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Analysis of Vegetation Index in Ambon City Using Sentinel-2 Satellite Image Data with Normalized Difference Vegetation Index (NDVI) Method based on Google Earth Engine

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ARTICLE INFO

Article history:
Received 15 April 2023
Revised 08 May 2023
Accepted 06 June 2023
Available online 06 June 2023

Keywords:
Ambon
NDVI
Google Earth Engine
Vegetation Index
Sentinel-2

IEEE style in citing this article:
H. Rakuasa and D. A. Sihasale, "Analysis of Vegetation Index in Ambon City Using Sentinel-2 Satellite Image Data with Normalized Difference Vegetation Index (NDVI) Method based on Google Earth Engine," Journal of Innovation Information Technology and Application (JINITA), vol. 5, no. 1, pp. 74–82, Jun. 2023.

ABSTRACT

Rapid urban development and increasing human activities in the city can affect the decline in the Vegetation Index in Ambon City. The research aims to analyze the vegetation index using sentinel-2 satellite image data with the Normalized Difference Vegetation Index (NDVI) method based on Google Earth Engine (GEE) in Ambon City in 2023. This research uses Sentinel-2 Satellite Image data which is analyzed using Google Earth Engine with the Normalized Difference Vegetation Index (NDVI) method. The results showed that the vegetation index value in Ambon City in 2023 was the lowest value of -0.672381 and the highest value of 0.949297. The vegetation index value is then divided into four classes, namely No Vegetation which has an area of 4,448.99 ha or 13.67%, Low Vegetation areas have an area of 1,611.06 ha or 4.95%, Moderate Vegetation areas have an area of 2,895.12 ha or 8.89% and High Vegetation areas have an area of 23,597.35 ha or 72.49%. Analysis of the vegetation index in Ambon City is very important to maintain environmental balance and a healthy and sustainable environment.

1. INTRODUCTION

The vegetation index is one of the parameters used to analyze and obtain information about the amount and quality of vegetation in an area [1]. Vegetation Index is very important in environmental studies and natural resource management. In environmental studies, the Vegetation Index can provide information on vegetation growth and condition, plant productivity, ecosystem health, and potential natural disasters [2]. In natural resource management, the Vegetation Index can be used to monitor plant growth and land productivity and to evaluate the impact of human activities on the environment.

The Vegetation Index can also be used in monitoring urban development. The use of the Vegetation Index can help identify land use changes and potential environmental damage within the city [3]. In this case, the use of the Vegetation Index can assist in determining suitable locations for the development of urban parks and green gardens, as well as determining areas that require environmental rehabilitation efforts [3]. In addition, the use of the Vegetation Index in monitoring the development of Ambon City can help in monitoring air quality around the city. Monitoring the value of the Vegetation Index can indicate the presence of air pollution and its impact on vegetation and the environment around the city [4].

The development of Ambon City and the decline in the Vegetation Index in Ambon City have a close relationship. Rapid urban development and increased human activities in the city can affect the decline in the Vegetation Index in Ambon City [5]. One of the main factors for the decline in the Vegetation Index

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in Ambon City is land use change, urban growth, and increased human activities in the city can lead to a reduction in the area of open land and forests, as well as changes in land use from agricultural or green land to residential or industrial land [6], [7]. This results in a reduction in the amount and quality of vegetation in the city. In addition, unsustainable urban development patterns that pay little attention to environmental aspects can also affect the decline in the Vegetation Index in Ambon City [8]. The development of urban infrastructure such as roads, buildings, and other public facilities is often carried out without considering the impact on the environment and vegetation around the development area [9]. Climate change and air pollution can also affect the decline in the Vegetation Index in Ambon City [10]. In this case, the use of the Vegetation Index can help monitor the condition of vegetation in Ambon City and identify areas that require improvement or rehabilitation. In the development of a sustainable city, increasing the Vegetation Index in Ambon City should be one of the priorities to maintain environmental sustainability and public health in the city [10].

