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EMSN-065

Post Matthew monitoring of recovery activities in the South Region of Haiti.

Final Report

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Issue	Date	Description	Section/ page

Table of content

List of figures

List of tables

Acronyms and abbreviations

Abbr.	**Description**
AOI	Area of Interest
AU	Authorized User
EU	End User
CEMS	Copernicus Emergency Management Service
CEOS	Committe on Earth Observation
CIAT	Comité Interministériel d'Aménagement du Territoire
CNES	Centre National d'Etudes Spatiales
CNIGS	Centre National d'Information Géospatiale d'Haïti
COTS	Commercial Off-The-Shelf
CSCDA	Copernicus Space Component Data Access system
DAP	Data Access Portfolio
DEM	Digital Elevation Model
EO	Earth Observation
ESA	European Space Agency
ETL	Extraction, Transform, Load
FAO	Food and Agriculture Organization
FTP/sFTP	Secure File Transfer Protocol
GFDRR	Global Facility for Disaster Reduction and Recovery
GSD	Ground Sampling Distance
IDP	Internally Displaced People
IGN	Institut national de l'information géographique et forestière
ISO	International Organization for Standardization
ITT	Invitation To Tender
JRC	Joint Research Center
LIDAR	Light Detection And Ranging
LULC	Land Use Land Cover
NDVI	Normalized Difference Vegetation Index
OBIA	Object-Based Image Analysis
OSM	Open Street Map
QA	Quality Assessment
QC	Quality Control
RENOP	REseau National d'Observation par Points
RO	Recovery Observatory
RRM	Risk & Recovery Mapping
SI	Shadow Index
VHR	Very high resolution
WB	World Bank

Reference documents

Ref	Title	Issue	Date
[RD01]	Framework Contract Copernicus EMS FLEX, No: 938352-IPR-2019	1.0	14.01.2020

Applicable documents

Ref	Title	Issue	Date
[AD01]	EN-8. LOT 1-FLEXEMS RRM_FLEX_TS - Annex A.docx.pdf	V1.1	15.05.2019
[AD02]	EN ISO 19157:2013, Geographic information - Data quality	V1.0	04.2014
[AD03]	EN ISO 2859-1:1999, Sampling procedures for inspection by attributes. Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection.	V1.0	1999
[AD04]	EN ISO 3951-1:2013, Sampling procedures for inspection by variables - Part 1: Specification for single sampling plans indexed by acceptance quality limit(AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL	V1.0	2013

1 Overview of the specific service request

1.1 Service context

Cyclone Matthew damage to Haiti

Cyclone Matthew struck southwest Haiti as a Category 4 storm on October 4th, the first Category 4 hurricane to strike Haiti since Hurricane Cleo in 1964. With upwards of 1,300 lives lost across the Caribbean, and more than a 1,000 lives lost in Haiti, the storm is the deadliest hurricane to strike in the Caribbean since Jeanne in 2004. The impact of Matthew will be lasting. While flooding caused significant damage and loss of life, the main impact was caused by the wind, which in some regions destroyed more than 95% of buildings and has completely destroyed trees and agriculture. In addition, widespread environmental damage occurred. It is worth noting that the area most affected has the largest concentration of natural, protected areas in Haiti.

On the 03 of October 2016, a Rapid Mapping activation was triggered upon request of the EC Services (DG ECHO) for Haiti since the Cyclone Matthew, a slow-moving storm, was expected to dump of torrential rainfall over Haiti in the next hours, with great danger for population and infrastructures. The damage, mostly concentrating on buildings and infrastructure, over many parts of Haiti was mapped over the following days, focussing on Grand'Anse in particular.

The Recovery Observatory in Haiti

Since 2014, the Committee on Earth Observation Satellites (CEOS) has been working on means to increase the contribution of satellite data to recovery from such major events. A Recovery Observatory oversight team was created with representatives from the satellite data providers, the international recovery stakeholder community and value-added providers. It is co-chaired by the French Space Agency CNES, and the GFDRR / WB.

After the impact of Hurricane Matthew in Haiti, CEOS Executive officially triggered the Recovery Observatory Haiti in December 2016 (named by its initial: RO). A project team made up of CEOS agencies, national partners and international DRM stakeholders is being established to oversee this project for a period of three to four years.

Co-built with Haitian partners (i.e. CNIGS, CIAT, etc.), the RO organizes recurrently workshops in Haiti. From these workshops the thread of the project was born: the definition of cartographic products, their improvements and their validations are carried out directly by the Haitian partners. Since the beginning of 2017, many themes have been followed: the recovery of Buildings, Transport networks, Agricultural activities, Watershed, Terrain Motion and Environmental rehabilitation.

Scope of the request

The scope of the service request EMSN-065 is to monitor the recovery phase of the vegetation after the passage of Matthew cyclone on the 4th of October 2016. The activation is related to a protected area (Makaya Park) and five agricultural areas (Les Cayes, Port-Salut, Jérémie, Dame-Marie and Pestel).

The aim is to build a comprehensive database to perform recovery aid organization and recovery monitoring of the critical resources destroyed. Information provided will be used by local governmental organisation and users.

1.2 Area of Interest

The areas of interest cover several places of Haiti's southern region, ranging from Dame-Marie, Jérémie, Makaya Park, Port-Salut, Les Cayes and Pestel (Figure 1).

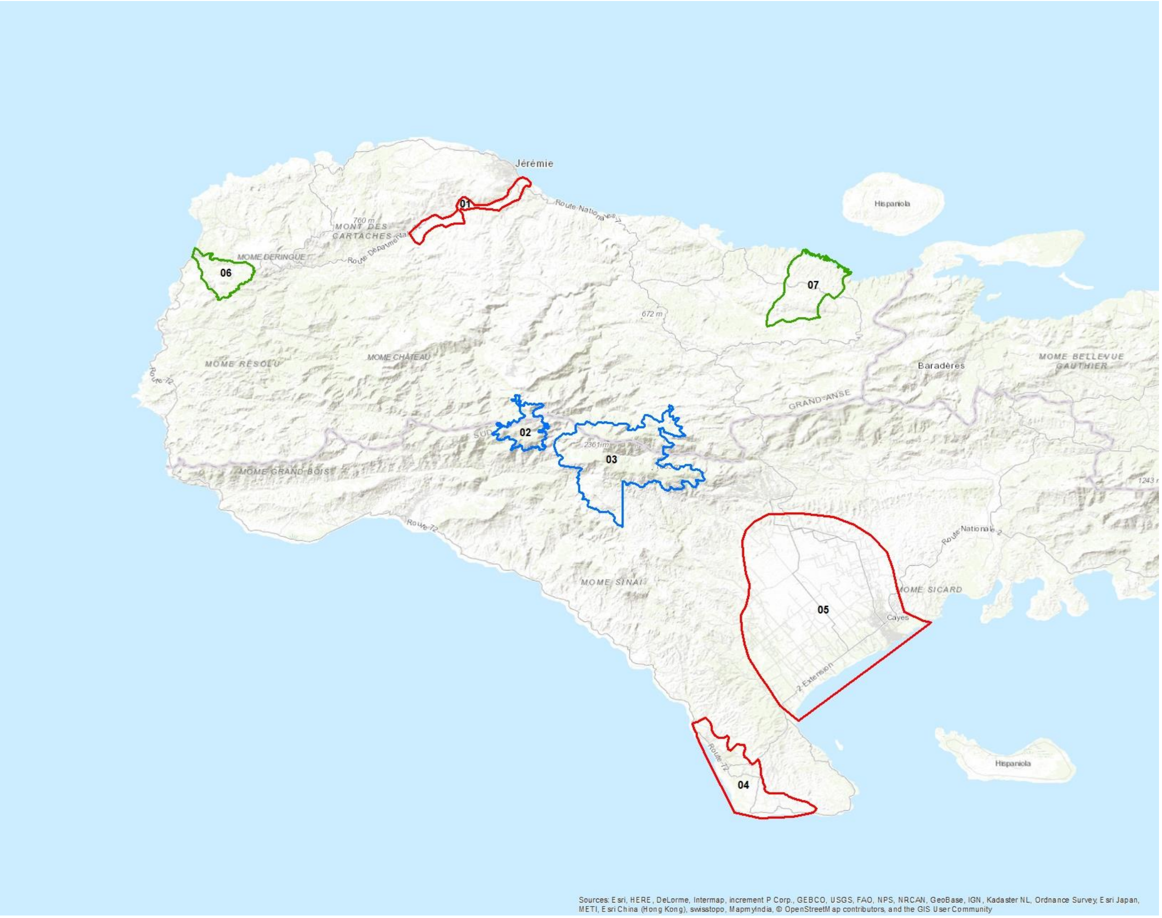

Figure 1: Area of interest for EMSN-065

The AOI names and their corresponding extent are listed in Table 1. AOI boundaries have been slightly reshaped for Dame-Marie and Pestel in order to better stick with road network (AOI6) or to well capture all the coastline (AOI7).

Table 1: AOI overview

AOI No.	Name	Area (km²)
01	Jérémie	14.2
02	Makaya West	15.1
03	Makaya East	87.2
04	Port-Salut	47.0
05	Les Cayes	274.0
06	Dame-Marie	17.2
07	Pestel	39.2

2 Outline of the technical approach and deliverables

2.1 Technical approach

The present study EMSN-065 is in the direct continuation of the work realized in the frame of the CEMS RRM EMSN-050 and (mostly) EMSN-051 activations. The methodology proposed here for the vegetation classification and status change are strongly based on this previous study (i.e. EMSN-051). This is motivated mainly by two reasons:

- To ensure comparability between the two analysis.
- To reproduce a methodology that has been already accepted by JRC and appropriated by the End User.

Adaptations may be performed to transfer the methodology from the image availability in EMSN-051 to the foreseen EO data in this activation, especially regarding crop cycles and cloud coverage. The core steps for EMSN-065 are identified as follows:

- Semi-automated vegetation classification respectively over all agricultural and protected areas.
- Identification of relevant changes between each timestamp.
- To compute relevant statistics (provided into the final report) in addition of map products.

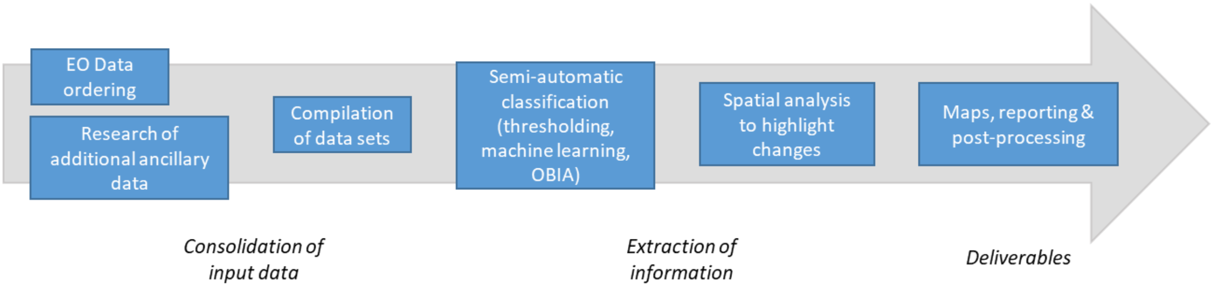

Figure 2: Brief overview of methodological approach

2.2 Deliverables

The deliverables include all requested elements as specified in the Technical Annex to ITT EMSN-065.

Output reference system: set to WGS84 UTM 18N for all AOIs (EPSG: 32618).

Core element of delivery: Geospatial datasets for the support to recovery aid organization and recovery monitoring of the critical resources destroyed.

Additional reference information: Topographic feature layers used to visualize in the overview maps.

Map and statistics visualize the vegetation classification for the pre-/post timestamps for all AOIs and land status and its change in the agricultural areas.

Reporting: Fully in line with the requested elements as specified in the Technical Annex to ITT EMSN-065.

Metadata & Quality assessment: All products are delivered with their respective ISO 19115/19139 metadata .xml file. Description and results of quality assessment are reported in chapter 4.2.

The following table gives an overview of the delivered products for EMSN-065.

Table 2: Products delivered for EMSN-065

Deliverable	Description	Data Type	Comment
Geospatial data	Results for monitoring of the recovery phase of vegetation in the Southern Region of Haiti within 7 AOIs	.gdb, .geojson	
	Symbology	.lyr, .sld	
Printable Maps	23 Overview Maps, 2 to 5 per AOI	GeoPDF	Scale: 1:10,000 - 1:40,000, A1 format
EO/ raster data	Pre-processed VHR1/VHR2 data per AOI and per timestamp	.tiff (Geotiff)	
Reporting	Final Report	.docx	
	Factsheet	.docx	
	Flyer	.docx .tiff for figures/ pictures	
QA	QA sampling data set	.shp	
Metadata	Metadata files for maps, EO imagery data and vector data	.xml	INSPIRE/ISO-conform
Other	Statistics of land status changes in agricultural areas	.xlsx	

2.3 Challenges

Requested product generation time

The timeline of thirty (30) calendar days for production for the seven (7) AOIs was a demanding challenge against the number of images per timestamp and per areas to handle. Due to distribution of tasks and AOIs between the production sites that issue was supposed to be solved by parallel processing. Meanwhile, to cope with the unexpected spread of Covid-19 crisis over Europe, drastic sanitary measures have been taken by Public Authorities in respective countries by the end of the first week after production start. Lockdown rules forced production sites to move towards home office solutions without any real anticipation. This situation had an important impact on production capacities and rapidly a postponement of four weeks for the deadline has been requested and approved by JRC.

EO data availability and suitability

AOIs 1, 4 & 5:

While a reasonable amount of EO data is available for each AOI at T2 allows a proper extraction of the different vegetation layers, a very limited number of cloud-free data are available to well catch different vegetation/crop stages at T3. Changes analysis is a tricky challenge considering that the agricultural land status for 2019 is not well representative of the whole year. Reported changes are difficult to assess for Jérémie and Port-Salut.

AOI2:

Availability of VHR2 data (e.g. SPOT-6/7) would have been better for vegetation mapping. However, acquisition date of the current VHR1 data and its complete coverage are optimal.

AOI3:

The main challenge over AOI3 is to ensure a full coverage with cloud-free VHR1/VHR2 data. Actually, a composite of three VHR1 data has been used in this study. The difference between acquisition dates, and hence in terms of illumination and vegetation sate, makes the classification process difficult. Once again, VHR2 data would have been better for vegetation mapping.

AOI6:

The combination of different patches of VHR1/ VHR2 data in order to generate the vegetation classification was demanding. Repeated cloud coverage reduced the availability of multiple data per Tn covering the complete AOI. This limits the differentiation of low vegetation classes. A further imitating factor was the strong illumination effects related to terrain in some of the data.

Having only VHR1 data available would have been lead to better vegetation mapping results, e.g. with respect to the identification of the status of elevated vegetation such as trees, shrub, and managed vegetation. Further, VHR2 data limited the visibility of combined land cover classes of agriculture underneath tree crowns. Due to a fast regrowth of elevated vegetation, a differentiation between natural regrowth and agricultural growth almost not possible.

Data availability in terms of temporal distribution put constraints on the differentiation between vegetation classes 232, 242 and 336.

AOI7:

The timestamps were supplied with different combination of satellite data which made the data extraction more demanding since no single method could fit all. T0 was covered partially (about 50% of AOI) with a single date VHR1 and the rest of the area was covered with VHR2 images. Single sensor Multi-temporality was assured only with the VHR2 images. T1 was only covered with VHR2 imagery which created additional challenges for the classification, due to the loss of spatial detail and consequent texture detail, specifically in regard to the discrimination of shrubs and trees, copse and isolated trees areas. T3 was the unique timestamp fully covered with a VHR1 imagery but again multi-temporality was only achieved through an additional VHR2 imagery, with consequent limitations to the classification accuracy.

3 Technical methodology

3.1 Input data

3.1.1 Imagery data

The used data sources in order to extract the requested information are a combination of satellite imagery, preferably VHR1/VHR2 data for detail scale processing and reference data to be applied in the context of pre-/post LULC datasets and map composition.

Table 3 shows the imagery considered in order to extract the requested information. The data were procured under the ESA-GSC-DA mechanism and RO website.

