



**FRAMEWORK SERVICE CONTRACT FOR
COPERNICUS "EMERGENCY MANAGEMENT
SERVICE - RISK AND RECOVERY MAPPING"**

**EMSN-050:
Post Mathew Damage Assessment and Monitoring
of Recovery Activities in the South Region of Haiti
FINAL REPORT**

August 2018

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Acronyms

| AOI | Area of Interest |
|----------|--|
| APTOPIX | APTOPIX Photography |
| BUA | Built-Up Area |
| CIAT | <i>CIAT - Comité Interministériel d'Aménagement du Territoire</i> |
| CLC | Corine Land Cover |
| CNIGS | <i>Centre National de l'Information Géo-Spatiale</i> |
| DEM | Digital Elevation Model |
| DTM | Digital Terrain Model |
| EO | Earth Observation |
| FWC | Framework Contract |
| GDB | Geographical Data base |
| GIS | Geographical Information System |
| GSD | Ground Sample Distance |
| IDP | Internally Displaced Person |
| IGN | <i>Institut National de L'information Géographique et Forestière</i> |
| IOM | International Organization for Migration |
| JRC | Joint Research Centre |
| LU/LC | Land Use / Land Cover |
| MINUSTAH | United Nations Stabilization Mission in Haiti |
| OSM | Open Street Map |
| POI | Point of Interest |
| QA | Quality Assurance |
| QC | Quality Control |
| RO | Recovery Observatory |
| RRM | Risk and Recovery Mapping |
| UA | Urban Atlas |

1. INTRODUCTION

1.1 EVENT LOCATION AND CHARACTERISTICS

Cyclone Matthew struck Haiti on October 4, 2016, as a Category 4 cyclone. The combined effects of wind, coastal flooding and rain caused heavy flooding, landslides, and the destruction of infrastructure, agricultural crops and natural ecosystems. In all, 546 people were killed, more than 175,000 people sought refuge in shelters, and about 1.4 million people required immediate humanitarian assistance¹.

Haiti has been one of the most impacted countries with an estimated loss of over a billion USD².

According to UNITAR-UNOSAT Cyclone Mathew Report, Grand'Anse Department (included in one of the AOIs of this activation), was one of the most affected areas in Haiti, with over 80% of population identified to be in need of humanitarian aid.

In some areas, 90% of homes were destroyed. Farming, fishing and small scale commercial activities were severely hit (e.g.: Grand'Anse and Sud departments - localization of the 2 AOIs included in this activation- had 70% of crops destroyed)³.

The recovery after cyclone Mathew will take several years. UNDP has developed a three-year Post Matthew Recovery Programme which aims to create the conditions for long-term recovery, resilience and sustainable development in Haiti, while meeting the immediate needs for affected regions.

Given the great impact of Cyclone Matthew over Haiti, especially in both regions selected for this activation, and the long term recovery actions that are being carried out, the main aim of this proposal is to supply accurate and up-to-date information about the damages caused and the recovery progress after the 4th of October 2016.

This assessment will not only focus on infrastructure damages and agricultural damages, but also on displaced people due to the cyclone effects. Before the cyclone, humanitarian needs throughout the country were already quite significant: after the 2010 earthquake there were still many internally displaced persons (IDPs). Nearly seven years after the earthquake, about 55,100 IDPs continue living in 31 camps, mainly in the metropolitan area of Port-au-Prince⁴.

Therefore, the purpose of this activation will be to analyse and supply cartographic information of the damages and provide assessment on the progress of the recovery actions from the moment of the event up to 12 months after.

¹<http://www.worldbank.org/en/results/2017/10/20/rapidly-assessing-the-impact-of-hurricane-matthew-in-haiti>

²

https://reliefweb.int/sites/reliefweb.int/files/resources/UNOSAT_PreliminaryDamageAssessment_GrandAnse_Sud_Haiti_31Oct2016_TC20161003HTII_Update2_MASTER.pdf

³<http://www.undp.org/content/undp/en/home/blog/2017/1/11/Three-months-after-Hurricane-Matthew-seven-years-after-the-earthquake.html>

⁴ <https://reliefweb.int/report/haiti/haiti-humanitarian-needs-overview-2017>

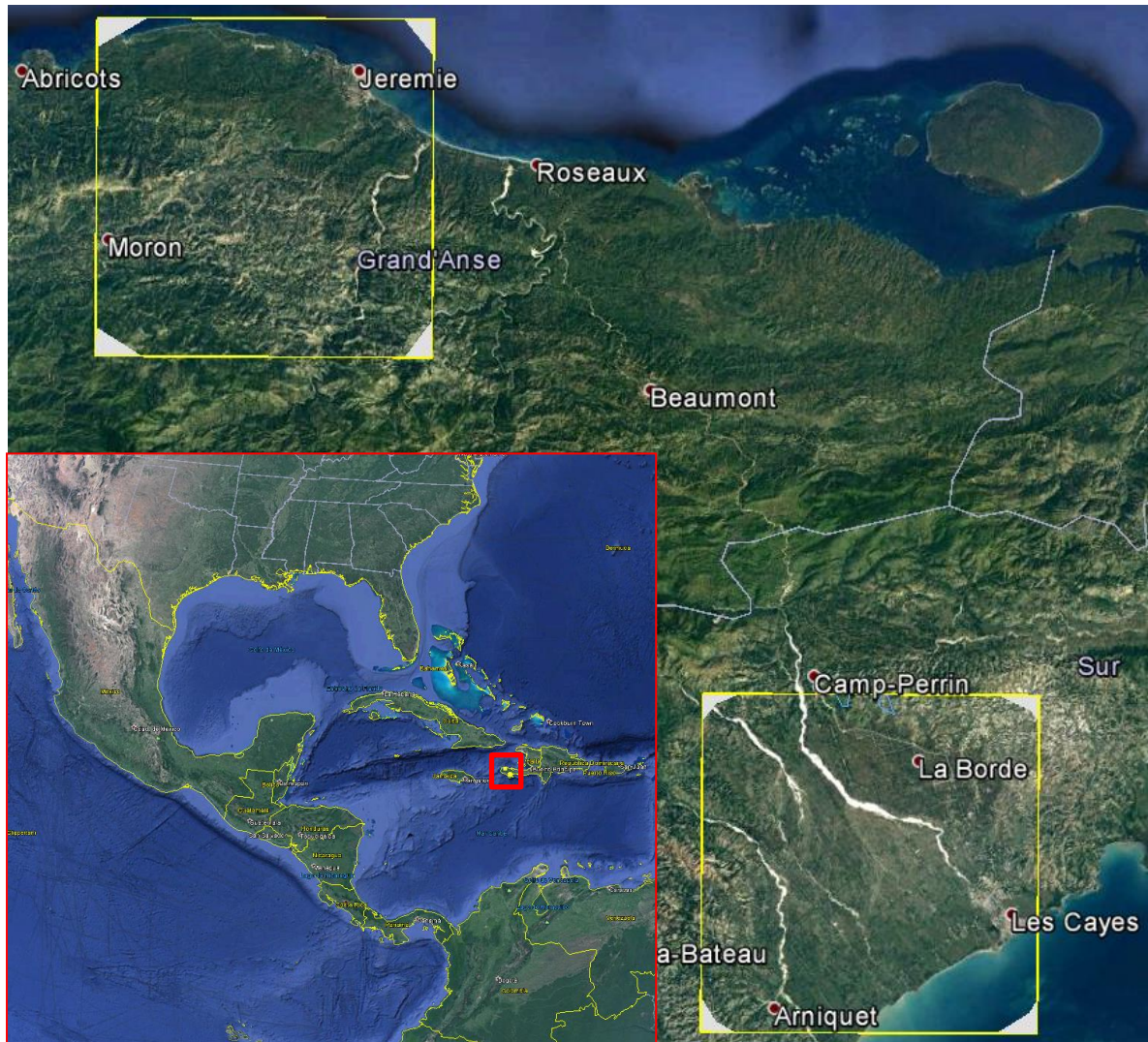


Figure 1-1: AOI location

1.2 OBJECTIVE

The objective of the current activation is to provide a general reference content to support activities of administration in reconstruction work of damages caused by Cyclone Matthew (October 2016) over two areas of interest containing the cities of Jérémie and Les Cayes, and to understand vulnerabilities during the recovery period. The focus of EMSN-050 activation was put on detecting buildings and assets of all kinds, affected by the cyclone, and understanding how people temporarily had to relocate their dwelling in the so called Internally Displaced People (IDP) camps, while the reconstruction works were taking place.

The technical approach was to build a complete GDB containing the baseline data, and the status of assets and IDP camps in all the required stages, using the same schema to make them comparable.

Spatial and temporal analysis was then performed by comparing the status of assets and IDP camps between the different stages.

Results are presented in tables containing, between other indicators, damages of assets, statistics at each monitoring interval, reconstruction progress rates, grouped by administrative boundary of interest (i.e.: sub-commune).

Pre-event baseline conditions (t_0) were compared against post-event situation in three moments:

- t_1 : days after the event, (11 days in AOI 01 and two days in AOI 02).
- t_2 : approx. approx. 6 months after (only IDP camps).
- t_3 : approx. approx. 12 months after.

The products are:

- Evolution state of the IDP camps.
- Damage assessment of assets, with focus on buildings, and monitoring of reconstruction activities of the affected assets.

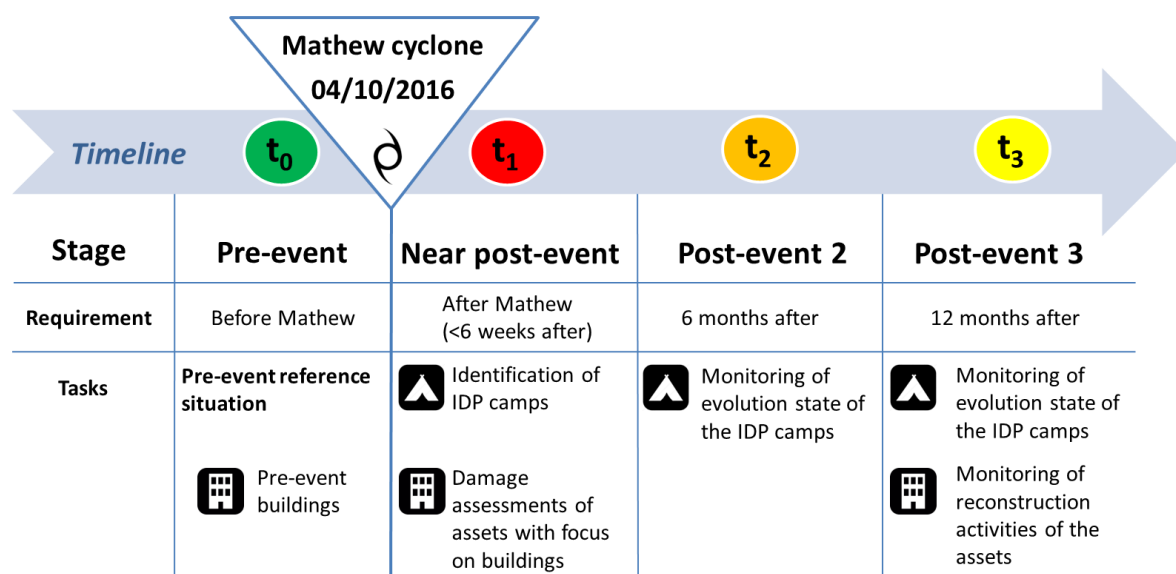


Figure 1-2: Timeline

1.3 PRODUCT DESCRIPTION

Results are reported as vectors (included in GDB), screenshots and tables, including cross-tabulates assets of all kind, statistics tables, and reconstruction progress rates and evolution state of the IDP camps.

In addition to this, a **flyer** was delivered explaining the activation as well as a **factsheet** including the activation metadata.

The following table includes a list of products delivered:

| <i>Name</i> | | <i>Description</i> | <i>Type</i> | <i>Scale</i> | <i>Num.</i> |
|----------------------------|----|---|------------------------|---------------------------------|-------------------|
| REFERENCE | 1 | Reference Cartography | Map | 1:40,000 | 2 |
| | 2 | Land Use / Land Cover | Map | 1:40,000 | 2 |
| RISK AND RECOVERY PRODUCTS | 3 | Damage Assessment (t ₁) | Map | 1:40,000 | 2 |
| | 4 | Identification of IDP camps (t ₁) | Map | 1:40,000 | 4 |
| | 5 | Monitoring of evolution state of IDP camps (t ₂ and t ₃) | Map | 1:40,000 | 4 |
| | 6 | Monitoring of reconstruction activities of the assets (t ₃) | Map | 1:40,000 | 2 |
| GDB | 7 | Results in vector format | GDB | 1:5,000 | 1 |
| QC | 8 | QC files | GDB | 1:5,000 | 1 |
| Tech. Specs. FWC | 9 | Nomenclature | Metadata and csv files | According to JRC specifications | According to maps |
| | 10 | One page flyer | In the report | N/A | 1 |
| | 11 | Factsheet | N/A | N/A | 1 |
| | 12 | Final Report | Report | N/A | 1 |

Table 1-1: Products to be delivered in EMSN-050

The mapping scale corresponds to a cartographic scale of 1:5,000 according to the Technical Specifications. Two overview maps at scale 1:40,000 for both AOIs were requested.

Regarding to the UTM zoning, both AOIs are in UTM 18N (EPSG: 32618).

1.3.1 Task and distribution

The production was carried out by Indra, GeoVille and Z_Gis.

The following table summarizes the main tasks and their distribution between the different members of the team:

| <i>Name</i> | | <i>Task Description</i> | <i>Partner</i> |
|-------------------|----|--|-------------------|
| REFERENCE | 1 | Reference Cartography (t_0) – AOI1 Reference Cartography (t_0) – AOI2 | Indra GeoVille |
| | 2 | Land Use / Land Cover (t_0) – AOI1 Land Use / Land Cover (t_0) – AOI2 | Indra GeoVille |
| RISK AND RECOVERY | 3 | Damage Assessment (t_1) – AOI1 Damage Assessment (t_1) – AOI2 | Indra GeoVille |
| | 4 | Identification of IDP camps (t_1) | Z_GIS |
| | 5 | Monitoring of evolution state of IDP camps (t_2, t_3) | Z_GIS |
| | 6 | Monitoring of reconstruction activities of the assets (t_3) – AOI1 Monitoring of reconstruction activities of the assets (t_3) – AOI1 | Indra GeoVille |
| GDB | 7 | Gather all results in vector format | Indra |
| Tech. Specs. FWC | 8 | Nomenclature | Indra |
| | 9 | Factsheet | Indra |
| | 10 | One page flyer | Indra |
| | 11 | Final Report | Indra |
| MANAGEMENT | 12 | Coordination of the production team. | Indra |
| DATA PROCUREMENT | 13 | Request of images and pre-processing of data for the production team | Indra |
| QUALITY CONTROL | 14 | Data and project quality and quality controls of all products delivered | Indra |

Table 1-2: Main Task Distribution in EMSN-050

1.4 DATA SOURCES

With the aim of speeding up the process of data acquisition from JRC and CSCDA, Indra requested all sources as soon as possible after the notification of the contract award.

The award of the contract was notified by e-mail during Easter holidays, on Thursday 29/03/2018. The contract was signed on 04/04/2018, and all sources were requested the same day.

1.4.1 EO Data (t_0 , t_1 , t_2 , t_3)

The RO provided **ortho-imagery** for the pre-event reference cartography production. The flight was performed by IGN France in **2014** with **25 cm ground sample distance**.

The ortho-images were used as **ground truth** for the creation of rectified VHR mosaics for the damage assessment in each monitoring period.

The following table contains the most updated set of optical imagery covering the AOIs for post-event analysis in the three time stages required, without cloud cover, as well as providing an appropriate resolution that assured EMSN-050 requirements. Regarding to the time stages requirement of 6 and 12 months after the event, it was necessary to extend the last observation beyond the 12 months, to obtain sub-metric imagery, which had to be prioritized over time stage requirement due to the dwellings expected to be found within the IDP camps are very small features.

| | AOI | Time stage | Sensor | GSD | Off-Nadir Angle | Cloud Cover (%) | Acq. Date (dd/mm/yyyy) |
|------------------------------|--------|------------|-----------------------|------|-----------------|-----------------|------------------------|
| Pre-event Aerial Ortho-photo | 01, 02 | t_0 | N/A | 0.25 | N/A | 0 | 2014 |
| Post-event Satellite Imagery | 01 | t_1 | WV-03 | 0.50 | 24.9 | 1.3 | 15/10/2016 |
| | | t_2 | SPOT 7 | 2 | 7.5 | 0.4 | 17/02/2017 |
| | | t_3 | Pléiades (two images) | 0.5 | 4.5-12.8 | 0 | 15/12/2017 |
| | 02 | t_1 | Pléiades | 0.5 | 29.3 | 0.6 | 08/10/2016 |
| | | t_1 | SPOT 6 | 2 | 23.4 | 3.18 | 08/10/2016 |
| | | t_2 | WV-03 | 0.5 | 1.3 | 5 | 07/03/2017 |
| | | t_3 | Pléiades | 0.5 | 9.9 | 0 | 05/02/2018 |

Table 1-3: EO Data for EMSN-050 Reference Mapping and RRM products

EMSN-050: Post Mathew Damage Assessment and Monitoring of Recovery Activities in the South Region of Haiti

As shown in the previous table, it was not possible to find archive sub-metric imagery for stage t_2 for AOI 01. Therefore, SPOT 7 (2m) imagery was selected.

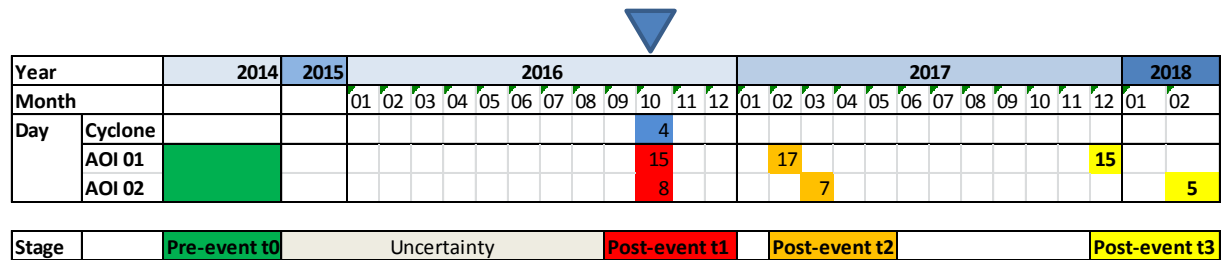


Figure 1-3: EO Data for EMSN-050 timeline

The following table summarizes the details about the imagery procurement:

| AOI | Time stage | Submitted | Received | Downloaded |
|---------|------------|------------|-------------------------------|---------------------------|
| 01 , 02 | t_0 | 04/04/2018 | Friday 06/04/2018 (after 16h) | Monday 09/04/2018 (8.00h) |
| 01 | t_1 | 04/04/2018 | 05/04/2018(18.40h) | 05/04/2018 (19.00h) |
| 01 | t_2 | 04/04/2018 | 04/04/2018 (21h) | 05/04/2018 (8.30h) |
| 01 | t_3 | 04/04/2018 | 05/04/2018 (13.50h) | 05/04/2018 (14.00h) |
| 02 | t_1 | 04/04/2018 | 04/04/2018 (23h) | 05/04/2018 (8.30h) |
| 02 | t_1 | 04/04/2018 | 05/04/2018 (16.15h) | 05/04/2018 (16.15h) |
| 02 | t_2 | 04/04/2018 | Friday 06/04/2018 (16.28h) | Monday 09/04/2018 (8.00h) |
| 02 | t_3 | 04/04/2018 | 04/04/2018 (23h) | 05/04/2018 (8.30h) |

Table 1-4: EMSN-050 Imagery procurement details

All requested images were ortho-rectified based on the ortho-image mosaic from 2014 (IGN France, 25cm) provided for the activation as pre-event reference imagery and used as ground truth.

Imagery was requested as Pansharpened and no orthorectified product. The ortho-rectification process was performed in-house.

1.4.2 Ancillary Data (t_0, t_1, t_2, t_3)

Indra got in touch with the RO that made available the following datasets:

| <i>Data Input</i> | <i>Provider</i> | <i>Format</i> | <i>Spatial coverage</i> | <i>Use</i> |
|---------------------------|-----------------|---------------|-------------------------|---|
| MNT | IGN France | Lidar | Haiti | Reference physiographic features extraction |
| Administrative Boundaries | Annex 1 EMS use | Vector | Haiti | Administrative limits |
| Territorial Diagnostic* | Annex 1 EMS use | Vector | Grand Sud | To be determined |
| Points of Interest | RO - USG | Vector | Haiti | POI |

Table 1-5: Ancillary data provided by activator

The main data provided by the RO was maps in raster formats and vector data from USG and CIAT. The scale of CIAT vectors is very coarse and its accuracy limited for this activation, thus OSM vector data has been used instead due to its higher accuracy in some vector features such transportation network. Most of the USG vector data has been used to complete the OSM layer of Points of Interest.

Indra was also given a user/password to enter into the RO website. The information was mainly satellite imagery with limited use for this activation and just a few samples of vector datasets that cover very small areas.