The Normalized Difference Vegetation Index (NDVI) method using Sentinel-2 satellite image data is very effective and useful for analyzing vegetation conditions, especially in urban areas [11]. NDVI measures the reflectance difference between red and infrared light in the measured area. Healthy, green-leaved plants will absorb more red light and reflect more infrared light, while land areas without vegetation will absorb less red light and reflect less infrared light [12]. Sentinel-2 satellite image data offers an excellent spatial resolution of 10 meters, making it possible to map vegetation with high accuracy [12]. In addition, these data also provide useful information about the state of the environment such as land surface temperature, air humidity, and water quality [13]. The utilization of NDVI in vegetation index analysis helps monitor urban and environmental development in urban areas [13]. With this method, areas that require vegetation rehabilitation can be identified, improving environmental conditions and maintaining air quality in the area.

In addition, Sentinel-2 satellite image data with the NDVI method can also be used for monitoring potential natural disasters, such as forest fires or floods [11]. In this case, vegetation index analysis can help in predicting the likelihood of natural disasters and taking preventive measures before it is too late. In conclusion, the use of Sentinel-2 satellite image data with the NDVI method is very helpful in analyzing the vegetation index in urban areas. In the context of sustainable urban development, vegetation index analysis can help in maintaining the balance between urban growth and the preservation of the environment and vegetation in the city.

This research uses Google Earth Engine to analyze the vegetation index in Ambon City in 2023. Google Earth Engine (GEE) is a cloud computing platform developed by Google for large-scale processing and analysis of satellite imagery and other geospatial data [14]. GEE provides access to various sources of satellite imagery data and allows users to access and analyze the data easily and efficiently. GEE has powerful data processing and data analysis features, including image processing algorithms, interactive mapping, and data visualization. GEE is used for a variety of applications, including vegetation index analysis, climate change monitoring, biodiversity mapping, disaster risk mapping, and more [14].

The use of Google Earth Engine (GEE) for Vegetation Index analysis has proven effective as it provides easy access to satellite imagery data and image processing algorithms [15]. The following are some of the advantages and effectiveness of using GEE for Vegetation Index analysis; GEE allows users to analyze vegetation indices on a large scale, even globally, GEE uses cloud computing technology that allows users to access data and perform analysis quickly and efficiently, GEE provides access to various satellite image data sources such as Sentinel-2, Landsat, MODIS, and others [13]. This allows users to select the most appropriate data source for the vegetation index analysis being conducted, GEE has sophisticated image processing algorithms, including algorithms for calculating vegetation indices such as Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), and GEE allows users to easily create interactive maps and visualization of vegetation index analysis results [16].

Previously Latuconsina et al., have conducted NDVI analysis in Ambon City in 2020 using Landsat 5 Landsat 7 ETM +, and Landsat 8 image data which has a spatial resolution of 30 meters and data processing, and analysis is still recognized conventionally which must use a laptop that has high specifications [6]. Previous research certainly has differences from this research, where this research uses images of Teluk Ambon Subdistrict and Teluk Ambon Baguala Subdistrict. This research uses Sentinel-2 image data which has a 10-meter spatial resolution, which is certainly better than Landsat images. This research uses Google Earth Engine for NDVI analysis in contrast to previous studies that used GIS software such as Arc GIS and ENVI. Here are some of the key differences between NDVI analysis in GEE and other GIS software including; GEE allows users to access and analyze large-scale satellite data directly from cloud storage, while GIS software usually requires satellite data to be pre-downloaded and stored on

local hard drives, GEE has a lot of satellite data available with various resolutions and timeframes, while GIS software usually has limited data or requires additional fees to access additional data, GEE has more sophisticated and fast analysis capabilities compared to GIS software. In GEE, NDVI can be analyzed together with other data such as rainfall and land surface temperature, which can be used to create more complex prediction and analysis models, GEE uses efficient image processing algorithms to produce accurate results in less time, while GIS software requires longer processing times and may require special settings to obtain optimal results, and GEE can be used for free, while GIS software such as ArcGIS or ENVI requires license or membership fees.

