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Mapping of the Typhoon Haiyan Affected Areas in the Philippines Using Geospatial Data and Very High Resolution Satellite Images *

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Mapping of the Typhoon Haiyan Affected Areas in the Philippines Using Geospatial Data and Very High Resolution Satellite Images

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I. Introduction

The Philippines was struck by Typhoon Haiyan (local name Yolanda) on 08 November 2013, the deadliest and most destructive typhoon in recorded history. Haiyan was the strongest tropical cyclone ever observed based on the one-minute sustained winds of 315 km/hour as estimated by the Joint Typhoon Warning Center (JTWC) . The extreme wind speeds generated storm surges that caused the major damage and to the loss of 6,300 lives. Yolanda affected 1,473,251 families and resulted in more than $2 billion in damages along its path, shown in Figure 1.

President Benigno Aquino III, declared a state of calamity over the provinces of Samar, Leyte, Cebu, Iloilo, Capiz, Aklan, and Palawan through Proclamation No. 682, to facilitate the release of funds for relief and rehabilitation of the affected areas.

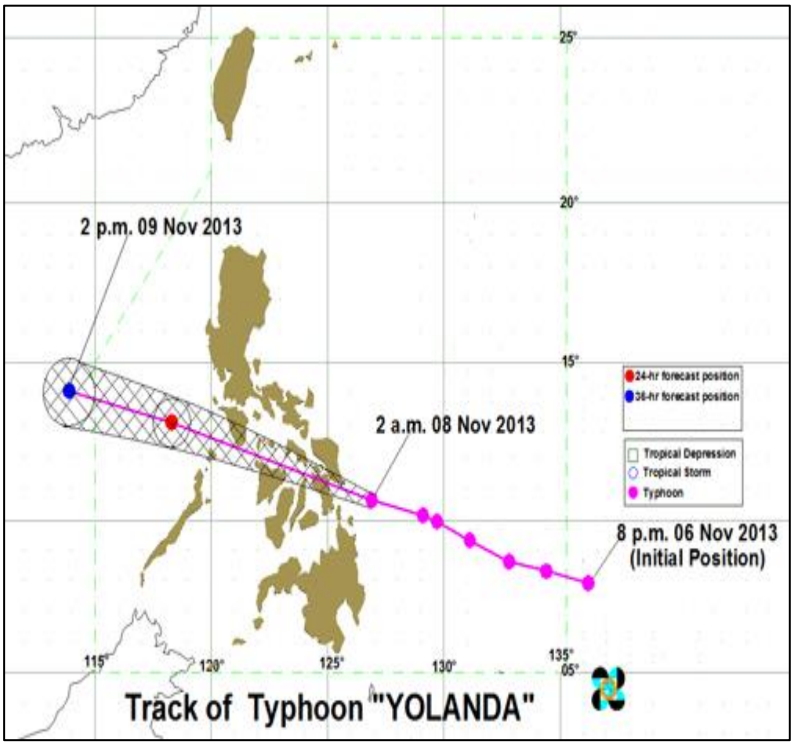

Figure 1. Path of Typhoon Haiyan (local name Yolanda). (Source: PAGASA)

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The Office of Presidential Assistant for Rehabilitation and Recovery (OPARR) was also formed to unify the efforts of government and other agencies involved in post-Yolanda to coordinate the release of funds for rehabilitation and recovery. In performing its mandate, the OPARR worked closely with the National Disaster Risk Reduction and Management Council (NDRRMC) and consulted with concerned local government units.

II. The Unified Mapping Program (UMP) of the National Mapping and Resource Information Authority (NAMRIA)

At the time of the disaster, the National Mapping and Resource Information Authority (NAMRIA), the central mapping agency of the government, was starting to implement the multi-year Unified Mapping Project (UMP) which aims to produce new topographic base maps covering the entire 30 million hectares of the Philippines at scale 1:10,000 with a total of 11,000 map sheets. It will serve as the common base maps of the government for all thematic applications.

