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Climate Crisis, Social Crisis: Measuring Inequality in Climate Impact Across Eastern Indonesia

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Abstract

The climate crisis is not only an environmental issue but also a profound social challenge, disproportionately affecting marginalized communities. In Indonesia—an archipelagic nation highly vulnerable to climate change—this disparity is especially pronounced in the eastern regions, which face both ecological fragility and systemic underdevelopment. This research investigates the intersection of climate vulnerability and social inequality across Eastern Indonesia, employing a multidimensional framework to measure differential climate impacts among provinces such as Nusa Tenggara Timur, Maluku, and Papua. Drawing on climate exposure data, socio-economic indicators, and adaptive capacity metrics, we develop a Climate Inequality Index (CII) tailored to the Indonesian context. The findings reveal that regions with lower income levels, limited infrastructure, and weaker governance structures suffer significantly greater climate burdens, despite contributing minimally to global emissions. The study's key contribution lies in its empirical quantification of inequality in climate impact at a sub-national level, offering a nuanced lens for assessing vulnerability beyond mere geographic exposure. By linking climate stressors to entrenched socio-political disparities, the research highlights how the climate crisis exacerbates existing social crises. Moreover, the Climate Inequality Index developed here provides a replicable model for policymakers and researchers aiming to target interventions more equitably. The results underscore the urgent need for climate justice frameworks in national adaptation strategies, particularly for peripheral regions often excluded from policy discourse. This research advances the conversation on climate equity in Southeast Asia and offers practical insights for integrating social justice into environmental governance.

[*Krisis iklim bukan hanya masalah lingkungan tetapi juga tantangan sosial yang mendalam, yang secara tidak proporsional memengaruhi komunitas yang terpinggirkan. Di Indonesia—negara kepulauan yang sangat rentan*

terhadap perubahan iklim—kesenjangan ini sangat kentara di wilayah timur, yang menghadapi kerapuhan ekologis dan keterbelakangan sistemik. Penelitian ini menyelidiki persimpangan kerentanan iklim dan ketidaksetaraan sosial di seluruh Indonesia Timur, menggunakan kerangka kerja multidimensional untuk mengukur dampak iklim yang berbeda di antara provinsi-provinsi seperti Nusa Tenggara Timur, Maluku, dan Papua. Dengan memanfaatkan data paparan iklim, indikator sosial-ekonomi, dan metrik kapasitas adaptif, kami mengembangkan Indeks Ketidaksetaraan Iklim (CII) yang disesuaikan dengan konteks Indonesia. Temuan menunjukkan bahwa wilayah dengan tingkat pendapatan yang lebih rendah, infrastruktur yang terbatas, dan struktur tata kelola yang lebih lemah mengalami beban iklim yang jauh lebih besar, meskipun kontribusinya terhadap emisi global minimal. Kontribusi utama studi ini terletak pada kuantifikasi empiris ketidaksetaraan dampak iklim di tingkat sub-nasional, menawarkan lensa yang lebih bernuansa untuk menilai kerentanan di luar sekadar paparan geografis. Dengan menghubungkan tekanan iklim dengan kesenjangan sosial-politik yang mengakar, penelitian ini menyoroti bagaimana krisis iklim memperburuk krisis sosial yang sudah ada. Lebih jauh lagi, Indeks Ketidaksetaraan Iklim yang dikembangkan di sini menyediakan model yang dapat direplikasi bagi para pembuat kebijakan dan peneliti yang bertujuan untuk menargetkan intervensi secara lebih adil. Hasil penelitian ini menggarisbawahi kebutuhan mendesak akan kerangka kerja keadilan iklim dalam strategi adaptasi nasional, khususnya untuk wilayah-wilayah terpencil yang seringkali dikecualikan dari wacana kebijakan. Penelitian ini memajukan percakapan tentang kesetaraan iklim di Asia Tenggara dan menawarkan wawasan praktis untuk mengintegrasikan keadilan sosial ke dalam tata kelola lingkungan.]

