Identification of Surface Temperature Relation to Total Suspended Solid in Beratan Lake Using Multi-Temporal Remote Sensing Imagery

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Abstract. This study aims to find out the correlation between lake surface temperature and the distribution of sedimentation from Landsat 8 OLI/TIRS imagery. As it is known that the Lake Beratan area is a tourism area that continues to grow and experiences changes in land use. As a result, the Beratan Lake area experiences changes in surface temperature and pollution both directly and indirectly and is supported by the potential for silting due to lake sedimentation. Therefore, a quick study is needed to carry out monitoring through an approach with remote sensing imagery using the SST and TSS methods in the identification carried out. The results show that the low (r2= 0.47) relationship or not relationship between the surface temperature of the lake and the sedimentation that occurs, even so, there is a decrease in surface temperature that occurs as a result of changes in the microclimate that exists in the tourism area of Lake Beratan.

Keywords: Beratan Lake, Landsat 8, SST, TSS

1 Introduction

Sedimentation is a very important matter to pay attention to, especially in lakes or reservoirs. Especially Indonesia which has two dominant climates to make the sedimentation of a lake rapidly increase. The impact of sedimentation in a short time is difficult to know just like that, but if over a certain period of time and occurs continuously, silting of the lake or pollution due to siltation is possible to occur [1]. Problems related to sedimentation do not only come from climate but from land changes around lakes or reservoirs in a particular watershed (DAS). The higher the change in land between agricultural land or forest into a built-up area, the faster the silting occurs because surface water will directly enter the river with all the materials carried up to the estuary in the form of lakes, reservoirs, or the sea [2].

Observation of sedimentation is something that is important to do as a form of control and conservation of watershed conditions whether they are healthy or not. The process of direct observation of sedimentation has a complex subject because it requires a long time, precise techniques, and high costs in laboratory measurements and tests. Furthermore, related to the surface temperature of the lake into one unit with the presence of sedimentation. There are indications that increased sedimentation will have a significant effect on lake surface temperature changes. This condition will change the microclimate around the lake and can slowly change the ecosystem, especially during the rainy and dry seasons. Therefore, fast and

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efficient methods with high accuracy are needed, such as field observations to observe sedimentation and lake surface temperature. Remote sensing is an appropriate method for observing sedimentation using remote sensing imagery. In addition, remote sensing can also be used for measurements related to vegetation, physical geography, or urban areas [3–9]. SST and TSS is part of method in remote sensing and is mostly used in coastal areas to determine the magnitude of changes in the coastal line or sedimentation carried by rivers to the sea and also to determine sea surface temperature. Remote sensing as a medium for measuring sedimentation uses the Total Suspended Solid (TSS) analysis approach and surface temperature which can be assumed to be the sedimentation value and surface temperature of the lake. Measurements through remote sensing imagery cannot be carried out at one time but must be multi-temporal to confirm changes in sedimentation and lake surface temperature in the measurement process through remote sensing imagery. Not only that, measurements related to changes in sedimentation associated with changes in lake surface temperature can be carried out through remote sensing imagery to be associated with changes in sedimentation that occur in the study area.

Surface area of the lake was carried out in the area of Lake Beratan, Bali. Lake Beratan is one of the largest lakes in Bali and is part of the Bali tourism area. Lake Beratan is a tourist location for domestic and foreign tourists because of its location in a mountainous area and has complete facilities to enjoy. Therefore, land use change in the Lake Beratan area is unavoidable due to an increase in population and high economic growth in the area. It is known that the Lake Beratan area is the highest visited area as a tourist location for lakes in Bali, both domestic and foreign (Table 1), so the impact of environmental change, especially sedimentation, cannot be avoided. Furthermore, not only sedimentation in the form of material but tourism waste is part of the sedimentation in Lake Beratan such as oil and oil from motor boats.

Previously, research had been carried out related to sedimentation and water quality on the pollution experienced by Lake Beratan from increased human activity and changes in land use. Atmaja [10] states that Lake Beratan has an increased PH as a result of the addition of other organic matter and increased sedimentation from soil and small gravel. Not only that, Atmaja [11,12] conducted research on the quality of water in residential areas and found that the water in the wells was unfit for consumption because the Total Disolved Solid (TDS) and turbidity values exceeded the provisions set by the Indonesian Ministry of Health No. 907/MENKES /SK/VII/2002. Therefore, it is necessary to know that rapid monitoring of changes in sedimentation and surface temperature can have an impact on water quality around Lake Beratan. In addition, this research is the basis for direct sedimentation measurement research and as a comparison of how much difference the two methods have in measuring sedimentation over a large area. Furthermore, changes in lake surface temperature are important for reviewing climate change in the area due to excessive lake evaporation so that it can change the microclimate of the area around Lake Beratan. Knowing from this explanation, research related to changes in sedimentation and lake surface temperature is important to carry out not only as a method test but also as an initial reference in measuring the surface temperature of a lake with gravity.

