Climate Impacts and Vulnerability Analysis: Indonesia

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Abstract

Climate change is a growing concern worldwide, with the potential to impact almost every aspect of human life. The extensive use of fossil fuels needed to meet the energy demands and desired levels of comfort in the Global North is severely disrupting the earth's ability to return to a state of equilibrium before the next disruption. The perpetual cycle of consumption, waste, and repetition is causing the depletion of the earth's natural resources at rates that cannot be replenished naturally. These cycles of overconsumption and overexploitation perpetuate global social, cultural, and economic drivers of vulnerability, resulting in events such as water scarcity, food insecurity, habitat and biodiversity loss, and the increased frequency and severity of extreme weather events.

Increasingly, people in communities around the world are being forced to adapt to changing climatic and environmental conditions and explore new avenues for providing for their families. This investigation aims to assess the impact of climate change on the agricultural industry in Indonesia by examining historical and future trends of temperature, precipitation, and its effect on the agricultural sector. Additionally, this climate impacts and vulnerability analysis seeks to provide clarity on and examine the relationship of physical, social, economic, and political drivers of vulnerability. The interconnectedness of these four fundamental drivers of vulnerability is not only being exemplified in Indonesia, but can also be seen on a worldwide scale with respect to climate change and development. These physical, economic, social, and political drivers of vulnerability can often times even exacerbate each other, resulting in a myriad of negative impacts. This climate impacts analysis of the nation of Indonesia seeks to explore historical and future climate projections, the expected impacts on the health of the nation’s agricultural industry, and evaluate the interconnected relationships between the main four drivers of vulnerability to detail the need for increased climate adaptation infrastructure in the region.

Analysis of Historical Climate Trends

Climate change has historically been considered a naturally-occurring phenomenon, characterized by long periods of ice age conditions, heat cycles, and melting periods. However, recent recorded and

patterned climate data suggest that departures from expected numbers are occurring at unnatural rates. This acceleration of climate change is widely attributed to human activity, including the constant accumulation of waste, overconsumption of fossil fuel energy sources, and overexploitation of natural resources at unsustainable and unreplenishable rates. This behavior is having detrimental effects on the health of human and ecosystem life worldwide.

Agriculture is one sector that is particularly vulnerable to the effects of climate change. In Indonesia, which is heavily dependent on agriculture, climate-related hazards can cause significant damage to crops and livelihoods. Climate-related hazards can take many forms, including extreme weather events such as floods, droughts, and heatwaves, as well as longer-term changes in temperature and precipitation patterns. These hazards can have significant impacts on agriculture, affecting crop yields, soil quality, and water availability. In Indonesia, the agriculture sector is particularly vulnerable to these hazards due to the country's dependence on small-scale farming and the prevalence of natural disasters such as floods and landslides.

One of the key climate-related hazards affecting agriculture in Indonesia is increased temperature. Rising temperatures can lead to decreased crop yields, as well as changes in the timing of planting and harvesting. According to a study by the Asian Development Bank, the average temperature in Indonesia has increased by 0.3°C per decade over the past 30 years. This increase in temperature has already had a significant impact on rice production, which is a key crop in Indonesia. The study found that a 1°C increase in temperature can lead to a 10% decrease in rice yields (Asian Development Bank 2021).

Another key hazard is changes in precipitation patterns. Indonesia is particularly vulnerable to changes in rainfall patterns, with much of the country's agriculture relying on rain-fed irrigation systems. Climate change is expected to cause more extreme rainfall events, with longer dry periods in between. This can lead to flooding, drought, and extreme desertification events, all of which can have significant impacts on crop yields. In 2018, for example, a series of floods and landslides in Indonesia's Central Java province caused significant damage to crops and infrastructure.

