

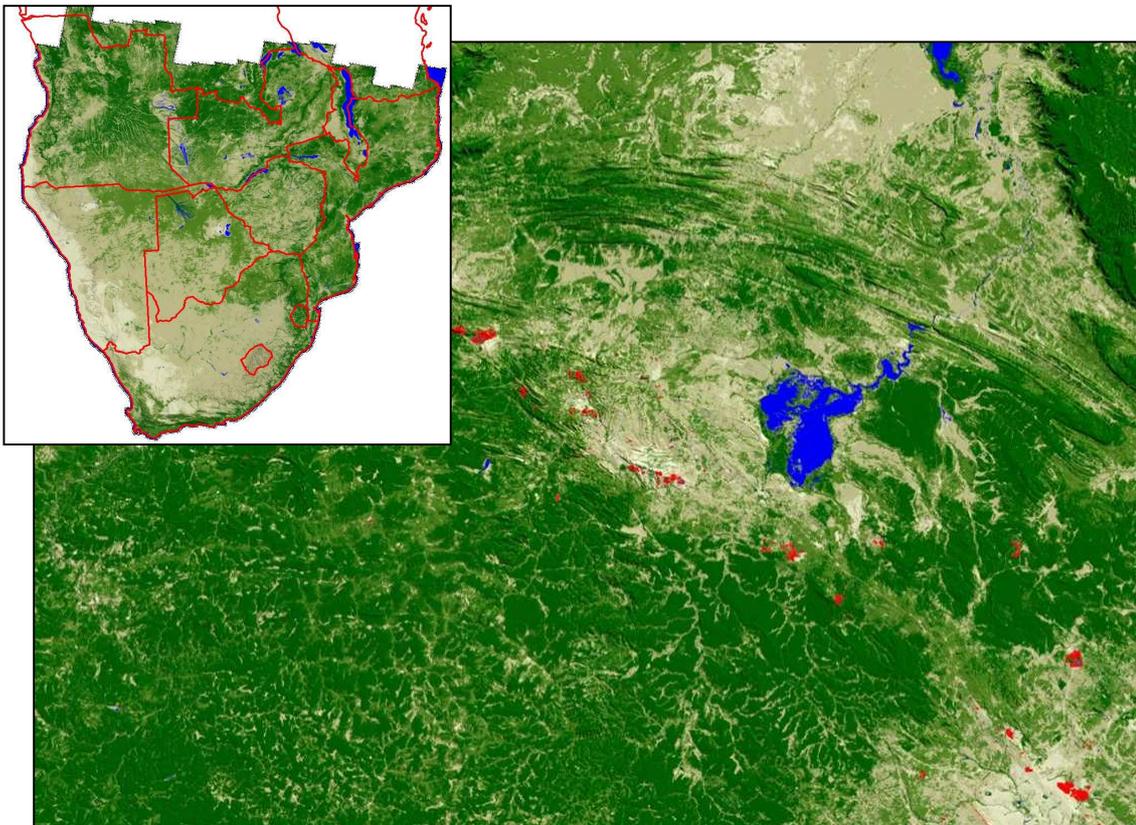
Southern African Land Cover (2015)

Including Mines and Settlements

(Thematic Data)

Data Users Report and Meta Data

(version 4.1)



A Commercial Spatial Data Product Developed by

GeoTerraImage (Pty) Ltd, South Africa

(www.geoterraimage.com)

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1. INTRODUCTION

Understanding and being able to spatially quantify and characterize the landscape is a key requirement for many environmental and resource assessment studies. Whilst land-cover is the primary component of any given landscape, land-use is often the driver or catalyst of changes in land-cover. The ability to be able to spatially quantify *both* land-cover and land-use in terms of end-user applicable scale and information content is therefore an important component and often a pre-requisite in many regional assessment or monitoring procedures where spatial intelligence is required in support of decision making.

