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Research Paper

Correlation Analysis Between Climatic Parameters And Their Effect On Evapotranspiration At Bhitarkanika National Park Region, Odisha, India

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Abstract

In order to evaluate the link between a few chosen meteorological characteristics and their association with potential evapotranspiration (PET), which was determined using the correlational approach, a research was conducted in the Bhitarkanika National Park Area, Odisha. Temperature, humidity, wind speed, and sun radiation made up the chosen climatic variables. Strong positive and negative correlations between PET and temperature, sun radiation, wind speed, and humidity were observed to show the effects on mangrove ecosystems . In addition, rainfall was abundant from April through October, with August seeing the most. Investigating their potential future changes and related implications requires accurate simulations of these variables from climate models, both in terms of values and changes over time. This paper aims to explain the usefulness of the linear correlation coefficient between two variables in identifying the level of multicollinearity and the mediating/moderating status of independent variables in a model.

Keywords: *Temperature, Solar Radiation, Windspeed, Potential Evapotranspiration*

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I. Introduction:

Correlation analysis is commonly employed in numerous studies to examine the level of association between variables under investigation. It serves as a tool for exploring the extent of relationship between two variables. The linear correlation coefficient (r) is a measure that offers insights into the degree of closeness between two variables. It is important to note that correlation analysis can be conducted using linear or non-linear methods. The primary objective of conducting correlation analysis remains consistent across various studies, which is to investigate the associative relationship between independent and dependent variables.

In 1896, correlation coefficient is first formulated and explored by Karl Pearson[1], with the concepts of correlation by Francis Galton and the relative contribution by Auguste Bravais[2]. Hauke and Kossowski (2011) do endorse that the Pearson's Product Moment Correlation Coefficient (r) is a scale to measure the strength of linear association between variables[2].

Transpiration and evapotranspiration in the Bhitarkanika ecosystem are highly dependent on the health of its mangrove vegetation. These dense forests play a critical role in releasing water vapor into the atmosphere, contributing to the local hydrological cycle. The climate in Bhitarkanika, characterized by high temperatures, humidity, and seasonal variations in rainfall, directly influences the rates of transpiration and evapotranspiration. These weather conditions are essential drivers of the ecosystem's water cycling processes.

Tidal fluctuations, a common feature in Bhitarkanika due to its coastal location, impact the availability of water for transpiration and evapotranspiration. The salinity levels in the water are also affected by these tides, which can, in turn, influence these essential ecological processes.

Human activities such as deforestation, shrimp farming, and water extraction can disrupt the natural conditions of transpiration and evapotranspiration in the ecosystem. These activities can lead to changes in water levels and salinity, affecting the overall ecosystem health. Sediment deposition in the water can impact the availability of nutrients and water for plant transpiration. A buildup of sediments can alter the conditions for vegetation in the area, potentially affecting the health of the mangroves.

Climate change, including rising temperatures and sea levels, is a significant concern for the Bhitarkanika ecosystem. These changes can impact the conditions of transpiration and evapotranspiration, leading to shifts in vegetation composition and distribution, which can have profound ecological consequences.

Water is absorbed into the atmosphere through various processes, including direct evaporation of solid and liquid water from soil and plant surfaces, as well as transpiration. These processes are collectively referred to as evapotranspiration (ET), as it is difficult to distinguish between them[3].

The rate of evapotranspiration, or ET, is influenced by climatic variables and the time of year. When there is enough water available to meet evapotranspiration, the ET will reach its maximum potential value, known as potential evapotranspiration (PET). However, if there is insufficient water, the actual evapotranspiration (AET) will be less than PET. To accurately estimate evapotranspiration, the Penman-Monteith method, as modified by Allen et al. (1998), is considered the most precise[1]. This method is preferred because it takes into account temperature, relative humidity, wind speed, and sunshine hours data, which are readily available in the area.

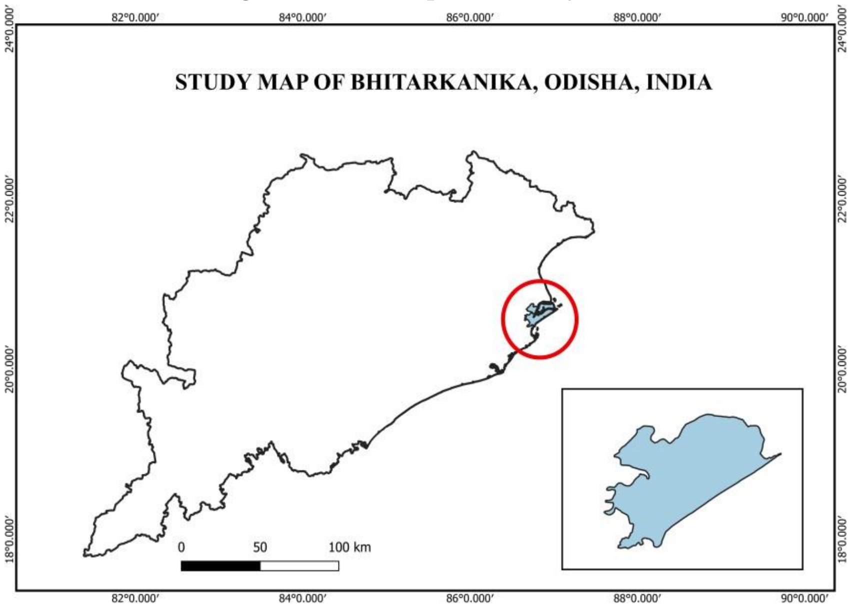
II. Materials And Methods:

Bhitarkanika is the second largest mangrove ecosystem in India situated on the east coast of the country, between 20°33′–20°47′N latitude and 86°48′–86°03′E longitude. This mangrove environment was classified as a Ramsar site of international significance in 2002 due to its high biodiversity.

