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Literature Study on Conditions of Sea Surface Temperature and Seawater Rise in Indonesia Detected by Remote Sensing

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Abstract

The Sea Surface Temperature (SST) is an important parameter for climate dynamic issues either globally or regionally as well as for global warming issues. In some condition the parameter can cause melting glaciers that will influence the rise of the sea levels. The further effect will be the climate change with the weather phenomena such as storms, hurricanes and heavy rains. As the result, the changes of the planting seasons occur and all of these will harm human life on earth. If there is no prevention with the condition of the parameter it is predicted that by 2040 the sea levels will rise highly because of the melting polar ice caps that will cause the sink of the islands. The SST has been detecting using remote sensing methods for 32 years in Indonesia. The trend has increased to reduce the damage of infrastructure and the activity disturbance of coastal communities. Indonesian country optimistically commits to achieve the target of net zero emission by 2060. The Indonesian government has stated nationally the climate target commitments determined for Indonesia and will strive to maintain the main target of reducing greenhouse gas emission into 41% by 2030.

Keywords: Sea surface temperature, Global warming, Sea-level rise, Remote sensing

1. Introduction

Remote sensing is one of the technologies to overcome some problems mostly occurred in archipelagic countries. The technology of remote sensing can perform encroachment on territorial boundaries, determine the location of natural resources, and carry out early detection of natural disaster. The technology can also measure effectively the Sea Surface Temperature (SST) as a very important parameter of climate dynamics issues either globally or regionally as well as for global warming issues (Mulyani, 2021a). The measurement outcome can be carried out spatially and timely in a short time on a wider scale. Hence, in this case, very broad information can be obtained on a global scale. The satellite capabilities can make the remote sensing technology capture the mapping images of an area based on its specifications. By using the remote sensing techniques, the information needed for areas or places that are difficult to reach will be obtained more easily. This process can be done without having to collect data directly because the remote sensing system can detect objects on the earth's surface from the satellite sensors. The system works when the electromagnetic radiation emitted by objects on earth' s surface is detected by the satellite sensors.

The increase of average temperatures in the atmosphere, at the sea, and on the land of the earth's surface can cause global warming. According to the scientists, there are many human activities contributing to global warming that makes the excessive amounts of greenhouse gases to the atmosphere. The greenhouse gases such as carbon dioxide can build up in the atmosphere. The heat of the gasses is trapped and normally released into the atmosphere. The heat is then absorbed by seawater that increases the SST which can cause global warming. Sequentially the effects of global warming are melting glaciers, climate change, extreme weather, and decreasing food quality that will harm human life. The melting glaciers can change the climate that makes the weather phenomena become extreme. There can be much more storms, hurricanes, heavy rains and changes in planting

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seasons. In addition, threat of tropical storms, tsunamis, floods, landslides, and droughts which can increase the potential causes of fires can occur. Moreover, various types of fishes can become extinct, coral reefs can be damaged, and there can be clean water crisis that can increase the spread of parasitic diseases (Mulyani, 2021a; Triana, 2008). Scientists who are members of the Intergovernmental Panel on Climate Change IPCC) from several countries have observed the temperature changes on earth. It turned out to the various problems. They found that within 15 years from 1990 to 2005 the temperature on earth was evenly increased with the range from 0.15^0C to 0.3^0C. As a result, the melting ice in Greenland and Antarctica occurred and caused the rising sea levels approximately 1 meter every year that sank small islands. Based on the research performed by scientists who are members of the Antarctic Survey Institute, more than one million hectares of icebergs in the western part of Antarctica can be melted or broke. It indicates that the condition in Antarctica or the southern polar circle will change rapidly due to the increase of the earth's temperature. If this situation continues, it is predicted that in 2040 the polar ice caps will melt, the sea levels will rise, and the islands will sink; of course, it is a serious disaster of the earth and everything in it (Al Tanto, 2020).