2. PRODUCT OVERVIEW

The 2015 Southern African GEOTERRAIMAGE land-cover dataset is a spatially precise, up-to-date inventory of key land-cover and land-use characteristics in Southern Africa, covering Angola, Botswana, Malawi, Mozambique, Namibia, Lesotho, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe, and the DRC's copper-belt region. The information is available as a geospatial map-based commercial product, suitable for GIS¹ applications and is the ideal reference base on which to converge end-user business intelligence with the products location intelligence to help reveal or confirm important regional insights on current landscape patterns.

2.1 Hill-shaded Data Product

A *hill-shaded version* of the southern African GTI land-cover dataset has been created by draping the land-cover dataset over the 30m resolution SRTM² terrain data, and applying a hill-shade factor based on 45° sun azimuth and zenith angle, with a 3 x height exaggeration factor. The hill-shaded version is intended primarily for use as a visual backdrop in cartographic map production activities, or similar uses which do not require quantitative geo-spatial analyses. The hill-shaded dataset has no thematic information content in terms of user-definable or extractable information classes.

3. BACKGROUND AND DATA SUMMARY

Access to current and relevant land-cover and land-use information is typically an important and key pre-requisite for most landscape-based assessments. Access to both land-cover and land-use information allows both the current status and potential drivers of landscape change to be understood and spatially quantified. In support of this type of information requirement,

¹ Geographic Information Systems

² Shuttle Radar Topographic Mission.

GEOTERRAIMAGE has produced a seamless, spatially detailed and information rich up-to-date land-cover / land-use map of Southern Africa. The dataset is designed primarily to be used as an input into GIS based mapping and analysis tools, as an integral and complimentary data component of a wider suite of project specific information. The ability to be able to spatially quantify current landscape characteristics from a regional, and often cross-border context, irrespective of administrative boundaries, can be an important pre-requisite in many regional assessment or monitoring procedures where spatial intelligence is required in support of decision making.

Using recent 30 meter resolution, Landsat 8 satellite imagery, GEOTERRAIMAGE has mapped and spatially quantified land-cover and land-use characteristics across 11 countries in Southern Africa, from the Cape Town in South Africa to the copper-belt mines in Southern DRC.

The Southern African land-cover / land-use dataset represents one example of several regional and national land-cover / land-use datasets available from GeoTerraImage. Please contact GeoTerraImage for more information on these or other spatial information products.

4. PRODUCT DESCRIPTION AND DATA CONTENT

The latest release of the 2015 Southern African land-cover dataset provides spatial representation on regional vegetation characteristics (i.e. tree, bush and grass dominated landscapes), all surface water bodies, bare non-vegetated surfaces, mining activity and major settlements. The dataset has been generated as a desk-top only mapping exercise. Other than for qualitative comparison of interim and final outputs to public accessible reference material, such as high resolution Google Earth © imagery, no formal verification or map accuracy assessment has been undertaken.

Note that the mines information covers the full extent of all the mapped areas in Angola, Botswana, Malawi, Mozambique, Namibia, Lesotho, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe, and the DRC's copper-belt region. However the settlement information only covers Botswana, Malawi, Mozambique, Namibia, Lesotho, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. Settlements for Angola and the mapped extent of the DRC's copper-belt will be included in future data updates.

The dataset is presented in spatially referenced digital raster format, suitable for GIS-based mapping and analysis; and is based on 30 meter cells equivalent to the resolution of the source Landsat satellite imagery. The data is delivered in ERDAS IMAGINE *.img format based on UTM 35 North / WGS84 map projection. The 30 meter resolution format of the source satellite imagery, and all

derived land-cover / use information, is compatible with spatial mapping analyses based on \pm 1:100,000 scale or coarser data, with a theoretical minimum feature mapping area of \pm 1 ha.

The 2015 Southern African land-cover dataset is currently based on a basic 11 x class information legend, that describe the full extent of the landscape in the mapped geographical area. Table 1 lists the 11 x class legend content for the latest data release.

Note that the tree, bush, grass, bare and water cover classes are "pure", broad-level land-cover categories, such that other than for the mines and settlement classes, each cover class may represent several other land-cover or land-use sub-classes. For example, the tree related cover class may represent either a natural or man-made tree dominated environments, such as indigenous forest or orchards . Similarly the bare class may represent a non-vegetated erosion area or a natural beach area. These information land-cover classes are essentially "foundation classes" that can be used as "building blocks" that can be used to adapt the current land-cover dataset into more detailed sub-classes as and where required.

