SURINAME

MapBiomas General “Handbook” Algorithm Theoretical Basis Document (ATBD)

Collection 1

Version 1

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1. Introduction

1.1. Scope and content of the document

The objective of this document is to describe the theoretical basis, justification, and methods applied to produce annual maps of land use and land cover (LULC) of MapBiomas Suriname. This collection is the result of the first working group and includes maps from 1985 to 2025. The document describes the classification methods of the first collection, the approach to integrating the regions, background information, and a general description of the method applied. The specific description of classes can be found in the appendix 1. The classification algorithms are available on the MapBiomas Suriname GitHub.

1.2. Overview

The MapBiomas project started in Suriname in January 2024 in order to strengthen LULC initiatives in the country, using the Mapbiomas methods. MapBiomas provides an ideal environment to enhance and share skills and abilities by collaborators from different locations and perspectives, and a shared belief in learning by doing. Google Earth Engine and open source technology provide the technical basis to process large-scale datasets of satellite imagery, resulting in the MapBiomas products.

The Mapbiomas Suriname Collection 1 maps cover the entire Surinamese territory over the years 1985 - 2025, have resolution of 30m x 30m, and contain the following 10 classes:

1. Forest Formation
2. Mangrove
3. Wetland
4. Grassland
5. Agriculture
6. Mosaic of uses
7. Urban Area
8. Mining
9. Other non-Vegetated Area
10. River, Lake and Ocean

MapBiomas maps are continually evolving and the following collections will be further improved and available in the future.

1.3. Region of interest

For the purpose of the MapBiomas Suriname analysis, the territory was divided into two operational regions: the coastal region and the interior region (figure 1). The regionalization was established to account for differences in vegetation cover, soil characteristics, hydrology, ecosystem distribution, and Land-use patterns, thereby improving the accuracy of land-use and land-cover classification.

Figure 1. Scope of the different regions or working groups

The coastal region is a low-lying sedimentary plain characterized by mangroves, extensive wetlands, agriculture areas, and urban settlements. With distinct hydrological conditions, vegetation types, and land-use patterns associated with coastal and estuarine environments.

In contrast, the interior region is primarily dominated by dense tropical rainforest, forest–savanna mosaics, inselbergs, and upland ecosystems. This region has forest-dominated ecosystems, topography, and ecological processes that differ substantially from coastal environments.

2. Overview and Background Information

2.1. MapBiomas Global Network

Mapbiomas is a network of non-governmental organizations (NGOs), universities, research institutions and tech startups that produce and promote LULC data in South America and other tropical and subtropical regions. As a network, we are committed to generating data, methods, tools and information to qualify the understanding, analysis and decision-making on conservation and sustainable management of continental natural resources.

2.2. General Characteristics of the Country

The Republic of Suriname is located on the northeastern coast of South America, bordered by Guyana to the west, French Guiana to the east, Brazil to the south, and the Atlantic Ocean to the north (figure 2). The country covers 163,820 km² and forms part of the Guiana Shield - one the world's oldest geological formations and one of the most intact tropical forest regions on Earth. Around 90% of Suriname's territory remains covered by natural vegetation, primarily tropical rainforest, making the country one of the most forested nations globally and an important contributor to regional biodiversity conservation and climate regulation.

