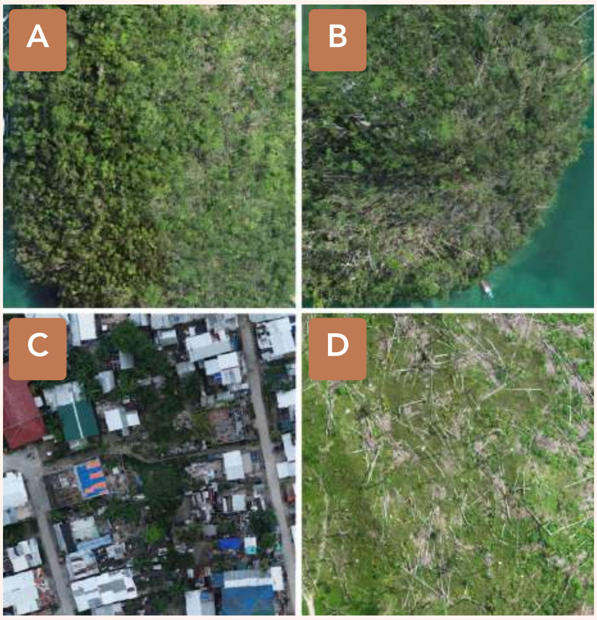

Figure 11. Orthomosaic image showing vegetation with damaged trees on limestone hills (A&B); damaged infrastructure and settlements (C) ; and uprooted palm trees (D) in Brgy. Caub, Del Carmen.

c. Pilar

The Municipality of Pilar appears to have experienced relatively minimal damage, possibly due to its location not being in the direct path of the typhoon, or probably because any previous damages have already been mitigated. The post-typhoon observations revealed minor damages to grassland and perennial cropland as indicated by the presence of fallen trees, but still there is a noticeable presence of cutting the uprooted palm trees to smaller pieces in Brgy. Pilaring (Figure 12D).

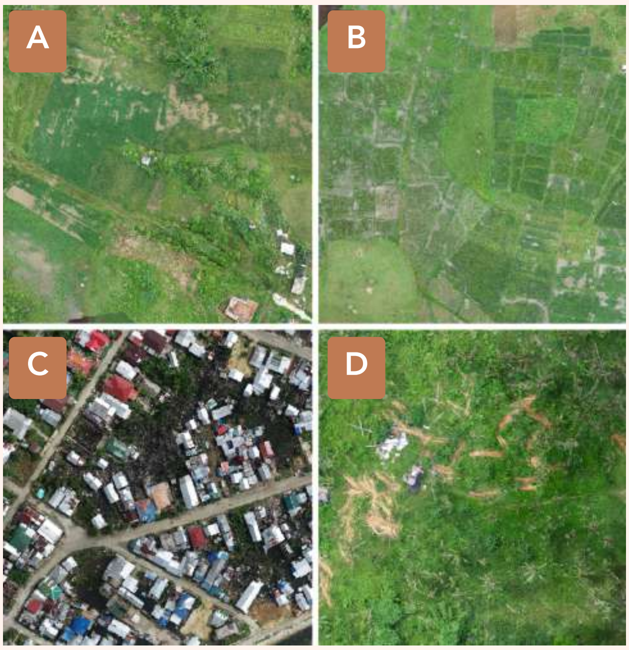

Figure 12. Orthomosaic image showing vegetation with damaged cropland (A & B); damaged infrastructure and settlements (C) ; and uprooted palm trees (D) in different barangay across the jurisdiction of Pilar.

d. Santa Monica

As the topmost part of Siargao island, the municipality of Sta. Monica also had damages on shrubland and agricultural landscape after the typhoon Odette event. There are visible signs of damage in mangrove areas in Brgy. Magsaysay (Figure 13A), presence of cutting the uprooted palm trees to smaller pieces in barangays T-arlan and Tangbo (Figure 13B & 13 D); while in the populated area of Brgy. Rizal there's apparent damage in settlements (Figure 13C).