For the implementation of the UMP, the NAMRIA was able to acquire raw Very High Resolution Satellite Data covering the country consisting of World View-2 and GeoEye images. For elevation data, Interferometric Synthetic Aperture Radar (IfSAR) was acquired in early June 2013 composed of Orthorectified Image (ORI) at 0.6m resolution, and Digital Terrain Model (DTM) with 5-meter posting. Coverage of both data is shown in Figure 2.

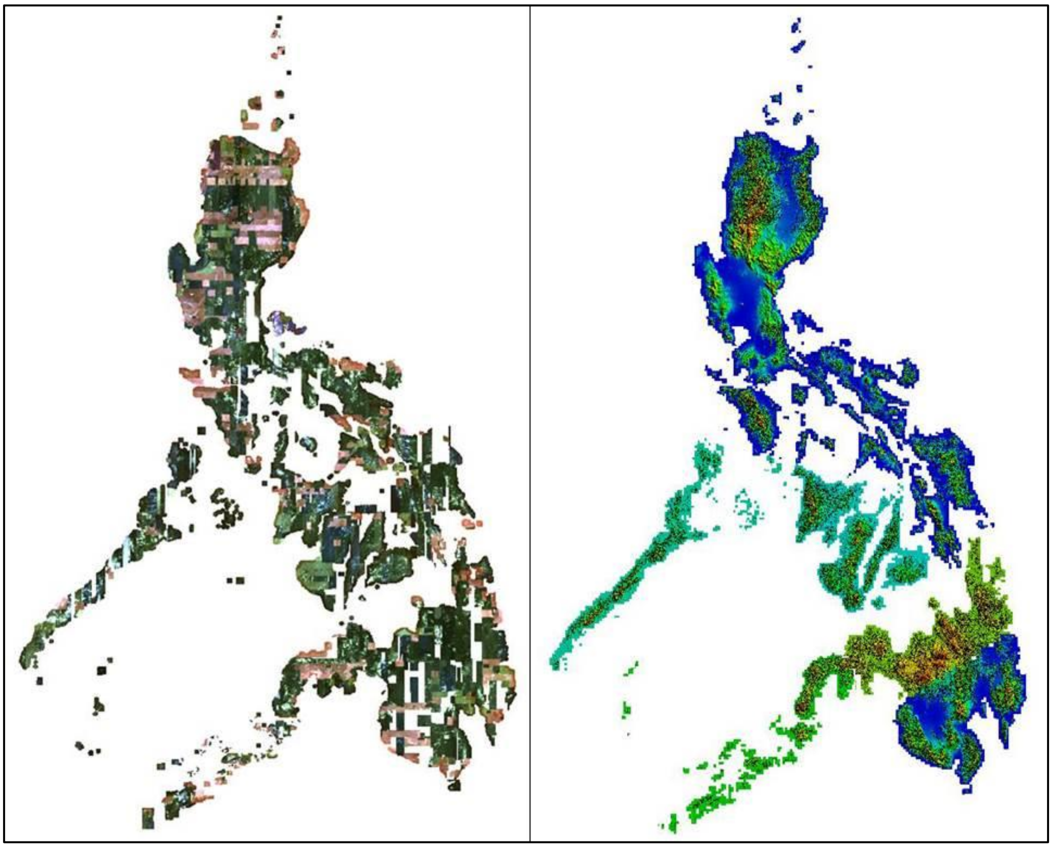

Figure 2. Coverage of Very High Resolution Satellite Images (VHRI), *at left*, and Digital Terrain Model (DTM) derived from Interferometric Synthetic Aperture Radar (IfSAR), *at right*.

The original priority areas then for mapping was the 18 major river basins of the Philippines with a total of 11 million hectares, as shown in Figure 3.

