A Research Note on Natural Reclamation Processes that Support Mangrove Biodiversity Spheres: Sedimentation in Three Major River Deltas in Northwestern Luzon Using Aerial Imagery

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Abstract

River deltaic regions feature natural reclamation processes that generate mangrove-viable environments. The new sediments that fan out and are reconcentrated by coastal waves become newer land extensions or even river islands and islets that become a spawning ground for mangrove ecosystems. The temporal dimension of these changes is showcased through case studies that tap on multiscalar remote sensing and geographic information systems (RS-GIS) tools (micro, meso, and macro) in studying mangrove ecosystems.

In this research note, I provide a contemporary historical record of the sedimentation in three river deltas in Northwestern Luzon: the Bauang/Naguilian, Aringay, and Amburayan Rivers. As a baseline, topographic maps from the NAMRIA 711 series at 1:50000 scale are used dating to aerial photography in the 1960s to 70s. These historical imageries are then contrasted to April 2013 WorldView 2 satellite (Digital Globe Foundation) imagery at 2 meters spatial resolution. The resulting output is a geographic information systems (GIS) shapefile of new sedimentation that has reclaimed part of the sea or even part of the river conduits. This macroscale output was then compared to more macro to meso scalar data taken from a Consumer Off the Shelf Remotely Piloted Aircraft Systems (COTS-RPAS). Special focus will be given to the mangrove ecosystem that has made these silt accumulations a new home.

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Introduction

There is a flurry of artificial reclamation activities globally for residential, commercial, and even military land use. This research note wants to highlight more natural processes that result in the creation of mangrove biodiversity spheres. The Aringay, Bauang/Naguilian, and Amburayan Rivers are three of the major rivers in Northwestern Luzon (Figure 1). These are presently located within the province of La Union, Philippines. These river systems drain Southwestern Cordillera. These river deltas have also been commonly cited as areas where ancient settlements could be found (i.e. see Newson 2011, Mateo 2004, Bagamaspad and Hamada- Pawid 1985). These early settlements offer strategic meeting places wherein overseas traders (Chinese, South Indians, etc…), as well as interior traders (Cordilleran gold), can meet and exchange wares (see Canilao 2020).

Figure 1. Map of research sites (Shuttle Radar Topography Mission data SRTM)

Newer landforms in river deltas are formed by mass wasting resulting in sedimentation (Figure 2). After some heavy rains in the upriver areas, a mix of organic materials, like dry stems leaves branches and others, are mixed with non-organics, including dislodged sediments from the upriver areas. These accumulate at the river deltas and over a long period of time begin to form river islands. At the river deltas, there are also processes that contribute to the emergence of mangrove viable environments and the biodiversity it supports. One is the mixing of sea water and river water (Figure 3) through the process of tidal flushing, which creates iron oxides and kaolinite clay. This results in a brackish water environment wherein mangroves take root and support biodiverse flora and fauna. The mangroves serve as producer level followed by primary (i.e, brackish water mollusks including univalves and bivalves [i.e., *Pectinidae* spp. *Solenidae* spp. *Conidae* spp.]), secondary (i.e., Fiddler crabs *Uca spp*.), tertiary (Collared kingfisher *Todiramphus chloris* Striated herons *Butorides striata*, Black-crowned night herons *Nycticorax nycticorax*, etc.) and eventually quaternary consumers (Brahminy kites *Haliastur indus*, Western ospreys *Pandion haliaetus*, Peregrine falcons *Falco peregrinus*, etc.). In another article, I have shown how the newer compact consumer off-the-shelf remotely piloted aircraft systems (compact COTS-RPAS) are proving quite useful in biodiversity studies (Canilao 2023).

Methods

The main method used is remote sensing and geographic information systems (RS-GIS). Tapping a more multiscalar approach that allows access to the macro, meso, and micro. The Macro, meso, and to some extent micro scale can be accessed using satellite assets in space depending on the spatial temporal and spectral resolutions.

