Green Assessment Framework

A Biodiversity and Ecosystem-based Analysis for Post-Disaster Needs Assessment, Green Reconstruction, and Resilience Planning

PHILIPPINES SUSTAINABLE INTERVENTIONS FOR BIODIVERSITY, OCEANS, AND LANDSCAPES (SIBOL) ACTIVITY

GREEN ASSESSMENT FRAMEWORK: A Biodiversity and Ecosystem-based Analysis for Post-Disaster Needs Assessment, Green Reconstruction, and Resilience Planning

FY 2023 Q3: May 2023

Activity Title:	Philippines Sustainable Interventions for Biodiversity, Oceans, and Landscapes (SIBOL) Activity
Sponsoring USAID Office:	USAID/Philippines
Cooperative Agreement Number:	72049220CA00005
Recipients:	RTI International
Subrecipients:	Center for Conservation Innovations PH Inc. (CCIPH) Resources, Environment and Economics Center for Studies, Inc. (REECS) Forest Foundation Philippines (FFP) Zoological Society of London (ZSL)
Date of Submission:	December 2022

This publication was produced by the Philippines Sustainable Interventions for Biodiversity, Oceans, and Landscapes Activity under Cooperative Agreement No. 72049220CA00005 and prepared by RTI International and consortium partners at the request of the United States Agency for International Development (USAID). This document is made possible by the support of the American people through USAID and its contents are the sole responsibility of RTI and its consortium. This report does not necessarily reflect the views of USAID or the U.S. Government

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I. RATIONALE

The experience of post-disaster recovery around the world has shown that ecosystem services, biodiversity, and ecosystem planning are not usually appropriately considered at the beginning of the reconstruction process. Most of the efforts have been devoted to humanitarian causes. Experience has also revealed that a community's risk of disaster increases when humanitarian efforts are unable to solve environmental problems.

This follows the notion that the greater the potential occurrence (or reoccurrence) of a hazard and the more vulnerable a population (human and biodiversity), the greater the disaster risk. Human vulnerability is the inability to foresee, manage, and recover from its effects. Hence, vulnerability rises when the natural environment is damaged.

The **Green Assessment (GA) Framework** was specifically developed to provide pre- and post-disaster studies based on ecosystems and biodiversity that will serve as the foundation for planning for future disaster risks as well as green reconstruction and resilience planning.

This Framework has three tiers: Stage 1, which involves Rapid Appraisal to determine the extent of damage to ecosystems; Stage 2, which entails post-disaster comprehensive assessment of biodiversity, ecosystems, and ecosystem services, and Stage 3 is the development of the green recovery plans. (see Figure 1)

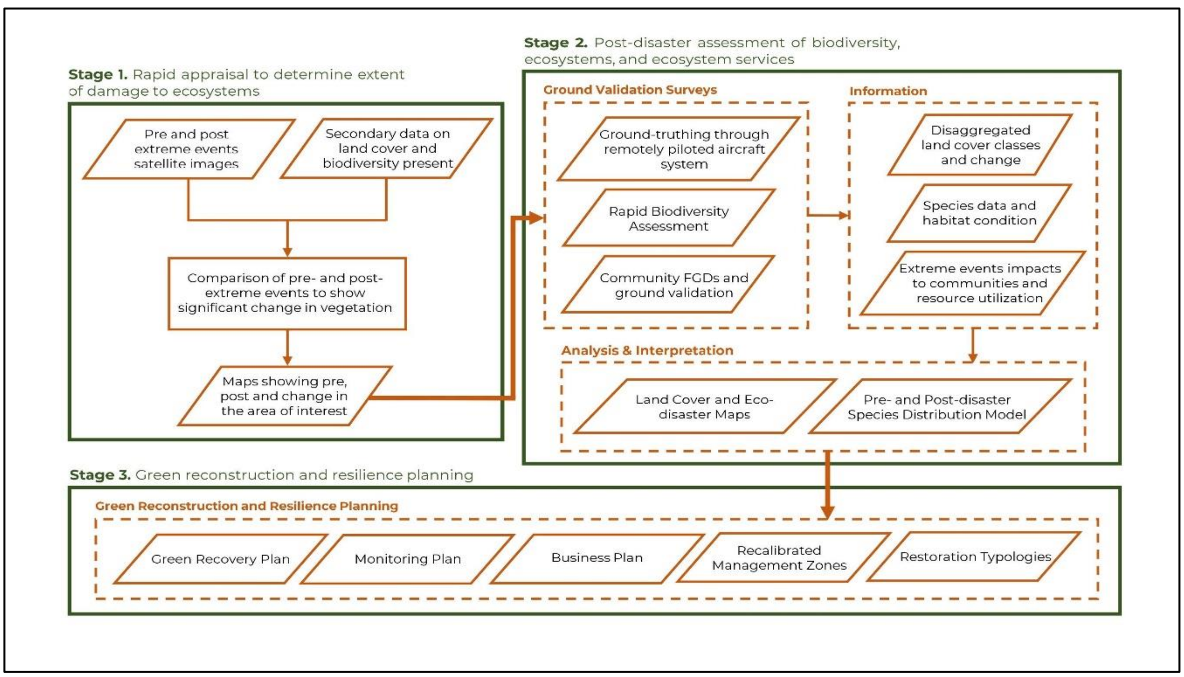


Figure 1. The green assessment framework diagram shows three critical stages: (1) Rapid Appraisal to determine the extent of ecosystem damage caused by a disaster; and (2) Post-disaster assessment of biodiversity, ecosystems, and ecosystem services; (3) Green Reconstruction and Resilience Planning.

II. METHODS

STAGE 1 - Rapid Appraisal Stage

The first stage aims to quickly map the aftermath of an extreme weather event on land cover, ecosystems, and biodiversity. This stage involves three critical components.

The first component is rapid mapping using normalized difference vegetation index (NDVI). The NDVI is the most commonly used vegetation index in remote sensing and measures vegetation as related to the relative density and health of their vegetation or "vegetation greenness"[1]. The process involves collection of pre- and post-disaster data and information from satellite images and comparisons of the two-event scenarios. The NDVI values range from -1 to +1. Values below zero represent the absence of vegetation while values very close to zero are likely settlement areas[2]. Values closer to one indicate the presence of dense vegetation akin to the lush growth of shrubs and forests[1]. As the NDVI values decrease, it is assumed that vegetation density is also decreasing.

The second component of the rapid appraisal is the review of existing biodiversity data and information. Preliminary habitat suitability models of trigger species identified during desk review are produced using the NDVI change maps and other biophysical attributes of the landscape being studied. The habitat suitability models predict possible changes in species distribution and survival envelopes. The third and final component is the mapping of reference points and polygons as guides for selecting sites where further ground validation for Stage 2 will be conducted.

STAGE 2 - Post-disaster Comprehensive Assessment

The post-disaster comprehensive assessment involves conducting the following ground validation surveys in evaluating the high conservation values after an extreme weather event: (a) aerial ground truthing using remotely piloted aircraft systems (RPAs); (b) rapid biodiversity field assessments; and (c) community focus group discussions.

Ground truthing using RPAs makes use of drone technology to provide a quick and innovative way of surveying visible damages and gathering training data. The latter is necessary to feed into further image processing of satellite data to convert into historical (pre-disaster) and contemporary (post-Odette) land cover maps. However, RPA surveys cannot be extensively deployed because of limitations in resources, logistics, and field conditions (e.g., flight obstructions, moisture, and fog at high altitudes). Hence, the RPA survey is combined with foot patrols as part of the rapid biodiversity assessments, and validation of land use change. The rapid biodiversity assessment (RBA) evaluates the post-disaster status of key species and their remaining habitats with attention given to rare, threatened, and endemic species. Standard biodiversity techniques are employed to gather data on species detection, encounter rates, and occurrences. Damage-themed habitat assessments are conducted to determine the extent and severity of impact to key habitat resources (e.g., nesting and breeding sites, understory cover) at the local level. Predictive species-habitat models are then produced to determine potentially vulnerable habitats in need of localized remedial measures for conservation and recovery. Results are validated through focus group discussions (FGDs) and key informant interviews (KII) with key stakeholders and local communities.

[1] USGS 2018

[2] GISGeography. 2022. What is NDVI (Normalized Difference Vegetation Index). [cited 10 October 2022]. Retrieved from https://gisgeography.com/ndvi-normalized-difference- vegetation-index/

These consultations also provided information on how local communities are affected by changes to biodiversity, ecosystems, and ecosystem services.

Piloting the Green Assessment Framework in Palawan

The Green Assessment Framework was developed and pilot-tested in Palawan, specifically in Puerto Princesa Subterranean River National Park (PPSRNP) and Cleopatra's Needle Critical Habitat (CNCH) in Puerto Princesa City, and areas in the municipalities of Roxas and San Vicente to assess the extent and severity of Super Typhoon Odette, which battered the Philippines in December 2021.

The Category 5 typhoon brought violent, 160 mph winds and torrential downpours, which caused storm surges, landslides, and severe damage to several provinces of Visayas, Surigao del Norte in Mindanao, and Palawan.

The GA Initiative brought together different organizations to collaborate by pooling their respective knowledge, skills, expertise, and resources. The United States Agency for International Development (USAID) Philippines Sustainable Interventions for Biodiversity, Oceans, and Landscapes Project (SIBOL), Palawan Council for Sustainable Development Staff (PCSDS), DENR Provincial Environment and Natural Resources Office (PENRO), DENR Community Environment and Natural Resource offices (CENRO) of Puerto Princesa City and Roxas, PPSRNP protected area management office, CNCH technical working group, Puerto Princesa City Environment and Natural Resources Office (City ENRO), Puerto Princesa City Disaster Risk Reduction Management Office (CDRRMO), and the local governments of San Vicente and Roxas have all joined forces in one concerted effort to maximize the coverage of the assessment. Rapid appraisals were conducted in January 2022, while the post-disaster comprehensive assessment was administered from March to July 2023.

Figure 2. Launching of the Green Assessment in Palawan. SIBOL worked with partner agencies to conduct ground validation surveys in Puerto Princesa Subterranean River National Park (PPSRNP), Cleopatra's Needle Critical Habitat (CNCH), and the larger Cleopatra's Needle Forest Reserve (CNFR).

III. RESULTS

Stage 1. Rapid Appraisal

Rapid mapping using the normalized difference vegetation index (NDVI) showed how extensive the impact of Super Typhoon Odette was to central and northern Palawan (Figure 3). Initial cursory analysis revealed that 96% of dense vegetation was reduced to moderately dense from pre-Odette to post-Odette. We produced an NDVI difference map to better visualize the severity of change across the landscape as displayed in Figure 4. Areas showing a more prominent red color indicate a drastic change in the NDVI values. Vegetation loss was particularly evident in the southern part of PPSRNP, and the northwestern forests of Cleopatra's Needle extending to Roxas and San Vicente. Lighter shades of red (pinkish) signify smaller change. Areas shaded in white suggest no change in vegetation while blues and greens indicate leaves piling up on the ground due to defoliation or strong winds. The latter was validated during comprehensive assessment in Stage 2.