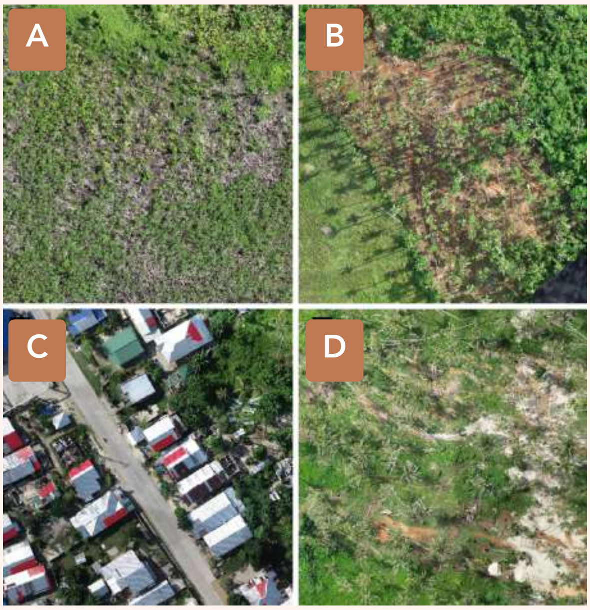

Figure 13. Orthomosaic image showing vegetation with damaged mangrove area (A); damaged infrastructure and settlements (C) ; and uprooted palm trees (B & D) in different barangay across the jurisdiction of Santa Monica.

e. Burgos

Located along the seaside, Burgos was one of the areas directly hit by Typhoon Odette. Figure 14A shows the impact of damage in shrubland and grassland areas in Brgy. Bita-Uo Similar to the other parts of Siargao, there are presence of disturbances on the ground like activities of cutting the uprooted palm trees into smaller pieces in barangays of Poblacion 1 and Baybay, that may be useful in construction of new homes and other structures. (Figure 14B & 14D).

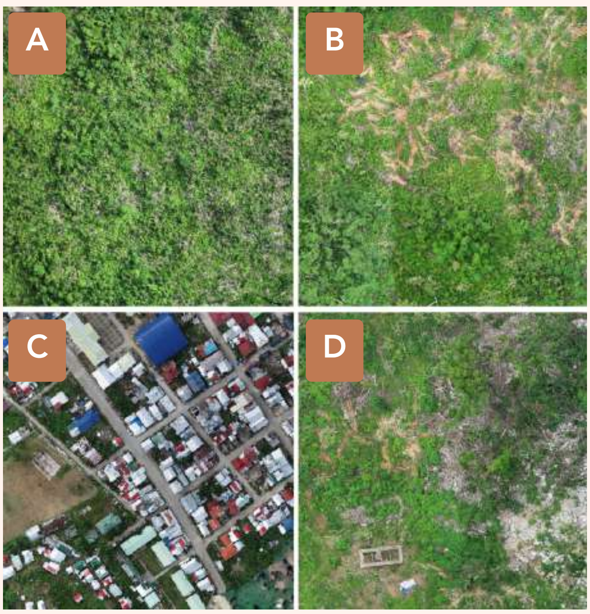

Figure 14. Orthomosaic image showing mixed vegetation(A); damaged infrastructure and settlements (C) ; and uprooted palm trees (B & D) in different barangay across the jurisdiction of Burgos.

f. San Isidro

Observations in the municipality of San Isidro revealed the presence of damages on perennial cropland in Brgy. Pacifico, particularly in palm trees (Figure 15A & 15B). The same was seen in areas with damaged cropland in Brgy. Buhing Kalipay (Figure 15D).

Figure 15. Orthomosaic image showing vegetation with uprooted palm trees (A & B); damaged infrastructure and settlements (C) ; and damaged cropland (D) in different barangay across the jurisdiction of San Isidro.

g. San Benito

The aftermath of the typhoon left a noticeable impact on San Benito's agricultural landscape, affecting crops such as palm trees in barangays of San Juan and Talisay (Figures 16A & 16B); defoliated and damaged trees are also seen in hilly limestone areas in Brgy. De Ocampo (Figures 16C & 16D).

Figure 16. Orthomosaic image showing vegetation with damaged mixed vegetation and uprooted palm trees in different barangay across the jurisdiction of San Benito.

h. Socorro

The team faced challenges in maximizing aerial ground-truthing surveys in Socorro due to limitations related to land disputes and safety/security concerns. Nevertheless, we were able to note significant damages to mangroves in the area in Brgy. Pamosaingan (Figure 17A & 17B), damaged shrubland in Brgy. Dona Helen (Figure 17C), and damaged infrastructure and settlements in Brgy. Rizal (Figure 17D).