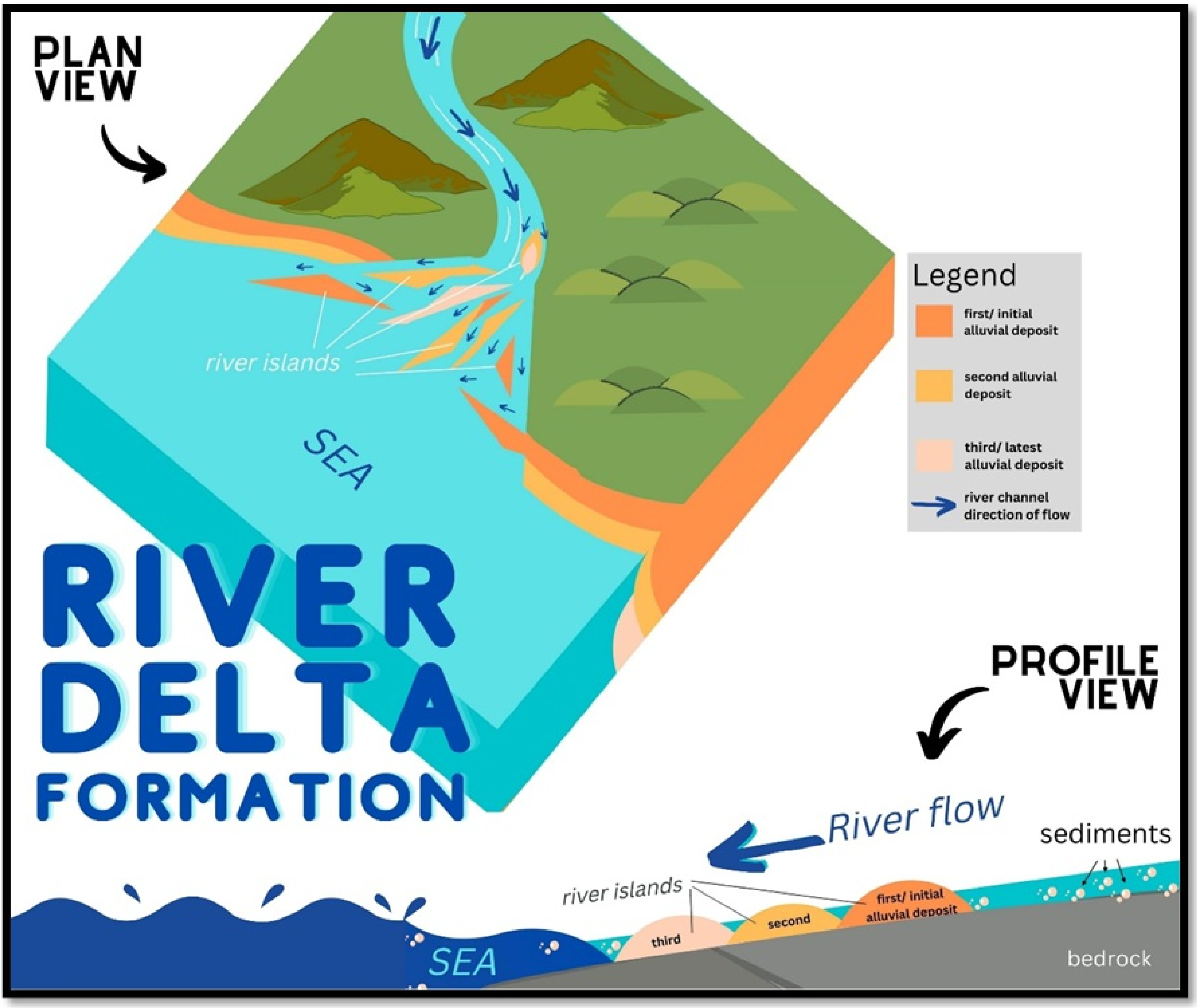

Figure 2. Illustration of river delta formation

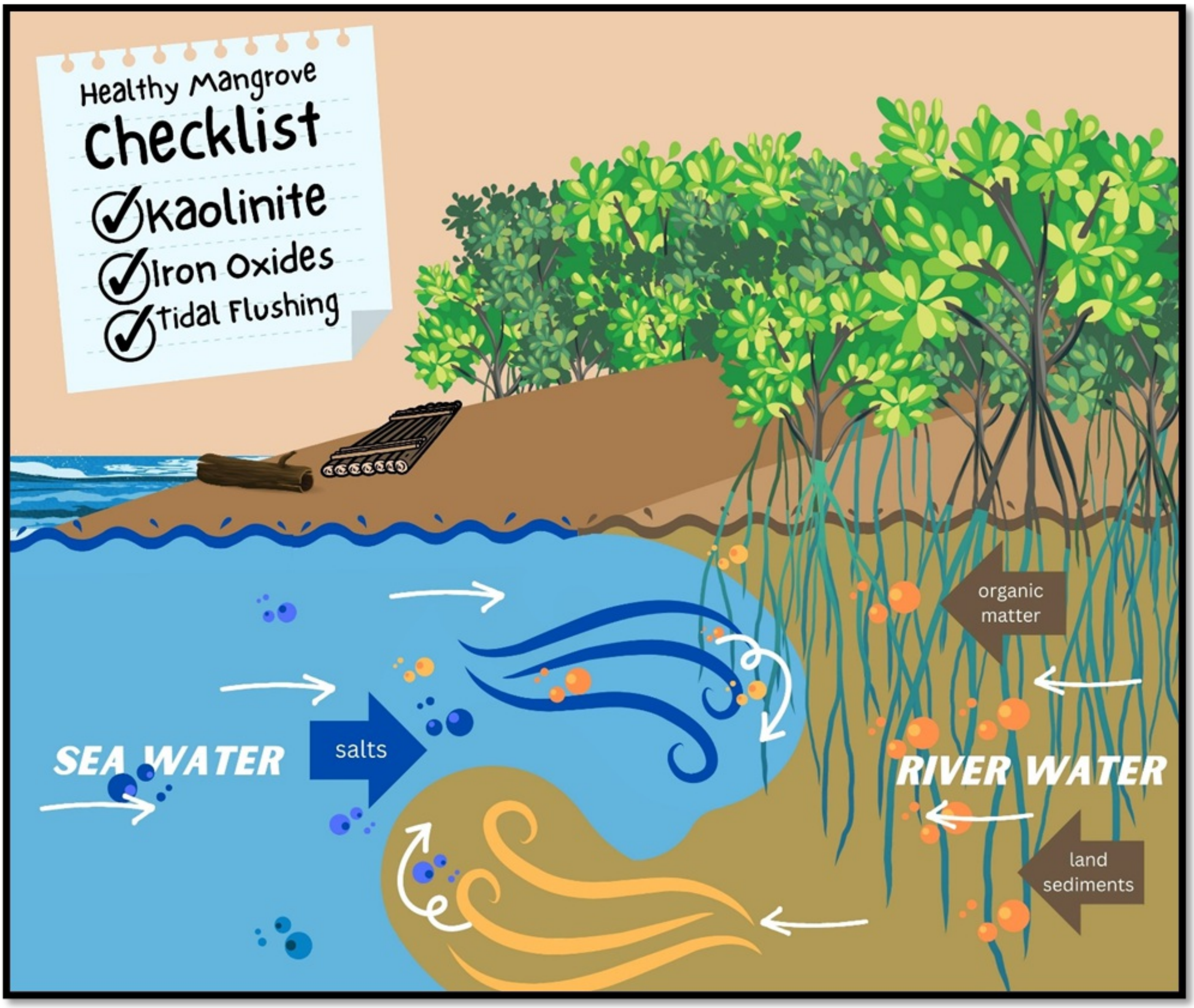

Figure 3. Illustration of tidal flushing

The mesoscale up to the microscale is primarily accessed through the use of piloted (i.e., CESSNA Caravan aircraft with imaging payload) or remotely piloted aircraft (compact COTS-RPAS). Ground truthing may be carried out if feasible. The challenge with ground truthing will depend on the prevailing tidal and siltation/sedimentation conditions in these deltaic environments. Often the water level is low and it is quite difficult to utilize shallow draft watercraft to approach riverine mangrove islands (see Figure 4). The researcher is then left with the option of wading through the brackish water environment which entails at times getting into waist-deep water since the legs will sink into the mud, not to mention that the lower limb tends to stick to the mud once it sinks into the mud. Due to this limitation, a COTS-RPAS that fulfills the meso and micro perspective will indeed come in quite handy.

The historical component of this research was accessed using National Mapping and Resources Information Agency 711 series topographic maps (1979) at a 1:50000 scale. To carry out change detection, as a contemporary dataset, April 2013 WorldView 2 satellite (Digital Globe Foundation) imagery at 2 meters spatial resolution was used. The DJI Mavic Pro 2

COTS-RPAS was used in the ground truthing of the new sediments in the delta.

