ANALYSING EFFECTS OF DROUGHT ON INUNDATION EXTENT AND VEGETATION COVER DYNAMICS IN THE OKAVANGO DELTA

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Abstract

The impacts of global change especially the recent climate-related extremes such as floods and droughts reveal significant vulnerability and exposure of freshwater ecosystems and related human systems to current climate variability. However, the effects of the extreme drought in the Okavango Delta system are not well understood and documented. Therefore, the objective of this use case was to apply the products from Digital Earth Africa namely: the Water Observation from Space (WOfS) derived from Landsat, vegetation cover baseline derived from Sentinel 2 data; and data from the meteorological agencies such as rainfall and measured river discharge data to evaluate the effects of drought in the Okavango Delta wetland system in relation to its upstream areas in Angola. In particular, we used the 2019 drought as a case study to assess inundation extent and vegetation cover dynamics with an emphasis on floodplain and dryland vegetation. Our preliminary results reveal that the Okavango Delta permanent marshes are resilient to drought, whereas seasonal floodplains are susceptible to drought. Further, we discovered that the geospatial location of floodplains has a direct effect on the timing of desiccation, with the western tributaries that flow into Lake Ngami and Thamalakane River being the last to dry out due to drought. In addition, we found that the drought phenomenon in the Cubango-Okavango River Basin region started earlier than 2019 spanning over a period of 5 years; with 2018 as the year when the wetland system reached a minimum threshold for a tipping point triggered by the 2019 drought. In addition, the results contribute to the development of large-scale drought risk information and products for the Cubango-Okavango River Basin with a major focus in the Okavango Delta. Further, this use case provides recent baseline information on the effects of drought on vegetation cover and river flows in the Okavango Delta system at a landscape approach, which are essential elements for making informed science-based decisions on climate risks management and Sustainable Development Goals (SDGs) by relevant authorities in the Okavango Delta and the whole of Cubango-Okavango River Basin. In conclusion, this use case will be upscaled to other transboundary river basins in the Southern Africa Development Community.

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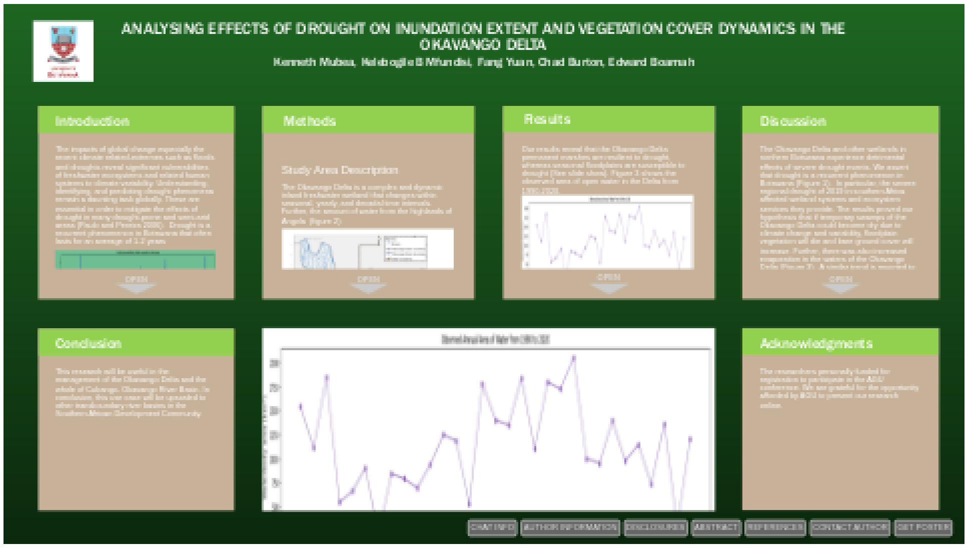

