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SCIENTIFIC STUDY ON EFFECT OF CLIMATE CHANGE IN BANDA ACEH BEFORE AND AFTER TSUNAMI DISASTER

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Abstract

Banda Aceh is one of the cities located in Aceh and became the capital of Aceh province, Indonesia. As the center of government, Banda Aceh has become the center of all economic activity, political, social and cultural. Aceh province has a tropical climate. It means that in a year consisting of the dry season (March to August) and rainy season (September to February). After the tsunami disaster that happened seven years ago that is exactly on December 26, 2004, the tsunami disaster caused by the earthquake of 9.2 Richter scale in Samudera Indonesia (Indonesia Ocean) thus temperatures continue to rise in Aceh province. This disaster resulted in hundreds of thousands of inhabitants and destroyed more than 60% of the buildings of this city. Tsunami disaster in Aceh cause the temperature in the city of Banda Aceh rises continuously. The tidal waves that devastated the city of Banda Aceh not only destroyed the buildings and a lot of casualties but also damaged the vegetation. Because of the number of damaged and missing vegetation of cover land, the temperature in Banda Aceh and its surrounding has rose. It happens because there is no direct solar radiation barrier and absorption of CO₂ by vegetation.

Keywords: *climate change, before tsunami disaster, after tsunami disaster*

INTRODUCTION

Banda Aceh is one of the cities located in Aceh and became the capital of Aceh province, Indonesia. The city formerly named Kutaraja, then since December 28, 1962 its name was changed to Banda Aceh. As the center of government, Banda Aceh has become the center of all economic activity, political, social and cultural. Location of astronomical Banda Aceh is 05° 33'03" north latitude, 95° 19'42" east longitude. Aceh province has a tropical climate. It means that in a year consisting of the dry season (March to August) and rainy season (September to February).

Air humidity in Aceh province has reached 79%, with an average rainfall is 131.4 mm. In coastal areas, rainfall ranges from 1000-2000 mm and in the highlands and the south west coast is between 1500-2500 mm. Rainfall distribution to all regions is not the same, in the highlands and the south west coast is relatively higher. The average air temperature reached 26.9 °C with an average air temperature of 32.5 °C maximum and the minimum is 22.9 °C, and the air pressure reaches 1008.8 atm.

After tsunami disaster that happened ten years ago that is exactly on December 26, 2004, the tsunami disaster caused by the earthquake of 9.2 Richter scale in *Samudera Indonesia* (Indonesia Ocean) thus temperatures continued to rise in Aceh province. This disaster resulted in hundreds of thousands of inhabitants and destroyed more than 60% of the buildings of this city. Tsunami disaster in Aceh cause the temperature in the city of Banda Aceh rises continuously. The tidal waves that devastated the city of Banda Aceh not only destroyed the buildings and a lot of casualties but also damaged the vegetation. Because of the number of damaged and missing vegetation of cover land, the temperature in Banda Aceh and its surrounding has rose. It happens because there is no direct solar radiation barrier and absorption of CO₂ by vegetation.

In terms of the health, climate change affects health badly, especially for communicable diseases through the medium of water, air, insects, mosquitoes and food. Climate change is also caused by global warming that is happening lately. Global warming impacts on the global climate change as a result of the greenhouse effect and the fulfillment of CO₂ emissions in the air which can lead to change in temperature global conditions and influences the meteorological and geological conditions of the cycle, which cause natural disaster where disaster conditions linked to the global warming and sea level rise due to the addition of mass sea water due to melting polar ice every year, the occurrence of El Nino, flooding due to erratic weather factors and often also coincided with landslides, tropical storms and cyclones.

Disaster risks that can be caused are by the loss of functions of society, victims, material damage, physical damage and environmental damage. In the last two decades there has been a growth in population in the world rapidly, the need to meet his living needs resulting in increased supply of gas emissions and greenhouse effect on Earth that is not balanced with the capacity of its territory, this condition will occur from year to year, which became a serious problem for the world as the impact of climate change. Ecological disasters will occur if the balance between living things and place of residence are not met, so that it becomes a threat (hazard) that can lead to disaster risk if there is vulnerability in a community environment in receiving threats. In addition, global warming occurs as a result of the activities of large-scale exploitation of natural resources that are part of the natural balance of the cycle (Petrasa, 2009).

