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Assessment of Impact on Mangroves from Climate Change

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ABSTRACT

Mangrove forests have been providing numerous benefits to densely populated areas such as providing protection from soil erosion, sources of food and habitats and mitigating climate change. Nevertheless, mangroves are becoming increasingly vulnerable to climate change impacts especially from the increasing sea-level.

This paper assesses whether climate change has an effect on mangrove forests using the Google Earth Engine (GEE) computing platform. Applying the 35+ year quasi-global rainfall CHIRPS dataset with the GEE platform provided the Precipitation and Evapotranspiration data. This data can be used to correlate with the climate variables, CO2 emissions and Temperature.

This paper aims to analyse the correlation between Precipitation and Evapotranspiration with the climate variables to assess the climate change effect on the Al Zorah Natural Reserves mangrove in the UAE.

Keywords: Mangroves, Climate Change, Precipitation, Evapotranspiration, Temperature, T value, Calculate

1. INTRODUCTION

Mangroves tropical ecosystems, referred to as a tree or a shrub, have had a significant environmental importance on the UAE providing several benefits to the country. The most common UAE mangrove, Avicennia Marina, is the only plant that naturally grows well in the Arabian Gulf environment, having suitable adaptations to grow in the UAE [1].

Mangroves have been declining in population as a result of human degradation, specifically, Climate Change. The mangroves have had a number of responses to an increase in precipitation varying the growth according to the precipitation net change [2] and to changes in increasing Temperature, increasing mangrove population [3]. An increase in precipitation can cause a net increase in mangrove area whereas a decrease in precipitation from increasing soil salinity can cause a decrease in mangrove area [4]. There is a direct relationship between increasing precipitation as climate change increases temperatures warming the environment [5] to increase Evapotranspiration.

We can assess the correlation between Precipitation data and Evapotranspiration data over the year using the to GEE to assess the climate change effect on the mangrove area.

2. METHOD

A correlation between Precipitation and Evapotranspiration data can be made on GEE using the CHIRPS dataset and the MODIS Evapotranspiration dataset to chart and apply onto a table.

To first get data of the mangrove area, a geometry variable can be made according to the region of interest. The CHIRPS and Evapotranspiration data is then imported to GEE, filtering the date and area to the geometry. Daily Precipitation and Evapotranspiration can be calculated from the average of the image to map onto the image collection. The image collection can be charted as an image series with the Precipitation and Evapotranspiration (mm) on the x axis and the Year on the y axis as a line chart.

Geometry Variable Mapping

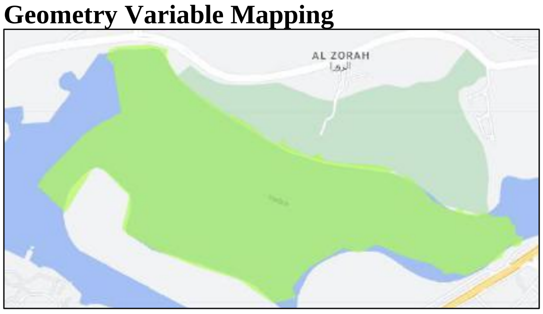

Figure 1: Al Zorah Natural Reserve mangrove, United Arab Emirates Geometry Variable

Code charting Precipitation to geometry

```
var Precipitation= ee.ImageCollection("UCSB-CHG/CHIRPS/PENTAD").filterDate('2022-01-01', '2023-12-31').select('precipitation');
var chart= ui.Chart.image.doySeriesByYear( Precipitation,'precipitation',geometry, ee.Reducer.mean(), 500);
var chartStyle = {
    title: 'Annual Precipitation Time Series',
      series: {
    1: { color: 'E37D05'}
    },
};
chart.setOptions(chartStyle);

print(chart);
```

Code charting Evapotranspiration to geometry

```
var Evapotranspiration= ee.ImageCollection("MODIS/061/MOD16A2").filterDate('2022-01-01', '2023-12-31').select('ET');
var chart= ui.Chart.image.doySeriesByYear( Evapotranspiration,'ET',geometry, ee.Reducer.mean(), 500);
var chartStyle = {
    title: 'Annual Evapotranspiration Time Series',
      series: {
    1: { color: 'E37D05'}
    },
};
chart.setOptions(chartStyle);

print(chart);
```

3. RESULTS AND ANALYSIS

The codes output a chart that displays the average Precipitation and Evapotranspiration in millimetres each day between 2023 (Orange Curve) to 2024 (Blue Curve).

