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Spatial Analysis of Vegetation Condition in the El Nino Phase of 2023 in Parangloe District, Gowa Regency

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ABSTRACT

The El Nino phenomenon is a climate anomaly that has a significant impact on environmental conditions, including decreased rainfall and vegetation degradation in tropical regions such as Indonesia. This study aims to analyse vegetation conditions during the El Nino phase in 2023 in Parangloe District, Gowa Regency spatially using a remote sensing approach. The data used includes satellite images to calculate the Normalised Difference Vegetation Index (NDVI). This research shows that the El Nino phenomenon in 2023 has a significant impact on vegetation conditions in Parangloe District, Gowa Regency. There was a decrease in the area with high vegetation index from 13,155 hectares in July, to 7,477 hectares in September, which means a decrease of 5,678 hectares or about 43%. In contrast, the area with no vegetation increased drastically from 725 hectares to 3,040 hectares. In addition, the area of low vegetation also increased from 607 hectares to 2,215 hectares, reflecting the widespread ecological stress caused by the drought. This decline in vegetation not only impacts the ecological function of the area, but also has the potential to disrupt local food security and increase vulnerability to environmental disasters such as erosion and extreme drought.

1. INTRODUCTION

Global climate change that has become increasingly evident in recent decades has caused various impacts on environmental systems, one of which is a climate anomaly known as El Nino [1]. The El Nino phenomenon is a warming sea surface temperature event in the central and eastern Pacific Ocean region that affects global weather patterns, including Indonesia. In Indonesia, El Nino generally causes a significant decrease in rainfall, even to prolonged drought in some areas, which ultimately impacts the agricultural sector and vegetation conditions in general [2]

Vegetation is an important component of terrestrial ecosystems that are highly sensitive to changes in climate and weather [3]. Reduced rainfall due to El Niño can cause water stress in crops, decreased agricultural productivity, and significant changes in land cover [4]. Therefore, it is important to monitor the condition of vegetation during the El Niño phase, both for disaster mitigation, land use planning, and environmental conservation.

Parangloe sub-district, located in Gowa Regency, South Sulawesi Province, is one of the areas that has various forms of land cover, including agricultural land, forests, shrubs, and residential areas. The region also has varied topographical conditions, which can affect vegetation responses to climate change, including El

Niño. Gowa Regency in general is vulnerable to drought during the El Niño phase, which has a direct impact on food security and the sustainability of community agricultural activities. This makes Parangloe sub-district a relevant area to study in the context of analysing the impact of El Niño on vegetation.

With advances in remote sensing technology and geographic information systems (GIS), it is now possible to monitor vegetation conditions spatially and temporally with increasing accuracy. One commonly used approach in vegetation monitoring is through the analysis of vegetation indices, such as Normalized Difference Vegetation Index (NDVI) [5]. NDVI is an indicator that measures the greenness or health of vegetation based on spectral reflectance from the Earth's surface captured by satellite sensors [6]. High NDVI values indicate healthy and dense vegetation, while low values indicate stressed vegetation or open land.

This research is expected to make a scientific contribution in understanding the impact of extreme climate on the environment at the local level, especially at the sub-district scale. In addition, the results of this spatial analysis can also be used as a reference by local governments, non-governmental institutions, and communities in developing mitigation and adaptation strategies to drought and in maintaining the sustainability of the ecological function of vegetation.

Based on the description above, this study aims to analyse the vegetation condition in Parangloe District during the El Nino phase spatially using remote sensing data. This analysis is expected to identify patterns of vegetation change, measure the level of vulnerability, and provide spatial-based recommendations that are applicable in environmental management efforts based on scientific evidence.

2. MATERIALS AND METHOD

2.1 Research Location and Object

In Figure 1, Parangloe sub-district is located in Gowa Regency, South Sulawesi Province, Indonesia. The region has diverse geographical characteristics, ranging from lowlands to areas with undulating topography and hills. Parangloe is known as an area with diverse land cover, including agricultural areas, forests, shrubs, and settlements. This diversity makes Parangloe a representative area to study the impact of climate change, especially the El Nino phenomenon, on vegetation conditions

2.2. Data Source

Satellite Imagery

The metadata information of the downloaded satellite images can be seen in Table 1. This table contains information about all the images analysed in this study. Based on the results of research conducted by [7] found that Sentinel-2 satellite imagery has the best resolution, both spatially and temporally in monitoring changes in various types of vegetation. The higher resolution of a satellite image will provide more detailed analysis results [8].

