ASSESSING CORAL REEF CHANGES THROUGH SUPERVISED CLASSIFICATION AND ITS CORRELATION WITH SST AND CHLOROPHYLL-A: A REMOTE SENSING APPROACH.

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ABSTRACT

Coral reefs are vital ecosystems that support underwater life, protect coastlines by reducing wave power, and provide significant income for millions globally. However, coral reefs are declining due to climate change and human activities like pollution. Remote sensing has become essential for monitoring changes in coral reefs and associated environmental parameters. Remote sensing techniques was employed to assess coral reef status and its correlation with environmental indicators in the study area. We utilized supervised classification algorithms for coral reef classification and time series analysis, along with chlorophyll-A indices for content mapping and sea surface temperature (SST) data from NOAA. Pearson's correlation coefficient was used for correlation analysis among these parameters. The research integrates supervised classification, time series analysis, and ARIMA modeling to provide a comprehensive understanding of coral reef ecosystems and their responses to environmental changes. ARIMA modeling enhances the study's predictive capability, allowing for the prediction of future SST trends and their impacts on coral reef health. The study results include the creation of accurate coral reef classification maps, identification of SST and coral trends, and insights into the relationship between chlorophyll-A concentrations and coral health. Key findings reveal a negative correlation between corals and SST, and a weak positive correlation between corals and chlorophyll-A content. This research advances the understanding of coral reef ecosystems and their monitoring using remote sensing, contributing valuable knowledge for the conservation and management of these critical habitats. By providing detailed temporal change detection of coral reefs and their correlation with environmental indicators, this study highlights the importance of remote sensing in monitoring and predicting the health of coral reefs, offering essential insights for addressing the challenges posed by climate change and human activities.

INTRODUCTION

Coral reefs, though occupying a small fraction of the world's oceans, support a vast amount of marine biodiversity and offer significant ecological, economic, and cultural benefits. These reefs, formed by corals that deposit calcium carbonate, provide habitats for thousands of marine species. However, rising sea surface temperatures (SST) pose a severe threat, leading to coral bleaching and potential coral mortality.

This project leverages remote sensing to monitor and analyze coral reef dynamics, using time series analysis and predictive modeling to understand the correlation between SST, coral bleaching, and chlorophyll-A concentrations. By examining indicators such as coral cover and bleaching events, the study aims to predict future changes and develop effective conservation strategies. Expanding knowledge on how SST affects coral bleaching and predicting SST patterns are critical for the long-term survival of coral reefs. The insights gained will inform strategies to mitigate the impacts of climate change on coral reefs, enhancing their resilience and conservation efforts.

OBJECTIVES

Primary Objective
The primary objectives of the project is:

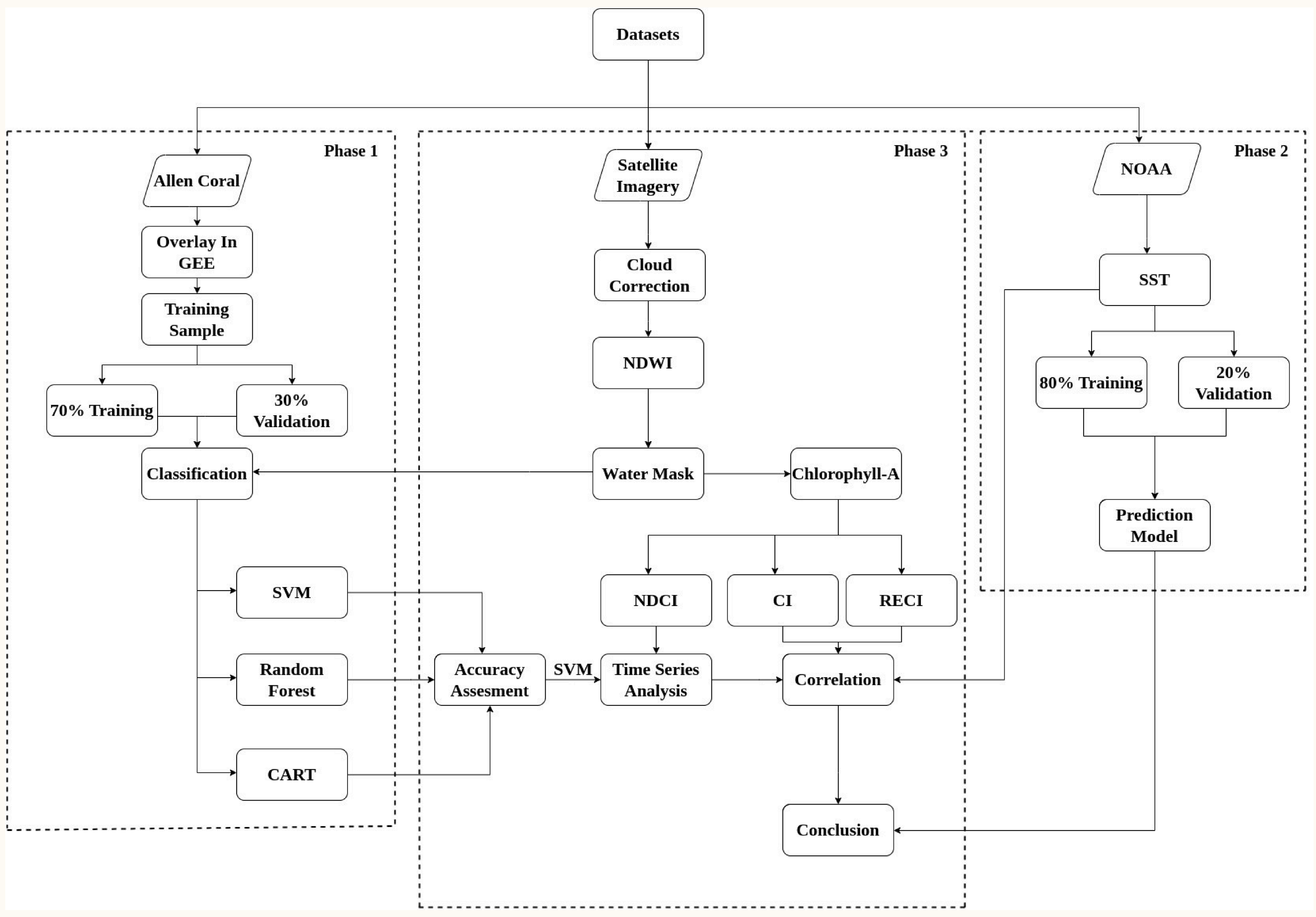
- To analyze the trends of coral reefs through supervised classification and time series analysis and correlating it with SST and Chlorophyll-A.