Based on the description above, this research aims to analyze the vegetation index using sentinel-2 satellite image data with the Normalized Difference Vegetation Index (NDVI) method based on the google earth engine in Ambon City in 2023.

2. RESEARCH METHODS

This research was conducted in Ambon City which is the capital of Maluku Province. Administratively, Ambon City consists of Sirimau District, Nusaniwe District, South Leitimur District, Teluk Ambon District, and Teluk Ambon Baguala District. This research uses Sentinel-2 MSI image data: MultiSpectral Instrument, Level-2A using the NDVI Normalized Difference Vegetation Index algorithm which is accessed and analyzed on the Google Earth Engine Platform.

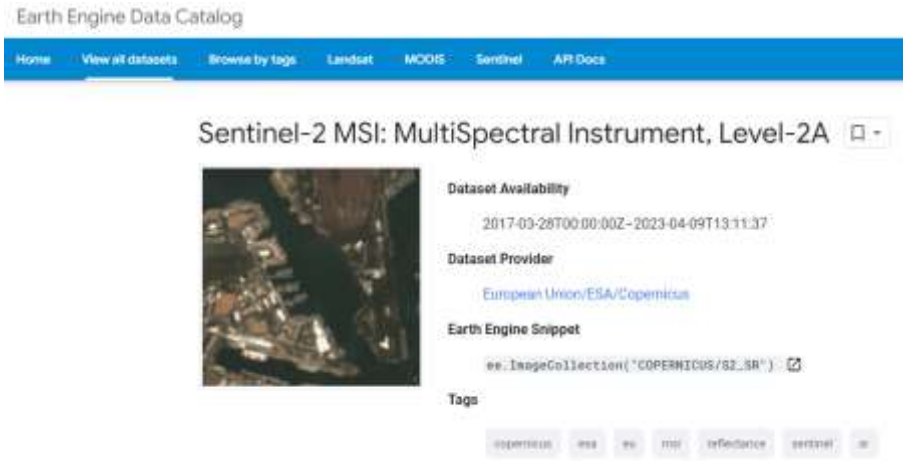

Figure 1. Display of Sentinel-2 MSI Image Dataset in GEE

Sentinel-2 MSI (MultiSpectral Instrument) is an instrument on the Sentinel-2 satellite used to take multispectral images of the Earth from orbit. It consists of 13 scanning bands capable of measuring the reflectance of the Earth's surface at various wavelengths, ranging from 443 nanometers to 2190 nanometers. The imagery data produced by Sentinel-2 MSI is very useful for remote sensing applications, including vegetation monitoring, land use mapping, water quality monitoring, and so on. Level-2A is a processing level of Sentinel-2 MSI image data that has been processed and corrected radiometrically and atmospherically to produce higher-quality images. Level-2A data has been calibrated and corrected for factors such as illumination, atmosphere, and geometry, providing more accurate results that can be used for analysis and mapping. This Level-2A data is publicly available and can be accessed through platforms such as Google Earth Engine in Figure 1.

This research uses the Normalized Difference Vegetation Index (NDVI) method. The NDVI (Normalized Difference Vegetation Index) method is a remote sensing method for measuring the amount and quality of vegetation using satellite or aircraft image data that measures light in various spectra [13]. This method is based on the reflectance difference between the red and near-infrared spectra emitted by the Earth's surface [12]. The NDVI method calculates the difference between the reflectance of light in the red spectrum (which is produced by chlorophyll in plants) and the near-infrared (which is produced by plant cells that reflect light). This method uses a simple formula that has previously been used by researchers, previous researchers [10], [11], [13], [14]:

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

Equation 1 explains that NIR is the reflectance in the near-infrared spectrum and RED is the reflectance in the red spectrum. The NDVI index provides values from -1 to 1, with positive values indicating the presence of healthy and productive vegetation, while negative values indicate areas not covered by vegetation or unhealthy vegetation. The NDVI method is very useful in vegetation monitoring and land management at various scales, including agriculture, forestry, nature conservation, and environmental research [15]. Satellite image data processed with the NDVI method can provide valuable information on vegetation productivity, soil quality, and climate change [14].

