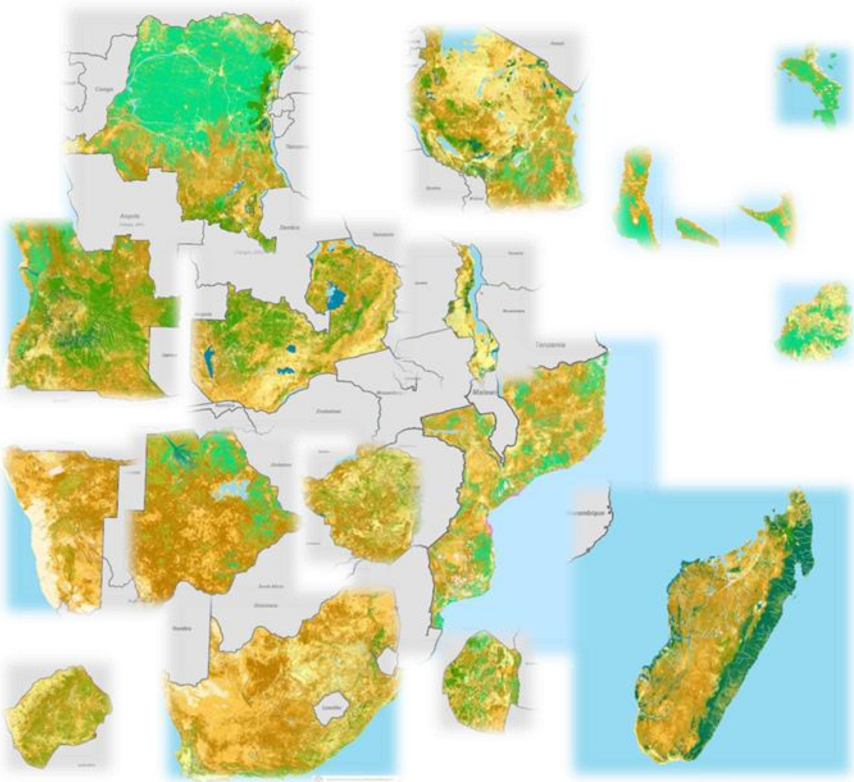
PROJECT FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT OF FOREST RESOURCES IN SOUTHERN AFRICA

SADC REGIONAL FOREST INFORMATION SYSTEM (RFIS) DESIGN DOCUMENT



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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

AUTHORS

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ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
AGB	Above Ground Biomass
DEM	Digital Elevation Models
DRC	Democratic Republic of Congo
EC	European Commission
EWG	Expert Working Group
FAO	Food and Agriculture Organization
FDM	Forest Distribution Map
FRA	Forest Resources Assessment
GIS	Geographical Information System
GLC2000	Global Land Cover (2000)
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
JRC	Joint Research Centre
LCLU	Land Cover and Land Use
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NIR	Near Infra-Red
RFIS	Regional Forest Information System
SADC	Southern African Development Community
SRTM	Shuttle Radar Topography Mission
SVM	Support Vector Machine
TOA	Top Of Atmosphere (Reflection)

FOREWORDS

This material is part of a series by SADC-JICA's Project for Forest Conservation and Sustainable Management of Forest Resources in Southern Africa. The objectives of this material are to visualize inputs, processing methodologies and outputs of the SADC's Regional Forest Information System.

The Southern African region has a rich natural heritage of global significance to the world's climate and biological diversity, which can contribute a critical role in the global climate changes. Forest resources have been contributing to the well-being of many communities across the Southern African Development Community (SADC) region. It is widely recognized that there are strong links between local forestry, biodiversity and poverty reduction. Effective forest management encourages forest resource use in a way that supports long-term poverty alleviation and the protection of biodiversity. Effective management of forest resources across the SADC region requires coordination in utilization and long term enhancement of forest resources.

Working in partnership, JICA and the Southern African Development Community, with the financial support of the Japan Government, the SADC-JICA Forestry Project developed this Regional Forest Information System (RFIS) to help SADC Member States on providing information about changes of the forest resources, supporting to its governments on designing better development, management plans and policies.

Figure 1. Forest cover in SADC

PART ONE: OVERVIEW

The SADC's Regional Information System consists 4 main components. Those components are linked together in order for calculations, processing and generating output information. Each of components will be explained in detail as below.

1. Forest Area

Forest Distribution Map at the year of 2015 (FDM 2015) for all 16 SADC Member States have been developed by classifying satellite images (Landsat 8 and Sentinel 2 sensors).

Definitions of forest and non-forest in this system are in accordance with definition of FAO (United Nations, Foods and Agriculture Organization) which says, forested area is "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ" (FRA 2015 Terms and Definitions, FAO). The forest types (land cover types) that defined in this RFIS are in accordance with Global Land Cover 2000 Map (GLC2000) of the Joint Research Centre (JRC) of the European Commission (EC) and for the purpose of reference only.

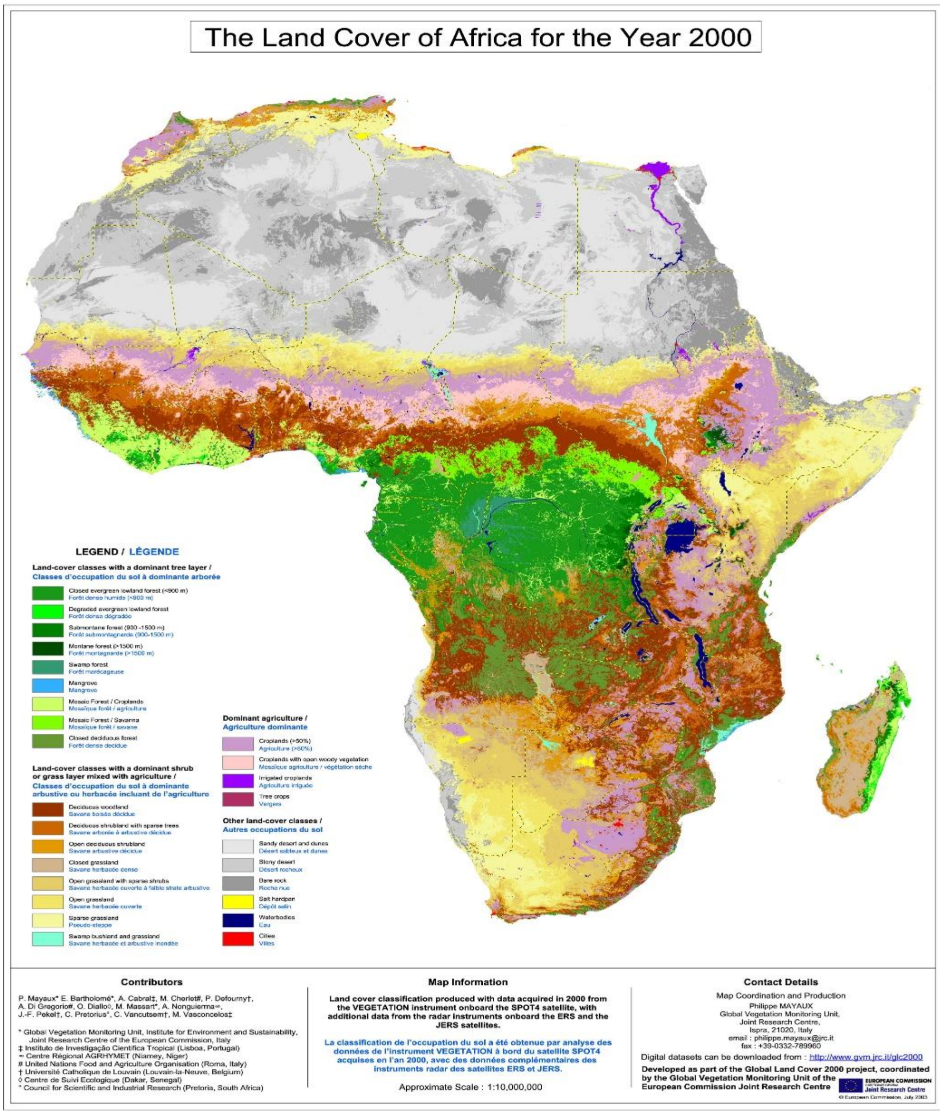

Figure 2. The Land Cover of Africa for the year of 2000 (by EU's JRC)

The satellite imagery data firstly classified as forest and non-forest categories under above mentioned FAO's Forest Definition.

In order to detailed quantify area and volume for each member state or eco-region, a discussion has been conducted between the SADC-JICA Forestry Project and its Expert Working Group (EWG) about the sub-categories of forest/non-forest classification. Results from the discussion show that the sub-categories (land use types) shall be in accordance with EU's GLC 2000 and for the plantation, it shall be added into the GLC 2000 legend list as additional sub-category. Based on the agreement reached at the discussion, the following land-use types has been applied for RFIS.

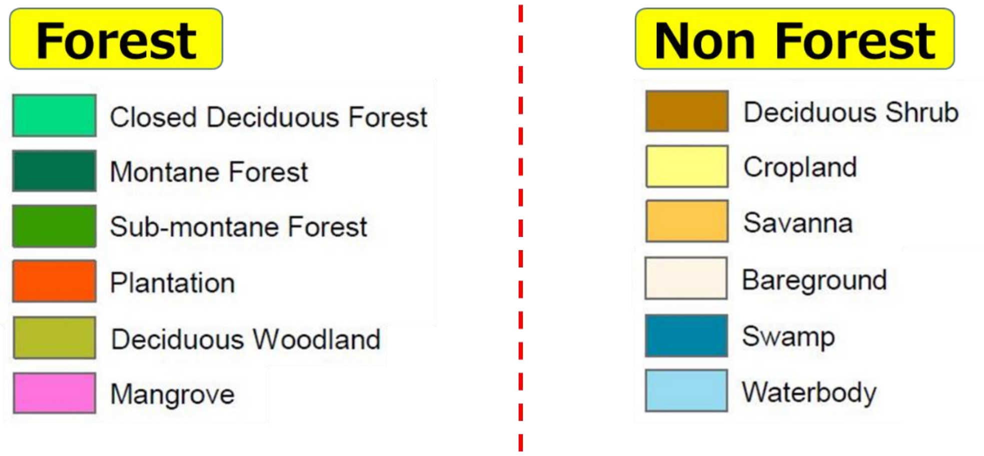

Figure 3. Relation between FAO's forest/non-forest and FDM 2015 sub-categories

To classify with the above land-use types, the following classification decision-tree has been applied, with the source of NDVI, NIR indices and Red-band of the above mentioned satellite imagery data and elevation model from NASA's Shuttle Radar Topography Mission (SRTM).

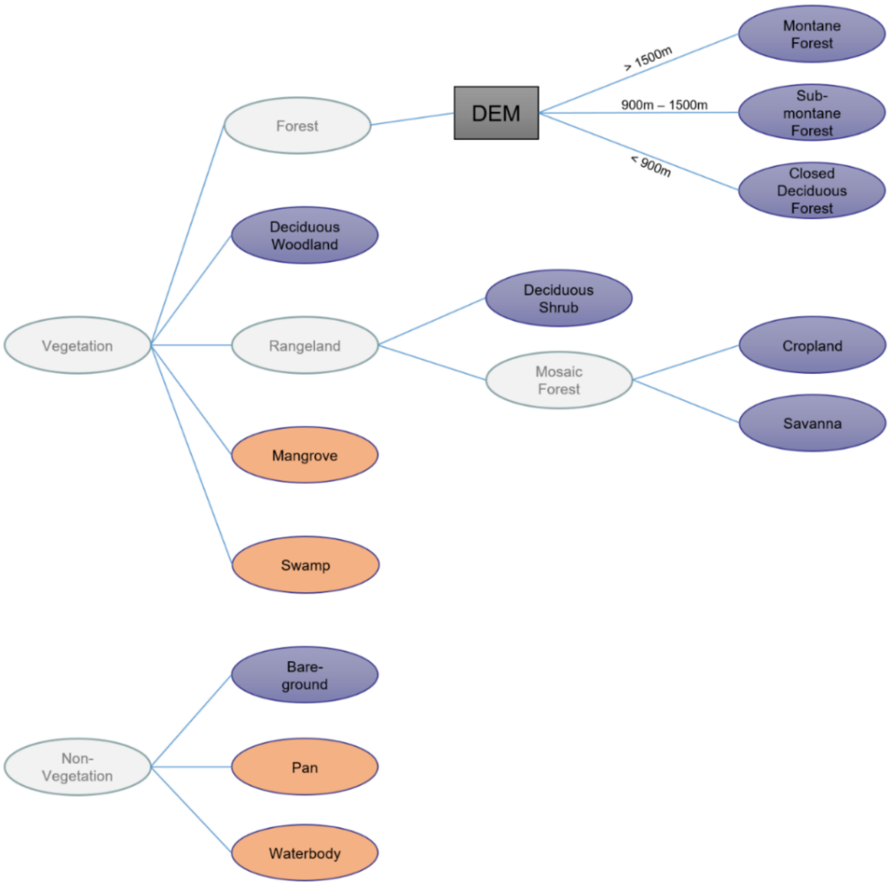

Figure 4. Classification decision tree designed for SADC's basemap generation

As a result, area of each land cover type for each member state will be calculated based on the FDM 2015 to be used as the basemap for monitoring the forest changes in the years after 2015.

The FDM 2015 of SADC Member States are illustrated in PART SEVEN: ANNEXES.

2. Forest Changes

Term of forest changes in this material is meaning of the (1) loss of certain area in the forested area, it means the changes from forested to non-forest land and (2) gain of a certain area from non-forested in certain year become forested area after a certain period of time.

Changes in forest area entirely are calculated based on the basemap (FDM 2015), using time-series methodology with Landsat-8 as data source.

