

## Monitoring of Lake Water Quality Through Streamlit Web Application (Case Study: Lake Matano and Lake Towuti, South Sulawesi)

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**Abstract:** The Indonesian government, through the National Medium Term Development Plan (RPJMN) 2015-2019, stated that water reservation, including the function of lakes, is one of the priorities. Lakes are not only functioned to maintain the ecological balance but also to provide water, protein, mineral, energy sources, and even tourism to support the community's economic growth. Lake Matano and Lake Towuti are designated as Nature Tourism Park areas. However, the lakes' environment is starting to be damaged. The damages exist in areas such as water-absorbent areas, lake borders, and lake waters. In addition, these damages increase the disaster risk. Therefore, to maintain the lake's sustainability, it is necessary to conduct research on the parameters of the condition of the fertility level of the lake waters. One of the parameters of the fertility level of the waters is *chlorophyll-a*. In the previous studies, observations of *chlorophyll-a* in Lake Matano and Lake Towuti have been carried out using Landsat-8. However, with these observations, a *chlorophyll-a* had not properly been monitored by using an application through web-based satellite imagery using web applications using the primary python programming language. The data for processing *chlorophyll-a* itself are obtained through the geemap library. *Chlorophyll-a* itself was processed using the existing algorithm. The current web application displays several features, namely the web application information and the results of the *chlorophyll-a* map. The results of the estimated value of *chlorophyll-a* range from 0 - 0.6 mg/m<sup>3</sup>. The minimum value of *chlorophyll-a* was found in 2014 which was 0.4 mg/m<sup>3</sup>, while the highest value of chlorophyll-a was found at 0.6 mg/m<sup>3</sup> in 2016. The results of this chlorophyll-a analysis were categorized into oligotrophic waters with low fertility.

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Keywords: Chlorophyll-a; geemap; Jaelani Algorithm 2015; Landsat 8; Remote Sensing; Streamlit

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### Introduction

Indonesia is an archipelagic country that has many lakes. Through the National Medium Term Development Plan 2020-2024, the government states that water sustainability, including the existence of lakes, is one of the priorities. The lake is not only functioned as a keeper of the ecological balance but also as a provider of water sources, protein, minerals, energy, and even additional functions such as tourism to support the community's economic growth. These roles are appointed to fifteen priority lakes, namely Rawapening Lake, Rawa Danau in Banten, Batur Lake, Toba Lake, Kerinci Lake, Maninjau Lake, Singkarak Lake, Poso Lake, Mahakam-Semayang Cascade Lake, Melintang Lake, Tondano Lake, Tempe Lake, Lake Matano, Lake Limboto, Lake Sentarum, Lake Jempang, and Lake Sentani (Marroli, 2017).

Regarding Ecosystem Conservation, Director General of Natural Resources and Ecosystem Conservation, Wiratno said that the lake is a home to hundreds of species. They live on the bottom of the lake, on the surface, and on its borders. Damaged lake conditions will encourage the loss of species as biological entities, loss of genetic material, and biochemistry, and disruption of the lake ecosystem. According to Wiratno, the threat of lake ecosystem comes from the threat of the introduction of foreign species, forest conversion, garbage, weeds, illegal logging, erosion, and sedimentation, as well as law enforcement which is increasingly difficult due to increasingly sophisticated modus operandi. Wiratno added that of the fifteen Priority Lakes, only three lakes

are included in the conservation area: Rawa Danau in Banten, Matano Lake in South Sulawesi, and Sentarum Lake in West Kalimantan. (Hadi, 2019).

Matano Lake is a lake located in East Luwu Region, South Sulawesi Province. Close to Lake Matano, there is Lake Towuti which is at the exact location. Historically, the two lakes are designated as protected forest areas in the Decree of the Minister of Agriculture No.45/KPTS/UM/1/1978 on January 25, 1978. Then in 1979, those lakes were designated as a Nature Tourism Park area through Letter No.1243/Dj/I/1979 by the Minister of Agriculture (Unit Pelaksana Teknis Kementerian Lingkungan Hidup dan Kehutanan, 2018).