Secondary Objective
The secondary objectives of the project are:

- To make an accuracy assessment of different supervised classification algorithms used for classification,
- To prepare chlorophyll-A content map,
- To prepare time series analysis of SST, and chlorophyll-A,
- To build the prediction model of SST.

METHODOLOGY

Our study comprises different phases arranged in a structured workflow. In the initial phase, we focused on image classification, employing various algorithms to discern features using training samples derived from Allen Coral and satellite imagery data. Our objective was to compare the accuracy of these algorithms, aiming to identify the most robust classification approach. Transitioning to the second phase, our attention turned predictive modeling. Here, we developed prediction models for Sea Surface Temperature (SST). Through rigorous analysis, we sought to unveil the correlations between SST fluctuations and coral change detection, providing insights into environmental dynamics. Finally, in the concluding phase, we delved into Chlorophyll A indices, calculated the Normalized Difference Water Index (NDWI) and conducted time series analyses of coral change. This involved examining various indices related to Chlorophyll A concentrations and evaluating temporal change trends in corals. By systematically executing these phases, our study provided a comprehensive understanding of the intricate interplay between environmental factors and coral reef ecosystems, contributing valuable insights for conservation and management efforts.



RESULT AND DISCUSSION

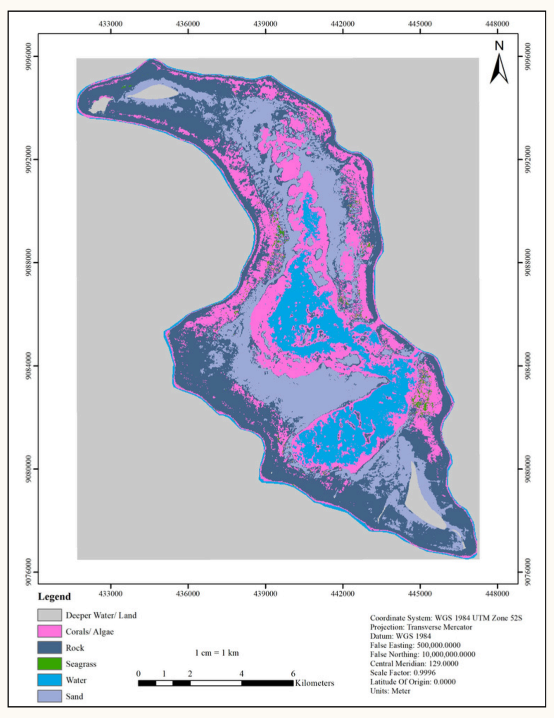
The study focused on the classification and monitoring of coral reefs using advanced remote sensing techniques and statistical models. Machine learning algorithms, including Random Forest (RF), Support Vector Machine (SVM), and Classification and Regression Tree (CART), were compared for classification accuracy, with SVM yielding the highest overall accuracy of 91.81% and a Kappa coefficient of 0.90. Time series analysis revealed temporal changes in coral reef coverage, with fluctuations observed over the years. From 2016 to 2023, coral reef area ranged from 25.94 km² to 31.06 km². Chlorophyll-A indices, including NDCI, CI, and RECI, depicted increasing trends in chlorophyll-A content, indicating potential coral bleaching events. SST data showed a forecasted stability over the next five years, with a maximum predicted SST of 29.82 degrees and a minimum of 26.63 degrees. Correlation analysis revealed a negative correlation (-0.270) between coral area and SST, indicating reduced coral area with higher SST. Weak positive correlations were observed between coral area and chlorophyll indices (NDCI: 0.138, CI: 0.221, RECI: 0.243), suggesting a potential relationship between higher chlorophyll levels and coral area. Overall, the results underscore the complexity of coral ecosystem dynamics and emphasize the importance of multi-faceted conservation approaches under changing environmental conditions.