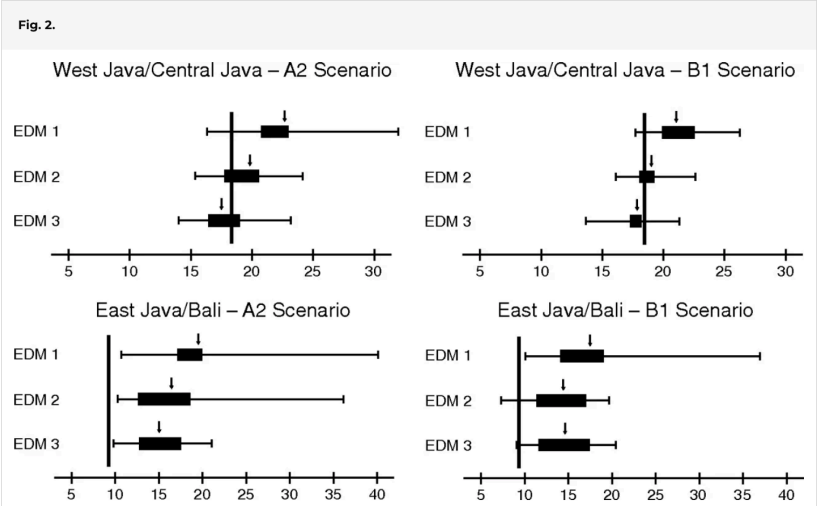
In addition to these direct impacts on agriculture, climate change can also have broader socio-economic impacts. For example, changes in temperature and precipitation patterns can affect food security, leading to higher food prices and reduced access to food. Climate-related hazards can also lead to displacement, as communities are forced to leave their homes due to floods, landslides, or other natural disasters which would have their own selection of long-term physiological and emotional impacts on the health and well-being of the Indonesia natives.

To better understand the impact of climate change on agriculture in Indonesia, it is important to examine historical climate trends. According to the Intergovernmental Panel on Climate Change (IPCC), there is a high degree of certainty that the Earth's climate has warmed since the mid-20th century. The IPCC attributes this warming to human activities such as the burning of fossil fuels and deforestation. In Indonesia, deforestation has been a significant contributor to climate change, with the country losing an average of 1.6 million hectares of forest per year between 2000 and 2012 (Hoegh-Guldberg 2018).

In addition to these broad climate trends, there is also evidence of specific impacts on the Indonesian agricultural industry. For example, a study published in the journal Climate Risk Management examined the impact of climate change on rice yields in Indonesia. The study found that between 1990 and 2015, rice yields had decreased by 0.04% per year, which the authors attributed to increased temperatures and changes in precipitation patterns (Ansari 2021). This is a concerning metric in the context of these particular social, cultural, and economic spheres especially when considering how reliant rice yields are to the livelihoods and survival of entire communities of people living in Indonesia.

Similarly, the Proceedings of National Academy of the Sciences (PNAS) case study investigating the impacts of greenhouse gas emissions and increased rainfall events on the regional El Niño lead to more concrete determinations on the impacts of climate change. Their investigation into the Indonesian rice economy details that “during El Niño events, Indonesia's production of rice, the country's primary food staple, is affected in two important ways: (*i*) delayed rainfall causes the rice crop to be planted later in the monsoon season, thus extending the “hungry season” (*paceklik*, the season of scarcity) before the main rice harvest; and (*ii*) delayed planting of the main wet-season crop may not be compensated by

increased planting later in the crop year, leaving Indonesia with reduced rice area and a larger than normal annual rice deficit" (Naylor 2007). The PNAS study provided 50-year projection figures to demonstrate this impact taking into account two regions of analysis West Java/Central Java and East Java/Bali under two different conditions:



Source: Proceedings of the National Academy of Sciences: Assessing Risks of Climate Variability and Climate Change

The projections account for two varying scenarios A2 (5 models), B1 (6-7-6 models), and the three models for their developed empirical downscaling models (EDMs) "map the observed large-scale circulation patterns and humidity distributions to the observed regional-scale precipitation for Indonesia over the past 50 years" (Naylor 2007). Not only do these particular models confirm concerns for large increases in annual rainfall, they also point to an increasing likelihood of a delayed monsoon onset that exceeds the threshold for significant impact on rice fields and are likely to lead to the widespread destabilization of the health of rice production around the country. The PNAS full report details the potential threats to the agricultural rice sector considering a continuation of a global 'business as usual' while providing the proper background on the uncertainty of these projections to fully encompass the ferocity of the climate issue in Indonesia.