2 Study Area and Data

2.1 Study Area

The research location is focused on the Beratan Lake area which is located in the Bedugul highland caldera, which is one of the tourist attractions on the island of Bali, located approximately 50 kilometers to the north of Denpasar city and approximately 43 kilometers to the northeast of Tabanan city. The area of the study area based on the Topographical Map of the 1: 50,000 scale in 2000 was calculated using a grid system covering an area of 17.25 square kilometers, consisting of a catchment area of 14.26 square kilometers and a lake surface area of 3.764 square kilometers.

2.2 Remote Sensing Data

This research uses Landsat 8 OLI/TIRS imagery in May 2019 and can be obtained for free on the USGS's official website http://earthexplorer.usgs.gov. The stages of Landsat image processing are carried out starting from radiometric correction, such as changing the Digital Number (DN) to Reflectant then Top of Atmospheric (TOA) correction and ending with Dark Object Subtraction (DOS) correction [13–15]. In the geometric correction, no changes were made because Landsat 8 already has an accuracy level according to the position of the earth's surface and it has been stated in the metadata and also the image level, namely level 1T [16].

3 Method

The data processing in this study are shown in Figure 1.

3.1 Sea Surface Temperature (SST)

Sea Surface Temperature uses an algorithm developed by Cahyono et al., [17] which uses two thermal bands on the Landsat 8 OLI/TIRS imagery. The equation for identifying the surface temperature of the data is shown in Equation 1 below.

$$\mathrm{SST} = b10 * \big(2.946 * (b10 - b11)\big) - 0.038 \quad (1)$$

Where the values of b10 and b11 are Landsat 8 thermal bands after atmosferic correction.

3.2 Total Suspended Solid (TSS)

The TSS for Landsat 8 OLI/TIRS uses the method developed for the Mahakam waters through the Bio Optical Modeling method used for remote sensing technology. The equation for TSS is shown in Equation 2 below.

$$\mathrm{T}SS = ((8.1429 * (\exp(23.704 * 0.94 * b4)) \quad (1)$$

Where b4 is red band in Landsat 8 OLI and the b4 used after correction atmosferic.

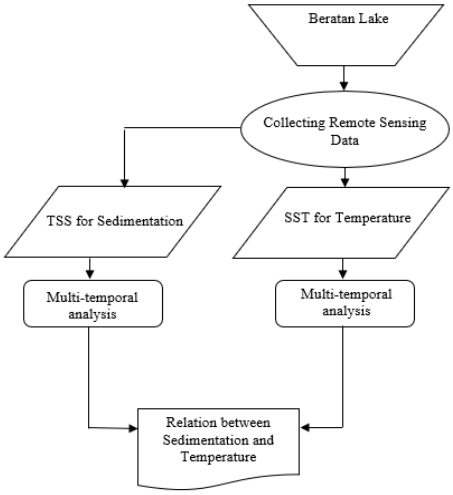

Fig. 1. Research Flowchart

4 Result and Discussion

Measurements of Lake Beratan surface temperature using multi-temporal remote sensing imagery show that there has been a decrease in temperature from 2015 – 2021. The remote sensing imagery used is Landsat imagery which was recorded in the same month, October. The decrease in surface temperature that will occur in 2021 is possible due to changes in the microclimate in the Bedugul tourist area. It should be noted that the measurement process with remote sensing imagery for lake surface temperature adopts land surface temperature measurements. Nugraha [18,19] said that land surface temperature measurements with remote sensing imagery have a high degree of accuracy. This of course depends on the method used to obtain the surface temperature which is divided into three methods for surface temperature extraction [20,21].

The steps carried out are similar, it's just that the determination of the surface temperature of the lake is different. The algorithm used for lake surface temperature comes from a study by Cahyono et al., [17] by considering both thermal bands from Landsat 8 imagery. This is similar to the Split windows algorithm method which uses two thermal bands to obtain land surface temperatures [7,19,21]. As previously stated, there is a decrease in surface temperature from 2015 to 2021 due to activities and changes in the physiographic characteristics of the research area. In 2015 the Bedugul tourist area still uses one tourist route with natural hilly conditions even though the tourist route is a dense area of vehicles and is able to provide climate change, especially temperature. In addition, Lake Beratan itself has cooler air temperatures than the surrounding area because the area is located at an altitude of 1239 meters above sea level. The cause of the lake's surface temperature having a high value is because the pollution of vehicles that cross Lake Beratan does not directly decrease in the air but is in the area around Lake Beratan which causes the surface temperature of the lake to be higher than in 2021 (Figure 2).