Figure 17. Orthomosaic image showing vegetation with damaged mangrove (A & B); damaged shrubland (C) ; and damaged infrastructure and settlements (D) in different barangay across the jurisdiction of Socorro.

Preliminary Visualization of Damages Using NDVI Stage 1 Outputs vis-à-vis NAMRIA's 2020 Land Cover Map

While the RPA raw images were subjected to pre-processing and interpretation, the remote sensing team attempted to visualize the extent of damages by overlaying the NDVI map from Stage 1 with the NAMRIA 2020 land cover map (Figure 18). The 2020 land cover map gives us an idea which covered areas were damaged. Damaged areas were denoted by red pixels taken from the NDVI difference map. The overlain map shows there is pronounced vegetation loss towards the western part of SIPLAS, particularly in areas classified as mangrove forests by the 2020 NAMRIA land cover map (Figure 19).

Figure 18

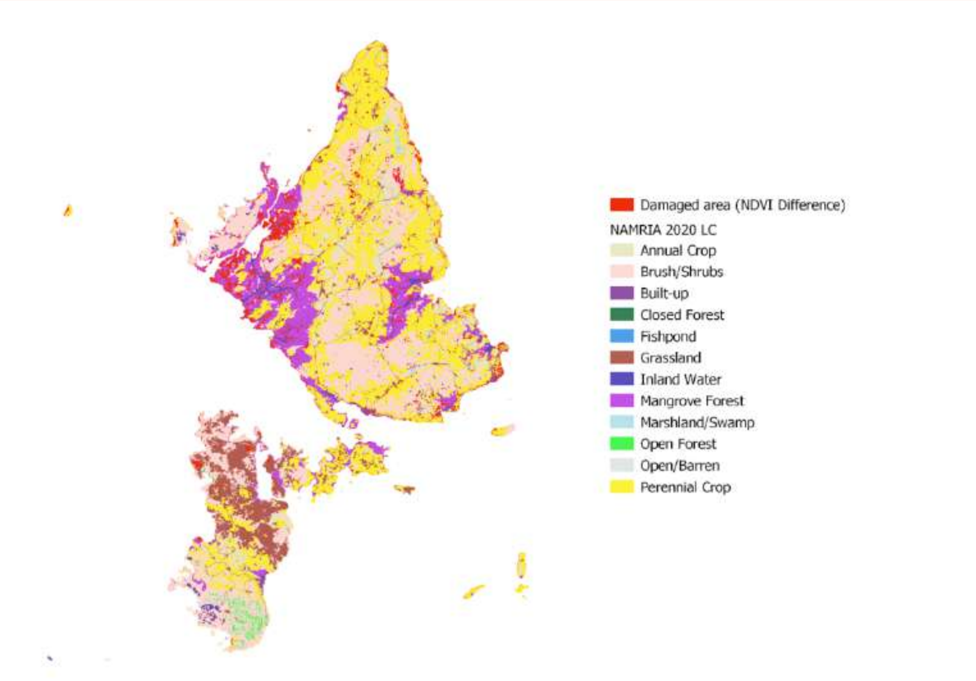

Figure 18. Overlay of the NDVI difference map from Stage 1 with the 2020 NAMRIA land cover map. *Red pixels indicate areas where probable vegetation damages occurred.*