Results

The area of interest (AOI) within the three river deltas were delineated and a side-by-side comparison is undertaken between the 1979 data and the 2013 data.

Figure 4. Researcher is left with the option of wading through the brackish water when shallow draft watercrafts cannot enter the shallow water (Photo of Author at Caoayan Ilocos Sur 2011)

In the case of the Aringay delta, both the Worldview 2 bathymetry (green band- blue band- coastal blue band) and coastal (coastal blue band- yellow band- red edge band) combinations were used because the combinations enhance sedimentation features in the Aringay delta (Figure 5). The Worldview 2 satellite has the coastal blue band (band 1) which is quite useful in such analysis of sedimentation. In terms of sedimentation in Aringay, a total new area of 1720 square meters has been formed (Figure 6). This new landform is then viewed utilizing the World view 2 False color composite (Figure 7) for highlighting vegetation density (near infrared 2 band- yellow band, red edge band). This composite allows us to appreciate the mangrove density in the new landform with higher levels of mangrove vegetation appearing as deeper reds. Aside from the orthogonal views, horizontal or side-looking imagery taken by the COTS RPAS also provides validation of the satellite data specifically the density of mangroves in the new landform (Figure 8). A video is also taken by the COTS-RPAS and the link to the video is provided.

In the case of Bauang Delta Worldview 2 bathymetry (green band- blue band- coastal blue band) and coastal (coastal blue band- yellow band- red edge band) combinations were also used (Figure 9). In terms of the sedimentation in Bauang a total new area of 2040 square meters has been formed (Figure 10). This new landform is then viewed utilizing the World view 2 False color composite (Figure 11) for highlighting vegetation density (near infrared 2 band- yellow band, red edge band). Horizontal or side-looking imagery taken by the COTS RPAS also provides validation of the satellite data specifically the density of mangroves in the new landform (Figure 12). A video was also taken by the COTS-RPAS and a link to the video is provided.

In the case of Amburayan Delta Worldview 2 bathymetry (green band- blue band- coastal blue band) and coastal (coastal blue band- yellow band- red edge band) combinations were also used (Figure 13). In terms of the sedimentation in Amburayan a total new area of 1130 square meters has been formed (Figure 12).

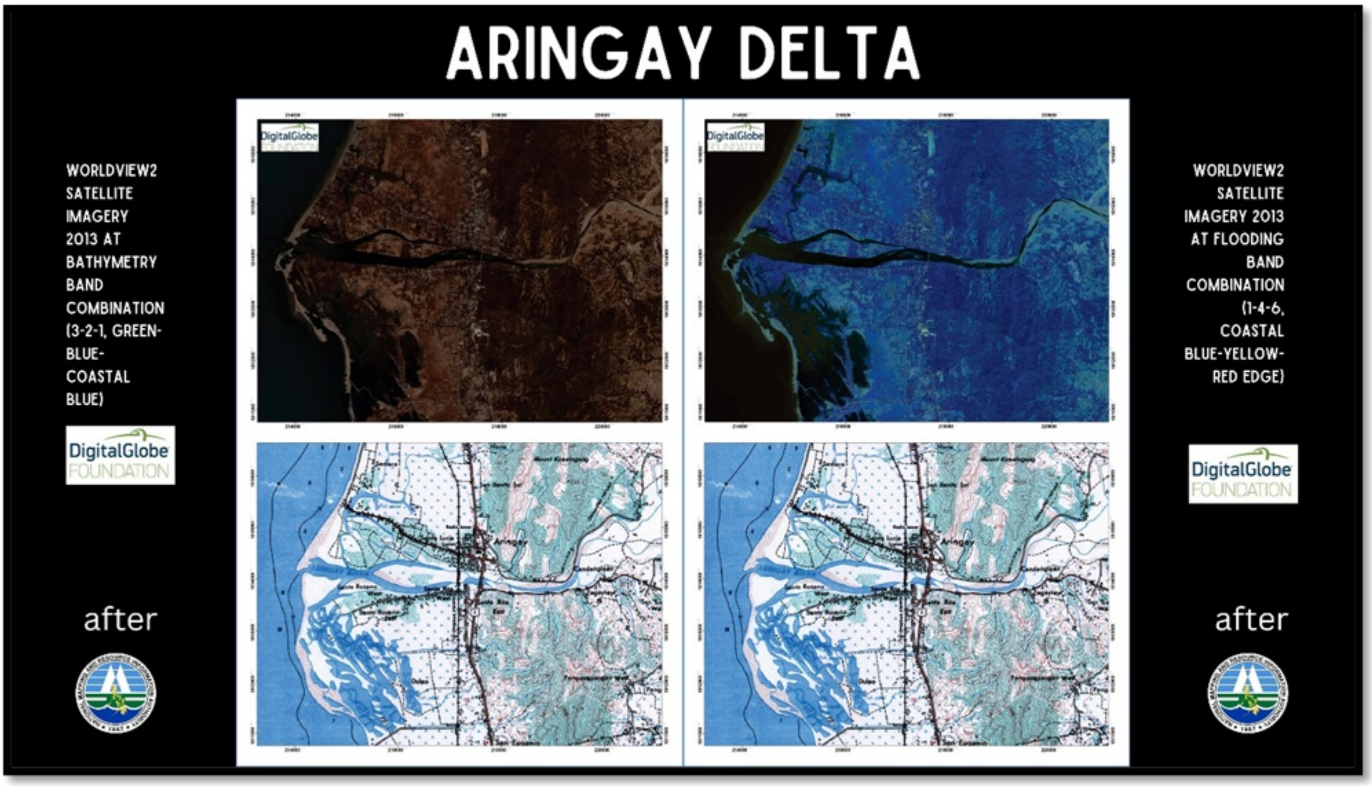

Figure 5. Composite image showing the Aringay River Delta. Top is WorldView2 satellite imagery 2013 at bathymetry band combination and coastal band combination (DigitalGlobe Foundation). Scale 1:50000 Topographic map Series 711 based on aerial photographs from the 1960-70s (NAMRIA). Projected WGS 84 UTN 51N.