However, the lake environment began to deteriorate. Starting from damage to water catchment areas (DTA), damage to lake borders, damage to lake waters, and a high risk of disaster. The environmental damage to the lake is caused by a large number of contributors of waste at the dock, such as household waste and market waste (Yunus, 2021).

To maintain the lake's sustainability, it is necessary to conduct research on the parameters of the fertility level of the lake waters. One of the parameters of the fertility level of these waters is chlorophyll-a. Chlorophyll-a is one of the most important photosynthetic pigments for aquatic organisms. In previous studies, observations of chlorophyll-a in Lake Matano and Lake Towuti have been carried out using Landsat-8. However, with these observations, no one has yet made a chlorophyll-a monitoring application through web-based satellite imagery using streamlit.

Therefore, with this research, it is expected to be able to create a web-based application for monitoring chlorophyll-a every year using Landsat-8 medium resolution satellite imagery data. This research was conducted to determine chlorophyll-a's spatial and temporal value from processing Landsat-8 image data using the remote sensing approach based on the 2015 Jaelani algorithm and to create a web-based chlorophyll-a monitoring application on Lake Matano and Lake Towuti using streamlit.

## Data and Method

### 1. Location Study

This research was conducted in Lake Matano and Lake Towuti, which have geographic coordinates of  $2^{\circ}28'29.87''\text{LS}$  and  $121^{\circ}20'9.35''\text{E}$ ;  $2^{\circ}44'0.28''\text{LS}$  and  $121^{\circ}31'25.48''\text{E}$ , respectively.

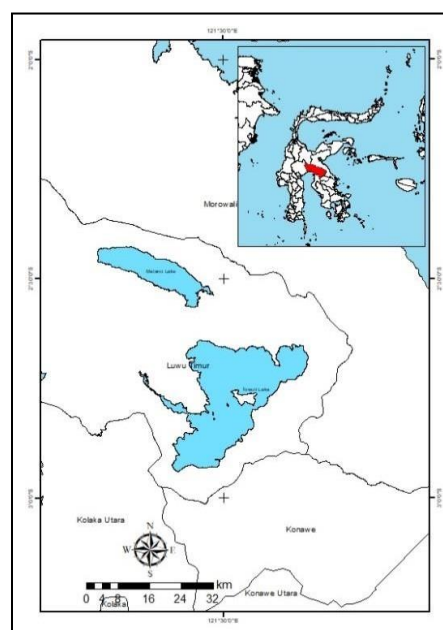


Figure 1. Location Study

## 2. Data and Tools

The data used in this study are Landsat-8 Surface Reflectance Tier 1 satellite images from 2013-2020. The tools used in making web-based applications are divided into two categories, namely hardware in the form of a computer. As for the software used, namely Anaconda which is used for library storage, processing data and running web-based applications; GitHub for script storage and deploying Google Earth Engine to Streamlit; Google Earth Engine as the beginning of scripting using the JavaScript language; Streamlit as a framework in building a website application; ArcGIS is used for map layout; and Visual Studio Code as a code editor at the scripting stage.

## 3. Method

In data processing, there are several steps taken as follows:

