A study on the long-term dynamics and phenology of mangrove forests based on the narratives of inhabitants in western India using Landsat

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Kutch, Gujarat, Western India (Kutch), is under an arid and semi-arid environment, and the terrestrial ecosystem is dominated by drought and salinity tolerant plants. Mangroves grow in the coastal areas of Kutch and have been continuously used by the local communities for timber, livestock feed, and as fishery resources. However, the ecosystem services of these mangrove forests have partly been lost due to the development of salt pans in coastal areas and disturbed by natural disasters such as cyclones and earthquakes. In order to use mangrove forests with maintaining the sustainability of ecosystem services, it is necessary to accumulate knowledge on the dynamics of these mangrove forests and their response to environmental changes.

In this study, the following three aspects were analyzed by using satellite images in order to understand the long-term and the phenology over the past 30 years. 1) The long-term changes in biomass of mangrove forests in the area. 2) How arid environment or droughts affects the biomass. 3) In the meantime, where have the mangrove forests expanded or shrunk due to development and other environmental alteration?

For 1), we used Landsat-5, 7&8 images, medium spatial resolution data, to investigate the long-term dynamics of mangrove forests by calculating NDVI, one of the vegetation indices that is considered to indicate the plant activity or biomass. For 2), the Standardized Precipitation Index (SPI), which is an index of the drought and dryness, was calculated from the precipitation data in the study area. For 3), the changes in mangrove coverage in the area were evaluated by pixel-based landcover maps for two years, 1988 and 2019.

The NDVI of mangrove forests in the area has basically increased from 1988 to the present, suggesting an increase in biomass. However, it decreased from the late 1990s to the early 2000s. The most possible reason was the increase in water stress due to the continuous occurrence of low precipitation period from the late 1990s to the early 2000s. The lack of significant changes in NDVI by single-year drought suggests that mangrove forests had the resilience against dryness and/or drought, and that continuous dryness affected mangrove vegetation. Several factors, such as relatively high precipitation from 2003, were considered to be responsible for the long-term increase in NDVI in mangrove forests over a 30-year period.

NDVI of mangrove forests in the area was found to be monotonically decreasing since the middle of the dry season (January) and started increasing with the onset of the rainy season. This was due to the leaf growth of mangroves was enhanced by the relief of water stress-related to salinity due to precipitation during the rainy season. On the other hand, during the dry season, the leaf area decreased by the leaf longevity and photosynthesis suppression caused by the increase in water stress.

The relief of water conditions for mangroves was due to the direct supply of freshwater to the soil by

rainfall and groundwater from inland. Considering the long-term relationship between NDVI changes, mangrove seasonality, and precipitation, it was possible that the amount of available water resources significantly affects mangrove leaf growth in these arid and semi-arid regions. It is important to evaluate the availability of water resources accurately in the future.

The comparison of the landcover maps of 1988 and 2019 showed that the main reasons for the decrease of mangrove forests were the erosion of sandy soil by tides and land-use conversion associated with the development of coastal areas. On the other hand, some mangrove forests expanded their area in areas that were not significantly affected by tides.

The information from this study will be provided to local communities, the government, and NGOs for use in formulating policies for the continuous usage of mangrove forests toward the future.

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