Outputs of the changed area are in raster format and the figure of area (in hectare) and figure of volumes (in cubic meter) are calculated from this raster outputs.

In order to provide more details about the changes in each forest type as a reference, there are 4 forest types to be taken into account for calculation of forest changes, those are (1) Closed Deciduous Forest; (2) Montane Forest; (3) Sub-montane forest and (4) Deciduous Woodland. Since plantations are usually changed by the pattern of harvesting then replanting, this type of forest is not taken into account. In addition, mangrove forests are not taken into account biomass calculation under IPCC (refer to 3. Forest Volumes below for more information), so this forest type of mangrove is also not taken into account.

3. Forest Volumes

Forest volumes are calculated by the mean of multiplying the forest area (in hectare) of each forest type with averaged volume per hectare of corresponding type.

The Intergovernmental Panel on Climate Change (IPCC) has provided a detailed guideline (2006 IPCC Guidelines for National Greenhouse Gas Inventories([1])) with tables of detailed forest volumes for each ecoregion around the world. This guideline has been refined by the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories"([2]) which also refined to be more precise the forest volume of every ecoregion around the world. Ecoregions and their volumes for SADC's Member States can be found in this material([3]).

There are also 6 land cover types which recognize as forested area (see Figure 3. Relation between FAO's forest/non-forest and FDM 2015 sub-categories for more information), of which the plantations and mangroves will not be taken into account the calculation of volume, the remaining forest types with volume and changes to be calculated, including (1) Closed Deciduous Forest; (2) Montane Forest; (3) Sub-montane forest (4) Deciduous Woodland.

According to the FAO's "Global Forest Resources Assessment 2000"([4]), we got the ratio between above ground biomass by area and wood volume by area for Africa by the method below is about 0.66.

Table 2-3. Forest volume and above-ground biomass by region

Region	Forest area	Volume		Biomass	
		by area	total	by area	total
	million ha	*m^3/ha*	*Gm^3*	*t/ha*	*Gt*
Africa	650	72	46	109	71

Ratio between Volume and Biomass = 72/109 = 0.66055

Based on above sources, the following table shows averaged above ground biomass (AGB) and wood volume of the 11 ecoregions for entire SADC Member States.

Number	Forest type	AGB (t/ha)	Wood volume (m3/ha)
1	Tropical rainforest	212.9	140.51
2	Tropical mountain systems	190.0	125.40

([1]) Source: https://www.ipcc.ch/report/2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/
([2]) Source: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/
([3]) Refer to Table 4.12, Chapter 4, Volume 4 (AFOLU), 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
([4]) Refer to Chapter 2, Table 2-3. Forest volume and above-ground biomass by region.

3	Tropical moist deciduous forest	127.4	84.08
4	Tropical dry forest	69.6	45.94
5	Subtropical dry forests	65.2	43.03
6	Subtropical humid forests	54.1	35.71
7	Subtropical steppe	50.5	33.33
8	Tropical shrublands	48.4	31.94
9	Subtropical mountain systems	35.1	23.17
10	Water	-	-
11	Tropical desert	-	-

4. Eco-Regions

The SADC Member States are divided into 11 ecoregions, two of them are without biomass (water and tropical desert). The RFIS is designed to calculate base maps, forest changes, forest area, forest volumes and forest outlooks based on region name.

Most of ecoregions which one spreads over more than one member state. In this case, the ecoregion will be split based on the state's boundaries, and so users are easy to view the ecoregions which cover specific member state.

Below figure shows the map of ecoregions which cover all SADC Member States.

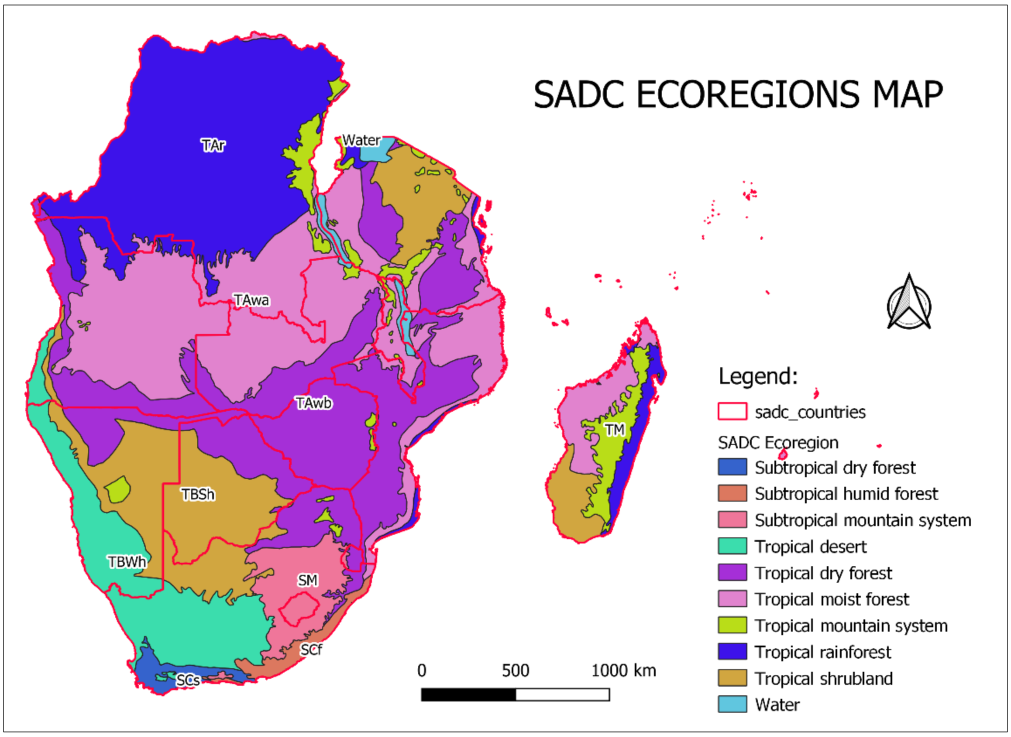

Figure 5. Map of Ecoregions for Southern Africa

PART TWO: FOREST AREA (FDM BASEMAP)

The following information to show data sources, processing method, classification method and outputs of the basemap of FDM 2015 for SADC Member States:

1. Data sources and pre-processing method

The basemap generated for each country from below satellite sensors:

Number	Country name	Satellite sensor
1	Angola	Landsat-8 + SRTM
2	Botswana	
3	Democratic Republic of Congo	
4	Eswatini	
5	Lesotho	
6	Madagascar	
7	Malawi	
8	Mozambique	
9	Namibia	
10	South Africa	
11	Tanzania	
12	Zambia	
13	Zimbabwe	
14	Comoros	Sentinel-2 + SRTM
15	Mauritius	
16	Seychelles	

For temporal, all images which capture the surface of targeted countries within the year of 2015 were processed. For several countries which data of 2015 are not enough after cloud masking, an extension of temporal until June 2016 has been applied.

The following steps of pre-processing the data sources have been applied:

- ✓ Acquisition of all image scenes within the specific temporal period;
- ✓ Cloud and cloud-shadow masking;
- ✓ Terrain and atmospheric correction;
- ✓ Phenology normalization;
- ✓ Mosaic all images into a single image per country;
- ✓ Clip to get mosaicked image within the country's boundary.
- ✓ Evaluation of quality of output image by EWG meeting.
- ✓ Resampling to nearest-neighbour
- ✓ Accepted Level-1 image correction
- ✓ Colour balancing/histogram stretched to the entire image

2. Classification method

Basically, semi-automated supervised classification with visual interpretation and reference data as training source was applied, with the following applications:

- ✓ Visual interpretation.
- ✓ Semi-automated algorithm.
- ✓ Decision-tree approach.
- ✓ Classification done per scene (517 landsat-8 scenes, 3 sentinel-2 scenes)
- ✓ Reference data used to guide classification (Global LCLU datasets, Google Earth, Historic land cover maps).

3. Outputs

As a result of the FDM2015 data processing and classifications, the following outputs have been produced, to be used as basemaps for forest monitoring in the forest information system. All below outputs are for each of the 16 SADC Member States.

- ✓ Forest distribution map of 2015 (digital format).
- ✓ Accuracy Assessment document (refer to Annex for more information).
- ✓ Printable PDF maps (A3 sized).

4. Uncertainty analysis and precautions

Since the basemaps were generated based on optical satellite imagery data, there are several limitations that the users should notes:

- ✓ There still are some effects of topology conditions (mountain shadows might be classified as rich forests);
- ✓ There still are some effects of phenology conditions (crop fields at thick vegetation might be classified as forests);
- ✓ There still are some cloudy pixels remaining, which might be classified as bare land area.
- ✓ Optical data might be blind on deciduous area when all leaves gone, as a result, such area might be classified as shrubs or bare lands.

For more information about the uncertainty, please refer to the Accuracy Assessment in Annex 2.

PART THREE: FOREST CHANGES

As defined in the Overview part above, forest changes in this system are (1) the loss of certain area of forest, becoming non-forested area, and (2) the gain of certain area of forest which gradually growing from non-forest area to become forested area.

The following sub-sections explain how the forest changes are detected and calculated.

1. Data sources

In order to calculate of forest change (in term of forest area, firstly), all Landsat data from the year of 1990 to current year (as of the date of system design, data available to the year of 2018) have been processed. It means, data sources are including Landsat 5, Landsat 7 and Landsat 8. All of data sources are at Top Of Atmosphere (TOA) Reflectance.

2. Methodology

To process huge data volume for a vast area of SADC Member States, Google Earth Engine platform and Landsat Time-Series Algorithm (LandTrendR([5])) have been mobilized. The LandTrendR algorithm is ported as a library into Google Earth Engine platform, however there are some uncertainty of data with original LandTrendR, and so SADC-JICA Consultant team customized this library in order to reduce the uncertainty.

Additionally, the Consultant team developed a Google Earth Engine script to produce the changes within the area of SADC Member States and for specific year only. With this script, technicians at SADC Secretariat can run once a year (after the Project ended) to produce the outputs. It could be as easy as several mouse clicks for each member state.

An area will be considered as a loss (called forest loss) if it is confirmed as non-forested area through at least 3 consecutive cloud-free scenes in compare with previously forested area.

An area will be considered as a gain (called forest gain) if it is confirmed as forested area through at least 3 consecutive cloud-free scenes and compare with the same area of non-forested land of at least 10 years as the case of natural forests.

3. Outputs

The developed script in Google Earth Engine generates a single band raster image for each year from 2016, which stores possible changed area (pixel value = 1). This output will be stored in the designated Google Earth Engine Asset (server storage for RFIS) for the purpose of calculation of changes in specific forest types and calculation of changes in volume as well. There is no design for downloading this raster data from the server to the client computers. However, figures (in hectare) calculated from number of pixel of possible changed area are possible to be downloaded in a text format.

([5]) LandTrendR has been originally developed by Kennedy et al., 2010 and developed, documented, app and API by Oregon State University's eMapR Lab in 2018.

4. Uncertainty analysis and precautions

Like all other optical data, Landsat data possess may factors (e.g. cloudiness, shadows, aerosols, …) that can affect to the uncertainty of the outputs, especially for the area near the equator.

Furthermore, most of forest vegetation in Southern Africa is miombo woodland, which is not much dense in term of vegetation, and optical data at moderate resolution may “confuse” with permanent bare land, particularly for the deciduous season.

LandTrendR algorithm has built for the purpose of processing to detect the changed data globally for all years since Landsat data starts capture the global surface, it is thus LandTrendR tries to equalize its accuracy at global scale but not for a specific country or region.

It is therefore, although it is at high level of reliable, the outputs from this data source of Landsat and the processing methodology of time-series using LandTrendR are still with certain level of uncertainty. Outputs from these source and methodology do not intending to confirm the changes here or there, and a best suggestion is that the SADC Member States would use this source as a reference and do the ground-truthing for confirmation by themselves.

PART FOUR: FOREST VOLUMES

Changes in forest volume also will be calculated and produced the output figures by this system of RFIS, by multiply the changed area (loss and gain) data with averaged volume per hectare of corresponding forest type.

Sub-sections below explain more details.

1. Processing method

Generally, RFIS will produce average forest volume lost and gain in certain year. However, since one SADC Member State can be covered by several ecoregions (refer to Figure 5. Map of Ecoregions for Southern Africa for more information) and each ecoregion possesses different value of the mean volume. It is therefore, RFIS was designed to calculate the changes in term of volume in each ecoregion for each member state . The calculation is just simply as multiplying changed area (calculated from changed pixels on any of 4 forest types mentioned in Part Three above) with mean value of the ecoregion which the changed areas situated in.

2. Data analysis

The mean volume (recognized in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and FAO's Global Forest Resources Assessment 2000([6])) of each ecoregion shall be applied to the calculation of forest changes in volume.

With the above data of mean volume of each ecoregion, figures of forest changes in term of forest volume will be calculated by multiplying this mean volume of each ecoregion with the changed area that situated within that ecoregion. All these analysis and calculation will be done automatically in RFIS server-side script.

3. Output

In line with text formatted figures of changed area, the figures of changed volume will be produced in parallel, and able to be downloaded.

4. Precautions

Since all data sources and algorithms are with certain level of uncertainty, outputs of the changed volume calculated using the data sources and algorithms will be at certain level of uncertainty as well. This output also does not intend to confirm how big the forest volume changed, and the SADC Member States should use this data for reference only and arrange a solution of ground truth data to confirm.

([6]) Refer to PART ONE, section 3. Forest Volumes

PART FIVE: REGIONAL FOREST INFORMATION SYSTEM

The SADC's Regional Forest Information System is designed to reflect forest changes (in term of forest area and forest volume) by each forest type, based on basemap (FDM2015) and data source of Landsat time-series (multiple temporal in series).

The following sub-sections explain what the SADC's Regional Forest Information System is, and how it works, what are the outputs.