The settlement areas have been incorporated into the land-cover dataset as a series of information classes that have allowed retention of the original 'base vegetation / bare ground' information content, so that the original extent of these base information classes can be re-created if desired. This approach also provides additional information on whether an settlement is vegetation covered or primarily composed on bare ground such as sealed surfaces.

4.1 Future Updates

The current legend content and coverage is continuously being updated for the entire Southern Africa land-cover data coverage. The following additional land-cover / use classes will be released shortly to enhance the information content of the data:

- Cultivated land area (sub-divided into commercial and subsistence practices)
- Rural Settlements³
- Wetlands
- Permanent and Seasonal Water sub-classes
- Plantation forestry boundaries

³ Note all settlements for Angola will be generated as part of future updates.

Please contact GeoTerraImage for more information on these or other spatial information products (www.geoterraimage.com).

5. DATA GENERATION

The Landsat 8 imagery used to generate the land-cover dataset was sourced from the web-based image archives of the United States Geological Survey (USGS). The original image data was sourced in geo-corrected UTM (north), WGS84 projection format, and all land-cover classifications and modeling was completed using this projection format.

5.1 Base Land-Cover Classification

The 'base' land-cover classification (i.e. water, vegetation and bare ground), has created using semi-automated modelling procedures, from multi-seasonal image data, across 165 x Landsat image frames that cover the 11 x southern African countries, plus the DRC's copper-belt region. Typically an average of 7 images from different acquisition dates within one annual, seasonal cycle were used to generate the land-cover data within *each* image frame, with a minimum of 3 and a maximum of 9 images per image frame. In excess of 1,200 individual images were processed as part of the multi-seasonal Landsat image acquisition dates. The eastern coastal regions of Mozambique and northern KwaZulu-Natal Province (South Africa) typically had the least number of image acquisition dates per frame due to persistent cloud cover conditions.

The 30m resolution Landsat 8 imagery used to generate the 'base' land-cover classes (i.e. water, vegetation, bare ground), in the GTI southern African land-cover classification was all acquired between 2013 and 2015. The South African imagery was primarily acquired during 2013-14, whereas the other country coverage was from imagery acquired primarily between 2014-15. A very small number of older Landsat 5 images were required over selected frames in South Africa as a result of persistent cloud cover problems in some coastal areas during the 2013 - 2014 window, from which the South African Landsat 8 image coverage was sourced.

The base land-cover image date distribution is illustrated in Figure 1.

5.2 Mines Classification

The mine information class represents all non-vegetated, bare ground areas resulting from mining activities, including extraction pits, tailings dumps, dust-impacted areas and surface infrastructure, which are represented collectively as a single mining activity 'footprint'. The mine footprints include

both active and decommissioned mines, ranging from small roadside ‘borrow-pits’ and quarries to large commercial operations. Where water occurs within a mapped mining footprint, the water has been classified as “mines-water”, in order to separate this from other natural and man-made water bodies.