The recording date of the Sentinel-2 MSI image data selected for this study is 1-01-2023-31-03-2023. This was done to determine the average vegetation index value of Ambon City in 2o23. The vegetation index analysis in this study was carried out on the Google Earth Engine (GEE) cloud computing platform by modifying the script previously used by previous researchers [15], [14]. Script display used in GGE can be seen in Figure 2.

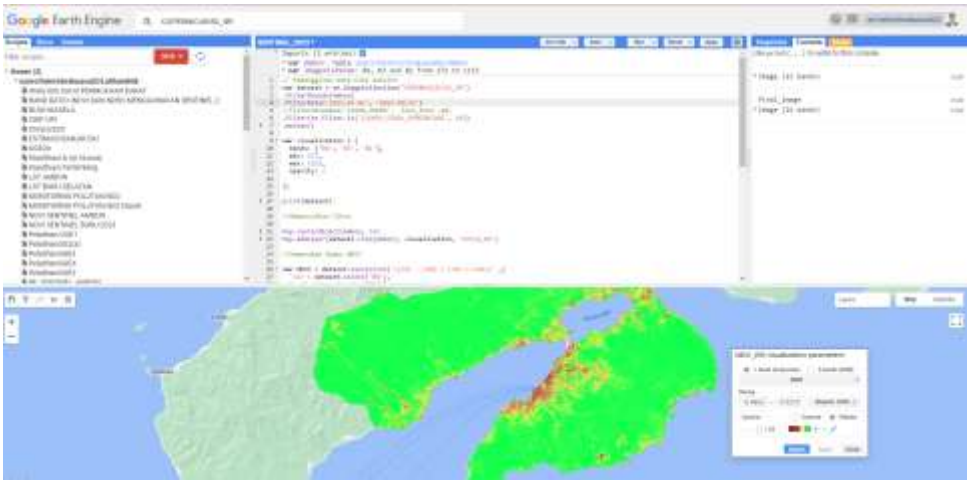

Figure 2. Display of Script used in GGE

The process of data processing and analysis is entirely done with JavaScript in Google Earth Engine. The stages of data processing and analysis are as follows:

```
// Selecting Satellite Imagery Data
var dataset = ee.ImageCollection("COPERNICUS/S2_SR")
.filterBounds(Ambon)
.filterDate('2022-01-01', '2022-01-31')
//filterMetadata('CLOUD_COVER', 'less_than',20)
.filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', 20))
.median()

var visualization = {
  bands: ['B4', 'B3', 'B2'],
  min: 272,
  max: 1153,
  opacity: 1

};

print(dataset)

// Displaying Sentinel-2 MSI satellite imagery

Map.centerObject(Ambon, 14)
Map.addLayer(dataset.clip(Ambon), visualization, 'Citra_ Ambon')
```

```
// Inputting NDVI algorithm

var NDVI = dataset.expression('((nir - red) / (nir + red))' ,{
  'nir': dataset.select('B8'),
  'red': dataset.select('B4')
}).rename('NDVI')

// Display NDVI analysis results

var igbpPalette = [

  'ca3f16',
  '37a300',
  '00ff14',
  'ffa22f',
  'fbff00',

  ];

Map.addLayer(NDVI.clip(Ambon), {palette: igbpPalette}, "NDVI_ Ambon");
  var final_image = dataset.addBands(NDVI)

  print ("final_image", final_image)

  //Export Data

  Export.image.toDrive({
    image: NDVI.clip(Ambon),
    description: 'NDVI_Ambon',
    scale: 50,
    region: Ambon
  });
```

After the results of the vegetation index analysis are downloaded from Google Drive, classification is carried out in Arc GIS software which refers to research [17]. The classification of the vegetation index can be seen in Table 1.