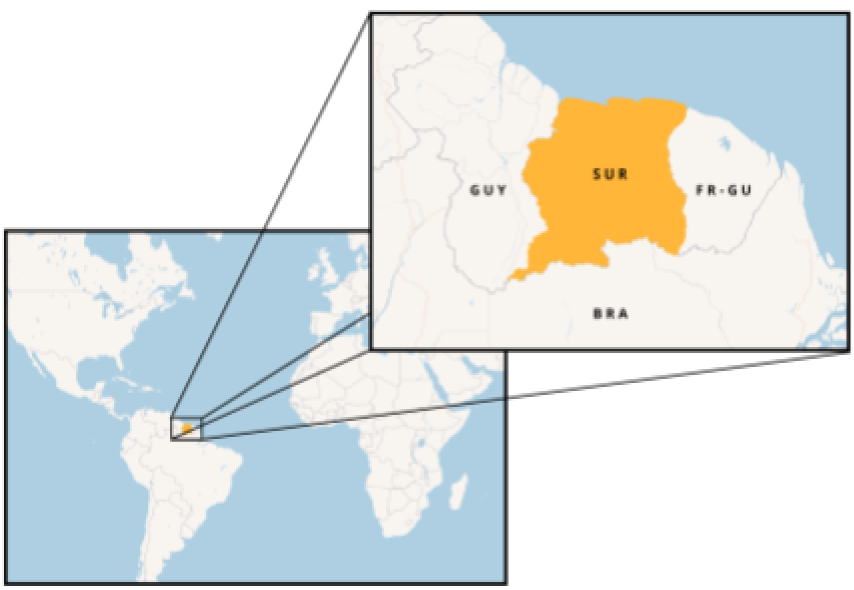

Figure 2. Map of Suriname.

Within the framework of MapBiomas Amazonia and the Amazon Network of Georeferenced Socio-Environmental Information (RAISG), the entire territory of Suriname is included within the Amazonian region. The country contains extensive tracts of continuous tropical forest, as well as wetlands, savannas, mangrove ecosystems, and freshwater systems that support high levels of biodiversity and endemism.

The coastal region of Suriname consists of low-lying sedimentary landscapes characterized by mangrove forests, swamps, freshwater marshes, and seasonally flooded ecosystems. South of the coastal zones lies a belt of white sand-savannas, which transitions further down south into a forested landscape. The central and southern regions are dominated by dense tropical rainforest developed on the formations of the Guiana Shield. Elevation gradually increases toward the southern border with Brazil, where mountain ranges and inselbergs form a rugged landscape that remains largely undisturbed.

The country's climate is tropical, with high temperatures and humidity throughout the year. Annual precipitation generally ranges from 1500 mm in the coastal region to more than 3000 mm in parts of the interior. The hydrological network is dominated by major river basins including the Corantijn, Coppename, Saramacca, Suriname, Marowijne, and Commewijne rivers, which flow northward toward the Atlantic Ocean and play a fundamental role in ecosystem functioning, transportation, and human settlement patterns.

Although Suriname retains one of the highest proportions of intact forest cover in the Amazon Basin, increasing pressures from gold mining, logging, infrastructure development, and agriculture expansion pose localized threats to natural ecosystems. The pressures are particularly evident in areas accessible by river corridors and transportation networks. Consequently, monitoring land-cover and land-use dynamics is essential for supporting sustainable management, biodiversity, conservation, and climate-change mitigation efforts within the country.

3. Methodology

3.1. Remote Sensing Data

The imagery used in the MapBiomas project was derived from the Landsat satellite program, specifically from the Thematic Mapper (TM), Enhanced Thematic Mapper plus (ETM+), and Operational land Imager/Thermal Infrared Sensor (OLI-TIRS) instruments aboard Landsat 5, Landsat 7, Landsat 8, and Landsat 9. The data were accessed through Google Earth Engine and National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS).

The cloud-free Landsat composites were generated using imagery acquired during specific time periods selected to maximize spectral differences among land use and land cover (LULC) classes. Cloud and shadow contamination were minimized through a processing workflow that combined information from the Landsat Quality Assessment (QA) band with the median reduction function available in Google Earth Engine (GEE). The QA band identifies pixels potentially affected by clouds, shadows, or other image artifacts, thereby supporting data quality control (USGS, 2017). Additionally, the median reducer calculates the median value of each pixel from a temporal stack of images, effectively reducing the influence of anomalously bright pixels, such as clouds, and unusually dark pixels, such as shadows. This approach produces more reliable composite images by retaining representative spectral values for each band over time.