Other ancillary data sources in EMSN-050 activation were mostly available anytime on internet and free to download:

| <i>Data source</i> | <i>Provider</i> | <i>Availability</i> |
|---|-----------------|-----------------------------|
| Open Street Map | OSM | Free download |
| Transportation Network | CNIGS | Free download haitidata.org |
| Inland waters - River lines and polygons and wetlands | CNIGS | Free download haitidata.org |
| Wikimapia | Wikimapia | Free download |
| Google Earth and Google Maps | Geoportal | Free download |

Table 1-6: Other ancillary data used in EMSN-050

2. TECHNICAL APPROACH

2.1 REFERENCE DATA PROCESSING

In the following sections, a description of the works performed to compile all the reference data is detailed.

2.1.1 Reference Data Integration

The reference cartography describes the main topographic features and the status of the land cover in the pre-disaster situation. Reference imagery date is 2014.

The EMSN-050 reference GDB is based on an international schema: MGCP. Data from disparate sources and schemas is cross referenced to MGCP feature subtypes, and complemented with any other needs from the particular activation. Hereinafter a summary of the origin of the datasets and tasks performed to get the required information:

- **Buildings** play a special role in EMSN-050 activation. Building footprints were manually digitized using the pre-event aerial ortho-imagery from 2014.
 - In the case of buildings, the field **Status_t0** contains the interpretation of status made using the aerial pre-event ortho-photo. If the building present evidences of functionality it was coded '*1-Fully Functional*', while if the building was under construction, abandoned, or damaged in the pre-event situation, it was coded as '*2-Not functional (pre-event)*'. This will be the most important attribute to be compared between post-event time stages.
- **Transportation network**, primary source is OpenStreetMap duly updated using the reference pre-event imagery. OpenStreetMap was checked to make sure all transportation features were present. Special attention was paid to road hierarchy (classification based on CNIGS dataset) and road names that were translated into English.
- **Populated places** primary source is OSM. It contains the name of main populated places within the AOIs. Populated places have been classified by order of importance.
- **Land Use/Land Cover**, classified according to Corine Landcover level 3 legend. The LULC layer was generated following the general Urban Atlas semi-automatic approach methodology, using the transportation network skeleton and manually digitation of LULC polygons. Classification was performed by means of visual interpretation of pre-event imagery.
- **Points of Interest, Industries and Utilities** point layer primary source is OpenStreetMap complemented with additional information provided by RO.
- **Hydrographic features** include watercourse lines and polygons, with primary origin in CNIGS, they were edited in order to meet mapping scale, and coastline was manually edited using reference imagery.
- **Physiographic features** are contour lines and elevation spot points, which are derived from the provided MNT. Contour lines were generated every 5m.
- **Administrative boundaries** source is CNIGS. The smaller administrative division available is the commune.
- **Settlement** type was photo interpreted based on pre-event imagery.

The following table summarizes the data integrated into the EMSN-050 GDB:

| <i>Them. Group</i> | <i>Geom. type</i> | <i>Feature Name</i> | <i>Feature Class</i> | <i>Feature data set</i> |
|---------------------------|--------------------------|--------------------------------|--------------------------------|--------------------------------|
| ADM | A | Admin. boundaries | hti_admnbnldl_adm_CNIGS2013c | EMSN |
| HYD | L | Water courses | WatercrsL | EMSN |
| HYD | A | Water bodies | WatercrsA / LakersA | EMSN |
| LU/LC | A | Land use/land cover | LULC | EMSN |
| PHYS | P | Spot heights | ElevP | EMSN |
| PHYS | L | Contour lines | ContourL | EMSN |
| PHYS | L | Land Water Boundary | CoastL | EMSN |
| POI | P | POIs | PolS | EMSN |
| POP | P | Populated Places | BuiltupP | EMSN |
| POP | A | Buildings | BuildA | EMSN |
| POP | A | Settlements | BuiltupA | EMSN |
| TRANS | L | Roads | RoadL | EMSN |
| TRANS | L | Cart Tracks | TrackL | EMSN |
| TRANS | L | Bridges | BridgeL | EMSN |
| DAMAGE | P | Other Assets Damages | DamAssessP | EMSN |
| IDP | A | IDP settlements AOI1 T1 | IDP_settlements_AOI1_T1 | EMSN_IDP |
| IDP | A | IDP settlements AOI1 T2 | IDP_settlements_AOI1_T2 | EMSN_IDP |
| IDP | A | IDP settlements AOI1 T3 | IDP_settlements_AOI1_T3 | EMSN_IDP |
| IDP | A | IDP settlements AOI2 T1 | IDP_settlements_AOI2_T1 | EMSN_IDP |
| IDP | A | IDP settlements AOI2 T2 | IDP_settlements_AOI2_T2 | EMSN_IDP |
| IDP | A | IDP settlements AOI2 T3 | IDP_settlements_AOI2_T3 | EMSN_IDP |
| IDP | A | IDP settlements Change AOI1 T1 | IDP_settlements_Change_AOI1_T1 | EMSN_IDP |
| IDP | A | IDP settlements Change AOI1 T2 | IDP_settlements_Change_AOI1_T2 | EMSN_IDP |
| IDP | A | IDP settlements Change AOI1 T3 | IDP_settlements_Change_AOI1_T3 | EMSN_IDP |
| IDP | A | IDP settlements Change AOI2 T1 | IDP_settlements_Change_AOI2_T1 | EMSN_IDP |
| IDP | A | IDP settlements Change AOI2 T2 | IDP_settlements_Change_AOI2_T2 | EMSN_IDP |
| IDP | A | IDP settlements Change AOI2 T3 | IDP_settlements_Change_AOI2_T3 | EMSN_IDP |
| IDP | Raster | IDP Density AOI 01 t1 | EMSN_IDP_Density_AOI_01_t1 | EMSN_IDP |
| IDP | Raster | IDP Density AOI 01 t2 | EMSN_IDP_Density_AOI_01_t2 | EMSN_IDP |
| IDP | Raster | IDP Density AOI 01 t3 | EMSN_IDP_Density_AOI_01_t3 | EMSN_IDP |
| IDP | Raster | IDP Density AOI 02 t1 | EMSN_IDP_Density_AOI_02_t1 | EMSN_IDP |
| IDP | Raster | IDP Density AOI 02 t2 | EMSN_IDP_Density_AOI_02_t2 | EMSN_IDP |
| IDP | Raster | IDP Density AOI 02 t3 | EMSN_IDP_Density_AOI_02_t3 | EMSN_IDP |
| Other | A | Cloud cover in AOI 01 | AOI_01_cloud_cover | - |
| Other | A | Cloud cover in AOI 02 | AOI_02_cloud_cover | - |

Table 2-1: List of data integrated on the reference EMSN-050 GDB

The output vector data format is ESRI File Geodatabase (GDB) and OGC.

The mapping scale for building footprint is equivalent to 1:5,000 while the scale of the Overview maps is 1:40,000, with the exception of maps representing IDPS, which have been fit to the results, and the final scale is around 1:15,000.

Overview maps are delivered in JPEG (with their respective .jgw) and PDF formats. The resolutions for both file formats are 100 dpi and 300 dpi. UTM zoning is 18N.

2.2 RRM ANALYSIS

2.2.1 Identification and Monitoring of IDP Camps (t_1 , t_2 , t_3)

2.2.1.1 Overview and objective

The work presented here is part of the Framework Service Contract No. 259811 (“Emergency Management Service – Risk and Recovery Mapping”). The scope of the service request EMSN-050 was to support and assist monitoring and recovery after the passage of Matthey cyclone on 4th of October 2016 in two selected areas, including, respectively, the cities of Jérémie and Les Cayes in the Departments Grande Anse and Sud. In this context, Z_GIS provided input to INDRA for the following specific information products requested in the tender (3.2):

“Identification of Internally Displacement Person (IDP) camps close to secondary cities (AOI: 1 and 2). The IDP camps with tents have been forbidden by the government but precarious housing has developed after the event with people coming from the countryside to the major centers. For example, there are identified areas (along the airport road in Jérémie; in Les Cayes plain; along the road from Jérémie to Camp Perrin) where significant precarious housing has developed. This task is not limited to the mentioned locations but should be performed over the entire AOI’s.”

And:

“Monitoring of evolution state of the IDP camps in two areas of interest. Detection and evolution of IDPs is critical to understanding vulnerabilities during the recovery period. The information about evolution should be delivered including, vector data, statistic and report. Time intervals foreseen are 6 and 12 months after the event.”

To this end, dwellings that could be indicative of IDPs were mapped in three time steps. The results are presented here.



Figure 2-1: Overview of study areas: AOI 1 around Jérémie in the Grande Anse Department, and AOI 2, covering the plain at Les Cayes, Sud Department

2.2.1.2 Data

- **Image data**

For this study, four time stages were available for each of the two areas of interest:

| | t_0 | t_1 | t_2 | t_3 |
|---------------|--|--|---|---|
| AOI 01 | Aerial ortho-images 0,25 m/pixel Bands R-G-B Date: 2014 | WV-3 0.5 m/pixel Bands I-R-G Date: 15 Oct 2016 | SPOT-7 2 m/pixel Bands R-G-B-I Date: 14 Feb 2017 | Pléiades-1B 0.5 m /pixel Bands R-G-B-I Date: 15 Dec 2017 |
| AOI 02 | Aerial ortho-images 0,25 m/pixel Bands R-G-B Date: 2014 | Pléiades-1B 0.5 m /pixel Bands R-G-B-I Date: 08 Oct 2016 SPOT-7 2 m/pixel Bands R-G-B-I Date: 08 Oct 2016 | 0.5 m /pixel Bands I-R-G Date: 07 Mar 2017 | Pléiades-1B 0.5 m /pixel Bands R-G-B-I Date: 05 Feb 2018 |

Table 2-2: List of image data used for IDP identification

The data consisted of aerial ortho-images with a spatial resolution of 0.25 m/pixel, and various satellite images from WorldView-3, Pléiades and SPOT-7, with 0.5 m/pixel, 0.5 m/pixel and 2.0 m/pixel, respectively. The structures interpreted as IDP dwellings have an extent of only a few square meters. Therefore, the SPOT-7 imagery with its spatial resolution of 2 m partly proved to be too coarse for the identification and mapping of individual dwellings. This issue was already addressed in the tender proposal as a potential outcome, but because of the non-availability of higher resolution archive data and the nature of the monitoring task (the SPOT image is in between the two other time steps) the SPOT image has been selected.

All pre-processing (orthorectification, co-registration, selection of bands) was done by INDRA.

- **Additional data**

In addition to images, data from the Displacement Tracking Matrix (DTM) of the International Organization for Migration IOM was used (<http://haiti.iom.int/dtm>). It provides information on occupancy numbers of sites known to IOM to host IDPs. The above website provides weekly updates. For this study, the date of 13 Oct 2017 was chosen, as it corresponds to 12 months after the storm event, as requested in the tender. The IOM data file also contains the information from all previous weekly counts since the storm event. The data is in tabular form, but contains coordinates. Therefore, it was georeferenced to overlay with the imagery.

2.2.1.3 Methods

- **Identification of dwellings of internally displaced persons**

Dwellings of internally displaced persons are understood in this context as precarious housings of people who have left their previous place of living, in order to settle in open spaces available to them, preferably at the fringe of existing informal settlements.

Indications for precarious housing are groupings of dwellings with a disordered arrangement, and a relatively small size. Thus, not every new building appearing in the post-event images was considered an IDP dwelling. New, single buildings adjacent to existing ones were not mapped. Also, newly constructed regular buildings or buildings under construction were not mapped as IDP dwellings. Where available, dwellings were compared to data collected by the IOM-DTM displacement matrix. The dwellings were also compared with OpenStreetMap to avoid confusion with market stands, which can have a somewhat similar appearance. The main difficulty is the distinction between regular settlements that formed after the storm events, and informal settlements of internally displaced people. Therefore, some of the settlements shown here might in reality represent regular settlements. On the other hand, as IDP dwellings in the sense used here were identified by their spatial pattern, it is possible that new individual small buildings within the city house IDPs, but that these buildings were not identified as such.

These dwellings were identified visually by comparison with pre-Matthew imagery (t_0). Automated approaches were not applicable in this difficult, heterogeneous situation. To this end, the areas of interest were subdivided into smaller working areas to distribute the work among different co-workers, experienced in refugee and IDP camp analysis. Then, a regular grid net with 500 m cell size was used to check the imagery cell by cell, by comparing the individual time steps using a swipe tool.

The first time step (t_1) contains putative informal dwellings indicative of IDPs, which were not yet present in the pre-event imagery (t_0). It is unclear if these dwellings formed directly after the storm, or if they formed in the two years since acquisition between the t_0 and t_1 imagery. Apparent “regular” dwellings were not mapped. The time step t_2 contains all dwellings marked in t_1 , which still existed, plus all new potential IDP dwellings observed in the t_2 imagery. The procedure for t_3 was exactly the same as for t_2 .

All co-workers were instructed to mark all potential IDP dwellings, even if their identification was uncertain. Finally, the four-eyes-principle was employed by counter-checking all marked dwellings by an experienced mapper to ensure a consistent interpretation of the structures observed in the imagery. The three time steps were analysed sequentially ($t_1 \rightarrow t_2 \rightarrow t_3$) in the order that the images were delivered by INDRA. At the end of the procedure, all produced layers were revised in light of imagery from a later time, as sometimes the later, but higher resolving imagery helped clarify the identification of certain features.

- **Dwelling Density**

The density of putative IDP dwellings was calculated for all time steps for the two AOIs, using a kernel density approach⁵.

⁵ Silverman, B. W. Density Estimation for Statistics and Data Analysis. New York: Chapman and Hall, 1986.

- **Change detection**

The change of putative IDP dwellings was calculated for the time steps $t_1 \rightarrow t_2$, $t_2 \rightarrow t_3$ and $t_1 \rightarrow t_3$ for both AOIs. We used the centroid of each dwelling in one layer to identify the corresponding dwelling in the other layer: A dwelling was considered “persistent” if its centroid mapped at time t_1 would fall into a polygon at time t_2 . Dwellings in t_2 not having a corresponding dwelling in t_1 were considered “new”; dwellings in t_1 with whose centroid did not fall into a dwelling polygon in t_2 were considered “removed”. To avoid confusion with newly constructed dwellings at the location of a removed dwelling (which would be identified as “persistent” dwelling instead of “new” dwelling), all persistent dwellings were checked visually, and corrected according to the visual interpretation. The same methodology was employed for the other time steps, respectively.

2.2.1.4 Results

- **Area of Interest 1: Jérémie**

In AOI 1, most informal settlements indicative for IDPs are located around Jérémie. An example for a putative IDP settlement is shown in next figure. The area is uninhabited in t_0 . In time t_1 , several small huts can be seen. The image of t_2 is of lower resolution. Therefore, this analysis is less reliable. At t_3 , most of the dwellings on the open grassland have disappeared.

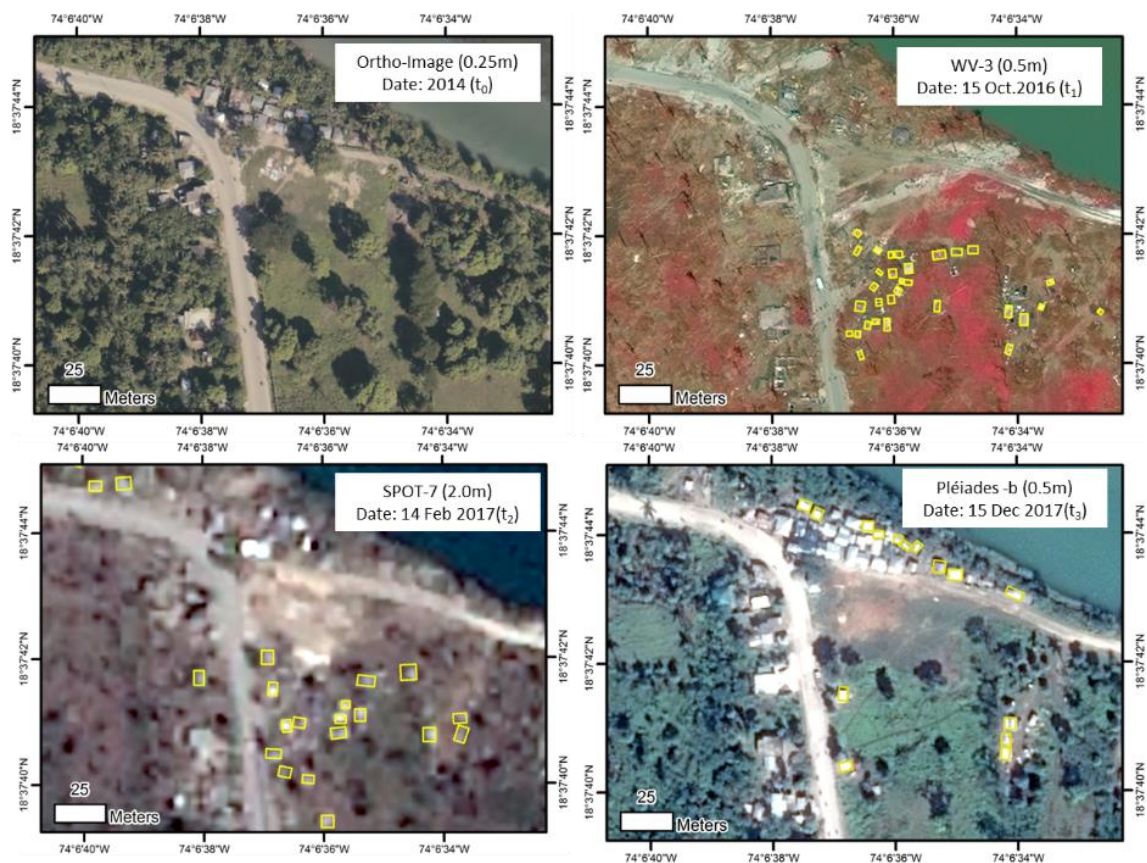


Figure 2-2: Development of a putative IDP settlement outside Jérémie. Yellow: Potential IDP dwellings.



Figure 2-3: Putative IDP settlement on beach east of Jérémie. Shown is t3.

Further concentrations of assumed IDP dwellings are found along the beach east of Jérémie (previous figure) and east of Vieux Bourg de Jérémie.

One larger potential IDP settlement is located approximately 2 km south-west of the town center of Jérémie (next figure).

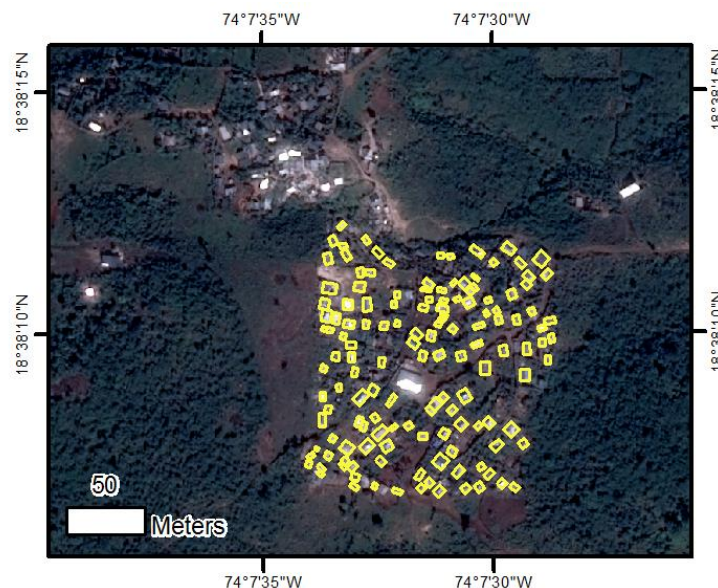


Figure 2-4: Potential IDP settlement southwest of Jérémie. Shown is t3.

The specifications for this tender stated, that informal settlements are located along the road to the airport west of the town centre. Along that particular road, no structures immediately apparent as IDP settlements have been found. The specifications also mention the road from Jérémie to Camp Perrin, which is mostly outside of the two AOIs.

In total 110 putative IDP dwellings have been mapped in t₁, 173 in t₂ and 639 in t₃.

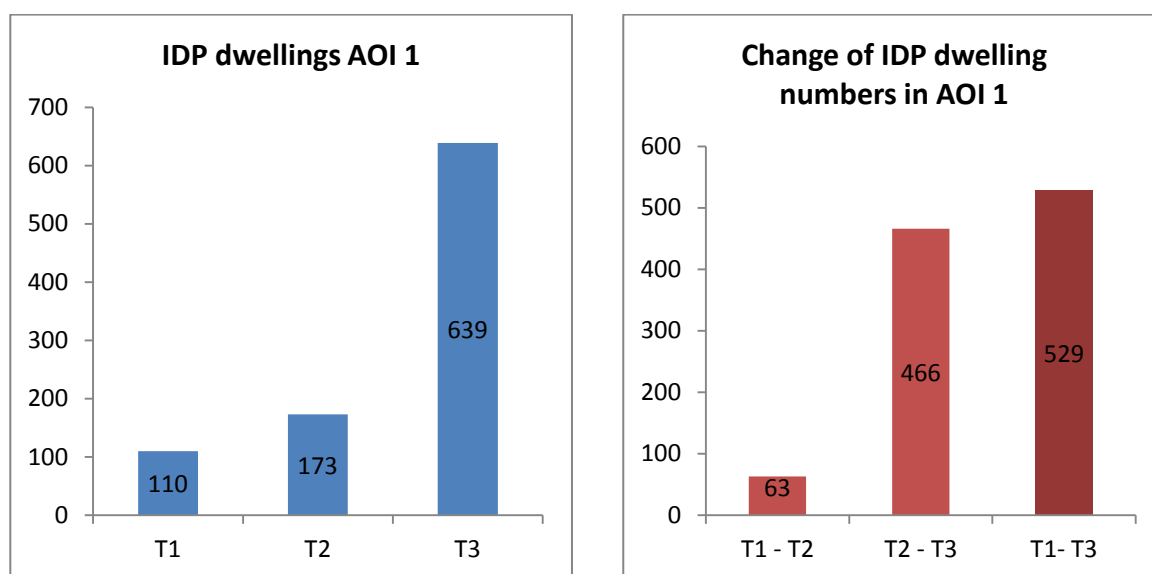


Figure 2-5: Diagram showing the development of putative IDP dwelling numbers in AOI 1 over time and the change of dwelling numbers between T1-T2, T2-T3 and T1-T3.