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INTRODUCTION

The impacts of global change especially the recent climate related-extremes such as floods and droughts reveal significant vulnerabilities of freshwater ecosystems and related human systems to climate variability. Understanding, identifying, and predicting drought phenomena remain a daunting task globally. These are essential in order to mitigate the effects of drought in many drought-prone and semi-arid areas (Paulo and Pereira 2006). Drought is a recurrent phenomenon in Botswana that often lasts for an average of 1-2 years

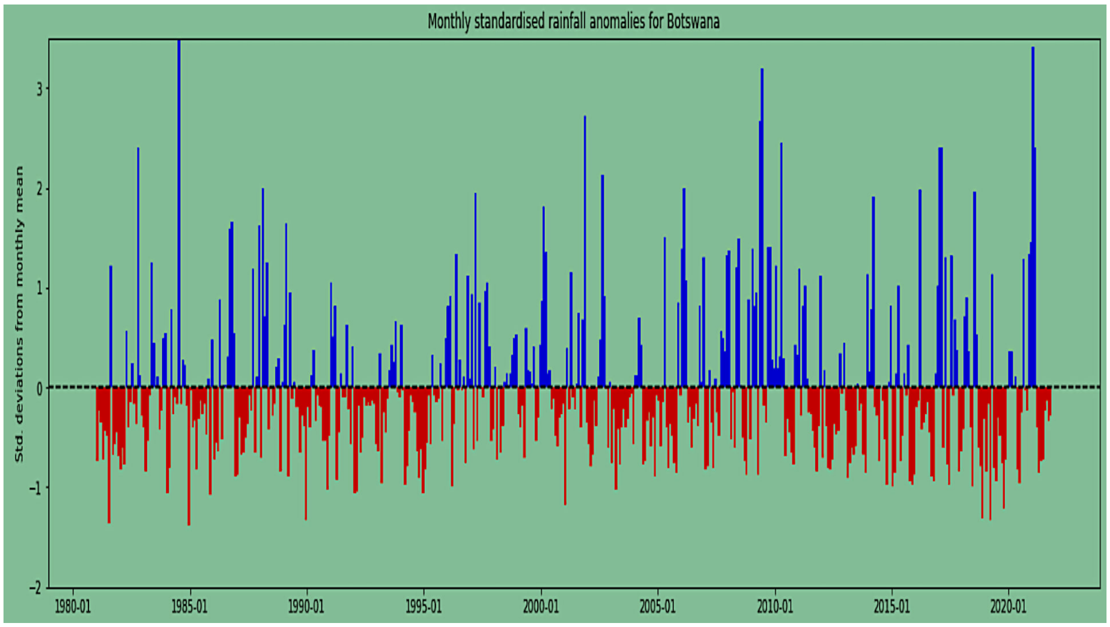


Figure1. Rainfall Anomalies in Botswana

(Figure 1). Although intense drought spans over a short period of time in the country, its effects are multifaceted ranging from crop failures, livestock and wild animal mortality, vegetation and land degradation to shortages of water. However, there is a limited understanding of how drought affects the inundation extent and vegetation cover dynamics in the Okavango Delta and the rippling effects it has on the mainstay for local development and sustainable livelihoods through tourism and fisheries. Therefore, we hypothesize that if temporary swamps of the Okavango Delta could become dry due to climate change and variability, floodplain vegetation will die and bare ground cover will increase. Further, there will be increased evaporation in the waters of the Okavango Delta. In particular, we used the 2019 drought as a case study to assess the effects of drought on inundation extent and vegetation cover dynamics in the Okavango Delta, with an emphasis on Lake Ngami.

