2 Methodology

Building SIBOL's Local Partner Capacities on Remotely Piloted Aircraft Systems

Before conducting our surveys, we conducted capacity-building activities with local partners in SIPLAS on using RPAs for ground truthing and mapping post-disaster events. The five-day training was conducted from June 20 to 24, 2022 in New Pastoral, Dapa, Surigao del Norte. The training was attended by 20 participants (17 males and 3 females) from several regional and local agencies in Visayas and Mindanao. The participants came from the DENR - Community Environment and Natural Resources Office (CENRO) San Juan; DENR Regions 7, 8, 10, and 13; Local Government Units (LGU) of Dapa, Del Carmen, Pilar, San Isidro, Santa Monica, and Socorro; SIPLAS Protected Area Management Office; and the Surigao State College of Technology (Annex A). Training participants also participated in the field campaign.

Figure 2. (A & B) Hands-on demonstration of operating an RPA; (C) participants and facilitators share a candid photo after the training session; and (D) discussion about the pre-processing of RPA images using image stitching software.

Identification of Sampling Sites

To identify ground validation sites, the team made use of the Normalized Difference Vegetation Index (NDVI) maps produced during stage 1 of the green assessment. A map showing reference points or polygons was created to guide the ground-truthing in areas where possible changes in vegetation occurred because of the typhoon. The reference points are areas where the RPA will be flown to collect training data for interpreting the Intergovernmental Panel on Climate Change (IPCC) land cover classes. The land cover classes (i.e. forest, -

- grassland, wetland, cropland, settlements, and other lands) have been discussed with the Palawan Council for Sustainable Development (PCSD) when the GA Framework was piloted in Palawan. The map below shows the location of the reference points in SIPLAS. For a more detailed explanation of this process, please refer to the *Technical Report on Green Assessment in Siargao Stage 1 - Rapid Appraisal, section 2.2 Creating Reference Points and Polygons.*