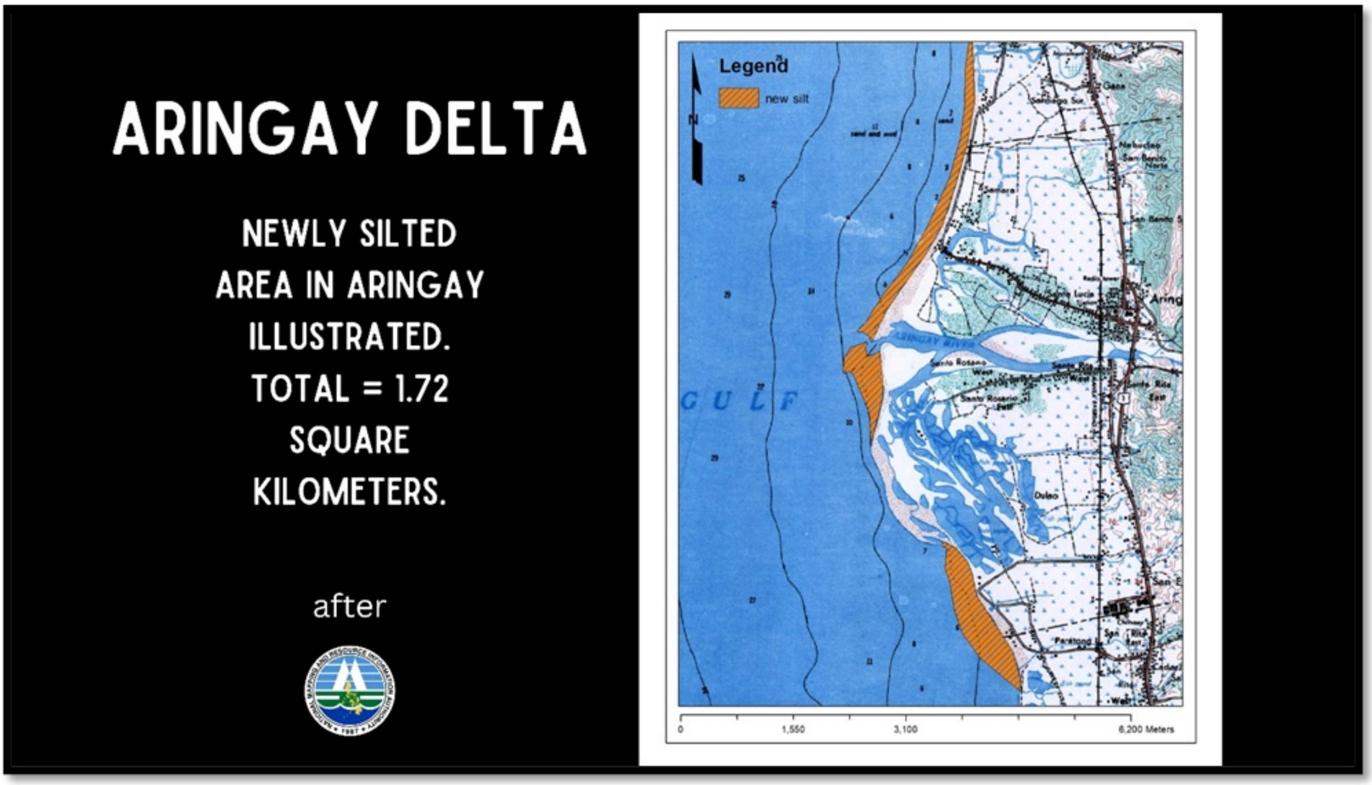

Figure 6. New landform reclaimed from the sea in Aringay Delta. Scale 1:50000 Topographic map Series 711 based on aerial photographs from the 1960-70s (NAMRIA). Projected WGS 84 UTN 51N.

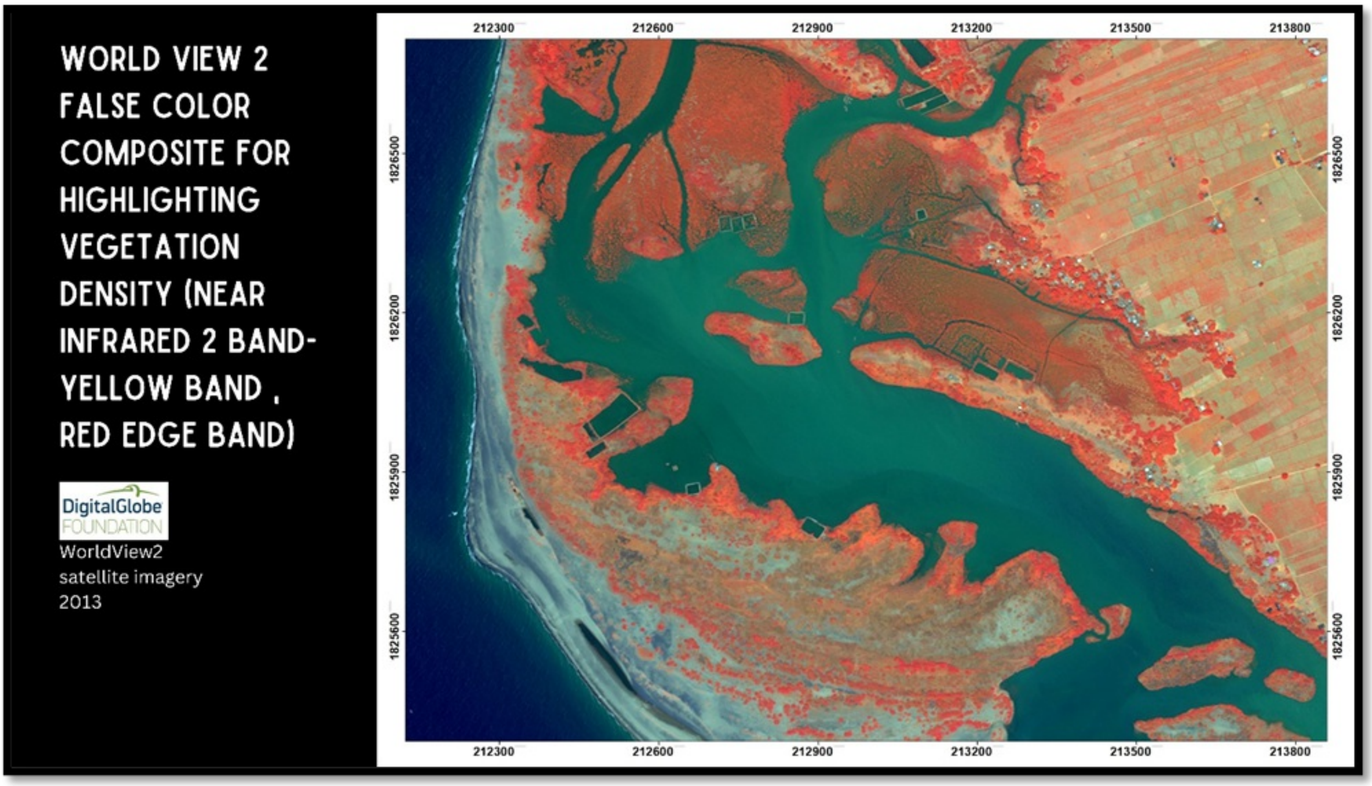

Figure 7. Aringay River Delta. False color composite for highlighting vegetation density (near infrared 2 band- yellow band, red edge band). This composite allows us to appreciate the mangrove density in the new landform with higher levels of mangrove vegetation appearing as deeper reds (DigitalGlobe Foundation).

