel" with RLCM is more problematic. In addition, the grid generation can be done for the all spatial extend of the Area of Interest; using MadCat, the grid can be generated only in selected areas. For the test in the Gedaref region, some of the previously areas labelled as "High Modification" have been selected and used as reference to generate the grid. Finally, from the change grid points rough polygons can be extracted.

<u>Procedure 1 - ArcGIS RLCL</u>

The first phase is the grid generation. Its step and the accuracy must be determined for each case. Then the related legend must be imported. ArcGIS RLCL Tool is designed to import LCCS legend but its manageability is very problematic. On the other hands, a re-lineament on fly tool of the images permits the abortion of small shift between scenes.
However, the procedure is designed in such way that to the active dot points of the grid can be associated a new codes when a change occurs. In figure 15, an example from Gedaref area is shown. The distance between dots is 2km. Different colours highlighted that some changes have been detected and new codes is given. Colours reflect the legend classes.

<u>Output</u>

Statistical table.

<u>Time</u>

Relatively fast.

<u>Cost</u>

Costs concern the software (ArcGIS 9.2 must be available) and man/days.

<u>Advantages and disadvantages</u>

Advantages

- relatively fast;
- table "from-to" available;
- no particularly skill are required even if a good RS background is recommended;
- exact location of changes;
- no strong pre-processing is necessary even so it is recommended;
- no anniversary date images must be employed;

- local registration of scenes.

Disadvantages

- no accurate delimitation;
- no exact extension of changes;
- no shape file available;

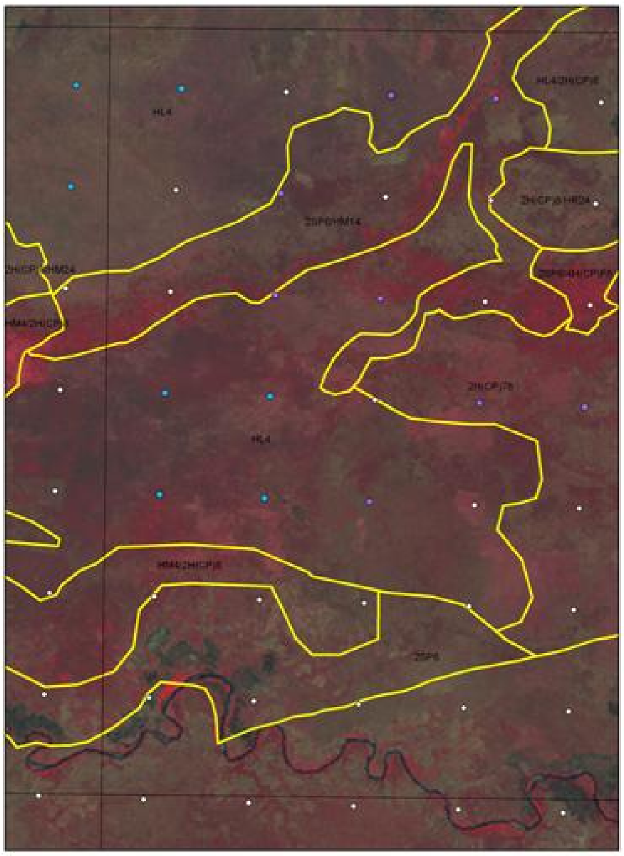


Figure 15 – Grid generated using ArcGis-RLCM Tool.

Procedure 2 – MadCat

The procedure follows the same steps previously described. Madcat has a very high manageability of the LCCS legend and also the possibility to generate a grid on selected areas/polygons, see figure 16. In figure 16a the output in the Gedaref area mapped for the previously square labelled High modification is shown. In addition, the possibility to work with synchronized windows is a powerful tool not available in RLCL where the comparable analysis must be done switch on/off the overlapped images.

Output

Statistical table and draft generation of polygon in a shape file format.

Time

Relatively fast.

Cost

Man/days.

Advantages and disadvantages

Advantages

- relatively fast;
- table "from-to" available;
- no particularly skill are required;
- exact location of changes;
- no strong pre-processing is necessary even so it is recommended;
- no anniversary date images must be employed even so it is recommended;
- rough shape file available;

Disadvantages

- no accurate delimitation;
- no exact extension of changes.