METHODS

Study Area Description

The Okavango Delta is a complex and dynamic inland freshwater wetland that changes within seasonal, yearly, and decadal time intervals. Further, the amount of water from the highlands of Angola (figure 2)

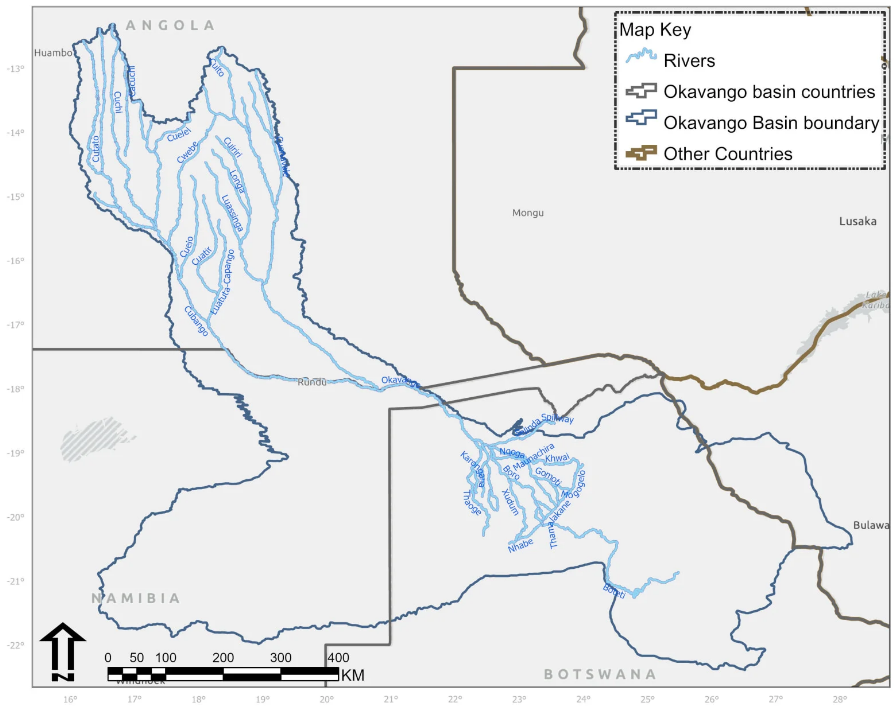


Figure 2. Map of the Cubango-Okavango River Basin

reaching the Okavango River in Botswana supplemented by local rainfall has a direct impact on Spatio-temporal variation in inundation extents over the Delta. This results in a mosaic of landcover types of particularly open water, permanent marshes, islands, floodplains, riparian vegetation, and drylands. In addition, the extent of vegetation cover is variable depending on the inundation extent and duration. Nevertheless, we hypothesize that if temporary swamps of the Okavango Delta could become dry due to climate change and variability, floodplain vegetation will die and bare ground cover will increase. Further, there will also be increased evaporation in the waters of the Okavango Delta.

Data Sources and Analysis

We applied the products from Digital Earth Africa namely: the Water Observation from Space (WOfS) derived from Landsat, vegetation cover baseline derived from Sentinel 2 data with a focus on lake Ngami; and data from the meteorological agencies such as rainfall and measured river discharge data to evaluate the effects of drought in the Okavango Delta wetland system in relation to its upstream areas in Angola.

RESULTS

Our results reveal that the Okavango Delta permanent marshes are resilient to drought, whereas seasonal floodplains are susceptible to drought (See slide show). Figure 3 shows the observed area of open water in the Delta from 1990-2020.

