

## Multi-Stressor Analysis of Climate Vulnerability in Indonesia: A Study on Environmental Policy Ethics and Maladaptation Risk

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**Abstract:** This article aims to explore climate change multi-stressors through the development of environmental policies in Indonesia. Over time, this tropical country has been increasingly exposed to global warming and climate change phenomena that generate significant national vulnerabilities. In addressing these challenges, policy attention has predominantly focused on climatic factors. However, vulnerability is not solely a climatic issue; rather, it reflects collective systemic incapacity, which is further exacerbated by extreme weather events. Vulnerability constitutes a core concept in environmental social sciences, yet existing discussions often remain climate-centric, with limited engagement with other contributing dimensions that intensify vulnerability.

**Purpose:** This article seeks to analyze climate vulnerability multi-stressors in Indonesia, including an examination of environmental policy ethics and the risks of maladaptation. It aims to provide a foundational reference and contribute to broader knowledge and understanding of Indonesia's vulnerability context for future research and policy applications.

**Design/Methodology/Approach:** This study employs a secondary research methodology, drawing upon the analysis and synthesis of existing sources, particularly qualitative data related to environmental policies, climate vulnerability cases in Indonesia, and the implementation of relevant policies in addressing these challenges.

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**Findings:** Climate vulnerability in Indonesia remains relatively high. Efforts to address multiple stressors, particularly through policy formulation and implementation, continue to face significant obstacles and institutional stalling. Comprehensive and carefully designed planning is therefore essential to minimize maladaptation risks and to foster ethically grounded climate resilience.

**Originality/value:** This study contributes to the field of environmental policy by addressing research gaps in existing literature concerning climate vulnerability in Indonesia, particularly about the role of multi-stressors and maladaptation risks in shaping vulnerability outcomes.

**Keywords:** Multi-stressors; climate vulnerability; environmental policy; maladaptation risk

**Paper Type:** Research-Article

## **Introduction**

Climate vulnerability in Indonesia remains high, driven by multiple stressors and the risk of maladaptation arising from policies whose implementation has yet to reach optimal effectiveness. As a tropical archipelagic state, Indonesia is particularly susceptible to the impacts of global climate change, including extreme temperatures and heatwaves (Zou 2025). These phenomena pose threats not only to the environment but also to the national economy, public health, and food security.

This condition, both in practice and in terms of mitigation efforts, is closely linked to Indonesia's participation in the Paris Agreement, which commits signatory states, including Indonesia, to progressively reduce carbon dioxide emissions and other greenhouse gases to limit global warming to "well below 2.0 degrees Celsius," as adopted in 2015. The Paris Agreement further underscores the significance of this context by employing the phrase "avert, minimize, and address" in articulating the concept of loss and damage.

Prevention, in this context, is pursued through the reduction of greenhouse gas emissions, while minimization is achieved through adaptation measures. Various mitigation efforts have been implemented to limit the increase in global temperatures to below 2 degrees Celsius as much as possible in order to address the avoidable impacts of climate change. Nevertheless, unavoidable climate change impacts continue to persist. These remaining impacts must therefore be addressed to enable effective prevention, a concept referred to as “Loss and Damage” in the Paris Agreement (Siregar 2023). This concept captures the negative impacts of climate change that occur despite mitigation and adaptation efforts, subsequently affecting vulnerable communities and ecosystems, with broader implications that extend to national-level vulnerability and risk.

As vulnerability increases, climate change and multiple stressors generate tangible negative effects across various global dimensions, including physical and mental health, economic stability, and social conditions. Empirical evidence further indicates that climate-related foodborne and waterborne diseases have increased as heightened vulnerability expands the scope and intensity of these adverse impacts. A range of climatic and non-climatic hazards affect and cascade across both urban and rural environments, influencing livelihoods, infrastructure, transportation, and water systems. These impacts accumulate gradually, resulting in economic losses, reduced well-being, and diminished public services, with a disproportionate burden borne by socioeconomically marginalized urban populations (Fischer 2025).