To enhance mosaic quality and minimize noise, a filtering procedure was developed to assess individual images and remove those containing excessive cloud cover or limited useful information. In contrast, for the Amazon biome, each Landsat image was independently classified using the Random Forest algorithm. The resulting classifications were subsequently reclassified and integrated to produce annual land use and land cover (LULC) maps.

3.2 Google Earth Engine and MapBiomas Computer Applications

MapBiomas image processing is based on Google technology, which includes image processing in cloud computing infrastructure, programming with Javascript and Python via Google Earth Engine, and data storage using Google Cloud Storage. Google defines Google Earth Engine as a platform for petabyte-scale scientific analysis and visualization of geospatial datasets, both for public benefit and for business and government users.

3.3 Workflow

The methodological procedures applied in the different working groups or “regions” included several stages (Figure 3). The first stage consisted of generating annual Landsat mosaics based on defined temporal windows, with the objective of maximizing spectral contrast and improving the distinction between land use and land cover (LULC) classes across the mapped regions. The second stage was the derivation of all feature space attributes from the Landsat bands to train the random forest classifier for each year. After that yearly training samples were taken in each region according to the accessibility and statistically required information. The classification process results in an annual LULC map for each region, produced by the random forest classifier using the training samples for the respective years. If needed, additional samples were taken to improve the classification results. Based on the adjusted training data set, a supervised classification was run. As post-classification, filters were applied to further improve the LULC maps.

Due to the lack of images in the interior region in the year 1985, this region could only be classified from 1986 to 2025.

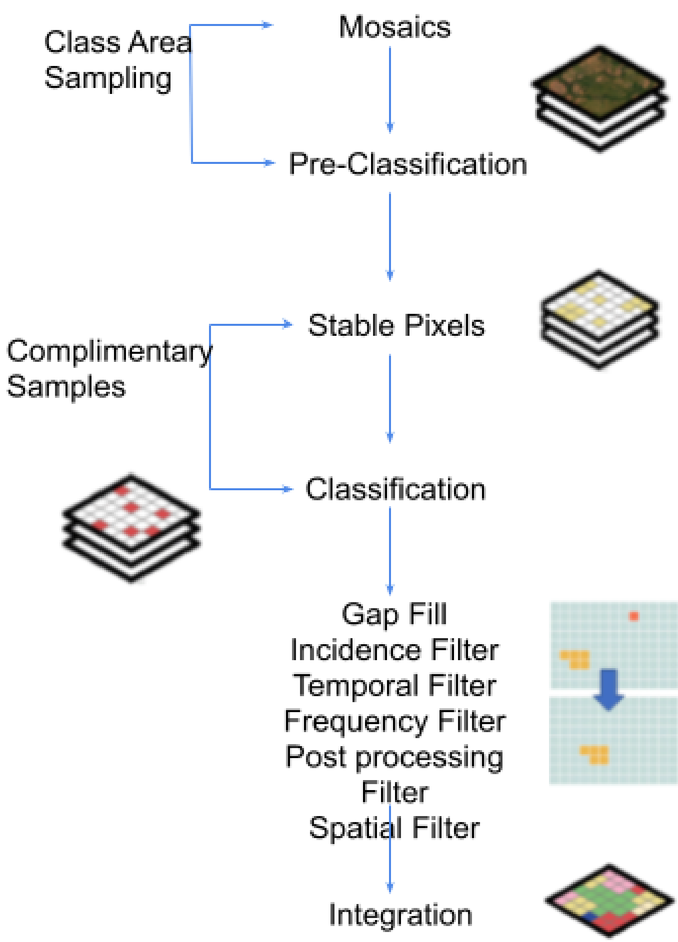

Figure 3. Overview of the classification process for MapBiomas Suriname.

3.4. Map legend

The classification for the first collection of MapBiomas Suriname consists of 10 land use and land cover (LULC) classes as shown in table 1 below. The definition of the classes can be found in appendix 1.

Table 1. Land cover and land use classes for MapBiomas Suriname - Collection 1.