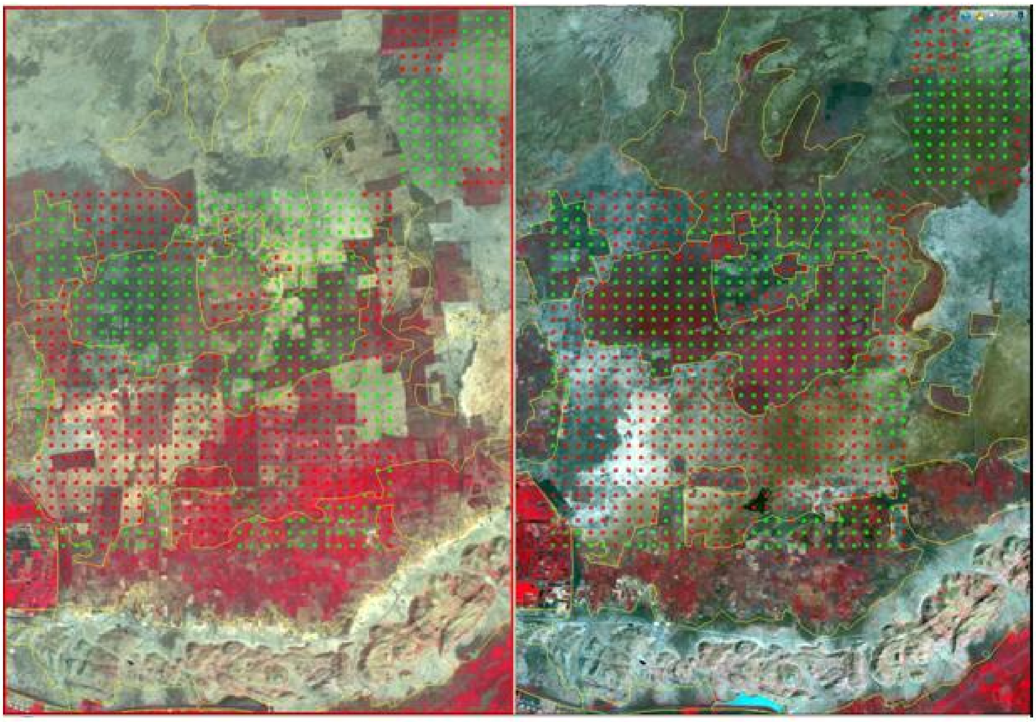


Figure 16 – Grid generated using MadCat- DotGrid Tool.

Test is carry out in some hot spot cells previously labelled "High Modification". The resulting polygons, automatically generated from the dot grid change values are shown in the figure 16a. The high number of cell labelled "Low" refers to the information "burned units" that is not included in LCCS classification/Wall to wall method.

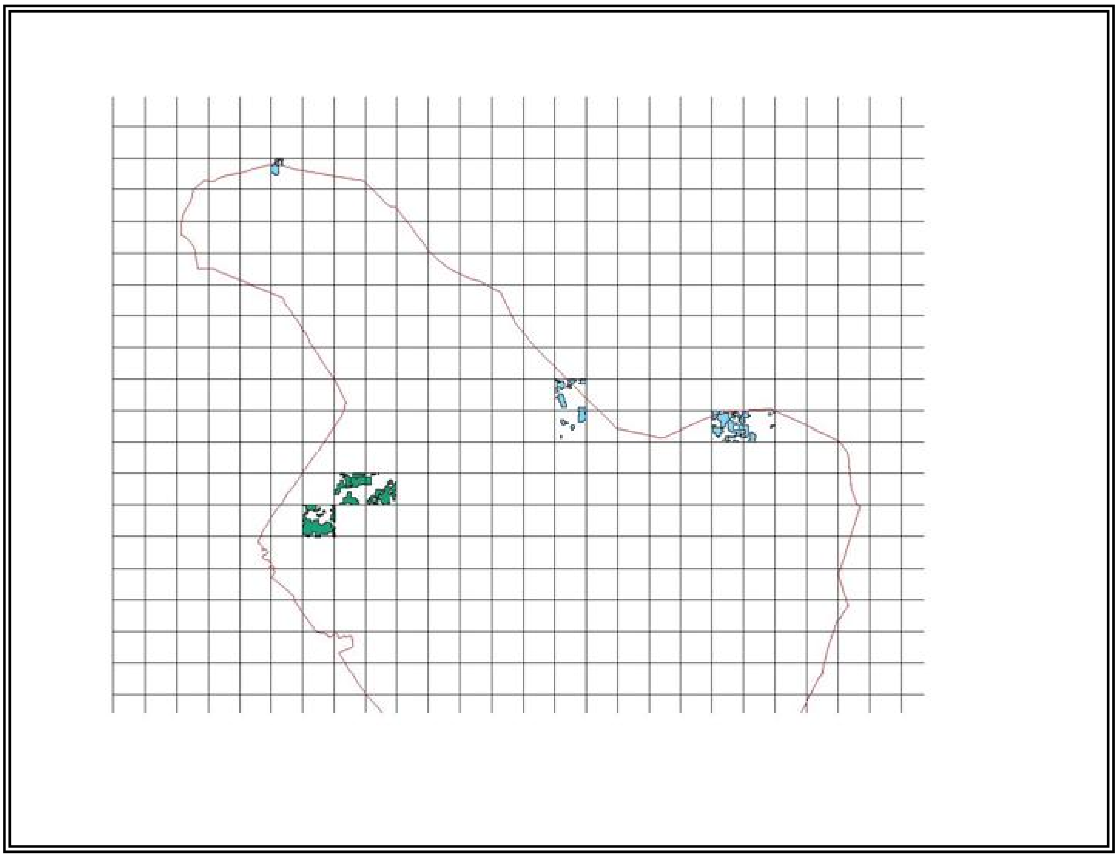
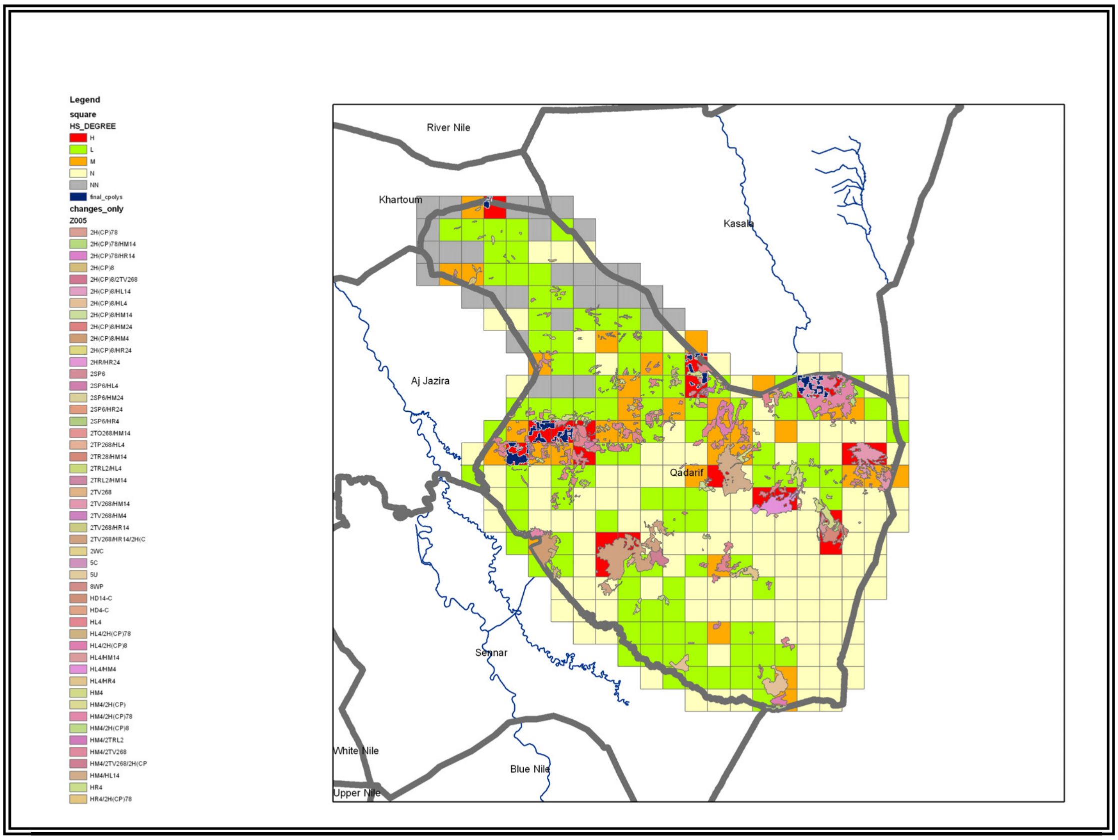