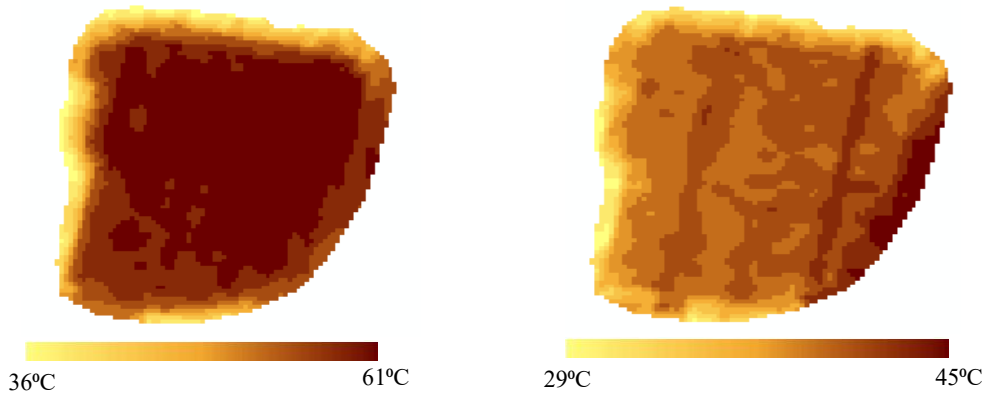

Fig. 2. Sea Surface Temperature result (a) SST Landsat 2015 and (b) SST Landsat 2021

In 2021, significant changes have been made to the Bedugul tourist area around Lake Beratan. The changes made are to break up the flow of vehicles by making short cut roads so that traffic in the tourist area is divided. This has an impact on air temperature conditions in particular, because some of the pollution that comes out can immediately decompose into the atmosphere and is not retained as a result of the temperature differences that exist in the Beratan Lake area. It should be noted that changes in the dynamics of lake surface temperature are more dynamic than ground surface temperature because several factors also have a role as well as climate, especially sunlight which has a big impact on lake surface temperature changes. The results of the research that has been carried out have different values from previous studies, namely Cahyono et al., [17] and Alfatinah [22] where they measured sea surface temperature with a range of values between 27 - 34ºC. The temperature difference generated by research in the lake is possible because the material contained in seawater and lake water is different. The difference is due to the significantly high sedimentation rate in Lake Beratan, as researched by Atmaja et al., (2016) which states that in Lake Beratan there are three sedimentary materials, namely soil, sand, and clay with the highest content being soil material of 78% (Figure 3).

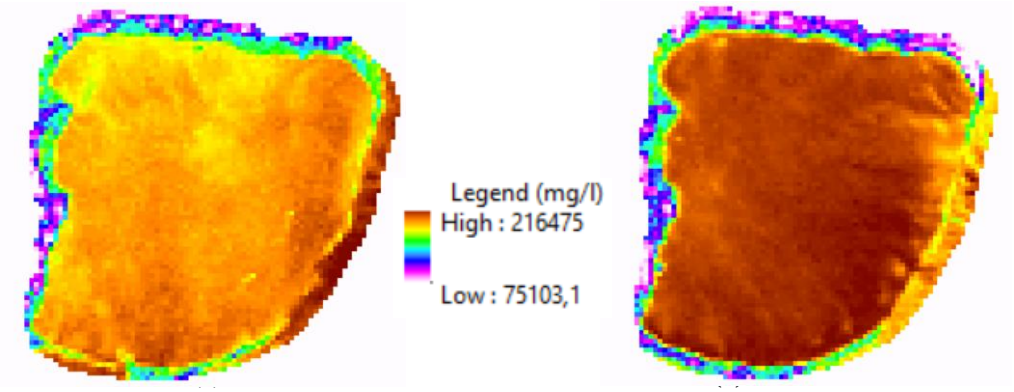

Fig. 3. Total Suspended Solid result (a) TSS Landsat 2015 and (b) TSS Landsat 2021

Thus, it can be said that in 2015 the surface temperature of the lake identified by remote sensing imagery came from climate change caused by vehicles, but in 2021 the surface temperature of the lake came from the sedimentation process that continues to occur in the lake area, considering the intensity of vehicles has been broken down. and the resulting level of pollution has been reduced. Therefore, it is necessary to conserve the lake area, especially in the case of sedimentation on the outskirts of the lake, and this can cause lake siltation and increase the surface temperature of the lake to rise slowly.

5 Conclusion

Comparison Identification of lake surface temperature through Landsat 8 imagery can be carried out of course with consideration and conducting a micro-study of the area because differences in lake surface temperature can not only occur during the processing process but are possible from external factors such as sedimentation and vehicle pollution. Surface temperature and sedimentation are associated with a linear relationship that does not have a direct correlation. Considering that sedimentation has an effect on lake siltation and surface temperature, identifying the temperature of the surface water of the lake, although it is possible that sedimentation material may still exist in the area around the surface of the lake, it is very micro-sized and difficult to identify directly in the field and must be measured in the laboratory.

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