Table 3: EO data considered

Timestamp	Sensor	Acquisition period
Pre-event (T0)	GeoEye-1, WorldView-2, WorldView-3, Pléiades, Deimos-2, Kompsat-2, Kompsat-3, SPOT-6/7	Over 2015 and 2016 (up to early October)
Post-event (T1)	GeoEye-1, WorldView-2, WorldView-3, WorldView-4, Pléiades, Deimos-2, Kompsat-3, SPOT-6/7	Over 2016 (starting from mid-October) and 2017
Mid-2018 (T2)	GeoEye-1, WorldView-2, WorldView-3, WorldView-4, Pléiades, Deimos-2, Kompsat-3, SPOT-6/7	Over 2018 and even early 2019 (due to cloud coverage and agricultural calendar)
Most recent (T3)	GeoEye-1, WorldView-2, WorldView-3, Pléiades, Deimos-2, Kompsat-3, SPOT-6/7	Over 2019 and 2020

3.1.1.1 Pre-event situation (T0)

Table 4 provides an overview on the use of each VHR1/VHR2 imagery for both pre-Matthew (T0) reference mapping and thematic processing over Dame-Marie (AOI6) and Pestel (AOI7).

Table 4: Imagery data procured for at T0

Sensor	Date	AOI	Use
SPOT-7	17/11/2014	AOI6	This image was not used due to date – major changes towards 2016 had been identified
WorldView-3	12/05/2015	AOI6	This image was used as most important reference image due to visibility of recent agricultural activities
WorldView-3	24/10/2015	AOI6	This image was used as 2nd reference image, standardized multi-temporal analysis limited due to cloud coverage
SPOT-7	26/01/2016	AOI6	Only image without clouds, but lower resolution
WorldView-2	17/07/2016	AOI6	Used as adjacent image layer, restriction due to limitations in data coverage and visibility of agriculture
WorldView-3	28/07/2016	AOI6	Used as adjacent image layer, restriction due to limitations in data coverage and visibility of agriculture Very high resolution
Pléiades	05/12/2015	AOI7	This image was used as most important reference image due to the higher spatial resolution
SPOT-6	06/01/2016	AOI7	This image was not used due to limited visibility in the areas that needed to be covered

Sensor	Date	AOI	Use
SPOT-7	14/01/2016	AOI7	This image was used as 2nd reference image to complement the areas that were not covered by the first reference image
SPOT-7	25/06/2016	AOI71	This image was used to improve classification specifically in regard to the agricultural classes, by providing a multi temporal view of the AOI

3.1.1.2 Post-event situation (T1)

Table 5 presents the use of each VHR1/VHR2 imagery for both post-Matthew (T1) reference mapping and thematic processing over Dame-Marie (AOI6) and Pestel (AOI7).

Table 5: Imagery data procured for at T1

Sensor	Date	AOI	Use
Pléiades	12/10/2016	AOI6	Used as important image layer: damage and surface vegetation visible, adjacent to 15/10/2016 Very high geometric/ low spatial resolution
WorldView-3	15/10/2016	AOI6	Used as important image layer: damage and surface vegetation visible, 1 week after event Very high geometric/ low spatial resolution
SPOT-7	14/02/2017	AOI6	This image was used to fill cloudy region of 21/02/2017, which was more suitable for analysis
WorldView-2	21/02/2017	AOI6	Main important classification image, texture and spectral analysis; good temporal fit – before significant recovery of vegetation
SPOT-7	24/09/2017	AOI6	This image was not used due to limited visibility and highly vital status of most regions
SPOT-7	11/10/2017	AOI6	This image was not used due to cloud impact and date.
SPOT-7	12/10/2017	AOI6	This image was not used due to cloud impact and date.
SPOT-7	18/10/2017	AOI6	This image was not used due to date (almost situation T3).
GeoEye-1	12/12/2017	AOI6	Used as adjacent image, shows significant vegetation regrowth effects
Pléiades	15/12/2017	AOI6	Used as adjacent image, shows significant vegetation regrowth effects; limited coverage
SPOT-6	08/10/2016	AOI7	This image was not used due to its date
SPOT-7	14/02/2017	AOI7	Reference classification image, texture and spectral analysis; good temporal fit – before significant recovery of vegetation
SPOT-7	18/10/2017	AOI7	This image was used in order to improve classification results whenever possible, due to offering the multi temporal view (again important for agricultural classes). However, relevant vegetation recovery was already present which was contradictory with the reference image.

3.1.1.3 Post-event situation (T2)

Table 6 presents the use of each VHR1/VHR2 imagery for both post-Matthew (T2) reference mapping and thematic processing over Jérémie (AOI1), Port-Salut (AOI4) and Les Cayes (AOI5).

Table 6: Imagery data procured at T2

Sensor	Date	AOI	Use
Pléiades	28/06/2018	AOI1	This image was used for reference mapping
SPOT-6	13/08/2018	AOI1	This image was used for extraction of vegetation classes
SPOT-7	05/11/2018	AOI1	This image was used for extraction of vegetation classes
SPOT-6	02/12/2018	AOI1	This image was used for extraction of vegetation classes
GeoEye-1	13/12/2018	AOI1	This image was used for reference mapping
SPOT-7	13/02/2018	AOI4	Used as main image for determining woodlands and shrub classes. Almost cloud-free
GeoEye-1	10/11/2018	AOI4	Used for temporal series processing in order to detect croplands, reference mapping. Half coverage
GeoEye-1	13/11/2018	AOI4	Used for temporal series processing in order to detect croplands, and reference mapping. Half coverage
SPOT-7	03/12/2018	AOI4	Used for temporal series processing in order to detect croplands. Almost cloud-free
Pléiades	05/02/2018	AOI5	This image was used for reference mapping
SPOT-7	13/02/2018	AOI5	Extraction of woodland, shrubs, croplands, low-lying vegetation, bare soils In combination with the S7 acquired the 14/11/2018
WorldView-2	15/09/2018	AOI5	This image was used for reference mapping
WorldView-2	15/09/2018	AOI5	This image was used for reference mapping
SPOT-7	14/11/2018	AOI5	Extraction of woodland, shrubs, croplands, low-lying vegetation, bare soils In combination with the S7 acquired the 13/02/2018

3.1.1.4 Most recent situation (T3)

Table 7 presents the use of each VHR1/VHR2 imagery for both post-Matthew (T3) reference mapping and thematic processing over Jérémie (AOI1), Makaya Park (AOIs 2&3), Port-Salut (AOI4), Les Cayes (AOI5), Dame-Marie (AOI6) and Pestel (AOI7).

Table 7: Imagery data procured at T3

Sensor	Date	AOI	Use
Pléiades	21/06/2019	AOI1	This image was used for reference mapping
SPOT-7	04/11/2019	AOI1	This image was extensively used for vegetation change analysis
Pléiades	21/06/2019	AOI2	This image was used for both reference mapping and vegetation change analysis
GeoEye-1	01/01/2019	AOI3	This image was used to cover the missing cloudy parts
Pléiades	08/10/2019	AOI3	This image was extensively used for both reference mapping and vegetation classification
Pléiades	15/01/2020	AOI3	This image was used to fulfil missing coverage over AOI3
SPOT-7	30/11/2019	AOI4	Used as main Image for determining woodland and shrub classes
WorldView-2	14/01/2020	AOI4	Used for temporal series processing and reference mapping

Sensor	Date	AOI	Use
WorldView-3	02/03/2020	AOI4	Used for temporal series processing and reference mapping
SPOT-7	11/07/2019	AOI5	Extraction of woodland, shrubs, croplands, low-lying vegetation, bare soils In combination with the SPOT-7 acquired on the 30/11/2019
Pléiades	11/07/2019	AOI5	This image was used for reference mapping
SPOT-7	30/11/2019	AOI5	Extraction of woodland, shrubs, croplands, low-lying vegetation, bare soils In combination with the SPOT-7 acquired on the 11/07/2019
SPOT-7	07/08/2018	AOI6	This image was just used for identification of bare soil/ fields; almost redundant Due to LC change in-between T3, concentration on 2019 EO data
SPOT-7	02/12/2018	AOI6	Spectral analysis in order to identify bare soil/ fields; used as adjacent layer to separate complex cultivation from permanent low lying vegetation
Pléiades	14/06/2019	AOI6	Used to support differentiation process bare soil/ complex cultivation/ low lying vegetation All data of 2019 was primarily used for classification
SPOT-7	11/07/2019	AOI6	This image was not used due to cloud impact and resolution.
Pléiades	10/10/2019	AOI6	Primary imagery for classification of T3; differentiation process transitional/ woodland and bare soil/ complex cultivation/ low lying vegetation; complete coverage!
WorldView-2	02/12/2019	AOI6	Imagery for classification of differentiation process bare soil/ complex cultivation/ low lying vegetation; only regional consideration; important due to date
SPOT-7	11/07/2019	AOI7	This image was used as support to the classification of bare soil/ complex cultivation/ low lying vegetation
WorldView-2	02/12/2019	AOI7	Reference classification image for T3, with good texture and spectral quality; good temporal fit – after significant recovery of vegetation

3.1.2 Ancillary data

A set of relevant ancillary geospatial data to be used as input for the reference mapping, imagery pre-processing, information extraction and thematic analysis, have been procured by both JRC and End User. The table below provides an exhaustive list of available datasets in the frame of the EMSN-065 specific request. Data of higher temporal up-to-dateness and spatial resolution were also considered, especially OSM which provides a homogeneous, reliable and the most complete situational picture, primary used for the most recent point in time (T3). For backward analysis, this data is adapted based in the Aerial/ VHR imagery data.

Table 8: Ancillary data procured

Data set/source	Description/content
EMSN-050: Post Matthew Damage Assessment and Monitoring of Recovery Activities in the South Region of Haiti	• **Description**: CEMS RRM activation. Support monitoring of recovery after the passage of the Category 5 Hurricane Matthew on the 4th of October 2016. Detection of buildings and assets of all kinds affected by the cyclone, and understanding how people temporarily had to relocate their dwelling to the so called IDP camps, while the reconstruction works were taking place

Data set/source	Description/content
Source: https://emergency.copernicus.eu/mapping/list-of-components/EMSN050	• **Up-to-dateness**: pre/post status ranging from 2015 to 2017 • **Geometric resolution**: corresponds to a map of 1:5.000 scale **Thematic accuracy**: >=85% • **Usability**: Use of reference topographic features and of LULC classes (when/where relevant) at T0 and T1 over AOIs 1-2-3-4-5
EMSN-051: Post Matthew monitoring on rural areas, South Region of Haiti Source: https://emergency.copernicus.eu/mapping/list-of-components/EMSN051	• **Description**: CEMS RRM activation. Support monitoring of recovery after the passage of the Category 5 Hurricane Matthew on the 4th of October 2016.Six areas were selected to analyse several environmental aspects, including agricultural activities, forest in protected areas, mangrove areas, and finally coastline modifications. • **Up-to-dateness**: various status ranging from 2015 to 2017 • **Geometric resolution**: corresponds to a map of 1:5.000 scale • **Thematic accuracy**: >=85% • **Usability**: Use of reference topographic features and of LULC classes (when/where relevant) at T0 and T1 over AOIs 1-2-3-4-5. Use of vegetation classifications as of baseline for monitoring purposes
CIAT/CNIGS: Diagnostic territorial du Grand Sud	• **Description**: Pre-Matthew reference mapping over South Region of Haiti. Environmental and demographic analysis. • **Up-to-dateness**: Released in 2017, but situation as of up to Matthew cyclone • **Geometric resolution**: corresponds to a map of 1:10.000 scale • **Thematic accuracy**: Not available • **Usability**: Main source for reference topographic features at T0 over AOIs 6-7
OSM Source: http://www.openstreetmap.org/	• **Description**: crowd-sourced free editable global map offering topographic features (e.g. administrative boundaries, hydrology, transportation, toponyms, land cover) • **Up-to-dateness**: based on GPS tracking and digitization of available aerial and satellite images. • **Geometric resolution**: corresponds to a map of 1:10.000 scale • **Usability**: additional data sources to derivation of the additional geometric or attributive information for
Aerial ortho-photo	• **Description**: Countrywide aerial ortho-photo coverage performed by IGN and released by CNES • **Up-to-dateness**: 2014 • **Geometric resolution**: 0.25m • **Usability**: Reference mapping (RGB bands only)
Lidar DEM	• **Description**: Countrywide aerial Lidar DEM coverage performed by IGN and released by CNES • **Up-to-dateness**: 2014 • **Geometric resolution**: 1.5m • **Usability**: Orthorectification, hillshade, contours, spot heights
RENOP: National network of observations by points	• **Description**: Regular grid of points describing the corresponding LULC, according to the CNIGS nomenclature • **Up-to-dateness**: 2014 • **Geometric resolution**: Regularly spaced points (125m) • **Thematic accuracy**: Not available • **Usability**: Provided only for Makaya Park for vegetation classification at T0 over AOIs 2-3. This layer will be updated for the same purposes at T3 based on the corresponding VHR1/VHR2 imagery

3.2 Product processing

3.2.1 Workflow

The workflow in order to generate the requested products is presented in Figure 3.

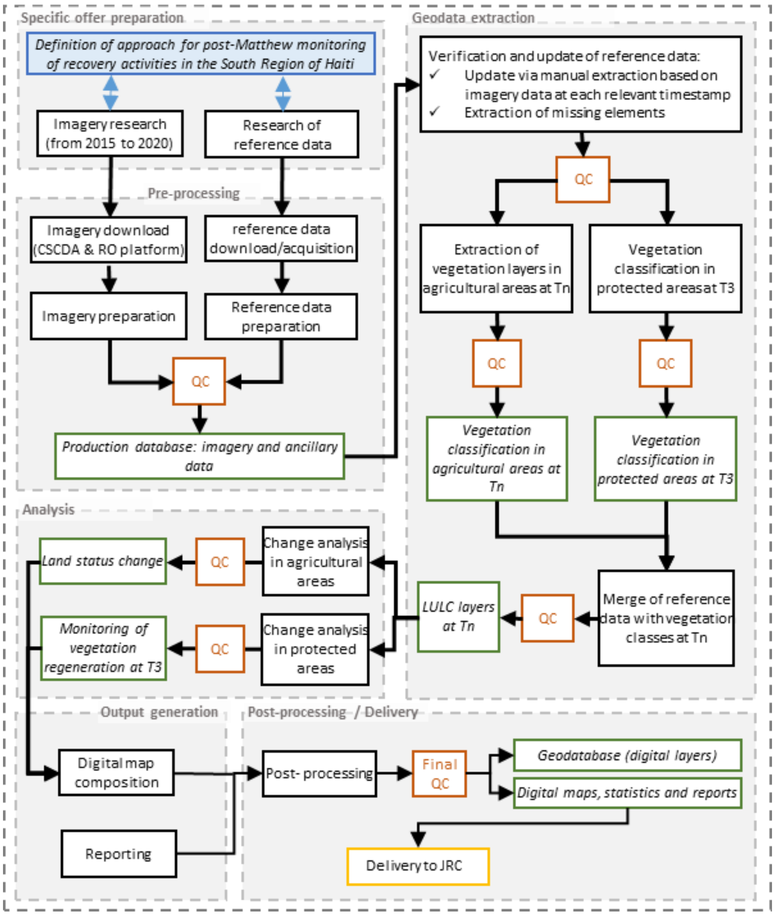

Figure 3: Processing workflow

Main drivers for the definition of the approach for the Post Matthew monitoring of recovery activities in the South Region of Haiti are as follows:

- Continuity to workflow and respective results of EMSN-051 approach applied in the same area,
- Availability of low-cloud VHR1/VHR2 satellite imagery time series with respect to the requested timestamps,
- High degree of automation.

Table 9 lists all relevant workflow items and their respective technical approach to guarantee homogenous and high-quality results (geospatial datasets) ready to use by the End Users. Each AOI is addressed following its requested timestamps, where a vegetation classification for both agricultural and protected areas is performed accordingly.

At timestamps corresponding to pre- (T0) and post-event (T1/T2/T3), a LULC layer is produced for each AOI.

Once all these thematic layers are consolidated for each timestamp, the requested land status changes and the monitoring of vegetation regeneration is addressed over the respective AOIs. For these specific products, all map products are followed by detailed statistics resulting from the change analysis.

Overview maps for each AOI and per product have been prepared and general findings, a characterization of the results aggregated within this report.