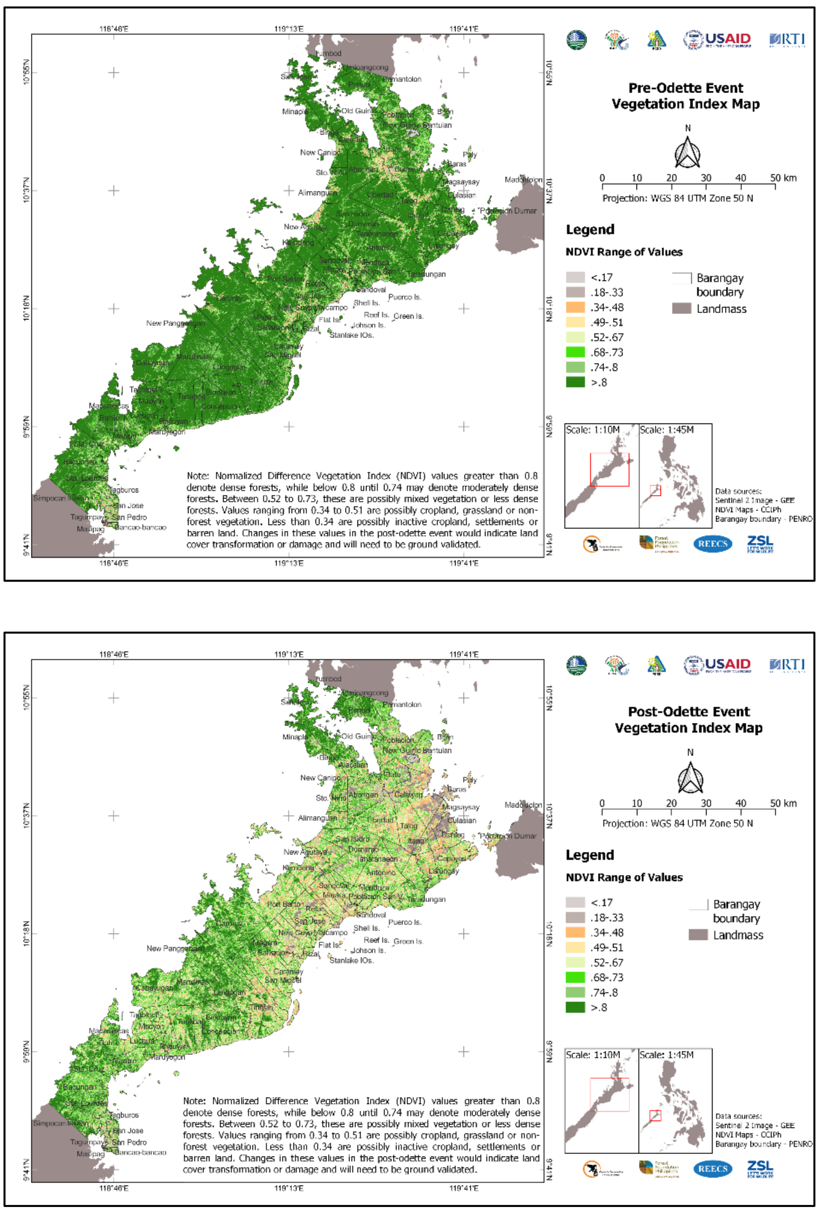


Figure 3. Normalized Difference Vegetation Index (NDVI) Map showing the changes in pre- and post-Odette vegetation.

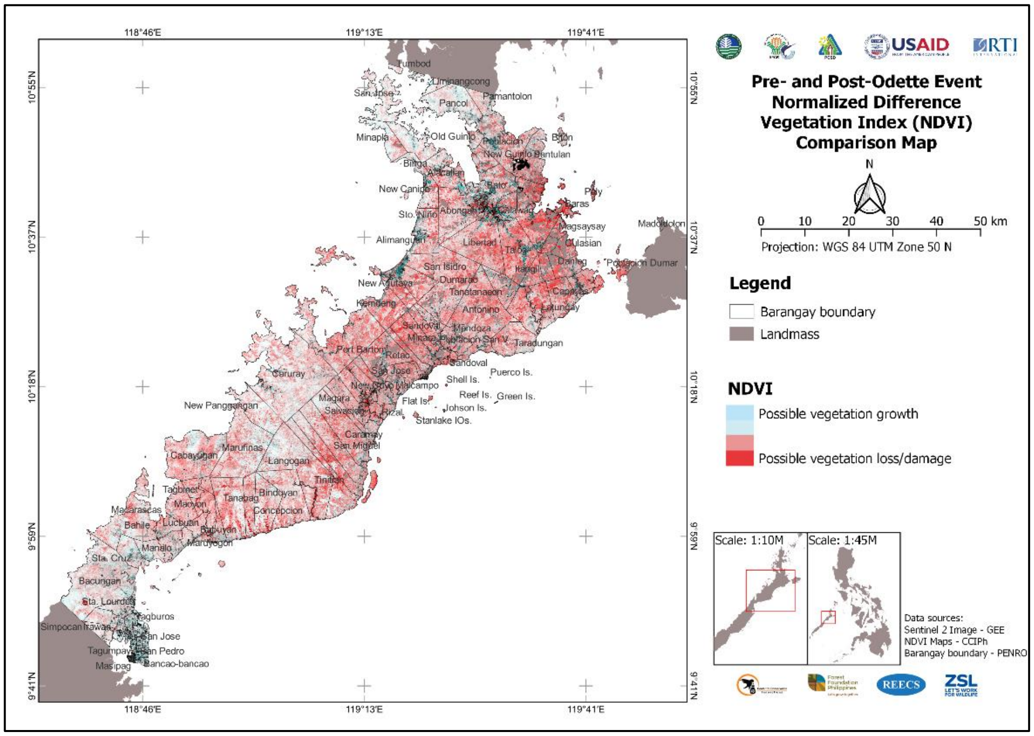


Figure 4. NDVI difference map showing the severity of changes in pre- and post-Odette vegetation. *Areas in red indicate possible loss or damage caused by the typhoon based on the results of the NDVI. Cloud-free satellite images from available Sentinel 2 images dated January 1 to November 30, 2021 (pre-Odette), and December 2021 to February 2022 (post-Odette) were used to generate the map.*

STAGE 2. Post-disaster Comprehensive Assessment

Detailed Mapping Revealed the Impacts of Odette on the Landscape

- *Damaged Forests*: Palawan's land cover has changed to a great extent because of Super typhoon Odette. Damaged forests cover an area of 126, 371.29 ha (33.74%) of the whole area of interest. The previously (pre-Odette) closed and open forests were extremely damaged as evidenced by fallen and uprooted trees, broken stems and branches, bark tearing, and severe crown defoliation.
- *Devastated Coconut Plantations:* The entirety (100%) of coconut plantations were devastated. Some coconuts left with intact shoots may recover.
- *Damaged Mangroves:* Mangroves were either uprooted or defoliated. Approximately 6,447 ha (50%) of the mangrove areas were heavily damaged.
- *Croplands, Shrublands, and Mixed vegetation:* Croplands and areas with mixed vegetation had the least impact from the typhoon. The total damaged area for croplands was 1,938 ha (8.39%), and 7,606 ha (4.07%) for mixed vegetation.
- *Damaged Settlements:* More than half (56.87%) of settlements, excluding roads, were annihilated by the typhoon. Damage was more prominent in CNCH due to river flooding and landslides.

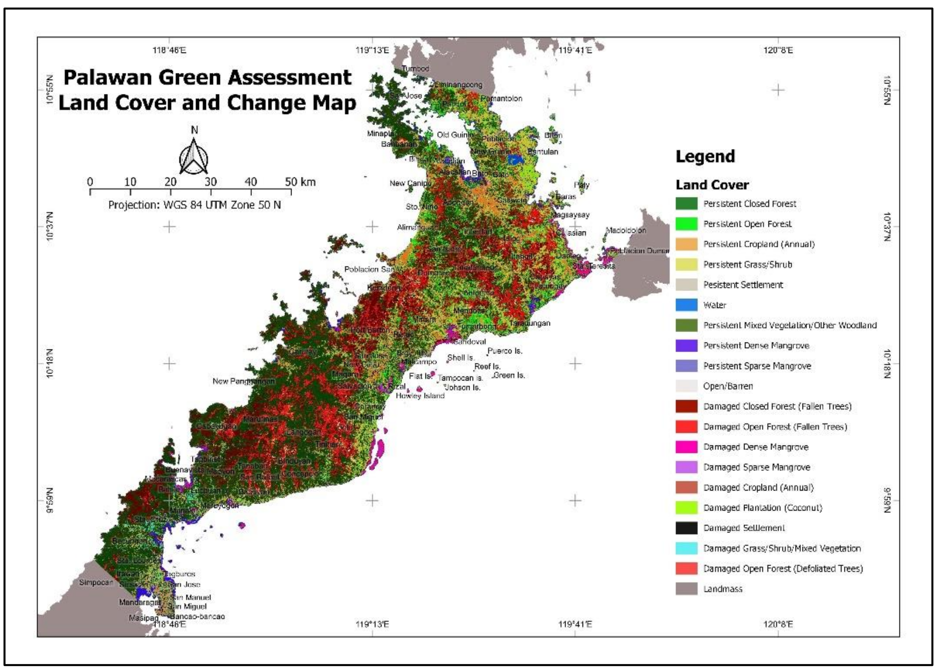


Figure 5. Map of the Area of Interest (AOI) in Palawan illustrating the different land cover types and the changes thereof because of the damages caused by Super Typhoon Odette.

Table 1. Area calculations of the land cover types in parts of central and northern Palawan in a post-Odette scenario.