1. Overview

The figure below shows concept design of the SADC's Regional Forest Information System.

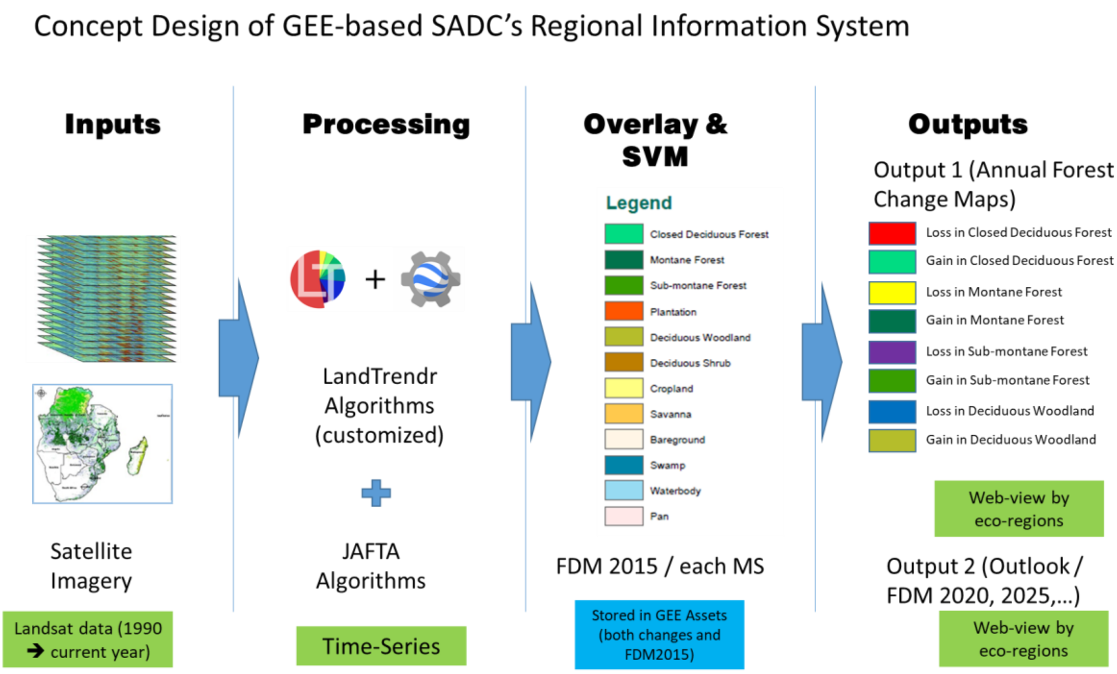

Figure 6. Concept design of SADC's RFIS

The "Time-Series LandTrendR Algorithms" is introduced as below:

LandTrendR is a set of spectral-temporal segmentation algorithms that are useful for change detection in a time series of moderate resolution satellite imagery (primarily Landsat) and for generating trajectory-based spectral time series data largely absent of inter-annual signal noise.

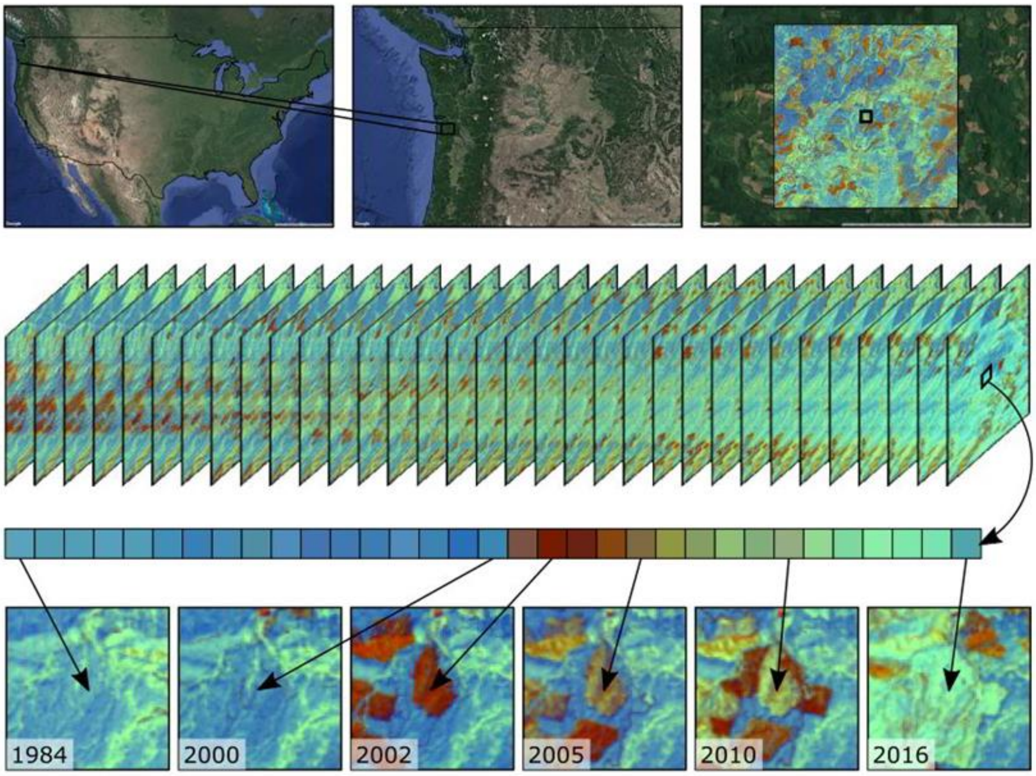

Figure 7. Visualizing Time-Series LandTrendR Algorithms

For more information, please visit https://emapr.github.io/LT-GEE/index.html

2. Workflows

Workflows to produce outputs are:

- ✓ Basemaps (FDM2015, which has generated as explained in Part Two: Forest Area (FDM Basemap) above, which has done by Hatfield Consulting) for each SADC member state has uploaded into the GEE's Assets (one time only, done by SADC-JICA Forestry Project team).
- ✓ Acquisition of all Landsat data from beginning of 1990 to the current year (the year that technician runs the Google Earth Engine script) of the area of interest (SADC Member States) using Google Earth Engine Code Editor;
- ✓ Generation of yearly change (loss and gain) pixels, using customized Time-Series LandTrendR Algorithms (original developed by Kennedy et al., 2010, ported to Google Earth Engine platform by Oregon State University, 2018) using GEE's JavaScript script developed by SADC-JICA Forestry Project team and uploading generated data into GEE's Assets (once a year at the beginning of the following year, almost steps are automated).
- ✓ Server-side python scripts and algorithms of RFIS (developed by SADC-JICA Forestry Project team) will automatically calculate annual forest changes on each forest type based on the basemap.

3. Interfaces

Major RFIS interface is a web-based application where the users can generate necessary outputs.

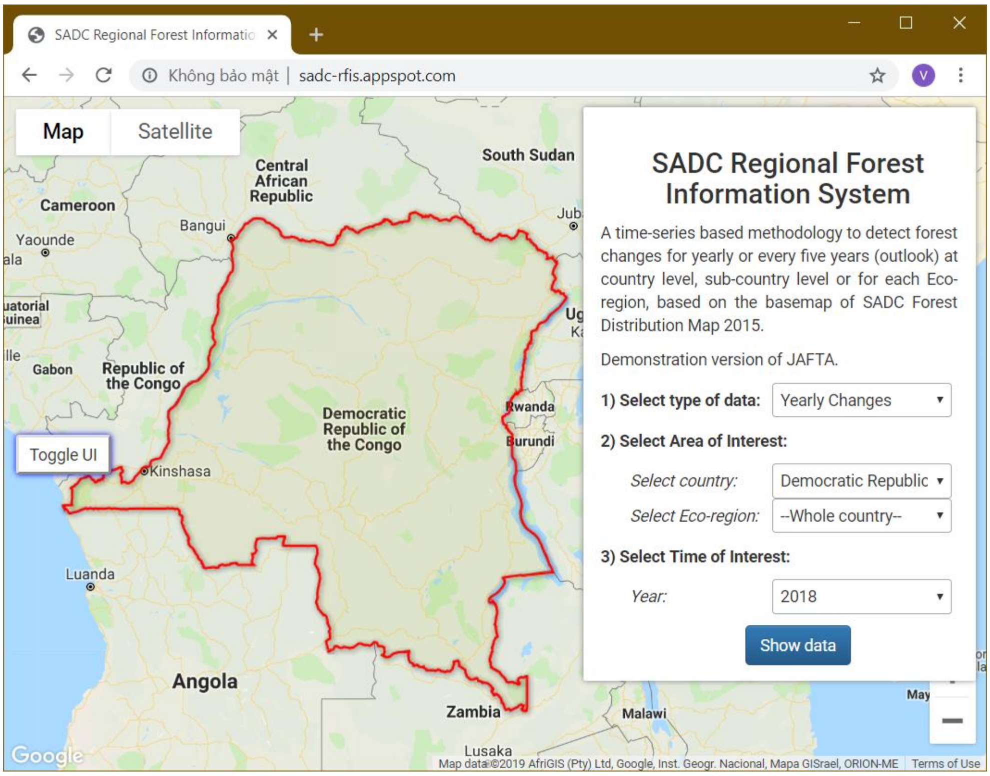

Figure 8. Demonstration version of RFIS

4. Annual report

Output 1 (yearly changes (loss/gain), for each forest type) will be generated automatically every time the web-users want to view the data on web-interface.

Initial basemap that used to compare the changes is FDM2015.

Annual forest changes (in term of area) are detected using Temporal segmentation algorithms (LandTrendR) based on Landsat data from the year of 1990 to current year.

This annual forest change data (from 2016 forwards) will be compared with FDM2015. The changed area detected by LandTrendR but located on non-forested area and/or plantations based on FDM2015 will be removed.

Remaining changed area (which located on forested area except plantations based on FDM2015) will be shown on the screen and to be used for calculation of areal figures.

Calculated areal data will be used to calculate annual volume data to be shown on the interface and downloadable link as text file as well.

Sample of one of the yearly changes output is illustrated in below figure.

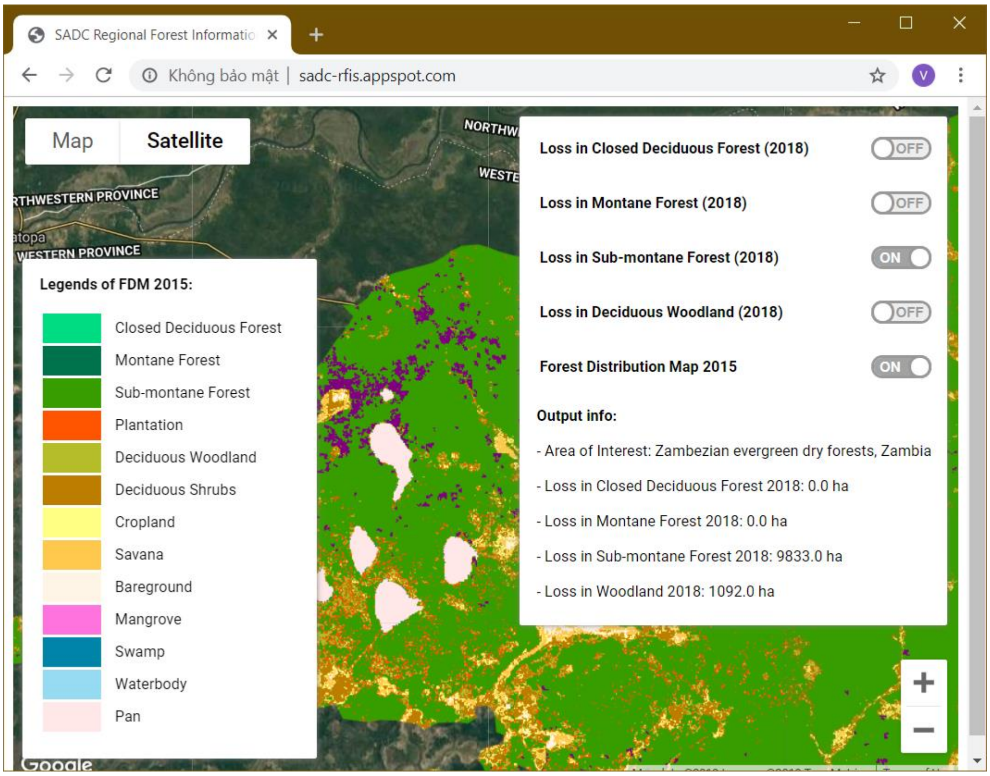

Figure 9. An output of Yearly Changes function within RFIS

5. Forest Outlooks

Output 2 (changes in every 5 years and the basemap of next 5 years cycle, for example, changes between 2015 and 2020, changes between 2020 and 2025, … and basemap (FDM) of 2020, 2025, …) will be generated automatically at the end of the cycle of interest as Forest Outlook of every five years.

Forest 5 years outlook is the aggregated changes which happened between a five years period. In this RFIS, yearly change data will be aggregated to be the changes from the year of basemap data (2015, as initial).

Outlook data will be shown as the same way as the one of the Yearly Changes above. However, calculated data is for 5 years in between the beginning and ending of each period.

User interface for Outlook function is illustrated in below figure.