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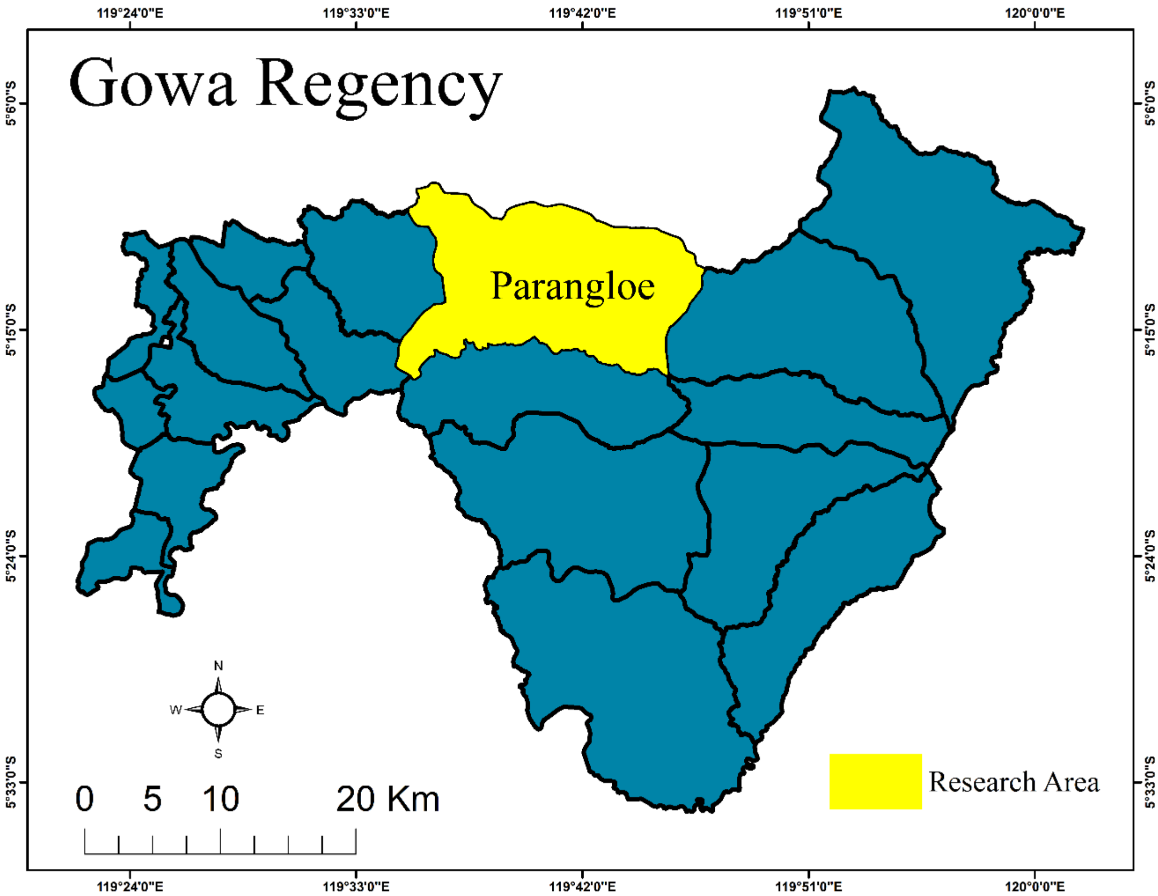

Figure 1. Research area

Table 1. Sentinel-2 L2A Characteristic Features of Satellite Data

Name	Level	Date	Band	Resolution
T50MQV_20230728T022331_B04	2A	28/07/2023	4 (Red)	10 meters
T50MQV_20230827T022331_B04	2A	27/08/2023	4 (Red)	10 meters
T50MQV_20230911T022331_B04	2A	26/09/2023	4 (Red)	10 meters
T50MQV_20230728T022331_B08	2A	28/07/2023	8 (NIR)	10 meters
T50MQV_20230827T022331_B08	2A	27/08/2023	8 (NIR)	10 meters
T50MQV_20230926T022331_B08	2A	26/09/2023	8 (NIR)	10 meters

El Nino condition

Multivariate ENSO Index (MEI) used to provide information related to ENSO events such as El Nino. Based on Figure 2, it can be seen that in 2023 in July-September there were El Nino conditions. The value for each month is obtained directly from the data provided by NOAA without going through the calculation process.