COLLECTION 1 - CLASSES	Pixel id	Hexadecimal code	Color
1.Forest	**1**	**#1f8d49**	
1.1. Forest Formation	3	#1f8d49	
1.2. Mangrove	5	#04381d	
2. Herbaceous and Shrubby Vegetation	**10**	**#d6bc74**	
2.1. Wetland	11	#519799	
2.2. Grassland	12	#d6bc74	
3. Farming	**14**	**#ffefc3**	
3.1. Agriculture	18	#E974ED	
3.2. Mosaic of Uses	21	#ffefc3	
4.Non vegetated Area	**22**	**#d4271e**	
4.1. Urban Area	24	#d4271e	
4.2.Mining	30	#9c0027	
4.3.Other non Vegetated Area	25	#db4d4f	
5. Water	**26**	**#2532e4**	
5.1. River, Lake and Ocean	33	#2532e4	
6. Not observed	**27**	**#ffffff**	

3.5. Classification

At first reference datasets are created by combining stable land cover areas with masks that exclude unstable or transitional pixels. By removing pixels that have changed over time, the reference data consist only of locations with high confidence in their class labels, thereby reducing uncertainty during classifier training. Within the study region, a stratified random sampling approach is applied to generate representative samples for each land cover class. Stratified sampling ensures that a sufficient amount of samples is selected from each class, resulting in a balanced training dataset and reducing potential bias during model development.

For each year of the study period, the corresponding annual Landsat mosaic was retrieved and the spectral information at each sampled location was extracted. The resulting training dataset therefore consists of the reference class label together with the associated spectral variables derived from the satellite imagery. Finally, a separate training dataset is exported for each year, allowing annual LULC classifications to be developed while maintaining a consistent sampling framework throughout the time series.

The annual LULC classification was implemented in Google Earth Engine using the Random Forest algorithm. For each year of the study period, the corresponding Landsat mosaic and annual training dataset were loaded. The spectral bands of the Landsat imagery served as predictor variables, while the reference labels contained in the training samples represented the response variable used to train the classifier. Where necessary, additional training samples could be incorporated to improve class representation.

A Random Forest classifier consisting of multiple decision trees was trained independently for each year and subsequently applied to classify the Landsat mosaic. The resulting annual classification maps were stacked into a single multi-band image representing the complete temporal record. Finally, the classification product, together with its associated metadata, was exported as an asset for subsequent post-processing and accuracy assessment.

3.6. Post Classification

Because the land use and land cover (LULC) maps were generated using a pixel-based classification approach over a long temporal series, post-classification filtering procedures were applied to reduce classification noise and improve the temporal consistency of the results. Each cross-cutting theme employed a specific combination and sequence of filters tailored to its environmental characteristics and mapping requirements.

Several types of post-processing filters were used. The gap-fill filter was first applied to replace missing or unclassified pixels by utilizing information from neighboring years, thereby ensuring a continuous annual time series. Spatial filters were then used to eliminate isolated or fragmented pixels that were unlikely to represent real land cover patterns, resulting in more coherent and spatially consistent maps.

To further improve temporal stability, consistency filters were applied using moving windows of three, four, and, in the case of forest classes, five years. These filters identified and corrected abrupt land cover transitions that were considered ecologically or physically implausible, helping to reduce classification errors caused by image noise or model uncertainty. In addition, frequency-based filters evaluated how often a particular land cover class occurred throughout the entire time series. This approach minimized unrealistic oscillations between classes, reduced false-positive classifications, and preserved long-term land cover trajectories that reflected actual landscape dynamics.

An incident filter was also implemented to identify pixels exhibiting an unusually high number of class changes over the 41-year observation period. Such repeated transitions are often indicative of classification errors rather than genuine land cover change; therefore, these pixels were reassigned to more probable classes based on their temporal behavior.