The lifestyle and the irregular increase of population growth can make various human activities that influence the earth's temperature to become warmer which can damage the environment (Mulyani, 2021b). Hence, many human activities including deforestation and forest burning, motorized vehicles, industrial pollution can become the trigger of global warming. Besides, acidification of seawater, extreme weather, and excessive heat absorption of the oceans will occur and worsen the condition. Human behavior and other factors can impact the increase of ocean temperature that sequentially causes the melting of ice in Antarctica and the rising of sea levels. In fact, the process of global warming has begun even since hundreds of years ago. The effects, however, start to happen and can be felt nowadays. They are climate instability, heat energy, water vapor in the atmosphere, much higher rainfall, larger hurricanes, shifts in the rainy and dry seasons as well as unpredictable and extreme weather changes anomalies. The climate instability can cause storms and high waves that disrupt fishing activities. The rising sea levels can increase floods in cities closed to the coast.

The other impact continues that global warming can disrupt agricultural products because of the extreme weather which can causes severe drought during the dry season in tropical countries. The drought can dry up most of the agricultural lands. Meanwhile, the extreme weather can also make viruses as well as bacteria grow and multiply stronger and faster that can cause new diseases. As global warming has been getting worse, the solution must be started immediately by converting barren land into green land and educating people to live with a healthy and energy-efficient lifestyle.

The remote sensing technology that is developed increasingly can be used to detect surface water temperature related to SST. It is the first step to detect the possibility of disaster on earth because SST is one of the important indicators of climate change. As a consequence of global warming, people must adapt themselves to live in condition of hot air. Alternatively, the triggers of global warming must be reduced. It is necessary to take action or attempt to reduce emissions and greenhouse gases.

This paper aims to detect SST waters in Indonesia for 32 years and sea-level conditions in some waters also in Indonesia using remote sensing methods with data obtained from satellite imagery. The changes of symptoms and temperature are needed to be monitored regularly to analyze the distribution pattern of SST. The initial results of surface temperature detection are intended to anticipate disasters through policies carried out by the competent authorities. The method used is a literature study obtained from scientific reviews that have been previously carried out and published as scientific journals.

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2. Materials and Methods

Materials-Literature Review

NO	Author, Year	Research result
1.	Al Tanto, (2020)	This research uses a literature review method on detection. Indonesia's average sea surface temperature is around 26ºC - 31ºC (NOOA estimation 1993-2003), with an accuracy of > 90%; the difference between SST measurements with the field and the estimation results is 0.2ºC. SST conditions in Indonesia were quite high in July 2015, around 29.1ºC-29.8ºC (MODIS estimate), with a correlation coefficient of r = 0.72 and Root Mean Square Error (RMSE) 0.72ºC. In the eastern waters of Indonesia (north of Papua), the MODIS (Aqua) estimation results are 29.10ºC - 29.36ºC. MODIS (Terra) of 28.88ºC - 29.19ºC. The RMSE values obtained from MODIS image interpretation are 0.2461ºC (Aqua) and 0.4854ºC (Terra). In these waters, the average SST value is 29.11ºC-29.65ºC (NOAA estimates, 2010 - 2012) with a bias of -0.43 and an average RMSE of 0.2228ºC. The accuracy of the microwave sensor in SST reaches 0.5ºC, free from the influence of cloud cover. The distribution of SST TRMM (Tropical Rainfall Measuring Mission/Microwave in 2008) in Indonesian waters is 21ºC-31ºC. Correlation coefficient value of 0.95 and an RMSE value of 0.24 K. It turns out that there are differences in the estimated values in the use of some of the satellite imagery data used. In general, a better SST value is found in the NOOA-AVHRR satellite measurement with a fairly low bias and RMSE, but it is at risk because it is affected by cloud cover. The use of the TRMM (Microwave) sensor has slightly higher accuracy but is not affected by cloud cover.
2.	Alfajri, Mubarak, & Mulyadi, (2017)	The study was conducted in Sumatera Barat Waters using Aqua Modis to determine the fluctuation and distribution of SST and the factors causing it. The study was carried out from March to April 2016, with daily results observed from February 15, February 20, February 25, March 2, March 7, and March 12, 2016. The results show that the highest temperature was 34.54ºC occurred on February 15, and the lowest temperature of 27.41ºC occurred on March 12, 2016. Meanwhile, the average SST between April 2015 and March 2016 was 27.07ºC - 34.98ºC.
3.	Ariani, (2018)	Data observed from the Topex/Poseidon, Jason 1, Jason 2, Jason 3 altimetry satellite reference missions used to analyze the trend of sea-level rise in Indonesia and its spatial distribution. After doing the least square intercalibrated and seasonal-trend decomposition procedure based on loess, it is known that the sea level rise rate in Indonesia is 4.6 ± 0.2 mm/year in the period 1993-2018. The linear trend is positive; it shows that the sea level in Indonesia will continue to increase with the equation y = 4.6x - 9133.5. Where y is the sea level anomaly in mm, and x is the time in years. Based on the analysis of the spatial distribution of sea-level rise with a 3x3º grid, it is known that the fastest sea-level rise occurs around the islands of Madura and Bali, as well as parts of Flores Island at a speed of 7.4 mm/year.
4.	Azizah & Wibisana, (2020)	The research results from 2018-2020 are that the temporal variation of SST using Terra Modis in the coastal area of Malang has increased. SST in 2018 ranged from 25ºC-26ºC, and in 2019 the SST value ranged from 26ºC-27ºC, while in 2020 the SST value ranged from 30ºC-31ºC. The highest SST value occurred on May 23, 2020, with an average temperature reaching 30.8ºC. The lowest SST occurred on May 22, 2018, at 25.7ºC. The distribution of SST was made by mathematical modeling, and the most optimum mathematical model was at 667 nm wavelength occurred on May 23, 2020, with the equation model Y = -0.498 ln x + 27.936, which results