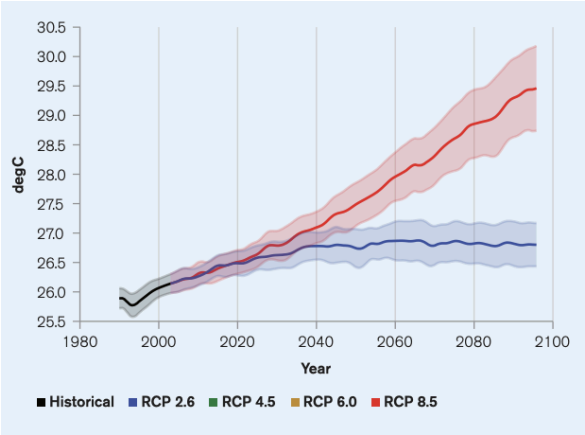
The historical climate data for Indonesia paints a concerning picture. Indonesia's average temperature increased by 0.4°C over the period from 1971 to 2010. This is higher than the global average increase of 0.8°C over the same period (Asian Development Bank 2021). Furthermore, the Development Bank report affirms the notion that Indonesia has experienced an increase in extreme weather events, including droughts, floods, landslides, increases in rainfall, and desertification events over this same 40 year period of time, a phenomenon that leaves the southeast nation vulnerable to a changing environmental landscape and without the proper political and economic resources to address it.

Exploration of the Future Projections and Major Climate Related Hazards

Some climate-related hazards that Indonesia expects to see in the near future include, the rise of average temperatures, a decrease in yearly rainfall, and more frequent and intense extreme events like heat waves and drought. All of the above have harsh impacts on the agricultural sector of Indonesia. The IPCC states that for Indonesia there will be a consistent warming trend in the next few decades in all scenario projections. There seems to be an overall increase in rainfall in the western and southern parts of the country and a decrease in the southern islands (Hecht 2016).

The Coupled Model Intercomparison Project Phase 5 (CMIP5) is a good indicator of possible future scenarios for climate change. Good climate sources like the IPCC and the Fifth Assessment Report (AR5) use data from the CMIP5 to estimate future climate change projections (Morin and Bucher 2021). Multiple estimated scenarios are presented regarding what the climate could possibly be like in the future depending on what actions humans do now. Indonesia’s climate risk report presents four main projections where the two extremes are labeled RCP 2.6 and RCP 8.5 (Morin and Bucher 2021). RCP 2.6 is the scenario that shows what temperatures would be like when high mitigation efforts are implemented. RCP 8.5 assumes that no significant change in policy or action is made (Morin and Bucher 2021). Figure 3 below shows a visual example of the projected temperature changes in both the RCP 2.6 and RCP 8.5 scenario.

Figure 3: Projected Temperature Changes, the RCP 2.6 And RCP 8.5 Scenarios.



Source: World Bank Group: Climate Risk Profile Indonesia

In Table 1 provided below, the projected average temperature anomaly changes in the four different scenarios by season in the years 2040-2059 and 2080-2099.

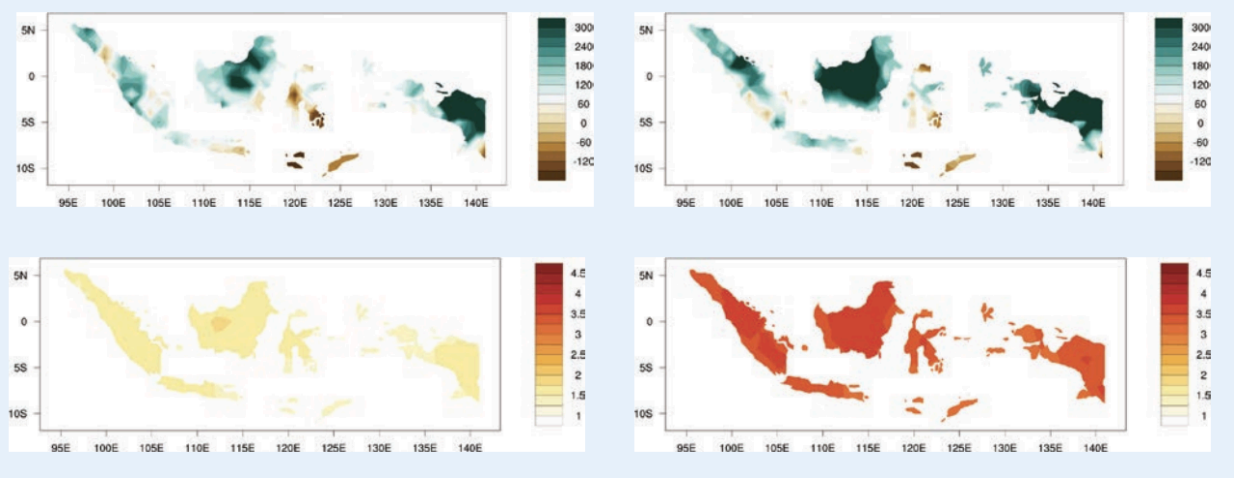
Table 1: Projected Average Temperature Anomaly Changes Years 2040-2059 And 2080-2099