The impact of climate change before and after tsunami in Banda Aceh is very different. It can be seen from the climate graphs, charts temperature, changes in public health, change in the field of social, and economic. Therefore, in this paper the author would like to remind people how the climate change is occurring at the time before and after the tsunami so that people can keep the environmental conditions and physical well, what are the impacts are given in the presence of climate change and how is the influence of climate change with the ecological disaster.

REVIEW OF THE LITERATURE

• Definition of Climate Change

Climate change is a change that occurs significantly on weather patterns which is calculated based on the statistics in the time range of tens to hundreds of years. Many factors affect climate change such as biological processes, solar radiation, pressure tectonic, volcanic eruptions, etc.

While the definition of climate change according to the Environmental Protection Agency (EPA) is a significant climate change that occurs in a specific time period. In other words, climate change could also be interpreted as a drastic change in temperature, rainfall, wind patterns, and etc. Keep in mind that the earth's temperature change one degree within the last 100 years.

The occurrence of climate change is not happening suddenly, this is because there are some factors that cause whether due to natural phenomena or human behavior. Some factors that may cause the occurrence of climate change to human activities such as illegal logging, the phenomenon of global warming, the greenhouse effect events, the occurrence of El Nino and El Nina in the ocean, and the depletion of the ozone layer in the earth's atmosphere.

• The Process of Climate Change

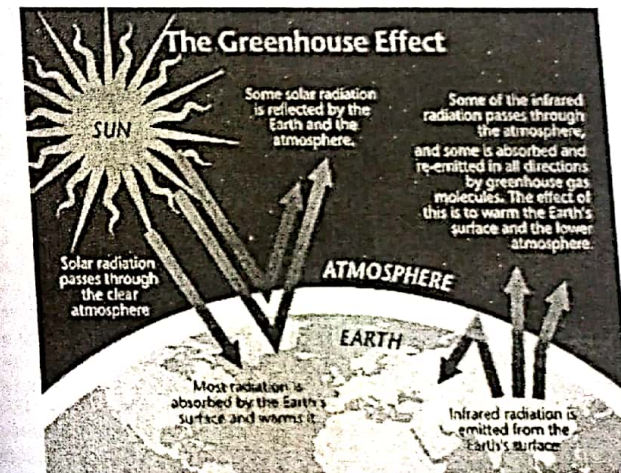
Climate change is not a new issue. The global climate has always been changing. Millions of years ago, some parts of the world that were covered by ice in the has become warmer now, and some of the last century, the average temperature has been up and down seasonally, as a result of fluctuations in solar radiation, for example, or as a result of volcanic eruptions periodically. However, what is new is that climate change current and future can be caused not only by natural events but rather due to various human activities. Rapid progress of our economic development gives a serious impact on the world climate, such as through the massive burning of coal, oil, and wood, as well as deforestation.

In the latest report, the Fourth Assessment Report, reported by the Intergovernmental Panel on Climate Change (IPCC), one of PBB which consists of 1,300 scientists from around the world, revealed that 90% of human activity over the last 250 years is what makes our planet is getting hotter. Since the Industrial Revolution, carbon dioxide levels rising from 280 ppm to 379 ppm in the past 150 years. It is no joke that the increase of the concentration of CO₂ in Earth's atmosphere was the highest since the last 650,000 years! The IPCC also concludes that 90% of greenhouse gases produced by humans, such as carbon dioxide, methane, and nitrous oxide, especially during the last 50 years, has been drastically raise the temperature of the Earth. Before the industrial era, human activities do not spend a lot of greenhouse gases, but the population growth, deforestation, industrial farming, and the use of fossil fuels causes greenhouse gases in the atmosphere multiply and contribute to the global warming.