Human factors and activities further exacerbate existing vulnerabilities. As stated in the Summary for Policymakers, globally less than 15% of land, 21% of freshwater, and 8% of marine areas are designated as protected areas. In many of these protected areas, management practices remain inadequate to

reduce climate-related damage or to enhance resilience to climate change (Jarraud 2012). Locations characterized by poverty, governance limitations, restricted access to basic services and resources, violence, and climate-sensitive livelihoods are inherently more vulnerable and responsive to climate-related changes. These conditions are further intensified by the absence of equity, persistent marginalization, and structural inequalities (Legionosuko 2019).

Regional disparities also shape levels of risk, with the highest vulnerability occurring in areas where climatic factors—such as prolonged rainfall and drought—and non-climatic factors—such as poverty and infrastructure gaps—persist simultaneously. Under such conditions, vulnerability continues to escalate. Increasing pressure on food production and affordability represents another tangible consequence of climate change. Food security is critically important yet remains under threat due to the growing intensity and frequency of droughts and floods (Cardona 2012). Climate change is projected to further intensify pressures on food production and access, particularly in vulnerable regions, thereby undermining food security and nutrition (high confidence). Increasing frequency and intensity of extreme events, coupled with rising sea levels, compound these challenges.

Ethics refers to human attitudes and actions that can be evaluated in terms of moral judgment, as determined by human reason and rationality. Ethical analysis of environmental policy is inseparable from environmental law, which comprises the rules, regulations, and policies established by governments to govern human interactions with the environment. Ethics within environmental law guides the underlying rationale of human actions and shapes their consequences for the natural environment. Empirically, Indonesia's environmental legal framework demonstrates a positive trajectory through the development and revision of laws and regulations aimed at

addressing evolving environmental challenges. However, implementation continues to face substantial obstacles, including low environmental literacy, weak law enforcement, limited public awareness, and conflicts of interest. These factors ultimately function as non-climatic drivers that contribute to multiple stressors.

Vulnerability is inherently dynamic and multidimensional, shaped by economic, social, geographic, demographic, institutional, and governance factors, and remains closely linked to both extreme and non-extreme weather events. Accordingly, effective responses require comprehensive approaches and in-depth analyses of underlying drivers, including multiple stressors and the risks of maladaptation that may arise from intervention strategies. Supportive policies are therefore essential. In their formulation and adoption, such policies must be grounded in appropriate methodologies and risk management frameworks. Indicators, indices, and probabilistic metrics constitute critical tools for vulnerability and risk analysis (Panarello 2024). Beyond the concept of multiple stressors, maladaptation risk has emerged as a closely related framework within environmental vulnerability discourse. This risk materializes when efforts intended to address existing conditions inadvertently exacerbate negative impacts. In Indonesia, maladaptation risk remains high, as policies and regulations—despite continuous revisions—are often short-term in nature or lack detailed guidance and clear implementation mechanisms.

Several policies have been identified as carrying maladaptation risks by environmental organizations in Indonesia, including critiques by WALHI, Yayasan Konservasi Alam Nusantara (YKAN), and Mongabay. These organizations highlight Indonesia's tendency to prioritize large-scale infrastructure development—often characterized by hard engineering solutions—while neglecting Nature-Based Solutions

(NbS), governance challenges, limited planning integration, and persistent socioeconomic inequalities (Widayati 2021). Several scholars have therefore advocated for the development of assessment frameworks to integrate adaptation to multiple risks into policy processes, such as Policy Adjustment–Adaptation Risk frameworks (Murieta 2021). Such frameworks aim to evaluate whether and how climate change adaptation policies incorporate risk knowledge and information. Further research is needed to systematically assess adaptation and resilience to climate-related disaster risks and to address uncertainties appropriately, given the diverse hazards and interdisciplinary dimensions involved.

