GIS-BASED VULNERABILITY ASSESSMENT TO CLIMATE CHANGE FOR COASTAL RESOURCES IN THE PHILIPPINES: FRAMEWORK, IMPLEMENTATION AND RECOMMENDATIONS

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ABSTRACT: The nationwide mapping and inventory of coastal resources (mangrove, seagrass, and corals) from remote sensing surveys in the Philippines provided a number of applications, mainly in the management and protection of these resources. A method for assessing the vulnerability of coastal resources to climate change was developed using existing coastal vulnerability assessment tools together with remote sensing data, and implemented by different partner institutions on selected study sites throughout the country. This paper describes the vulnerability assessment framework, its implementation, and synthesis of the results from the different studies to come up with a summary of issues that increases the sensitivities of coastal resources to climate change hazards and the recommendations to increase the adaptive capacity of these resources and the communities that engage with them. The vulnerability of the resources was evaluated in three general aspects, namely Intrinsic Characteristics and Governance, Anthropogenic Activities, and Habitat Characteristics. These aspects were integrated to produce an overall vulnerability assessment for each type of coastal resource. Using this framework, the implementing institutions were able to identify the areas of concern for each study site and were able to recommend the necessary management actions for the stakeholder's to mitigate the effects of climate change to these resources. It was found that the most of the coastal resources in the study sites have a medium to high vulnerability to the impacts of climate change. The most at risk are the mangroves, since these are found within close distance to anthropogenic activities. Seagrasses and corals have medium to high vulnerabilities; however, these have higher adaptive capabilities than mangroves as the Marine Protected Areas set are commonly focused on these resources. The recommendations for the study sites include increasing the communities' awareness on the importance of these coastal resources and intensifying the implementation of policies aimed at the conservation and protection of these resources.

1. INTRODUCTION

A project on the application of LiDAR data products in the mapping of natural resources was undertaken by selected universities and colleges in the Philippines. The nationwide mapping and inventory of coastal resources (mangrove, seagrass, and corals) from remote sensing surveys, such as LiDAR and satellite imaging, provided a number of applications, mainly in the management and protection of these resources. One application of resources maps is in the vulnerability assessment of coastal habitats to climate change impacts. The existing coastal vulnerability assessment tools in the country have identified the importance of maps and other spatial information to aid in the analysis. Information on the current status of the available coastal resources in particular areas, such as type, location, and extent, enables a more accurate valuation of the vulnerable units and the potential impact that climate change hazards may pose. Spatial analysis, with the use of Geographic Information Systems (GIS), on the available data, allows for the quantitative characterization of vulnerability components—Exposure, Sensitivity and Adaptive Capacity. The analysis, when integrated with data obtained from local knowledge and community inputs, can produce a fine scale evaluation of vulnerability in the form of vulnerability maps.

A method for assessing the vulnerability of coastal resources to climate change was developed using existing coastal vulnerability assessment tools together with remote sensing data, and implemented by different partner institutions on selected study sites throughout the country. This paper describes the vulnerability assessment framework, its implementation, and synthesis of the results from the different studies to come up with a summary of issues that increases the sensitivities of coastal resources to climate change hazards and the recommendations to increase the adaptive capacity of these resources and the communities that engage with them.

2. METHODOLOGY

2.1 Data

The data used for the analysis were the maps of mangrove, seagrass and coral features obtained from remote sensing surveys. Also included were the urban and aquaculture features within distance of the resources which served as representations of the anthropogenic effects of the surrounding communities to the habitats. Data on the resource use of the coastal communities in the project sites, particularly, on the status of health of the coastal resources and water quality, fishery practices and ordinances relating to coastal resources use in the area, were also gathered to assess the vulnerability of the coastal resources to climate change. These were collected through participatory mapping and focus group discussions conducted on selected communities or barangays within the project site.

The exposure data used in the vulnerability analysis was from a study done by the Marine Science Institute (David, et al., 2015). The exposure factors considered are sea-level rise, waves and storm surge, sea-surface temperature, and rainfall. Its data contains climate exposure clusters with relative ratings for each type of hazard in each cluster. The study was based on an analysis of historical air-sea climate exposure obtained from a series of satellite images. The study also serves as input to other existing vulnerability assessment studies in the Philippines.