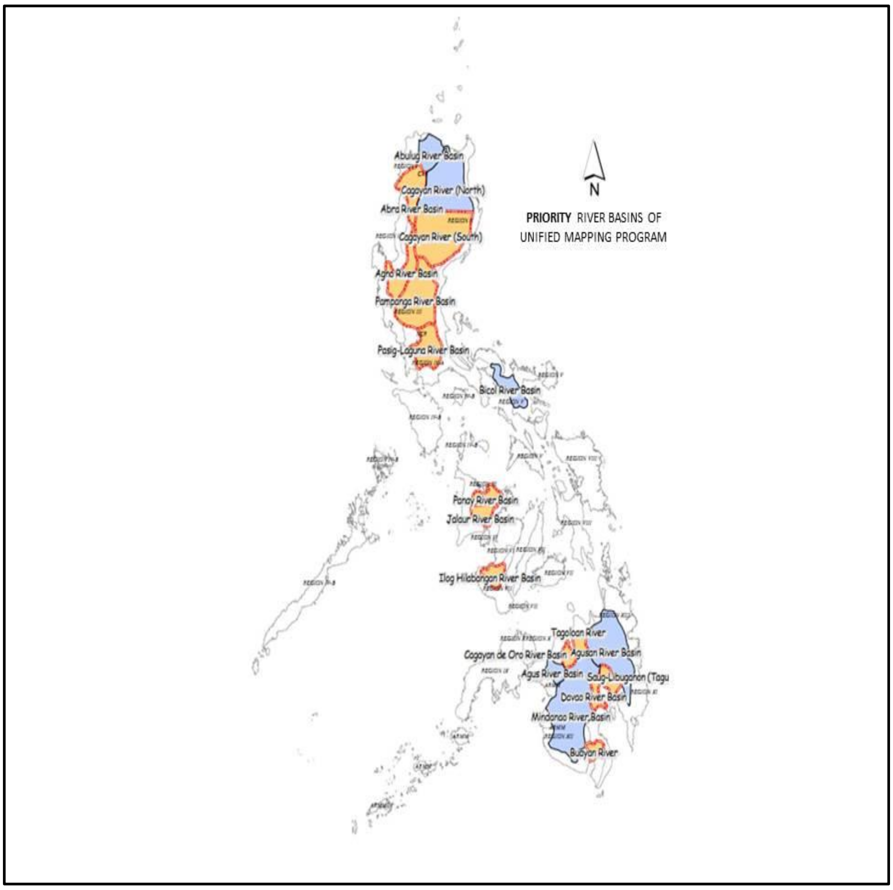

Figure 3. The 18 major river basins covered by the Unified Mapping Program of NAMRIA.

III. Prioritizing the Disaster-Affected Area for Base Map Production

After Yolanda, the top priority target areas of NAMRIA for the UMP shifted to the typhoon-affected areas, upon coordination with the OPARR and the NDRRMC, so that the outputs could be immediately used in the rehabilitation and reconstruction efforts. It would also be utilized as base data in the preparation of multi-hazard maps by technical agencies of the government, particularly the Mines and Geosciences Bureau (MGB), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Philippine Institute of Volcanology and Seismology (PHIVOLCS).

Figure 4 shows the provinces affected by the typhoon with land area of 2.4 million hectares consisting of 800 map sheets.

At present, there are no available nationwide homogeneous large scale base maps for detailed disaster management and hazard mapping, since the existing base map series is still at scale 1:50,000.