CONCLUSION

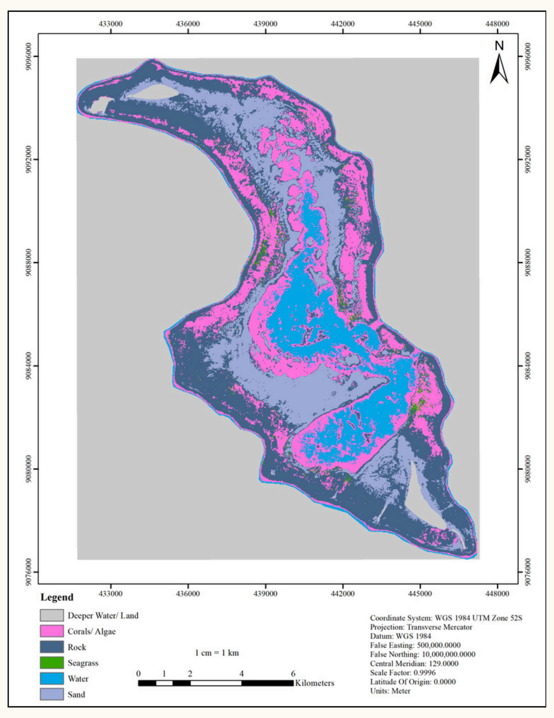
In conclusion, our study employed advanced remote sensing techniques and statistical models to classify and monitor coral reefs. SVM emerged as the most accurate classifier among the evaluated machine learning algorithms. Time-series analysis of Daily Sea Surface Temperature (SST) data, coupled with ARIMA modeling, provided insights into future SST trends. Correlation analysis between Chlorophyll indices and coral data revealed weak negative correlations with SST and weak positive correlations with Chlorophyll concentrations. These findings underscore the adverse effects of rising sea surface temperatures and increased chlorophyll concentrations on coral health. Continuous monitoring and conservation efforts are imperative to mitigate these impacts. Recommendations for future work include utilizing higher resolution imagery and in-situ data for enhanced accuracy and employing remote sensing and supervised classification for large-scale conservation strategies aimed at detecting coral reefs.

ANNEXES

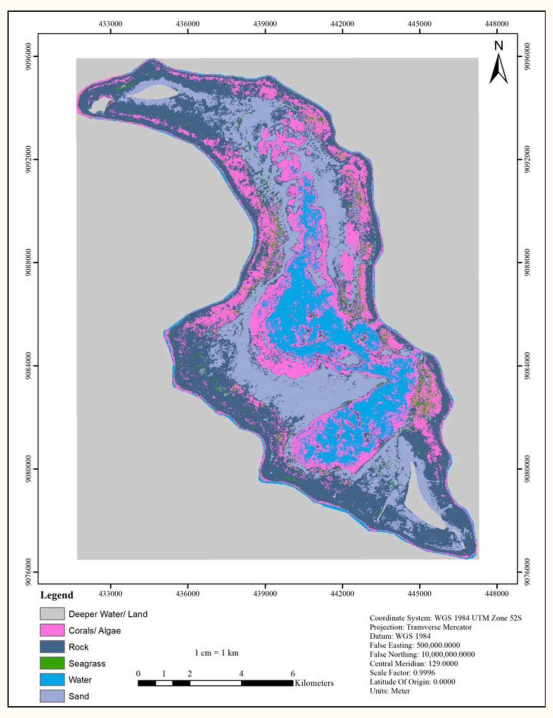
IMAGE CLASSIFICATION USING DIFFERENT MACHINE LEARNING ALGORITHM.



Random Forest
(RF)

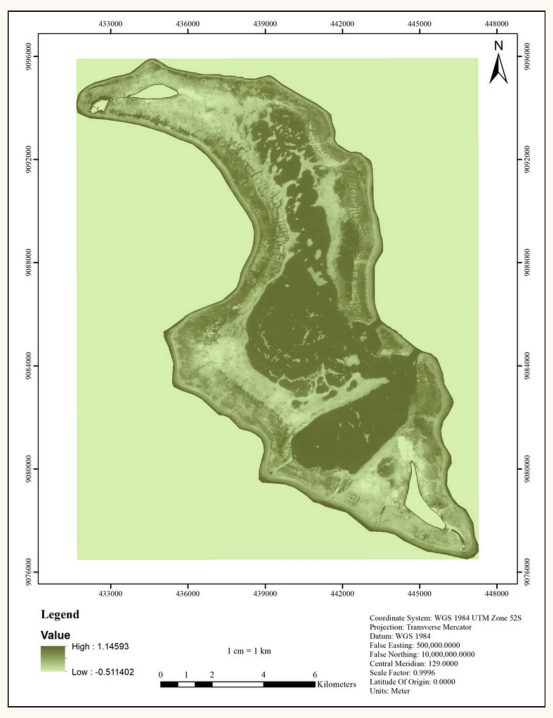


Support Vector Machine
(SVM)

