Our Place in Space

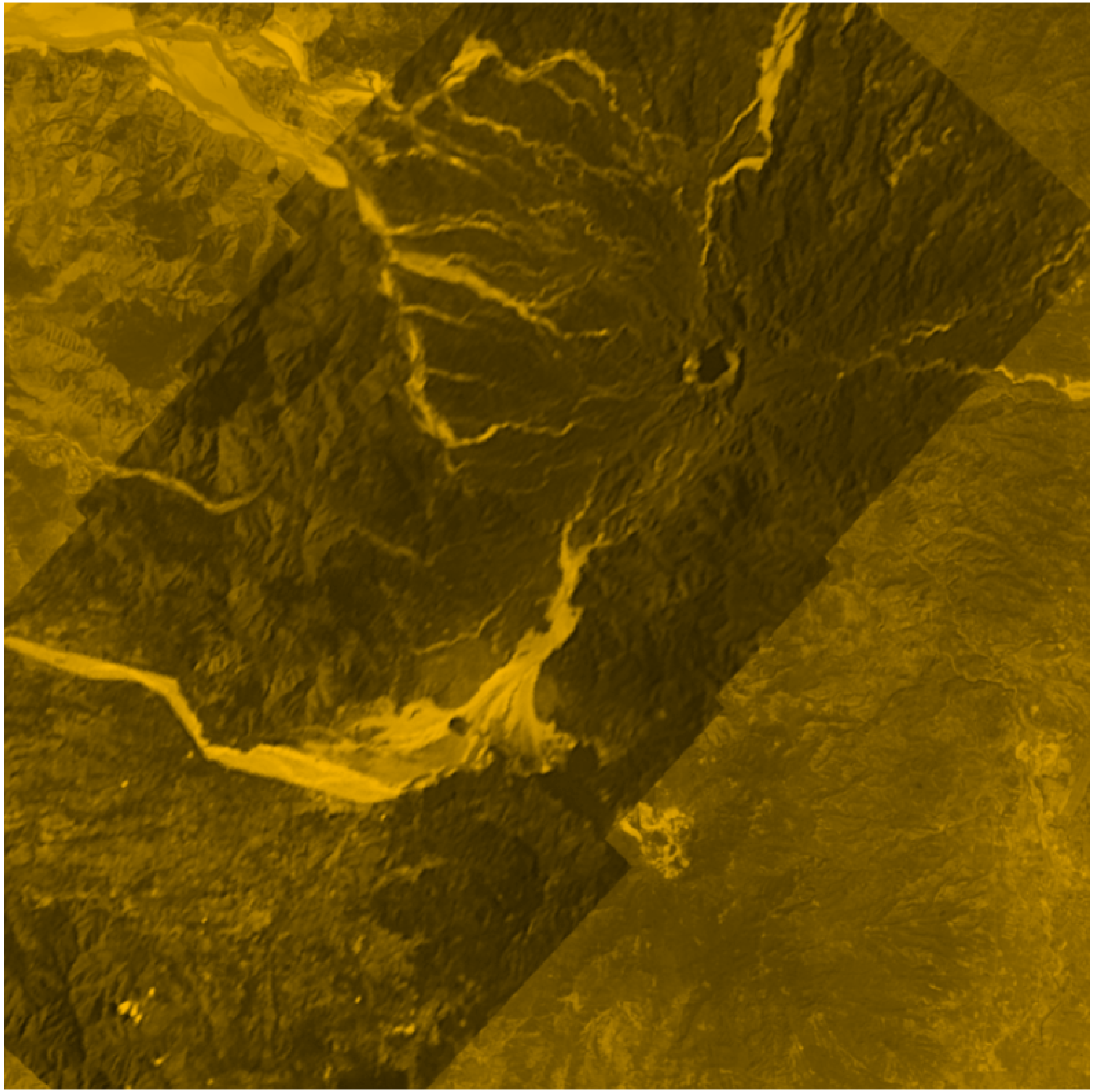
Space S&T and Applications in the Philippines

VOLUME 1

Space Data Mobilization

2016 to 2020

Philippine Space Agency



Foreword

Space is the expanse above us, which can bridge our islands, communities and wherever Filipinos may go on Earth. Space travel and rockets uplift us, figuratively, in mind and spirit (and literally). Being in space, building in space, with its high vantage point, empowers us.

The Philippines has taken significant steps in space science and technology applications (SSTA) over the period 2014-2020. A number of SSTA activities implemented as project-based initiatives have been initiated and continue to be pursued with the support of the Department of Science and Technology's (DOST) Grants-in-Aid (GIA). Projects such as the Philippine Scientific Earth Observation Microsatellite Program (PHL- Microsat) and its successor, the Space Technology and Applications Mastery, Innovation and Advancement Program (STAMINA4Space) have led to the development, launch, operation and utilization of the country's own small satellites for scientific Earth observation, DIWATA-1 launched in 2016, followed by DIWATA-2 in 2018 and MAYA-1, the country's first nanosatellite, also launched in 2018. DIWATA and MAYA provide a blueprint that enable the development of small satellites to be sustained, proliferated and localized in the country. These achievements have enabled the Philippines to join the ranks of countries that not only own and operate satellites, but have been able to build and develop them.

Thes satellite development activities are joined by complementary ground infrastructure and services, such as multi-mission satellite receiving stations, which we call the Philippine Earth Data Resource Observation (PEDRO) Center, as well as high performance computing (HPC) facilities for the processing, archiving and distribution of satellite images and other spaceborne data. There is also the Remote Sensing and Data Science Help Desk or DATOS, which have been developing a gamut of applications from the satellite image data. These investments have equipped the Philippines with a capacity to create and add value from space, specifically through the generation, processing, dissemination and utilization of data obtained by satellites and space infrastructure.

The success and value of these prior efforts confirmed that we need a dedicated and specialized agency to champion a national space program. On August 8, 2019, President Rodrigo Roa Duterte signed Republic Act No. 11363 or the "The Philippine Space Act". By virtue of this law, the Philippine Space Agency or PhilSA was established to serve as the primary policy, planning, coordinating, implementing, and administrative entity of the Executive Branch of the government that will plan, develop, and promote our national space program. The Philippine Space Act recognizes these prior efforts that have produced our emergent local technological capacity in space. With foundational elements in capabilities, infrastructure and people in place, the PhilSA is therefore building from the ground up and not starting from scratch. The PhilSA's succeeding programs shall grow, expand and nurture these resources so they can yield further socio-economic benefits and impact for Filipinos.

In Our Place in Space, we compile and select showcases from the prior initiatives in Space Science & Technology and Applications (SSTA) in the Philippines. These activities have been undertaken by different groups from the academe, research institutions and government agencies, which we acknowledge at the end of each of the three Volumes in the compilation. Each Volume highlights a different component of SSTA that contribute to the growth of the space ecosystem in the country. The simple and humble goal is to create better awareness of local SSTA capabilities and the benefits that they bring to Filipino society.

In coming up with the compilation, we considered the segmentation of the space economy and industry into two complementary sectors: the "Upstream" and the "Downstream". "Upstream space" activities consist of the design, assembly, integration and testing of satellites and other spacecraft and their payloads, systems, subsystems, and components. This also includes the infrastructure necessary to launch and operate them from Earth. In other words, the upstream segment is the sector of space that makes or manufactures, controls and launches objects such as satellites, rovers, space probes and other spacecraft into space orbit. "Downstream space" uses these spacecraft and systems to deliver products and services for scientific, experimental and commercial use on Earth, such as telecommunications, navigation, surveillance and Earth observation, among others.

Our country has been an active users in the downstream of satellites and space. That is, the utilization of and the applications arising from the data generated by satellites, such as images and other spaceborne data. That is valuable since the downstream is expected to largely account for the growth of the space sector and therefore its contributions to the economic growth of nations. Data and the resulting actionable information and intelligence is the currency of the knowledge economy. Current downstream activities in SSTA are discussed in Volume 1: Space Data Utilization.

A strong presence in the space upstream sector is important for our country as well. The upstream involves components of the space value chain that offer a strategic advantage to those who master and control such technologies. For example, the detailed knowledge and competence on the upstream engagement serves as the basis for the development of standards and operations that influence the downstream, such as end user applications and the needs of satellite operators. Building space satellite payloads and buses equip us with the wherewithal to adapt to and anticipate evolving downstream requirements, thus the ability to customize solutions for existing and new downstream verticals. Building satellites enables us to understand the source of the solutions – the source of the data. Current upstream activities in SSTA in the Philippines are addressed primarily in Volume 2: Space Technology.

By engaging in both the upstream and downstream of space, we can instantiate a "virtuous cycle" in this exponentially growing and exciting new area that our country should nurture and feed. The virtuous cycle will enable us to develop endogenous S&T capacity that will supplant the vicious cycle of technological dependence.

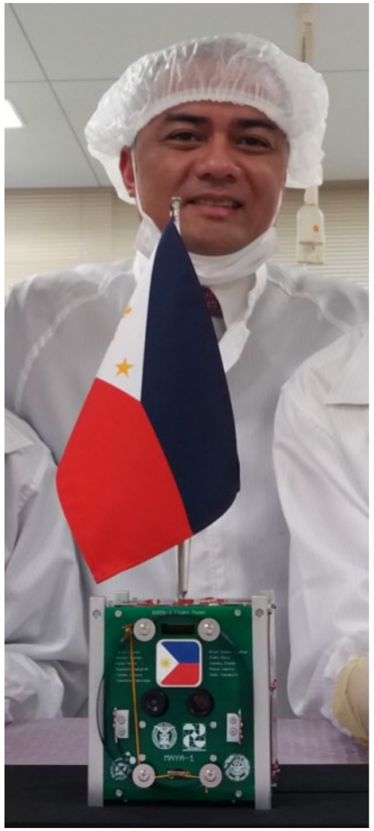
The downstream and upstream SSTA activities that have catapulted our country's capabilities in space need to be proliferated, disseminated and sustained. In Volume 3: Capacity-building, Outreach and Sustainability, we provide a window to the inward- and outward-facing initiatives aimed at developing people, institutions, linkages, partnerships and outreach activities. These activities are essential in cascading the gains and benefits obtained from our satellite development and space data mobilization efforts to society.

Finally, through this compilation, it is our aim to impart the PhilSA's vision – A Filipino nation bridged, uplifted and empowered through the peaceful uses of outer space; and our mission – To promote and sustain a robust Philippine space ecosystem that adds and creates value in space for and from Filipinos and for the world.

By capturing the best (so far) of our fledgling Philippine space ecosystem, we hope that you will find this compilation not only informative, but also inspiring. Through these pages, we find and truly affirm Our Place in Space.

Joel Joseph S. Marciano, Jr. PhD
Director General
Philippine Space Agency (PhilSA)

09 October 2020



Prologue

Volume 1: Space Data Utilization provides examples of actual, real-world end use of spaceborne data, i.e. the downstream space segment, in the Philippines across various domains. Data from space can help uplift our condition and better our lives through data-driven and evidence-based policies. Amidst concerns in food security, satellites are able to gather relevant data through remote sensing of agricultural crops, watersheds, fisheries, forests and other natural resources. Through satellite connectivity, space can bridge Filipinos and our communities, especially the underserved or unserved populations in Geographically Isolated and Disadvantaged Areas (GIDA). In promoting better health services amidst the lack of health workers, satellite coverage enables medical and public health services, through telemedicine.

Our country has been an active user of downstream of satellites and space. That is, the utilization of and the applications arising from the data generated by satellites, such as images and other spaceborne data. This is a valuable endeavor since the downstream is expected to largely account for the growth of the space sector and therefore its contributions to the economic growth of nations. Data and the resulting actionable information and intelligence is the currency of the knowledge economy. The use cases in this Volume focus on the application of satellite images to generate actionable information across applications such as disaster risk management, agriculture and fisheries, natural and built environment monitoring, defense and security, and planning and econometrics.

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Natural and Built Environment Monitoring

1

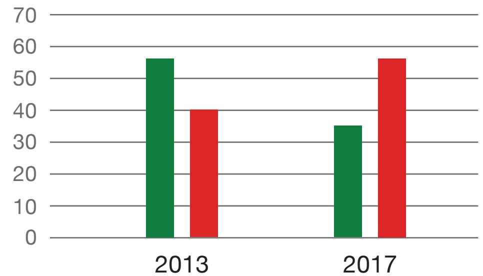
Monitoring Built-Up Areas

New Developments in Boracay

These satellite images show the changes in the urban sprawl of Boracay island from 2013 to 2017. Through satellite images, researchers monitored the decline of vegetation and the rise of built-up areas in the island.

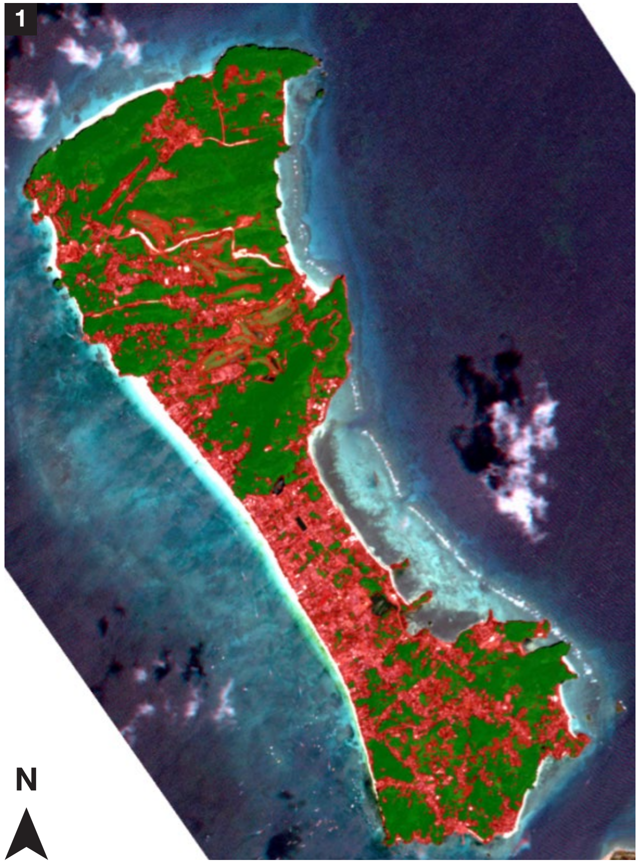
Boracay island – a famous tourist destination – underwent a six-month rehabilitation program in 2018. These images were used by the Boracay rehabilitation monitoring team.

Comparison between 2013 & 2017



LEGEND

- Vegetated Areas
- Built-up Areas



- 56.78%
- 40.10%

1

Satellite: Rapid Eye
Accessed via: DOST-ASTI PEDRO Center
Capture date: 10 February 2013
Payload: Optical
Resolution: 5 m
Basemap: PhilGIS, Google Earth

- 35.27%
- 57.65%

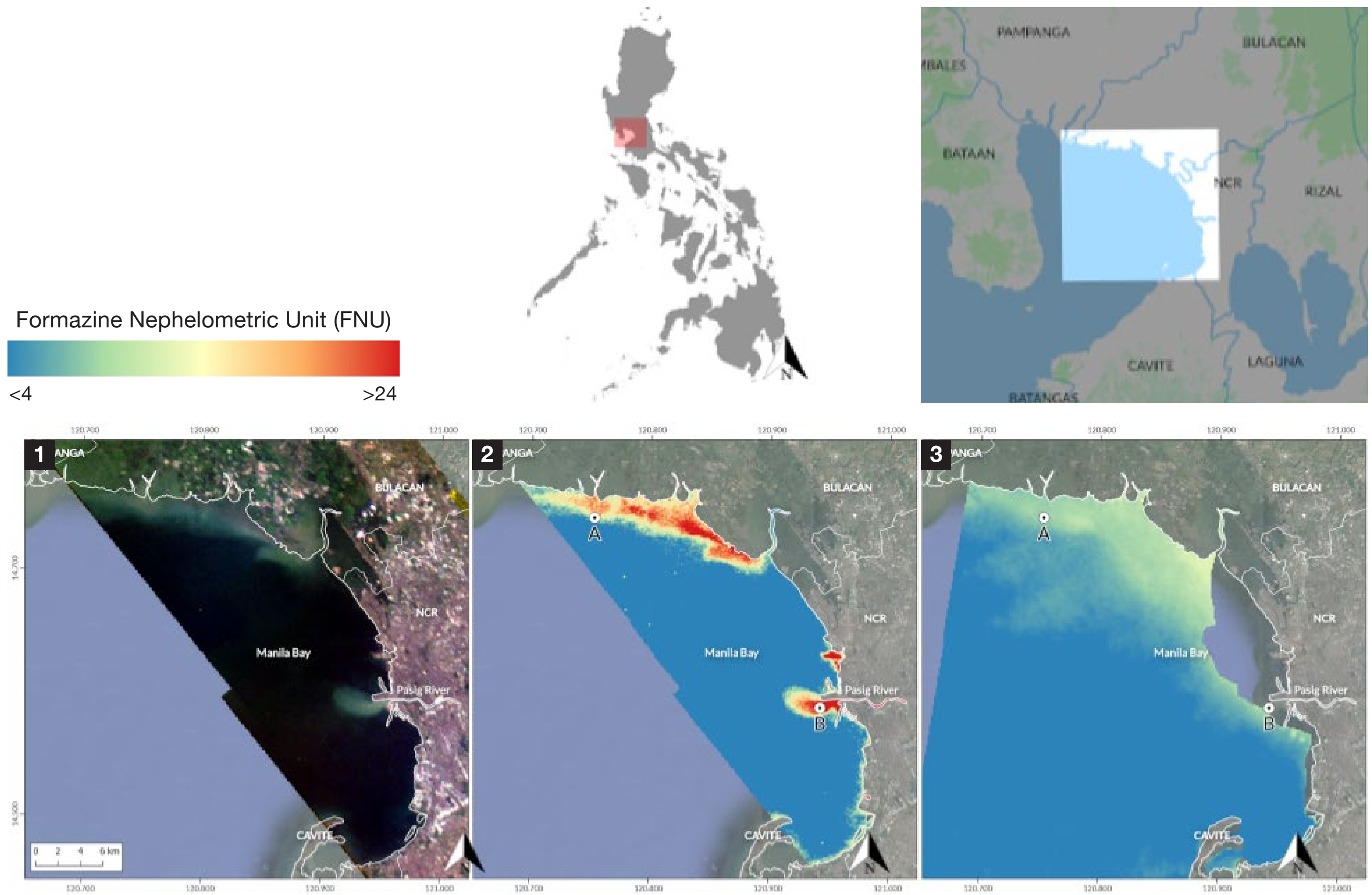
2

Satellite: Rapid Eye
Accessed via: DOST-ASTI PEDRO Center
Capture date: 10 February 2017
Payload: Optical
Resolution: 5 m
Basemap: PhilGIS, Google Earth

Assessing Water Quality

New Developments in Manila Bay

Analyzing Manila Bay's water quality using satellite imagery is important in identifying how human activities affect coastal resource degradation. Turbidity, or the murkiness (versus clarity) of water, is one of the indicators studied here. Possible changes in turbidity or clarity of Manila Bay's coastal waters before and after its rehabilitation as observed through images captured by Diwata-1 in 2018 (leftmost) and Diwata-2 in 2019 (rightmost). The Diwata-1 image shows murky waters at the mouth of Pasig River (red areas in the middle image). Additionally, monitoring this area at different times of the year can contribute to existing and future studies assessing the results of the ongoing Manila Bay rehabilitation efforts.



1

True-Color Image

Satellite: Diwata-1
Accessed via: STAMINA4Space
Capture date: 19 February 2018
Payload: Spaceborne Multispectral Imager (SMI)
Resolution: 66m
Basemap: PhilGIS
Image: Google Earth

2

Turbidity Map

Satellite: Diwata-1
Accessed via: STAMINA4Space
Capture date: 19 February 2018
Payload: Spaceborne Multispectral Imager (SMI)
Resolution: 66m
Basemap: PhilGIS
Image: Google Earth

3

Turbidity Map

Satellite: Diwata-2
Accessed via: STAMINA4Space
Capture date: 05 June 2019
Payload: Spaceborne Multispectral Imager (SMI)
Resolution: 127m
Basemap: PhilGIS
Image: Google Earth

Assessing Water Quality

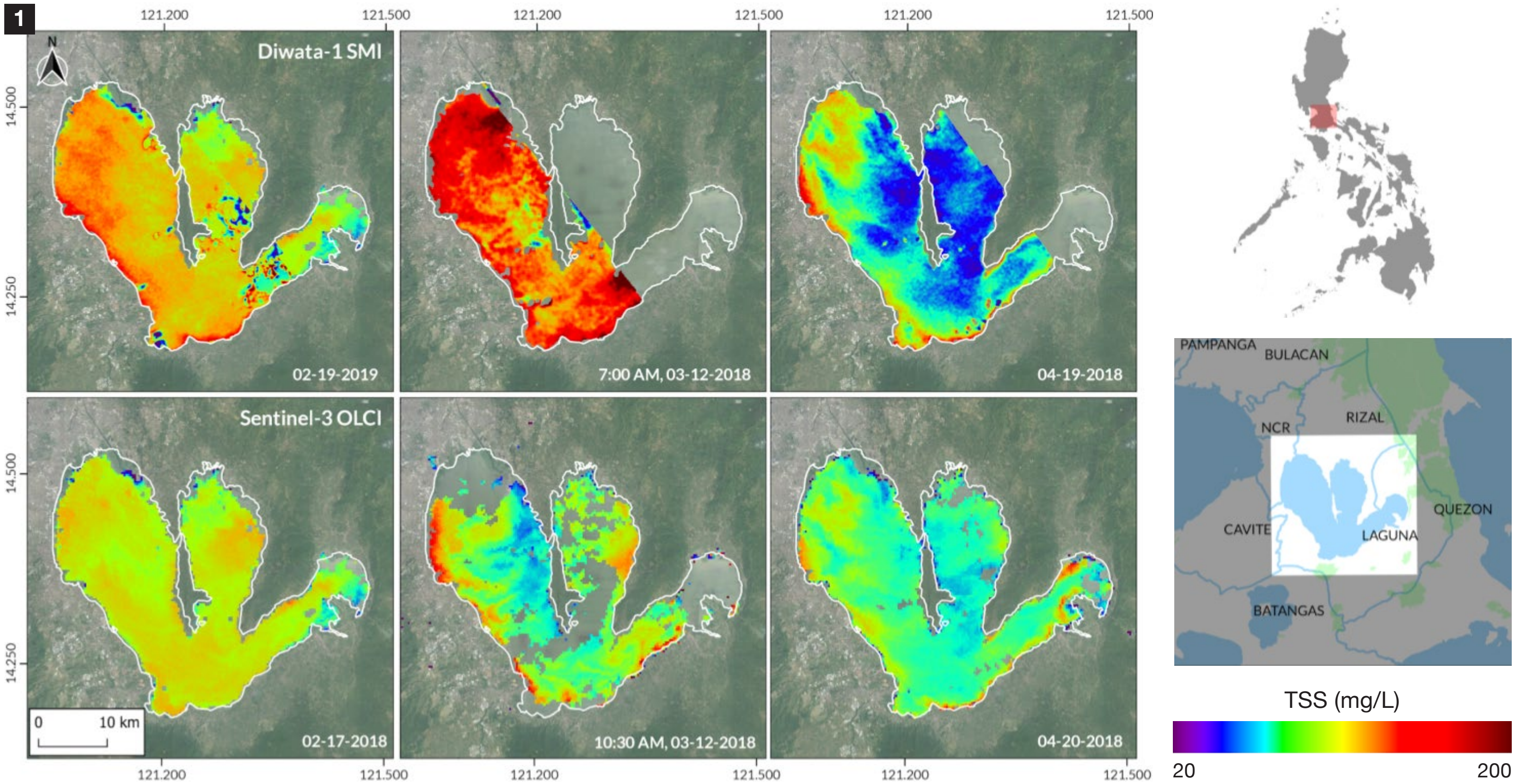
Mapping Total Suspended Solids (TSS) in Laguna Lake

Using Diwata-1 and Sentinel-3 images, researchers have captured the total suspended solids (TSS) in Laguna de Bay at different times of the year. This technique of capturing several images at different times in a given period is called spatiotemporal monitoring. Diwata images can provide a spatially comprehensive assessment of water quality (see below) which is difficult and tedious to do through conventional water quality monitoring approach. "Hotspots" or areas with high, frequent TSS values can be easily identified from satellite images. This is crucial in identifying potential pollution sources and areas vulnerable to low dissolved oxygen, which may result to fish kill. Complementary use of Diwata imageries with other optical satellites such as Sentinel-3 may increase the temporal monitoring of Laguna Lake.