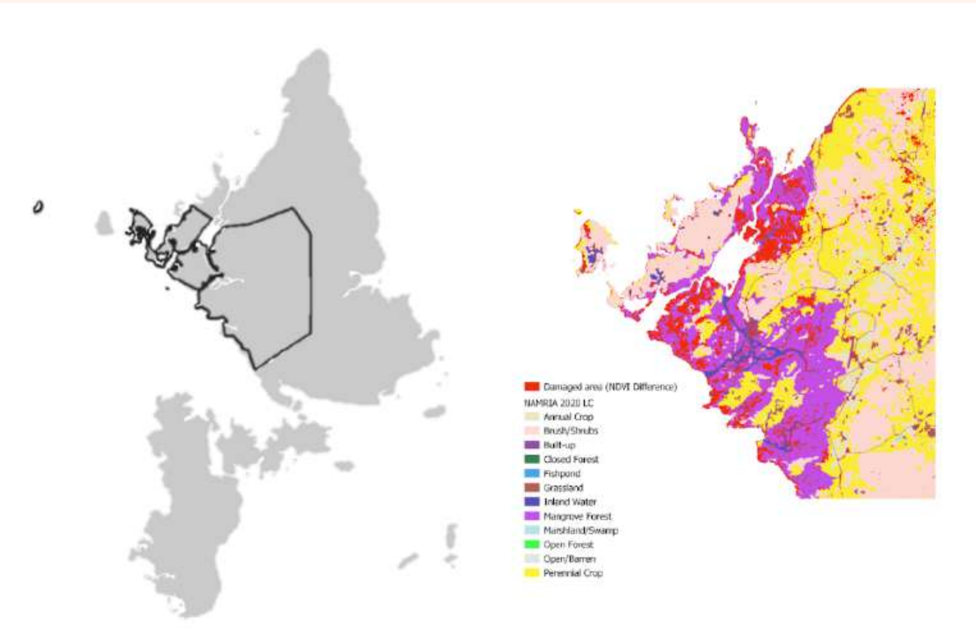

Figure 19. A closer look of the Municipality of Del Carmen showing an overlay of the NDVI map from Stage 1 with the 2020 NAMRIA land cover map. *Red pixels indicate areas where probable vegetation damages occurred.*

Conformity of acquired RPA images with the NDVI difference map from Stage 1

To confirm the Stage 1 NDVI difference map with information of damages observed from satellite imagery, Figures 20 and 23 illustrate selected positions on the ground where the orthophotos from remotely piloted aircraft validate what has happened on the ground. This also served as a test to determine how well the orthophotos conformed with results of the NDVI difference map generated from satellite imagery. The damage map on the left side is zoomed-in to a particular spot in Caub, overlaid with the RPA orthomosaic image showing a high resolution representation of the obvious vegetation damage.

Another representation of conformity of Stage 2 output from the RPA survey was seen in Brgy. Don Paulino, Dapa. Figure 22 shows that damaged areas (red pixels) from Stage 1 satellite imagery conforms with that of the Stage 2 output from drone imagery.

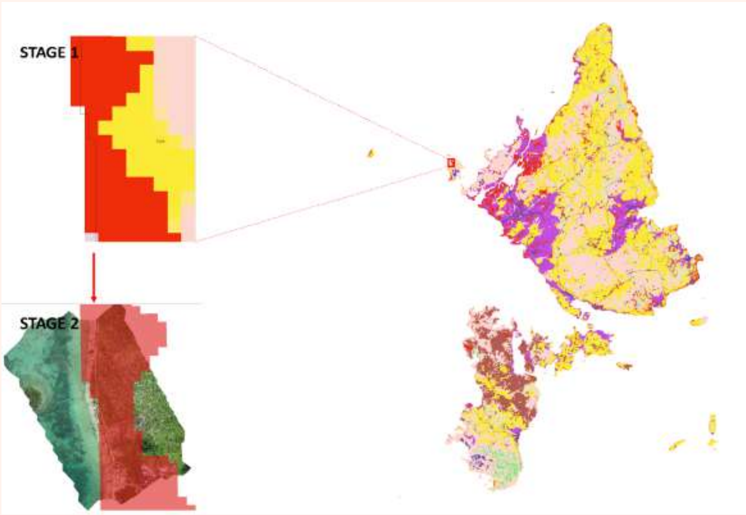

Figure 20. Sample output of the RPA survey collected in Brgy. Caub, Del Carmen; superimposed with the results of the NDVI difference map from Stage 1. *Red pixels indicate areas where probable vegetation damages occurred.*

Figure 21. SOrthomosaic image captured in Brgy. Caub, Del Carmen showing uprooted and defoliated palm trees. *Red polygon on the right image shows uprooted palm trees.*