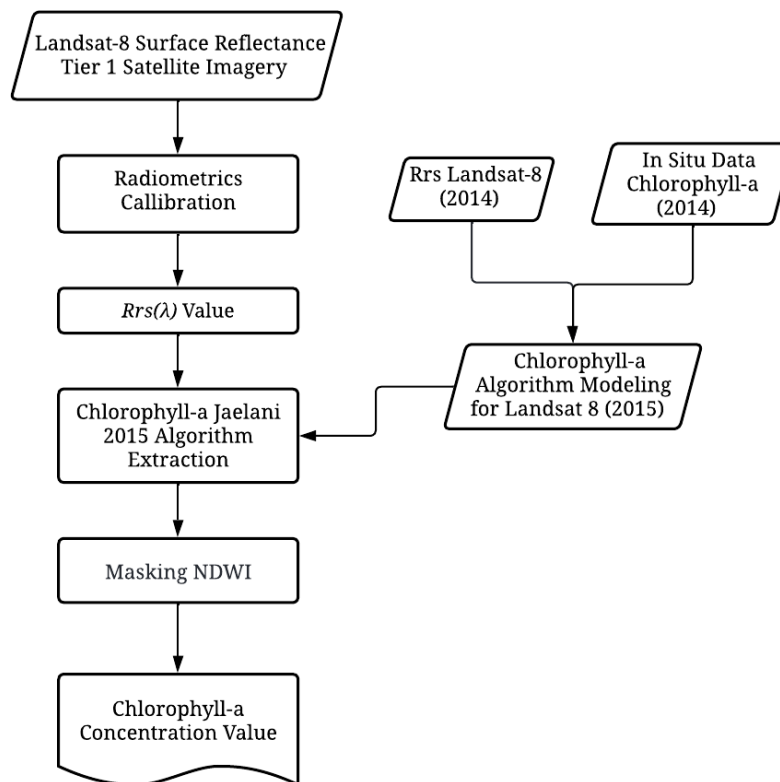


Figure 2. Flow Chart Chlorophyll-a Processing on the Google Earth Engine

The first step is compiling a script to process Landsat 8 Surface Reflectance Tier 1 data, which this arrangement was performed on the google earth engine. Since the data processing in google earth engine still uses the javascript language, it is needed to convert it to python in streamlit. Data processing was processed by first correcting radiometrically on the Landsat-8 Surface Reflectance Tier 1 image to change the digital number value and make  $Rrs(\lambda)$ . Landsat image processing also uses the median reducer to eliminate noise. Then, the chlorophyll-a algorithm was extracted using Jaelani algorithm 2015 and masked the area with NDWI to distinguish between land and water. Jaelani 2015 algorithm was used as follows:

$$\log(Chl - a) = -0,9889 \frac{Rrs(\lambda_4)}{Rrs(\lambda_5)} + 0,3619 \quad (1)$$

Next, the script was converted via computer on anaconda into python language. The steps can be seen in the flow chart in Figure 3. Before the conversion process, it is necessary to create an environment on anaconda which is useful as a directory containing a collection of packages conda that has been installed. The automatic conversion is certainly not perfect; thus, improvements need to be made to improve the script quality. The error from this

imperfection was caused by the incompatibility of the script with the existing library and the basic python programming language. The script preparation for processing Landsat 8 Surface Reflectance Tier 1 data was processed using the geemap, ee, pandas, and streamlit libraries. After that, do the preparation of scripts to create web applications by including a streamlit framework in visual studio code. When the script is finished, it can be used to run streamlit which was on the terminal on anaconda. Furthermore, the script that has been finished and successfully run on a local computer was entered into GitHub, as a place to store scripts.

Then, the script that has been entered into GitHub was deployed via <https://share.streamlit.io/>. Finally, a trial was conducted to determine whether the appearance and function that had been created show any errors. This test was carried out with the help of a user, who then coordinates whether there are errors in running the web application. If it shows an error, the script will be corrected so that the web application can run properly.

