Mitigation and adaptation of climate change disaster

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Abstract. Climate change is a long-term change in the statistical distribution of weather patterns over time periods ranging from decades to millions of years. It can also be interpreted as a shift in average weather conditions or a change in the distribution of average weather events. Climate change can occur locally, in specific regions, or across the entire planet’s surface. This change is characterized by at least four characteristics:, first rising global temperature, second rising sea levels, third extreme weather conditions and others, and four changes in rainfall patterns. Climate change is currently marked by an increase in the frequency of hydrometeorological disasters, such as decreased water availability and or even excess water discharge at other times, as well as forest and land fires. Based on future climate change projections, these hydrometeorological disasters have the potential to worsen threatening the resilience of water, food, and energy resources. Climate change is frequently associated with disaster due to an increase in hydrometeorological events over time. However, climate change is not the only cause. The disaster impacts are the results and indicators of more complex issues caused by larger environmental, social changes, and economic changes. These various disaster challenges in the future will necessitate earlier anticipatory preparations so that Indonesia and the rest of the world can adapt and mitigate appropriately.

1. Introduction

The pattern of climate change in Indonesia has been evident in the last 30 years. Indications of the pattern among others, can be seen from the pattern of increasing air temperature. In the last 30 years the air temperature in Indonesia has risen by about 0.1 degrees Celsius. The increase appears minor but the world has agreed that the temperature change should not exceed 1.5 degrees Celsius until 2030, Since 1866, the increase in temperature in Indonesia has nearly reached 1.6 degrees Celsius until 2020 [1]. Meanwhile, the warming climate in Indonesia will also be accompanied by an increasingly dry season in several parts of the country, including South Sumatra, Java, Madura, Bali, West Nusa Tenggara and East Nusa Tenggara.

At the global level, hydrometeorological disasters account for more than two-thirds of the total natural disasters, and these conditions increase along with global warming. As stated in the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the phenomenon of global warming will cause imbalances weather in various regions of the earth as stated in the 4th Assessment Report, Intergovernmental Panel on Climate Change (IPCC) [2], including an increase in drought in mid-latitude and semi-arid areas, water shortages, an increase in storm events due to rising sea surface temperature [3], an increase in flooding and landslides [4],[5]. Meanwhile, [6] reported that the impact of climate change varies greatly depending on the location and one of the obvious impacts is
ranging sea levels, which make lowland coastal areas and small islands are very vulnerable. In other ecosystems, particularly those in mountainous areas, the presence of biodiversity and agricultural commodities have a very high level of vulnerability to even small climate changes.

It is widely acknowledged that climate change has introduced new risks to humankind all over the world. Understanding the impact of climate change risks is critical because humans and their natural environments are highly vulnerable to climate change. The vulnerability of humans and their natural surroundings requires the right adaptation process to climate change. The proper adaptation process which includes capacity building from governments, communities and all parties, has the potential to mitigate the adverse impacts of climate change [7]. The adaptation process can result in maximum reduction of the impact of disaster risk if it is coordinated with mitigation efforts. This is very reasonable, because while some adaptation efforts can contribute to reduce greenhouse gas emissions, on the other hand, mitigation efforts can be used to reduce the risk and adverse effects of natural disasters [2]. Efforts to mitigate and adapt to the natural disasters require accurate prediction of climate change at the local, national, regional, and global levels. Accurate climate change predictions frequently face challenges due to the large number of variables used and are very complex, resulting in inaccurate results in the long term [7].

Natural disasters in addition to causing physical impacts of damage, will have an impact on certain communities or groups that are very susceptible to their effects [8] and will trigger the dynamics of the community to change the vulnerability of certain regions or community groups from time to time in the form of more adaptive efforts on the risks of natural disasters, especially those related to climate change including its vulnerability assessment [9],[10],[11],[12],[13],[14]. The impact of natural disasters is the result of various complex issues caused by larger environmental, social, and economic changes [7]. The various challenges of natural disasters in the future and their impacts require early anticipation through appropriate mitigation and adaptation efforts. This paper aims to provide an understanding of mitigation and adaptation efforts to natural disasters caused by climate change, including future challenges.

2. Climate change increases natural disaster risk
Climate change has increased the risk of natural disasters and has had a significant impact. This fact is evident from the database of events and impacts of damage from climate-related natural disasters including, climatological, hydrological, and meteorological aspects, in the Asian region from 1983 to 2012 (Table 1, Source of EM-DAT data in [15]). Based on these data, it appears that the water-related natural disasters, including drought, flood, and landslide, are very prevalent. These disasters accounted for 58% of the total of 2,860 natural disasters. It proves that water issues are at the center of the impacts of climate change [15]. Serious attention is being paid to water-related natural disasters in vulnerable area, such as, low-lying deltas and coastal megacities, drylands, small islands, and mountains and their rivers [16]. Water-related natural disasters of water problem as the dominant impact of climate change are in accordance with the [17] who have discovered that climate change tends to cause changes in the frequency, intensity, spatial extent, duration and timing of weather and climate extremes, and can result in extreme disasters.