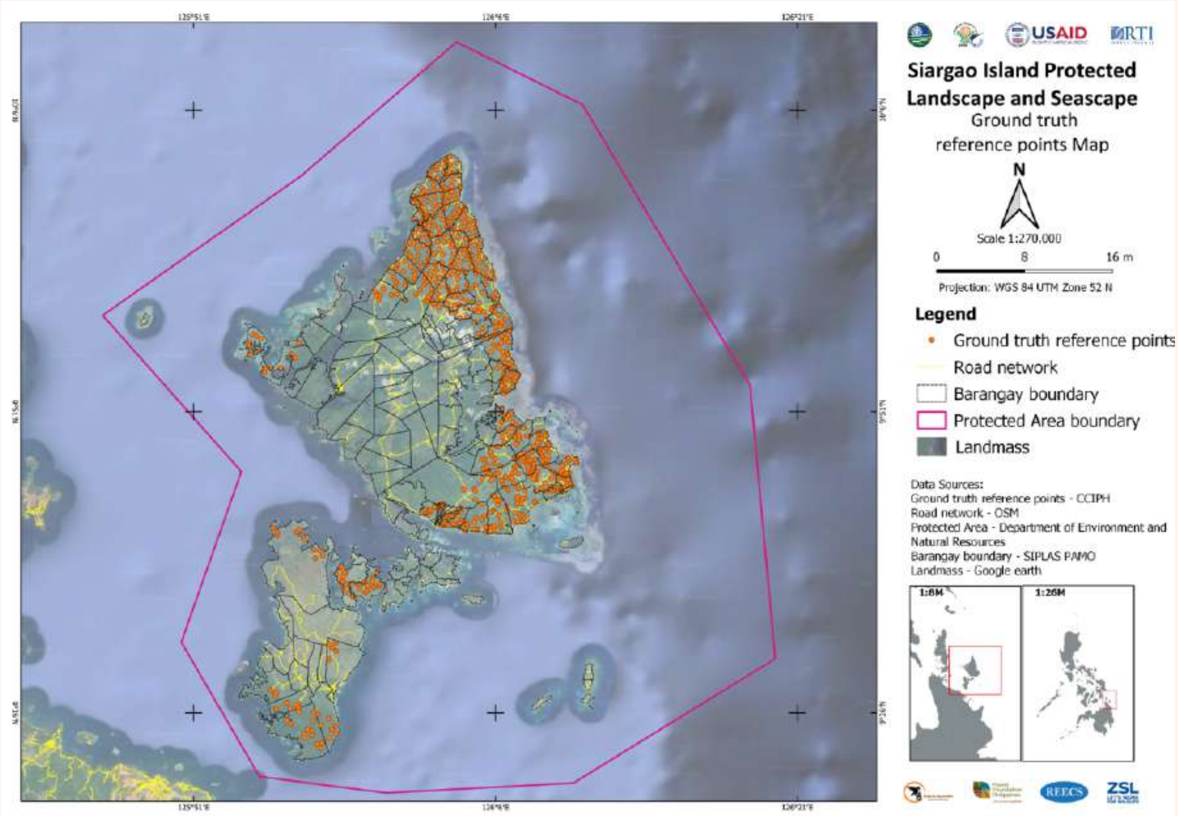

Figure 3. Location of reference points for ground-truthing in Siargao Island Protected Landscape and Seascape.

Field survey preparations

The team conducted a reconnaissance survey of the target sites from June 25 to 27, 2022, before the field data collection. The reconnaissance aimed to determine the correct flight plan, locate safe take-off and landing points, and strategize the RPAS team's daily flight missions.

Ground-truthing through RPAS survey

Aerial images were acquired using the DJI Phantom 4 RTK and DJI D-RTK base station (Annex B & C), which is a commercially available equipment for aerial mapping. The RPA was used to map desired areas across the AOI where the targeted reference points and established ground control points were located.

Flight plans were prepared using either the GS-RTK application or DJI Terra software. All flight plans were uploaded to the RPA remote controller prior to any flight missions. Flight plans consist of flight parameters, flight pattern, altitude, and image or video capture specifications.

Flight parameters (Table 1) were set to maximize the area covered by each flight and ensure the RPA's safe return to the landing point. Ground control point markers were not established before each flight because the equipment used in this survey was RTK-enabled, thus, the RPA can receive real-time corrections from the base station and calculate its position with improved accuracy or high precision in positioning information.

Table 1. Flight parameters used during flight missions using either the GS-RTK application or DJI Terra software.

Fixed variables	Description	Values
Mission Altitude	The vertical distance of the RPA from the home point ground	50 - 120 meters
Camera angle	The angle is always set in a bird's eye view to have a good view of the land area.	90 degrees (bird's eye view)
Front ratio overlap	This refers to the percentage of front overlap between flight images.	50 - 90%
Side ratio overlap	This refers to the percentage of side overlap between flight images.	50 - 90%
Speed	This is the time rate at which the RPA is moving along a flight line.	1-10 m/s
Main course angle	The angle of the primary flight path when using the software.	0-360 degrees
Margin	The buffer or extra coverage of the area around the map region.	-21 to +21 m
Mission Altitude	The vertical distance of the RPA from the home point ground	50 - 120 meters

Figure 4

Figure 4. Sample screenshot showing the parameters set in the DJI Terra software.

Figure 5. Ground-truthing through RPAS survey at Brgy. T-Arlan, Sta.Monica, Surigao del Norte. *This photo shows our RPA pilot (A); spotter (B); and the staff of the SIPLAS Protected Area Management Office who took on the roles of RPA pilot and encoder (C), respectively.*

Flight Missions

We surveyed 144 flight missions with 88 reference points within the AOI. The number of flights, locations, and survey dates are summarized in Table 3. Sampling sites were generally characterized as severely damaged with highly defoliated vegetation.

Table 2. List of no. of flight missions and duration per Municipality.

Municipality	Date of flight mission	Number of flight mission
General Luna	June 28 – July 1, 2022	28
Dapa	July 5, 2022	8
Del Carmen	July 6, 2022	5
Pilar	July 7 - 8, 2022	8
Sta Monica	July 12 - 20, 2022	36
Burgos	July 20 - 22, 2022	19
San Isidro	July 23 - 29, 2022	23
San Benito	July 29, 2022	7
Socorro	August 1 - 9, 2022	10
Total		**144**

Reference point or polygon validation on the ground using the sub-sub-sub-classes of the IPCC agreed during Stage 1

Reference points established in Green Assessment Stage 1 served as guiding markers for the RPAS team during their flights. These reference points served as flight points, ensuring that the RPAS team collected RPA images and data from a specific area of interest. Ground-truthing will help verify whether the land cover types detected during stage [1] aligned with the actual land cover types found on the ground. Figure 6 shows the sub-sub-classes of the land cover type validated during Stage 2.

