Generation of detailed, GIS compatible, digital urban land-use / land-cover spatial data

for the INTERACT-Bio project

(TANZANIA, INDIA & BRAZIL)

Report and Meta Data

(version 1.0)

INTERACT-Bio
Integrated action on biodiversity

Project supported by

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag

Project implemented by

ICLEI
Local
Governments
for Sustainability

Report developed for

ICLEI-Africa, Cape Town, South Africa

By

GeoTerra Image (Pty) Ltd, South Africa (www.geoterraimage.com)

INTERACT-Bio
Integrated action on biodiversity

Project name: INTERACT-Bio

Full title: Integrated subnational action for biodiversity: Supporting implementation of National Biodiversity Strategy and Action Plans through the mainstreaming of biodiversity objectives across city-regions

Funded by: German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through the International Climate Initiative (IKI)

Project duration: Four years - January 2017 to December 2020

Project countries: Brazil, India and Tanzania

INTERACT-Bio is a four-year project designed to **improve the utilization and management of nature** within fast-growing cities and the regions surrounding them. It aims to provide expanding urban communities in the Global South with **nature-based solutions** and associated long-term benefits.

The project will enable governments at all levels – from local to national – to **integrate their efforts for mainstreaming biodiversity and ecosystem services into core subnational government functions** such as spatial planning, land-use management, local economic development and infrastructure design.

The project will support city-regions to understand and unlock, within their specific local context, the **potential of nature to provide essential services and new or enhanced economic opportunities**, while simultaneously protecting and enhancing the biodiversity and ecosystems on which these services and opportunities depend. In doing so, these actions will place the participating city-regions on a more resilient and sustainable development path.

INTERACT-Bio is implemented by ICLEI – Local Governments for Sustainability. The ICLEI World Secretariat is responsible for project management and coordination in close collaboration with the ICLEI Cities Biodiversity Center (CBC) which provides technical leadership to the project. The CBC is located in the ICLEI Africa office, one of three offices in ICLEI responsible for the regional implementation of INTERACT-Bio. ICLEI South Asia and ICLEI South America are the other two implementing partners.

Technical support for the ecosystem assessment components of the project is provided by Helmholtz-Zentrum für Umweltforschung – UFZ. The Secretariat of the Convention on Biological Diversity is an endorsing partner.

The project is supported by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through the International Climate Initiative (IKI).

ABOUT ICLEI

ICLEI - Local Governments for Sustainability is the leading global network of more than 1,500 cities, towns and regions committed to building a sustainable future.

By helping the ICLEI Network to become sustainable, low-carbon, resilient, ecomobile, biodiverse, resource-efficient and productive, healthy and happy, with a green economy and smart infrastructure, we impact over 25% of the global urban population.

ABOUT ICLEI CBC

ICLEI's Cities Biodiversity Center (CBC) is located in Cape Town, South Africa, embedded in the Africa Regional Office of ICLEI. We offer cities a broad portfolio of supportive services through our dedicated team of passionate, skilled and dynamic biodiversity and urban development experts.

Through our ICLEI CBC programmes and initiatives we seek local solutions and promote innovation to address the complex issues surrounding natural capital and the degradation of ecosystem services in a rapidly urbanizing world. The CBC recognizes the crucial role that cities and local governments play in the pursuit of a greener existence through efficiently integrating urban development and biodiversity management at the local level.

ICLEI CBC offers ICLEI members the following opportunities and services:

- Access to dedicated tools and capacity-building engagements, such as:
  - Workshops and training webinars
  - Urban biodiversity guidelines
  - Peer-to-peer learning and networking opportunities
- International profiling and engagement platforms, including:
  - The Urban-Nature series (a parallel event to ICLEI's tri-annual world congresses)
  - The cities and regions biodiversity summit in partnership with the secretariat of the Convention on Biological Diversity (CBD)
- Participation in global regional and national cities-led programmes.

CONTACT US

• biodiversity@iclei.org • +27 21 202 0381 • www.cbc.iclei.org •

LEGAL TERMS:

DATA COPYRIGHT.

Full copyright of the digital land-cover/use and terrain data resides with ICLEI-Africa. All Intellectual Property Rights regarding the production and mapping methodologies of the digital land-cover data reside with GeoTerraImage (GTI) Pty Ltd.

DATA DISTRIBUTION / LICENCE AGREEMENTS.

ICLEI-Africa has the sole right to authorize distribution and use of the digital land-cover/use and terrain data and accompanying report. Use of this data, in whatever form or application whatsoever implies full understanding and acceptance of these conditions, including all associated or implied restrictions and penalties.

LIABILITIES

The user / client has to verify prior to his commitment, the adequacy of GEOTERRAIMAGE datasets and products to the specific data and analyses needs as set out by the client. GEOTERRAIMAGE will in no event be liable for any direct, indirect, incidental or consequential damages including lost savings or profit, legal fees, lost data, lost sales, loss of commitments, business interruption, including loss of or other damage, resulting from its datasets and products, whether or not GEOTERRAIMAGE has been advised of the possibility of such damage. This includes damages incurred by the client or any third party.

GEOTERRAIMAGE datasets and products are processed from sources like topographic maps and satellite images. The data and data products are provided “as is”, without warranty of any kind, either express or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.

Whilst all possible care and attention will be taken in the production of the defined dataset and report product(s), neither GeoTerraImage (GTI), or any of their respective sub-organizations or employees, accept any liability whatsoever for any perceived inaccuracies or misrepresentations of the information presented within the digital data or accompanying report, as a result of the nature of land-cover mapping and modelling from coarse and medium resolution satellite imagery. Any image mapped boundaries

1. Objective and Background

GEOTERRAIMAGE was approached by ICLEI-Africa to assist in the generation of detailed, GIS compatible, digital urban land-use / land-cover maps for City Region areas located in Brazil, India and Tanzania. This information is required by ICLEI as primary base reference data in support of the INTERACT-Bio project. The general areas of interest within which the City Regions (CR's) are located in each county are defined primarily by country specific administrative area boundaries. The actual City Boundary Regions (CBR's) which define the land-use / land-cover mapping extents have been more precisely defined using a combination of satellite image, terrain data and administrative boundary combinations, which are detailed later.