Figure 8. Aringay River Delta side-looking, horizontal view using compact COTS-RPAS. Scan the QR code to see a video of the delta.

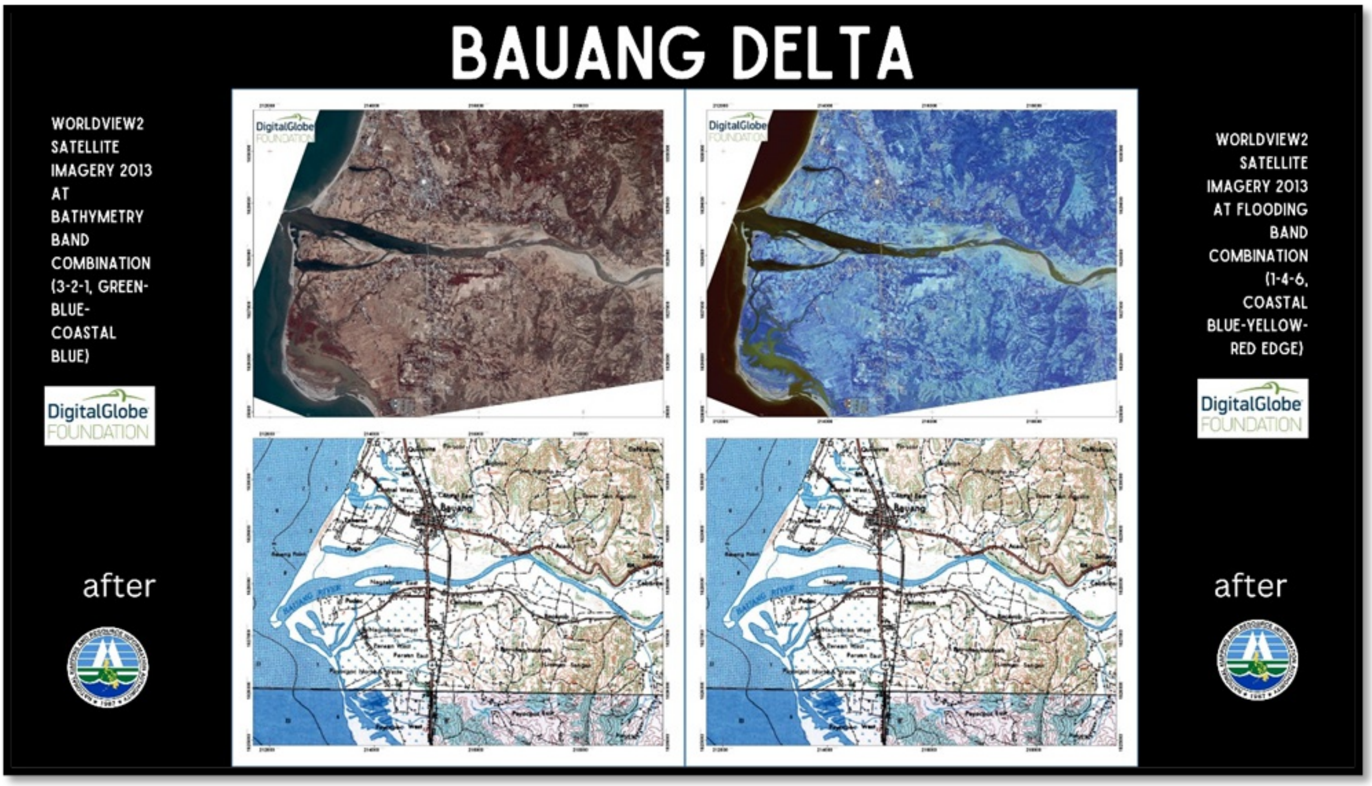

Figure 9. Composite image showing the Bauang River Delta. Top is WorldView2 satellite imagery 2013 at bathymetry band combination and coastal band combination (DigitalGlobe Foundation). Scale 1:50000 Topographic map Series 711 based on aerial photographs from the 1960-70s (NAMRIA). Projected WGS 84 UTN 51N.