According to research conducted by CRIC, in critical areas such as infrastructure, financing, subsidies, and real-time information systems for addressing climate vulnerability, the capacities of stakeholders, policymakers, and local leaders remain insufficient. This limitation is largely attributable to the complexity of the challenges and the multitude of issues and conflicts that must be addressed simultaneously (J 2020). Reducing vulnerability is therefore not only complex but also dynamic, requiring policies that are not only targeted, effective, and efficient, and capable of minimizing maladaptation risks, but also ethically grounded and integrative across all levels of society (Abdillah 2017).

### **Methods**

This study employs a research methodology that involves a comprehensive analysis and review of existing literature, documents, articles, academic journals, and policy frameworks as secondary data sources. This approach enables an in-depth investigation and a broad understanding of climate vulnerability, multiple stressors, and maladaptation risks, while simultaneously giving due attention to existing legal frameworks and mitigation efforts as examined through the lenses of ethics and their practical implementation in addressing the identified challenges. Through

this method, the study seeks to derive a nuanced understanding of the relevant cases by drawing upon previously established knowledge and empirical evidence.

## **Discussion and Findings**

### **Conditions**

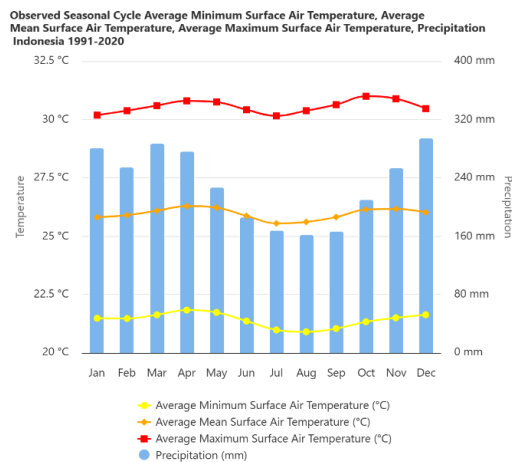
Various disasters that have occurred over the past several years are closely linked to ongoing climatic changes, with both the frequency and intensity of hazards increasing in line with existing levels of vulnerability. The rise in global temperatures over the past decade (2015–2025) indicates an increasingly extreme trend, with the average global temperature over the last three years reaching approximately 1.42 degrees Celsius above pre-industrial levels. This trend has intensified heatwaves and heat stress, phenomena that were previously limited to specific periods or seasons. As a result, multiple stressors have been exacerbated beyond the national capacity for adaptation and resilience in responding to climate change, thereby generating heightened vulnerability.

Vulnerability refers to the degree to which individuals or groups are able to cope with risks or adverse impacts. The higher the level of vulnerability, the more susceptible a group becomes to environmental changes, disasters, and other disruptive conditions. According to a study by Bappenas (2019), economic losses resulting from climate change impacts are projected to increase by 12.8 percent over five years, rising from IDR 102.36 trillion in 2020 to IDR 115.53 trillion in 2024. In response, Bappenas has sought to address these challenges through the formulation of various policy measures.

Heatwaves and heat stress create uncomfortable living conditions and hinder communities' ability to carry out daily activities. Consequently, labor productivity declines as temperatures rise. Extreme temperatures exceeding 40 degrees Celsius have led to sustained reductions in agricultural

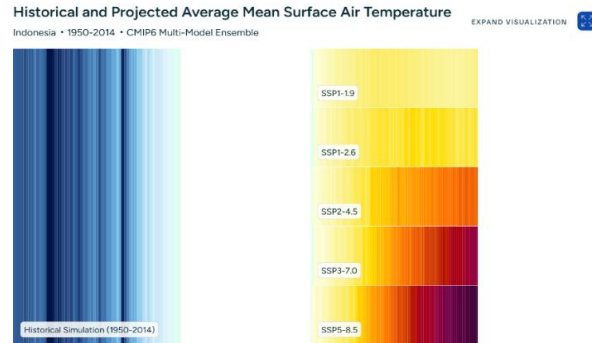
productivity, while simultaneously exacerbating impacts on other sectors, particularly public health, through the emergence of heat-related illnesses such as heatstroke. Maladaptation may arise in this context if communities respond by excessively and intensively using water for cooling purposes without considering local water resource constraints. If sustained, such practices may contribute to water scarcity and drought.