Table 1: City Region Mapping Areas

Country	State
Tanzania	Arusha
	Dar-es-Salaam
	Kilimanjaro
Brazil	Belo Horizonte
	Londrina
	Campinas
India	Panaji
	Mangaluru
	Kochi

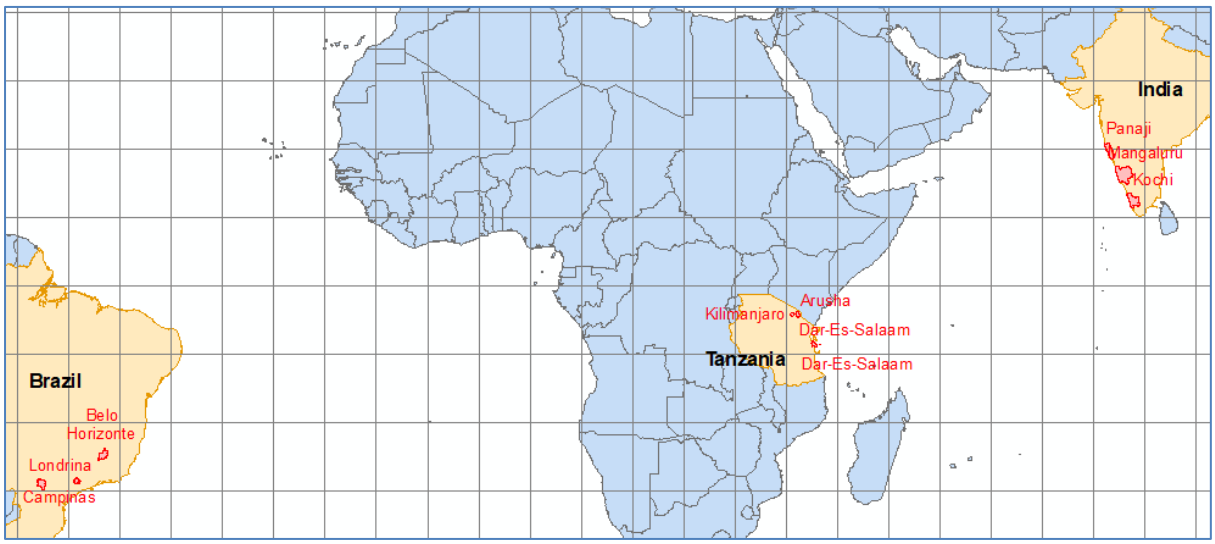


Figure 1. Country / State Locations for City Region Mapping

2. Defining the City Region Boundaries

Since no formal geo-spatial representation of each City Region Boundary (CRB) existed, other than in broad conceptual terms, the first priority was to develop a set of generic geographic spatial modelling rules that could be used to define the actual CRB areas, as well as define other areas in the future. These rules were to be developed using appropriate satellite imagery as the primary reference base against with the CRB boundaries could be determined.

Preliminary modelling procedures were used to establish the spatial extents of long-term, temporal profiles of urban extents, using a combination of multi-temporal 20m Sentinel2 multispectral satellite imagery, and 60m Sentinel1 radar (SAR) imagery, accessed and processed through Google Earth Engine (GEE) cloud-based image data archives. This image-modelling approach was based primarily on establishing the long-term spatial extent of all non-vegetated ground, which was used as a proxy indicator of settlement areas, based on an image-determined size threshold. The area threshold used to define an urban area varied between the CR areas in each country, and was determined through visual image-based inspection based on to the spatial characteristics of the settlement patterns within each landscape, in terms of fragmentation and associated unit area size ranges and distribution. Spatial buffering of these permanent non-vegetated areas generated the first draft of the required CRB area delineations. Whilst this analyst-independent approach resulted in good representations of the actual urban extents within each CR area, it did not provide sufficient area coverage of the hinterland between the urban settlement areas. It was therefore decided, in consultation with the client, to adapt these image-generated CRB extents, using a combination of administrative boundaries, road network coverage and key landscape characteristics, such as water areas; to ensure a more representative CRB extent that provided greater spatial corridor linkages between key urban centers, as well as the surrounding hinterland. This CRB boundary adaption process was primarily undertaken using analyst-defined bespoke GIS modelling, with modelling parameters and rules being CR area specific in most cases.

The figures below illustrate the process of generating the CRB extents, and compares the original image-only defined outputs with the final adapted CRB that was eventually accepted for each CR area. This illustrated procedure, from the Arusha (Tanzania) project area represents, (a) the image generated long-term, permanently bare areas, (b) the bare areas larger than 5 ha, (c) the 5km buffer around these 5 ha bare ground areas, and (d) the final CRB generated after clipping (c) to the required administration boundaries.