Table 9: Technical approach per workflow item

Detailed workflow item	Description of technical approach
Data research, download and pre-processing	• Download of EO and ancillary data (e.g. reference data) • Preparation of EO data "ready to use" (orthorectification, cloud masking, computation of required spectral/textural indices) for each timestamp addressed per AOI
Verification and update of reference data	• Quality check of the End User's and open source data (actuality, completeness, logic) • Review on available geo-data • Merge of different data sources, and preparation of reference data (ETL) to cope with the technical specifications of the products GDB. • Update of the reference dataset via manual extraction based on the corresponding imagery for each timestamp addressed
Extraction of vegetation classes in agricultural areas	• Semi-automatic extraction of the tree surfaces and breakdown into tree cover classes (i.e. woodland, copse, isolated trees) • Density based sub-division of the woodland class • Semi-automatic extraction of low-lying vegetation and cropland separation • Manual extraction of mangrove and rice fields • Creation of non-vegetation layers where reference data are not applicable
Vegetation classification in protected areas	• Manual update of samples according to T3 imagery • Supervised classification
LULC production	• Merge of reference dataset with vegetation/non-vegetation classes into a separate LULC layer
Land status change analysis in agricultural areas	• Spatial analysis between T3-T1 and T3-T1 vegetation classes (AOIs 6/7) • Spatial analysis between T3-T2 vegetation classes (AOIs 1-4-5) • Aggregation of relevant changes for each addressed time interval
Monitoring of vegetation regeneration in protected areas	• Spatial analysis between T0 and T3 vegetation classifications • Selection within the T0 woodland class of both objects that are still/no longer woodland • Overall changes as statistics
Digital map production	• Preparation of map product, as overview map for each AOI
Final-processing of deliverable geospatial datasets	• Post-processing of geo-data (topologic check and consistency checks), Quality Assessment of the several outputs • Provision of relevant data to the user
Reporting & statistics	• Provision of results and a summary on the applied methodology • Preparation of one-pager for internet presentation (emergency mapping webpage) • Suitable summaries (in line with EMSN-051 reference project and as agreed with the user)

3.2.2 Single processing steps

3.2.2.1 Data research, download and pre-processing

The analysis starts by selecting, checking and preparing all necessary input data. This comprises EO imagery, official and open source reference layers. All was reviewed within the proposal phase, detailed listings are provided in chapter 3.1. A detailed listing of the available EO imagery is contained in Annex 1.

The EO satellite imagery procurement has been repeated in order to assure that any unlikely update to the catalogue of available imagery is detected and accounted for this activity. After download through the expected channels (ESA-DAP and RO platform) the EO data were checked for quality and consistency. After verified and approved, the data were subject to a number of pre-processing procedures in order to improve the imagery radiometry, correct for atmospheric effects and properly geolocate it through its orthorectification:

- COTS models were used to implement the radiometric, atmospheric corrections and orthorectification.
- The orthorectification of the images used the most detailed DEM available (i.e. Lidar DEM) together with the image RCPs improved with GCPs collected on top of reference data (e.g. the ancillary ortho aerial imagery provided by the user).

Considering the overall extraction process that has to be carried out in this study, the following additional pre-processing steps were required:

- Verification of geometric consistency over time-series,
- Co-registration when required and feasible (i.e. due to the mix of spatial resolutions),
- Delineation of cloudy regions,
- Combination of best suitable dates and coverages,
- Computation of spectral and textural indices (i.e. NDVI, SI).

It has to be noticed that order and delivery dates, as well as encountered delivery delays or quality issues are reported in Annex 1. Moreover, all the geometric accuracies (i.e. RMSE) of processed images are reported in chapter 4.2.1.

3.2.2.2 Verification and update of reference data

In order to provide a basic set of reference topographic features in the map products, and to create LULC layers, it was necessary to build an exhaustive reference dataset per AOI and at all required timestamps. Ancillary datasets listed in chapter 3.1.2 were used for this purpose.

The reference data were checked for its relevance and quality (e.g. completeness, accuracy, temporal adequacy, etc.) prior to deciding upon its utilization. This was done through a feasibility assessment where at least two senior expert analysts inspected (e.g. visual check against the satellite data, confidence building approaches by comparing with other datasets, etc.) the information available and reached an agreement on the pertinence of the data.

Post decision on the data to be used coming from ancillary reference datasets, the data went through an ETL (extract, transform, load) procedure in order to achieve the required consistency with the technical specifications of the output products.

The reference data supported the mapping of a number of features, namely urban and industrial areas, hydrology and road infrastructures. Once aggregated, the reference database were then modified and/or updated using the corresponding VHR1/VHR2 imagery, in order to meet target levels for both thematic completeness and geometric accuracies. At T0 over AOIs 6-7, the reference imagery was provided by the aerial ortho-photo acquired in 2014.

3.2.2.3 Extraction of vegetation classes in agricultural areas

Given the fact that all five AOIs (except for AOI 6 – Dame-Marie) are mostly low-lying they are considered to be agricultural landscapes. Urban areas, road infrastructures and many agricultural fields are present within this area. All tree cover located in these AOIs are considered as part of the agricultural domain whether close to urban areas or not as they could be tree crops.

To proceed, urban areas, road infrastructure and hydrology was removed along with extraction sites and industrial areas observed.

The classification nomenclature proposed in EMSN-051 is derived from a CNIGS classification nomenclature document that was provided by JRC with the specific ITT. The proportion of tree coverage in agricultural areas is one of the main classification criteria in this nomenclature. The classification method is built on the following two parts:

- Tree surface classification,
- Non-forested surface classification (persistent low-lying vegetation, crops, and persistent bare soils / outcrops).

Tree surface classification

The objective here is to obtain as an input to an agricultural activities reference map by:

- A tree covered area classification,
- Followed by a subdivided tree cover density based classification with woodland, copse and isolated tree classes.

Tree cover classification

The most optimal images was first of all selected based on the contrast between forested/tree high vegetation and low-lying persistent and/or agricultural crops. Image processing was applied to selected VHR1/VHR2 satellite data using pan-sharpened channels to obtain an NDVI, a Shadow Index (SI) and a texture channel per image per AOI. A principle image was chosen which was used to derive an initial tree-cover layer.

Woodland, copses and isolated trees

Once the tree-cover classification was accepted, geo-spatial analysis was applied to distinguish between woodlands, copses and isolated trees based on tree-cover density per 0.5 ha. The tree cover classes were attributed according to the criteria in the table below. The specific tree-cover corresponding to mangrove was digitized manually and removed from the current classification.

Table 10: Tree cover geospatial classification criteria

Class number	Tree cover class	Class criteria
313	Mixed forest	Density >= 10% Size >= 0.5 hectares
314	Mangrove	N/A (photo-interpreted)
315	Copse	Size >= 0.02 hectares and <=0.5 hectares
316	Isolated trees	Trees outside the above classes (>4px)

Woodland density classes

Secondly, the woodland class is sub-divided into further tree density classes as outlined in the table below. The tree density classes are added as an extra attribute to the woodland class.

Table 11: Woodland density classification criteria

Class Number	Tree density class	Class criteria
1	Low density trees within agricultural area	Density >= 10% and Density < 30%
2	Trees within agri-forestry system	Density >= 30% and Density < 65%
3	Dense woodland	Density >= 65%

Non-forested agricultural land classification

This part of the classification concerns low-lying vegetation, croplands and persistent bare soils/outcrops. It is the most challenging part as the agricultural patterns are complex to say the least being illustrated in the figure below and described in the table and text below which refers to the diagram.

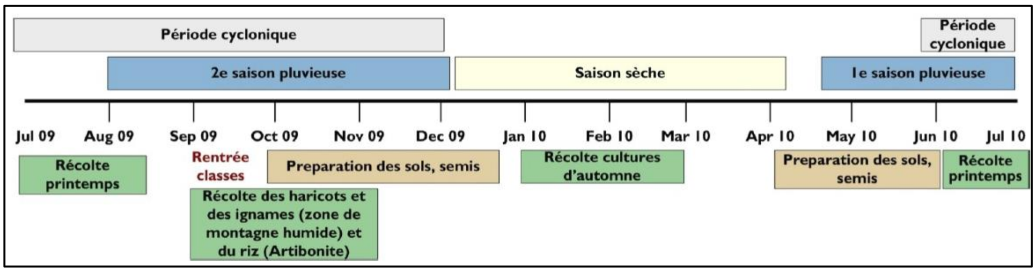

Figure 4: Cyclone, wet-dry season and agriculture time table in Haiti

As there are not enough cloud-free satellite data, the fact that the CNIGS classification nomenclature does not mention specific crops, and there are no recent field data available at the time, a crop classification was not implemented. Hence, a compromise was developed based on the CNIGS nomenclature.

Table 12: Low-lying LULC classes and method overview

Class number	CNIGS Class	Proposed classification	Method overview and comments
324	Shrub (< 5m height)	Transitional Woodland Shrub	Areas that may have a certain similarity to forestry but have less texture/shadowing effects The class could be complex and may be extracted by a combination of NDVI, Shadow Index and texture derived from selected satellite imagery
213	Cultivated and Managed Terrestrial Areas	Rice fields	Photo-interpretation from satellite imagery
232	Herbaceous Crops (prairies, grasslands)	Persistent low-lying vegetation	Non-tree low-lying vegetation in all images: this class will be derived from areas of low vegetation changes and low texture
242	Cultivated and Managed Terrestrial Areas	Complex cultivation	Alternating vegetation / bare soils: a semi-automatic extraction will be carried out to map areas that changed from mineral to vegetal and vice versa.
331	Intertidal area	Beaches, dunes and sand plains	Coastal predominantly mineral surfaces that will be photo-interpreted from satellite imagery
336	Natural open space without or with very little vegetation	Bare soil	Bare soils in all images: this class will be comprised of areas showing very low vegetation index values over the period of analysis. This could be rock outcrops, various mineral surfaces and cropland that wasn't seen covered in vegetation by the satellite images
411	Continental waters	Inland marshes	Wetland areas detected in Les Cayes
511	Continental waters	Water courses	River water bodies
512	Continental waters	Water bodies	Lake water bodies
523	Marine waters	Sea and ocean	Non-terrestrial water bodies

Given the complexity of the agricultural season, the differentiation between low-lying agricultural classes was less sure than for the forestry classes. The separation of persistent low-lying vegetation from crops was in parts difficult depending on image coverage of seasonal variations. Bare soils did also persist where images did not cover the complete agricultural cycle. As such, fields that remain bare soils in essentially cropland area were considered as predominantly cropland.

3.2.2.4 Vegetation classification in protected areas

Even if it's not possible to ensure the same data for AOI2 and AOI3 (ch. 3.1.1.4), the same methodology was applied for each part of Makaya Park. In this densely forested natural area, a vegetation classification based on a supervised machine learning algorithm as forest cover is widespread, and homogeneous was applied.

This supervised approach required an existing reference database which is used to extract labelled samples, on one hand train the classification model (i.e. learning phase), and on the other hand to perform a statistical validation of the resulting classification.

During the EMSN-051 activation, an evaluation of the reference ortho-photo (2014) has been performed, and according to the CNIGS nomenclature it led to the vegetation classification summarized in Table 13. The same class names were used in EMSN-065 map products, vector attributes and associated statistics.

Table 13: Intended class names for vegetation classification over AOIs 2-3

Proposed classification	Class number
Woodland	313
Shrubs	324
Herbaceous vegetation	321
Bare soil	336

As initial samples, the national point's dataset of regular 125m spacing and describing the Haitian LULC for 2014 (RENOP) have been used. However, it is obvious that this dataset is no more up to date since the Matthew cyclone crisis, and hence each point attribute was recoded when necessary using the selected VHR1/VHR2 data for T3. The total number of samples is of 968 for AOI2 and of 5595 for AOI3.

The selected EO data were processed as follows:

- Creation of a binary cloud mask by photo-interpretation
- Calculation of NDVI based on red and near-infrared bands
- Calculation of Shadow Index (SI) based on red and green bands
- Layer stack of blue, green, red, NDVI, and SI bands

A random sample selection is performed from the reference dataset created previously by selecting 75% of the available points for the learning phase. These selected samples are then crossed with the image stack in order to extract as attribute values the measurements in each channel. The ''updated'' samples are used to train a Random Forest algorithm for the construction of a classification model.

This model is applied to the whole image stack (associated to the cloud mask if any), in order to classify the whole Makaya Park extent. Classification result in that case were filtered by removing objects and filling holes with an area less than 0.01 ha. A confusion matrix and an associated overall accuracy are computed from the validation sample set (i.e. the remaining 25%).

3.2.2.5 LULC production

The LULC maps are conform to the nomenclature specified (CNIGS Land Use nomenclature) as requested in the ITT. These are produced through the integration of the vegetation classification with the reference data and complemented via a manual post editing to fill any gaps in the required wall-to-wall coverage over the AOI. It has to be noticed that as a general rule, tree cover classes supersede the urban area class, in order to stay compliant with the reference project EMSN-051.

The output of this integration was thematically harmonized with the CNIGS nomenclature via a nomenclature correspondence table. Given that the vegetation classification nomenclature offers higher detail but in a hierarchical compatible way with CNIGS, the conversion to this latter classification was of the N-to-1 and/or 1-to-1 type, thus guarantying a direct conversion without the generation of uncertainties.

In addition to the above approach it is sometimes decided that the update of the CNIGS nomenclature is more interesting since it allows to keep the higher detail information developed in the vegetation classifications, while simultaneously contributing to its adaptation and evolution to a more specific description of the Haitian landscape (i.e. mangroves, rice fields, bare soils). These intended updates are fully in line with what has been produced in the reference project EMSN-051.

3.2.2.6 Land status change analysis in agricultural areas

The extraction process was carried out by a spatial analysis (i.e. geometric intersection with a join of attributes) highlighting an actual agricultural land status (i.e. at Tn) within the previously known agricultural land status (i.e. at Tn-1). Hence the land status change analysis was performed as follows:

- Between T1 and T0 for AOIs 6-7
- Between T3 and T1 for AOIs 6-7
- Between T3 and T2 for AOIs 1-4-5

Only changes that occurred within the pre-Matthew LULC classes that are the main scope of vegetation classification in agricultural areas (i.e. woodland classes, cropland and shrubs) were selected and displayed. This approach is once more in line with the product already proposed in the reference project EMSN-051.

The principle is that if one woodland subclass is downgraded to a "lower one" (i.e. from mixed forest to copse/isolated trees, or from cops to isolated trees) this is considered as a damaged woodland. However, this terminology is only applicable when addressing changes that occurred between T1-T0 (AOIs 6-7), meaning right after the passage of Matthew cyclone. For woodland downgrade which may occur between T3-T1 (AOIs 6-7) or between T3-T2 (AOIs 1-4-5), the correct proposed change name is woodland regression.

The same principle apply for both cropland and shrubs, with a possible downgrade to respectively an anymore managed land or a less vegetated one.

It has to be noticed that positive changes are also addressed within this study, meaning that appeared woodland, cropland and shrubs are highlighted as well. An additional occurrence is when some woodland regeneration happen during T3-T1 and T3-T2 timeframes, considering that no major climatic event occurred in the meantime.

As a summary, all the proposed land status changes for the EMSN-065 activation are listed in the table below.

Table 14: Proposed classes for land status change over agriculture areas

Initial class	Final class	Change class name
313	315/316	Woodland - Damaged (for T1-T0) Woodland - Regression (for T3-T1 and T3-T2)
315	316	Woodland - Damaged (for T1-T0) Woodland - Regression (for T3-T1 and T3-T2)
313/315/316	Different from 31x	Woodland - Disappeared

Initial class	Final class	Change class name
314	Different from 314	Woodland - Disappeared
Different from 31x	313/314/315/316	Woodland - Appeared
315/316 316	313 315	Woodland - Regenerated (for T3-T1 and T3-T2)
242	Different from 242 and 213	Complex cultivation - Disappeared
Different from 242 and 213	242	Complex cultivation - Appeared
324	Different from 31x and 324	Transitional woodland shrub - Disappeared
Different from 31x and 324	324	Transitional woodland shrub - Appeared

The above table is in line with the previous activation EMSN-051. However, for AOI6, which was not subject of this, the identification of change classes was slightly adapted. Whereas other subsets show a significant conglomeration of different land cover classes, AOI6 is dominated by woodland and a hardly visible combination of the latter with agricultural activities on ground. Therefore changes are rather related to the density classes (Table 13) than to classes itself. Here changes in density of 313 had been considered as documented changes. This serves both: continuation of strategy EMSN-051 in general and accounting of changes in AOI6 as newly implemented subset.