Figure 16a – Change Polygons generated with using MadCat- DotGrid Tool.

Figure 16b – Overlapped polygons generated from different Change analysis methods.



5.4 Method 4 – Semi-automatic detection method using Object Based Change Detection - OBCD by NRCE

OBCD (Object Based Change Detection) method is the procedure developed in NRCE.

The object-based approach is applicable to change detection techniques related to changes in land cover / vegetation over time. From a multi-date image a single multi-resolution segmentation delineates multi-date objects characterized by their reflectance difference statistics. Based on the analysis, abnormal values of normalized reflectance differences statistics are identified, a threshold is defined and objects of interest are classified based on the relative area of change per polygon, and the corresponding objects are labeled as likely changed. This approach uses image tone, shape, texture, area, and context, rather than just spectral information, to create an easily interpreted, object-oriented classification.

The segments are rated using predefined classes with class value indicating the likelihood of change. Spatial clustering is applied to aggregate the polygons. The clustered polygons are labelled and validated by local experts. Replicable results are achieved. However, it is noted that the change is not homogeneous inside the polygon. Additional tools are required to classify and adjust the percentage of changes inside the polygon. The segmentation parameters, thresholding and classification criteria are subject to further research and testing.

It is also noted that in order to obtain acceptable results it is often required to overshoot a larger number of segments. However, manual labelling remains a difficult and time consuming process.
The object-based approach is implemented through the methodology showed below. The process flow chart shows the sequence and the level of automation of the processes. Loading of temporal and multi-band imagery is fully automated using Definiens Developer Customized import function. Object delineation based on multi-date and multilevel segmentation is also fully automated using existing multilevel segmentation algorithm. Various classifications and clustering of polygons based on the likelihood of changes are developed using various methods in Definiens Developer and ArcInfo software.
Pre-processing steps such as creation and / or validation of cloud, forest and water bodies masks and post-processing such as clustering, aggregation and exporting of data are semi-automated providing a series of tools that facilitate the process.

