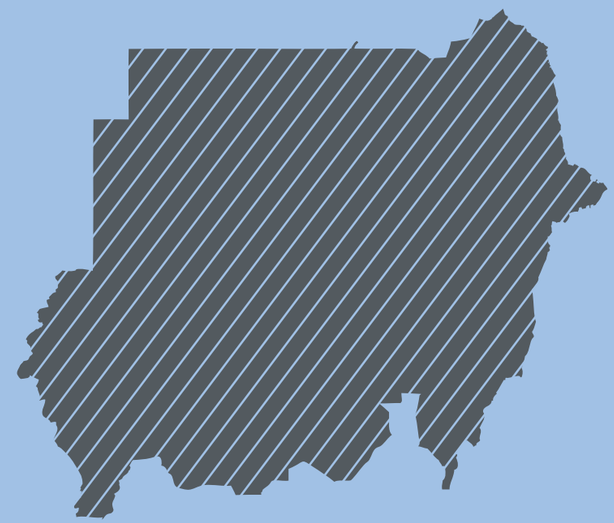
The Land Cover Atlas of *Sudan*



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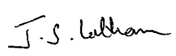

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PARTNER ORGANIZATIONS

The Sudan Institutional Capacity Program: Food Security Information for Action (SIFSIA) aims at strengthening human, physical and institutional capacity in analyzing, designing, monitoring and evaluating food security policies and programs. SIFSIA, with the objective of building sustainable food security in Sudan, achieves several outputs, including strengthening the natural resource management information system. Land cover is a key variable in assessing and monitoring natural resources at national, regional and global scale. SIFSIA is a Government of Sudan program funded by the European Commission and implemented by the Food and Agriculture Organization of the UN (FAO).

With a strong technical leadership from Natural Resources and Environment, Land and Water division of FAO (FAO-NRL), the project developed a strong national capacity for future Landcover update and similar initiatives. The land cover module, an important part of SIFSIA initiative, was implemented by NRL geospatial unit in collaboration with the GLCN group based in Florence (Italy). The Remote Sensing Authority (RSA), the Forests National Corporation (FNC) and the Ministry of Agriculture's Food Security Technical Secretariat (FSTS) are the major implementing partners. More than 20 Government experts trained in practical use of FAO's Land Cover Classification System (LCCS); satellite image interpretation of SPOT and Landsat imagery through FAO's tool box for land cover mapping plus google-earth and field verification. Experts have already developed an LCCS legend and database for Sudan. The production of the updated land cover database is an important task for the SIFSIA project. The current database, which heavily relies on high resolution images from 2010, updates the existing AFRICOVER database (dated 1999-2000). The database also uses a combination of other high and medium resolution satellite data and locally collected data (2006 – 2010).

Main Outputs

- → Production of a detailed and harmonized national land cover database using remote sensing products and automatic segmentation;
- → Support the national capacity to produce the land cover database and more in general to manage remote sensing data and related issues;
- → Present the GLCN methodology, tools and software for mapping and fieldwork activities;
- → Show the benefits and the importance of a reliable, detailed and updated land cover data for a national cartographic information system;
- → Involve national experts in the different steps of the national mapping production chain to be able to replicate in other mapping projects.

FAO-NRL has completed a new land cover of Sudan with the technical input of the Global Land Cover Network (GLCN) under the SIFSIA project (the Food Security Technical Secretariat of the Ministry of Agriculture and Irrigation) and the Remote Sensing Authority (RSA) of the National Research Centre of the Ministry of Science and Technology.

SIFSIA has established a framework for the development of land cover products for Sudan. Many applications require detailed, updated, reliable and accurate land cover information to support environmental modelling and evaluate ecosystem and landscape dynamics. In particular in the field of agriculture, a reliable inventory of land cover supports improved statistical design and accuracy of reporting. The dataset will form a basis for a new comprehensive agricultural census methodology for crop production estimation and it will improve the assessment of food security. The Ministry of Environment will receive support in the management and monitoring of the status of natural resources including woody biomass. The Ministry of Animal Resources, Fisheries and Rangelands will be supported in the management of the natural resources for livestock production. The Land Commission will benefit from the monitoring of the distribution of agricultural land, etc.

UNEP (United Nation Environmental Program) supported the part concerning the implementation of the interpretation exercise, the training and workshops as well some trans-boundary activities for the harmonization of the final database. The International Fund for Agriculture Development (IFAD) and the Global Monitoring for Food Security (GMFS) have also allowed the project to access their high resolution images in Kordofan.

FOREWORD

The major part of Sudan is mainly desert with few agricultural areas mainly concentrated along the rivers; in contrast, in the central part (from eastern Darfur to Gedaref State) agricultural crops are the main cover types. Agriculture is the main source of non-oil contributions to the GDP, ahead of services and construction and much ahead of industry. Across the country the terrain and climate vary widely, with zones of desert, and mountain ranges.

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. Several socio-economic, technical, managerial and institutional constraints affect the attainment of sustainable development within the agricultural sector. Any accurate analyses of the different elements that influence food security and economic development need to be based on reliable indicators of small-holder and commercial agriculture, including natural resources management. Alternative patterns of growth in the agricultural sector are urgently required to address the renewed importance attached to the agricultural sector and the changing circumstances connecting to land availability, rainfed systems, livestock movement and long-term investment. The formulation of sound policies requires reliable information and accurate agricultural statistics.

Therefore, an updated and detailed land cover was strongly suggested in various FAO based reports and several months of consultancies were spent to prepare the necessary background and dataset to carry out the mapping activity. In addition, an accurate selection of the most appropriate satellite products for land cover interpretation purpose was performed.

The Africover project first, and the GLCN group afterwards were designed to address the lack of reliable information on land cover and its changes in Africa. Such information is an essential requirement for sustainable management of land and water resources, disaster preparedness, impact assessment and damage mitigation, planning sustainable agricultural development, and providing the national and regional early warning systems on food security with baseline information on land cover status and its changes. Continuing high rate of population growth in most African countries, combined with impacts of climate change, result in land cover changes such as land degradation, depletion of fresh water resources, and deforestation, with profound societal consequences. Adoption of new strategies for rural land use planning and land management is urgently required to reduce hunger and poverty among rural population of African countries and to assure sustainable food and feed production for future generations. The availability of reliable information on the current status of land cover and its changes is indispensable to development and implementation of such strategies.

There is also a need for reliable land cover information at the global and regional levels for implementation of the UN Millennium Development Goals, the UN environmental conventions, the recommendations by the UNCED Agenda 21 and the WSSD Plan of Implementation.

The United Nations environmental summits recommended that closing the information gap between industrialized and developing countries should become one of the development priorities. They further recommended increased effort for capacity building in the use of advanced geo-information technologies of remote sensing, geographic information systems and global positioning systems for updating inventories of natural resources in developing countries.

FAO–NRL in particular, has been one of the earliest users of advanced geo-information technologies in its agricultural, forestry and water resources projects in developing countries. Moreover, a significant contribution can be made through training courses developing the local capacity in producing, undertaking, maintaining, archiving and disseminating land cover data and preparing information products for decision making.

ABSTRACT

The Land Cover Atlas of Sudan provides information on the land cover distribution by administrative divisions. The dataset has been created using the FAO/GLCN methodology and tools. Main data sources include high resolution satellite imagery from SPOT, Landsat, IRS (Indian Satellite), Aster, existing Africover land cover database and ancillary data.

The legend was prepared using the Land Cover Classification System (LCCS): a comprehensive, standardized a priori classification system, designed to meet specific user requirements and created for mapping exercises, independent of the scale or means used to map. The classification uses a set of independent diagnostic criteria that allows the correlation with existing classifications and legends.

Satellite images of Sudan were segmented into homogeneous polygons and they were interpreted according to the FAO/GLCN methodology for the production of a seamless and detailed land cover dataset for the whole country. Field verification was completed by national experts who received a customized training on methodology and tools.

The final land cover product has around 490,000 polygons, classified into 83 different classes and eventually aggregated into 7 major classes for ease of analysis and display.

The Land Cover Atlas is organized into two main sections: country and states. Each section provides information on the distribution of aggregated land cover as map and table. These products provide the user with valuable information on the availability and distribution of land resources through a multi-faceted approach.

ACKNOWLEDGEMENTS

The publication of the Land Cover Atlas of Sudan is the result of the outstanding efforts of many institutions and individuals working in close partnership. The following paragraphs attempt to acknowledge everyone who supported and contributed to this atlas.

The Land Cover Atlas of Sudan was made possible by the contributions (financial and in-kind) of the partner organizations involved in the SIFSIA programme: the Government of Sudan, the Food and Agriculture Organization of the United Nations (FAO) and the European Union (EU), which funds the SIFSIA Programme.

This activity was implemented in collaboration with the Food Security Technical Secretariat of the Ministry of Agriculture and Irrigation (MoAI), the Remote Sensing Authority (RSA) of the Ministry of Science and Technology, the Forests National Corporation (FNC) of the Ministry of Environment and other relevant stakeholders in Sudan.

We acknowledge also the cooperation of the following institutions and experts for their support in the process of the update of the Sudan Land Cover (image interpretation and classification, field verification, dissemination and uptake): Alemu Asfaw (Chief Technical Advisor, FAO-SIFSIA Programme in Sudan), Sadig Elamin and Sara Elsafi (FAO-SIFSIA Information Systems & Capacity Building Specialists), Dr. Amna Ahmed Hamid, Remote Sensing Authority (Chief Remote Sensing Authority, RSA), Mohammed Osman M. Elhassan (RSA), the effort of the photo-interpreters group and of the fieldwork team (from RSA and Forestry National Corporation (FNC) that undertook field validation activities travelling extensively under difficult circumstances in the most remote areas of East Sudan.

Thanks also to the Global Monitoring for Food Security (GMFS), EFTAS Remote Sensing Transfer of Technology GmbH and the International Fund for Agricultural Development who generously allowed access to their high resolution imageries.

Image processing, photo-interpretation, database creation, map production: John Latham, Renato Cumani, Ilaria Rosati, Luigi Simeone, Giulio Marchi, Antonio Di Gregorio, Paola Codipietro, Daniela Mattina, Saverio Stoppioni, Rosanna Padelletti, Lorenzo Vita. The contribution of all of the above, along with input from many other unnamed people has been vital for the success of this project. Assistance in preparing the atlas for publication was received from Ane Louise Gaudert (graphic design) Luigi Simeone.

The entire landcover update would have been very difficult, if not impossible, without the strong coordination role of John Latham.

LIST OF ACRONYMS

ADG	Advanced Database Gateway
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
CAPES	Crop Agricultural Production Estimation System
CSA	Central Statistics Authority
DPKO	Department for Peacekeeping Operation
EC	European Community
EFTAS	Remote Sensing Transfer of Technology
ESA	European Space Agency
ETM	Enhanced Thematic Mapper
FAO	Food and agricultural Organization of United Nations
FNC	Forest National Corporation
GeoVIS	Geographical Vector Interpretation System
GLCN	Global Land Cover Mapping
GLC	Global Land Cover
GPS	Global Positioning System
GMFS	Global Monitoring for Food Security
HAC	Humanitarian Aid Commission
IAO	Istituto Agronomico per l'Oltremare
IRS	Indian Remote sensing Satellite
LCCS	Land Cover Classification System
LRIMS	Land Resources Information Management System
MAD-CAT	Mapping Device–Change Analysis Tool
MAP	Mapping Accuracy Program
MMU	Minimum Mapping Unit
MoA	Ministry of Agriculture
NRL	Natural Resources Land and Water Division
RHAP	Regional Harmonization Programme
RSA	Remote Sensing Authority
SIFSIA	Sudan Institutional Capacity Programme : Food Security Information for Action
SPOT	Satellite Pour l' Observation de la Terre
TCEO	Technical Cooperation Dept. Emergency Operation
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDPKO	United Nations Department for Peacekeeping Operations
UNEP	United Nations Environmental Programme
UNLB	United Nations Logistic Base
UTM	Universal Transverse of Mercator
USGS	United States Geological Survey
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping
WSSD	World Summit on Sustainable Development

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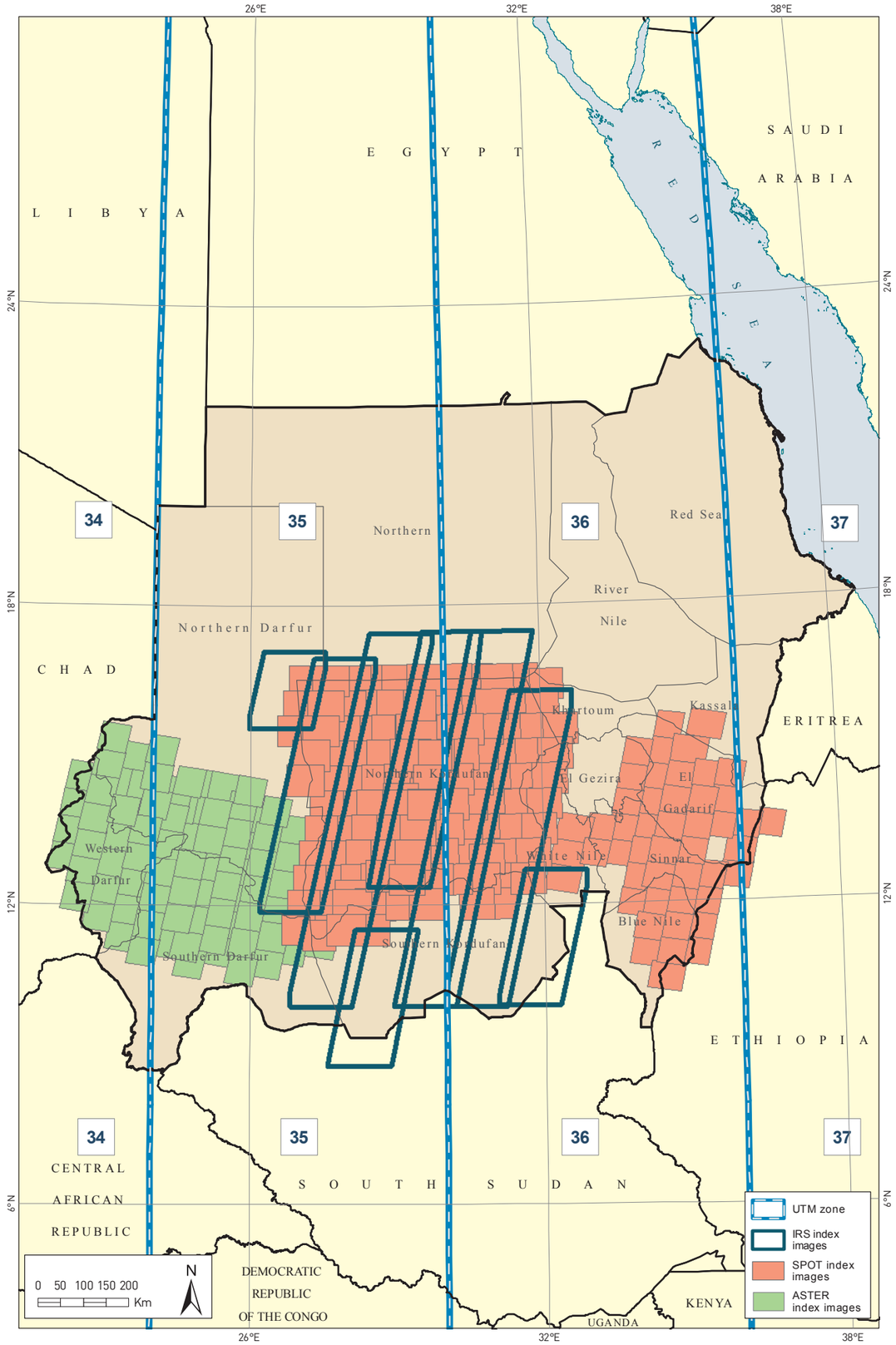


Figure 2 - GLS Landsat and ASTER images index

INTRODUCTION

Management practices need detailed, reliable and up-to-date information on the status of the land, most often obtained from land cover maps, as well as information on changes of inland cover over time, depicting eventual trends in land conversions. Developing countries are usually most affected by the lack of assessment data and monitoring tools, making their future management decisions more difficult. FAO is heavily involved in the development of tools for supporting countries in the assessment of land cover and monitoring it over time. Starting from the development of technical tools for land cover mapping and change assessment, to the standardization of procedures for land cover classification and analyses, FAO's work represents a significant contribution to the development of tools that provide essential land cover data needed for management purposes.

In the framework of SIFSIA, FAO is assisting the national institutions of Government of Sudan to undertake assessment of land resources using FAO methodology and tools.

The activities for the creation of the land cover dataset consisted in four main phases: i) image interpretation and classification; ii) field verification; iii) data harmonization and finalization; and iv) capacity building, including dissemination of results and training.

The main objective was the preparation of an accurate, up-to-date land cover dataset of Sudan in order to allow effective and focused decision making about rehabilitation activities and development planning, especially for the country's environment and agricultural sector.

The dataset provides up-to-date and reliable information on land cover distribution in Sudan needed for sustainable land management. Methodology, tools, definitions, data sources, legend, maps and statistics are provided in the following chapters.

Chapter 2 describes the methodology used for the creation of an integrated imagery coverage based on existing land cover products to extract agricultural areas.

Chapter 3 provides information on the land cover legend derived from LCCS and details on the major "Primarily Vegetated Areas" and "Primarily Non-Vegetated Areas".

Chapter 4 describes the steps followed to create the final database.

Chapter 5 lists the full resolution land cover classes and their aggregations.

Chapter 6 includes all the land cover maps and statistics by country, and states. All the maps included in the atlas are prepared in UTM 36 N projection (WGS 84). Administrative divisions are provided by the Sudan National Survey Authority.

Figure 3 - Field validation points

METHODOLOGY

The methodology implemented for the creation of the land cover database is based on the FAO/GLCN approach. The major steps of the compilation of the database include creation of an integrated imagery coverage, image processing and interpretation, validation of the interpretation. FAO/GLCN toolbox[1] is used to implement the methodology.

The GLCN mapping approach is a multifaceted procedure derived by the decadal experience in building up detailed national databases of natural resources. It can be considered a dynamic process that evolves and develops continuously in a constant balance of theoretical and technical aspects derived from the remote sensing and GIS technologies.

2.1. Integrated imagery coverage

The Sudan land cover mapping is carried out with the interpretation of an integrated coverage of Landsat satellite images and updated higher resolution SPOT, IRS (Indian satellite) and Aster images. This approach is adopted to improve the accuracy of the interpretation and to emphasize the land cover features in the agricultural production areas, starting from the existing Africover Sudan data base dated circa 2002.

2.1.1 SATELLITE DATA ACQUISITION AND PRE-PROCESSING

The selection of the appropriate data sources are a fundamental step. The interpretation is based on the possibility to discriminate features in the image. Therefore, the accurate selection of the data source, keeping in mind the final mapping purpose, is a critical step of the overall landcover update process.

Landsat imagery (pixel resolution 30 m dated 2005-2010). FAO-NRL has provided the complete coverage. A complete review of the availability of LANDSAT imagery dataset in the NRL repository was checked and updated - images were download from the UGSS website and the band composite (432) appropriate for land cover prepared (see figure 2 for Landsat coverage).

- Northern State Landsat coverage was used for the interpretation of Northern part of Sudan.

SPOT imagery new acquisitions (pixel resolution 20 m dated 2009-2010). The high resolution SPOT coverage was considered for the central area where the most agricultural activities are concentrated and a good discrimination of the features were required. The data set available are the following:

- Kordofan SPOT coverage was provided by GMFS project (Global Monitoring for Food Security) ESA project.
- Eastern part of the country. Acquisition of 50 SPOT from Egypt Ground Station.

SPOT imagery existing dataset on site (Spot images pixel resolution 5 - 2.5 -10 - 20 m) were available from UNLB for some sites in the central area and along the North-South border. All the indexes of the available SPOT coverage are shown in figure 3.

IRS imagery (23 m pixel resolution dated 2007) The Indian satellite dataset were available in the RSA (Remote Sensing Authority) in Khartoum. It was very useful to cover the southern part of the Kordofan where the GMFS spot coverage was missing and only the Landsat imagery was available; a rapid assessment of IRS data was conducted using the Landsat imagery. The assessment was done in Rome and it found that IRS imagery has an irregular shift versus Landsat pixels. The shift and rotation appears to be randomly distributed. Based on these findings it was recommended that the IRS images were rectified using image-to-image rectification procedures. The processing was run in FAO-HQ and the correct geo-referenced data set delivered to Khartoum for interpretation; the resolution accuracy of the final dataset is about 1-2 pixels (see figure 4 for IRS coverage).

Aster dataset (pixel resolution 15 m) - For the Darfur central area, a separate project was carried out. For it, a selection from archive of ASTER images from ERSDAC was considered and carried out in Rome. At the beginning of July, 2011, the complete coverage was available in FAO and IAO. (See Figure 5 for IRS coverage). The mapping in this area was carried out with the help of this dataset.

2.1.2 QUALITY CONTROL / IMAGES REPLACEMENT

The acquisitions are analysed and the quality of images are assessed for eventual replacements. The accuracy of the geometric correction and the cloud coverage is checked to evaluate whether the data meets the quality requirements needed for the interpretation or not.