	2040–2059		2080–2099	
Scenario	**Jun–Aug**	**Dec–Feb**	**Jun–Aug**	**Dec–Feb**
RCP2.6	0.9 (0.3, 1.6)	0.9 (0.4, 1.4)	0.9 (0.3, 1.6)	0.8 (0.3, 1.5)
RCP4.5	1.2 (0.6, 1.8)	1.2 (0.6, 1.7)	1.7 (1.0, 2.4)	1.6 (1.0, 2.4)
RCP6.0	1.1 (0.5, 1.6)	1.0 (0.5, 1.6)	2.1 (1.3, 2.8)	1.9 (1.3, 2.8)
RCP8.5	1.7 (1.0, 2.3)	1.6 (1.0, 2.2)	3.5 (2.6, 4.6)	3.3 (2.5, 4.4)

Source: World Bank Group: Climate Risk Profile Indonesia

Below is Figure 4 that shows an estimate of what the change in precipitation and temperature will be between the years of 2040 to 2059 on the left and 2080 to 2090 on the right in the RCP 8.5 scenario. These are representative of the RCP 8.5 scenario which is the highest extreme scenario.

Figure 4: Change In Precipitation and Temperature (years 2040-2059 shown on the left and years 2080-2090 displayed on the right, Scenario RCP 8.5).



Source: World Bank Group: Climate Risk Profile Indonesia

The future is not always certain. This is why the IPCC and CMIP5 have created multiple projections of possible outcomes. Everything that is being done in the present will have an impact on what will end up happening in the future and which of these scenarios are to happen is still left to be seen.

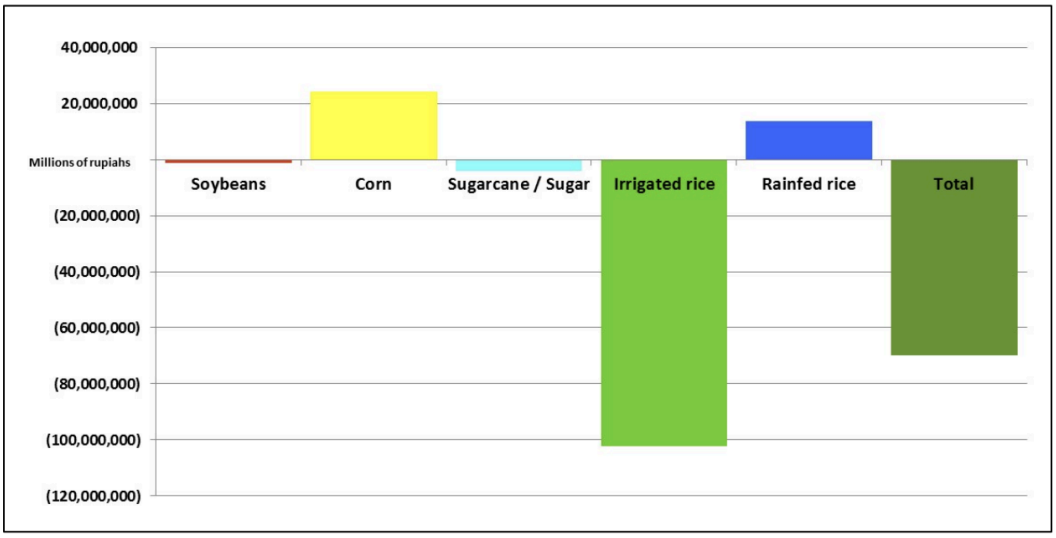
The Projected Effects on Agriculture

Annual and interannual precipitation patterns caused by the Southern Oscillation El Niño which is a natural occurrence are heavily influential on agricultural yield, incomes of rural cities, and food prices. During El Niño events, Indonesia's climate tends to be dry and it has more droughts meaning the rainfall is delayed. Because of climate change the time period for El Niño is expected to last longer (Morin and Bucher 2021). This causes the rice crops to be planted later in the monsoon season which widens the gap of what is called the “hungry season” (Naylor et al. 2007). Another impact is if the rice crop is not able to