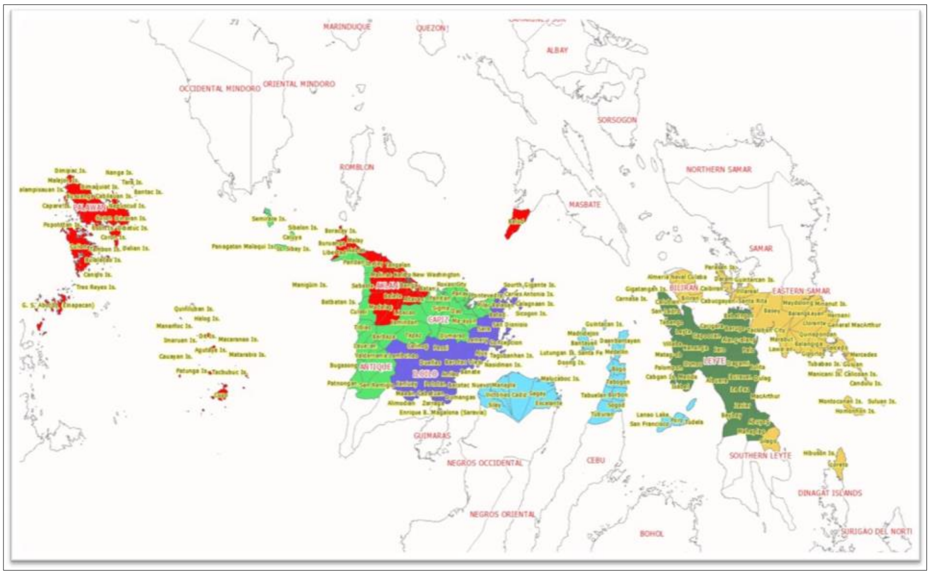

Figure 4. Provinces affected by Typhoon Yolanda.

IV. Base Mapping of the Typhoon Affected Areas

The map production process, in general, involved the combination of processing raw satellite images, geodetic control survey, feature extraction, field verification and secondary data gathering and geodatabasing.

a. Sources of Other Satellite Images

For patching of cloud-covered areas in the satellite images obtained for the UMP, the project had to find other data sources. Additional images came from the Japan International Cooperation Agency (JICA) which provided Pleiades satellite data covering the coastlines of Leyte and Eastern Samar, as indicated in Figure 5.

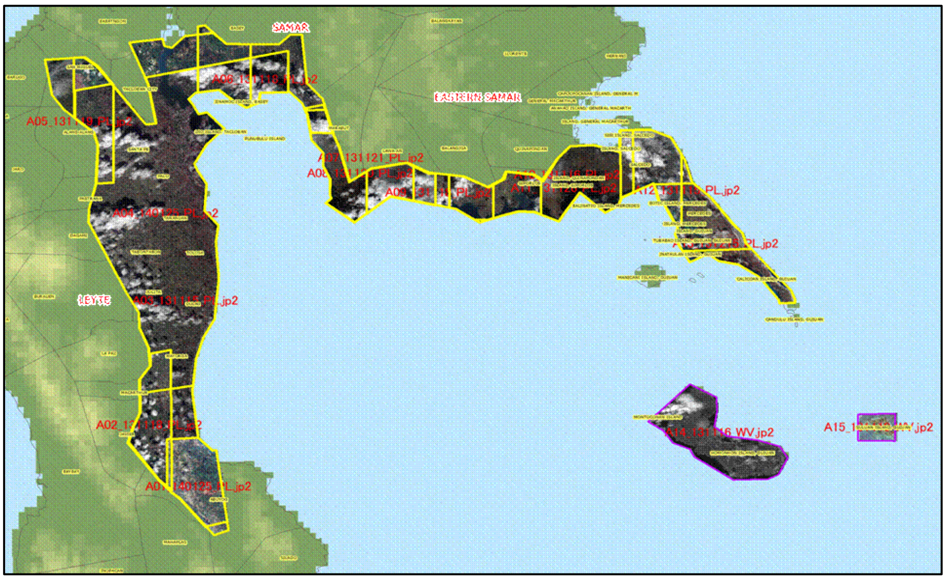

Figure 5. Composite images of Pleiades satellite at 0.6m resolution covering coastlines of provinces of Leyte and southern Samar.

Additionally, newly acquired images were provided by the Department of Science and Technology (DOST)-Project NOAH which they utilized in their flood modeling activities, as shown in Figure 6.