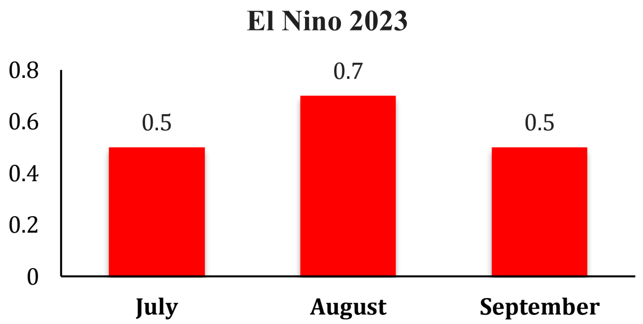

Figure 2. Graph Value The Multivariate ENSO Index (MEI)
Source: https://psl.noaa.gov/enso/mei/#data

Climate Parameters

The climate parameter data used in this study were obtained from the Meteorological, Climatological and Geophysical Agency (BMKG). These two parameters serve as the main indicators of climate variability. The information on both graphs is used to describe climate variability in 2023 during the El Niño phase. The data from these two parameters provide an overview of how climate variability caused by ENSO appears in the study area.

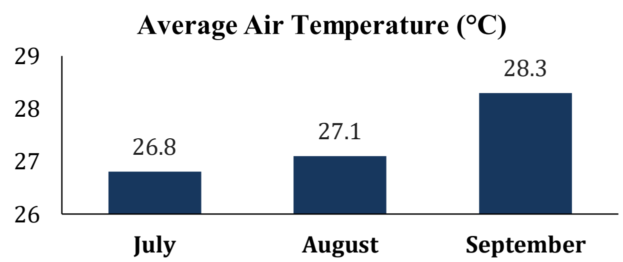

Figure 3. Average air temperature chart
Source: BMKG

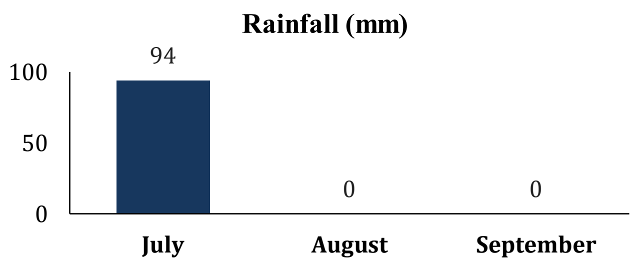

Figure 4. Average rainfall chart
Source: BMKG

2.3 Processing

NDVI calculation

NDVI is the most commonly used vegetation index to describe the greenness of plants because it is sensitive to the amount of chlorophyll and photosynthetically active leaves [9]. NDVI is calculated using the following formula:

$$\text{NDVI} = \frac{NIR - RED}{NIR + RED}$$

Where NIR represents the Nir Infrared band and RED represents the Red band [10]. On Sentinel-2A, it is calculated with the following formula:

$$\text{NDVI} = \frac{Band\ 8 - Band\ 4}{Band\ 8 + Band\ 4}$$

NDVI Classification

In NDVI analysis, vegetation density can be observed from a range of values between -1 and +1, where higher values usually indicate better vegetation health and density than lower values. These values can also be used as primary data as they have a positive relationship with actual conditions on the ground [11]. The NDVI Value Classification Range can be seen in Table 2.

Table 2. NDVI Value Classification Range

Classification	NDVI Range
Water body	NDVI ≤ 0
No vegetation	0 < NDVI ≤ 0.2
Low vegetation index	0.2 < NDVI ≤ 0.3
Moderate vegetation index	0.3 < NDVI ≤ 0.5
High vegetation index	0.5 < NDVI ≤ 1

[4]

3. RESULTS AND DISCUSSION

Vegetation condition during the El Nino Phase in Parangloe District, Gowa Regency

Based on the NDVI analysis results, Figure 5 displays a map of vegetation conditions during the El Niño period of 2023, particularly in July, August and September. Each vegetation category is depicted with a different colour according to its classification on the map. Furthermore, the results of the NDVI maps were quantitatively analysed using ArcGIS 10.8 software to determine the extent of each of the five NDVI classifications in each period. The results of this analysis are presented in Table 3, and to facilitate understanding of the patterns of change, the data is also visualised in graphical form in Figure 6.