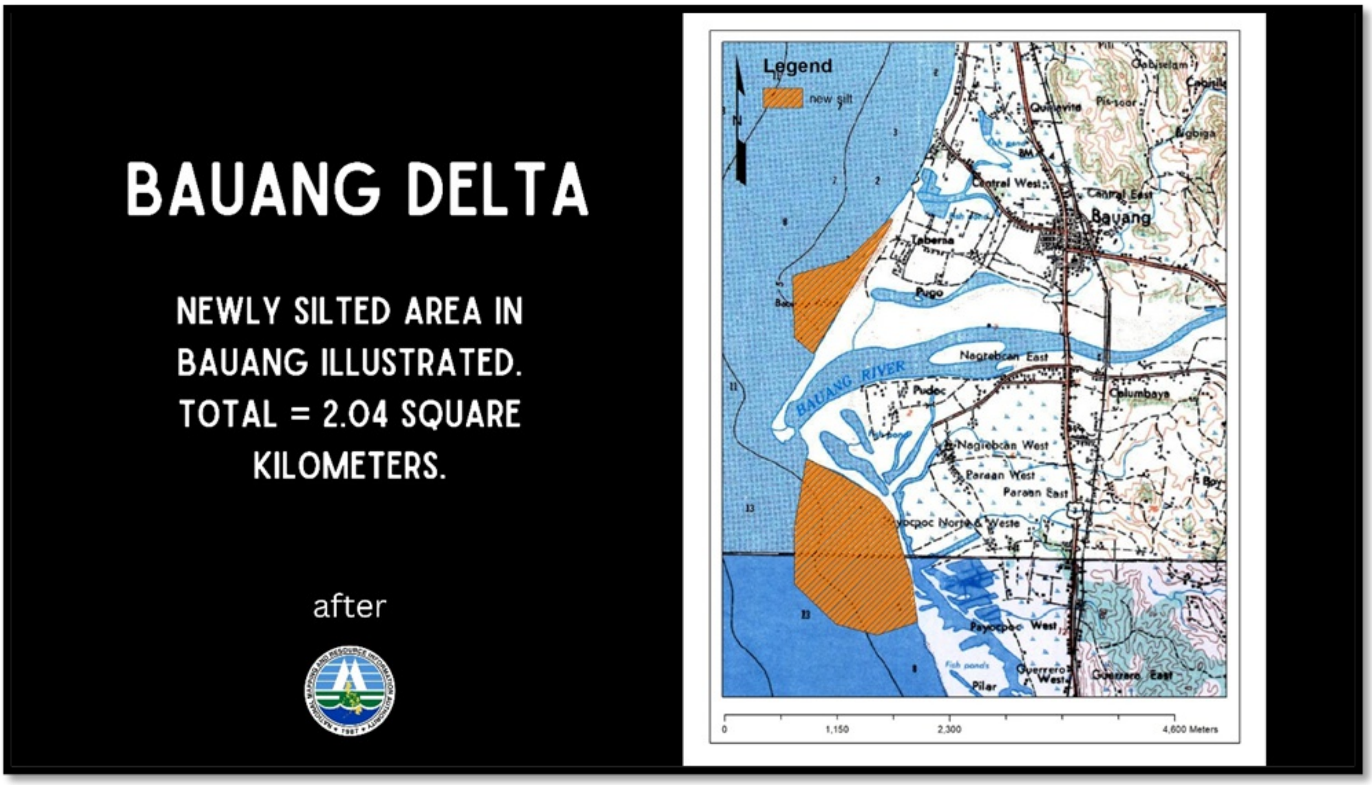

Figure 10. New landform reclaimed from the sea in Bauang Delta. Scale 1:50000 Topographic map Series 711 based on aerial photographs from the 1960-70s (NAMRIA). Projected WGS 84 UTN 51N.

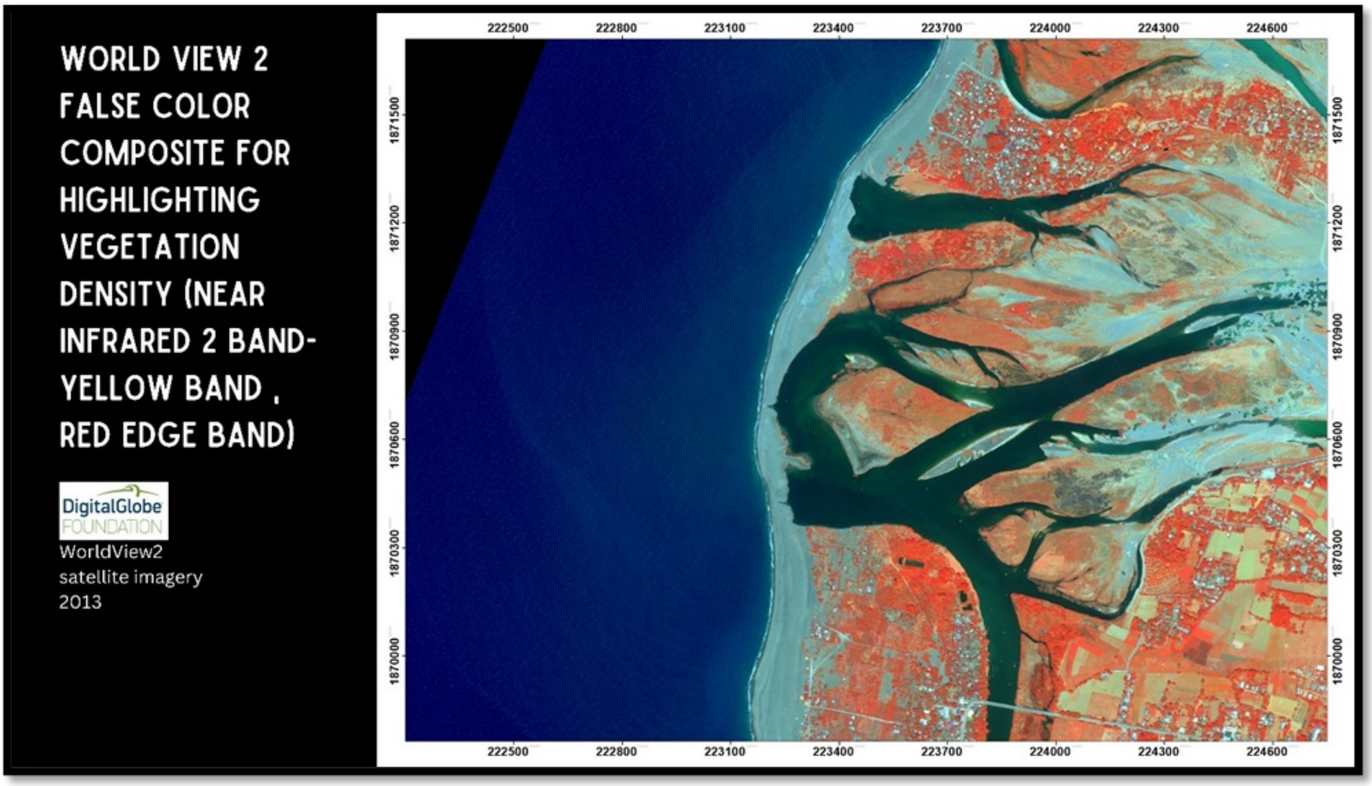

Figure 11. Bauang River Delta. False color composite for highlighting vegetation density (near infrared 2 band- yellow band, red edge band). This composite allows us to appreciate the mangrove density in the new landform with higher levels of mangrove vegetation appearing as deeper reds (DigitalGlobe Foundation).

Figure 12. Bauang River Delta side-looking, horizontal view using compact COTS-RPAS. Scan the QR code to see a video of the delta.