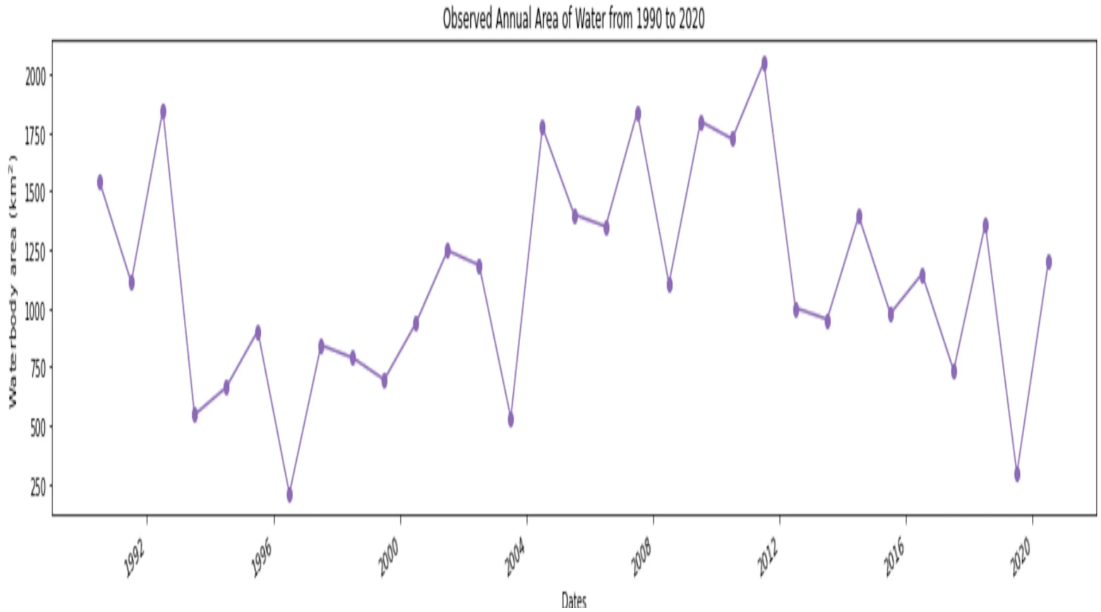


Figure 3. Observed area of Open water in the Okavango Delta, 1990-2020

In 2019 the amount of observed open water was the lowest recorded in 20years. Further, we discovered that Lake Ngami is a pertinent indicator of environmental change and climate variability in the Cubango -Okavango River Basin. This is revealed through spatial and temporal changes in water extent (Figure 4)

and vegetation cover (Figure 5) over the lake in 2019.

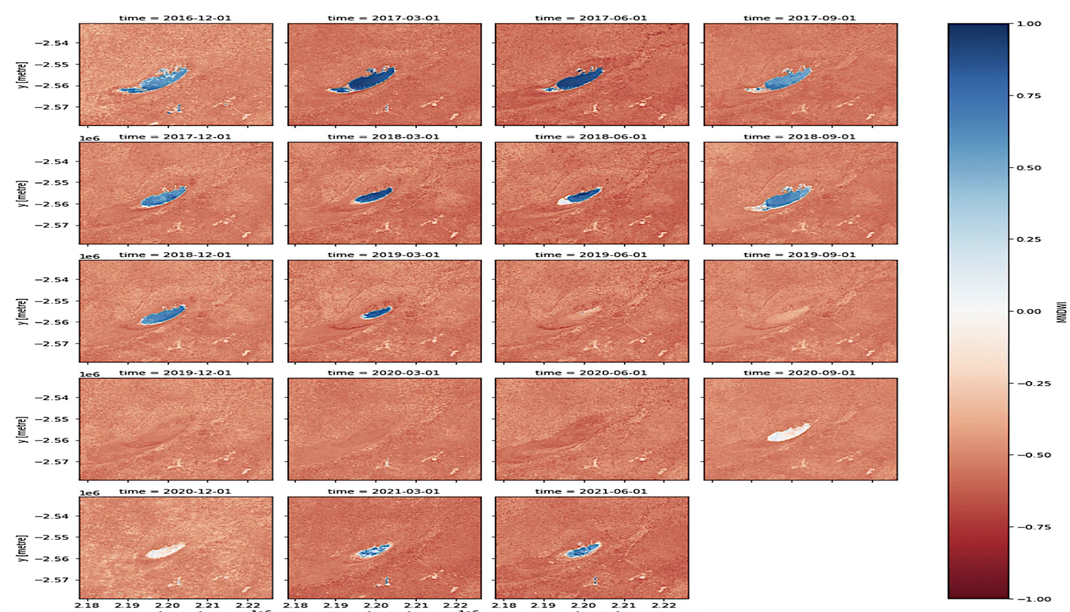


Figure 4. Spatial and temporal variation in water extent in Lake Ngami

Additionally, we found that the drought phenomenon in the Cubango-Okavango River Basin region started earlier than 2019 spanning over a period of 5years; with 2018 as the year when the wetland system reached a minimum threshold for a tipping point triggered by the 2019 drought.