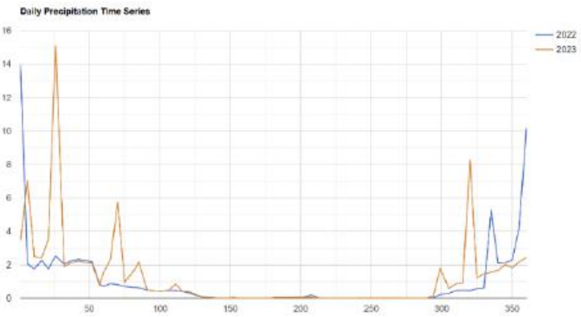

Figure 2: Precipitation Chart Daily Between 2022 to 2023

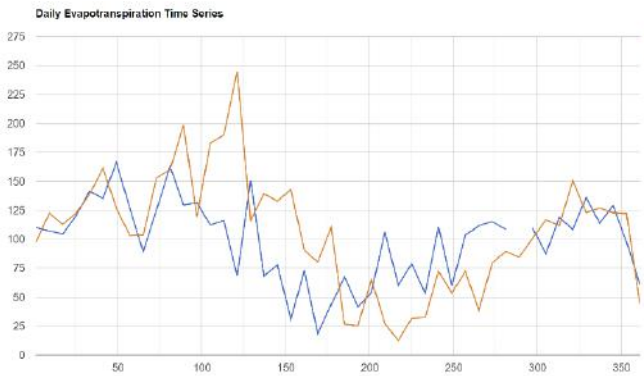

Figure 3: Evapotranspiration Chart Daily Between 2022 to 2023

These data points can be extracted to tables to calculate the various statistics to correlate and assess with.

Table 1 Precipitation Sample points across different days between 2022 to 2023

Day	2022 Precipitation (mm)	2023 Precipitation (mm)
1	13.948	3.424
32	2.036	1.911
111	0.463	0.859
157	0.003	0.003
238	0.001	0.001
244	0.011	0.011
350	2.275	1.829

Calculating the average of the 2022 precipitation returns 2.35 mm and the average of the 2023 precipitation returns 1.07 mm using Table 1 data.

Net percentage change in average Precipitation:

$$\frac{1.07 - 2.35}{2.35}(100) = -54.4\%$$

Table 2 Evapotranspiration Sample points across different days between 2022 to 2023

Day	2022 Evapotranspiration (mm)	2023 Evapotranspiration (mm)
1	109.982	97.193
113	116.163	189.984
145	77.914	132.875

217	60.292	12.594
273	115.287	79.587
313	119.027	111.566
337	113.947	126.788

Calculating the average of the 2022 Evapotranspiration returns 89.08 mm and the average of the 2023 Evapotranspiration returns 93.82 mm using Table 2 data.

Net percentage change average Evapotranspiration:

$$\frac{93.82-89.08}{89.08}(100) = +5.32\%$$

To understand the difference between the net percentage change of the average Precipitation and Evapotranspiration, a T test can be used to exactly measure the difference to the variation of the dataset.

Sample Variance:

$$S^2 = \frac{\Sigma(x_i - \overline{x})^2}{n-1}$$

Precipitation Variance 2022:

$$S_P^2 = \frac{\Sigma\left(x_i - (2.35)\right)^2}{355-1} = 4.7278$$

Precipitation Variance 2023:

$$S_P^2 = \frac{\Sigma\left(x_i - (1.07)\right)^2}{355-1} = 5.2783$$

Evapotranspiration Variance 2022:

$$S_E^2 = \frac{\Sigma\left(x_i - (89.078)\right)^2}{355-1} = 1215.7374$$

Evapotranspiration Variance 2023:

$$S_E^2 = \frac{\Sigma\left(x_i - (93.82)\right)^2}{355-1} = 2532.3523$$

Equal Variance T-Test:

$$T = \frac{mean1 - mean2}{\sqrt{\frac{(n1-1)\times\sigma_1^2 + (n2-1)\times\sigma_2^2}{n1+n2-2} \times \frac{1}{n1} + \frac{1}{n2}}}$$

$$T = \frac{\left(\frac{89.08+93.82}{2}\right) - \left(\frac{2.35+1.07}{2}\right)}{\sqrt{\frac{(354\times 5)+(354\times 1874)}{355+355-2} \times \frac{2}{35}}}$$

$$T = 12.25$$

Accordingly, this T value suggests no correlation as the value has a figure suggesting a difference between Precipitation correlating Evapotranspiration. Whereas the net percentage changes suggest ways Precipitation and Evapotranspiration are changed with environment factors such as Climate Change in the mangrove area.

We can correlate this data to climate change with the CO2 emissions and Temperature data to extract data on Climate Change numerically.

According to CO2 Emissions from the Executive Summary [6], the CO2 emissions grew from 1.1% and the UAE temperatures increased from 23 C to 37 C [7].

As a result of temperatures increasing as Climate Change increases, Precipitation and Evapotranspiration usually increase. As Evapotranspiration of the Al Zorah Natural Reserve increased from 5.32%, the positive correlation between temperature and evapotranspiration then proves the general trend with these climate variables.

Whereas the Precipitation of the Al Zorah Natural Reserve decreased from –54.4% with a negative correlation between Precipitation and temperature. A negative correlation between Precipitation and temperature can be explained as temperature decreasing the saturation to decrease precipitation and to increase condensation [8]. As this process is at high temperatures, the Al Zorah Natural reserve would have to have high temperatures to satisfy the process decreasing precipitation to the mangrove.

4. CONCLUSION

The high temperatures occurring as a result of increasing Climate Change has had a direct effect on Precipitation and Evapotranspiration as these climate variables have had a significant net percentage change to the Al Zorah Natural reserve, UAE mangrove area. Extracting data computationally on GEE on Precipitation and Evapotranspiration as climate variables has provided evidence to support that Climate Change has had a direct effect on mangroves and to the Al Zorah Natural reserve, UAE mangrove area.

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