Table 1. Climate-related disasters in Asia from 1983 to 2012

| Type of disaster          | Number of events | Killed  | Damage (in x 1,000 USD) |
|---------------------------|------------------|--------|------------------------|
| Drought                   | 101              | 5,028  | 33,731,347             |
| Cold wave                 | 64               | 6,504  | 1,466,133              |
| Extreme winter conditions | 9                | 1,889  | 21,940,000             |
| Heat wave                 | 45               | 8,932  | 401,000                |
| Wildfire/forest fire      | 44               | 726    | 11,892,500             |
| Shrub/grassland fire      | 8                | 22     | --                     |
| Flood/unspecified         | 257              | 31,021 | 32,930,129             |
| Type of disaster          | Number of events | Killed  | Damage (in x 1,000 USD) |
|--------------------------|------------------|---------|-------------------------|
| Flash flood              | 250              | 17,216  | 25,707,434              |
| General flood            | 784              | 75,301  | 259,030,591             |
| Storm surge/coastal flood| 39               | 2,060   | 8,472,324               |
| Avalanche                | 44               | 2,457   | 50,000                  |
| Debris flow              | 1                | 106     | --                      |
| Landslide                | 227              | 13,395  | 2,666,916               |
| Subsidence               | 1                | 287     | --                      |
| Storm/unspecified        | 204              | 6,915   | 4,029,756               |
| Local storm              | 157              | 5,445   | 7,944,022               |
| Tropical cyclone         | 625              | 369,134 | 151,332,062             |

Source: [15]

Along with the rise in global temperatures as a result of climate change, the risk of hydrometeorological natural disasters increases from time to time (Figure 1). Figure 1 depicts an ever increasing trend in hydrometeorological disasters from 1900 to 2005, with a very extreme increase from 1963 to 2005 (Source of data from UN ISDR Prevention and EM-DAT in [7]). Climate change’s increased risk of natural disasters can exacerbate water shortage conditions in many areas, hamper agricultural production and threaten food security and energy supply from hydropower. In addition to increasing the risk of hydrometeorological disasters, climate change phenomena can also trigger fires and forest degradation, damage coastal and marine resources, and increase the risk of infectious disease outbreaks [18].

The current state of the Covid-19 pandemic, which started at the beginning of 2020, as well as the emergence of new variants of Covid-19 can also be triggered by an increase in global temperature as a result of climate change. Changes in forest cover (deforestation and forest degradation) are factors contributing to an increase in carbon dioxide in the atmosphere and causing global warming. In this regards, there is evidence of a relationship between changes in forest cover and the spread of global infectious diseases. In tropical climates, there is a significant relationship in tropical climates between deforestation and zoonotic disease outbreaks in 47 countries and vector-borne diseases in 49 countries in the period 1990-2016 [19]. As a result national, regional and global efforts are needed to mitigate climate change and develop comprehensive plans to respond to health risks associated with current and projected climate change [20].

3. Natural disaster mitigation and adaptation efforts related to climate change

Efforts to mitigate and adapt to climate-related natural disasters are heavily reliant on funding and policy commitments in their implementation. The Ministry of Finance (Kemenkeu) noted that for the 2018-2020, the government had budgeted IDR 307.84 billion for climate change of. According to the Head
of the Center for Climate Change Financing Policy and Multilateral Fiscal Policy Agency (BKF) of the Ministry of Finance explained that since 2018-2020, the climate change budget has averaged Rp 102.65 billion or 4.3% per year.

Indonesia has a lot of natural ecosystem capital that can be used to help with mitigation and adaptation efforts. The Overshoot Days 2021, as shown in Figure 2, shows that Indonesian ecosystem still have excellent sustainability guarantees [21]. Indonesia is in the country’s position with the fewest remaining days in 2021, indicating that there are fewer days in which natural resources to be used cannot be returned (non-renewable). This condition indicated that future generations in Indonesia would not lose a large portion of their natural resources due to the current use of natural resources. This demonstrates that Indonesia has vast reserves of natural resources, a large capacity for natural resources recovery, and a large population (around 270 million according to the [22] population census) but efficient use of natural resources compared to other countries. In this regards, Indonesia is able to use its natural resources sustainably for future generations, which serves as a very good form of campaign for Indonesia in the international world today.