Keywords: Climate Change, Climate Justice, Climate Inequality Index, Social Crisis, Climate Impact

Introduction

Climate change is increasingly recognized not only as an environmental problem but also as a problem of inequality. Rising temperatures, changing rainfall patterns, droughts, floods, sea-level rise, and extreme weather events do not affect all populations in the same way. Their consequences depend on the extent to which individuals and communities are exposed to hazards, their sensitivity to those hazards, and their capacity to anticipate, absorb, and recover from their consequences. The Intergovernmental Panel on Climate Change (IPCC) emphasizes that climate risks are shaped by the interaction of hazards with exposure and vulnerability, while vulnerability itself is strongly influenced by socioeconomic conditions, institutional capacity, and historical inequalities (IPCC 2022).

This relationship between climate change and inequality is particularly important in developing countries, where communities with limited access to infrastructure, healthcare, education, income, and political institutions frequently possess fewer resources with which to adapt. Climate change can therefore function as a threat multiplier: existing inequalities increase vulnerability to climate impacts, while climate-related shocks can subsequently deepen poverty, reduce livelihood security, and weaken the capacity of marginalized communities to adapt to subsequent shocks. Climate vulnerability should consequently be understood as a social and political condition rather than simply a geographical characteristic.

Indonesia provides a particularly important case for examining this relationship. As an archipelagic country consisting of thousands of islands and highly diverse ecological and socioeconomic systems, Indonesia experiences substantial spatial variation in climate exposure and adaptive capacity. The country's eastern regions—including Nusa Tenggara, Maluku, and Papua—contain many communities whose livelihoods depend heavily on agriculture, fisheries, forests, and other natural resources. At the same time, several areas in Eastern Indonesia experience persistent challenges concerning poverty, infrastructure, public services, connectivity, and institutional capacity. These conditions can intensify the consequences of climate hazards.

Research on social vulnerability in Indonesia provides empirical evidence of these spatial inequalities. Siagian et al. (2014) demonstrate that social vulnerability to natural hazards is strongly associated with socioeconomic characteristics, including poverty, education, housing conditions, population characteristics, and access to resources. More recent spatial analysis similarly demonstrates that social vulnerability is highly heterogeneous across Indonesian districts, with several districts in Eastern Indonesia exhibiting particularly serious socioeconomic vulnerabilities (Kurniawan et al. 2020).

The significance of these inequalities becomes clearer when climate vulnerability is conceptualized as more than exposure. A geographically isolated island may face substantial exposure to sea-level rise or extreme weather, but its overall vulnerability depends partly on whether residents have access to roads, ports, healthcare, early-warning systems, financial resources, resilient housing, and effective government institutions. The same climatic event can therefore produce dramatically different social consequences in two regions.

Nusa Tenggara Timur (NTT), Maluku, and Papua illustrate this problem particularly well. In NTT, many rural and coastal livelihoods depend on climate-sensitive agricultural and fisheries systems. Research on Bajo fishing communities in Sikka, Flores, shows that climate variability and changing marine conditions affect fishing activities and require communities to develop new adaptation strategies based on local knowledge and innovation (Nurlaili 2015). Similarly, research on fishermen in Kupang demonstrates that extreme weather, rainfall variability, and large waves can affect fishing activities and household income (Batukh 2023).

In Maluku, the dependence of coastal communities on marine resources creates another dimension of vulnerability. Communities that rely heavily on fisheries can experience simultaneous ecological and socioeconomic pressures when marine ecosystems are affected by changing temperatures, ocean conditions, and extreme events. Meanwhile, social vulnerability research identifies Maluku and Papua as regions with particularly significant socioeconomic challenges, including limited electricity access, poverty, illiteracy, and inadequate sanitation (Kurniawan et al. 2021).

Papua presents a further dimension of climate inequality because environmental vulnerability intersects with geographic remoteness, infrastructure deficits, and socioeconomic disparities. Climate-related pressures in coastal areas, for instance, can interact with land-use change and ecosystem degradation. Research in Jayapura demonstrates that changes in land use and land cover contribute to environmental pressures and increase the importance of adaptation and mitigation strategies in vulnerable coastal areas (Pamungkas and Andriani 2023).

Against this background, this paper examines climate inequality in Eastern Indonesia through a multidimensional framework. It proposes the Climate Inequality Index (CII) as an analytical framework that connects climate exposure with socioeconomic vulnerability and adaptive capacity. Rather than treating vulnerability as a purely environmental measurement, the CII conceptualizes climate impact as the outcome of three interconnected dimensions: exposure to climate hazards, sensitivity arising from social and economic conditions, and the capacity to adapt and recover.