2.2 Framework

The spatial unit of assessment was the coastal resource object extracted from remotely sensed data for the study site that can be exported and manipulated in the GIS platform. The analysis in this scale provided for the spatial variability of the effect of vulnerability components to the resources across the municipal coastline. It enabled the identification of coastal resources that are relatively more vulnerable than others located in another area within the same municipalities, based on their proximity to anthropogenic activities. Seagrasses that are further ashore, for example, are less likely to be impacted by urban development and fishery practices, compared to those located near the shore.

The methodology for the vulnerability assessment of the coastal resource to climate change followed a framework adapted from the Tool for Understanding Resilience of Fisheries (TURF) (Vulnerability assessment tools for coastal ecosystems : a guidebook, 2013). The vulnerability of the resources is evaluated using three general criteria: a) Intrinsic Characteristics and Governance, b) Anthropogenic Activities and c) Habitat Characteristics. The vulnerability assessment process first characterized the three components of vulnerability.

The exposure of a unit or system to climate change hazards is considered here as a matter of its location. Given that all resources are exposed to climate change, some resources are more or less at risk, as determined by the type of hazards that have a higher impact on a specific location. The exposure is relative based on the where the vulnerable unit or system is situated. In the case of coastal resources, the hazards and exposure scores have already been identified based on the study from MSI (David, et al., 2015). Exposure scores were chosen among the 11 exposure clusters identified by the study based on where the municipality is located. The exposure scores for the coastal resource/seagrass were therefore the same for all the objects in the municipality.

The sensitivity of the coastal resource objects was identified as the present conditions of the system as it would respond the exposure factors. Several factors contribute to the sensitivity of a unit or system to climate change hazards. These sensitivity parameters were grouped into criteria based on the common issues affecting the resources. These include water quality, anthropogenic activities such as coastal development and the fisheries industry, habitat characteristics and governance. The scores were then computed from proxies and field data using GIS tools and existing vulnerability assessment scoring methods.

The adaptive capacity described the ability of the coastal resource to cope with climate change impacts. These include the coastal resource natural characteristics, such as species type, coverage, health and the management practices implemented by the community or municipality which promotes the resource's adaptive capabilities. The adaptive capacity was characterized by scores obtained from field interviews and spatial data on marine protected areas.

The vulnerability components, Potential Impact (Exposure x Sensitivity) and Adaptive Capacity, were computed within each general criteria to come up with vulnerability components. These criteria were then integrated to produce an overall vulnerability assessment for each type of coastal resource.

The analysis was performed on a GIS platform as it allows for the generation of the vulnerability component layers,

attribute attachment in the features and computation of the final vulnerability assessment scores.

2.3 Implementation

Coastal municipalities throughout the Philippines, recommended by partner institutions of the project, were selected as pilot sites for the method developed. The institutions generated the resources maps and collected the field data in the coastal communities. They then proceeded to perform the scoring based on the component matrix and integrated the scores to come up with overall vulnerability scores for each type of resource.

3. RESULTS AND DISCUSSION

The assessment was performed on 14 different coastal municipalities throughout the Philippines. Each municipality had at least two coastal habitats present. Vulnerability maps were generated with scores determined by the resources' proximity to anthropogenic activities and the communities' engagement with them.