Three fundamental elements determine the level of vulnerability experienced by a group: the degree of exposure, the level of sensitivity (the extent to which a group is affected by specific conditions), and adaptive capacity (the ability to adjust or respond to change—defined in this study as climate change). As commonly articulated, “the greater the level of exposure and sensitivity, the higher the vulnerability,” whereas “the greater the adaptive capacity, the lower the vulnerability.” As indicated by data from the Climate Change Knowledge Portal, Indonesia continues to experience significant climatic changes, particularly with respect to rising temperatures and the increasing occurrence of heatwaves.

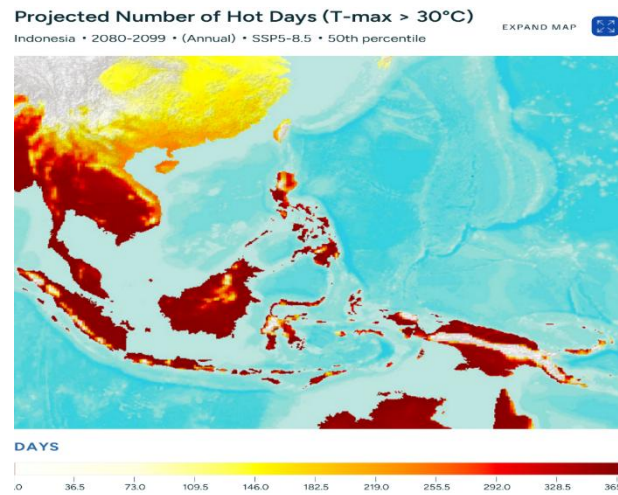


Sumber: Climate Change Knowledge Portal

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As outlined above, three key datasets are presented: average surface air temperature, average maximum surface air temperature, precipitation levels in Indonesia from 1991 to 2020, and the number of hot days during which maximum temperatures exceed 30°C. Taken together, these indicators support the argument that Indonesia has not yet achieved sufficient resilience to ongoing climate change and remains in a state of vulnerability.

Furthermore, vulnerability is not shaped by a single factor. In practice, it is driven by a range of interacting forces, commonly referred to as “multiple stressors.” Within the climate and environmental context, multiple stressors represent a convergence of environmental pressures or constraints that drive change and necessitate integrated resilience strategies. In simplified terms, multiple stressors describe conditions that exert sustained pressure and require adaptive adjustments to maintain stability within societies or communities.

These pressures can be traced to both climatic and non-climatic drivers. As implied by the plural term “multiple,” vulnerability arises not from isolated or singular factors, but from their cumulative and interacting effects. Given Indonesia’s geographical position along the equator and its status as a tropical country, climatic drivers are predominantly associated with hydrometeorological hazards and rising temperatures.

These include intense rainfall, prolonged dry seasons, flooding, landslides, tidal flooding, coastal abrasion, and heatwaves, among others. Such factors do not operate in isolation; rather, each stressor influences and amplifies others. Non-climatic factors often emerge in close interaction with climatic stressors and are frequently linked to human activities. These include deforestation and forest degradation, development in high-risk zones, rapid population growth, land subsidence, inadequate urban spatial planning, and, most critically, persistent poverty, inequality, and instability in food security.

#### **Maladaptation Risk**

Existing adaptation policies are often, if not entirely, sectoral in nature and rarely establish linkages across different policy domains. However, adaptation cannot operate in isolation; effective adaptation requires cross-sectoral collaboration to ensure that responses address the full range of societal dimensions. For instance, the agricultural sector must be coordinated with

environmental governance, underscoring the critical importance of inter-agency coordination – particularly given that Indonesia’s vulnerability is shaped not by a single factor, but by multiple stressors.