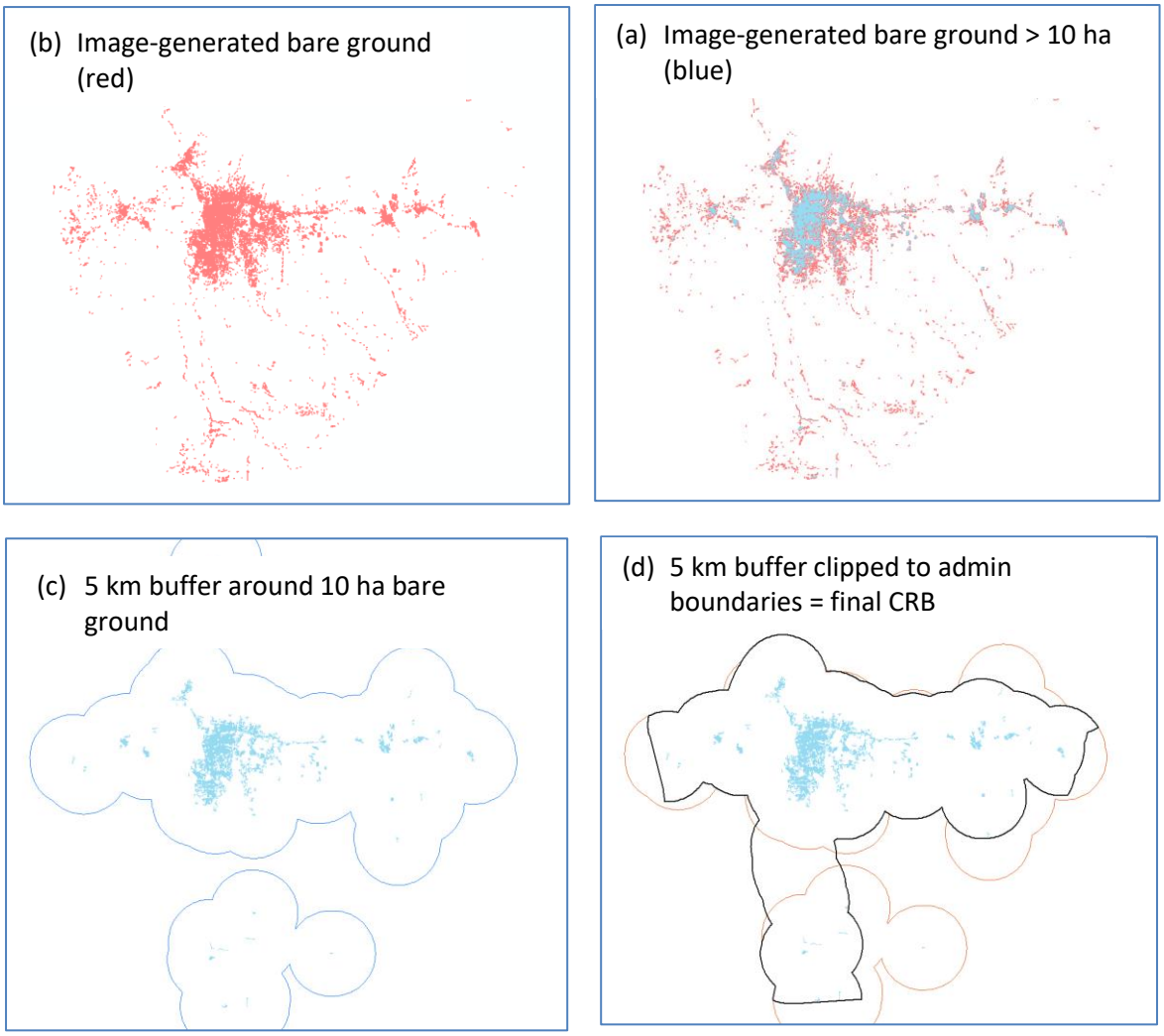


Figure 2. Example of CRB generation stages (Arusha, Tanzania)

Table 2 below summaries the CRB mapping stages and data modelling parameters that were used in the creation of the final CRB's for each project area:

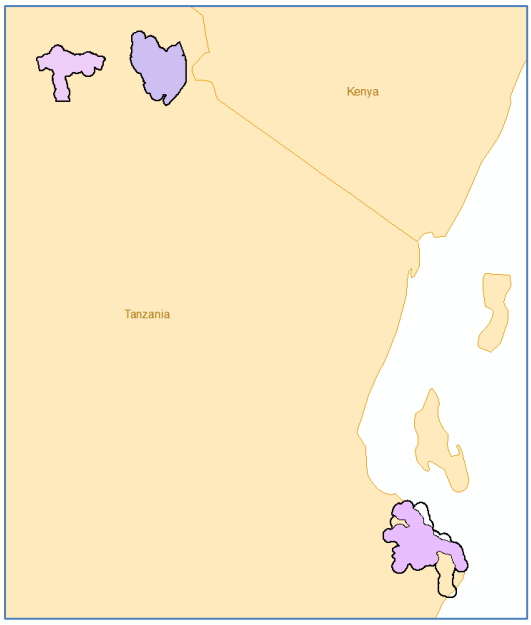
Table 2: City Region Boundary Spatial Modelling Parameters

Country	CRB	Image-generated bare ground and urban threshold ha	Image bare ground buffer extent	Inclusion of additional areas using:		
				Water area buffer extent	ICLEI specified areas (manual)	Road link buffers
Tanzania	Arusha	10 ha	5 km	5 km	n/a	n/a
Tanzania	Dar-es-Salaam	10 ha	5 km	5 km	X	5 km
Tanzania	Kilimanjaro	0.5 ha	5 km	5 km	n/a	n/a
Brazil	Belo Horizonte	2 ha	5 km	5 km	X	5 km
Brazil	Londrina	2 ha	5 km	5 km	X	5 km
Brazil	Campinas	2 ha	5 km	5 km	X	5 km
India	Panaji	5ha	5 km	5 km	X	5 km

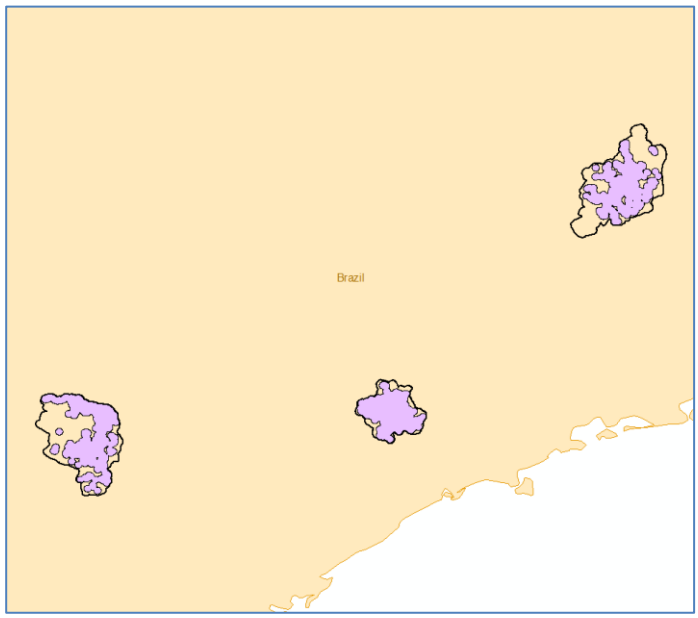
India	Mangaluru	5ha	5km	5km	X	5km
India	Kochi	5ha	5km	5km	X	5km

