

# The Effects of Cyclone Gati in Somalia through Satellite Imagery and Remote Sensing

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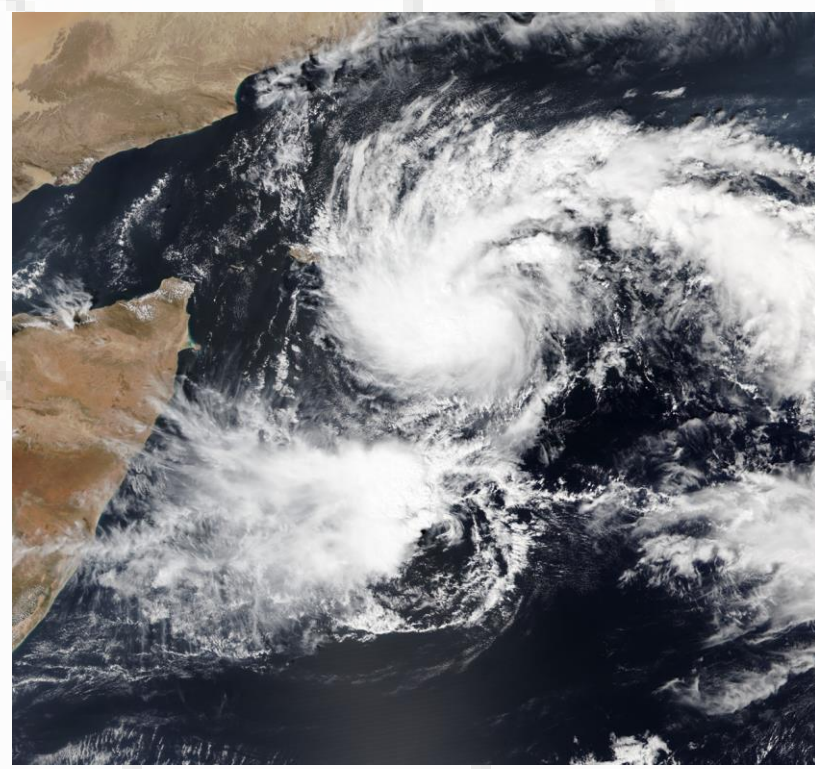


Figure 1: NOAA Visible Infrared Imaging Radiometer Suite Satellite Image Cyclone Gati formation in Arabian Sea November 21, 2020