3.2.2.7 Monitoring of vegetation regeneration in protected areas

The extraction process was carried out by a spatial analysis (i.e. geometric intersection with a join of attributes) highlighting the actual vegetation classification (i.e. at T3) within the initial vegetation classes (i.e. at T0).

Only changes that occurred within the pre-Matthew forest class over Makaya Park are selected and displayed, since this latter was the main scope of the EMSN-051 activation. This information is also more readable in map products. The change classes are as follows:

- Woodland under recovery
- Disappeared woodland

The table below presents what is the aggregation of T0/T3 attributes occurrences for each object in order to obtain the foreseen classes.

Table 15: Proposed monitoring classes over protected areas

Initial class	Final class	Monitoring class name
313	313	Woodland under recovery (since all woodland have been at least damaged after Matthew cyclone)
313	324/321/336	Disappeared woodland

3.2.3 Analysis and product generation

3.2.3.1 Reference and LULC mapping

<u>New agricultural areas</u>

The cyclone Matthew had an impact on the settlement structure in the AOI6 Dame-Marie. Over the three timestamps (T0-T1-T3) many destroyed buildings were demolished and replaced by new buildings. The settlement area has increased minimally. Nearly no changes have occurred in the road network.

In regard the Pestel AOI, the cyclone impact was large in particular in the forest areas, with significant and visible reduction of trees. The settlements were also affected however with destroyed building being replaced with new ones and not affecting significantly the total settlement area. The road network was largely unaffected.

Agricultural areas

Most of the reference mapping updates for AOIs 1, 4 and 5 are related to building footprints, since the settlement dynamic is very important in Haiti. This effort was necessary for both T2 and T3. The coastline delineation is also mandatory from year to year, at least for Les Cayes and Port-Salut, since the coastal erosion or progradation processes are important on the southern coast. Riverbeds are also some moving elements in Jérémie and Les Cayes. For all AOIs, transportation network remains stable.

Makaya Park

LULC classes in the protected areas of Makaya Park are mainly related to the vegetation and changes are driven by its behaviour after the passage of cyclone Matthew. However, human activities have an impact on some settlement dynamics (e.g. AOI3), but also on vegetation with important land burning practices (e.g. AOI2).

3.2.3.2 Vegetation classification and land status change in agricultural areas

Jérémie

Ten LULC classes have been retained to describe the agricultural land status over AOI1 Jérémie (cf. Table 16). Its agricultural landscape is predominated by tree cover (woodland, copse and isolated trees). Their relative magnitude is not yet equivalent to the pre-Matthew situation, but is already much more than in 2017. The second main elements are both low-lying vegetation and cropland, with nearly 300 ha each. The sum of shrub areas is almost equal to the surface occupied by the river within the AOI (167 ha at T2). By order of importance, bare soil, sea and water bodies are the remaining LULC classes addressed during the land status mapping.

Table 16: AOI1 - Jérémie - Agricultural land status at T2 and T3

Code	LULC Classes	T2 Surface (ha)	T3 Surface (ha)
232	Persistent low-lying vegetation	309.8	309.2
242	Complex cultivation	299.7	299.7
313	Mixed forest	232.9	233.5
315	Copse	87.4	86.3
316	Isolated tree	31.7	31.5
324	Transitional woodland shrub	167.8	166.7
336	Bare soil	30.8	33.2
511	Water courses	167.3	169.0
512	Water bodies	0.7	0.7
523	Sea and ocean	16.7	16.7

LULC changes over Jérémie between T2 and T3 are rather limited. No real difference in terms of land status management were obvious during this timeframe. Tree cover remain stable as well. This lack of visible changes is explained by the very limited amount of available imagery of this area in 2019. The images used were not suitable for highlighting active and non-active croplands. In addition, the VHR image used for woodland extraction was acquired at the same season as for T2, and hence no changes in terms vegetation behaviour has been detected neither. For this reason, change analysis performed over AOI1 might be considered as underestimated. It has to be noticed that during this time interval rivers banks remain stable compared to the important changes reported in EMSN-51 between pre and post land status.

Table 17: change statistics T2-T3 AOI1 Jérémie

Changes within the AOI	total in AOI [ha]
Complex cultivation - Appeared	0.2
Complex cultivation - Disappeared	0.0
Transitional woodland shrub - Appeared	0.0
Transitional woodland shrub - Disappeared	1.1
Woodland - Appeared	0.0
Woodland - Disappeared	0.8
Woodland - Regression	0.0

Port-Salut

These are ten LULC classes as well which have been retained to describe the agricultural land status over AOI4 Port-Salut (cf. Table 18), where the landscape is predominated by cropland (more than 1,500 ha). The second main vegetation classes are both shrubs and tree cover (woodland, copse and isolated trees) and are pretty equal in terms of relative surfaces. Low-lying vegetation and bare soils are kind of residual classes in such an anthropic landscape. Sand beaches and water bodies are the less representative classes.

Table 18: AOI4 - Port-Salut - Agricultural land status at T2 and T3

Code	LULC Classes	T2 Surface (ha)	T3 Surface (ha)
232	Persistent low-lying vegetation	226.7	732.6
242	Complex cultivation	1,904.1	1,566.8
313	Mixed forest	317.2	191.0
315	Copse	259.4	260.3
316	Isolated tree	83.0	95.6
324	Transitional woodland shrub	790.3	685.7
331	Beaches, dunes, sands	61.9	61.4
336	Bare soil	25.4	73.8
511	Water courses	9.8	9.8
523	Sea and ocean	835.3	836.1

LULC change analysis between T2 and T3 over Port-Salut is quite complex since both land classification have been performed with main VHR images acquired in opposite seasons. This implies that illumination conditions and phenological stage of woodland are rather different, and hence thematic extractions are not well superimposed, even if reliable. It creates a certain mechanism of apparition/loss for the benefice (or detriment) to land cover underneath such as low-lying vegetation, crops, bare soils or even shrubs. This impacts also the subclassification between mixed forest, copse and isolated trees. However, despite this noise effect the woodland balance seems rather negative with nearly 110 ha disappeared and 70 ha under regression. This could be also explained by a certain anthropic pressure over a densely populated agricultural area.

With more than 400 ha disappeared, cropland seems under pressure as well. Actually, this is explained by the fact that Port-Salut area has a specific production of vetiver, which is a persistent cultivation over the year. A vetiver field seen as plowed and then vegetated in 2018, will appear mainly vegetated in 2019. The consequence is a reclassification of cropland to low-lying vegetation (18%) or shrubs (2%) between 2018 and 2019. The reverse effect occurs a well but in a less magnitude with 16% of low-lying vegetation and 14% of bare soils of 2018 seen as cultivated in 2019.

Table 19: change statistics T2-T3 AOI4 Port-Salut

Changes within the AOI	total in AOI [ha]
Complex cultivation - Appeared	84.9
Complex cultivation - Disappeared	423.0
Persistent low-lying vegetation - Appeared	5.0
Persistent low-lying vegetation - Disappeared	1.5
Transitional woodland shrub - Appeared	30.5
Transitional woodland shrub - Disappeared	144.8
Woodland - Appeared	164.5
Woodland - Disappeared	275.7
Woodland - Regenerated	23.7
Woodland - Regression	93.8

Les Cayes

AOI5 Les Cayes represents the largest area of interest in this study, and corresponds to an intensive agricultural landscape. This latter classes represents more than 10,000 ha almost continuous over the plain. In addition, the southern part is covered by nearly 2,000 ha of rice fields. Low-lying vegetation and tree cover are equivalent with roughly 3,000 ha each. This latter class is spread within urban areas and over hills in the northern part of the plain. Some specific vegetation classes such as inland marshes and mangroves are present in AOI5. Shrubs corresponds to a minor vegetation class, and their extraction is quite challenging.

Table 20: AOI5 - Les Cayes - Agricultural land status at T2 and T3

Code	LULC Classes	T2 Surface (ha)	T3 Surface (ha)
213	Rice fields	2,017.4	1,990.6
232	Persistent low-lying vegetation	3,111.0	3,178.4
242	Complex cultivation	10,481.0	10,856.9
313	Mixed forest	1,702.7	1,700.0
314	Mangrove	84.7	84.6
315	Copse	1,676.6	1,672.4
316	Isolated tree	399.2	395.5

Code	LULC Classes	T2 Surface (ha)	T3 Surface (ha)
324	Transitional woodland shrub	43.5	40.7
331	Beaches, dunes, sands	41.4	42.7
336	Bare soil	1,656.0	1,258.6
411	Inland marshes	5.2	5.2
511	Water courses	968.3	965.9
512	Water bodies	130.2	110.2
523	Sea and ocean	1758.4	1758.3

Land status changes over Les Cayes between 2018 and 2019 are rather limited, and at least almost expected in such an area. Woodland losses are very limited with nearly 12 ha (less than 1%) for the benefit of low-lying vegetation. Main changes are related to cropland which appear whether managed (+1,101 ha) or unmanaged (-759 ha) in 2019. These gains and losses are counterbalanced by opposite trends for both low-lying vegetation and bare soils: 65% of these latter in 2018 are classified as cropland in 2019. In addition, some interesting changes are located on the northern part of the plain where depressions have been (re)filled by waters after the passage of Matthew cyclone. These areas are progressively vanishing in favour of croplands: 10% of water bodies are became cultivated surfaces in 2019.

Table 21: change statistics T2-T3 AOI5 Les Cayes

Changes within the AOI	total in AOI [ha]
Complex cultivation - Appeared	1,100.8
Complex cultivation - Disappeared	758.6
Persistent low-lying vegetation - Appeared	115.0
Persistent low-lying vegetation - Disappeared	73.2
Transitional woodland shrub - Appeared	0.0
Transitional woodland shrub - Disappeared	1.0
Woodland - Appeared	1.1
Woodland - Disappeared	12.7
Woodland - Regenerated	0.0
Woodland - Regression	2.8

Dame-Marie

AOI6 is located at the west coast of Haiti, characterized by fast growing vegetation within a mountainous context. Whereas the pre-Matthew-situation shows extended complex forest areas, with local clearings and agricultural activities, the region was heavily exposed and damaged during the hurricane. Compact forest was completely defoliated, majority of trees had fallen down as well as artificial structures had been destroyed significantly. However, even within the close post-event phase vegetation recovered quite fast. Therefore, the LULC of T1 should be seen as soon-after-event documentation. Due to fast transitional regrowth and new foliation of the remaining tree trunks, it was difficult to distinguish between recovered forest and transitional shrub vegetation. As shown in Table 22, the differentiation between the three density values of the mixed forest became the dominating change and was therefore highlighted for this specific AOI. It became noticeable that, besides these changes, almost no agricultural activities could be detected via EO data image analysis.

Table 22: AOI6 - Dame Marie - Comparison between T0, T1 and T3 LULCs

AOI6 - Dame Marie				
Code	**LULC Classes**	**T0 Surface (ha)**	**T1 Surface (ha)**	**T3 Surface (ha)**
111	Continuous urban fabric	58.6	61.25	60.84
112	Discontinuous urban fabric	4.74	2.18	2.91
122	Road and rail networks	17.58	17.69	17.65
232	Persistent low-lying vegetation	2.1	137.41	269.87
242	Complex cultivation	115.42	75.75	43.5
313	Mixed forest	147.1	321.19	55.6
		227.28	604.98	655.78
		1,106	360.23	487.59
315	Copse	25.65	35.66	20.84
316	Isolated tree	4.08	4.66	2.46
324	Transitional woodland shrub	0	64.41	86.5
336	Bare soil	1.28	21.23	4.81
511	Water courses	11.41	13.25	11.15
512	Water bodies	0.64	0.72	0.55
523	Sea and ocean	4.75	4.51	4.92

LULC change related to the hurricane event Mathew was significant within AOI6 Dame-Marie. 70% of the total area had changed due to the hurricane (T0-T1), whereas almost 57% of the area could recover or did change to a certain state compared to recent situation (T1-T3). Here, it has to be highlighted, that due to limited coverage and visibility in different EO data sources, classification did concentrate on specifically selected dates per T*, using other scenes as multi-temporal supplementary sources, especially addressing classes with specific temporal characteristics (e.g. open soil, agricultural area).

Table 23: change statistics T0-T1 AOI6 Dame-Marie

Changes within the AOI	**total in AOI [ha]**
Complex cultivation - Appeared	63.28
Complex cultivation - Disappeared	96.93
Persistent low-lying vegetation - Appeared	0.19
Persistent low-lying vegetation - Disappeared	0.12
Transitional woodland shrub - Appeared	6.46
Woodland - Appeared	6.84
Woodland - Damaged	756.29
Woodland - Disappeared	193.22
Woodland - Regenerated	87.10

Within this context, it was not possible for T3 (even based on more detailed visual inspection) to identify agricultural LC whereas this was possible and common for T0 in the characteristic combination of scattered trees. After the storm event in T1 almost no cropland pattern could be recognized even though data situation was of good temporal distribution (exception: complex cultivation at the SE border of the AOI). With respect to this significant change a change class related to Persistent low-lying vegetation had been introduced here. As mentioned in the previous chapter, Woodland classes show fast recovery.

Table 24 : change statistics T1-T3 AOI6 Dame-Marie

Changes within the AOI	total in AOI [ha]
Complex cultivation - Appeared	29.18
Complex cultivation - Disappeared	67.09
Persistent low-lying vegetation - Appeared	9.66
Persistent low-lying vegetation - Disappeared	3.44
Transitional woodland shrub - Appeared	17.20
Transitional woodland shrub - Disappeared	11.79
Woodland - Appeared	76.21
Woodland - Disappeared	238.43
Woodland - Regenerated	404.31
Woodland - Regression	119.14

Pestel

AOI7 Pestel is located at the Northern coast of Haiti and is characterized by a fast growing vegetation within a high relief context. The pre-Matthew-situation was characterized by extended complex forest areas and widely spread agricultural activities. During the hurricane natural and man-made elements were heavily exposed and damaged in the area. A large part of the forest greenness was completely vanished exposing the soil understory. This was especially evident in the slopes of the hills, particular those exposed to the storm front. Also several artificial structures were affected or destroyed (e.g. buildings). The high impact of the hurricane in the vegetation is quite visible in LULC for T1, were a large amount of agriculture and forest show a high decrease between T0 and T1. This fact contributed largely to the increase of the transitional woodland shrub class in T1 (as shown in Table 25). The transition to transitional woodland shrub is in fact the dominant change from T0 to T1. For LULC between T1 and T3, one of the most occurring changes, is the transitional woodland shrubs that evolved into forests, in line with what could be expected for such an environment whose edaphoclimatic conditions favour the rapid growing of the vegetation. An increase (recovery) of the agriculture activities was also noticed between T1 and T3.

Table 25: AOI7 - Pestel - Comparison between T0, T1 and T3 LULCs

AOI7 - Pestel				
Code	**LULC Classes**	**T0 Surface (ha)**	**T1 Surface (ha)**	**T3 Surface (ha)**
Continuous urban fabric	111	9.1	9.1	9.1
Discontinuous urban fabric	112	19.2	19.9	20.7
Road and rail networks	122	25.3	28.3	29.5
Complex cultivation	242	714.7	345.4	436.4
Mixed forest	313	2,276.9	723.4	3,199.3
Mangrove	314	5.9	3.8	4.1
Copse	315	17.7	84.0	36.3
Isolated trees	316	19.7	10.5	11.8
Transitional Woodland Shrub	324	651.9	1,734.8	
Bare soil	336	14.0	799.4	
Sea and ocean	523	153.1	148.9	157.0

Related to the impact of the hurricane Mathew about 68% of the LULC changed in AOI7 between T0 and T1. As already highlighted above, the agriculture and forest LULC classes were the ones that suffered the higher impact of the event. In Table 26 the list of the most occurring transitions with the natural vegetation and agriculture is depicted. The most frequent transition was the “the complex cultivation – Disappeared” with 603.21 ha, that represent mostly the loss of the agricultural fields into open areas. The second most common change is related with the recovering of the same agricultural class after the event, with new agriculture fields appearing (274.17 ha). This was taken mostly using other scenes as multi-temporal supplementary sources, and reflects the effort of the population in order to replace what has been lost and is essential for their subsistence.