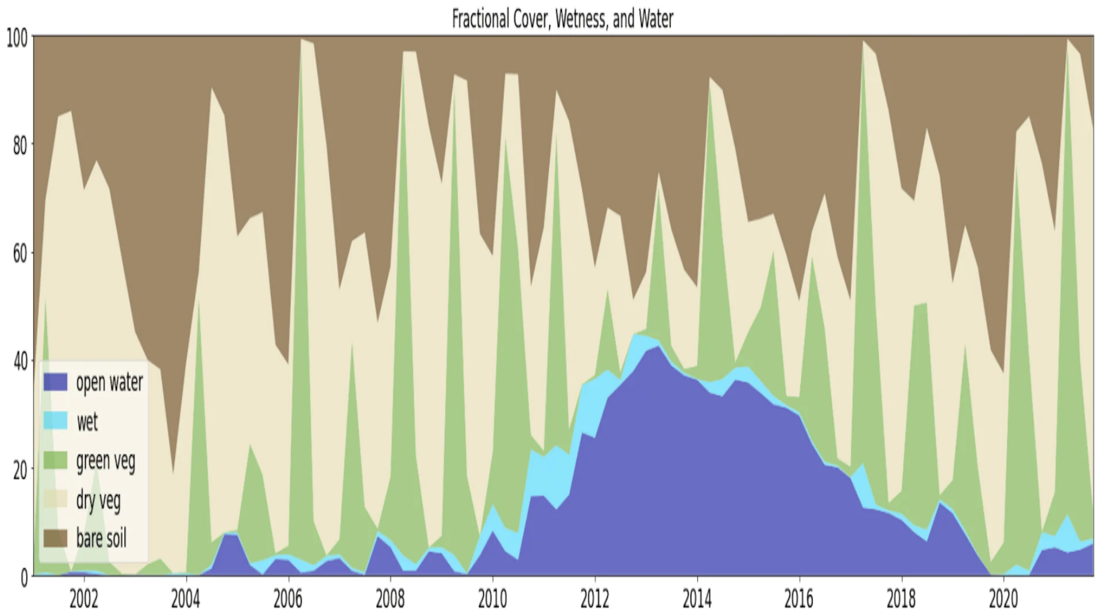


Figure 5. Changes in vegetation cover over Lake Ngami

DISCUSSION

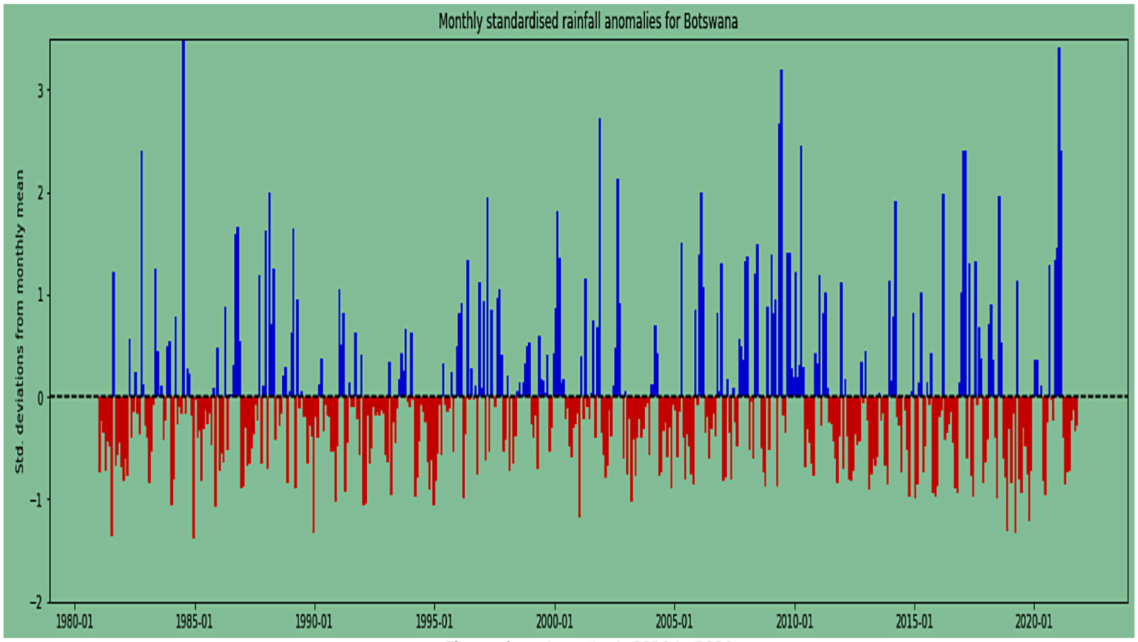
The Okavango Delta and other wetlands in northern Botswana experience detrimental effects of severe drought events. We assert that drought is a recurrent phenomenon in Botswana (Figure 1). In particular, the severe regional drought of 2019 in southern Africa affected wetland systems and ecosystem services they provide. The results proved our hypothesis that if temporary swamps of the Okavango Delta could become dry due to climate change and variability, floodplain vegetation will die and bare ground cover will increase. Further, there was also increased evaporation in the waters of the Okavango Delta (Figure 3). A similar trend is reported to occur