The following figures illustrated the difference between the original (image-only) and final (modified) CRB extents, per project area:

Tanzania (Arusha, Kilimanjaro & Dar es Salaam)



Brazil (Belo, Londrina & Campinas)



India (Panaji, Mangaluru & Kochi)

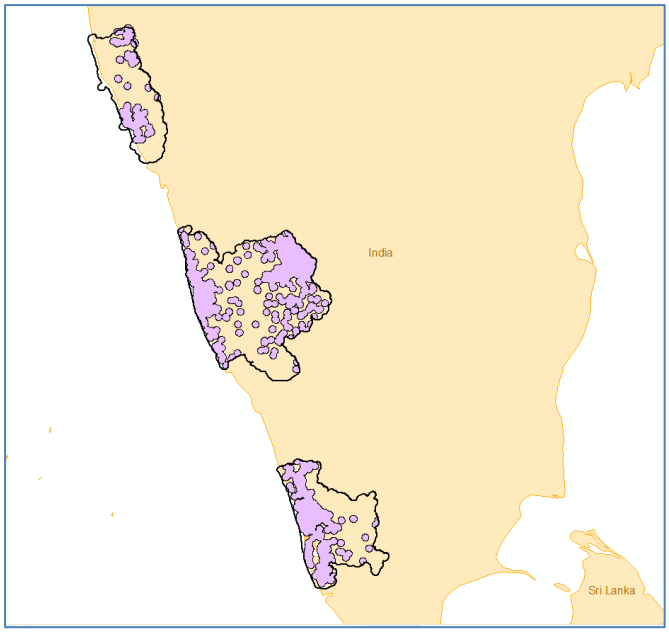


Figure 3. Comparison of Original (Image-only) and Final (Analyst Modified) CR Boundaries

The final area of each CRB extent is shown below in Table 3. This also represents the area of land-use / land-cover mapping detail in each case:

Table 3. Final Areas of Each CRB

Country	CRB	Area sq km
Tanzania	Arusha	1053
Tanzania	Dar-es-Salaam	2563
Tanzania	Kilimanjaro	1685
Brazil	Belo Horizonte	12300
Brazil	Londrina	11635
Brazil	Campinas	5490
India	Panaji	12267
India	Mangaluru	33160
India	Kochi	17075

The total mapped area for Tanzania is 5,301 sq km, and for Brazil 29,425 sq km, and for India 62,502 sq km. The total mapped area for all three countries is 97,228 sq km.

The final CRB datasets are delivered in ESRI ArcGIS vector (polygon) shape file format, in the following UTM / WGS84 map projections:

Table 4. Map Projections for Each CRB

Country	CRB	Projection
Tanzania	Arusha	UTM 37 south
Tanzania	Dar-es-Salaam	UTM 37 south
Tanzania	Kilimanjaro	UTM 37 south
Brazil	Belo Horizonte	UTM 23 south
Brazil	Londrina	UTM 22 south
Brazil	Campinas	UTM 23 south
India	Panaji	UTM 43 north
India	Mangaluru	UTM 43 north
India	Kochi	UTM 43 north

3. Generating Land-Use / Land-Cover Thematic Detail

Detailed land-use / land-cover thematic maps were generated for each final CRB extent. The land-use / land-cover information was mapped from primarily from the best cloud-free, multi-seasonal, 2016-2017, 20m resolution, Sentinel 2 satellite multi-spectral imagery, available from global data archives. The multispectral imagery was in all cases supplemented with similar period, multi-seasonal 20m resolution Sentinel 1 SAR / radar imagery to enhance and improve the identification and separation of key landscape characteristics; associated with seasonal vegetation profiles that in some cases were obscured through partial cloud cover in the multi-spectral imagery. Where appropriate and useful, SRTM30 terrain data was used as additional input data into the land-use and land-cover modelling, if terrain-based parameters could be used to separate spectral characteristics shared between two different information classes. For example, the non-vegetated spectral characteristics of urban area compared to steep cliff rock exposures, or sea-adjacent beach areas.

The land-use / land-cover generation process involved a combination of both conventional image-pixel based classification procedures and bespoke spatial modelling procedures, developed for this specific project and the image datasets used. All land-use / land-cover data processing utilized desk-top only procedures, rather than cloud-based analyses. However, several of the input datasets used within the desk-top classification procedures, such as the long-term NDVI maximum value composites, were generated from and within cloud-based image data archives, after which the results were downloaded to a desk-top PC environment for inclusion in final land-use / cover mapping. The following Sentinel 2 imagery was used as the *primary* cloud-free reference for land-use / land-cover mapping, (although additional image datasets were used for cloud-obscured in-fills).

Table 5. Acquisition Dates for Source Sentinel 2 Satellite Imagery for Each CRB

Country	**CRB**	**Sentinel 2 image dates used in the land-use / land-cover mapping**
Tanzania	Arusha	2016-05-02
Tanzania	Dar-es-Salaam	2016-07-10, 2016-07-30
Tanzania	Kilimanjaro	2016-02-04, 2016-05-02
Brazil	Belo Horizonte	2016-07-01, 2016-07-06, 2017-11-13
Brazil	Londrina	2016-11-09, 2017-07-22
Brazil	Campinas	2016-06-16, 2017-09-19, 2017-09-27
India	Panaji	2016-11-01, 2016-11-11, 2016-11-16, 2017-04-30, 2017-11-16
India	Mangaluru	2016-11-08, 2016-08-18
India	Kochi	2017-02-03, 2017-02-16, 2017-01-10

All final CRB land-use / land-cover datasets have been delivered as 20m resolution, raster format datasets, is equivalent to the original 20m resolution of the source Sentinel 2 satellite imagery. The datasets are in ERDAS IMAGINE *img raster format, in the map projections listed in Table 4.