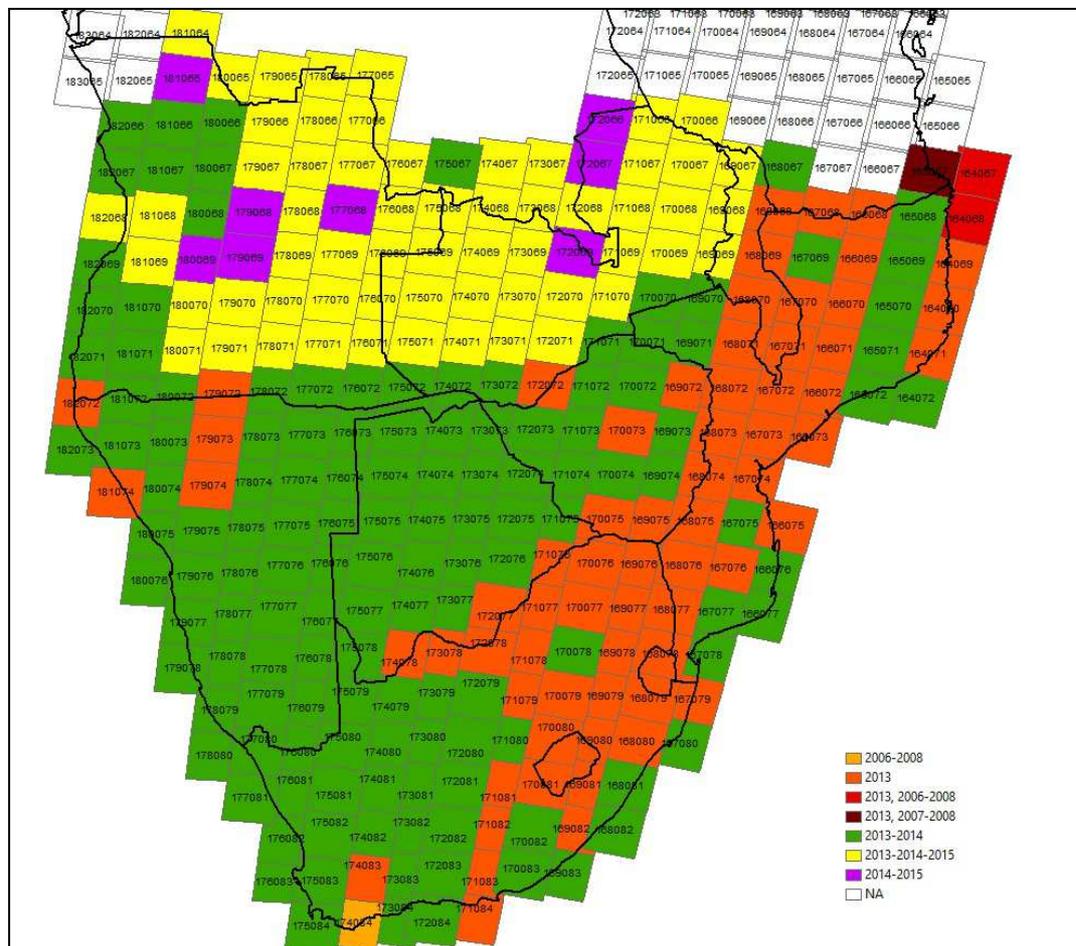


Figure 1. Landsat 8 image acquisition dates for the base land-cover data generation.

The mines were mapped by modifying and enhancing the bare ground cover mapped as part of the base land-cover data generation, and combining this, where required, with more current single-date imagery. This involved using a combination of analyst-assisted interpretation and conventional pixel-based digital classification techniques in order to identify, select and delineate all non-vegetated areas associated with mining activity. The output was visually checked against high resolution Google Earth © imagery acquired during comparable time-frames to confirm the accuracy of interpretation and mapping.

The 30m resolution Landsat 8 imagery used to generate the ‘mine’ land-cover class was all acquired between 2013 and 2016. The South African image coverage was primarily acquired during 2014-15,

whereas the other country coverage was from imagery acquired primarily between 2015-16. The decision to use of more up-to-date Landsat8 imagery for the compilation of the mine information, compared to the slightly older 'base' class information, was to ensure that the mapped footprints were as current as possible, at the time of data production.

The mine class image date distribution is illustrated in Figure 2.