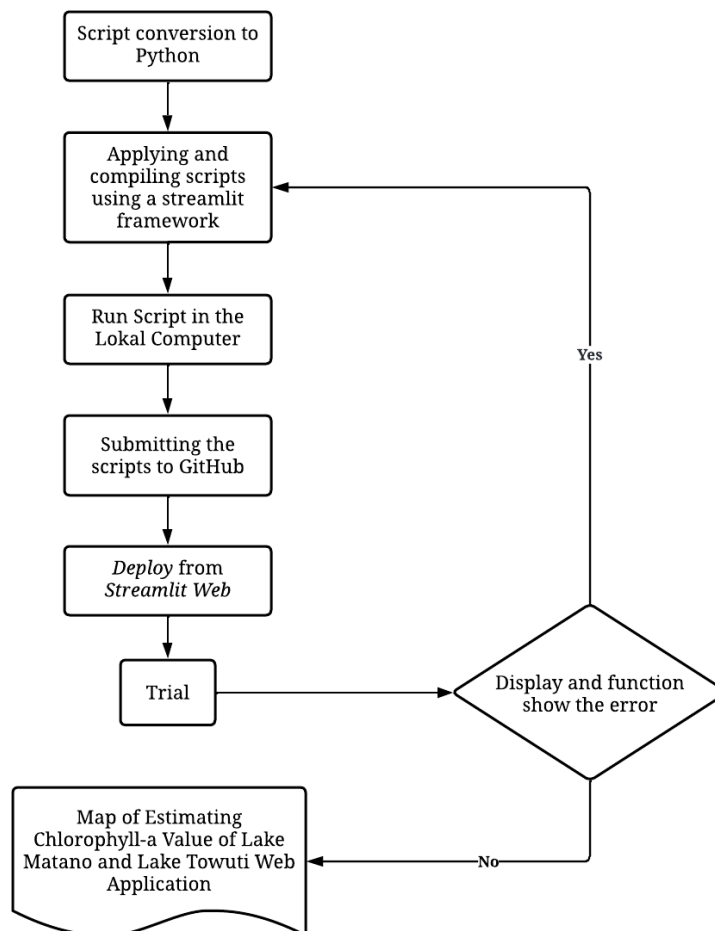


Figure 3. Flow Chart Application Web Modelling on the Streamlit

## Results and Discussion

### 1. Results of Web Application Design

In designing the web application that has been built, an application that displays "Home" and "Chlorophyll-a" has been formed. The results obtained from chlorophyll-a processing are displayed on the "Chlorophyll-a" menu whereas in the "Chlorophyll-a" menu there is "Select Image" which select an image using Landsat 8 Surface Reflectance Tier 1. For the image processing, this application show a chlorophyll-a line, table of values for each year of chlorophyll-a values, time-lapse of chlorophyll-a, and maps of chlorophyll-a every year. The results of the web application design can be seen via the following link: <https://martantiaji-streamlit-klorofila-streamlit-app-wwqtkv.streamlitapp.com/>.

Making web applications using streamlit in the field of mapping is a breakthrough. Streamlit is a free open-source framework that can be accessed by everyone. There are still many streamlit features that need to be explored and researched further. This is because streamlit can provide an attractive and interactive display. Streamlit allows developers to build interactive dashboards and machine learning-based web applications. Streamlit can be categorized into server-side scripting. Server-Side Scripting is a scripting technology or web programming where scripts (programs) are compiled or translated on the server. Designing web applications using this streamlit framework is also easy to use. The python language needed in the design only requires the basic python language. In addition, in web design using a streamlit framework, there is no need to understand how to set the display using CSS, HTML, or JavaScript. The drawback in making this streamlit application is the case sensitivity of making scripts. This sensitivity is due to streamlit using the python programming language which is a case sensitive programming language and a high-level language. For example, in making a script in a variable without using brackets, then wanting to create a new line without using a backslash will cause an error or the script will not run, besides that, for example also using tabs. The following is a display of the results of designing a web application.