[1] Municipalities with less than 10 flights are scheduled for one to two days of flight data acquisition, hence, the minimal number of flight missions.

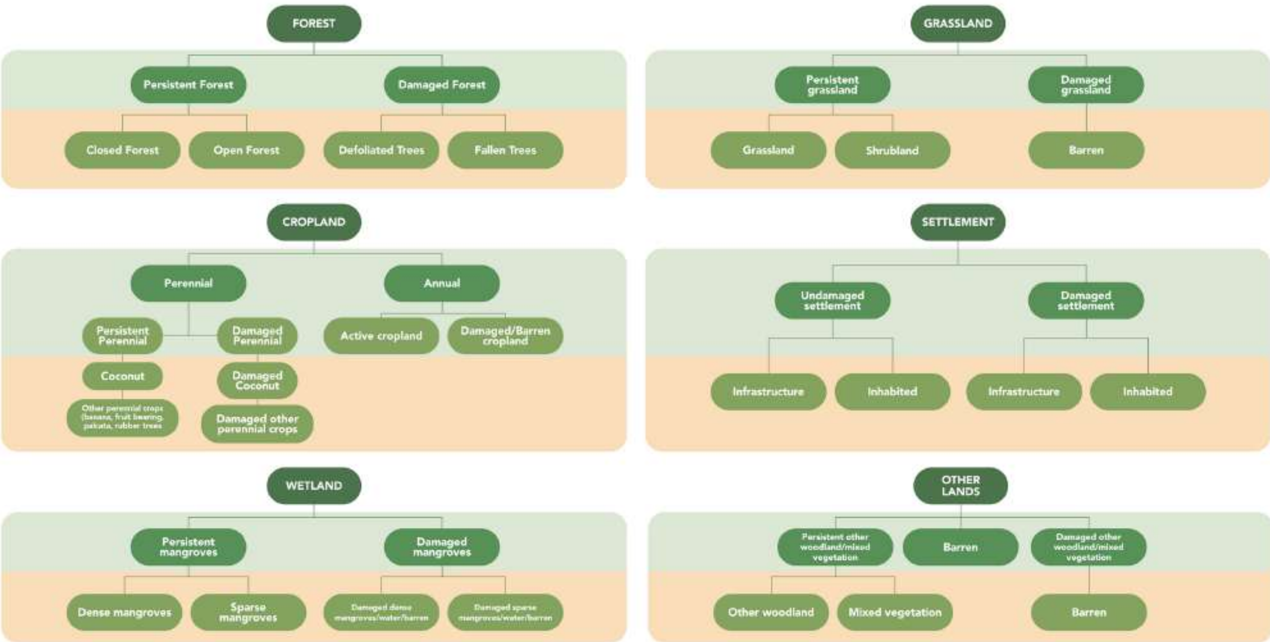

Figure 6. Hierarchy of land cover classes with a disaster theme. This was used in deciding during the Stage 1 activity i.e., where to place the reference polygons to represent sub-classes (green band), and where the identified reference locations will be used for validating on the ground with sub-sub-classes (orange band). *The topmost land cover class represents the six IPCC land categories with sub-classes along the green band, which might be deciphered from the Stage 1 NDVI maps. These are designated as reference polygons to validate their existence on the ground corresponding to the sub-sub-classes in the orange band. The above land cover categories will be the basis for generating a disaster-themed land cover map from satellite imagery.*

Data Cleaning and transition of Acquired RPA Images

Thorough inspection of all acquired images are conducted to ensure accuracy, eliminate the need for potential re-flights, and to catch any discrepancies or errors in the data collected. For each flight data acquisition, the team diligently completed a digital flight log form that collects field information using a smartphone (Annex F), including crucial flight details such as the flight plan and the number of raw RPA images acquired. The comprehensive records are organized and stored in a designated flight mission file folder (Figure 7), creating an organized repository for future reference and analysis. Subsequently, the compiled data undergoes a data-cleaning process which entails refining the information to enhance its quality and accuracy. The data then transitions from a collection of multiple images into a seamlessly stitched single image, ready for further analysis and utilization.