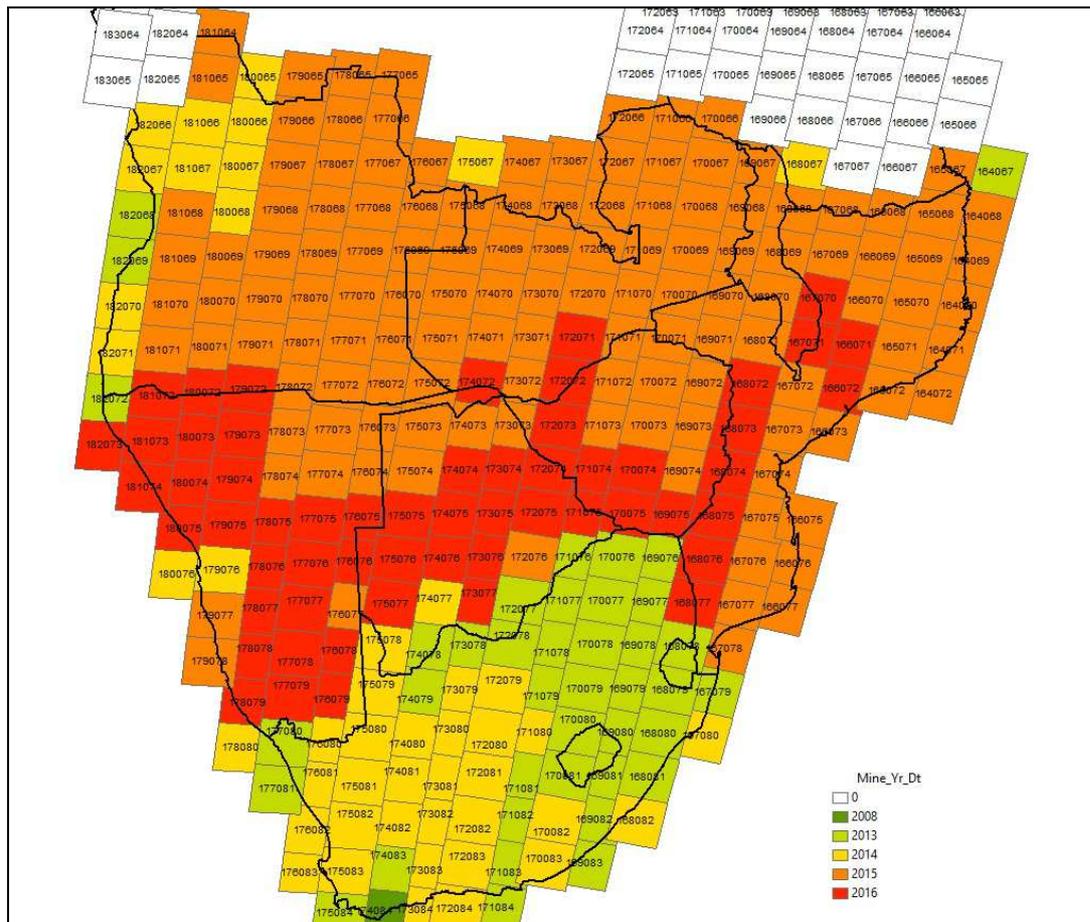


Figure 2. Landsat 8 image acquisition dates for the mine data generation.

5.3 Settlements Classification

The currently mapped settlement data represents all major settlements and built up areas within the mapped land-cover extent, with the exclusion of Angola, the data for which will be included in a future update. Smaller, rural settlement areas will also be included in future upgrades in parallel with the completion of the cultivated land-mapping, since the mapping process for both these information classes is conducted as an integrated procedure.

Settlement areas are represented in 4 x information classes, according to both the mapping / modelling technique used to create the settlement information, and a decision to retain the original 'base' vegetation cover information within the settlement content. The mapped settlement classes represent, without distinction, all built-up areas representative of residential, commercial and industrial land-uses.

The settlement data has been created as an independent process to the background land-cover mapping. The primary aim of the original settlement mapping was to generate a regional population distribution dataset. The results population distribution modelling have been adapted for the land-cover dataset to represent major settlement boundaries. The final representation of settlement boundaries is a combination of the population distribution outcomes (circa 2011) and spectral-spatial characteristics extracted from Landsat 8 satellite imagery (circa 2013). The Landsat 8 imagery used is the same as that used to create the GTI southern African land-cover dataset.