Based on climate parameter data, Parangloe sub-district experienced a drastic decrease in rainfall during the El Nino 2023 period. In July, rainfall was still recorded at 94 mm, but in August and September, rainfall dropped to 0 mm. This drastic decline reflects the direct impact of El Niño in reducing water supply from precipitation. At the same time, air temperatures showed an increasing trend from 26.8°C in July to 28.3°C in September. This combination of very low rainfall and increasing temperatures creates unfavourable environmental conditions for optimal vegetation growth.

The NDVI classification results show striking dynamic changes over the three months of observation. In general, there was a decrease in vegetation quality from July to September. In July, the area with a high vegetation index was recorded at 13,155 hectares. However, this dropped dramatically to 10,080 hectares in August and again to 7,477 hectares in September. This decline indicates that the vegetation was under increasing stress over time during the El Niño period.

Table 3. Change rate of vegetation area based on NDVI classification

NDVI Classification	El Nino 2023		
	July	August	September
Water Body	1136 Ha	847 Ha	507 Ha
No Vegetation	725 Ha	1494 Ha	3040 Ha
Low Vegetation Index	607 Ha	1769 Ha	2215 Ha
Moderate Vegetation Index	4214 Ha	5646 Ha	6598 Ha
High Vegetation Index	13155 Ha	10080 Ha	7477 Ha