However, according to the United Nations' report on livestock and the environment published in 2006 revealed that, "the livestock industry is

the biggest producer of the greenhouse gas emissions (18%), this number is more than the total of emissions of greenhouse gases throughout the transportation worldwide (13%)". Nearly one-fifth (20 percent) of carbon emissions come from livestock. This total exceeds the combined emissions from all vehicles in the world.

Incoming solar radiation to the earth is in the form of short waves that penetrate the Earth's atmosphere and then turned into a long wave when it reaches the earth's surface. After reaching the earth's surface, some of the waves are reflected back to the atmosphere. However, unfortunately not all the wavelengths that are reflected back by the earth can penetrate the atmosphere into space due to obstructed and absorbed by gases in the atmosphere which are called greenhouse gases (GHGs). This natural event is known as the Greenhouse Effect (ERK).



METHODOLOGY

For research on climate change, a literature search using Pubmed using English. Article taken a research/original research in the last 10 years. Parameters that a keyword is ((climate [Title / Abstract]) AND Effect [Title / Abstract] AND Tsunami [Title / Abstract]).

Articles obtained from this keyword is as much as 30 articles and relevant to research on climate and tsunami as much as 6 articles. Research on climate change before and after the tsunami taken from several journals at home and abroad either in the form of literature reviews and original research.

DISCUSSION AND RESULTS

Results of research conducted abroad on the effect of climate change factors are presented in the table below:

No	Researcher Name	Title	Desain and analysis	Results
1	Subhashni Taylor, dkk	Climate Change and the Potential Distribution of an Invasive Shrub, <i>Lantana camara</i> L	CLIMEX for Windows Version 3 was used to develop a model of the potential distribution of <i>L. camara</i> under current and future climate scenarios. CLIMEX is based on the observation that the distribution of plants and poikilothermal animals is primarily determined by climate. The software works on the basis of an eco-physiological model that assumes that at each location, a species may experience a favourable season with positive population growth and an unfavourable season that causes population decline. The user can use the model to infer parameters that describe the species' response to climate based on its geographic range or phenological observations.	The modelled global climate suitability for <i>lantana</i> compares well with its known native distribution in South and Central America as well as its exotic range in South Africa and Asia. A comparison of the present global distribution of <i>lantana</i> consistent with the Ecoclimatic Index values resulting from the CLIMEX model. Much of the tropics and subtropics are projected to have suitable climatic conditions for <i>lantana</i> . Large areas of South and Central America, the southern states of the USA, Asia, sub-Saharan Africa, Madagascar and the high volcanic Pacific island groups such as Fiji, Vanuatu, Samoa and New Caledonia among others, have highly suitable climate for the species. Warm temperate areas such as northern New Zealand and southern Mediterranean Europe including Portugal, Italy and Greece are predicted to have

Rodrigo Caballero, dkk	State-dependent climate sensitivity in past warm climates and its implications for future climate projections	Data-Based Estimate of Early Eocene Global Mean Temperature, Model and Simulations. We use the NCAR CCSM3	unsuitable climates. recently revised proxy temperature reconstructions for the early Paleogene indicate much warmer conditions than previously thought. As described in <i>Methods</i> , the proxy data compilation reveals global mean temperatures ~13 °C warmer than present global mean temperatures. This is a roughly threefold increase over previous proxy estimates of ~4 °C warming. This estimate is independently confirmed by analyzing the global mean temperatures produced by climate model simulations that are the best fit to proxies on a point-by-point basis. Such extreme warming compared with current temperatures requires some combination of very strong radiative forcing in the early Paleogene compared with modern conditions and/or enhanced climate sensitivity due to strong positive feedbacks of either the fast or slow variety.
Clark Gray, dkk	Studying Displacement After a Disaster Using	Multivariate regression models	presents results from the multivariate analysis. Estimates are reported as odds ratios, which can be interpreted as the