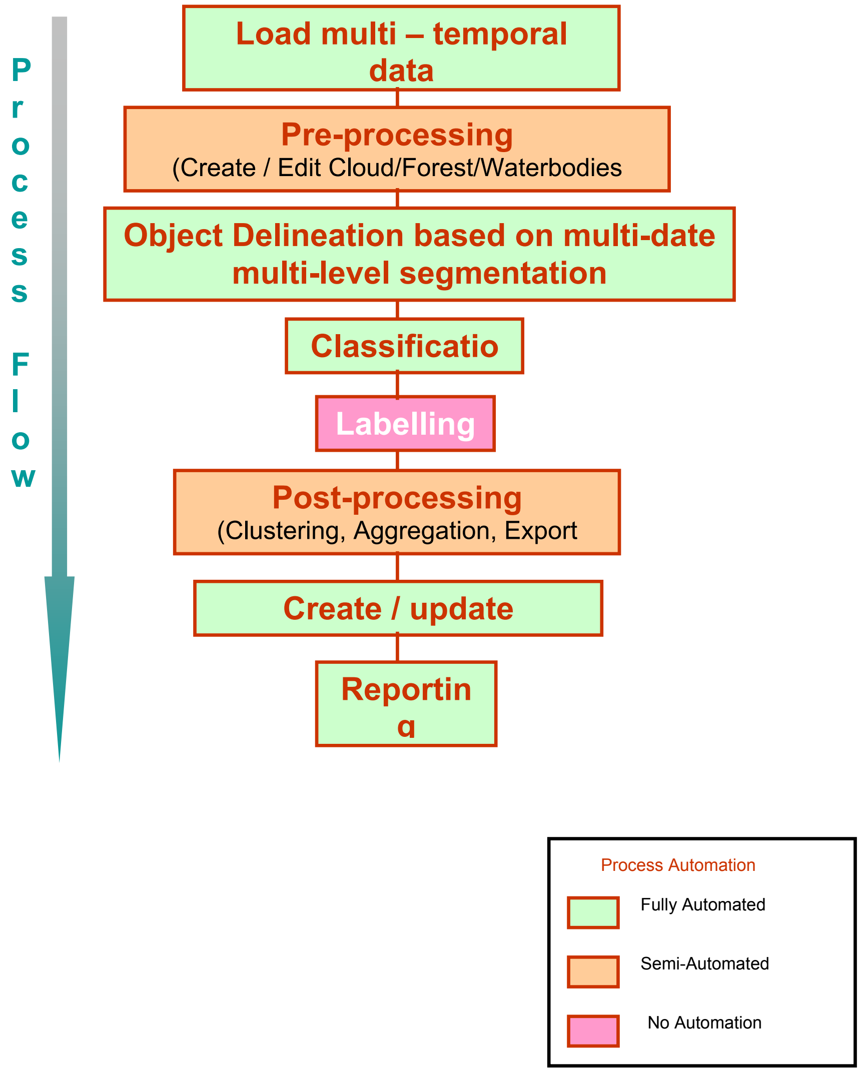


Fig17 - Object-Based process flow

<u>Procedure</u>

The process is completely automatic. It can be performed in short time without a specific knowledge of the programming rules and actions. However, a basic knowledge of the IDefinies software is required. Alternatively, the procedure can be run by expert user (NRCE) and the output delivered to national RS photointerpreters for supervision, checking and labelling. Result is shown in figure 18. The red polygons are the areas where the changes have a high probability to occurs and the areas that could be supervised previously.

<u>Output</u>

Shape file with indication of likelihood area of changes.

<u>Time</u>

Very fast (it refers to machine-time) but it must also considered the time to label and check the output.

<u>Cost</u>

Software (Definiens must be available) and man/days.

Advantages and disadvantages

Advantages:

- very fast;
- shape file available;
- useful to detect area of changes;
- exact location of changes;
- accurate delimitation;
- table “from-to” available after labelling;
- performable for large areas in automatic.

Disadvantages

- it is recommended employ anniversary date images;
- pre-processing is necessary;
- for agricultural analysis detected changes can be overestimated;
- software knowledge is required;

The procedure is carry out in a hot spot cell previously labelled “High Modification”.

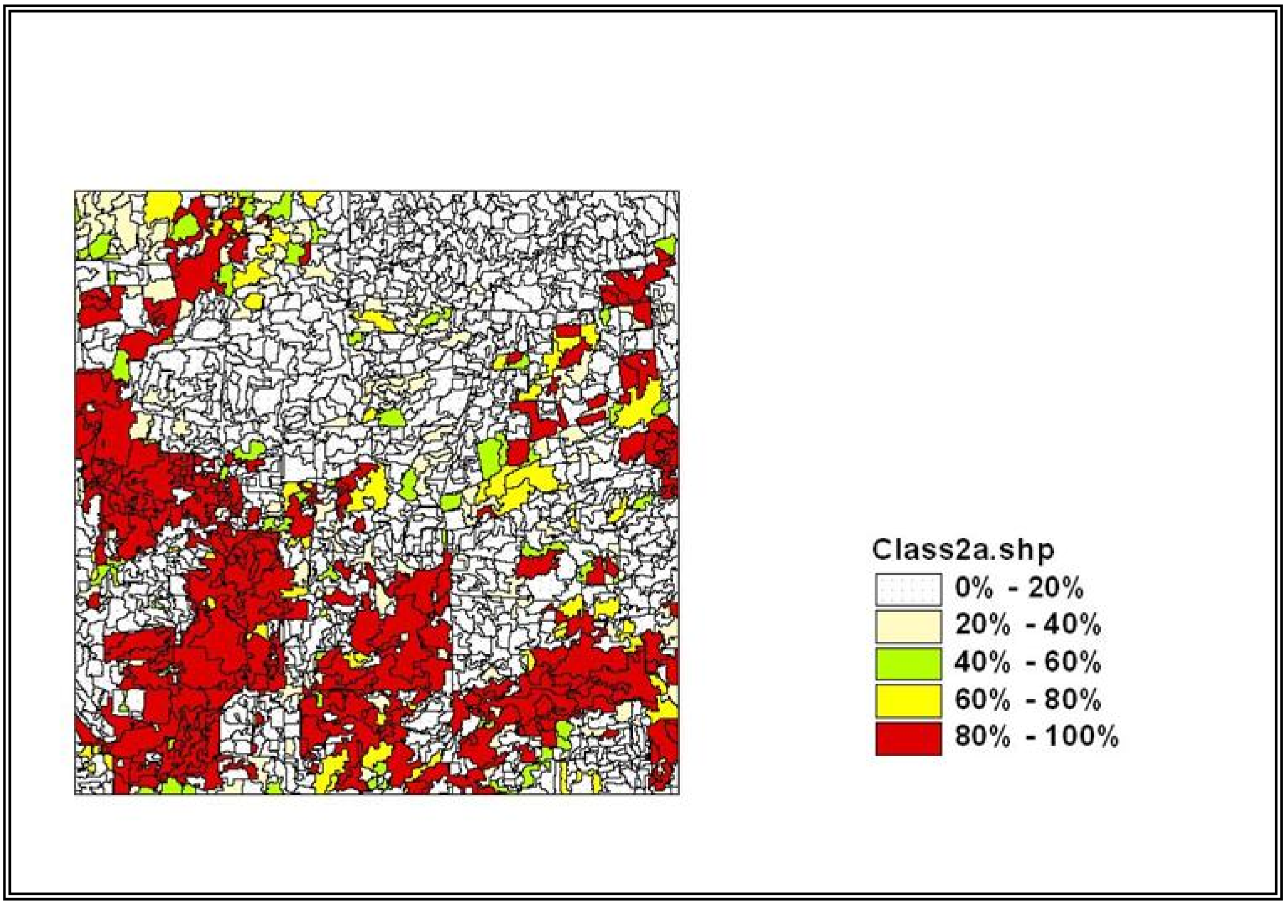


Fig18 - Object-Based Change Detection output1 cell.