The population distribution modelling was based on several independent data inputs, including the 2014 (Landsat generated), thematic land-cover data, transportation network densities, satellite night-time illumination data, population density data and population distribution datasets. Additional information on this urban modelling is available in the GTI data product report *"Population Distribution Modelling Methodology. Data Users Report and MetaData. Version 1.0, October 2016."*

Class	Class Name	Description
1	Water	All areas of open water that can be either man-made or natural, excluding mine water. Based on the maximum extent of surface water identified in all seasonal image acquisition dates.
2	Bare	Bare, non-vegetated areas dominated but not entirely covered by loose soil, sand, rock or artificial surfaces. May include some very sparse scattered grass, low shrub and / or tree and bush cover. Can be either natural (i.e. beach, rock exposure) or man-made, excluding mines and major built-up areas.
3	Low Vegetation & Grassland	Grass and low shrub dominated areas, typically with no or only a few scattered trees and bushes (i.e. very sparse to sparse tree/bush cover). Mainly natural or semi-natural vegetation communities in both urban and rural environments. This class will also include cultivated lands if crop covered.
4	Tree / Bush Dominated Vegetation	Low tree and bush dominated areas, typically with lower canopy heights and denser tree / bush canopy densities (i.e. sparse to moderate tree/bush cover), than the tree dominated class 5. Includes natural, semi-natural and planted vegetation communities in both urban and rural environments. Will also include young planted forest plantation stands and potentially some high biomass (typically irrigated) croplands, which will be re-classified when the cultivated lands class is added.
5	Tree Dominated Vegetation	Tall tree and bush dominated areas, typically with higher canopy heights and more compact canopy densities (i.e. moderate to dense) than the tree / bush class 4. May also include very dense, closed canopy thicket areas even if not composed of tall structures. Includes natural, semi-natural and planted vegetation communities in both urban and rural environments. Will also include mature planted forest plantation stands and windbreaks, and potentially some high biomass (typically irrigated) croplands, which will be re-classified when the cultivated lands class is added.
6	Mines	All mine activity areas represented by permanent bare ground surfaces. The class includes all mine types from small roadside borrow pits and quarries to larger commercial mining operations, and evaporative salt mines. The mapped footprint represents the combined spatial extent of all extraction pits, tailings dams and associated surface infrastructure.
7	Mines water	All water surfaces associated with mapped mine activity areas. Typically this represents either flooded pits and/or ponded tailings dams. The water extent may be permanent or seasonal.
8	Urban bare	Built-up areas, comprising residential, industrial and / or commercial urban land-use areas, which are characterized by bare, non-vegetated surfaces (i.e. class 2), which may either be man-made or natural in origin.
9	Urban low veg.	Built-up areas, comprising residential, industrial and / or commercial urban land-use areas, which are characterized by low vegetation cover (i.e. class 3), which may either be man-made or natural in origin.
10	Urban tree-bush	Built-up areas, comprising residential, industrial and / or commercial urban land-use areas, which are characterized by a mix of tree and bush vegetation cover (i.e. class 4), which may either be man-made or natural in origin
11	Urban tree	Built-up areas, comprising residential, industrial and / or commercial urban land-use areas, which are characterized by tree dominated vegetation cover (i.e. class 5), which may either be man-made or natural in origin

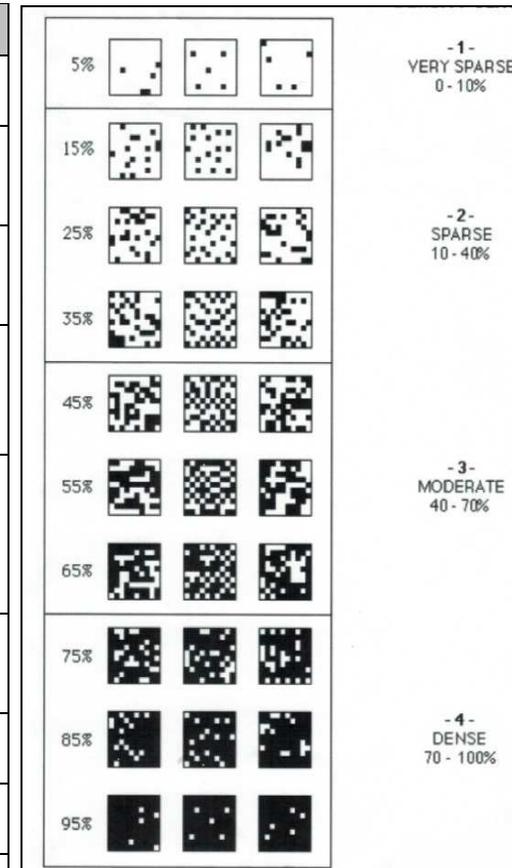


Table 1. Class legend for the latest release of the GTI Southern Africa land-cover dataset, including representative cover density charts for the indicated woody vegetation canopy cover densities (*adapted from Paine, D.P., 1981, Aerial photography and image interpretation for resource management: New York, John Wiley & Sons, p422*).