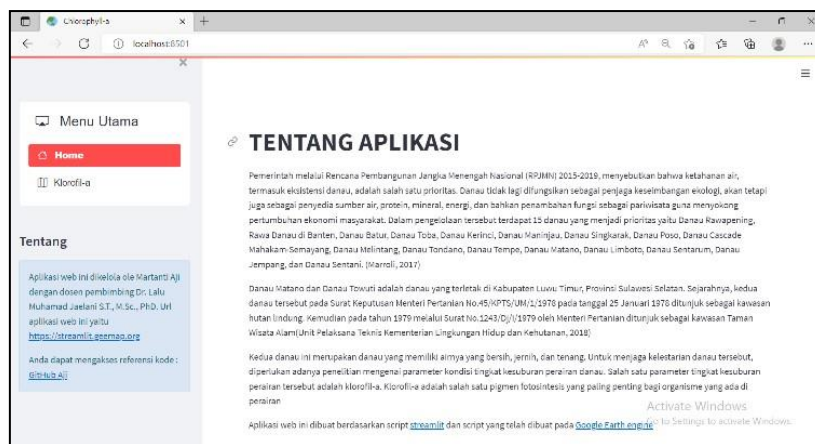


Figure 4. The Display of "Home" menu

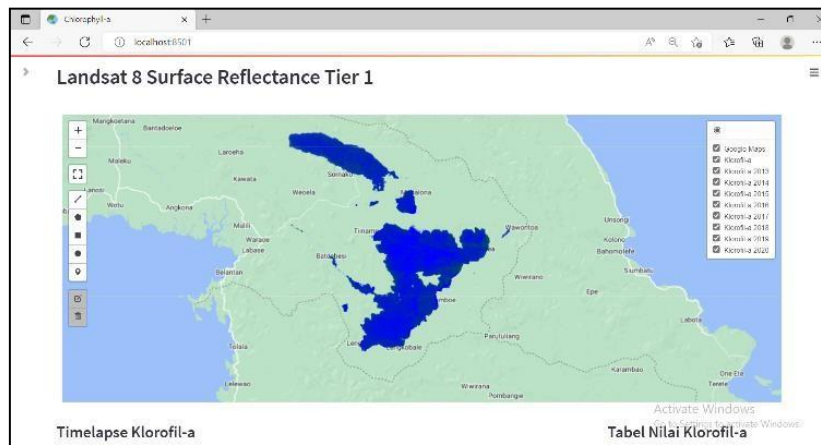


Figure 5. The Display of "Chlorophyll-a" Menu That an Annual Map Section

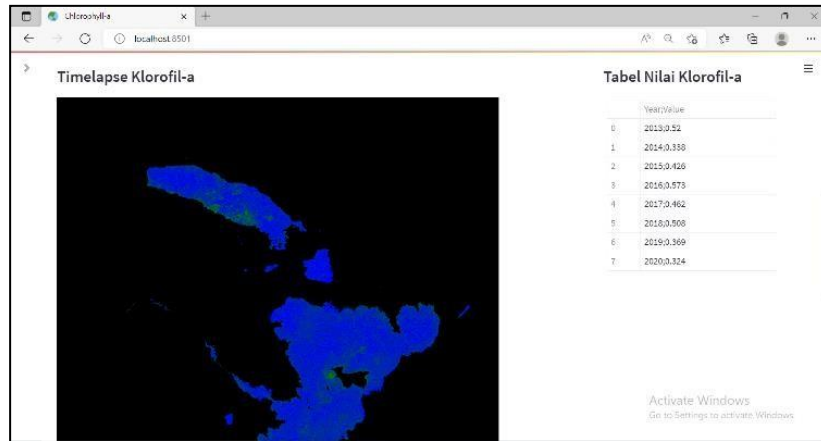


Figure 6. The Display of "Chlorophyll-a" Menu That a Timelapse and Table of Chlorophyll-a Values Section