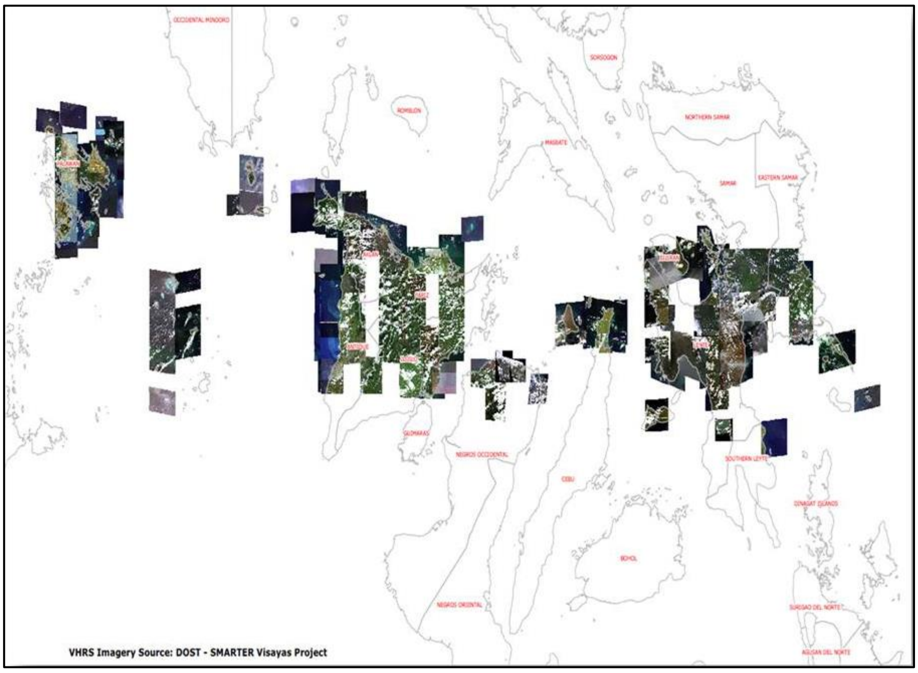

Figure 6. Satellite tasking of World View-2 images of typhoon-affected areas.

b. Ground Control Survey

Image Control Point (ICP) survey using Global Navigation Satellite System (GNSS) instruments, as shown in Figure 7, was conducted to determine ground coordinates of points identifiable in the image to be used in the orthorectification process.

Figure 7. Field team conducting Image Control Point (ICP) survey.

c. Image Processing

The raw satellite images were processed using Digital Elevation Model (DEM) and ORI from IfSAR. Use of ICPs increased the accuracy of the orthorectified images.

For WorldView-2 and Geo-Eye data, pansharpened images at 0.5 m resolution were merged with the 2-meter multispectral images. The resulting orthoimages were then resampled to 0.5 m resolution. For Pleiades data, the final resampled orthoimages are at 0.6 m resolution. Figure 8 shows the summary process flow.

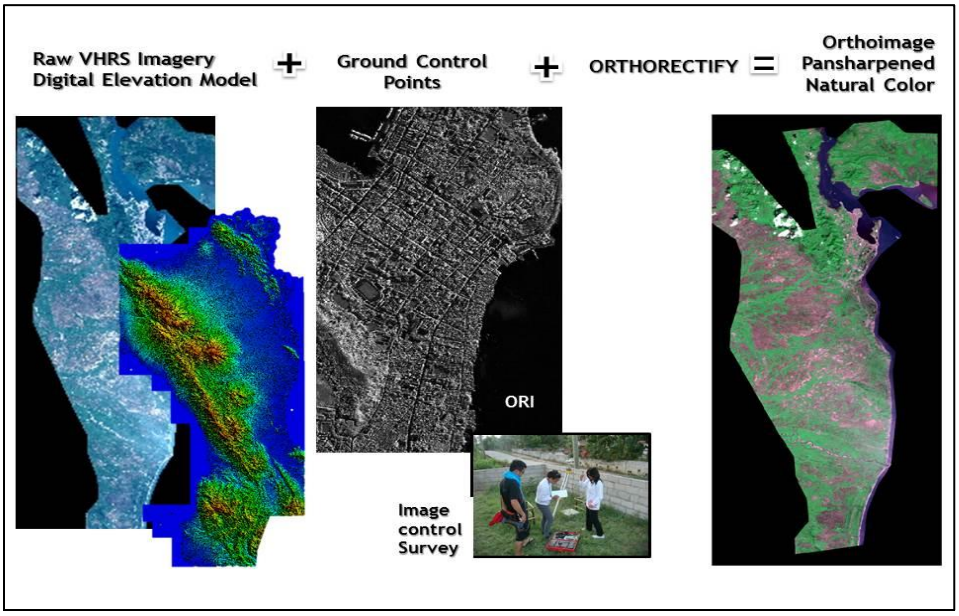

Figure 8. Process flow in orthoimage production.