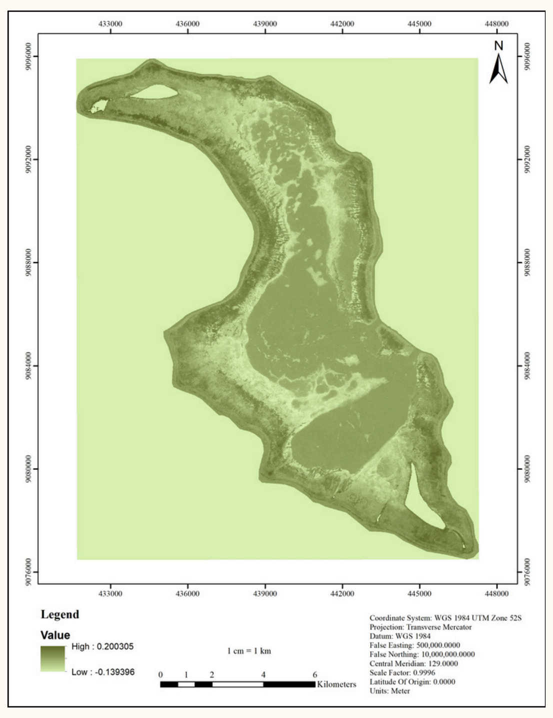


Classification and Regression Tree
(CART)

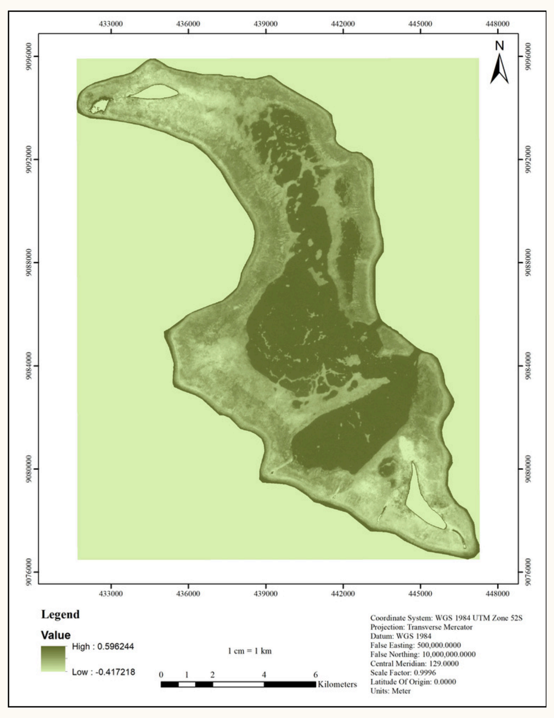
DIFFERENT INDICES CALCULATION OF CHLOROPHYLL-A.



Chlorophyll Index
(CI)

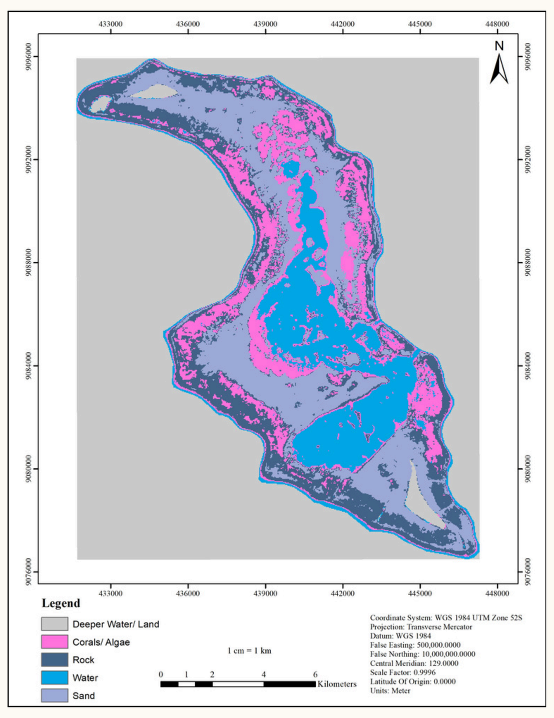


Normalized Difference
Chlorophyll Index (NDCI)

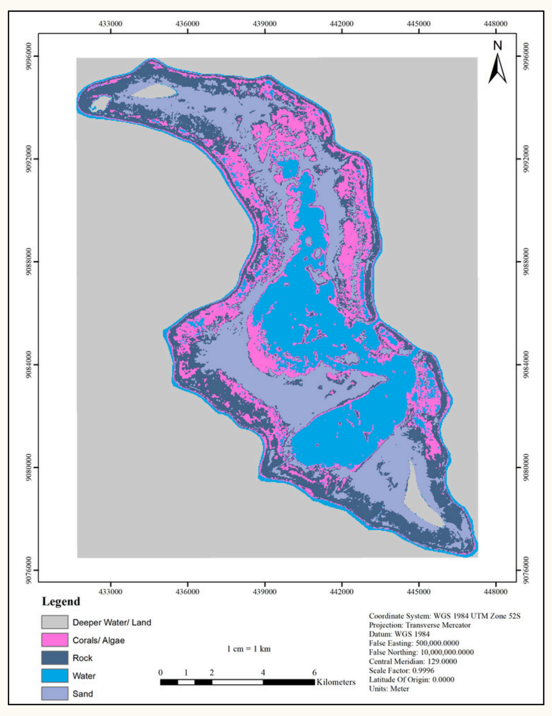


Red Edge Chlorophyll Index
(RECI)