2.2. IMAGE PROCESSING AND INTERPRETATION

2.2.1 SEGMENTATION OF DATA

The recent developed technique allows for automatically generating very detailed layer of polygons in short time eliminating the interpreter subjectivity and increasing the cost/benefit efficiency. Image segmentation is based on a region-merging technique of the divisions of the image into spatially continuous and spectrally homogeneous regions or objects. The segmentation produces a vector layer of objects that represent regions with similar pixel values with respect to some characteristic or computed property such as color, intensity or texture. Different segmentation parameters are applied to the two types of imagery due to their diverse spatial ground resolutions and spectral characteristics. The testing procedure is a fundamental step to find the optimal calibration of segmentation parameters that produce an accurate balance between the total number of polygons and detail required in delineating the land cover features and it is important to reach a good compromise between level of detail and number of polygons. The segmentation of the study area is a work that can be executed in the FAO-GLCN topic centre or in country depending on software availability and there are different commercial software that can be utilised for this purpose.

The visual interpretation and labelling of the polygons is the next step that is carried out during the interpretation exercise. The Africover Sudan database was used as a source during the interpretation process and the existing Africover labels are assigned to each polygon of the vector

layer. This information is very useful particularly for natural vegetation.

2.2.2. TRAINING AND CAPACITY BUILDING ON-SITE

As explained before, capacity building is one of the pillars of GLCN approach. The involvement of national specialists in the mapping activity is fully considered in any GLCN work plan, the percentage varying according to specific local conditions and level of specialization of the experts. To do so, national experts are exposed for at least two or three weeks to the basic concepts and principles of GLCN methodology; after that, they receive a full immersion course on the practical aspects of the mapping, using remote sensing imagery. As a result, they are immediately able to use the software and tools dedicated with a low rate of production at the beginning that increase rapidly during the first months of work. This was done effectively in the Sudan Landcover update exercise. The training course gives several benefits in cascade: first, the participation from the local governmental institutions, through their experts, in the mapping process renders proper recognition that the final database as part of the national effort. Then, the trainers will contribute directly to the creation of the database with the detailed information that can come only from an intimate knowledge of the territory and local conditions. Moreover, the work will reinforce their background in remote sensing and GIS, their interpretation capabilities and the capacity to perform further applications using the same methodologies and tools. Finally, the international GLCN standard approach will be part of the knowledge of the country.

2.2.3 PHOTO-INTERPRETATION ACTIVITY

The photo-interpretation procedure uses satellite imagery, land cover legend based on LCCS, existing land cover products, photo-keys and tools. Mapping Device Change Analysis Tools (MAD-CAT) software developed by FAO is used for the photo-interpretation.

The interpretation follows a precise procedure with a standard sequence of operations. The first phase is the preliminary interpretation, when the interpreter studies the image and all the available data and assigns a land cover label to each object. The Minimum Mapping Unit (MMU) used in the interpretation phase is 2 ha.

The photo-interpreters must have deep knowledge and capacity in the fields of:

1. remote sensing data processing,
2. vector data management,
3. interpretation software tools management,
4. ability to discriminate different land cover types and knowledge of the area.

It is, in fact, a complex and heavy work because it implies the control of huge amount of polygons (from 40,000 to 100.000 per Landsat scene), the recognition in the scenes of land units and /or complex association of land cover types which required a consistent labelling work into broad thematic categories.

Next, a subset of areas is selected and ground checked with a systematic fieldwork campaign. This procedure gives the possibility to minimize the interpretation errors and to improve the level of detail and the quality of the final output.

The final phase is the correction of interpretation errors and the harmonization of the land cover dataset, with the validation of the interpretation.

2.3 Validation

GLCN has strongly supported the phase of validation of the interpretation in the ground for different reasons:
-enhance the reliability of the database
-minimize the interpretation errors
-improve the knowledge of the interpreters in remote sensing interpretation, recognizing the detectable features visible in the image in the ground.

In addition, the team improves their ability to use GPS, camera, the orientation ability in the ground using cartographic points, the standard GLCN procedure in filling the field form. At the end, the field information and the pictures can be linked with geographic coordinates to the database and/or in Google Earth and became a valuable dataset for any further applications.

The fieldwork is conducted by national experts with supervision and guidance from FAO/GLCN experts using the standardized field survey form and methodology. During the preliminary interpretation, the areas to survey are selected on the image, and the points of interest are identified; the field truths are later generalized to the areas having a similar reflectance. For each selected point, the land cover types and the coordinates have to be recorded. The areas and point coordinates are acquired and uploaded into the GPS, and each group prepares a daily schedule and route of points to survey.

Survey points, photos and field observations are collected during the surveys for the final revision of the land cover dataset. Remote sensing techniques combined with in situ measurements enabled to generate reliable and efficient information. The contribution of national experts is crucial to address issues of remoteness, security or accessibility.

2.3.1 HARMONIZATION AND FINAL GENERATION OF THE LAND COVER DATABASE

The interpretation module carried out with limited numbers of international experienced experts or, in the interested country, with several local experts. In any case, at the end, the final review is a crucial step for its consolidation. The harmonization work must generate a consistent land cover model of the area minimizing the differences coming from the subjectivities of the different interpreters. In addition, the technical and semantic aspects must be checked with attention. The final database must have a correct topology (the correct geometric arrangement of point, line, and polygon features), a correct arrangement of the attribute's table, a continuous labelling along the images'edges and a consistent labelling. To correctly generate such database, GLCN has developed several standard procedures that required skilled experts.

LEGEND

The legends are the keys for the database. All the information included in the database is explicitly stated in the legend. The LCCS is the classification system developed by GLCN to systematically describe the cover. It has been tested in different geographic places around the world and it will be approved and recognised as ISO standard (LCCS v3). This gives explanation about the importance for a nation to adopt activity the GLCN standard international approach for their mapping exercises. The set up of the first drafted version of the legend can easily be achieved by the experienced international remote sensing experts. However, detailed information about the local aspect of the cover that enriched the legend information comes only in collaboration with national experts during the different phases of the interpretation. Nevertheless, the final national legend prepared using FAO Land Cover Classification System (LCCS) will be an output compatible with similar LCCS-derived products around the globe.

The legend classes can also be integrated with photo keys. The preparation of an exhaustive table that documents all the aspects of the land cover units (photo characteristics and aspect in the ground) is an important stage, because both the different peculiarities (texture, tone, color and reflectance) of the land cover units present in the images can be widely clarified before the start-up of the interpretation exercise and this analysis will give the same interpretation keys to all the interpreters, helping the harmonization process. Very often, the interpretation unit consists of several experts. To avoid the creation of a fragmented and inconsistent interpretation, a common effort on photo-keys definition is strongly recommended at the beginning of the mapping exercise. For this, several images of the area as well as some spots in Google Earth must be examined, extracted and discussed in order to reach and agree on similar interpretation of the land cover types.

At the start-up of the Darfur mapping module, the former South Sudan legend was re-elaborated and a new preliminary version compatible with the Darfur land cover classes were prepared. During the training course in Khartoum in 2011, the existing legends, Africover, Darfur and South Sudan, were showed to the participants for their approval and modifications (if required); the classes were then widely discussed and properly adapted to the rest of the country in collaboration with the participants and the RSA technical staff, which take advantages from their knowledge and familiarity with the area. Finally, the preliminary version (in mbd extension) was ready to be imported in MADCAT software and used during the interpretation exercise.

There are slight differences in the land cover classes between Sudan and South Sudan that are explained by the different phases and mapping project carried out in the area. However, a final version of the legend (Darfur, South Sudan and Sudan) was generated with 83 land cover classes. The main classes of the legend are described in the next paragraphs.:

3.1 Primarily Vegetated Areas

3.1.1 Natural and Semi-Natural Vegetation (A12)

Natural vegetated areas are defined as areas where the vegetative cover is in balance with the abiotic and biotic forces of its biotope. Semi-natural vegetation is defined as vegetation not planted by humans but influenced by human actions. These may result from grazing, possibly overgrazing the natural phyto-censes, or else from practices such as selective logging in a natural forest whereby the floristic composition has been changed. Previously cultivated areas that have been abandoned and where vegetation is regenerating are also included. This classifier is "Primarily vegetated Terrestrial Artificiality of Cover: (Semi-) natural" (LCCS, 2005).

Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation (A24)

This class describes areas that are transitional between pure terrestrial and aquatic systems and where the water table is usually at or near the surface or the land is covered by shallow water. The predominant vegetation, at least periodically, comprises hydrophytes. Marshes, swamps, bogs or flats where drastic fluctuations in water level or high concentration of salts may prevent the growth of hydrophytes are all part of this class. The vegetative cover is significantly influenced by water and dependent on flooding (e.g. mangroves, marshes, swamps and aquatic beds). Natural Vegetated Aquatic habitats are defined as biotopes where the vegetative cover is in balance with the influence of biotic and abiotic forces. Semi-Natural Aquatic vegetation is defined as vegetation that is not planted by humans but which is influenced directly by human activities that are undertaken for other, unrelated purposes. This classifier is "Primarily vegetated Aquatic or Regularly Flooded Artificiality of Cover: (Semi-) natural" (LCCS, 2005).

Cultivated and Managed Terrestrial Areas (A11)

This class is "Primarily vegetated Terrestrial Artificiality of Cover: Artificial/managed". It refers to areas where the natural vegetation has been removed or modified and replaced by other types of vegetative cover of anthropogenic origin. This vegetation is artificial and requires human activities to maintain it in the long term. In between the human activities, or before starting crop cultivation, the surface can be temporarily without vegetative cover. All vegetation that is planted or cultivated with intent to harvest is included in this class (LCCS, 2005). This class is concentrated on the north coast and other scattered small areas.

Cultivated Aquatic or Regularly Flooded Areas (A23)

This class includes areas where an aquatic crop is purposely planted, cultivated and harvested, and which is standing in water over extensive periods during its cultivation period. In general, it is the emerging part of the plant that is fully or partly harvested (LCCS, 2005).

Primarily Non-Vegetated Areas

Artificial Surfaces and Associated Areas (B15). This class describes areas that have an artificial cover as a result of human activities, such as construction (cities, towns and transportation), extraction (open

mines and quarries) or waste disposal. The classifier is “Primarily non-vegetated Terrestrial Artificiality of Cover: Artificial/managed” (LCCS, 2005).

Bare Areas (B16)

This class describes areas that do not have an artificial cover as a result of human activities. These areas include areas with less than 4% vegetative cover. Included are bare rock areas, sands and deserts. This classifier is: “Primarily non-vegetated Terrestrial Artificiality of Cover: (Semi) natural” (LCCS, 2005).

Artificial - Natural Water bodies, Snow and Ice (B27 and B28)

This class refers to areas that are naturally covered by water, such as lakes, rivers, snow or ice. In the case of rivers, the lack of vegetation cover is often due to high flow rates and/or steep banks. In the case of lakes, their geological origin affects the life conditions for aquatic vegetation. The classifier is “Primarily non vegetated Aquatic or Regularly Flooded Artificiality of Cover: (Semi-) natural” (LCCS, 2005).

DATABASE COMPILATION

Following the completion of the land cover interpretation, the resulting dataset was spatially verified and harmonized. Procedures for edge matching and topology control were applied in order to check and to adjust for bordering polygons, small polygons, overlaps or gaps, etc. It is a very comprehensive and complete database with almost 500,000 polygons and 83 LCCS land cover single classes; it represents a reliable model of the land cover in the country. After more than 8 months of interpretation activity carried out by more than 30 interpreters, it was finalised in circa 3 months after an intense work performed by a restricted group of 4 international experts. Using high resolution images and segmentation procedure, the detail achieved is very high. In addition, the MMU was fixed to 1 ha with a remarkable implication in terms of number of polygons in the final output. Therefore, for a fast visualization and manageable database, it was decided to create full resolution databases at the states level and one aggregate layer at the country level compatible and consistent with the South Sudan database.

AGGREGATION

The 83 original land cover classes were aggregated into 7 generalized and simple classes. The result is an aggregation which keeps a good level of information though providing a quick estimate of the different land cover typologies in both Sudan and South Sudan.

The following table describes the aggregation of the main classes into 7 aggregated classes:

1. Agriculture in terrestrial and aquatic/regularly flooded land (AG)
2. Trees closed to very open in terrestrial and aquatic/regularly flooded land (TCO)
3. Shrubs closed to sparse in terrestrial and aquatic/regularly flooded land (SCO)
4. Herbaceous closed to sparse in terrestrial and aquatic/regularly flooded land (HCO)
5. Urban areas (URB)
6. Bare Rocks and Soil and/or Other Unconsolidated Material(s) (BS)
7. Seasonal/perennial, natural/(artificial) Water bodies (WAT)

The final database will be displayed using this aggregated field; all the detailed information are linked to the polygons in the attribute table and therefore can be extracted when and if necessary.

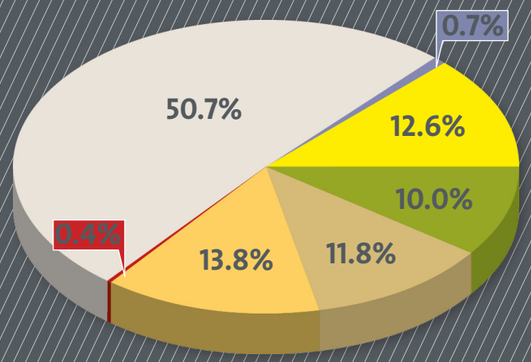
LAND COVER CLASSES

LCCS CODE	LCCS LABEL	AGG[1]
1HM-is	Scattered Isolated Field(s) Of Rainfed Herbaceous Crop(s)	AG
1Hs-is	Scattered Isolated Small Sized Field(s) Of Rainfed Herbaceous Crop(s)	AG
1SHs-is	Scattered Isolated Small Sized Field(s) Of Rainfed Shrub Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop With Simultaneous Period)	AG
1HL	Rainfed Herbaceous Crop(s)	AG
1HL+2TS	Rainfed Herbaceous Crop(s) + Sparse Trees	AG
1HLi	Permanently Cropped Area With Surface Irrigated Herbaceous Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop Sequentially) .	AG
1HM	Rainfed Herbaceous Crop(s)	AG
1HM+2TS	Rainfed Herbaceous Crop(s) + Sparse Trees	AG
1HMi	Permanently Cropped Area With Surface Irrigated Herbaceous Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop Sequentially) .	AG
1HS	Small Sized Field(s) Of Rainfed Herbaceous Crop(s)	AG
1HS+2TS	Small Sized Field(s) Of Rainfed Herbaceous Crop(s) + Sparse Trees	AG
1Hsi	Permanently Cropped Area With Small Sized Field(s) Of Surface Irrigated Herbaceous Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop Sequentially) .	AG
1Hs-Y	Post Flooding Cultivation Of Small Sized Field(s) Of Herbaceous Crop(s)	AG
1SHs	Small Sized Field(s) Of Rainfed Shrub Crop(s) (One Additional Crop) (Herbaceous Terrestrial Crop With Simultaneous Period) . Crop Cover: Orchard(s)	AG
1TPL	Permanently Cropped Area With Rainfed Tree Crop(s) Crop Cover: Plantation(s)	AG
1TPLBD-t	Permanently Cropped Area With Rainfed Broadleaved Deciduous Tree Crop(s)	AG
2HCO	Herbaceous Closed to Open Vegetation	HCO
2HCOTS	Closed to Open Herbaceous Vegetation with Trees and Shrubs	HCO
2HR	Sparse Herbaceous Vegetation	HCO
2SC	Closed Shrubland (Thicket)	SCO
2SO	Open Shrubs (Shrubland)	SCO
2SR	Sparse Shrubs	SCO
2TCS	Trees with Shrubs	TCO
2TOS	Woodland with Shrubs	TCO
3HL	Large Sized Field(s) Of Graminoid Crops On Permanently Flooded Land Dominant Crop: Cereals - Rice (Oryza spp.)	AG
3HM	Medium Sized Field(s) Of Graminoid Crops On Permanently Flooded Land Dominant Crop: Cereals - Rice (Oryza spp.)	AG
4HCF	Closed Herbaceous Vegetation On Temporarily Flooded Land. Water Quality: Fresh Water	HCO
4HCFF	Closed to Open Herbaceous Vegetation On Permanently Flooded Land Water Quality: Fresh Water	HCO
4HCTF	Closed Herbaceous Vegetation With Emergents On Temporarily Flooded Land Water Quality: Fresh Water	HCO
4SCHF	Closed to Open (100-40)% Shrubs With Herbaceous Vegetation On Temporarily Flooded Land.	SCO
4SCHFF	Closed to Open (100-40)% Shrubs With Herbaceous Vegetation On Permanently Flooded Land	SCO
4TCF	Trees On Temporarily Flooded Land. Water Quality: Fresh Water	TCO
4TOF	Woodland On Temporarily Flooded Land. Water Quality: Fresh Water	TCO
5A	Non-Linear Built Up Area(s) Built-Up Object: Airport	URB
5OF	Built Up Area(s) Built-Up Object: Other - Oil Fields	URB
5U	Urban Area(s)	URB
6R	Bare Rock(s)	BS
6S	Bare Soil And/Or Other Unconsolidated Material(s)	BS
8WFBS	Non-Perennial Natural Waterbodies (Flowing) (Surface Aspect: Sand)	WAT
8WFP	Perennial Natural Waterbodies (Flowing)	WAT
8WFT	Non-Perennial Natural Waterbodies (Flowing) (Surface Aspect: Bare Soil)	WAT
8WSP	Perennial Natural Waterbodies (Standing)	WAT
8WST	Non-Perennial Natural Waterbodies (Standing) (Surface Aspect: Bare Soil)	WAT

[1] AGG: aggregated class

National Land Cover

LAND COVER PERCENTAGE



INDEX MAP

LEGEND

Administrative Boundaries & Roads

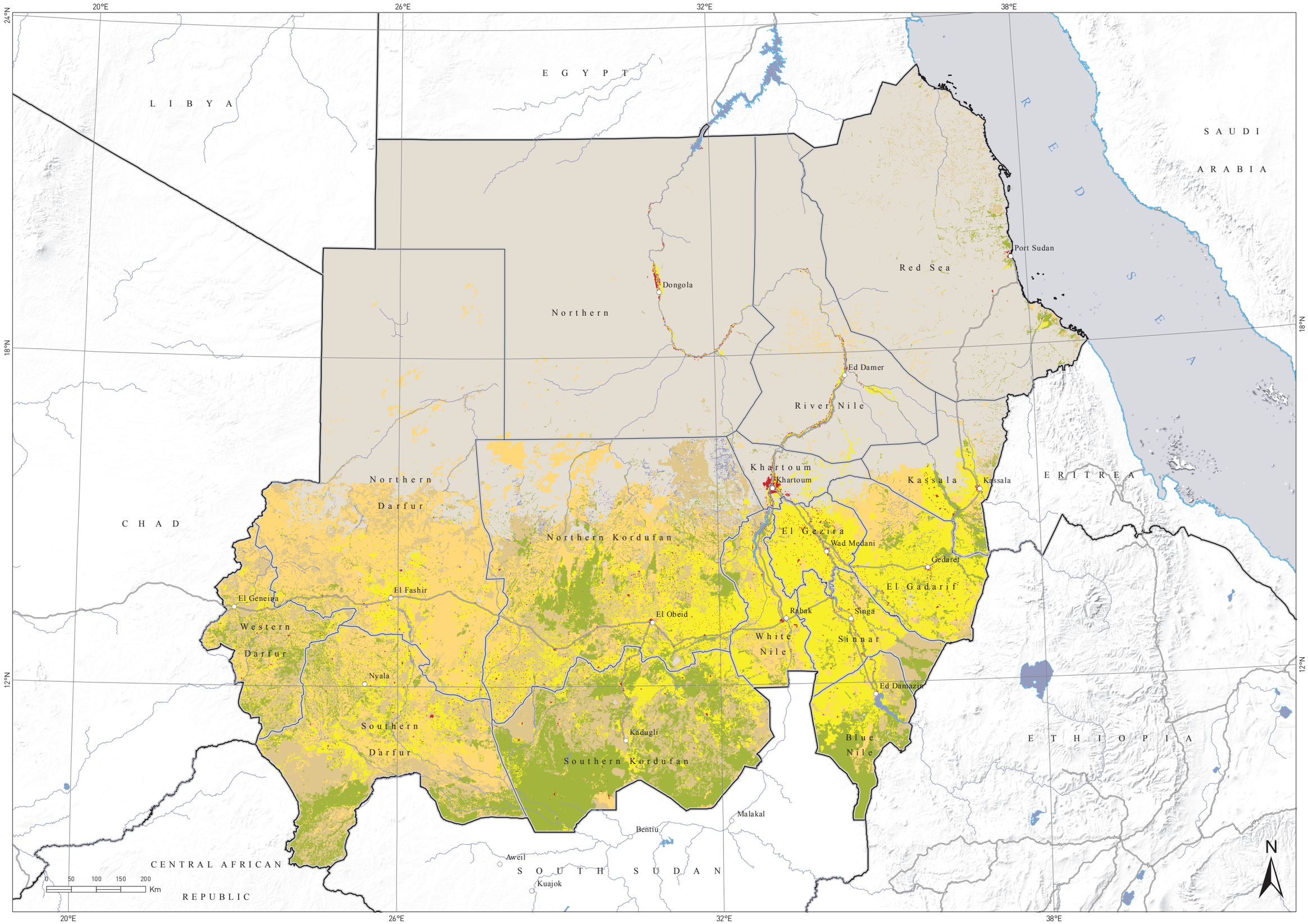
- State capital
- Main town
- Road network
- River/stream network
- International boundary
- Localities boundary