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		in a correlation value of R = 0.6561.
5.	Cheng et al., (2021)	The SST reached a new record in 2019 with the warmest level recorded history, reaching 228 Zettajoules (ZJ), above 1981 to 2010 average temperature and 25 ZJ above 2018. The research results in 2020, with temperature measurements at a depth of 2000 meters, show that SST reached higher values than the data in 2019. At the top of the world's oceans, it absorbs 20 Zettajoules more than the previous year (1 Joules=1.0E-21 Zettajoules). The researchers took the data from various sources then used it to calculate the temperature of seawater, especially seawater, at a depth of 0 to 2,000 meters.
6.	Dwi Ayu, Sukojo, & Jaelani, (2011)	The research was conducted in Java, Madura and Bali islands using Aqua Modis. The results showed that the average SST in 2005 it was 26.89ºC, in 2006 it was 26.25ºC, in 2007 it was 29.89ºC, in 2008 it was 28.87ºC, in 2009 it was 28.22ºC and in 2010 it was 22.9ºC. In 2010 the average SST decreased because the rainy season was so long that clouds covered the earth.
7.	Emiyati, Setiawan, Manopo, Budiman, & Hasyim, (2014).	SST analysis was carried out temporally and spatially in 2009-2013 using MODIS (Moderate Resolution Imaging Spectroradiometer) Aqua Terra, the research site was divided into two, namely the northern waters of Lombok and South Lombok. The maximum SST value in the northern waters of Lombok and the southern waters of Lombok occurs in April, and the minimum value occurs in August. The distribution of SST for one year in Lombok waters forms a sinusoidal pattern, and SST in northern Lombok waters has a higher value than southern Lombok waters. The SST trend for five years in the waters north of Lombok and south of Lombok tends to decrease.
8.	Gaol, Tambunan, Osawa, Pasaribu, & Nurjaya, (2017)	Satellite altimetry data for 23 years (1993-2016), tide gauges, and Digital Elevation Model (DEM) data are used to determine the impact caused by an average sea-level rise. Sea-level rise on the east coast of North Sumatra has a significant negative impact on coastal activities and ecosystems. The regional mean sea level trend during the period estimated from satellite altimetry is 5.0 mm/year. The potential loss of coastal areas in these areas due to 1 m and 2 m inundation can range from 11.9 km2 to 63.8 km2, respectively.
9.	Mansawan, Lumban-Gaol, & Panjaitan, (2016)	The study was conducted in the coastal waters of Cilacap and Bali with analysis of Envisat satellite altimetry data for the period 2003 to 2010 plus data collected from various altimetry satellites from 2006 to 2014. Tidal data was used as a comparison of altimetry satellite data. More than 90% of satellite altimetry data in the waters of Cilacap and Benoa can be used to assess variations and sea-level rise during the 2003-2010 period. The rate of sea-level rise in both tidal data and satellite altimetry shows the same figure is 3.5 mm/year in Cilacap; in Benoa, it is 4.7 mm/year and 5.60 mm/year.
10.	Mayasari & Handoko, (2010)	Utilization of Topex/Poseidon altimetry satellite data and SST data from 2002-2005 is expected to correlate between changes in sea level position and sea surface temperature to know changes in sea-level rise in Indonesian Waters. Binary data processing from the Topex/Poseidon altimetry satellite using the Basic Radar Altimetry Toolbox (BRAT) 2.0.0 software. The previous data processing used Matlab software to compare the BRAT software.
11.	Mujadida, Setiyono, Handoyo, Hariyadi, & Marwoto, (2021)	This study aims to analyze the dynamics of sea-level change in the Java Sea and predict future data using a machine learning approach with a Recurrent Neural Network (RNN) network architecture. The main data used is data on