1

Satellite: Diwata-1 and Sentinel-3
Accessed via: STAMINA4Space
Payloads: Spaceborne Multispectral Imager (SMI) & Ocean and Land Color Imager (OLCI)
Resolution: 66m and 300m
Basemap: PhilGIS and Google Earth
Capture dates and times indicated on the images

1



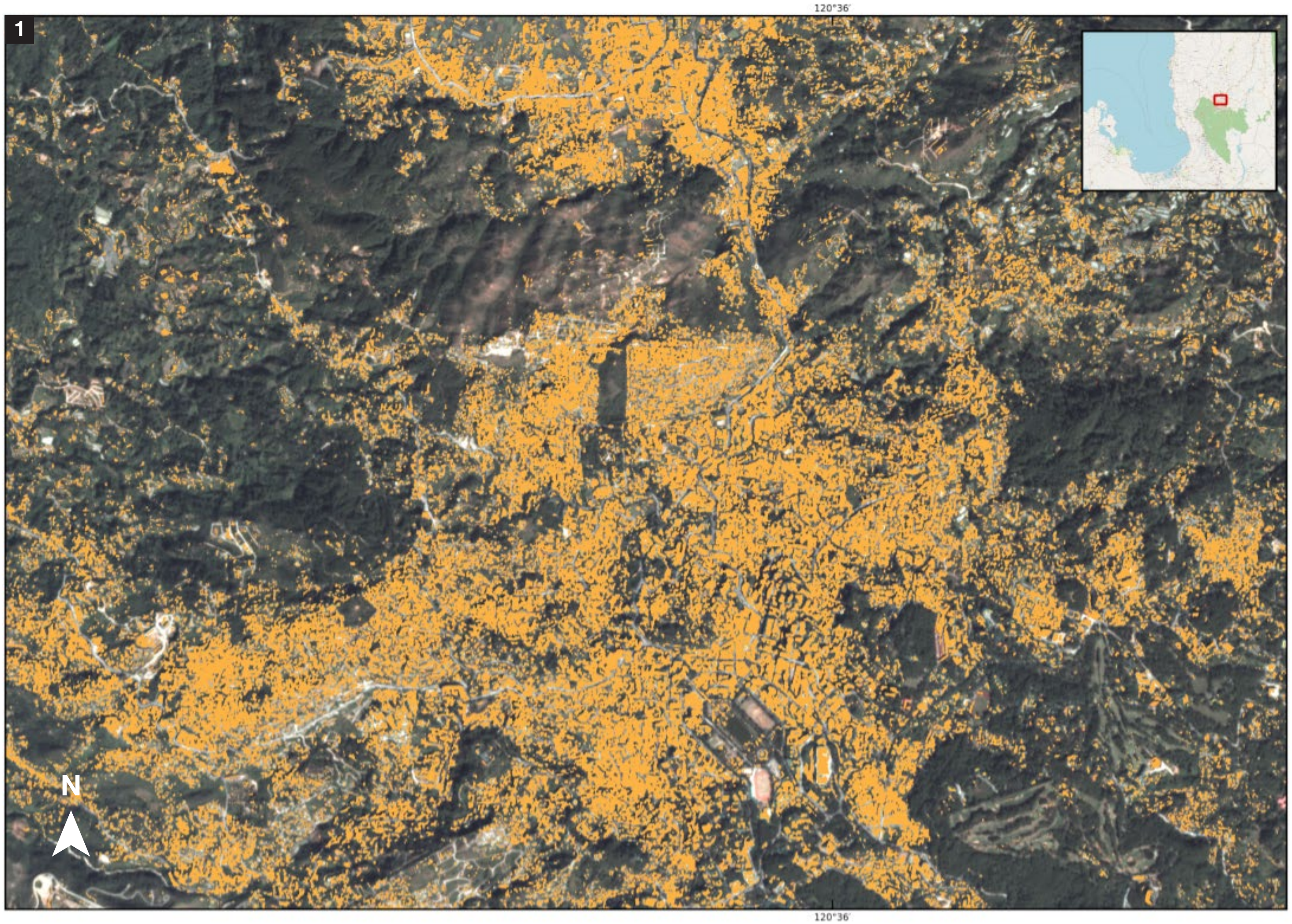
Detecting Built-Up Area Changes

Built-up areas in Baguio City

Maps of built-up areas show intensive use of the land covered by structures. They are generated to monitor the evolution of cities and settlements, including their characteristics, extent, and attributes. Built-up areas show the increase and expansion of large urban centers.

This map shows the urban density in Baguio City. Changes can be analyzed throughout time by using various processing techniques and models like Artificial Intelligence (AI) to predict the urban extent in the future.

Built-up areas were generated using three (3) Planetscope.



LEGEND

Built-up Areas

Satellite: Planet Dove
Accessed via: DOST-ASTI PEDRO Center
Payload: Optical
Capture dates: 22 December 2016, 11 May 2017, and 23 June 2018
Resolution: 3m
Basemap: OpenStreetMap (inset)

Cartographic Information

Coordinate System: WGS 84/UTM

0 0.45 0.9 1.35 1.8 km

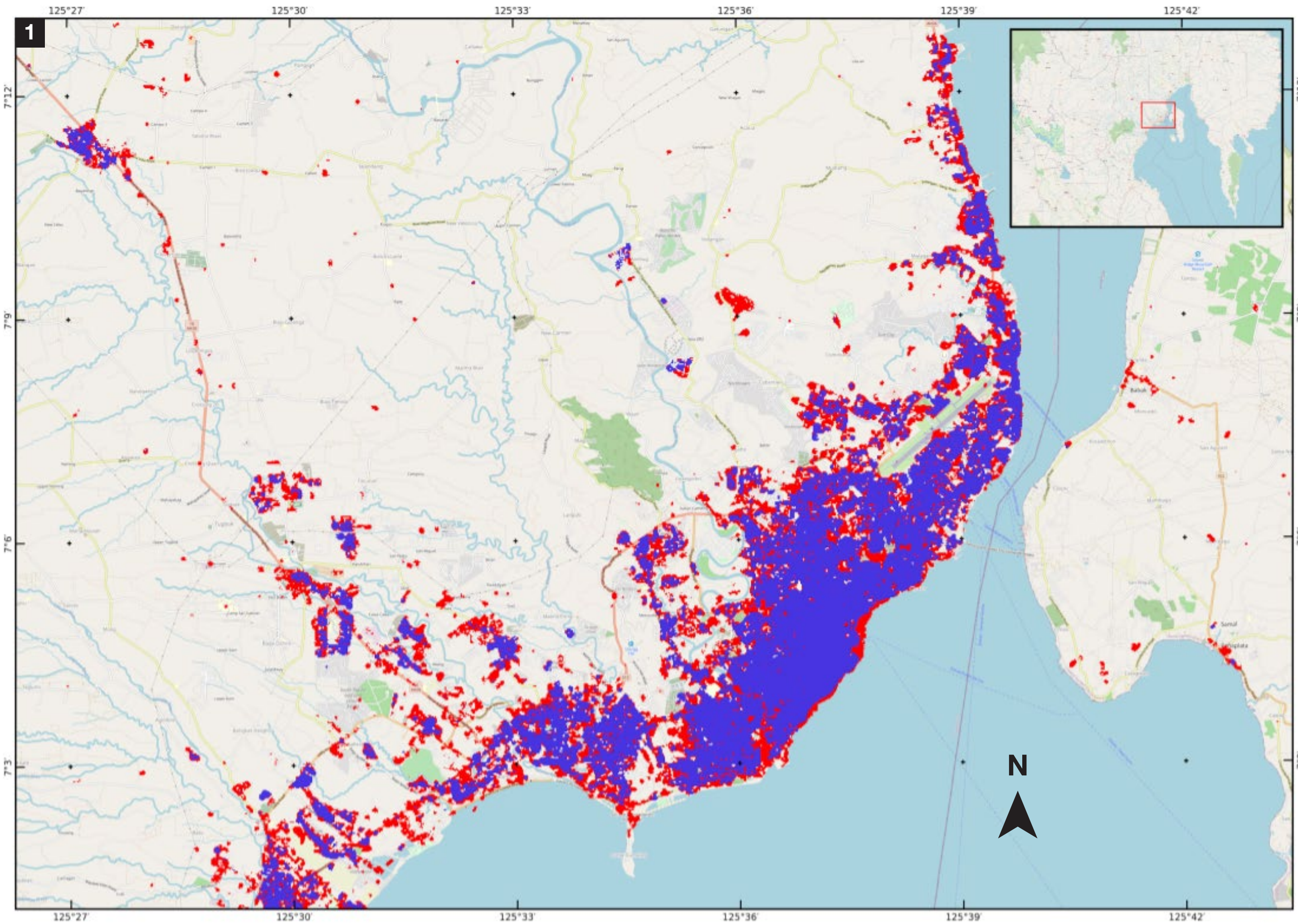
Assessing Urban Sprawl

Urban Sprawl in Davao City

The image shows the increase of settlements in Davao City from 2013 to 2016.

Using historical images as training materials, Artificial Intelligence (AI) models were trained to differentiate changes in land cover using satellite images. Employing automated and unsupervised processing that would accelerate extraction of images is useful for further studies such as projecting growth of urban areas.

Sizes larger than the original 30m resolution were digitized and used as training data.



LEGEND

- Land Area
- 2013 Built-up Areas
- 2016 Built-up Areas

1 **Multi-temporal Optical Imagery**

Satellite: Landsat 8
Capture date: Whole year predictions (2013 and 2016)
Accessed via: DOST-ASTI PEDRO Center

Payload: Optical
Resolution: 3m
Basemap: OpenStreetMap

Detecting Road Network Changes

Road Network of Muntinlupa City, Metro Manila

Through machine learning—a component of Artificial Intelligence (AI)—road features that are continuous, long, and with homogenous hue throughout their length are digitized and used as training data to detect road network changes.

AI is able to simulate human vision to detect features, and can also see beyond what is visible to the naked eye. This allows it to detect and isolate these features more accurately.

Cartographic Information

Coordinate System: WGS 84/UTM

0 0.15 0.3 0.45 0.6 km

LEGEND

Roads

N

1

Satellite: Planetscope
Accessed via: DOST-ASTI PEDRO Center
Capture date: 30 April 2018
Payload: Optical
Resolution: 3m

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Agriculture, Fisheries, and Resource Management

2

Mapping Water Sources

Monitoring Drought

Monitoring Coastlines

Mapping Agricultural Crops

Mapping Land Cover Classes

Mapping Fishponds and Fish Pens

Detecting Trees

Mapping Water Sources

La Mesa Dam water level

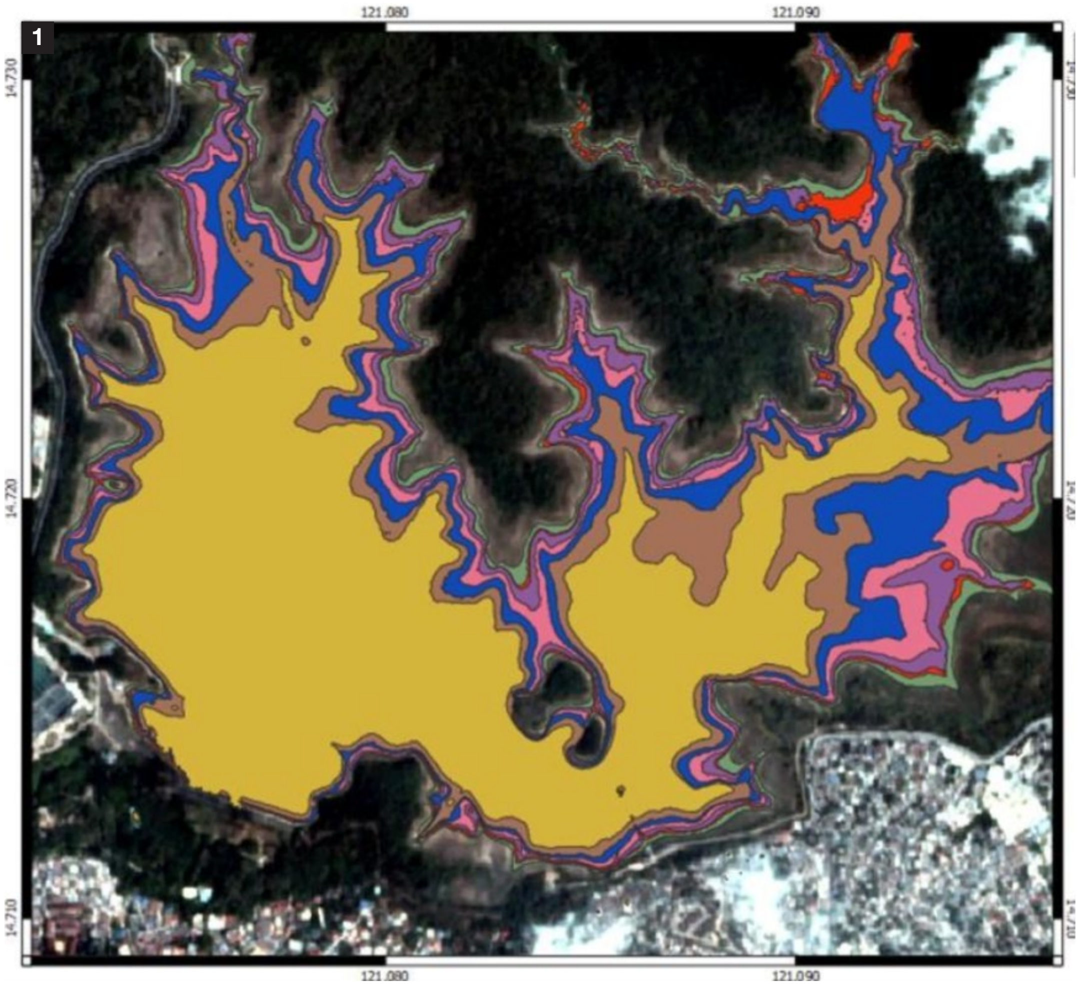
To see the effects of El Niño on the La Mesa Dam, a time series of satellite images from December 2018 to March 2019 were analyzed. The images used Normalized Difference Water Index (NDWI) which highlights the change in the extent of the water surface area. This is then used to compute for an estimation of the volume of the water in the dam.

LEGEND

Extracted water features

- March 10, 2019
- February 24, 2019
- February 8, 2019
- January 17, 2019
- January 4, 2019
- December 18, 2018
- March 16, 2018

0 250 500 m



N

1

Satellite: PLANETSCOPE
Accessed via: DOST-ASTI PEDRO
Center Capture date: Dec 2018 to March 2019
Payload: Optical
Resolution: 3 m
Basemap: OpenStreetMap

18 December 2018

17 January 2019

24 February 2019

10 March 2019

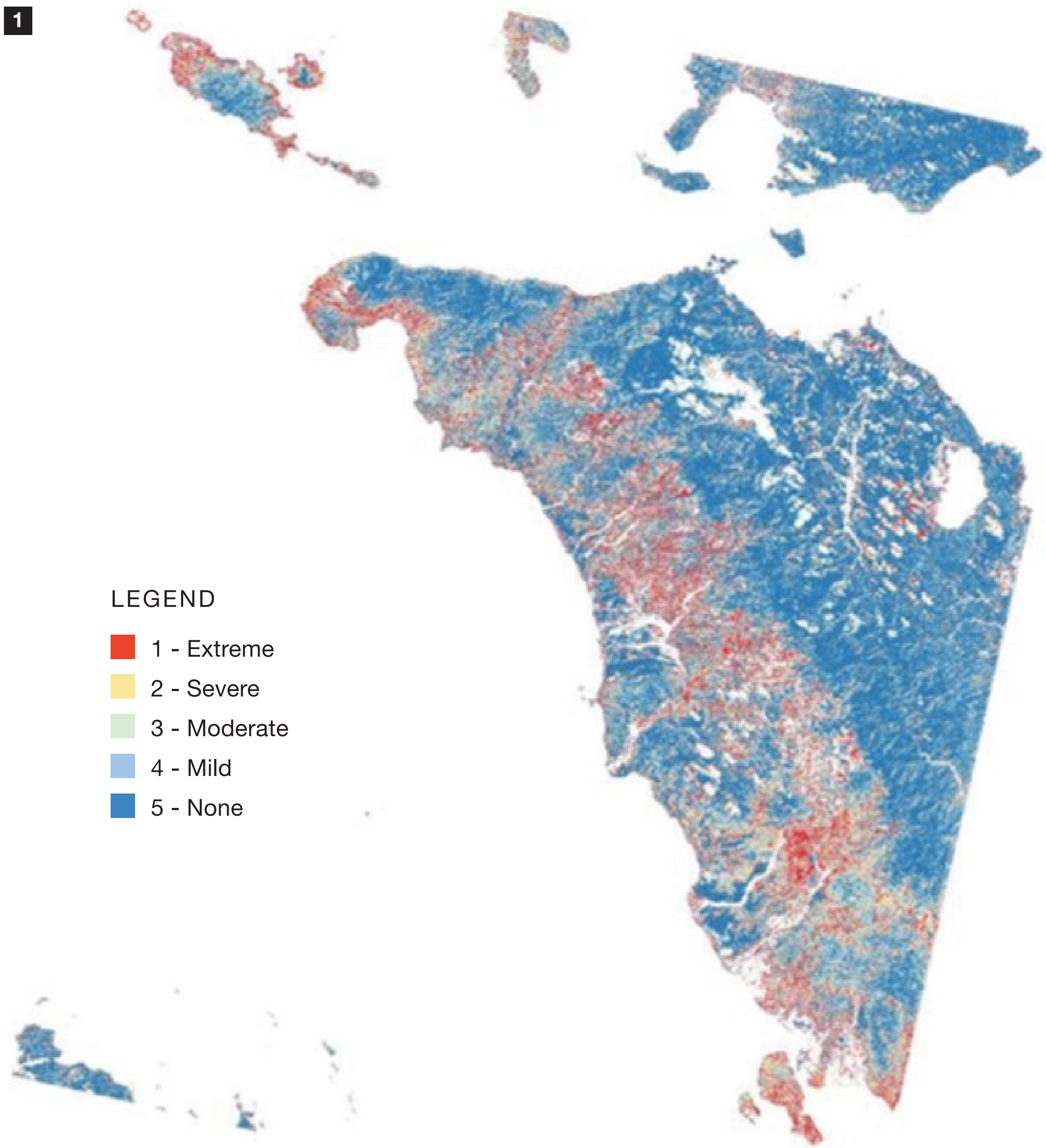
Monitoring Drought

Vegetation Health Index (VHI) of Occidental Mindoro

The VHI indicates whether or not an area is experiencing drought. “Low health” of a vegetated area denotes “high stress levels” of vegetation due to dryness and heat. This can be detected from satellite images. The more “stressed” the vegetation is, the more likely that it is experiencing drought.

During the agricultural drought in early 2019, the DATOS project acquired snapshots of the VHI of Mindoro Island for February 2 & 21, 2019, 2019, and March 9, 2019. Note the extreme “stress levels” experienced by the vegetation in Occidental Mindoro on the lower left (in red).

1



1

Multi-temporal Optical Imagery

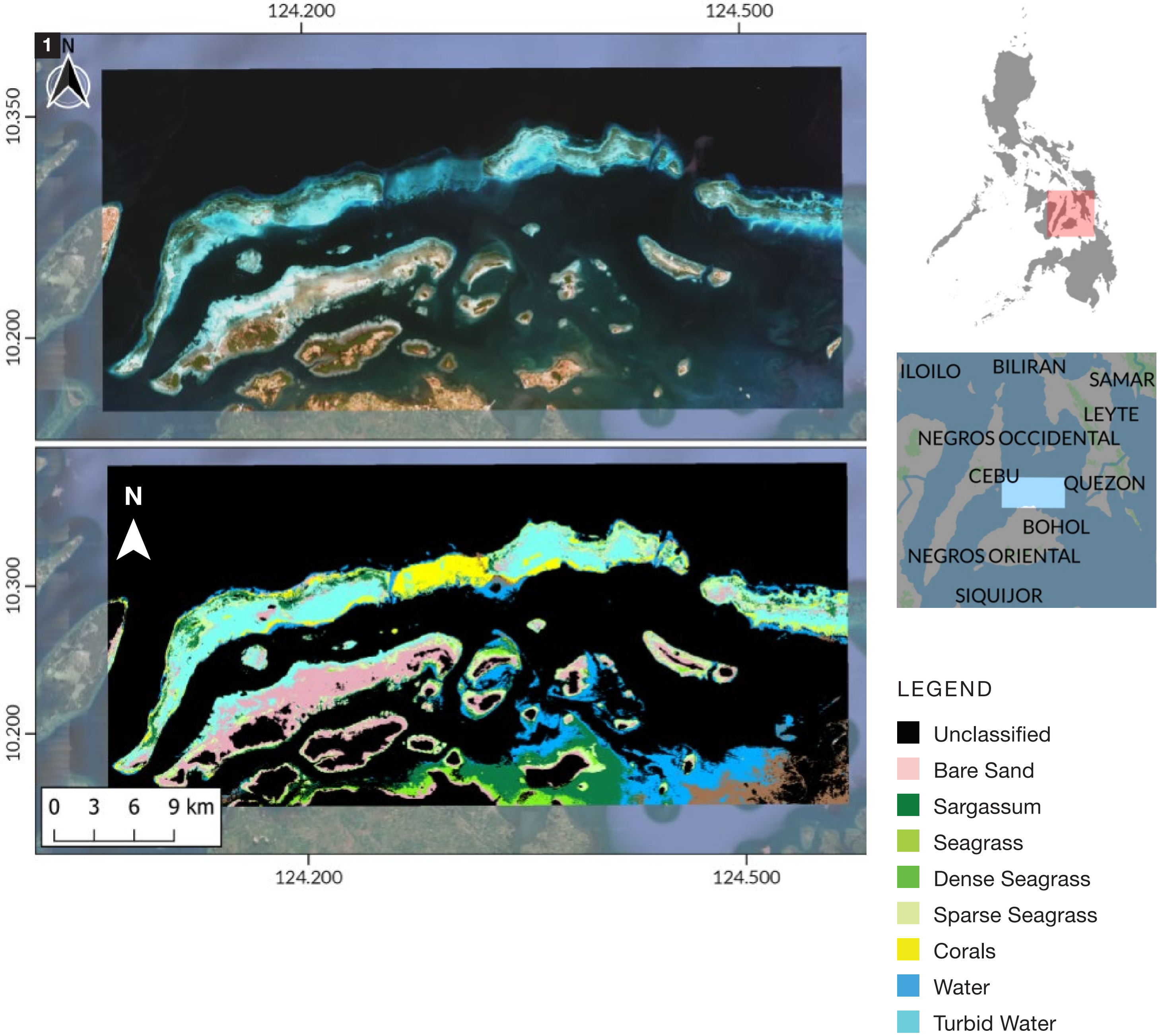
Satellite: Landsat 8
Accessed via: DOST-ASTI PEDRO Center
Capture dates: 02 February 2019, 21 February 2019, and 09 March 2019
Resolution: 30m

Monitoring Coastlines

Double barrier reef in Bohol

It is important to monitor seagrasses, corals, mangroves, and sandy areas because they are home to various marine species. This area shown, which is under the National Integrated Protected Areas System (NIPAS), was mapped and processed to identify these features.

Constant monitoring of these sites helps us determine if there is a decline in the NIPAS site's benthic habitats and at what rate the habitat is declining. This can then give us science-based recommendations for stricter protection, conservation, and rehabilitation if needed.



1

Satellite: Sentinel-2 MSI
Accessed via: STAMINA4Space
Capture date: March 23, 2019
Resolution: ~127m
Basemap: PhilGIS, Google Earth

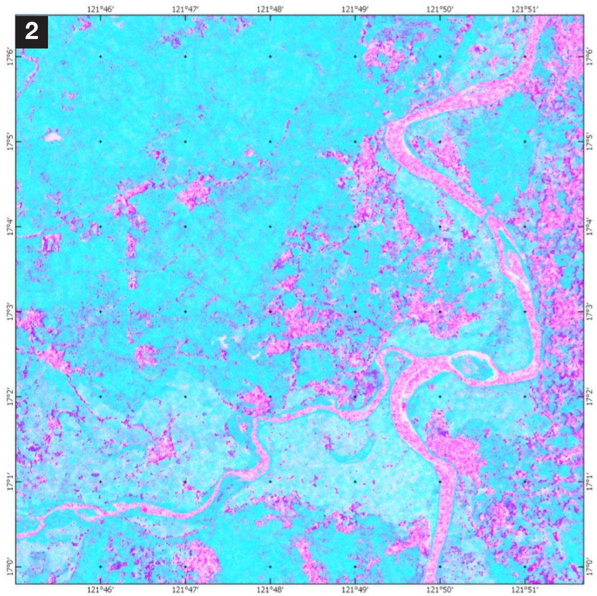
Mapping Agricultural Crops

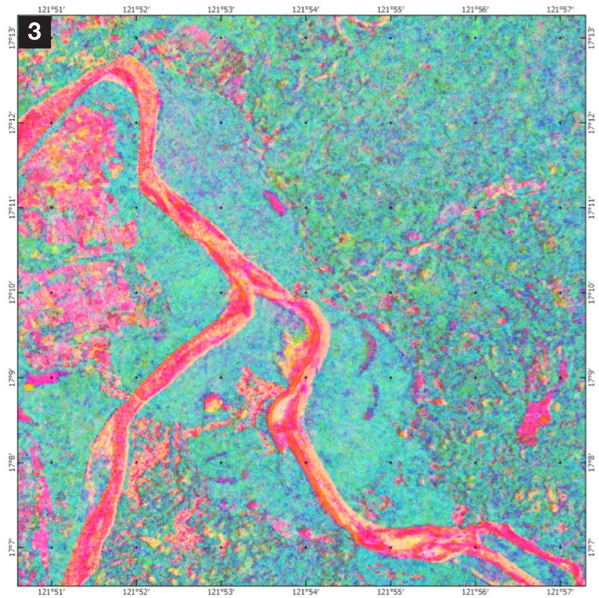
Sugar Cane, Rice, and Corn Mapping

Research on remote sensing (RS) techniques allows for faster methods in mapping agricultural resources. In cooperation with the Department of Agriculture and Sugar Regulatory Administration, mapping these high-value crops using advanced RS methods would help streamline and hasten activities in inventory, yield projection, monitoring, data analysis, and assessment.

LEGEND

Cyan areas indicate plantations of high-value seasonal crops, such as sugarcane, rice, and corn. These can be identified through satellite images (temporal SAR) using automated remote sensing methods like time series analysis.