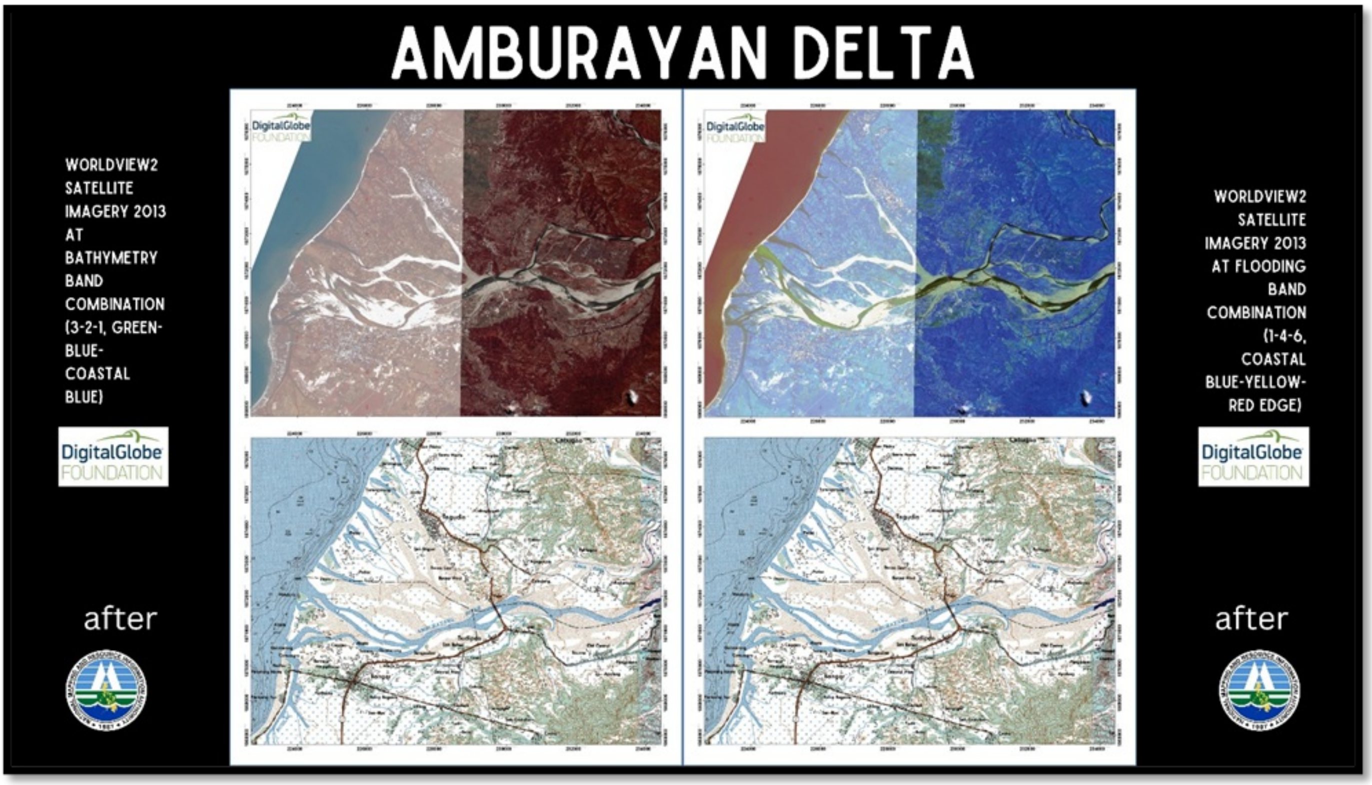

Figure 13. Composite image showing Amburayan River Delta. Top is WorldView2 satellite imagery 2013 at bathymetry band combination and coastal band combination (DigitalGlobe Foundation). Scale 1:50000 Topographic map Series 711 based on aerial photographs from the 1960-70s (NAMRIA). Projected WGS 84 UTN 51N.

Horizontal or side-looking imagery taken by the COTS RPAS also provides validation of the satellite data specifically the density of mangrove in the new landform (Figure 14). This new landform is then viewed utilizing the World view 2 False color composite (Figure 15) for highlighting vegetation density (near infrared 2 band- yellow band, red edge band). A video was also taken by the COTS-RPAS (Figure 16) and a link to the video is provided.