Land Cover

- **Agriculture** in terrestrial and aquatic/regularly flooded land
- **Trees** closed-to-sparse in terrestrial and aquatic/ regularly flooded land
- **Shrubs** closed-to-sparse in terrestrial and aquatic/ regularly flooded land
- **Herbaceous** closed-to-sparse in terrestrial and aquatic/ regularly flooded land
- **Urban** areas
- **Bare Rocks and Soil** and/ or Other Unconsolidated Material(s)
- Seasonal/perennial, natural/ artificial **waterbodies**

LAND COVER CLASSES IN HECTARES

STATES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Blue Nile	1,275,917	1,582,755	553,158	338,253	13,413	16,248	37,209	3,816,953
El Gadarif	3,458,932	598,354	197,738	1,207,604	39,799	331,314	124,163	5,957,904
El Gezira	2,075,149	68,536	16,991	335,004	75,660	128,948	13,149	2,713,437
Kassala	1,077,738	401,488	157,925	791,092	23,756	2,377,681	41,544	4,871,224
Khartoum	224,523	44,618	34,301	203,224	84,682	1,513,983	15,578	2,120,909
Northern	110,858	29,635	112,526	150,729	55,148	35,995,792	114,488	36,569,177
Northern Darfur	1,458,402	469,914	2,733,627	8,853,330	47,407	18,081,358	107,158	31,751,197
Northern Kordufan	4,571,176	2,852,632	5,776,385	5,135,514	146,862	5,188,063	385,136	24,055,768
Red Sea	30,155	458,962	1,030,880	578,602	17,522	19,479,544	27,033	21,622,699
River Nile	227,937	22,408	72,130	507,026	44,245	12,112,321	42,828	13,028,895
Sinnar	2,458,947	480,173	504,186	400,492	37,659	9,963	32,808	3,924,228
Southern Darfur	2,122,492	3,157,458	4,722,374	4,034,753	48,996	10,414	66,245	14,162,732
Southern Kordufan	1,963,585	7,174,761	4,134,598	675,395	36,182	11,999	89,235	14,085,754
Western Darfur	599,674	1,120,237	1,690,251	1,969,654	17,016	9,771	69,258	5,475,861
White Nile	2,054,539	271,251	494,257	802,049	41,985	10,328	124,166	3,798,575
Grand Total	**23,710,025**	**18,733,182**	**22,231,327**	**25,982,720**	**730,331**	**95,277,727**	**1,290,000**	**187,955,312**


20°E
26°E
32°E
38°E
24°N
18°N
12°N
L I B Y A
E G Y P T
S A U D I
A R A B I A
R E D S E A
Port Sudan
Red Sea
Dongola
Northern
Ed Damer
River Nile
Khartoum
Khartoum
Kassala
Kassala
E R I T R E A
Northern
Darfur
C H A D
Northern Kordufan
El Gezira
Wad Medani
Gedaref
El Gadarif
El Fashir
El Geneina
El Obeid
Rabak
Singa
Western
Darfur
White
Nile
Sinnar
Nyala
Ed Damazin
Southern
Darfur
Kadugli
Blue
Nile
E T H I O P I A
Southern Kordufan
Malakal
Bentiu
Aweil
S O U T H S U D A N
Kuajok
CENTRAL AFRICAN
REPUBLIC
0 50 100 150 200
Km
N

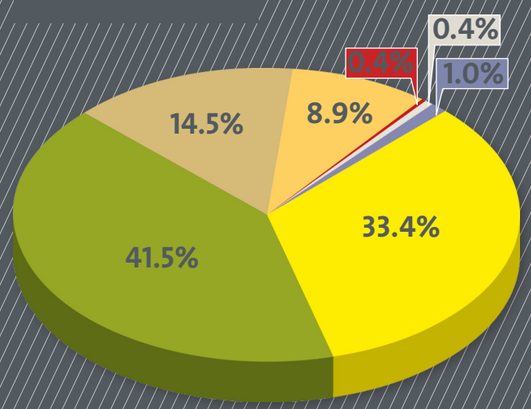
Land cover by:

State

Land cover maps and statistics are compiled for the whole country and for each Sudan state. The land cover distribution is reported in the tables as disaggregated at the second administrative level.

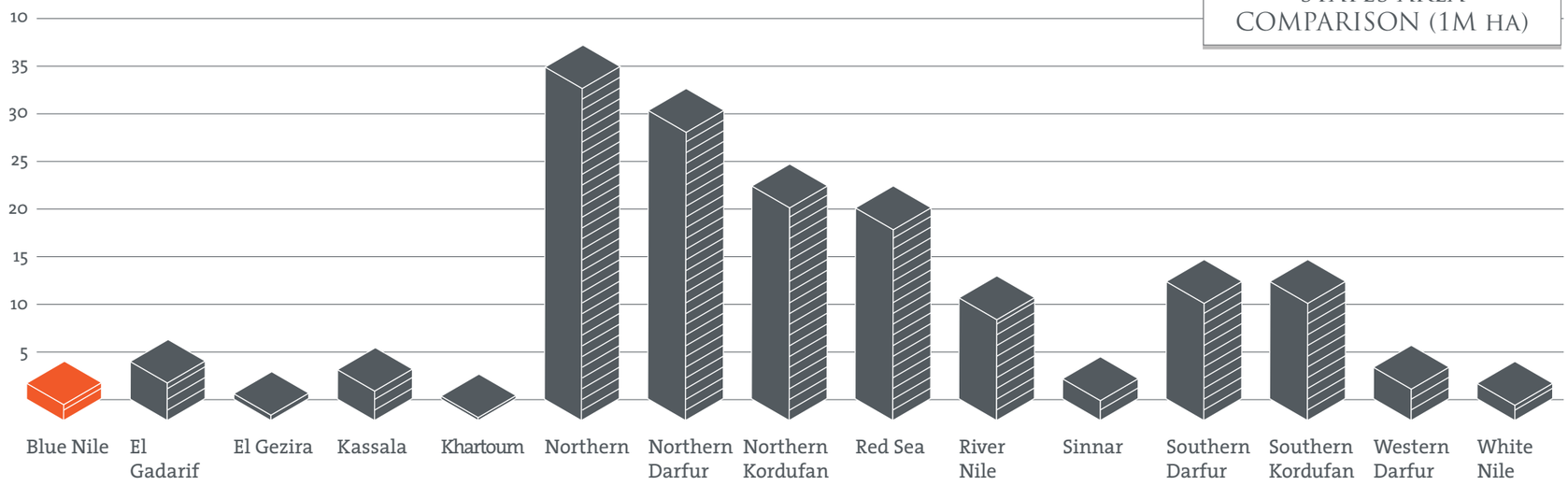
Blue Nile

LAND COVER PERCENTAGE



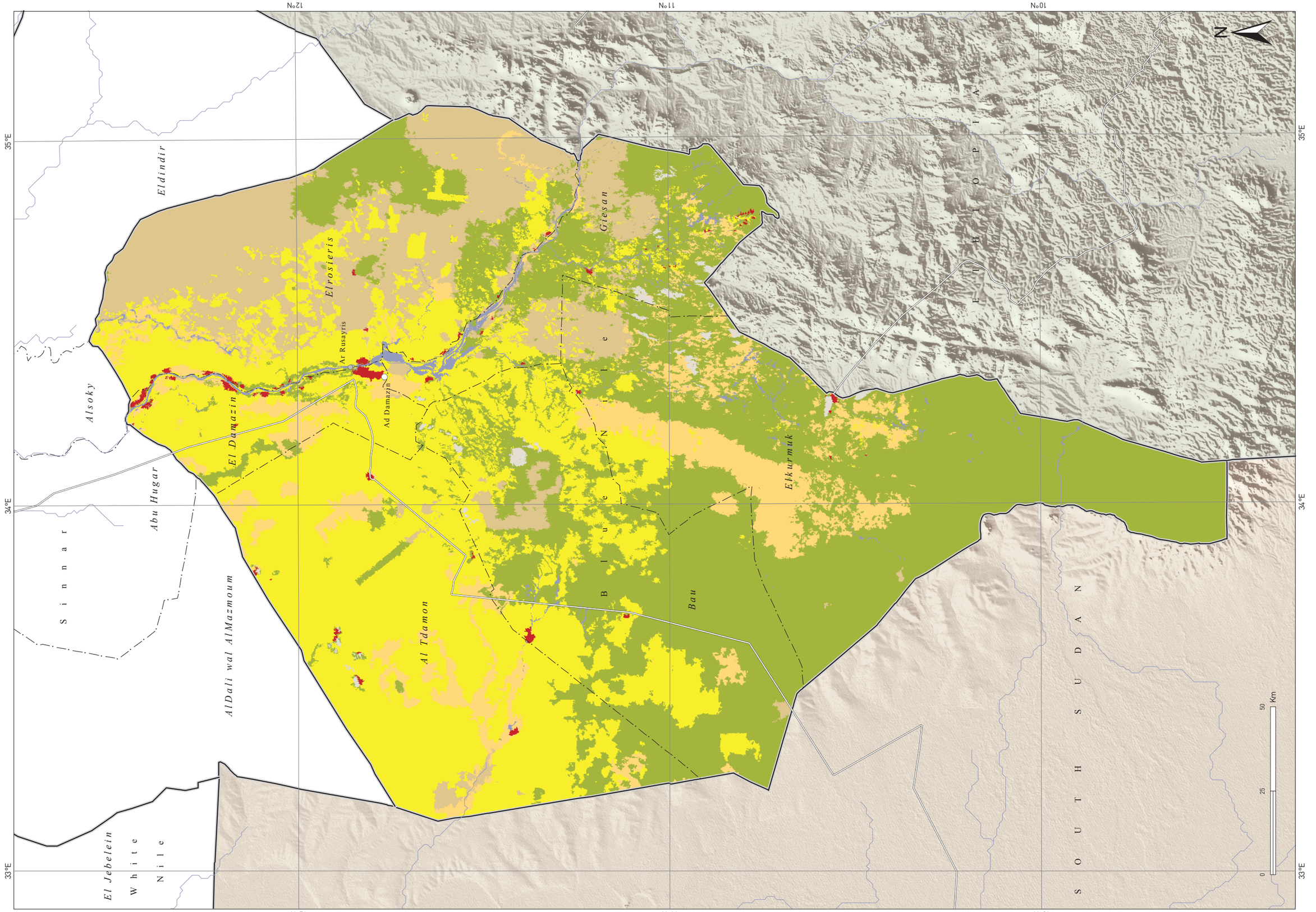
INDEX MAP

STATES AREA COMPARISON (1M HA)



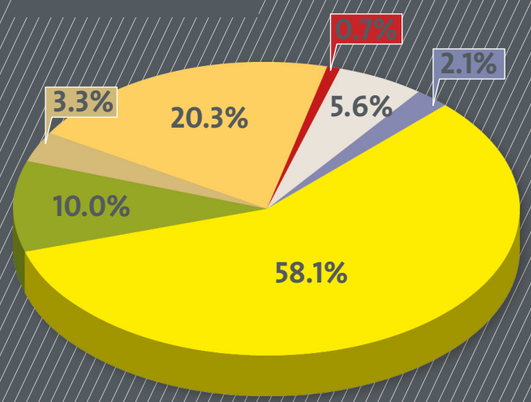
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Al Tdamon	631,730	64,788	12,449	87,825	1,857	897	282	799,827
Bau	208,214	463,051	22,537	23,101	1,028	4,018	2,400	724,349
El Damazin	135,505	16,059	781	28,336	5,257	105	3,254	189,297
Elkurmuk	29,662	739,864	29,248	161,619	711	3,997	7,233	972,333
Elrosieris	213,253	126,180	416,475	18,562	3,001	156	6,424	784,052
Giesan	57,553	172,813	71,668	18,810	1,559	7,075	17,617	347,095
Grand Total	**1,275,917**	**1,582,755**	**553,158**	**338,253**	**13,413**	**16,248**	**37,209**	**3,816,953**


12°N
11°N
10°N
35°E
34°E
33°E
Eldindir
Alsoky
Abu Hugar
Sinnar
El Damazin
Ar Rusayris
Ad Damazin
Elrosieris
Giesan
Blue Nile
Bau
Elkurmuk
AlDali wal AlMazmoum
Al Tdamon
El Jebelein
White Nile
ETHIOPIA
SOUTH SUDAN
N
50
25
0
Km

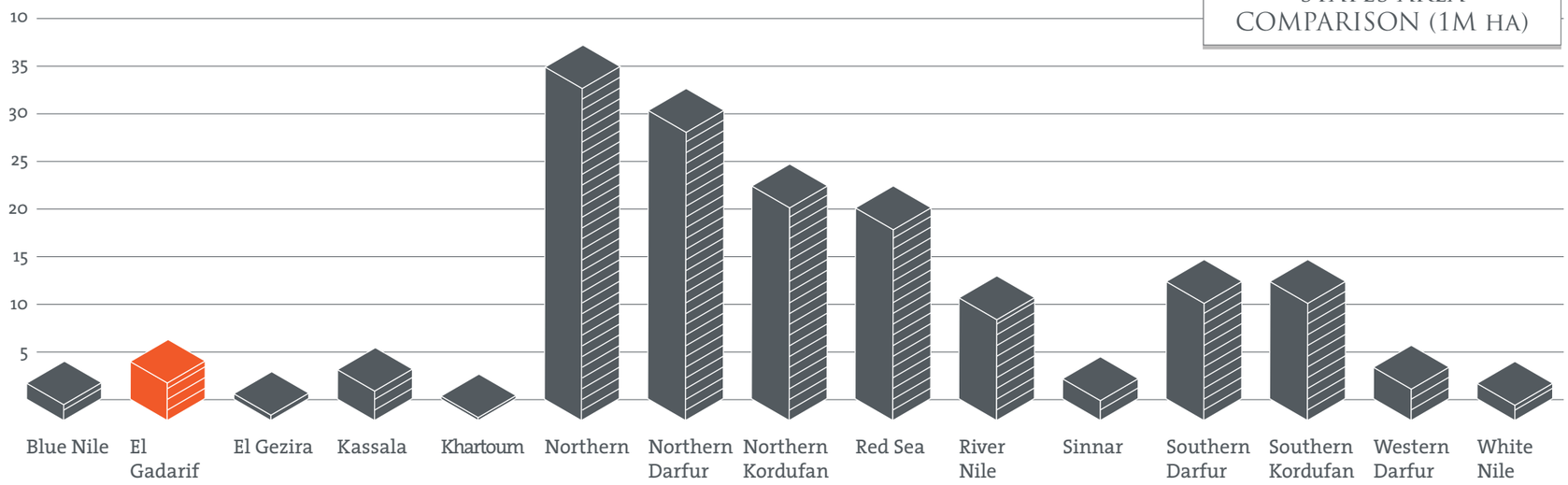
El Gadarif

LAND COVER PERCENTAGE



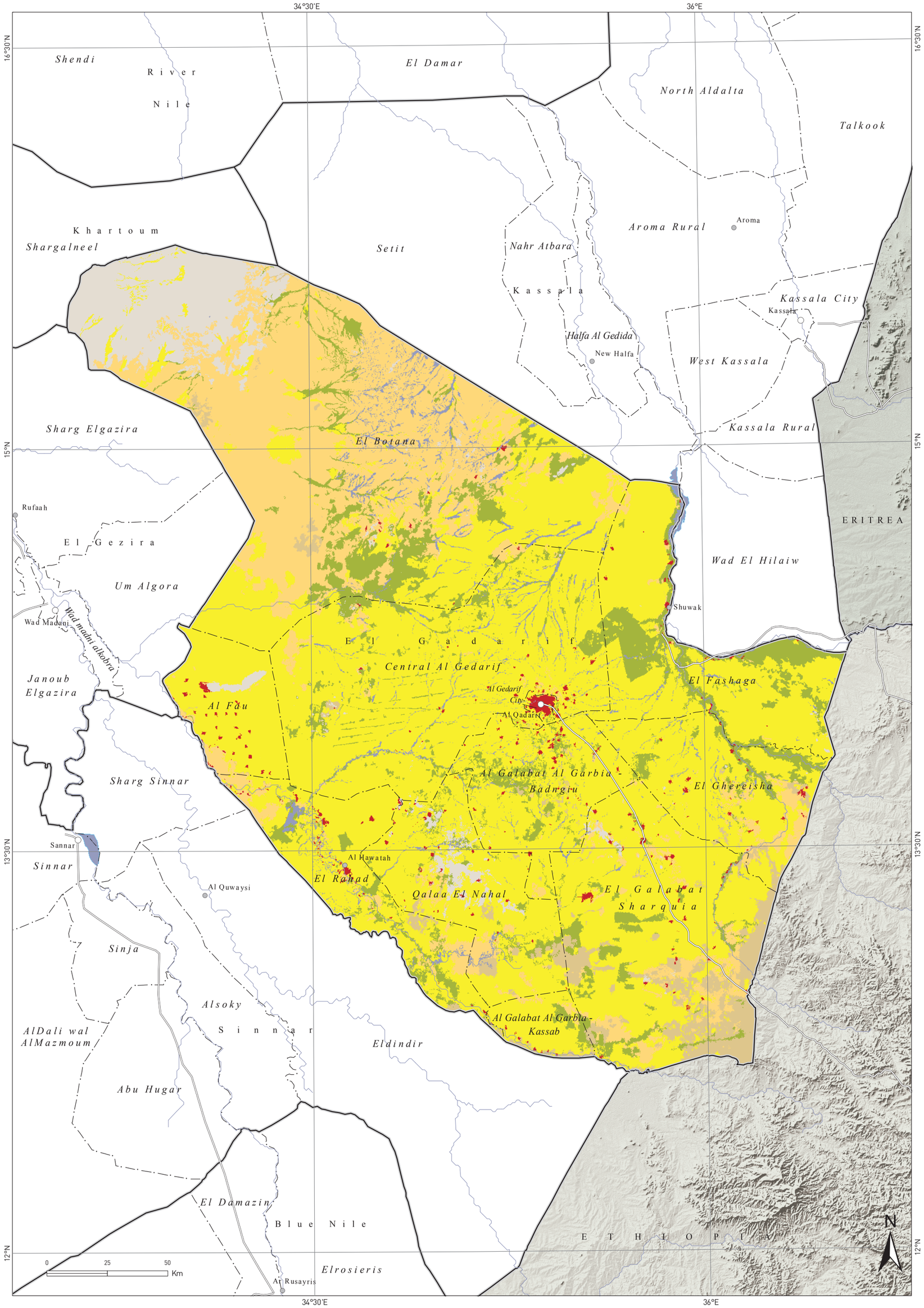
INDEX MAP

STATES AREA COMPARISON (1M HA)



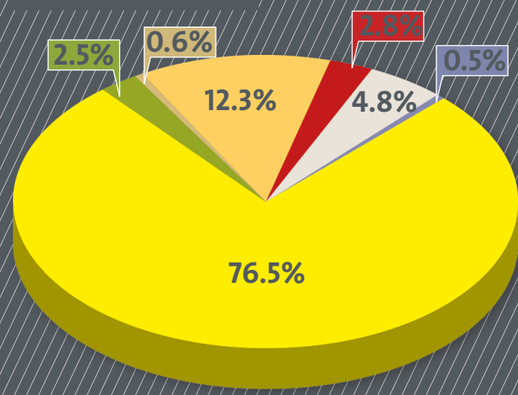
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Al Fau	186,170	396	407	15,053	4,447	8,120	2	214,596
Al Galabat Al Garbia - Badngiu	268,184	34,765	4,722	4,158	3,905	458	7,120	323,312
Al Galabat Al Garbia - Kassab	65,828	8,510	6,627	3,809	672	0	285	85,731
Al Gedarif City	4,747	402	0	128	6,452	0	141	11,869
Central Al Gedarif	836,202	62,603	2,485	22,322	4,169	1,413	28,944	958,137
El Botana	436,683	166,902	19,417	990,968	1,204	298,209	46,857	1,960,239
El Fashaga	339,031	159,371	20	5,796	2,507	565	13,497	520,787
El Galabat Sharquia	518,837	56,284	126,814	71,473	5,919	3,694	2,484	785,505
El Ghereisha	258,934	39,400	12,101	34,550	2,790	303	6,942	355,020
El Rahad	253,246	37,040	6,930	37,343	4,734	113	11,815	351,220
Qalaa El Nahal	291,072	32,681	18,215	22,005	3,000	18,438	6,077	391,488
Grand Total	**3,458,932**	**598,354**	**197,738**	**1,207,604**	**39,799**	**331,314**	**124,163**	**5,957,904**