1 Multi-temporal SAR Imagery

Satellite: Sentinel-1A, 1B
Location: Tarlac Mill District
Accessed via: DOST-ASTI PEDRO Center
Capture period: 01 November 2016 to 08 March 2018
Payload: SAR
Resolution: 15 m
Basemap: OpenStreetMap (inset)

2 Multi-temporal SAR Imagery

Location: Isabela
Satellite: Sentinel-1A, 1B
Accessed via: DOST-ASTI PEDRO Center
Capture period: 06 April 2017 to 12 June 2018
Payload: SAR
Resolution: 15 m
Basemap: OpenStreetMap (inset)

3 Multi-temporal SAR Imagery

Location: Isabela
Satellite: Sentinel-1A, 1B
Accessed via: DOST-ASTI PEDRO Center
Capture period: 06 April 2017 to 12 June 2018
Payload: SAR
Resolution: 15 m
Basemap: OpenStreetMap (inset)

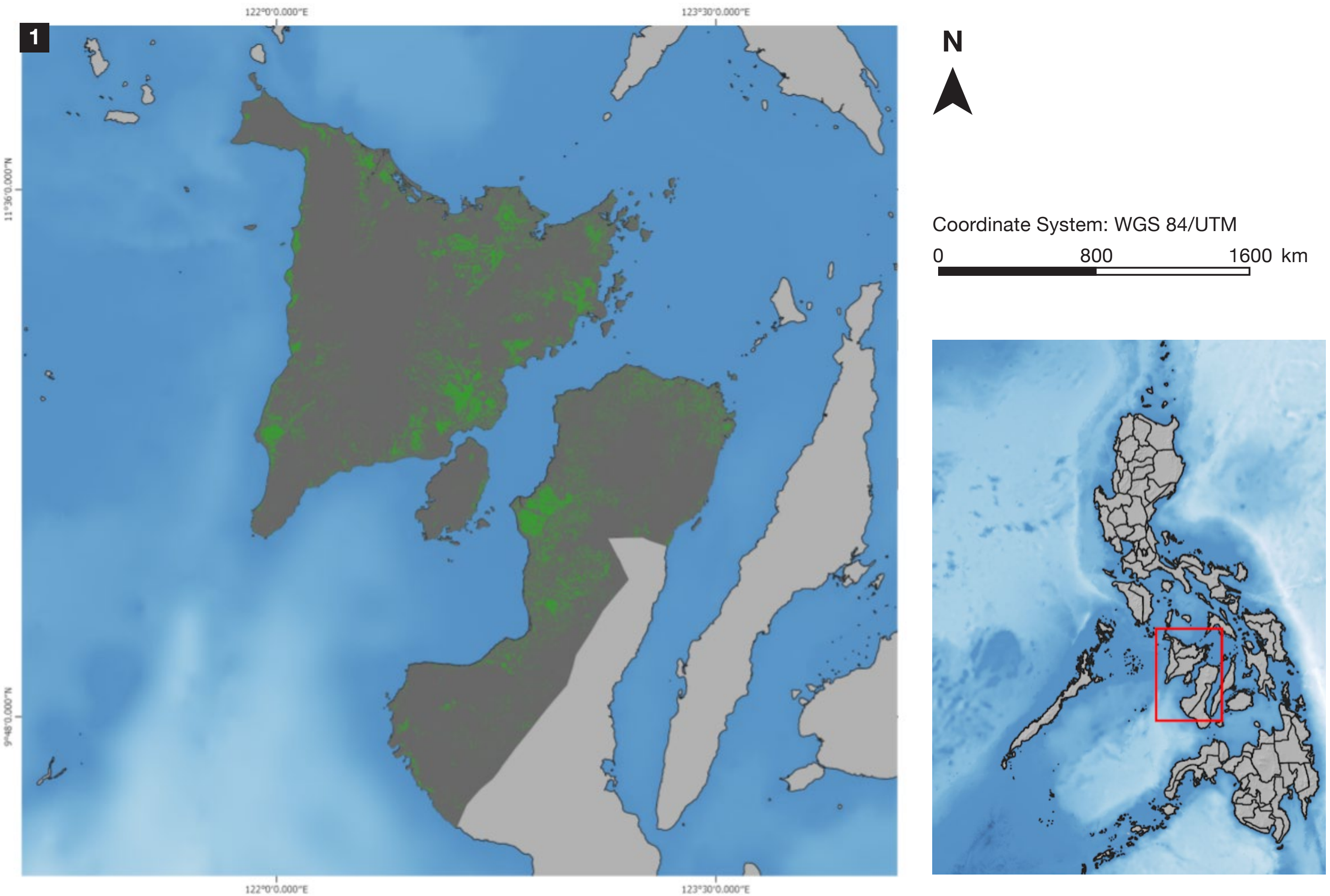
Mapping Agricultural Crops

Rice Mapping in Region VI

The average length of time it takes for rice to grow is about 120 days. The temporal variation of the radar signal of a rice field can be regarded as a function of its rice crop growth. The MaPalay Project, a collaborative project between the University of the Philippines and Department of Agriculture (DA) - Philippine Rice Research Institute (PhilRice), this rice classification map shows the rice detected in the pre-processed SAR images using the algorithm developed. The datasets used are images from September 2018 to March 2019, which correspond to the first rice cropping season of 2019 (also known as the 'wet season').

Region 6 was selected as the test site for processing because of its complexity. This includes the presence of asynchronous and heterogeneous planting of rice, its size which involves merging of different tiles of satellite images to complete the whole region, and the availability of ground data which are all used for accuracy assessment.

1



LEGEND

- Rice
- Not rice

1

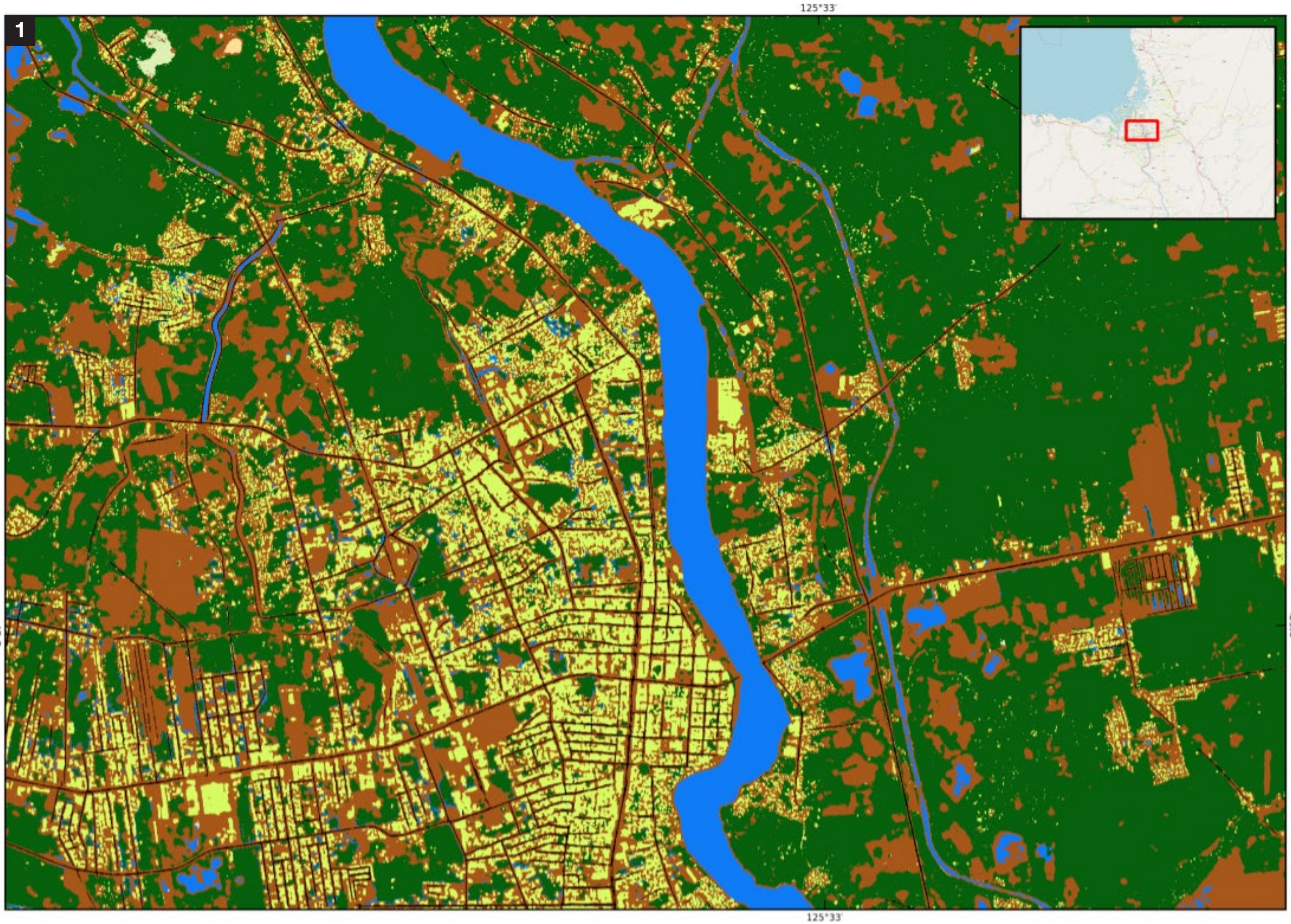
Satellite: Sentinel-1A
Accessed via: MaPalay Project
Capture date/time or capture period: September 2018 to March 2019
Payload: Radar
Resolution: 20m
Basemap: ESRI and General Bathymetric Chart of the Oceans at British Oce-anic Data Center (GEBCO-BODC)

Mapping Land Cover Classes

Butuan City, Agusan del Norte

With the increasing availability of Earth observation data such as those in the form of satellite images, deep learning methods (e.g. AI & Convolutional Neural Networks) have shown promising results in identifying the physical aspect of the earth's surface (land cover). Through these methods and automated systems developed by the DATOS Project, updating of land cover classifications can now be expedited.

In partnership with NAMRIA, different models were created for each class and were later merged to create a land cover map.



N

LEGEND

- Roads
- Bare soil
- Water
- Built-up
- Vegetation

1

Satellite: Planetscope Image
Accessed via: DOST-ASTI PEDRO Center
Capture date: August 25, 2017
Payload: Optical
Resolution: 3m
Basemap: OpenStreetMap

Cartographic Information

Coordinate System: WGS 84/UTM

0 0.35 0.7 1.05 1.4 km

Mapping Fish Ponds and Fish Pens

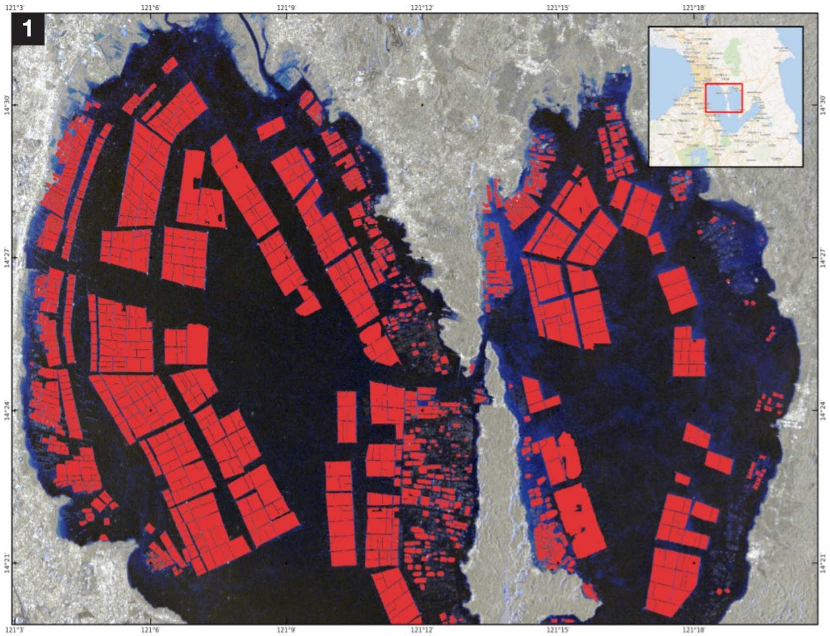
Nationwide aquaculture mapping

Aquaculture research and operations have begun adopting technologies, such as Artificial Intelligence, in accounting, mapping, and monitoring nationwide fish ponds and fish pens facilities.

DOST-ASTI conducts research in partnership with the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture to assist them in creating a nationwide inventory that can be used to monitor fish pens and fish ponds in over highly dense areas all over the country.

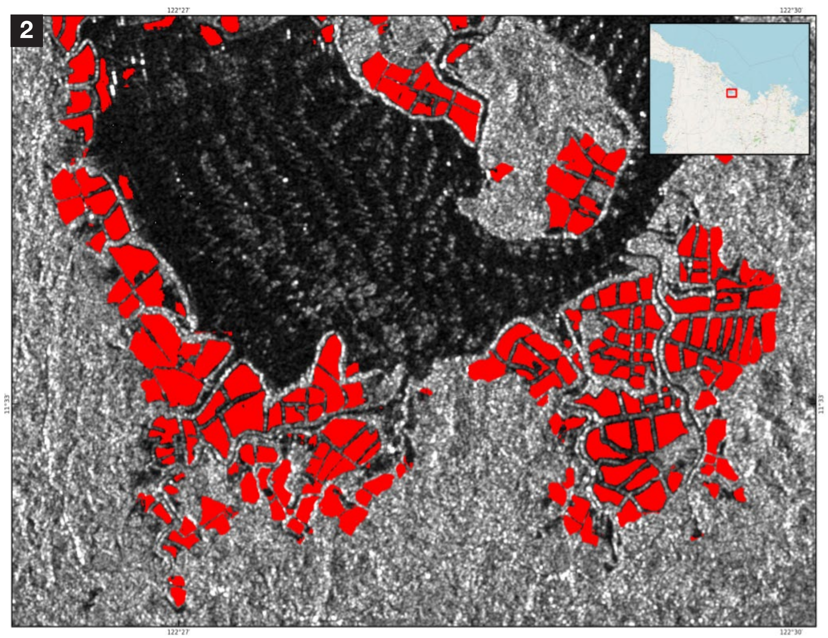
LEGEND

Detected fishpen and dish cages



1

Location: Laguna Lake
Satellite: Sentinel-1
Accessed via: DOST-ASTI PEDRO Center
Capture date: June 2018
Payload: SAR
Resolution: 15m
Basemap: OpenStreetMap (inset)



2

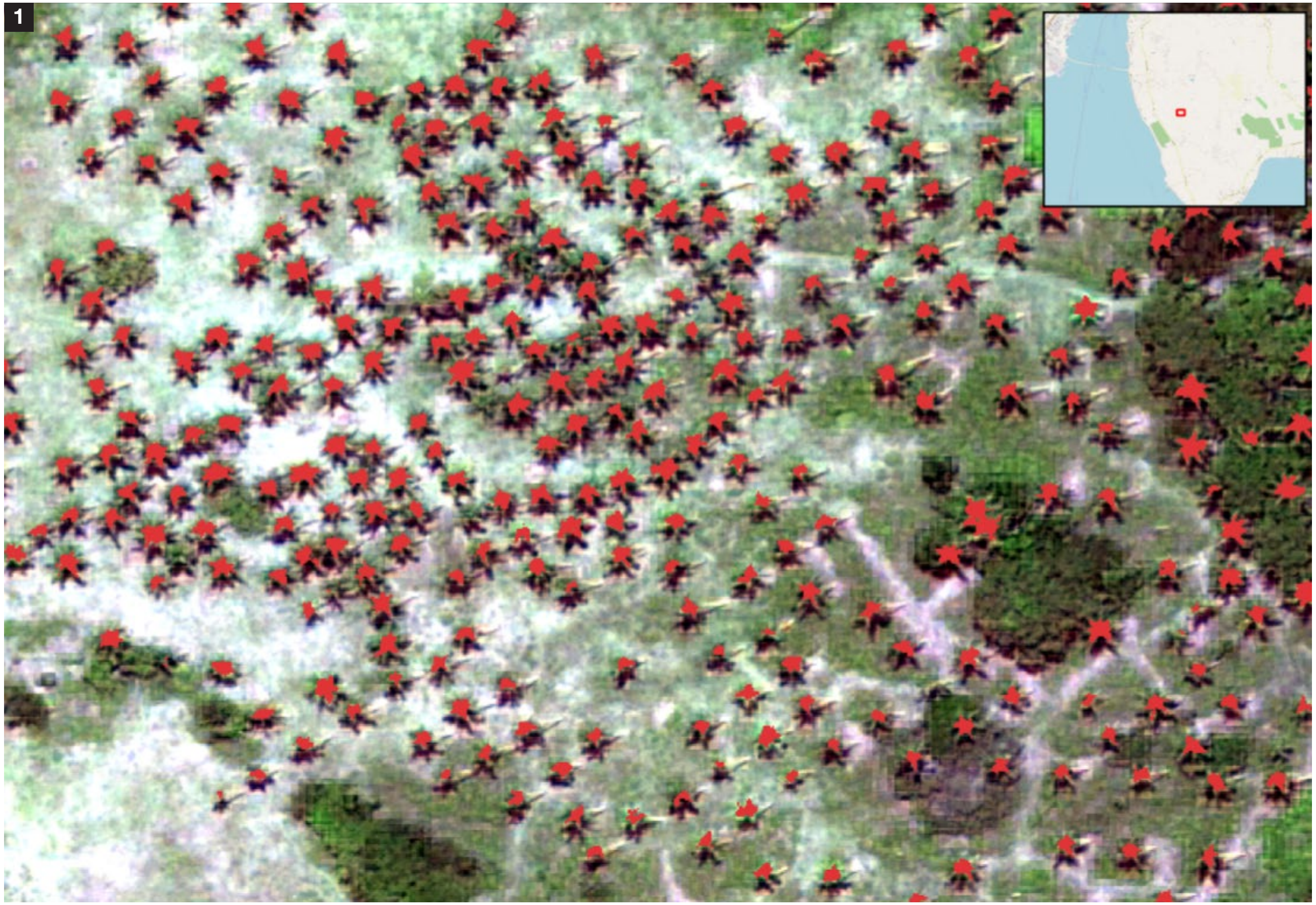
Location: Laguna Lake
Satellite: Sentinel-1
Accessed via: DOST-ASTI PEDRO Center
Capture date: June 2018
Payload: SAR
Resolution: 15m
Basemap: OpenStreetMap (inset)

Detecting Trees

Coconut trees in Davao City

Coconuts account for 25% of total agricultural land in the country, playing an important role in the Philippine's national economy . It remains to be a major export, contributing 3.6% of the country's gross value-added in agriculture. However, according to reports from Philippine Coconut Authority, coconut production had been stagnant.

With the available image processing techniques and earth observation data from DOST-ASTI, damage detection and rapid inventory of coconut trees in a given area is now possible. Artificial Intelligence can be used on earth observation data to detect and map distinct features from satellite images.



N

LEGEND

Coconut trees

Cartographic Information

Coordinate System: WGS 84/UTM

0 0.01 0.02 0.03 0.04 km

1

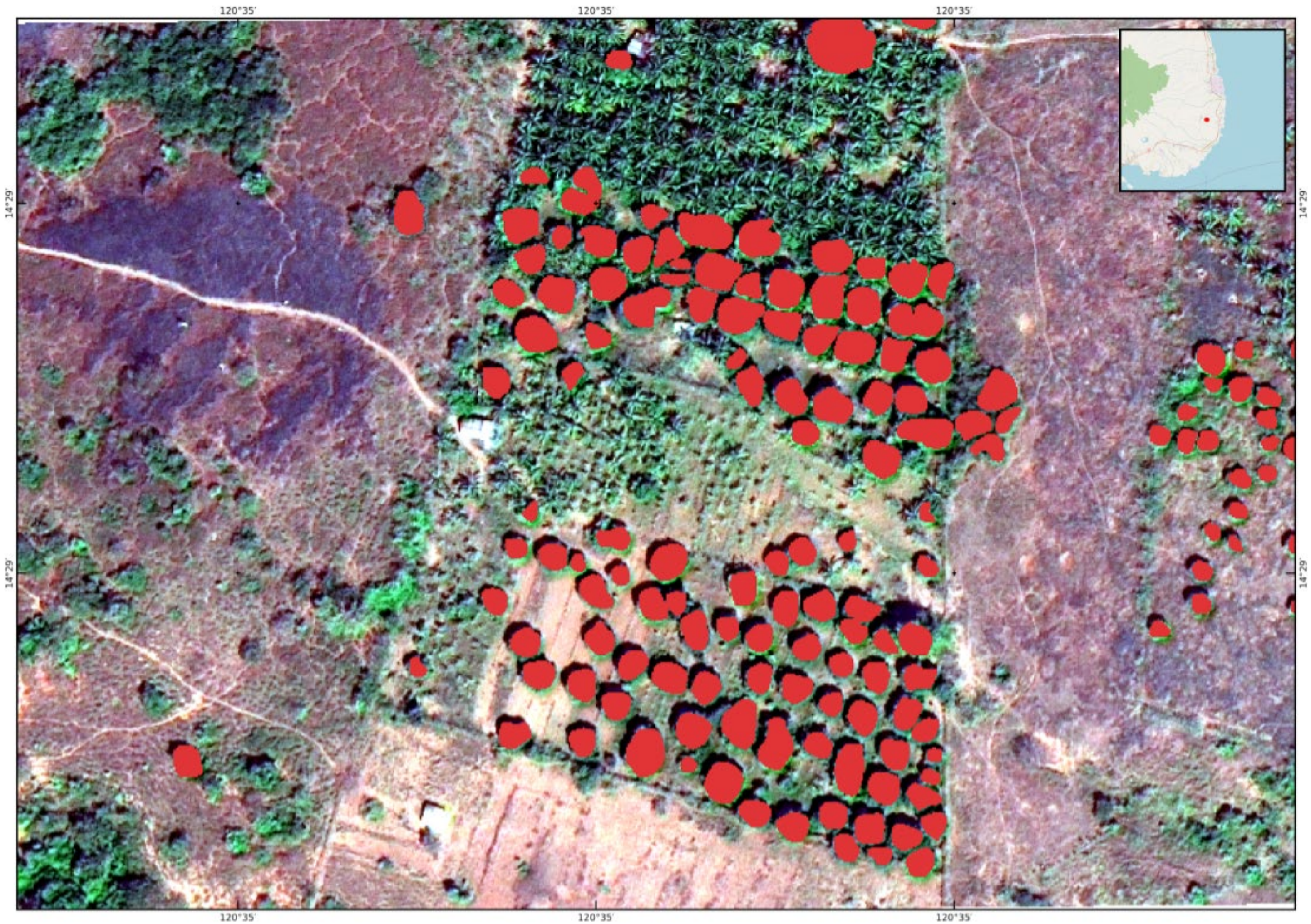
Satellite: Digital Globe
Accessed via: DOST-ASTI PEDRO Center
Capture date : May 2018
Payload: Optical
Resolution: 0.5 m
Basemap: OpenStreetMap (inset)

Detecting Trees

Satellite Detection of Fruit Bearing Trees

According to the Department of Agriculture, the volume of production and yield of mango have significantly deteriorated over the years. Despite hectares of mango farms around the country, there is no sufficient data on mango tree inventory. With the available image processing techniques and Earth observation data from DOST-ASTI, a rapid inventory of mango trees in a given area as well as assigning their geographic coordinates for ground-truthing is now possible.

In an ongoing collaboration with the Bataan Peninsula State University, DOST-ASTI employs this research for the province-wide Mango Detection Project of Bataan (for inventory and potential damage assessment).