be planted on time in the wet season then it cannot be planted later on to make up for the lost time which will decrease the rate of yield that year (Naylor et al. 2007). The World Bank Group conducted a climate risk assessment and estimated that the probability of a month's delay due to drought in the dry season will increase from 9-18% in the wet season in the next few years and 30-40% by 2050 (Morin and Bucher 2021). This can especially harm rice since it is highly sensitive to temperature and is a major influence in Indonesian cuisine. It is also predicted that, even if the needs are met and warming is limited to 1.5 degrees celsius, there will be a 5-6% decline in global wheat and maize production rates (Morin and Bucher 2021). Indonesia is the biggest export of palm oil and it is projected to gradually be more scarce until 2100. 15% of Indonesia's land is agricultural and is used for the cultivation of export crops. Additionally, most of these lands are operated by smallholder farmers that are likely to have a lower level ability to properly adapt to these impacts of climate change (Hecht 2016).

Although most crops and grains will have decreased in yield in the next few years, there are some that will thrive. A policy brief indicating the cost of climate change in Indonesia presents the figure below. It demonstrates projections for the overall impact of climate change on the value of agricultural output by crop in the year 2050. Overall the value of agricultural output will decrease except; however, the values of corn and rainfed rice are expected to increase by 25% and 50% respectively (Hecht 2016). Even so, the negatives to the effects of climate change in Indonesia are largely considered to outweigh the positives in this case due to models of irrigated rice decreasing by 20 percent. These projected scenarios for the future of agriculture in Indonesia will more than likely lead to threats in food security and lead to large-scale export losses to their local, regional, and national economies.

Figure 5: Impact of Climate Change on the Value of Agricultural Output by Crop in 2050.



Source: USAID: Indonesia Costs of Climate Change in the Year 2050

The Fundamental Physical and Economic Drivers of Vulnerability

As discussed in this course over the semester, vulnerable populations tend to bear the brunt of climate change disproportionately than other groups of people. There are a multitude of key drivers of vulnerability, both with respect to climate change and worldwide development as a whole. In this section, a collection of the key physical, economic, political, and social drivers of vulnerability will be considered and evaluated with respect to Indonesia, and also in a more broad context.

As aforementioned above, climate-related hazards, including the rise of average temperatures, a decrease in yearly rainfall, and more frequent and intense extreme events like heat waves and drought, are amongst the projections for future climate patterns in the country of Indonesia. This is specifically noteworthy because these projected impacts are likely to have a profound impact on agriculture, which makes up a large percentage of the Indonesian economy, and therefore, a profound impact on many citizens' livelihoods and survival. The interconnectedness of physical geographic location with the economic drivers of vulnerability is not only being exemplified in Indonesia, but can also be seen on a worldwide scale. In fact, the physical and economic drivers of vulnerability can often times exacerbate each other, resulting in the multiplication of experienced negative impacts.

There are two key physical drivers of vulnerability with respect to climate change and worldwide development overall, and both are heavily interconnected with the economic drivers of vulnerability.

Through a historic lens, vulnerability can be simplified to the population's geographic area it is inhabiting as well as the natural resources that are located there for their use and survival. Populations with advantageous climates and a surplus of natural resources have historically been more likely to be able to develop their countries, infrastructure, and economies much faster than civilizations of people without such resources. An example of this would be Britain or the United States, who exploited their own and other countries' natural resources and used this exploitation to stimulate the development and growth of their economy during the time of the industrial revolution. The results of this process generated a substantial amount and excess of greenhouse gas emissions, to such an extent that if all other parts of the world took the same steps in the development process, the world would likely go well past any IPCC goal.

Present day, physical and economic drivers of vulnerability with respect to climate change are still entirely intertwined. As greenhouse emissions continue to rise every year, so does the planet's overall temperature. And as aforementioned above, although the exact predictions of temperature increases and resulting impacts are not 100% comprehensive as this can not entirely be known, there is a strong consensus amongst the leading climate scientists of the general negative impacts that are to be expected in the coming years around the globe. Sea levels will continue to rise which, when coupled with the more drastic rainfall and wind associated with more intense storms, will cause hundreds of thousands of miles of coastline around the world to become virtually uninhabitable.