		sea-level anomalies in the Java Sea from 1993 to 2019 published by the Copernicus Marine Environment Monitoring Service (CMEMS) supported by a map of the Indonesian Earth and a map of surface currents in the Java Sea. The analysis results show that there has been an increase in sea level values since 1993, around 37,545 mm/year. The fastest trend of sea-level rise in the Java Sea reached a value of 72,313 mm in 2015-2016, while the slowest trend occurred in 2002-2005 at around 16.7 mm. Due to El Nino and La Nina phenomena, changes in extreme sea level trends occurred in 1996-1998 and 2010-2016. Evaluation of the RNN model obtained an MSE value of 0.000343, an RMSE value of 0.0058564, an R2 value of 0.993, and an MAE (Mean Absolute Error) value of 0.0045024. The evaluation results show a very small error value, so it can conclude that the RNN model is very accurate in predicting the sea surface dynamics.
12.	Putra, Karang, & Putra, (2019)	Putra et al. (2019) used AVHRR (Advanced Very High Resolution Radiometer), to monitor SST in Indonesian marine waters. In general, it was found that there was an increasing trend of 0.28ºC SST in Indonesian marine waters for 32 years (1981 - 2012). The domain is located at 14ºC North Latitude – 15ºC South Latitude and 90º East Longitude – 145º East Longitude. While the amount of SST ranges from 26.8ºC-29.1ºC
13.	Syaifullah, (2015)	Syaifulah was conducted SST observation research to know the relationship between the increase in SST and global warming in Indonesian waters. The data used in SST data for 32 years (1982 - 2014) is made in time series with spatial analysis and temporal analysis methods. During a period of 32 years, it turns out that there have been changes in temperature in Indonesian waters that vary. In general, the southern region of Java waters increased in SST for 32 years, as well as the waters of West Sumatra increased in SST for 32 years, and lastly, the South China waters also increased in SST for 32 years, but the increase was lower than the waters of Java and waters of West Sumatra. The greatest increase in temperature occurred in the waters of the western Pacific Ocean to the north of Papua. SST anomalies were also found, namely deviations from the sea surface temperature from its normal/historical value at a certain time, while sea surface temperatures in Indonesia ranged from 26ºC - 31.5ºC.
14.	Sulaiha, Handoko, & Yuwono, (2020)	Sea level variations observed in the Java Sea and the South China Sea using Altimetry satellites, Jason 1, Jason 2, and Jason 3 from 2002-2019 showed a sea-level rise rate of 4.1 mm/year, where high velocity occurred around the North or South Java Sea, with a value of 7-9 mm/year.
15.	Tampubolon, & Gustin, (2016)	Aqua Modis was used in Riau Islands Province to monitor of temperature, symptoms of changes, and their distribution can be well described by channels 20, 31, and 32. The validation test carried out was worth 88.6%; this shows that the SST image processing results represent the real condition. The results are presented in an SST information map, and the temperature distribution is presented in web-based spatial information.

The method used in this study is a literature study approach taken from scientific journal publications**.** The monitoring of SST in Indonesian territorial waters becomes the materials to find out whether there is an increase of temperature and the rise of sea**-**levels using remote sensing methods. Consequently, if the increase of sea surface temperature that can cause disasters occurs, the anticipation must be done to prevent such disasters**.** For this research, a study of scientists' findings is carried out as much as possible to get the best results.