N

LEGEND

Mango trees

1 VHR Imagery

Satellite: Digital Globe
Accessed via: DOST-ASTI PEDRO Center
Capture date: May 2018
Payload: Optical
Resolution: 0.5m
Basemap: OpenStreetMap (inset)

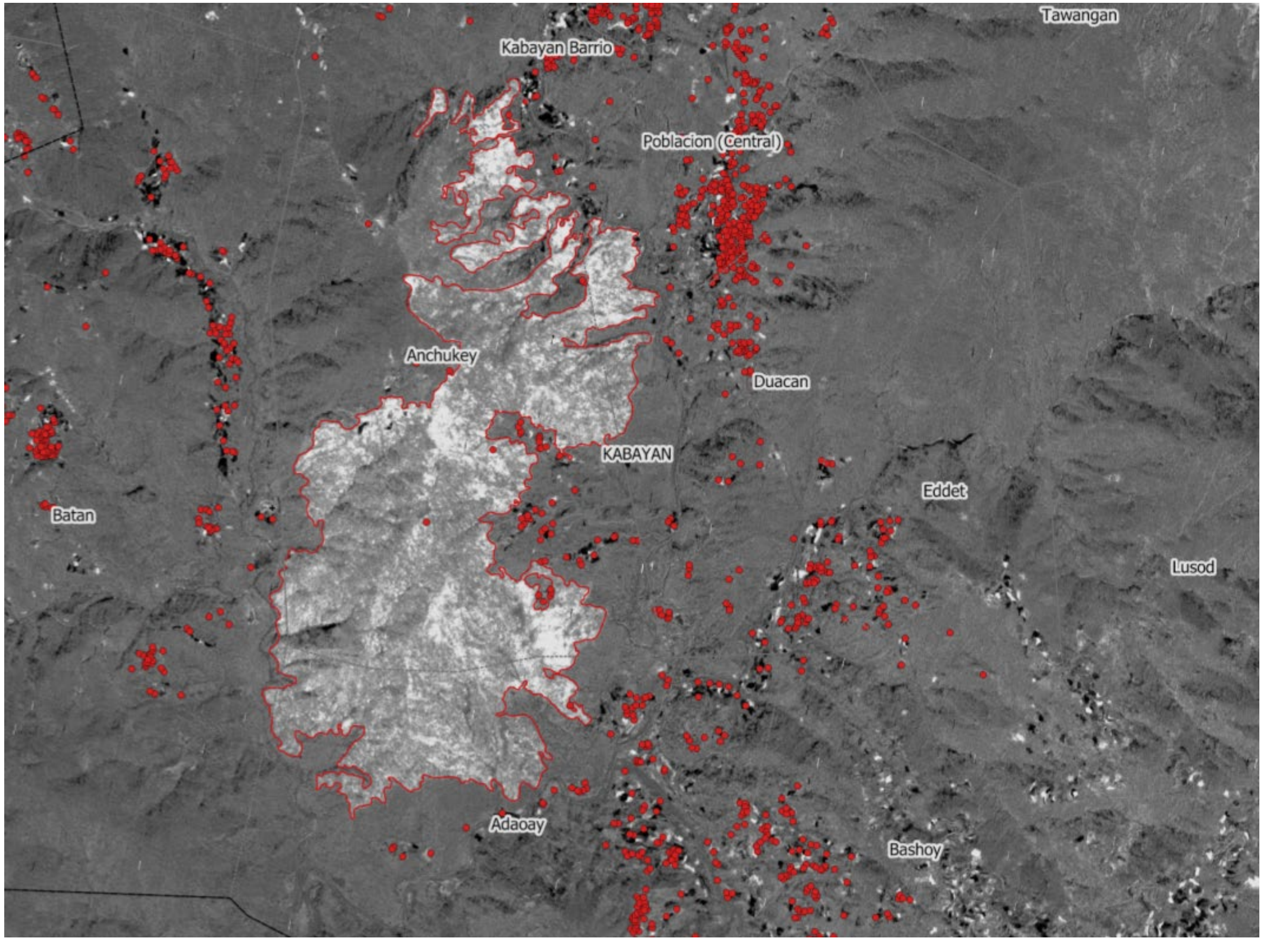
Cartographic Information

Coordinate System: WGS 84/UTM

0 0.02 0.04 0.06 0.08 km

Disaster Risk Management

3



Estimating Typhoon Strength

Assessing Flood Damage

Enabling Timely Disaster Response

Assessing Earthquake Damage

Assessing Forest Fire Damage

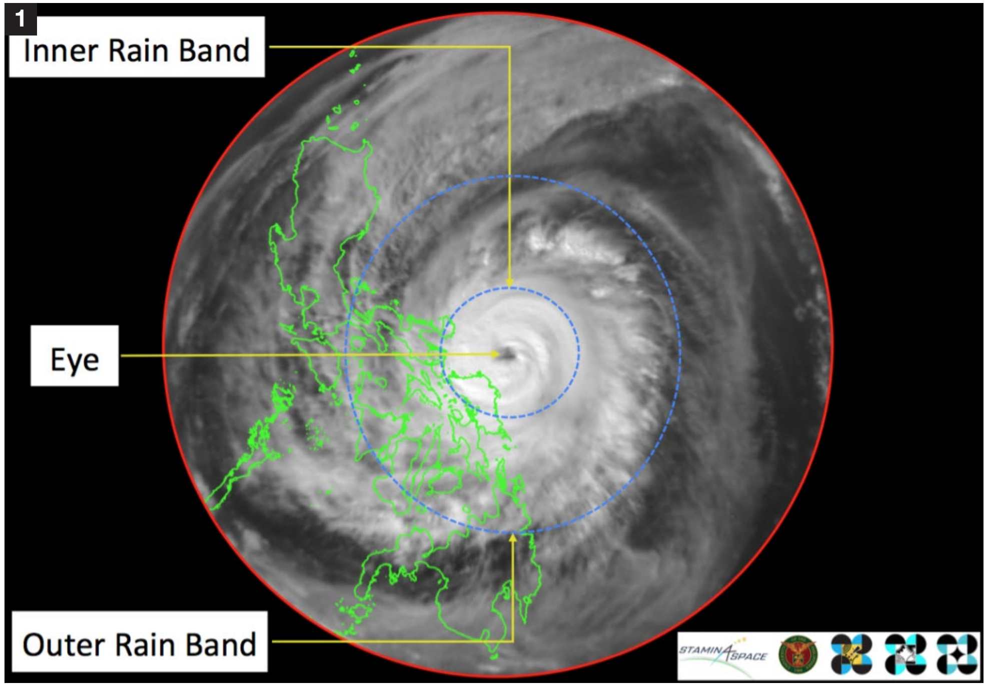
Monitoring Volcanic Activity

Estimating Typhoon Strength

Typhoon Tisoy (Kammuri) over the Philippine Area of Responsibility (PAR)

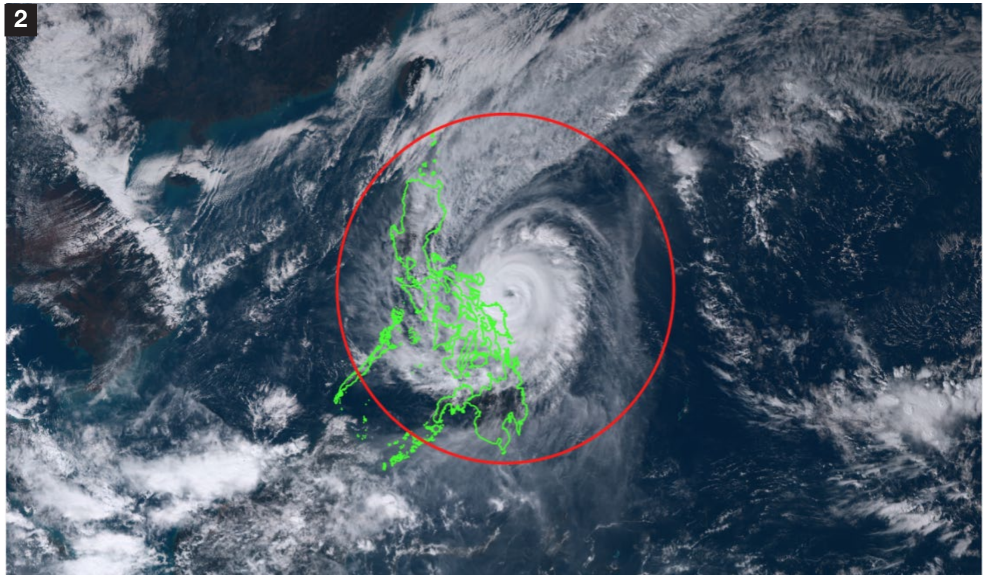
While Diwata-1 and Diwata-2 are used for Earth Observation, they can also give us images that can be used to study atmospheric conditions like typhoons. These images of Typhoon Tisoy (Kammuri) were captured before it made landfall in Sorsogon on December 2, 2019. By analyzing the image captured by Diwata-2's Wide Field Camera (WFC) further, researchers were able to estimate the intensity of the typhoon.

Based on the presence of a well-defined eye and curved rain band patterns estimates a Current Intensity (CI) number of 4.5, which is equivalent to a maximum sustained winds of 143 kph. This was validated in a weather bulletin released by the Philippine Atmospheric, Geophysical and Astronomical Services and Administration (PAGASA) released at 2:00 p.m. on December 2, where it reported a maximum sustained winds of 150 kph.



1

Satellite: Diwata-2
Accessed via: STAMINA4Space Program
Capture date: 09 December 2019
Payload: Wide Field Camera (WFC)
Resolution: 7km



2

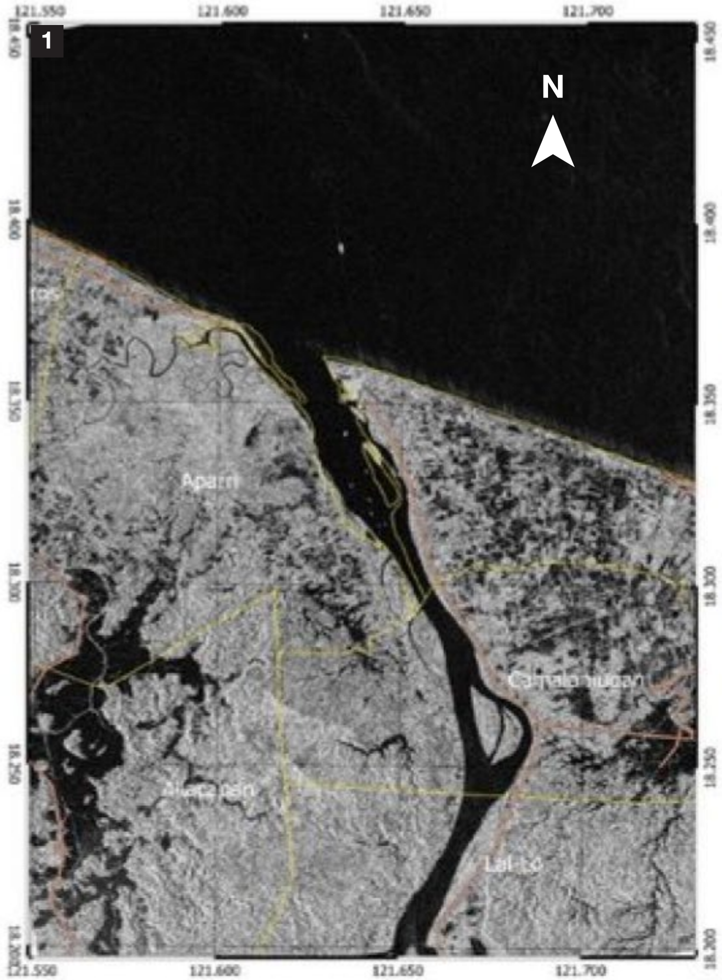
An RGB subset from Himawari-8 acquired on 02 December 2019 at 13:00 PHT.

The red circle indicates the extent of area captured using Diwata-2's Wide Field Camera (WFC).

Assessing Flood Damage

Aparri, Cagayan during Typhoon Falcon

Comparing the pre-disaster and post-disaster images, areas affected by possible flooding were identified. These are the areas with more than 95% change in pixel identity.



LEGEND

- Road Networks
- Possible Findings
- Municipal Boundaries

1

SAR Image

Satellite: KOMPSAT-5
Accessed via: DOST-ASTI PEDRO Center
Capture date: 16 July 2019
Resolution: 2m

2

SAR Image

Satellite: KOMPSAT-5
Accessed via: DOST-ASTI PEDRO Center
Capture date: 25 May 2018
Resolution: 2m

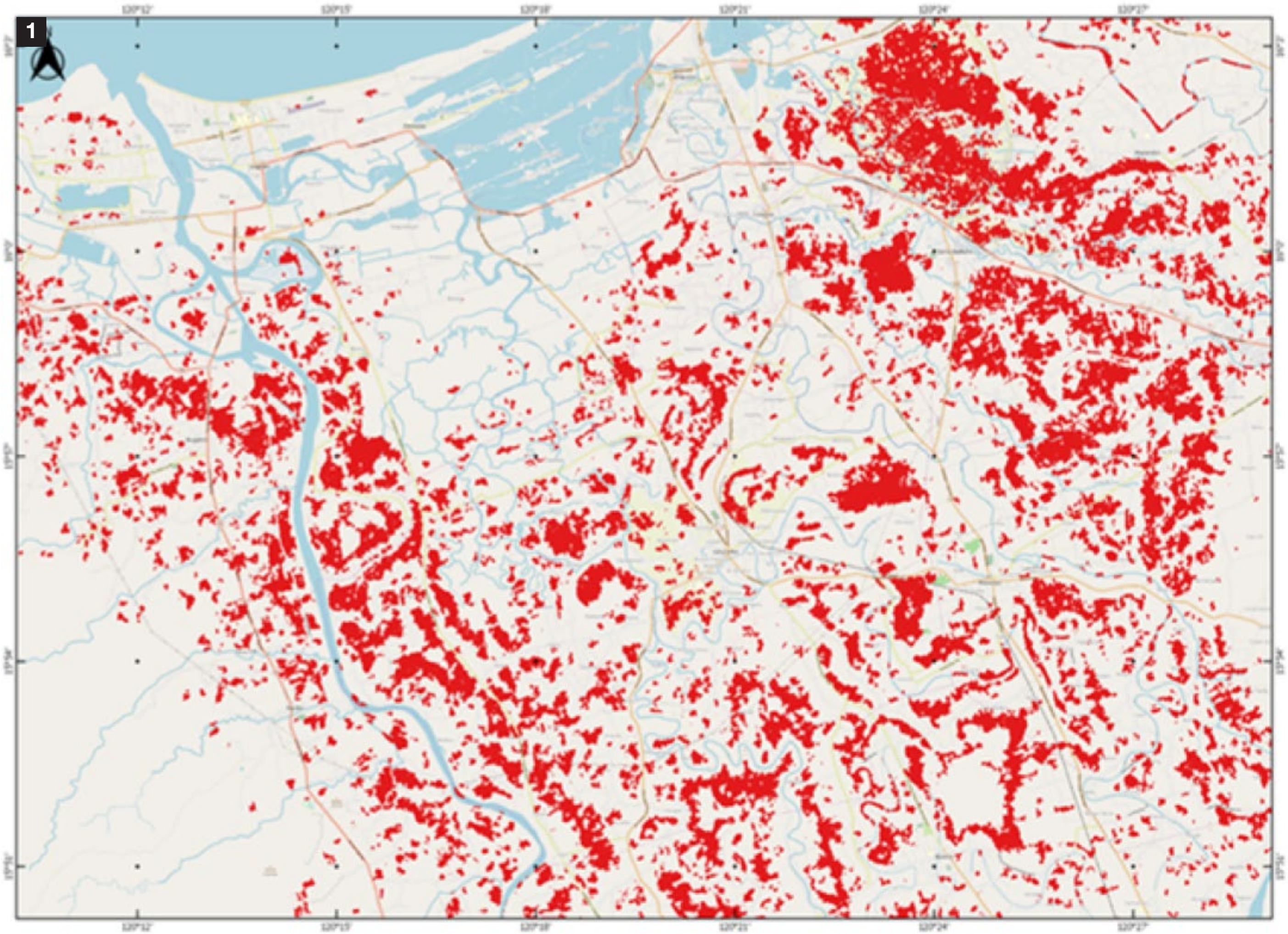
Assessing Flood Damage

Flood Situation Map in Region 2

Areas in red were potentially-flooded areas in Northern Leyte during the onslaught of Tropical Storm Agaton (Bolaven) in January 2018.

The research employs the use of Convolutional Neural Networks in processing satellite images to detect potentially-flooded areas during hazard events.

The flood situation maps, generated every after extreme weather events, are sent to NDRRMC, OCD, DOST, and affected LGUs to aid in their damage assessment efforts.



N

LEGEND

Potentially-flooded areas

1 Multi-temporal SAR Imagery

Satellite: Sentinel-1A, 1B
Accessed via: DOST-ASTI PEDRO Center
Capture date and time: 10 April 2018, 22 April 2018, 30 December 2016, approximately 6:00 PM PHT
Resolution: 15m
Basemap: OpenStreetMap

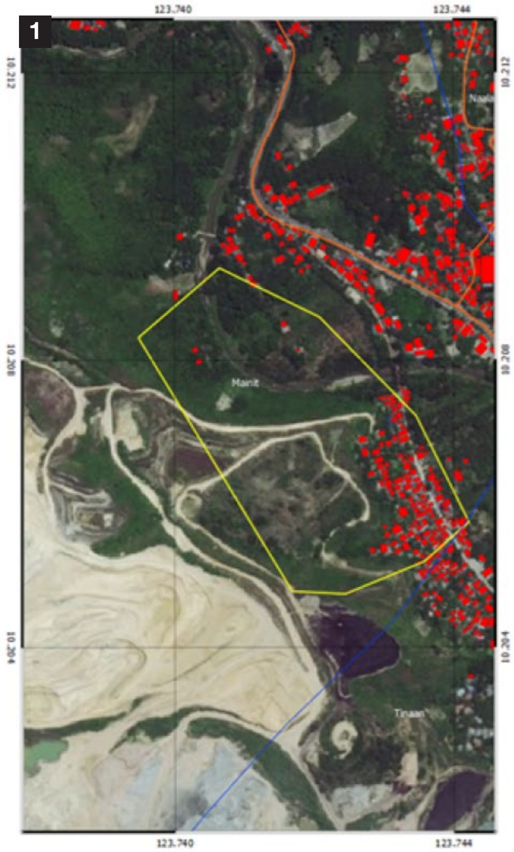
Enabling Timely Disaster Response

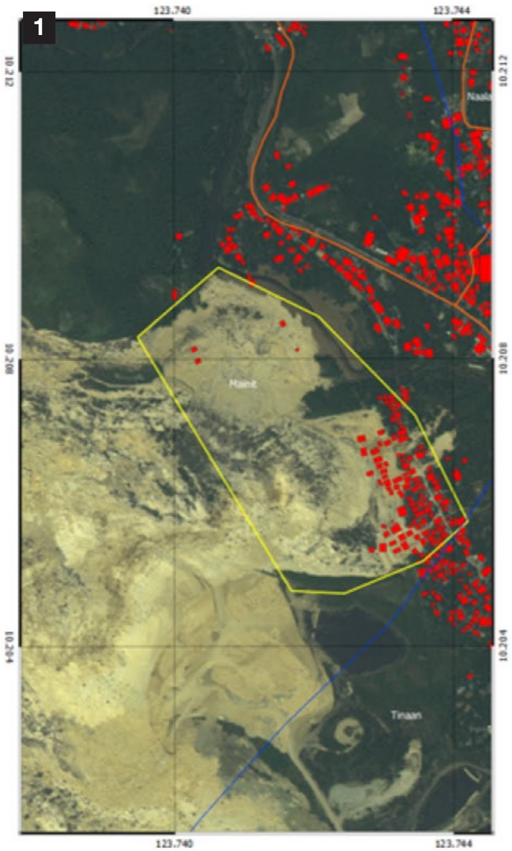
Rapid disaster response in Naga, Cebu landslide

The image shows the areas before and after the landslide event in Naga, Cebu. The map layout was immediately sent a team on the ground. Techniques like machine learning and AI helped enhance rapid disaster response in this situation. The ability to generate this [map] information in a timely manner was crucial.

Identifying building footprints was critical to overlay the extent of the landslide event.

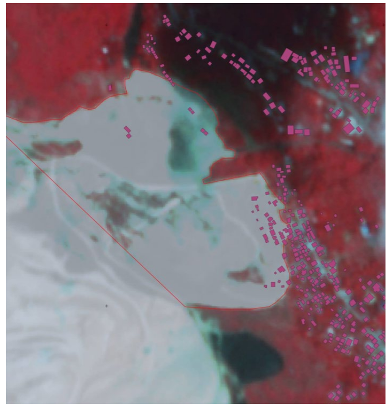
It enabled rescuers to prioritize areas for search and rescue.





LEGEND

- Barangays
- Roads
- Building Footprint
- Landslide Affected Area



1

Satellite: KOMPSAT-3
Accessed via: DOST-ASTI PEDRO Center
Capture date: 21 September 2018
Payload: Optical
Resolution: 0.5 m
Basemap: ESRI (Pre-landslide)

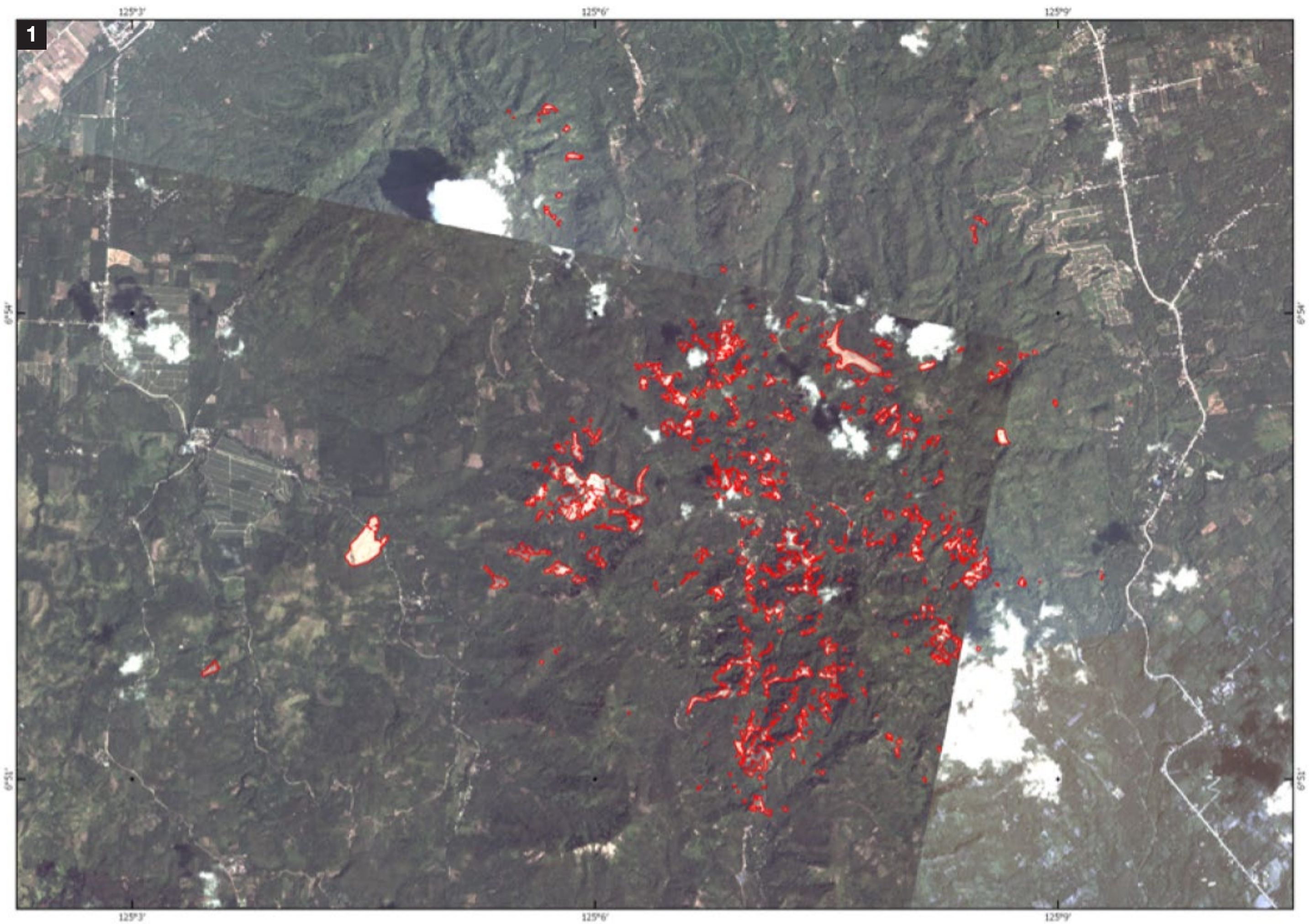
Assessing Earthquake Damage

Rapid detection and mapping of earthquake-induced landslides in Makilala, Cotabato

The image shows the areas potentially affected by earthquake-induced landslides in Makilala, Cotabato. Artificial Intelligence (AI) models were used to predict the bare soil and vegetation cover from Planetscope satellite images. Areas with changes from vegetation to bare soil are interpreted as the potential landslide areas. The hazard event was triggered by multiple quakes that hit large parts of Mindanao in 29-31 October 2019.

Identifying the extent of landslides through advanced image processing techniques immediately after the event can potentially aid in the rapid damage assessment and response operations of DRRM actors on the ground.

This image was shared with Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the Cotabato LGU.



N

LEGEND

Landslide areas

1

Satellite: Planetscope
Accessed via: DOST-ASTI PEDRO Center
Capture date : 08 November 2019
Resolution: 3m

Cartographic Information

Coordinate System: WGS 84/UTM Zone 51N

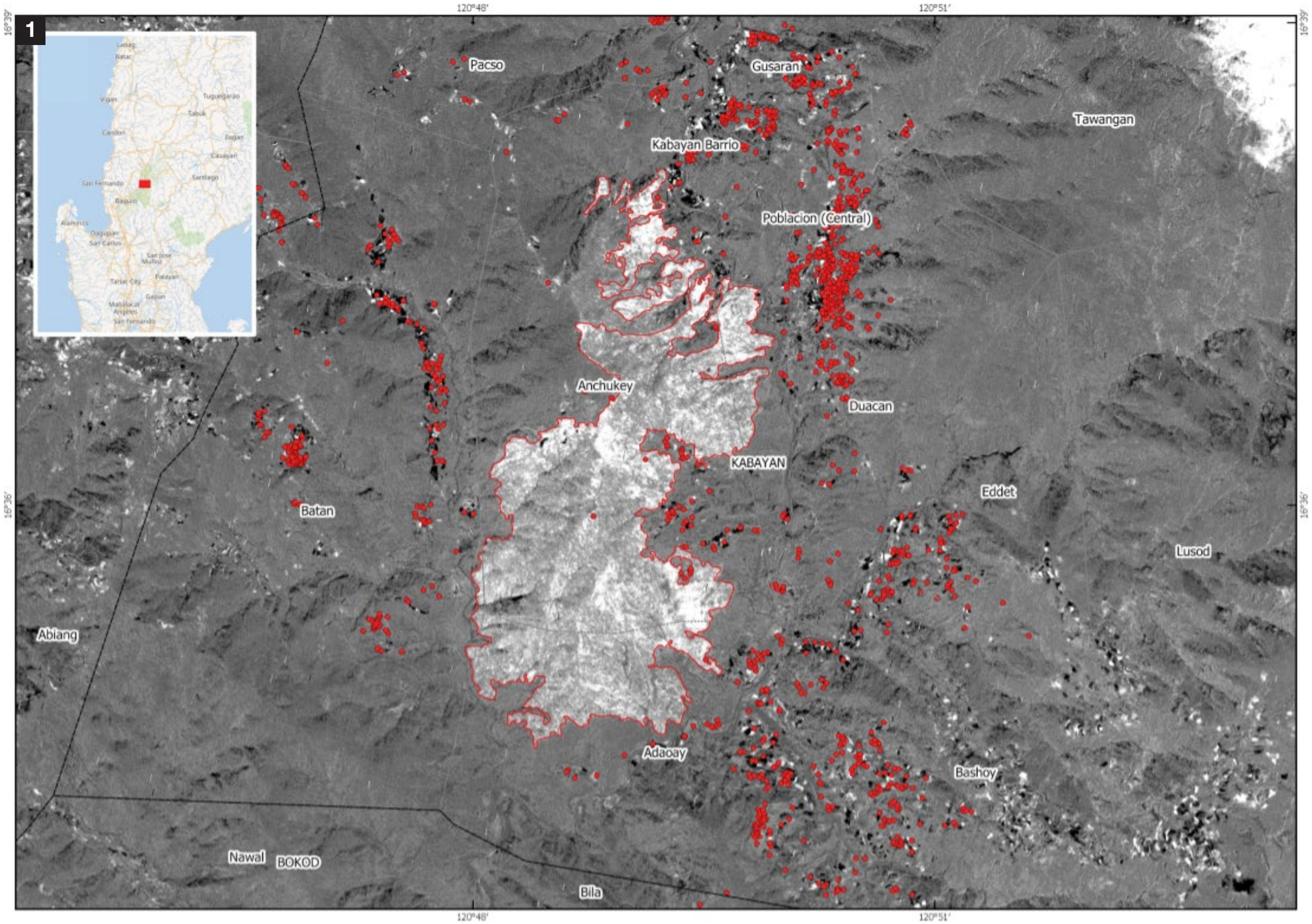
0 1 2 3 4 km

Assessing Forest Fire Damage

Rapid detection of affected areas in Kabayan, Benguet

The image shows potentially burnt areas in Barangays Adaoay, Anchokey, and Kabayan Barrio in Kabayan, Benguet. The fire extents are detected by analyzing change in vegetation (NDVI) from Planetscope Images captured from 28 January and 22 February 2020.