Site	Condition	Forest (ha)	Mangroves (ha)	Mixed Vegetation, shrubs, grasslands (ha)	Cropland (ha)	Plantation (ha)	Settlement (ha)	Overall Total (ha)
PPSRNP	Damaged	**9,619.34 (57.69%)**	27.52 (73.17%)	229.52 (3.54%)	1.03 (0.25%)	60.16 (100%)	26.44 (56.01%)	9,964.01 (42.01%)
	Persistent	7,054.97 (42.31%)	10.09 (26.82%)	6250.96 (96.46%)	418.08 (99.75%)	0	20.77 (43.99%)	13754.87 (57.99%)
	Total	16,674.31 (70.30%)	37.61 (0.16%%)	6,480.48 (27.32%)	419.11 (1.77%)	60.16 (0.25%)	47.21 (0.20%)	23,718.88
CNCH	Damaged	**15,728.03 (50.20%)**	-	212.73 (1.40%)	20.81 (4.65%)	104.64 (100%)	37.21 (69.77%)	16,231.98 (34,44%)
	Persistent	15,600.9 (49.80%)	-	14,945.76 (98.60%)	426.8 (95.35%)	0	16.12 (30.22%)	30,895.88 (65.55%)
	Total	31328.93 (66.53%)	-	15,158.49 (32.19%)	447.61 (0.95%)	104.64 (0.22%)	53.33 (0.11%)	47,093.00
San Vicente	Damaged	**23,985.38 (59.39 %)**	163.96 (26.98%)	845.81 (4.25%)	121.94 (3.44%)	793.01 (100%)	291.94 (29.07%)	26,202.04 (39.61%)
	Persistent	16,300.36 (40.46 %)	443.66 (73.02%)	19,063.35 (95.71%)	3,420.67 (96.56%)	-	712.42 (70.39%)	39,940.46 (60.39%)
	Total	40,285.74 (60.91%)	607.62 (0.92%)	19,909.16 (30.10%)	3,542.61 (5.36%)	793.01 (1.20%)	1,004.36 (1.52%)	66,142.50
Roxas	Damaged	**42,495.98 (64.57%)**	2,581.99 (87.09%)	1,249.75 (3.03%)	920.62 (15.33%)	3,920.55 (50%)	819.47 (30.24%)	51988.36 (42.36%)
	Persistent	23,320.02 (36.43%)	382.81 (12.91%)	40,060.60 (96.98%)	5,085.57 (84.67%)	3,920.55 (50%)	1,890.73 (69.76%)	70739.73 (57.64%)
	Total	65,816.00 (51.97%)	2,964.80 (2.34%)	41,310.35 (32.62%)	6,006.19 (4.74%)	7,841.10 (6.19%)	2,710.20 (2.14%)	126,648.64
Overlap between San Vicente and Roxas[3]	Damaged	**2,184.58 (29.28%)**	-	144.89 (3.84%)	60.33 (13.57%)	166.86 (100%)	115.79 (85.68%)	2672.45 (22.31%)
	Persistent	5,277.47 (70.72%)	-	3,626.69 (96.16%)	384.23 (86.43%)	-	19.35 (14.32%)	9307.74 (77.69%)
	Total	7,462.05 (62.29%)	-	3,771.58 (31.48%)	444.56 (3.71%)	166.86 (1.39%)	135.14 (1.13%)	11,980.19
Whole Extent of AOI (PPSRNP, CNCH, San Vicente and Roxas)	Damaged	**125,581.07 (56.54%)**	6,446.68 (50.17 %)	7,606.26 (4.07%)	1,938.01 (8.39%)	10,065.99 (100%)	4,733.28 (56.87%)	156,371.29 (33.74%)
	Persistent	96,544.38 (43.46%)	64,03.89 (49.83%)	179,439.03 (95.93%)	21,150.99 (91.61 %)	0	3,589.4 (43.13%)	307,127.69 (66.26%)
	Total	222,125.45 (47.92%)	12,850.57 (2.77%)	187,045.29 (40.36%)	23,089 (4.98%)	10,065.99 (2.17%)	8,322.68 (1.80%)	463,498.98

[3] Overlapping municipal boundaries currently exists for San Vicente and Roxas. For this report, we used administrative data provided by the municipal planning and development office of Roxas for the area computations.

Impacts on the Landscape

*Pre-Odette***:** The land cover in northern and central Palawan is predominantly forests (48% or 222,125 ha), consisting of closed (dark green) and open forests (lighter green) as seen in Figure 6.
*Post Odette***:** Forty-three percent (43% or 96,544 ha) of the 222,125 ha remains unchanged post-disaster. About 57% (125,581 ha) was transformed to open forest (light green) or non-forest (gray) as seen on the maps below. Damaged areas are presumed to have high numbers of fallen and uprooted trees, and defoliated crown cover.

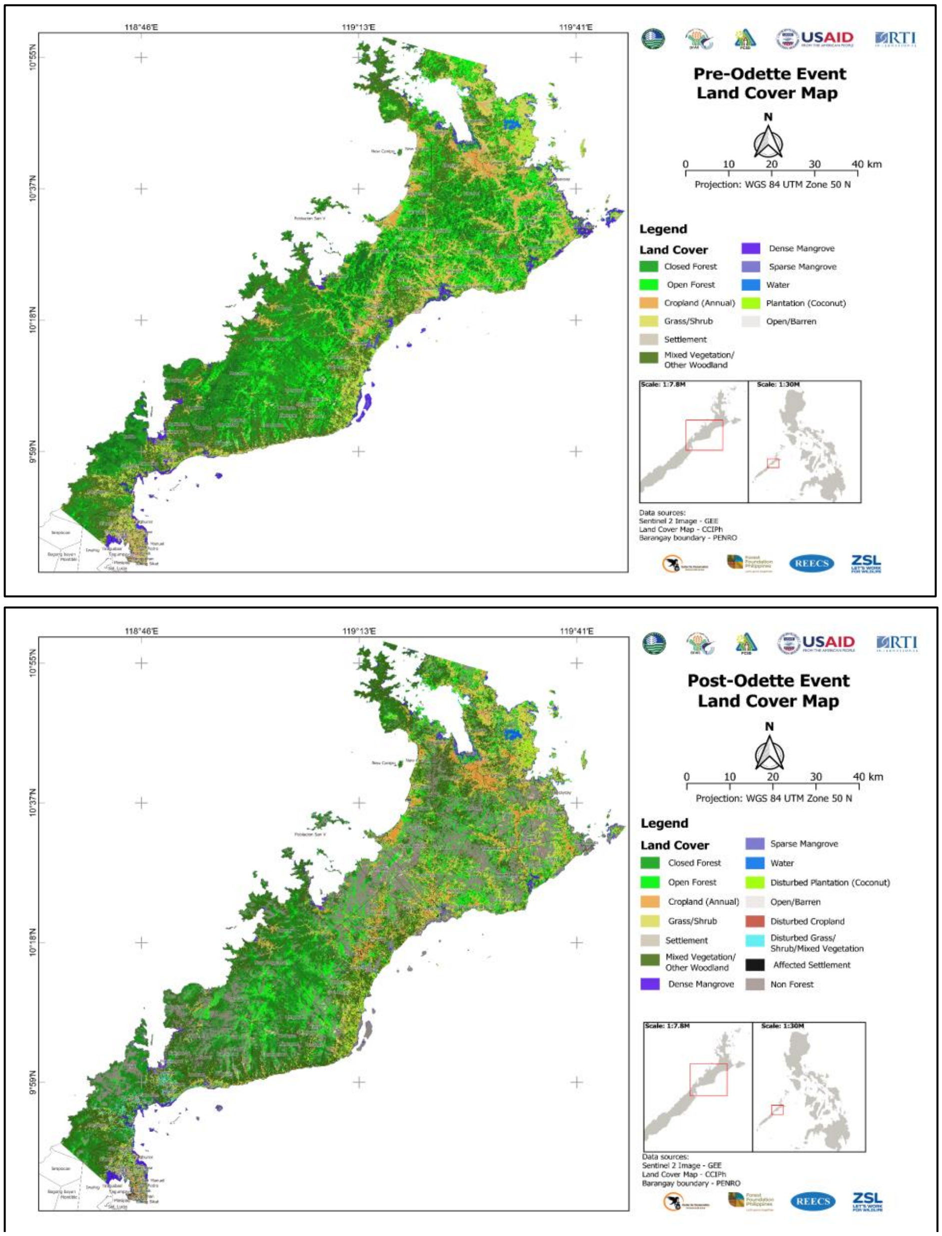


Figure 6. Land cover map of the Area of Interest (AOI) in Palawan showing the differences and change in land cover composition during pre- Odette and post-Odette scenarios.

The Puerto Princesa Subterranean River National Park Up Close

- **Pre-Odette:** PPSRNP's land cover was dominated by closed and open forests at 16,674 ha (70%). The protected area contains large forest blocks, particularly in Marufinas and New Panggangan, with forest patches at the western portion of Cabayugan, and sparse forests scattering around Tagabinet.
- **Post Odette:** More than half (58%) or 9,619 ha of the forests were damaged. Mid to high elevation forests were converted into non-forest areas.

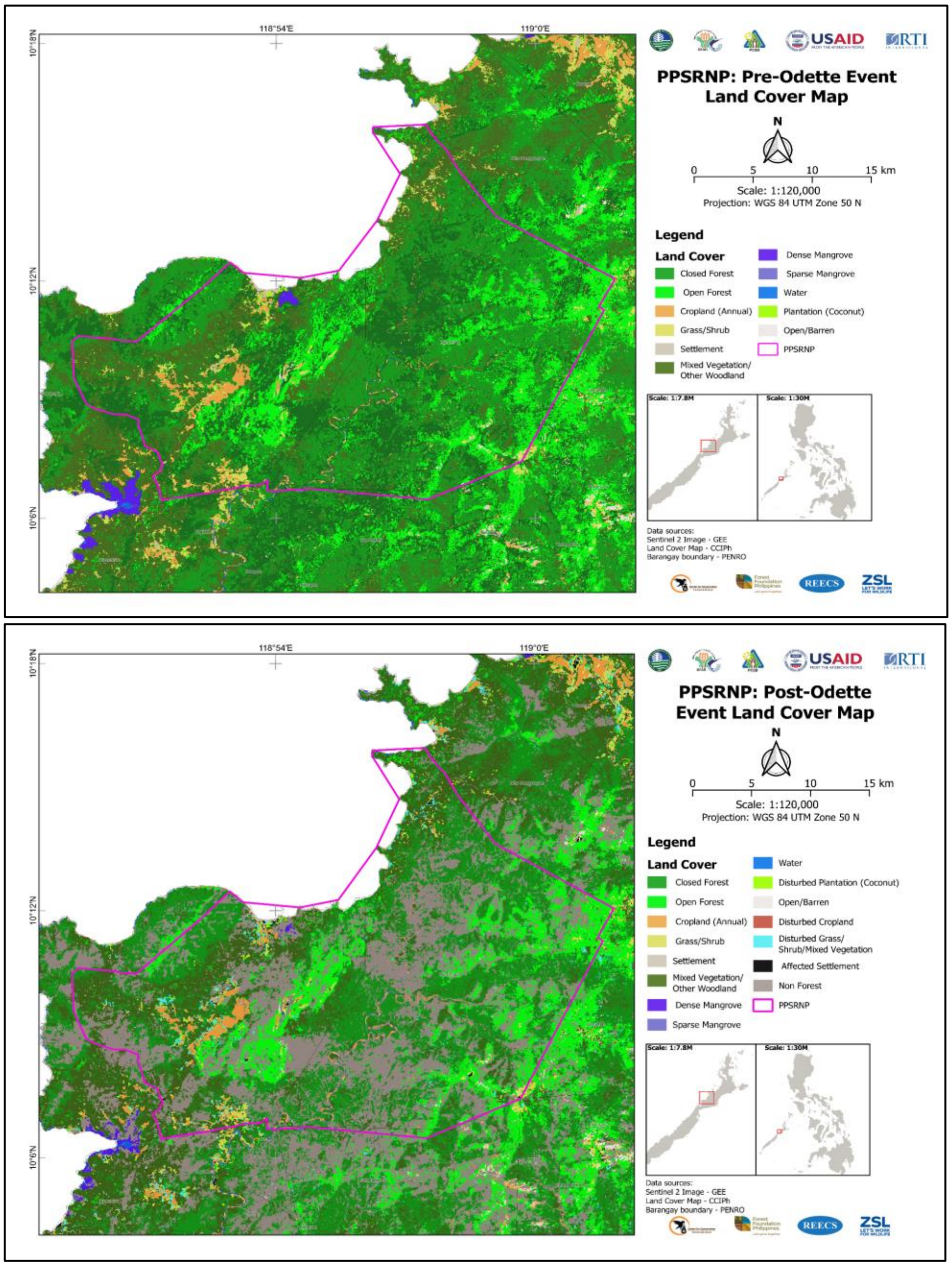


Figure 7. Land cover map of the Puerto Princesa Subterranean River and National Park showing the differences and change in land cover composition during pre-Odette and post-Odette scenarios.