Table 1. NDVI Classification [17]

NDVI Value		Classification
Min	Max	
-1	0	Non Vegetation
0	0,2	Low Vegetation
0,2	0,5	Medium Vegetation
0,5	1	High Vegetation

The results of the analysis of the vegetation index of Ambon City in 2023 were then calculated in the area of change and map layout in Arc software. GIS software and Microsoft Excel.

3. RESULTS AND DISCUSSION

The results of the vegetation index analysis using the Normalized Difference Vegetation Index (NDVI) method in equation one show that non-vegetated areas have an area of 4,448.99 ha or 13.67%, low vegetation areas have an area of 1,611.06 ha or 4.95%, medium vegetation areas have an area of 2,895.12 ha or 8.89% and highly vegetated areas have an area of 23,597.35 ha or 72.49%. The spatial distribution of the vegetation index of Ambon City in 2023 can be seen in Figure 3.

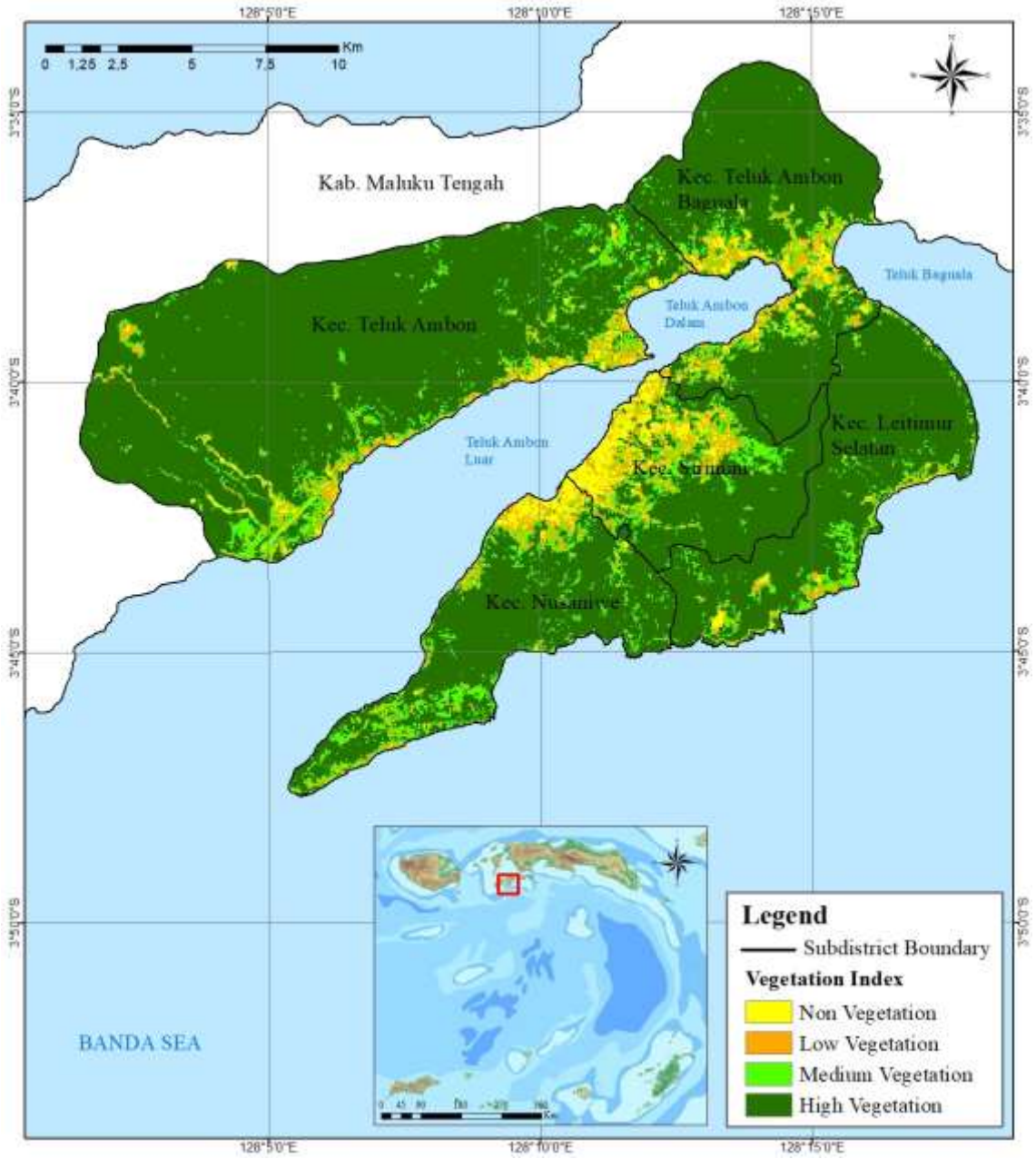

Figure 3. Vegetation Index Map of Ambon City

The vegetation index value in Ambon City in 2023 is the lowest value of -0.672381 and the highest value of 0.949297. The vegetation index in Ambon City is strongly influenced by the existing land cover. Land cover is a term that refers to the type and condition of land use in an area. Different types of land use can affect the quality of vegetation and thus the value of the Vegetation Index. For example in Figure 4, a large and well-maintained green area such as an urban park