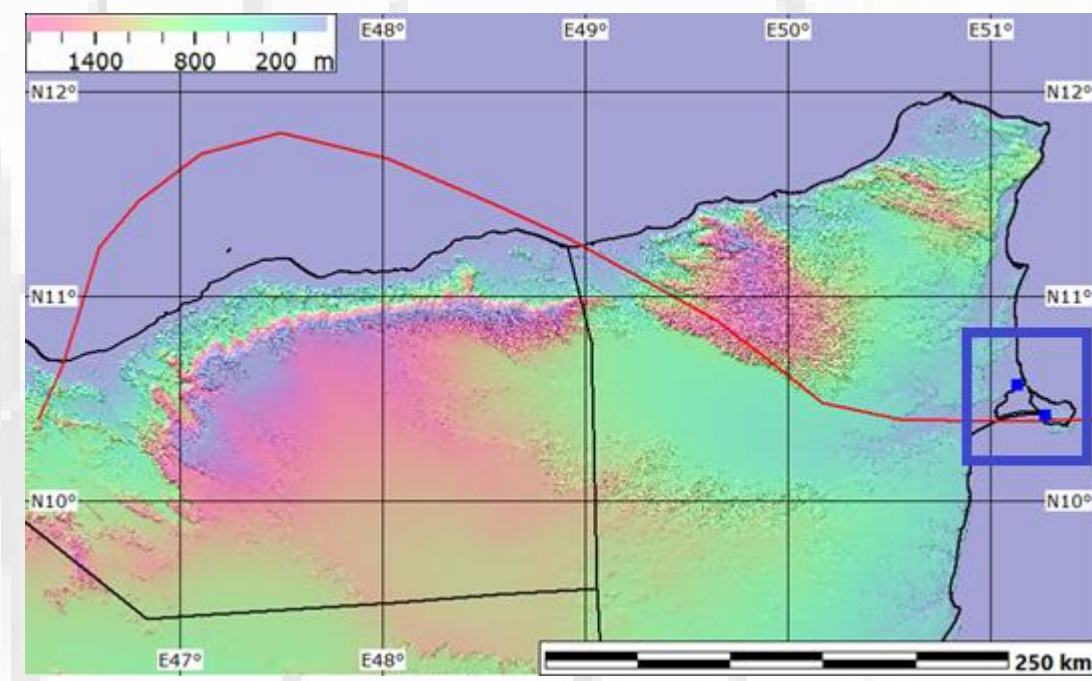


Figure 2: Copernicus DEM of Cyclone Gati track over Somalia and areas of interest outlined in blue.

## INTRODUCTION

On November 22, 2020 Tropical Cyclone Gati struck the Bari Province of Somalia. This was the most severe tropical storm recorded in Somali history, where winds peaked at 185 km/h. This storm formed on November 21, 2020 as shown in (Figure 1). Over a 12-hour period, Cyclone Gati had the largest increase in wind speed ever documented in the Indian Ocean. Millions of dollars of damage were a result of the storm. Gati's track is shown in (Figure 2) on a digital elevation model (DEM) of Somalia. Specifically within the Bari Province, Xaafun and Hurdiyo experienced flash flooding, storm surges, as well as livestock and residential damage. These two cities will be the area of interest for this analysis, shown in (Figure 2). Satellite imagery was used to assess the aftermath of the storm, along with a Normalized Difference Vegetation Index (NDVI) to compare vegetation growth before and after the storm. Cyclone Gati was unforeseen, and has had significant impact to the economy and people of Bari Province.

## RESULTS

In total Gati affected over 70,000 people in Somalia. Over 15,000 were internally displaced due to dangerous water levels. There were 9 fatalities, over 360 recorded damaged houses, and 52km<sup>2</sup> land area flooded within the Bari province. The storm lasted for three days, bringing two years worth of rain to the desert community. This created flash flooding, highlighted in the moisture index as shown in (Figure 5). The flash flooding from the storm and torrential rainfall brought heavy winds; furthermore, Gati was labeled a Category 3 Tropical Storm, with devastating damage upon landfall. Primarily within the Bari province, houses, fishing boats, and aquaculture farms were destroyed. Some devastation to the area of interest is highlighted in (Figure 6) and (Figure 7). With the use of high resolution imagery from MAXAR Technologies, roofs and houses were shown to be either blown off, or reconstructed after the storm. Despite the destruction from the storm, one critical asset which showed visible improvement is vegetation growth. Hurdiyo, which has transitioned from an economy of salt mining to aquaculture, saw an increase in vegetation growth after the storm. Hurdiyo's aquaculture is illustrated in the NDVI comparison in (Figure 8). This is consistent with the vegetation growth seen near Xaafun, highlighted in (Figure 4).

## MATERIALS

Satellite imagery was acquired from two platforms: Sentinel 2 via the United States Geological Survey and World View-3 via MAXAR Technologies. Both platforms have an aerial view of the Bari Province, but their spatial resolution differed making their purposes in the analysis of the storm different. Sentinel 2 has a spatial resolution of 10-20 m, where World View-3 has a resolution of 30 cm. Therefore, when analyzing large scale changes in the province Sentinel 2 was used. The NDVI assessment was completed with Sentinel 2 imagery due to Sentinel having visual and near-infrared images. MAXAR images used pan sharpened MSI and the panchromatic band, with a resolution of 30 cm.