4. Land-Use / Land-Cover Legend Content.

A standard land-use / land-cover legend content, and associated class definitions were used for all CRB project areas, in order to ensure data standardization throughout all supplied data products. Note that the full suite of information classes is not replicated in all CRB mapping areas, simply as a result of this specific information class not being located in that particular CRB area. Table 6 below defines the legend content and the associated class definitions for all CRB areas.

5. Hill-shaded Representation of the Land-Use / Land-Cover Dataset

A hill-shaded (i.e. 3D) representation of each land-use / land-cover dataset has been provided from each CR area, which provides an enhanced visual representation of the classified land-use / land-cover detail. The hill-shaded dataset has been generated by draping the land-use / land-cover dataset over the SRTM30 terrain dataset, using a standard 45 degree sun azimuth and zenith to model the shadow characteristics. This dataset is intended for visual presentation purposes only, such as a cartographic backdrop, and does not contain any thematic intelligence that can be incorporated or used within spatial analyses. This dataset is best viewed within spatial software by setting the colour contrasts parameters to 'max-min'. See Figure 4.

Table 6. Land-Use / Land-Cover Legend Detail and Class Definitions

Class	Name	Arusha	Kilimanjaro	Dar-es-Salaam	Belo	Londrina	Campinas	Panaji	Mangaluru	Kochi	Definition
1	Built-up commercial	X	X	X	X	X	X	X	X	X	Image identifiable areas containing permanent building structures associated primarily with commercial activities.
2	Built-up industrial	X	X	X	X	X	X	X	X	X	Image identifiable areas containing permanent building structures associated primarily with industrial and manufacturing activities.
3	Built-up formal residential	X	X	X	X	X	X	X	X	X	Image identifiable areas containing permanent building structures associated primarily with formal residential areas. Note 01: In the Indian datasets an area-based threshold was used to split all image-modelled residential areas into formal (3) and informal / rural (4) components, based on fragmentation appearance. This value was modified according to local landscape characteristics, i.e. Kochi & Panaji 0.25 ha, and Mangaluru 0.75 ha.
4	Built-up other (various informal / rural scattered)	X	X	X			X	X	X	X	Image identifiable areas containing permanent and/or semi-permanent building structures associated primarily with informal and/or smaller rural-based residential areas. Note 1: in the Tanzanian datasets (Arusha, Kilimanjaro and Dar es Salaam), this class refers more to a combination of open, rural settlements *and* very dense informal urban areas. Note 02: in the Indian datasets (Panaji, Kochi and Mangaluru), this class refers to the widely scattered and disbursed rural settlements, which may still be considered formal rather than informal. The Indian landscape is very different from both Tanzania and

Class	Name	Arusha	Kilimanjaro	Dar-es-Salaam	Belo	Londrina	Campinas	Panaji	Mangaluru	Kochi	Definition
											Brazil, and is composed of a few major settlements, with many smaller but still formal settlements, and a huge number of widely disbursed individual structures and farms. Note 03: The Brazilian landscape is a *very* regulated and formal landscape, within which it has proved very difficult to ID any informal structural class areas, resulting in no class content in Londrina, and only 1 or two instances in Campinas and Belo.
5	Bare non-vegetated land	X	X	X	X	X	X	X	X	X	Image identifiable areas containing permanent and semi-permanent bare, non-vegetated ground. Can be associated with both natural (i.e. beach, rock, river sand) and human-induced conditions (i.e. erosion).
6	Water	X	X	X	X	X	X	X	X	X	Image identifiable areas containing open water surfaces, associated with both natural (river, sea), and man-made features (dam, mine pit).
7	Wetlands	X	X	X	X	X	X	X	X	X	Image identifiable areas containing wetlands, within which the water level either at or near the surface is typically covered in vegetation (either floating or rooted). Includes all wetland types, including seasonal pans, with the exception of coastal Mangrove which is mapped as a separate information class. This class may contain small areas of within-wetland cultivation fields, which are unable to be mapped as separate entities at the scale and detail provided by Sentinel imagery. Where such fields are mappable, then they have been included in class # 15.
8	Tree & bush vegetation	X	X	X	X	X	X	X	X	X	Image identifiable areas which are dominated by natural and semi-natural woody trees and/or tall bushes and shrubs, typically representative of forest, woodland and/or bushland areas. In some Indian and Tanzanian datasets, this class includes palm tree plantations that could not be

Class	Name	Arusha	Kilimanjaro	Dar-es-Salaam	Belo	Londrina	Campinas	Panaji	Mangaluru	Kochi	Definition
											separated from other tree and bush cover at the resolution provided by Sentinel imagery, but which were identifiable on higher resolution Google Earth reference imagery.
9	Grass & low shrub vegetation	X	X	X	X	X	X	X	X	X	Image identifiable areas which are dominated by natural and semi-natural grasslands and/or low shrubs. In some cases, especially in the Tanzanian and Indian datasets this class may include some small scale subsistence field areas (i.e. abandoned, fallow), that were not possible to separate from grasslands at the level of detail provided by Sentinel imagery.
10	Cultivated commercial farms	X	X		X	X	X			X	Image identifiable areas which are dominated by large-scale, commercial crop cultivation activities, often associated with irrigation management practices such as pivot schemes and big field sizes. Note01: In the Indian (Kochi and Mangaluru) and Brazil datasets, this class included orchard crops which could not be separated from other tree & bush covers at the resolution provided by Sentinel, but which were identifiable on higher resolution Google Earth reference imagery.
11	Cultivated smallholder farms	X	X	X				X	X	X	Image identifiable areas which are dominated by small-medium scale, subsistence and/or emerging farmer crop cultivation activities, often associated with rain-fed management practices and small field sizes.
12	Mines			X	X	X	X	X	X	X	Image identifiable areas which contain small or large scale surface mining activities, where the mapped footprint can represent a combination of the extraction pit, tailing dams and resource dumps.
13	Forest Plantations	X	X		X	X	X	X		X	Image identifiable areas which contain man-planted commercial forest plantations. The mapped extent includes both areas containing standing timber crops and temporarily cleared stands awaiting re-planting.