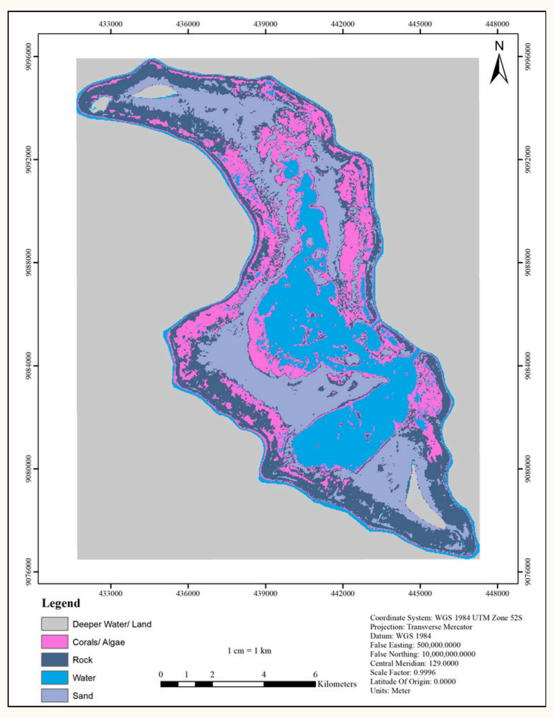
TIME SERIES ANALYSIS OF CORAL REEF (2016-2023).