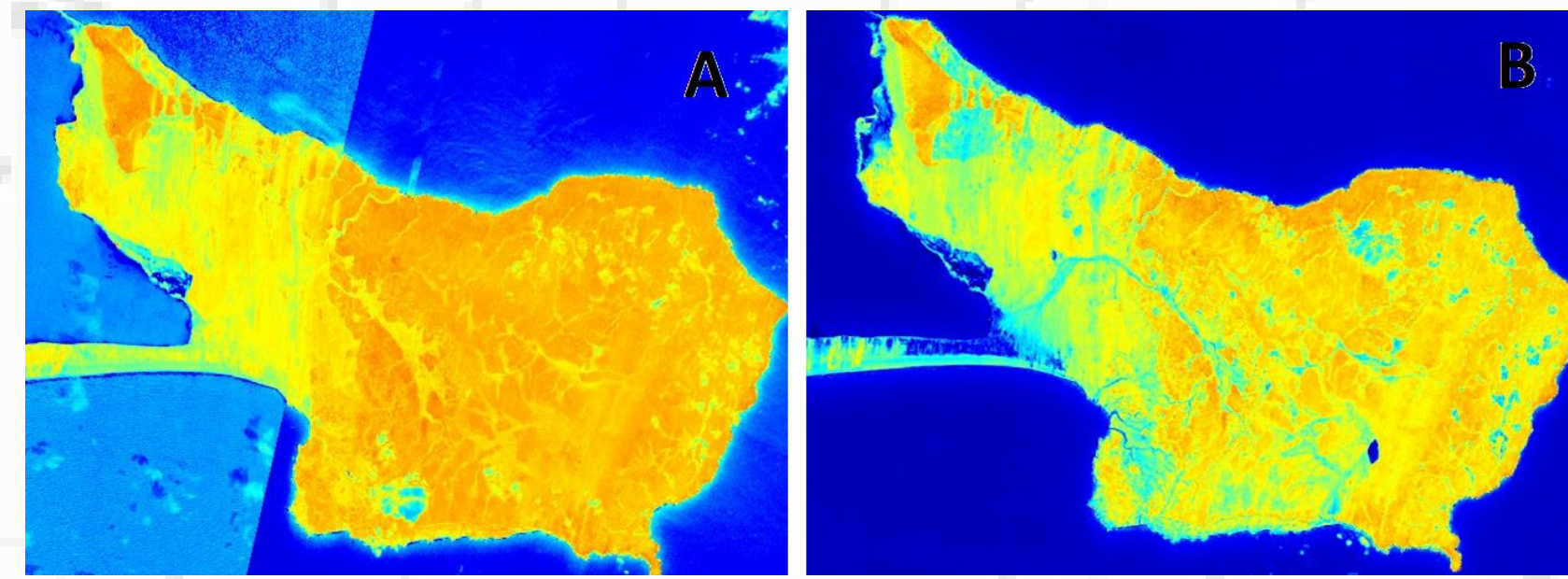


Figure 5: A Sentinel imagery moisture index (A) November 19, 2020 and (B) November 24, 2020.