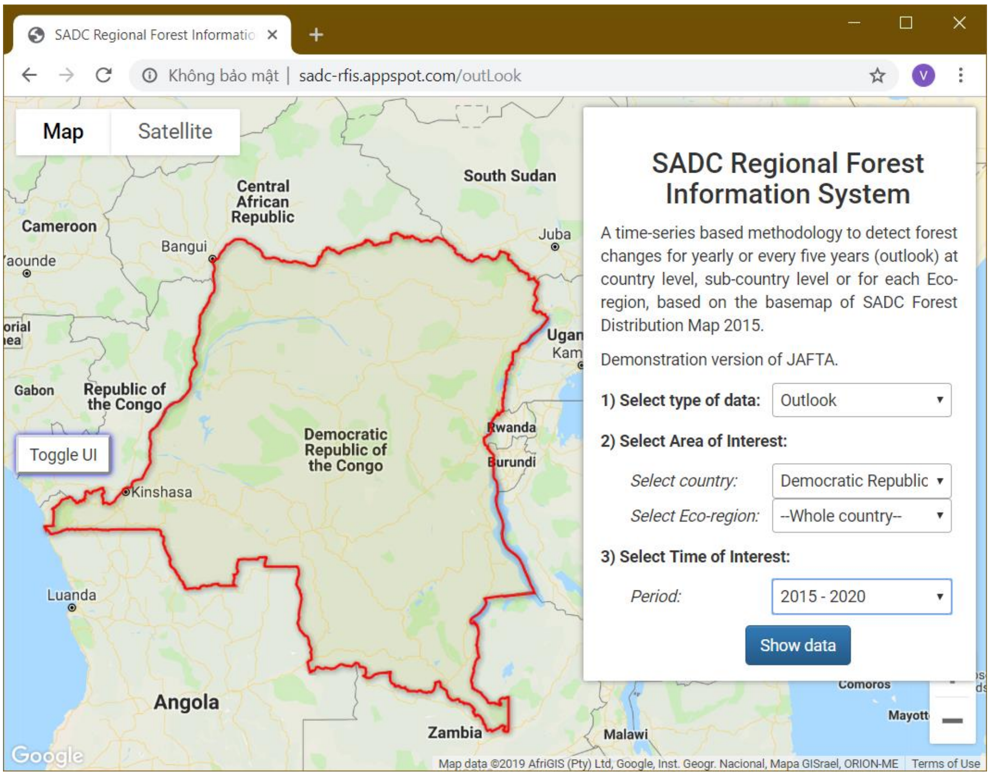

Figure 10. Sample interface of Outlook function in RFIS

6. Next Forest Distribution Maps

This RFIS itself does not calculate automatically the next Forest Distribution Maps for every next five years from FDM 2015 without confirmation of the SADC Member States.

However, output of forest outlook is the aggregation of forest changes within corresponding period (five years). It is therefore, the SADC Member States can easily overlay outlook data on the previous FDM in order to generate a tentative Forest Distribution Maps for the next cycle, and use this tentative data for the ground truth confirmation before uploading to the RFIS server storage for the next cycle forest change monitoring. It is necessary to emphasize, that ground truth data confirmation through field surveys is the only way to confirm the satellite data, and the only way to reduce the uncertainty of the data.

PART SIX: CHALLENGES AND DISCUSSIONS

Whole system design of the RFIS has been explained above. However, there might be several challenges and discussions especially for sustainable operations of the system, and the uncertainty of the outputs.

1. Challenges and discussions for sustainable operation of the system

For operation of the RFIS, technicians at SADC Secretariat and the others at SADC Member States need to learn and to master the whole system, with their specific roles.

Currently and until the end of the Project for Forest Conservation and Sustainable Management of Forest Resources in Southern Africa, the RFIS has been up and running well without operation of the SADC Secretariat's technicians. However, SADC Secretariat's technicians should fully master the system by the end of the project for the sustainable operation of the system.

2. Challenges and discussions for the uncertainty of the outputs

The design of RFIS seems to be good and meet all requirements from the JCC meetings. However, there are still at least one shortcoming to be improved, that is the uncertainly of the output data.

For this, data shall be improved from the basemaps, and annual changes detected and output calculations (particularly, the forest volume changes) if the SADC Member States can support in providing feedbacks on the area where inappropriate results appeared so that developer team can improve the algorithms and thresholds. And if so, accuracy will be increased higher and higher.