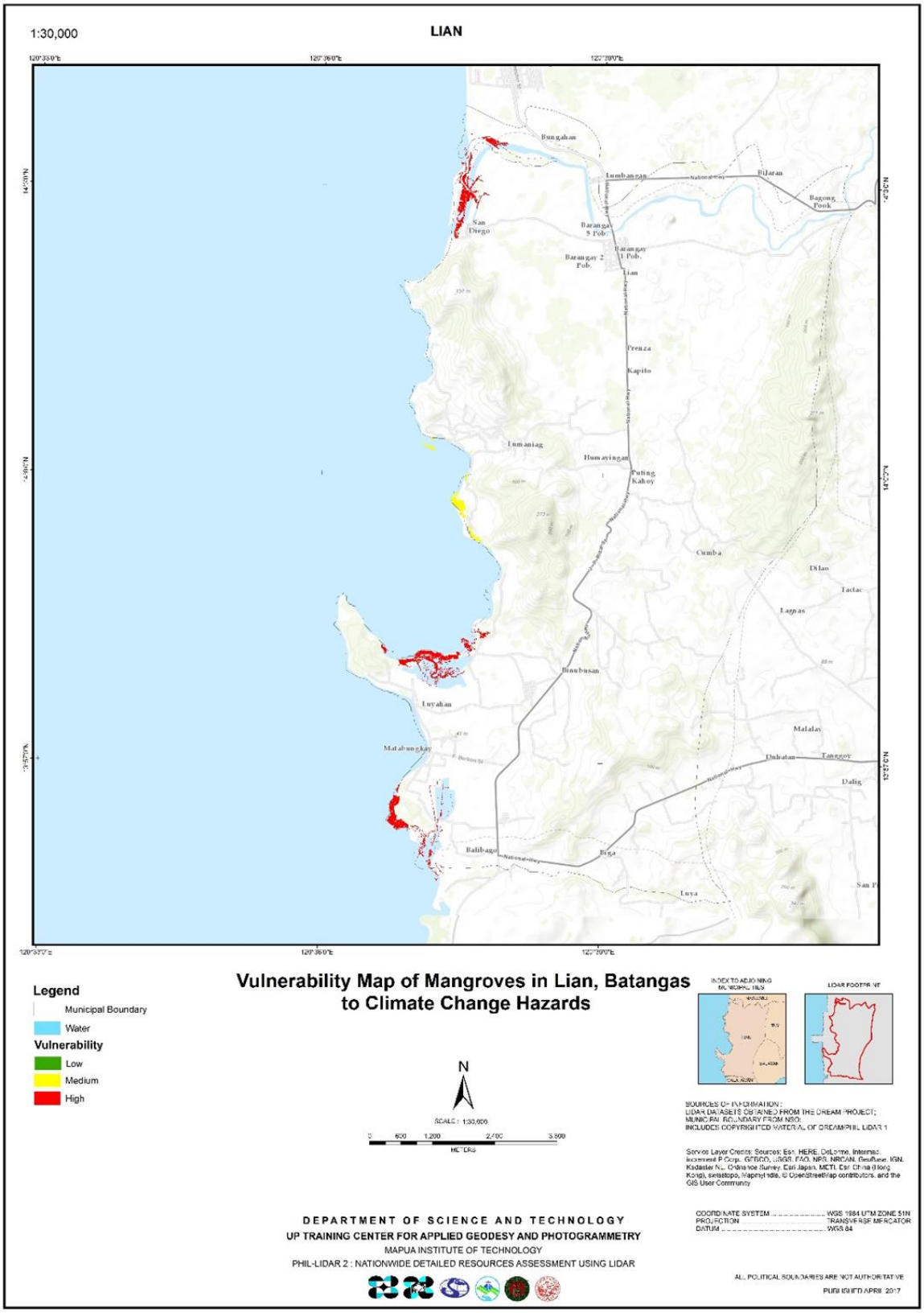

Figure 1: Sample Mangrove Vulnerability Map

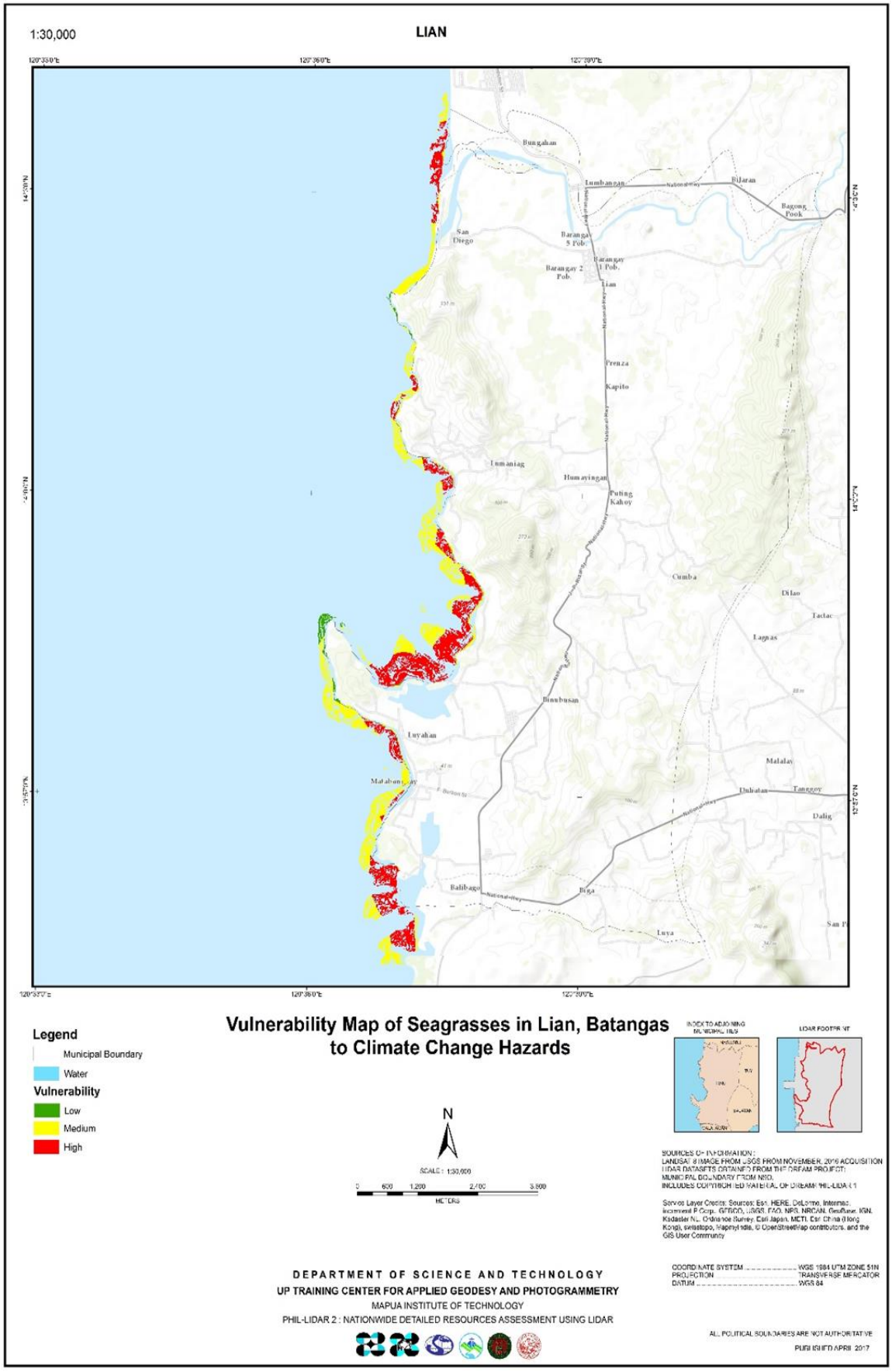

Figure 2: Sample Seagrass Vulnerability Map

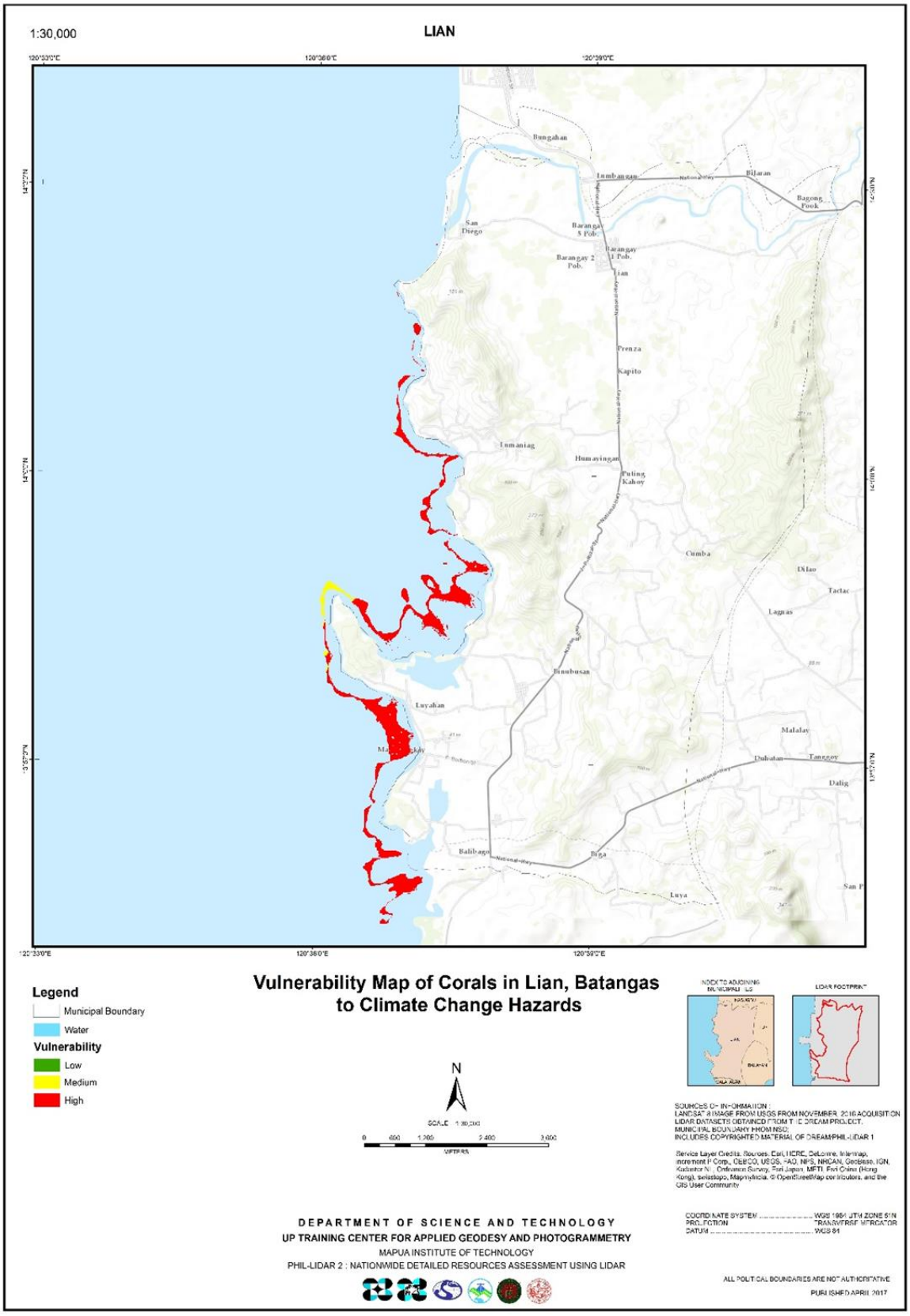

Figure 3: Sample Coral Vulnerability Map

The sample maps showed the variability of vulnerability across the coastline of the study site and with the different coastl resource types. With the maps, better visualization and identification of highly vulnerable sites and resources was achieved.

Based on the assessments performed by the different partner institutions, it was found that most of the coastal resources in the study sites have a medium to high vulnerability to the impacts of climate change. This was partly due to the already high exposure of the Philippines to the different impacts of climate change.