The IOM Displacement Tracking Matrix mentions four sites in AOI 1 (Table 2-3). Site Versay appears to be an informal settlement that existed before the passage of cyclone Matthew. It shows very little change over the three time steps analysed here. Site Vertigo is an inconspicuous looking location, where no clearly identifiable IDP dwellings are located. At Site Chateau, growing numbers of putative IDP dwellings are found at a location where putative precarious housings existed already before the storm.

| Site name | Type | Number of pot. IDP dwellings in vicinity | | | Latitude | Longitude |
|--------------|----------------------|--|-------|-------|----------|-----------|
| | | t_1 | t_2 | t_3 | | |
| Site Versay | Camp-like settlement | 0 | 0 | 0 | 18,63559 | -74,10993 |
| Kafou Diri | Camp-like settlement | 33 | 23 | 15 | 18,62876 | -74,10999 |
| Site Vertigo | Camp-like settlement | 0 | 0 | 0 | 18,61802 | -74,11551 |
| Site Chateau | Camp-like settlement | 13 | 37 | 66 | 18,6223 | -74,09286 |

Table 2-3: Sites of displaced persons identified by IOM-DTM

- **Area of Interest 2: Les Cayes**

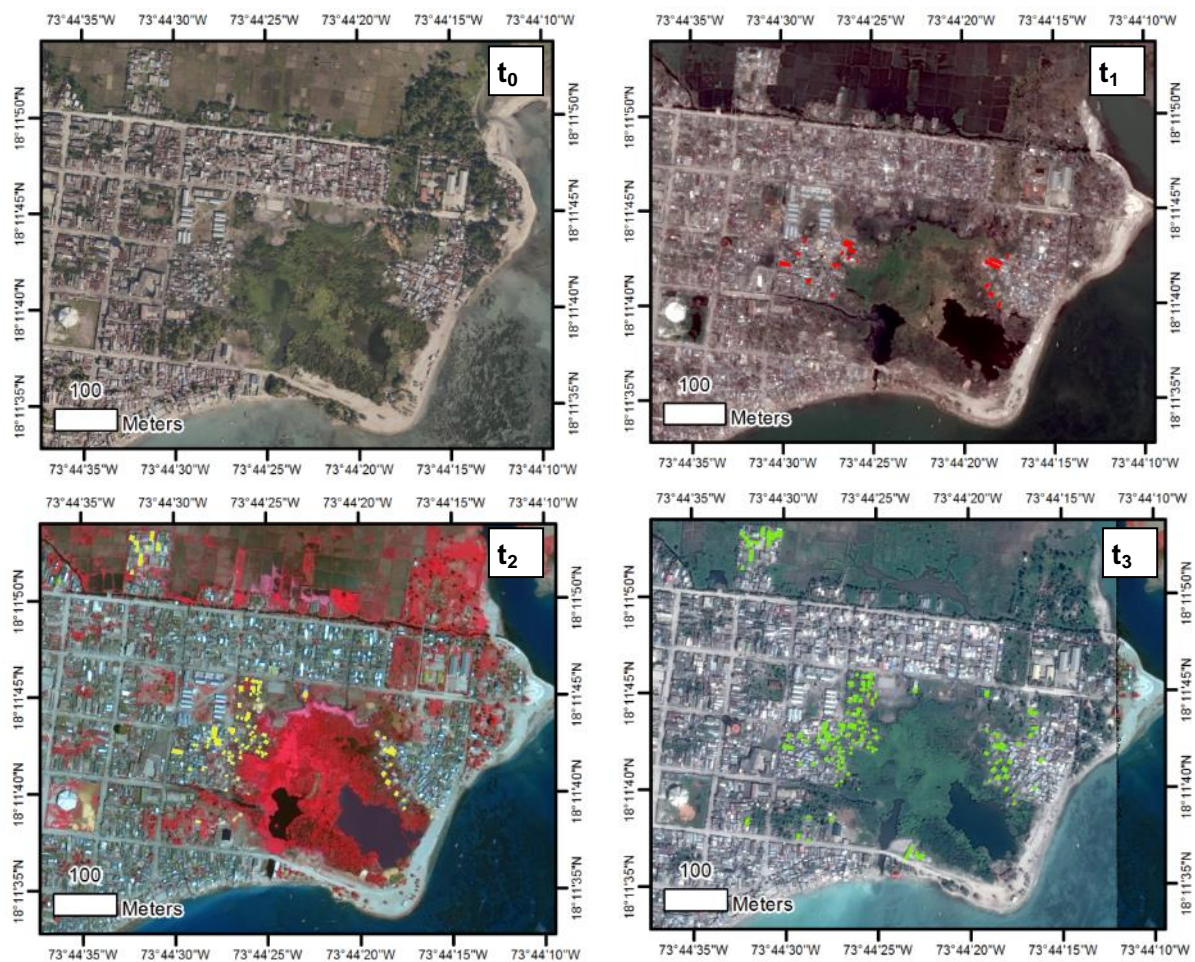


Figure 2-6: Development of a putative IDP settlement in the eastern part of Les Cayes.

As in AOI 2, only a very low number (24) of putative IDP dwellings have been mapped at t_1 . They are located almost exclusively in an area in the eastern part of Les Cayes (previous figure). Here, an apparent informal settlement grew into an area that was formerly covered by wetland. The number of putative precarious housings in this area increases to 85 at t_2 , and then to 142 in t_3 .



Figure 2-7: putative IDP settlement along Ravine du Sud in Les Cayes. Shown is situation at t_3 .

Further putative IDP settlements have been found along the river *Ravine du Sud*, in the western part of the town (see previous figure). The location of these small dwellings perched against the surrounding walls of neighbouring lots suggests that these are precarious housings, potentially inhabited by internally displaced persons affected by cyclone Matthew.

In total, 24 potential IDP dwellings were mapped in t_1 , 171 in t_2 and 289 in t_3 .

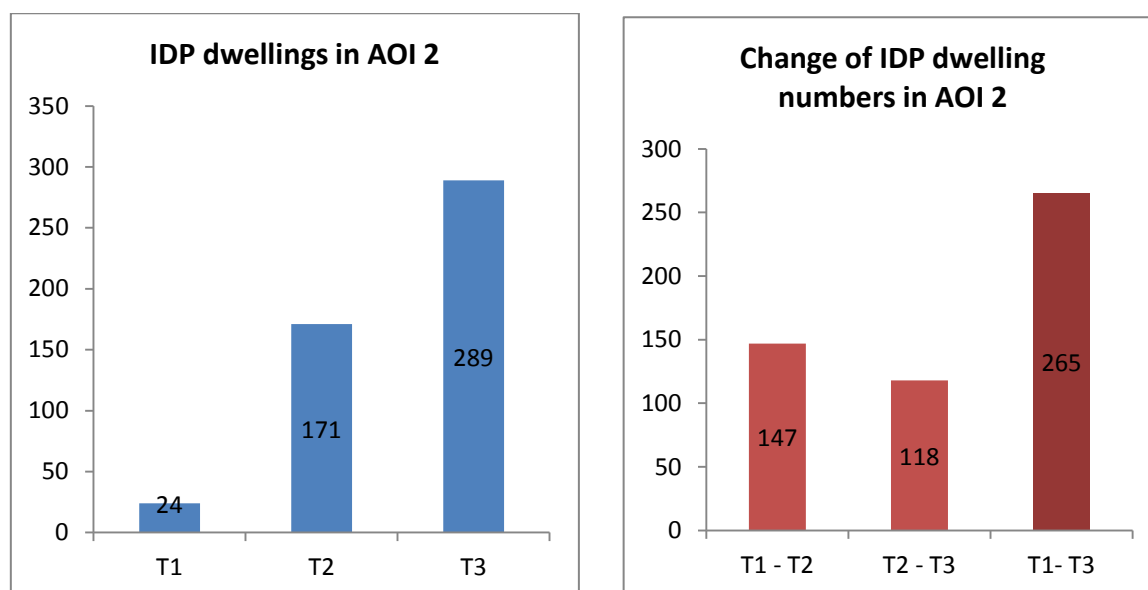


Figure 2-8: Diagram showing the development of putative IDP dwelling numbers in AOI 2 over time.

The technical specifications for this tender state that significant precarious housing had developed in the Les Cayes plain (see citation above). Despite our thorough and methodical analysis of the entire AOI, it is not clear to which settlements the text refers to. While several new buildings or buildings under construction are visible locally, indications of precarious housing, such as small building sizes, irregular spacing and orientation of dwellings, forming clusters in unfavourable locations, such as the swampland and the river bank shown above, were found only rarely. Therefore, the number of IPD dwellings mapped here might underrepresent the total number of people requiring assistance.

The IOM-DTM data utilized in this study shows nine IDP sites in AOI 2. Most of these sites are schools serving as evacuation centre. No tents or huts were identified on the premises of these schools in any of the three time steps. One location is mapped by IOM as “camp-like settlement”. However, also at this site no huts or other types of precarious housings were found in the imagery.

| <i>Site name</i> | <i>Type</i> | <i>Latitude</i> | <i>Longitude</i> |
|---|----------------------|-----------------|------------------|
| Resd Senateur Herve Foucan | Centre d'évacuation | 18,22413 | -73,74054 |
| Ecole Frère du Sacre Coeur | Centre d'évacuation | 18,19784 | -73,74832 |
| Parc Larco | Centre d'évacuation | 18,20913 | -73,77216 |
| Ecole Communautaire de la fond R. Rhau | Centre d'évacuation | 18,25127 | -73,82156 |
| Ecole St Therese | Centre d'évacuation | 18,23272 | -73,88506 |
| Ecole Nationale de Perrien | Centre d'évacuation | 18,19141 | -73,84608 |
| Eglise Mont des Diviers de Cazeau | Camp-like settlement | 18,1411 | -73,89023 |
| Presbitere de Chateau | Centre d'évacuation | 18,17405 | -73,91673 |
| Chez Monseigneur Romellus | Centre d'évacuation | 18,17963 | -73,92393 |

Table 2-4: Sites of displaced persons identified by IOM-DTM

- **Discussion**

Overall, very low numbers of putative IDP dwellings have been observed for both AOIs at t_1 . This suggests that in the few days following the passage of the storm until the satellite image acquisition, most affected people had not yet constructed new shelters. At time t_2 , numbers of potential IDP dwellings have risen in both sites, but remain low (AOI 1: 173, AOI 2: 171) compared to the absolute number of estimated 180,000 individuals displaced by cyclone Matthew (for entire Haiti; http://www.internal-displacement.org/countries/haiti#link_patterns). IDP dwelling numbers then rise to 639 and 289 dwellings, for AOI 1 and 2 respectively. The low absolute numbers might reflect the difficulty of identifying dwellings of displaced persons from satellite imagery, but maybe also a result of the governmental decisions to forbid IDP camps with tents (cf. tender document). In this study, only clusters of dwellings were considered potential IDP dwellings, whereas new individual huts and buildings at the countryside were interpreted as reconstruction of destroyed housings by “undisplaced” inhabitants, and therefore not mapped. Thus, the low number of potential IDP dwellings does not imply a low number of internally displaced persons.

Analysis of field visits at shelters and counting travellers at bus stations performed by IOM-DTM suggest that many people affected by Matthew moved towards the large cities in the east of the country around Port-au-Prince, while at the same time movement from underserved rural areas to the towns of Jérémie and Les Cayes, as well as a backward movement from the east back to the southern peninsula set in. This is reflected in the increase of putative IDP dwelling numbers at t_3

(https://haiti.iom.int/sites/default/files/documents_files/DTM_Matthew_Report_Round%204.pdf).

2.2.2 Damage Assessment of Assets (Status at t_1)

Damage assessment of assets in EMSN-050 AOIs was performed by specialized photo-interpreters comparing the reference pre-event ortho-imagery (t_0) and satellite optical imagery for stage t_1 .

The main focus was put on buildings, although other damaged assets were also identified in this time stage.

The photo-interpretation of satellite imagery for damage assessment with focus on buildings has some limitations worth to be commented:

- a. Damage to the façade of buildings cannot easily be distinguished with typically vertical looking with a sub-meter spatial resolution satellite alone.
- b. In high density areas, satellite images have limitations and the capacity of detecting damages in single buildings had limited capabilities.
- c. Cross-check with media sources is very helpful to locate the most affected areas but it is usually not enough, not reliable or very coarse, and it is difficult to improve the precise location of the reported damages.

For this proposal, a set of rules served as examples to identify the damages and the level of severity using the satellite data.

A table with the codes explained hereinafter is attached in Annex A.

- **Building area feature class**

In the case of buildings, the field **Status_** t_1 contains the interpretation of damage made using the corresponding imagery. If the building showed any evidence that could have potential damage, this field was coded as '*2-Damage*', while if no evidences of damages were present it was coded '*1-Not Visible Damage*'.

Water on plain roof is not considered damage, indeed this was an evidence of a solid construction made of concrete. A good example is shown in screenshots a) where there is a large building of a church with a plain roof accumulating water on top pointed by blue arrows. The majority of the building roofs made of veneer/iron sheet (rusty or not) were blown away by Mathew. These observations can be seen in all the screenshots hereinafter:



Figure 2-9: Examples of buildings in t_1 compared with pre-event t_0

- **Other assets**

Damages on other assets were assessed by adding a point on the potential damages identified, referring to the affected asset, and coding the field **Status_t1**. The focus was put on infrastructures, and the majority of the detected damages were on walls (see examples a and b) and roads (c).

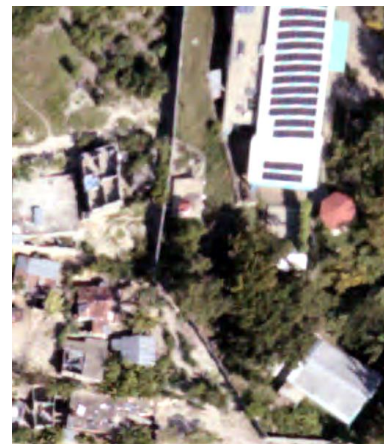
Post t₁



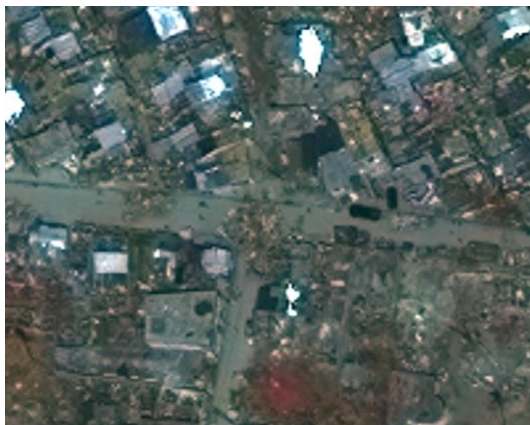
Pre t₀



a) Collapsed Wall 74°7'13.537"W 18°38'26.021"N



b) Collapsed Wall 74°7'22.268"W 18°38'26.743"N



c) Blocked Road 74°6'55.444"W 18°38'54.158"N

Figure 2-10: Examples of other damaged assets in t₁ compared with pre-event t₀

2.2.3 Reconstruction Activities of the Assets (Status at t_3)

- **Building area feature class**

In the case of buildings, the field **Status_** t_3 contains the interpretation of status of buildings made using the corresponding imagery approximately 12 months after the event. In the majority of the situations, the buildings showed evidences of reconstruction, and they were coded '*1-Not Visible Damage*' (a), while the buildings that still presented evidences of potential damage were coded '*2-Damage*'. There were other frequent situations such buildings that were not present in t_3 , which were coded as '*3-Cleared*' (b and c), meaning there are no evidences of being there anymore, and also new constructions that were coded as '*4-New buildings*' (b and c).



Figure 2-11: Examples of buildings in post-event t_3 compared with post-event t_1

- **Other assets**

Damages detected in t_1 were double checked in t_3 , in order to verify if the damages are solved approximately one year after the cyclone. The status in this time stage was coded in the field **Status t_3** . The majority of the detected damages in t_3 were presented signs of recovery. Some of the detected damages in t_1 could not be verified in t_3 , especially walls, because sometimes the impressive vegetation recovery, after one year, hindered the damaged features observed after the hit of Mathew, where the majority of vegetation was devastated.

| DamAssessP | | | | | | |
|------------|------------|---------|----------------|--------------------|--------------|-------------------------------|
| | OBJECTID * | SHAPE * | ASSET | Status t_0 | Status t_1 | Status t_3 |
| | 193 | Point | Wall/Fence | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 194 | Point | <Null> | 1-Fully functional | 2-Damage | 2-Damaged |
| | 195 | Point | Road | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 196 | Point | Bridge | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 197 | Point | Soil | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 198 | Point | Wall/Fence | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 199 | Point | Pylon | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 200 | Point | Industrial Fac | 1-Fully functional | 2-Damage | 1-Fully functional (improved) |
| | 201 | Point | Other | 1-Fully functional | 2-Damage | 2-Damaged |
| | 202 | Point | Wall/Fence | 1-Fully functional | 2-Damage | 999-Unk |
| | 203 | Point | Wall/Fence | 1-Fully functional | 2-Damage | 999-Unk |

Figure 2-12: Example of other assets coded in EMSN-050 GDB

If the cloud coverage of any of the imagery sources was obstructing the interpretation, the Status was coded as '9-Unknown'.

For more examples of other damaged assets in the three time stages see Annex B.



Figure 2-13: Examples of other assets in post-event t_3 compared with post-event t_1

2.2.3.1 Supporting information for monitoring purposes

A deep research was conducted during the activation in order to identify additional reliable sources of information to support the monitoring of reconstruction activities. Images compiled by MINUSTAH for AOI 01 Jérémie were found. Well known buildings were identified in the bird's-eye view and it was used as reference. Images for AOI 02 were more difficult to find, or identify in the ground. Due to similarities between both AOIs, after a preliminary analysis, it was possible to say that conclusions extracted from oblique pictures in AOI 01 Jérémie could be extrapolated to AOI 02 Les Cayes as well.

- **Example used for poster production**

This photography from MINUSTAH⁶ was taken on the 06/10/2016 only 2 days after the event. The people were drying their belongings on the street and on top of the flat and concrete not damaged buildings. Streets look trafficable in this area, although debris is present along the road.

In the following picture, the street that runs from top to bottom is the *Avenue Simon Duvalier*, the one from left to right is *Abbé Huet Street*, in the northern part of the City of Jérémie (74° 6'52.54"W 18°38'53.96"N). The picture was taken from a helicopter while overflying the city looking from the West to the East; the North is to the right.



Figure 2-14: Bird's-eye view of Jérémie from MINUSTAH (example #3)

Satellite imagery for t_1 can be seen in the next screenshot, and was taken on 15/10/2016, eleven days after cyclone Matthew. Apparently there are not as many clothes present on top of the buildings as they were 2 days after the event. There is still water on the rooftops of not damaged buildings. Concrete may be wet already. The vast majority of tin roofs are blown away.

⁶ <https://www.flickr.com/photos/minustah/sets/72157674904349345>



Figure 2-15: Buildings from bird's-eye view identified in the t_1 satellite image (AOI 01)⁷

Next figure shows an example of the maps created ad-hoc for the “2nd Recovery Observatory User Workshop, organized by CNIGS and CNES” using this source:



Figure 2-16: Map created ad-hoc for the Workshop

⁷ Note that the north is to the right of this satellite image screenshot. Position was changed in order to make easier the identification of features from bird's eye view from MINUSTAH.

- **More examples of MINUSTAH pictures on the ground in AOI 01 Jérémie**

Additional examples of MINUSTAH pictures uploaded in their Flickr page⁸ were found on EMSN-050 AOIs, all of them in AOI 01 City of Jérémie.

They were a very valuable source of information that usually is not available.

They were used to build better criteria for photointerpretation of the features visible in the satellite imagery.

The picture used in the previous example is picture #3. In this section, the next pictures are located and some of the visible features in them commented in order to show the user how things are seen from above versus how things are seen as we usually do: bird's eye views.