PART SEVEN: ANNEXES

1. Forest Distribution Map of all SADC Member States

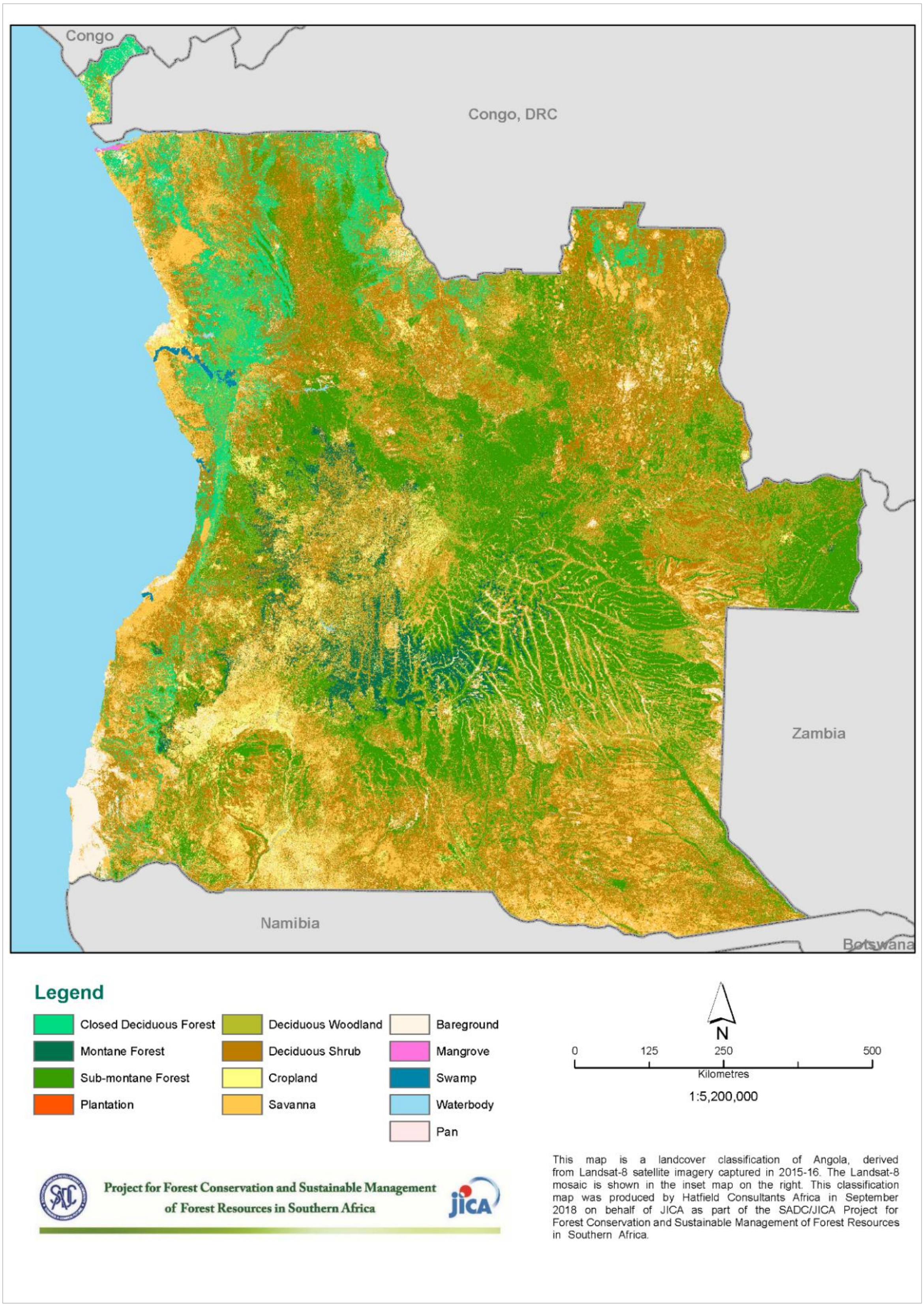

Figure 11. Forest Distribution Map 2015 of Angola

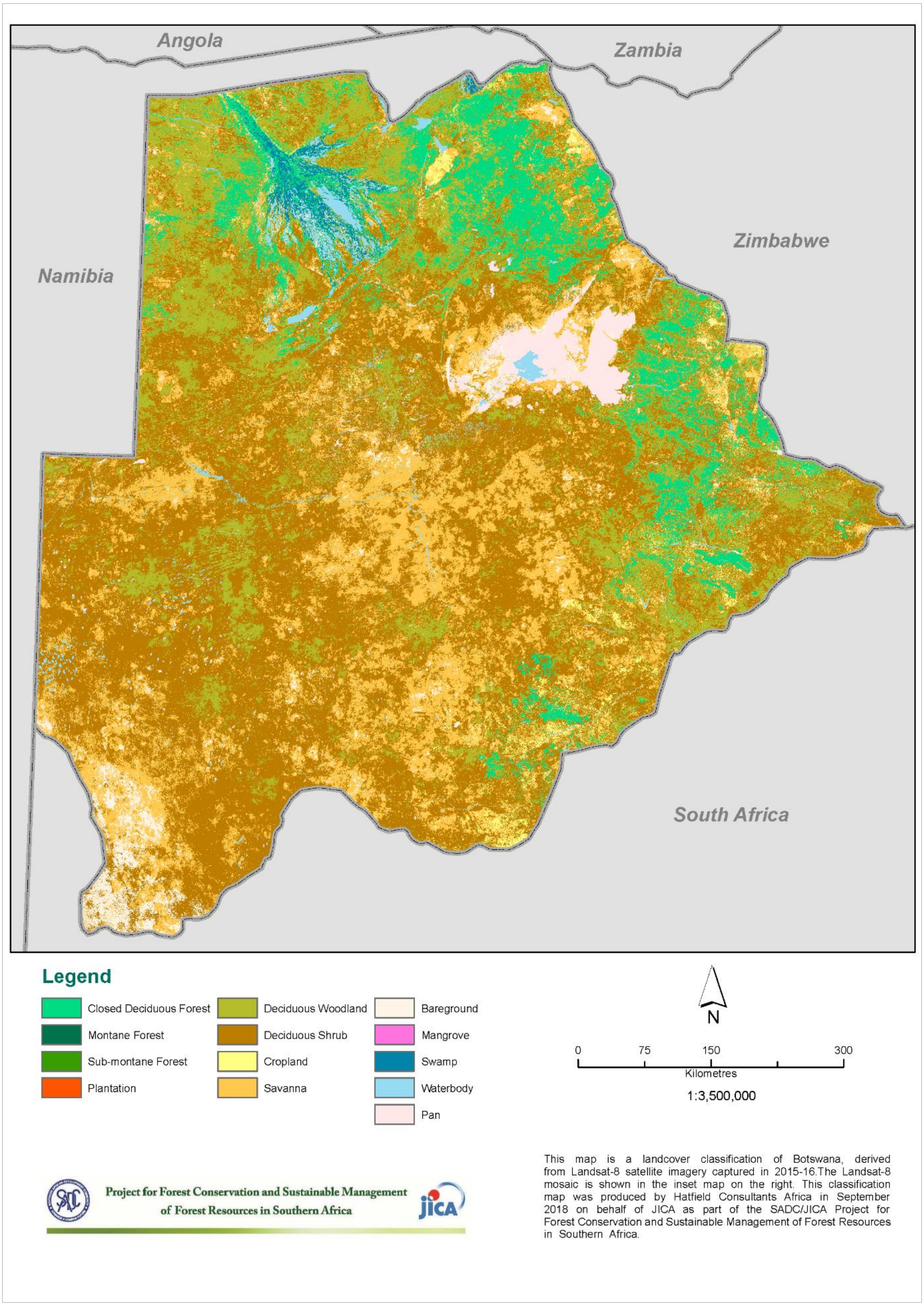

Figure 12. Forest Distribution Map 2015 of Botswana

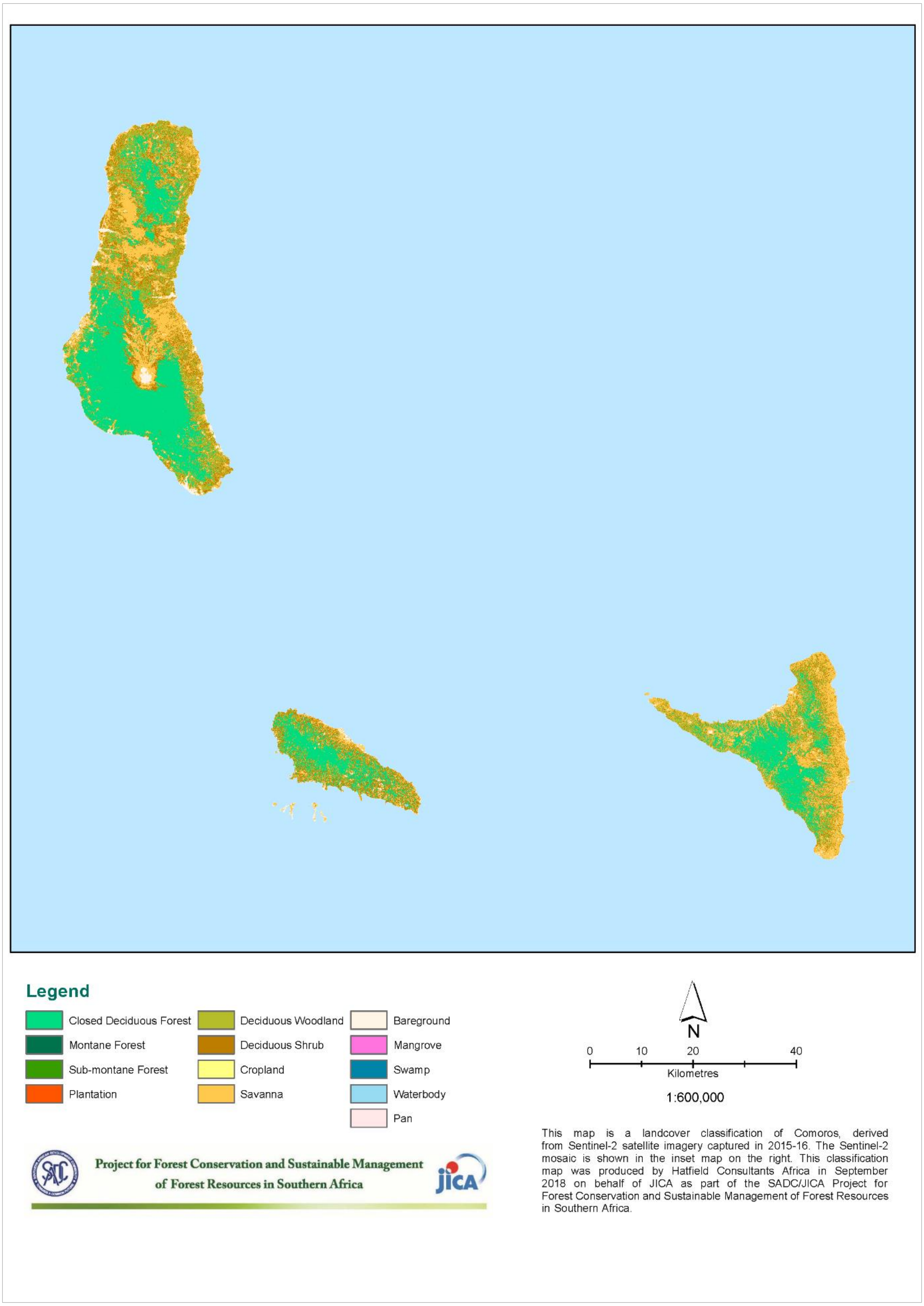

Figure 13. Forest Distribution Map 2015 of Comoros

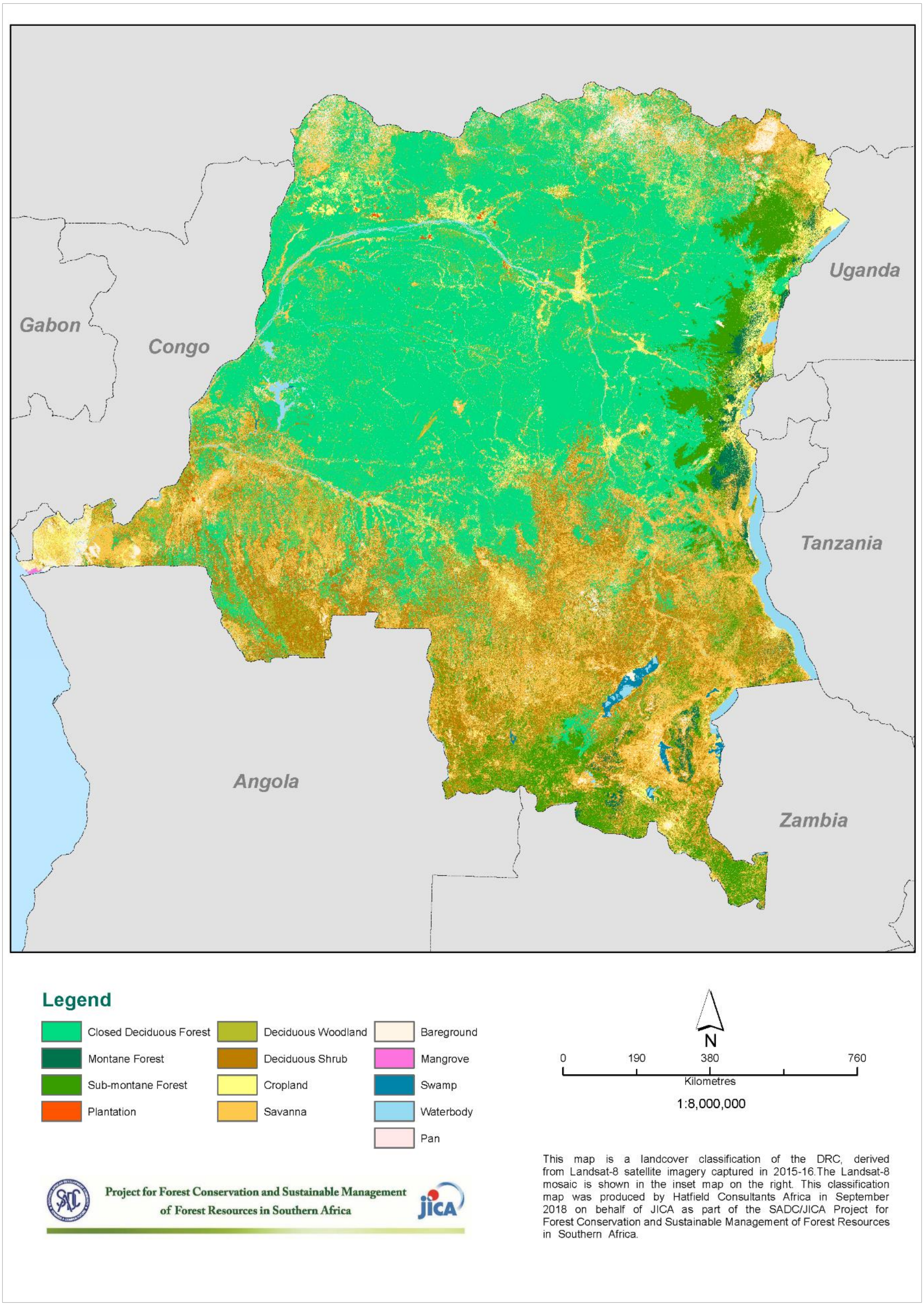

Figure 14. Forest Distribution Map 2015 of Democratic Republic of Congo

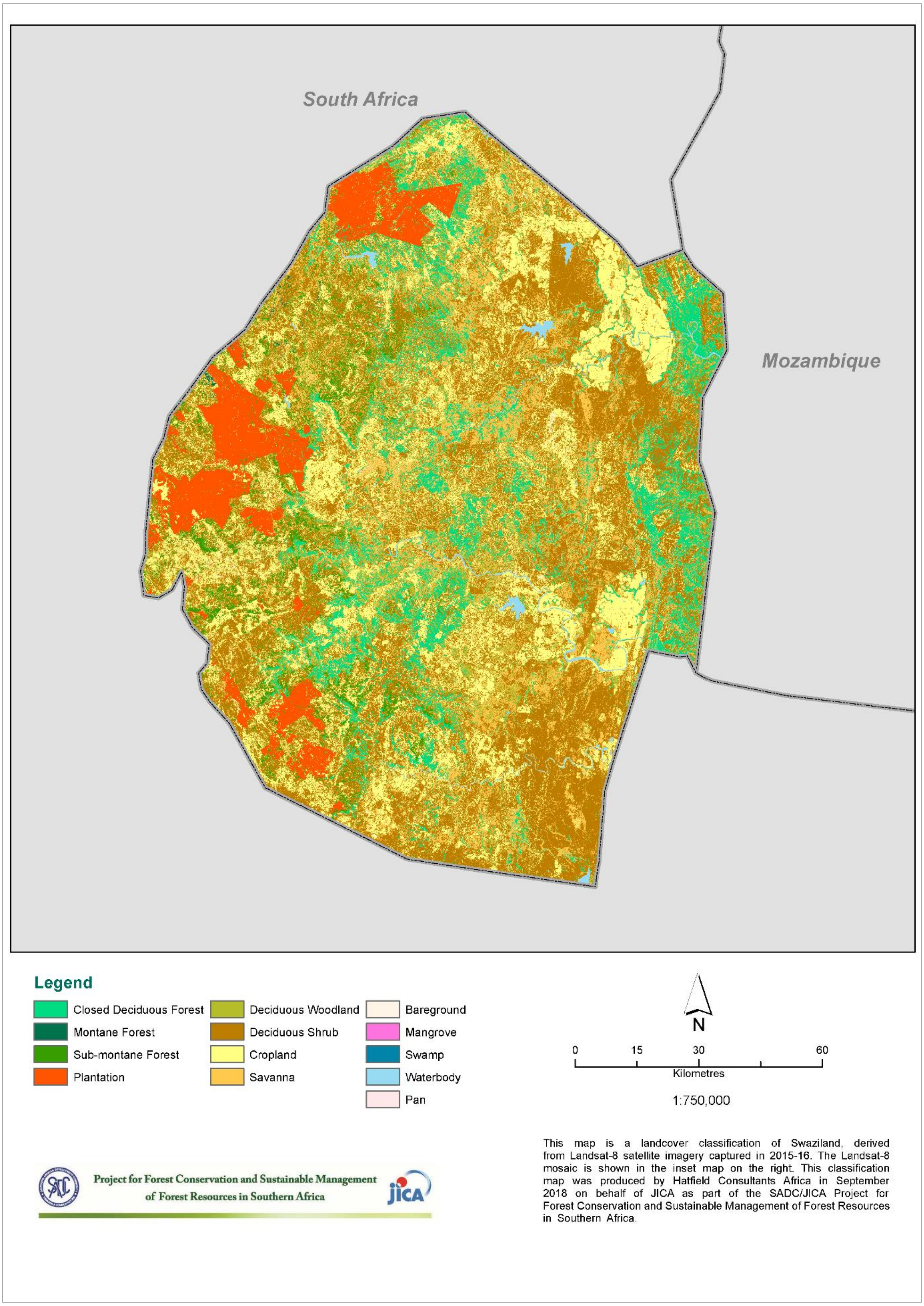

Figure 15. Forest Distribution Map 2015 of Eswatini

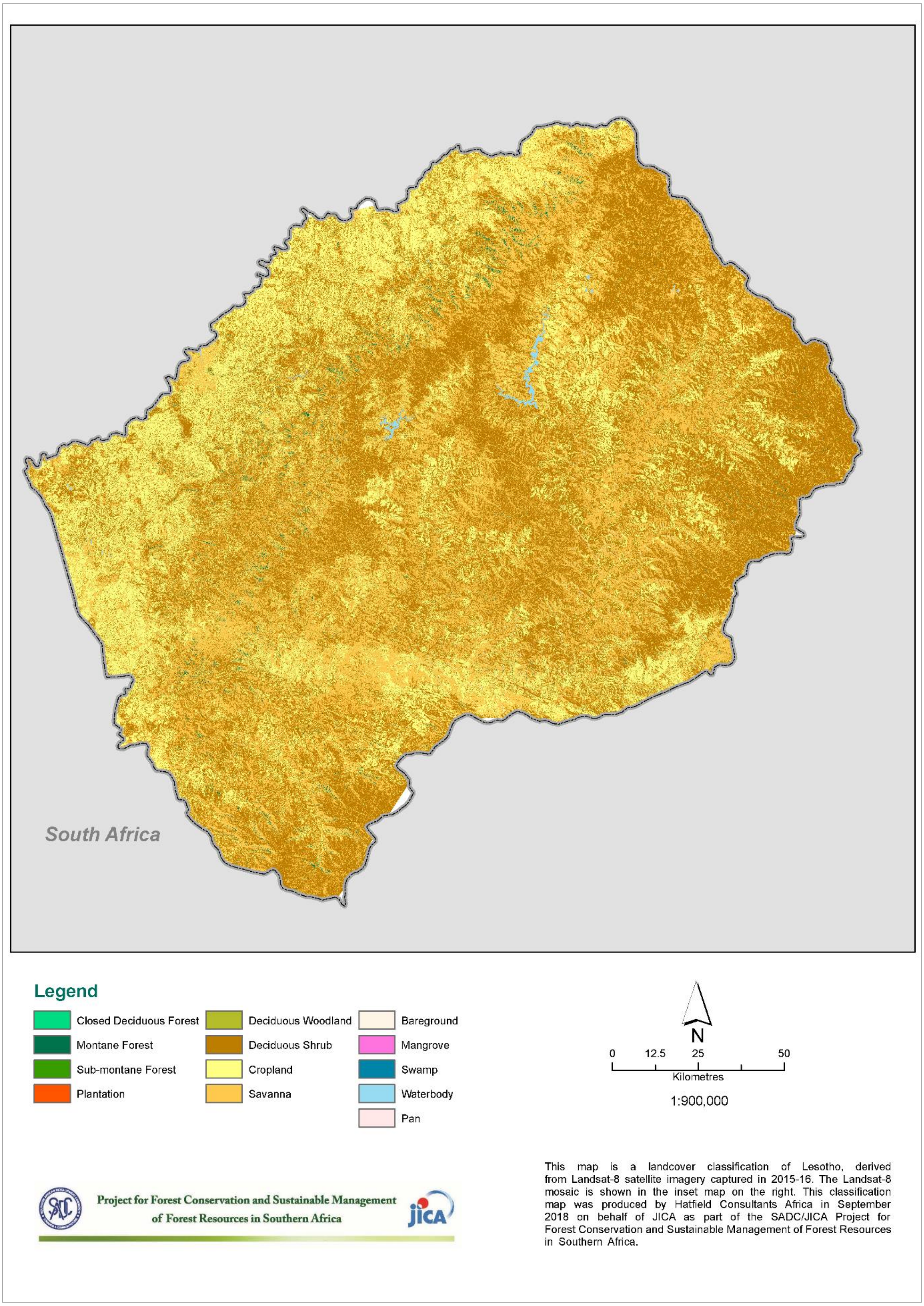

Figure 16. Forest Distribution Map 2015 of Lesotho

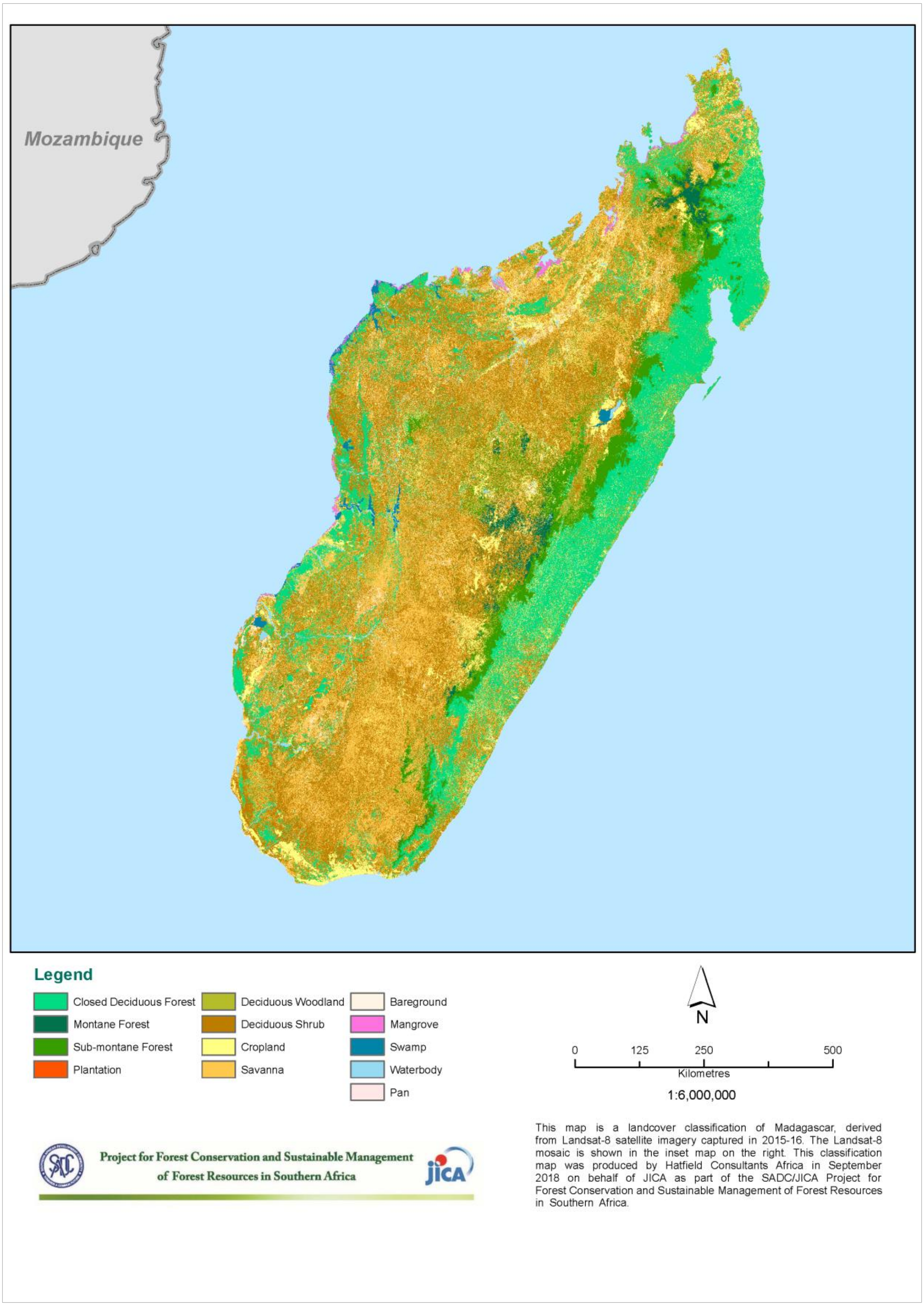

Figure 17. Forest Distribution Map 2015 of Madagascar

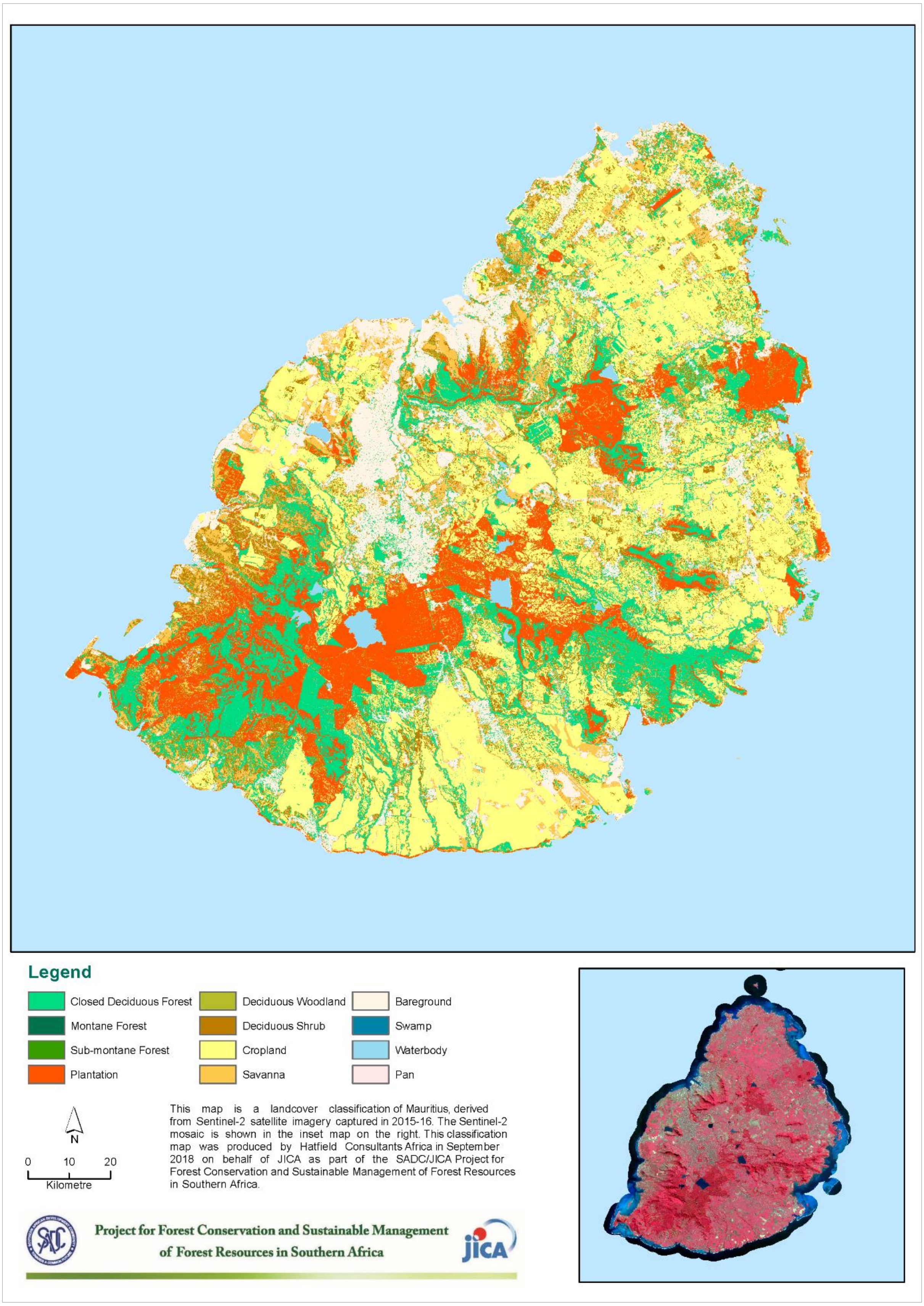

Figure 18. Forest Distribution Map 2015 of Mauritius

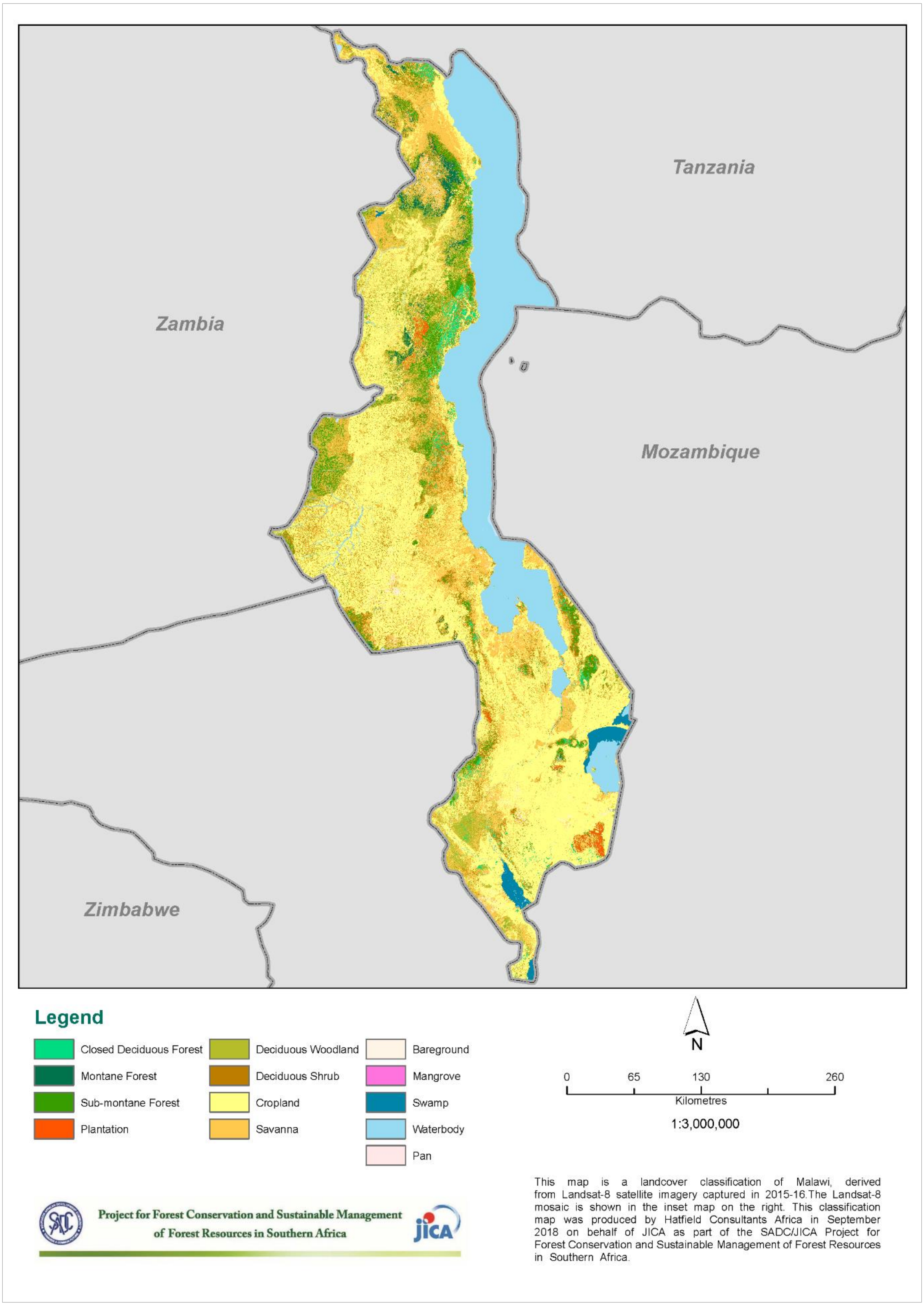

Figure 19. Forest Distribution Map 2015 of Malawi

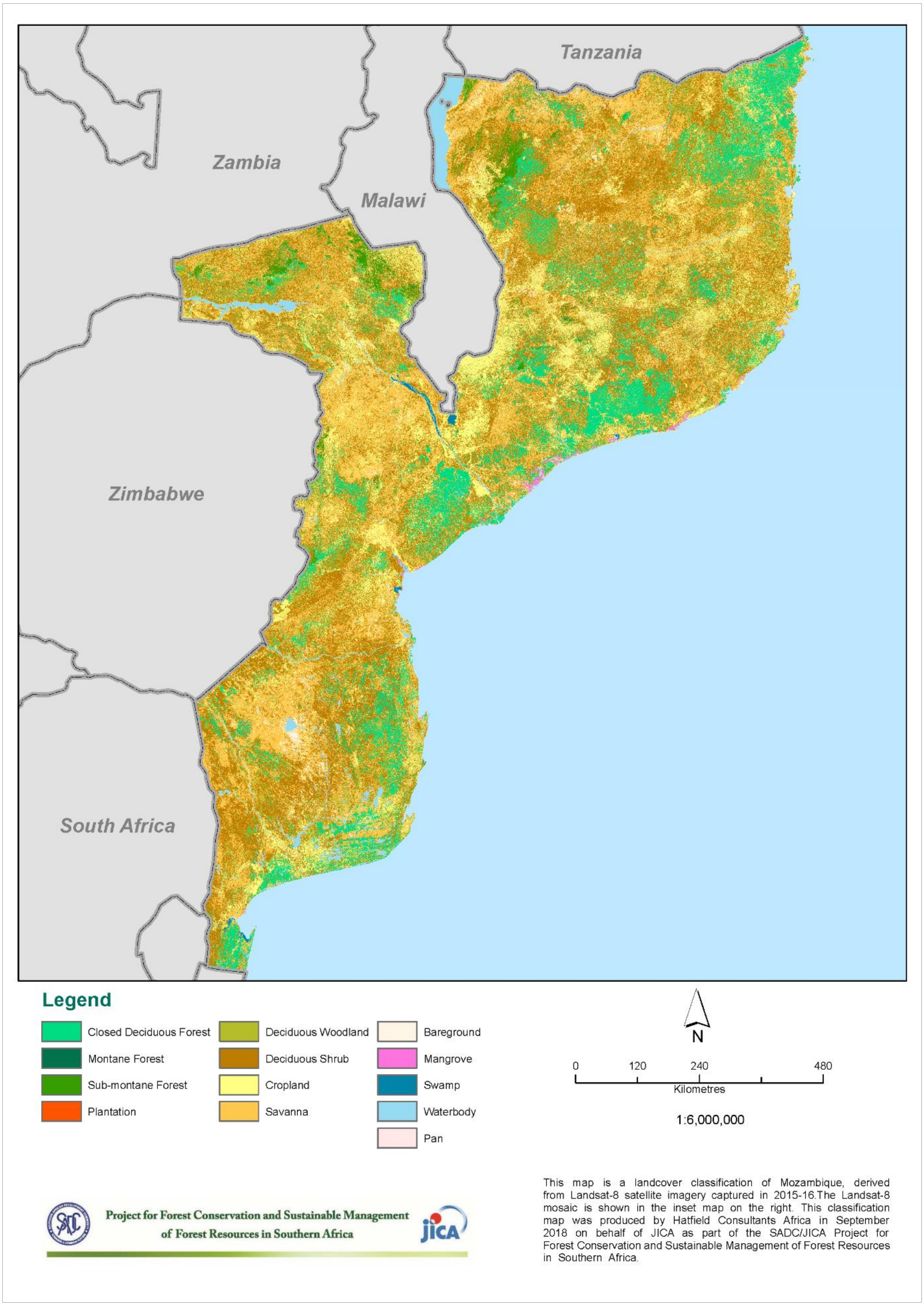

Figure 20. Forest Distribution Map 2015 of Mozambique

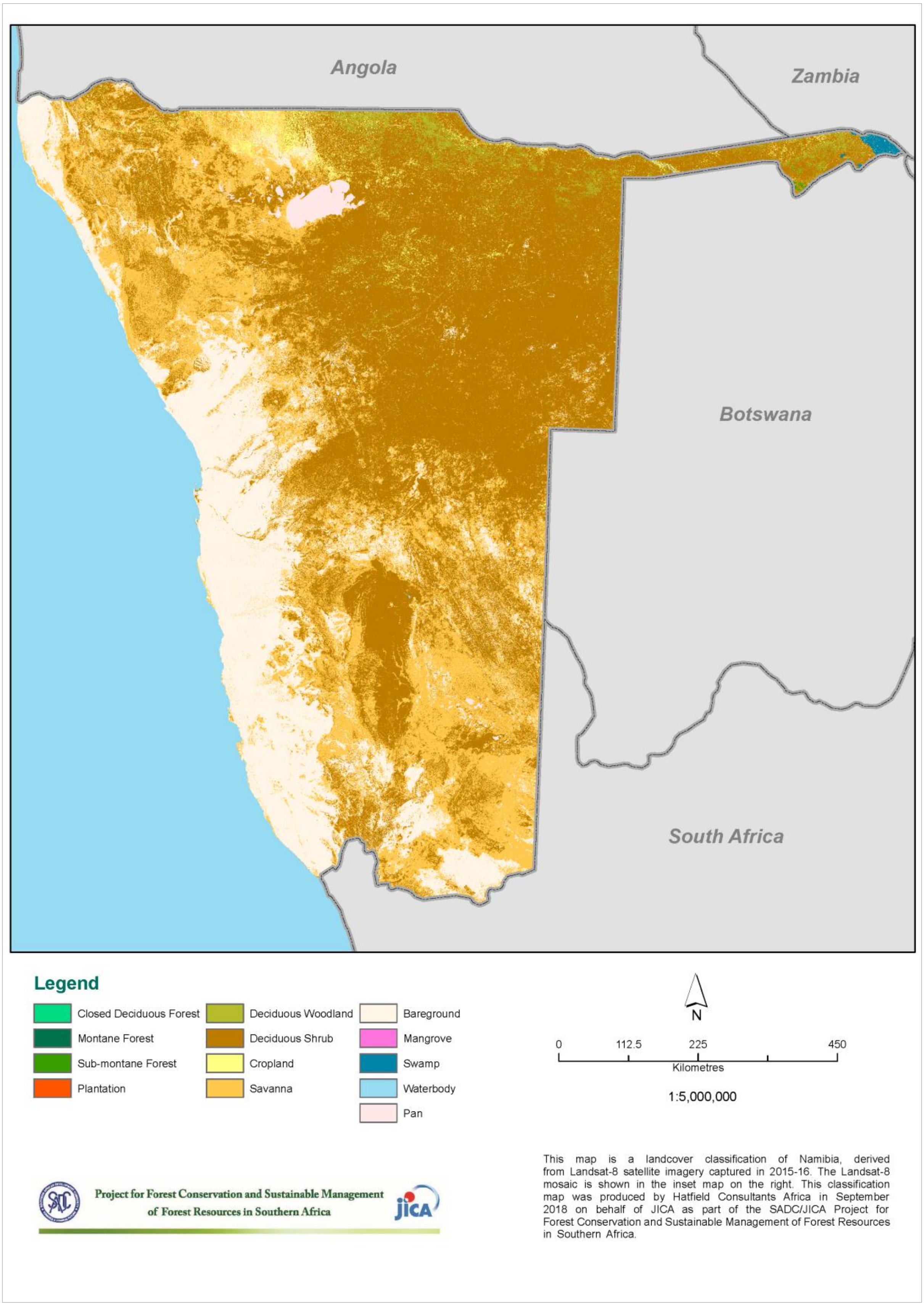

Figure 21. Forest Distribution Map 2015 of Namibia

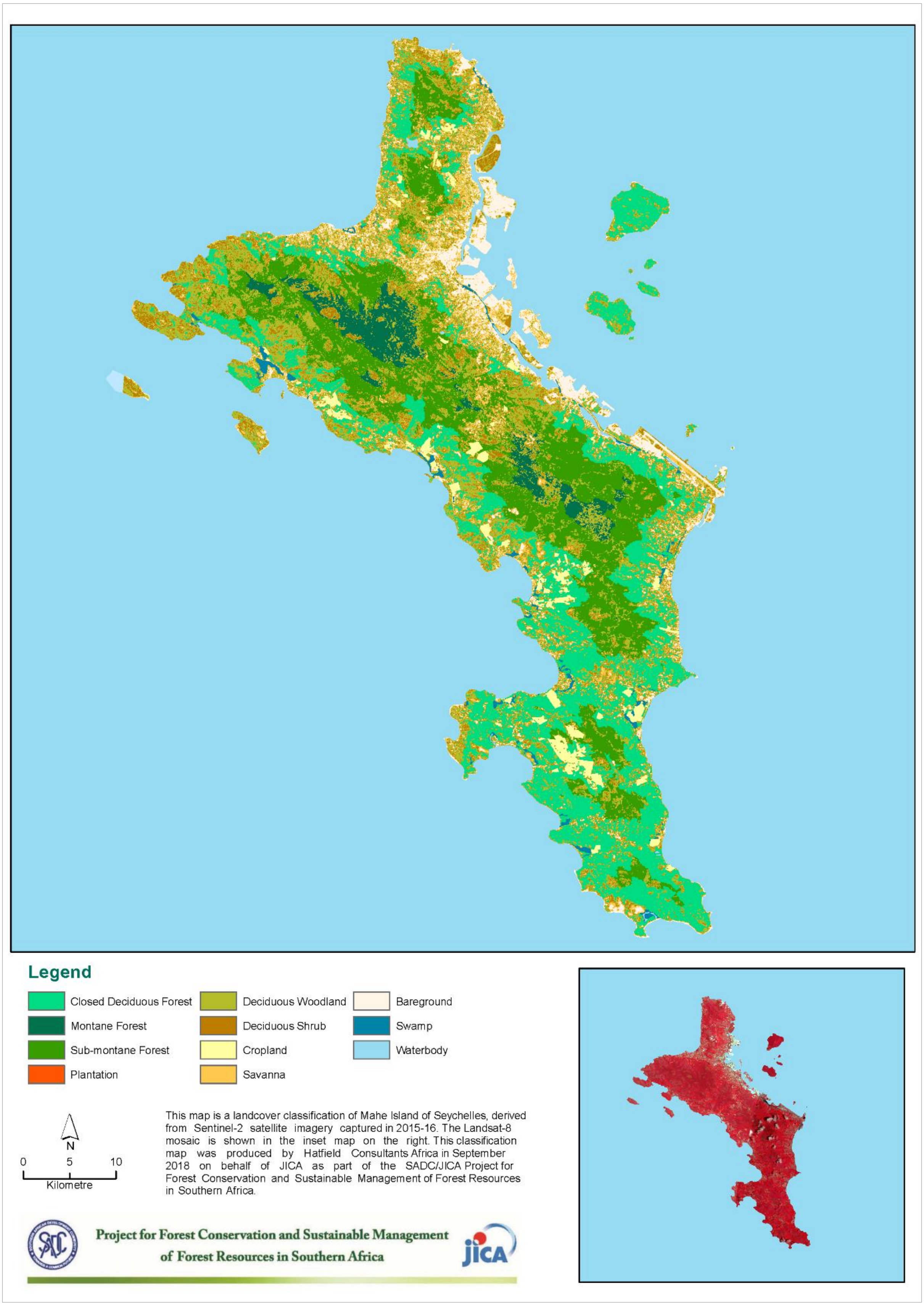

Figure 22. Forest Distribution Map 2015 of Seychelles

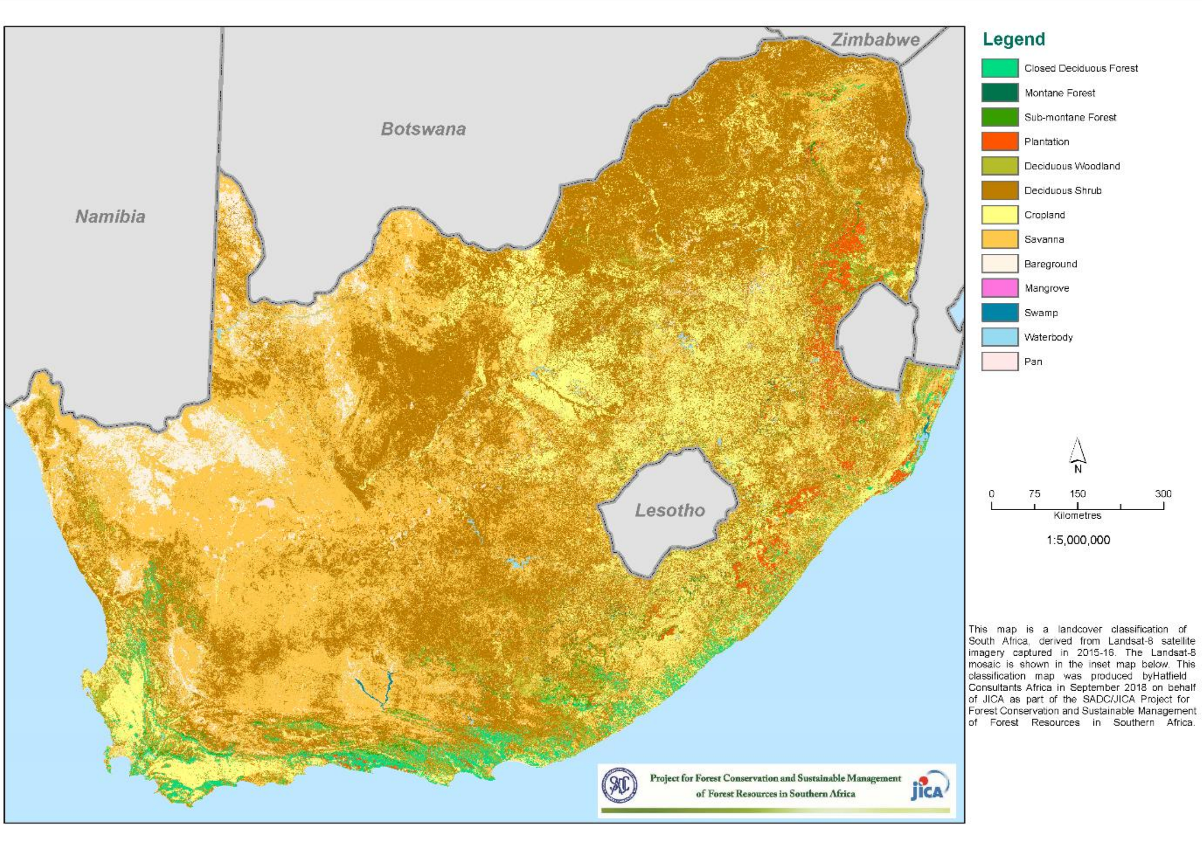

Figure 23. Forest Distribution Map 2015 of South Africa

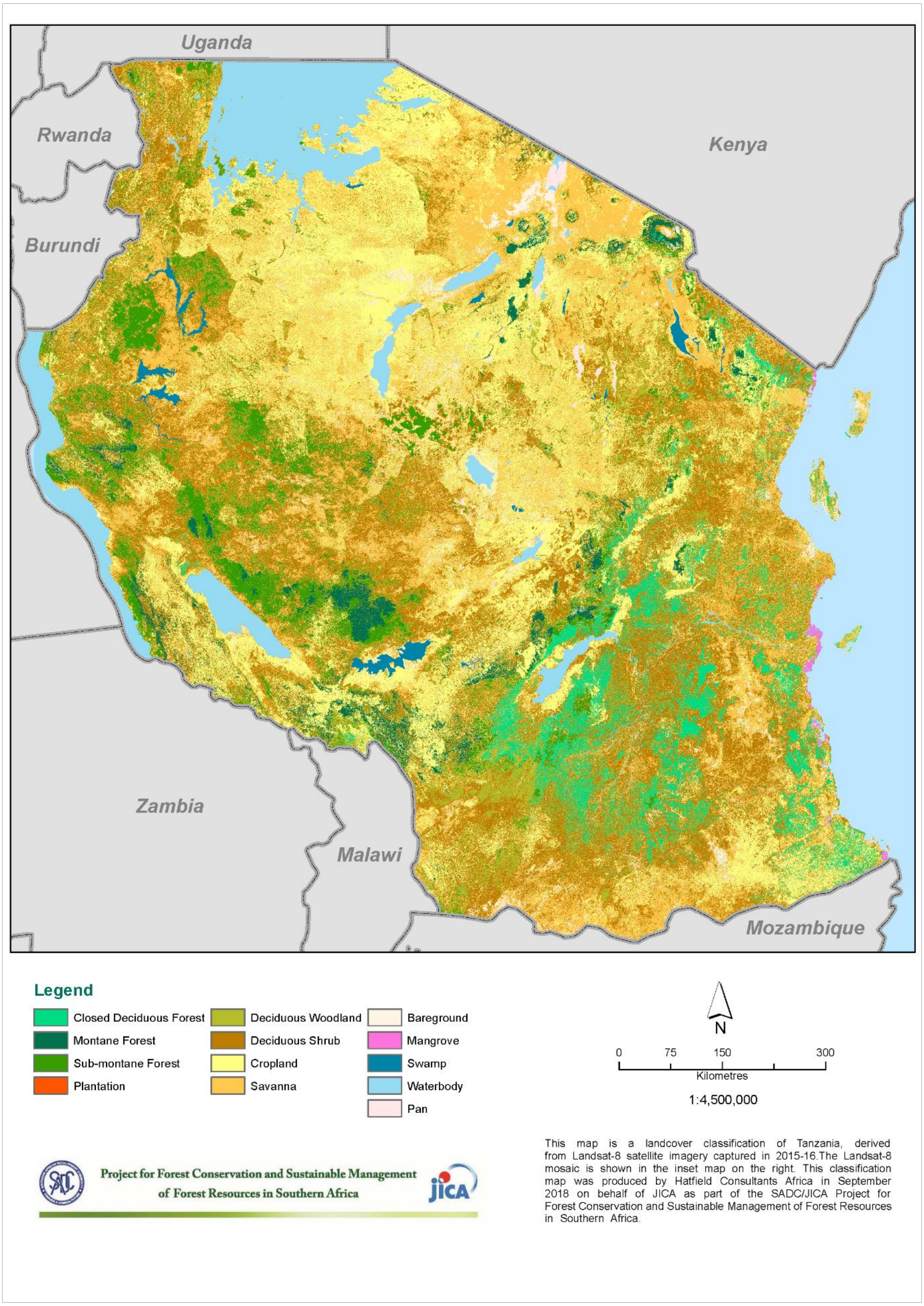

Figure 24. Forest Distribution Map 2015 of Tanzania

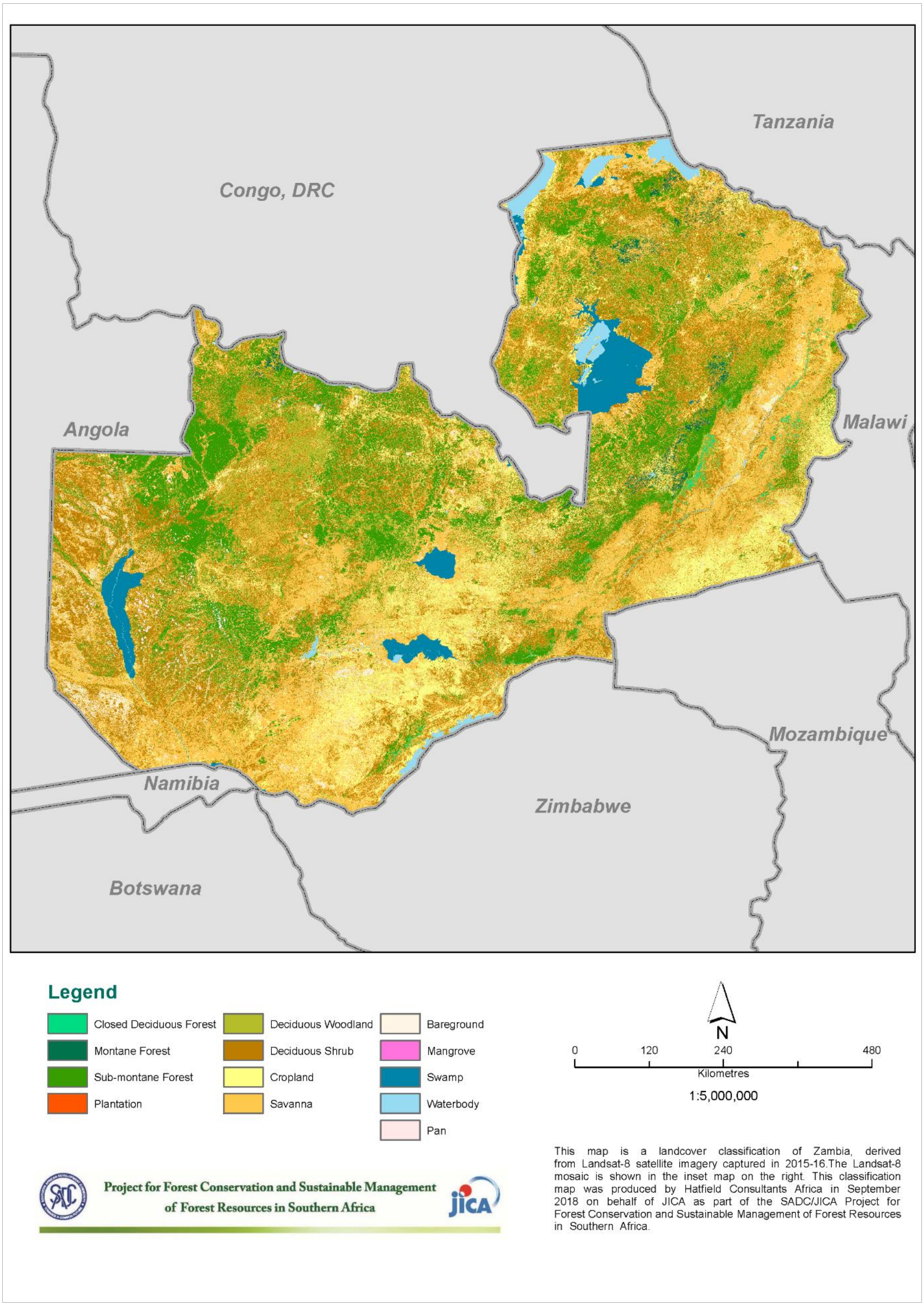