Class	Name	Arusha	Kilimanjaro	Dar-es-Salaam	Belo	Londrina	Campinas	Panaji	Mangaluru	Kochi	Definition
14	Mangrove wetlands			X				X	X	X	Image identifiable areas containing coastal mangrove wetlands, consisting of dense woody mangrove trees and bushes .
15	Wetlands cultivated commercial									X	Image identifiable wetland areas that have been extensively converted to flood-based cultivation practices. This class, which is restricted to the Indian Kochi dataset, has only been mapped where such cultivated fields are clearly observable and mappable on the Sentinel imagery.

The following figures illustrate the final CRB land-use / land-cover classifications (as hill-shaded representations) for all the mapped CRB Areas.

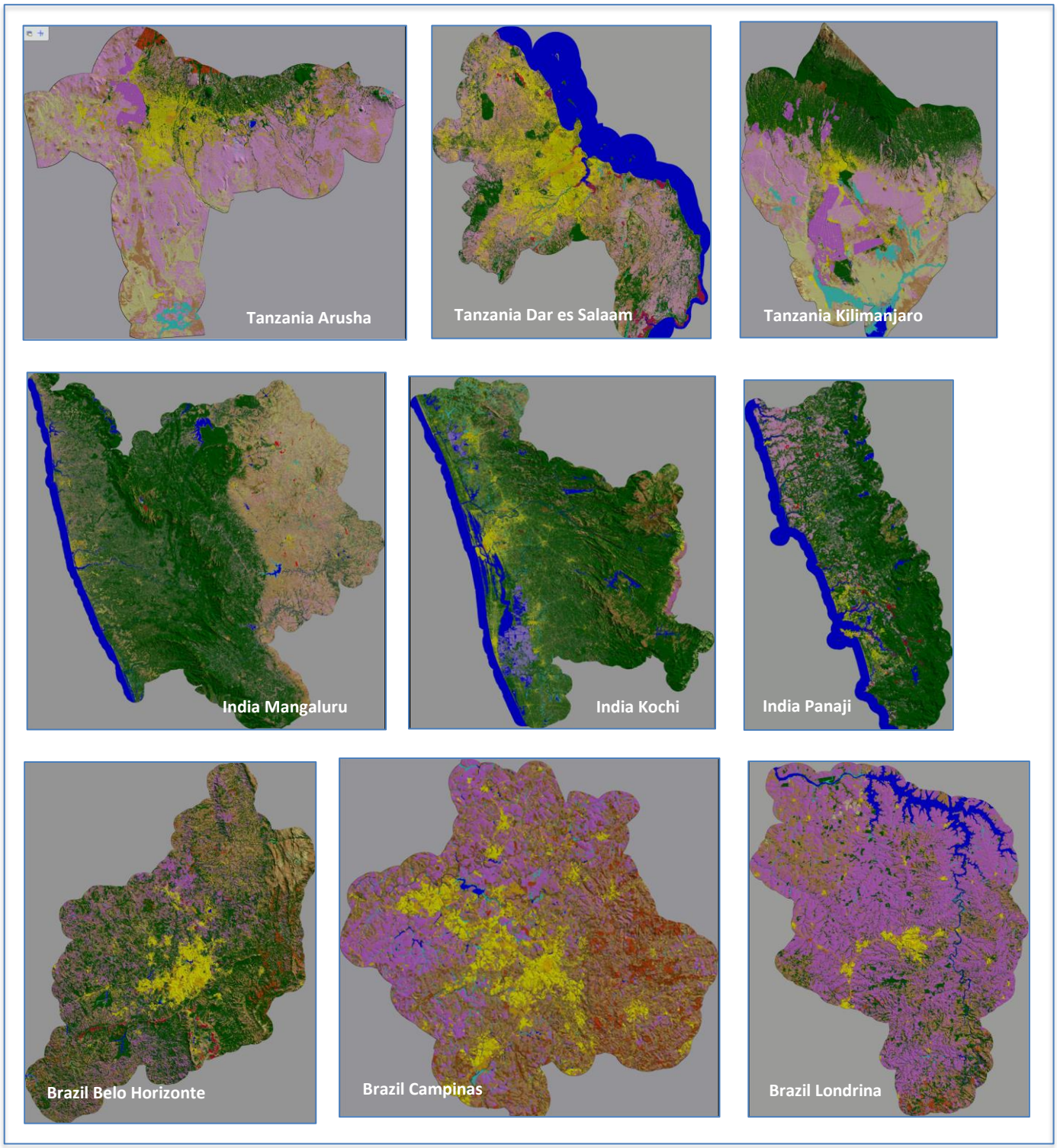


Figure 4. Hill-shaded CR Area Land-Use / Land-Cover Datasets

6. Generating Potential Flood Area Thematic Datasets.

The SRTM30 terrain data was also used to generated potential flood area datasets for each CRB extent, in order to illustrate potential flood risk areas, irrespective of land-cover and land-use, for ICLEI. The potential flood plain datasets represent the horizontal extent of a range of channel in-fill modelled flood heights, based on 1 meter increments, up to 5 meters, above normal stream / river height. Normal stream / river heights have been determined by flow-line modelling on the SRTM30 terrain dataset. Horizontal flood potential areas are modelled on local channel profile characteristics and not a standard distance buffer. Figure 5 below provides an example of the potential flood data coverage, based on India Mangaluru CR Area.