Cleopatra's Needle Critical Habitat Up Close

- **Pre-Odette:** Closed and open forests occupy about 67% (3,1329 ha) of CNCH's total land area. Contiguous forests can be observed in Barangays Langogan, Tanabag, San Rafael, and Conception, while forest patches.
- **Post-Odette:** Fifty percent (50%) or 15,728 ha of forests were reduced into open forests or non-forest overnight.

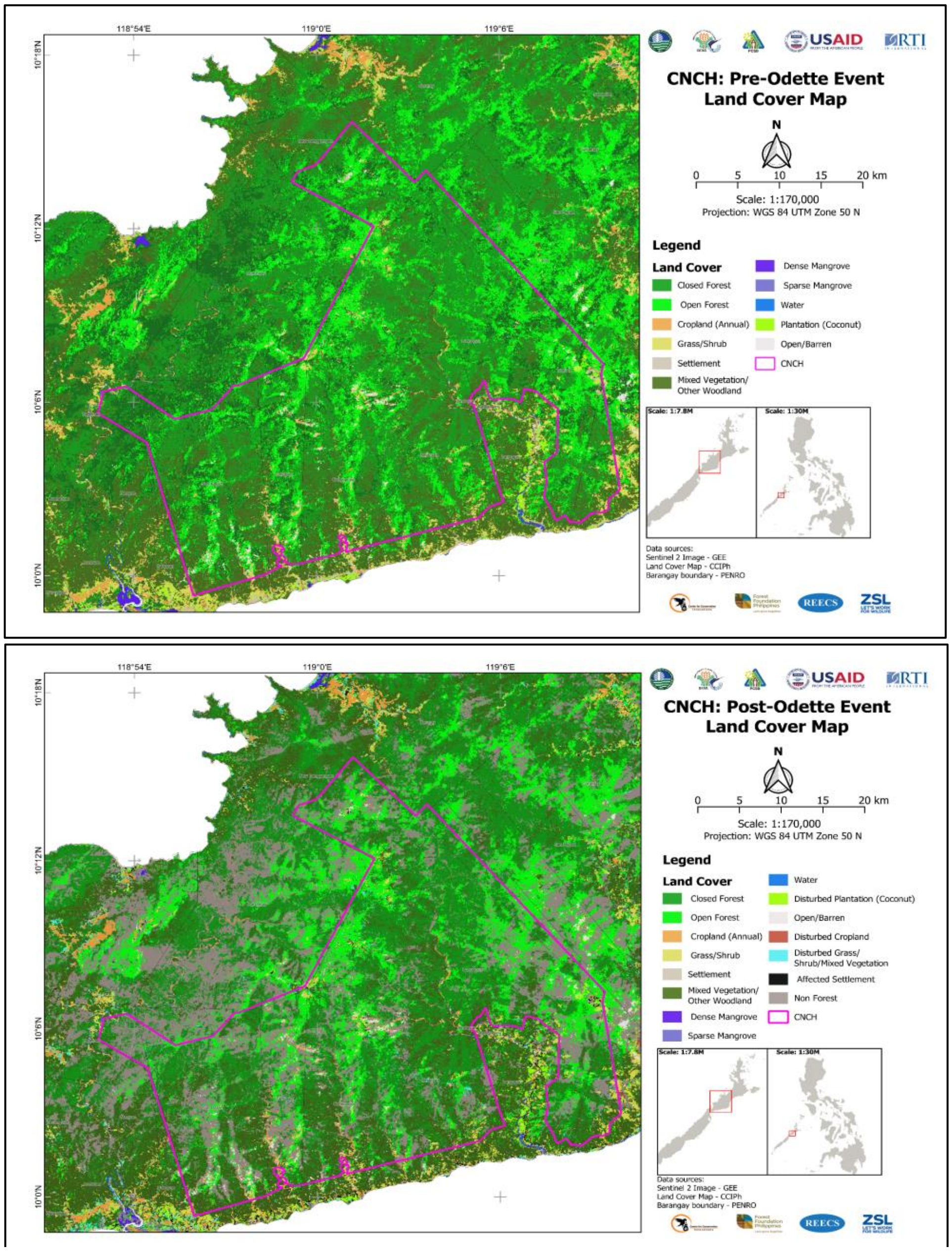


Figure 8. Land cover map of the Cleopatra's Needle Critical Habitat (CNCH) showing the differences and change in land cover composition during pre- Odette and post-Odette scenarios.

Cleopatra's Needle Forest Reserve Up Close

- **Pre-Odette:** Sixty-seven percent (67%) or 70,068 ha of CNFR consists of forest cover, with open forests located in Jolo, San Miguel, Caramay, Port Barton, and Kemdeng. Secondary forests can be seen in the Municipality of Roxas and San Vicente which is primarily influenced by activities related to seasonal slash-and-burn agriculture.
- **Post-Odette:** Nearly 50% or 33,785 ha has been damaged and transformed into open forests.

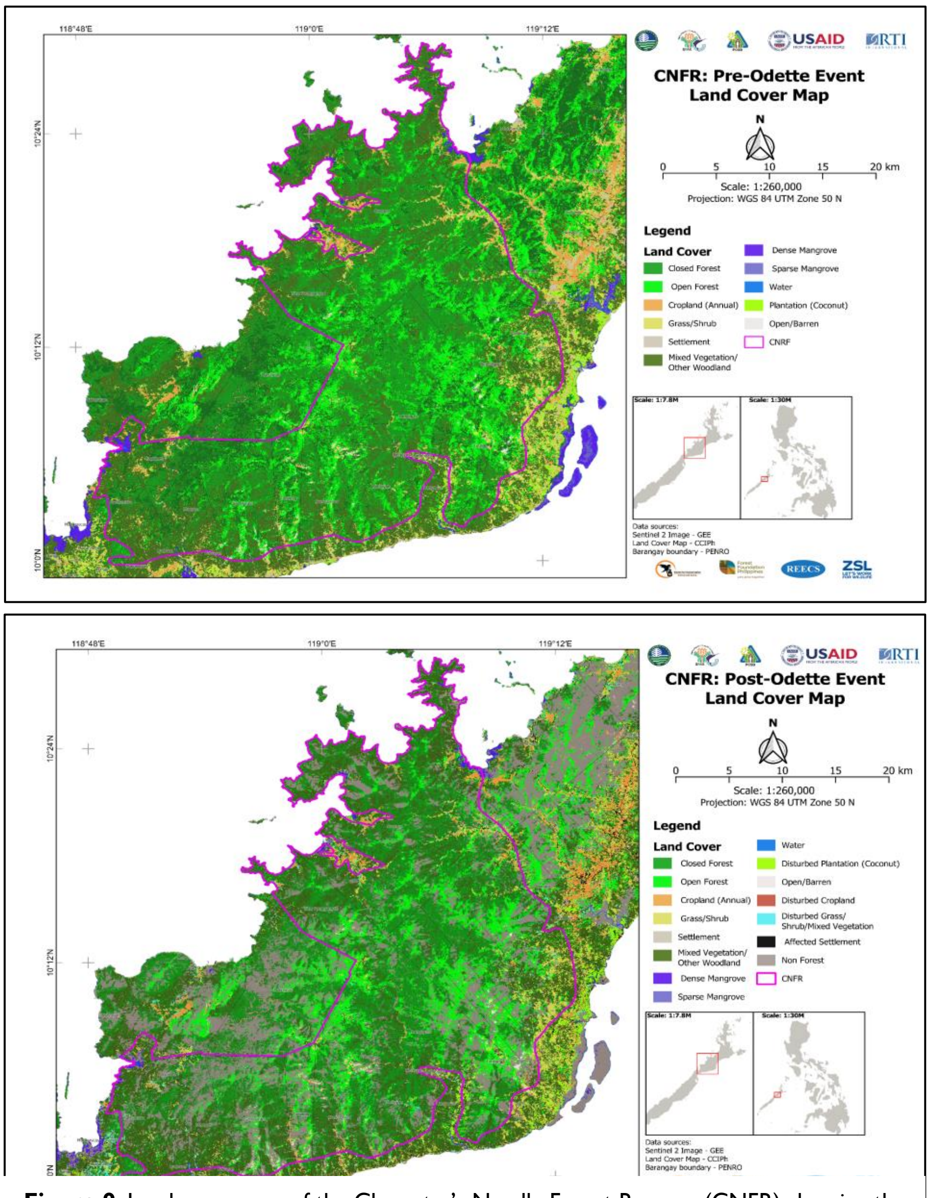


Figure 9. Land cover map of the Cleopatra's Needle Forest Reserve (CNFR) showing the differences and change in land cover composition during pre- Odette and post-Odette scenarios.

Impacts on Biodiversity

We recorded a total of 399 species of flora and fauna, comprising 97 birds, 15 amphibians, 21 reptiles, 28 mammals, and 238 plant species during the green assessment.

Globally important flora species such as *Dillenia luzoniensis* (Kambog), *Pandanus simplex* (Pandan), *Dipterocarpus grandiflorus* (Apitong), and *Pterocarpus indicus* (Narra) were documented. Faunal species of global conservation importance include the *Cacatua haematuropygia* (Red-vented cockatoo), *Polyplectron napoleonis* (Palawan peacock-pheasant), *Philautus longicrus* (Palawan bubble-nest frog), *Cuora amboinensis* (Southeast Asian box turtle), and *Acerodon leucotis* (Palawan fruit bat). Interestingly, our records also include newly discovered three species of *Begonia,* two *Psychotria,* one *Chassalia,* one *Jasminum,* and one *Ardisia* (Figure 10).

We observed high species richness, but species detection and encounter rates were relatively lower compared to pre-Odette scenarios. This may be due to the damaged habitats as evinced by high numbers of fallen and broken trees, damaged understories, and defoliated vegetation.

Figure 10. Possible new species of (A) Chassalia sp.; (B) Ardisia sp.; (C) Psychotria sp.; and (D) Begonia sp. recorded.