Figure 7

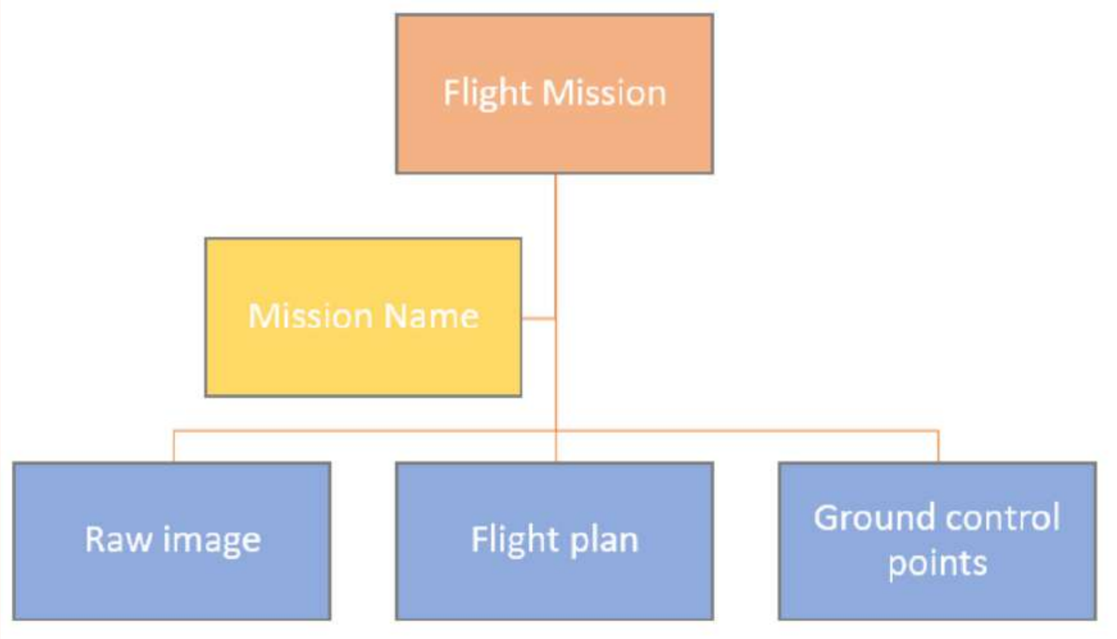

Figure 7. Flight data acquisition management for transition.

Data Pre-processing

Utilizing DJI Terra software (Annex D), the captured RPA images undergo a reconstruction process, yielding valuable outputs crucial for various applications. The DJI Terra software facilitates the creation of several key digital models, including an orthophoto mosaic image, a Digital Terrain Model (DTM), a Digital Surface Model (DSM), and a 3D model. These digital models play a pivotal role in providing an accurate representation of the environment, free from perspective distortions. They achieve this by precisely projecting a high-resolution map of each pixel from the original images onto the geographic position.

Out of 144 flight missions, there are a total of 132 successful flight data acquisitions for analysis and interpretation. These outputs serve as foundational data for a multitude of purposes, but notably, they find substantial use in the image interpretation process. In this process, the orthophoto mosaic, DTM, DSM, and 3D model collectively enable detailed analysis and interpretation of the environment, facilitating tasks such as vegetation assessment, land cover classification, and topographic mapping. The accuracy and precision of these digital models, free from distortions, enhance the reliability of the information extracted during the Green Assessment.