NDVI or Normalized Difference Vegetation Index (NDVI) is an index used as an index indicator to determine features in an image with live green vegetation because vegetated areas have high values of NDVI. A drastic change (drop) in the NDVI values indicates activities contributing to the death or removal of live green vegetation.



N

LEGEND

- Buildings/Houses
- Burnt Extent
- Barangay Boundary
- Municipal Boundary

1 **Satellite:** Planetscope
Accessed via: DOST-ASTI PEDRO Center
Capture date : 28 January to 22 February 2020
Resolution: 3m
Basemap: OpenStreetMap

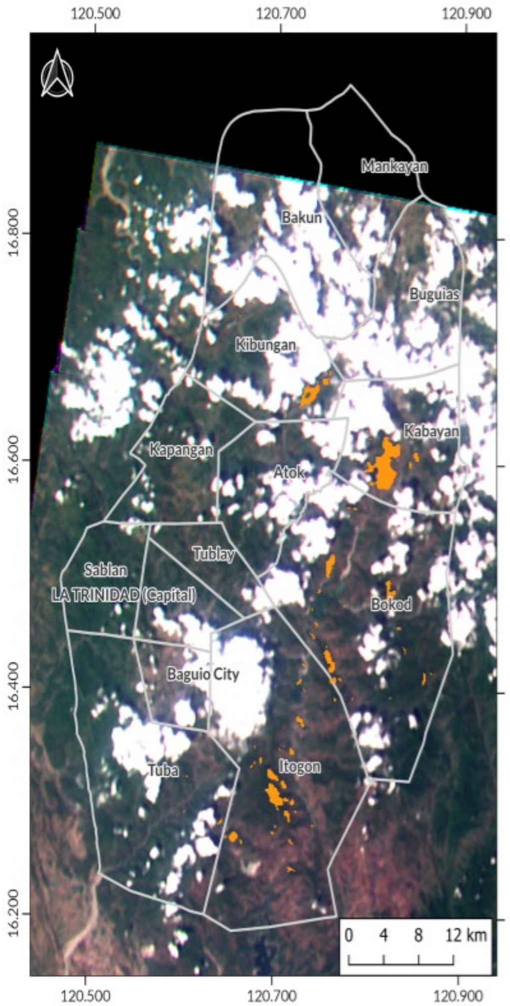
Assessing Forest Fire Damage

Identifying other affected areas in Benguet using Diwata-2

In the same event mentioned previously, Diwata-2 was used to identify other areas in Benguet that were affected. Approximately 2,714.59 hectares were burnt, excluding other possibly undetected areas covered by clouds and their shadow. Affected areas include Itogon, Bokod, Kabayan, Kibungan, and some parts of Tuba. Maps like these, made using Support Vector Machine (SVM) and Burned Area Index (BAI), can be used to complement other data used by agencies tasked with post-disaster assessment and rehabilitation.

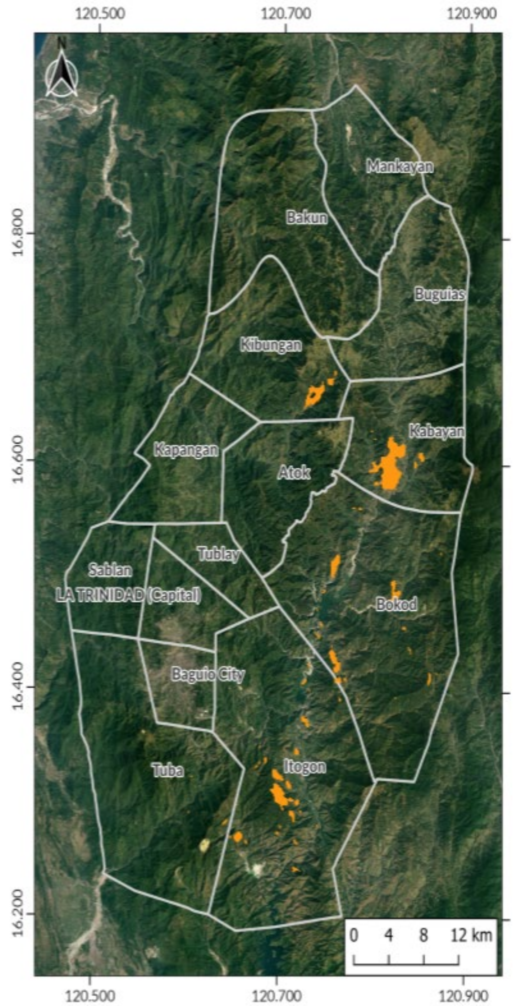
LEGEND

- Benguet municipal boundary
- Burned areas



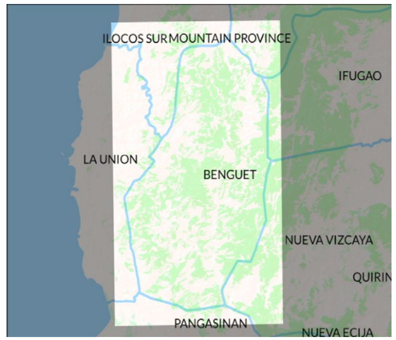
1 **True-Color/RGB image with identified burned areas**

Satellite: Diwata-2
Accessed via: STAMINA4Space
Capture date: 29 February 2020
Payload: Spaceborne Multispectral Imager (SMI)



2 **Diwata-2 Burned Area Map**

Overlaid on an RGB basemap, using Support Vector Machine (SVM) and Burned Area Index (BAI)



Monitoring Volcanic Activity

Tracking Mayon Volcano's eruption plume

When the Mayon Volcano erupted on January 2018, the PEDRO Center accessed optical images of Albay, Bicol captured by Planet's Dove satellites (top image). The danger zones and affected areas were identified. These images were distributed to local government units and government agencies like the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and National Disaster Risk Reduction and Management Council (NDRRMC) to assist in their operations.

Plumes and ashfall from Mayon Volcano eruption

The Diwata-1 image (bottom) was captured two weeks after the image shown above was captured. This image shows volcanic plumes coming from Mayon Volcano, vividly depicted as a bright white streak near the center of the image. Wind simulations show that the wind direction in the area during the acquisition time was coming from the northeast. This coincides with the observed dispersion of plumes relative to the volcano. Other portions of the image appear whitish due to the cloud cover passing over the captured areas at that time.

1

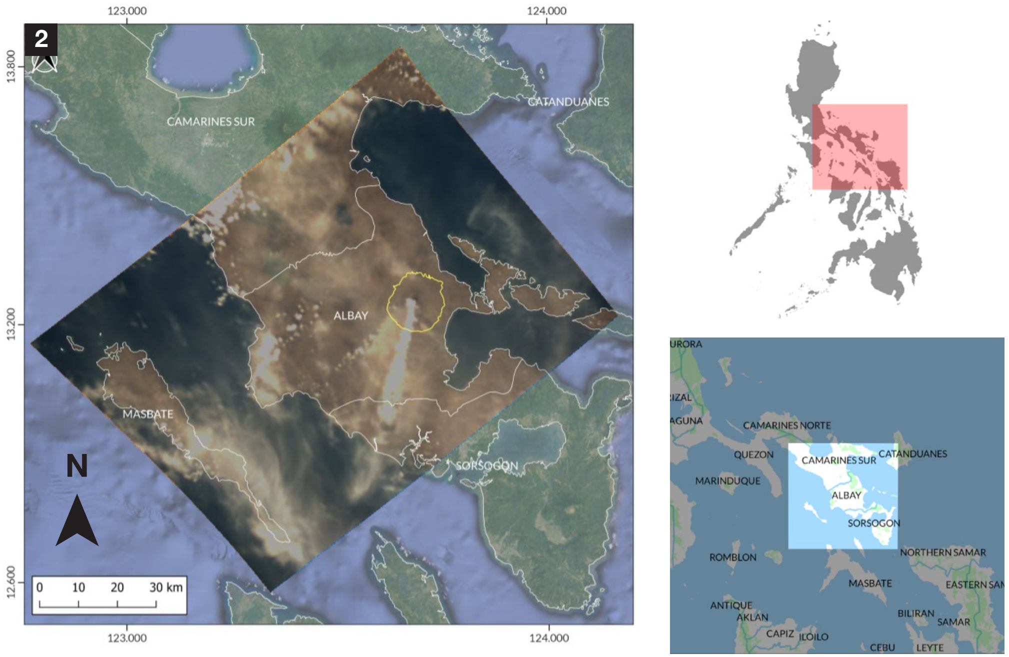
Satellite:
PlanetScape

Accessed via:
DOST-ASTI PEDRO Center

Capture date:
21 January 2018

Payload:
Optical

Resolution:
3m



2

Satellite:
Diwata-1

Accessed via:
STAMINA4Space

Capture date:
30 January 2018

Payload:
Middle Field Camera (MFC)

Resolution:
287m

Basemap:
PhilGiS and Google Earth

LEGEND

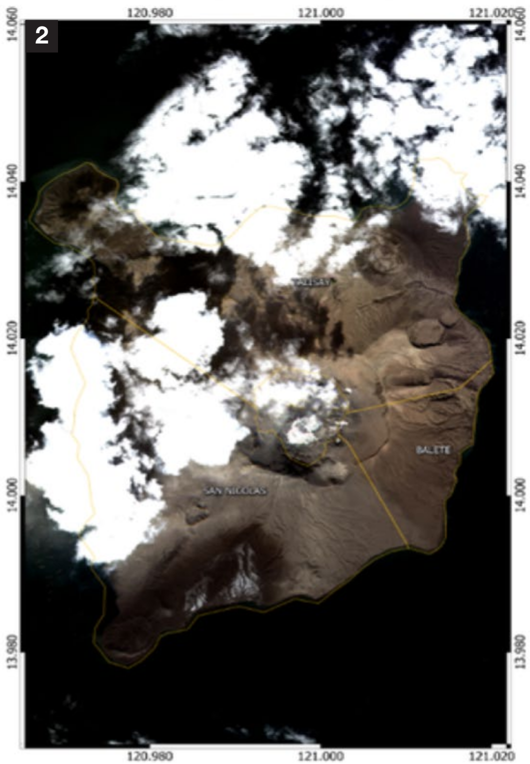
Mayon Volcano

Monitoring Volcanic Activity

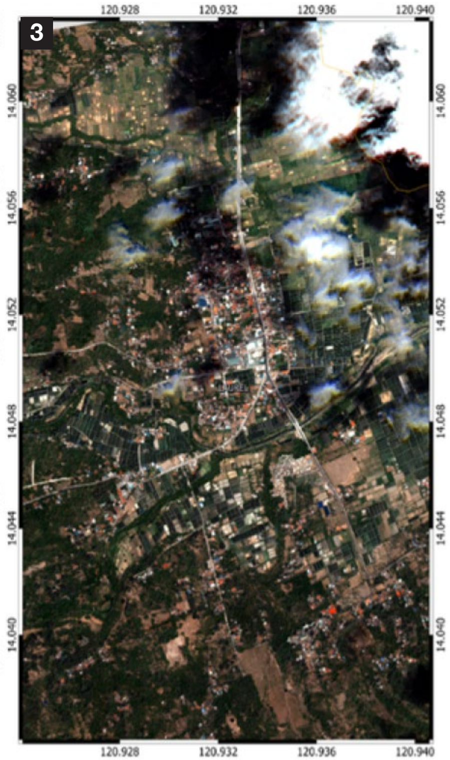
Ashfall from Taal Volcano Eruption last January 2020

The extent of the ashfall from the Taal Volcano eruption may be used by LGUs for post-disaster resource prioritization. For example, the ashfall reaching bodies of water such as Laguna de Bay may induce a change in its water quality.

Emissions of the Taal Volcano



Pre- and Post-Disaster Images



1 Optical Image

Satellite: KOMPSAT-3A
Accessed via: DOST-ASTI PEDRO Center
Capture date: 05 April 2019
Payload: KOMPSAT-3
Resolution: 70 cm
Basemap: OpenStreetMap

2 Optical Image

Satellite: KOMPSAT-3A
Accessed via: DOST-ASTI PEDRO Center
Capture date: 16 January 2020
Payload: KOMPSAT-3
Resolution: 70 cm
Basemap: OpenStreetMap

3 Optical Image

Satellite: KOMPSAT-3A
Accessed via: DOST-ASTI PEDRO Center
Capture date: 05 April 2019
Payload: KOMPSAT-3
Resolution: 70 cm
Basemap: OpenStreetMap

4 Optical Image

Satellite: KOMPSAT-3A
Accessed via: DOST-ASTI PEDRO Center
Capture date: 16 January 2020
Payload: KOMPSAT-3
Resolution: 70 cm
Basemap: OpenStreetMap

Defense and Security

4

Monitoring Offshore Infrastructure

Detecting Damages

Enhancing Maritime Domain Awareness

Monitoring Offshore Infrastructure

Infrastructure in Mischief Reef, Subi Reef, and Fiery Cross Reef

The Philippines is a mission partner in the NovaSAR-1 satellite, which has Synthetic Aperture Radar (SAR) imaging capability. As a mission partner, the country can undertake data tasking and acquisition, allowing access to NovaSAR-1 SAR raw data and image processing for various applications. SAR is ideal for continuous monitoring of tropical countries like the Philippines for its ability to penetrate clouds, allowing us to capture clear images even on cloudy skies. Shown in this picture are details of built infrastructure such as those in offshore islands.

In the figure below, we compared images from an optical satellite and NovaSAR- 1. Due to its cloud penetrating capability, images from NovaSAR-1 gave us an unobstructed view of the built infrastructure on the offshore islands.

1 Mischief Reef

Satellite: NovaSAR
Capture date: 19 March 2020, 11:04:04 AM PHT
Accessed via: SiyaSAT Portal
Payload: Stripmap_HH
Resolution: 6m

2 Subi Reef

Satellite: NovaSAR
Capture date: 01 December 2019, 10:06:13 AM PHT
Accessed via: SiyaSAT Portal
Payload: Stripmap_HH
Resolution: 6m

3 Fiery Cross Reef

Satellite: NovaSAR
Capture date: 07 January 2020, 10:06:13 AM PHT
Accessed via: SiyaSAT Portal
Payload: Stripmap_HH
Resolution: 6m

Detecting Damages

Prototype damage detection using Artificial Intelligence (AI) in Marawi City

AI is capable of analyzing spatial patterns, shapes and forms. With this capability, it is able to identify damaged areas due to their non-uniform shapes or forms.

1 VHR Optical Imagery

Satellite: Worldview
Accessed via: DOST-ASTI PEDRO Center
Capture date: April 2018
Resolution: 0.5m
Basemap: OpenStreetMap (inset)

N

LEGEND

Damaged areas

Cartographic Information

Coordinate System: WGS 84/UTM

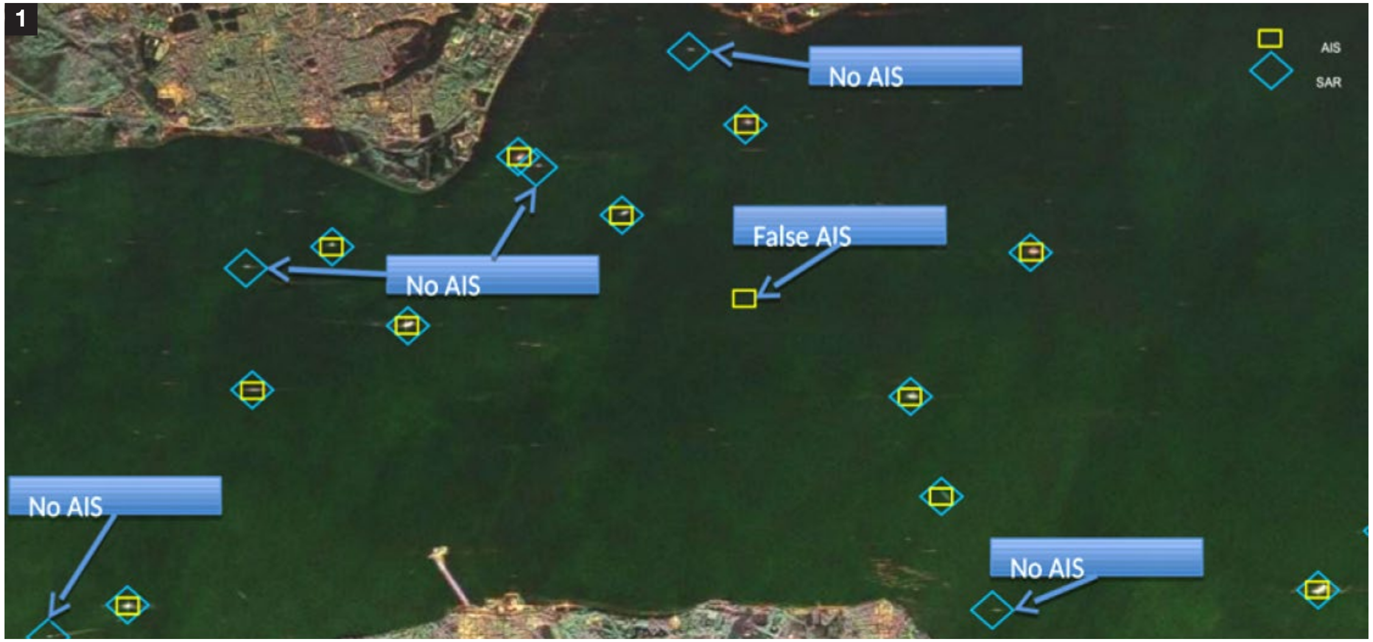
0 0.01 0.02 0.03 0.04 km

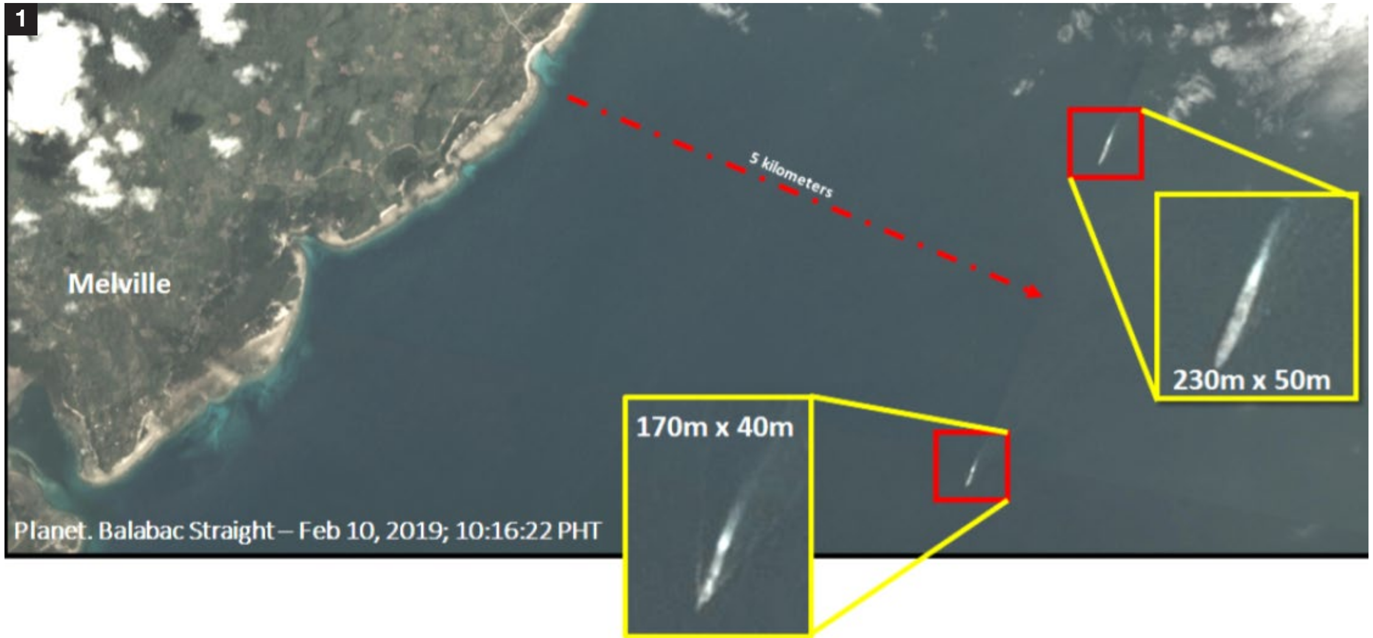
Enhancing Maritime Domain Awareness

Detecting ships in Balacbac Strait, Palawan

An automatic ship detection algorithm will be built into the SIYASAT portal to serve as a complementary maritime surveillance and monitoring system for the National Coast Watch.

These images have been used to validate reports of sightings of foreign vessels in collaboration with the Philippine Navy's Maritime Research Information Center.



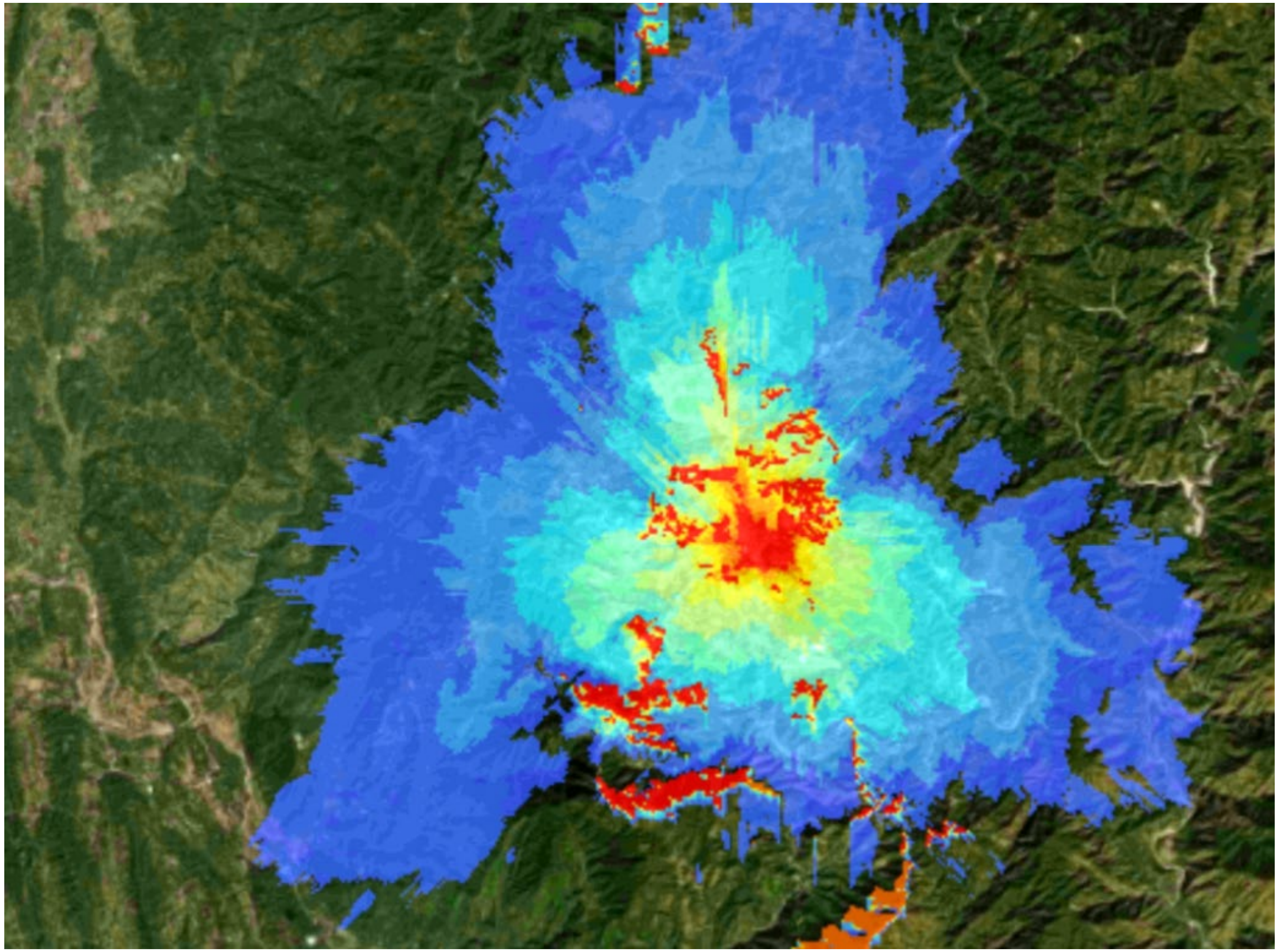


1

Satellite: Dove Satellites
Accessed via: DOST-ASTI PEDRO Center
Capture date: 20 February 2019
Payload: PlanetScope
Resolution: 3m
Basemap: OpenStreet Map

Planning and Econometrics

5



Mapping Connectivity

Identifying Warming Economic Zones

Monitoring Post-Disaster Recovery Using Nightlights

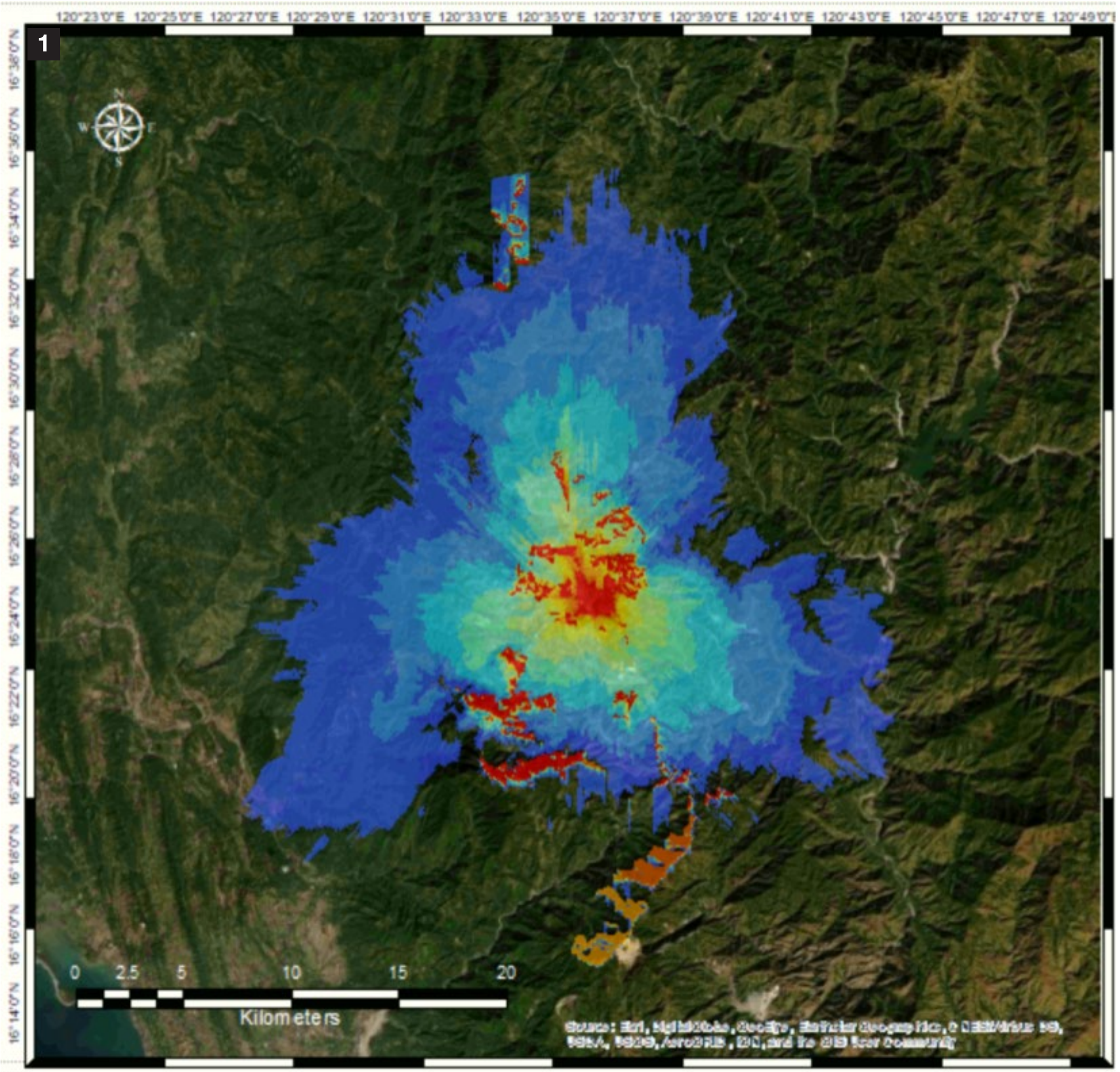
Assessing Population Displacement Using Nightlights

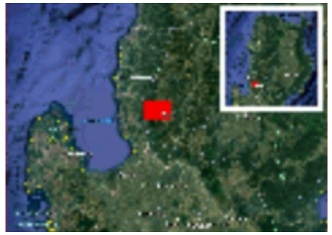
Predicting Poverty and Consumption-based Wealth Using Nightlights

Mapping Connectivity

Signal Assessment using Geospatial Analysis Project (SAGAP)

Currently, DOST-ASTI is conducting data collection and processing to examine the potential of radio frequency modelling and planning in assessing signal propagation. The study will use satellite images from the PEDRO Center, Diwata microsatellites, open source satellite data, and elevation data from the PHL-Lidar project and NAMRIA. The information generated from these assessments can be used by the Department of Information and Communications Technology (DICT), telecommunication companies, TV and radio operators, and other stakeholders operating wireless sensor networks and rural networks to strategically place their transmitters while considering radio parameters, geographical conditions, and possible obstructions.