Bhitarkanika experiences a tropical monsoon climate, characterized by distinct wet and dry seasons. The region encounters high temperatures and humidity throughout the year. The summer months, from March to June, are hot and humid, with temperatures often soaring above 35°C (95°F). During this period, the area receives little to no rainfall. The monsoon season, spanning from July to September, brings relief from the heat as heavy rains drench the landscape.

The region receives a substantial amount of precipitation during these months, rejuvenating the lush mangrove forests and estuarine ecosystem. The winter season, from October to February, is relatively dry and more comfortable, with temperatures ranging from 15°C to 25°C (59°F to 77°F). This milder climate is often preferred by tourists, making it an ideal time to explore the natural wonders and diverse wildlife of Bhitarkanika. Overall, Bhitarkanika's climate plays a crucial role in shaping the unique biodiversity and ecological balance of this enchanting coastal region.

Fig. 1 Location map of the study area



Climatic Data Source

The climatic data used in the study was retrived from the **OPEN ACCESS VIEWER, NASA POWER** for a period of 30 years (1990-2021). The climatic data included rainfall, temperature, humidity and wind speed . This data was used to estimate reference evapotranspiration using Penman Monteith method by Allen et al., 1998. The actual evapotranspiration which involved satellite imageries was also estimated using the **Climate Engine Access by (Google Earth Engine, 2014).**

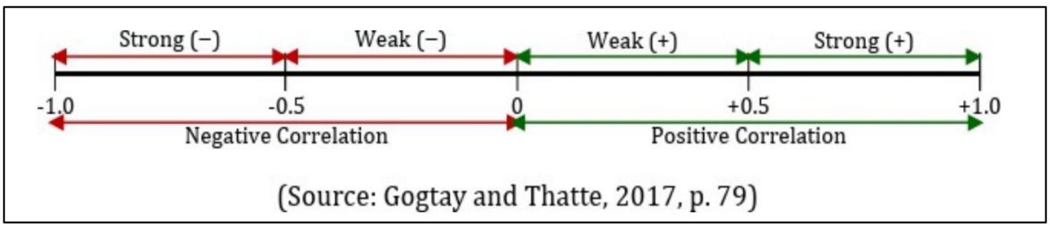
Statistical Analysis

Data collected were subjected to statistical analysis by using Microsoft Excel with xlstat add-on. Pearson correlation coefficient was calculated to test the degree of relationship between climatic parameters.

According to Pallant, 2011, a correlation coefficient can be termed as: small correlation $-0.10 \leq r \leq 0.29$, medium correlation - $0.30 \leq r \leq 0.49$ and large correlation - $0.50 \leq r \leq 1.0$. The positive and the negative point to the direction of the relationship, where the positive indicates an increase in one variable associated with an increase in the other, whilst the negative correlation means an increase in one variable related to a decrease in the other.

The coefficient of determination which explains the changes in one variable as explained by the changes in the other variable (r2) was calculated.

Figure 2: Basic spectrum of interpreting correlation coefficient



Hypothesis formulation:

The null hypothesis typically posits that there is no significant effect or relationship between variables. By conducting a hypothesis test, compare the calculated p-value to a predetermined significance level, often denoted as alpha (α). If the p-value is less than or equal to alpha (α), it suggests that the observed results are statistically significant, and may reject the null hypothesis in favor of their alternative hypothesis. On the other

hand, if the p-value exceeds alpha (α), it implies that the results are not statistically significant, and there is insufficient evidence to reject the null hypothesis.
Whereas,

- Ho: There is no significant correlation between temperature, humidity and precipitation.
- Ha: There is a significant correlation between temperature, humidity and precipitation.

III. Result and Discussion:

The basic criteria for estimating evapotranspiration are temperature, precipitation, wind speed and humidity. Table 1 and 2 show the selected climatic parameters and correlation coefficient among selected climatic parameters at Bhitarkanika. Figure 3 represents the variations of PET and AET at the study area.

Table 1. Climatic parameters of the study area.