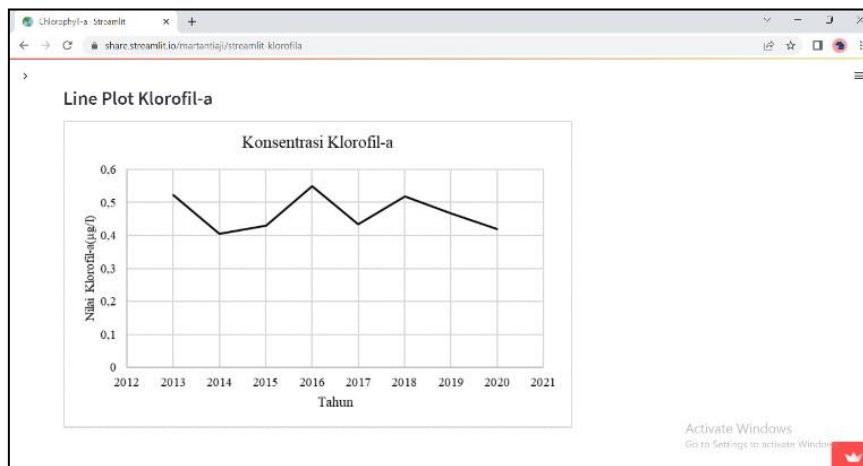


Figure 7. The Display of "Chlorophyll-a" Menu That a Line Graph Section

## 2. Chlorophyll-a Processing Results

In the processing of chlorophyll-a, the estimated value is 0-0.6 mg/m<sup>3</sup>. The minimum value of chlorophyll-a was obtained in 2014 which was 0.4 mg/m<sup>3</sup>. While the highest value of chlorophyll-a was obtained in 2016 with a value of 0.5 mg/m<sup>3</sup>. In the processing of the estimated value of chlorophyll-a, it is found that green areastend to be on the edge of lake waters that occur in shallow areas, or it can be said to be areas close to the edgeof the lake. In addition, the results obtained are in blue, which tends to be in the middle of the waters with deepwaters and away from the mainland. The results of this chlorophyll-a processing are classified into low level,which is included in the type of natural or oligotrophic waters based on Wetzel's 2001 research in accordancewith the Regulation of the State Minister of the Environment Number 28 of 2009. Oligotrophs are the trophicstatus of the lake and/or reservoir water containing nutrients. The low level indicates that the water quality is still natural, not polluted by sources of nitrogen and phosphorus nutrients. However, this oligotrophic trophicstatus has a low fertility rate. The distribution map of chlorophyll-a can be seen in the appendix. It can be seenin Table 1 that the value of chlorophyll-a in processing is in accordance with the average value of the contentin Indonesian waters listed in the journal Nontji (2002), which is 0.19 mg/m<sup>3</sup>. The processing of chlorophyll- a data, it makes the monitoring process easier and closes the shortcomings that exist in conventional methodswhich are limited to problems of spatial and temporal variations, according to the journal Jaelani 2015.



Table 1. Chlorophyll-a Values Every Years

No	Tahun	Nilai Klorofil-a ( $\text{mg}/\text{m}^3$ )
1	2013	0.5
2	2014	0.4
3	2015	0.4
4	2016	0.6
5	2017	0.4
6	2018	0.5
7	2019	0.5
8	2020	0.4