The paper is organized into four analytical discussions. First, it examines climate inequality as a problem of unequal exposure and vulnerability. Second, it discusses the socioeconomic mechanisms through which climate shocks become social crises. Third, it examines the spatial dimensions of climate inequality in NTT, Maluku, and Papua. Fourth, it discusses the Climate Inequality Index as a tool for developing more equitable climate governance and adaptation policy. The central argument is that climate justice in Indonesia requires policymakers to measure not only where climate hazards occur, but also who is most likely to suffer from them and why.

Climate Inequality: From Unequal Exposure to Unequal Vulnerability

The concept of climate inequality begins with a simple observation: climate hazards are environmental phenomena, but climate impacts are socially produced. A flood, drought, cyclone, or prolonged period of extreme heat does not automatically become a social crisis. Its consequences depend on the characteristics of the population and the systems in which people live. The vulnerability framework developed within climate-change research provides a useful starting point. Vulnerability is commonly understood through exposure, sensitivity, and adaptive capacity (IPCC 2007; IPCC 2022). Exposure refers to the

presence of people, livelihoods, infrastructure, or ecosystems in places affected by climate hazards. Sensitivity concerns the degree to which those systems are affected by a hazard. Adaptive capacity refers to the ability to adjust, respond, and recover.

This framework is particularly useful for understanding inequality because each dimension can vary substantially between regions. Two districts may experience similar rainfall changes but have different levels of vulnerability because one has stronger infrastructure, better healthcare, greater household income, and more effective institutions.

Social vulnerability research in Indonesia supports this interpretation. Siagian et al. (2014) demonstrate that vulnerability is influenced by socioeconomic characteristics rather than hazard exposure alone. Similarly, Kurniawan et al. (2020) found substantial spatial variation in social vulnerability across Indonesian districts and identified socioeconomic factors as dominant drivers in several highly vulnerable areas. Their research is especially relevant because it demonstrates that vulnerability assessment can identify not only the intensity of hazards but also the social conditions that determine their consequences.

The distinction between exposure and vulnerability is therefore critical. A coastal village in Papua may be highly exposed to sea-level rise, but its vulnerability becomes significantly greater if residents have limited access to evacuation infrastructure, health services, transportation, financial resources, or alternative livelihoods. Similarly, an agricultural community in NTT may experience drought, but the consequences become substantially more severe when households depend almost entirely on rain-fed agriculture and have limited access to irrigation, credit, crop insurance, or alternative employment.

This produces a hierarchy of climate impacts. At the first level is the physical hazard. At the second level is the immediate effect on livelihoods, infrastructure, ecosystems, or health. At the third level are socioeconomic consequences such as income loss, food insecurity, displacement, unemployment, and declining access to education. Finally, these effects can reinforce pre-existing inequalities and create a cycle in which vulnerable communities become progressively less capable of adapting to future climate events.

This cycle is especially significant in regions with persistent socioeconomic disadvantage. When a household has sufficient savings, insurance, secure employment, and access to public services, it may be able to recover from a climate-related loss relatively quickly. A poor household dependent on climate-sensitive livelihoods may have to sell productive assets, withdraw children from school, reduce food consumption, borrow money, or migrate. The climate shock therefore becomes a mechanism for producing long-term socioeconomic decline.

Climate inequality consequently needs to be distinguished from simple climate vulnerability. Vulnerability measures the susceptibility of a population to climate impacts, whereas climate inequality asks how vulnerability and impacts are distributed between different populations. The latter is inherently comparative and political.

A climate-justice perspective therefore requires asking three questions: Who is exposed? Who is vulnerable? And who possesses the capacity and resources to adapt? These questions reveal why climate policy based exclusively on hazard mapping can overlook the people most affected by climate change.

When Climate Stress Becomes a Social Crisis

Climate impacts become social crises when environmental disruption interacts with weak socioeconomic conditions. In Eastern Indonesia, this interaction is particularly visible in agriculture, fisheries, water security, health, infrastructure, and household income. Agriculture is one of the clearest examples. Many rural households in Eastern Indonesia depend on climate-sensitive agricultural systems. Variations in rainfall and temperature can affect planting seasons, crop yields, livestock, and food availability. When agricultural production declines, the effects extend beyond farmers. Reduced production can affect local food prices, household income, employment, nutrition, and government expenditures.