34°30'E
36°E
16°30'N
15°N
13°30'N
12°N
Shendi
River Nile
El Damar
North Aldalta
Talkook
Khartoum
Shargalneel
Setit
Nahr Atbara
Aroma Rural
Aroma
Kassala
Kassala City
Halfa Al Gedida
New Halfa
West Kassala
Kassala Rural
Sharg Elgazira
El Botana
ERITREA
Rufaah
El Gezira
Um Algora
Wad Madani
Wad madni alkobra
Wad El Hilaiw
Shuwak
El Gadarif
Central Al Gedarif
Al Gedarif City
Al Qadarif
El Fashaga
Janoub Elgazira
Al Fau
Sharg Sinnar
Al Galabat Al Garbia - Badngiu
El Ghereisha
Sannar
Sinnar
Al Hawatah
El Rahad
Qalaa El Nahal
El Galabat Sharquia
Al Quwaysi
Sinja
Alsoky
AlDali wal AlMazmoum
Sinnar
Eldindir
Al Galabat Al Garbia - Kassab
Abu Hugar
El Damazin
Blue Nile
ETHIOPIA
Elrosieris
Ar Rusayris
0
25
50
Km
N

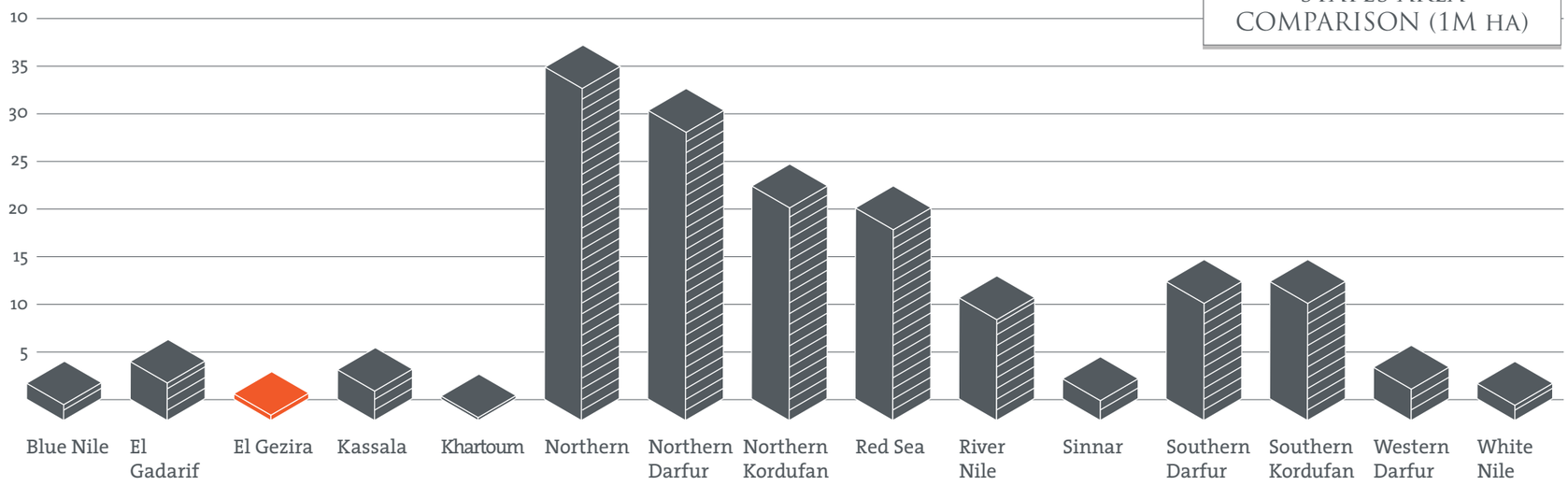
El Gezira

LAND COVER PERCENTAGE



INDEX MAP

STATES AREA COMPARISON (1M HA)



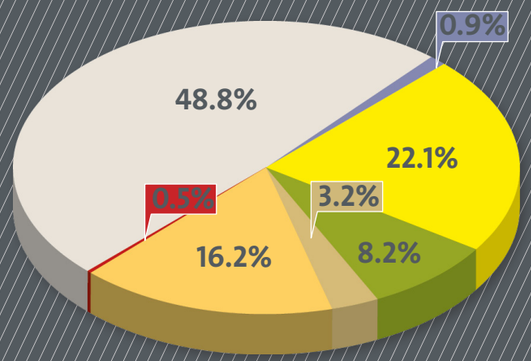
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
El Hasaheisa	347,968	8,874	11	38,243	16,976	2,326	1,538	415,935
El Kamlin	156,085	0	0	472	6,751	17,461	1,728	182,497
El Managil	604,194	11,059	6,378	55,745	9,781	5	0	687,163
Janoub Elgazira	289,256	8,486	5,038	10,313	7,965	0	3,871	324,930
Sharg Elgazira	337,715	36,053	4,902	141,780	18,492	109,072	3,358	651,371
Um Algora	301,267	3,339	662	80,389	7,107	85	9	392,859
Wad madni alkobra	38,664	724	0	8,061	8,587	0	2,645	58,682
Grand Total	**2,075,149**	**68,536**	**16,991**	**335,004**	**75,660**	**128,948**	**13,149**	**2,713,437**

33°E
34°E
16°N
15°N
14°N
Bahri
Karrari
Kassala
Oumbada
Khartoum
Shargalneel
Omdurman
Khartoum
Khartoum
Umdurman
Jabel Awliya
El Gadarif
Wad Rawah
El Kamlin
Sharg Elgazira
Al Qutaynah
El Hasaheisa
Rufaah
El Gezira
Um Algora
El Geteina
El Managil
Wad Madani
Wad madni alkobra
Al Mansoll
Janoub Elgazira
Al Fau
Ad Duwaym
Eldiwiem
Sharg Sinnar
El Rahad
Sinnar
Sannar
Eldindir
White Nile
Rabak
Al Quwaysi
Sinnar
Kosti
Rabak
El Jebelein
Sinja
AlDali wal AlMazmoum
0
25
50
km
N

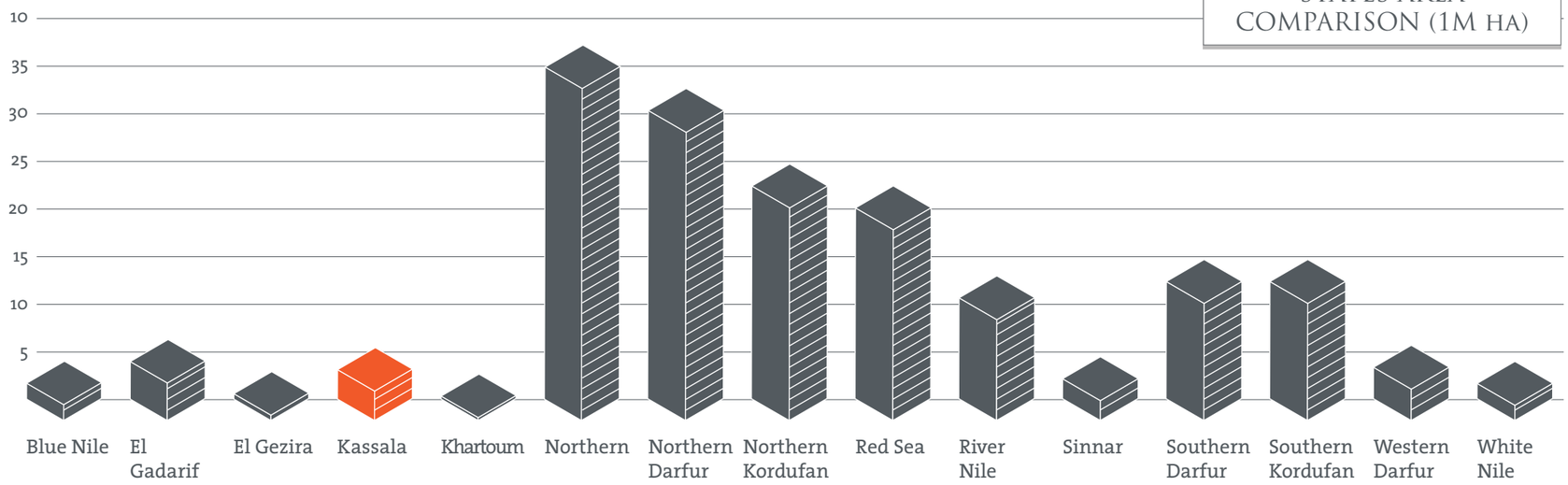
Kassala

LAND COVER PERCENTAGE



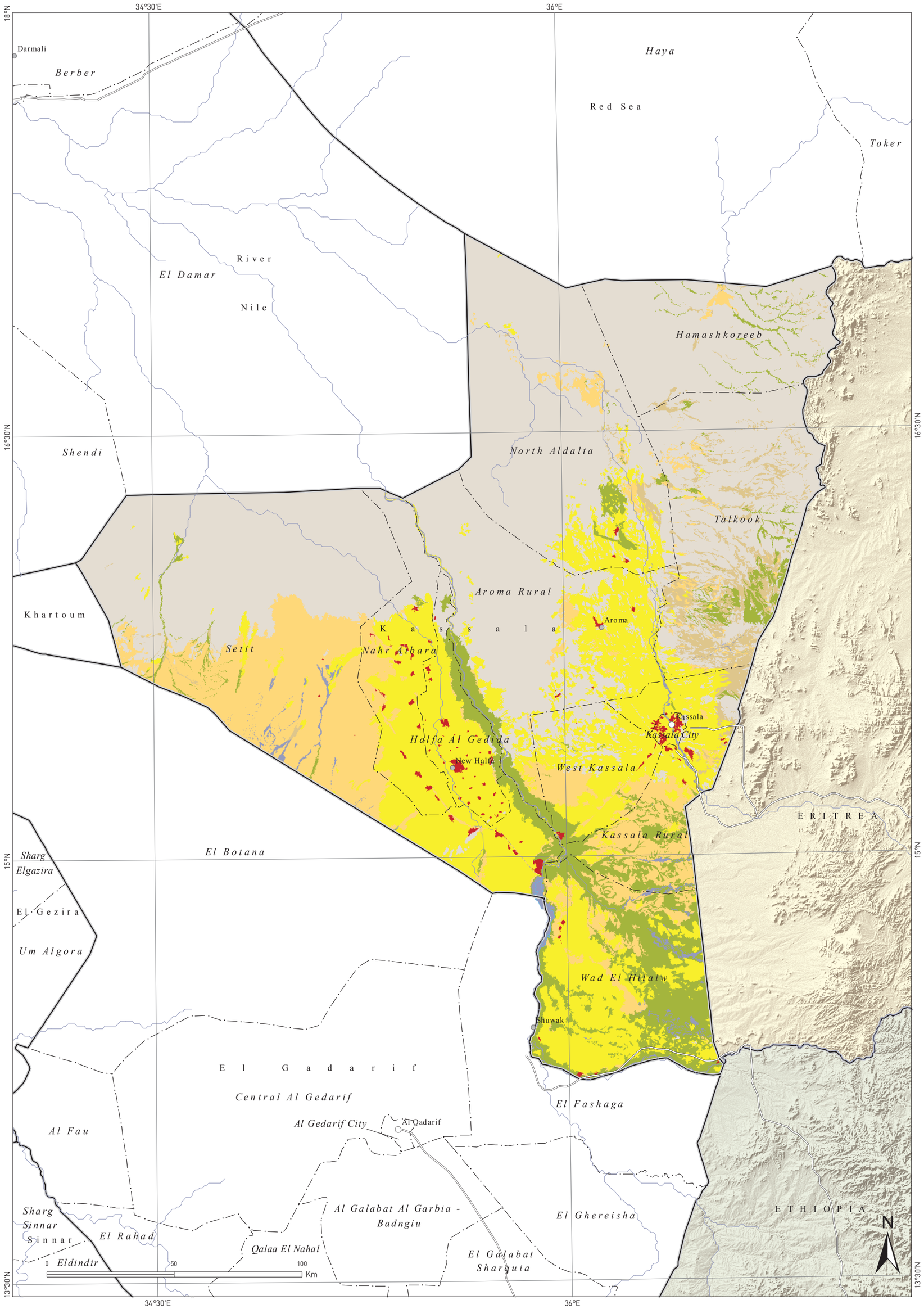
INDEX MAP

STATES AREA COMPARISON (1M HA)



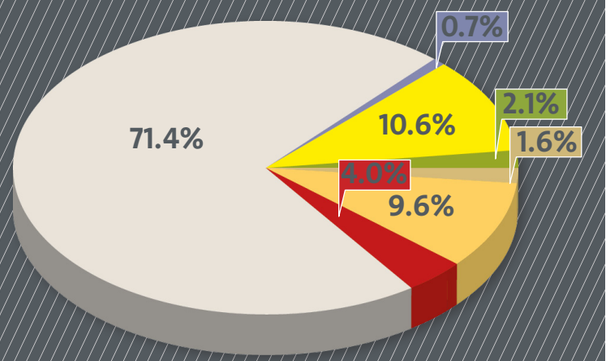
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Aroma Rural	150,824	29,877	4,506	29,619	1,317	374,757	5,111	596,011
Halfa Al Gedida	111,811	20,789	609	3,882	5,331	10,180	53	152,656
Hamashkoreeb	0	12,005	6,562	20,811	0	354,509	0	393,887
Kassala City	7,795	0	35	0	3,938	890	621	13,280
Kassala Rural	108,503	46,468	16,365	88,932	2,029	14,278	5,809	282,383
Nahr Atbara	140,209	902	449	36,986	4,259	55,283	455	238,543
North Aldalta	69,958	15,212	14,543	51,314	767	584,708	76	736,579
Setit	150,720	30,568	5,979	408,171	3,798	595,476	13,911	1,208,623
Talkook	14,861	37,013	108,856	54,836	43	348,387	842	564,838
Wad El Hilaiw	215,479	196,735	0	59,914	1,173	289	14,459	488,049
West Kassala	107,577	11,919	19	36,627	1,101	38,924	208	196,376
Grand Total	**1,077,738**	**401,488**	**157,925**	**791,092**	**23,756**	**2,377,681**	**41,544**	**4,871,224**


18°N
34°30'E
36°E
16°30'N
15°N
13°30'N
Darmali
Berber
Haya
Red Sea
Toker
River
El Damar
Nile
Hamashkoreeb
Shendi
North Aldalta
Talkook
Aroma Rural
Aroma
Khartoum
Setit
Kassala
Nahr Atbara
Halfa Al Gediida
New Halfa
West Kassala
Kassala City
ERITREA
Kassala Rural
Sharg
Elgazira
El Botana
El Gezira
Um Algora
Wad El Hilaiw
Shuwak
El Gadarif
Central Al Gedarif
El Fashaga
Al Gedarif City
Al Qadarif
Al Fau
Sharg
Sinnar
Sinnar
El Rahad
Al Galabat Al Garbia -
Badngiu
El Ghereisha
ETHIOPIA
Qalaa El Nahal
El Galabat
Sharquia
Eldindir
0
50
100
Km
N

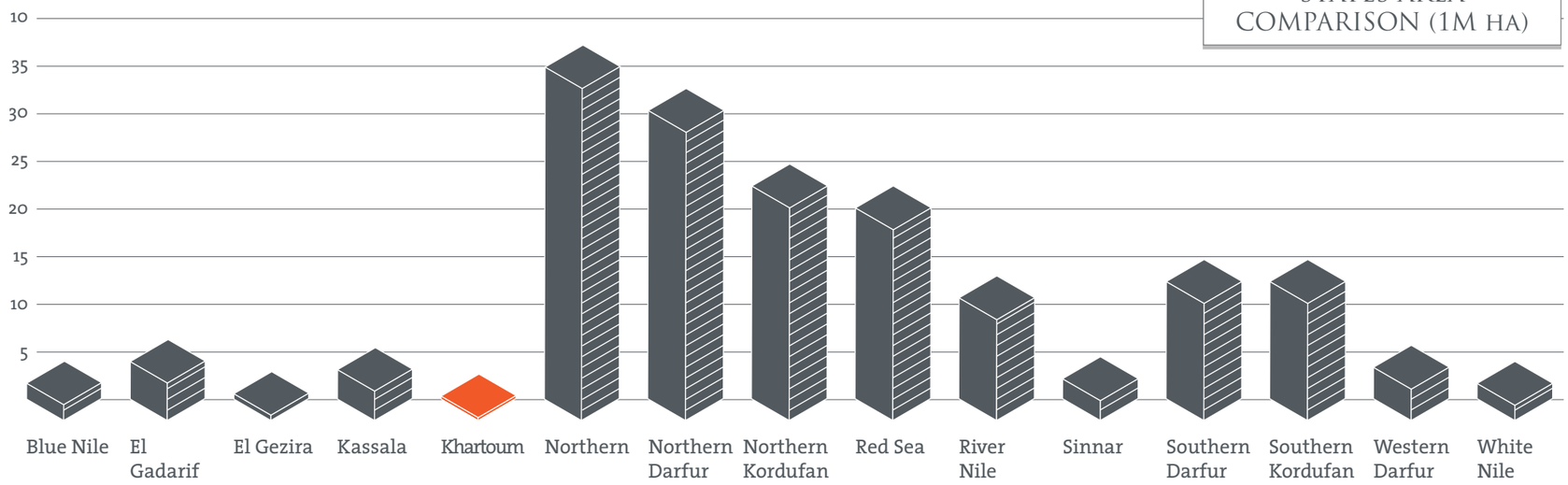
Khartoum

LAND COVER PERCENTAGE



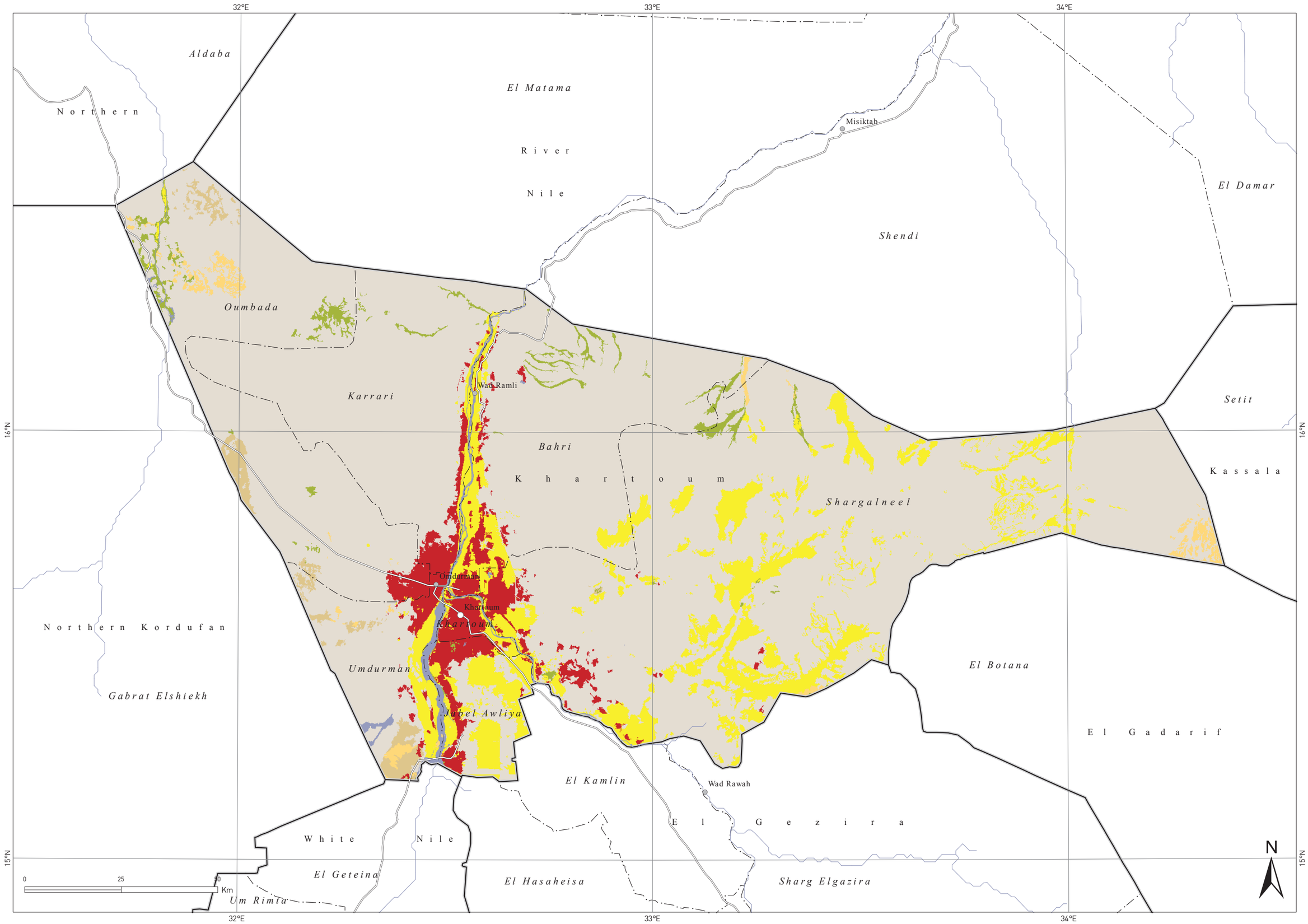
INDEX MAP

STATES AREA COMPARISON (1M HA)