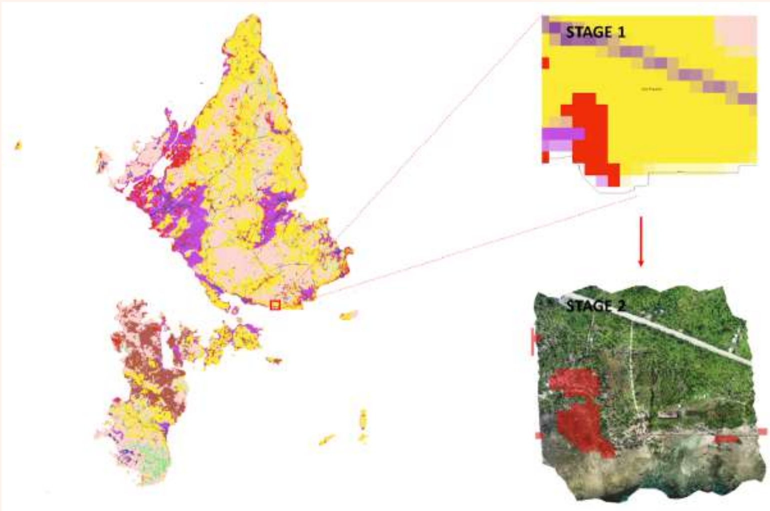

Figure 22. Sample output of the RPA survey in Brgy. Don Paulino, Dapa; superimposed with the results of the NDVI difference map from Stage 1. *Red pixels indicate areas where probable vegetation damages occurred.*

Figure 23. Orthomosaic image captured in Brgy. Don Paulino. *Yellow box shows damage in mangrove areas, while the red box shows uprooted palm trees.*

4 Preparation for Analysis and Interpretation

After preprocessing the RPA images to create orthomosaic images, the next step will involve interpreting the images based on specific IPCC land cover classes. The process will include assessment of training data polygons and validation points within the images. The training data polygons and validation points will be carefully chosen to represent homogeneous regions with unique characteristics related to forest, non-forest, and other existing vegetation cover.

Once the interpretation and assessment are completed, data from the training polygons and validation points will be used for post-processing to perform land cover classification and change detection analysis. The processing stage aims to classify the land cover within the orthomosaic image and identify any changes that occurred over time. The resulting outputs will include detailed land cover maps and change detection maps based on the initial interpretation and assessments.

5 References

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Annexes

Annex A shows the number of participants that participated during the training, while Annex B,C & D shows the technical specifications of the equipment used in the ground-truthing survey and pre-processing. Annex E shows the list of the team who conducted the ground-truthing survey. Lastly, Annex F shows how the team captured detailed information about the flight missions conducted in SIPLAS.

Annex A. Number of participants that participated during the ground-truthing through RPAS training in SIPLAS.

Agency/ Organization	No. of participants
Community Environment and Natural Resources Office - San Juan	1
Department of Environment and Natural Resources - Region 7	1
Department of Environment and Natural Resources - Region 10	2
Department of Environment and Natural Resources - Region 13	2
Local Government Unit - Dapa	2
Local Government Unit - Del Carmen	1
Local Government Unit - Pilar	2
Local Government Unit - San Isidro	1
Local Government Unit - Santa Monica	2
Local Government Unit - Socorro	1
Protected Area Management Office - SIPLAS	3
Surigao State College of Technology	2
Community Environment and Natural Resources Office - San Juan	1

Annex B. Technical specification of the Phantom 4 RTK aircraft used during the ground-truthing through RPAS in SIPLAS.

Parameter	Specifications
Aircraft	
Takeoff weight	131 g
Diagonal distance	350 mm
Max service ceiling (asl)	6000 m
Max speed	31 mph
Max flight time	Approx. 30 minutes
Operating temperature range	0 to 40 °C
Transmission power	2.400 GHz to 2.483 GHz
Hover accuracy range	RTK enabled: Vertical & Horizontal ±0.1 m
Image position offset	Positive x,y & z axes of the aircraft body
GNSS	
Single frequency	GPS + BeiDou + Galileo + GLONASS
Multiple frequency	GPS + BeiDou + Galileo + GLONASS with high-precision RTK
Mapping Functions	
Mapping accuracy	The actual accuracy depends on surrounding lighting and patterns, aircraft altitude, mapping software used, and other functions used

Annex B. Technical specification of the Phantom 4 RTK aircraft used during the ground-truthing through RPAS in SIPLAS.