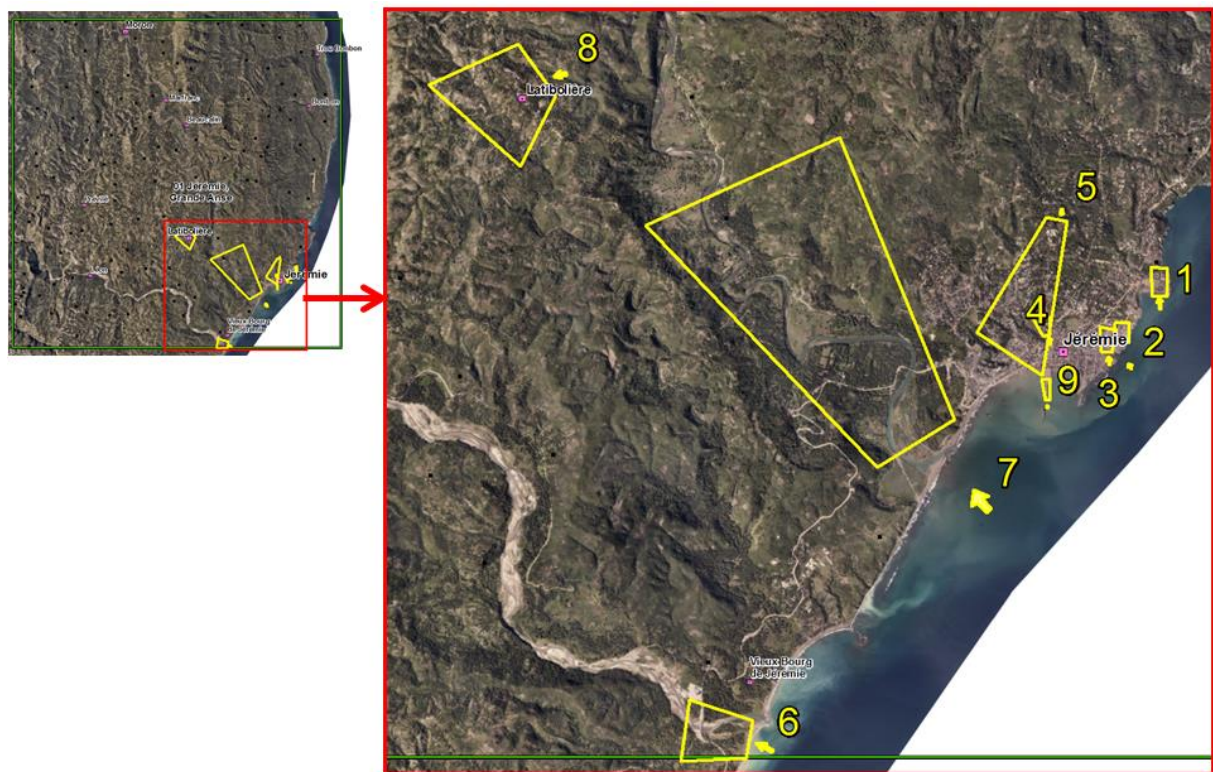


Figure 2-17: Identification of other MINUSTAH bird's eye pictures on the ground

⁸ <https://www.flickr.com/photos/minustah/albums/72157674904349345/with/29550147854/>

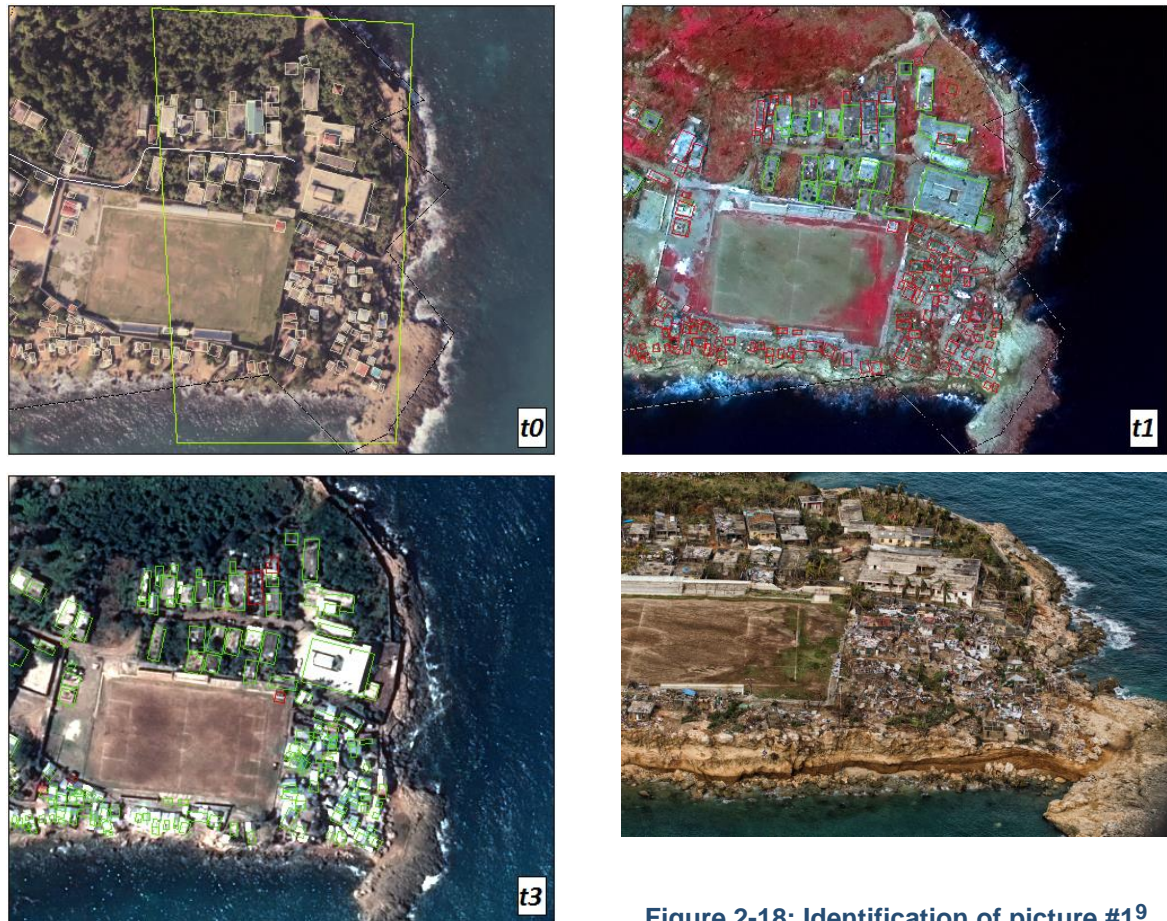


Figure 2-18: Identification of picture #1⁹

This picture was taken looking from the West to the East (the North is to the right) near *Côtes de Fer* Bight, there is a football ground and a neighbourhood to the front and left of the picture, where the houses are informal precarious and small (a). Behind the sports ground there are other type of constructions made of better building materials like concrete (b). The informal constructions are destroyed in the t_1 imagery, in the majority of them the roof was blown away. In some cases the walls are also blown away or collapsed, in some others, the walls made of bricks/concrete are still standing up. In example (b) a collapsed facility wall can be seen as well.



Figure 2-19: detail of buildings in picture #1¹⁰

⁹ <https://www.flickr.com/photos/minustah/30064482332/in/album-72157674904349345/>

¹⁰ <https://www.flickr.com/photos/minustah/30064482332/in/album-72157674904349345/>



Figure 2-20: Identification of picture #211

This picture was taken looking from the West to the East (the North is to the right) while overflying the northern coast of City of Jérémie ($74^{\circ}6'55.856''\text{W}$ $18^{\circ}38'59.057''\text{N}$). The facility that can be seen at the back of the picture is Jérémie Hospital *la Source*. As seen in the detail below, a part of the Hospital with gabled tin roof was damaged (blown away roof) while the other building with flat concrete roof within the facility (at the front of the picture) looks fully functional after Mathew. The damaged building in t_1 is reconstructed one year ago t_3 . The neighbourhood at the front of the picture was majorly devastated then, but recovered nowadays at t_3 .



Figure 2-21: detail of Jérémie Hospital *la Source* facility #2

¹¹ <https://www.flickr.com/photos/minustah/30064482332/in/album-72157674904349345/>

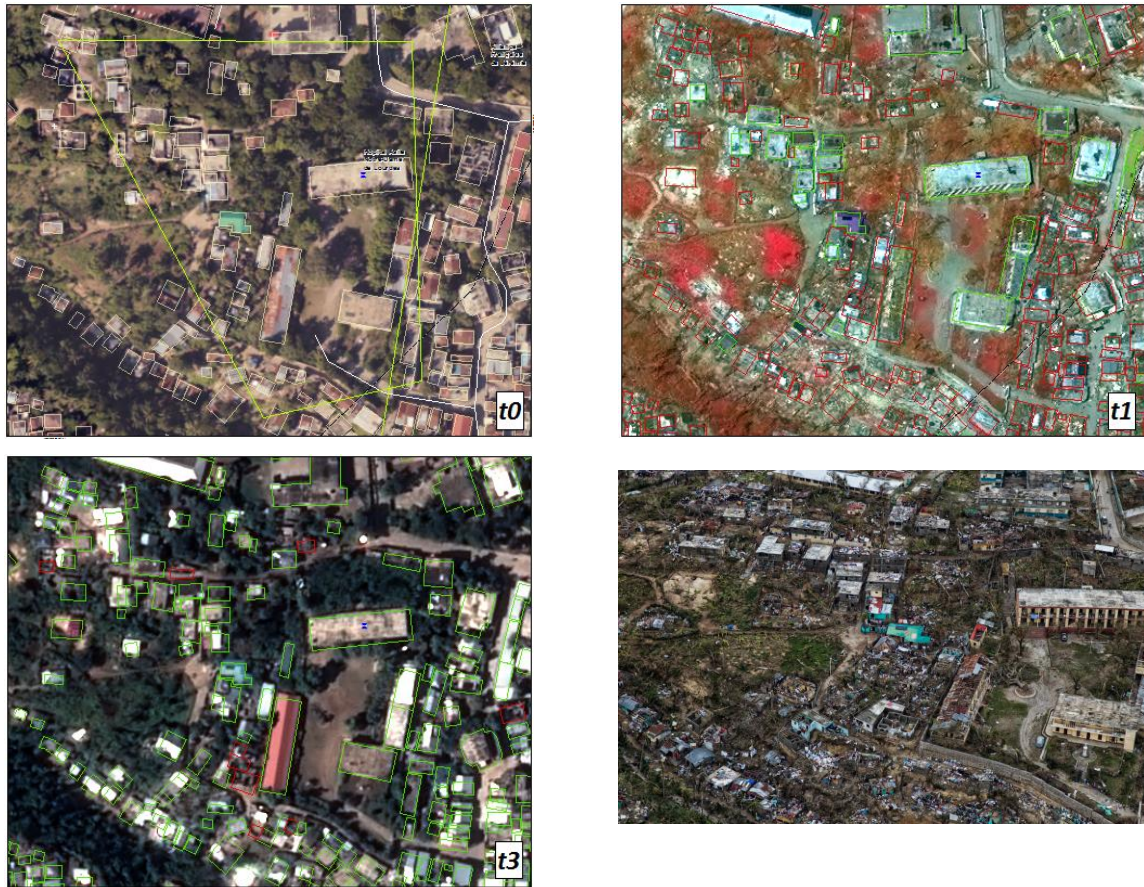


Figure 2-22: Identification of picture #4¹²

This picture was taken looking from the West to the East (the North is to the right) while overflying the City of Jérémie (74°6'57.996"W 18°38'34.152"N). The main visible facility to the right of the picture is Asylum Hospital *Notre-Dame de Lourdes*. There are several buildings within the facility, and again, as observed in the previous example the gabled tin roof was blown away (to the left of the facility) while the flat concrete roofed buildings within the facility look functional. The majority of the buildings to the left of the facility wall look damaged in the near post-event t_1 , and reconstructed one year after the event t_3 .



Figure 2-23: detail of Jérémie Asylum Hospital Notre-Dame de Lourdes facility #4

¹² <https://www.flickr.com/photos/minustah/30064482332/in/album-72157674904349345/>



Figure 2-24: Identification of picture #5¹³

This picture was taken from east to west at the southern outskirts of the City of Jérémie, where the plain of the city ends and the slope of the mountain starts. Features at the back are difficult to see; nevertheless the extent reflects the whole extent of the bird's eye view.

The facility at the front of the picture is religious (red cross on top) but its name is unknown, no ancillary data was available. At the left of the picture, it is also visible the HHF Hospital, with possible solar panels on top, which presents evidences of being functional in t_1 .



Figure 2-25: detail of religious and medical facilities in picture #5

¹³ <https://www.flickr.com/photos/minustah/30144517196/in/album-72157674904349345/>

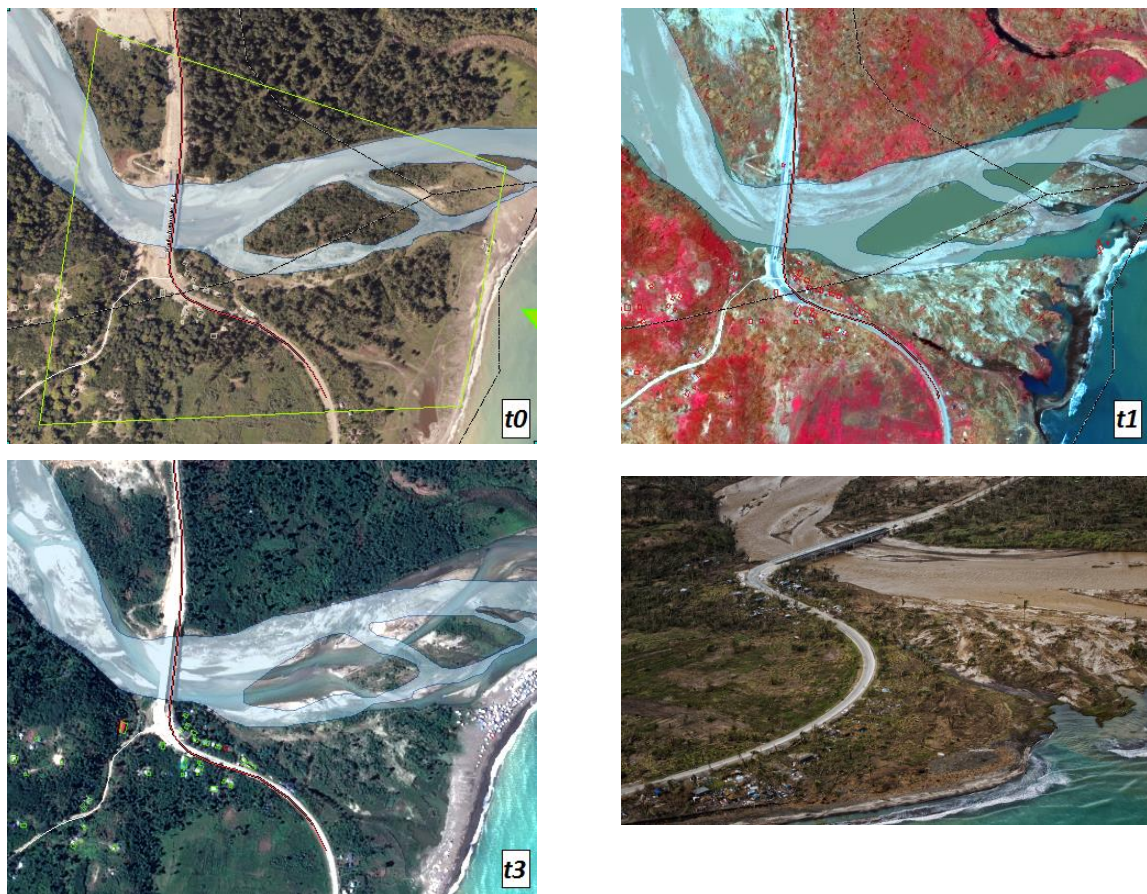


Figure 2-26: Identification of picture #6¹⁴

This picture is taken NW to SE at the western boundary of AOI 01 Jérémie, at the crossing of *Route Nationale #7* over The *Voldroque* River mouth close to *Vieux Bourg de Jérémie*. The status of the road and the bridge look functional. The hamlet by the road look affected and in the picture it is also visible how the people dry their clothes on the ground surface. The trees and palm trees are visibly affected in t_1 (no shadows projected in satellite imagery), most of them lying down on the ground. One year after Mathew in t_3 , the settlement look recovered (roofs rebuilt), and so the vegetation which presents a very good self-recovery.



Figure 2-27: detail of hamlet and vegetation in picture #6

¹⁴ <https://www.flickr.com/photos/minustah/29550148854/in/album-72157674904349345/>

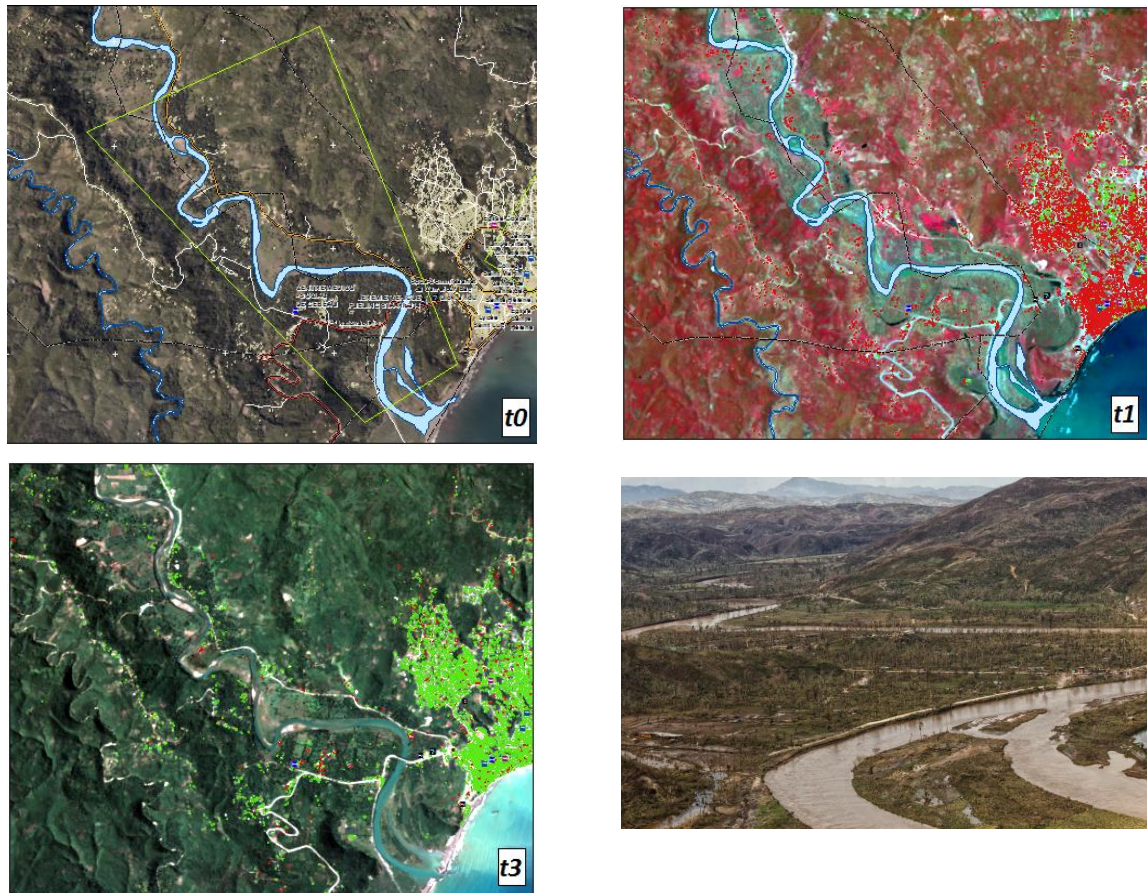


Figure 2-28: Identification of picture #715

In this picture a bigger area is portrayed, mostly showing the great devastation that Mathew caused on the vegetation. The picture shows the *Grand'Anse* River, very close to its river mouth at 74°6'17.824"W 18°37'50.474"N, in the outskirts to the East of City of Jérémie.

As seen in previous picture, there was a vast devastation on arboreal vegetation. It is visible in several pictures before, in next picture, there is a closer look.



