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Using Satellite Data Analysing Cyclone Ana in the Mozambique Channel

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Abstract

A simplified impact assessment of tropical cyclones on coastal habitats, particularly in the Mozambique Channel, still lacks sufficient information. We modelled the extent of flooding and its impact following the "severe tropical storm" Ana, which passed over the Mozambique Channel from January 20 to January 25, using data from Sentinel-1 and Sentinel-2 and socio-ecological parameters like mangrove forest health and population density. We adapted a model from the United Nations Platform for Space-Based Information for Disaster Management and Emergency Response (UN-SPIDER) to effectively assess storm impacts at a resolution of up to 10 meters, focusing on areas affected by Ana, the Sofala, Zambezia and Boeny, Melaky, provinces in Mozambique and Madagascar, respectively. Our findings revealed that more than 195,977 people have the potential to be affected by Ana, while this number was reduced to 79, The Boeny province was responsible for the majority of the flooding as a percentage of its total area, but the majority of the flooding occurred in the central region of Zambezia. The Sofala district of Mozambique showed the most noteworthy impacted populace and most elevated impacted metropolitan region, with 108,400 uncovered individuals. However, it was discovered that urban areas accounted for only 1.4% of the flooded areas in all regions of interest (ROIs) that were affected. Despite the presence of degraded mangrove patches in close proximity to barren areas at a fine scale low mangrove normalized-difference vegetation index (NDVI) changes were observed throughout all ROIs prior to the 2021–2022 cyclone seasons. Finally, healthy mangrove forest ecosystems in the Mozambique Channel were found to effectively shield densely populated areas from cyclonic storms for an average of 40 kilometres.

Keywords: Impact analysis • Tropical cyclone • Mozambique • Mangrove • Satellite data

Introduction

Some of the most devastating natural disasters are tropical cyclones, which have far-reaching effects like the displacement of people, economic loss and changes to the environment. Tropical cyclones are low-pressure systems with organized deep convection and maximum sustained surface winds of 63–118 km/h that form over warm tropical waters. One of the major tropical cyclone regions in the world and the most active in the Southern Hemisphere is the South western Indian Ocean. Depression systems occur frequently under favourable conditions like high sea surface temperature, weak vertical wind shear and vertical humidity profiles. This is reflected in local parameters, such as above-average geopotential height anomalies at 500 hPa, a southerly wind shear with height and high sea surface temperatures (SSTs) with an average of 29.6 °C in the Mozambique Channel. Every year, three to twelve cyclones form in the Mozambique Channel. Madagascar experiences the highest annual number of cyclones on the African continent, with 1.5 cyclones on average between November and March. On the other hand, the cyclone season in Mozambique runs from November to April and it is estimated that the region experiences 1.16 cyclones annually on average.

Literature Review

The five extreme tropical weather events that occurred in the Mozambique Channel between mid-March 2022 and mid-March 2023 have displaced approximately 960,000 people and left them in need of health care, water, housing and alternative means of subsistence. Therefore, developing climate-adapted solutions necessitates estimating the effects of increasing frequency of tropical weather events. Global mangrove loss rates, which exceed those of many inland tropical forests, are estimated to be between 1 and 2% annually over the past few decades. Mangroves are ecosystems that receive nutrients from both the sea and land and are highly productive, carbon-rich ecosystems. Local populations rely on mangroves for fuel wood, construction materials, medicine, food from mangrove fisheries, timber and tannins, as well as for supporting local ecological ecosystems. The species responses to these ecosystems factors like river discharge, temperature and precipitation, land surface elevation and salinity have been linked to the pronounced zonation of mangrove forests. Due to their aerial rooting systems and associated biological processes, such as the deposition of plant litter and woody debris, root accumulation, sediment trapping and algal mat development on the soil surface, mangrove ecosystems also play a significant role in vertical elevation gains in the context of rising sea levels [1].

Discussion

Mangroves, which cover almost the entire coast in Mozambique and serve as a crucial first defence against damaging tropical storms and rising sea levels, protect the local population. With 3054 km2, it has one of the largest mangrove areas in Africa, second only to Nigeria's (8573 km^2). Most of the time, oil spills and deforestation for construction or firewood pose a threat to mangroves. Between 1972 and 2004, the area of Mozambican mangrove forests decreased from 408,000 ha in 1972 to 357,000 in 2004. It is thought that similar patterns of degradation are occurring all over the country in line with this trend. Madagascar, on the other hand, had 2% of the world's mangrove forested areas the fourth largest in Africa and 2800 km^2 in total. However, the average rate of deforestation there is between 1% and 2%. It is essential to investigate the effects of sea level rise and tropical cyclones on these ecosystems because these two nations in the Mozambique Channel have some of the largest mangrove ecosystems in Africa and are increasingly under threat from both [2].

Ana was designated a "severe tropical storm" by Meteo-France La Reunion and a "TC" by OCHA due to its wind speeds of 89–117 km/h, which correspond to

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a natural hazard of medium intensity (Meteo France Reunion, 2022). In contrast, cyclone Idai, which had sustained winds of 166–213 km/h for 10 minutes, was categorized as an "intense TC." Then, the data from various sources and our model of TC Ana's flooding impact were compared. More than 185,429 people in Mozambique were affected by TC Ana, according to emergency reports from Relief Web, a UN-OCHA initiative. Our model's prediction of 195,977 affected people is supported by this estimate. The National Institute for Disaster Management and Risk Reduction (INGD) reported 45,000 affected people in the Zambezia region in immediate damage assessments published on January 31. This is almost twice as few as our predictions, possibly due to differences between field surveys and remotely sensed data. In Madagascar, the Public Office for Hazard and Catastrophe the executives (BNGRC3), assessed that there were in excess of 131,555 impacted individuals all through the 12 locales of the nation [3].

This is in line with our estimate, especially given that the majority of the affected populations were in the Boeny and Melaky regions of the ROI. Public evaluations in Madagascar will more often than not be similar to this concentrate as they will generally be somewhat detected Copernicus information joined with Public Meteorological Administrations information, meteo Madagascar. Our flooding model showed that between 5 and 15% of the study areas were flooded. This range was between 50 and 60% when compared to previous TCs, such as TC Idai in Mozambique in March 2019, which had 10 minutes of sustained winds between 166 and 213 km/h, making it an "intense TC." These ranges match the category differences of the cyclone, despite being very different events. As a result, the study's flooding model appears to be less accurate than cyclone Idai in terms of the area affected by flooding [4-6].

Conclusion

The purpose of this study was to map the effects of TC Ana as it passed over Madagascar and Mozambique, two of the countries most affected by the tropical depression. The regions of Zambezia, Mozambique and Boeny, Madagascar, were found to have the greatest number of flood-related impacts and environmental and anthropogenic impacts across all four ROIs. In addition, it was discovered that urban areas had a lower risk of flooding across all nations. In terms of ecology, this study found a difference in the state of the region's vegetation before and after the cyclone season. In spite of this, in 2022, mangrove forests in all ROIs were thought to be generally healthy. Finally, it was discovered that areas near mangroves fared better in terms of the exposed population than areas further inland without mangroves. As a result, this study adds to the global and local push for reforestation of mangroves in tropical-coastal ecosystems to safeguard vulnerable communities from natural disasters worldwide.

Acknowledgement

None.

Conflict of Interest

None.

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