LEGEND

Received power (dBm)

- less than -110
- -109 to -105
- -104 to -100
- -99 to -95
- -94 to -90
- -89 to -85
- -84 to -80
- -79 to -75
- -74 to -70
- -69 to -65
- -64 to -100

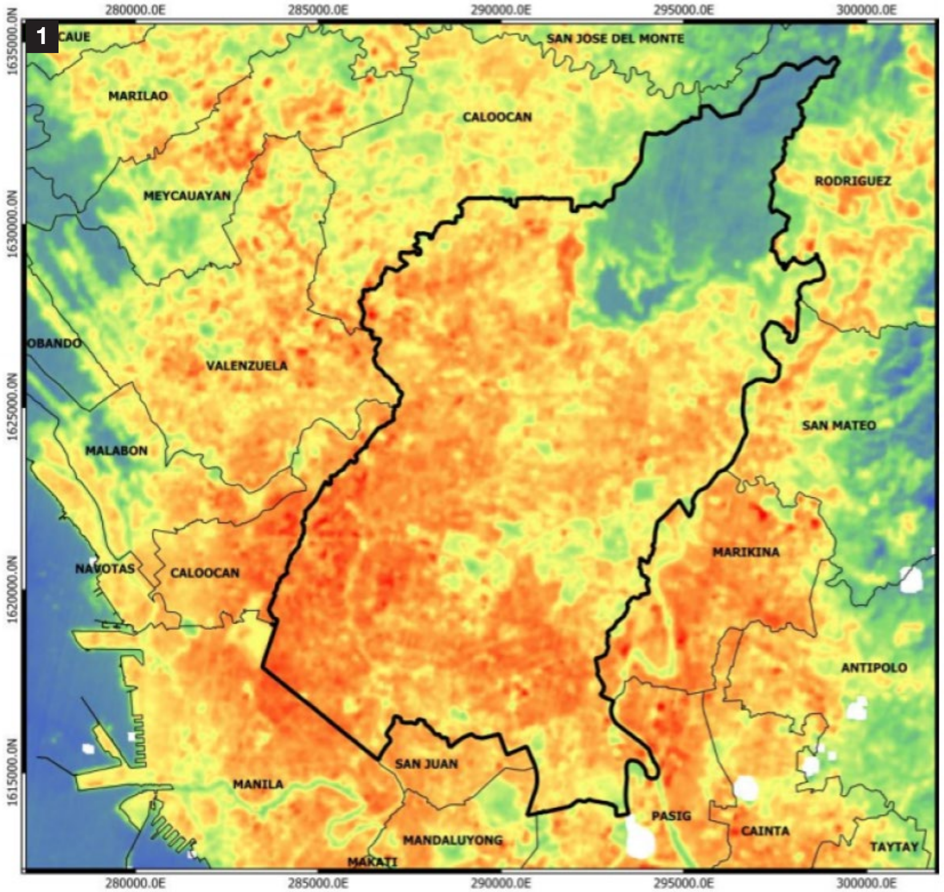
1 **Satellite:** Advanced Land Observing Satellite "DAICHI" (ALOS)
Accessed via: JAXA EORC
Capture date and time: 2016 (release of global DSM)
Payload: Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM)
Resolution: 30m (Digital Surface Model)
Basemap source: ESRI

Identifying Warming Economic Zones

Geospatial Assessment and Modelling of Urban Heat Islands (GUHeat) in Quezon City

This image is the daytime Land Surface Temperature (LST) map of Quezon City. Here, one can see which areas are hotter (dense clusters of establishments) as indicated in red. This is the work of Geospatial Assessment and Modelling of Urban Heat Islands in Philippine Cities (GUHeat), which studies thermal images from satellites to minimize the warming of urban areas or urban heat islands (UHIs), and even reverse it to decrease electricity consumption and air pollution, reduce health risks and diseases, that will result to greater livability.

The project was formed to find ways to mitigate the harmful effects of the rising temperatures in urban areas, assessing the development of urban heat islands in rapidly urbanizing and highly urbanized cities in the Philippines using satellites and modeling-simulation techniques.

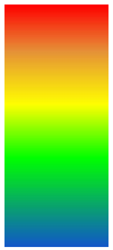


0 1 2 3 4 5 km

1 : 120 000

N

LST
(Degree Celsius)



LEGEND

☐ Quezon City

☐ Boundary

1

Satellite: Sentinel 2-A
Accessed via: Project GuHEAT
Capture date: 05 February 2019
Resolution: 30m
Basemap: Google

For the microclimate modelling in Quezon city, specific sites were chosen within the Commercial Business District (CBD) of the city. The areas of study are the following: Timog Avenue, Tomas Morato, Visayas Avenue and UP Diliman.

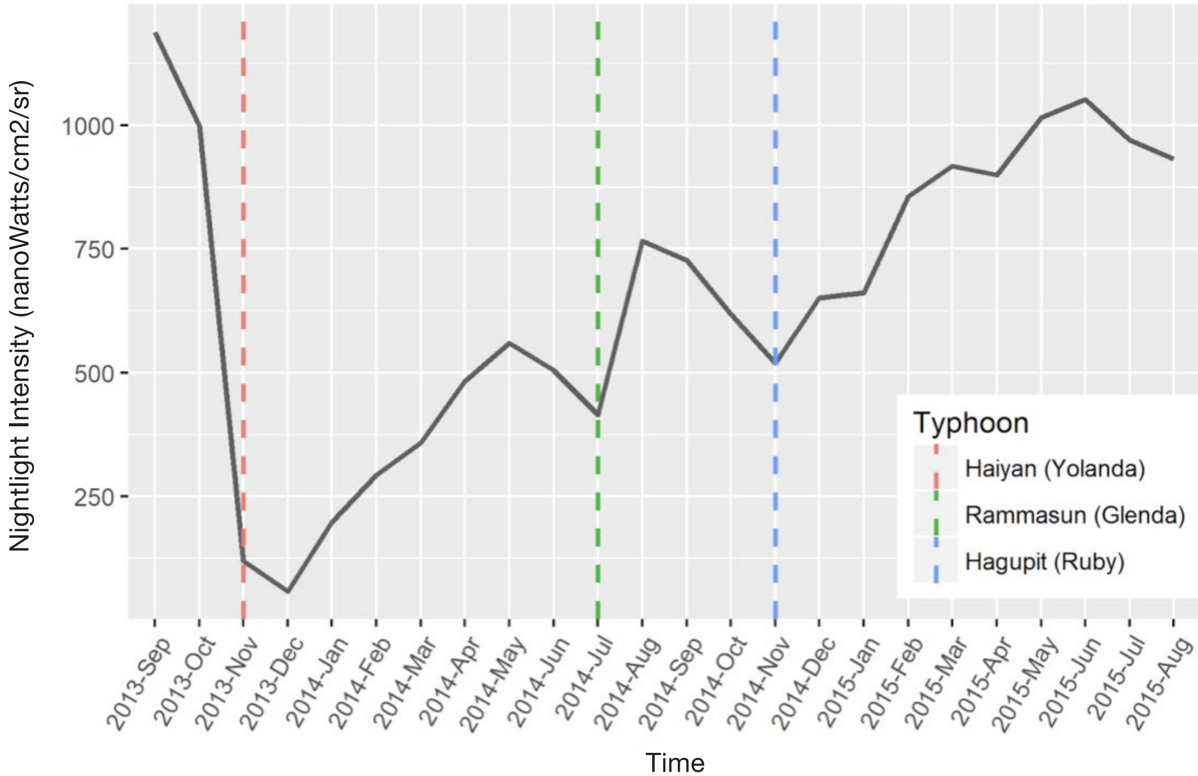
Monitoring Post-Disaster Recovery Using Nightlights

Rehabilitation and recovery in Tacloban, Leyte after Typhoon Yolanda

Nightlights can also be used to track rehabilitation efforts done for disaster-stricken areas like Tacloban, after it was hit by Typhoon Yolanda (Haiyan) on November 2013.

This graph shows that it took 20 months for Tacloban's nighlight intensity to resume to its pre-typhoon record.

Tacloban, Leyte Nightlights (2013 to 2015)



1

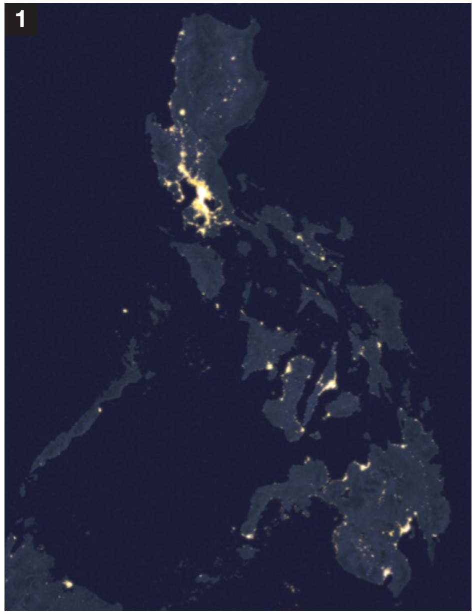
Satellite: Suomi-National Polar Partnership satellite
Accessed via: DOST-ASTI PEDRO Center
Capture date: September 2013 to August 2015
Payload: Visible Infrared Imaging Radiometer Suite (VIIRS)

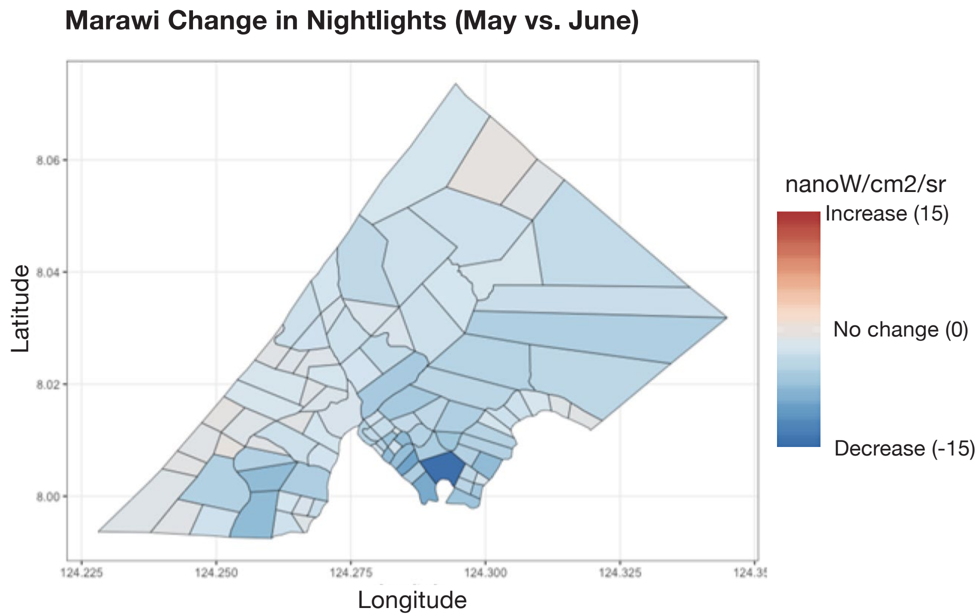
Assessing Population Displacement Using Nightlights

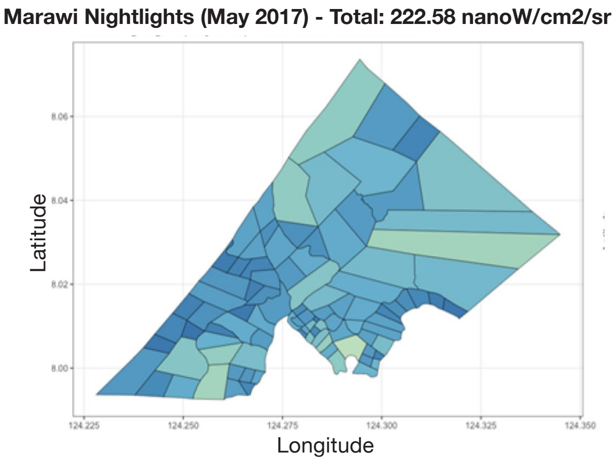
Tracking electrification in Marawi City after the Marawi Siege

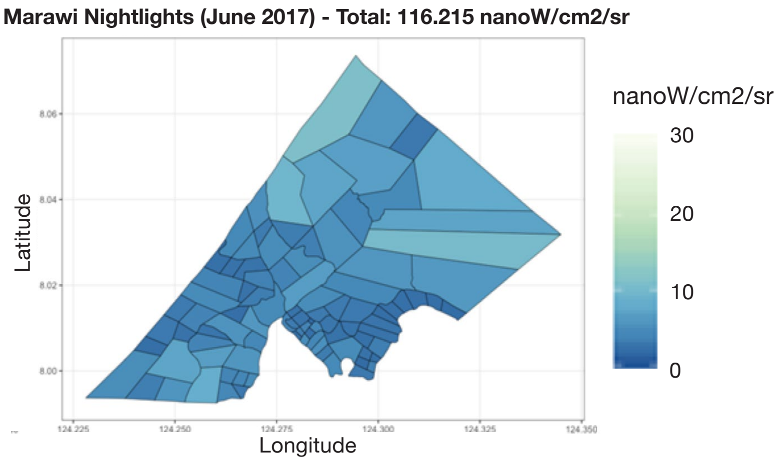
Since electrification is visible in space, studying nightlights can give us data that can be useful in sustainable development studies. In these Visible Infrared Imaging Radiometer Suite (VIIRS) scans of Marawi City, nightlights were seen to have decreased from May 2017 (the start of the Marawi Siege) to June 2017.

The nightlight intensity on a given place can be studied to assess how populations are possibly displaced from the major areas of war to the neighboring cities. In armed conflicts, this kind of intelligence can also aid humanitarian efforts by lessening the need to deploy people on the ground for data collection.









1

Satellite: Suomi-National Polar Partnership satellite
Accessed via: DOST-ASTI PEDRO Center
Capture date: September 2013 to August 2015
Payload: Visible Infrared Imaging Radiometer Suite (VIIRS)

Total nightlight intensity (clustered per barangay) in Marawi City before and after the breakout of the armed conflict.

Predicting Poverty and Consumption-based Wealth Using Nightlights

Nighttime illumination corresponds to wealth through the following assumptions:

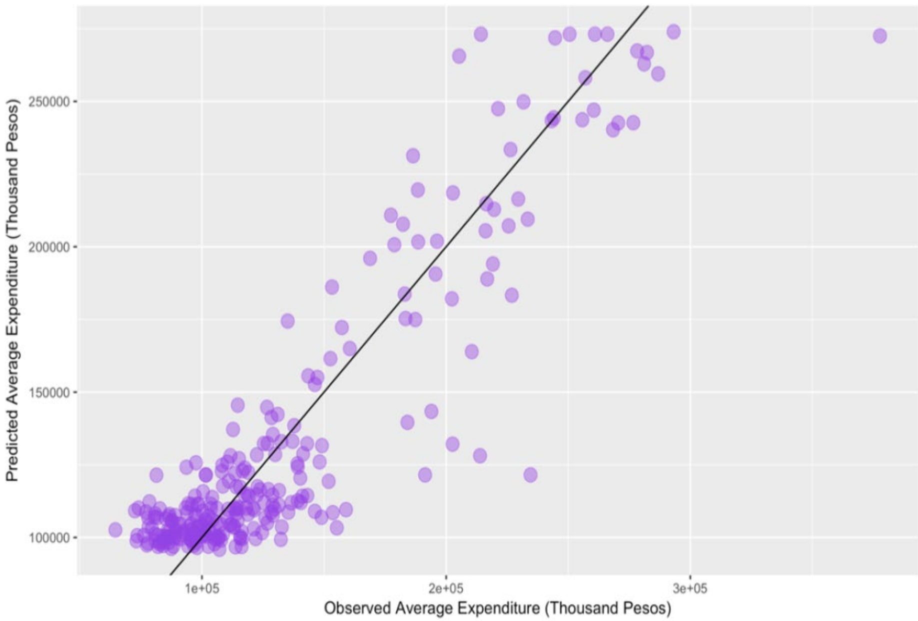
(1) Access to power grid requires financial resources;

(2) Nightlights indicate economic activity leading to higher levels of wealth;

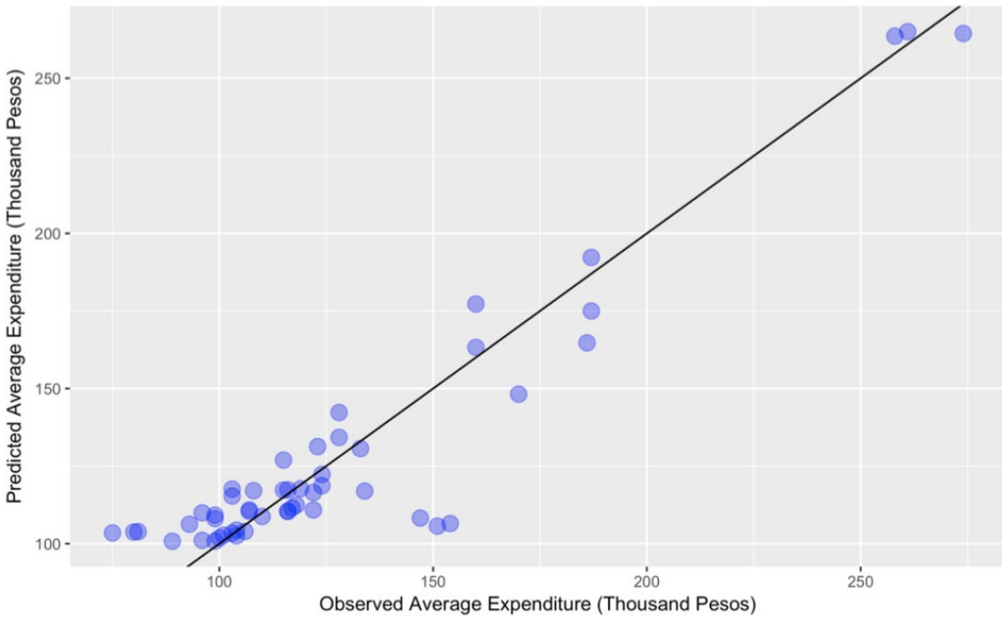
(3) Nighttime illumination (street lamps) can be a result of preferential treatment for specific societal groups.

Analytical models are used to fit the features to household expenditure collected by Philippine Statistics Authority

Generalized Additive Model (Province Nightlights 2006, 2009, 2012)



Generalized Additive Model (Region Nightlights 2006, 2009, 2012)

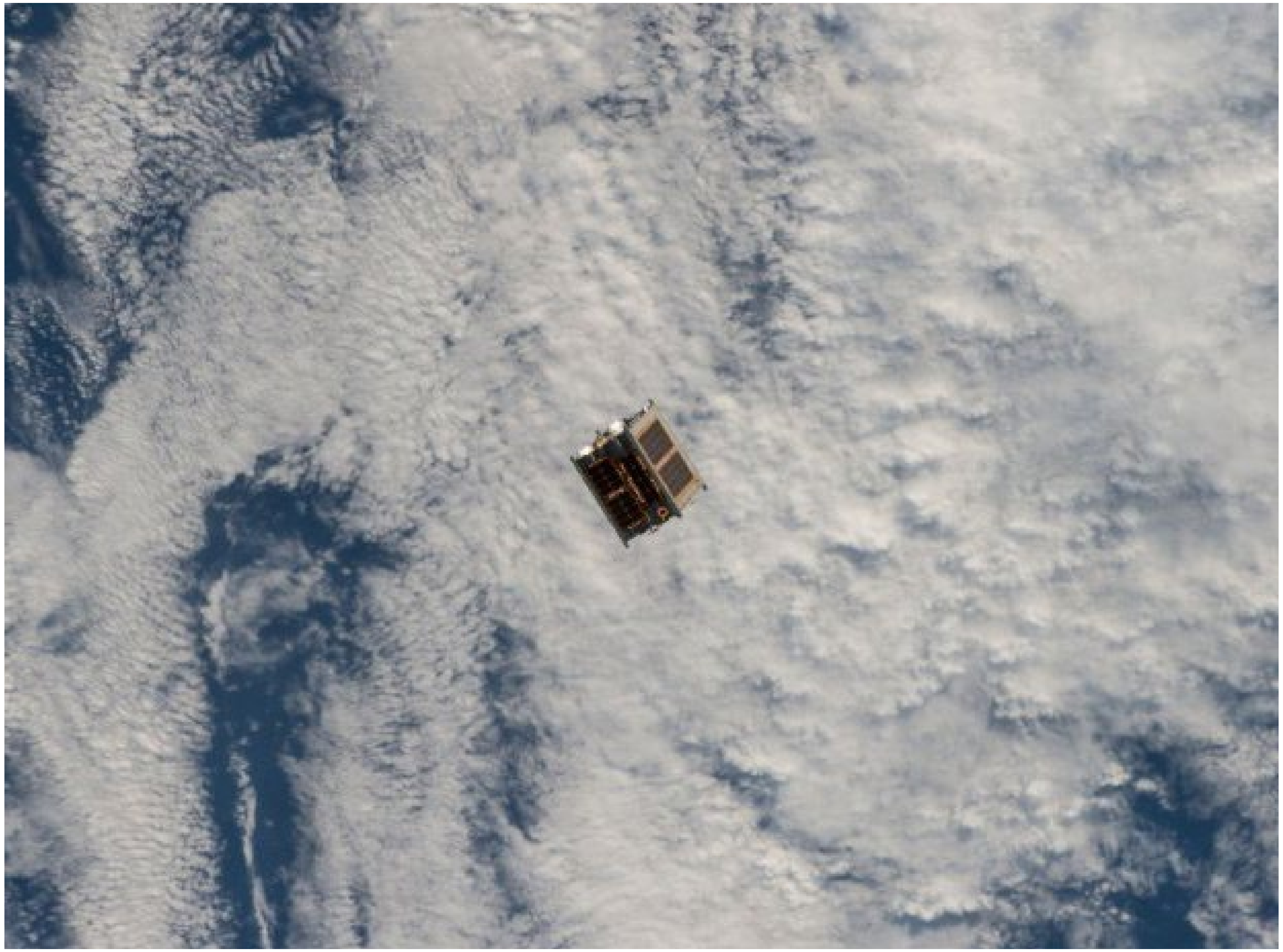


Portfolio of Earth Observation Satellites: In use and accessed

6

Fast Facts:

- Diwata-1
- Diwata-2
- Maya-1
- Maya-2
- Maya-3
- Maya-4
- IRIS-A & B
- KOMPSAT 3, 3A, & 5
- Planet
- GeoEye-1
- WorldView 2, 3, & 4
- COSMO-SkyMed
- NovaSAR-1
- Sentinel
- Landsat



Diwata-1

Fast Facts

Class	Microsatellite (Microsat)
Mass	52.40 kg
Type	Scientific Earth Observation
Dimensions	55 cm x 35 cm x 55 cm
Orbit	Low Earth
Payloads	High Precision Telescope (HPT), Spaceborne Multispectral Imager with Liquid Crystal Tunable Filter (SMI w/ LCTF), Middle Field Camera (MFC), Wide Field Camera (WFC)
Launch	23 March 2016 via Atlas V Rocket from Kennedy Space Center (Cape Canaveral, Florida)
Release	27 April 2016 from the International Space Station (ISS)
Mission/s	*Disaster Response and Management* 1. Assess damages caused by natural disasters by taking pre and post disaster images in the area. *Environmental and Natural Resource Assessment* 1. Multi-spectral Earth Observation for remote sensing applications. 2. Derive geophysical parameters for land and ocean applications.
Image acquisition	Approximately 38% or 114,087 km. sq. Philippine land covered
Status	Decommissioned (06 April 2020)

Actual image of Diwata-1

Trivia

Diwata-1 is the first Filipino-built satellite under the Development of Philippine Scientific Earth Observation Microsatellite (PHL-Microsat) Program, in partnership with Japanese Universities Hokkaido University and Tohoku University. PHL-Microsat is funded by the Department of Science and Technology (DOST), DOST-Philippine Council for Industry, Energy and Emerging Technology Research and Development (PCIEERD), and implemented by the University of the Philippines Diliman together with DOST-Advanced Science and Technology Institute.