![Figure 2. Overshoots days 2021](image)

The potential of natural resource ecosystems in Indonesia, which is still very good and sustainable for future generations, makes Indonesia have the ability and strength of a very good ecosystem to reduce the risk of disasters and the impact of climate change. The ecosystems, which can reduce physical vulnerability, can also reduce social vulnerability to the impact of natural disasters related to climate change [23], [24]. Many studies have found that ecosystems play an important role in mitigating the hazard effects of natural disasters. Ecosystems can act function as natural buffers, natural barriers, natural infrastructure, green and blue infra-structures, bioshields, and protective greenbelt. Some real evidence of the important role of the ecosystem in mitigating the impact of the hazard of natural disasters was observed in the aftermath of the 2004 Indian Ocean Tsunami, where the locations with a magnificent mangrove forest expanse were able to avoid the level of more severe damage [25], [26], [27], [28], [29]. Wetlands, such as peat swamp, can also serve as buffers and regulating floodwater discharge [30], [31]. Based on the Ramsar Convention on wetlands show that riparian vegetation can stabilize the riverbank [4].

The natural protection structure of ecosystems can provide many benefits including: a) increasing community ownership of reducing the risk of natural disasters; b) adapting to changing conditions, including recovery from natural disasters; c) being easier to apply in poor countries because it is more cost-effective and does not need significant funding support; d) preventing environmental degradation; and e) maintaining human well-being and improving health quality [4], [32], [33]. The benefits of ecosystem function in preventing the severity of natural disasters caused by climate change and as cost-
effective solution [34]. A constantly dynamic ecosystem will experience changes and humans play an essential role in determining adaptation and mitigation effort to deal with the impact of natural disasters due to climate change which can affect the sustainability of the lives of ecosystems and society [17].

At the moment efforts to mitigate and adapt to natural disasters (hydrometeorological disasters, spread of disease outbreaks) caused by climate change can be accomplished by: a) preserving natural forests with high biodiversity; and b) improving forest management by reducing deforestation, which will provide benefits in increasing biodiversity, carbon sequestration, community livelihoods and local health [19].

Considering the potential of ecosystems in Indonesia which is still very good, an ecosystem-based mitigation adaptation approach is the best option at this time, as stated by [35] that cost efficiency and long-term ecosystem sustainability could be taken into consideration for adapting ecosystem-based mitigation. Indonesia's commitment to implementing natural disaster adaptation mitigation related to climate change has manifested itself in the form of a climate change adaptation and mitigation strategy that seeks to carry out conservation, preservation and protection of ecosystems that can contribute to mitigate the impact of climate change.

4. Future challenges
The future success of climate change mitigation and adaptation efforts to natural disasters is highly dependent on good cooperation from all parties including multistakeholders and multidiscipline as well as the need for more program activities that are implementable and have a significant impact [7]. A multi-stakeholder and multidisciplinary approach as well as a program of implementing activities that have a large impact will be the main challenges in the future in carrying out adaptation mitigation activities because they are closely related to existing governance. Good governance will play an important role in efforts to mitigate adaptation to natural disaster risks, which includes the governance of balanced-social, economic and ecological systems running in a balanced manner [36], [37].

Institutional aspects, risk assessment, awareness through education and strengthening of preparedness to face natural disasters, especially those related to climate change, are also challenges that must be addressed in the future so that adaptation mitigation efforts yield maximum results [38]. Efforts to strengthen these aspects can be carried out through strengthening enabling conditions, integrating adaptation mitigation into development planning, increasing knowledge awareness, strengthening institutions, protecting natural resources, providing financial assistance, developing partnerships with local stakeholders, actively involving groups at risk of being affected (community based initiatives) and non-government organizations and preparing special strategies [39], [40], [41]. The consolidations of the efforts made in these various aspects is expected to further strengthen governance at the local level/community groups who are at risk of being affected [41], [42], [43]. On way to integrate adaptation mitigation efforts into development plans is to work on increasing community resilience to disaster risk through a consistent, precise and accurate land use planning system [44].

5. Conclusion
The appropriate mitigation and adaptation efforts can be used as early anticipation to address the impacts of the various natural disaster challenges of natural disasters in the future. Indonesia still has very good and sustainable ecosystems for future generations. This condition makes Indonesia has the ability and strength to reduce the risk of disasters and the impact of climate change. Several efforts can be made to mitigate and adapt to natural disasters can be achieved through: a) preserving natural forests with high biodiversity; and b) improving forest management by reducing deforestation which will provide benefits in increasing biodiversity, carbon sequestration, community livelihoods and local health. At the present, the ecosystem-based mitigation adaptation approach is the best option due to cost efficiency and long-term ecosystem sustainability. The main challenges in the future in carrying out adaptation and mitigation activities in the future include a multistakeholder and multidisciplinary approach as well as a program of implementing activities that have a large impact. The key success for addressing those challenges is good governance, which will play an important role in efforts to mitigate adaptation to natural disaster risks, including the governance of balanced social, economic and ecological systems.
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