GEOTERRAIMAGE SOUTHERN AFRICAN (HILL-SHADED) LAND-COVER DATASET including MINES and SETTLEMENTS (2015) : CORE METADATA ELEMENTS (SANS1878)

1(M) Dataset title: sadc_3d_landcover_vs3_utm35n_wgs84

2(M) Dataset reference date: November 2016

3(O) Dataset responsible party: Produced by GeoTerra Image (GTI) Pty Ltd (Mark Thompson, www.geoterraimage.com).

4(C) Geographic location of the dataset.

WestBoundLongitude: -1226274.00 (Upper Left X)
EastBoundLongitude: 2062656.00 (Lower Right X)
NorthBoundLongitude: -541312.00 (Upper Left Y)
SouthBoundLongitude: -3974332.00 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 35 North, WGS84 (datum), meters.

5(M) Dataset language : "English" (eng)

6(C) Dataset character set: UTF8 (8-bit data)

7(M) Dataset topic category: 010 = Base Map earth coverage

8(O) Scale of the dataset: Original Southern African land-cover mapped from 30m resolution Landsat 8 imagery therefore recommended for $\pm 1:100,000$ scale or coarse mapping & modeling applications.

9(M) Abstract describing the dataset: Southern African land-cover generated from multi-seasonal 30 m resolution Landsat 8 imagery, acquired between 2013 – 2015, using desk-top digital modelling and mapping procedures. The land-cover dataset provides seamless data coverage for all of Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe, and the Copper-belt region of the DRC. Dataset is based on 11 x information classes. The dataset is available as a quantitative thematic dataset or as a qualitative, hill-shaded visual cartographic backdrop, after draping over the 30m SRTM terrain data to create a 3D topographic effect. All copyright and Intellectual Property Rights remain at all times with GeoTerraImage.

10(O) Dataset format name: ERDAS Imagine *.img raster format.

11(O) Dataset format version: version 2

12(O) Additional extent information for the dataset: (vertical and temporal)

Vertical Extent:
Minimum Value: n/a
Maximum Value: n/a
Unit Of Measure: n/a

Vertical Datum: n/a

Temporal Extent: Datasets completed in August 2016, based on 2013-15 Landsat 8 imagery.

14(O) Reference system: Universal Transverse Mercator (UTM) 35 North

CRS:
Projection Used: Universal Transverse Mercator (UTM) 35 North
Spheroid used: WGS84
Datum used: WGS 84

Ellipsoid parameters:
Ellipsoid semimajor axis
axis units
denominator of flattening ratio

Projection Parameters:
UTM Zone: 35 (North)
Standard parallel
Longitude of central meridian: 27:00:00.00 East
Latitude of projection origin: 00:00:00.00 North
False easting: 500000.00 meters
False northing: 10000000.00 meters
Scale factor at equator: 0.999600
Projection units: meters

15(O) Lineage statement: Current Southern African land-cover dataset generated in-house by GeoTerraImage (Pretoria) in August 2016, based on 2013-16 Landsat 8 multi-seasonal imagery. Imagery sourced from USGS GLOVIS web-based Landsat data archives, and used as-is in terms of geo-location

16(O) On-line resource: n/a

17(O) Metadata file identifier: n/a

18(O) Metadata standard name: SANS I878

19(O) Metadata standard version: version 01

20(C) Metadata language: English (eng)

21(C) Metadata character set: 021 (UsAscii)

22(M) Metadata point of contact:

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23(M) Metadata time stamp: 22 November
2016