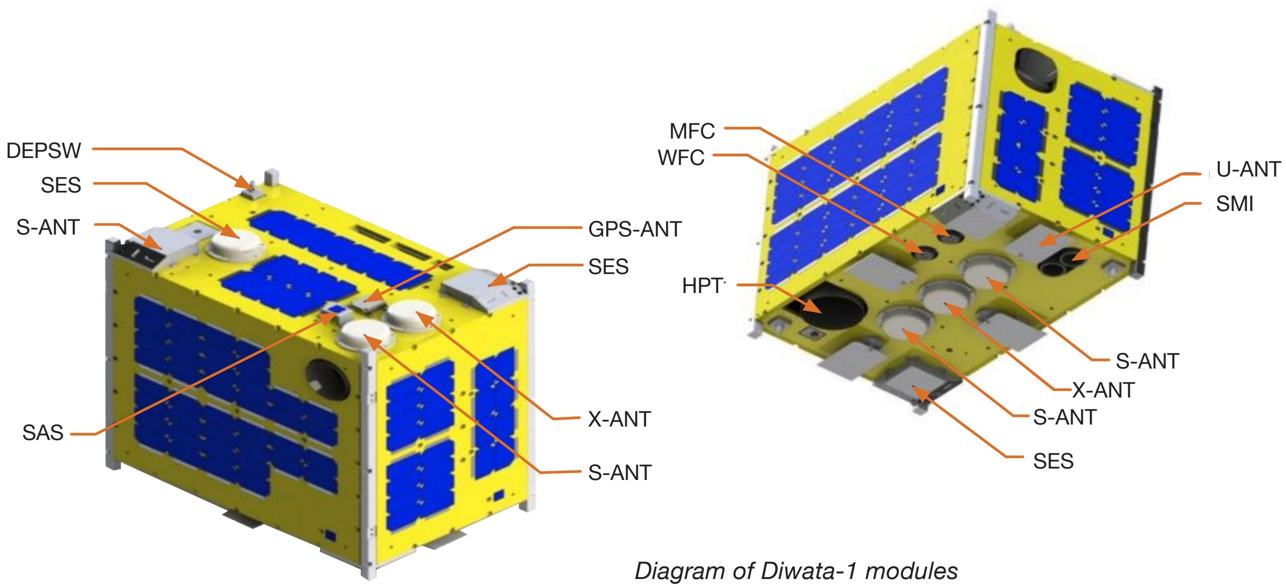
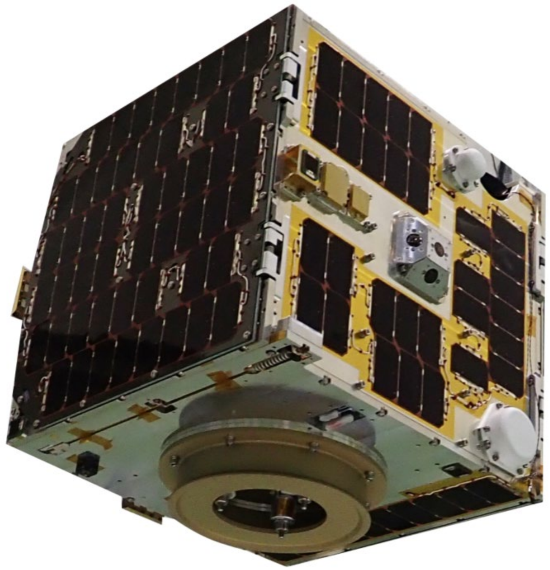


Diagram of Diwata-1 modules

Diwata-2

Fast Facts

Class	Microsatellite (Microsat)
Mass	57.36 kg
Type	Earth Observation
Dimensions	50cm x 50 cm x 50 cm (Stowed State)
Orbit	Low Earth, Sun-Synchronous
Payloads	High Precision Telescope (HPT), Spaceborne Multispectral Imager with Liquid Crystal Tunable Filter (SMI w/ LCTF), Middle Field Camera (MFC), Wide Field Camera (WFC), Enhanced Resolution Camera (ERC), Deployable Solar Array Panels (DSAP), an Amateur Radio Unit (ARU), Zenith Sun Sensor Module (SAS-Z), and an Extended Attitude Control Unit (ACU-Ex)
Launch	29 October 2018
Release	Direct release to space via rocket
Mission/s	(1) Multi-spectral Earth Observation for remote sensing applications; (2) Data Collection by Store-and-Forward Mechanism; (3) Provide Satellite data to agriculture, fisheries, forestry , and other sectors; (4) Assess damages caused by natural disasters by taking pre and post disaster images in the area; (5) Provide means of communication for emergency responders through amateur radio; (6) Automatic Packet Reporting System (APRS) Message Digipeater
Image acquisition	Approximately 80% or 245,063 km sq. of Philippine land area covered (as of June 2020)
Status	In orbit (since 29 October 2018)

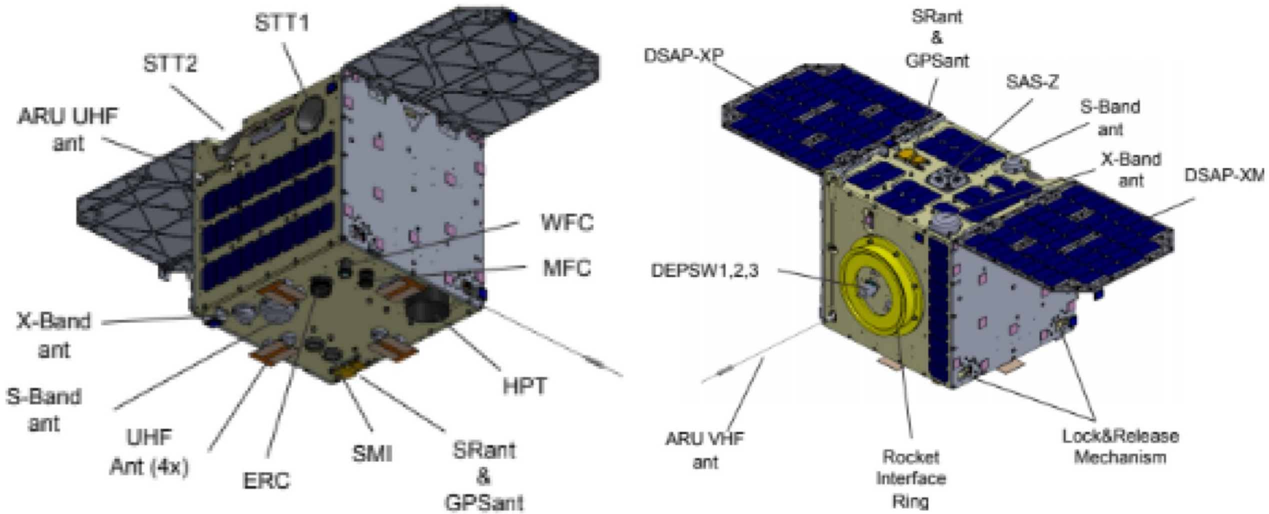


Actual Image of Diwata-2

Trivia

Diwata-2 is the successor of Diwata-1 that is also built through PHL-Microsat, with satellite operations continued under the STAMINA4Space Program. Significant enhancements were made to Diwata-2, such as its deployment to a Sun-Synchronous Orbit, the addition of deployable solar arrays for additional power provision, and the inclusion of an Enhanced Resolution Imager camera and an Amateur Radio Unit (ARU) which can be used as an alternative means of communication during disasters on the ground.

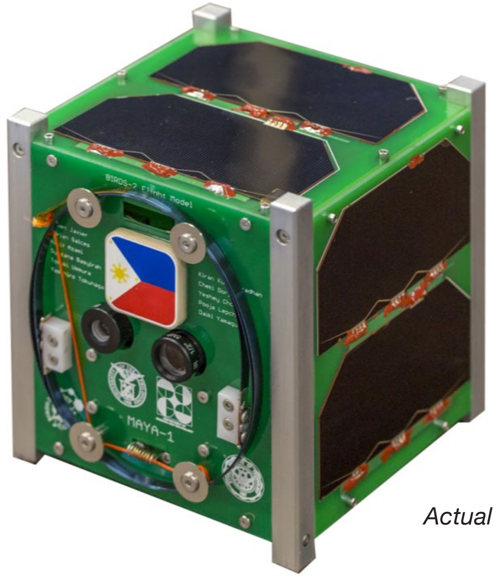
Diwata-2 Modules Diagram



Maya-1

Fast Facts

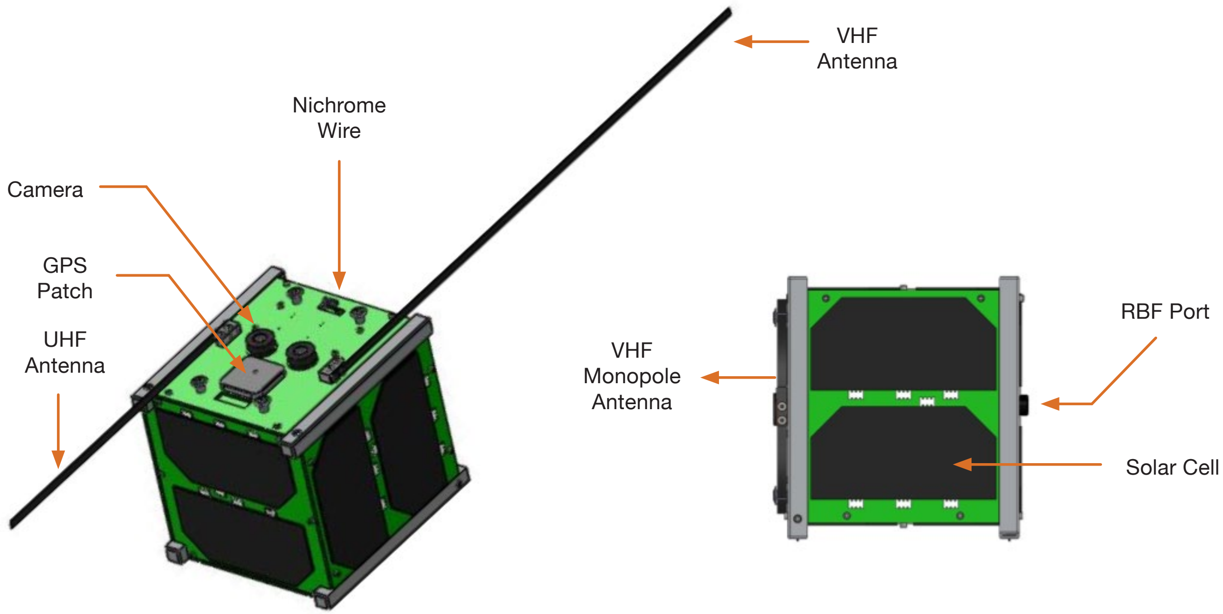
Class	Cube Satellite (Cubesat)
Mass	1.11 kg
Type	Technology Demonstration
Dimensions	10cm x 10 cm x 10 cm (Stowed State)
Payloads	Camera, Global Positioning System (GPS) chip, Automatic Packet Reporting System Message Digipeater (APRS-DP) payload, Anisotropic Magnetoresistance Sensor
Launch	June 29, 2018 via SpaceX Falcon 9 rocket launched from Kennedy Space Center, Cape Canaveral (Florida, USA)
Release	August 20, 2018 via International Space Station (ISS)
Mission/s	1. Remote Data Collection by Store-and-Forward (S&F) Mechanism 2. Commercial off-the-shelf (COTS) APRS-Digipeater Payload Demonstration on Cubesat 3. Image and Video Capture GPS Chip Demonstration 4. Detection of an Electronics Circuit Anomaly due to Space Radiation 5. Magnetic Field Measurement in space using an Anisotropic Magnetoresistance Sensor
Status	In orbit (since August 10, 2018)



Actual Image of Maya-1

Trivia

Maya-1 is the first cube satellite (CubeSat) developed by Filipino engineers through the PHL-Microsat Program. It is part of the 2nd Joint Global Multi-Nation Birds Satellite project of the Kyushu Institute of Technology in Japan, which launched Maya-1 together with BHUTAN-1 (Bhutan) and UiTMSAT-1 (Malaysia). The Maya-1 bus design is currently used as the reference design of the first locally built CubeSats Maya-3 and Maya-4.



Maya'1 Modules Diagram

Maya-2

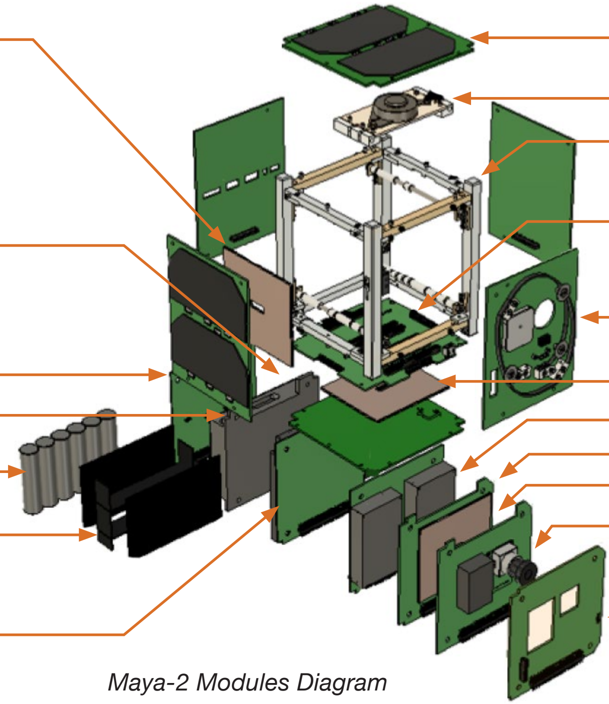
Fast Facts

Class	Cube Satellite (Cubesat)
Mass	1.3 kg
Type	Technology Demonstration
Dimensions	10cm x 10 cm x 10 cm (Stowed State)
Payloads	Camera, Automatic Packet Reporting System Message Digipeater (APRS-DP) payload, Attitude determination and control units, Perovskite solar cells, Latchup-detection chip
Launch	Target: February 2021
Release	To be determined
Mission/s	1. Remote Data Collection by Store-and-Forward (S&F) mechanism (S&F mission) 2. Commercial off-the-shelf (COTS) APRS-Digipeater Payload Demonstration on Cubesat (APRS-DP Mission) 3. Image and Video Capture (CAM mission) 4. Demonstration of active attitude stabilization and control 5. Testing of perovskite solar cells in space 6. Demonstration of CubeSat structure as antenna 7. Test of latchup-detection chip 8. Test of COTS glue for solar cell attachment
Status	Under development

Actual Image of Maya-2

Trivia

Maya-2 is currently being developed by Filipino students in Kyushu Institute of Technology in Japan, and is part of the 4th Joint Global Multi-Nation Birds Satellite project. The Filipino students building Maya-2 came from different Philippine universities, and is the country's first inter-university satellite project. Maya-2 builds from the Maya-1 heritage, and incorporates more advanced technology demonstration missions. The satellite will be launched along with Tsuru (Japan) and GuaraniSat-1 (Paraguay).



Maya-2 Modules Diagram

Maya-3

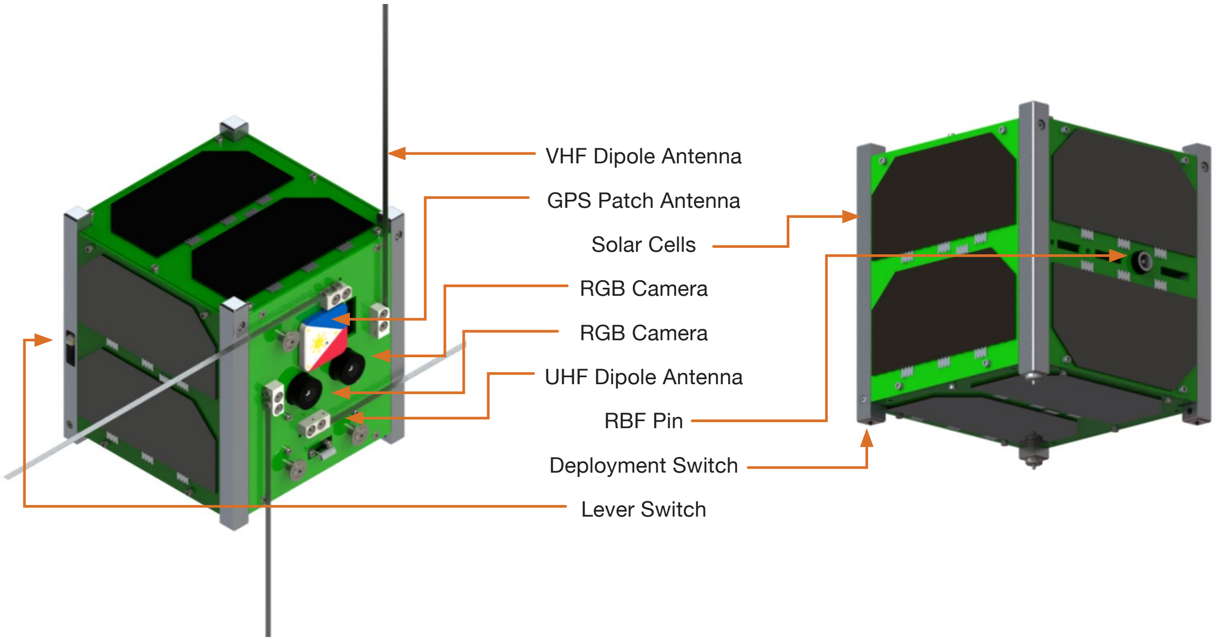
Fast Facts

Class	Cube Satellite (Cubesat)
Mass	1.08 kg
Type	Technology Demonstration
Dimensions	10cm × 10cm × 11.4cm (Stowed State)
Payloads	RGB Camera, Automatic Packet Reporting System Message Digipeater (APRS-DP) Payload, Global Positioning System (GPS) Chip, Anisotropic Magnetoresistance Sensor
Launch	Target: May 2021
Release	To be determined
Mission/s	1. Demonstration of Ground Data Acquisition using Store and Forward (S&F mission) 2. Commercial off-the-shelf (COTS) APRS-Digipeater Payload Demonstration on Cubesat (APRS-DP mission) 3. Image and Video Capture (RGB CAM Mission), Demonstration of an NIR Camera (NIR CAM Mission) 4. GPS Chip Demonstration (GPS Mission) 5. Detection of an Electronics Circuit Anomaly due to Space Radiation (SEL mission) 6. Magnetic Field Measurement in Space using an Anisotropic Magnetoresistance Sensor (AMR-MM mission)
Status	Under development

Actual Image of Maya-3 Engineering Model

Trivia

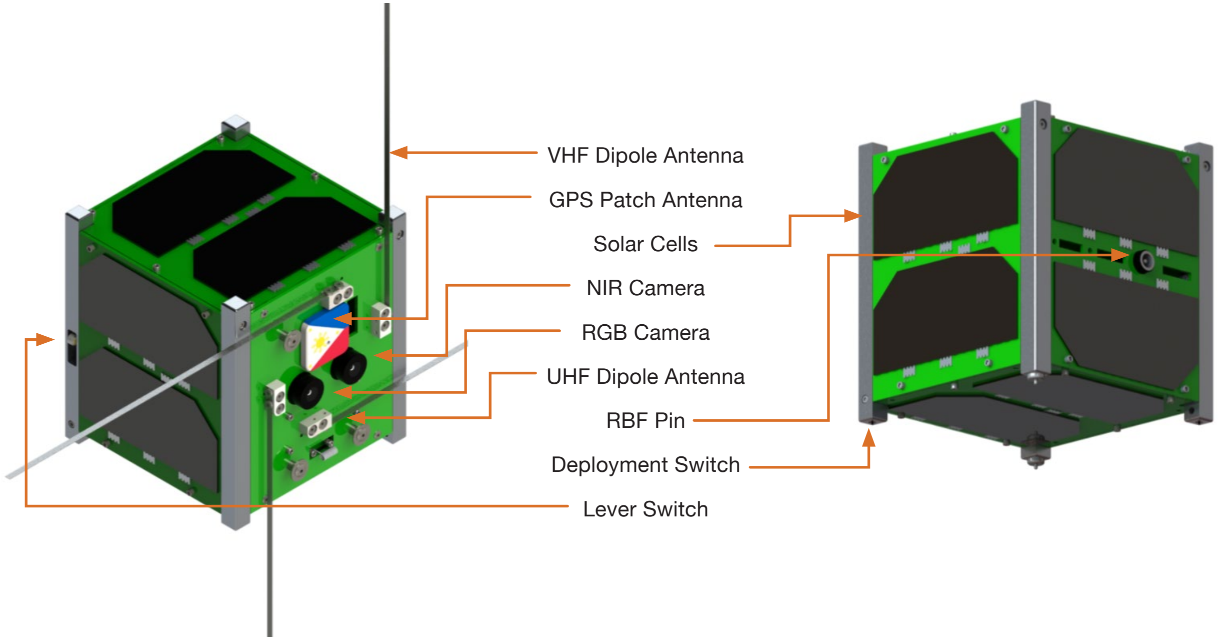
Maya-3 and Maya-4 (see next page) are the first Philippine-university built CubeSats developed under the STAMINA4Space Program. The project aims to gain and locally extend the knowledge and skills on satellite development acquired from foreign schooling, and utilize the domestic capabilities for satellite development. The two share the same bus but differ in some payloads: Maya-3 has two 5MP visual camera that will take photos and/or videos of the country, while Maya-4 has a combination of a 5MP visual camera and a near-infrared camera.