Month	Temp	Humidity	Wind speed	Precipitation	PET	AET
	^0C	%	m/s	mm/day	mm/day	mm/day
January	22.01	10.7	3.21	0.41	56.1	51.4
February	24.3	12.9	3.39	0.77	70.1	51.8
March	27.55	16	4.24	0.96	91.33	46.9
April	29.3	18.7	5.5	2.11	106.9	46.8
May	29.8	20.8	5.59	5.49	109.5	91
June	29.3	21.7	6.12	9.16	102.6	131.1
July	28.5	21.4	6.12	11.71	85.5	115.5
August	28.3	21.3	5.47	11.26	82	116.8
September	28.2	20.7	4.39	9.86	81.4	111.5
October	27.7	18	3.48	5.61	74.2	104.02
November	25.2	14.1	3.29	1.33	69.4	74.2
December	22.5	11.01	3.25	0.41	58.6	53.4

PET: Potential Evapotranspiration, AET: Actual Evapotranspiration

Correlation Analysis

According to Pearson correlation coefficient, potential evapotranspiration showed strong positive correlation with temperature (r= +0.90), humidity (r= +0.76) and wind speed (r= +0.86) but the actual evotranspiration is highly correlated with precipitation (r= +0.92).

This implies that changes in temperature, precipitation and wind speed affect evapotranspiration. The degree of association for temperature, precipitation, humidity and wind speed for evapotranspiration is strong and positive.

This is justified because at higher temperatures, more water is lost from the earth surface and from plant cells to the atmosphere due to low humidity in the atmosphere[5]. During this period so much water will be lost from the surface and plant cell or tissues.

Table 2. Correlation coefficient among climatic parameters.

Parameters	Temperature	Humidity	Wind speed	Precipitation	PET	AET
Temperature	**1**					
Humidity	**0.94**	**1**				
Wind speed	**0.82**	**0.86**	**1**			
Precipitation	**0.65**	**0.86**	**0.71**	**1**		
PET	**0.90**	**0.76**	**0.82**	**0.37**	**1**	
AET	**0.58**	**0.79**	**0.58**	**0.92**	**0.30**	**1**

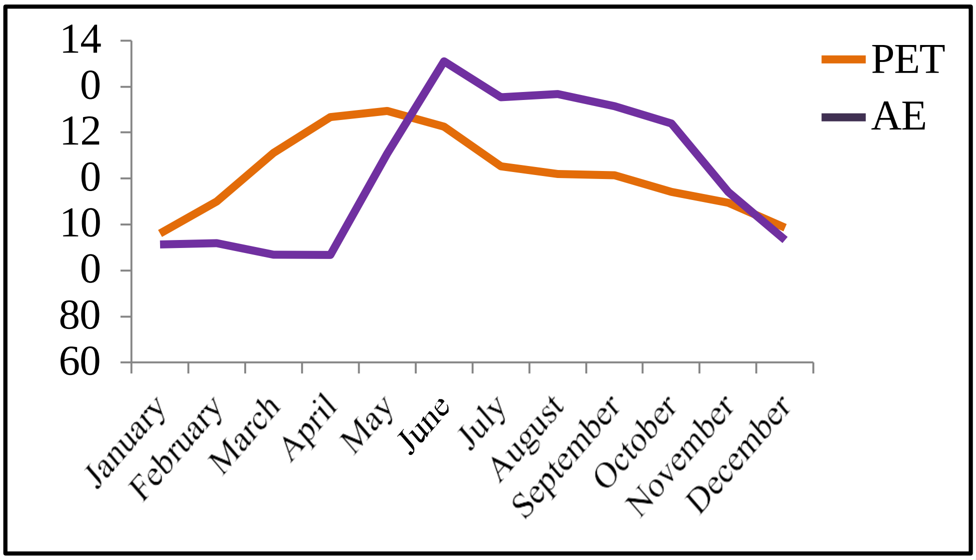
The regression output shows that the temperature, humidity, precipitation and wind speed predictor variables are statistically significant because their p-values is less than 0.05.

p-values (Pearson):				
Variables	Temp	Humidity	Precipitation	Wind speed
Temp	0			
Humidity	<0.0001	0		
Precipitation	0.02	0	0	
Wind speed	0.001	0	0.009	0

P<0.05 is significant , P>0.05 is not significant

(Table 1), Baier and Robertson, 1982 did similar study and conclusion was in line with the above findings[6]. The monthly distribution of PET and AET shown in figure 4 indicated that at the peak of the rainy season where there was sufficient amount of water to meet soil moisture content where AET was high. This occurred between the months of July and October and no irrigation was required at this stag e (Figure 3).

Figure 3. Variations of PET and AET at the study area.



IV. Conclusion:

The research conducted at the bhitarkanika mangroves ecosysytem region of odisha concluded that some parameters that control evapotranspiration are temperature, wind speed, humidity and Precipitation. These parameters are useful for climate regulation and freshwater supply, supporting the rich biodiversity of the region. All climatic parameters like temperature, humidity, wind speed, and precipitation are strongly correlated with each other and evotranspiration. The potential evotranspiration is high in the summer season with high temperatures, humidity, and wind speeds, which increase the precipitation rate in the water cycle. In monsoon, the potential evotranspiration is decreased by increased actual evotranspiration, the other climatic parameters drop continuously, and the precipitation rate is high. The null hypothesis is rejected and alternative hypothesis is accepted that there is significant correlation between climatic parameters. All parameters are important for the water cycle and regulate the weather pattern on earth.

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