Parameter	Specifications
Mapping Functions	
Ground Sample Distance (GSD)	(H/36.5) cm/pixel; H means the aircraft altitude relative to shooting scene (unit : m)
Data Acquisition Efficiency	Max. operating area of approximately 1 sq km for a single flight (at an altitude of 120 m; GSD at 3.3 cm/pixel)
Camera	
Sensor	1" CMOS, 20M pixels
Lens	FOV 84°
Max Image size	4864 x 3648 (4:3); 5472 x 3648 (3:2)
Photo format	JPEG
Supported File Systems	FAT32
Supported SD cards	MicroSD; Class 10; storage up to 128GB
Remote Controller	
Operating Frequency	2.400 GHz to 2.483 GHz
Max Transmission Distance	7 km (Unobstructed, free of interference)
Power consumption	16 W
Display	5.5 in, Android operating system

Annex B. Technical specification of the Phantom 4 RTK aircraft used during the ground-truthing through RPAS in SIPLAS.

Parameter	Specifications
Remote Controller	
Operating temperature range	0 to 40 °C
Intelligent Flight Battery	
Capacity	5870 mAH
Voltage	15.2 V
Battery type	LiPo 4S
Net weight	468 g
Charging temperature range	-10 to 40 °C
Max charging power	160 W

Annex C. Technical specification of the D-RTK 2 mobile station used during the ground-truthing through RPAS in SIPLAS.

Parameter	Specifications
GNSS Receiver	
GNSS Frequency	2.400 GHz to 2.483 GHz
Positioning Accuracy	RTKHorizontal: ± 1 cmVertical: ± 2 cm
Recapture Time	> 99.99 %
Data Format	RTCM

Annex C. Technical specification of the D-RTK 2 mobile station used during the ground-truthing through RPAS in SIPLAS.

Parameter	Specifications
IMU	
Features	Built-in high-precision 6-axis accelerometer; movement monitoring; sloping measurements; and electronic bubble level
Communication and Storage	
Data Link	OcuSync; WiFi, LAN, 4G
Operating Frequency	2.400 GHz to 2.483 GHz
Operating Mode	Mode 4; between the aircraft and mobile station
Communication Distance	5 km (Unobstructed, free of interference at a flying altitude of about 120 m)
Memory Capacity	16 GB
Characteristics	
Dimension	168 mm x 168 mm x 1708 mm; D-RTK body with extension rod
Power consumption	12 W
Power supply	16.5 to 58.8 VDC
Battery type	Lithium ion
Battery capacity	4930 mAH
Operating temperature range	-22 to 55 °C

Annex D. Technical specification of the DJI Terra software used during the pre-processing of RPA images captured during the ground-truthing surveys in SIPLAS.

Parameter	Specifications
RPA Image Pre-processing Software	
Software version	DJI Terra Pro
Image output	2D map reconstruction, 2D multispectral reconstruction, 3D model reconstruction & Digital Surface Model (DSM)

Annex E. Ground-truthing survey team composition.

Role	Designation	Name	Description
Geospatial Solutions Technology Team Leader	*Geospatial Solutions Technology Team Lead*	Dr. Oliver G. Coroza	Oversee the RPAS subteam's ground-truthing survey operations.
RPAS survey coordinator	*Technical Associate*	Regina Aedrianne C. Felismino-Inovejas	Prepare all equipment and logistical details during the ground-truthing survey.
RPA Pilot	*Technical Associate*	Regina Aedrianne C. Felismino-Inovejas & Daniel Glenn Darapiza	The one who operates and flies the RPA.
Spotter/ Visual observer	*Research Associate*	Daniel Glenn Darapiza & Regina Aedrianne C. Felismino-Inovejas	Checks for possible obstruction during flight missions.
Ground Control Point (GCP) observer	*Field assistant*	Renald Cortes	Overlays the GCP markers and obtain its positioning data on the ground.
Encoder	*Field assistant*	Jessa Castillon	Encode all information details for each flight mission.

Annex F. Sample digital flight log form using Earthranger (CCIPH,2023).