or urban forest, can have a high Vegetation Index because there are many living and healthy plants in the area. Conversely, urban areas that are densely built up and lack green areas may have a low Vegetation Index due to the lack of green land cover.

DOI: doi.org/10.35970/jinita.v5i1.1869

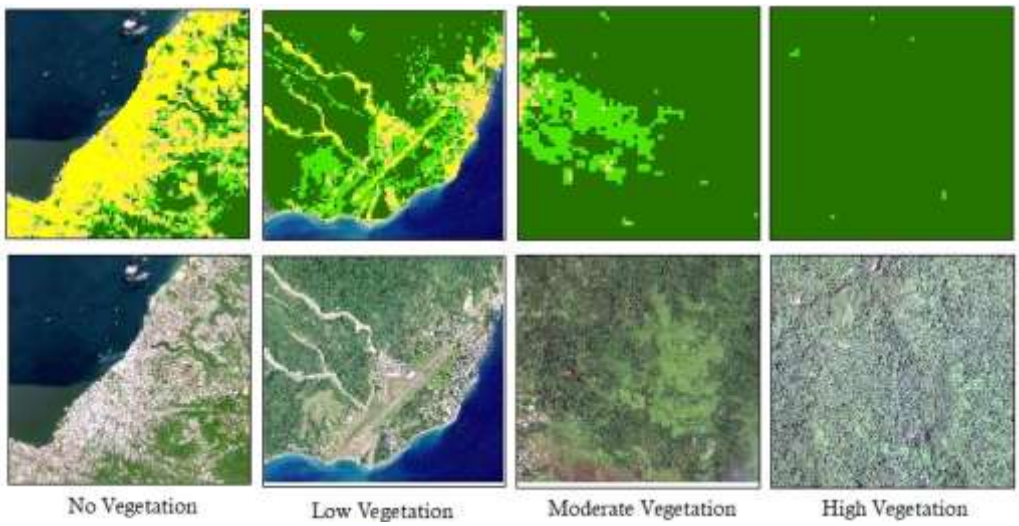

Figure 4. Comparison of Vegetation Index analysis results and RGB display of Sentinel-2 Imagery

Based on Figure 4, it can be seen that the Vegetation Index can help identify changes in land cover, especially in green areas. In this case, if the Vegetation Index value decreases, it can indicate that green land cover is decreasing, and the area may be experiencing environmental damage and degradation. The Vegetation Index can be used as an indicator to monitor changes in built-up land in Ambon City. In this case, the Vegetation Index can help estimate the extent to which the development of built-up land in Ambon City has affected the environment and the health of vegetation in the area. In this case, if the Vegetation Index shows a decrease, it may indicate that built-up land in Ambon City has increased along with the reduction of green areas and the deterioration of environmental quality. Conversely, if the Vegetation Index increases, it could indicate that efforts are being made to improve the environment and maintain the sustainability of green land in Ambon City.