In the case of the families and communities in coastal areas around the globe, tropical storms of differing classifications and strengths have the potential of demolishing entire homes and towns, or worse, putting entire nations under water to never be inhabited again. This form of displacement leaves a substantial percentage of the global population incredibly vulnerable to the prospects of more extreme weather events and increased sea levels. And depending on the country in which they live in and their respective socioeconomic standing, their options to adapt to such devastation may be severely limited. Whereas if this sort of phenomenon were to happen in a country such as the United States, there is a better chance that the house will have been insured, and the family will be able to get some financial

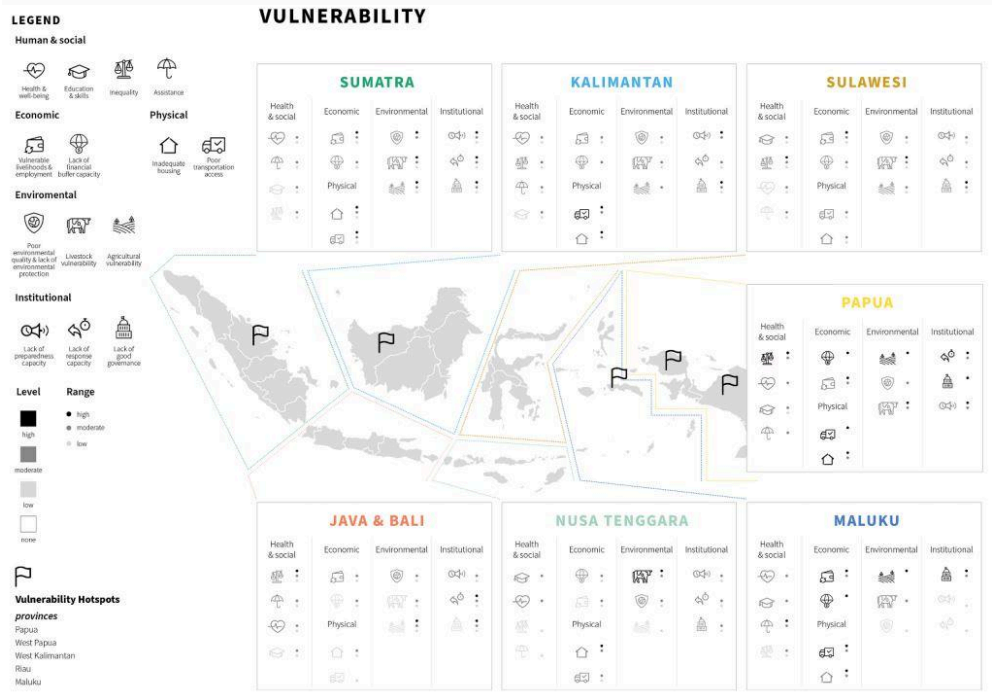
reimbursement for their damages and recourse for providing for themselves and their family in the meantime. The devastation of the future of climate events in the context of a ‘poor’ family in a ‘developing’ country, they are likely to not receive any financial aid at all and be left stranded with nowhere to turn.

In addition to the broad climate change related impacts, and as mentioned before, climate change is specifically expected to impact the agriculture sector in Indonesia. While there will be some crop benefits, overall the results of climate change experienced in the southeast Asian nation will be incredibly negative due to the overarching impacts on rice production. And because the economy of Indonesia relies so much on their agriculture, this is a major driver of vulnerability and threatens many citizens' livelihoods and survival in the decades to come.

The Key Political and Social Drivers of Vulnerability

The Government of Indonesia has made impressive efforts in promoting economic development, reducing the poverty rate from 17.4% to 9.5% in the past two decades (unfccc.int 2022). The goal is to reduce this to below 4% by 2025. To achieve this, the major drivers of social and political vulnerability across Indonesia must be identified. Indonesia suffers from high social vulnerability across the country as a whole. One of the primary issues contributing to this is the lack of ability to provision services such as access to decent health-care. This can be attributed to the low number of health-care workers in both rural and urban areas. For example, West Java has the highest population of all provinces at over 43 million, but only has 10 health-care workers per 1,000 people (Sett et al. 2022). This issue exists in a positive feedback loop with weaknesses in education and social insurance systems.

Figure 6: Vulnerability Map of Regions in Indonesia.