This creates what can be described as a climate-poverty feedback loop. Climate shocks reduce productive capacity; reduced productive capacity lowers income; lower income reduces the ability to invest in adaptation; and inadequate adaptation increases vulnerability to subsequent climate shocks. The resulting cycle means that climate change can deepen poverty even where communities make significant efforts to adapt.

The same process occurs in fisheries. Coastal communities often depend directly on marine ecosystems for employment and food. Changes in sea temperature, weather conditions, currents, wave patterns, and marine ecosystems can therefore affect both income and food security. Nurlaili's (2015) study of Bajo fishermen in Sikka demonstrates that climate-related changes require livelihood adaptations based on knowledge construction and innovation.

The study of fishermen in Kupang similarly illustrates the connection between climate variability and income. Batukh (2023) finds that changing environmental conditions, particularly wind conditions, are associated with fishing-income fluctuations and encourages livelihood diversification as part of adaptation. These examples demonstrate that adaptation is not merely an environmental process. It is a livelihood process. When climate change reduces the reliability of one livelihood, households must search for alternatives. Households with greater financial, educational, and social resources have more options. Poor households have fewer.

Infrastructure is another important mechanism. Roads, bridges, ports, electricity systems, telecommunications, irrigation, schools, hospitals, and water infrastructure influence adaptive capacity. Infrastructure deficits can amplify climate impacts by increasing isolation during disasters and reducing access to markets and essential services.

This problem is especially relevant to small islands. Salamanca et al. (2013) found that adaptation challenges in Indonesian islands were strongly connected to geographic isolation, livelihood dependence on natural resources, limited local capacity, and insufficient implementation of adaptation policy. The assessment highlighted NTT among the areas requiring significant adaptation attention. The IPCC similarly identifies Eastern Indonesian islands as contexts in which high poverty, limited stakeholder capacity, and environmental and social change complicate climate-resilient development. Infrastructure such as roads, ports, and irrigation can be crucial to resilience, but poorly designed infrastructure can itself create maladaptation (IPCC 2022).

The concept of maladaptation is particularly important for climate inequality. If governments respond to climate risk through infrastructure that primarily benefits economically stronger communities, climate adaptation can unintentionally increase inequality. For example, a coastal protection project may protect a major economic center while leaving smaller settlements exposed. Likewise, irrigation infrastructure may disproportionately benefit commercial agricultural producers if smallholders lack access to it. Climate change therefore exposes weaknesses in development systems. A community without adequate healthcare, transport, education, sanitation, or income security is likely to experience a climate shock more severely than a community with stronger social infrastructure.

This is why climate policy and social policy cannot be separated. Poverty reduction, infrastructure development, public health, education, and social protection are simultaneously adaptation policies because they increase people's capacity to withstand environmental shocks.

Eastern Indonesia and the Geography of Climate Inequality

The geography of Eastern Indonesia demonstrates why national averages can conceal significant inequalities. NTT, Maluku, and Papua have different ecological and socioeconomic characteristics, but they share several structural conditions that can increase climate vulnerability: geographic fragmentation, dependence on natural-resource livelihoods, infrastructure constraints, and uneven access to public services.

1. Nusa Tenggara Timur

NTT is particularly exposed to climate variability because of its relatively dry climate and dependence on climate-sensitive livelihoods. Rural communities frequently depend on agriculture and livestock, while coastal communities depend on fisheries. Water availability is therefore a critical component of climate resilience. Research on the Aesesa watershed in Flores demonstrates the importance of assessing the vulnerability of water resources to climate variability. Using the exposure-sensitivity-adaptive-capacity framework, the study identifies the need to understand water vulnerability through interactions between climatic conditions and local resource characteristics (Pujiono and Setyowati 2015).

The vulnerability of NTT is also evident in fisheries. Nurlaili (2015) documents how Bajo fishermen in Sikka respond to climate-related changes through livelihood knowledge and innovation. The Kupang case similarly demonstrates that changing weather and marine conditions affect fishing activities and income, reinforcing the importance of livelihood diversification (Batukh 2023).