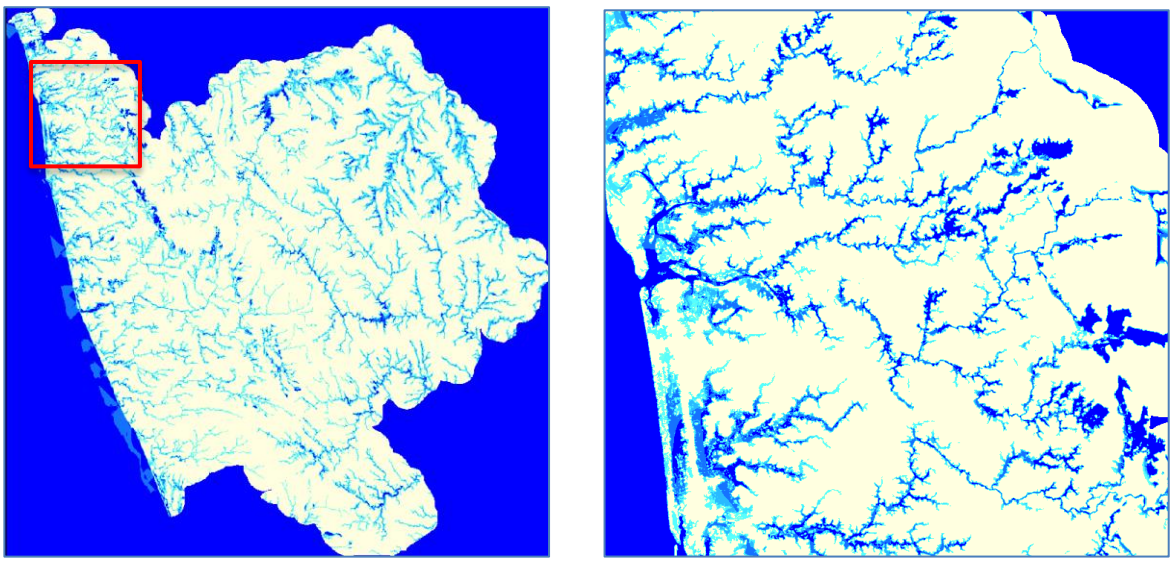


Figure 5. Example of modelled potential flood area coverage for Mangaluru (India) CR Area.

7. Final Data Deliverables.

The following digital datasets have been delivered for all 9 (nine) CR Areas in Tanzania, Brazil and India:

- Final City Region Boundary extent, supplied as a polygon-based digital vector GIS coverage, in the appropriate UTM WGS84 map projection format, in ESRI ArcGIS *.shp format.

- Land-use / land-cover classification of the final CRB extent, supplied as a 20m resolution digital raster GIS coverage, in the appropriate UTM WGS84 map projection format, in 8-bit ERDAS IMAGINE *.img format.

- Hill-shaded version of the land-use / land-cover classification of the final CRB extent, supplied as a 20m resolution digital raster GIS coverage, in the appropriate UTM WGS84 map projection format, in 8-bit ERDAS IMAGINE *.img format.

- Modeled potential flood area classification of the final CRB extent, supplied as a 30m resolution digital raster GIS coverage, in the appropriate UTM WGS84 map projection format, in 16-bit ERDAS IMAGINE *.img format.

- Copy of the original SRTM 30 terrain dataset of the final CRB extent, supplied as a 30m resolution digital raster GIS coverage, in the appropriate UTM WGS84 map projection format, in 16-bit ERDAS IMAGINE *.img format.

ICLEI_Africa: City Region Boundary Datasets for Tanzania, India and Brazil (2016 / 17) :

CORE METADATA ELEMENTS (SANS1878)

1(M) **Dataset titles:** landcover_*[country]*_*[crbname]*_crb_2016-17_utm*[zone]*.img (.rrd)
landcover_*[country]*_*[crbname]*_crb_2016-17_utm*[zone]*_hillshade.img (.rrd)
srtm30_*[country]*_*[crbname]*_crb_2016-17_utm*[zone]*.img (.rrd)
srtm30_*[country]*_*[crbname]*_utm*[zone]*_potential_floodplain_5classes.img (.rrd)
CRB_ *[country]*_*[crbname]*_final_utm*[zone]*.shp (.dbf, .evs, .prj, .cpg, .shx)

2(M) **Dataset reference date:** May 2018

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

4(C) **Geographic location of the dataset. MBR**

(India Kochi)

WestBoundLongitude: 599673 (Upper Left X)
EastBoundLongitude: 768033 (Lower Right X)
NorthBoundLongitude: 1196546 (Upper Left Y)
SouthBoundLongitude: 1001246 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 43 North, WGS84 (datum), meters.

(India Mangaluru)

WestBoundLongitude: 450179 (Upper Left X)
EastBoundLongitude: 681519 (Lower Right X)
NorthBoundLongitude: 1548767 (Upper Left Y)
SouthBoundLongitude: 1314907 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 43 North, WGS84 (datum), meters.

(India Panaji)

WestBoundLongitude: 313130 (Upper Left X)

EastBoundLongitude: 434770 (Lower Right X)

NorthBoundLongitude: 1847865 (Upper Left Y)

SouthBoundLongitude: 1641885 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 43 North, WGS84 (datum), meters.

(Brazil Londrina)

WestBoundLongitude: 413600 (Upper Left X)

EastBoundLongitude: 532840 (Lower Right X)

NorthBoundLongitude: 7499928 (Upper Left Y)

SouthBoundLongitude: 7348568 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 22 South, WGS84 (datum), meters.

(Brazil Campinas)

WestBoundLongitude: 235355 (Upper Left X)

EastBoundLongitude: 332615 (Lower Right X)

NorthBoundLongitude: 7518941 (Upper Left Y)

SouthBoundLongitude: 7425021 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 23 South, WGS84 (datum), meters.