A second test was carried out in four adjacent cells. Result in figure 18a. The square hot spot cells previously identified are very practical when apply this method. In fact, it seems evident that the procedure produces better detailed results when run in a limited number of pixels.

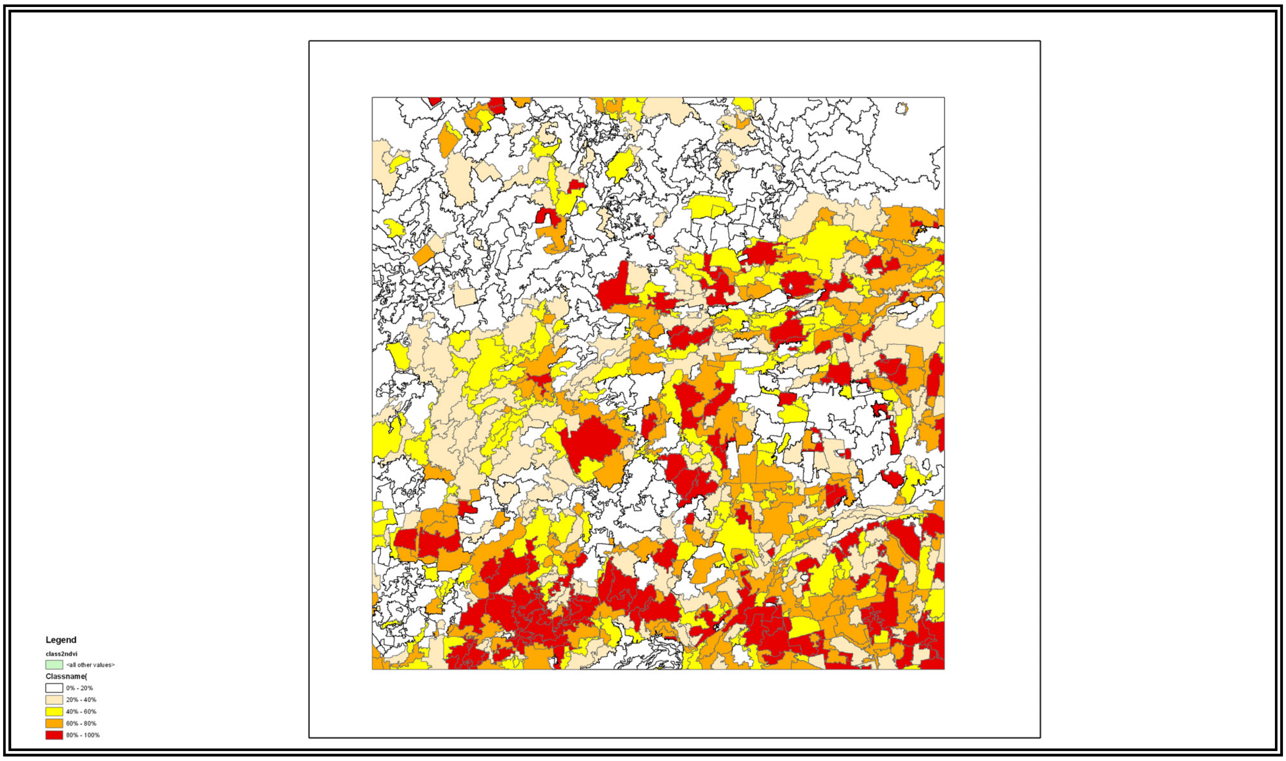


Fig18a - Object-Based Change Detection output 4 adjacent cells.

5.5 Other Madcat tool

To detect changes other tools have been developed in Madcat software. The software is still in its implementing phase. However, the new final relies will be ready very soon.

5.5.1 Change by pixel values

This method refer is based on the analysis of the difference in pixel values in two images of different dates. The automatic segmentation for polygons generation is the first step. Later, changes are highlighted with different probability percentages when a threshold, interactively set up, is fixed.

Output

Shape file with indication of likelihood area of changes.

Time

Very fast (it refers to machine-time) but it must also considered the time to label and check the output.

Cost

Man/days.

Advantages and disadvantages

Advantages:

- very fast;
- shape file available;
- useful to detect area of changes;

- exact location of changes;
- accurate delimitation;
- table “from-to” available after labelling;
- performable for large areas in automatic.

Disadvantages

- it is recommended employ anniversary date images;
- pre-processing is necessary;
- for agricultural analysis detected changes can be overestimated;
- software knowledge is required;

The procedure is carry out in a hot spot cell previously labelled “High Modification”. Result in figure 19.