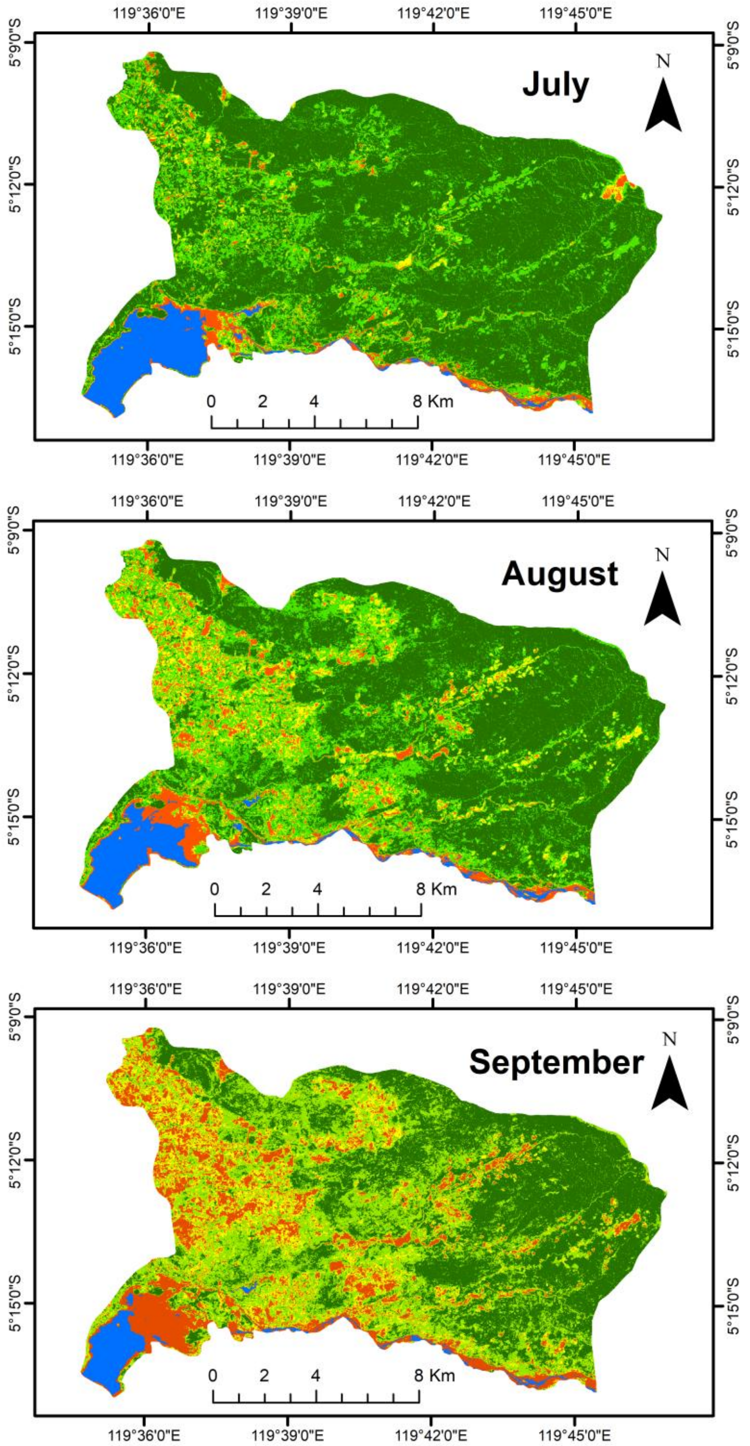

Figure 5. Vegetation condition in El Nino Phase in 2023

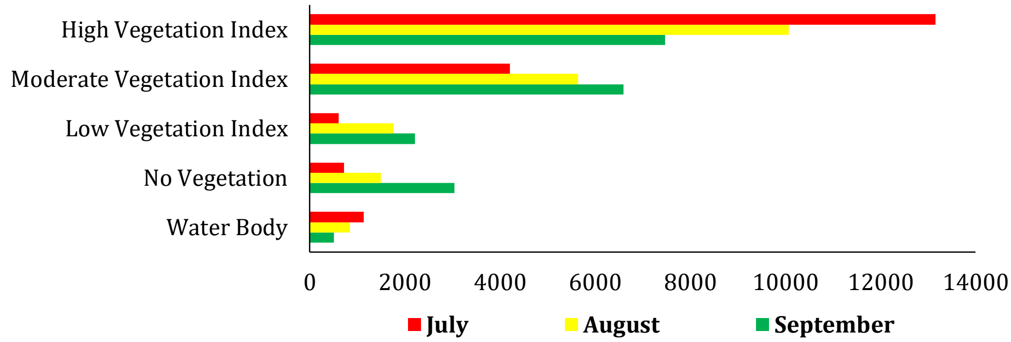

Figure 6. Scatter distribution of NDVI classification in each month

The NDVI classification results show striking dynamic changes over the three months of observation. In general, there was a decrease in vegetation quality from July to September. In July, the area with a high vegetation index was recorded at 13,155 hectares. However, this dropped dramatically to 10,080 hectares in August and again to 7,477 hectares in September. This decline indicates that the vegetation was under increasing stress over time during the El Niño period.

In contrast, the area without vegetation increased significantly. The area without vegetation increased from 725 hectares in July to 1,494 hectares in August, and reached 3,040 hectares in September. This spike indicates that areas that previously had vegetation cover are starting to lose their density or even become open land due to high environmental pressure. Similar changes occurred in the low and medium vegetation index classes.

The area with a low index increased from 607 hectares in July to 2,215 hectares in September. Meanwhile, areas with a medium vegetation index showed an increasing trend from 4,214 hectares in July to 6,598 hectares in September. This increase indicates that most of the vegetation has degraded, dropping from the "high" category to "mederate" or "low". Interestingly, the area classified as water bodies also decreased from 1,136 hectares in July to 507 hectares in September. This may reflect the shrinkage of surface water volume due to high evapotranspiration and the absence of water supply from rain over the past two months.

Spatially, vegetation degradation shows patterns that may be influenced by land cover type and topography. Areas with rainfed agricultural land are likely to be the most affected, given their heavy reliance on rainfall for irrigation. Forest and shrub cover, which are more resilient to drought, may still be able to maintain a moderate NDVI index, but are still under pressure. The ecological implications of declining vegetation indices are serious. Large-scale vegetation stress or mortality can disrupt the local microclimate balance, reduce the capacity of land to store water, and increase the risk of soil erosion. Furthermore, a decline in agricultural land productivity directly impacts the food security of local communities, given that a large proportion of the population in Parangloe Sub-district depend on the agricultural sector for their livelihoods.

4. CONCLUSION

This study shows that the El Nino phenomenon in 2023 has a significant impact on vegetation conditions in Parangloe District, Gowa Regency. There was a decrease in the area with high vegetation index from 13,155 hectares in July, to 7,477 hectares in September, which means a decrease of 5,678 hectares or about 43%. In contrast, the area with no vegetation increased drastically from 725 hectares to 3,040 hectares. In addition, the area with a low vegetation index also increased from 607 hectares to 2,215 hectares, reflecting the widespread ecological stress caused by the drought.

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