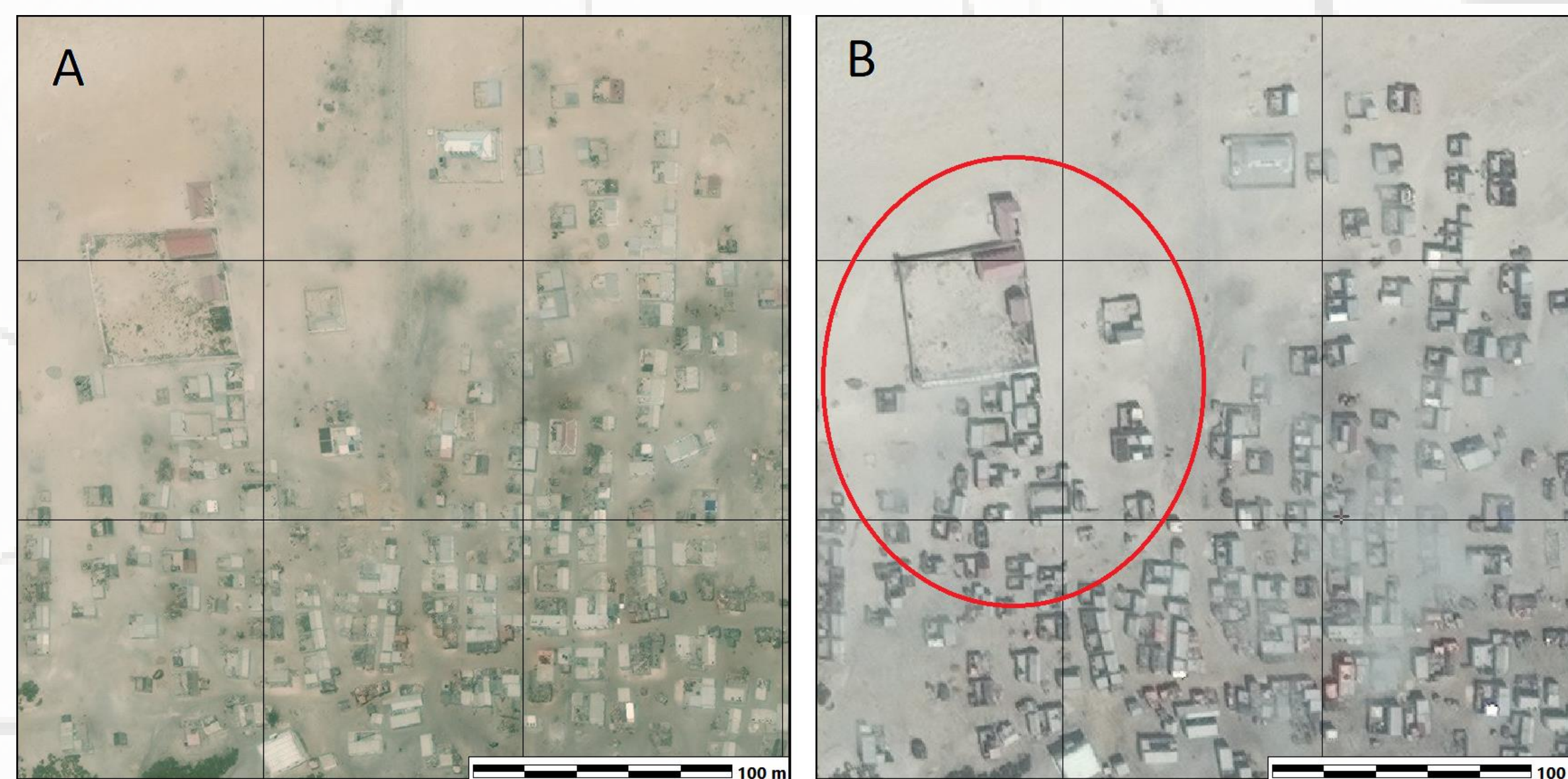


Figure 6: A MAXAR full spectrum imagery of Hurdiyo October 26, 2020. B MAXAR full spectrum imagery of Hurdiyo December 12, 2020.