Maladaptation risk emerges when adaptation measures intended to reduce vulnerability instead generate adverse impacts or losses in other sectors. Such outcomes often stem from fragmented decision-making processes that fail to address sectoral fundamentals, resulting in flawed policy design. This is frequently compounded by governance deficiencies, including limited transparency, weak accountability, and restricted public participation in policy formulation. Low levels of participation can lead to implementation errors that disproportionately benefit socioeconomically advantaged groups while further exacerbating the conditions of already vulnerable populations.

Several potential cases of maladaptation are evident in the Indonesian context. Large-scale coastal infrastructure projects, such as the construction of giant sea walls in Jakarta and Semarang, may offer localized protection but risk intensifying coastal erosion or redirecting water flows toward unprotected areas. Such interventions can alter coastal geomorphology, degrade ecosystems such as mangroves, and potentially increase exposure to large waves – the very hazards these structures are intended to mitigate.

Similarly, land-use conversion from agriculture to monoculture plantations, such as oil palm, is often justified on the grounds of greater drought tolerance. However, if poorly planned or implemented, such transitions can disrupt hydrological cycles and exacerbate environmental vulnerability. In crises, excessive groundwater extraction is another commonly employed response; when undertaken without careful assessment, it can lead to declining groundwater tables and land subsidence, thereby heightening flood risks.

These examples illustrate the range of maladaptation risks that may arise, primarily due to misaligned policies or inadequate implementation. Consequently, there is a pressing need for ethical policy and regulatory frameworks that extend beyond narrow, short-term solutions and instead promote long-term, equitable, and sustainable adaptation pathways.

### **Financing**

Between 2018 and 2020, approximately 4.1 percent of Indonesia's State Budget (APBN) was allocated to emission reduction efforts. The Ministry of Finance, the Ministry of Environment and Forestry, and the National Development Planning Agency (Bappenas) are among the key institutions responsible for advancing a more sustainable and resilient environment. Their roles include mobilizing climate-related financing and developing sustainable financial planning mechanisms to support Indonesia's responses to both climatic and non-climatic stressors.

At the international level, mechanisms such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) are designed specifically for tropical and subtropical countries by providing incentives to address deforestation and support the management of tropical rainforests. In addition, the Adaptation Fund (AF) aims to assist countries in adapting to future climate impacts. Despite the availability of these funding sources, complex project design and planning requirements often limit access, particularly for local communities.

From a policy perspective, Indonesia has enacted several supportive legal frameworks to address existing stressors. These include Law No. 6 of 1994 on Environmental Sustainability, Forestry Law No. 41 of 1999, Law No. 32 of 2009 guaranteeing the right to a good and healthy environment, and Law No. 16 of 2016 ratifying the Paris Agreement.

Institutionally, the Ministry of Environment and Forestry (KLHK), Bappenas, and the Ministry of Finance (Kemenkeu) play complementary roles in addressing climate vulnerability in Indonesia. KLHK and Bappenas are responsible for coordinating policy formulation and development planning, while Kemenkeu ensures that financial resources are available to support implementation. Key policy instruments pursued include the National Action Plan for Greenhouse Gas Emission Reduction (RAN-GRK) and the National Action Plan for Climate Change Adaptation (RAN-API). Through these frameworks, climate vulnerability considerations are integrated into the work plans and budgets of ministries and agencies. Subnational governments also play an important role by proposing mitigation action plans and priority scales, as well as allocating budgetary resources to support implementing institutions and funding mechanisms. Beyond RAN-GRK and RAN-API, additional strategic frameworks have been established, including the National Medium-Term Development Plan (RPJMN), the Long-Term Strategy for Low Carbon and Climate Resilience Development (LTS-LCCR) 2050, and the Low Carbon Development Strategy.