Table 26: change statistics T0-T1 - AOI7 Pestel

Changes within the AOI	total in AOI [ha]
Complex cultivation - Disappeared	603.21
Complex cultivation - Appeared	274.17
Woodland - Appeared	142.64
Woodland - Disappeared	117.60
Transitional woodland shrub - Disappeared	110.29
Woodland - Regression	72.35
Woodland - Regenerated	0.94

For LULC in T3 a very high resolution image was available (WV2) that made possible to better discriminate between the different densities of forest that were present within the AOI, compared with the partial coverage of Pleiades and Spot6/7 in T0 and only Sport6/7 in T1. With the analysis of the WV2 it was visible that the transitional woodland totally evolved to forest with different densities. In Table 27, we can verify that the highest increase between T1 and T3 is in fact the appearance of the woodland (2,445.85), coming mostly from the transitional woodland and shrubs. Also worth to mention is the appearance of more agriculture (Complex cultivation - Appeared), that can be related with the activity of the population in that region.

Table 27: change statistics T1-T3 - AOI7 Pestel

Changes within the AOI	total in AOI [ha]
Woodland - Appeared	2,445.85
Complex cultivation - Appeared	393.49
Woodland - Regenerated	90.95
Woodland - Disappeared	16.83
Transitional woodland shrub - Disappeared	6.27
Complex cultivation - Disappeared	1.14
Woodland - Regression	0.85

3.2.3.3 Vegetation classification and regeneration monitoring in protected areas

The Table below summarizes the total areas for each vegetation class over AOIs 2 and 3. The main changes for AOIs 2 & 3 occur within the initial forest stands - mainly in favour of shrubs - with roughly 70% to 80% of surface reduction. Another significant variation between 2016 and 2019 for AOI 2 is the relative increase of bare surfaces (+61%). Moreover, for both AOI's most of these surfaces correspond to former vegetated areas. Some photo-interpretation led to understand that the current non vegetated surfaces are related to burnt areas (for agricultural purposes) and to an important soil erosion due to the loss of vegetation coverage. The full cross comparison with pre-Matthew situation is provided for AOIs 2 and 3 in Annex 2.

Table 28: AOIs 2 & 3 - Makaya Park - Vegetation classification at T3

Code	Class name	AOI2 - Surface (ha)	Variation 2016-2019 (%)	AOI3 - Surface (ha)	Variation 2016-2019 (%)
313	Woodland	171.2	-79.50%	1,315.4	-72.00%
324	Shrub	608.2	+296.50%	5,004.4	+121.60%
321	Herbaceous vegetation	597.2	+36.10%	2,127.2	+54.20%
336	Bare soil	133.7	+61.50%	272.2	-27.70%

The Table below presents the current status of vegetation within the former forest stands mapped in 2016 before the passage of cyclone Matthew. As a reminder, these latter have been completely damaged or destroyed (cf. EMSN-051 reference project). It appears that nearly 18% of these former stands are currently under recovery over AOI2, and 23% over AOI3. Obviously, the state of remaining forest stands is still not yet similar to 2016 in terms of crown size and density. Most of the disappeared stands are now mainly spread in the shrub class. An overall change matrix is available for AOIs 2 and 3 in Annex 2.

Table 29: Pre-Matthew forest stands monitoring over AOIs 2 & 3

Class name	AOI2 - Surface (ha)	Relative to 2016	AOI3 - Surface (ha)	Relative to 2016
Woodland under recovery	153.5	18.4%	1,098.5	23.3%
Disappeared woodland	681.8	81.6%	3,606.1	76.7%

4 Quality assurance

The internal quality assurance system comprises a set of measures which will be executed aiming permanent product quality. It focusses on the completeness and correctness of all deliverables. It includes the quality control and assessment procedures which are specifically aimed at the products.

Quality Control (QC) is the actions taken to ensure delivery of products that satisfy standards and guidelines identified in the product specifications. A grouping of quality control checks is applied to provide a clear structure of their implementation during the production workflow. Several quality control levels, containing various QC verifications each, are implemented. In short QC focuses on identification of errors in the products.

Quality Assessment (QA) regards to the activities undertaken to assess the quality of the products. QA describes the need to statistically evaluate the data to determine whether products are in compliance with defined specifications and quality requirements. The results of the QA process are reported in chapter 4.2.

4.1 Quality Targets

Thematic map products

Map products were examined on a visual basis (full inspection) with respect to readability as well as completeness of all map and map frame elements (e.g. all layers visible, existence of map scale, map description). A consistency check was applied to guaranty the consistency of not only with one map and its elements (e.g. scale in relation to symbology representation) but as well in-between the different maps produced.

Errors should be reported as zero (0).

Geospatial data - vector

Vector data were examined with respect to logical consistency (e.g. topological errors, overlap) and domain consistency for attribute value conformance. Checks were implemented over whole AOIs applying automated QC-checks.

Errors should be reported as zero (0).

For quality assurance methodology and results regarding completeness, positional accuracy and thematic accuracy see chapter 4.2.

Raster data

Input raster EO data were examined with respect to logical consistency (e.g. correct number of bands, spatial resolution reference system, and artefacts).

For processed satellite imagery data (e.g. orthorectification) the error should be reported as ≤ 5px (Chapter 4.2.1).

4.2 Quality assessment

On the subject of the quality assessment it is mandatory that all products fulfil a given target accuracy. As such, and following the best practices established by several expert authors[1] in the LULC maps validation domain, and the practices defined in the standards ISO 19157, ISO 2859 and ISO 3951-1:2005, it was determined a two-fold approach for the most efficient quality assessment of the developed maps: i) all non-LULC features would be evaluated for completeness and positional accuracy – i.e. reference layers; and ii) the LULC features – i.e. vegetation layers, would be evaluated for thematic accuracy, since these present wall-to-wall coverage and, through a contingency table, allow to measure the misclassification rate and completeness, while the sample design is more efficient to implement. The positional accuracy of the vegetation layers was not considered applicable due to the fact that these natural areas have most often fuzzy boundaries – e.g. it is very subjective if not impossible to ascertain where the boundary that separates a forest from a transitional forest area is – and furthermore the thematic accuracy is already constraint to the positional accuracy of the mapped layer.

The quality assessment was implemented through statistically sound sampling approaches, in order to be efficient while guaranteeing that the inspection results can be extrapolated to the population at a certain level of confidence and within a controlled margin of error. The sampling strategies, which include sampling protocols, size and units, are based in the expert knowledge of the team together with the best practices established in the reference documents cited above.

Two different sampling protocols were used due to appropriateness depending on the data quality elements to be evaluated: Area guided sampling for the completeness and positional accuracy; and stratified random sampling for the thematic accuracy. The sample size calculation also differ for the different strategies. In the area-guided sampling we based our approach in the hypergeometric distribution, while in the stratified random sampling we based our approach in the equation that implements the normal approximation to the binomial distribution to estimate the required sample sizes. The sampling unit was based on the feature object (e.g. polygon, line, point).

The next sections provide detailed information on the different implementations to evaluate the maps on the subject of the referred data quality elements.

4.2.1 Positional accuracy of satellite imagery

All VHR1/VHR2 satellite data have been ordered as ortho-ready datasets, meaning that the Service Provider is responsible of orthorectification process. This allows some control on positional accuracy, since image RCPs are improved with GCPs collected on top of reference data (e.g. aerial imagery). Table 30 provides an overview of RMSEs related to each single satellite data.

Table 30: Detailed positional accuracy of satellite imagery

Sensor	Date	AOI/ TX	RMSE (m)
Pléiades	28/06/2018	AOI1/ T2	0.80
SPOT-6	13/08/2018	AOI1/ T2	0.61
SPOT-7	05/11/2018	AOI1/ T2	1.11

[1] Hay, A. 1979. Sampling designs to test land-use map accuracy; Miguel-Ayanz, J. S. and G. S. Biging 1997. Comparison of single-stage and multi-stage classification approaches for cover type mapping with TM and SPOT data;
Congalton, R. G. and K. Green 1999. Assessing the accuracy of remotely sensed data: principles and practices;
Stehman, S. V. 1999. Basic probability sampling designs for thematic map accuracy assessment;
Stehman, S. V. 2001. Statistical rigour and practical utility in thematic map accuracy

Sensor	Date	AOI/ TX	RMSE (m)
SPOT-6	02/12/2018	AOI1/ T2	1.70
GeoEye-1	13/12/2018	AOI1/ T2	0.72
Pléiades	21/06/2019	AOI1/ T3	0.46
SPOT-7	04/11/2019	AOI1/ T3	0.72
Pléiades	21/06/2019	AOI2/ T3	0.81
GeoEye-1	01/01/2019	AOI3/ T3	0.76
Pléiades	08/10/2019	AOI3/ T3	0.61
Pléiades	15/01/2020	AOI3/ T3	0.67
SPOT-7	13/02/2018	AOI4/ T2	1.2
GeoEye-1	10/11/2018	AOI4/ T2	0.62
GeoEye-1	13/11/2018	AOI4/ T2	0.71
SPOT-7	03/12/2018	AOI4/ T2	1.2
SPOT-7	30/11/2019	AOI4/ T3	1.34
WorldView-2	14/01/2020	AOI4/ T3	0.70
WorldView-3	02/03/2020	AOI4/ T3	0.74
Pléiades	05/02/2018	AOI5/ T2	0.42
SPOT-7	13/02/2018	AOI5/ T2	0.51
WorldView-2 (west)	15/09/2018	AOI5/ T2	0.96
WorldView-2 (east)	15/09/2018	AOI5/ T2	0.92
SPOT-7	14/11/2018	AOI5/ T2	0.43
SPOT-7	11/07/2019	AOI5/ T3	1.27
Pléiades	11/07/2019	AOI5/ T3	0.94
SPOT-7	30/11/2019	AOI5/ T3	0.53
SPOT-7	14/11/2014	AOI6/ T0	1.55
WorldView-3	12/05/205	AOI6/ T0	0.60
WorldView-3	24/10/2015	AOI6/ T0	0.76
SPOT-7	26/01/2016	AOI6/ T0	3.59
WorldView-2	17/07/2016	AOI6/ T0	0.60
WorldView-3	28/07/2016	AOI6/ T0	0.97
Pléiades	12/10/2016	AOI6/ T1	1.93
WorldView-3	15/10/2016	AOI6/ T1	0.86
SPOT-7	14/02/2017	AOI6/ T1	3.57
WorldView-2	21/02/2017	AOI6/ T1	0.82
SPOT-7	24/09/2017	AOI6/ T1	3.33
SPOT-7	11/10/2017	AOI6/ T1	1.59
SPOT-6	12/10/2017	AOI6/ T1	1.54
SPOT-7	18/10/2017	AOI6/ T1	1.51
GeoEye-1	12/12/2017	AOI6/ T1	0.77
Pléiades	15/12/2017	AOI6/ T1	3.56
SPOT-7	07/08/2018	AOI6/ T3	1.78
SPOT-7	02/12/2018	AOI6/ T3	1.85
Pléiades	14/06/2019	AOI6/ T3	2.42
SPOT-7	11/07/2019	AOI6/ T3	2.03
Pléiades	10/10/2019	AOI6/ T3	2.8
WorldView-2	02/12/2019	AOI6/ T3	0.94

Sensor	Date	AOI/ TX	RMSE (m)
Pléiades	05/12/2015	AOI7/ T1	1.42
SPOT-6	06/01/2016	AOI7/ T1	1.52
SPOT-7	14/01/2016	AOI7/ T1	1.63
SPOT-7	25/06/2016	AOI7/ T1	1.26
SPOT-6	08/10/2016	AOI7/ T2	1.81
SPOT-7	14/02/2017	AOI7/ T2	2.10
SPOT-7	18/10/2017	AOI7/ T2	1.92
SPOT-7	11/07/2019	AOI7/ T3	2.40
WorldView-2	02/12/2019	AOI7/ T3	0.89

4.2.2 Completeness and Positional Accuracy of Reference data - Area-guided sampling

For every Lot image analysts interpreted the universe of discourse ("ground truth", given by the satellite image available with highest quality and spatial resolution) and compared it with the mapped layers to determine commission and omission errors and as well to measure the positional accuracy. The total number of Lot areas is determined by the number of features necessary to evaluate, to reach the minimum sample size for the inspected layer or group of layers, based on the hypergeometric distribution (Table 31).

Table 31: Statistical values based on the hypergeometric distribution for testing of number of conforming/non-conforming items for a significance level 95 %

Population size		p_0 =	0,5 %	1,0 %	2,0 %	3,0 %	4,0 %	5,0 %
From	To	Sample size (n)	Rejection limit					
1	8	All	1	1	1	1	1	1
9	50	8	1	1	1	2	2	2
51	90	13	1	1	2	2	2	3
91	150	20	1	2	2	3	3	4
151	280	32	1	2	3	3	4	4
281	400	50	2	3	3	4	5	6
401	500	60	2	3	4	5	6	7
501	1200	80	3	3	5	6	7	8
1201	3200	125	3	4	6	8	10	11
3201	10000	200	4	6	8	11	14	16
10001	35000	315	5	7	12	16	20	23
35001	150000	500	6	10	16	23	28	34
150001	500000	800	9	14	24	33	42	51
> 500000		1250	12	20	34	49	63	76

The Commission and Omission errors were registered and used to determine the rate of excess and missing items. For measuring positional accuracy (relative or internal accuracy, i.e. in relation to the satellite images) we deterministically selected points that were suitable for establishing coordinate values accepted as, or being, the "ground truth" – this was done without looking to the map. These points belong to recognized geometries – without uncertainty – and consequently are appropriate to use. After selected, these points were made correspond to the respective feature instances from the map to measure the position difference. The RMSE was calculated and compared with the established requirements for determining if the map relative or internal accuracy is acceptable.

For all AOI the map is the Reference Data and the respective data quality elements to be controlled are identified in Table 32.

Table 32: Data quality elements, measures and targets for Reference Data of T0

Data quality element	Data quality measure	Target
Completeness	Omission	AOI1: <= 4 (p0=1%) AOI2: <= 1 (p0=1%) AOI3: <= 1 (p0=1%) AOI4: <= 6 (p0=1%) AOI5: <= 10 (p0=1%) AOI6: <= 4 (p0=1%) AOI7: <= 4 (p0=1%)
Completeness	Commission	AOI1: <= 4 (p0=1%) AOI2: <= 1 (p0=1%) AOI3: <= 1 (p0=1%) AOI4: <= 6 (p0=1%) AOI5: <= 10 (p0=1%) AOI6: <= 4 (p0=1%) AOI7: <= 4 (p0=1%)
Positional Accuracy	Relative positional accuracy	< 2.5 m RMSE

For the area-guided sampling all AOIs were divided in a regular grid (Lots), where the size of the Lot was deterministically selected taking into account the size of the AOI and the number and distribution of the Reference Data, for assuring that the sample would be representative of the entire population. The Lots were then drawn following a random selection in order to guide the Quality Assessment. From the total number of Lots, the selected ones were inspected to reach the desired sample size for omission and commission.

For the positional accuracy assessment therefore the required assessment points were generated inside the selected Lots.