Figure 2-29: Devastation on arboreal vegetation 16

¹⁵ <https://www.flickr.com/photos/minustah/29550147854/in/album-72157674904349345/>

¹⁶ <https://www.flickr.com/photos/minustah/29550130274/in/album-72157674904349345/>

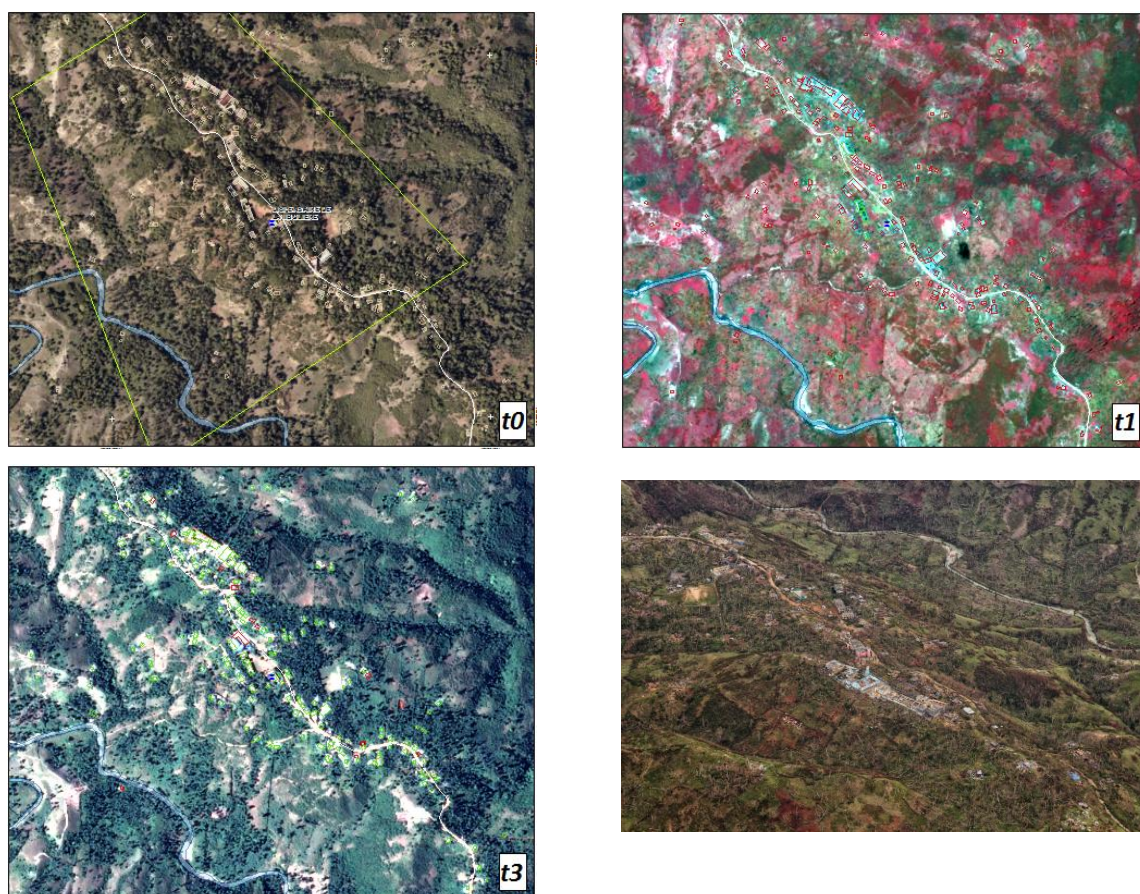


Figure 2-30: Identification of picture #8¹⁷

In this picture it is portrayed the rural populated place of *Latiboliere*. In the middle of the picture (with a white and green façade) it is possible to see the *Dispensarie de Latiboliere*, surrounded by a wall. All the facility looks functional right before the hit of Mathew. The residential building at the surroundings look damaged in t_1 and almost all recovered in t_3 .



Figure 2-31: detail of *Dispensarie de Latiboliere* in picture #8

¹⁷ <https://www.flickr.com/photos/minustah/30144513736/in/album-72157674904349345/>

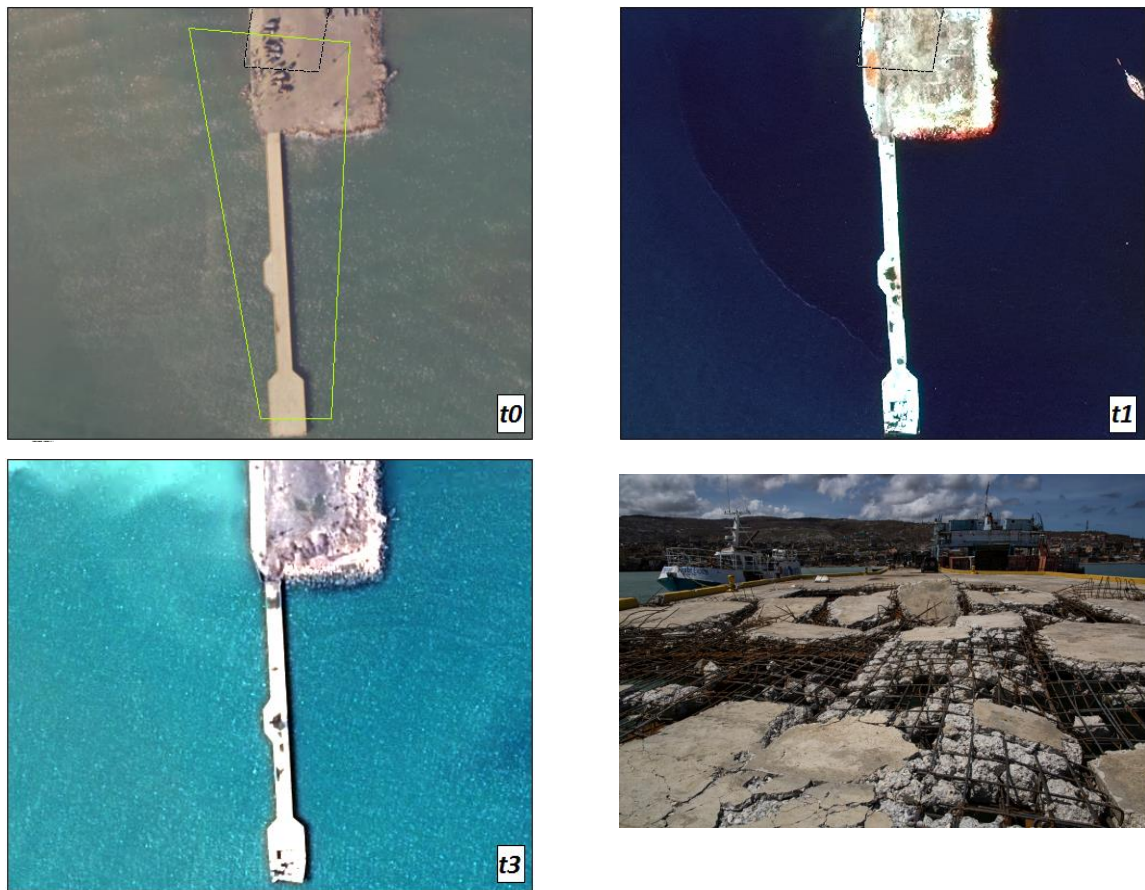


Figure 2-32: Identification of picture 9#¹⁸

This is the last picture of MINUSTAH that could be recognized on the ground of EMSN-050 AOIs. The pier at Jérémie port is clearly damaged on satellite imagery of t_1 and t_3 , and the picture from the ground just confirms this status.

¹⁸ <https://www.flickr.com/photos/minustah/30252476876/in/album-72157673950984970/>

- **Other example for AOI 02 Les Cayes**

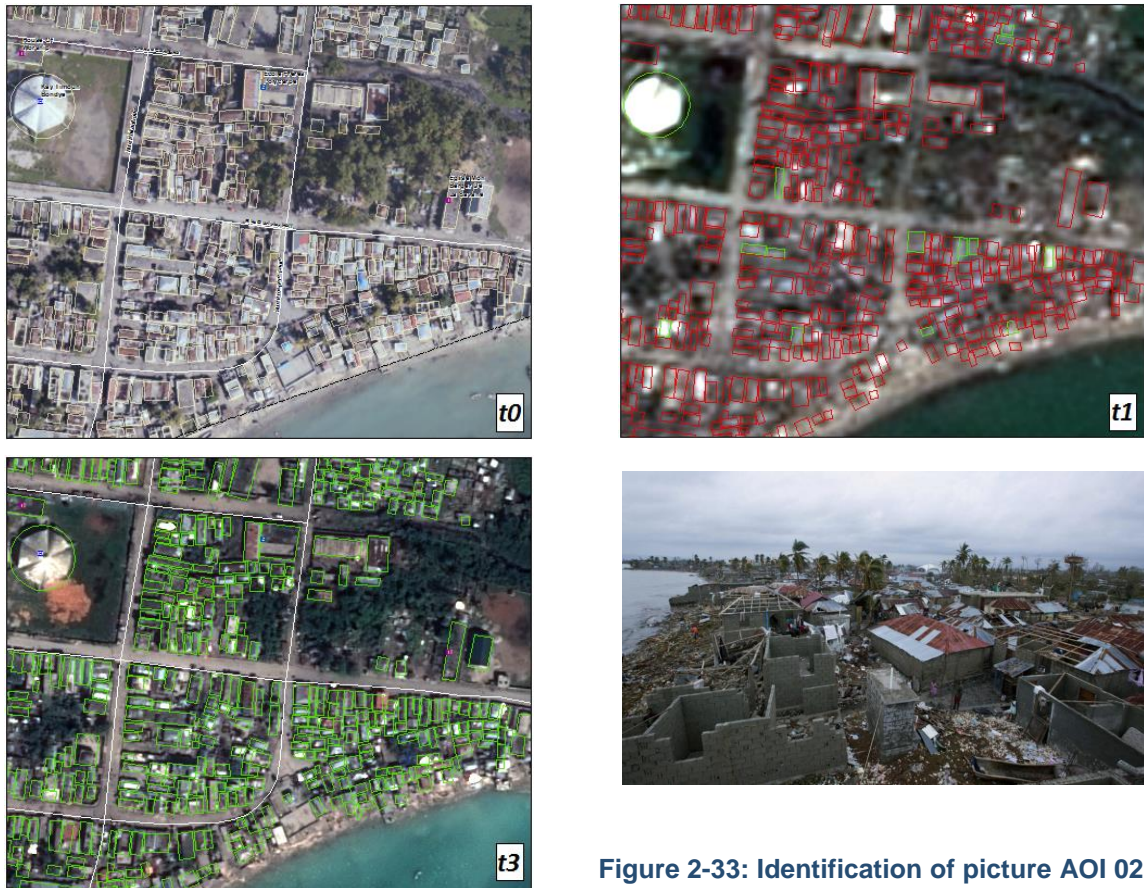


Figure 2-33: Identification of picture AOI 02¹⁹

This image from APTOPIX was taken a few days after the event (exact date unknown). It shows a very dense populated area in the eastern part of the City of Les Cayes, located on the coastline and seen from South to North. At the back of the picture it is visible a white “dome”, it is the Kay Timoun Bondye medical facility, which roof look fully functional.

The roofs of many of the masonry built buildings are removed or damaged, much debris and household furniture lies on the streets and areas in between the buildings. First reconstructions for shelter against rain have made.

Satellite imagery from t_1 was taken on 08/10/2016, just four days afterwards. The images appear to show massive destruction, but this is partially due to the image quality, the urban density and debris. Due to damages on the roofs of most buildings, nearly all buildings are mapped as damaged. Just few buildings are not damaged.

In satellite image from t_3 , most buildings have been reconstructed; the building footprints of many look alike as in the reference imagery of 2014.

¹⁹ <https://www.bz-berlin.de/media/aptopix-haiti-hurricane-matthew>

2.2.4 Analysis of results

As a result of the tasks performed in EMSN-050, a total of 115,724 buildings footprints were collected in the BuildA Feature Class. Each record has three attribution fields with status in every of the three time stages. In order to make things simple, the same Feature Class was used for the three time stages, storing a building feature that has been observed in any of the three time stages. Combination of status codes in the three stages gives the damages (Status_ t_0 vs. Status_ t_1) and the recovery (Status_ t_1 vs. Status_ t_3). It has happened that in t_1 and t_3 there were observed more buildings that there were present in t_0 . They were also collected and coded as “additional” buildings (with code 5), when referring to the baseline conditions= t_0 = pre-event.

The following table shows the geographical distribution of the collected buildings by administrative unit commune and sub-commune:

| Administrative unit | Number of buildings | Administrative unit | Number of buildings |
|----------------------|---------------------|---------------------|---------------------|
| Abricots | 527 | Arniquet | 847 |
| Anse du Clerc | 527 | Arniquet | 847 |
| Bonbon | 3,316 | Camp Perrin | 3,954 |
| Désormeau | 3,316 | Lévy Mersan | 3,744 |
| Jérémie | 41,201 | Tibi Davezac | 210 |
| Basse Guinaudée | 2,959 | Chantal | 3,953 |
| Basse Voldrogue | 2,521 | Fonds Palmiste | 2,055 |
| Fonds Rouge Dahere | 6,874 | Melonière | 1,898 |
| Fonds Rouge Torberck | 6,924 | Les Cayes | 37,004 |
| Haute Guinaudée | 3,880 | Bourdet | 24,879 |
| Haute Voldrogue | 3,764 | Fonfrède | 4,098 |
| Iles Blanches | 3,073 | Laborde | 3,167 |
| Marfranc | 6,601 | Laurent | 1,680 |
| Ravine à Charles | 4,605 | Mercy | 3,180 |
| Moron | 5,455 | Maniche | 16 |
| Anotte | 2,602 | Maniche | 16 |
| Sources Chaudes | 2,853 | Port-Salut | 2,115 |
| Roseaux | 604 | Anse à Drick | 1,344 |
| Fonds Cochon | 35 | Barbois | 478 |
| Grand Vincent | 533 | Lazarre | 293 |
| Les Gomiers | 36 | Torbeck | 16,732 |
| Grand'Anse | 51,103 | Bérreault | 5,685 |
| | | Bourry | 6,552 |
| | | Moreau | 961 |
| | | Solon | 3,534 |
| | | Les Cayes | 64,621 |

Table 2-5: Buildings distribution by administrative unit

2.2.4.1 Results at every time stage (t_0 , t_1 , t_3)

Looking at the results with more depth, the next three tables show the building status for each time each stage, providing a general understanding of the evolution of the buildings between t_0 and t_3 .

As seen in following t_0 table, **before Mathew the 96-97% of the buildings in both AOIs appeared to be functional.** Not functional buildings represented a small share of the total (3-4%), and included not only destroyed buildings, but also under construction ones.

| STATUS t_0 | AOI_01 Jérémie | AOI_02 Les Cayes | Total general | AOI_01 % | AOI_02 % | Total % |
|----------------------|----------------|------------------|----------------|-------------|-------------|-------------|
| 1-Fully Functional | 41,160 | 56,686 | 97,846 | 97% | 96% | 97% |
| 2-Not functional | 1,196 | 2,165 | 3,361 | 3% | 4% | 3% |
| Total general | 42,356 | 58,851 | 101,207 | 100% | 100% | 100% |

Table 2-6: Number of buildings by status in t_0 by AOI

Now focusing in the next time stage, the situation took a sharp turn and, **in t_1 (right after Matthew) the 93-94% of the buildings in both AOIs presented evidences of damages** looked from above, such blown away and destroyed roofs. Only a 5-7% presented no visible damages far from presence of water on top of plain concrete roofed houses.

| STATUS t_1 | AOI_01 Jérémie | AOI_02 Les Cayes | Total general | AOI_01 % | AOI_02 % | Total % |
|----------------------|----------------|------------------|----------------|-------------|-------------|-------------|
| 1-Not visible damage | 2,184 | 4,282 | 6,466 | 5% | 7% | 6% |
| 2-Damage | 41,233 | 55,496 | 96,729 | 94% | 92% | 93% |
| 9-Unknown | 671 | 307 | 978 | 2% | 1% | 1% |
| Total general | 44,088 | 60,085 | 104,173 | 100% | 100% | 100% |

Table 2-7: Number of buildings by status in t_1 by AOI

There are two main explanations to these figures: the devastating force of Matthew Cyclone winds and the precarious constructions of the majority of the buildings in both AOIs, whose roofs are made of metal and wood planks, thatch, straw, or even palm leaves.

Only the houses made of concrete roof built within the cities and surrounding appear mainly functional in t_1 imagery.

Please note that a small amount of buildings could not be checked due to the presence of clouds in the post-event imagery t_1 , all were coded 9-Unknown. Additional comment was added in order to highlight this limitation.

The next pictures show some examples of type of buildings in Haiti.



House with *clissage*²⁰ walls and plain roof probably wooden boards or tin planks²¹



House with earthen walls and palm leaves double gable roof²²



House with walls and palm leaves double gable roof²³



Slum house made of pieces of tin planks²⁴



Wooden house with traditional gabled roof²⁵



Wattle and daub house with gabled roof and front porche²⁶

Figure 2-34: some examples of type of houses in Haiti

²⁰ Wooden structure filled with stone and bound together with a mix of lime and earth

²¹ https://www.doubleharvest.org/index.php/where_we_work/haiti/housing/

²² https://www.doubleharvest.org/index.php/where_we_work/haiti/housing/

²³ <https://www.pinterest.co.uk/pin/529665606147302334/>

²⁴ <https://www.gettyimages.es/detail/fotograf%C3%ADa-de-noticias/woman-sweeping-in-front-of-her-home-in-wharf-fotograf%C3%ADa-de-noticias/595066558#woman-sweeping-in-front-of-her-home-in-wharf-jeremie-a-slum-that-is-picture-id595066558>

²⁵ <http://journals.sagepub.com/doi/pdf/10.1177/0956247811418736>

²⁶ <http://journals.sagepub.com/doi/pdf/10.1177/0956247811418736>

In the last time stage, approximately **one year after Mathew**, reconstruction activities are **evident in the satellite imagery**.

The two AOIs combined present a 67% of the buildings with evidences of recovery, being AOI 02 Les Cayes in better shape than AOI 01 Jérémie with 74% of fully functional buildings, while Jérémie is only 58% yet.

There was also observed a remarkable number of buildings that were present in previous time stages that were cleared in t_3 , the majority of them are destroyed buildings in t_1 whose debris are not present anymore in t_3 . In AOI 01 Jérémie there were observed 11,301, while in AOI 02 Les Cayes there were only 4,289.

New constructions are also a figure worth to be highlighted in this time stage, being AOI 01 Jérémie before AOI 02 Les Cayes in number with 7,015 new buildings constructed compared to the 4,536 of the second.

Again in t_3 there was a small amount of buildings that could not be checked due to the lack of imagery (there is a small part of the AOI 02 Les Cayes not covered with t_3 image at the eastern part), they were all coded 9-Unknown. Additional comment was added in order to highlight this limitation.

| STATUS t_3 | AOI_01 Jérémie | AOI_02 Les Cayes | Total general | AOI_01 % | AOI_02 % | Total % |
|----------------------|----------------|------------------|----------------|-------------|-------------|-------------|
| 1-Not visible damage | 29,843 | 48,046 | 77,889 | 58% | 74% | 67% |
| 2-Damaged | 2,944 | 7,442 | 10,386 | 6% | 12% | 9% |
| 3-Cleared | 11,301 | 4,289 | 15,590 | 22% | 7% | 13% |
| 4-New building | 7,015 | 4,536 | 11,551 | 14% | 7% | 10% |
| 9-Unknown | 0 | 308 | 308 | 0% | 0% | 0% |
| Total general | 51,103 | 64,621 | 115,724 | 100% | 100% | 100% |

Table 2-8: Number of buildings by status in t_3 by AOI

Regardless of the status categorized in the three time stages, it is **remarkable the growth of the total number of buildings in approximately 15,000 new constructions** since t_0 . This increase is more noticeable in AOI 01 Jérémie, where there were 42,366 buildings in t_0 and 51,521 in t_3 , being an increase of more than 9,100 buildings in approximately four years; while in AOI 02 Les Cayes the number of houses do not reach 6,000.

| | AOI_01 Jérémie | AOI_02 Les Cayes | Total general |
|-----------------|----------------|------------------|---------------|
| t_0 | 42,356 | 58,851 | 101,207 |
| t_3 | 51,103 | 64,621 | 115,724 |
| Increase | 8,747 | 5,770 | 14,517 |

Table 2-9: Increase in number of buildings $t_0 - t_3$

2.2.4.2 Evolution of the status of buildings ($t_0 > t_1 > t_3$)

The evolution of the status of buildings provides the information about the reconstruction status. The evolution was monitored by concatenation the three status codes at the three time stages: Status_ t_0 , Status_ t_1 and Status_ t_3 . The possible combination of codes in the three-time stages was analysed and interpreted their meaning.

For the sake of convenience and after analysing the evolution in the status, some of these results were grouped in order to give the **more relevant conclusions about the reconstruction status**.








| Colour | Reconstruction Class | Interpretation |
|---|-------------------------------|---|
|  | Unchanged functional | Buildings resistant to Mathew |
|  | Unchanged not functional | Not functional buildings in the three time stages observed |
|  | Damaged and rebuilt | Evidences of damages after Mathew and evidences of reconstruction after one year |
|  | Damaged and still not rebuilt | Evidences of damages after Mathew and no evidences of reconstruction |
|  | Damaged and removed | Buildings that were damaged by Mathew, or where not functional before and in the end there were cleared away |
|  | New building in t_3 | New construction observed in t_3 |
|  | Abandoned | Functional buildings with no evidences of damages after Mathew that in t_3 present appearance of being not functional (no roof) |

Table 2-10: Summary of classes

Please, in order to understand the ungrouped codes and meaning, remember:

- The t_0 image is almost two years before Mathew
- The t_1 image is right after cyclone
- The t_3 image is approximately one year after the event

This must be highlighted because there are uncertainties corresponding to what could have happen between t_0 image and right before Mathew hit Haiti.

In the next table, the ungrouped codes and meanings with nuances are shown. The next clarification serves as example to be applied to the rest of classes.

Unchanged functional class refers to three codes: '111' are fully functional buildings in t_0 , t_1 , and t_3 , while '211' refers to a not fully functional in t_0 , that look functional in t_1 and t_3 . Probably, during the time between t_0 and t_1 , the building was improved in its construction, making it a fully functional building right before the cyclone (but this could not be checked due to lack of near pre-event imagery). Right after Mathew it looked functional, and so one year afterwards. Probably, this is an unchanged functional building. The same happens with '511', the number five in the first position refers to a not observed building in t_0 that was found functional in t_1 , and also in t_3 . Probably, during the time between t_0 and t_1 , the building was completely constructed.

In terms of understanding the reconstruction classes, these three classes represent the same: buildings of a good construction that were resistant to cyclone Mathew.