in the Ohio Valley, United States (Matheus and Maxwell, 2018). Our results contribute to the development of large-scale drought risk information and products for the Cubango- Okavango River Basin with a major focus in the Okavango Delta. Further, this use case provides recent baseline information on the effects of drought on vegetation cover and river flows in the Okavango Delta system (Figure 6) at a landscape approach. The rippling effects of severe drought on the natural resources base that sustain livelihoods of local communities, particularly reduction in fisheries resources resulted from the diminished inundation extent over the Delta.

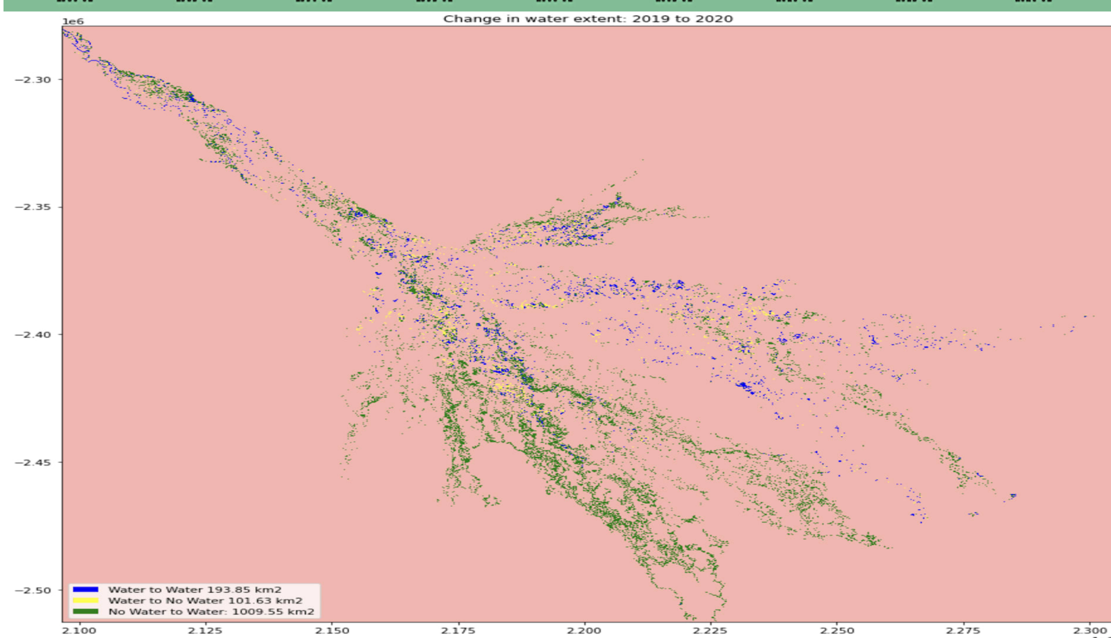
Figure 6. Photo showing the effect of reduced river flow on vegetation cover (Photo taken by Kelebogile Mfundisi)