Table 33: Details of Lots for each AOI

AOI	Grid size [km]	Total number of Lots	Number of selected Lots
1	0.5x0.5	102	20
2	0.5x0.5	98	20
3	1x1	125	25
4	1x1	67	12
5	2x2	87	16
6	0.5x0.5	93	20
7	0.1x0.1	4,090	88

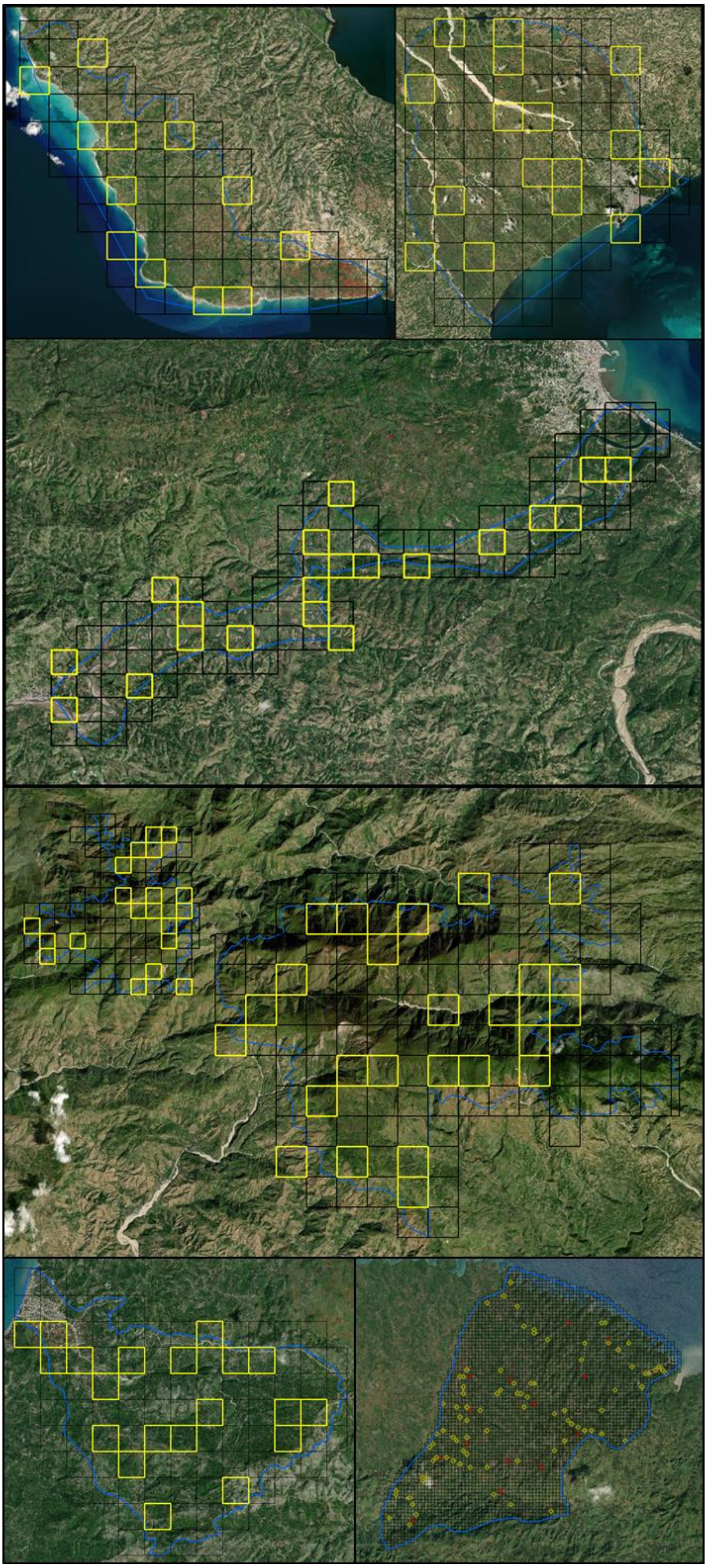

Figure 5: Quality assessment areas distribution

Each Lot was analysed in order to check for e.g. commission and omission errors with the "ground truth" obtained from the available VHR1 imagery or from Aerial imagery of Haiti National data of 2014 (AOI6).

Table 34: Commission and omission errors table

AOI	Population size (# of features in the GDB)	Sample size (# sampled features)	Omission count	Commission count	Pass/Fail
1	1,666 (T2)	125	3	1	Passed
2	12 (T3)	8	0	0	Passed
3	331 (T3)	50	0	0	Passed
4	4,481 (T2)	200	3	0	Passed
5	53,485 (T2)	500	6	4	Passed
6	3,011 (T0)	125	3	2	Passed
7	2,772 (T3)	125	4	0	Passed

Table 35: Positional accuracy results table

AOI	Positional error (m)	Pass/Fail
1	1.46	Passed
2	0.80	Passed
3	0.74	Passed
4	0.96	Passed
5	2.39	Passed
6	0.73	Passed
7	0.27	Passed

4.2.3 Thematic accuracy - Stratified random sampling

The thematic accuracy assessment was carried for the vegetation layers and was based on the following sampling design:

- It was decided to use a stratified random sampling to guaranty that
  - the sample was randomly distributed, for independence from human bias;
  - the sample was stratified per vegetation layer to guaranty that the inclusion probabilities are nonzero for all elements in the population;
- The level of confidence and margin of error set for the assessment was 95% and 5% respectively, assuring a high confidence result;
- The sample size was determined using the equation that implements the normal approximation to the binomial distribution, and using the above referred parameters;
- The sample unit was the polygon mapped, but having removed the information about the classified category (i.e. vegetation layer);
- The sample stratification (i.e. distribution per mapped category) was done according to population size, i.e. the sample distribution was weighted by the number of polygons per category to ensure that the map accuracy is based on the adequate test of each category.

In brief, the approach focused in the comparison of mapped area features (polygons) with a reference database ("ground truth", based in the visually interpretation of the satellite images used for the development of the vegetation layers) - to produce a confusion matrix and calculate the misclassification rate (overall accuracy). We proposed to measure the overall thematic accuracy weighted by the area of each vegetation layer, in order to account with the relative importance each category has on the overall map.

Table 36: Data quality elements, measures and targets for the vegetation classification

Data quality element	Data quality measure	Target
Thematic accuracy	Overall accuracy rate (%)	≥ 85%

4.2.3.1 AOI1 - Jérémie

For the assessment of the classification correctness, the vegetation classes were randomly selected. To fulfil the minimum sample size 600 for T2 and 585 for T3 of vegetation class polygons were sampled. The selected vegetation classes were inspected with the "ground truth" obtained from the most recent VHR1 image with respect to correct classification of the vegetation classification.

Table 37: Confusion matrix of T2 assessment results

	Classification results												Users Accuracy
Ground truth		232	242	313	315	316	324	336	511	512	523	Total	
	232	80	1	2	2	0	1	3	0	0	0	89	89.9%
	242	9	58	1	3	0	0	1	0	0	0	72	80.6%
	313	2	0	64	3	1	5	0	0	0	0	75	85.3%
	315	0	0	0	86	0	5	0	0	0	0	91	94.5%
	316	0	0	0	0	87	8	0	0	0	0	95	91.6%
	324	2	0	3	2	0	85	1	0	0	0	93	91.4%
	336	8	1	0	0	0	0	71	0	0	0	80	88.8%
	511	0	0	0	0	0	0	0	2	0	0	2	100.0%
	512	0	0	0	0	0	0	0	0	2	0	2	100.0%
	513	0	0	0	0	0	0	0	0	0	1	1	100.0%
	Total	101	60	70	96	88	104	76	2	2	1	600	
Producers Accuracy		79.2%	96.7%	91.4%	89.6%	98.9%	81.7%	93.4%	100.0%	100.0%	100.0%		

Table 38: Confusion matrix of T3 assessment results

	Classification results											Users Accuracy
Ground truth		232	242	313	315	316	324	336	511	512	523	Total	
	232	81	3	2	0	0	0	2	0	0	0	88	92.0%
	242	2	54	10	0	0	0	2	0	0	0	68	79.4%
	313	0	0	69	0	0	1	0	0	0	0	70	98.6%
	315	0	0	0	80	0	10	0	0	0	0	90	88.9%
	316	8	0	1	0	75	10	0	0	0	0	94	79.8%
	324	4	1	7	0	0	76	4	0	0	0	92	82.6%
	336	4	2	8	1	0	0	63	0	0	0	78	80.8%
	511	0	0	0	0	0	0	0	2	0	0	2	100.0%
	512	0	0	0	0	0	0	0	0	2	0	2	100.0%
	513	0	0	0	0	0	0	0	0	0	1	1	100.0%
	Total	99	60	97	81	75	97	71	2	2	1	585	
Producers Accuracy		81.8 %	90.0 %	71.1 %	98.8 %	100.0 %	78.4 %	88.7 %	100.0 %	100.0 %	100.0 %		

Table 39: Thematic accuracy table

Target	Overall accuracy (%)	Pass/Fail
>= 85% thematic accuracy	88.9 (T2) 89.5 (T3)	Passed Passed

4.2.3.2 AOI 2 & 3 - Makaya Park

For the assessment of the classification correctness over Makaya Park, the vegetation classes were randomly selected following a specific approach as described in Chapter 3.2.2.4. To fulfil a representative sample size 25% of the points contained in the reference database (i.e. RENOP) were randomly selected over AOIs 2 and 3 according to the class proportion. 242 and 1397 points were respectively inspected with their “ground truth” (updated from VHR1 imagery) image with respect to correct classification of the vegetation classification.

Table 40: Confusion matrix of T3 assessment results (AOI2)

	Classification results						Users Accuracy
Ground truth		Woodland	Shrub	Herbaceous	Bare soil	Total	
	Woodland	27	4	0	0	31	87.1%
	Shrub	11	78	3	0	92	84.8%
	Herbaceous	1	8	89	0	98	90.8%
	Bare soil	0	0	0	21	21	100.0%
	Total	39	90	92	21	242	
Producers Accuracy		69.2%	86.7%	96.7%	100.0%		

Table 41: Confusion matrix of T3 assessment results (AOI3)

	Classification results						Users Accuracy
Ground truth		Woodland	Shrub	Herbaceous	Bare soil	Total	
	Woodland	187	49	18	0	254	73.6%
	Shrub	27	720	43	2	792	90.9%
	Herbaceous	1	22	270	4	297	90.9%
	Bare soil	0	0	10	44	54	81.5%
	Total	215	791	341	50	1397	
Producers Accuracy		87.0%	91.0%	79.2%	88.0%		

Table 42: Thematic accuracy table

Target	Overall accuracy (%)	Pass/Fail
>= 85% thematic accuracy	88.8% (AOI2) 87.4% (AOI3)	Passed Passed

4.2.3.3 AOI4 - Port-Salut

For the assessment of the classification correctness over AOI4, the vegetation classes were randomly selected. To fulfil the minimum sample size 702 for T2 and 710 for T3 of vegetation class polygons were sampled. The selected vegetation classes were inspected with the “ground truth” obtained from the most recent VHR1 image with respect to correct classification of the vegetation classification.

Table 43: Confusion matrix of T2 assessment results

	Classification results											Users Accuracy
Ground truth		232	242	313	315	316	324	331	336	511	523	Total	
	232	80	3	4	5	0	1	0	0	0	0	93	86.0%
	242	7	72	5	1	0	0	0	7	0	0	92	78.3%
	313	0	0	67	3	0	2	0	0	0	0	72	93.1%
	315	1	5	1	76	4	7	0	0	0	0	94	80.9%
	316	3	3	0	3	77	10	0	0	0	0	96	80.2%
	324	0	0	7	2	1	83	0	1	0	0	94	88.3%
	331	0	0	0	0	0	0	20	0	0	0	20	100.0%
	336	4	5	2	0	0	1	0	75	0	0	87	86.2%
	511	0	0	0	0	0	0	0	0	49	0	49	100.0%
	523	0	0	0	0	0	0	0	0	0	5	5	100.0%
	Total	95	88	86	90	82	104	20	83	49	5	702	
Producers Accuracy		84.2 %	81.8 %	77.9 %	84.4 %	93.9 %	79.8 %	100.0 %	90.4 %	100.0 %	100.0 %		

Table 44: Confusion matrix of T3 assessment results

	Classification results											Users Accuracy
Ground truth		232	242	313	315	316	324	331	336	511	523	Total	
	232	83	0	5	3	0	0	0	2	0	0	93	89.2%
	242	6	75	0	0	0	0	0	4	0	0	85	88.2%
	313	2	0	60	4	2	4	0	0	0	0	72	83.3%
	315	0	4	1	80	8	1	0	0	0	0	94	85.1%
	316	1	0	0	0	83	12	0	0	0	0	96	86.5%
	324	4	0	6	2	0	83	0	0	0	0	95	87.4%
	331	0	0	0	0	0	0	30	0	0	0	30	100.0%
	336	4	0	0	0	0	0	5	86	0	0	95	90.5%
	511	0	0	0	0	0	0	0	0	43	0	43	100.0%
	523	0	0	0	0	0	0	0	0	0	7	7	100.0%
	Total	100	79	72	89	93	100	35	92	43	7	710	
Producers Accuracy		83.0 %	94.9 %	83.3 %	89.9 %	89.2 %	83.0 %	85.7 %	93.5 %	100.0 %	100.0 %		

Table 45: Thematic accuracy table

Target	Overall accuracy (%)	Pass/Fail
>= 85% thematic accuracy	86.0 (T2) 90.2 (T3)	Passed Passed

4.2.3.4 AOI5 - Les Cayes

For the assessment of the classification correctness over AOI5, the vegetation classes were randomly selected. To fulfil the minimum sample size 853 for T2 and 850 for T3 of vegetation class polygons were sampled. The selected vegetation classes were inspected with the “ground truth” obtained from the most recent VHR1 image with respect to correct classification of the vegetation classification.

Table 46: Confusion matrix of T2 assessment results

	Classification results																Users Accuracy
Ground truth		213	232	242	313	314	315	316	324	331	336	411	511	512	523	Total	96.4
	213	81	0	0	0	0	1	0	0	0	0	0	2	0	0	84	82.3
	232	0	79	2	2	0	2	0	8	0	3	0	0	0	0	96	80.0%
	242	1	2	76	4	0	8	0	1	0	3	0	0	0	0	95	81.7%
	313	0	0	5	76	0	1	6	0	0	4	0	1	0	0	93	100.0%
	314	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	89.6%
	315	0	0	0	1	0	86	9	0	0	0	0	0	0	0	96	88.5%
	316	1	0	1	0	0	9	85	0	0	0	0	0	0	0	96	92.2%
	324	0	0	2	0	0	0	0	47	0	0	2	0	0	0	51	95.8%
	331	0	0	0	0	0	0	0	0	23	0	0	1	0	0	24	93.6%
	336	0	1	4	0	0	1	0	0	0	88	0	0	0	0	94	100.0%
	411	0	0	0	0	0	0	0	0	0	0	9	0	0	0	9	94.4%
	511	0	0	0	1	0	3	1	0	0	0	0	85	0	0	90	100.0%
	512	0	0	0	0	0	0	0	0	0	0	0	0	21	0	21	100.0%
	523	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	96.4%
	Total	83	82	90	84	3	111	101	56	23	98	11	89	21	1	853	
Producers Accuracy		97.6%	96.3%	84.4%	90.5%	100.0%	77.5%	84.2%	83.9%	100.0%	89.8%	81.8%	95.5%	100.0%	100.0%		

Table 47: Confusion matrix of T3 assessment results

	Classification results																Users Accuracy
Ground truth		213	232	242	313	314	315	316	324	331	336	411	511	512	523	Total	90.4 %
	213	75	0	0	5	0	0	1	1	0	1	0	0	0	0	83	81.3 %
	232	0	78	6	6	0	4	0	2	0	0	0	0	0	0	96	87.4 %
	242	0	0	83	3	0	6	0	0	0	2	0	1	0	0	95	88.0 %
	313	0	2	2	81	0	7	0	0	0	0	0	0	0	0	92	100.0 %
	314	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	86.5 %
	315	0	4	2	0	0	83	5	1	0	0	0	1	0	0	96	81.3 %
	316	0	2	4	6	0	3	78	3	0	0	0	0	0	0	96	93.3 %
	324	0	0	0	1	0	1	0	28	0	0	0	0	0	0	30	100.0 %
	331	0	0	0	0	0	0	0	0	23	0	0	0	0	0	23	76.8 %
	336	0	0	18	0	0	1	0	0	3	73	0	0	0	0	95	100.0 %
	411	0	0	0	0	0	0	0	0	0	0	9	0	0	0	9	96.6 %
	511	0	1	0	1	0	1	0	0	0	0	0	86	0	0	89	85.7 %
	512	0	0	2	0	0	3	0	0	0	0	1	0	36	0	42	100.0 %
	523	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	90.4 %
	Total	75	87	117	103	3	109	84	35	26	76	10	88	36	1	850	
Producers Accuracy		100.0%	89.7%	70.9%	78.6%	100.0%	76.1%	92.9%	80.0%	88.5%	96.1%	90.0%	97.7%	100.0%	100.0%		

Table 48: Thematic accuracy table

Target	Overall accuracy (%)	Pass/Fail
>= 85% thematic accuracy	85.8 (T2) 87.5 (T3)	Passed Passed

4.2.3.5 AOI6 - Dame-Marie

For the assessment of the classification correctness over AOI6, the vegetation classes were randomly selected. To fulfil the minimum sample size 373 for T0, 463 for T1 and 437 for T3 of vegetation class polygons were sampled. The selected vegetation classes were inspected with the "ground truth" obtained from the most recent VHR1 image with respect to correct classification of the vegetation classification.