These cases show that NTT's climate vulnerability cannot be reduced to rainfall or temperature indicators. Climate impacts become severe because environmental stress interacts with livelihood dependence and limited economic alternatives.

2. Maluku

Maluku presents a different configuration of climate inequality. Its archipelagic geography means that many communities are heavily dependent on coastal and marine ecosystems. Geographic fragmentation can make the provision of infrastructure and public services more difficult and expensive. Social vulnerability data provide evidence of this structural disadvantage. Kurniawan et al. (2021) identify Maluku and Papua as regions with significant socioeconomic vulnerability, including problems related to electricity, poverty, literacy, sanitation, and disaster preparedness.

Climate change can therefore compound pre-existing infrastructure and service deficits. Coastal communities dependent on fisheries may experience ecological disruption while simultaneously facing limited access to alternative employment, markets, financial services, and public infrastructure. The result is a form of compounded vulnerability. Environmental vulnerability and social vulnerability reinforce one another. A household with limited income may depend more heavily on marine resources, but climate change can reduce the reliability of those resources. At the same time, limited income reduces the household's ability to diversify away from fisheries.

Research on community resilience in Maluku similarly shows that communities dependent on natural resources can experience substantial climate vulnerability but can also develop localized adaptation strategies (Abdullah 2014). This highlights an important principle: high vulnerability does not mean an absence of resilience. Communities can possess considerable adaptive knowledge even when structural conditions limit their options.

3. Papua

Papua presents perhaps the most complex case because climate vulnerability intersects with geographic remoteness, infrastructure limitations, environmental change, and socioeconomic inequality. Climate risks vary significantly between inland, highland, forest, and coastal communities. Coastal areas face particular challenges. Research on Jayapura shows that land-use and land-cover changes contribute to environmental pressures in coastal areas and require integrated mitigation and adaptation strategies (Pamungkas and Andriani 2023).

The social dimension is equally important. Kurniawan et al. (2020) identify several districts in Eastern Indonesia, including districts in Papua, among areas with particularly significant socioeconomic vulnerability. This suggests that Papua's climate inequality is not adequately captured by measuring climate exposure alone. Remote communities may experience a hazard with fewer resources to respond, weaker infrastructure connections, and longer recovery periods. Consequently, the same magnitude of climate event can produce substantially greater social damage.

Across the three regions, a consistent pattern emerges: climate impact is greatest where environmental exposure intersects with socioeconomic disadvantage and limited adaptive capacity. This finding supports the need for a multidimensional measurement framework rather than a single climate-risk indicator.

Constructing a Climate Inequality Index for Equitable Climate Policy

To operationalize the concept of climate inequality, this paper proposes a Climate Inequality Index (CII) that integrates three dimensions: climate exposure (E), social sensitivity (S), and adaptive capacity (A). The conceptual structure can be expressed as:

$$CII_i = w_E E_i + w_S S_i + w_A(1 - A_i)$$

where:

- CII_i = Climate Inequality Index for region i;
- E_i = climate exposure;
- S_i = socioeconomic sensitivity;
- A_i = adaptive capacity;
- w_E, w_S, w_A = weights assigned to each dimension.

The use of $1 - A$ means that higher adaptive capacity reduces the final inequality score. The index should be normalized to a common scale, for example from 0 to 1, where higher values indicate greater climate inequality.

The first dimension, exposure, can include indicators such as changes in temperature, rainfall variability, drought frequency, flood occurrence, coastal exposure, sea-level rise, and other relevant climate hazards. Exposure indicators should be selected according to the ecological characteristics of each region rather than applying exactly the same indicators everywhere. The second dimension, social sensitivity, measures the characteristics that determine how strongly communities are affected by climate hazards. Potential indicators include poverty, income inequality, dependence on climate-sensitive livelihoods, food insecurity, health conditions, educational attainment, housing quality, population characteristics, and access to basic services. The third dimension, adaptive capacity, captures the resources available to respond to climate impacts. Potential indicators include access to electricity, roads, healthcare, education, financial

services, communications, social protection, disaster preparedness, institutional capacity, and access to climate information.