Figure 25. Forest Distribution Map 2015 of Zambia

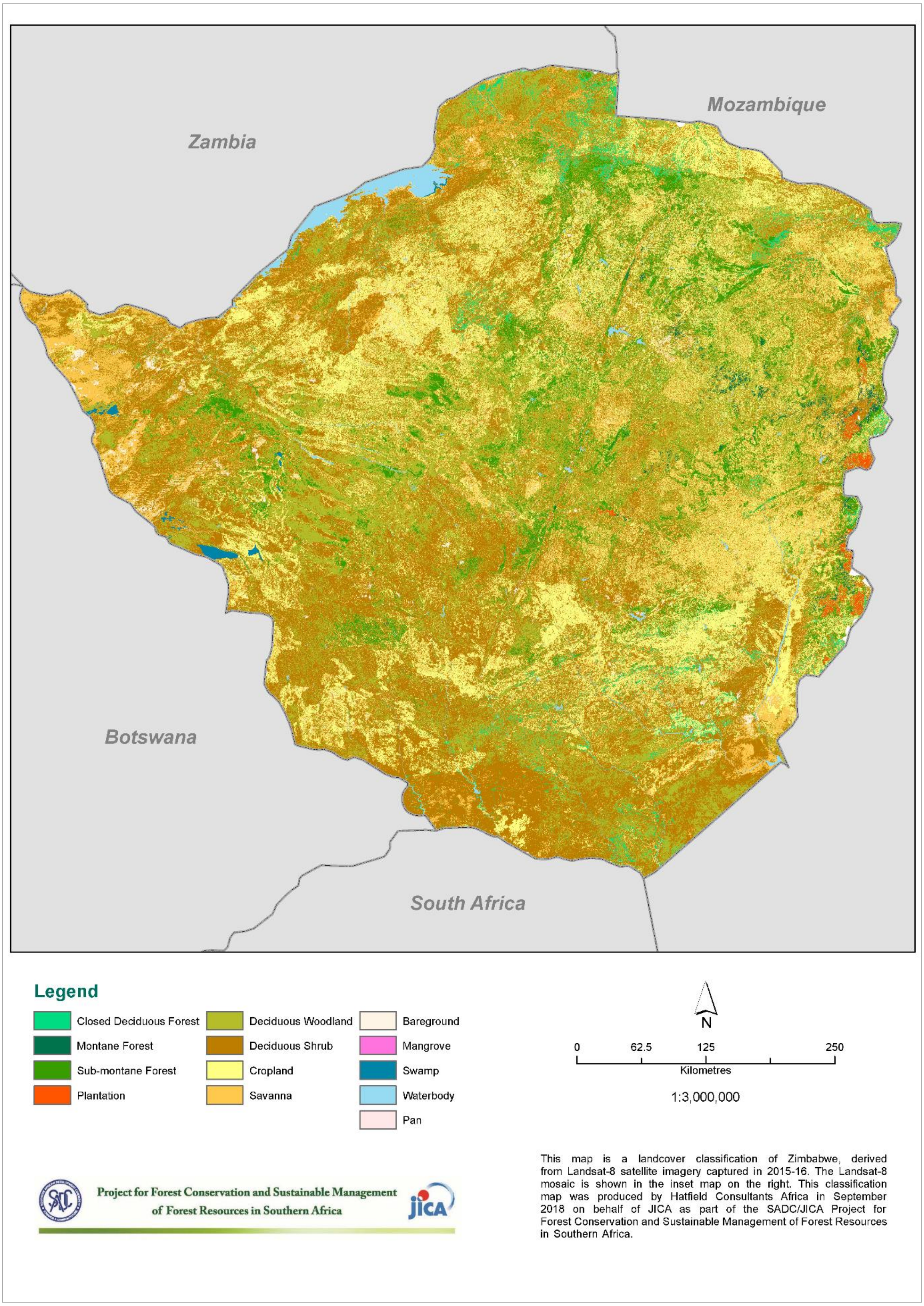

Figure 26. Forest Distribution Map 2015 of Zimbabwe

2. FDM 2015 Accuracy Assessment

Example of a SADC member state's FDM Accuracy Assessment Matrix:

Angola FDM 2015 Accuracy Assessment Matrix

	Forest	Woodland	Shrub	Cropland	Savanna	Bareground	Mangrove	Swamp	Waterbody	Pan	**Total selected sample points**	**Commision Error (User accuracy)**
Forest	18	8									26	69%
Woodland		4	2								6	67%
Shrubs	1	6	8	4	3						22	36%
Cropland	1		2	9	2	2					16	56%
Savanna		2	7	4	9						22	41%
Bareground			1	2	6	18			1		28	64%
Mangrove							20				20	100%
Swamp								20			20	100%
Waterbody				1					19		20	95%
Pan										20	20	100%
Total selected sample points	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	200	
Omission Error (Producer's accuracy)	90%	20%	40%	45%	45%	90%	100%	100%	95%	100%		**72.5%**

Overall FDM 2015 Accuracy Assessment:

A simplified accuracy assessment was conducted to estimate the overall reliability of each Member State classification map. Twenty (20) random verification points were independently collected for each country from high-resolution imagery in the Google Earth platform and used as input to create a per-country confusion matrix. The results obtained from this approach should be considered to be highly subjective as the vintage of the imagery within Google Earth is not the same as that of the imagery used for classification; however, due to lack of field verified data, an accuracy greater than 65% was deemed acceptable.