Table 49: Confusion matrix of T0 assessment results

Classification results												Users Accuracy
Ground truth		232	242	313	315	316	336	511	512	523	Total	
	232	5	0	0	0	0	0	0	0	0	5	100%
	242	0	79	0	0	0	0	0	0	0	79	100%
	313	0	0	88	0	0	0	0	0	0	88	100%
	315	0	0	0	87	0	0	0	0	0	87	100%
	316	0	0	23	5	60	0	0	0	0	88	68%
	336	0	0	2	0	0	11	0	0	0	13	85%
	511	0	0	0	0	0	0	10	0	0	10	100%
	512	0	0	0	0	0	0	0	2	0	2	100%
	523	0	0	0	0	0	0	0	0	1	1	100%
	Total	5	79	113	92	60	11	10	2	1	373	
Producers Accuracy		100%	100%	78%	95%	100%	100%	100%	100%	100%		

Table 50: Confusion matrix of T1 assessment results

Classification results													Users Accuracy
Ground truth		232	242	313	315	316	324	336	511	512	523	Total	
	232	66	0	0	0	0	0	0	0	0	0	66	100%
	242	0	56	0	0	0	0	0	0	0	0	56	100%
	313	0	0	80	1	0	4	1	0	0	0	86	93%
	315	0	0	0	81	1	0	0	0	0	0	82	99%
	316	0	0	23	0	55	0	0	0	0	0	78	71%
	324	0	0	0	0	0	42	0	0	0	0	42	100%
	336	0	0	1	0	0	0	38	0	0	0	39	97%
	511	0	0	0	0	0	0	0	10	0	0	10	100%
	512	0	0	0	0	0	0	0	0	3	0	3	100%
	523	0	0	0	0	0	0	0	0	0	1	1	100%
	Total	66	56	104	82	56	46	39	10	3	1	463	
Producers Accuracy		100%	100%	77%	99%	98%	91%	97%	100%	100%	100%		

Table 51: Confusion matrix of T3 assessment results

Classification results													Users Accuracy
Ground truth		232	242	313	315	316	324	336	511	512	523	Total	
	232	77	0	0	0	0	0	0	0	0	0	77	100%
	242	0	62	0	0	0	0	0	0	0	0	62	100%
	313	0	0	83	0	0	0	0	0	0	0	83	100%
	315	0	0	0	73	0	0	0	0	0	0	73	100%
	316	0	0	0	0	54	15	0	0	0	0	69	78%
	324	0	0	0	0	0	32	0	0	0	0	32	100%
	336	0	0	2	0	0	4	16	0	0	0	22	73%
	511	0	0	0	0	0	0	0	11	0	0	11	100%
	512	0	0	0	0	0	0	0	0	7	0	7	100%
	523	0	0	0	0	0	0	0	0	0	1	1	100%
	Total	77	62	85	73	54	51	16	11	7	1	437	
Producers Accuracy		100%	100%	98%	100 %	100%	63%	100%	100%	100%	100%		

Table 52: Thematic accuracy table

Target	Overall accuracy (%)	Pass/Fail
>= 85% thematic accuracy T0	91.96%	Passed
>= 85% thematic accuracy T1	93.30%	Passed
>= 85% thematic accuracy T3	95.19%	Passed

4.2.3.6 AOI7 - Pestel

For the assessment of the classification correctness over AOI7, the vegetation classes were randomly selected. To fulfil the minimum sample size 389 for T0, 389 for T1 and 389 for T3 of vegetation class polygons were sampled. The selected vegetation classes were inspected with the "ground truth" obtained from the most contemporaneous and highest resolution satellite image with respect to correct classification of the vegetation classification.

Table 53: Confusion matrix of T0 assessment results

	Classification results									Users Accuracy
Ground truth		242	313	314	315	316	324	336	Total	
	242	44					5		49	89.80%
	313	1	17				2		20	85.00%
	314			6					6	100.00%
	315	2			24		1		27	88.89%
	316	34	30			157	18		239	65.69%
	324	4					39		43	90.70%
	336						1	4	5	80.00%
	Total	85	47	6	24	157	66	4	389	
Producers Accuracy		51.76%	36.17%	100.00%	100.00%	100.00%	59.09%	100.00%		

Table 54: Confusion matrix of T1 assessment results

	Classification results									Users Accuracy
Ground truth		242	313	314	315	316	324	336	Total	
	242	18					4		22	81.82%
	313		41				2		43	95.35%
	314			1					1	100.00%
	315		6	1	129		21	10	167	77.25%
	316	3	5			72	1		81	88.89%
	324	1	2				35		38	92.11%
	336	1					5	31	37	83.78%
	Total	23	54	2	129	72	68	41	389	
Producers Accuracy		78.26%	75.93%	50.00%	100.00%	100.00%	51.47%	75.61%		

Table 55: Confusion matrix of T3 assessment results

	Classification results								Users Accuracy
Ground truth		242	313	314	315	316	324	Total	
	242	40	2					42	95.24%
	313	2	43				3	48	89.58%
	314			3				3	100.00%
	315	7	4		83			94	88.30%
	316	18	9			175		202	86.63%
	Total	67	58	3	83	175	3	389	
Producers Accuracy		59.70%	74.14%	100.00%	100.00%	100.00%	100.00%		

Table 56: Thematic accuracy table

Target	Overall accuracy (%)	Pass/Fail
>= 85% thematic accuracy T0	86.90%	Passed
>= 85% thematic accuracy T1	89.60%	Passed
>= 85% thematic accuracy T3	90.24%	Passed

Annex

Annex 1 Data lists of procured EO data

Annex 2 Overall change statistics

Annex 1 Data lists of procured EO data

Table 57: List of all procured EO data

Image Name	Sensor	Date	Time	GSD (m)	CC (%)	Incidence angle (°)	Submitted	Availability	Download
01JEREMIE									
SP07_NAO_PMS_1A_20191104T151504_20191104T151521_TOU_1234_1a03	SPOT-7	04/11/2019	15h15	1.5	0.00	19.24	06/03/2020	12/03/2020	12/03/2020
PH1B_PHR_FUS_1A_20190621T153726_20190621T153728_TOU_1234_ecff	Pléiades	21/06/2019	15h37	0.5	0.43	4.74	06/03/2020	11/03/2020	11/03/2020
GY01_GIS_PSH_SO_20181213T154645_20181213T154701_DGI_54878_AB97	GeoEye-1	13/12/2018	15h46	0.5	0.0	27.3	06/03/2020	10/03/2020	10/03/2020
SP06_NAO_PMS_1A_20181202T150504_20181202T150520_TOU_1234_c607	SPOT-6	02/12/2018	15h05	1.5	0.0	17.33	06/03/2020	09/03/2020	09/03/2020
SP07_NAO_PMS_1A_20181105T151506_20181105T151523_TOU_1234_5ddb	SPOT-7	05/11/2018	15h15	1.5	2.22	17.88	06/03/2020	09/03/2020	09/03/2020
SEN_SPOT6_20180813_151059500_000	SPOT-6	13/08/2018	15h10	1.5	10.84	10.91	N/A	06/03/2020	06/03/2020
DS_PHR1A_201806281540317_FR1_PX_W075N18_1115_01244	Pléiades	28/06/2018	15h41	0.5	5.84	8.54	N/A	06/03/2020	06/03/2020
02MAKAYAWEST									
PH1B_PHR_FUS_1A_20190621T153816_20190621T153821_TOU_1234_4629	Pléiades	21/06/2019	15h38	0.5	1.5	24.8	06/03/2020	09/03/2020	09/03/2020
03MAKAYAEAST									
DS_PHR1B_202001151536456_FR1_PX_W074N18_0210_02128	Pléiades	15/01/2020	15h37	0.5	2.6	3.4	N/A	06/03/2020	06/03/2020
PH1B_PHR_FUS_1A_20191008T154843_20191008T154846_TOU_1234_d6ed	Pléiades	08/10/2019	15h48	0.5	0.7	24.3	06/03/2020	10/03/2020	10/03/2020
GY01_GIS_PSH_SO_20190101T154158_20190101T154213_DGI_55156_3B8A	GeoEye-1	01/01/2019	15h42	0.5	0.0	22.9	06/03/2020	11/03/2020	11/03/2020
04PORTSALUT									
EW03_WV3_PSH_SO_20200302T155800_20200302T155816_DGI_30096_3183	WorldView-3	02/03/2020	15h58	0.5	0.0	27.3	06/03/2020	11/03/2020	11/03/2020
EW02_WV1_PSH_SO_20200114T154652_20200114T154704_DGI_53876_4737	WorldView-2	14/01/2020	15h46	0.5	0.0	19.0	06/03/2020	11/03/2020	11/03/2020
SP07_NAO_PMS_1A_20191130T151458_20191130T151507_TOU_1234_c360	SPOT-7	30/11/2019	15h14	1.5	0.0	17.3	06/03/2020	12/03/2020	12/03/2020
SP07_NAO_PMS_1A_20181203T150026_20181203T150034_TOU_1234_d4dd	SPOT-7	03/12/2018	15h00	1.5	2.1	27.6	06/03/2020	09/03/2020	09/03/2020
GY01_GIS_PSH_SO_20181113T154826_20181113T154830_DGI_54439_3CE8	GeoEye-1	13/11/2018	15h48	0.5	0.0	27.1	06/03/2020	11/03/2020	11/03/2020

Image Name	Sensor	Date	Time	GSD (m)	CC (%)	Incidence angle (°)	Submitted	Availability	Download
GY01_GIS_PSH_SO_20181110T153856_20181110T153909_DGI_54395_1B9B	GeoEye-1	10/11/2018	15h38	0.5	0.0	18.9	06/03/2020	11/03/2020	11/03/2020
SP07_NAO_PMS_1A_20180213T150406_20180213T150415_TOU_1234_a269	SPOT-7	13/02/2018	15h04	1.5	8.8	14.8	06/03/2020	09/03/2020	09/03/2020
05LESCAYES									
SP07_NAO_PMS_1A_20191130T151458_20191130T151507_TOU_1234_0aa1	SPOT-7	30/11/2019	15h15	1.5	2.51	17.25	06/03/2020	09/03/2020	09/03/2020
DS_PHR1A_201907111533055_FR1_PX_W074N18_0306_01788	Pléiades	11/07/2019	15h33	0.5	8.1	9.5	N/A	06/03/2020	06/03/2020
SEN_SPOT6_20180813_151059500_000	SPOT-7	11/07/2019	15h05	1.5	7.0	3.0	N/A	06/03/2020	06/03/2020
SP07_NAO_PMS_1A_20181114T145637_20181114T145646_TOU_1234_cf2f	SPOT-7	14/11/2018	14h56	1.5	0.2	21.01	06/03/2020	09/03/2020	09/03/2020
EW02_WV1_PSH_SO_20180915T153214_20180915T153220_DGI_46893_ECC8	WorldView-2	15/09/2018	15h32	0.5	0.0	24.4	06/03/2020	11/03/2020	11/03/2020
EW02_WV1_PSH_SO_20180915T153202_20180915T153208_DGI_46893_DF51	WorldView-2	15/09/2018	15h32	0.5	0.1	23.8	06/03/2020	11/03/2020	11/03/2020
SP07_NAO_PMS_1A_20180213T150406_20180213T150415_TOU_1234_1bc1	SPOT-7	13/02/2018	15h04	1.5	8.5	14.9	06/03/2020	09/03/2020	09/03/2020
DS_PHR1B_201802051540562_FR1_PX_W074N18_0212_02113	Pléiades	05/02/2018	15h41	0.5	0.0	10.1	N/A	06/03/2020	06/03/2020
06DAMEMARIE									
ORT_SPOT7_20141117_151210500_000	SPOT-7	17/11/2014	15h12	1.5	0.69	11.28	06/03/20	09/03/2020	09/03/2020
104001000BB91D00	WorldView-3	12/05/2015	15h41	0.5	18.0	11.13	06/03/20	17/03/2020	17/03/2020
10400100139DFD00	WorldView-3	24/10/2015	15h57	0.5	27.0	26.43	06/03/20	17/03/2020	17/03/2020
ORT_SPOT7_20160126_151327300_000	SPOT-7	26/01/2016	15h13	1.5	0.46	16.88	N/A	06/03/2020	06/03/2020
103001005A732000	WorldView-2	17/07/2016	15h33	0.5	20.0	16.0	06/03/20	17/03/2020	17/03/2020
104001001FB3E200	WorldView-3	28/07/2016	16h04	0.5	12.0	28.67	06/03/20	17/03/2020	17/03/2020
DS_PHR1A_201610121540123_FR1_PX_W075N18_0812_03186	Pléiades	12/10/2016	15h40	0.5	18.53	13.89	N/A	06/03/2020	06/03/2020
1040010023BF7100	WorldView-3	15/10/2016	15h46	0.5	11.0	33.23	06/03/20	17/03/2020	17/03/2020
ORT_SPOT7_20170214_150306600_000	SPOT-7	14/02/2017	15h03	1.5	0.26	17.95	N/A	06/03/2020	06/03/2020
10300100662CCA00	WorldView-2	21/02/2017	15h49	0.5	2.0	14.65	06/03/20	17/03/2020	17/03/2020
ORT_SPOT7_20170924_145540400_000	SPOT-7	24/09/2017	14h55	1.5	0.0	32.89	06/03/20	09/03/2020	09/03/2020
SEN_SPOT7_20171011_151412500_000	SPOT-7	11/10/2017	15h14	1.5	15.53	11.55	N/A	06/03/2020	06/03/2020

Image Name	Sensor	Date	Time	GSD (m)	CC (%)	Incidence angle (°)	Submitted	Availability	Download
SEN_SPOT6_20171012_150719100_000	SPOT-6	12/10/2017	15h07	1.5	15.40	10.78	N/A	06/03/2020	06/03/2020
SEN_SPOT7_20171018_151033300_000	SPOT-7	18/10/2017	15h10	1.5	8.64	3.67	N/A	06/03/2020	06/03/2020
105001000D5A1900	GeoEye-1	12/12/2017	15h40	0.5	21.0	22.19	06/03/20	17/03/2020	17/03/2020
DS_PHR1B_201712151541233_FR1_PX_W075N18_0912_05017	Pléiades	15/12/2017	15h41	0.5	0.0	4.83	06/03/20	13/03/2020	13/03/2020
SEN_SPOT7_20180807_150815900_000	SPOT-7	07/08/2018	15h08	1.5	18.96	14.13	N/A	06/03/2020	06/03/2020
ORT_SPOT6_20181202_150510900_000	SPOT-6	02/12/2018	15h05	1.5	2.0	18.29	06/03/20	09/03/2020	09/03/2020
DS_PHR1B_201906141542095_FR1_PX_W075N18_0710_02862	Pléiades	14/06/2019	15h42	0.5	18.26	29.01	06/03/20	13/03/2020	13/03/2020
DS_PHR1B_20191010153526_FR1_PX_W075N18_0713_03231	Pléiades	10/10/2019	15h33	0.5	7.48	28.94	N/A	06/03/2020	06/03/2020
103001009D60D800	WorldView-2	02/12/2019	15h30	0.5	1.0	24.87	06/03/20	17/03/2020	17/03/2020
ORT_SPOT7_20141117_151210500_000	SPOT-7	17/11/2014	15h12	1.5	0.69	11.28	06/03/20	09/03/2020	09/03/2020
07PESTEL									
ORT_SPOT7_20160625_150343900_000	SPOT-7	25/06/2016	15:03	1.5	0.7	14.9	N/A	06/03/2020	06/03/2020
ORT_SPOT7_20170214_150243600_000	SPOT-7	14/02/2017	15:02	1.5	0.37	12.9	N/A	06/03/2020	06/03/2020
SEN_SPOT6_20160106_151850100_000	SPOT-6	06/01/2016	15:18	1.5	2.5	22.8	N/A	06/03/2020	06/03/2020
ORT_SPOT6_20161008_145608900_000	SPOT-6	08/10/2016	14:56	1.5	8.93	22.99	N/A	06/03/2020	06/03/2020
SEN_SPOT7_20160114_150655100_000	SPOT-7	14/01/2016	15:06	1.5	26.0	25.2	N/A	06/03/2020	06/03/2020
DS_PHR1A_201512051540484_FR1_PX_W074N18_0414_01938	Pléiades	05/12/2015	15:40	0.5	0.0	9.59	N/A	06/03/2020	06/03/2020
DS_PHR1A_201512051540381_FR1_PX_W074N18_0215_01504	Pléiades	05/12/2015	15:40	0.5	0.0	8.47	N/A	06/03/2020	06/03/2020
SEN_SPOT7_20190711_150520600_000	SPOT-7	11/07/2019	15:05	1.5	10.0	2.66	N/A	06/03/2020	06/03/2020
SEN_SPOT7_20171018_151012500_000	SPOT-7	18/10/2017	15:10	1.5	8.04	10.75	N/A	06/03/2020	06/03/2020
20300105C49BAE00	WorldView-2	02/12/2019	15:29	0.5	0.0	2.36	06/03/20	09/03/2020	09/03/2020
20300105C49BC700	WorldView-2	02/12/2019	15:29	0.5	0.0	1.84	06/03/20	09/03/2020	09/03/2020