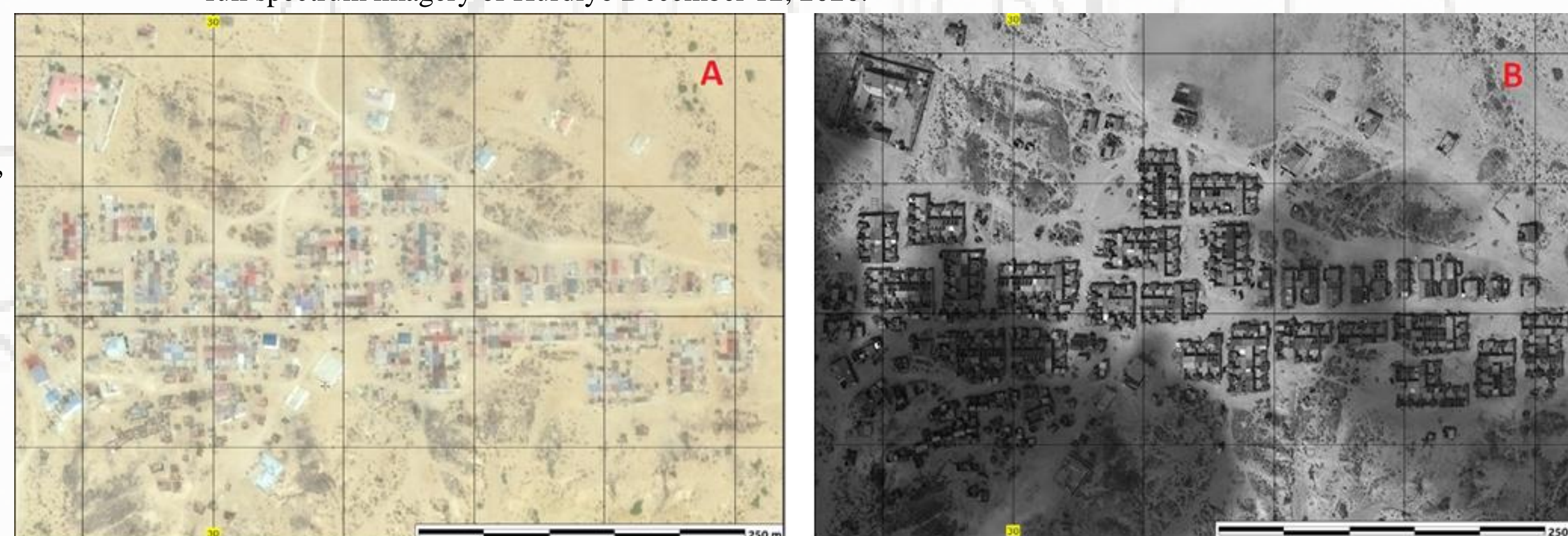


Figure 7: A MAXAR pan sharpened image of Xaafun October 26, 2020. B MAXAR panchromatic image of Xaafun December 12, 2020.