Ecological Models Revealed the Impacts of Typhoon Odette on Indicator Species

Indicator species are species that reflect the overall conditions of the ecosystems that they inhabit. Using indicator species that occur in the AIO, we created species distribution models to map and predict areas of suitable habitats or species survival envelopes. The models (Figures 11 to 13) showed that before the onslaught of Odette, species survival envelopes were quite extensive and followed the extent of good quality forest habitats, particularly in forest blocks along increasing elevation.

Palawan hornbill *(Anthracoceros marchei)* - The post-Odette distribution model for the Palawan hornbill shows that habitat connectivity of the species has diminished, especially within PPSRNP. The species' long-term survival is greatly compromised as this may contribute to isolation from the rest of the island.

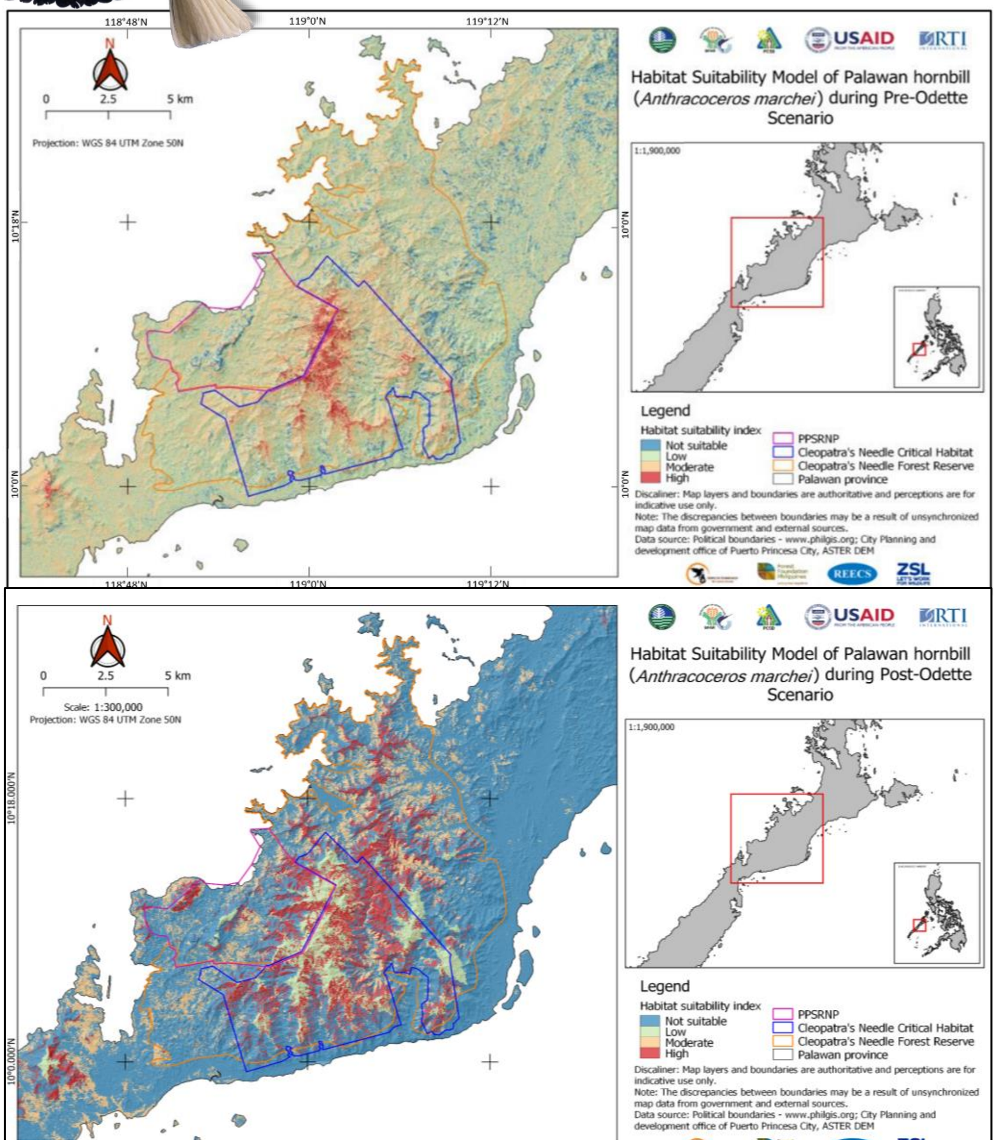
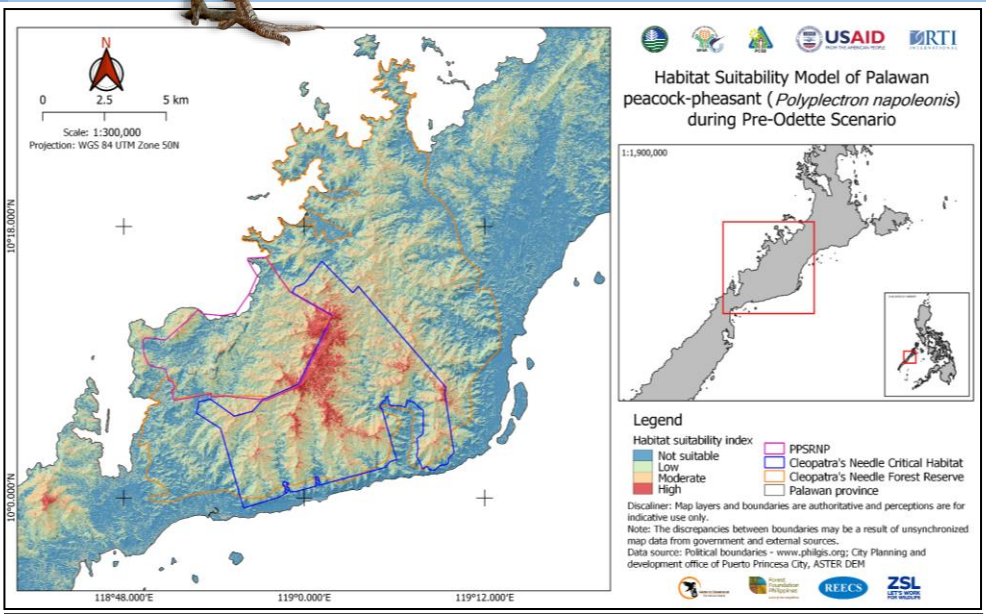


Figure 11. Habitat Suitability Model of the Palawan hornbill, showing the areas with low (green) to high (red) habitat suitability in a pre- and post-Odette scenario.

Palawan Peacock-pheasant *(Polyplectron napoleonis)* - Palawan Peacock Pheasant, a lowland forest species is found only in Palawan. Its habitat preference is forest. The better the quality of the forest, the better for this species. The models show a shift of suitable habitats towards higher elevations, where living conditions could be more severe for the species.



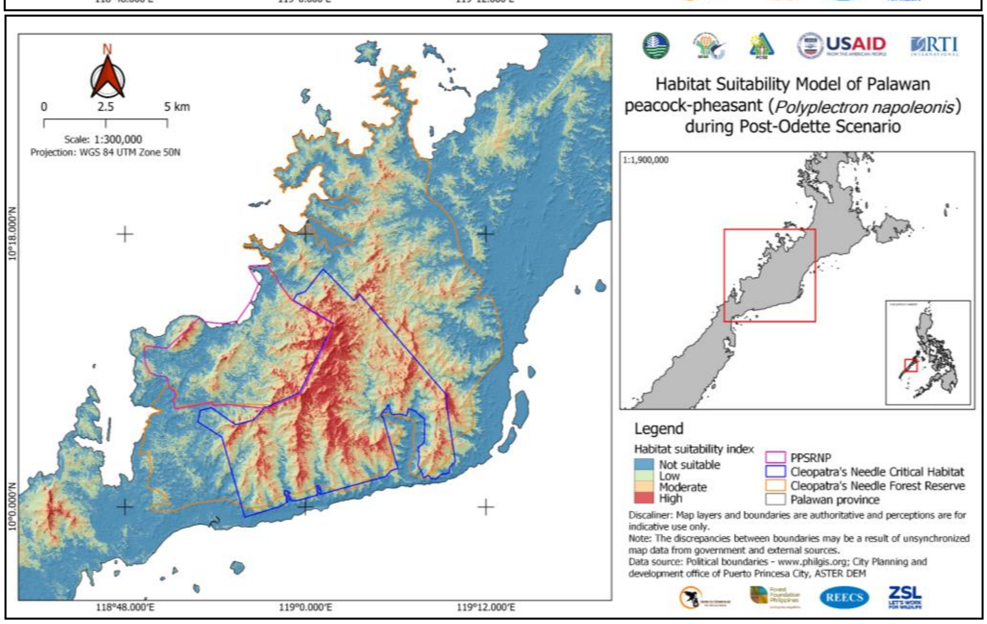


Figure 12. Habitat Suitability Models of the Palawan peacock-pheasant, showing the areas with low (green) to high (red) habitat suitability in a pre- and post-Odette scenario.

Busuanga wart frog *(Limnonectes acanthi)* - Much of Busuanga wart frog's suitable habitats in lowland areas have diminished. Being a strict lowland forest specialist, the long-term survival of this species is apparently in peril.