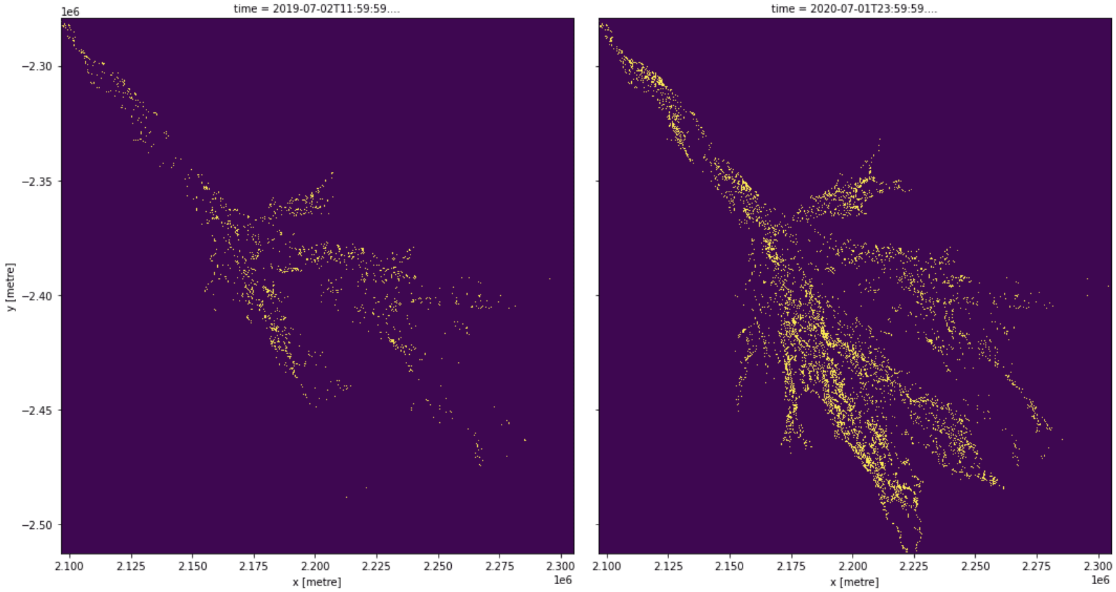
This was particularly observed by researchers in the whole system including Lake Ngami.

CONCLUSION

This research will be useful in the management of the Okavango Delta and the whole of Cubango- Okavango River Basin. In conclusion, this use case will be upscaled to other transboundary river basins in the Southern African Development Community.