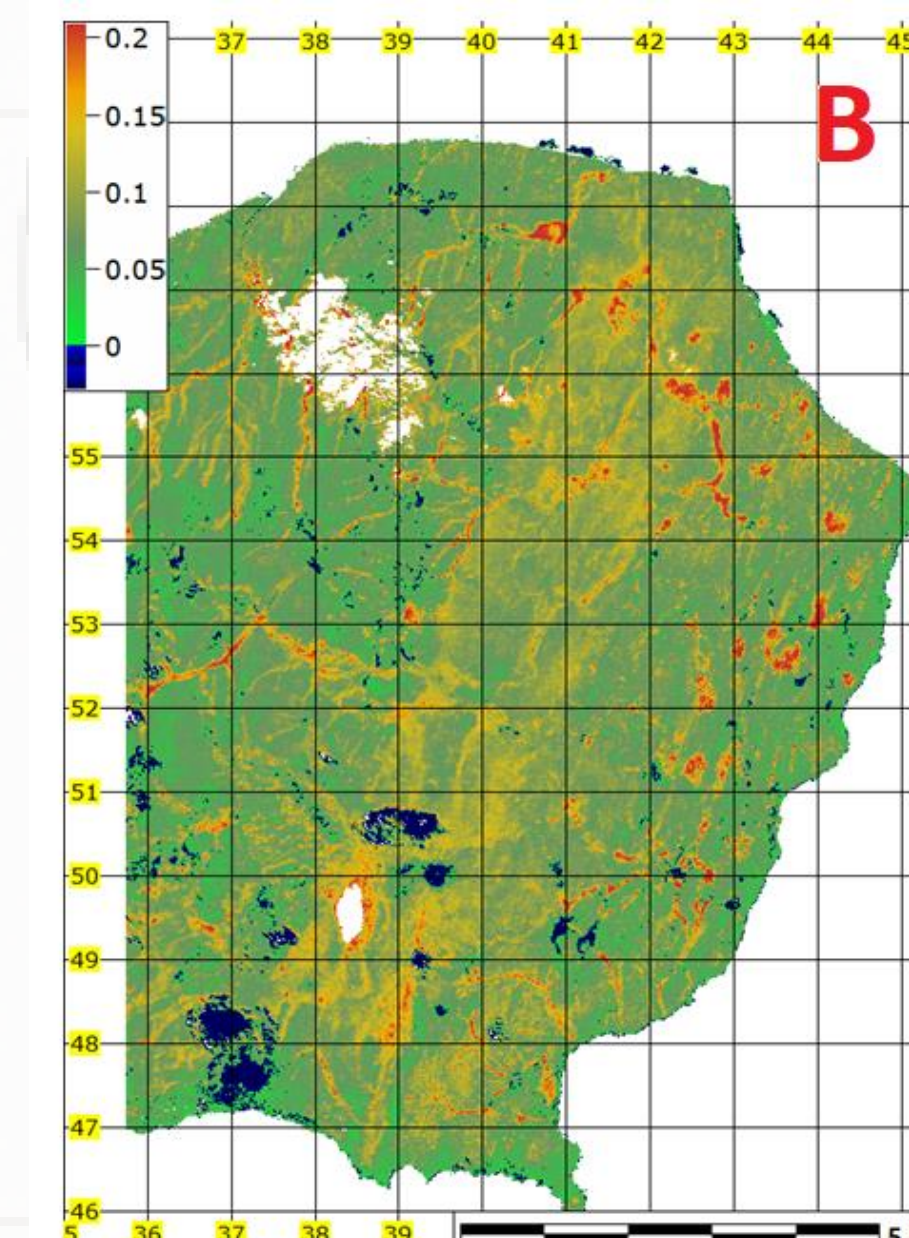
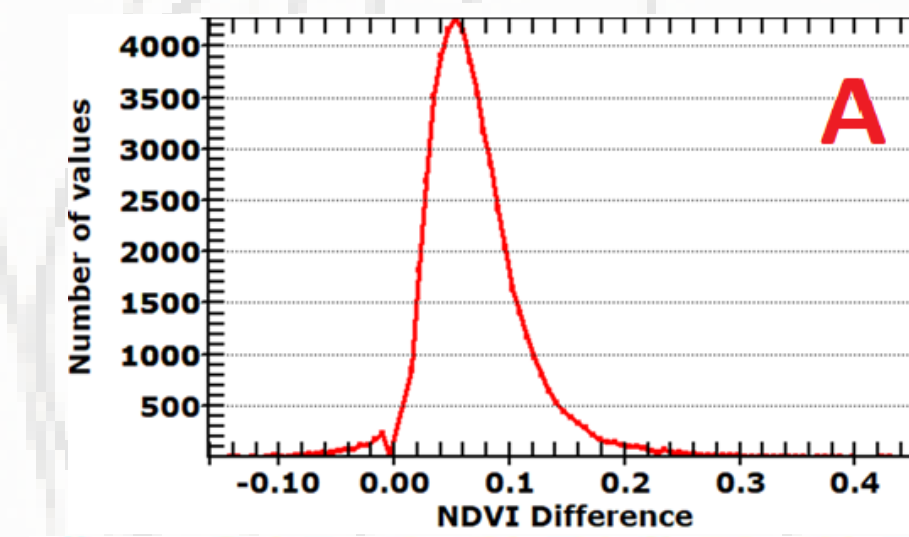


Figure 4: A Histogram of NDVI histogram from 09 Dec - 19 Nov. B NDVI difference grid from 09 Dec - 19 Nov.