(Brazil Belo Horizonte)

WestBoundLongitude: 499999 (Upper Left X)

EastBoundLongitude: 710539 (Lower Right X)

NorthBoundLongitude: 7899172 (Upper Left Y)

SouthBoundLongitude: 7676552 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 23 South, WGS84 (datum), meters.

(Tanzania Arusha)

WestBoundLongitude: 221625 (Upper Left X)
EastBoundLongitude: 275965 (Lower Right X)
NorthBoundLongitude: 9639351 (Upper Left Y)
SouthBoundLongitude: 9594791 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 37 South, WGS84 (datum), meters.

(Tanzania Kilimanjaro)

WestBoundLongitude: 295556 (Upper Left X)
EastBoundLongitude: 349856 (Lower Right X)
NorthBoundLongitude: 9660057 (Upper Left Y)
SouthBoundLongitude: 9591687 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 37 South, WGS84 (datum), meters.

(Tanzania Dar es Salaam)

WestBoundLongitude: 495896 (Upper Left X)
EastBoundLongitude: 562857 (Lower Right X)
NorthBoundLongitude: 9277940 (Upper Left Y)
SouthBoundLongitude: 9201000 (Lower Right Y)

Projection coordinates based on Universal Transverse Mercator UTM 37 South, WGS84 (datum), meters.

5(M) **Dataset language :** “English” (eng)

6(C) **Dataset character set:** UTF8 (8-bit data), UTF16 (16-bit data),

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

8(O) **Scale of the dataset:** Land-use / land-cover mapped from primarily from 20m resolution Sentinel 2 imagery therefore recommended for ± 1:60,000 scale or coarse mapping & modeling applications. Floodplain data modelled from 30m resolution SRTM30 terrain data, therefore recommended for ± 1:90,000 scale or coarse mapping & modeling applications

9(M) **Abstract describing the dataset:** Single date representation of regional land-use and land-cover within each defined City Region Boundary (CRB) area, derived primarily from 20m resolution Sentinel 2 satellite imagery, acquired between 2016-2017, and classified using desk-top mapping and modelling procedures. Datasets cover nine CRB areas in Tanzania (Arusha, Kilimanjaro and Dar es Salaam), Brazil (Londrina, Campinas and Belo Horizonte), and India (Kochi, Mangaluru and Panaji). The land-use / land-cover datasets contain a maximum of 15 x information classes for GIS modeling applications.

10(O) **Dataset format name:** ERDAS Imagine *img raster formats. ESRI ArcGIS *shp vector format

11(O) **Dataset format version:** version 1

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 generated in May 2018, based on range of ESA's Sentinel 2 imagery acquired during 2016 & 2017 (see Table 4).

14(O) **Reference system:** Universal Transverse Mercator (UTM) : see Table 5

CRS:

(1) **Projection Used: Universal Transverse Mercator (UTM) 37 South**

Spheroid used: WGS84

Datum used: WGS 84

Ellipsoid parameters:

Ellipsoid semimajor axis

axis units

denominator of flattening ratio

Projection Parameters:

UTM Zone: 37 (South)

Standard parallel

Longitude of central meridian: 39:00:00.00 East

Latitude of projection origin: 00:00:00.00 East

False easting: 500000.00 meters

False northing: 1000000.00 meters

Scale factor at equator: 0.999600

Projection units: meters

(2) **Projection Used: Universal Transverse Mercator (UTM) 43 North**

Spheroid used: WGS84

Datum used: WGS 84

Ellipsoid parameters:

Ellipsoid semimajor axis

axis units

denominator of flattening ratio

Projection Parameters:

UTM Zone: 43 (North)

Standard parallel

Longitude of central meridian: 75:00:00.00 East

Latitude of projection origin: 00:00:00.00 East

False easting: 500000.00 meters

False northing: 1000000.00 meters

Scale factor at equator: 0.999600

Projection units: meters

(3) Projection Used: Universal Transverse Mercator (UTM) 23 South

Spheroid used: WGS84

Datum used: WGS 84

Ellipsoid parameters:

Ellipsoid semimajor axis

axis units

denominator of flattening ratio

Projection Parameters:

UTM Zone: 23 (South)

Standard parallel

Longitude of central meridian: 45:00:00.00 East

Latitude of projection origin: 00:00:00.00 East

False easting: 500000.00 meters

False northing: 1000000.00 meters

Scale factor at equator: 0.999600

Projection units: meters

(4) Projection Used: Universal Transverse Mercator (UTM) 22 South

Spheroid used: WGS84

Datum used: WGS 84

Ellipsoid parameters:

Ellipsoid semimajor axis

axis units

denominator of flattening ratio

Projection Parameters:

UTM Zone: 22 (South)

Standard parallel

Longitude of central meridian: 51:00:00.00 East

Latitude of projection origin: 00:00:00.00 East

False easting: 500000.00 meters

False northing: 1000000.00 meters

Scale factor at equator: 0.999600

Projection units: meters

15(O) **Lineage statement:** Land-use / land-cover data generated in-house by GeoTerraImage (Pretoria) in May 2018, based various 2016 & 2017 Sentinel 2 satellite imagery (see Table 5). All imagery either used in-situ within Google Earth Engine data archives, or downloaded and used as-is within a desk-top processing environment.

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:**

Name:	Mark Thompson
Position Name:	Director Remote Sensing
Organisation Name:	GeoTerraImage Pty Ltd

Physical Address:

Building	Grain Building (1st Floor)
Street	Witherite
Street_Suffix	Street
Street_Nr	477
Suburb	Die Wilgers
City	Pretoria
Zip	0184
State	Gauteng
Country	South Africa

Postal Address :

Box	295
Suburb	Persequor Park
City	Pretoria
Zip	0020
State	Gauteng
Country	South Africa

23(M) **Metadata time stamp:** 03 May 2018