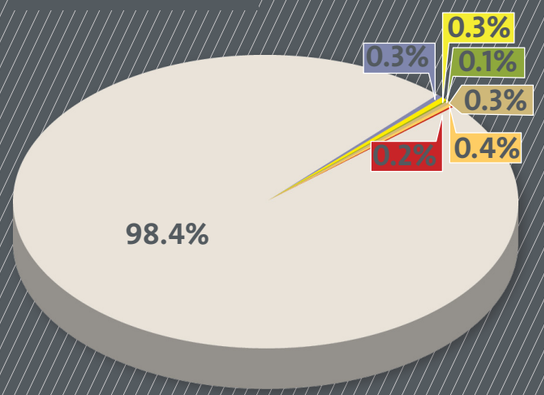
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Bahri	27,750	18,226	24	41,576	13,147	216,394	2,648	319,766
Jabel Awliya	31,527	517	10	48	15,415	26,785	3,668	77,970
Karrari	5,491	1,897	0	26,990	12,039	242,813	2,155	291,386
Khartoum	4,112	105	302	0	10,689	318	1,183	16,709
Oumbada	1,007	11,251	14,296	39,465	7,957	272,660	2	346,638
Shargalneel	141,051	12,546	5,452	89,696	16,490	680,377	872	946,485
Umdurman	13,585	76	14,217	5,448	8,943	74,637	5,050	121,956
Grand Total	**224,523**	**44,618**	**34,301**	**203,224**	**84,682**	**1,513,983**	**15,578**	**2,120,909**

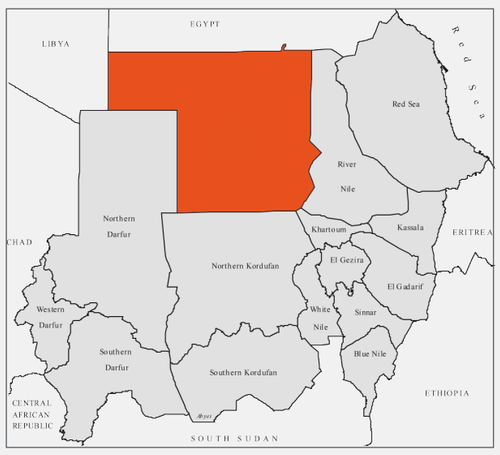

32°E
33°E
34°E
16°N
15°N
Aldaba
Northern
El Matama
River
Nile
Misiktab
El Damar
Shendi
Oumbada
Karrari
Wad Ramli
Setit
Bahri
Khartoum
Kassala
Shargalneel
Omdurman
Khartoum
Northern Kordufan
Umdurman
Jabel Awliya
El Botana
Gabrat Elshiekh
El Gadarif
El Kamlin
Wad Rawah
El Gezira
White
Nile
El Geteina
El Hasaheisa
Sharg Elgazira
Um Rimta
0
25
50
Km
N

Northern

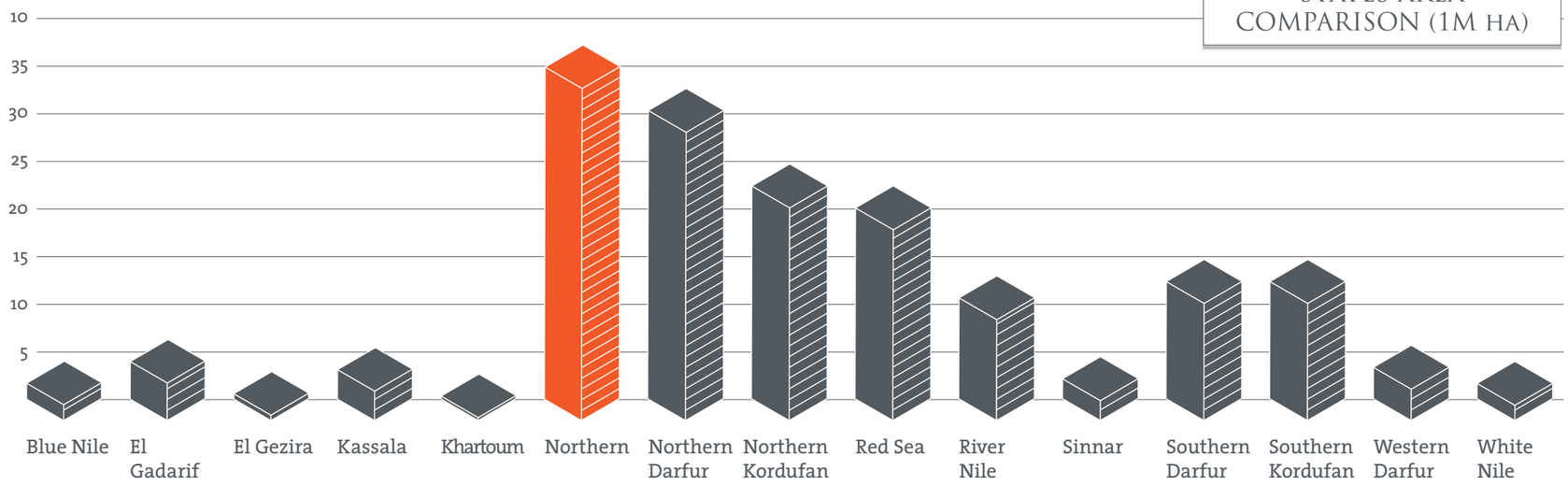
LAND COVER PERCENTAGE



INDEX MAP

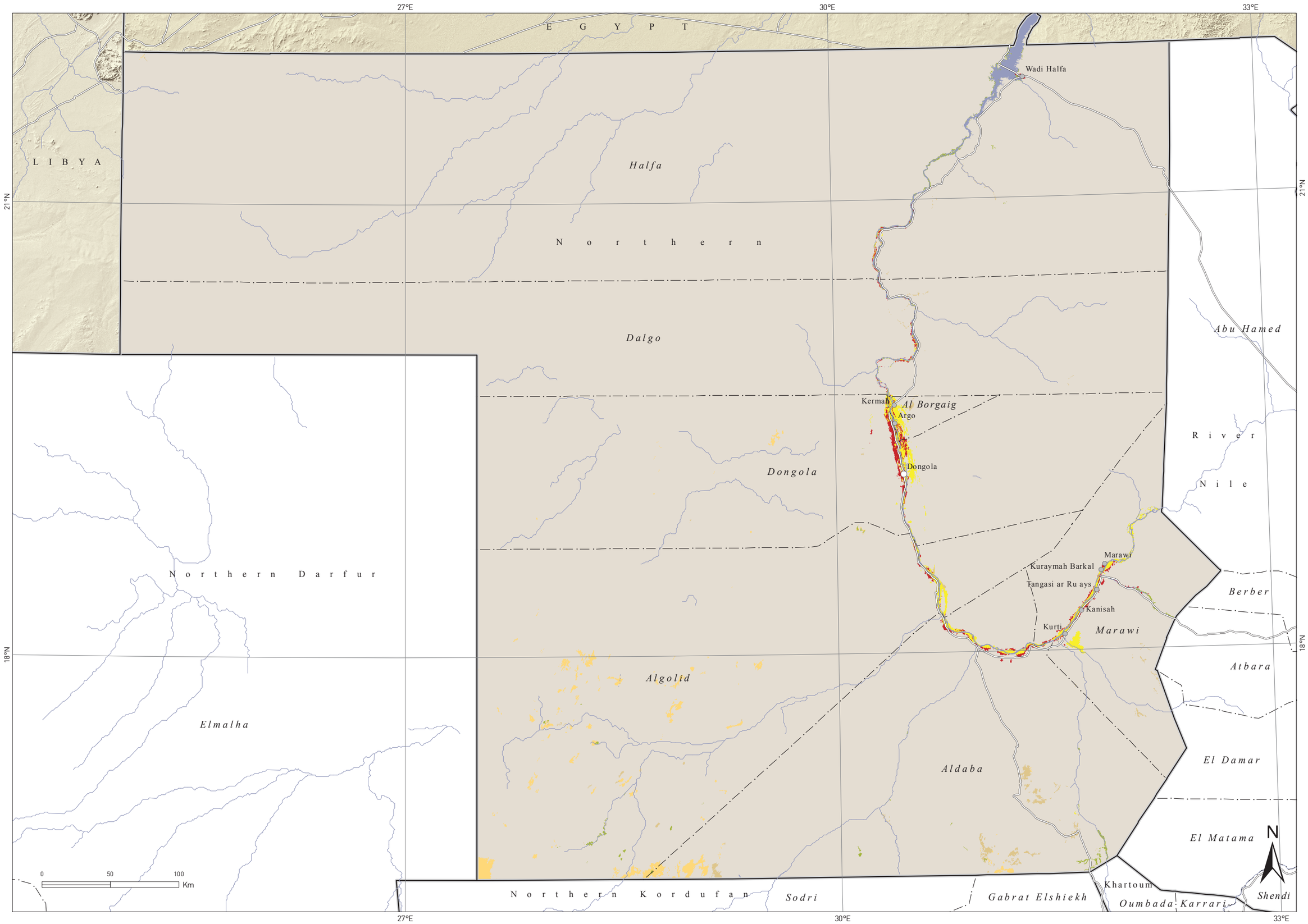


STATES AREA COMPARISON (1M HA)



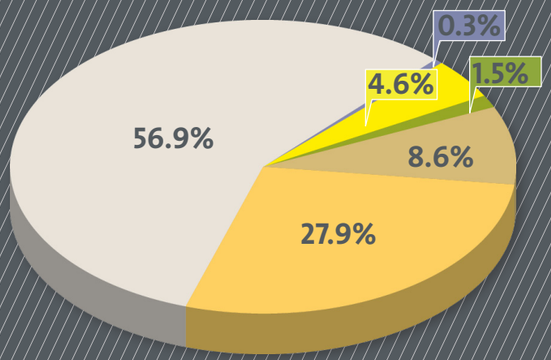
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Al Borgaig	16,840	0	2,248	0	3,706	117,389	2,152	142,335
Aldaba	13,863	8,648	70,953	59,116	7,682	4,363,499	7,039	4,530,800
Algolid	16,396	4,852	5,551	85,336	3,303	6,464,072	4,139	6,583,649
Dalgo	3,067	1,689	5,642	0	4,537	5,721,304	8,690	5,744,929
Dongola	31,208	81	1,135	4,682	20,537	4,783,891	6,505	4,848,037
Halfa	1,853	10,884	4,314	229	4,095	12,862,162	75,917	12,959,454
Marawi	27,632	3,481	22,683	1,367	11,289	1,683,475	10,046	1,759,973
TOTAL AREA	**110,858**	**29,635**	**112,526**	**150,729**	**55,148**	**35,995,792**	**114,488**	**36,569,177**


27°E
30°E
33°E
21°N
18°N
E G Y P T
L I B Y A
Halfa
N o r t h e r n
Dalgo
Wadi Halfa
Abu Hamed
Kermah
Al Borgaig
Argo
Dongola
R i v e r
N i l e
Marawi
Kuraymah Barkal
Tangasi ar Ru ays
Berber
Kanisah
Kurti
Marawi
Atbara
Algolid
Aldaba
El Damar
El Matama
N
Khartoum
Shendi
Oumbada Karrari
Gabrat Elshiekh
Sodri
N o r t h e r n K o r d u f a n
N o r t h e r n D a r f u r
Elmalha
0
50
100
Km

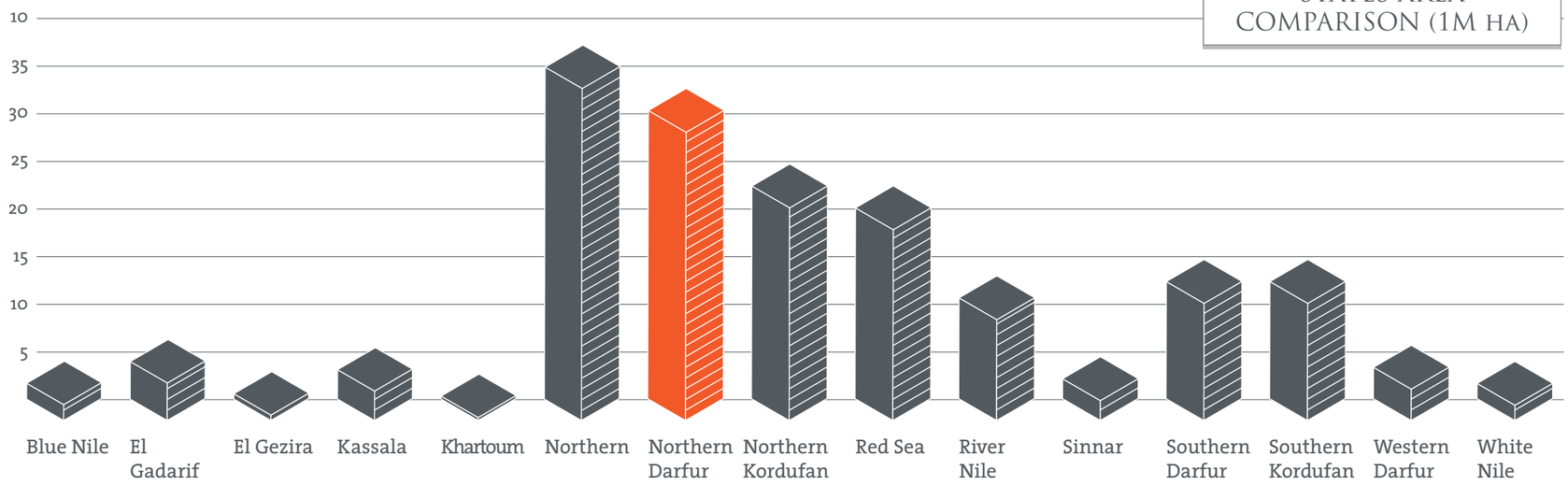
Northern Darfur

LAND COVER PERCENTAGE



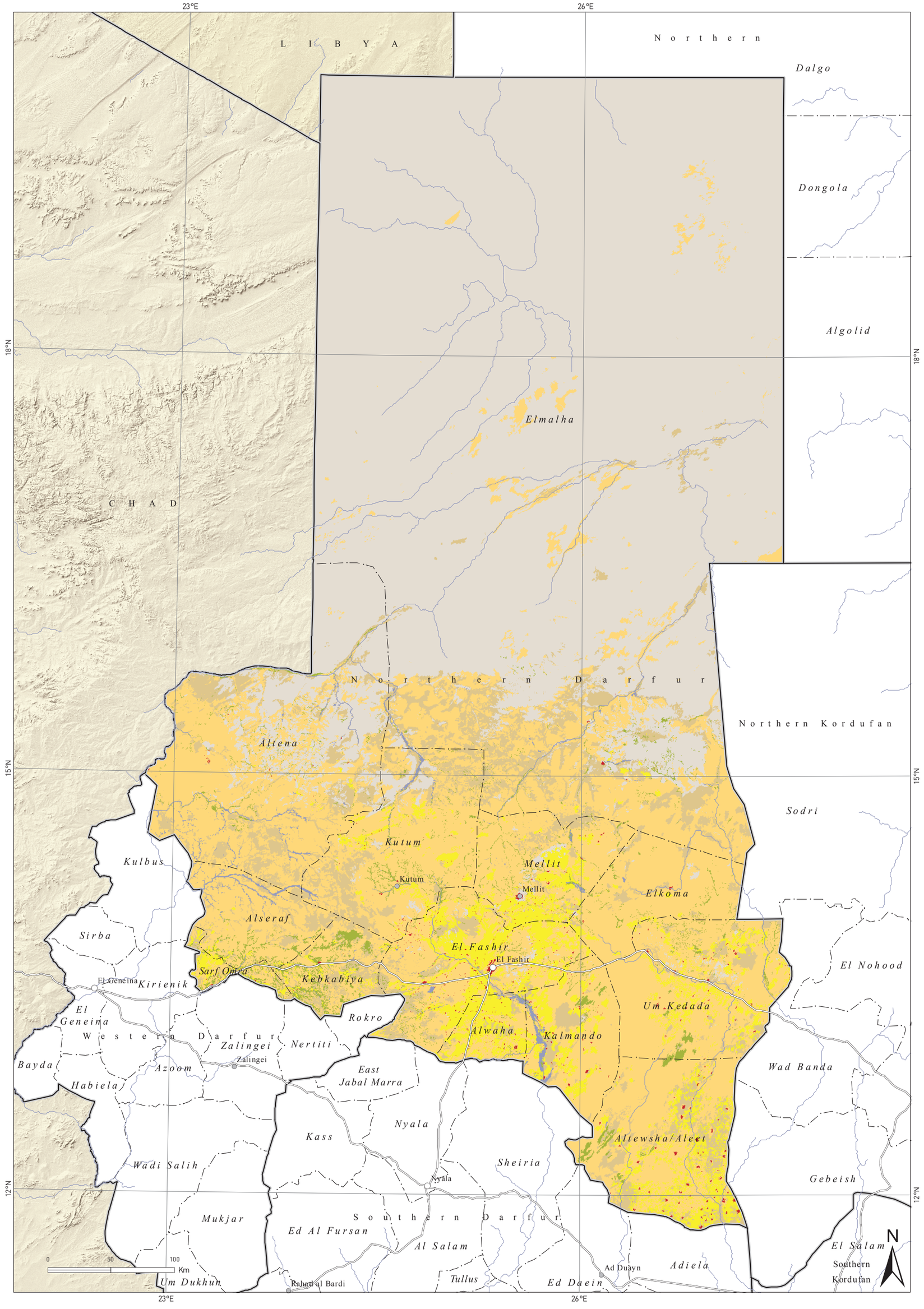
INDEX MAP

STATES AREA COMPARISON (1M HA)



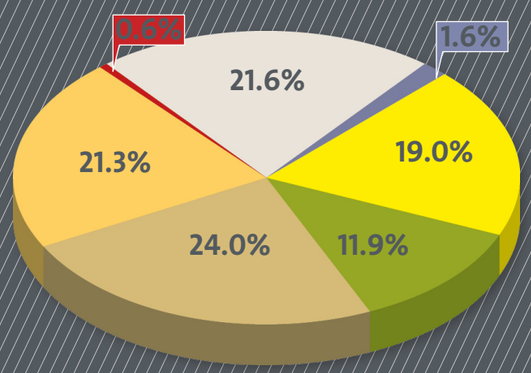
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Alseraf	13,734	47,494	84,830	481,410	63	0	14,554	642,085
Altena	12,243	58,633	477,601	1,131,951	1,188	3,965,876	25,066	5,672,558
Altewsha/Aleet	271,367	25,190	426,993	651,950	13,274	0	487	1,389,261
Alwaha	128,742	3,417	22,043	140,755	2,515	70	4,447	301,988
El Fashir	343,416	26,527	131,235	643,676	12,439	17,974	6,381	1,181,647
Elkoma	21,474	43,723	58,016	668,569	951	6,071	622	799,427
Elmalha	10,866	50,056	846,534	1,885,554	772	13,955,147	10,380	16,759,308
Kalmando	147,672	15,115	118,185	417,100	4,016	1,168	21,898	725,153
Kebkabiya	25,099	75,337	104,736	235,887	817	187	2,623	444,686
Kutum	78,631	40,230	256,977	1,013,436	1,594	64,864	14,085	1,469,817
Mellit	168,648	26,229	48,248	545,790	4,096	48,657	4,399	846,068
Sarf Omra	43,832	16,004	22,661	66,449	1,049	0	2,029	152,024
Um Kedada	192,677	41,957	135,567	970,805	4,634	21,345	189	1,367,174
Grand Total	**1,458,402**	**469,914**	**2,733,627**	**8,853,330**	**47,407**	**18,081,358**	**107,158**	**31,751,197**