d. Feature Extraction

During planimetric compilation, natural and man-made features, such as road network, vegetation, river systems and buildings and other infrastructures were digitized using cartographic and GIS software. Sample of extracted ground features is shown in Figure 9.

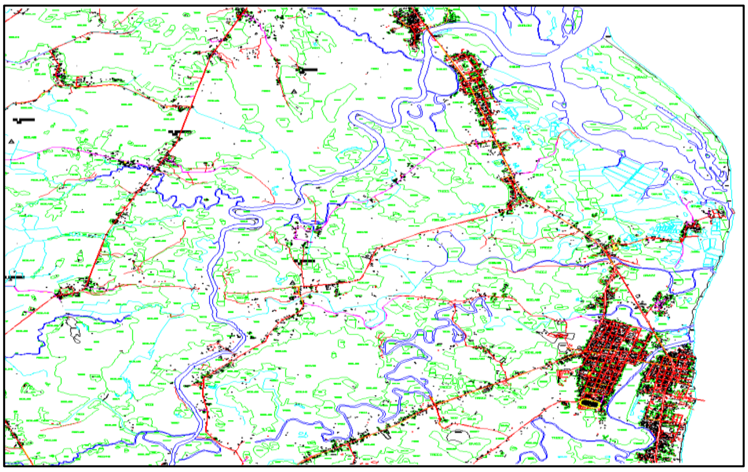

Figure 9. Ground features extracted from orthorectified satellite image.

e. Field Verification and Validation

The ground features plotted in the map manuscripts were validated on the ground as to type of vegetation, road class, land forms, etc. At the same time, secondary information were gathered such as the names of streets, rivers, bridges, buildings and other prominent features. Figure 10 shows a field team conducting this activity.

Figure 10. Field team conducting field validation activity.

f. Geodatabasing

The extracted features from the rectified images and secondary data gathered from the field were integrated into a central topographic database, as shown in Figure 11. It is organized into feature layers in accordance with the established NAMRIA topographic map production system.

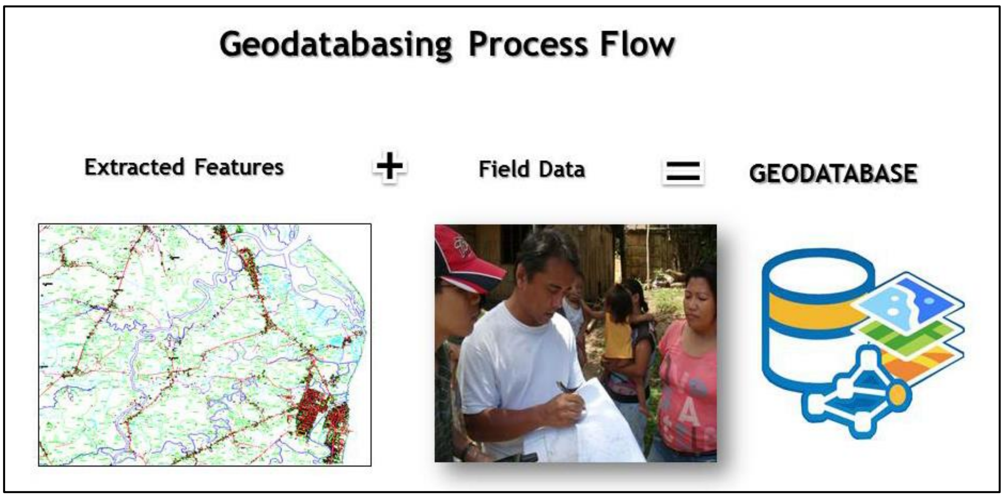

Figure 11. Process flow for geodatasing.