The results of vegetation index analysis can provide useful information including through vegetation index analysis, monitoring of vegetation conditions in Ambon City can be done [10]. This can help in identifying disaster-prone areas, areas that require maintenance, and areas that require rehabilitation or reforestation. Vegetation index analysis can also be used to monitor land changes in Ambon City [7]. Land changes such as forest encroachment, settlement or agricultural expansion, and mining can be seen through changes in the vegetation index value of the area. The vegetation index can provide information about plant health in Ambon City so that it can help in better plant management and improve environmental quality [5].

Some solutions that can be done based on the results of vegetation index analysis in Ambon City include the results of vegetation index analysis can be used to make better vegetation and environmental management policies and programs. This includes reforestation, land rehabilitation, and forest preservation, the use of vegetation index analysis results can help in water and soil management in Ambon City [18]. By knowing the condition of vegetation, the level of soil moisture, the ability to absorb water in the soil, and so on, vegetation index analysis can be used to help agricultural development in Ambon City [9]. Knowing the condition of vegetation and the availability of good land can help in choosing the type of plants that are suitable for planting and improving agricultural productivity. The results of vegetation index analysis can help in disaster risk reduction in Ambon City [19]. By knowing the condition of vegetation and land changes, disaster-prone areas can be identified, and preventive measures are taken. areas prone to disasters and appropriate preventive measures can be taken.

In making decisions based on the results of the vegetation index analysis in Ambon City, collaboration between the government, community, and other related institutions is required. This will enable holistic and sustainable action to maintain the sustainability of the environment and the overall development of Ambon City. By regularly monitoring the Vegetation Index, the government and community can take action to ensure that the development of built-up land in Ambon City does not damage the environment and maintains a balance between built-up and green land [8]. In addition, by paying attention to the Vegetation Index, can also help in estimating the impact of environmental and climate change in Ambon City and taking appropriate mitigation measures to overcome these problems.

4. CONCLUSION

The vegetation index value in Ambon City in 2023 is the lowest value of -0.672381 and the highest value of 0.949297. The vegetation index value is then divided into four classes, namely non-vegetation which has an area of 4,448.99 ha or 13.67%, low vegetation areas have an area of 1,611.06 ha or 4.95%, medium vegetation areas have an area of 2,895.12 ha or 8.89% and highly vegetated areas have an area of 23,597.35 ha or 72.49%. The results of the vegetation index analysis can be utilized as basic data in further research including; the results of the vegetation index analysis can be used as basic data in environmental change studies. By combining vegetation index data from several different times, it is possible to analyze trends in environmental changes such as deforestation, urbanization, or changes in cropping patterns. The results of vegetation index analysis can also be utilized in environmental health studies. The vegetation index can be used as an indicator of environmental conditions that can affect human health such as the presence of green areas around settlements or the impact of pollution on vegetation. The results of vegetation index analysis can be used in studies on the relationship between vegetation and climate change. By utilizing vegetation index data from recent years, it is possible to analyze changes in vegetation and its impact on climate. The vegetation index can be utilized for mapping and crop monitoring studies. The vegetation index data obtained can provide information on plant health and productivity, which can help in managing and monitoring crops more effectively. The results of vegetation index analysis can also be used to evaluate the effectiveness of vegetation management programs that have been carried out. By comparing vegetation index data before and after the program, it can be seen whether the vegetation management program is effective or not. Thus, the analysis of the Vegetation Index in Ambon City is very important to maintain environmental balance and a healthy and sustainable environment.

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