Among the three resources, the most at risk were the mangroves, since these were found within close distance to anthropogenic activities. These activities include coastal development and household consumption which may be due to the ineffective implementation of policies caused by the lack of community information and logistical capability of the local managers to properly enforce them.

Seagrasses and corals have medium to high vulnerabilities, which was attributed to the high reliance of the communities to fisheries as their source of livelihood. However, these have higher adaptive capabilities than mangroves as the Marine Protected Areas set are commonly focused on these resources.

From these results, the recommendations for the study sites include increasing the communities' awareness on the importance of these coastal resources and intensifying the implementation of policies aimed at the conservation and protection of these resources. These recommendations were based on the adaptation strategies suggested by the coastal vulnerability assessment tools aimed to address the issues identified from the interviews with the communities.

4. CONCLUSIONS AND RECOMMENDATIONS

In summary, the study was able to develop and implement a coastal vulnerability assessment framework for different study sites in the Philippines. Vulnerability maps were generated which provided visual representations on which coastal resources are at risk and where these resources are located.

With these results, the implementing institutions were able to identify the areas of concern for each study site and were able to recommend the necessary management actions for the stakeholder's to mitigate the effects of climate change to these resources.

The outputs of the study can contribute to the literature concerning the risks involves from the impacts of climate change on the coastal environment.

5. ACKNOWLEDGEMENT

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