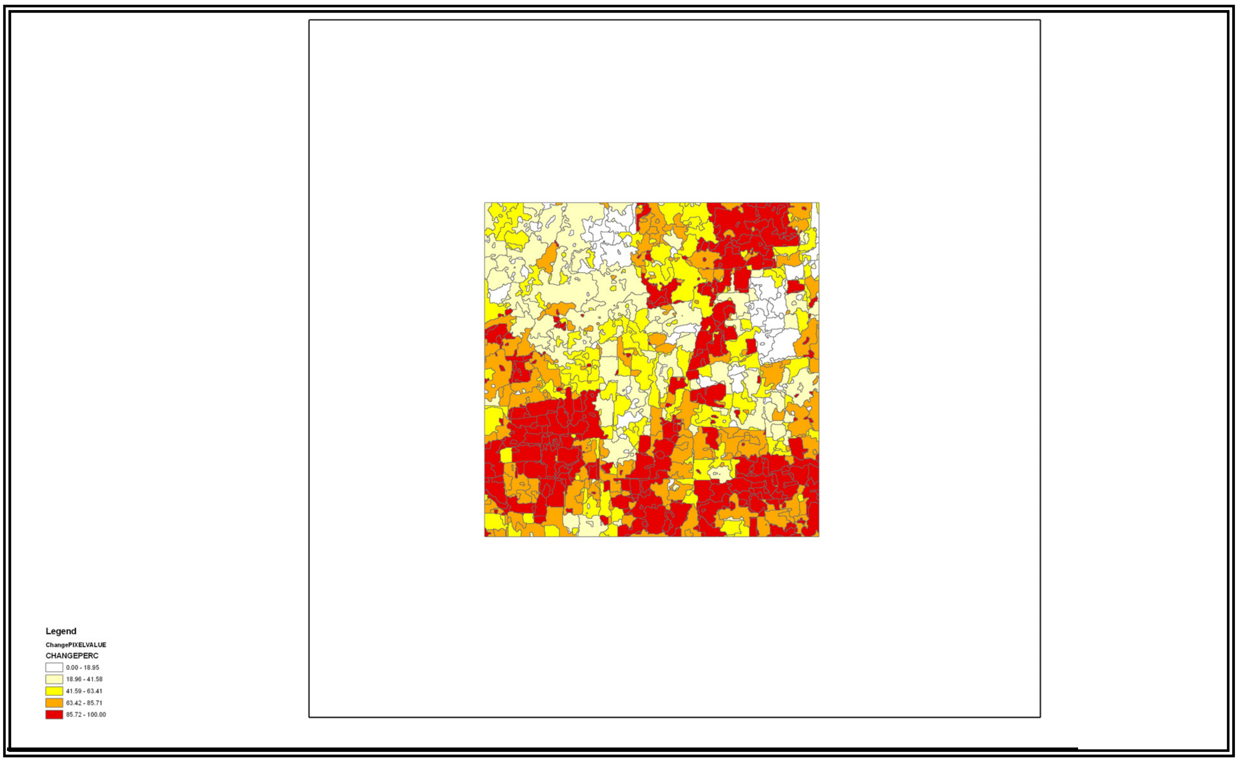


Fig19 – Pixel Value Change Detection output1 cell.

In the table 1, the results are summarized. Criteria adopted are expressed in a scale high, medium and low (H, M and L). The items are explained below.

Table 1

	M1 (square cells)	M2 (“wall-to-wall”)	M3 (dot grid)	M4 (OBCD)	M5 (pixel values)
Able to detect changes[1]	L	H	M	M-H	M-H
Comprehensive and replicable[2]	H	L	H	L	H
Accurate[3]	L	H	L	M	M
Time[4]	fast	long	fast	very fast	fast
Cost-effective[5]	H	M	L	M	L
Sustainable[6]	H	L	M	L	H
Flexible[7]	L	H	L-M	M	M
Comparable[8]	L	H	H	L	H

1 Depending on the user skill, but it refers mainly to the sensitivity of the method to detect changes.
2 The criteria refer to the capacity to learn and apply the new methodology by RS/GIS experts.
3 Ability to detect finer changes.
4 Time required to perform the work.
5 Costs are linked to software costs and man/days. Cost-effective is linked to the productivity. the parameters should indicate the balance between requested time and quality of result.
6 Methods and data outputs must be manageable by RS/GIS expert/not expert staff.
7 Result must be and useful for different applications.
8 Result can be used among years without massive re-mapping.

6. Conclusions and recommendations

1 Based on the image research undertaken for the project it can be concluded the following:

- Imagery from Landsat data is available free of charge for the area in the 2005 period but would need to be enhanced and processed to co- register with the previous imagery by a specialized organisation before it can be used for updating purpose.

- Complete coverage of CBERS Imagery from INPE is not yet available; the images available are downloaded and are now available in NRCE data repository. A request for new acquisitions has been sent but it may still take some time to acquire over Africa.

- Request for new acquisition of SPOT 4 imagery has been sent for the whole area and with varying image modes (i.e. some Panchromatic and some multi-spectral). Imagery from SPOT 4 will need to be systematically acquired in panchromatic and multi-spectral modes.

- Imagery from SPOT 4 in both Panchromatic and Colour modes will need to be merged (sharpened to 10m) geometrically corrected and if possible mosaiced to reduce the number of images to be handled; this can be done by the Egyptian ground station after acquisition has been completed under contract.

- Imagery from SPOT 5 is available from SPOT archive (date2006). Imagery form SPOT 4 is more cost efficient for the purposes of revision and closer to the overall budget of the project than SPOT 5. However, given the number of images careful selection it is critical to keep he cost down.

- Imagery from SPOT 4 can be acquired at lower cost via the Egyptian station than directly from central SPOT Image, processing costs are also less.

- Costs for processing typically includes only sharpening from SPOT IMAGE while from Egypt they include sharpening, geometric correction, mosaicing for designated areas and radiometric balancing across scenes to allow mosaicing.

- A more detailed assessment of the specific imagery to be acquired according to exact locations of the agricultural area needs to be undertaken prior to ordering of the SPOT 4 data if this imagery is accepted as the basis of the study.

- Landsat data should, in addition, be downloaded and used as a basis of non agricultural area analysis, additional image processing will be required to be coincident/adjacent with the SPOT 4 data.

2 About updating and upgrading the land cover database can be done the following considerations and recommendations:

- Africover data base has greatly reinforced national capacities for the establishment, update and use of land cover maps and spatial databases. However, to proceed toward a mapping approach valid also for statistical analysis, the effort must be made to create a more detailed and up dated. Considering budget, resources and time frame, it is strongly recommended to update the land cover database utilizing high resolution imagery. Depending on the budget availability SPOT 5 m resolution is an excellent solution to be used also for statistical analysis. However less expensive solutions options such as 10 meter resolution imagery can be adopted.