		Large Scale Survey Methods: Sumatra After the 2004 Tsunami		multiplicative effect of unit increase in the predictor on the odds; that form of displacement relative to no displacement. The significance level for the test that each odds ratio is different from one is indicated by the coefficient. Wald tests for the joint significance of groups of covariates are reported at the foot of the table.
4	V. Ramana Dhara, dkk	Climate change & infectious diseases in India: Implications for health care providers	his article reviews common and prevalent infectious diseases in India, their links to climate change, and how health care providers might discuss preventive health care strategies with their patients.	Climate change has the potential to influence the earth's biological systems, however, the effects on human health are not well defined. Developing nations with limited resources are expected to face a host of health effects due to climate change, including vector-borne and water-borne diseases such as malaria, cholera, and dengue.

• The Impacts of Climate Change from Various Sectors
The Impacts of Climate Change If Air Temperature Rose

According to Mark Lynas (2007) states that if the air temperature rose 1°C to 6°C, there would be a few cases, such as below:

- a. If the air temperature rises 1°C
 The sea began to lose the glaze on it and will absorb more heat and accelerates global warming; fresh water lost from a third of the Earth's surface; low-lying areas on the coast will be hit by the floods.
- b. If the air temperature rose 2°C
 European received an exposure of high heat; forests damaged by fire; plants are stressed, instead of absorbing carbon, it began to release carbon which have absorbed into the atmosphere; third of the world's species are threatened with extinction.
- c. If the air temperature rose 3°C

- d. If the air temperature rose 4°C
 The thaw of glaze uncontrollably effects global warming cannot be stopped; most areas in UK are uninhabitable due to flooding setting; abandoned populated Mediterranean region.
- e. If the air temperature rose 5°C
 Methane gas coming out of the ocean floor will accelerate global warming; ice at the North Pole and South Pole will be disappeared; human are on the move to look for food, though in vain, to live like animals in the wild.
- f. If the air temperature rose 6°C
 Life on Earth will end due to a large storm, flood, fire ball hydrogen sulfide and methane swirling quickly flashed around the world with the power of the atomic bomb; only fungus that can survive.

The Impacts of Climate Change in the field of Agriculture of Before and After Tsunami

Agriculture field is still a mainstay of business for the people of Nanggroe Aceh Darussalam. Where in year 2000 accounted for about 21 percent of the total GDP and in 2004 accounted for about 24 percent. Target development in agriculture is characterized by strengthening characteristic food of self-supporting dynamically and continuously, as well as development of agribusiness systems with control of post-harvest technology and marketing results (Elvira, 2013).

However, the tsunami disaster and drought cause damage to land and facilities/ infrastructure support so that agricultural production in general do not achieve the goals and targets as expected. There are 9 districts in Aceh province that experienced the tsunami, one of them is Banda Aceh and was damaged badly enough its farmland. The conditions in the field of post-tsunami can be seen through the conditions of dead grass in total. People were worried that their rice field cannot be planted for a long time because the salt content is too much. Beside rice paddies, hundreds of thousands of residents' well were also polluted. These conditions led to the development of the agricultural sector stalled and require serious treatment to repair. Level of damaged land that occurs among other rice field (including horticulture) covering 20,101 ha, upland fields (crops and Horti) 31 345 ha, and it is expected about 56,500 estates. Rubber plantation, coconut, oil palm, coffee, cloves, nutmeg, nuts, chocolate, patchouli, and ginger estimated 102 461 ha. As for the number of animals that died or lost is 78 450 cattle, 62 561 buffaloes, 16 133 sheep, 73 100 goats, and 1,624,431 poultry (data of FAO and Ministry of Agriculture, 2005).

According to Elvira (2013) in his study, total area of used land of the entire land area of the village before the tsunami is about 277, 35 acres with the main use is in the agricultural sector, namely paddy fields,

fields and gardens. Before the tsunami, 72.48% of the entire villages destroyed by the tsunami, which is dominated by damage on the agricultural land. Damage is indicated by the accumulation of sludge on the soil surface and the large pile of garbage that is difficult to be moved in agricultural areas. After rehabilitation activities carried out, 34.69% of the total area in the study area has been rehabilitated by the government and foreign aid agencies and 65.31% of the land has not been rehabilitated.