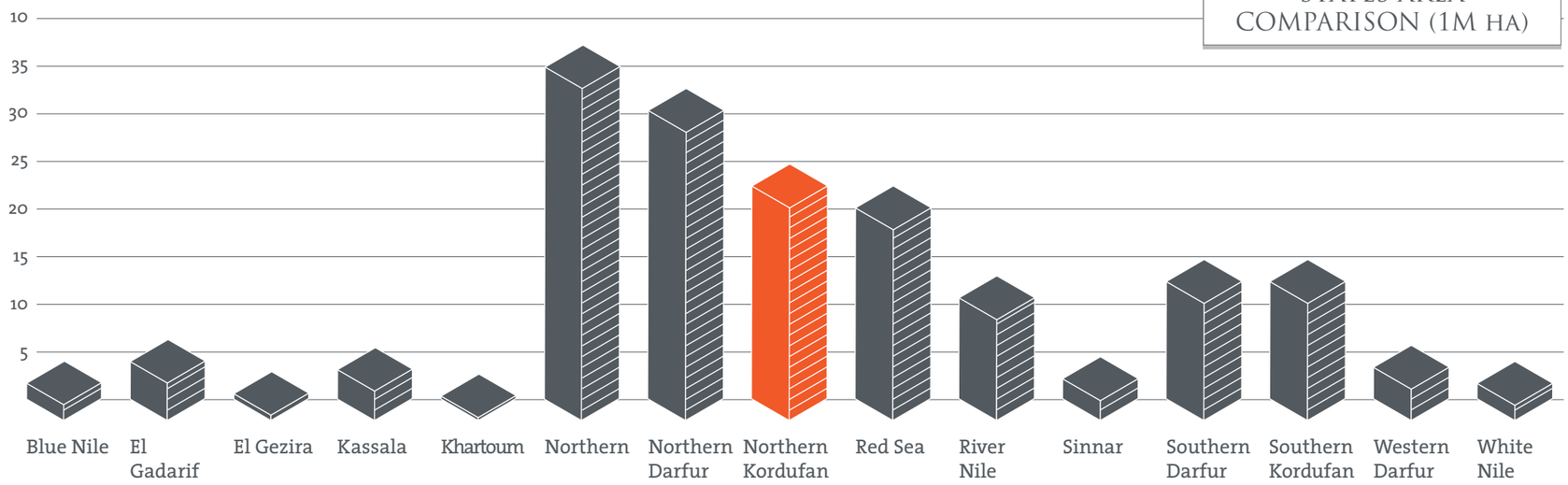

23°E
26°E
18°N
15°N
12°N
L I B Y A
C H A D
N o r t h e r n
Dalgo
Dongola
Algolid
Elmalha
N o r t h e r n D a r f u r
Northern Kordufan
Altena
Sodri
Kutum
Kutum
Mellit
Mellit
Elkoma
Kulbus
Alseraf
Sirba
El Fashir
El Fashir
El Nohood
Sarf Omra
Kebkabiya
El Geneina
Kirienik
Um Kedada
El Geneina
Rokro
Alwaha
Kalmando
W e s t e r n D a r f u r
Zalingei
Nertiti
Zalingei
Wad Banda
Bayda
Azoom
East Jabal Marra
Habiela
Nyala
Kass
Altewsha/Aleet
Wadi Salih
Sheiria
Nyala
Gebeish
Mukjar
S o u t h e r n D a r f u r
Ed Al Fursan
Al Salam
El Salam
Southern Kordufan
Adiela
Ad Duayn
Tullus
Ed Daein
Um Dukhun
Rahad al Bardi
0
50
100
Km
N

Northern Kordufan

LAND COVER PERCENTAGE



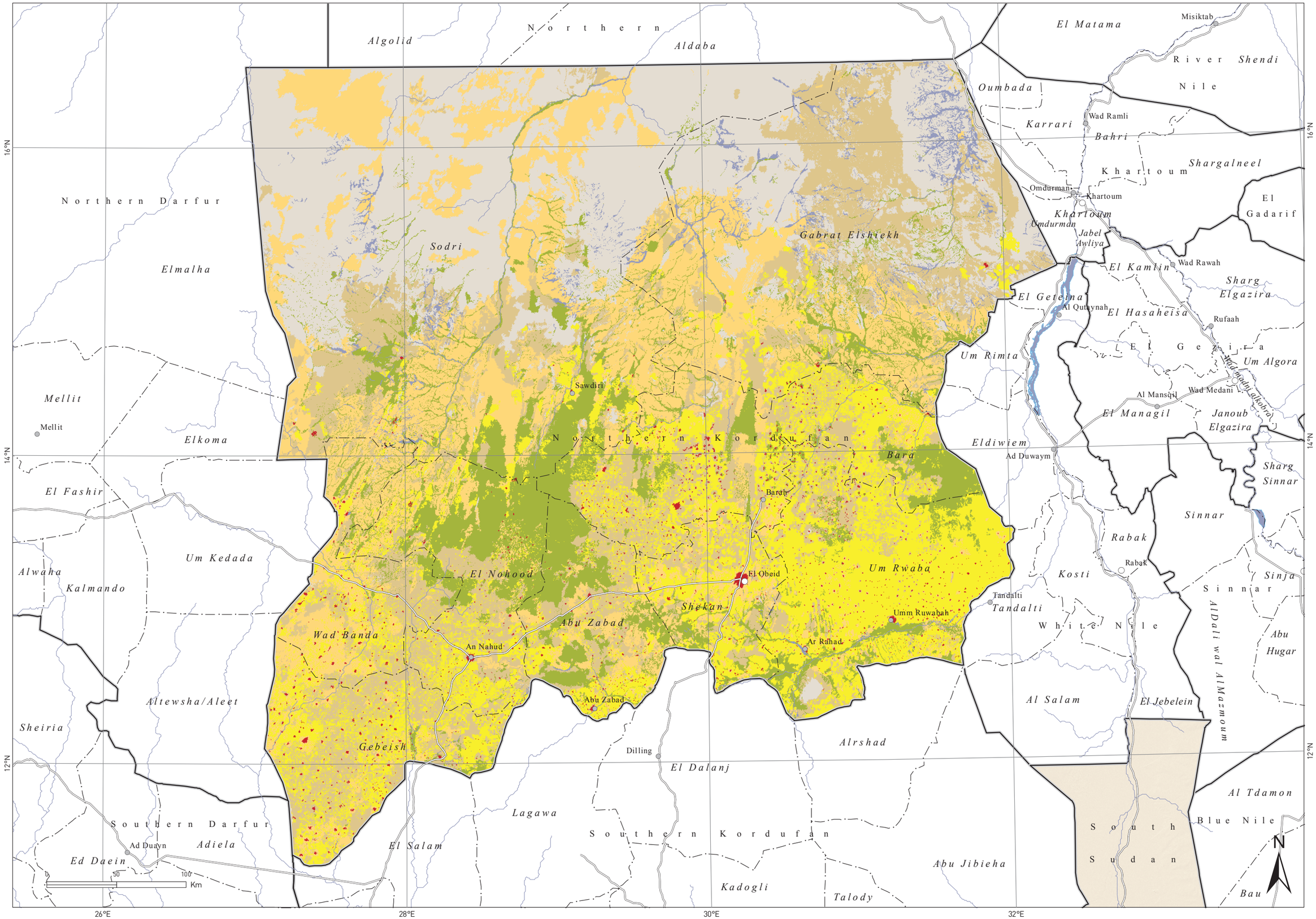
STATES AREA COMPARISON (1M HA)



INDEX MAP

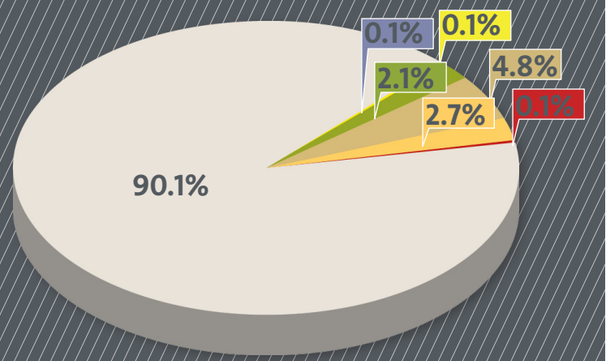
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Shekan	379,611	90,257	197,201	152,970	16,616	1,382	5,664	843,703
Sodri	192,735	695,644	1,159,141	2,356,398	3,931	3,776,834	121,862	8,306,546
Um Rwaba	1,521,836	225,034	330,168	97,109	30,537	12,953	10,908	2,228,544
Wad Banda	222,703	106,796	330,408	463,575	13,711	6,040	4,026	1,147,260
Abu Zabad	234,283	388,057	282,923	174,834	10,379	730	1,321	1,092,528
Bara	860,474	420,566	691,295	275,465	30,309	10,550	355	2,289,014
El Nohood	382,309	548,953	406,024	228,017	13,082	3,063	2,266	1,583,713
Gabrat Elshiekh	162,721	353,109	1,763,621	1,202,053	2,657	1,376,511	236,744	5,097,417
Gebeish	614,502	24,214	615,604	185,092	25,640	0	1,990	1,467,042
Grand Total	**4,571,176**	**2,852,632**	**5,776,385**	**5,135,514**	**146,862**	**5,188,063**	**385,136**	**24,055,768**

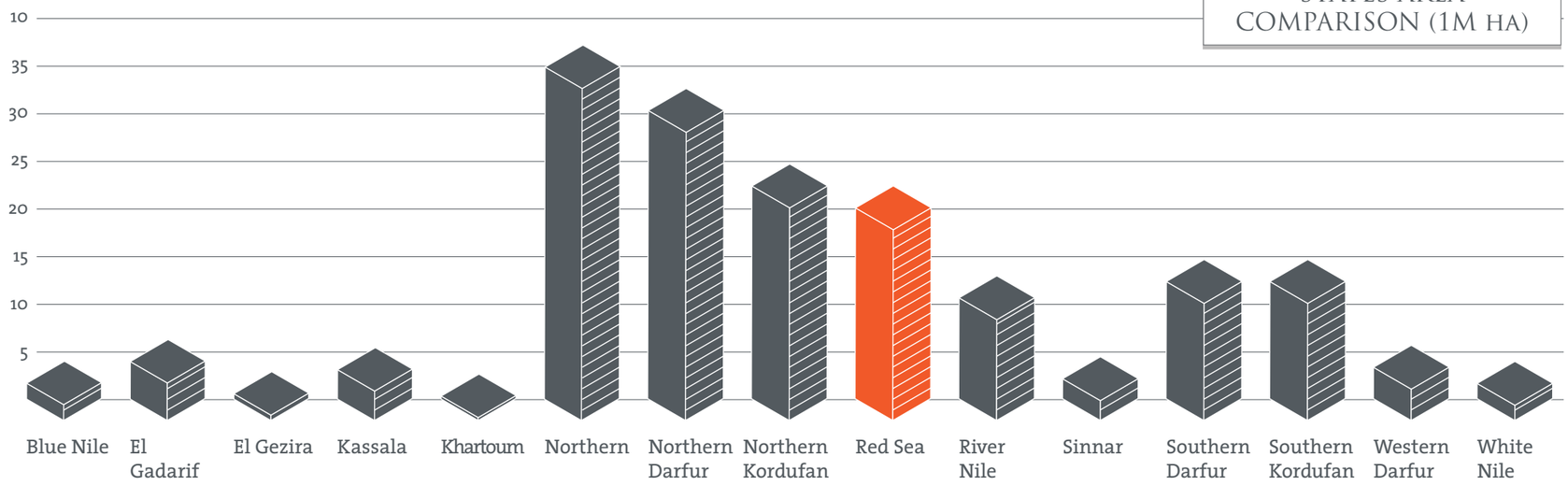

26°E
28°E
30°E
32°E
34°E
16°N
14°N
12°N
Algolid
Northern Aldaba
El Matama
Misiktab
River Shendi
Nile
Oumbada
Karrari
Wad Ramli
Bahri
Shargalneel
Khartoum
Omdurman
Khartoum
El Gadarif
Khartoum
Omdurman
Jabel Awliya
Northern Darfur
Sodri
Gabrat Elshiekh
Elmalha
El Kamlin
Wad Rawah
Sharg Elgazira
El Geteina
Al Qutaynah
El Hasaheisa
Rufaah
El Gezira
Um Rimta
Um Algora
Wad Madani Alkobra
Sawdiri
Mellit
Mellit
Al Mansûl
Wad Medani
El Managil
Janoub Elgazira
Elkoma
Northern Kordufan
Bara
Eldiwiem
Ad Duwaym
Sharg Sinnar
El Fashir
Barah
Sinnar
Rabak
Um Kedada
Alwaha
Kalmando
El Nohood
El Obeid
Um Rwaba
Kosti
Rabak
Sinja
Shekan
Tandalti
Tandalti
Sinnar
Abu Zabad
Umm Ruwabah
White Nile
Wad Banda
An Nahud
Ar Rahad
Abu Hugar
Altewsha/Aleet
Abu Zabad
Al Salam
El Jebelein
Sheiria
Gebeish
Dilling
Alrshad
Aldali wal Almazmoum
El Dalanj
Al Tdamon
Lagawa
Southern Darfur
Southern Kordufan
South Sudan
Blue Nile
Ad Duayn
Adiela
El Salam
Ed Daein
Abu Jibieha
Kadogli
Talody
Bau
0
50
100
Km
N

Red Sea

LAND COVER PERCENTAGE



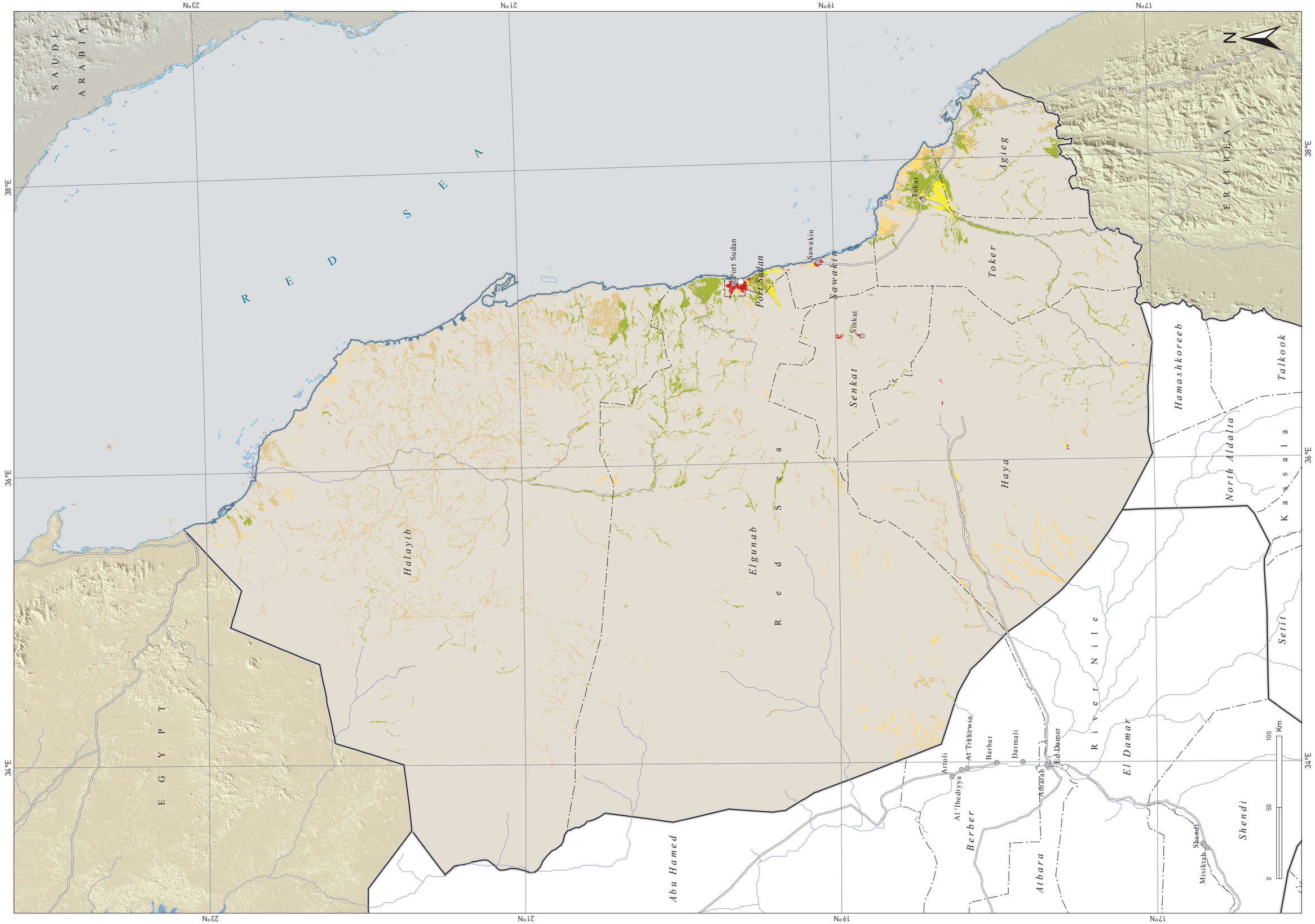
STATES AREA COMPARISON (1M HA)



INDEX MAP

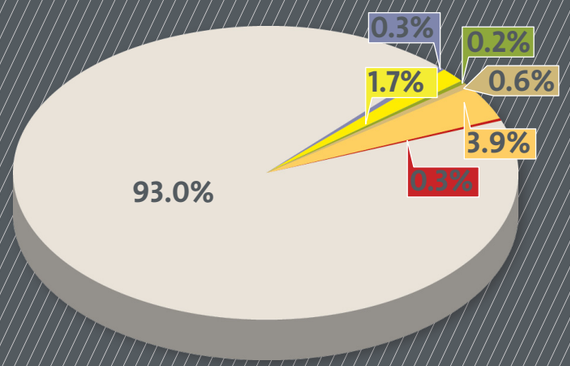
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Agieg	1,700	54,255	44,706	57,655	0	600,529	3,343	762,188
Elgunab	4,952	117,295	213,513	139,830	336	6,575,594	710	7,052,230
Halayib	0	156,711	685,608	57,919	2,032	7,209,838	11,551	8,123,659
Haya	4,333	33,414	39,878	189,371	848	3,212,241	5	3,480,091
Port Sudan	3,185	13,187	6,452	5,476	10,578	13,237	1,249	53,363
Sawakin	707	2,027	4,888	40,427	1,280	148,955	4,132	202,415
Senkat	350	4,613	2,833	3,559	1,722	792,992	5	806,074
Toker	14,928	77,461	33,001	84,365	725	926,158	6,040	1,142,679
Grand Total	**30,155**	**458,962**	**1,030,880**	**578,602**	**17,522**	**19,479,544**	**27,033**	**21,622,699**


23°N
21°N
19°N
17°N
38°E
36°E
34°E
N
SAUDI ARABIA
RED SEA
ERITREA
EGYPT
Port Sudan
Sawakin
Tokar
Agieg
Toker
Sinkat
Senkat
Hayan
Hamashkoreeb
Talkook
North Aldalta
Kassala
Setit
Halayib
Elgunab
Red Sea
Abu Hamed
River Nile
El Damar
Berber
Atbara
Shendi
Misiktab
Artoli
Al 'Ibediyya
Ar Tikkewin
Barbar
Darmali
Atbarah
Ed Damer
0
50
100
Km