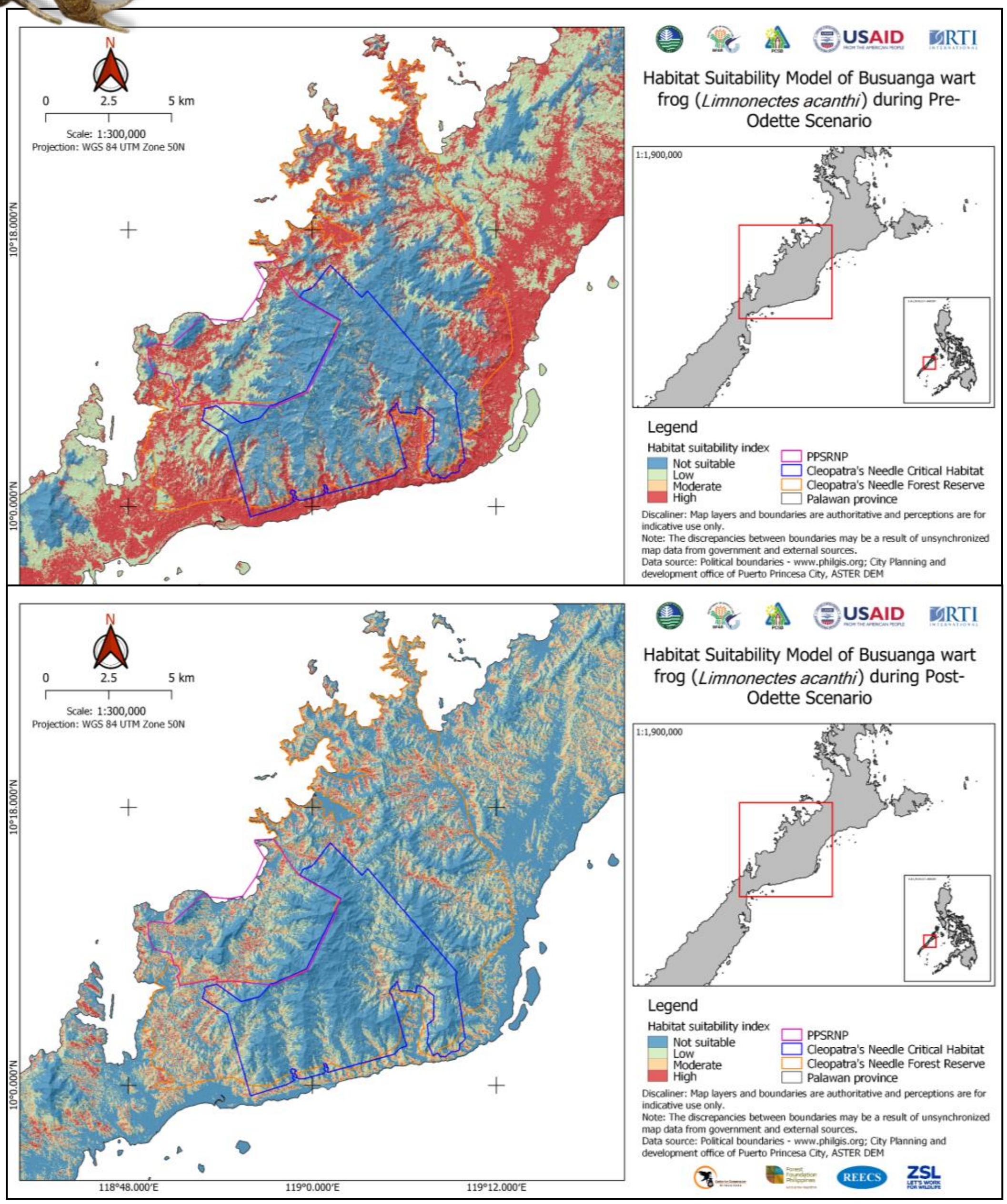


Figure 13. Habitat Suitability Models of the Busuanga wart frog, showing the areas with low (green) to high (red) habitat suitability in a pre- and post-Odette scenario.

Almaciga *(Agathis philippinensis)* - Almaciga is usually found in elevations ranging from 500 to 700 meters above sea level, usually on top of high ridges with steep slopes. The post-Odette distribution model shows a noticeable decrease in the extent of habitats that are highly suitable for Almaciga. In addition to the diminished connectivity of the species' suitable habitats, unsustainable harvests of resin, due to the limited resource, may pose added impacts to the remaining Almaciga trees.

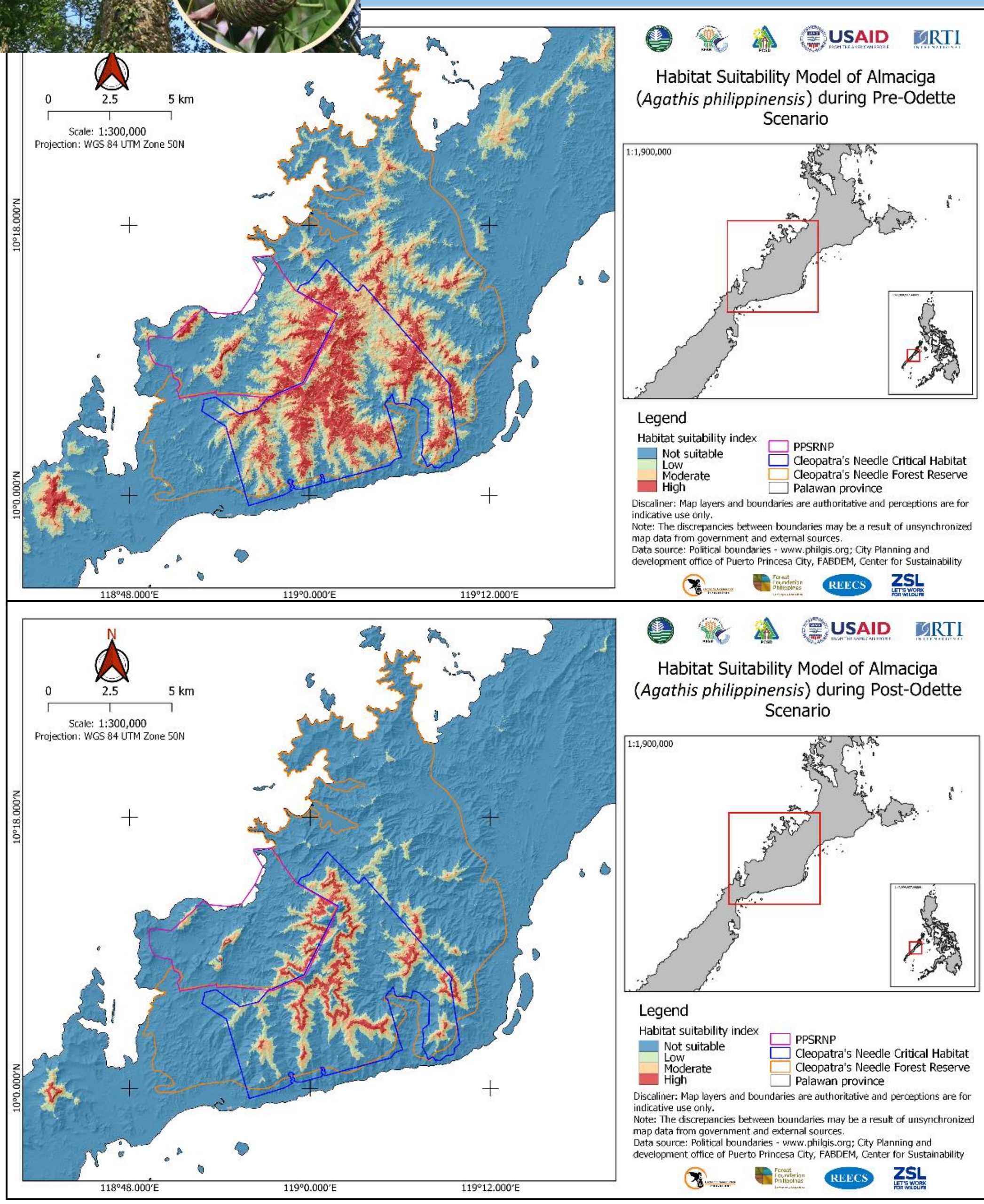
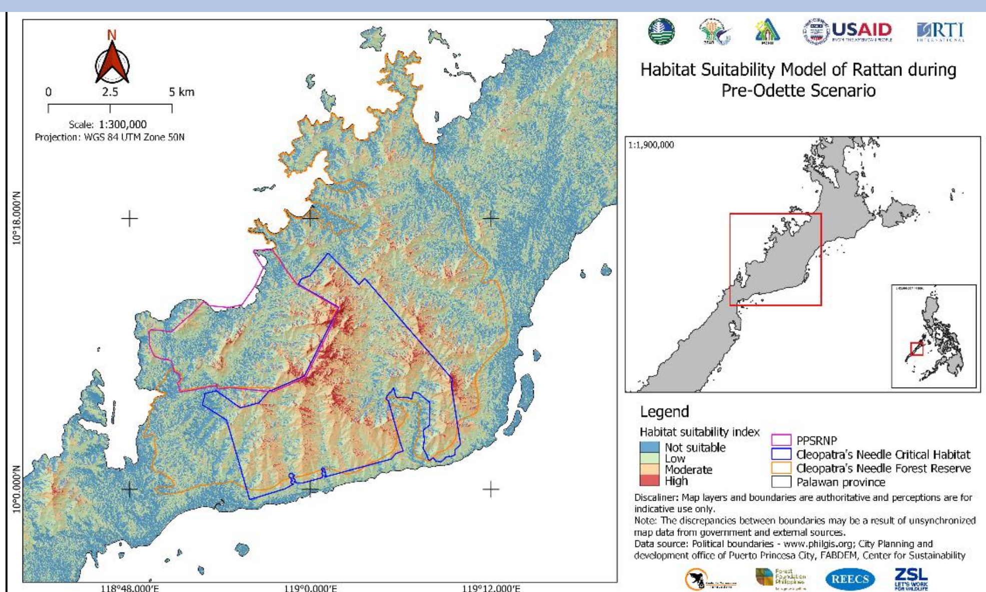


Figure 14. Habitat Suitability Models of Almaciga showing the areas with low (white) to high (red) habitat suitability in a pre- and post-Odette scenario.

Rattan - Rattan is recognized as one of the most important non-timber forest products (NTFPs) and is well-known for its economic importance in the Philippines. The models show a very wide distribution of the species across the landscape during pre-Odette. However, the post-Odette scenario revealed a massive fragmentation of the species' habitats, with higher suitability in damaged forest areas. This could be attributed to the fact that rattan is an opportunistic species that grow in highly disturbed areas. However, better quality rattans are associated with healthy forest conditions. Rattans are highly valued for their economic importance, hence the remaining suitable habitats for this species may compromise the quality of rattan production.



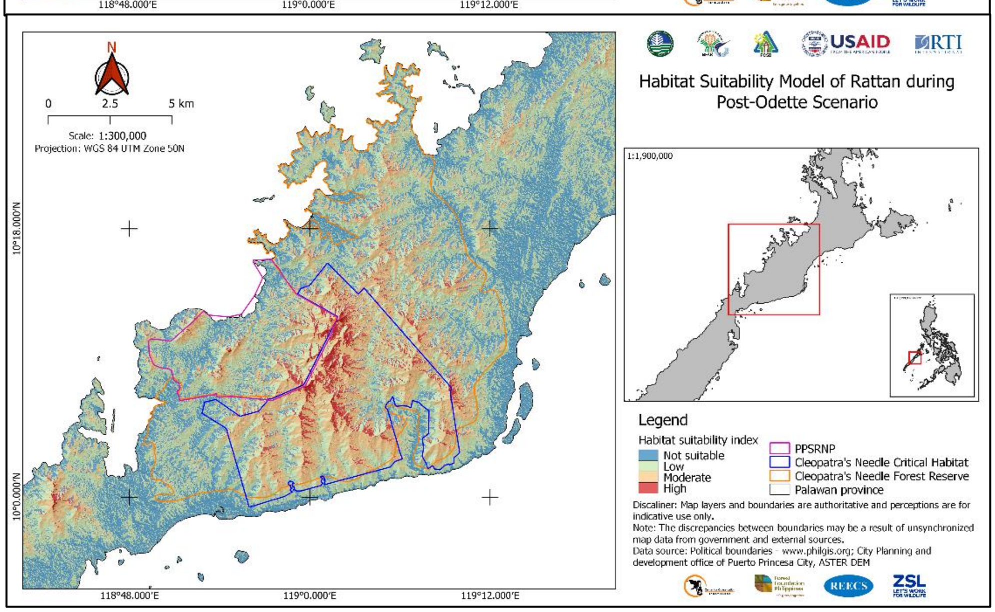


Figure 15. Habitat Suitability Models of rattan showing the areas with low (white) to high (red) habitat suitability in a pre- and post-Odette scenario.