Effective climate action in Indonesia requires collective engagement between the government and society, particularly through adaptation measures. However, such adaptation efforts are not feasible without adequate financing. Indonesia continues to face challenges in closing the gap between available climate finance and the funding required to achieve its Nationally Determined Contribution (NDC) targets. To address this gap, the government has introduced several innovative financing instruments, including Green Sukuk and the Indonesia Climate Change Trust Fund (ICCTF), both of which are directed toward renewable energy development and financing initiatives that support innovative policy actions and national investment in the renewable energy sector. At the international level, additional

funding mechanisms include the Green Climate Fund (GCF), which supports developing countries in reducing emissions, as well as the Global Environment Facility (GEF) and the Adaptation Fund, both of which prioritize vulnerability reduction through financing in remote and economically disadvantaged regions.

Policy implementation often encounters stalling when inter-institutional communication and coordination remain limited. Low levels of climate finance literacy and unclear information further contribute to public confusion regarding access to available funding mechanisms. These challenges are multifaceted, encompassing overlapping regulations among ministries and agencies, a disproportionate focus on response rather than prevention, access disparities in geographically remote or highly vulnerable areas, and business interests that may delay substantive engagement with climate vulnerability issues in favor of short-term economic gains (Fanggidae 2023).

Overlapping mandates and fragmented authority are particularly likely when central ministries pursue competing interests or projects. At the subnational level, fragmentation may also arise between provincial and district governments, or between districts and subdistricts, particularly in the absence of clear hierarchical governance structures for resource management. These issues are further compounded by inefficient resource allocation, such as duplicated programs – most notably subsidized fertilizer schemes implemented across regions or sectors without effective targeting.

Inconsistent reporting standards across institutions further complicate data consolidation, as different ministries may employ distinct metrics or indices. Climate budget tagging remains uneven and insufficiently standardized due to the absence of comprehensive national guidelines, leading to divergent interpretations that ultimately delay decision-making. Finally, and most critically, weak vertical coordination between central

and local governments persists. This challenge is frequently linked to fiscal transfers that lack transparent and accountable monitoring mechanisms. If left unaddressed, such shortcomings risk undermining projects intended to strengthen Indonesia's climate resilience, resulting instead in failure due to miscommunication or misalignment of priorities.

### **Policy Barriers and Constraints**

Beyond the financing challenges discussed earlier, one of the primary obstacles to addressing climate vulnerability lies in the involvement of numerous institutions. Insufficient coordination and, in some cases, conflicting interests among these actors often result in policy overlap and fragmentation. In addition, regional disparities persist, whereby poorer and more remote areas tend to face greater difficulties in accessing assistance and financial support.

Political cycle bias further contributes to short-term policy orientations, wherein public officials prioritize projects with rapid and visible outputs to serve electoral interests. As a consequence, long-term and sustainable investments are frequently deprioritized or sacrificed. Electoral considerations are closely tied to election cycles, which pressure policymakers to demonstrate tangible results within a four- to five-year timeframe. In contrast, innovations with enduring impacts—such as mangrove restoration or the development of climate-resilient infrastructure—require significantly longer time horizons, often extending over decades.

This emphasis on “quick wins” ultimately undermines long-term adaptation processes, as available resources are diverted toward temporary investments and solutions that remain vulnerable to multiple stressors. As previously discussed, coastal infrastructure such as sea walls, while intended to protect urban areas, may instead redirect flooding toward downstream communities. In practice, policymakers frequently focus on short-

term gains or immediate economic returns rather than on development strategies that function as long-term investments.

Moreover, development planning has yet to fully embrace principles of equity. Policy attention and investment remain disproportionately concentrated on already developed islands, while remote regions and underdeveloped areas—commonly referred to as the 3T regions (frontier, outermost, and least developed)—continue to be marginalized.