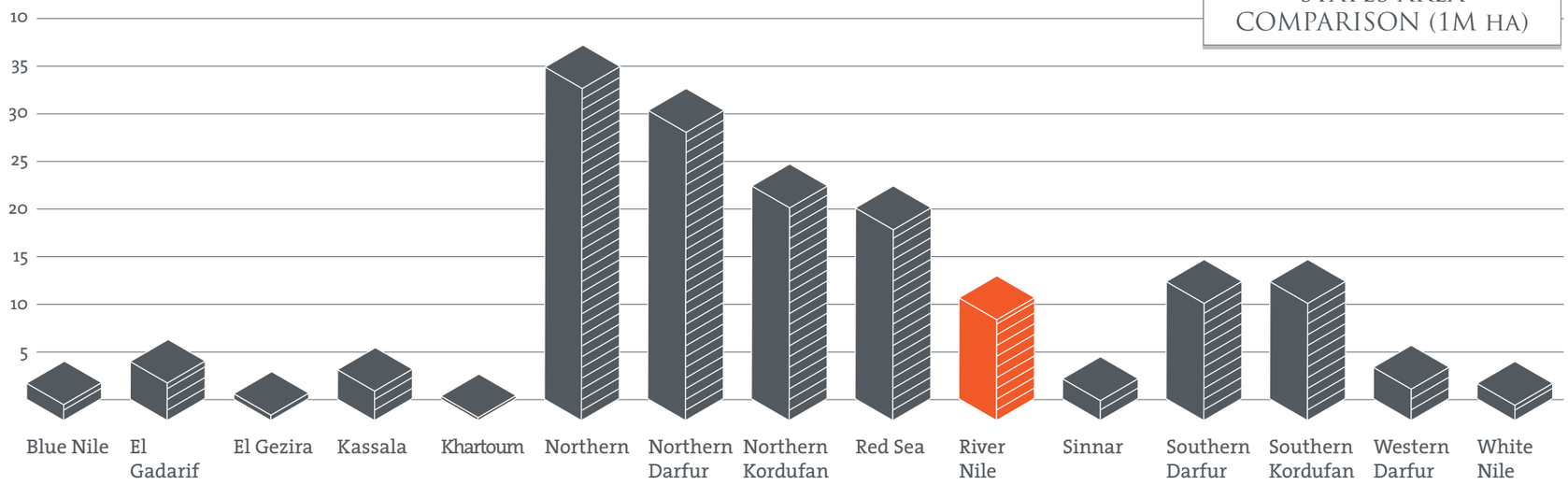
River Nile

LAND COVER PERCENTAGE



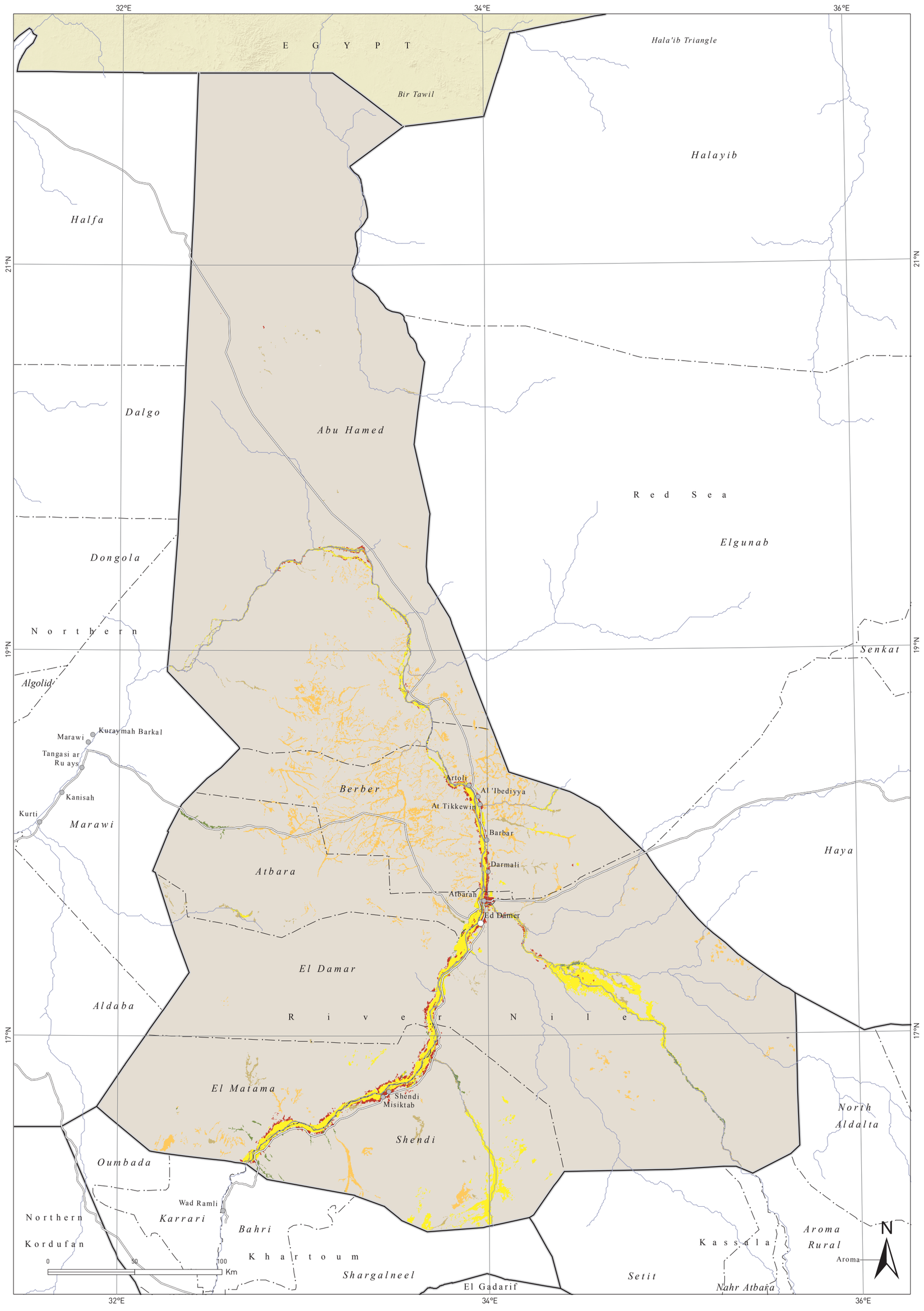
INDEX MAP

STATES AREA COMPARISON (1M HA)



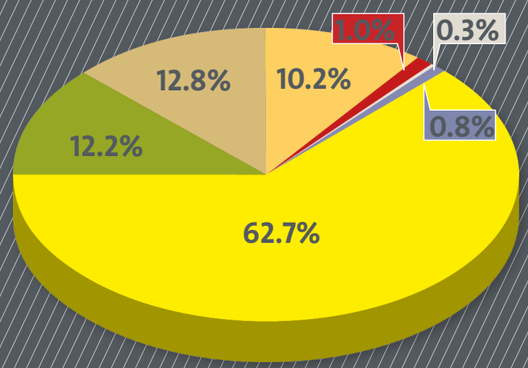
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Abu Hamed'	20,187	38	8,925	85,982	4,313	4,878,315	15,083	5,012,843
Atbara'	9,640	4,209	10,474	43,931	3,405	787,999	1,542	861,201
Berber'	23,057	8	6,942	156,758	8,939	1,140,609	7,547	1,343,860
El Damar'	80,470	4,616	24,472	71,514	8,997	3,501,588	9,741	3,701,398
El Matama'	31,172	1,992	9,757	77,535	7,595	792,802	5,837	926,688
Shendi'	63,411	11,544	11,560	71,306	10,996	1,011,007	3,078	1,182,903
Grand Total	**227,937**	**22,408**	**72,130**	**507,026**	**44,245**	**12,112,321**	**42,828**	**13,028,895**

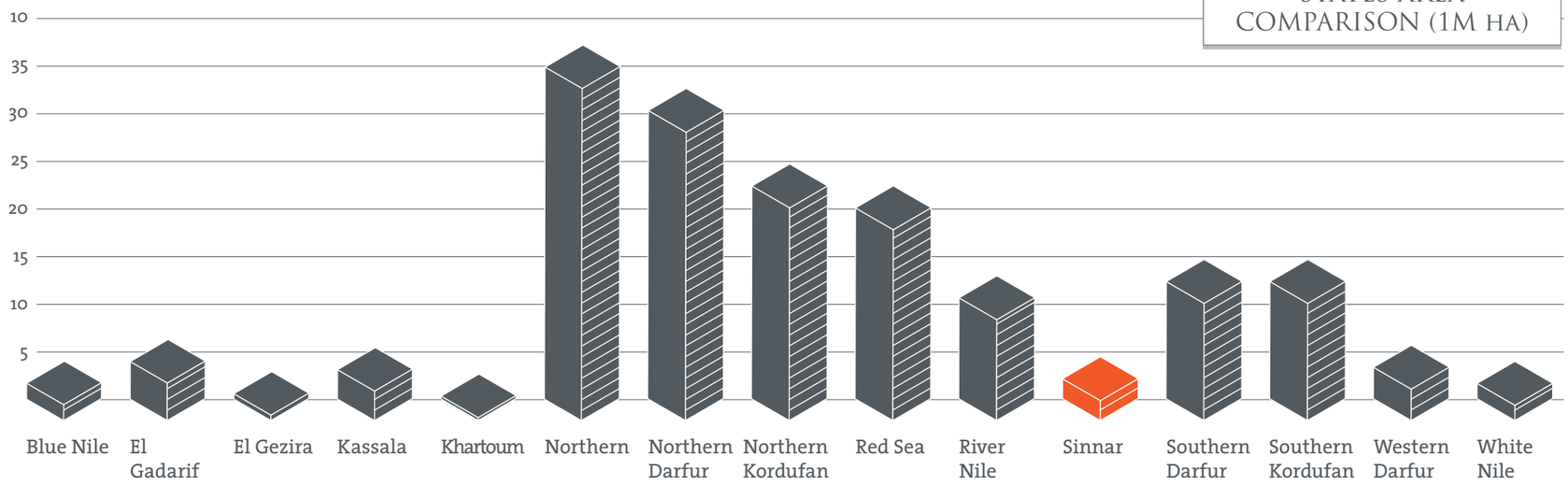

32°E
34°E
36°E
21°N
19°N
17°N
E G Y P T
Hala'ib Triangle
Bir Tawil
Halayib
Halfa
Dalgo
Abu Hamed
Red Sea
Elgunab
Dongola
Northern
Senkat
Algolid
Marawi
Kuraymah Barkal
Tangasi ar Ru ays
Kanisah
Kurti
Marawi
Berber
Artoli
Al 'Ibediyya
At Tikkewin
Barbar
Darmali
Haya
Atbara
Atbarah
Ed Damer
El Damar
Aldaba
R i v e r N i l e
El Matama
Shendi
Misiktab
Shendi
North Aldalta
Oumbada
Wad Ramli
Northern Kordufan
Karrari
Bahri
K h a r t o u m
Shargalneel
El Gadarif
Setit
Kassala
Aroma Rural
Aroma
Nahr Atbara
0
50
100
Km
N

Sinnar

LAND COVER PERCENTAGE



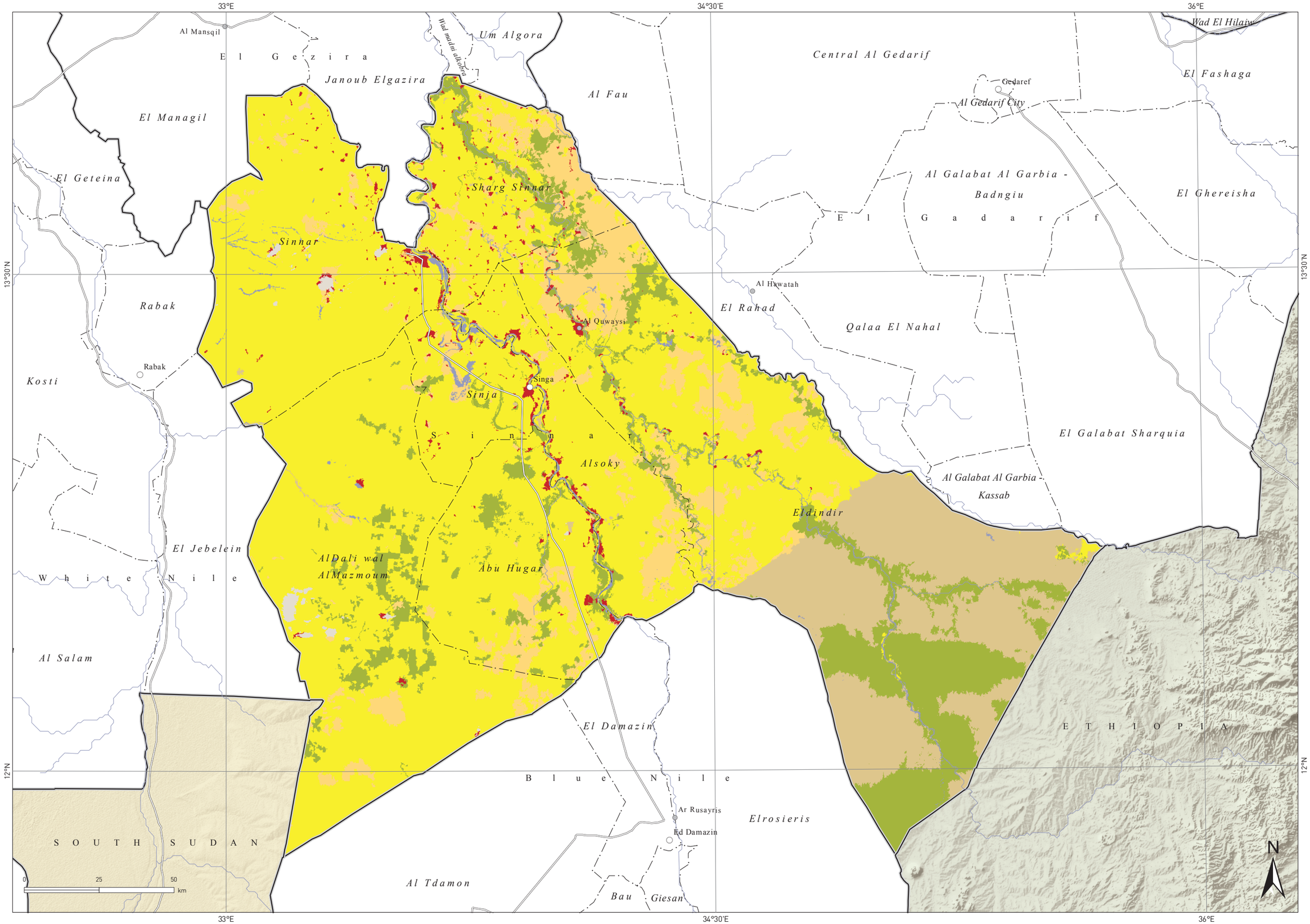
STATES AREA COMPARISON (1M HA)



INDEX MAP

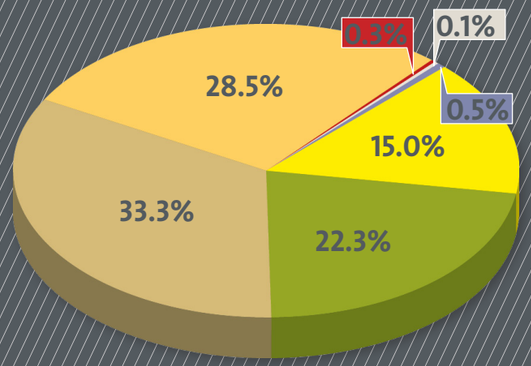
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Abu Hugar	293,832	42,417	547	39,875	4,338	204	1,497	382,710
AlDali wal AlMazmoum	705,004	60,839	1,176	34,521	1,424	4,920	1,145	809,030
Alsoky	228,545	9,815	1,823	25,699	6,033	9	5,984	277,908
Eldindir	391,632	318,043	498,741	191,641	5,150	0	8,855	1,414,062
Sharg Sinnar	182,527	42,538	978	78,406	7,531	0	3,406	315,387
Sinja	143,175	6,340	144	11,698	5,261	0	5,690	172,307
Sinnar	514,232	180	777	18,652	7,922	4,830	6,231	552,823
Grand Total	**2,458,947**	**480,173**	**504,186**	**400,492**	**37,659**	**9,963**	**32,808**	**3,924,228**


33°E
34°30'E
36°E
13°30'N
12°N
Al Mansqil
E l G e z i r a
Janoub Elgazira
Wad madni dkobra
Um Algora
Al Fau
Central Al Gedarif
Wad El Hilaiw
El Fashaga
Gedaref
Al Gedarif City
El Managil
El Geteina
Sharg Sinnar
Sinnar
Al Galabat Al Garbia -
Badngiu
E l G a d a r i f
El Ghereisha
Rabak
Al Hawatah
El Rahad
Qalaa El Nahal
Al Quwaysi
Rabak
Kosti
Singa
Sinja
S i n n a r
Alsoky
El Galabat Sharquia
Al Galabat Al Garbia -
Kassab
Eldindir
El Jebelein
W h i t e N i l e
AlDali wal
AlMazmoum
Abu Hugar
Al Salam
El Damazin
E T H I O P I A
B l u e N i l e
Ar Rusayris
Elrosieris
Ed Damazin
S O U T H S U D A N
Al Tdamon
Bau
Giesan
0
25
50
km
N

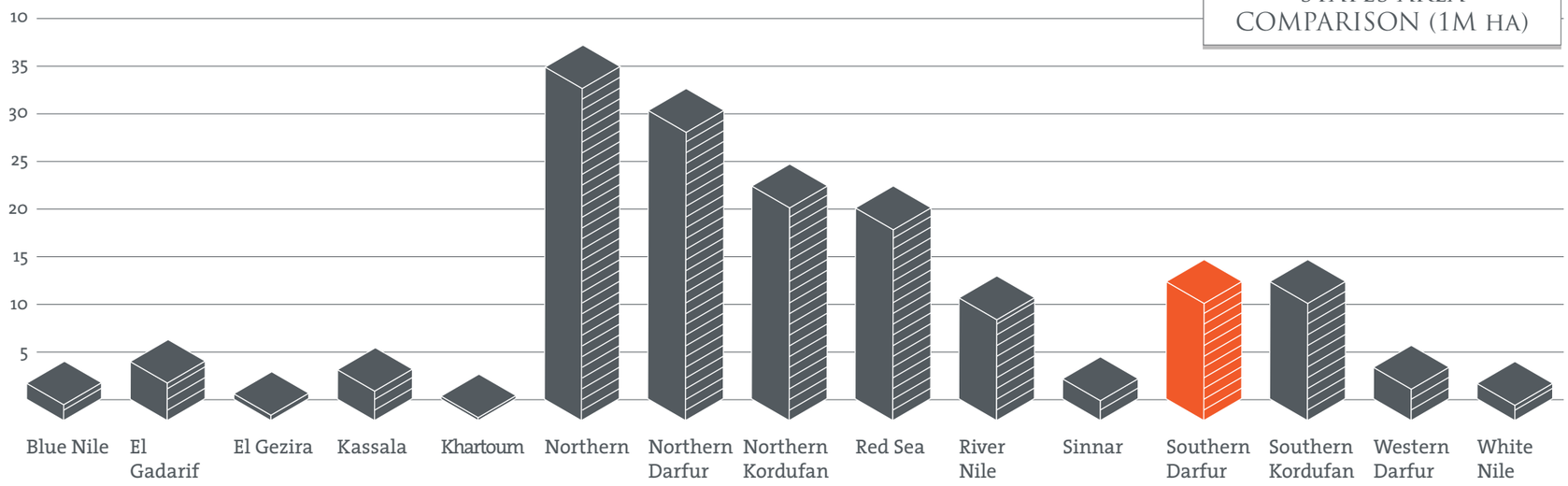
Southern Darfur

LAND COVER PERCENTAGE



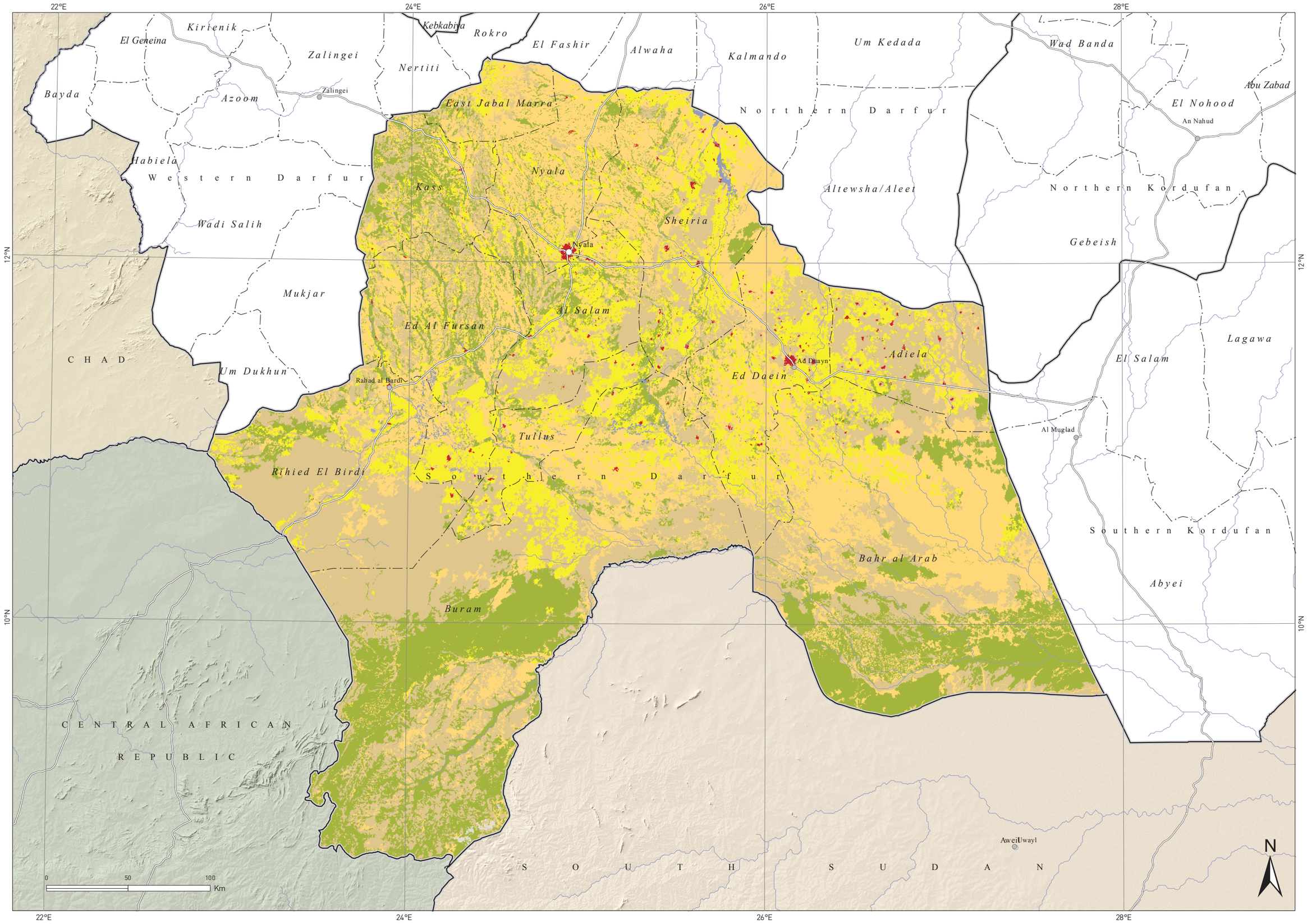
INDEX MAP

STATES AREA COMPARISON (1M HA)