Impacts on Ecosystem Services

We conducted community interviews and focus group discussions in key representative sites across the affected areas to gather information on the communities' perceived impacts i.e., extent and severity of Super Typhoon Odette on their resources and livelihoods. This information was triangulated with the technical data that we have gathered in the comprehensive ground surveys. Based on these conversations, the communities have identified the following key concerns and issues (Figure 16):

A. Damaged vegetation caused by fallen and uprooted trees required clearing of debris. This led to unregulated logging, particularly in PPSRNP.
B. Altered flow regulation led to the drying up of some rivers. Consequently, some areas experienced water supply insecurity.
C. Damage and loss of NTFPs such as rattan, and Almaciga trees, with the latter being utilized as source of resin for livelihood. Due to the scarcity of Almaciga resin, there has been an unsustainable collection of resin from remaining Almaciga trees. Croplands were also damaged, which impacted copra, cashew nut harvests, rice, and sweet potato crops. Thus, some of the locals sought alternative livelihoods such as fishing and raising native chickens.
D. Soil erosion was prominent, causing siltation in rivers, while others were filled with debris.
E. Recurring landslides were reportedly common. This may have contributed to further vegetation loss.
F. Areas for honey collection were severely damaged. Collection of honey is a crucial source of income for the IPs. Moreover, the loss of flowering trees and source areas for honey may have affected pollination, not only in the impacted areas but also in the surrounding areas.

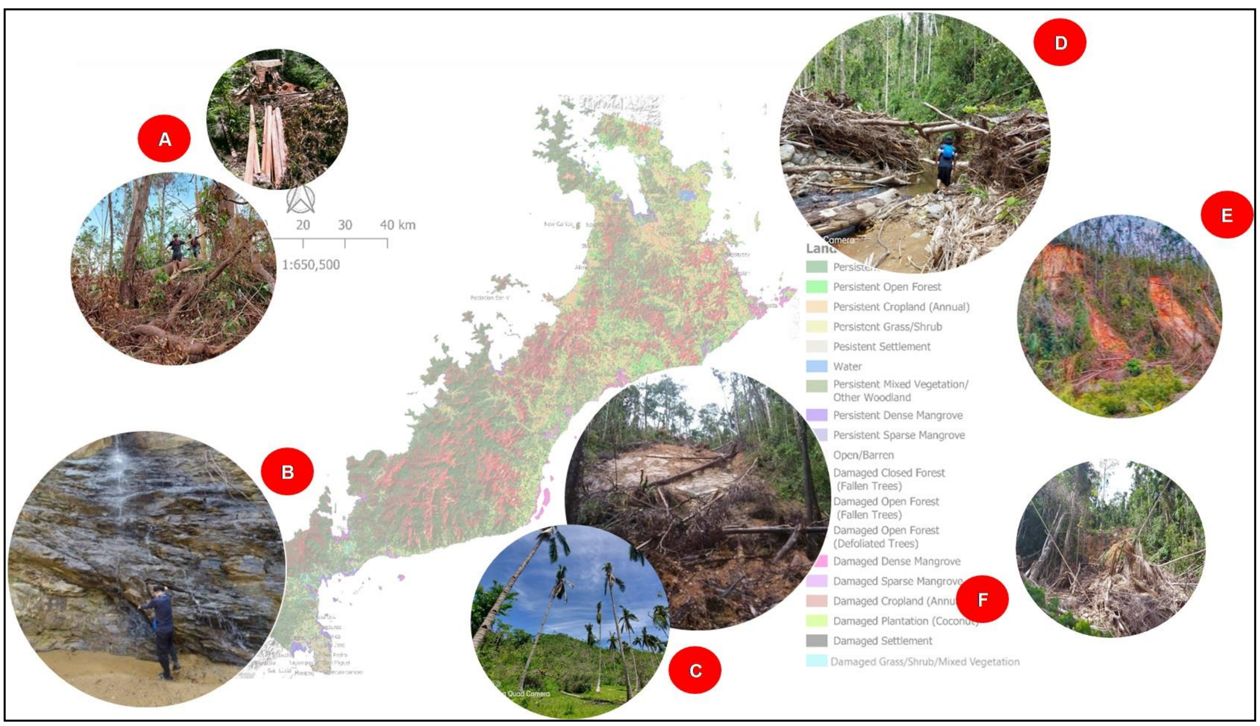


Figure 16. Damaged areas presented different impacts on ecosystem services.

IV. IMPLICATIONS AND WAY FORWARD

The Green Assessment Framework presents a viable evidence-based and science-driven approach to assess the status of biodiversity and ecosystem services that will build from the post-disaster needs assessment (PDNA) and the "build back better" program of government. The results of the GA are critical inputs to the green reconstruction and resilience planning (Stage 3), and present science-driven options and recommendations to mitigate risks from future and upcoming disasters. Moving forward, below are the possible actions:

Possible Action for Damaged Forests (Fallen Trees)

Damaged areas dominated by fallen trees (See figure 17; dark red) will require more interventions than those with defoliated trees. A combination of passive and active interventions can be utilized to rehabilitate damaged forests, particularly in Cabayugan, Marufinas, Tanabag, Bahile, Macarascas, Port Barton, and Kemdeng.

The following interventions are recommended:

- Determine the appropriateness of existing zones vis-a-vis restoration, rehabilitation, and management targets
- Clearing of debris
- Control opportunistic species
- Assisted Natural Regeneration with natural enrichment planting in areas with natural regenerants
- Reforestation (tree planting) in areas with severe vegetation loss (e.g., Miyawaki, Framework species method, Analos forest, Rewilding)

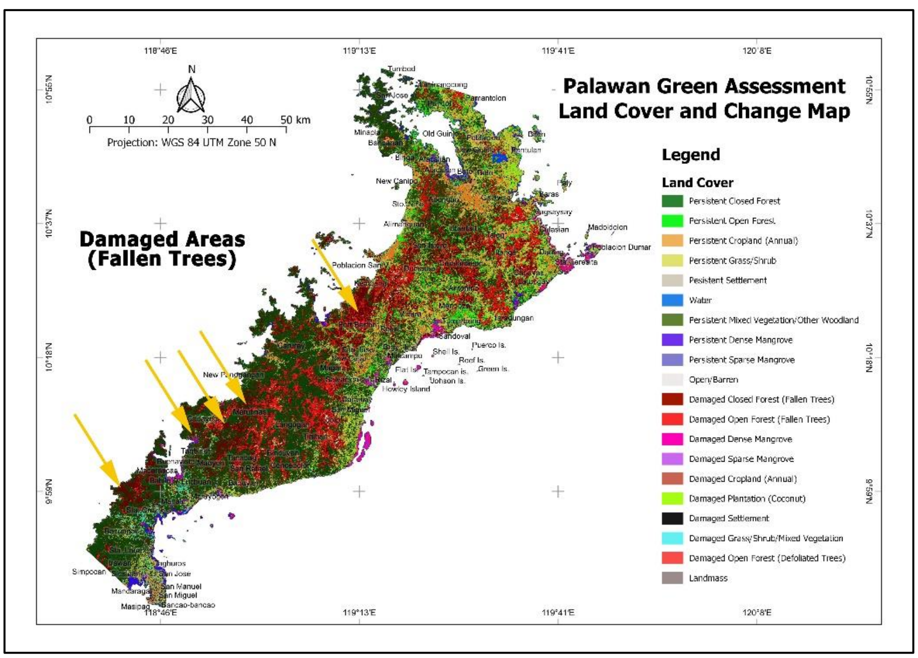


Figure 17. Land cover change map of Palawan highlighting (yellow arrows) areas that are predominantly caused by fallen trees.

Possible Action for Damaged Forests (Defoliated Trees)

Damaged forests that are dominated by defoliated trees (See Figure 18; lighter red) are vulnerable to insect and fungal infections. These areas should therefore be monitored, particularly those that are likely to recover. When developing monitoring plans, it is important to take into consider the risks of poaching and forest fires. Damaged areas caused by defoliated trees can be seen in Cabayugan, Marufinas, Tanabag, Langogan, Binduyan, San Rafael, and Magara.

The following interventions are recommended:

- Determine the appropriateness of existing zones vis-a-vis restoration, rehabilitation, and management targets
- Monitoring of trees to assess the tree conditions (e.g., infested trees, signs of decay)
- Prevention of further damage through regular monitoring (e.g., prevention of timber poaching, forest fires, etc.)
- Removal of tree stands that have no chance of survival, including trees with a leaning angle of more than 45 degrees
- Replacement of removed trees

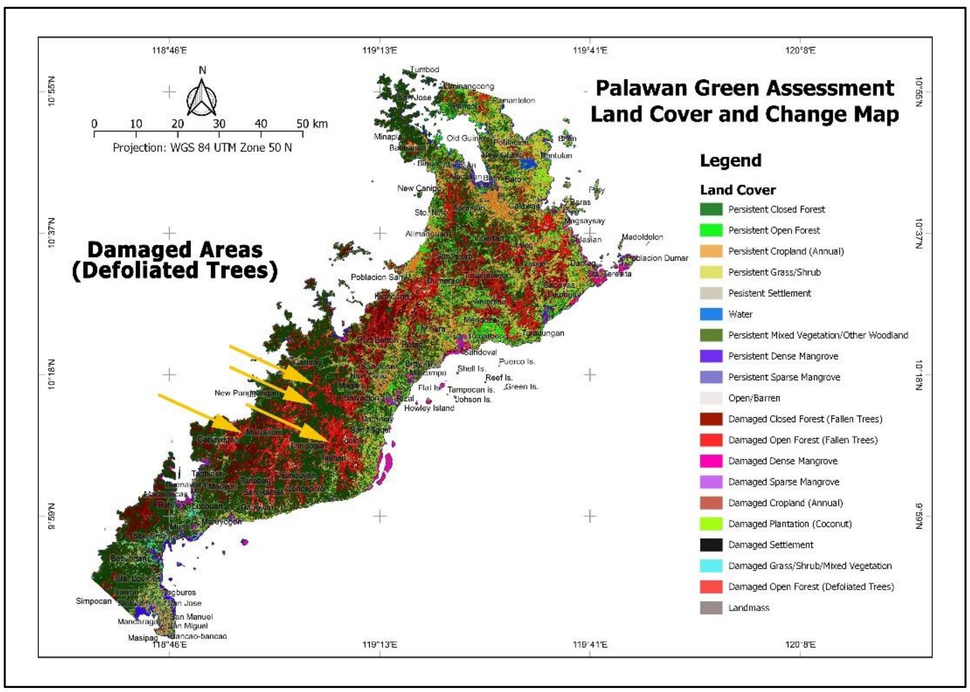


Figure 18. Land cover change map of Palawan, highlighting (yellow arrows) damaged areas that are predominantly caused by defoliated trees.