Elvira also added that the availability of land is very prominent difference is the availability of rice paddy fields, where if the pre-tsunami rice paddy fields percentage of the total village land is 20:09%, then after the tsunami wetland amount available after rehabilitation is 9.17 acres or just at 3:30 % of the total land area of the village before the tsunami. The same situation also happened in the area of fields and farms, which are 3 main types of land needed to drive the economy of the community who mainly works in agriculture and fisheries.

What is often being a problem in the disaster victims residence and their land is very close to the beach so that all their assets lost in the tsunami and rural communities generally do not have sufficient savings. This happens because generally rural communities keep their property in the form of land, pets, business equipment, jewelry, or keep their money at home. This condition causes a high degree of dependence on external support and only use land that has been rehabilitated to resume their lives.

The Impacts of Climate Change in the field of Health Before and After Tsunami

When it comes to climate change, the human health will be in a time of uncertainty. Cases can occur at any time with the quantity and quality impacts that cannot be ascertained. Health care system will meet a wide variety of complex challenges such as rising health care costs, communities experiencing premature aging, and various other challenges so that the effective prevention strategies are needed. The possibility of diseases such as malaria and dengue fever increased. Residents with low adaptive capacity will be increasingly vulnerable to diarrhea, malnutrition, and the changing patterns of distribution of diseases that are transmitted through a variety of insects and animals. "Global warming" is also leading to increased cases of tropical diseases such as malaria and dengue fever. Residents with low adaptive capacity will be increasingly vulnerable to diarrhea, malnutrition, and the changing patterns of distribution of diseases that are transmitted through a variety of insects and animals (Jusuf, 2013).

Climatic factors influence the risk of transmission of vector-borne diseases such as dengue hemorrhagic fever (DHF) and malaria. The higher rainfall, the higher dengue cases will increase. The temperature is negatively related to the case of dengue, therefore an increase in temperature per week will reduce dengue cases. People with allergies and asthma will increase significantly. The heat wave that hit Europe in 2005 increased the number of "heat stroke" (strong heat stroke) are deadly, salmonella infection, and "hay fever" (allergic hay fever).

Diseases that are vulnerable in a disaster situation such as acute respiratory infections, diarrhea, skin disorders, coupled with the quality of inadequate clean water, air evacuation is not organized, highly likely to cause long-term health problems for victims of the disaster. Moreover, it may occur some specific diseases in some conditions, such as leptospirosis in the flood disaster. Psychological, mental disorders can occur in the absence of treatment and adequate mental care to treat the trauma of shock due to be affected. Disease Control Priorities Project (2007) make a note that the health and economic losses caused by natural disasters turns disproportionately occur in developing countries compared to developed countries, with more than 90% of the disaster that led to the death, and most of the impact on the poor economy. Although the amount of economic loss in the currency of the larger developed countries, but when taken in conjunction with the gross national product, developing countries much more loss than developed countries when affected (Jusuf, 2013).

After tsunami disaster in 2004, the incidence of infectious diseases is increasing, especially respiratory illness (ARI). In some health centers and hospitals in Banda Aceh showed the incidence of ARI and pneumonia ranked first for the incidence of infectious diseases, followed by diseases of dengue, malaria, skin diseases also increased due to changes in soil moisture and temperature (Health Service Prov. Aceh, 2013).

The Impact of Climate Change on Coral Reefs Before and After Tsunami

Sabang city has the potential of beautiful coral reef to attract people to look at. Coral reefs are complex ecosystems with various high biological that supports the fishery and protect the coast from wave action. Coral reefs are very important in marine ecosystems, where coral reefs are shelter, feeding, spawning for fish (Terangi, 2012). From approximately 800 species of hard corals were identified in the world, there are approximately 450 of them are found in Indonesia, Indonesian reef fish species alone reached more than 2,400 species (A. Besse Rimba, dkk, 2012)

After tsunami disaster that happened on December, 26, 2004, there is not much quantitative information regarding the condition of coral reefs in the waters around the island of Weh Sabang Aceh. Research on the condition of coral reefs was conducted in six observation stations spread across the western, central and eastern island of Weh by using Line Intercept Transect (LIT) based life forms coral and other components.