This structure is consistent with established vulnerability research while introducing a stronger inequality perspective. Social vulnerability research in Indonesia has already demonstrated the usefulness of multidimensional indicators and spatial analysis. Kurniawan et al. (2020) use spatial fuzzy clustering to identify different vulnerability profiles among Indonesian districts, while Wijaya and Halim (2023) apply principal component analysis and clustering to identify major dimensions of social vulnerability at the district level.

The value of the CII is therefore not simply that it generates a numerical ranking. Its greater value is diagnostic. A region may have a high CII because of high climate exposure, high socioeconomic sensitivity, low adaptive capacity, or a combination of all three.

For example, suppose Region A has high exposure but strong infrastructure and high adaptive capacity, while Region B has moderate exposure but extreme poverty and limited infrastructure. A conventional climate-risk assessment may prioritize Region A because its physical exposure is greater. The CII could instead identify Region B as requiring more urgent social adaptation assistance because its population possesses fewer resources with which to respond.

This distinction is central to climate justice. The CII can also be used to identify policy mismatch. A region with high exposure but relatively strong adaptive capacity may require infrastructure and risk-reduction investments. A region with moderate exposure but severe poverty may require social protection and livelihood diversification. A region with high exposure, high sensitivity, and low adaptive capacity may require comprehensive intervention.

The index should, however, not be treated as a definitive measurement of justice. Composite indices necessarily involve choices about variables, weights, normalization, and data quality. A poorly constructed index can conceal inequalities rather than reveal them. Kurniawan et al. (2020) emphasize that different Indonesian districts can have different dominant vulnerability factors, demonstrating the limitations of treating vulnerability as a uniform phenomenon. The CII should therefore be combined with qualitative research and community participation. Quantitative indicators can reveal spatial patterns, but they cannot fully capture local knowledge, cultural values, informal institutions, political exclusion, or community perceptions of risk.

A robust CII methodology should consequently follow four principles. First, it should be multidimensional. Climate exposure alone is insufficient. Second, it should be spatially disaggregated. Provincial averages can conceal substantial differences between districts and villages. Third, it should be socially disaggregated. Where data permit, vulnerability should be examined by income, gender, age, disability, livelihood, ethnicity, and other relevant characteristics. Fourth, it should be policy-oriented. The purpose of measuring inequality should be to improve resource allocation rather than simply to rank regions.

In this sense, the CII can function as a bridge between climate science and climate justice. It translates abstract differences in vulnerability into evidence that can inform decisions about where adaptation finance, infrastructure, social protection, and institutional strengthening are most urgently required. The broader policy implication is that Eastern Indonesia should not be treated as a homogeneous "vulnerable region." NTT, Maluku, and Papua contain substantial internal differences. A justice-oriented approach must identify these differences and direct resources toward the specific mechanisms producing vulnerability in each location.

Conclusion

The climate crisis in Eastern Indonesia is simultaneously an environmental crisis and a social crisis. Climate hazards become unequal social impacts because exposure interacts with poverty, livelihood dependence, infrastructure deficits, limited public services, and unequal adaptive capacity. Evidence from NTT, Maluku, and Papua demonstrates that communities dependent on agriculture, fisheries, and other natural resources can experience particularly severe consequences when climate variability disrupts their livelihoods. Existing socioeconomic disadvantages can further limit their capacity to recover, creating cycles in which climate shocks deepen poverty and poverty increases future climate vulnerability.

This paper argues that climate justice therefore requires moving beyond hazard-based assessments toward measurements of climate inequality. The proposed Climate Inequality Index integrates exposure, social sensitivity, and adaptive capacity to provide a multidimensional framework for identifying where climate impacts are likely to be most unequal. Such an approach can complement existing social-vulnerability and disaster-risk assessments in Indonesia by explicitly connecting environmental risks with socioeconomic inequalities. The central policy implication is that adaptation resources should be allocated according to need rather than exposure alone. Eastern Indonesia requires place-specific and socially targeted interventions that combine resilient infrastructure, livelihood diversification, social protection, public services, disaster preparedness, and community participation. The CII should not be used as a substitute for local knowledge or participatory governance; rather, it should function as an evidence-based tool that helps policymakers identify structural inequalities and prioritize interventions. Ultimately, climate resilience in Indonesia will be meaningful only when communities facing the greatest climate burdens are also provided with the greatest opportunities and resources to adapt.

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