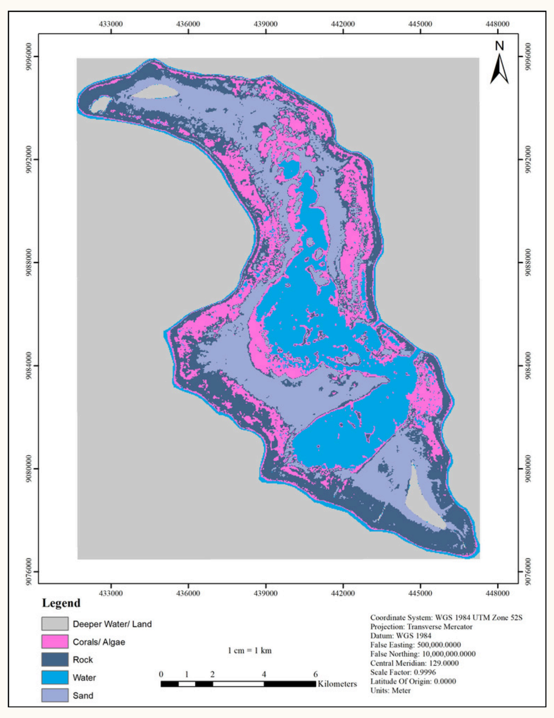
2016



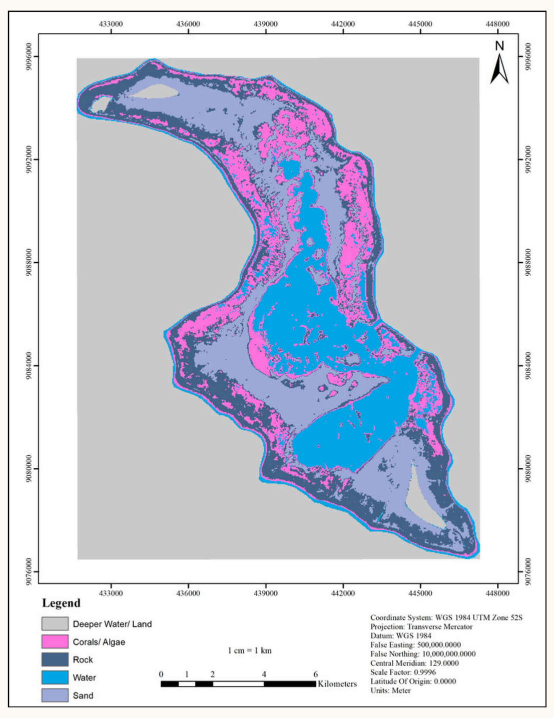
2017



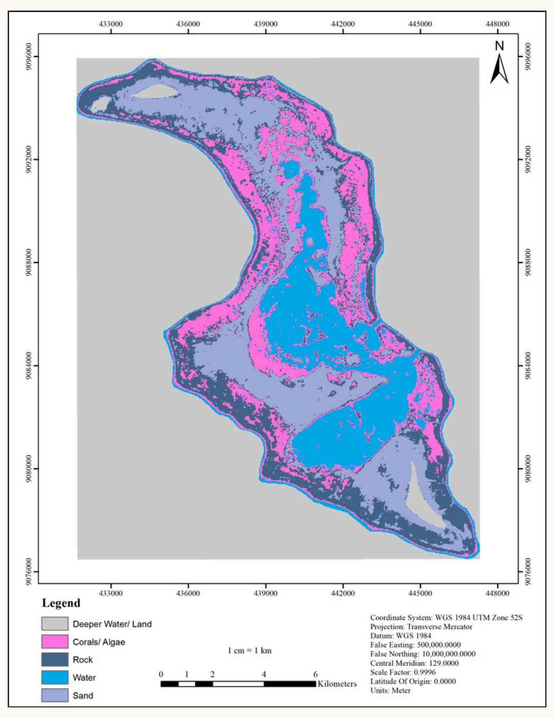
2018



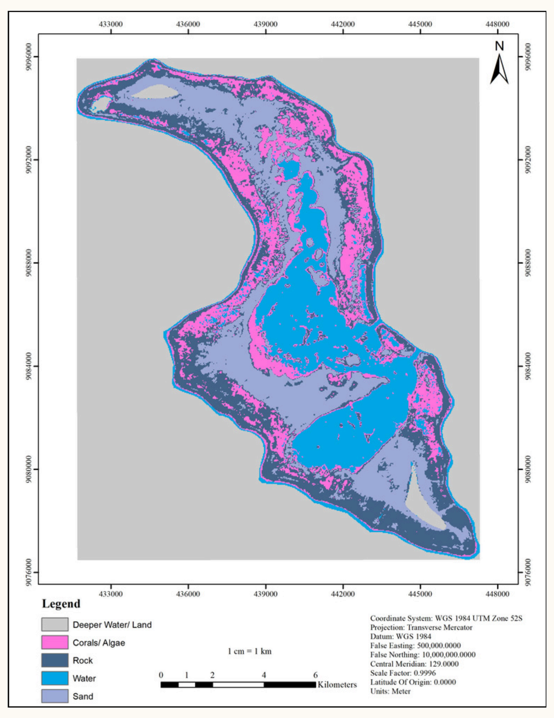
2019



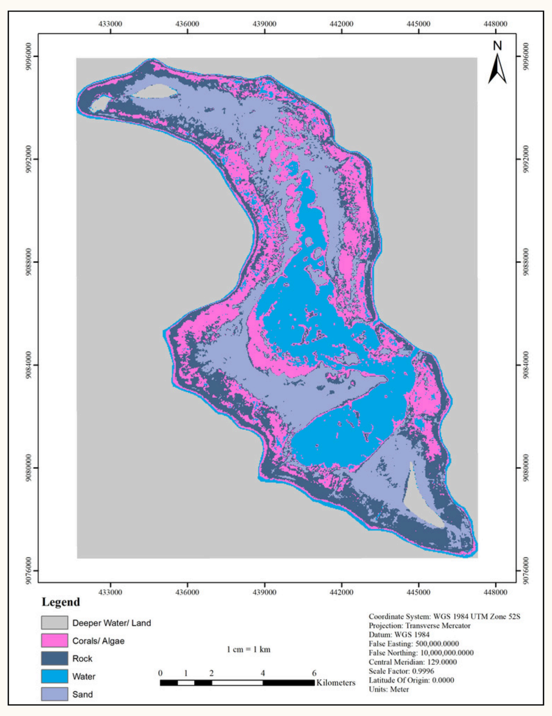