The next table shows the possible combinations of codes, their meaning and the aggrupation of them into Reconstruction classes.

| Code | Reconstruction Class | Comments | Additional comments |
|------|-------------------------------|---|-------------------------------|
| 111 | Unchanged functional | Unchanged functional, fully functional buildings in t_0 , t_1 , and t_3 | N/A |
| 211 | Unchanged functional | Unchanged functional, fully functional buildings from t_1 | N/A |
| 511 | Unchanged functional | Unchanged functional, not present in t_0 | Building not present in t_0 |
| 222 | Unchanged not functional | Unchanged not functional | N/A |
| 522 | Unchanged not functional | Unchanged not functional, not present in t_0 | Building not present in t_0 |
| 121 | Damaged and rebuilt | Damage and rebuilt, when the reconstruction work has been completed | N/A |
| 221 | Damaged and rebuilt | Damage and rebuilt, when the reconstruction work has been completed (damaged in t_0) | N/A |
| 521 | Damaged and rebuilt | Damage and rebuilt, when the reconstruction work has been completed, not present in t_0 | Building not present in t_0 |
| 122 | Damaged and still not rebuilt | Damaged and still not rebuilt, visible damage in t_1 but still not functional in t_3 (possible ongoing rebuilt) | N/A |
| 123 | Damaged and removed | Removed, cleared at t_3 , but there existed a building at t_0 or t_1 | N/A |
| 523 | Damaged and removed | Removed, cleared at t_3 , but there existed a building at t_1 , not present in t_0 | Building not present in t_0 |
| 223 | Removed | Not functional building in t_0 and t_1 and finally removed in t_3 | N/A |
| 554 | New building in t_3 | New structure visible in t_3 , not present in t_0 or t_1 | Building not present in t_0 |
| 112 | Abandoned | Building without maintenance and not functional in t_3 | N/A |

Table 2-11: Selected most representing reconstruction classes

Additionally there are buildings whose evolution could not be checked due to lack of imagery to check whether the damage (Status_ t_1) or the reconstruction (Status_ t_3), due to presence of clouds in t_1 (code 9 in second position of Reconstruction code) or due to lack of imagery in a small sliver in the eastern part of AOI 02 in t_3 time stage (code 9 in third position of Reconstruction code).

The possible combination of codes is shown in the next table, separated from the most meaningful classes, in the aforementioned one.

| Code | Class | Comments | Additional comments |
|------|-------------------------------|---|---|
| 191 | Unknown damage | Unknown damage (possibly rebuilt) | Buildings affected by clouds in t_1 image |
| 192 | Unknown damage | Unknown damage (possibly not rebuilt) | |
| 193 | Unknown damage | Unknown damage (possibly damage and removed) | |
| 291 | Unknown damage | Unknown damage (possibly rebuilt or unchanged functional from t_1) | |
| 292 | Unknown damage | Unknown damage (possibly unchanged not functional) | |
| 293 | Unknown damage | Unknown damage (possibly removed) | |
| 119 | Unknown reconstruction status | Not damaged but unknown reconstruction status (possibly unchanged functional) | AOI 02 Les Cayes, buildings with no t_3 image to check reconstruction |
| 129 | Unknown reconstruction status | Damaged but unknown reconstruction status | |
| 229 | Unknown reconstruction status | Damaged but unknown reconstruction status (possibly unchanged not functional) | |

Table 2-12: Evolution of status in the three time stages – damage or reconstruction not confirmed

The possible combination of codes is shown in the next table, separated from the most meaningful classes, in the aforementioned one.

| Class | Code | AOI_01 Jérémie | AOI_02 Les Cayes | Total general | AOI_01 Jérémie | AOI_02 Les Cayes | Total general |
|--------------------------------------|--------|-------------------|---------------------|------------------|-------------------|---------------------|------------------|
| Unchanged functional | | 2,179 | 4,253 | 6,432 | 4% | 7% | 6% |
| | 1,835 | 3,942 | 5,777 | 4% | 6% | 5% | 5% |
| | 139 | 108 | 247 | 0% | 0% | 0% | 0% |
| | 205 | 203 | 408 | 0% | 0% | 0% | 0% |
| Unchanged not functional | | 544 | 926 | 1,470 | 1% | 1% | 1% |
| | 376 | 655 | 1,031 | 1% | 1% | 1% | 1% |
| | 168 | 271 | 439 | 0% | 0% | 0% | 0% |
| Damaged and rebuilt | | 27,267 | 43,633 | 70,900 | 53% | 68% | 61% |
| | 25,877 | 41,600 | 67,477 | 51% | 64% | 58% | 58% |
| | 400 | 1,293 | 1,693 | 1% | 2% | 1% | 1% |
| | 990 | 740 | 1,730 | 2% | 1% | 1% | 2% |
| Damaged and still not rebuilt | | 2,345 | 6,416 | 8,761 | 5% | 10% | 8% |
| | 2,345 | 6,416 | 8,761 | 5% | 10% | 8% | 8% |
| Damaged and removed | | 11,077 | 4,240 | 15,317 | 22% | 7% | 13% |
| | 10,431 | 4,126 | 14,557 | 20% | 6% | 13% | 12% |
| | 369 | 20 | 389 | 1% | 0% | 0% | 0% |
| | 277 | 94 | 371 | 1% | 0% | 0% | 0% |
| New building in t3 | | 7,015 | 4,536 | 11,551 | 14% | 7% | 10% |
| | 7,015 | 4,536 | 11,551 | 14% | 7% | 10% | 10% |
| Abandoned | | 5 | 2 | 7 | 0% | 0% | 0% |
| | 5 | 2 | 7 | 0% | 0% | 0% | 0% |
| Unknown damage | | 671 | 307 | 978 | 1% | 0% | 1% |
| | 395 | 157 | 552 | 1% | 0% | 0% | 0% |
| | 49 | 97 | 146 | 0% | 0% | 0% | 0% |
| | 223 | 47 | 270 | 0% | 0% | 0% | 0% |
| | 2 | 3 | 5 | 0% | 0% | 0% | 0% |
| | 1 | 1 | 2 | 0% | 0% | 0% | 0% |
| | 1 | 2 | 3 | 0% | 0% | 0% | 0% |
| Unknown reconstruction status | | 0 | 308 | 308 | 0% | 0% | 0% |
| | 0 | 27 | 27 | 0% | 0% | 0% | 0% |
| | 0 | 272 | 272 | 0% | 0% | 0% | 0% |
| | 0 | 9 | 9 | 0% | 0% | 0% | 0% |
| Total general | | 51,103 | 64,621 | 115,724 | 100% | 100% | 100% |

Table 2-13: Summary of buildings by reconstruction class and AOI

Twenty three combinations of status of building codes were grouped in **seven selected most representing classes representing the current (end 2017-beginning 2018) reconstruction status of buildings**. Selected classes, ordered by importance, are:

- **Damaged and rebuilt.** In the 61% of the buildings there were observed evidences of damages after Mathew and evidences of reconstruction after one year correspond to this class (53% in AOI 01 Jérémie and a 68% in AOI 02 Les Cayes)..
- **Damaged and removed.** After the hit of Mathew some buildings were not reconstructed in the same place, but cleared away leaving no debris behind. They sum up to 13% of the total (22% in AOI 01 Jérémie and a 7% in AOI 02 Les Cayes).
- **New buildings in t₃.** There were also observed a significant amount of new buildings in both AOIs, representing a 10% in total (14% in AOI 01 Jérémie and a 7% in AOI 02 Les Cayes).
- **Damaged and still not rebuilt.** There is still a total of 8% of the buildings pending to be reconstructed (5% in AOI 01 Jérémie and a 10% in AOI 02 Les Cayes).
- **Unchanged functional.** They are usually well constructed buildings with solid foundations and usually concrete plain roofed represent a total of 6% (4% in AOI 01 Jérémie and a 7% in AOI 02 Les Cayes).
- **Unchanged not functional,** they are a marginal number of buildings whose observed status is not functional in the three stages; represent a 1% in AOI 01 Jérémie and AOI 02 Les Cayes.
- Abandoned, unknown damage and unknown reconstruction status are marginal results that represent less than the 1% of the results.

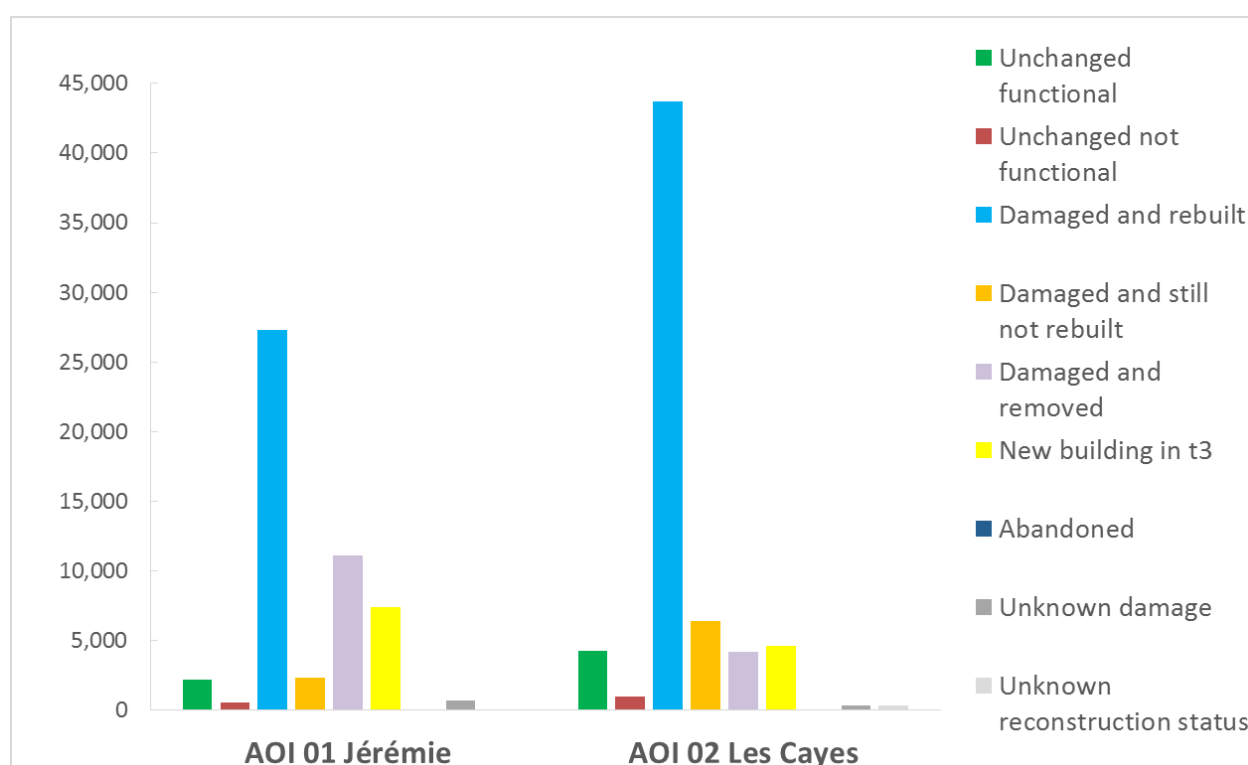


Figure 2-35: Buildings by reconstruction class and AOI

2.2.4.3 Conclusions

The results of the current activation can be read in very different ways, grouped with different point of views and disaggregated by using different overlaying layers.

Nevertheless, an effort was performed to provide meaningful conclusions. The aggregated figures could drive to the following main conclusions (although they are not the only ones):

1. **There has been an important reconstruction effort in the first year after Matthew, with a total of 61% of buildings recovered up to the beginning of 2018.**
2. **But there is still an 8% pending of recovery activities.**
3. **The buildings that are not subject to cyclones in both AOIs do not even reach the 6% of the total.**

The last figure worth to highlight (already commented before in Table 2-9) is the **remarkable number of additional buildings in t_3 with respect to pre-event conditions representing an additional 10% of the total buildings in t_3 .**

3. QUALITY CONTROL

This chapter is dedicated to the description of the quality control results carried out for the products of this activation.

The Quality Control is focused on the **thematic and geometric accuracy** of the identification and monitoring of IDP camps and interpreted damages and subsequent recovery classification.

A search for media sources to help in the location of affected areas was done, with not enough results to serve in validation. It was also difficult to cross-check the interpreted damages.

Notwithstanding, the thematic accuracy was assessed by an expert photo-interpreter using the best cartographic judgement.

Due to the lack of additional imagery sources or other ground truth data, it had to be performed with the same imagery used at every time stage of the activation.

3.1 QUALITY CONTROL OF IDENTIFICATION AND MONITORING OF IDP CAMPS (T1, T2, T3)

Thematic accuracy focused on the distinction between IDP dwellings and regular new buildings, which was difficult to make in this study area. New dwellings were considered putative IDP dwellings only if they were:

- new (not present in t0 imagery)
- clustered in groups or adjacent to previous potential informal settlements
- oriented in an irregular pattern
- located at spots not ideal for settlement, for example beaches, swamps

This definition leaves room for interpretation. To counter this, the potential IDP dwellings were first mapped (manually) in a sequential order ($t_1 \rightarrow t_2 \rightarrow t_3$), and all potential IDP dwellings were included, even when the visual evidence was less compelling. Then, in a final step, all results were checked in light of all time steps by a different operator, and all non-compelling putative IDP dwellings were re-labeled as regular new buildings.

The quantitative accuracy of the correctness of the mapping of IDP settlements was performed by an operator not previously involved in this project. The following methodology was employed. First, the entire area of the AOIs was divided into cells of 100 m by 100 m. Then, all of these cells that overlapped at least one structure mapped as IDP dwelling were selected. From these cells, a random selection of 10% of the cells was chosen, and all IDP structures were mapped within them. Finally, the user's and producer's accuracy were calculated by comparing these results with the original IDP dwellings.

The adopted accuracy assessment procedure assumes that IDP dwellings might have been missed close to structures already mapped as IDP dwellings. The general difficulty of discerning between IDP dwellings and regular newly constructed buildings has already been discussed above, and is also reflected by the low producer's accuracy in the case of AOI2 t_3 , where some dwellings are ambiguous.

The results presented in the next pages show the thematic **overall accuracy of 90%** in most of the cases, except in AOI 02- t_3 , where 69% of producer accuracy was reported. The quality of the image available at this time made challenging the identification of IDP's dwellings and its differentiation from damaged houses, producing an error of omission of 30.5%.

The results of the cross validation of the **geometric accuracy** reveal the balance between the geometric commission and the omission of error, translating it into **a global accuracy of more than 80%**.

AOI 01

Thematic

| | |
|---------------------------------|-------------|
| AOI 01 t₁ | |
| IDP dwellings correctly mapped: | 21 |
| IDP dwellings missed: | 2 |
| False positives: | 0 |
| User's accuracy: | 100% |
| Producer's accuracy: | 91% |

| | |
|---------------------------------|-------------|
| AOI 01 t₂ | |
| IDP dwellings correctly mapped: | 13 |
| IDP dwellings missed: | 0 |
| False positives: | 0 |
| User's accuracy: | 100% |
| Producer's accuracy: | 100% |

| | |
|---------------------------------|-------------|
| AOI 01 t₃ | |
| IDP dwellings correctly mapped: | 78 |
| IDP dwellings missed: | 5 |
| False positives: | 0 |
| User's accuracy: | 100% |
| Producer's accuracy: | 94% |

Geometric (area assessment)

| Error type | Area (m ²) | % |
|---------------------------------|------------------------|--------------|
| Commission | 51 | 15.2 % |
| Agreement | 194 | 57.7 % |
| Omission | 90 | 26.8 % |
| Total general | 336 | 100 % |
| Deviation (Commission-Omission) | 39 | 11.6% |
| Accuracy | | 88.4% |

| Error type | Area (m ²) | % |
|---------------------------------|------------------------|--------------|
| Commission | 104 | 17.2 % |
| Agreement | 330 | 54.4 % |
| Omission | 172 | 28.4 % |
| Total general | 606 | 100 % |
| Deviation (Commission-Omission) | 68 | 11.2% |
| Accuracy | | 88.8% |

| Error type | Area (m ²) | % |
|---------------------------------|------------------------|--------------|
| Commission | 326 | 15.6 % |
| Agreement | 1286 | 61.4 % |
| Omission | 482 | 23.0 % |
| Total general | 2094 | 100 % |
| Deviation (Commission-Omission) | 156 | 7.4% |
| Accuracy | | 92.6% |

Table 3-1: Summary of IDP QC results in AOI 01 Jeremie

AOI 02

Thematic

| AOI 02 t ₁ | |
|---------------------------------|-------------|
| IDP dwellings correctly mapped: | 5 |
| IDP dwellings missed: | 0 |
| False positives: | 0 |
| User's accuracy: | 100% |
| Producer's accuracy: | 100% |

Geometric (area assessment)

| Error type | Area (m ²) | % |
|---------------------------------|------------------------|--------------|
| Commission | 98 | 31.9 % |
| Agreement | 161 | 52.5 % |
| Omission | 48 | 15.6 % |
| Total general | 307 | 100 % |
| Deviation (Commission-Omission) | 50 | 20.6% |
| Accuracy | | 79.4% |

| AOI 02 t ₂ | |
|---------------------------------|------------|
| IDP dwellings correctly mapped: | 14 |
| IDP dwellings missed: | 1 |
| False positives: | 1 |
| User's accuracy: | 93% |
| Producer's accuracy: | 93% |

| Error type | Area (m ²) | % |
|---------------------------------|------------------------|--------------|
| Commission | 60 | 14.4 % |
| Agreement | 272 | 65.6 % |
| Omission | 83 | 20.0 % |
| Total general | 415 | 100 % |
| Deviation (Commission-Omission) | 23 | 5.6% |
| Accuracy | | 94.4% |

| AOI 02 t ₃ | |
|---------------------------------|-------------|
| IDP dwellings correctly mapped: | 9 |
| IDP dwellings missed: | 4 |
| False positives: | 0 |
| User's accuracy: | 100% |
| Producer's accuracy: | 69% |

| Error type | Area (m ²) | % |
|---------------------------------|------------------------|--------------|
| Commission | 59 | 12.8 % |
| Agreement | 261 | 56.7% |
| Omission | 140 | 30.5 % |
| Total general | 460 | 100 % |
| Deviation (Commission-Omission) | 71 | 17.7% |
| Accuracy | | 82.3% |

Table 3-2: Summary of IDP QC results in AOI 01 Jeremie

3.2 QUALITY CONTROL OF BUILDING RECOVERY STATUS

The 6% of the extent of the AOI was randomly selected using a grid routine that selects a percent of choice from an already created grid.

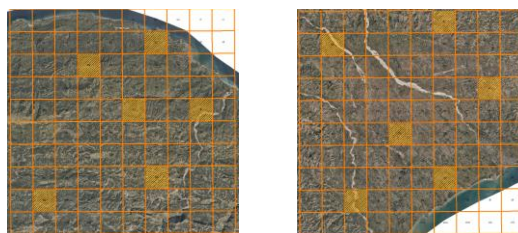


Figure 3-1: Quality control sample areas in AOI 01 and 02

To assess the **quality control on object delineation**, the approach followed was a cross validation re-digitalizing buildings by replicating the production environment using the pre-event ortho-image.

An external QC technician was provided with the sampling grid, where 120 samples were collected. This number complies with ISO 19157, where in *table F.4 – Statistical numbers for testing standard deviation 95% significance level*, it is stated that for a population size between 35,000 and 150,000 a total of 150 samples is enough. As there are approx. 115,700 building footprints recorded, 120 samples were considered sufficient for this QC.

Spatial overlay was done between QC files and original building footprints, obtaining the areas coincident (Agreement), the areas that were digitized in first photointerpretation and not in QC (Commission) and the areas that have been photo interpreted in QC and there were not collected before (omission).

Below, there are some examples of quality control files, where first delineation was compared against new quality control delineation.



Figure 3-2: QC files on object delineation

The table with the summary of the results is:

| | AOI 01 | | AOI 02 | |
|---------------------------------|------------------------|--------|------------------------|--------|
| Error type | Area (m ²) | % | Area (m ²) | % |
| Agreement | 5580.37 | 81.91% | 6650.79 | 72.68% |
| Commission | 603.38 | 8.86% | 1116.21 | 12.20% |
| Omission | 628.78 | 9.23% | 1383.73 | 15.12% |
| Total general | 6812.53 | 100% | 9150.74 | 100% |
| Deviation (Commission-Omission) | -25.41 | 0.37% | -267.52 | 2.92% |
| Accuracy | | 99.63% | | 92.60% |

The results of the cross validation reveal the deviation is a negative number, which implies a small amount of geometric area under collection, however the balance between the geometric commission and omission error is translated into a **global accuracy of 99% in AOI 01 and 93% in AOI 02**.

For more details see Annex C.

Regarding to the **thematic accuracy**, the external QC technician assessed the classification of building status and recovery by checking all the buildings coincident in the 6% of the AOI (coincident with sampling grid). A total of 5,621 buildings reconstruction status, out of a total of more than 115,000, were assessed.