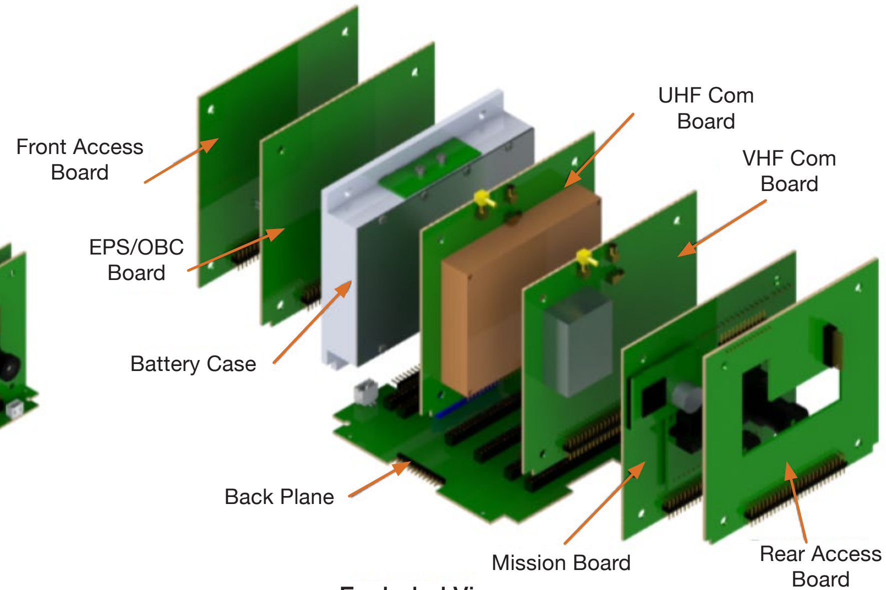
Maya-4

Fast Facts

Class	Cube Satellite (Cubesat)
Mass	1.08 kg
Type	Technology Demonstration
Dimensions	10cm × 10cm × 11.4cm (Stowed State)
Payloads	RGB Camera, Near-Infrared (NIR) Camera, Automatic Packet Reporting System Message Digipeater (APRS-DP) Payload, Global Positioning System (GPS) Chip, Anisotropic Magnetoresistance Sensor
Launch	Target: May 2021
Release	To be determined
Mission/s	1. Demonstration of Ground Data Acquisition using Store and Forward (S&F mission) 2. Commercial off-the-shelf (COTS) APRS-Digipeater Payload Demonstration on Cubesat (APRS-DP mission) 3. Image and Video Capture (RGB CAM Mission), Demonstration of an NIR Camera (NIR CAM Mission) 4. GPS Chip Demonstration (GPS Mission) 5. Detection of an Electronics Circuit Anomaly due to Space Radiation (SEL mission) 6. Magnetic Field Measurement in Space using an Anisotropic Magnetoresistance Sensor (AMR-MM mission)
Status	Under development



Internal Boards

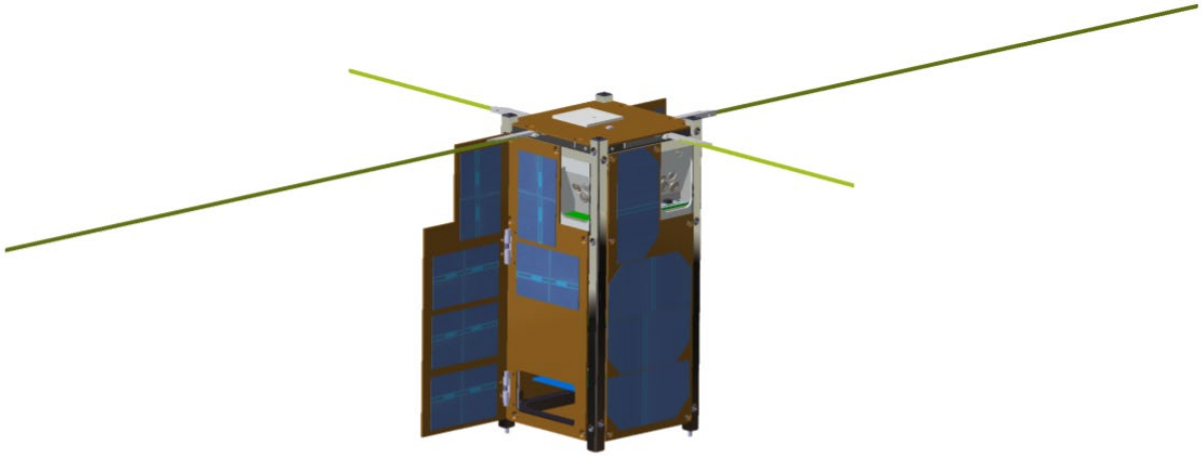


Exploded View

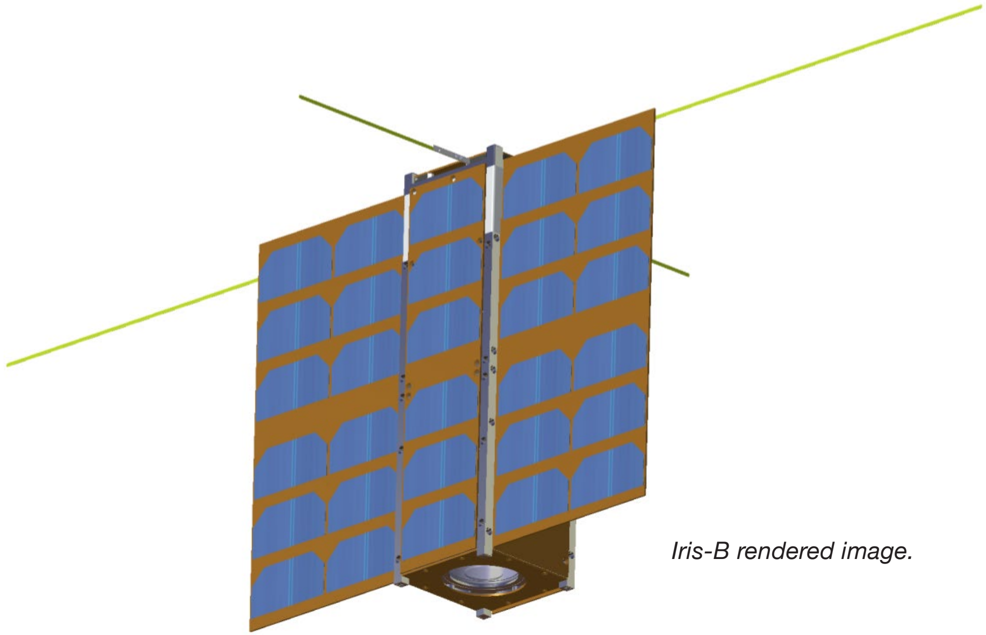
IRIS-A & B

Fast Facts

Class	IRIS-A: 2U Cube Satellite (Cubesat) IRIS-B: 3U Cube Satellite (Cubesat)
Mass	IRIS-A: 2.42 kg IRIS-B: TBD
Type	Technology Demonstration
Dimensions	IRIS-A: 22.7cm x11.2cm x11.2cm IRIS-B: 34x11.3x11.3
Payloads	AI Software (Inference) (NCNU), Optical Mechanism Structure (NSPO), Image Capture/Processing Boards (Liscotech)
Launch	To be determined
Release	To be determined
Mission/s	*IRIS A:* Demonstrate Internet of Things (IoT) *IRIS B:* Demonstrate in-orbit intelligent remote sensing technology
Status	Under development



Iris-A rendered image.



Iris-B rendered image.

Trivia

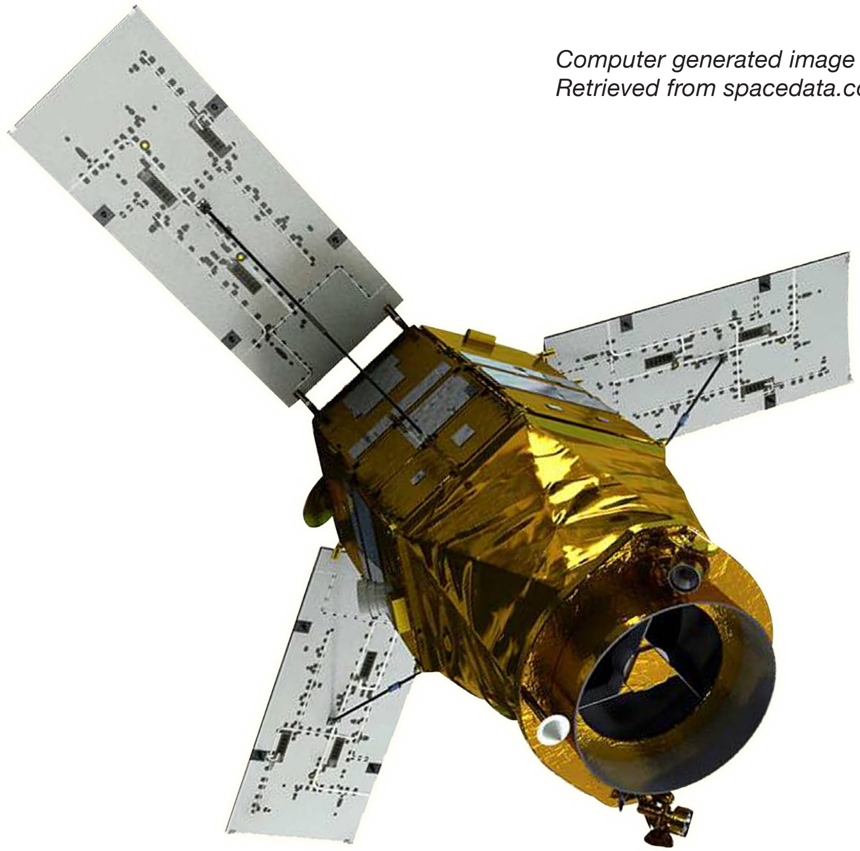
IRIS-A and IRIS-B are CubeSats that are part of the IRIS satellite series initiated by Taiwan's National Cheng Kung University (NCKU) and STAMINA4Space. Two Filipino engineers are involved in the development of this series.

IRIS-A will be equipped with Internet of Things (IoT) technologies to achieve a Doppler shift estimation and improve the quality of downlink signal, increasing the efficiency of future IoT constellations of nanosatellites intended to monitor objects from space.

KOMPSAT 3 & 3A

Fast Facts

Country	South Korea
Class	*KOMPSAT 3:* Medium satellite *KOMPSAT 3A:* Large satellite Both optical high-resolution satellites
Mass	*KOMPSAT 3:* ~980 kg *KOMPSAT 3A:* less than 1,100 kg
Type	Optical Earth Observation
Dimensions	Both 3.5m tall with a diameter of 2m
Payloads	*KOMPSAT 3:* Advanced Earth Imaging Sensor System (AEISS) *KOMPSAT 3A:* Advanced Earth Imaging Sensor System-A (AEISS-A) & Infrared Imaging System (IIS)
Launch	*KOMPSAT 3:* 17 May 2012, Tanegashima Space Center of JAXA, Japan *KOMPSAT 3A:* 25 March 2015, Jasny Dombarovsky, Russia
Mission/s	*KOMPSAT 3:* Earth observation continuity from the previous KOMPSATs Geographical Information Systems (GIS) Environmental monitoring *KOMPSAT 3A* Obtain infrared and high resolution electro-optical images for GIS Environmental monitoring



Computer generated image of KOMPSAT 3. Retrieved from spacedata.copernicus.eu

Trivia

KOMPSAT 3 is a high-resolution earth observation satellite by the Korea Aerospace Research Institute (KARI) and funded by the Ministry of Education, Science and Technology (MEST). KOMPSAT 3 was launched in 2012 to continue the missions of KOMPSAT-1 and 2.

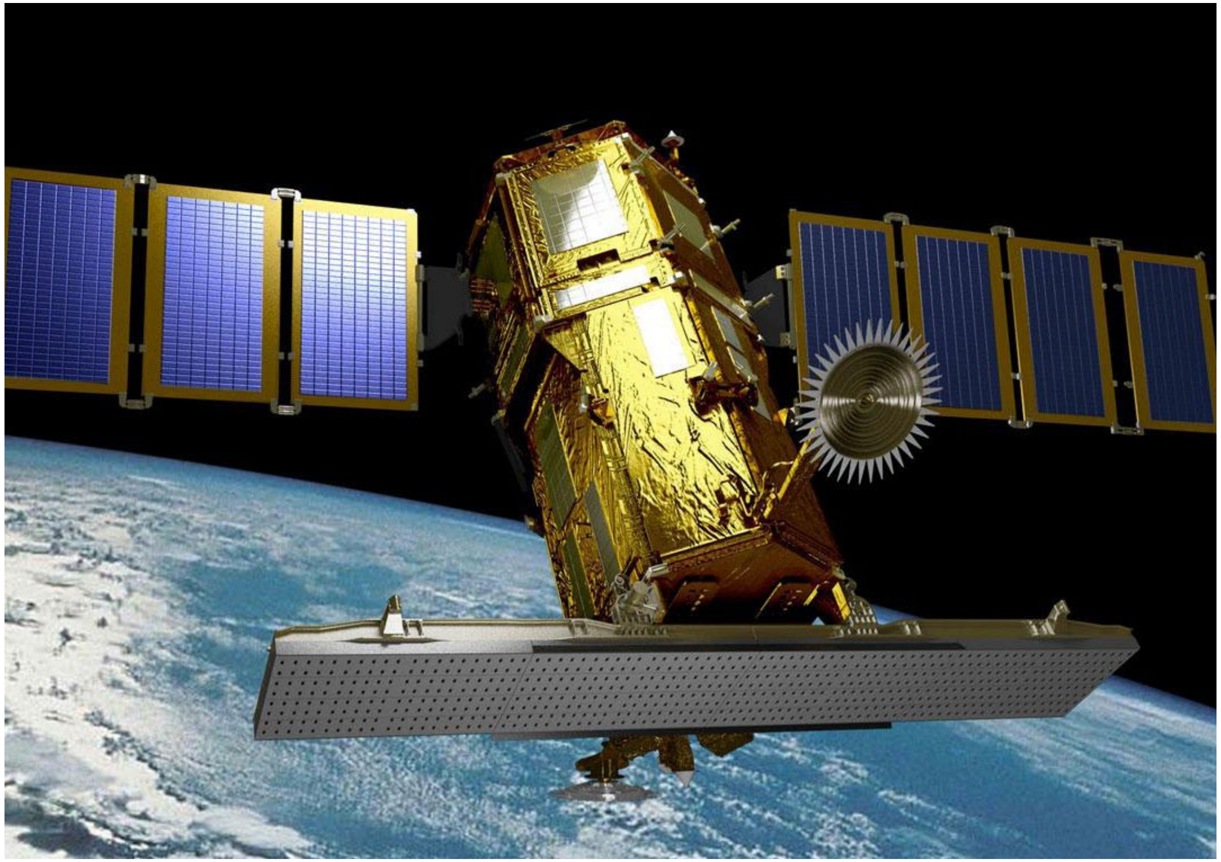
KOMPSAT 3A, launched in 2015, is South Korea's first satellite to have two imaging systems onboard. Its main mission is to obtain infrared and high resolution electro-optical images for Geographic Information Systems (GIS).

The PEDRO Center is subscribed to both satellites through Skymap Global Philippines.

KOMPSAT 5

Fast Facts

Country	South Korea
Class	Large satellite
Mass	~1400 kg
Type	X-band Synthetic Aperture Radar
Payloads	Corea SAR Instrument (COSI), Atmosphere Occultation and Precision Orbit Determination, Laser Retro Reflector Array
Launch	22 August 2013 from Yasny, Russia
Resolution	1m, 2.5m and 20m
Mission/ Attributes	Develop, launch and operation of a Synthetic Aperture Radar (SAR) satellite for: Geographic information applications; Disaster and environmental monitoring; Ocean and land management



Computer generated image of KOMPSAT 5 in orbit.
Retrieved from telespazio.co.uk

Trivia

KOMPSAT 5 is a Synthetic Aperture Radar mission developed by KARI.
Its main mission is to provide satellite imagery for GIS applications, ocean and land management, and disaster and environmental monitoring.

The PEDRO Center is subscribed to the satellite via Skymap Global Philippines.

Dove Satellites

Fast Facts

Country	USA (Commercial)
Class	Satellite constellation consisting of 130+ nanosatellites
Mass	~ 5 kg per satellite
Type	Earth Observation
Dimensions	10 cm x 10 cm x 30 cm
Spatial Resolution	3 - 5 meters
Launch	2013 to April 2019
Mission/ Attributes	The entire constellation can cover all of Earth's land everyday.

Computer generated image of Dove Satellites in orbit. Retrieved from altaonline.com

Trivia

Dove is a commercial satellite constellation made up of more than 130 nanosatellites. This constellation can cover the Earth's land every day.

The PEDRO Center is subscribed to the satellite constellation through Geospectrum Marketing Services.

GeoEye-1

Fast Facts

Country	USA (Commercial)
Class	Large satellites
Mass	1955 kg
Type	Earth Observation
Dimensions	4.35 m x 2.7m
Payloads	GEOEYE Imaging System
Spatial Resolution (at nadir)	Panchromatic: 41cm. GSD Multispectral: 1.64m GSD
Launch	September 6, 2008
Mission/ Attributes	The satellite can produce over 350,000 sq. km. of pan-sharpened multispectral satellite imagery daily.

Computer generated image of GeoEye-1 in orbit.
Retrieved from spacenews.com

Trivia

GeoEye-1, formerly known as OrbView-5, is a commercial satellite by GeoEye Inc. launched in 2008. The satellite is equipped with a pushbroom imager. As of 2013, the satellite is being operated by DigitalGlobe after their merger with GeoEye Inc.

The PEDRO Center is subscribed to the satellite via Geo-Surveys & Mapping Inc.

WorldView 2 & 3

Fast Facts

Country	USA (Commercial)
Class	Large satellites
Mass	*WorldView 2:* 2,800 kg *WorldView 3:* 2,812 kg
Type	Earth Observation
Dimensions	*WorldView 2:* 4.3 m x 2.5 m x 7.1 m *WorldView 3:* 5.7 m x 2.5 m x 7.1 m
Payloads	*WorldView 2:* WorldView-110 camera *WorldView 3:* WorldView-3 camera and CAVIS (Cloud, Aerosols, Vapors, Ice and Snow) Imager.
Launch	*WorldView 2:* 08 October 2009 *WorldView 3:* 13 August 2014
Mission	High-resolution satellite imagery

Computer generated image of WorldView 2 in orbit.
Retrieved from satnews.com

Trivia

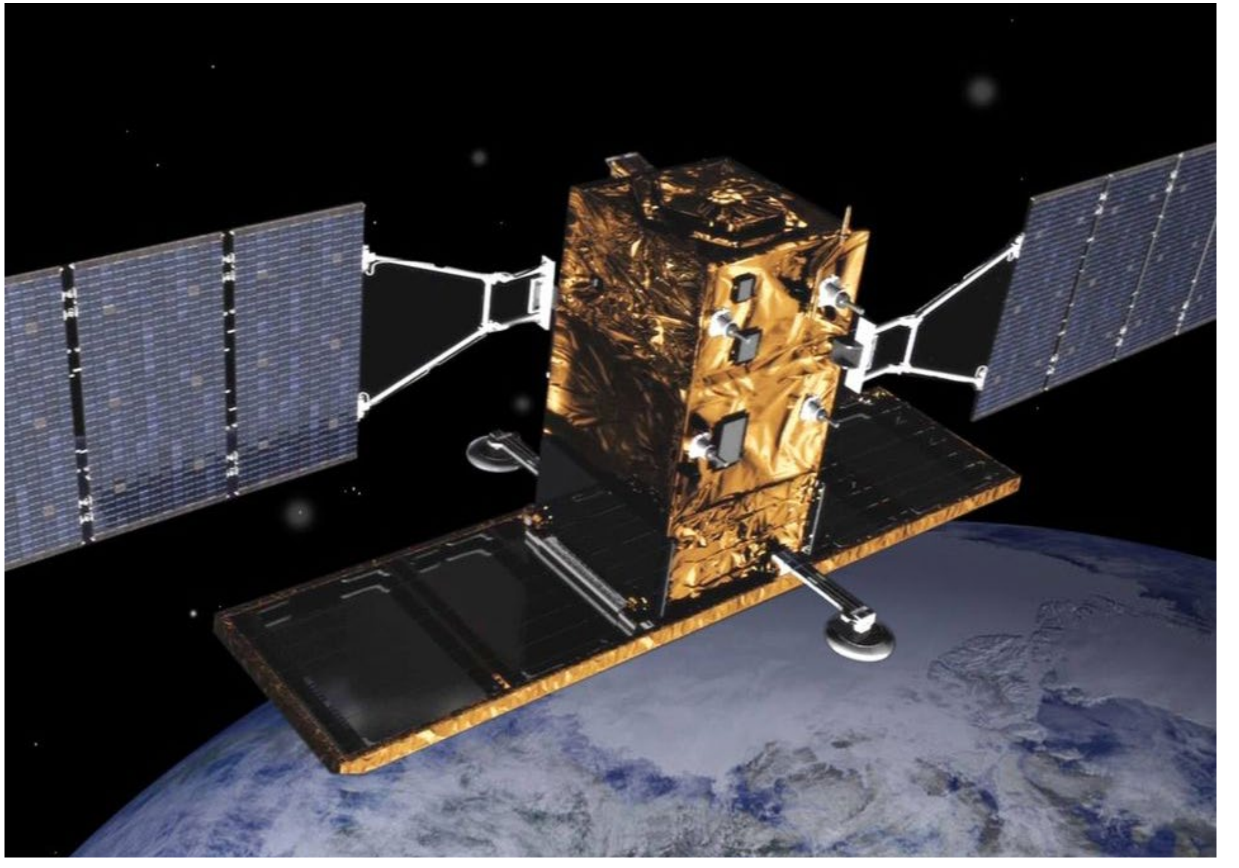
WorldView 2 & 3 are commercial satellites from DigitalGlobe Inc. These satellites are made to provide high-resolution satellite imagery. Aside from its imagers, WorldView 3 is equipped with its CAVIS payload which enables the satellite to monitor the atmosphere.

The PEDRO Center is subscribed to these satellites via Geo-Surveys & Mapping Inc.

COSMO-SkyMed

Fast Facts

Country	Italy (commercial)
Class	Constellation satellite (four satellites), large satellites
Mass	Each satellite weighs about 1700 kg
Type	Earth Observation
Payloads	SAR-2000, X-band , multi-resolution and multi-polarisation imaging radar
Launch	June 2007 to Nov 2010
Mission	Global Earth observation Defense and security applications DIsaster management Environmental monitoring



Computer generated image of COSMO-SkyMed in orbit.
Retrieved from Thales Alenia Space Facebook page.

Trivia

COSMO-SkyMed is a constellation of four satellites managed by the Agenzia Spaziale Italiana (ASI). It is funded by the Italian Ministry of Research and Italian Ministry of Defense. These SAR satellites were made for the needs of the military and the general public.

The PEDRO Center is subscribed to these satellites via Geo-Surveys & Mapping Inc.

NovaSAR-1

Fast Facts

Country	United Kingdom (commercial)
Class	Synthetic Aperture Radar minisatellite
Mass	430 kg
Type	Earth Observation
Orbit	Low Earth
Payloads	S-band Synthetic Aperture Radar (SAR), Automatic Identification System (AIS)
Launch	16 September 2018 from ISRO (Sriharikota, India)
Mission	*Disaster Management and Environmental Monitoring* Assess an area by taking SAR images. This is especially helpful when cloud cover is an issue *Maritime Monitoring* Through AIS, detect ships and track their movements.
Modes of Operation	*ScanSAR:* 20m resolution, 100 km swath *Maritime mode:* 30m, 400-750 km swath *Stripmap:* 6m resolution, 20 km swath *ScanSAR wide:* 30m resolution, 140 km swath
Status	In orbit (since September 2018)

Computer generated image of NovaSAR-1 in orbit. Retrieved from research.csiro.au

Trivia

The PEDRO Center's ground receiving stations have access to 10% of NovaSAR-1's capacity for the satellite's lifetime. Other mission partners include UK Space Agency, Australia's Commonwealth Scientific and Industrial research Organization and Indian Space Research Organization.

Sentinel 1 & 2

Fast Facts

Country	Europe
Class	Large satellite
Mass	Sentinel-1: 2,300 kg Sentinel-2: 1140 kg
Type	Sentinel-1: Synthetic Aperture Radar Sentinel-2: Multispectral Imaging Satellite
Orbit	Sun-synchronous
Payloads	Sentinel-1: C-band Synthetic Aperture Radar Sentinel-2: Multispectral Imager (10m, 20m, 60m)
Launch	Sentinel-1A: 03 April 2014 Sentinel-1B: 25 April 2016 Sentinel-2A: 23 June 2015 Sentinel-2B: March 2017
Mission	Sentinel-1: Continuity for the C-Band Synthetic Aperture Radar operational application and services Sentinel-2: Land observation
Status	Ongoing

Computer generated image of Sentinel 1 in orbit. Retrieved from ESA.int

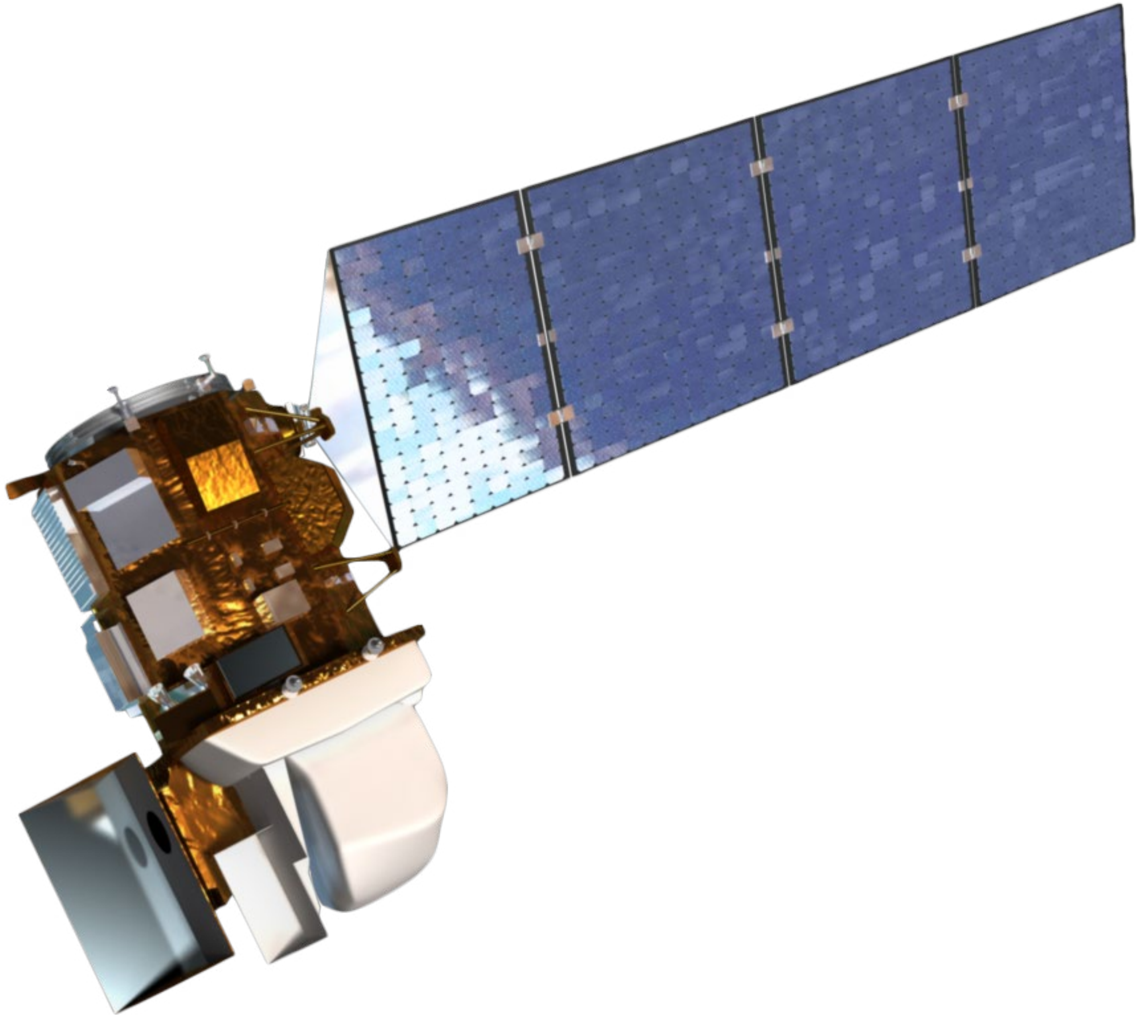
Trivia

The Sentinel missions are developed and designed by the European Space Agency and funded by the European Commission.

Landsat-8

Fast Facts

Country	United States of America
Class	Large satellite
Mass	2071 kg
Type	Earth Observation
Orbit	Sun-synchronous
Payloads	Operational Land Imager Thermal Infrared Sensors
Launch	11 February 2013
Mission	Collect and archive moderate resolution reflective and thermal multispectral image data to provide coverage for the world in less than 5 years.
Status	Ongoing



Landsat-8
Retrieved from NASA.gov

Trivia

Landsat-8 was a collaboration between NASA and U.S. Geological Survey.

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