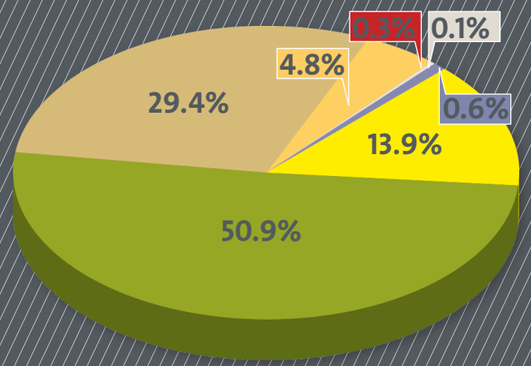
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Adiela	144,133	33,011	397,075	56,781	6,850	0	0	637,850
Al Salam	215,543	160,222	202,500	151,731	3,260	42	3,104	736,403
Bahr al Arab	180,131	906,851	771,087	1,082,807	1,765	0	1,156	2,943,797
Buram	288,662	1,224,673	1,403,641	625,034	2,009	6,334	10,661	3,561,015
East Jabal Marra	33,940	36,920	39,953	180,488	796	911	395	293,404
Ed Al Fursan	208,421	184,679	240,664	363,787	2,866	415	14,476	1,015,308
Ed Daein	272,608	20,437	330,090	264,217	10,043	94	1,840	899,329
Kass	55,699	187,728	124,405	178,872	1,682	969	4,591	553,946
Nyala	68,561	83,518	28,721	377,724	7,304	119	4,097	570,045
Rihied El Birdi	175,151	114,035	811,287	188,137	1,333	1,196	7,589	1,298,728
Sheiria	337,151	150,792	273,861	472,416	9,419	274	15,269	1,259,183
Tullus	142,492	54,591	99,089	92,757	1,668	60	3,067	393,724
Grand Total	**2,122,492**	**3,157,458**	**4,722,374**	**4,034,753**	**48,996**	**10,414**	**66,245**	**14,162,732**


22°E
24°E
26°E
28°E
12°N
10°N
Kirienik
El Geneina
Kebkabiya
Rokro
El Fashir
Alwaha
Kalmando
Um Kedada
Wad Banda
Abu Zabad
El Nohood
An Nahud
Zalingei
Nertiti
Bayda
Azoom
East Jabal Marra
Habiela
Western Darfur
Nyala
Kass
Northern Darfur
Altewsha/Aleei
Northern Kordufan
Wadi Salih
Sheiria
Gebeish
Nyala
Mukjar
Al Salam
Ed Al Fursan
Lagawa
El Salam
CHAD
Um Dukhun
Rahad al Bardi
Ad Damyn
Adiela
Ed Daein
Al Muglad
Tullus
Rihied El Birdi
Southern Darfur
Southern Kordufan
Bahr al Arab
Abyei
Buram
CENTRAL AFRICAN
REPUBLIC
Aweil
Uwayl
SOUTH SUDAN
0
50
100
Km
N

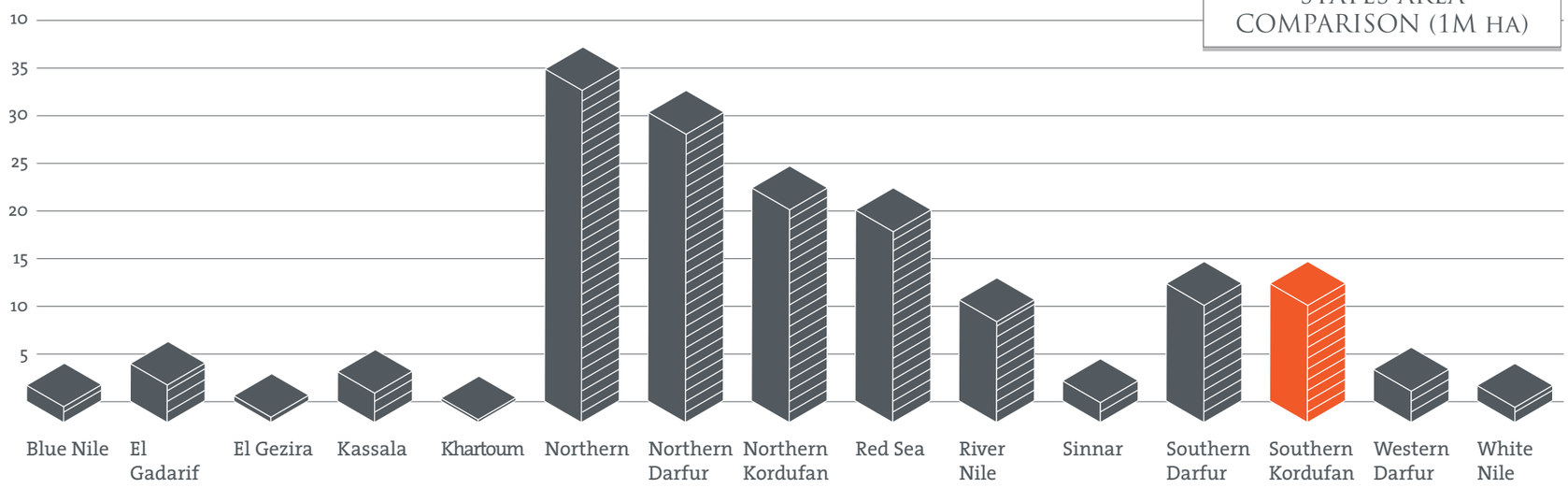
Southern Kordufan

LAND COVER PERCENTAGE



INDEX MAP

STATES AREA COMPARISON (1M HA)



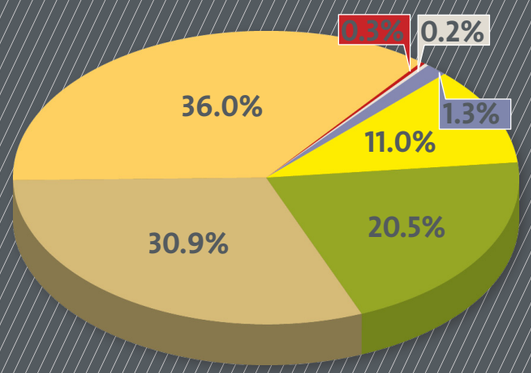
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Abu Jibieha	517,586	930,832	767,530	170,775	2,253	2,083	16,675	2,407,736
Abyei	87,202	2,282,625	194,003	125,746	7,033	0	9,261	2,705,871
Alrshad	305,097	406,704	134,265	42,896	3,043	266	21,396	913,667
El Dalanj	539,422	592,717	379,801	114,287	9,893	4,835	10,465	1,651,419
El Salam	56,300	516,425	540,574	24,902	5,174	210	12,768	1,156,353
Kadogli	186,076	383,957	548,669	27,974	2,506	3,222	10,282	1,162,687
Kielak	26,984	631,459	186,605	32,985	1,050	124	2,710	881,916
Lagawa	171,288	375,693	777,544	98,714	4,593	981	5,230	1,434,042
Talody	73,630	1,054,348	605,607	37,117	637	278	448	1,772,064
Grand Total	**1,963,585**	**7,174,761**	**4,134,598**	**675,395**	**36,182**	**11,999**	**89,235**	**14,085,754**

28°E
30°E
32°E
12°N
10°N
N. Darfur
Um Kedada
Wad Banda
El Nohood
Abu Zabad
Shekan
Northern Kordufan
El Obeid
Um Rwaba
Umm Ruwabah
Ar Rahad
Tandalti
Kosti
Tandalti
White Nile
Al Salam
An Nahud
Abu Zabad
Gebeish
Dilling
Alrshad
El Dalanj
Altewsha
Aleet
Lagawa
El Salam
Southern Kordufan
Abu Jibieha
Al Muglad
Kadugli
Kadogli
Talawdi
Kielak
Talody
Southern Darfur
Abyei
Malakal
South Sudan
Bentiu
0
50
100
Km
N

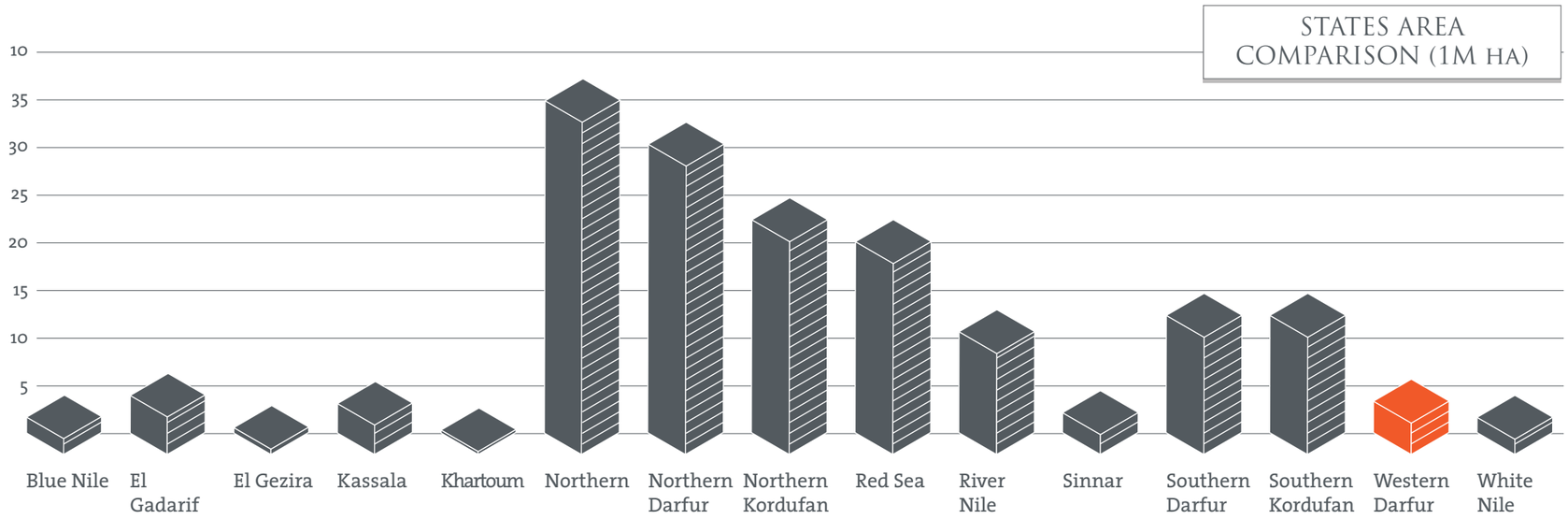
Western Darfur

LAND COVER PERCENTAGE



INDEX MAP

STATES AREA COMPARISON (1M HA)



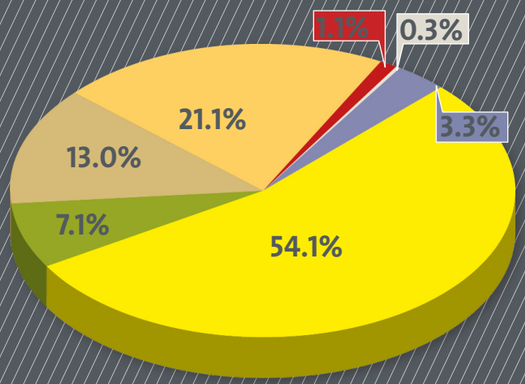
LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Azoom	15,075	85,882	104,883	113,657	1,070	171	8,724	329,461
Bayda	26,687	48,651	23,488	85,786	1,213	0	3,280	189,105
El Geneina	43,405	45,717	109,995	76,615	3,215	1,344	3,143	283,434
Habiela	35,412	71,904	69,468	137,381	1,295	0	4,006	319,465
Kirienik	114,854	84,899	217,186	168,867	3,328	1,241	6,503	596,878
Kulbus	43,527	32,600	205,894	402,359	270	1,675	17,985	704,309
Mukjar	51,362	140,513	272,548	169,017	191	2,655	4,044	640,332
Nertiti	24,707	86,812	35,976	91,756	1,211	15	1,185	241,662
Rokro	28,321	23,033	43,163	62,308	631	44	31	157,531
Sirba	26,943	2,518	88,581	80,120	430	2,030	2,108	202,731
Um Dukhun	38,268	73,803	131,517	35,401	109	0	1,316	280,414
Wadi Salih	99,043	279,101	230,630	280,149	2,061	112	8,302	899,399
Zalingei	52,071	144,806	156,921	266,237	1,991	483	8,631	631,139
Grand Total	**599,674**	**1,120,237**	**1,690,251**	**1,969,654**	**17,016**	**9,771**	**69,258**	**5,475,861**

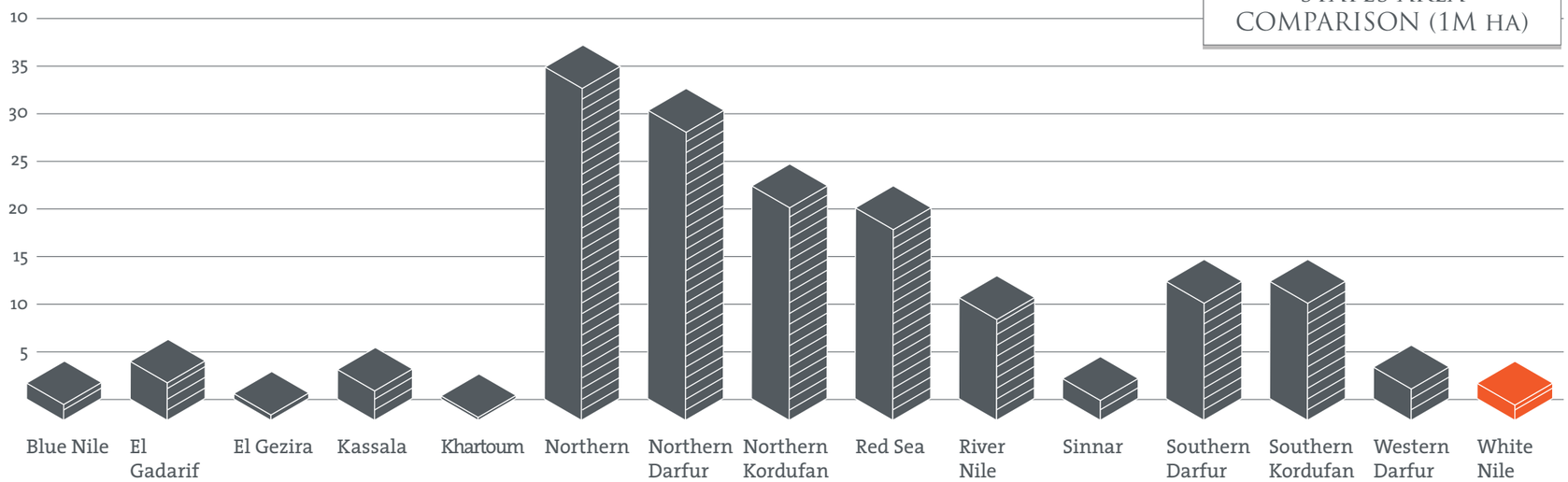
22°E
24°E
14°N
12°N
Altena
Kutum
Kulbus
Northern Darfur
Kutum
Alseraf
Sirba
Sarf Omra
Kebkabiya
El Fashir
El Geneina
Kirtenik
El Geneina
Rokro
Zalingei
Nertiti
Bayda
Azoom
Zalingei
East Jabal Marra
Habiela
Western
CHAD
Darfur
Nyala
Kass
Wadi Salih
Nyala
Mukjar
Ed Al Fursan
Al Salam
Um Dukhun
Rahad al Bardi
Southern Darfur
Tullus
Rihied El Birdi
CENTRAL AFRICAN
REPUBLIC
Buram
N
0
50
100
Km

White Nile

LAND COVER PERCENTAGE



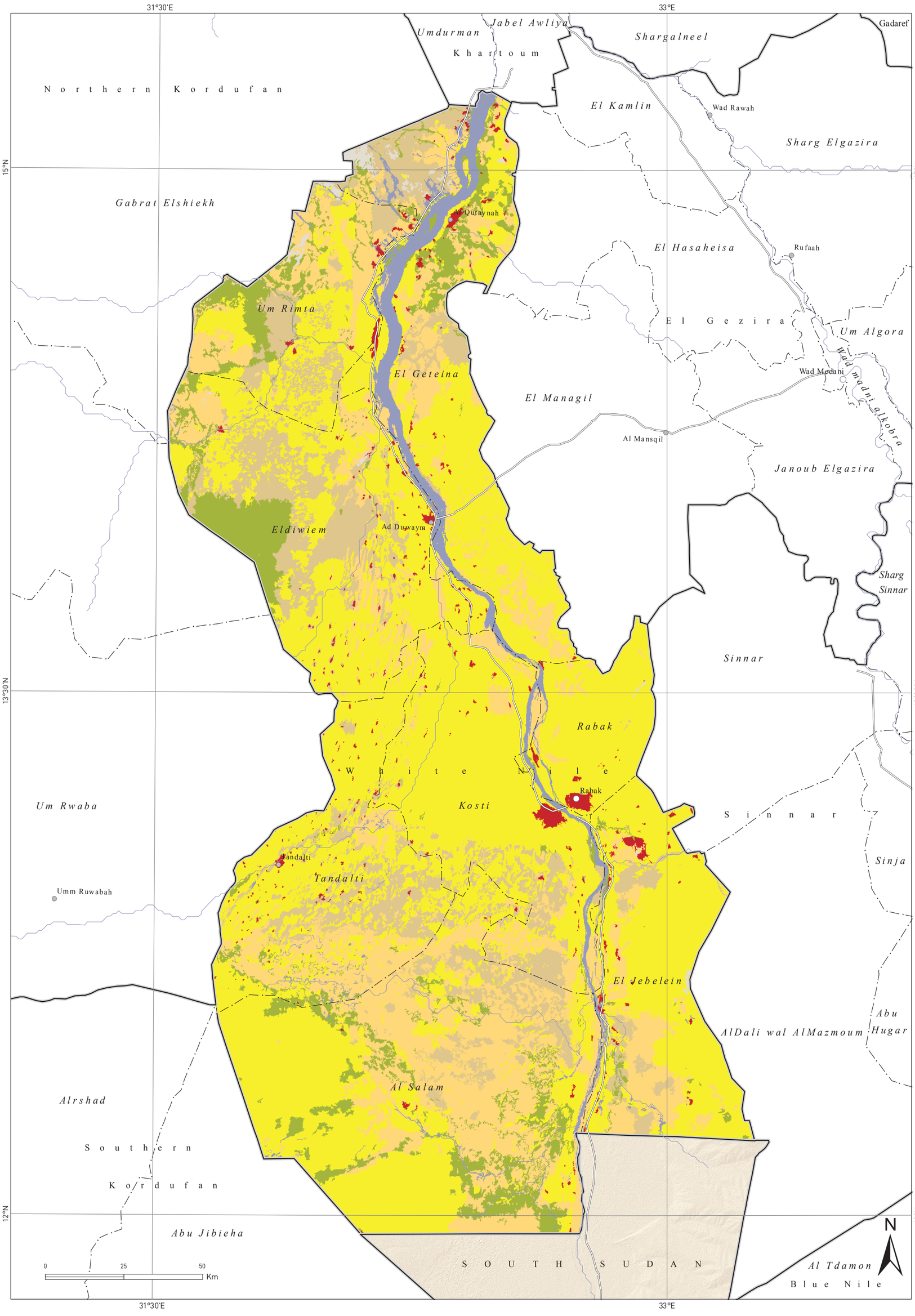
STATES AREA COMPARISON (1M HA)



INDEX MAP

LAND COVER CLASSES IN HECTARES

LOCALITIES	AG	TCO	SCO	HCO	URB	BS	WAT	TOTAL AREA
Al Salam	393,441	93,790	70,184	305,471	1,383	15	6,983	871,267
El Geteina	247,398	44,611	68,425	120,173	7,586	6,378	79,632	574,203
El Jebelein	273,752	7,056	30,431	72,279	6,893	728	5,823	396,963
Eldiwiem	296,346	67,114	138,767	70,193	6,359	807	7,249	586,834
Kosti	336,405	2,648	49,210	53,803	7,119	0	12,579	461,765
Rabak	148,997	456	153	8,671	4,984	223	5,368	168,850
Tandalti	251,444	11,931	76,218	89,558	4,283	0	3,976	437,409
Um Rimta	106,755	43,646	60,870	81,902	3,378	2,176	2,557	301,284
Grand Total	**2,054,539**	**271,251**	**494,257**	**802,049**	**41,985**	**10,328**	**124,166**	**3,798,575**


31°30'E
33°E
15°N
13°30'N
12°N
Umdurman
Jabel Awliya
Khartoum
Shargalneel
Gadaref
Northern Kordufan
El Kamlin
Wad Rawah
Sharg Elgazira
Gabrat Elshiekh
Al Qufaynah
El Hasaheisa
Rufaah
Um Rimta
El Gezira
Um Algora
El Geteina
Wad madni-alkobra
Wad Medani
El Managil
Al Mansqil
Janoub Elgazira
Eldiwiem
Ad Duwaym
Sharg Sinnar
Sinnar
Rabak
White Nile
Rabak
Um Rwaba
Kosti
Sinnar
Tandalti
Tandalti
Sinja
Umm Ruwabah
El Jebelein
Abu Hugar
AlDali wal AlMazmoum
Al Salam
Alrshad
Southern Kordufan
Abu Jibieha
SOUTH SUDAN
Al Tdamon
Blue Nile
0
25
50
Km
N

The Land Cover Atlas of

Sudan