Additionally, corresponding attribute data were attached to the different ground features. A sample table is in Figure 12.

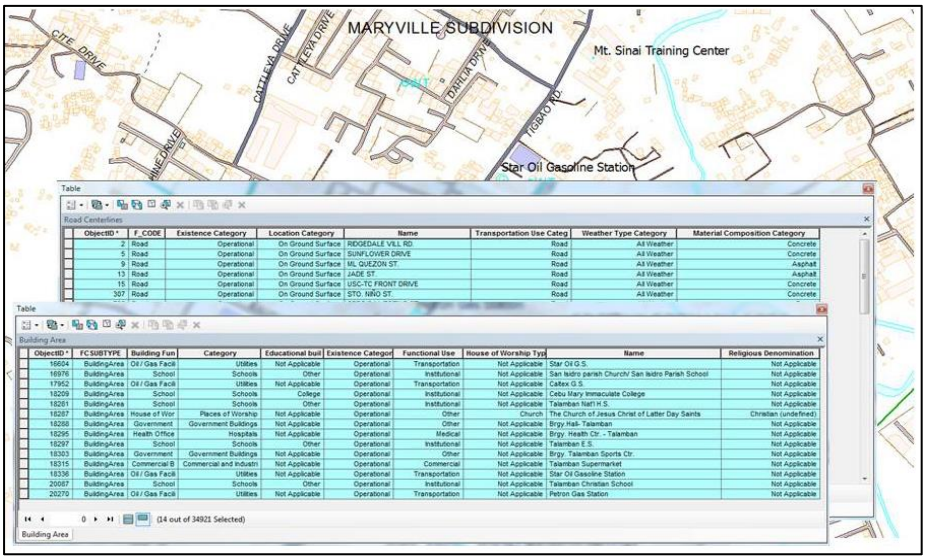

Figure 12. Geospatial data with attributes stored in database.

V. Final Output

Figure 13 shows a composite index map of the orthoimage and vector line maps produced for the Province of Leyte. The vector maps are GIS-ready and can be readily utilized by the typhoon-affected local government units down to the municipal level for disaster management and hazard mapping applications, including updating of their comprehensive land use plans.

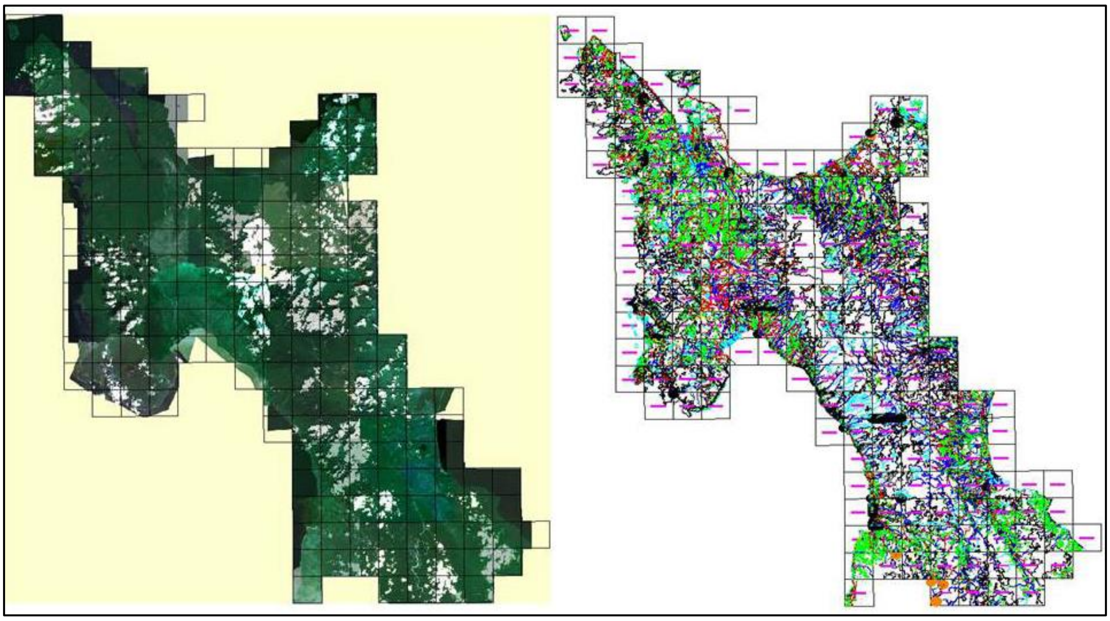

Figure 13. Index map of orthoimge and line maps of Leyte Province.