Together, these post-classification procedures enhanced the spatial and temporal reliability of the final LULC products by reducing noise, correcting inconsistencies, and ensuring more realistic land cover trajectories. All filtering and post-processing operations were carried out within the Google Earth Engine (GEE) cloud-computing platform, enabling efficient analysis and management of large-scale geospatial datasets.

3.7. Statistics

Zonal statistics of the mapped classes were calculated for different spatial units, such as the districts and resorts, as well as watersheds, protected areas, and Indigenous and Tribal peoples living areas. A toolkit in the Google Earth Engine is available to upload user-defined polygons and download the LCLU maps.

4. References

Breiman, L. 2001. Random forests. Machine learning, v. 45, n. 1, p. 5-32.

USGS. Landsat Collection 1 Level 1 Product Definition. 2017. Available online: https://landsat.usgs.gov/sites/default/files/documents/LSDS-1656_Landsat_Level-1_Product_Collection_Definition.pdf

Appendix 1.

Description of the classes of land use and land cover used in the Legend of MapBiomas Suriname Collection 1.

Class Level 1	Class Level 2	Region	Description	FAO classes***	IPCC classes****	Google Earth
Forests	Forest	Coastal Area Interior	An area mostly covered by indigenous trees. Forest resulting from degradation processes or natural succession processes, after the total or partial suppression of primary vegetation by anthropogenic actions or natural causes, and remnant trees of primary vegetation may occur.	6661	Forest Land	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
	Mangrove	Coastal Area	Forest restricted to coastal areas dominated by halophytic trees, mostly occurring in intertidal zones.	6661	Wetland	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
Natural Herbaceous and Shrub Vegetation	Wetland	Coastal Area	Mixed marsh covered mostly with palm trees and herbaceous or shrubby vegetation. The lowland wetlands are subject to periodic flooding resulting in saturated soils and vegetation adapted to wet conditions.	6662	Wetland	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd

		Interior				
	Grassland	Coastal Area	An area mostly covered by indigenous grass, shrubs and herbaceous plants, with few or no trees.	6662	Grassland	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				
Agricultural and Livestock Area	Agriculture	Coastal Area	Areas where the original land cover has been modified or replaced by annual, seasonal, and perennial crops. Agricultural areas may include croplands, plantations, pastures, and fallow land, and are primarily shaped by anthropogenic activities.	6602, 6610	Cropland	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				
	Mosaic of Use	Coastal Area	An area shaped by both anthropogenic actions and natural processes where multiple land cover types and human uses occur in close proximity, including cultivated fields, pastures, secondary vegetation, settlements, and remnant natural patches. Areas not mapped in other classes can occur.	6602, 6610	Settlement	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				
Non-Vegetated Area	Urban Area	Coastal Area	An area of human settlement with built-up infrastructure, including dams, airports, air strips, industrial areas, solar panels, and clustered houses and connected roads. It also includes urban development and population centers located on the peripheries that are constantly expanding.		Settlement	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				

	Mining	Coastal Area	An area used for the extraction of minerals or other geological materials, characterized by clear soil exposure and altered land surfaces. It is not differentiated whether the activity is industrial, artisanal, riverine, informal, or illegal, and all such extraction areas are included in this class.		Settlement	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				
	Other Non-Vegetated Area	Coastal Area	Natural or anthropogenic areas with little or no vegetation, not mapped in other classes.		Settlement	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				
Water	River, Lake and Ocean	Coastal Area	Extent of natural or artificial surface water. Includes rivers, lakes, reservoirs, and other bodies of water.	6680, 6773	Wetland	https://drive.google.com/drive/folders/1TUMtfWpBHp7nz8E-NhBpbDDUDNkP4cPd
		Interior				
Not Observed						

*** FAO: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 3: Consistent Representation of Lands, pp 3.9-3.10. Link: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

**** IPCC: LAND USE, IRRIGATION AND AGRICULTURAL PRACTICES - DEFINITIONS (2017). Link: https://www.fao.org/fileadmin/templates/ess/ess_test_folder/Definitions/Land_Use_Definitions_FAOSTAT.xlsx