The results of the thematic quality control for the building features are summarized in the tables below:

| AOI | 01 | Interpreted | | | | | | | | Total | Omissions |
|----------------|-------------------------------------|------------------------------|----------------------------------|-----------------------------|--|----------------------------------|----------------------------|----------------|-----------|--------------|-----------|
| Total sample d | 2,805 | Unchan- ged functional | Unchan- ged not functional | Damag- ed and rebuilt | Damag- ed and still not rebuilt | Damag- ed and remov- ed | New buildin- g in t3 | Aband- oned | Unk- . | - | - |
| QC | Unchanged functional | 107 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 109 | 0 |
| | Unchanged not functional | | 63 | 0 | 2 | 0 | 0 | 0 | 0 | 65 | 0 |
| | Damaged and rebuilt | 1 | | 1,420 | 1 | 2 | 2 | 0 | 0 | 1,426 | 2 |
| | Damaged and still not rebuilt | 0 | 1 | 2 | 82 | 0 | 0 | 0 | 0 | 85 | 0 |
| | Damaged and removed | 0 | 0 | 79 | 0 | 535 | 0 | 0 | 0 | 614 | 1 |
| | New building in t3 | 0 | 0 | 0 | 0 | 0 | 473 | 0 | 0 | 473 | 5 |
| | Abandoned | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| | Unk. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 32 | 0 |
| | Valid samples | 108 | 65 | 1,502 | 85 | 537 | 475 | 1 | 32 | 2,805 | 8 |

| | |
|----------------------------------|---------|
| Commission error of damage class | 3,28 % |
| Users accuracy | 96,72 % |
| Omission error of damage class | 0,29 % |
| Producers accuracy | 99,71 % |
| Observed agreement | 2713 |
| Expected agreement | 969,87 |
| Kappa | 94,99 % |

Table 3-3: Summary of building recovery status QC results in AOI 01 Jeremie

| AOI | 02 | Interpreted | | | | | | | | Total | Omissions |
|---------------|-------------------------------|----------------------|--------------------------|---------------------|-------------------------------|---------------------|--------------------|-----------|-----|-------|-----------|
| Total sampled | 2,816 | Unchanged functional | Unchanged not functional | Damaged and rebuilt | Damaged and still not rebuilt | Damaged and removed | New building in t3 | Abandoned | Unk | - | - |
| QC | Unchanged functional | 93 | 0 | 20 | 2 | 0 | 1 | 0 | 0 | 116 | 0 |
| | Unchanged not functional | 0 | 49 | 2 | 0 | 0 | 1 | 0 | 0 | 52 | 1 |
| | Damaged and rebuilt | 0 | 7 | 1,570 | 47 | 8 | 16 | 0 | 0 | 1,648 | 6 |
| | Damaged and still not rebuilt | 0 | 0 | 4 | 408 | 6 | 2 | 0 | 0 | 420 | 0 |
| | Damaged and removed | 0 | 0 | 0 | 3 | 271 | 0 | 0 | 0 | 274 | 1 |
| | New building in t3 | 0 | 0 | 0 | 0 | 1 | 305 | 0 | 0 | 306 | 15 |
| | Abandoned | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Unkown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Valid samples | 93 | 56 | 1,596 | 460 | 286 | 325 | 0 | 0 | 2,816 | 23 |

| | |
|----------------------------------|---------|
| Commission error of damage class | 4,26 % |
| Users accuracy | 95,74 % |
| Omission error of damage class | 0,82 % |
| Producers accuracy | 99,18 % |
| Observed agreement | 2,696 |
| Expected agreement | 1075,89 |
| Kappa | 93,10 % |

Table 3-4: Summary of building recovery status QC results in AOI 02 Les Cayes

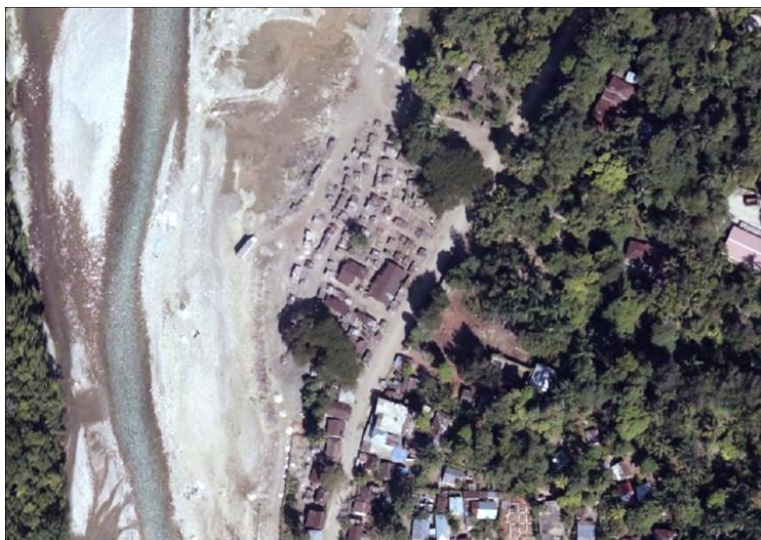


An overall **thematic accuracy better than 80%** for features inside both AOIs has been reached, and in all cases the omission/commission errors is below 5%.




4. ANNEX A

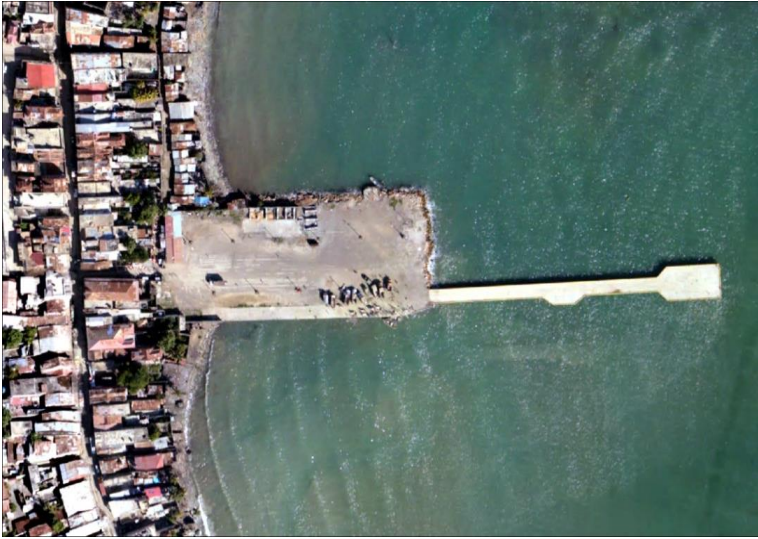
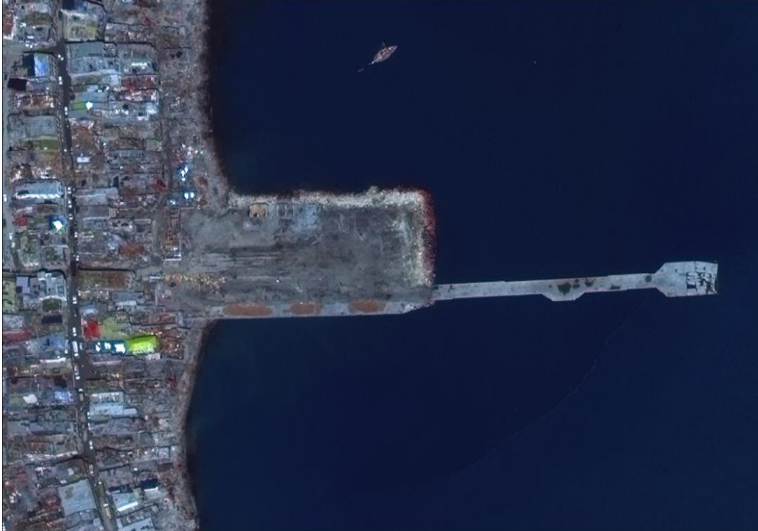

Codes used in every time stage.




| Code | t_0 | t_1 | t_3 |
|------|--------------------------------|------------------------|-------------------------|
| 1 | 1-Fully Functional (pre-event) | 1-Not visible damage | 1-Not visible damage |
| 2 | 2-Not functional (pre-event) | 2-Damage | 2-Damaged |
| 3 | N/A | N/A | 3-Cleared |
| 4 | N/A | N/A | 4-New building in t_3 |
| 5 | 5-Not present in t_0 | 5-Not present in t_1 | N/A |
| 9 | 9-Unknown | 9-Unknown | 9-Unknown |



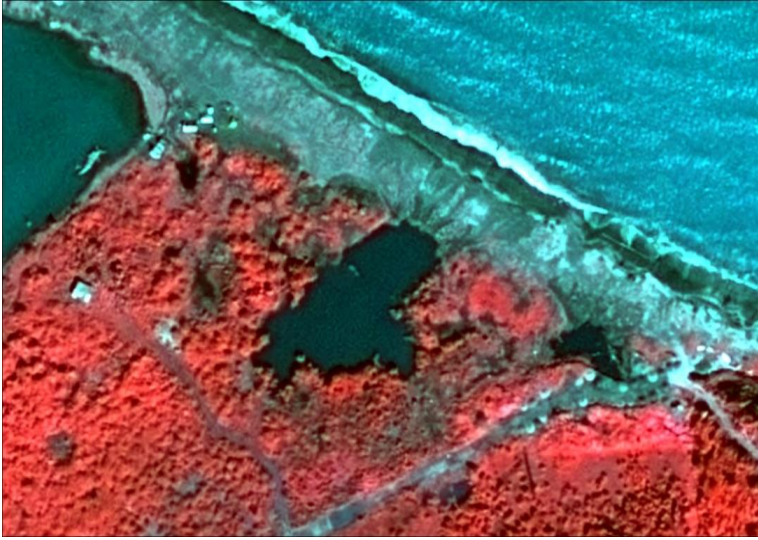
5. ANNEX B




| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | A small concentration of buildings close to the river shoreline is visible in t_0 . In t_1 those buildings were devastated by the hurricane. In t_3 , this building concentration was recovered, with a new distribution and brand new buildings. |
| t_1 |  | |
| t_3 |  | |


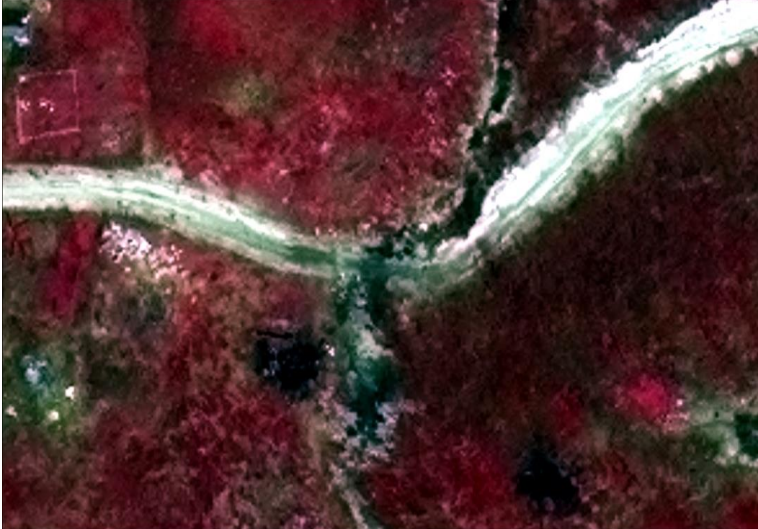

| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>This riverbank observed in t_0 was overflowed by the river flood caused by the hurricane. The riverbank has been turned into an island in t_1. In t_3 the river channel has been modified and the river banks have emerged but the island still isolated.</p> |
| t_3 |  | |




| Time stage | Images | Observations |
|------------|--|--|
| t_0 |  | |
| t_1 |  | The berthing structure observed in t_0 was damaged by the hurricane. The quay was completely damaged in t_1 and it stills damaged in t_3 . |
| t_3 |  | |



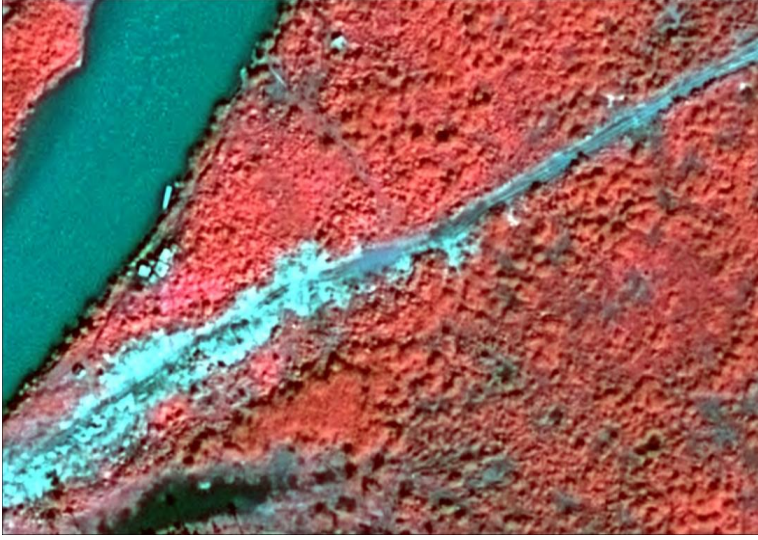
| Time stage | Images | Observations |
|----------------|--|---|
| t ₀ |  | |
| t ₁ |  | <p>The camp located in the river mouth in t₀ was severely damaged by the hurricane in t₁. The river mouth was modified in t₁ and the camp was destroyed. In t₃ the river mouth has been modified again and a new camp has arisen.</p> |
| t ₃ |  | |




| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>The coastal wetland observed in t_0 was delimited by the sand beach. It was overwhelmed by the tidal water in t_1. The sand beach has been recovered in t_3 and the wetland is separate from the sea again.</p> |
| t_3 |  | |




| Time stage | Images | Observations |
|------------|--|--|
| t_0 |  | |
| t_1 |  | The sand bar located in the river mouth in t_0 was completely removed in t_1 after the hurricane. In t_3 the sand bar has been naturally recovered in a different shape and the buildings located have been resettled. |
| t_3 |  | |


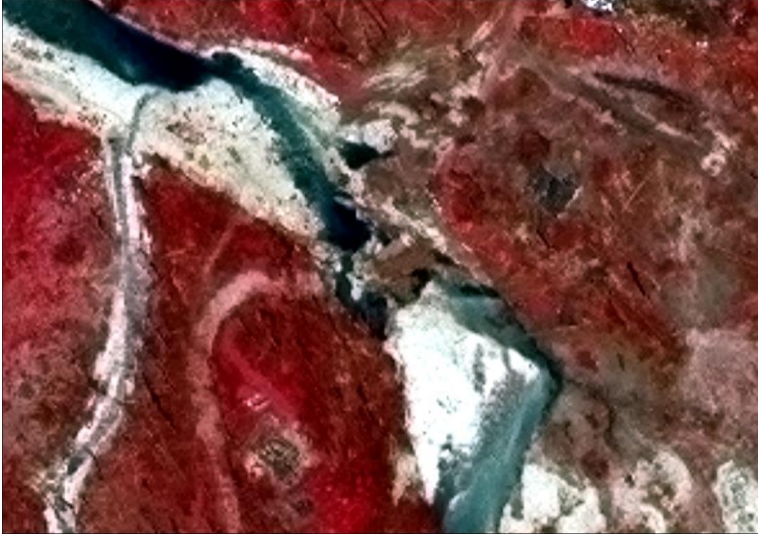
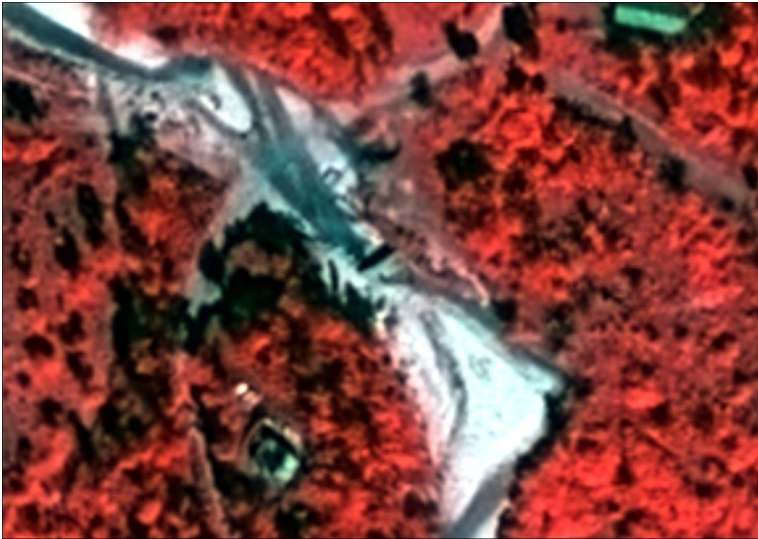
| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>This bridge was removed by the river flood caused by the hurricane in t_1. In t_3 it has been rebuilt.</p> |
| t_3 |  | |

| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>These bridges were affected by the hurricane in t_1. They have been completely cleaned in t_3.</p> |
| t_3 |  | |



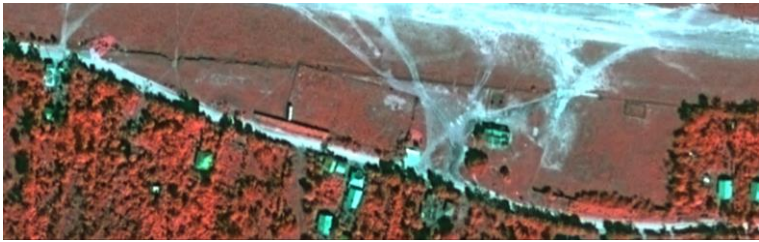
| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>This road was closed by the river flood caused by the hurricane in t_1. It has been partially reopened in t_3 but it still damaged in some points.</p> |
| t_3 |  | |


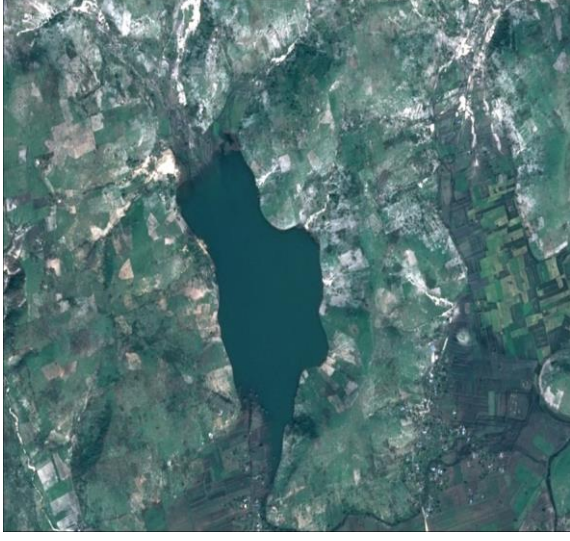

| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>The buildings collapse caused by the hurricane provokes debris barriers along this street in t_1. In t_3 the street is clean and the buildings are mostly rebuilt.</p> |
| t_3 |  | |




| Time stage | Images | Observations |
|----------------|--|--|
| t ₀ |  | |
| t ₁ |  | <p>After the hurricane, the debris was collected along the streets in order to facilitate the access and allow the trafficability. In this case, the debris was storage in the intersection in t₁.</p> <p>In t₃, the streets are completely clean as well as the buildings are mostly rebuilt.</p> |
| t ₃ |  | |


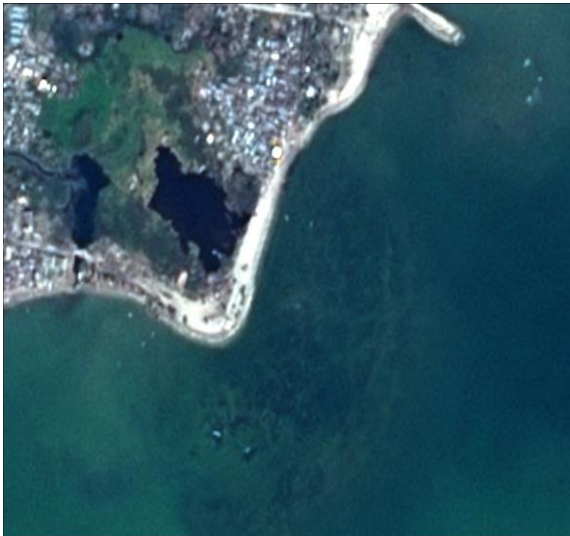

| <i>Time stage</i> | <i>Images</i> | <i>Observations</i> |
|-------------------|--|---|
| t_0 |  | |
| t_1 |  | <p>This bridge was removed by the river flood caused by the hurricane in t_1. In t_3 it has been rebuilt.</p> |
| t_3 |  | |




EMSN-050: Post Mathew Damage Assessment and Monitoring of Recovery Activities in the South Region of Haiti

| <i>Time stage</i> | <i>Images</i> | <i>Observations</i> |
|-------------------|---|--|
| t_0 |  | <p>Humanitarian help detected soon after the event (Jérémie Airport).</p> <p>Such help was not identified after one year of the event.</p> |
| t_1 |  | |
| t_3 |  | |

| Time stage | Images | Observations |
|------------|--|---|
| t_0 |  | |
| t_1 |  | <p>An extensive arable land is shown in t_0 boxed between high elevations, this concave area is flooded in t_1 creating a huge lake while in the previous image there was little presence of water; in t_3 part of the lake has retreated fifty per cent of the t_1 surface, where the north arable fields are visible again.</p> |
| t_3 |  | |

| <i>Time stage</i> | <i>Images</i> | <i>Observations</i> |
|-------------------------|--|--|
| <p>t_0</p> |  | <p>The most observable differences are in the river course and the tree cover; in t_0 there was a prominent wooded area and a little river width, in t_1 the river course is growing his course width maintaining it in t_3 while the forest has empty spaces and in t_3 the trees has occupied again these clear areas.</p> |
| <p>t_1</p> |  | |
| <p>t_3</p> |  | |

| Time stage | Images | Observations |
|---|--|--|
| <p>t_0</p> <p>t_1</p> <p>t_3</p> |    | <p>Focusing in the seafront, in t_0 we can observe the buildings and roads are in use, in t_1 the storm has destroyed the road accesses and part of the seafront corner and their houses; it has been recovered in t_3, specially the left access road and the buildings on them.</p> |

| <i>Time stage</i> | <i>Images</i> | <i>Observations</i> |
|-------------------|--|---|
| t_0 |  | |
| t_1 |  | <p>In the north part of the t_0 image there is only a little water area surface, this portion increase his size in t_1 communicating with the lake at the north and creating a new river course running to the SE, in t_3 it maintains the lake connection in the north but the water line in the SE is disappeared.</p> |
| t_3 |  | |