- Amongst a number of land cover classification systems such as Anderson classification, CORINE classification, and other the FAO-Land Cover Classification System LCCS is independent of the method or detail of the mapping being undertaken. It can be utilised to map land cover with any types of satellite products. For consistency and systematic results it is strongly recommended to use this FAO standard system for land cover classification.

- Derived product as Mechanized Index (MI) can be recalculated at more detailed scale, at sub-national administrative level; it is suggested to use a 0.5 km cell size. The result obtained in the Gedaref region can be validated using the large numbers of field ground truth data on hand and later extended to the other regions where no so many field data are available.

3 About change analysis methods to adopt:

- Change analysis can be undertaken using different methodologies as illustrated previously. The appropriate method is subject to resources, schedule and budget constrains.

- Initial results indicate that the best option in terms of quality of the final product is the “wall to wall’ interpretation methods. It produces detailed results with a full control of the change/modification land cover/agricultural units. However, it requires resources and it has a cost impacts as it is the most time consuming and the most expensive one. It is recommended to consider alternative methods mentioned earlier. The final methodology is subject to be decided based on availability of resources, schedule requirements and budget constrains.

- Dot Grid analysis using Madcat seems to an interesting alternative methodology that can be applied in large areas with the national experts as it is designed using LCCS complaint software and can handle change detection. The tool is still at its early stages and further enhancements are needed to have the tool operational.

- An alternative that required special attention is the fully or semi-automated procedure (pixel based values and/or OBCD). The methodology can be applied with some level of user control and it seem to require full supervision and detailed validation as often false changes are detected due to the seasonality changes and poor quality in imagery. The methodology is proven to yield enhanced results on high resolution imagery. It also has high requirements and depends on the quality of the source imagery. The methodology can be used if high resolution pre-processed imagery is available.

- Initial results indicate the acceptable results can be obtained by using the estimate of areas of changes and procurement of use of high quality imagery on the areas of medium to high rate of changes combined with semi-automated an interactive methodology and tools available at NRCE.

ANNEX I

List of Landsat 1994-98

Path	Row	Date	Path	Row	Date
170	047	08/10/1994	174	050	14/02/1997
170	048	29/06/1998	174	051	14/02/1997
170	056	28/01/1995	174	052	14/02/1997
171	045	16/07/1996	174	053	14/02/1997
171	046	16/07/1996	174	054	14/02/1997
171	047	16/07/1996	174	055	02/05/1996
171	048	16/07/1996	174	056	16/11/1998
171	049	16/07/1996	174	057	16/11/1998
171	050	16/07/1996	175	046	21/02/1997
171	051	08/01/1997	175	047	21/02/1997
171	052	28/02/1998	175	048	21/02/1997
171	053	13/01/1987	175	049	21/02/1997
171	054	28/02/1998	175	050	21/02/1997
171	055	20/02/1995	175	051	21/02/1997
171	056	04/02/1995	175	047	05/02/1997
171	057	30/01/1999	175	048	21/02/1997
172	045	31/03/1995	175	049	05/02/1997
172	046	31/03/1995	175	050	14/12/1994
172	047	27/10/1996	175	051	31/01/1995
172	048	27/10/1996	175	052	23/11/1998
172	049	27/10/1996	176	046	22/01/1995
172	050	27/10/1996	176	047	23/02/1995
172	051	27/10/1996	176	048	12/02/1997
172	052	17/03/1996	176	049	12/02/1997
172	053	13/01/1998	176	050	12/02/1997
172	054	18/01/1998	176	051	12/02/1997
172	055	04/12/1998	176	052	27/01/1997
172	056	03/02/1998	176	053	27/01/1997
172	057	17/01/1986	176	054	13/03/1996
173	046	28/06/1996	176	055	30/11/1998
173	047	28/06/1996	176	056	22/01/1995
173	048	28/06/1996	177	046	01/12/1996
173	049	28/06/1996	177	047	01/12/1996
173	050	27/05/1996	177	048	01/12/1996
173	051	27/05/1996	177	049	01/12/1996
173	052	11/05/1996	177	050	01/12/1996
173	053	07/02/1997	177	051	01/12/1996
173	054	06/01/1997	177	052	01/12/1996
173	055	07/01/1997	177	053	01/12/1996
173	056	27/05/1996	177	054	03/04/1995
173	057	18/02/1995	177	055	05/11/1998
174	046	14/02/1997	178	046	23/11/1999
174	047	14/02/1997	178	047	07/01/1996
174	048	14/02/1997	178	048	07/01/1996
174	049	14/02/1997	178	049	08/02/1998

178	050	08/02/1998
178	051	08/02/1998
178	052	16/02/1999
178	053	10/04/1995
178	054	16/02/1999
179	046	30/01/1996
179	047	30/01/1996
179	048	30/01/1996
179	049	30/01/1996
179	050	30/01/1996
179	051	07/10/1994
179	052	10/12/1994
180	050	19/02/1995
180	051	08/04/1995