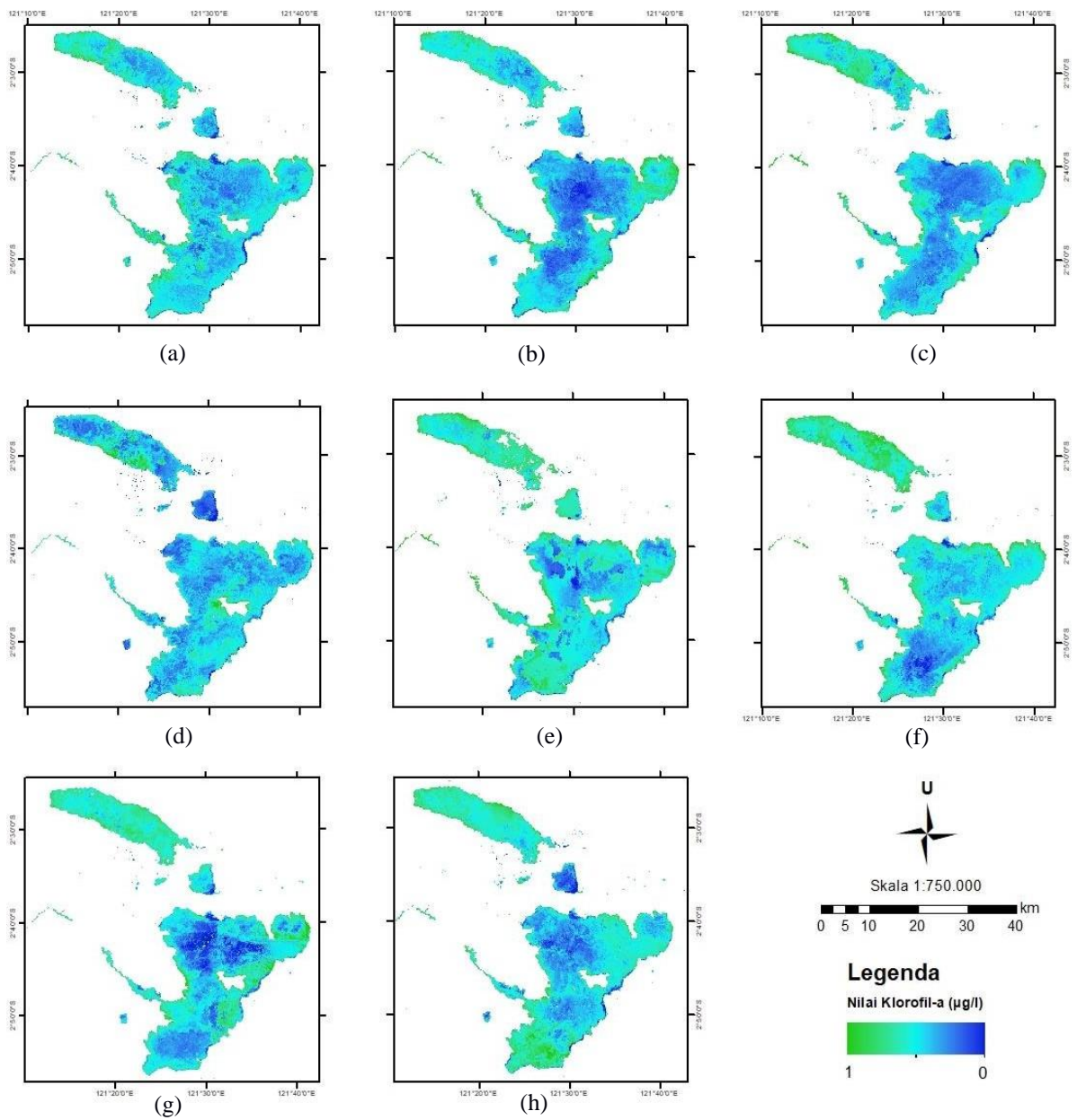


Figure 8. Distribution of Chlorophyll-a in Lake Matano and Towuti. a) Year 2013; b) Year 2014; c) 2015; d) Year 2016; e) Year 2017; f) Year 2018; g) Year 2019; h) Year 2020

## Conclusions

Based on the process of designing and processing chlorophyll-a, it can be concluded that the estimated value of chlorophyll-a ranges from 0-0.6 mg/m<sup>3</sup>. The range from this value is related to the status of oligotrophic waters, namely water quality at low fertility levels. The results of the web application design display an explanation of the web application created and the results of chlorophyll-a processing. The web application can be viewed via the link <https://martantiaji-streamlit-klorofila-streamlit-app-wwqtvk.streamlitapp.com/>. The advantages are that streamlit has a language that is easy to understand without the need to know how to display web creation using HTML, CSS, or JavaScript. However, streamlit also has drawbacks, namely in making streamlit applications, the sensitivity in making scripts is caused because streamlit uses the python programming language which is a case-sensitive programming language and high level language.

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