2020



2021

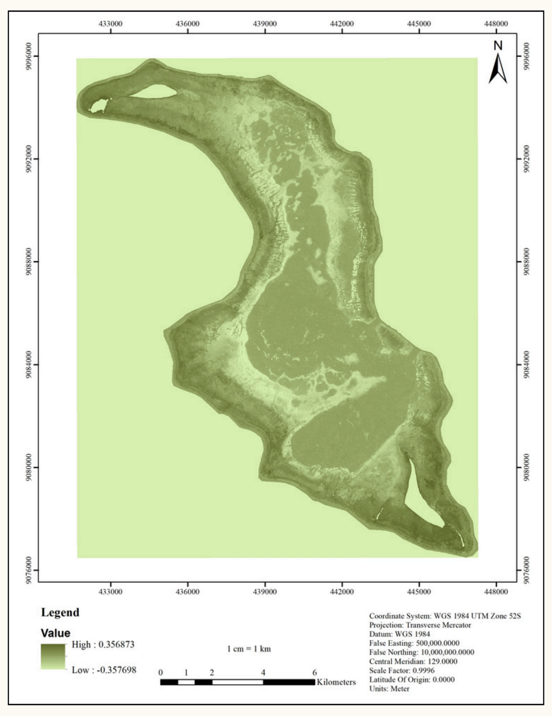


2022

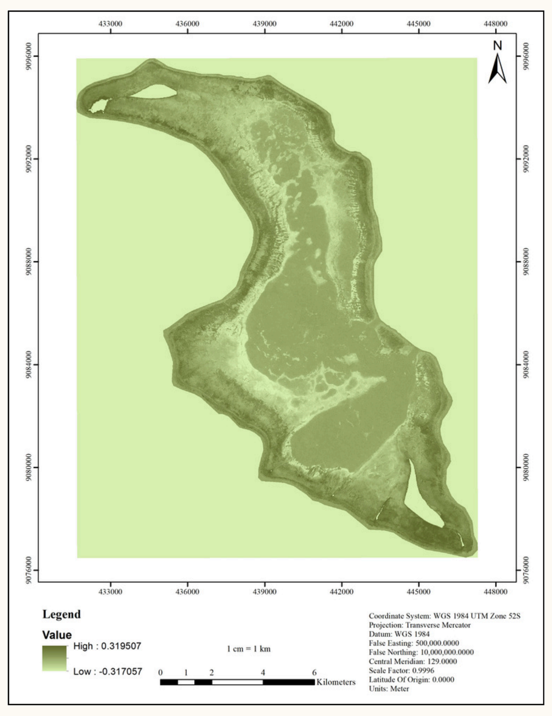


2023

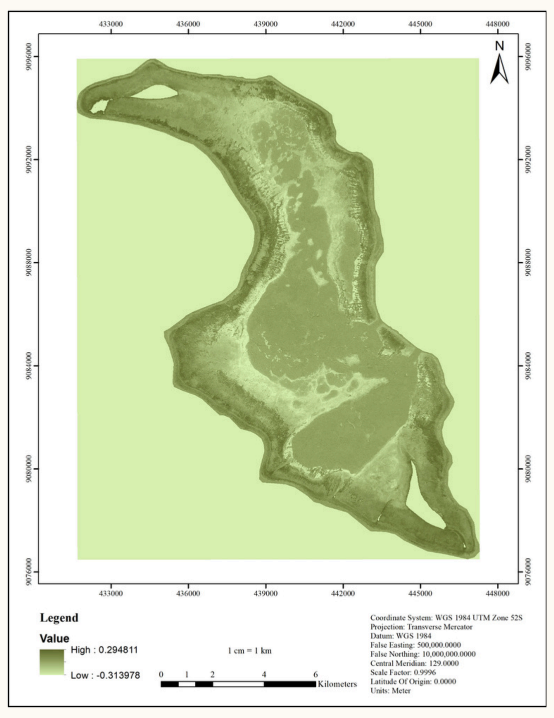
TIME SERIES ANALYSIS OF NDCI (2016-2023).