A sample map sheet of orthoimage and corresponding line map covering Tacloban City is shown in Figure 14.

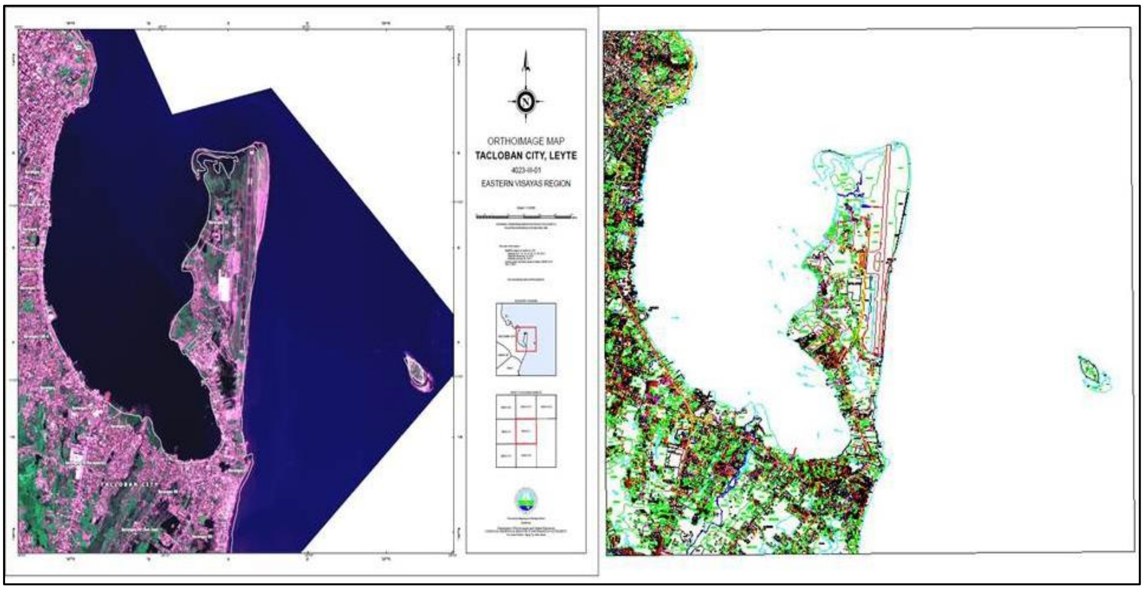

Figure 14. Orthoimage and line map of Tacloban City, Leyte Province.

VI. Conclusions

In responding to the need for large-scale topographic base maps for disaster management and risk reduction efforts in the wake of Typhoon Yolanda, the following are observations and comments based on past and present experiences of NAMRIA in undertaking disaster-related projects:

1. The problem of cloud cover for optical satellite data covering tropical regions like the Philippines always persist, which is major constraining factor for the timely production of base maps. Hence, in the initial planning process, finding other sources of multi-temporal images for patching cloud-covered areas should be one of the main considerations.

2. For disasters of this magnitude, multi-lateral agencies who are conducting their own damage assessment, researches and studies in the affected state using earth observation data may consider sharing their raw data with the national geospatial information agency (NGIA) of the said state to be used as additional input in the production of base maps, since these are the primary planning tool for rehabilitation, recovery and multi-hazard mapping activities, as well as in the formulation of updated land use plans by the local government units. Going even farther, in providing humanitarian and relief assistance, satellite imageries or other earth observation data should likewise be included.

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