Annex 2 Overall change statistics

Table 58: AOI1 Jérémie - Class by class comparison between post (T2) and post (T3) Matthew LULCs

	T2	111	112	122	232	242	313	315	316	324	336	511	512	523
T3	LULC classes													
111	Continuous urban fabric	95.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
112	Discontinuous urban fabric	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
122	Road and rail networks and associated land	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
232	Persistent low-lying vegetation	0.0%	0.0%	0.0%	99.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
242	Complex cultivation	0.0%	0.0%	0.0%	0.1%	99.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
313	Mixed forest	0.0%	0.0%	0.0%	0.0%	0.0%	99.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
315	Copse	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
316	Isolated trees	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
324	Transitional woodland shrub	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.4%	0.0%	0.0%	0.0%	0.0%
336	Bare soil	2.2%	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	0.6%	99.0%	0.0%	0.1%	0.0%
511	Water courses	2.3%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.8%	100.0%	0.0%	0.0%
512	Water bodies	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.9%	0.0%
523	Sea and ocean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	100.0%
	Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 59: AOI2 Makaya West - Class by class comparison between pre (T0) and post (T3) Matthew vegetation classification

	T3	313	324	321	336
T0	Vegetation classes				
313	Woodland	18.4%	6.7%	1.4%	1.6%
324	Shrub	52.0%	40.7%	24.6%	3.8%
321	Herbaceous vegetation	23.2%	42.3%	62.6%	77.1%
336	Bare soil	6.4%	10.2%	11.4%	17.5%
	Sum	100.0%	100.0%	100.0%	100.0%

Table 60: AOI3 Makaya Esat - Class by class comparison between pre (T0) and post (T3) Matthew vegetation classification

	T3	313	324	321	336
T0	Vegetation classes				
313	Woodland	23.3%	8.2%	1.7%	1.9%
324	Shrub	65.9%	57.7%	36.2%	27.1%
321	Herbaceous vegetation	9.5%	31.9%	57.2%	45.7%
336	Bare soil	1.3%	2.2%	4.9%	25.3%
	Sum	100.0%	100.0%	100.0%	100.0%

Table 61: AOI4 Port-Salut - Class by class comparison between post (T2) and post (T3) Matthew LULCs

	T2	111	112	122	232	242	313	315	316	324	331	336	511	523
T3	LULC classes													
111	Continuous urban fabric	81.5%	0.0%	0.4%	0.0%	0.0%	0.3%	1.1%	1.8%	0.0%	0.3%	0.1%	0.0%	0.0%
112	Discontinuous urban fabric	15.0%	49.9%	0.6%	0.1%	0.6%	0.1%	0.1%	0.1%	0.0%	0.1%	2.6%	0.0%	0.0%
122	Road and rail networks and associated land	0.2%	0.2%	97.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%
232	Persistent low-lying vegetation	0.1%	15.7%	0.5%	64.3%	17.7%	13.6%	16.2%	20.7%	18.0%	0.0%	7.5%	0.8%	0.0%
242	Complex cultivation	0.2%	28.8%	0.9%	15.6%	72.0%	9.4%	19.6%	25.4%	5.9%	0.2%	13.6%	1.0%	0.0%
313	Mixed forest	0.5%	0.5%	0.0%	1.3%	1.0%	43.9%	4.3%	2.0%	1.8%	0.1%	0.6%	8.8%	0.0%
315	Copse	1.1%	0.4%	0.1%	2.9%	2.7%	19.6%	39.5%	13.2%	3.0%	0.0%	0.3%	3.6%	0.0%
316	Isolated trees	1.2%	0.1%	0.0%	1.6%	1.5%	2.8%	8.7%	20.1%	1.8%	0.0%	0.1%	1.2%	0.0%
324	Transitional woodland shrub	0.0%	0.5%	0.1%	13.5%	2.1%	9.7%	9.8%	16.0%	69.1%	0.0%	0.8%	0.1%	0.0%
331	Beaches, dunes, sands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	96.0%	0.2%	5.2%	0.1%
336	Bare soil	0.1%	3.8%	0.2%	0.5%	2.4%	0.4%	0.5%	0.7%	0.4%	0.2%	74.0%	1.8%	0.0%
511	Water courses	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	77.4%	0.0%
523	Sea and ocean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.9%	0.0%	0.1%	99.9%
	Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 62: AOI5 Les Cayes - Class by class comparison between post (T2) and post (T3) Matthew LULCs

	T2	111	112	122	124	213	232	242	313	314	315	316	324	331	336	411	511	512	523
T3	**LULC classes**																		
111	**Continuous urban fabric**	100.0 %	0.9%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
112	**Discontinuous urban fabric**	0.0%	99.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
122	**Road and rail networks and associated land**	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
124	**Airports**	0.0%	0.0%	0.0%	100.0 %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
213	**Rice fields**	0.0%	0.0%	0.0%	0.0%	98.4%	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
232	**Persistent low-lying vegetation**	0.0%	0.0%	0.0%	0.0%	0.4%	97.2%	0.3%	0.1%	0.3%	0.1%	0.1%	1.8%	1.4%	6.5%	0.0%	0.5%	1.8%	0.0%
242	**Complex cultivation**	0.0%	0.0%	0.0%	0.0%	0.6%	0.4%	92.9%	0.0%	0.0%	0.1%	0.3%	4.3%	0.5%	64.8%	0.0%	0.0%	10.8%	0.0%
313	**Mixed forest**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
314	**Mangrove**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
315	**Copse**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	99.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
316	**Isolated trees**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	99.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	T2	111	112	122	124	213	232	242	313	314	315	316	324	331	336	411	511	512	523
324	**Transitional woodland shrub**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	93.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
331	**Beaches, dunes, sands**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	96.1%	0.1%	0.0%	0.0%	0.0%	0.0%
336	**Bare soil**	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	6.8%	0.0%	0.0%	0.0%	0.0%	0.4%	0.6%	28.4%	0.0%	0.3%	5.0%	0.0%
411	**Inland marshes**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
511	**Water courses**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.1%	0.0%	98.9%	0.0%	0.0%
512	**Water bodies**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	82.3%	0.0%
523	**Sea and ocean**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	Sum	100.0 %	100.0 %	100.0%	100.0 %	100.0 %	100.0%	100.0 %	100.0 %	100.0%	100.0 %	100.0 %	100.0%	100.0 %	100.0 %	100.0%	100.0 %	100.0 %	100.0%

Table 63: AOI6 Dame-Marie - Class by class comparison between pre (T0) and post (T1) Matthew LULCs

		T0	111	112	122	232	242	313	313	313	315	316	324	336	511	512	523
			0	0	0	0	0	1	2	3	0	0	0	0	0	0	0
T1	Density	LULC Classes															
111	0	Continuous urban fabric	95.1%	0.1%	0.5%	9.4%	0.0%	0.1%	0.0%	0.1%	11.2%	13.1%	0.0%	0.0%	0.3%	2.0%	0.0%
112	0	Discontinuous urban fabric	0.1%	35.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
122	0	Road and rail networks	0.3%	0.0%	98.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%
232	0	Persistent low-lying vegetation	0.1%	1.3%	0.1%	24.6%	19.9%	21.6%	18.6%	3.3%	10.8%	14.3%	0.0%	0.0%	0.7%	0.0%	0.0%
242	0	Complex cultivation	0.0%	2.1%	0.1%	18.0%	10.5%	14.2%	7.1%	2.1%	10.7%	9.8%	0.0%	6.3%	0.0%	0.0%	0.0%
313	1	Mixed forest	0.6%	19.3%	0.8%	43.7%	33.3%	27.6%	24.2%	15.6%	34.9%	26.1%	0.0%	4.4%	14.6%	27.4%	5.5%
313	2	Mixed forest	1.7%	21.8%	0.2%	0.0%	15.8%	16.5%	28.2%	44.7%	8.7%	13.1%	0.0%	2.4%	3.8%	0.0%	0.0%
313	3	Mixed forest	0.7%	8.6%	0.1%	0.0%	5.6%	10.7%	14.2%	27.4%	7.3%	7.3%	0.0%	9.4%	3.3%	0.0%	0.0%
315	0	Copse	0.7%	8.1%	0.1%	0.0%	2.2%	1.9%	2.4%	2.0%	9.3%	1.4%	0.0%	0.2%	0.8%	0.0%	0.0%
316	0	Isolated tree	0.2%	2.0%	0.0%	0.0%	0.3%	0.3%	0.3%	0.2%	3.0%	8.0%	0.0%	0.0%	0.2%	0.7%	0.0%
324	0	Transitional woodland shrub	0.0%	0.1%	0.0%	0.1%	5.5%	2.4%	3.9%	4.1%	1.5%	3.1%	0.0%	2.1%	0.7%	0.0%	0.0%
336	0	Bare soil	0.0%	1.6%	0.1%	0.0%	4.6%	4.5%	0.8%	0.5%	1.9%	3.3%	0.0%	74.9%	0.0%	0.0%	0.1%
511	0	Water courses	0.4%	0.0%	0.0%	2.3%	2.0%	0.2%	0.1%	0.0%	0.5%	0.5%	0.0%	0.0%	75.5%	0.0%	0.0%
512	0	Water bodies	0.1%	0.0%	0.0%	1.8%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	69.8%	0.0%
523	0	Sea and ocean	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	94.4%
		Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.0%	100.0%	100.0%	100.0%	100.0%

Table 64: AOI6 Dame-Marie - Class by class comparison between post (T1) Matthew and most recent (T3) LULCs

		T1	**111**	**112**	**122**	**232**	**242**	**313**	**313**	**313**	**315**	**316**	**324**	**336**	**511**	**512**	**523**
			0	0	0	0	0	1	2	3	0	0	0	0	0	0	0
T3	Density	**LULC Classes**															
111	0	**Continuous urban fabric**	86.0%	12.0%	0.2%	0.1%	0.3%	1.6%	0.1%	0.1%	2.0%	8.8%	0.0%	0.3%	0.7%	0.0%	0.1%
112	0	**Discontinuous urban fabric**	0.1%	74.6%	0.0%	0.0%	0.1%	0.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
122	0	**Road and rail networks**	0.0%	0.0%	99.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
232	0	**Persistent low-lying vegetation**	1.0%	7.0%	0.2%	39.5%	45.7%	25.3%	8.5%	4.2%	24.2%	21.5%	16.8%	42.2%	21.0%	28.4%	0.0%
242	0	**Complex cultivation**	0.1%	1.8%	0.0%	7.0%	5.6%	5.2%	0.7%	0.6%	3.1%	4.1%	1.1%	20.0%	2.4%	6.1%	0.0%
313	1	**Mixed forest**	0.0%	0.6%	0.0%	11.8%	7.5%	5.3%	1.4%	0.6%	6.9%	5.8%	1.5%	10.7%	0.0%	0.0%	0.0%
313	2	**Mixed forest**	5.7%	2.9%	0.0%	20.8%	26.9%	33.8%	56.6%	26.2%	36.2%	26.9%	61.9%	13.5%	7.1%	1.8%	0.0%
313	3	**Mixed forest**	1.7%	0.9%	0.0%	10.2%	6.2%	20.8%	25.6%	63.7%	16.3%	15.6%	14.0%	4.1%	2.3%	0.0%	0.0%
315	0	**Copse**	4.7%	0.0%	0.0%	1.2%	1.3%	2.1%	0.8%	0.3%	5.5%	8.7%	0.5%	0.5%	0.7%	9.5%	0.0%
316	0	**Isolated tree**	0.4%	0.0%	0.0%	0.3%	0.2%	0.1%	0.1%	0.0%	0.2%	2.1%	0.1%	0.3%	0.1%	0.4%	0.0%
324	0	**Transitional woodland shrub**	0.1%	0.1%	0.0%	8.8%	5.8%	4.2%	6.0%	4.2%	4.4%	4.9%	3.7%	2.9%	0.2%	0.0%	0.0%
336	0	**Bare soil**	0.0%	0.1%	0.0%	0.2%	0.3%	0.7%	0.0%	0.0%	0.7%	1.1%	0.3%	5.2%	3.5%	0.0%	0.2%
511	0	**Water courses**	0.1%	0.0%	0.0%	0.1%	0.0%	0.6%	0.1%	0.1%	0.3%	0.5%	0.1%	0.2%	61.5%	0.0%	0.0%
512	0	**Water bodies**	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	53.8%	0.0%
523	0	**Sea and ocean**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	99.7%
		Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 65: AOI7 Pestel - Class by class comparison between pre (T0) and post (T1) Matthew LULCs

	T0	111	112	122	242	313	314	315	316	324	336	523
T1	LULC Classes											
111	Continuous urban fabric	99.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
112	Discontinuous urban fabric	0.0%	99.6%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
122	Road and rail networks	0.1%	0.0%	99.9%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
242	Complex cultivation	0.0%	0.1%	0.0%	8.0%	10.5%	0.6%	16.6%	11.5%	6.7%	4.4%	0.0%
313	Mixed forest	0.0%	0.0%	0.0%	6.7%	26.4%	10.7%	4.3%	0.7%	10.6%	7.1%	2.2%
314	Mangrove	0.0%	0.0%	0.0%	0.0%	0.0%	55.2%	0.8%	0.0%	0.0%	0.0%	0.1%
315	Copse	0.1%	0.0%	0.0%	0.8%	2.8%	0.1%	5.2%	0.2%	2.1%	0.4%	0.4%
316	Isolated trees	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.7%	0.5%	0.1%	0.0%	0.0%
324	Transitional Woodland Shrub	0.0%	0.2%	0.0%	58.8%	38.2%	21.4%	48.4%	60.1%	63.7%	44.1%	1.6%
336	Bare soil	0.0%	0.1%	0.0%	25.5%	21.6%	2.4%	22.2%	26.2%	16.9%	44.0%	0.2%
523	Sea and ocean	0.0%	0.0%	0.0%	0.0%	0.1%	9.6%	1.8%	0.6%	0.0%	0.0%	95.5%
	Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 66: AOI7 Pestel - Class by class comparison between post (T1) Matthew and most recent (T3) LULCs

	T1	111	112	122	242	313	314	315	316	324	336	523
T3	LULC Classes											
111	Continuous urban fabric	97.4%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
112	Discontinuous urban fabric	0.0%	90.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%
122	Road and rail networks	0.4%	0.1%	90.3%	0.2%	0.1%	0.0%	0.1%	0.1%	0.1%	0.2%	0.0%
242	Complex cultivation	0.1%	1.6%	1.3%	9.8%	1.0%	0.1%	1.5%	6.3%	11.2%	24.9%	0.0%
313	Mixed forest	0.6%	0.4%	0.5%	6.5%	4.0%	1.0%	2.9%	2.4%	12.0%	6.1%	0.4%
313	Mixed forest	0.0%	0.4%	0.3%	6.2%	3.5%	5.0%	3.6%	5.9%	8.6%	5.3%	0.1%
313	Mixed forest	0.5%	7.3%	7.1%	76.1%	90.5%	14.3%	90.2%	82.8%	66.7%	60.6%	0.4%
314	Mangrove	0.0%	0.0%	0.0%	0.0%	0.1%	67.5%	0.0%	0.0%	0.0%	0.0%	0.2%
315	Copse	0.4%	0.1%	0.3%	0.9%	0.1%	0.0%	0.9%	1.9%	0.9%	2.0%	0.0%
316	Isolated trees	0.3%	0.1%	0.0%	0.2%	0.0%	0.1%	0.0%	0.1%	0.3%	0.7%	0.0%
523	Sea and ocean	0.2%	0.0%	0.0%	0.0%	0.7%	12.0%	0.8%	0.2%	0.2%	0.1%	98.8%
	Sum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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