Source: HEVA of Indonesia 2022

These weaknesses lessen the country's ability to maximize the professional capacity of its citizens, lowering the amount of health-care workers produced. However, the World Bank has recently approved the Indonesia Human Capital Development policy loan which will be used in, “nurturing human capital by strengthening quality and equity in nutrition, health, and social protection,” by supplying $350 million for key policy reforms (Worldbank.org 2022).

Observing vulnerabilities within and between provinces reveal concerning levels of inequality that may be overlooked at the national or regional scale. The Sumatra region has low overall social vulnerability compared to other regions. However, between provinces certain populations are provided a disproportionate amount of access to health services which increase the vulnerability of marginalized groups. In addition, high inequality is the primary contributor to Papua having the highest social vulnerability (Sett et al. 2022). Many communities in Papua are isolated by a lack of access to food and health facilities.

Indonesia has moderate to severe political vulnerability across all provinces that is attributed to poor governance, low preparedness and low response capacity. Local governments have put in great effort to build resilience and reduce risk, but development is stifled by low availability of financial resources and human capacity (unfccc.int 2022). For instance, despite the establishment of climate and disaster resilience working groups, very few schools in disaster prone areas have received any preparedness training (Sett et al. 2022). Coverage of social assistance is another struggle for governance, especially in rural areas. The majority of citizens living in Papua have never received or have lost their social protection card, used to receive payouts and other non-financial assistance, which requires a great amount of effort and time to replace (Sett et al. 2022). Then there is the arduous challenge of providing this assistance once approved, as rural areas such as Papau are plagued by poor transportation infrastructure.

Vulnerable Populations

Gan et al. conducted a scoping review of climate related disasters in China, Indonesia and Vietnam. For Indonesia, they reviewed publications from 1992 to 2020 and found that most research was focused on floods in Java and Sumatra in particular. These two regions have witnessed major climate related disasters and 78.19% of the total population lives in these two regions (Gan et al. 2021). The studies they surveyed also focused on climate related impacts on human health and found high numbers in the population suffering from respiratory diseases as a result of bushfires and floods. Mental health was also found to be affected by floods and landslides.

In terms of geography, groups living in coastal areas and low-lying areas and slopes are among the most disadvantaged communities since they were the most vulnerable to floods and landslides. Among these communities, children under 5, people with disabilities, women and poor people were determined to be most vulnerable to floods while also children under 5 and outdoor workers were found to be the most vulnerable groups to bushfires (Gan et al. 2021).

Oktari et al. conducted a survey of Indonesian governance and policies to overcome climate-related disasters. They found that efforts to reduce the risk of climate disasters were mostly reactive. The researchers also stated that lack of coordination between authorities and stakeholders in

response to disasters also increased the risk to vulnerable communities. Since then, the country has committed to a number of Nationally Determined Contributions (NDC) goals as a commitment from the Indonesian government in an effort to reduce the country's vulnerability and risk to climate change (Oktari et al. 2022). This also serves as Indonesia's contribution to the world effort to meet the goal set in the Paris agreement to limit the increase in global warming to a maximum of 1.5 to 2 degrees above pre-industrial level. Such commitment by the government will definitely help vulnerable communities and will lessen the occurrence and severity of climate related natural disasters.

Conclusion

Climate change is a global threat that is increasingly making its presence more known to people all around the world, policymakers, researchers, and the public alike. It is widely acknowledged that climate change is an international phenomenon that has significant consequences for the natural environment, as well as for economic and social vulnerability systems. The interconnectedness of the key physical, economic, political, and social drivers of vulnerability is not only being exemplified in Indonesia, but can also be seen on a world wide scale with respect to climate change and development. These physical, economic, social, and political drivers of vulnerability can often times even exacerbate each other, resulting in a myriad of negative impacts.

The agricultural sector is particularly sensitive to climate change, and this is especially the case for Indonesia. Rice, being the staple food for the majority of Indonesians, accounts for over half of the calories in the average daily diet. The endangerment of this agricultural crop due to climate change will not only increase food insecurity, but also threaten the livelihood of many Indonesian citizens who rely on farming rice to support their families. Vulnerabilities across scales must be addressed to increase resilience across scales in anticipation for future events. It is vital to explore the potential hazards that climate change poses to the agricultural sector to assess the risks and to develop policies that can minimize the adverse impacts.

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