Results of research conducted by Dini, et al (2014) show the condition of coral reefs in the waters of Pulau Weh are still good. Based on a field surveys conducted by a team of Marine Wildlife Conservation Society Marine Indonesia Program (WCS-IP) on May and July 2010 and February 2011 occurred in the area of coral bleaching and the island of Pulau Weh Aceh Indonesia. Coral bleaching occurs due to environmental pressures that could not faced by coral. The results of the analysis of

Landsat satellite images in 2002 and 2009 showed the morphological of shallow bottom waters cover. The results of the analysis using the algorithm Lyzenga explained that the basic substrate conditions waters in 2002 showed a significant difference with the condition in 2009 after the tsunami in Aceh.

The Location is clearly seen at several locations in a small strait between the island and the Seulako Rubiah Island, and at 5 observation location. The comparative of cover result analysis of Citra Landsat 2002 showed the Dead Reefs was 55.49 ha while in 2009 rose to 66.13 ha and Live Reef 2002 has been quite high 44.64 ha but in 2009 dropped to 24.2 ha. This is likely caused by water environmental stress around the study locations (Dini, et al, 2014).

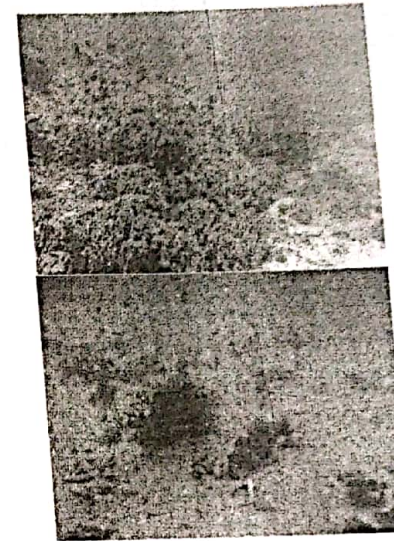
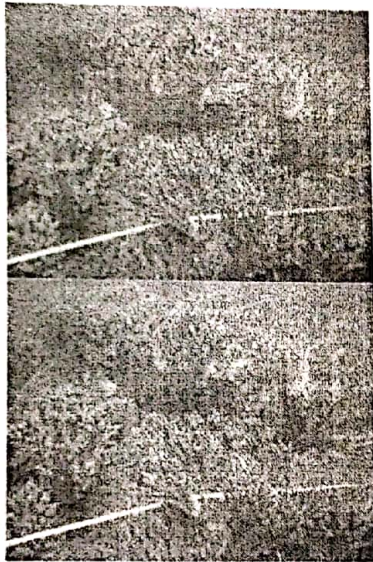


Figure 1. The condition of the Coral Reefs Before and After Tsunami Disaster

CONCLUSIONS AND SUGGESTIONS

Conclusion

1. Climate change is a significant change occurs on weather patterns which is calculated based on the statistics in the time range of tens to hundreds of years. Some factors affect climate change such as biological processes, solar radiation, pressure tectonic, volcanic eruptions, etc.
2. The tsunami that occurred in Aceh generally makes the temperature in Aceh, especially Banda Aceh increased. The waves that devastated the city of Banda Aceh not only destroyed the building and caused a lot of casualties but also damaged vegetation.
3. The changes of temperature in Banda Aceh and the surrounding not only caused absolutely by natural disasters that happened seven years ago, but is also supported by the factor of global climate change that is sweeping the world.

Suggestion

1. It is expected that the local government can improve both the process of reconstruction and rehabilitation of the agricultural sector, health,

- marine, and so on so that growth of community can increase continuously.
2. It is better that the community can maintain the conditions of the environment such as the use of a greenhouse that is not excessive.

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