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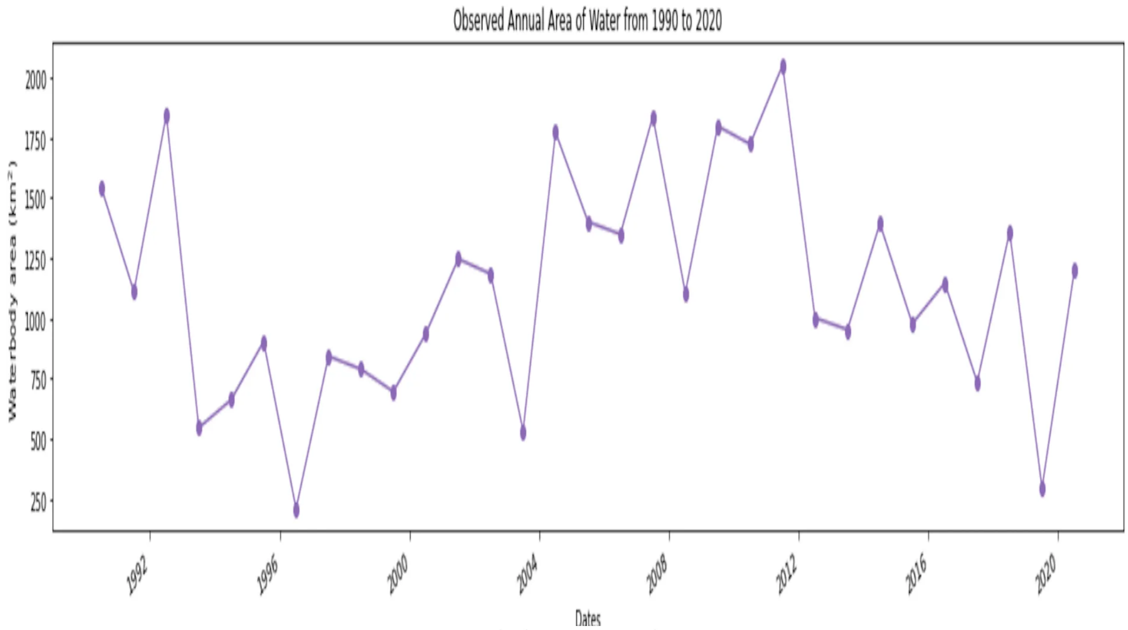
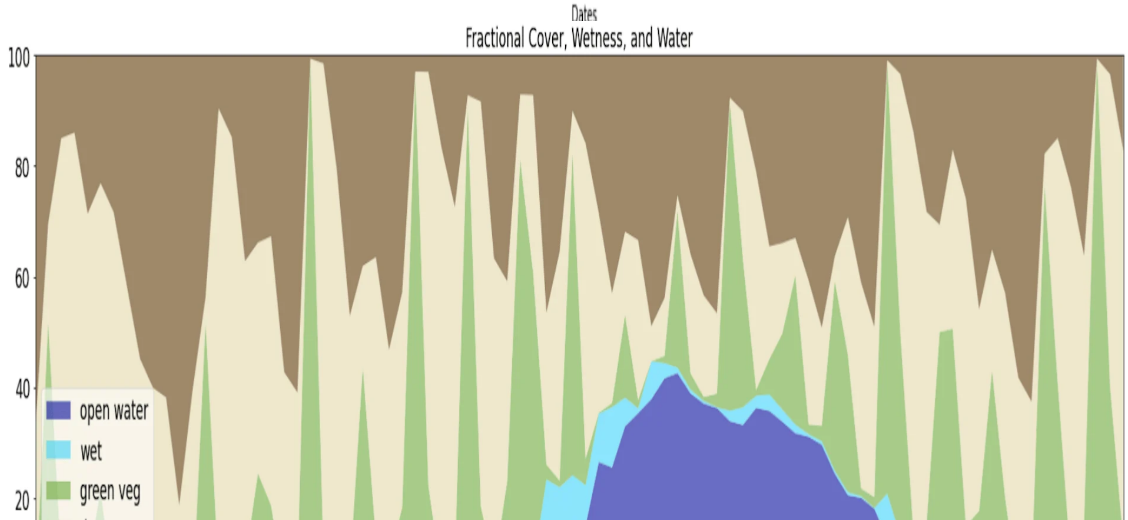

Observed Annual Area of Water from 1990 to 2020
Waterbody area (km²)
Dates


Fractional Cover, Wetness, and Water
open water
wet
green veg
dry veg
bare soil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DISCLOSURES

The authors have no conflict of interest in the research and its outcomes.

AUTHOR INFORMATION

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ABSTRACT

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