Possible Action for Persistent Forests

Canopy trees are the first line of defense during typhoons. Persistent forests (see Figure 19; dark green) must be protected at all costs. It is highly recommended that environmental enforcement be strengthened. Forest managers, law enforcers, and locals must ensure that timber poaching and hunting of species are avoided.

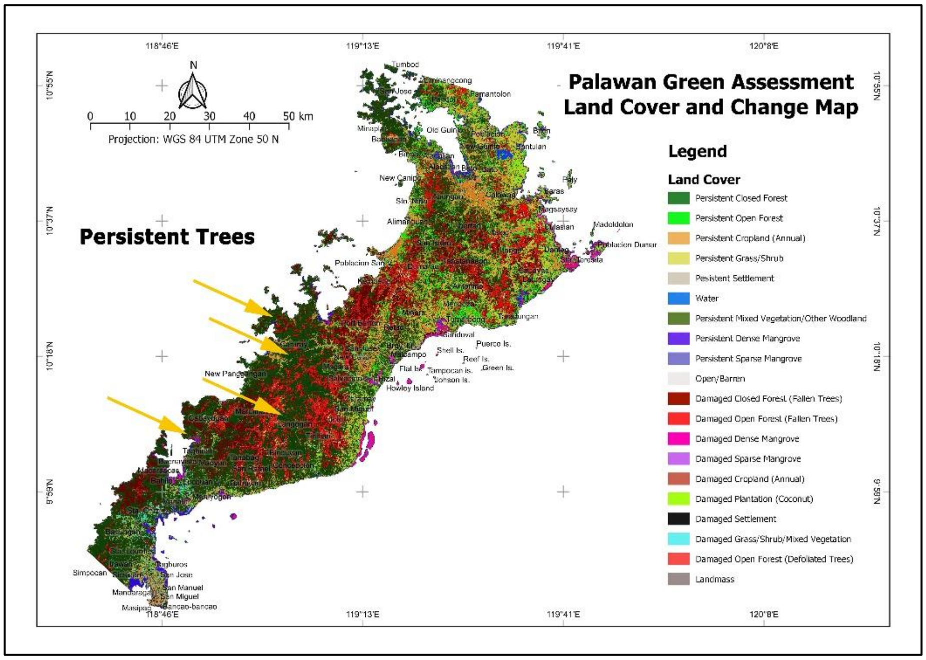


Figure 19. Land cover change map of Palawan highlighting (yellow arrows) persistent forests.

Possible Action for Damaged Sparse and Dense Mangroves

Areas with notable mangrove mortality can be considered for mangrove replanting programs (Figure 20). However, it is critical to bear in mind that replanting activities must be science-based, and that only the right species of mangrove must be planted at their respective suitable locations. This requires support and collaborative efforts from local communities, not only during replanting, but also during maintenance, protection, and other sustainable management interventions.

The following interventions are recommended:

- Clearing of debris
- Regular monitoring for signs of recovery

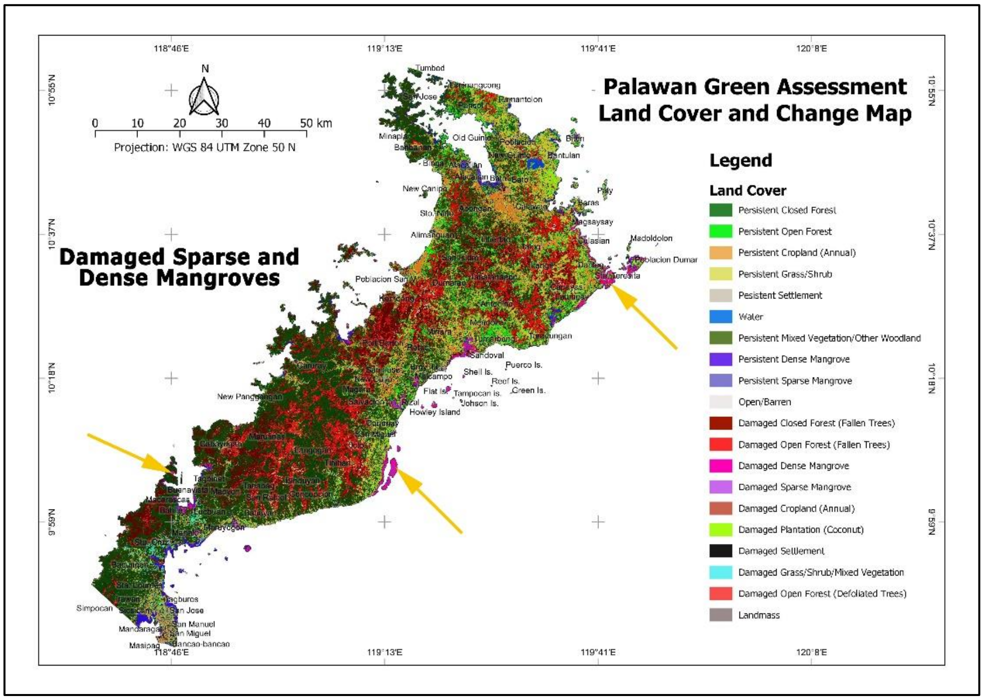


Figure 20. Land cover change map of Palawan highlighting (yellow arrows) areas with damaged spars and dense mangroves.

Possible Action for Persistent Mangroves

Mangrove ecosystems provide coastal protection from erosion, typhoons, and tsunami. It is therefore recommended that areas with persistent mangroves be protected at all costs (Figure 21).

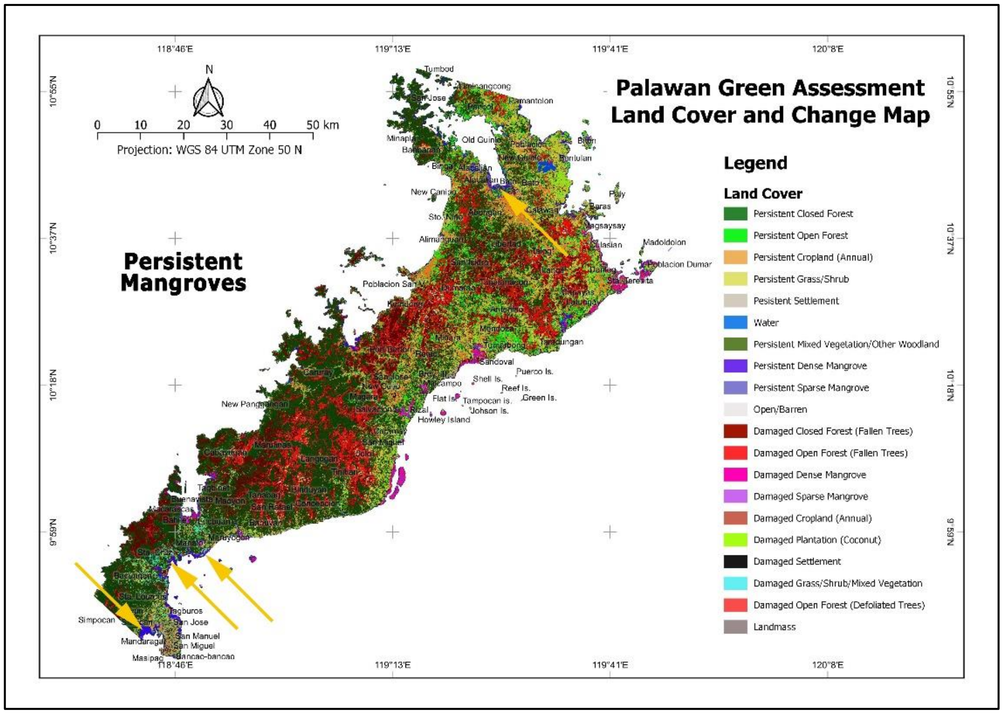


Figure 21. Land cover change map of Palawan highlighting (yellow arrows) areas with persistent mangroves.

Innovations

Monitoring through Citizen Science Information Gathering

One of the innovative approaches of the GA Framework is the incorporation of citizen science information gathering into the monitoring plans, which was ably demonstrated in the various components and stages of the project.

Citizen science is the practice of public participation and collaboration in scientific research to increase scientific knowledge. Through citizen science, ordinary people share and contribute to data monitoring and collection programs.

In the context of the GA Framework, citizen science information gathering enforces stakeholders to perform a monthly monitoring using mobile applications such as **Earthranger**, a software that aids protected area managers, ecologists, and wildlife biologists in making more informed operational decisions for wildlife conservation; and **CyberTracker**, a mobile data capture software that can be used by non-technical people, including IPs, to communicate their environmental observations.

The approach uses technology-based data capture and data curation tools for biodiversity. To capacitate stakeholders, we conducted two phases of training: (1) training of trainers; and (2) training of community members. We facilitated protected area staff, community partners, barangay volunteers, and other community development organizers in developing their monitoring plans and trained them in monitoring green recovery after the typhoon.

V. CONCLUSIONS

The key findings of the green assessment greatly underscore the importance of appropriate management interventions towards rehabilitation and restoration of damaged ecosystems.

At the same time, however, it is important to take note that immediate management actions do not always equate with replanting and revegetation activities in damaged areas. Some forest areas left to recover naturally have fared better, indicating that it is preferable to have minimal and selective management interventions. Hence, restoration strategies and the degree of conservation actions will depend on the extent of damage in an area.

The Green Assessment Framework has clearly demonstrated the importance of incorporating biodiversity, ecosystems, and ecosystem services into post-disaster needs assessment (PDNA) and strategic planning. This enables us to address both environmental issues and humanitarian needs, while reducing disaster risks at the same time.

The Framework has also established how a combined technical approach and citizen science methodology were able to generate data and information that can enhance existing pre- and post- disaster response approaches.

Moreover, the innovative approach introduced by the Green Assessment Framework addresses the existing gaps in the current PDNA which lacks several data and information generated by the GA Framework.

Ultimately, the innovative and comprehensive use of a biodiversity and ecosystem-based pre- and post-disaster analyses underpins green reconstruction, and future disaster risk and resilience planning

This Green Assessment Framework and Pilot in Palawan was prepared by the USAID Sustainable Interventions for Biodiversity, Ocean, and Landscapes (SIBOL) Activity. This document is a synopsis of a series of reports made on the green assessment (stage 1 and stage 2) in Palawan.

Authors

Neil Aldrin Mallari, Jennica Paula Masigan , Quennie Ann Uy, Mary Ann Bautista, DeAnne Rochelle Abdao, Jhonny Wyne Edaño, Kristine Joy Andaya, Oliver Coroza, Regina Aedrianne Felismino-Inovejas, Daniel Glenn Darapiza, Clark Jerome Jasmin, Lawrence Empillo, Adryon Rozz Javier, Rubelyn Batistin, Victor Yayen, John Lister Bibar, Dennis Tablazon, and James Patric Jimenez