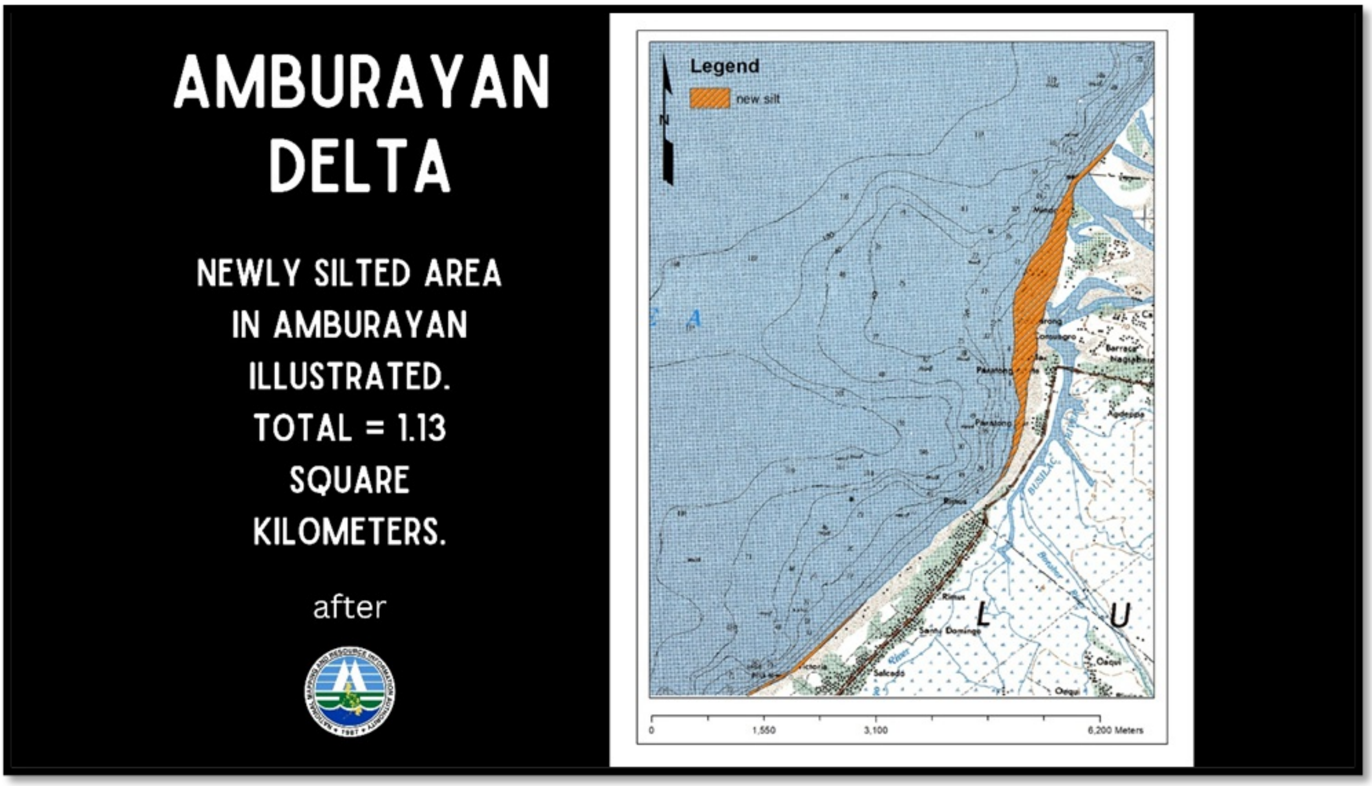

Figure 14. New landform reclaimed from the sea in Amburayan Delta. Scale 1:50000 Topographic map Series 711 based on aerial photographs from the 1960-70s (NAMRIA). Projected WGS 84 UTN 51N.

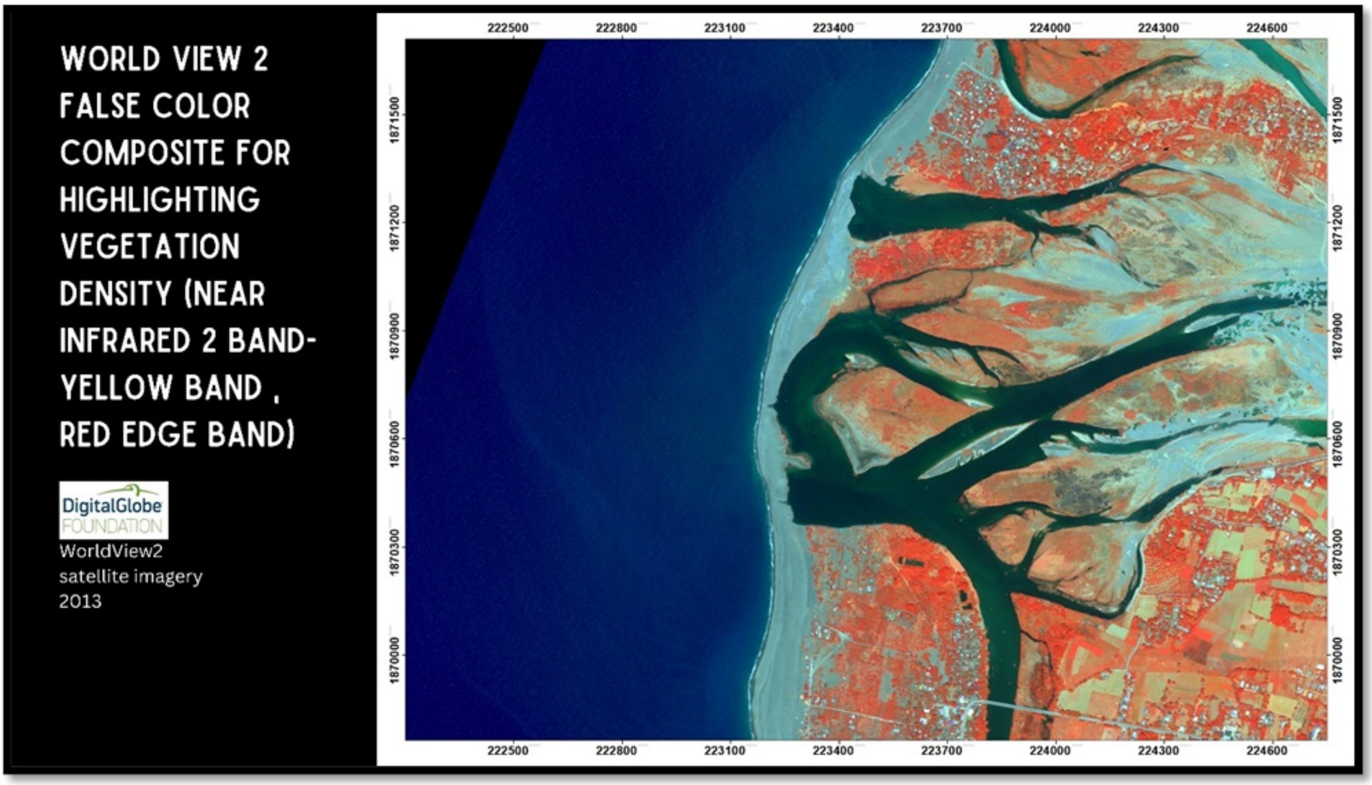

Figure 15. Amburayan River Delta. False color composite for highlighting vegetation density (near infrared 2 band- yellow band, red edge band). This composite allows us to appreciate the mangrove density in the new landform with higher levels of mangrove vegetation appearing as deeper reds (DigitalGlobe Foundation).

Figure 16. Amburayan River Delta side-looking, horizontal view using compact COTS-RPAS. Scan the QR code to see a video of the delta.

Conclusion

Close to half a century of sedimentation has reclaimed areas that used to be part of the sea in the Aringay, Bauang, and Amburayan Rivers in La Union. For the Aringay River, a total of 1072 square meters has been claimed from the sea. For the Bauang River, a total of 2040 square meters has been claimed from the sea. For the Amburayan River, a total of 1130 square meters has been claimed from the sea. The research note has shown the viability of tapping multiscalar tools (macro, meso, micro) in RS-GIS including satellites, piloted and remotely piloted aircraft (i.e., COTS-RPAS) in carrying out change detection in river deltas. The various tools employed allow the researcher to delineate new landforms as well as the ensuing mangrove insemination in the area due to the background processes of tidal flushing and siltation/sedimentation of organic and inorganic materials from upriver.

Applying the ridge-to-reef concept a possible explanation is also given in this paper why there is relatively more sedimentation seen in the Bauang River delta compared to Aringay and Amburayan. Bauang river delta is actually called the Balili River upriver. Balili River drains a rapidly urbanizing and expanding metro of Baguio and La Trinidad. Perhaps this is the reason for havier siltation sedimentation in this river.

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