Figure 8

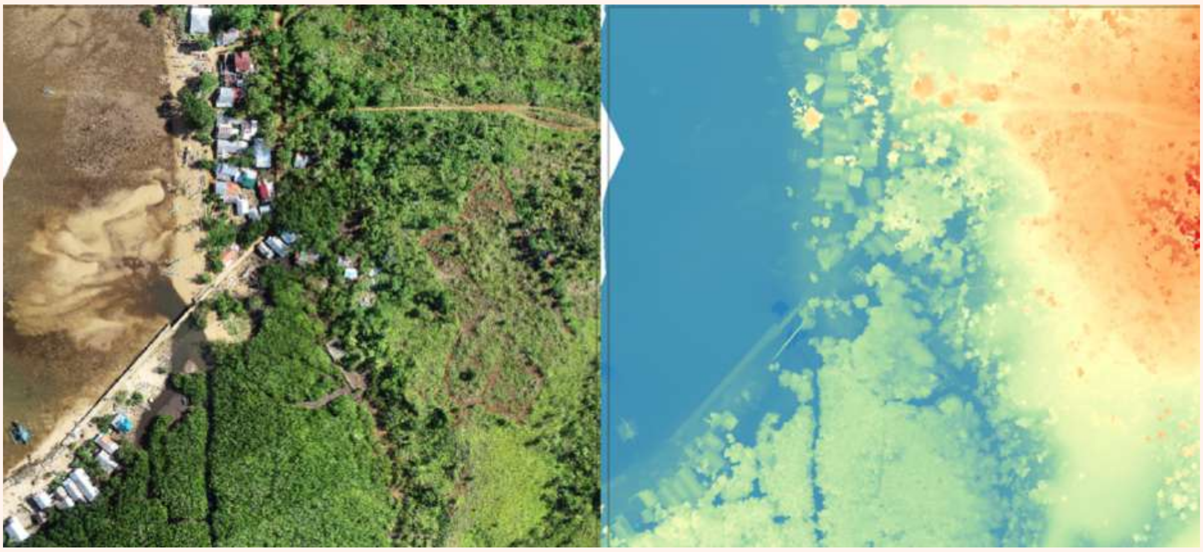

Figure 8. Sample orthophoto mosaic image (left) and Digital Surface Model (right) processed using DJI Terra software. This flight data acquisition is located at barangay Pamosaingan in the Municipality of Socorro.

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3 Ground-truthing Survey Results

Field Observations

Ground-truthing in SIPLAS was conducted from June 28, 2022, to August 9, 2022, six months after Typhoon Odette. The ground-truthing team observed signs of vegetation having already recovered, topmost layer of the mangrove forest area and some barren ground are starting to sprout new green canopy, vast palm tree plantations are lush once again, but there are still significant damages reflecting the impact of Typhoon Odette. Additionally, the majority of the observed damages in all municipalities were concentrated in vegetative areas with perennial crops and mangrove forests in coastal areas. The specific field observations in each municipality are specified below:

a. General Luna

General Luna being the main tourist area in SIPLAS, the ground-truthing team's observations revealed significant damage to both settlements and essential infrastructure. Sample RPA images showing damage due to the typhoon's destructive force, extended towards mangrove areas in Brgy. Malinao (Figure 9A & 9B); settlement and infrastructures in Brgy. Catangnan (Figure 9C); and perennial cropland in Brgy. Cabitoonan(Figure 9D).

Figure 9. Orthomosaic image of damaged mangroves (A & B); damaged infrastructure and settlements (C) ; and damaged cropland (D) in different barangay across the jurisdiction of General Luna.

a. Dapa

The observations unveiled significant damages on both settlements (Figure 10C) and agricultural landscape, with banana and palm tree plantations bearing the brunt of the devastation in Brgy. Don Paulino (Figure 10A). There's also an apparent quarrying activity in Brgy. Union which may contribute to the observed vegetation disturbance on the ground (Figure 10B).

Figure 10. Orthomosaic image showing vegetation with uprooted palm trees and damaged mangrove (A); signs of defoliated trees beside the quarry site and (B & D); and damaged infrastructure and settlements (C) in different barangay across the jurisdiction of Dapa.

b. Del Carmen

Observations in Del Carmen were constrained due to airspace restrictions in areas close to the airport, limiting the use of RPAs for comprehensive flight data acquisition. Despite these limitations, perennial crops, such as those of banana and palm trees displayed signs of damage (Figure 11D). On the island of Brgy. Caub, where the scenic limestone outcrops attract tourist visitors, the team observed notable damaged trees, particularly on its limestone hills (Figure 11A & 11B).

Figure 11