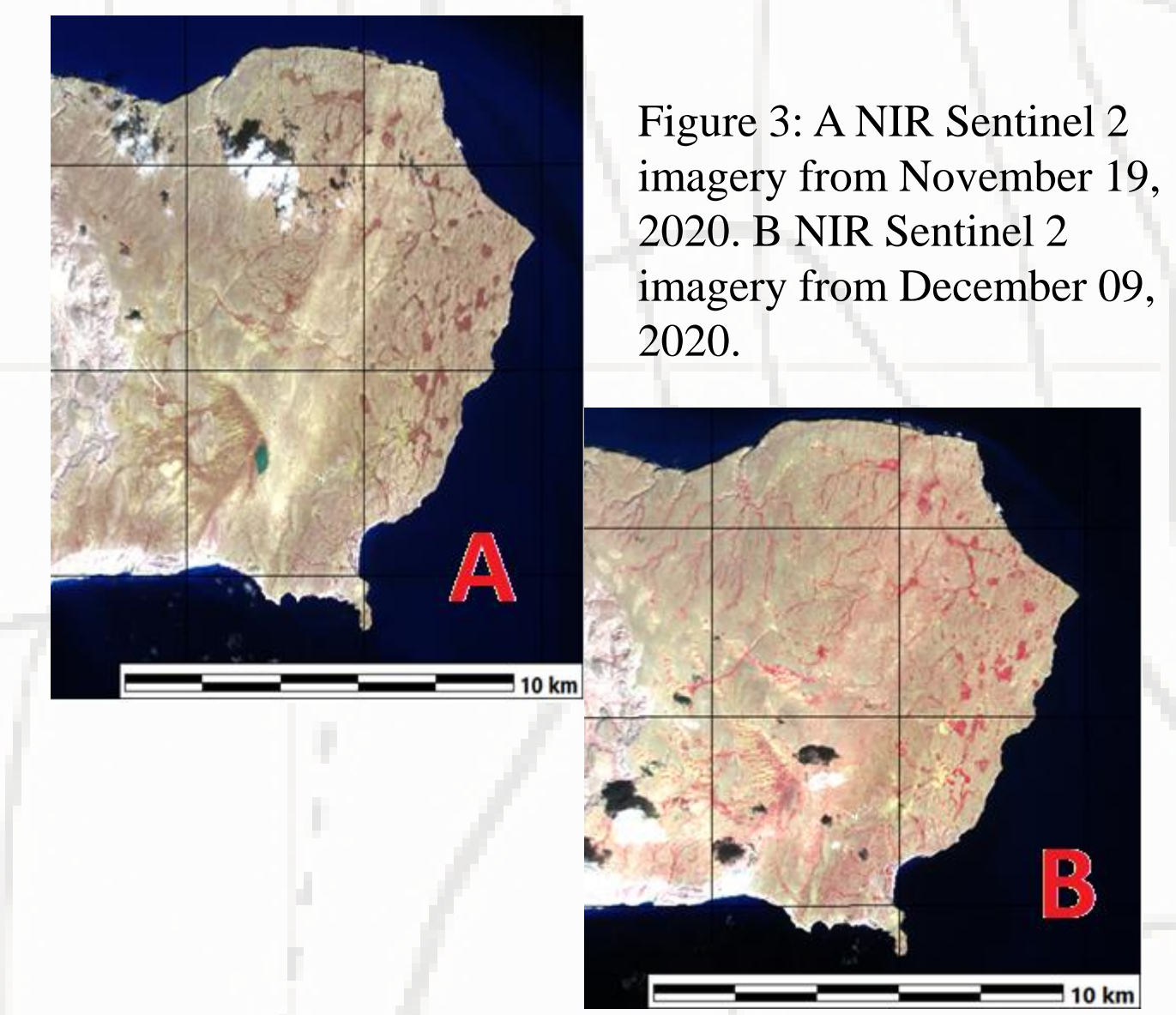


Figure 3: A NIR Sentinel 2 imagery from November 19, 2020. B NIR Sentinel 2 imagery from December 09, 2020.

## METHODS

NDVI monitored vegetation growth across the span of 20 days, one image before and after the storm (Figure 3). NDVI is a calculation of vegetation's ability to reflect red and near infrared light. Healthier vegetation will absorb the visible light and reflect NIR, leading to a large value for NDVI near +1, less healthy vegetation will have smaller values, with barren areas and water have very low or even negative values. The difference in NDVI grid and histogram is shown in (Figure 4). In addition to the NDVI, a comparison of before and after images using MAXAR high resolution images was used of the cities closest to Gati's track.