Country	Overall Accuracy (%)	Notes
Angola	73	Assessment results are within acceptable range. Additional data required in improve classification of woodland and shrub-land.
Botswana	85	High result was recorded because the assessment was done using field verified points
Comoros	65	Assessment results are within acceptable range. Additional data required in improve classification of woodland and shrub-land.
DR Congo	73	Assessment results are within acceptable range. Additional data required in improve classification of woodland and shrub-land.
eSwatini	61	Assessment results are below acceptable range. Additional data required to improve classification of woodland, shrub-land and savanna.
Lesotho	47	Additional data is required to improve this classification
Madagascar	66	Additional data required to improve classification of shrub-land and savanna
Malawi	53	Seasonality might be responsible for the poor results of this analysis. Cropland was observed as bare ground on Google. Additional data would be required to increase the accuracy of woodland and bushland
Mauritius	67	Assessment results are within acceptable range. Additional data required in improve classification of woodland and shrub-land.
Mozambique	62	Additional data is required to improve the classification of woodland and savanna.
Namibia	82	Assessment results are within acceptable range
Seychelles	66	Assessment results are acceptable though there is an over estimation of savanna. Additional data required to improve classification of shrub-land and savanna.
South Africa	71	Assessment results are within acceptable range. Additional data required in improve classification of savanna.
Tanzania	72	Assessment results are within acceptable range. Additional data required in improve classification of woodland and shrub-land.
Zambia	68	Assessment results are within acceptable range. Additional data required in improve classification of woodland and forest
Zimbabwe	65	Assessment results are within acceptable range. Additional data required in improve classification of woodland and shrub-land.

The individual confusion matrices derived from each accuracy assessment and the verification points have been provided in a separate file.

These results are intended as a general guide as they are subject to human error associated with interpretation of imagery within the Google Earth platform. Users are advised to re-assess accuracy once field validation data have been obtained.

3. Manual

There is a manual for annual running (once a year) the GEE scripts to generate data for feeding to the yearly changes functions and forest outlook (5 years basemap). This manual is for technician staff at SADC Member States only, to generate data for their own state in order to feed the RFIS to calculate current year's changes and also to calculate the forest outlook every five years.

SADC RFIS GUIDELINE (SYSTEM DESIGN DOCUMENT)
SADC-JICA FORESTRY PROJECT