ANNEX II

List of Landsat GLS5

Path	Row	Acquisition Date	Path	Row	Date
170	047	20/03/2005	175	045	26/03/2006
170	048	06/06/2006	175	047	19/02/2005
170	051	12/11/2004	175	048	22/02/2006
170	056	02/01/2006	175	049	22/02/2006
171	045	02/10/2005	175	050	18/11/2005
171	048	27/03/2005	175	051	17/10/2005
171	049	08/10/2006	175	056	18/11/2005
171	050	08/10/2006	175	057	18/11/2005
171	053	25/11/2006	176	045	02/04/2006
172	044	01/02/2006	176	047	14/03/2005
172	045	01/02/2006	176	048	14/03/2005
172	046	17/02/2006	176	050	25/11/2005
172	047	17/02/2006	176	052	24/10/2005
172	048	18/03/2005	176	053	09/11/2005
172	049	28/10/2005	176	045	02/04/2006
172	050	28/10/2005	177	045	09/04/2006
172	051	28/10/2005	177	046	09/04/2006
172	052	25/10/2004	177	047	24/03/2006
172	053	13/11/2005	177	048	05/03/2005
172	054	13/01/2005	177	049	05/03/2005
172	055	13/01/2005	177	050	19/11/2006
172	056	26/09/2005	177	052	31/08/2006
173	044	12/03/2006	177	054	18/10/2006
173	045	09/03/2005	178	045	28/03/2005
173	046	09/03/2005	178	046	28/03/2005
173	047	10/04/2005	178	047	16/04/2006
173	048	08/02/2006	178	048	13/04/2005
173	049	08/02/2006	178	049	13/04/2005
173	051	06/10/2006	178	050	22/10/2005
173	052	06/10/2006	178	051	22/10/2005
173	053	06/12/2005	178	052	07/11/2005
173	057	15/07/2005	178	053	10/11/2006
173	057	06/10/2006	178	054	07/11/2005
174	045	16/03/2005	179	045	22/03/2006
174	046	17/04/2005	179	047	07/04/2006
174	047	17/04/2005	179	048	07/04/2006
174	048	12/02/2005	179	049	29/10/2005
174	049	15/02/2006	179	050	29/10/2005
174	050	16/12/2006	179	052	01/11/2006
174	051	26/10/2005	179	053	14/11/2005
174	052	13/10/2006	180	050	07/10/2006
174	053	13/10/2006	180	051	04/10/2005
174	054	13/10/2006			
174	055	13/10/2006			
174	056	10/10/2005			

ANNEX III

List of CBERS imagery

N.	Path	Row	Acquisition Date
1	91	84	26-05-2008
2	91	85	26-05-2008
3	91	86	26-05-2008
4	90	84	29-05-2008
5	90	85	29-05-2008
6	90	86	29-05-2008
7	90	89	29-05-2008
8	90	90	29-05-2008
9	89	84	01-06-2008
10	89	85	01-06-2008
11	89	86	01-06-2008
12	89	87	01-06-2008
13	88	83	04-06-2008
14	88	84	04-06-2008
15	88	85	04-06-2008
16	88	86	04-06-2008
17	88	87	04-06-2008
18	88	88	04-06-2008
19	88	89	04-06-2008
20	88	90	04-06-2008
21	86	88	06-07-2008
22	86	89	06-07-2008
23	86	90	06-07-2008
24	85	77	21-10-2008
25	85	78	21-10-2008
26	85	79	21-10-2008
27	85	80	21-10-2008
28	85	81	21-10-2008
29	85	82	21-10-2008
30	85	83	21-10-2008
31	85	84	21-10-2008
32	85	85	21-10-2008
33	85	86	21-10-2008
34	85	87	21-10-2008
35	85	88	21-10-2008
36	85	89	21-10-2008
37	85	90	21-10-2008
38	85	91	21-10-2008

ANNEX VI - Price list

FINAL TABLE Cental-South Sudan SPOT imagery research
AOI total extension about 850. 000 Km^2 covering South-Central Sudan cultivated area

ARCHIVED IMAGERY				
Item AOI Central-South Level 2A, full image, 2006	**NOTES**	**Unit Cost (€)**	**Quantity**	**Total (€)**
Spot 5 5mC (Spot Image) *		5,400	308	**1.663.200**
Spot 4 10 m BW (Spot Image)*	Available in the same SPOT acquisition centres	2,700		
Spot 4 20 m C (Spot Image)* * for both, processing included			308	**831.600**
PROGRAMMED IMAGERY				
Item AOI Central-South Level 2A, full image		**Unit Cost (€)**	**Quantity**	**Total (€)**
Spot 5 5mC (Can be programmed - Spot Image)		6,200	330	**2.046.000**
Spot 4 10 m BW (Programmed NO Commitment - Ground Station Egypt)**		1,900		
Spot 4 20 m C (Programmed NO Commitment - Ground Station Egypt)**	Processing includes:		330	627.000
plus Processing 40%	1 2			250.800
Total	3			**877.800**
Spot 4 10 m BW (Can be programmed - Spot Image)	Processing includes:	3,500		
Spot 4 20 m C (Can be programmed – Spot Image)	1		330	**1.155.000**

C = colour BW=panchromatic
** ongoing
Processing includes the following:
1 data fusion (pansharpening)
2 geometric correction (Level 2A products rectified in a standard projection (UTM WGS 84)
3. mosaiking (output format Geotiff)

Landsat GLS5	Resolution 30 m	free of charge	86 images available from USGS
Landsat 1994-98	Resolution 30 m	available in NRCE	114 image available from NRCE
CBERS imagery	Resolution 20 m	free of charge	38 available now (sent request for total coverage)

REFERENCES

[1] LCCS – Land Cover Classification system, Classification concepts and user manual. Software version 2. Nov. 2004. Cooperazione Italiana, UNEP and FAO.

[2] Africover**:** **http://www.africover.org/**

[3] USGS**:** **http://landsat.usgs.gov/index.php**

[4] IMPE/CBERS: **http://www.cbers.inpe.br/en/index_en.htm**

[5] SPOT: **http://www.spotimage.fr/web/en/167-satellite-image-spot-formosat-2-kompsat-2-radar.php?countryCode=IT&languageCode=en**