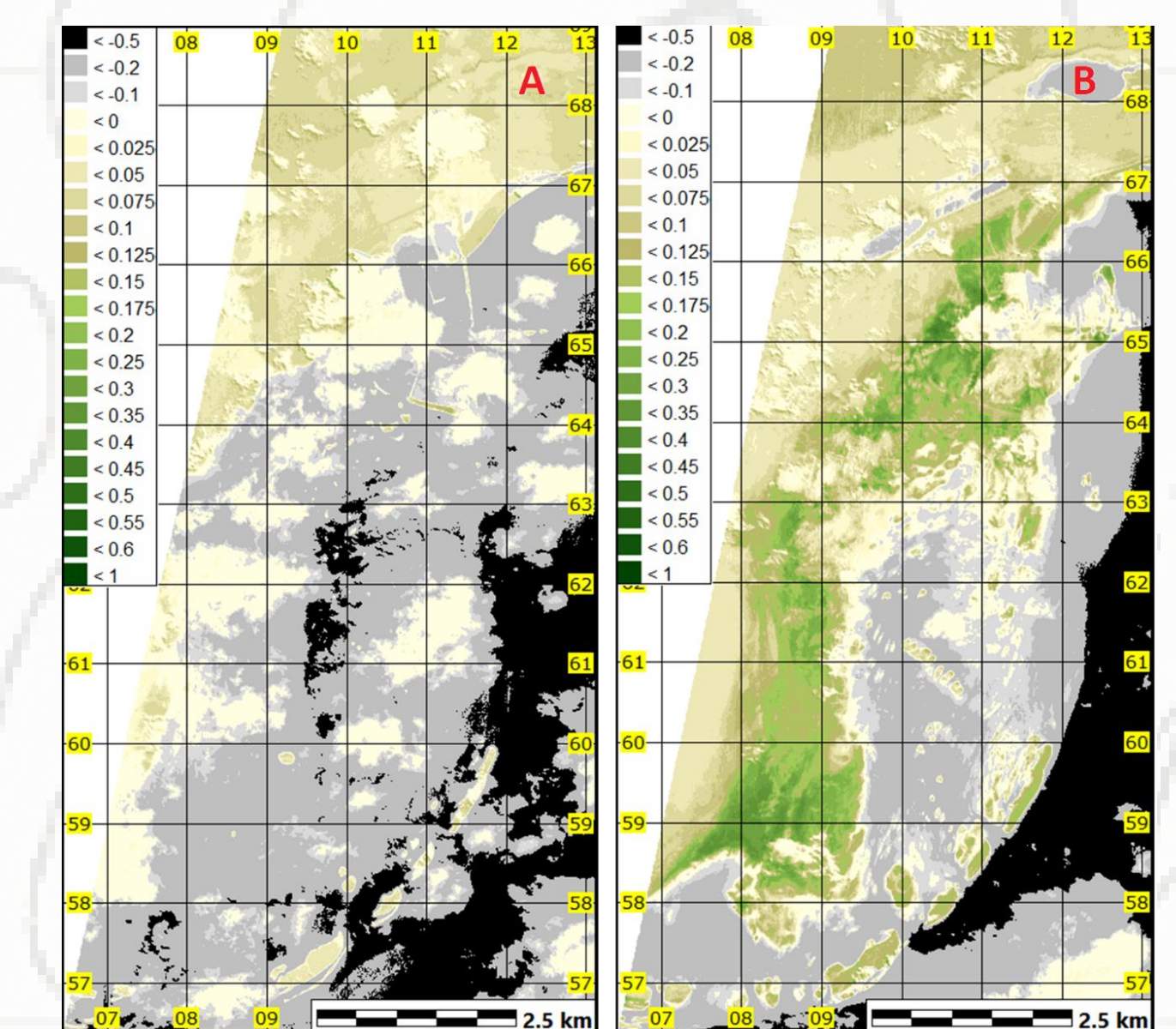


Figure 8: Sentinel 2 NDVI images showing damage to Hurdiyo aquaculture (A) November 17, 2020. (B) December 11, 2020.

## CONCLUSIONS

The varying spatial resolutions from Sentinel 2 and MAXAR Technologies provided an in-depth analysis of the effects of Cyclone Gati. Specifically, vegetation growth and a damage analysis of the two towns Xaafun and Hurdiyo were the assessments of the storm. In conclusion, despite the destruction of multiple residential buildings, the vegetation in Bari province flourished after the storm. This was seen via an application of NDVI. In future research, with more satellite images taken using the panchromatic band a higher resolution would give the ability to show more alterations to the area of study. In addition, this application of high resolution images would have significant impacts upon any humanitarian efforts and military operations in the future.