### **Policy Responses and Mitigation Strategies**

According to the IPCC, the acceleration of fragmentation and Indonesia's vulnerability to climate change, multiple stressors, and the risk of maladaptation may persist in the absence of substantive changes in policy decision-making, as discussed earlier. Political cycle bias continues to steer policymakers toward "quick win" policies rather than long-term innovations such as early warning systems. At the most fundamental level, climate-responsive policy is anchored in the RPJMN, which serves to integrate climate considerations into development strategies and to establish targets for climate-resilient development.

Another key instrument is the National Action Plan for Climate Change Adaptation (RAN-API), which provides a foundational framework for subnational governments in formulating and implementing climate adaptation policies. Spatial planning also constitutes a critical component in addressing non-climatic stressors by restricting development in high-risk zones. Through reports issued by the Ministry of Environment and Forestry (KLHK), operationalized in the National Adaptation Plan (NAP), the integration of adaptation into national development planning increasingly emphasizes the need to develop and evaluate adaptation measures to prevent maladaptation.

In addition, the Strategic Environmental Assessment of the National Long-Term Development Plan (KLHS RPJPN 2024–

2025), prepared by Bappenas, highlights not only the hazards of climate change and the necessity of cross-sectoral risk assessments, but also underscores that disparities in authority, insufficient coordination between central and local governments, and weaknesses in climate budget tagging may further exacerbate Indonesia's vulnerability to existing multiple stressors.

Beyond these core frameworks, several innovative policy instruments have been introduced. These include Climate Budget Tagging, aimed at ensuring equitable distribution of climate-related funding to remote regions; the One Map Policy, which seeks to prevent infrastructure maladaptation through integrated climate risk data; mangrove-based initiatives that reframe mangroves from purely environmental assets into community-based resources for coastal protection and flood mitigation; and mandatory Maladaptation Risk Assessments, which require all projects to assess maladaptation risks in addition to Environmental Impact Assessments (AMDAL) (Abdillah 2017).

### **Conclusion**

Climate vulnerability refers to a condition in which groups become susceptible to negative impacts resulting from change. In this context, vulnerability is driven not only by climatic factors but also by a constellation of both climatic and non-climatic drivers that place communities in vulnerable positions. The more vulnerable a group becomes, the more readily it is affected by environmental and socio-economic changes. In Indonesia, as a tropical country, these drivers are closely associated with marine and hydrometeorological hazards as well as rising temperatures. Flooding and heatwaves, for instance, do not occur in isolation; rather, one stressor reinforces another, further amplifying national vulnerability. Prolonged droughts and extreme heat reduce agricultural productivity, weaken food security, and constrain communities' capacity to meet basic needs and adapt, with similar cascading effects observed across other sectors.

Efforts to address these conditions necessarily involve policy formulation and implementation, ranging from the RPJMN to the RAN-API, as well as infrastructure development and governance interventions. These measures require adequate financing and careful planning to avoid maladaptation and implementation stalling. One prominent example of potential maladaptation in Indonesia – currently a central focus of public debate – is the construction of the Giant Sea Wall. Hasty and insufficiently rigorous policy formulation and implementation may cause this project to exacerbate existing negative impacts rather than mitigate them.

The development of a Giant Sea Wall risks intensifying coastal erosion and redirecting wave energy toward unprotected areas, ultimately generating inequitable outcomes and further aggravating vulnerability. To prevent maladaptation, comprehensive planning and sufficient financing are essential. Nevertheless, significant barriers to implementation remain, particularly in relation to financing constraints, limited institutional capacity to allocate funds effectively, the prevalence of short-term rather than long-term policy orientations, and overlapping or fragmented policy frameworks. Beyond existing policies and implementation mechanisms, further innovation is required to enhance effectiveness, as discussed earlier. Ultimately, the success of climate vulnerability mitigation in Indonesia depends on the ethical foundations of planning and decision-making. Policies must be equitable, long-term in orientation, and designed to serve collective and sustained resilience rather than short-term interests.

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