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3. Results and Discussion

Scientists performed the studies that have been carried out for approximately 32 years in various waters in Indonesia including Java, Madura, Bali, West Sumatra, South China, the Pacific Ocean at North of Papua, Lombok, and Malang**.** It turns out that the SST in most of the waters in Indonesia has increased**.** The lowest SST value occurred in 2008, that was around 21^0C, and the highest value in the same year reached 31^0C. Between April 2015 and March 2016 the lowest SST value was 27.07^0C and the highest SST value was 34.98^0C, and in 2020 the SST value was between 30^0C and 31^0C. Based on those data, it turns out that the lowest value occurred from year to year has increased. It started at 21^0C in 2008, then it became 27.07^0C between April 2015 and March 2016, and finally it reached 30^0C in 2020. The highest SST value was 34.98^0C that occurred between April 2015 and March 2016 (Alfajri et al., 2017). These findings observed by scientists are serious matter because SST is an important measure to determine the impact of climate change**.** The ocean can absorb more than 90% of the heat from the greenhouse gases generated by burning fossil fuels, forest fires, and other human activities**.** The condition of hot seawater over a long period is an important indicator of climate change both in the past and present.

The increase of temperature on earth is caused by various factors carried out mostly by humans. They include the burning of fossil fuels, the industrial sector, transportation, deforestation, agricultural and livestock activities**.** These human activities produce carbon emissions that impact the greenhouse effect as the cause of the increasing temperature on the earth**'**s surface. As the further result, it can disrupt the balance condition of ecosystem which is actually necessary to harmonize all living things with their environment. Obviously, the damage of the environment can disturb the balance condition of ecosystem that become a catastrophe which makes living things miserable. It turns out that human activity is the dominant element of ecosystem disturbances**.** All human beings must participate in the restoring process of the environmental balance**.** Humans are the God**'**s intelligence creatures who are responsible to create good environment (Mulyani, 2021b).

Global warming has started since the industrial revolution with the emission of greenhouse gases caused by human activities. The increase of the greenhouse gases is trapped in the atmosphere that has disrupted the flow of natural energy causing imbalance of the energy system on earth. The ocean absorbs more than 90% of heat due to greenhouse gases resulted from burning fossil fuels, forest fires, and other human activities. This condition can cause melting ice and rising sea levels that prove the change of the climate meaning that global warming occurs**.** It is a warning for Indonesia to be always vigilant due to the possible adverse effects. One of the consequences of global warming is the rising of sea**-**level that make the small islands sink. This is a very bad impact for developing archipelagic countries such as Indonesia. The rate of the sea**-**level rise for both tidal data and satellite altimetry in Cilacap is 3.5 mm / year; while in Benoa they are 4.7 mm/year and 5.60 mm/year (Mansawan et al., 2016).

To prevent the global warming, there are several activities that can be performed**.** Reducing the use of fossil fuels can reduce energy consumption. It can be implemented by reducing the use of motorized vehicles because they consume much energy and cause air pollution**.** The individual users of motorized vehicles can be encouraged to use public transportation to carry out them for their daily activities**.** Meanwhile, the public transportation must be supported with good facilities including security guide and standard comfortable requirements for passengers. All of the supporting facilities must be available to make people decide to use the public transportation instead of their own motorized vehicles**.** Currently, the Indonesian government has provided various public transportation**.** There are LRT (Light Rail Transit), MRT (Mass Rapid Transport), Trans Jakarta Buses, and other public transportation especially in big cities where air pollution is very worrying due to excessive use of motorized vehicles**.** Another policy in the field of energy**-**saving is the use of alternative energy that has been implementing in Indonesia and has started to be widely applied. The use of sunlight, hydropower, and wind power can become the alternative energy to reduce air pollution and the greenhouse effect. The preventive action can also be programmed for deforestation that must be followed by reforestation without burning the forests to avoid air pollution. The use of eco**-**friendly material must be encouraged to support the program of reforestation.

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The phenomenon of sea-level rise (Sea Level Rise or SLR) is an issue that arises along with the problem of global warming. The phenomenon of global warming can lead to thermal expansion and variations of water mass caused by previous results such as melting glaciers and polar ice caps as well as the changes of global average sea level. The rising of sea levels will certainly inundate sloping coastal land and those that can also fall due to land subsidence. This effect is important since it will influence socio-economic impact, infrastructure, disruption of human activities especially in coastal areas with their environment. As the result, the coastal area with more than 10% of the world's population living on the coast, especially for Indonesia as an archipelagic country, can become decreased because of the land loss around the area. The coastal area that will be suffered from the threatens of sinking land is inhabited by 60% of the population. Since the late 19th century, the changes of seawater position have been observed from tidal stations along the coastline. However, the observations have limitations in terms of number, distribution, and range as well as their contribution to land subsidence. Therefore, the presence of altimetry satellites can really help to monitor the sea-level rise. The rising of sea-level that occurs every year can be caused by unstable climate change. It happens when the earth's temperature is increased as the impact of the increasing greenhouse gases.