6. ANNEX C

| A OI | ID_BU | Area (m2) | | | | % | | | Area (m2) | | |
|---------|-------|-----------|------------|----------|--------|---------------|----------------|--------------|--------------------------|------|----------------|
| | | Agreement | Commission | Omission | Total | Agree ment | Commis sion | Omis sion | Photo interpre ted | QC | Diff. PI-QC |
| 1 | 13785 | 247.04 | 62.95 | 21.28 | 331.28 | 75% | 19% | 6% | 0.94 | 0.81 | 0.13 |
| 1 | 13808 | 177.99 | 39.69 | 48.83 | 266.50 | 67% | 15% | 18% | 0.82 | 0.85 | -0.03 |
| 1 | 13964 | 228.45 | | 95.76 | 324.21 | 70% | 0% | 30% | 0.70 | 1.00 | -0.30 |
| 1 | 14160 | 179.37 | 19.78 | 12.04 | 211.20 | 85% | 9% | 6% | 0.94 | 0.91 | 0.04 |
| 1 | 14170 | 161.20 | 29.76 | 13.08 | 204.05 | 79% | 15% | 6% | 0.94 | 0.85 | 0.08 |
| 1 | 14190 | 180.29 | 15.50 | 5.93 | 201.72 | 89% | 8% | 3% | 0.97 | 0.92 | 0.05 |
| 1 | 14204 | 104.30 | 8.30 | 14.99 | 127.59 | 82% | 7% | 12% | 0.88 | 0.93 | -0.05 |
| 1 | 14239 | 134.88 | 3.43 | 25.31 | 163.62 | 82% | 2% | 15% | 0.85 | 0.98 | -0.13 |
| 1 | 14344 | 423.82 | 39.30 | 4.54 | 467.66 | 91% | 8% | 1% | 0.99 | 0.92 | 0.07 |
| 1 | 14345 | 199.17 | 11.09 | 28.63 | 238.88 | 83% | 5% | 12% | 0.88 | 0.95 | -0.07 |
| 1 | 14664 | 132.67 | 1.61 | 9.47 | 143.75 | 92% | 1% | 7% | 0.93 | 0.99 | -0.05 |
| 1 | 14676 | 274.07 | 8.24 | 18.84 | 301.14 | 91% | 3% | 6% | 0.94 | 0.97 | -0.04 |
| 1 | 14697 | 125.27 | 28.10 | 2.98 | 156.35 | 80% | 18% | 2% | 0.98 | 0.82 | 0.16 |
| 1 | 14765 | 53.85 | 4.80 | 4.23 | 62.88 | 86% | 8% | 7% | 0.93 | 0.92 | 0.01 |
| 1 | 17903 | 70.51 | 14.20 | 0.01 | 84.72 | 83% | 17% | 0% | 1.00 | 0.83 | 0.17 |
| 1 | 17916 | 48.30 | 23.39 | | 71.69 | 67% | 33% | 0% | 1.00 | 0.67 | 0.33 |
| 1 | 18398 | 179.30 | 23.92 | 0.04 | 203.26 | 88% | 12% | 0% | 1.00 | 0.88 | 0.12 |
| 1 | 19458 | 38.82 | 7.03 | 2.27 | 48.12 | 81% | 15% | 5% | 0.95 | 0.85 | 0.10 |
| 1 | 19524 | 216.55 | 49.76 | 8.61 | 274.91 | 79% | 18% | 3% | 0.97 | 0.82 | 0.15 |
| 1 | 19573 | 46.11 | 4.85 | 3.48 | 54.44 | 85% | 9% | 6% | 0.94 | 0.91 | 0.03 |
| 1 | 20483 | 72.77 | 2.04 | 2.98 | 77.79 | 94% | 3% | 4% | 0.96 | 0.97 | -0.01 |
| 1 | 20485 | 28.25 | 0.59 | 6.26 | 35.10 | 80% | 2% | 18% | 0.82 | 0.98 | -0.16 |
| 1 | 20496 | 26.99 | 0.00 | 4.31 | 31.29 | 86% | 0% | 14% | 0.86 | 1.00 | -0.14 |
| 1 | 20499 | 25.70 | 0.59 | 3.71 | 30.00 | 86% | 2% | 12% | 0.88 | 0.98 | -0.10 |
| 1 | 20685 | 71.95 | 1.37 | 11.15 | 84.47 | 85% | 2% | 13% | 0.87 | 0.98 | -0.12 |
| 1 | 20956 | 60.62 | | 22.73 | 83.35 | 73% | 0% | 27% | 0.73 | 1.00 | -0.27 |
| 1 | 20997 | 54.09 | 2.03 | 12.27 | 68.40 | 79% | 3% | 18% | 0.82 | 0.97 | -0.15 |
| 1 | 21530 | 35.75 | 7.35 | 2.53 | 45.63 | 78% | 16% | 6% | 0.94 | 0.84 | 0.11 |
| 1 | 21762 | 87.68 | 0.53 | 4.94 | 93.15 | 94% | 1% | 5% | 0.95 | 0.99 | -0.05 |
| 1 | 21791 | 53.09 | 4.42 | 9.28 | 66.79 | 79% | 7% | 14% | 0.86 | 0.93 | -0.07 |
| 1 | 21792 | 60.32 | 12.86 | 5.83 | 79.02 | 76% | 16% | 7% | 0.93 | 0.84 | 0.09 |
| 1 | 21805 | 28.76 | 2.14 | 4.84 | 35.74 | 80% | 6% | 14% | 0.86 | 0.94 | -0.08 |
| 1 | 21808 | 82.54 | 1.16 | 4.55 | 88.24 | 94% | 1% | 5% | 0.95 | 0.99 | -0.04 |
| 1 | 21855 | 39.47 | 8.11 | 6.17 | 53.75 | 73% | 15% | 11% | 0.89 | 0.85 | 0.04 |
| 1 | 34889 | 45.48 | 15.27 | 5.55 | 66.31 | 69% | 23% | 8% | 0.92 | 0.77 | 0.15 |
| 1 | 36347 | 72.01 | 0.42 | 10.17 | 82.60 | 87% | 1% | 12% | 0.88 | 0.99 | -0.12 |
| 1 | 36378 | 32.71 | 4.64 | 2.64 | 39.99 | 82% | 12% | 7% | 0.93 | 0.88 | 0.05 |
| 1 | 36379 | 60.23 | 0.00 | 9.43 | 69.66 | 86% | 0% | 14% | 0.86 | 1.00 | -0.14 |
| 1 | 36701 | 55.87 | 12.50 | 11.33 | 79.70 | 70% | 16% | 14% | 0.86 | 0.84 | 0.01 |
| 1 | 36705 | 60.49 | 5.26 | 7.00 | 72.75 | 83% | 7% | 10% | 0.90 | 0.93 | -0.02 |

EMSN-050: Post Mathew Damage Assessment and Monitoring of Recovery Activities in the South Region of Haiti

| | | Area (m2) | | | | % | | | Area (m2) | | |
|---------|--------|-----------|------------|----------|--------|---------------|----------------|--------------|--------------------------|------|----------------|
| A OI | ID_BU | Agreement | Commission | Omission | Total | Agree ment | Commis sion | Omis sion | Photo interpre ted | QC | Diff. PI-QC |
| 1 | 36719 | 50.89 | 5.28 | 4.55 | 60.73 | 84% | 9% | 7% | 0.93 | 0.91 | 0.01 |
| 1 | 39517 | 39.82 | 8.48 | 6.10 | 54.40 | 73% | 16% | 11% | 0.89 | 0.84 | 0.04 |
| 1 | 39520 | 55.42 | 10.31 | 2.19 | 67.92 | 82% | 15% | 3% | 0.97 | 0.85 | 0.12 |
| 1 | 40918 | 90.73 | 0.10 | 22.40 | 113.23 | 80% | 0% | 20% | 0.80 | 1.00 | -0.20 |
| 1 | 40994 | 51.80 | 6.87 | 0.98 | 59.65 | 87% | 12% | 2% | 0.98 | 0.88 | 0.10 |
| 1 | 41005 | 43.21 | 1.55 | 7.19 | 51.95 | 83% | 3% | 14% | 0.86 | 0.97 | -0.11 |
| 1 | 41010 | 69.90 | 3.74 | 0.66 | 74.30 | 94% | 5% | 1% | 0.99 | 0.95 | 0.04 |
| 1 | 41015 | 89.88 | 2.31 | 9.53 | 101.72 | 88% | 2% | 9% | 0.91 | 0.98 | -0.07 |
| 1 | 41016 | 56.72 | 7.82 | 4.54 | 69.08 | 82% | 11% | 7% | 0.93 | 0.89 | 0.05 |
| 1 | 41023 | 50.45 | 8.47 | 2.75 | 61.68 | 82% | 14% | 4% | 0.96 | 0.86 | 0.09 |
| 1 | 41090 | 63.01 | 0.27 | 3.15 | 66.43 | 95% | 0% | 5% | 0.95 | 1.00 | -0.04 |
| 1 | 41098 | 34.73 | 11.90 | 6.65 | 53.27 | 65% | 22% | 12% | 0.88 | 0.78 | 0.10 |
| 1 | 41168 | 39.16 | 1.62 | 5.57 | 46.35 | 84% | 3% | 12% | 0.88 | 0.97 | -0.09 |
| 1 | 53232 | 83.99 | 2.11 | 6.74 | 92.84 | 90% | 2% | 7% | 0.93 | 0.98 | -0.05 |
| 1 | 53252 | 39.40 | | 24.37 | 63.77 | 62% | 0% | 38% | 0.62 | 1.00 | -0.38 |
| 1 | 53275 | 40.42 | 2.01 | 20.91 | 63.34 | 64% | 3% | 33% | 0.67 | 0.97 | -0.30 |
| 1 | 53880 | 234.56 | 31.77 | 9.69 | 276.02 | 85% | 12% | 4% | 0.96 | 0.88 | 0.08 |
| 1 | 53906 | 56.44 | 11.87 | 6.16 | 74.47 | 76% | 16% | 8% | 0.92 | 0.84 | 0.08 |
| 1 | 54005 | 44.20 | 5.73 | 10.98 | 60.91 | 73% | 9% | 18% | 0.82 | 0.91 | -0.09 |
| 1 | 54064 | 57.90 | 4.22 | 5.66 | 67.79 | 85% | 6% | 8% | 0.92 | 0.94 | -0.02 |
| 2 | 133068 | 158.03 | 13.03 | 48.50 | 219.56 | 72% | 6% | 22% | 0.78 | 0.94 | -0.16 |
| 2 | 135764 | 38.44 | 10.96 | 23.70 | 73.10 | 53% | 15% | 32% | 0.68 | 0.85 | -0.17 |
| 2 | 135804 | 168.12 | 21.92 | 42.52 | 232.56 | 72% | 9% | 18% | 0.82 | 0.91 | -0.09 |
| 2 | 135841 | 41.88 | | 30.79 | 72.66 | 58% | 0% | 42% | 0.58 | 1.00 | -0.42 |
| 2 | 138006 | 51.67 | 5.01 | 19.11 | 75.79 | 68% | 7% | 25% | 0.75 | 0.93 | -0.19 |
| 2 | 138643 | 63.47 | 26.30 | 14.86 | 104.64 | 61% | 25% | 14% | 0.86 | 0.75 | 0.11 |
| 2 | 138656 | 65.53 | 15.79 | 21.84 | 103.15 | 64% | 15% | 21% | 0.79 | 0.85 | -0.06 |
| 2 | 142185 | 367.03 | 44.15 | 14.02 | 425.20 | 86% | 10% | 3% | 0.97 | 0.90 | 0.07 |
| 2 | 143218 | 86.34 | 6.90 | 5.65 | 98.89 | 87% | 7% | 6% | 0.94 | 0.93 | 0.01 |
| 2 | 143244 | 117.51 | 8.65 | 8.29 | 134.45 | 87% | 6% | 6% | 0.94 | 0.94 | 0.00 |
| 2 | 143252 | 56.88 | 12.11 | 12.84 | 81.83 | 70% | 15% | 16% | 0.84 | 0.85 | -0.01 |
| 2 | 143265 | 492.45 | 42.13 | 108.82 | 643.40 | 77% | 7% | 17% | 0.83 | 0.93 | -0.10 |
| 2 | 144607 | 164.71 | 42.19 | 25.76 | 232.67 | 71% | 18% | 11% | 0.89 | 0.82 | 0.07 |
| 2 | 144609 | 131.41 | 21.74 | 28.23 | 181.39 | 72% | 12% | 16% | 0.84 | 0.88 | -0.04 |
| 2 | 145384 | 96.60 | 16.39 | 15.69 | 128.68 | 75% | 13% | 12% | 0.88 | 0.87 | 0.01 |
| 2 | 147056 | 45.30 | 7.76 | 24.21 | 77.27 | 59% | 10% | 31% | 0.69 | 0.90 | -0.21 |
| 2 | 147702 | 27.72 | 5.71 | 32.14 | 65.57 | 42% | 9% | 49% | 0.51 | 0.91 | -0.40 |
| 2 | 147719 | 29.93 | 36.29 | 12.42 | 78.65 | 38% | 46% | 16% | 0.84 | 0.54 | 0.30 |
| 2 | 147729 | 110.18 | 0.00 | 45.79 | 155.97 | 71% | 0% | 29% | 0.71 | 1.00 | -0.29 |
| 2 | 147743 | 24.75 | 0.00 | 20.20 | 44.95 | 55% | 0% | 45% | 0.55 | 1.00 | -0.45 |
| 2 | 147747 | 148.93 | 47.44 | 65.53 | 261.90 | 57% | 18% | 25% | 0.75 | 0.82 | -0.07 |
| 2 | 148054 | 72.79 | 21.93 | 13.60 | 108.31 | 67% | 20% | 13% | 0.87 | 0.80 | 0.08 |

EMSN-050: Post Mathew Damage Assessment and Monitoring of Recovery Activities in the South Region of Haiti

| | | Area (m2) | | | | % | | | Area (m2) | | |
|---------|----------------------|-----------------|----------------|----------------|-----------------|-------------|-------------|-------------|----------------------|-------------|----------------|
| A OI | ID_BU | Agreement | Commission | Omission | Total | Agreement | Commission | Omission | Photo interpreted | QC | Diff. PI-QC |
| 2 | 148059 | 216.95 | 4.77 | 56.34 | 278.07 | 78% | 2% | 20% | 0.80 | 0.98 | -0.19 |
| 2 | 148070 | 36.15 | 3.33 | 30.42 | 69.91 | 52% | 5% | 44% | 0.56 | 0.95 | -0.39 |
| 2 | 148324 | 56.01 | 5.27 | 12.52 | 73.81 | 76% | 7% | 17% | 0.83 | 0.93 | -0.10 |
| 2 | 148325 | 37.59 | 0.28 | 22.26 | 60.13 | 63% | 0% | 37% | 0.63 | 1.00 | -0.37 |
| 2 | 148331 | 62.50 | 8.15 | 12.69 | 83.34 | 75% | 10% | 15% | 0.85 | 0.90 | -0.05 |
| 2 | 148334 | 34.70 | 0.35 | 24.38 | 59.43 | 58% | 1% | 41% | 0.59 | 0.99 | -0.40 |
| 2 | 148340 | 59.58 | 42.35 | 21.06 | 123.00 | 48% | 34% | 17% | 0.83 | 0.66 | 0.17 |
| 2 | 150505 | 286.05 | 36.42 | 35.06 | 357.53 | 80% | 10% | 10% | 0.90 | 0.90 | 0.00 |
| 2 | 150508 | 67.96 | 8.09 | 14.36 | 90.41 | 75% | 9% | 16% | 0.84 | 0.91 | -0.07 |
| 2 | 150531 | 39.18 | 30.50 | 12.06 | 81.74 | 48% | 37% | 15% | 0.85 | 0.63 | 0.23 |
| 2 | 150535 | 37.50 | 4.46 | 6.32 | 48.28 | 78% | 9% | 13% | 0.87 | 0.91 | -0.04 |
| 2 | 151361 | 47.35 | 3.92 | 5.44 | 56.71 | 83% | 7% | 10% | 0.90 | 0.93 | -0.03 |
| 2 | 155865 | 388.27 | 22.66 | 72.66 | 483.58 | 80% | 5% | 15% | 0.85 | 0.95 | -0.10 |
| 2 | 158526 | 320.09 | 26.11 | 3.50 | 349.70 | 92% | 7% | 1% | 0.99 | 0.93 | 0.06 |
| 2 | 159121 | 56.17 | 5.30 | 13.34 | 74.81 | 75% | 7% | 18% | 0.82 | 0.93 | -0.11 |
| 2 | 159220 | 147.00 | 10.67 | 15.51 | 173.18 | 85% | 6% | 9% | 0.91 | 0.94 | -0.03 |
| 2 | 166639 | 184.36 | 23.71 | 5.35 | 213.42 | 86% | 11% | 3% | 0.97 | 0.89 | 0.09 |
| 2 | 166645 | 68.28 | 3.02 | 6.35 | 77.65 | 88% | 4% | 8% | 0.92 | 0.96 | -0.04 |
| 2 | 166671 | 64.48 | 1.59 | 5.05 | 71.11 | 91% | 2% | 7% | 0.93 | 0.98 | -0.05 |
| 2 | 166682 | 58.00 | 7.94 | 6.05 | 72.00 | 81% | 11% | 8% | 0.92 | 0.89 | 0.03 |
| 2 | 169864 | 148.77 | 17.75 | 35.90 | 202.42 | 73% | 9% | 18% | 0.82 | 0.91 | -0.09 |
| 2 | 171200 | 340.02 | 12.81 | 36.25 | 389.08 | 87% | 3% | 9% | 0.91 | 0.97 | -0.06 |
| 2 | 173190 | 61.84 | 16.71 | 15.73 | 94.27 | 66% | 18% | 17% | 0.83 | 0.82 | 0.01 |
| 2 | 173209 | 27.07 | 14.58 | 25.43 | 67.09 | 40% | 22% | 38% | 0.62 | 0.78 | -0.16 |
| 2 | 173344 | 55.92 | 13.73 | 23.19 | 92.84 | 60% | 15% | 25% | 0.75 | 0.85 | -0.10 |
| 2 | 173424 | 53.29 | 21.26 | 28.54 | 103.10 | 52% | 21% | 28% | 0.72 | 0.79 | -0.07 |
| 2 | 173426 | 78.61 | 9.46 | 28.08 | 116.14 | 68% | 8% | 24% | 0.76 | 0.92 | -0.16 |
| 2 | 174997 | 66.15 | 30.25 | 5.25 | 101.65 | 65% | 30% | 5% | 0.95 | 0.70 | 0.25 |
| 2 | 176749 | 28.45 | | 22.58 | 51.03 | 56% | 0% | 44% | 0.56 | 1.00 | -0.44 |
| 2 | 179809 | 250.14 | 149.40 | 0.89 | 400.43 | 62% | 37% | 0% | 1.00 | 0.63 | 0.37 |
| 2 | 179812 | 246.41 | 65.21 | 43.06 | 354.68 | 69% | 18% | 12% | 0.88 | 0.82 | 0.06 |
| 2 | 183752 | 57.60 | 9.34 | 19.82 | 86.76 | 66% | 11% | 23% | 0.77 | 0.89 | -0.12 |
| 2 | 185052 | 36.89 | 30.48 | 34.51 | 101.88 | 36% | 30% | 34% | 0.66 | 0.70 | -0.04 |
| 2 | 185579 | 46.46 | 2.54 | 3.21 | 52.21 | 89% | 5% | 6% | 0.94 | 0.95 | -0.01 |
| 2 | 185580 | 65.19 | 30.39 | 2.03 | 97.60 | 67% | 31% | 2% | 0.98 | 0.69 | 0.29 |
| 2 | 185632 | 40.18 | 8.65 | 3.64 | 52.47 | 77% | 16% | 7% | 0.93 | 0.84 | 0.10 |
| 2 | 185634 | 91.80 | 12.61 | 11.18 | 115.59 | 79% | 11% | 10% | 0.90 | 0.89 | 0.01 |
| 2 | 190051 | 125.40 | 15.76 | 29.17 | 170.33 | 74% | 9% | 17% | 0.83 | 0.91 | -0.08 |
| | Total general | 12231.16 | 1719.59 | 2012.52 | 15963.27 | 0.77 | 0.11 | 0.13 | 0.87 | 0.89 | -0.02 |
| | Total AOI 01 | 5580.37 | 603.38 | 628.78 | 6812.53 | 0.82 | 0.09 | 0.09 | 0.91 | 0.91 | 0.00 |
| | Total AOI 02 | 5491.35 | 553.46 | 656.00 | 6700.81 | 0.82 | 0.08 | 0.10 | 0.90 | 0.92 | -0.02 |