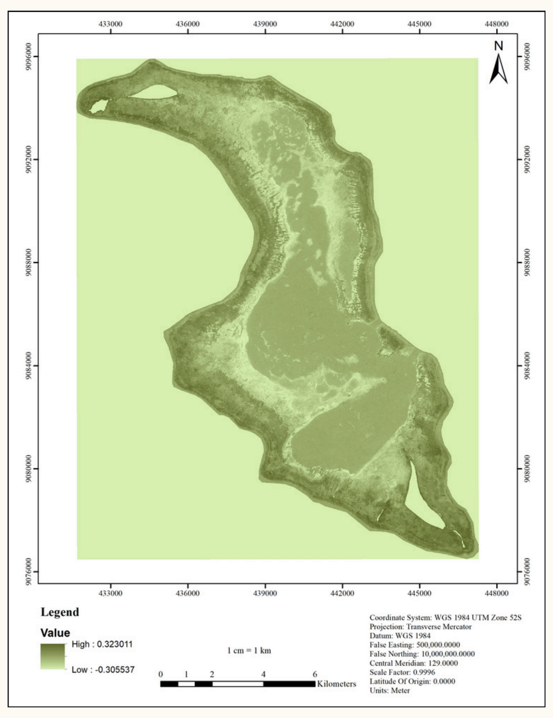
2016



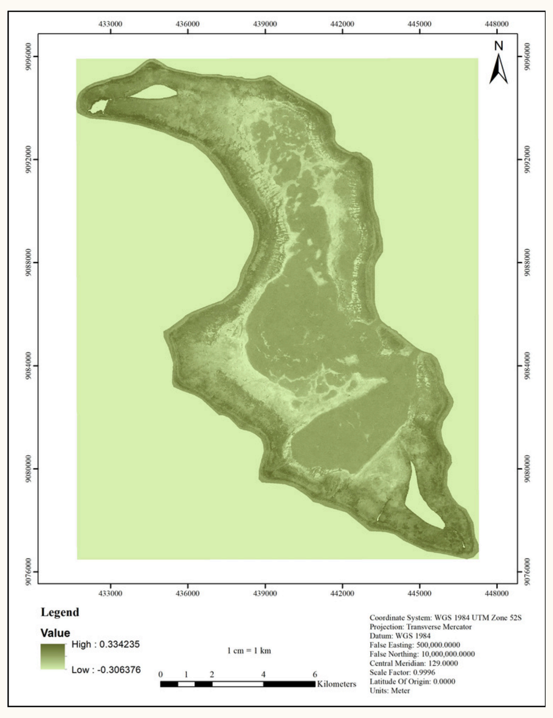
2017



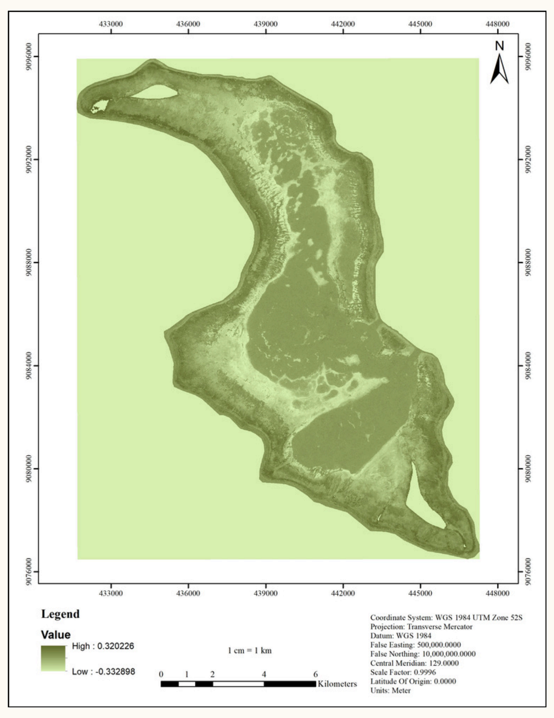
2018



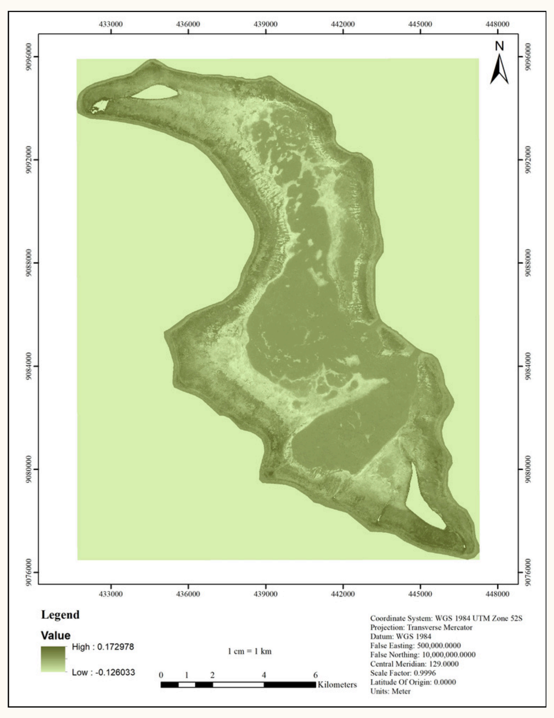
2019



2020



2021



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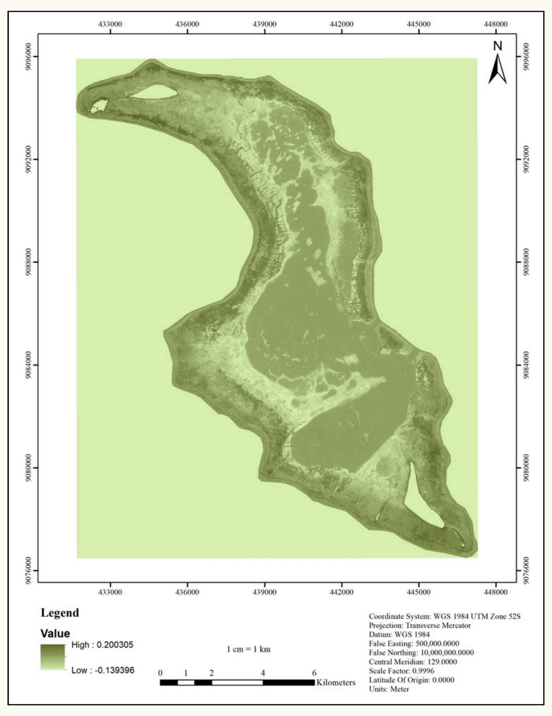
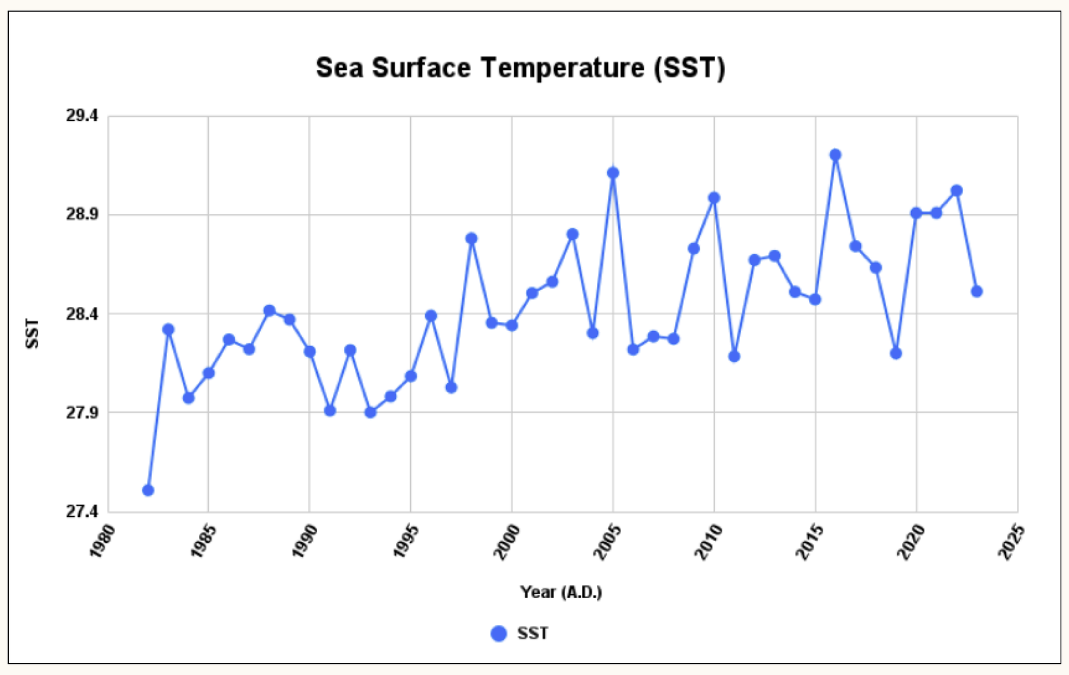


2023

LINE GRAPH SHOWING SEA SURFACE TEMPERATURE.



FORECASTING OF SEA SURFACE TEMPERATURE UP TO 2028.