Based on the findings of several scientists, sea-level rise on the east coast of North Sumatra has a significant negative impact on coastal activities and ecosystems. The regional mean of sea level trend for 23 years, i.e. 1993 - 2016, estimated from altimetry satellite, is 5.0 mm/year, and the potential loss of coastal areas in these areas due to 1 m and 2 m inundation can range from 11.9 km^2 to 63.8 km^2 (Gaol et al., 2017). The study results during the years 2002 - 2005 showed that the lowest sea-level rise of 1.83 mm/year was in the Flores Sea, while the fastest rising of sea level trend that reached a value of 72.313 mm was in the Java Sea area occurred in 2015 (Mujadida et al., 2021).

From the altimetry satellite, the observation data used for reference mission is provided by Topex/Poseidon, Jason 1, Jason 2, and Jason 3 to analyze the trend of sea-level rise in Indonesia and its spatial distribution. It turned out that the sea-level rise rate in Indonesia was 4.6 ± 0.2 mm/year for the period of 1993 - 2018. The positive linear trend with the equation of $y = 4.6x - 9133.5$ where y is the sea-level anomaly in mm and x is the time in years, indicates that the sea-level in Indonesia will continue to increase (Ariani, 2018; Handoko, Yuwono, & Ariani, 2020). Another impact of sea-level rise is that the coastline advances to the mainland can make the waves erode the harbor pier and wave barrier that can decrease the strength of building structures on the coast. According to these results, the decision-maker can carry out pre-event planning to prevent the impact of the sea-level rise in the future. The changes of SST must be informed early; therefore, it is necessary to monitor temperature symptoms temporarily in order to analyze the changes of surface temperature patterns. The early detection of surface temperature must be implemented as soon as possible to take strategic actions or real steps to anticipate disasters.

The remote sensing technology is very helpful for scientists to monitor the earth's surface, water temperature, and sea-level rise that the desired SST data can be obtained quickly on a global scale and even in a large area. As the archipelagic country with a very wide sea level, Indonesia really needs to be able to detect SST early to determine the condition of sea waters. Based on the results of research carried out by scientists, in general the SST in Indonesia has been increasing every year; this is a very serious problem that can become a challenge for Indonesia. The policy to reduce the negative impacts caused by the condition of SST can be considered by Indonesian government to be able to overcome the problems. As the indicator of climate change, the SST is important to avoid hot temperature and air on earth that can cause global warming. The strategic action should be determined to reduce the causes by lowering SST which can be followed by lowering the earth's surface and air temperature.

Indonesia maintains its headline target to lower greenhouse gas emission not more than 41% by 2030 with the international assistance. Indonesian government has updated its adaptation measures and included a new long-term development strategy for low carbon. For the energy sector, Indonesian government plans to stop using coal, oil, and gas by 2060 and aims to have 85% of its energy needs from renewable sources and the rest from nuclear energy (Reuters, 2021). Indonesia is also looking for utilizing energy storage and hydrogen fuel cell technology. A mega hydropower plant in North

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Kalimantan has been expected to start construction since October 2022 to support renewable energy contribution. While in 2020 Indonesia had reduced deforestation to its lowest level in the last decade, it should step up the efforts to address the climate crisis.

4. Conclusions

Based on the description above, the conclusions can be made in statements as follows:

a. The SST trends in Indonesia that were detected in some of the water areas using remote sensing methods for 32 years has increased.
b. Global warming has already happened in Indonesia with the climate change in the form of extreme weather that causes disasters such as hurricanes, extreme rains, landslides, and floods**.** The impact continues with the melting process of polar ice caps as the cause of sea level rise that can make the sinking process of small islands. As an archipelagic country, there is a possibility that Indonesia can have big losses with the sinking of small islands if the impact occurs caused by the rising of sea level.
c. The sea level in Indonesia has been increasing for some periodical time that in some conditions can damage infrastructure and disturb the activities of coastal communities. It is also the threat for small islands and coastal areas being submerged.

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